Red Hat JBoss Fuse 6.3

Deploying into Apache Karaf

Deploying application packages into the Apache Karaf container

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Deploying application packages into the Apache Karaf container

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Legal Notice

Abstract

The guide describes the options for deploying applications into a Red Hat JBoss Fuse container.

Table of Contents

PART I. THE RED HAT JBOSS FUSE CONTAINER

Abstract

The Red Hat JBoss Fuse container is a flexible container that supports a variety of different deployment models: OSGi bundle deployment and WAR deployment. The container is also integrated with Apache Maven, so that required artifacts can be downloaded and installed dynamically at deploy time.

CHAPTER 1. RED HAT JBOSS FUSE OVERVIEW

Abstract

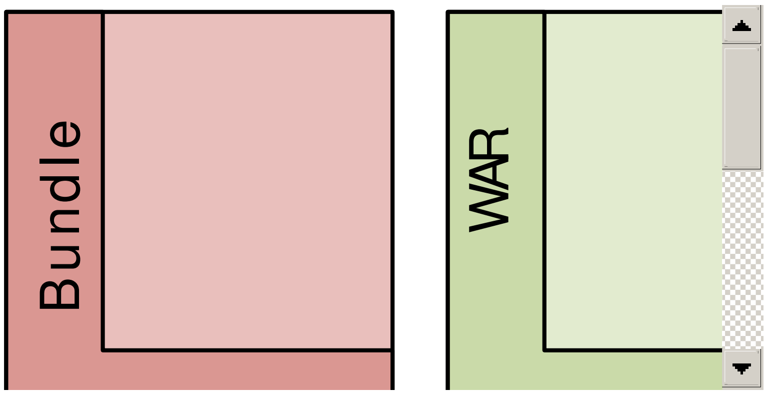
Red Hat JBoss Fuse is a flexible container that allows you to deploy applications in a range of different package types (WAR or OSGi bundle) and has support for both synchronous and asynchronous communication.

1.1. RED HAT JBOSS FUSE CONTAINER ARCHITECTURE

Overview

Figure 1.1, "Red Hat JBoss Fuse Container Architecture" shows a high-level overview of the Red Hat JBoss Fuse container architecture, showing the variety of deployment models that are supported.

Figure 1.1. Red Hat JBoss Fuse Container Architecture



Deployment models

Red Hat JBoss Fuse is a multi-faceted container that supports a variety of deployment models. You can deploy any of the following kinds of deployment unit:

OSGi bundle

An *OSGi bundle* is a JAR file augmented with metadata in the JAR's **META-INF/MANIFEST.MF** file. Because the Red Hat JBoss Fuse container is fundamentally an OSGi container, the OSGi bundle is also the native format for the container. Ultimately, after deployment, all of the other deployment unit types are converted into OSGi bundles.

WAR

A *Web application ARchive* (WAR) is the standard archive format for applications that run inside a Web server. As originally conceived by the Java servlet specification, a WAR packages Web pages, JSP pages, Java classes, servlet code, and so on, as required for a typical Web application. More generally, however, a WAR can be any deployment unit that obeys the basic WAR packaging rules (which, in particular, require the presence of a Web application deployment descriptor, **web.xml**).

Spring framework

The Spring framework is a popular dependency injection framework, which is fully integrated into the JBoss Fuse container. In other words, Spring enables you to create instances of Java objects and wire them together by defining a file in XML format. In addition, you can also access a wide variety of utilities and services (such as security, persistence, and transactions) through the Spring framework.

Blueprint framework

The blueprint framework is a dependency injection framework defined by the OSGi Alliance. It is similar to Spring (in fact, it was originally sponsored by SpringSource), but is a more lightweight framework that is optimized for the OSGi environment.

OSGi core framework

At its heart, Red Hat JBoss Fuse is an OSGi container, based on Apache Karaf, whose architecture is defined by the *OSGi Service Platform Core Specification* (available from http://www.osgi.org/Release4/Download). OSGi is a flexible and dynamic container, whose particular strengths include: sophisticated management of version dependencies; sharing libraries between applications; and support for dynamically updating libraries at run time (hot fixes).

For more details about the OSGi framework, see Chapter 5, *Introduction to OSGi*.

Red Hat JBoss Fuse kernel

The JBoss Fuse kernel extends the core framework of OSGi, adding features such as the runtime console, administration, logging, deployment, provisioning, management, and so on. For more details, see Section 5.1, “Red Hat JBoss Fuse” .

1.2. DEPLOYMENT MODELS

Overview

Although Red Hat JBoss Fuse is an OSGi container at heart, it supports a variety of different deployment models. You can think of these as virtual containers, which hide the details of the OSGi framework. In this section we compare the deployment models to give you some idea of the weaknesses and strengths of each model.

Table 1.1, “Alternative Deployment Packages” shows an overview of the package types associated with each deployment model.

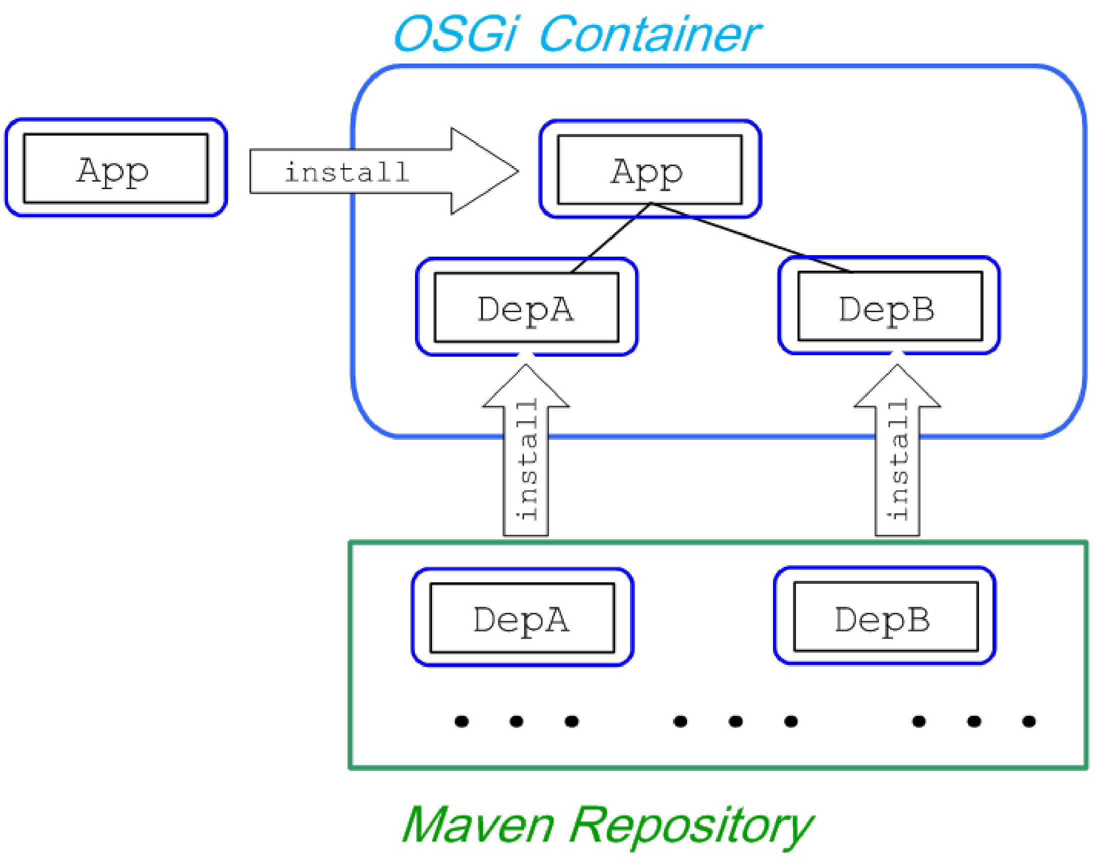
Table 1.1. Alternative Deployment Packages

Package	Metadata	Maven Plug-in	URI Scheme	File Suffix
Bundle	**MANIFEST.MF**	**maven-bundle-plugin**	*None*	**.jar**
WAR	**web.xml**	**maven-war-plugin**	**war:**	**.war**

OSGi bundle deployment model

Figure 1.2, “Installing an OSGi Bundle” gives an overview of what happens when you install an OSGi bundle into the Red Hat JBoss Fuse container, where the bundle depends on several other bundles.

Figure 1.2. Installing an OSGi Bundle

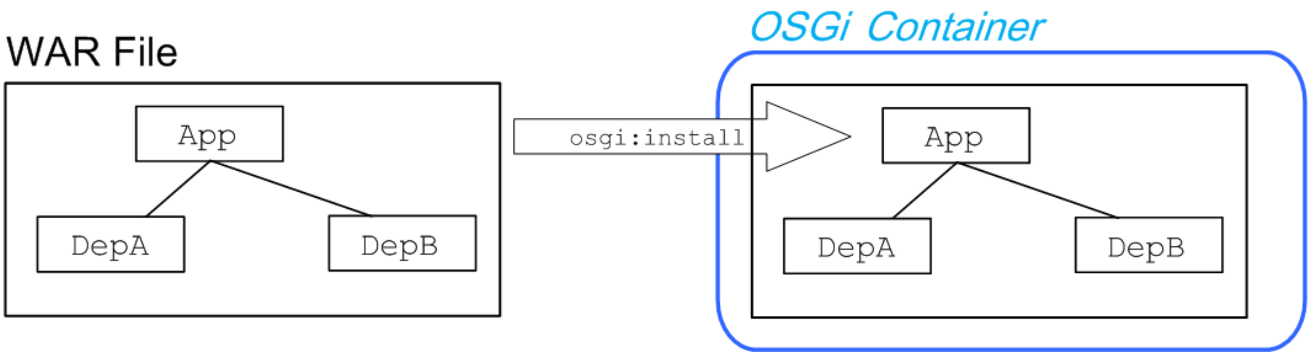


Implicitly, a bundle shares all of its dependencies. This is a flexible approach to deployment, which minimizes resource consumption. But it also introduces a degree of complexity when working with large applications. A bundle does *not* automatically load all of its requisite dependencies, so a bundle might fail to resolve, due to missing dependencies. The recommended way to remedy this is to use *features* to deploy the bundle together with its dependencies (see Chapter 8, *Deploying Features*).

WAR deployment model

Figure 1.3, "Installing a WAR" gives an overview of what happens when you install a WAR into the JBoss Fuse container.

Figure 1.3. Installing a WAR



The WAR has a relatively simple deployment model, because the WAR is typically packaged together with all of its dependencies. Hence, the container usually does not have to do any work to resolve the WAR's dependencies. The drawback of this approach, however, is that the WAR is typically large and it duplicates libraries already available in the container (thus consuming more resources).

1.3. DEPENDENCY INJECTION FRAMEWORKS

Dependency injection

Dependency injection or inversion of control (IOC) is a design paradigm for initializing and configuring applications. Instead of writing Java code that explicitly finds and sets the properties and attributes required by an object, you declare setter methods for all of the properties and objects that this object depends on. The framework takes responsibility for injecting dependencies and properties into the object, using the declared setter methods. This approach reduces dependencies between components and reduces the amount of code that must be devoted to retrieving configuration properties.

There are many popular dependency injection frameworks in current use. In particular, the Spring framework and the blueprint framework are fully integrated with Red Hat JBoss Fuse.

OSGi framework extensions

One of the important characteristics of the OSGi framework is that it is extensible. OSGi provides a framework extension API, which makes it possible to implement OSGi plug-ins that are tightly integrated with the OSGi core. An OSGi extension can be deployed into the OSGi container as an *extension bundle*, which is a special kind of bundle that enjoys privileged access to the OSGi core framework.

Red Hat JBoss Fuse defines extension bundles to integrate the following dependency injection frameworks with OSGi:

- *Blueprint*—the blueprint extensor is based on the blueprint implementation from Apache Karaf.
- *Spring*—the Spring extensor is based on Spring Dynamic Modules (Spring-DM), which is the OSGi integration component from SpringSource.

NOTE

The Spring-DM module is now deprecated. If you need an injection framework with OSGi integration, use Blueprint instead.

Activating a framework

The framework extension mechanism enables both the Spring extensor and the blueprint extensor to be integrated with the bundle lifecycle. In particular, the extenders receive notifications whenever a bundle is activated (using the command, **osgi:start**) or de-activated (using the command, **osgi:stop**). This gives the extenders a chance to scan the bundle, look for configuration files of the appropriate type and, if necessary, activate the dependency injection framework for that bundle.

For example, when we use Spring configuration, the spring extensor scans the bundle package, looking for any blueprint XML files in the standard location and, if it finds one or more such files, it activates the blueprint framework for this bundle.

Blueprint XML file location

The blueprint extensor searches a bundle for blueprint XML files whose location matches the following pattern:

```
OSGI-INF/blueprint/*.xml
```

NOTE

A blueprint XML file can also be placed in a non-standard location, by specifying the location in a bundle header (see the section called “Custom Blueprint file locations”).

Spring XML file location

The Spring extensor searches a bundle for Spring XML files whose location matches the following pattern:

```
META-INF/spring/*.xml
```

NOTE

A WAR package uses a different mechanism to specify the location of Spring XML files (see Section 11.3, “Bootstrapping a Spring Context in a WAR”).

1.4. SYNCHRONOUS COMMUNICATION

Overview

Synchronous communication between bundles in the OSGi container is realized by publishing a Java object as an OSGi service. Clients of the OSGi service can then invoke the methods of the published object.

OSGi services

An OSGi service is a plain Java object, which is *published* to make it accessible to other bundles deployed in the OSGi container. Other bundles then *bind* to the Java object and invoke its methods *synchronously*, using the normal Java syntax. OSGi services thus support a model of *synchronous communication* between bundles.

One of the strengths of this model is that the OSGi service is a *perfectly ordinary Java object*. The object is not required to inherit from specific interfaces nor is it required to have any annotations. In other words, your application code is not polluted by the OSGi deployment model.

OSGi registry

To publish an OSGi service, you must register it in the *OSGi registry*. The OSGi specification defines a Java API for registering services, but the simplest way to publish an OSGi service is to exploit the special syntax provided by the blueprint framework. Use the blueprint **service** element to register a Java object in the OSGi registry. For example, to create a **SavingsAccountImpl** object and export it as an OSGi service (exposing it through the **org.fusesource.example.Account** Java interface)

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <bean id="savings" class="org.fusesource.example.SavingsAccountImpl"/>

 <service ref="savings" interface="org.fusesource.example.Account"/>

</blueprint>
```

Another bundle in the container can then bind to the published OSGi service, by defining a blueprint **reference** element that searches the OSGi registry for a service that supports the **org.fusesource.example.Account** interface.

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <reference id="savingsRef"
          interface="org.fusesource.example.Account"/>

  <bean id="client" class="org.fusesource.example.client.Client">
    <property name="savingsAccount" ref="savingsRef"/>
  </bean>

</blueprint>
```

For more details, see Section 16.1.2, "Defining a Service Bean".

NOTE

Spring XML also supports the publication and binding of OSGi services.

Dynamic interaction between bundles

Another important feature of OSGi services is that they are tightly integrated with the bundle lifecycle. When a bundle is activated (for example, using the console command, **osgi:start**), its OSGi services are published to the OSGi registry. And when a bundle is de-activated (for example, using the console command, **osgi:stop**), its OSGi services are removed from the OSGi registry. Clients of a service can elect to receive notifications whenever a service is published to or removed from the OSGi registry.

Consequently, the presence or absence of an OSGi service in the registry can serve as a flag that signals to other bundles whether or not a particular bundle is available (active). With appropriate programming, clients can thus be implemented to respond flexibly as other bundles are uninstalled and re-installed in the container. For example, a client could be programmed to suspend certain kinds of processing until a bundle is re-activated, thus facilitating dynamic reconfiguration or updating of that dependent bundle.

1.5. ASYNCHRONOUS COMMUNICATION

JMS broker

You can optionally install a broker instance, typically Apache ActiveMQ, into the Red Hat JBoss Fuse container, to provide support for asynchronous communication between bundles in the container. Apache ActiveMQ is a sophisticated implementation of a JMS broker, which supports asynchronous communication using either queues or topics (publish-subscribe model). Some of the basic features of this JMS broker are as follows:

- *VM protocol*—the Virtual Machine (VM) transport protocol is ideal for communicating within the container. VM is optimized for sending messages within the same JVM instance.
- *Persistent or non-persistent messaging*—you can choose whether the broker should persist messages or not, depending on the requirements of your application.
- *Ease of use*—there is no need to create and configure destinations (that is, queues or topics) before you can use them. After connecting to a broker, you can immediately start sending and receiving messages. If you start sending messages to a queue that does not exist yet, Apache

ActiveMQ creates it dynamically.

- *External communication*—you can also configure a TCP port on the broker, opening it up to external JMS clients or other brokers.

For details of how to set up a JMS broker in Red Hat JBoss Fuse, see Chapter 17, *JMS Broker*.

1.6. FUSE FABRIC

Overview

Fuse Fabric is a technology layer that allows a group of containers to form a cluster that shares a common set of configuration information and a common set of repositories from which to access runtime artifacts. Fabric containers are managed by a Fabric Agent that installs a set of bundles that are specified in the profiles assigned to the container. The agent requests artifacts from the Fabric Ensemble. The ensemble has a list of repositories that it can access. These repositories are managed using a Maven proxy and include a repository that is local to the ensemble.

The added layer imposed on fabric containers does not change the basic deployment models, but it does impact how you specify what needs to be deployed. It also impacts how dependencies are located.

Bundle deployment

In a fabric container, you cannot directly deploy bundles to a container. A container's configuration is managed by a Fabric Agent that updates its contents and configuration based on one or more profiles. So to add a bundle to a container, you must either add the bundle to an existing profile or create a new profile containing the bundle. When the profile is applied to a container the Fuse Agent will install the bundle.

The installation process will download the bundle from a Maven repository and use the appropriate install command to load it into the container. Once the bundle is installed, the dependency resolution process proceeds as it would in a standalone container.

Things to consider

While installing bundles to a fabric container is not radically different from installing bundles in a standalone container, there are a number of things to consider when thinking about creating profiles to deploy your applications:

- Bundles must be accessible through the fabric's Maven proxy

  When a Fabric Agent installs a bundle, it must first copy the bundle to the container's host computer. To do so, the agent uses the fabric's Maven Proxy to locate the bundle in one of the accessible Maven repositories and downloads it. This mechanism ensures that all of the containers in the fabric have access to the same set of bundles.

  To address this issue, you need to ensure that the fabric's Maven proxy is configured to have access to all of the repositories from which your applications will need to download bundles. For more information see section "Configuring Maven Proxies Directly" in "Fabric Guide" .

- Fabric Agents only load the bundles specified in a profile

  A fabric container's contents is completely controlled by the profiles associated with it. The fabric agent managing the container inspects each of the profiles associated with the container, downloads the listed bundles, and features, and installs them. If one of the bundles in a profile depends on a bundle that is not specified in the profile, or one of the other profiles associated with the container, the bundle will not be able to resolve that dependency.

To address this issue you can do one of the following:

- construct your profiles to ensure that it contains all of the required bundles and their dependencies
- deploy the application as a feature that contains all of the required bundles and their dependencies

CHAPTER 2. DEPENDENCY INJECTION FRAMEWORKS

Abstract

Red Hat JBoss Fuse supports two alternative dependency injection frameworks: Spring and OSGi blueprint. These frameworks are fully integrated with the Red Hat JBoss Fuse container, so that Spring XML files and blueprint XML files are automatically activated at the same time the corresponding bundle is activated.

2.1. SPRING AND BLUEPRINT FRAMEWORKS

Overview

The OSGi framework allows third-party frameworks to be piggybacked on top of it. In particular, Red Hat JBoss Fuse enables the Spring framework and the blueprint framework, by default. In the case of the *Spring framework*, OSGi automatically activates any Spring XML files under the **META-INF/spring/** directory in a JAR, and Spring XML files can also be hot-deployed to the ***ESBInstallDir*/deploy** directory. In the case of the *blueprint framework*, OSGi automatically activates any blueprint XML files under the **OSGI-INF/blueprint/** directory in a JAR, and blueprint XML files can also be hot-deployed to the ***ESBInstallDir*/deploy** directory.

Prefer Blueprint over Spring-DM

The Blueprint container is now the preferred framework for instantiating, registering, and referencing OSGi services, because this container has now been adopted as an OSGi standard. This ensures greater portability for your OSGi service definitions in the future.

Spring Dynamic Modules (Spring-DM) provided much of the original impetus for the definition of the Blueprint standard, but should now be regarded as obsolescent. Using the Blueprint container does *not* prevent you from using the Spring framework: the latest version of Spring is compatible with Blueprint.

Configuration files

There are two kinds of file that you can use to configure your project:

- *Spring configuration*—in the standard Maven directory layout, Spring XML configuration files are located under ***ProjectDir*/src/main/resources/META-INF/spring**.
- *Blueprint configuration*—in the standard Maven directory layout, blueprint XML configuration files are located under ***ProjectDir*/src/main/resources/OSGI-INF/blueprint**.

If you decide to use the blueprint configuration, you can embed **camelContext** elements in the blueprint file, as described in the section called “Blueprint configuration file” .

Prerequisites for blueprint configuration

If you decide to configure your Apache Camel application using blueprint, you must ensure that the **camel-blueprint** feature is installed. If necessary, install it by entering the following console command:

```
JBossFuse:karaf@root> features:install camel-blueprint
```

Spring configuration file

You can deploy a **camelContext** using a Spring configuration file, where the root element is a Spring **beans** element and the **camelContext** element is a child of the **beans** element. In this case, the **camelContext** namespace must be **http://camel.apache.org/schema/spring**.

For example, the following Spring configuration defines a route that generates timer messages every two seconds, sending the messages to the **ExampleRouter** log (which get incorporated into the console log file, ***InstallDir*/data/log/fuse.log**):

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       >

  <camelContext xmlns="http://camel.apache.org/schema/spring">
    <route>
      <from uri="timer://myTimer?fixedRate=true&amp;period=2000"/>
      <to uri="log:ExampleRouter"/>
    </route>
  </camelContext>

</beans>
```

It is *not* necessary to specify schema locations in the configuration. But if you are editing the configuration file with an XML editor, you might want to add the schema locations in order to support schema validation and content completion in the editor. For the preceding example, you could specify the schema locations as follows:

```
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xsi:schemaLocation="
       http://www.springframework.org/schema/beans
http://www.springframework.org/schema/beans/spring-beans-3.0.xsd
       http://camel.apache.org/schema/spring http://camel.apache.org/schema/spring/camel-
spring.xsd">
    ...
```

Blueprint configuration file

Before deploying routes in a blueprint configuration file, check that the camel-blueprint feature is already installed.

You can deploy a **camelContext** using a blueprint configuration file, where the root element is **blueprint** and the **camelContext** element is a child of the **blueprint** element. In this case, the **camelContext** namespace must be **http://camel.apache.org/schema/blueprint**.

For example, the following blueprint configuration defines a route that generates timer messages every two seconds, sending the messages to the **ExampleRouter** log (which get incorporated into the console log file, ***InstallDir*/data/log/fuse.log**):

```
<?xml version="1.0" encoding="UTF-8"?>
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    >
```

```
  <camelContext xmlns="http://camel.apache.org/schema/blueprint">
    <route>
      <from uri="timer://myTimer?fixedRate=true&amp;period=2000"/>
      <to uri="log:ExampleRouter"/>
    </route>
  </camelContext>

</blueprint>
```

NOTE

Blueprint is a dependency injection framework, defined by the OSGi standard, which is similar to Spring in many respects. For more details about blueprint, see Section 16.1, "The Blueprint Container".

2.2. HOT DEPLOYMENT

Types of configuration file

You can hot deploy the following types of configuration file:

- Spring XML file, deployable with the suffix, **.xml**.
- Blueprint XML file, deployable with the suffix, **.xml**.

Hot deploy directory

If you have an existing Spring XML or blueprint XML configuration file, you can deploy the configuration file directly by copying it into the following hot deploy directory:

```
InstallDir/deploy
```

After deploying, the configuration file is activated immediately.

Hot undeploying an XML file

To undeploy a Spring XML file or a Blueprint XML file from the hot deploy directory, simply delete the XML file from the ***InstallDir*/deploy** directory *while the Apache Karaf container is running* .

IMPORTANT

The hot undeploy mechanism does *not* work while the container is shut down. If you shut down the Karaf container, delete the XML file from **deploy/**, and then restart the Karaf container, the automatically generated bundle corresponding to the XML file will *not* be undeployed after you restart the container (you can, however, undeploy the bundle manually using the **osgi:uninstall** console command).

Prerequisites

If you want to deploy Apache Camel routes in a blueprint configuration file, the **camel-blueprint** feature must be installed (which it is by default). If the **camel-blueprint** feature has been disabled, however, you can re-install it by entering the following console command:

```
JBossFuse:karaf@root> features:install camel-blueprint
```

Default bundle version

When a Spring XML file or a Blueprint XML file is hot deployed, the XML file is automatically wrapped in an OSGi bundle and deployed as a bundle in the OSGi container. By default, the generated bundle has the version, **0.0.0**.

Customizing the bundle version

If you prefer to customize the bundle version, use the **manifest** element in the XML file. The **manifest** element enables you to *override* any of the headers in the generated bundle's **META-INF/MANIFEST.MF** file. In particular, you can use it to specify the bundle version.

Specifying the bundle version in a Spring XML file

To specify the bundle version in a hot-deployed Spring XML file, define a **manifest** element as follows:

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       >

  <manifest xmlns="http://karaf.apache.org/xmlns/deployer/spring/v1.0.0">
      Bundle-Version = 1.2.3.4
  </manifest>

  <camelContext xmlns="http://camel.apache.org/schema/spring">
    <route>
      <from uri="timer://myTimer?fixedRate=true&amp;period=2000"/>
      <to uri="log:ExampleRouter"/>
    </route>
  </camelContext>

</beans>
```

The **manifest** element for Spring XML files belongs to the following schema namespace:

```
http://karaf.apache.org/xmlns/deployer/spring/v1.0.0
```

The contents of the **manifest** element are specified using the syntax of a Java properties file.

Specifying the bundle version in a Blueprint XML file

To specify the bundle version in a hot-deployed Blueprint XML file, define a **manifest** element as follows:

```
<?xml version="1.0" encoding="UTF-8"?>
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    >

  <manifest xmlns="http://karaf.apache.org/xmlns/deployer/blueprint/v1.0.0">
```

```
      Bundle-Version = 1.2.3.4
    </manifest>

    <camelContext xmlns="http://camel.apache.org/schema/blueprint">
      <route>
        <from uri="timer://myTimer?fixedRate=true&amp;period=2000"/>
        <to uri="log:ExampleRouter"/>
      </route>
    </camelContext>

  </blueprint>
```

The **manifest** element for Blueprint XML files belongs to the following schema namespace:

```
http://karaf.apache.org/xmlns/deployer/blueprint/v1.0.0
```

The contents of the **manifest** element are specified using the syntax of a Java properties file.

2.3. USING OSGI CONFIGURATION PROPERTIES

Overview

The OSGi Configuration Admin service defines a mechanism for passing configuration settings to an OSGi bundle. You do not have to use this service for configuration, but it is typically the most convenient way of configuring applications deployed in Red Hat JBoss Fuse.

Persistent ID

In the OSGi Configuration Admin service, a *persistent ID* is a name that identifies a group of related configuration properties. In JBoss Fuse, every persistent ID, *PersistentID*, is implicitly associated with a file named ***PersistentID*.cfg** in the ***ESBInstallDir*/etc/** directory. If the corresponding file exists, it can be used to initialize the values of properties belonging to the *PersistentID* property group.

For example, the **etc/org.ops4j.pax.url.mvn.cfg** file is used to set the properties associated with the **org.ops4j.pax.url.mvn** persistent ID (for the PAX Mvn URL handler).

Blueprint example

Example 2.1, "Using OSGi Configuration Properties in Blueprint" shows how to pass the value of the **prefix** variable to the constructor of the **myTransform** bean in blueprint XML, where the value of **prefix** is set by the OSGi Configuration Admin service.

Example 2.1. Using OSGi Configuration Properties in Blueprint

```
<blueprint
   xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0"
 xmlns:cm="http://aries.apache.org/blueprint/xmlns/blueprint-cm/v1.1.0"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   ... >
   ...
   <cm:property-placeholder persistent-id="org.fusesource.example">
      <cm:default-properties>
          <cm:property name="prefix" value="Blueprint-Example"/>
```

```
        </cm:default-properties>
    </cm:property-placeholder>

    <bean id="myTransform" class="org.example.camel.MyTransform">
        <property name="prefix" value="${prefix}" />
    </bean>

</blueprint>
```

The syntax, **{{prefix}}**, substitutes the value of the **prefix** variable into the blueprint XML file. The OSGi properties are set up using the following XML elements:

cm:property-placeholder

This element gives you access to the properties associated with the specified persistent ID. After defining this element, you can use the syntax, **{{*PropName*}}**, to substitute variables belonging to the specified persistent ID.

cm:property-placeholder/cm:default-properties

You can optionally specify default values for properties by defining **cm:property** elements inside the **cm:default-properties** element. If the corresponding **etc/*PersistentID*.cfg** file defines property values, however, these will be used instead.

Using multiple property placeholders in Blueprint

It is legal to define multiple property placeholders in a Blueprint XML file (that is, defining multiple **cm:property-placeholder** elements that reference different persistent IDs). One thing that you need to be aware of, however, is that there can be a clash if two properties from different property placeholders have the same name. In this case, the following rules determine which property takes precedence:

1. Explicitly defined property settings (for example, defined in a **etc/*PersistentID*.cfg** file) take precedence over default property settings (defined in a **cm:default-properties** element).

2. If there is more than one explicit setting for a given property, the setting from the last property placeholder in the Blueprint file takes precedence.

3. Default property settings (defined in a **cm:default-properties** element) have the lowest priority.

CHAPTER 3. BUILDING WITH MAVEN

Abstract

Maven is an open source build system which is available from the Apache Maven project. This chapter explains some of the basic Maven concepts and describes how to set up Maven to work with Red Hat JBoss Fuse. In principle, you could use any build system to build an OSGi bundle. But Maven is strongly recommended, because it is well supported by Red Hat JBoss Fuse.

3.1. MAVEN DIRECTORY STRUCTURE

Overview

One of the most important principles of the Maven build system is that there are *standard locations* for all of the files in the Maven project. There are several advantages to this principle. One advantage is that Maven projects normally have an identical directory layout, making it easy to find files in a project. Another advantage is that the various tools integrated with Maven need almost *no* initial configuration. For example, the Java compiler knows that it should compile all of the source files under **src/main/java** and put the results into **target/classes**.

Standard directory layout

Example 3.1, "Standard Maven Directory Layout" shows the elements of the standard Maven directory layout that are relevant to building OSGi bundle projects. In addition, the standard locations for Spring and Blueprint configuration files (which are *not* defined by Maven) are also shown.

Example 3.1. Standard Maven Directory Layout

```
ProjectDir/
  pom.xml
  src/
    main/
      java/
        ...
      resources/
        META-INF/
          spring/
            *.xml
        OSGI-INF/
          blueprint/
            *.xml
    test/
      java/
      resources/
  target/
    ...
```

NOTE

It is possible to override the standard directory layout, but this is *not* a recommended practice in Maven.

pom.xml file

The **pom.xml** file is the Project Object Model (POM) for the current project, which contains a complete description of how to build the current project. A **pom.xml** file can be completely self-contained, but frequently (particular for more complex Maven projects) it can import settings from a *parent POM* file.

After building the project, a copy of the **pom.xml** file is automatically embedded at the following location in the generated JAR file:

```
META-INF/maven/groupId/artifactId/pom.xml
```

src and target directories

The **src/** directory contains all of the code and resource files that you will work on while developing the project.

The **target/** directory contains the result of the build (typically a JAR file), as well as all all of the intermediate files generated during the build. For example, after performing a build, the **target/classes/** directory will contain a copy of the resource files and the compiled Java classes.

main and test directories

The **src/main/** directory contains all of the code and resources needed for building the artifact.

The **src/test/** directory contains all of the code and resources for running unit tests against the compiled artifact.

java directory

Each **java/** sub-directory contains Java source code (***.java** files) with the standard Java directory layout (that is, where the directory pathnames mirror the Java package names, with / in place of the **.** character). The **src/main/java/** directory contains the bundle source code and the **src/test/java/** directory contains the unit test source code.

resources directory

If you have any configuration files, data files, or Java properties to include in the bundle, these should be placed under the **src/main/resources/** directory. The files and directories under **src/main/resources/** will be copied into the root of the JAR file that is generated by the Maven build process.

The files under **src/test/resources/** are used only during the testing phase and will *not* be copied into the generated JAR file.

Spring integration

By default, Red Hat JBoss Fuse installs and activates support for Spring Dynamic Modules (Spring DM) , which integrates Spring with the OSGi container. This means that it is possible for you to include Spring configuration files, **META-INF/spring/*.xml**, in your bundle. One of the key consequences of having

Spring DM enabled in the OSGi container is that the lifecycle of the Spring application context is automatically synchronized with the OSGi bundle lifecycle:

- *Activation*—when a bundle is activated, Spring DM automatically scans the bundle to look for Spring configuration files in the standard location (any **.xml** files found under the **META-INF/spring/** directory). If any Spring files are found, Spring DM creates an application context for the bundle and creates the beans defined in the Spring configuration files.

- *Stopping*—when a bundle is stopped, Spring DM automatically shuts down the bundle's Spring application context, causing any Spring beans to be deleted.

In practice, this means that you can treat your Spring-enabled bundle as if it is being deployed in a Spring container. Using Spring DM, the features of the OSGi container and a Spring container are effectively merged. In addition, Spring DM provides additional features to support the OSGi container environment—some of these features are discussed in Chapter 16, *OSGi Services*.

Blueprint container

OSGi R4.2 defines a blueprint container, which is effectively a standardized version of Spring DM. Red Hat JBoss Fuse has built-in support for the blueprint container, which you can enable simply by including blueprint configuration files, **OSGI-INF/blueprint/*.xml**, in your project. For more details about the blueprint container, see Chapter 16, *OSGi Services*.

3.2. PREPARING TO USE MAVEN

Overview

This section gives a brief overview of how to prepare Maven for building Red Hat JBoss Fuse projects and introduces the concept of Maven coordinates, which are used to locate Maven artifacts.

Prerequisites

In order to build a project using Maven, you must have the following prerequisites:

- *Maven installation*—Maven is a free, open source build tool from Apache. You can download the latest version from the Maven download page .

- *Network connection*—whilst performing a build, Maven dynamically searches external repositories and downloads the required artifacts on the fly. By default, Maven looks for repositories that are accessed over the Internet. You can change this behavior so that Maven will prefer searching repositories that are on a local network.

> **NOTE**
>
> Maven can run in an offline mode. In offline mode Maven will only look for artifacts in its local repository.

Adding the Red Hat JBoss Fuse repository

In order to access artifacts from the Red Hat JBoss Fuse Maven repository, you need to add it to Maven's **settings.xml** file. Maven looks for your **settings.xml** file in the **.m2** directory of the user's home directory. If there is not a user specified **settings.xml** file, Maven will use the system-level **settings.xml** file at **M2_HOME/conf/settings.xml**.

To add the JBoss Fuse repository to Maven's list of repositories, you can either create a new **.m2/settings.xml** file or modify the system-level settings. In the **settings.xml** file, add the **repository** element for the JBoss Fuse repository as shown in bold text in Example 3.2, “Adding the Red Hat JBoss Fuse Repositories to Maven”.

Example 3.2. Adding the Red Hat JBoss Fuse Repositories to Maven

```
<?xml version="1.0"?>
<settings>

 <profiles>
  <profile>
   <id>extra-repos</id>
   <activation>
    <activeByDefault>true</activeByDefault>
   </activation>
   <repositories>
    <repository>
        <id>redhat-ga-repository</id>
        <url>https://maven.repository.redhat.com/ga</url>
        <releases>
            <enabled>true</enabled>
        </releases>
        <snapshots>
            <enabled>false</enabled>
        </snapshots>
    </repository>
    <repository>
        <id>redhat-ea-repository</id>
        <url>https://maven.repository.redhat.com/earlyaccess/all</url>
        <releases>
            <enabled>true</enabled>
        </releases>
        <snapshots>
            <enabled>false</enabled>
        </snapshots>
    </repository>
    <repository>
      <id>jboss-public</id>
      <name>JBoss Public Repository Group</name>
      <url>https://repository.jboss.org/nexus/content/groups/public/</url>
    </repository>
   </repositories>
   <pluginRepositories>
    <pluginRepository>
        <id>redhat-ga-repository</id>
        <url>https://maven.repository.redhat.com/ga</url>
        <releases>
            <enabled>true</enabled>
        </releases>
        <snapshots>
            <enabled>false</enabled>
        </snapshots>
    </pluginRepository>
    <pluginRepository>
        <id>redhat-ea-repository</id>
```

```
          <url>https://maven.repository.redhat.com/earlyaccess/all</url>
          <releases>
            <enabled>true</enabled>
          </releases>
          <snapshots>
            <enabled>false</enabled>
          </snapshots>
        </pluginRepository>
        <pluginRepository>
          <id>jboss-public</id>
          <name>JBoss Public Repository Group</name>
          <url>https://repository.jboss.org/nexus/content/groups/public</url>
        </pluginRepository>
      </pluginRepositories>
    </profile>
  </profiles>

  <activeProfiles>
    <activeProfile>extra-repos</activeProfile>
  </activeProfiles>

</settings>
```

Artifacts

The basic building block in the Maven build system is an *artifact*. The output of an artifact, after performing a Maven build, is typically an archive, such as a JAR or a WAR.

Maven coordinates

A key aspect of Maven functionality is the ability to locate artifacts and manage the dependencies between them. Maven defines the location of an artifact using the system of *Maven coordinates*, which uniquely define the location of a particular artifact. A basic coordinate tuple has the form, **{*groupId, artifactId, version*}**. Sometimes Maven augments the basic set of coordinates with the additional coordinates, *packaging* and *classifier*. A tuple can be written with the basic coordinates, or with the additional *packaging* coordinate, or with the addition of both the *packaging* and *classifier* coordinates, as follows:

```
groupdId:artifactId:version
groupdId:artifactId:packaging:version
groupdId:artifactId:packaging:classifier:version
```

Each coordinate can be explained as follows:

groupdId

Defines a scope for the name of the artifact. You would typically use all or part of a package name as a group ID—for example, **org.fusesource.example**.

artifactId

Defines the artifact name (relative to the group ID).

version

Specifies the artifact's version. A version number can have up to four parts: **n.n.n.n**, where the last part of the version number can contain non-numeric characters (for example, the last part of **1.0-SNAPSHOT** is the alphanumeric substring, **0-SNAPSHOT**).

packaging

Defines the packaged entity that is produced when you build the project. For OSGi projects, the packaging is **bundle**. The default value is **jar**.

classifier

Enables you to distinguish between artifacts that were built from the same POM, but have different content.

The group ID, artifact ID, packaging, and version are defined by the corresponding elements in an artifact's POM file. For example:

```
<project ... >
  ...
  <groupId>org.fusesource.example</groupId>
  <artifactId>bundle-demo</artifactId>
  <packaging>bundle</packaging>
  <version>1.0-SNAPSHOT</version>
  ...
</project>
```

For example, to define a dependency on the preceding artifact, you could add the following **dependency** element to a POM:

```
<project ... >
  ...
  <dependencies>
    <dependency>
      <groupId>org.fusesource.example</groupId>
      <artifactId>bundle-demo</artifactId>
      <version>1.0-SNAPSHOT</version>
    </dependency>
  </dependencies>
  ...
</project>
```

NOTE

It is *not* necessary to specify the **bundle** package type in the preceding dependency, because a bundle is just a particular kind of JAR file and **jar** is the default Maven package type. If you do need to specify the packaging type explicitly in a dependency, however, you can use the **type** element.

CHAPTER 4. LOCATING ARTIFACTS WITH MAVEN AND HTTP

Abstract

In Red Hat JBoss Fuse, Maven is the primary mechanism for locating artifacts and dependencies, both at build time and at run time. Normally, Maven requires Internet connectivity, so that dependencies can be downloaded from remote repositories on demand. But, as explained here, it is also possible to provide dependencies locally, so that the need for Internet connectivity is reduced.

4.1. LOCATING HTTP ARTIFACTS

Overview

You can specify the location of an OSGi bundle (and other kinds of resource) using a HTTP URL—for example, by specifying a HTTP URL as the argument to the **osgi:install** command. This approach is perhaps not as common as using Maven URLs, but it means that you have the option of providing OSGi resources through a Web server.

HTTP URL protocol

The HTTP URL protocol specifies the location of an OSGi bundle (or other resource) using a standard HTTP (or HTTPS) URL. Typically, a HTTP URL has a syntax like the following:

```
http[s]:Host[:Port]/[Path][#AnchorName][?Query]
```

In a standalone (non-Fabric) container, a HTTP URL lookup can be triggered by either of the following events:

- When **osgi:install** is invoked on a Maven URL to install an OSGi bundle;
- When **features:install** is invoked to install a Karaf feature (a Karaf feature typically includes one or more Maven URL references).

HTTP URL handler

JBoss Fuse uses Java's built-in HTTP protocol handler to resolve HTTP URLs. Hence, HTTP URL resolution behaves exactly as you would expect in standard Java.

Karaf bundle cache

When you pass a HTTP URL as the argument to the **osgi:install** command (or embedded in a Karaf feature description), JBoss Fuse downloads the referenced OSGi bundle resource, saves it in the Karaf bundle cache (under the **data/cache** directory), and loads the bundle into the Karaf container runtime. The Karaf bundle cache is used to persist all of the bundles currently installed in the Karaf runtime.

NOTE

When a Karaf container is stopped and restarted, it loads its installed bundles directly from the Karaf bundle cache, *not* from the local Maven repository (or anywhere else). Hence, if you have updated any artifacts in the local Maven repository in the meantime, those changes are *not* automatically reflected in the state of the Karaf container.

Configuring a HTTP proxy for HTTP URLs

To configure a HTTP proxy (which will be used when resolving HTTP URLs), open the ***InstallDir*/etc/system.properties** file in a text editor and set the **http.proxyHost** and **http.proxyPort** system properties with the host and port of the proxy—for example:

```
http.proxyHost=192.0.2.0
http.proxyPort=8080
```

You can optionally specify a list of non-proxy hosts (hosts that can be reached without going through the proxy) using the **http.nonProxyHosts** property—for example:

```
http.nonProxyHosts=localhost|*.redhat.com|*.jboss.org
```

NOTE

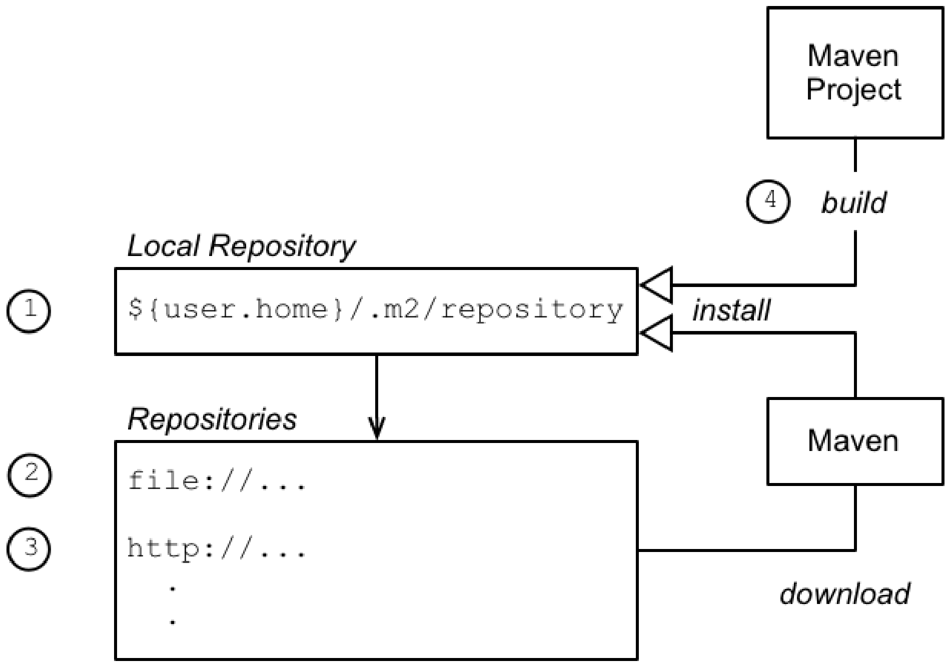
An advantage of using the system properties approach to configuring the proxy is that these settings will be used both by the **mvn** URL protocol handler and by the **http** URL protocol handler (see the section called "Configuring a HTTP proxy for Maven URLs").

4.2. LOCATING MAVEN ARTIFACTS AT BUILD TIME

Overview

When building projects, Maven implements a simple caching scheme: artifacts are downloaded from remote repositories on the Internet and then cached in the local repository. Figure 4.1, "How Maven Locates Artifacts at Build Time" shows an overview of the procedure that Maven follows when locating artifacts at build time.

Figure 4.1. How Maven Locates Artifacts at Build Time



Locating artifacts at build time

While building a project, Maven locates required artifacts (OSGi bundles, Karaf features, required plug-ins, and so on) as follows:

1. The first place that Maven looks for artifacts is in the *local repository*, **~/.m2/repository/** (which is effectively a cache where Maven stores the artifacts it has already downloaded or found elsewhere).
2. If an artifact is not available in the local repository, Maven attempts to download the artifact from one of the repositories listed in its configuration. This repository list can include both internal and remote repositories.
3. If the artifact is not available from an internal repository, the next repositories to try are the remote repositories (accessible through HTTP or HTTPS).
4. When a Maven project is built locally using the **mvn install** command, the project's Maven artifacts are installed into the local repository.

Adding a remote Maven repository

Remote repositories are configured in the same way as internal repositories, except that they should be listed *after* any internal repositories.

Adding an internal Maven repository

Maven enables you to specify the location of internal repositories either in your **settings.xml** file (which applies to all projects) or in a **pom.xml** (which applies to that project only). Typically, the location of an internal repository is specified using either a **file:**// URL or a **http:**// URL (assuming you have set up a local Web server to serve up the artifacts) and you should generally ensure that internal repositories are listed *before* remote repositories. Otherwise, there is nothing special about an internal repository: it is just a repository that happens to be located in your internal network.

For an example of how to specify a repository in your **settings.xml** file, see the section called “Adding the Red Hat JBoss Fuse repository”.

Customizing the location of the local repository

Maven resolves the location of the local repository, by checking the following settings:

1. The location specified by the **localRepository** element in the **~/.m2/settings.xml** file (UNIX and Linux) or **C:\Documents and Settings\*UserName*\\.m2\settings.xml** (Windows).
2. Otherwise, the location specified by the **localRepository** element in the ***M2_HOME*/conf/settings.xml** file.
3. Otherwise, the default location is in the user's home directory, **~/.m2/repository/** (UNIX and Linux) or **C:\Documents and Settings\*UserName*\\.m2\repository** (Windows).

4.3. LOCATING MAVEN ARTIFACTS AT RUN TIME

Abstract

At run time, the process of locating Maven artifacts is implemented by the Eclipse Aether library, which is bundled with the Karaf container (so that it is *not* necessary for Apache Maven to be installed on the container host). It is possible to customize the Karaf container's Maven configuration by editing the

etc/org.ops4j.pax.url.mvn.cfg file. For example, you can customize the list of remote Maven repositories and you can configure a HTTP proxy, if required.

4.3.1. Maven URL Handler Architecture

Overview

You can specify the location of an OSGi bundle using a Maven URL—for example, as the argument to the **osgi:install** command. When resolution of a Maven URL is triggered, JBoss Fuse uses a combination of the *Pax URL Aether* component and the *Eclipse Aether* component to implement artifact resolution. The basic strategy is to search the **system**/ directory, then search the local Maven repository, and then search the configured remote Maven repositories.

Maven URL protocol

The Maven URL protocol specifies the location of a Maven artifact, which can be retrieved either from local or remote Maven repositories. For example, an artifact with the Maven coordinates, ***GroupId*:*ArtifactId*:*Version***, can be referenced by the following Maven URL:

```
mvn:GroupId/ArtifactId/Version
```

In a standalone (non-Fabric) container, a Maven URL lookup can be triggered by either of the following events:

- When **osgi:install** is invoked on a Maven URL to install an OSGi bundle;
- When **features:install** is invoked to install a Karaf feature (a Karaf feature typically includes one or more Maven URL references).

Pax URL Aether layer

In Apache Karaf, the framework for resolving Maven URLs is the URL protocol handler mechanism, which is a standard feature of the Java language and JVM. To handle URLs prefixed by the **mvn:** scheme, Karaf registers the OPS4J Pax URL Aether protocol handler. The Pax URL Aether layer is thus responsible for resolving all **mvn** URLs in the JVM. This layer can be configured through one or both of the following configuration files:

***InstallDir*/etc/org.ops4j.pax.url.mvn.cfg**

Stores the OSGi Config Admin properties used to configure the Pax URL Aether layer. In particular, it is possible to specify the locations of local and remote Maven repositories through the settings in this file. For details of the available settings, see Section 4.3.5, "Pax URL Aether Reference" .

***UserHome*/.m2/settings.xml**

(Optional) You can optionally configure the Pax URL Aether layer to read its configuration from a standard Maven **settings.xml** file (by configuring the relevant settings in **org.ops4j.pax.url.mvn.cfg**).

The main purpose of the Pax URL Aether layer is to facilitate configuration. The Pax URL Aether layer does *not* actually implement resolution of Maven artifacts. That responsibility is delegated to the Eclipse Aether layer instead.

NOTE

In some old **org.ops4j.pax.url.mvn.cfg** configuration files, you might see the setting **disableAether=false**. This setting is *obsolete*, however, and has no effect on the **pax-url-aether** component. The current implementation of Pax URL Aether (previously called Pax URL Maven) is completely dependent on Eclipse Aether.

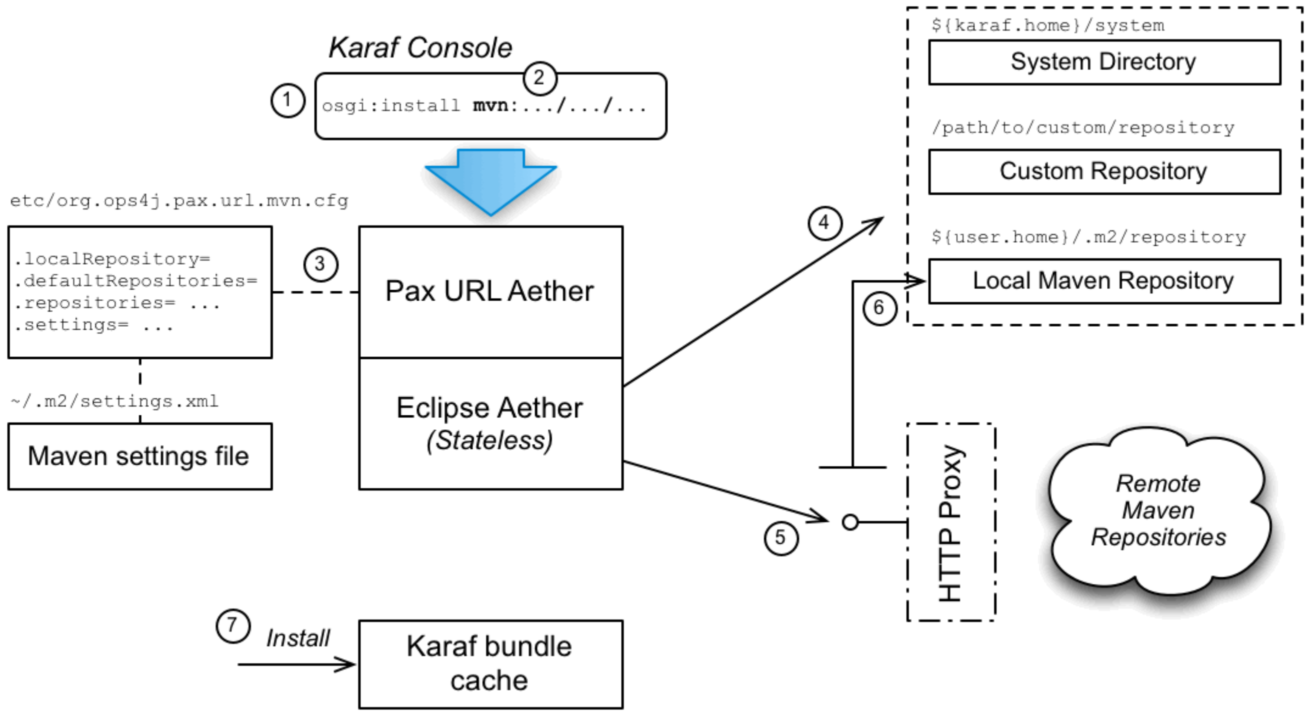
Eclipse Aether layer

The Eclipse Aether layer is fundamental to Maven artifact resolution in Apache Karaf. Ultimately, resolution of Maven artifacts for the Karaf container is *always* performed by the Aether layer. Note that the Aether layer itself is *stateless*: the parameters required to perform resolution of a Maven artifact are passed to the Aether layer with every invocation.

Locating artifacts at run time

Figure 4.2, "How the Container Locates Artifacts at Run Time" shows the mechanism for handling a Maven URL and resolving a Maven artifact at run time.

Figure 4.2. How the Container Locates Artifacts at Run Time



The steps followed to locate the required Maven artifacts are:

1. Resolution of a Maven artifact is triggered when a user invokes the **osgi:install** command on a Maven URL (or if a user invokes the **features:install** command on a feature that references some Maven URLs).

2. To resolve the Maven URL, the JVM calls back on the protocol handler registered against the **mvn** scheme, which happens to be the Pax URL Aether component.

3. The Pax URL Aether component reads its configuration from the ***InstallDir*/etc/org.ops4j.pax.url.mvn.cfg** file (and possibly also from a Maven **settings.xml** file, if so configured). The Pax URL Aether layer parses the requested Maven URL and combines this information with the specified configuration in order to invoke the Eclipse Aether library.

4. When the Aether library is invoked, the first step is to look up any local Maven repositories to try and find the Maven artifact. The following local repositories are configured by default:

   ***InstallDir*/system**

   The JBoss Fuse system directory, which contains all of the Maven artifacts that are bundled with the JBoss Fuse distribution.

   ***UserHome*/.m2/repository**

   The user's own local Maven repository in the user's home directory, ***UserHome***.

   If you like, you can customize the list of local repositories to add your own custom Maven repository.

   If the Maven artifact is found locally, skip straight to step 7.

5. If the Maven artifact cannot be found in one of the local repositories, Aether tries to look up the specified remote repositories (using the list of remote repositories specified in the Pax URL Aether configuration). Because the remote repositories are typically located on the Internet (accessed through the HTTP protocol), it is necessary to have Internet access for this step to succeed.

   NOTE

   If your local network requires you to use a HTTP proxy to access the Internet, it is possible to configure Pax URL Aether to use a HTTP proxy. For example, see the section called "Configuring a HTTP proxy for Maven URLs" for details.

6. If the Maven artifact is found in a remote repository, Aether automatically installs the artifact into the user's local Maven repository, so that another remote lookup will not be required.

7. Finally, assuming that the Maven artifact has been successfully resolved, Karaf installs the artifact in the *Karaf bundle cache* , ***InstallDir*/data/cache**, and loads the artifact (usually, an OSGi bundle) into the container runtime. At this point, the artifact is effectively installed in the container.

4.3.2. Redeploying Maven Artifacts in a Development Environment

Overview

An important aspect of the Karaf container architecture is that deployed Maven artifacts are stored in the container cache, which is separate from the local Maven repository. Bundles and features get copied from the local Maven repository into the cache at the time they are first deployed. After that, any changes to the artifact in the local Maven repository are ignored.

Immutable artifacts

Usually, it makes sense to ignore changes in the local Maven repository, because Maven requires each specific version of an artifact to be *immutable*: that is, once you make a particular version of a Maven artifact available in a Maven repository, it must *never* change. Hence, it should never be necessary to go back and check the Maven repository for changes to the artifact.

SNAPSHOT artifacts

On the other hand, there is a partial exception to this convention: in a development environment, the same artifacts are constantly being rebuilt and retested, which requires them to be redeployed into the Karaf container. The correct way to deal with this is to attach the suffix **-SNAPSHOT** to the Maven version specifier. Maven treats these artifacts differently: for example, by periodically checking remote Maven repositories for updates and downloading the changed artifacts to the local repository.

Explicitly redeploying

When working with SNAPSHOT artifacts, you will also need to redeploy the changed artifacts to the Karaf container. One approach is explicit redeployment.

For example, say you have already deployed the **org.example/myfoobundle/1.0.0-SNAPSHOT** Maven artifact into the Karaf container and this bundle has the bundle ID, **751**. If you now rebuild this bundle (for example, by executing **mvn install** in the bundle's Maven project), you can redeploy the changed bundle with the following console commands:

```
osgi:uninstall 751
osgi:install mvn:org.example/myfoobundle/1.0.0-SNAPSHOT
```

dev:watch command

Typically, a more convenient approach to redeploying SNAPSHOT artifacts is to enable automatic redeployment, using the **dev:watch** command. For example, given a particular bundle—with bundle ID, **751**—you can enable automatic redeployment by entering the command:

```
dev:watch 751
```

Now, whenever you rebuild and install the Maven artifact into your local Maven repository (for example, by executing **mvn install** in your Maven project), the Karaf container automatically re-installs the changed Maven artifact. For more details, see section "dev:watch, watch" in "Console Reference" .

IMPORTANT

Using the **dev:watch** command is intended for a development environment only. It is *not* recommended for use in a production environment.

4.3.3. Configuring Pax URL Aether Directly

Overview

The default approach to configuring the Pax URL Aether component is to edit the property settings in the ***InstallDir*/etc/org.ops4j.pax.url.mvn.cfg** file directly. This approach is particularly convenient for a production environment, because the Maven configuration is colocated with the rest of the container configuration.

NOTE

In order to use the direct configuration approach, you must at least set the **org.ops4j.pax.url.mvn.repositories** property. If this property is not set, Pax URL Aether falls back to reading configuration from the Maven **settings.xml** file.

Adding a remote Maven repository

To add a remote Maven repository to the Pax URL Aether configuration, open the ***InstallDir*/etc/org.ops4j.pax.url.mvn.cfg** configuration file in a text editor and edit the **org.ops4j.pax.url.mvn.repositories** property setting. The default is as follows:

```
org.ops4j.pax.url.mvn.repositories= \
    http://repo1.maven.org/maven2@id=maven.central.repo, \
    https://maven.repository.redhat.com/ga@id=redhat.ga.repo, \
    https://maven.repository.redhat.com/earlyaccess/all@id=redhat.ea.repo, \
    https://repository.jboss.org/nexus/content/groups/ea@id=fuseearlyaccess
```

Where the **org.ops4j.pax.url.mvn.repositories** property is defined as a comma-separated list of Maven repository URLs. The backslash character, \, functions as a (UNIX style) line continuation character and must be followed immediately by the newline character. The Pax URL Aether component supports special repository URL options, defined using the **@*Option*=*Value*** syntax—see the section called “Pax URL Aether repository URL syntax”.

NOTE

The **@id** option specifies the name of the repository and is *required* by the Aether layer.

NOTE

The presence of the **org.ops4j.pax.url.mvn.repositories** property setting has an important side effect: it signals that the Pax URL Aether component takes its configuration from the **etc/org.ops4j.pax.url.mvn.cfg**, *not* from a **settings.xml** file (even if the **org.ops4j.pax.url.mvn.settings** property has been set).

Adding a default Maven repository

The default repositories are a list of repositories that the container always checks first. To add a default Maven repository to the Pax URL Aether configuration, open the ***InstallDir*/etc/org.ops4j.pax.url.mvn.cfg** configuration file in a text editor and edit the **org.ops4j.pax.url.mvn.defaultRepositories** property setting. The default is as follows:

```
org.ops4j.pax.url.mvn.defaultRepositories=\
    file:${runtime.home}/${karaf.default.repository}@snapshots@id=karaf.${karaf.default.repository},\
    file:${runtime.home}/local-repo@snapshots@id=karaf.local-repo,\
    file:${karaf.base}/${karaf.default.repository}@snapshots@id=child.karaf.${karaf.default.repository}
```

Where the **org.ops4j.pax.url.mvn.defaultRepositories** property is defined as a comma-separated list of Maven repository URLs. The backslash character, \, functions as a (UNIX style) line continuation character and must be followed immediately by the newline character. Local repositories should be defined using a URL with the **file:** scheme. The Pax URL Aether component supports special repository URL options, defined using the **@*Option*=*Value*** syntax—see the section called “Pax URL Aether repository URL syntax”.

NOTE

It is recommended that you leave the container's system repository as the first entry in the list.

Customizing the location of the local Maven repository

The local Maven repository plays a special role, because it is the primary local cache of Maven artifacts:

whenever Maven downloads an artifact from a remote repository, it installs the artifact into the local repository. The usual location of the local Maven repository is **.m2/repository/** under the user's home directory. You can optionally customize the location by setting the **org.ops4j.pax.url.mvn.localRepository** property in the ***InstallDir*/etc/org.ops4j.pax.url.mvn.cfg** configuration file. For example:

```
org.ops4j.pax.url.mvn.localRepository= /home/jbloggs/path/to/local/repository
```

By default, this property is not set.

Configuring a HTTP proxy for Maven URLs

To configure a HTTP proxy (which will be used when connecting to remote Maven repositories), open the ***InstallDir*/etc/system.properties** file in a text editor and set the **http.proxyHost** and **http.proxyPort** system properties with the host and port of the proxy—for example:

```
http.proxyHost=192.0.2.0
http.proxyPort=8080
```

You can optionally specify a list of non-proxy hosts (hosts that can be reached without going through the proxy) using the **http.nonProxyHosts** property—for example:

```
http.nonProxyHosts=localhost|*.redhat.com|*.jboss.org
```

NOTE

An advantage of using the system properties approach to configuring the proxy is that these settings will be used both by the **mvn** URL protocol handler and by the **http** URL protocol handler (see Section 4.1, "Locating HTTP Artifacts").

4.3.4. Configuring Pax URL Aether through settings.xml

Overview

You can optionally configure Pax URL Aether using a standard Maven **settings.xml** file. This approach is particularly convenient in a *development environment*, because it makes it possible to store your build time settings and your run time settings all in one place.

Enabling the settings.xml configuration approach

To configure Pax URL Aether to read its configuration from a Maven **settings.xml** file, you must remove or comment out the **org.ops4j.pax.url.mvn.repositories** setting in the ***InstallDir*/etc/org.ops4j.pax.url.mvn.cfg** file. For example, you can comment out the default repositories setting by inserting a hash, **#**, at the start of the line, as follows:

```
#org.ops4j.pax.url.mvn.repositories= \
    http://repo1.maven.org/maven2@id=maven.central.repo, \
    https://maven.repository.redhat.com/ga@id=redhat.ga.repo, \
    https://maven.repository.redhat.com/earlyaccess/all@id=redhat.ea.repo, \
    https://repository.jboss.org/nexus/content/groups/ea@id=fuseearlyaccess
```

When the repositories setting is absent, Pax URL Aether implicitly switches to the **settings.xml** configuration approach.

Location of the settings.xml file

By default, Pax URL Aether looks in the standard locations for the Maven **settings.xml** file (usually ***UserHome*/.m2/settings.xml**). If you like, you can specify the location explicitly using the **org.ops4j.pax.url.mvn.settings** property. For example:

```
org.ops4j.pax.url.mvn.settings= /home/fuse/settings.xml
```

For full details of the search order for **settings.xml**, see the description of **org.ops4j.pax.url.mvn.settings** in the section called "Pax URL Aether configuration reference" .

Adding a remote Maven repository

To add a new remote Maven repository to your **settings.xml** file, open the **settings.xml** file in a text editor and add a new **repository** XML element. For example, to create an entry for the JBoss Fuse public Maven repository, add a **repository** element as shown:

```
<settings xmlns="http://maven.apache.org/SETTINGS/1.0.0"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="http://maven.apache.org/SETTINGS/1.0.0
http://maven.apache.org/xsd/settings-1.0.0.xsd">
  ...
  <profiles>
    <profile>
      <id>my-fuse-profile</id>
      <activation>
        <activeByDefault>true</activeByDefault>
      </activation>
      <repositories>
        <!--
         | Add new remote Maven repositories here
          -->
        <repository>
            <id>redhat-ga-repository</id>
            <url>https://maven.repository.redhat.com/ga</url>
            <releases>
                <enabled>true</enabled>
            </releases>
            <snapshots>
                <enabled>false</enabled>
            </snapshots>
        </repository>
        ...
      </repositories>
  </profiles>
  ...
</settings>
```

The preceding example additionally specifies that release artifacts can be downloaded, but snapshot artifacts cannot be downloaded from the repository.

Customizing the location of the local Maven repository

To customize the location of your local Maven repository, open the **settings.xml** file in a text editor and add (or modify) the **localRepository** XML element. For example, to select the directory, **/home/fuse/.m2/repository**, as your local Maven repository:

```
<settings xmlns="http://maven.apache.org/SETTINGS/1.0.0"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="http://maven.apache.org/SETTINGS/1.0.0
http://maven.apache.org/xsd/settings-1.0.0.xsd">
  ...
<!-- localRepository
 | The path to the local repository Maven will use to store artifacts.
 |
 | Default: ~/.m2/repository -->
  <localRepository>/home/fuse/.m2/repository</localRepository>
  ...
</settings>
```

For a detailed explanation of the search order for the local Maven repository, see the section called “Local Maven repository search order”.

Configuring a HTTP proxy for Maven URLs

To configure a HTTP proxy (which will be used when connecting to remote Maven repositories), open the **settings.xml** file in a text editor and add a new **proxy** XML element as a child of the **proxies** XML element. The definition of the proxy follows the standard Maven syntax. For example, to create a proxy for the HTTP (insecure) protocol with host, **192.0.2.0**, and port, **8080**, add a **proxy** element as follows:

```
<settings xmlns="http://maven.apache.org/SETTINGS/1.0.0"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="http://maven.apache.org/SETTINGS/1.0.0
http://maven.apache.org/xsd/settings-1.0.0.xsd">
  ...
  <proxies>
    <proxy>
      <id>fuse-proxy-1</id>
      <active>true</active>
      <protocol>http</protocol>
      <host>192.0.2.0</host>
      <port>8080</port>
    </proxy>
  </proxies>
  ...
</settings>
```

You can also add a proxy for secure HTTPS connections by adding a **proxy** element configured with the **https** protocol.

Reference

For a detailed description of the syntax of the Maven **settings.xml** file, see the Maven Settings Reference. But please note that *not all of the features* documented there are necessarily supported by the Pax URL Aether component.

4.3.5. Pax URL Aether Reference

Overview

This section provides a configuration reference for the Pax URL Aether component, which is used to configure the runtime behaviour of Maven in the Karaf container.

> **NOTE**
>
> The prefix appearing in the property names, **org.ops4j.pax.url.mvn.***, reflects the old name of this component, which was previously called Pax URL Mvn.

Local Maven repository search order

Pax URL Aether resolves the location of the local repository in the following order:

1. The location specified by the **org.ops4j.pax.url.mvn.localRepository** property in the **org.ops4j.pax.url.mvn.cfg** file.
2. Otherwise, the location specified by the **localRepository** element in the **settings.xml** file specified by the **org.ops4j.pax.url.mvn.settings** property in the **org.ops4j.pax.url.mvn.cfg** file.
3. Otherwise, the location specified by the **localRepository** element in the **.m2/settings.xml** file located under the user's home directory.
4. Otherwise, the location specified by the **localRepository** element in the ***M2_HOME*/conf/settings.xml** file.
5. Otherwise, the default location is **.m2/repository/** under the user's home directory.

Pax URL Aether Maven URL syntax

The protocol handler registered by Pax URL Aether supports the following Maven URL syntax:

```
mvn:[RepositoryUrl!]GroupId/ArtifactId[/Version[/Type]]
```

Where ***RepositoryUrl*** has the syntax specified by the section called “Pax URL Aether repository URL syntax”; and ***GroupId***, ***ArtifactId***, ***Version***, ***Type*** are the standard Maven location coordinates.

Pax URL Aether repository URL syntax

You specify a repository location using a URL with a **file:**, **http:**, or **https:** scheme, optionally appending one or more of the following suffixes:

@snapshots

Allow snapshot versions to be read from the repository.

@noreleases

Do not allow release versions to be read from the repository.

@id=*RepoName*

(Required) Specifies the repository name. This setting is required by the Aether handler.

@multi

Marks the path as a parent directory of multiple repository directories. At run time the parent directory is scanned for subdirectories and each subdirectory is used as a remote repository.

@update=*UpdatePolicy*

Specifies the Maven **updatePolicy**, overriding the value of **org.ops4j.pax.url.mvn.globalUpdatePolicy**.

@releasesUpdate=*UpdatePolicy*

Specifies the Maven **updatePolicy** specifically for release artifacts (overriding the value of **@update**).

@snapshotsUpdate=*UpdatePolicy*

Specifies the Maven **updatePolicy** specifically for snapshot artifacts (overriding the value of **@update**).

@checksum=*ChecksumPolicy*

Specifies the Maven **checksumPolicy**, which specifies how to react if a downloaded Maven artifact has a missing or incorrect checksum. The policy value can be: **ignore**, **fail**, or **warn**.

@releasesChecksum=*ChecksumPolicy*

Specifies the Maven **checksumPolicy** specifically for release artifacts (overriding the value of **@checksum**).

@snapshotsChecksum=*ChecksumPolicy*

Specifies the Maven **checksumPolicy** specifically for snapshot artifacts (overriding the value of **@checksum**).

For example:

```
https://repo.example.org/maven/repository@id=example.repo
```

Pax URL Aether configuration reference

The Pax URL Aether component can be configured by editing the **etc/org.ops4j.pax.url.mvn.cfg** configuration file (uses OSGi Config Admin service). In **pax-url-aether** version 2.4.2, the following configuration properties are supported:

org.ops4j.pax.url.mvn.certificateCheck

If **true**, enable the SSL certificate check when connecting to a remote repository through the HTTPS protocol. If **false**, skip the SSL certificate check. Default is **false**.

org.ops4j.pax.url.mvn.defaultRepositories

Specifies a list of default (local) Maven repositories that are checked *before* looking up the remote repositories. Specified as a comma-separated list of **file:** repository URLs, where each repository URL has the syntax defined in the section called “Pax URL Aether repository URL syntax” .

org.ops4j.pax.url.mvn.globalUpdatePolicy

Specifies the Maven **updatePolicy**, which determines how often Aether attempts to update local Maven artifacts from remote repositories. Can take the following values:

- **always**—always resolve the latest SNAPSHOT from remote Maven repositories.
- **never**—never check for newer remote SNAPSHOTS.
- **daily**—check on the first run of the day (local time).
- **interval:*Mins***—check every ***Mins*** minutes.

Default is **daily**.

org.ops4j.pax.url.mvn.localRepository

Specifies the location of the local Maven repository on the file system, overriding the default value (which is usually ***UserHome*/.m2/repository**).

org.ops4j.pax.url.mvn.proxies

Can be used to specify a HTTP proxy, a HTTPS proxy, and non-proxy host lists. The value consists of a semicolon, **;**, separated list of entries. You can include the following entries (where each entry is optional):

- **http:host=*Host*,port=*Port*[,nonProxyHosts=*NonProxyHosts*]**
- **https:host=*Host*,port=*Port*[,nonProxyHosts=*NonProxyHosts*]**

The **nonProxyHosts** setting is optional and, if included, specifies a list of hosts that can be reached without going through the proxy. The list of non-proxy hosts has its entries separated by a pipe, **|**, symbol—for example, **nonProxyHosts=localhost|example.org**.

Here is a sample **org.ops4j.pax.url.mvn.proxies** setting:

```
org.ops4j.pax.url.mvn.proxies= http:host=gateway,port=8080;https:host=sslgateway,port=8453
```

org.ops4j.pax.url.mvn.proxySupport

If **true**, enable HTTP proxy support through property settings. When this setting is enabled, the HTTP proxy can be configured in either of the following ways:

- Through the **org.ops4j.pax.url.mvn.proxies** property (takes precedence), or
- Through the **http.proxyHost**, **http.proxyPort**, and **http.nonProxyHosts** Java system properties, set in the **etc/system.properties** file.

If **false**, the preceding property settings are ignored. Default is **true**.

NOTE

This setting has no effect on proxy support when a Maven **settings.xml** file is selected to configure Pax URL Aether.

org.ops4j.pax.url.mvn.repositories

Specifies a list of remote Maven repositories that can be searched for Maven artifacts. Specified as a comma-separated list of **http:** or **https:** repository URLs, where each repository URL has the syntax defined in the section called "Pax URL Aether repository URL syntax" .

IMPORTANT

If the **org.ops4j.pax.url.mvn.repositories** property is *not* set, Pax URL Aether reads its Maven settings from the relevant Maven **settings.xml** file instead (usually, from ***UserHome*/.m2/settings.xml** by default). In other words, the absence of the **org.ops4j.pax.url.mvn.repositories** property implicitly enables the **settings.xml** configuration approach.

org.ops4j.pax.url.mvn.security

Specifies the path to a Maven **settings-security.xml** file. This can be used to enable server password encryption. Default is **${user.home}/.m2/settings-security.xml**.

org.ops4j.pax.url.mvn.settings

Specifies a path on the file system to override the default location of the Maven **settings.xml** file. Pax URL Aether resolves the location of the Maven **settings.xml** file in the following order:

1. The location specified by **org.ops4j.pax.url.mvn.settings**.
2. **${user.home}/.m2/settings.xml**
3. **${maven.home}/conf/settings.xml**
4. ***M2_HOME*/conf/settings.xml**

NOTE

All **settings.xml** files are ignored, if the **org.ops4j.pax.url.mvn.repositories** property is set.

org.ops4j.pax.url.mvn.timeout

Specifies the timeout to use while downloading artifacts, in units of milliseconds. Default is **5000** (five seconds).

PART II. OSGI BUNDLE DEPLOYMENT MODEL

Abstract

The OSGi bundle is the underlying unit of deployment for the Red Hat JBoss Fuse container. You can either package and deploy your applications directly as bundles or use one of the alternative deployment models (WAR).

CHAPTER 5. INTRODUCTION TO OSGI

Abstract

The OSGi specification supports modular application development by defining a runtime framework that simplifies building, deploying, and managing complex applications.

5.1. RED HAT JBOSS FUSE

Overview

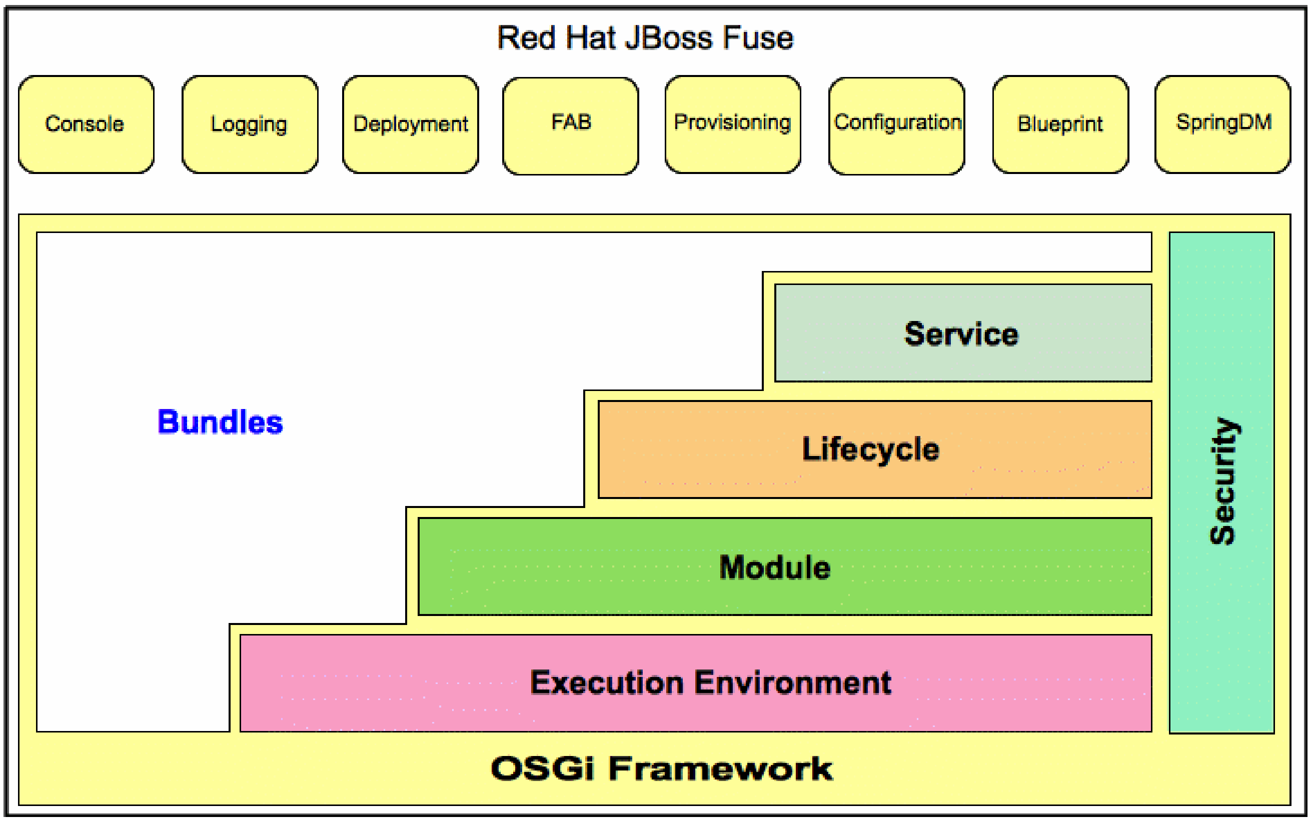
Red Hat JBoss Fuse has the following layered architecture:

- **Technology layer**—includes technologies such as JAX-WS, JAX-RS, JMS, Spring, and JEE
- **the section called “Red Hat JBoss Fuse”**—a wrapper layer around the OSGi container implementation, which provides support for deploying the OSGi container as a runtime server. Runtime features provided by the JBoss Fuse include hot deployment, management, and administration features.
- **OSGi framework** —implements OSGi functionality, including managing dependencies and bundle lifecycles

Red Hat JBoss Fuse

Figure 5.1 shows the architecture of JBoss Fuse.

Figure 5.1. Red Hat JBoss Fuse Architecture



JBoss Fuse is based on Apache Karaf, a powerful, lightweight, OSGi-based runtime container for deploying and managing bundles to facilitate componentization of applications. JBoss Fuse also provides native OS integration and can be integrated into the operating system as a service so that the lifecycle is bound to the operating system.

As shown in Figure 5.1, JBoss Fuse extends the OSGi layers with:

- **Console**– an extensible Gogo console manages services, installs and manages applications and libraries, and interacts with the JBoss Fuse runtime. It provides console commands to administer instances of JBoss Fuse. See the "Console Reference".
- **Logging**—a powerful, unified logging subsystem provides console commands to display, view and change log levels. See "Configuring and Running JBoss Fuse".
- **Deployment**—supports both manual deployment of OSGi bundles using the **osgi:install** and **osgi:start** commands and hot deployment of applications. When a JAR file, WAR file, or OSGi bundle is copied into the hot deployment folder *InstallDir*/**deploy**, it's automatically installed on-the-fly inside the Red Hat JBoss Fuse runtime. When you update or delete these files or bundles, the changes are made automatically (but only while the container is running!). See Section 7.1, "Hot Deployment".
- **Provisioning**—provides multiple mechanisms for installing applications and libraries. See Chapter 8, *Deploying Features*.
- **Configuration**—the properties files stored in the *InstallDir*/**etc** folder are continuously monitored, and changes to them are automatically propagated to the relevant services at configurable intervals.
- **Spring DM**—simplifies building Spring applications that run in an OSGi framework. When a Spring configuration file is copied to the hot deployment folder, Red Hat JBoss Fuse generates an OSGi bundle on-the-fly and instantiates the Spring application context.
- **Blueprint**—is essentially a standardized version of Spring DM. It is a dependency injection framework that simplifies interaction with the OSGi container—for example, providing standard XML elements to import and export OSGi services. When a Blueprint configuration file is copied to the hot deployment folder, Red Hat JBoss Fuse generates an OSGi bundle on-the-fly and instantiates the Blueprint context.

5.2. OSGI FRAMEWORK

Overview

The OSGi Alliance is an independent organization responsible for defining the features and capabilities of the OSGi Service Platform Release 4. The OSGi Service Platform is a set of open specifications that simplify building, deploying, and managing complex software applications.

OSGi technology is often referred to as the dynamic module system for Java. OSGi is a framework for Java that uses bundles to modularly deploy Java components and handle dependencies, versioning, classpath control, and class loading. OSGi's lifecycle management allows you to load, start, and stop bundles without shutting down the JVM.

OSGi provides the best runtime platform for Java, a superior class loading architecture, and a registry for services. Bundles can export services, run processes, and have their dependencies managed. Each bundle can have its requirements managed by the OSGi container.

JBoss Fuse uses Apache Felix as its default OSGi implementation. The framework layers form the container where you install bundles. The framework manages the installation and updating of bundles in a dynamic, scalable manner, and manages the dependencies between bundles and services.

OSGi architecture

As shown in Figure 5.1, "Red Hat JBoss Fuse Architecture" , the OSGi framework contains the following:

- **Bundles** — Logical modules that make up an application. See Section 5.4, "OSGi Bundles".
- **Service layer** — Provides communication among modules and their contained components. This layer is tightly integrated with the lifecycle layer. See Section 5.3, "OSGi Services".
- **Lifecycle layer** — Provides access to the underlying OSGi framework. This layer handles the lifecycle of individual bundles so you can manage your application dynamically, including starting and stopping bundles.
- **Module layer** — Provides an API to manage bundle packaging, dependency resolution, and class loading.
- **Execution environment** — A configuration of a JVM. This environment uses profiles that define the environment in which bundles can work.
- **Security layer** — Optional layer based on Java 2 security, with additional constraints and enhancements.

Each layer in the framework depends on the layer beneath it. For example, the lifecycle layer requires the module layer. The module layer can be used without the lifecycle and service layers.

5.3. OSGI SERVICES

Overview

An OSGi service is a Java class or service interface with service properties defined as name/value pairs. The service properties differentiate among service providers that provide services with the same service interface.

An OSGi service is defined semantically by its service interface, and it is implemented as a service object. A service's functionality is defined by the interfaces it implements. Thus, different applications can implement the same service.

Service interfaces allow bundles to interact by binding interfaces, not implementations. A service interface should be specified with as few implementation details as possible.

OSGi service registry

In the OSGi framework, the service layer provides communication between bundles and their contained components using the publish, find, and bind service model. The service layer contains a service registry where:

- Service providers register services with the framework to be used by other bundles
- Service requesters find services and bind to service providers

Services are owned by, and run within, a bundle. The bundle registers an implementation of a service with the framework service registry under one or more Java interfaces. Thus, the service’s functionality is available to other bundles under the control of the framework, and other bundles can look up and use the service. Lookup is performed using the Java interface and service properties.

Each bundle can register multiple services in the service registry using the fully qualified name of its interface and its properties. Bundles use names and properties with LDAP syntax to query the service registry for services.

A bundle is responsible for runtime service dependency management activities including publication, discovery, and binding. Bundles can also adapt to changes resulting from the dynamic availability (arrival or departure) of the services that are bound to the bundle.

Event notification

Service interfaces are implemented by objects created by a bundle. Bundles can:

- Register services
- Search for services
- Receive notifications when their registration state changes

The OSGi framework provides an event notification mechanism so service requesters can receive notification events when changes in the service registry occur. These changes include the publication or retrieval of a particular service and when services are registered, modified, or unregistered.

Service invocation model

When a bundle wants to use a service, it looks up the service and invokes the Java object as a normal Java call. Therefore, invocations on services are synchronous and occur in the same thread. You can use callbacks for more asynchronous processing. Parameters are passed as Java object references. No marshalling or intermediary canonical formats are required as with XML. OSGi provides solutions for the problem of services being unavailable.

OSGi framework services

In addition to your own services, the OSGi framework provides the following optional services to manage the operation of the framework:

- **Package Admin service**—allows a management agent to define the policy for managing Java package sharing by examining the status of the shared packages. It also allows the management agent to refresh packages and to stop and restart bundles as required. This service enables the management agent to make decisions regarding any shared packages when an exporting bundle is uninstalled or updated.

  The service also provides methods to refresh exported packages that were removed or updated since the last refresh, and to explicitly resolve specific bundles. This service can also trace dependencies between bundles at runtime, allowing you to see what bundles might be affected by upgrading.

- **Start Level service**—enables a management agent to control the starting and stopping order of bundles. The service assigns each bundle a start level. The management agent can modify the start level of bundles and set the active start level of the framework, which starts and stops the appropriate bundles. Only bundles that have a start level less than, or equal to, this active start level can be active.

- **URL Handlers service**—dynamically extends the Java runtime with URL schemes and content handlers enabling any component to provide additional URL handlers.
- **Permission Admin service**—enables the OSGi framework management agent to administer the permissions of a specific bundle and to provide defaults for all bundles. A bundle can have a single set of permissions that are used to verify that it is authorized to execute privileged code. You can dynamically manipulate permissions by changing policies on the fly and by adding new policies for newly installed components. Policy files are used to control what bundles can do.
- **Conditional Permission Admin service**—extends the Permission Admin service with permissions that can apply when certain conditions are either true or false at the time the permission is checked. These conditions determine the selection of the bundles to which the permissions apply. Permissions are activated immediately after they are set.

The OSGi framework services are described in detail in separate chapters in the *OSGi Service Platform Release 4* specification available from the release 4 download page on the OSGi Alliance web site.

OSGi Compendium services

In addition to the OSGi framework services, the OSGi Alliance defines a set of optional, standardized compendium services. The OSGi compendium services provide APIs for tasks such as logging and preferences. These services are described in the *OSGi Service Platform, Service Compendium* available from the release 4 download page on the OSGi Alliance Web site.

The *Configuration Admin* compendium service is like a central hub that persists configuration information and distributes it to interested parties. The Configuration Admin service specifies the configuration information for deployed bundles and ensures that the bundles receive that data when they are active. The configuration data for a bundle is a list of name-value pairs. See the section called “Red Hat JBoss Fuse”.

5.4. OSGI BUNDLES

Overview

With OSGi, you modularize applications into bundles. Each bundle is a tightly coupled, dynamically loadable collection of classes, JARs, and configuration files that explicitly declare any external dependencies. In OSGi, a bundle is the primary deployment format. Bundles are applications that are packaged in JARs, and can be installed, started, stopped, updated, and removed.

OSGi provides a dynamic, concise, and consistent programming model for developing bundles. Development and deployment are simplified by decoupling the service's specification (Java interface) from its implementation.

The OSGi bundle abstraction allows modules to share Java classes. This is a static form of reuse. The shared classes must be available when the dependent bundle is started.

A bundle is a JAR file with metadata in its OSGi manifest file. A bundle contains class files and, optionally, other resources and native libraries. You can explicitly declare which packages in the bundle are visible externally (exported packages) and which external packages a bundle requires (imported packages).

The module layer handles the packaging and sharing of Java packages between bundles and the hiding of packages from other bundles. The OSGi framework dynamically resolves dependencies among bundles. The framework performs bundle resolution to match imported and exported packages. It can also manage multiple versions of a deployed bundle.

Class Loading in OSGi

OSGi uses a graph model for class loading rather than a tree model (as used by the JVM). Bundles can share and re-use classes in a standardized way, with no runtime class-loading conflicts.

Each bundle has its own internal classpath so that it can serve as an independent unit if required.

The benefits of class loading in OSGi include:

- Sharing classes directly between bundles. There is no requirement to promote JARs to a parent class-loader.
- You can deploy different versions of the same class at the same time, with no conflict.

CHAPTER 6. BUILDING AN OSGI BUNDLE

Abstract

This chapter describes how to build an OSGi bundle using Maven. For building bundles, the Maven bundle plug-in plays a key role, because it enables you to automate the generation of OSGi bundle headers (which would otherwise be a tedious task). Maven archetypes, which generate a complete sample project, can also provide a starting point for your bundle projects.

6.1. GENERATING A BUNDLE PROJECT

Generating bundle projects with Maven archetypes

To help you get started quickly, you can invoke a Maven archetype to generate the initial outline of a Maven project (a Maven archetype is analogous to a project wizard). The following Maven archetypes can generate projects for building OSGi bundles:

- the section called "Apache CXF karaf-soap-archetype archetype" .
- the section called "Apache Camel archetype" .

Apache CXF karaf-soap-archetype archetype

The Apache CXF karaf-soap-archetype archetype creates a project for building a service from Java. To generate a Maven project with the coordinates, *GroupId*:*ArtifactId*:*Version*, enter the following command:

```
mvn archetype:generate \
  -DarchetypeGroupId=io.fabric8.archetypes \
  -DarchetypeArtifactId=karaf-soap-archetype \
  -DarchetypeVersion=1.2.0.redhat-630xxx \
  -DgroupId=GroupId \
  -DartifactId=ArtifactId \
  -Dversion=Version \
  -Dfabric8-profile=ProfileName
```

NOTE

The backslash character, \, indicates line continuation on Linux and UNIX operating systems. On Windows platforms, you must omit the backslash character and put all of the arguments on a single line.

Apache Camel archetype

The Apache Camel OSGi archetype creates a project for building a route that can be deployed into the OSGi container. To generate a Maven project with the coordinates, *GroupId*:*ArtifactId*:*Version*, enter the following command:

```
mvn archetype:generate \
  -DarchetypeGroupId=org.apache.camel.archetypes \
  -DarchetypeArtifactId=camel-archetype-blueprint \
  -DarchetypeVersion=2.17.0.redhat-630xxx \
  -DgroupId=GroupId \
  -DartifactId=ArtifactId \
  -Dversion=Version
```

Building the bundle

By default, the preceding archetypes create a project in a new directory, whose names is the same as the specified artifact ID, *ArtifactId*. To build the bundle defined by the new project, open a command prompt, go to the project directory (that is, the directory containing the **pom.xml** file), and enter the following Maven command:

```
mvn install
```

The effect of this command is to compile all of the Java source files, to generate a bundle JAR under the *ArtifactId*/**target** directory, and then to install the generated JAR in the local Maven repository.

6.2. MODIFYING AN EXISTING MAVEN PROJECT

Overview

If you already have a Maven project and you want to modify it so that it generates an OSGi bundle, perform the following steps:

1. the section called “Change the package type to bundle” .
2. the section called “Add the bundle plug-in to your POM” .
3. the section called “Customize the bundle plug-in” .
4. the section called “Customize the JDK compiler version” .

Change the package type to bundle

Configure Maven to generate an OSGi bundle by changing the package type to **bundle** in your project's **pom.xml** file. Change the contents of the **packaging** element to **bundle**, as shown in the following example:

```
<project ... >
  ...
  <packaging>bundle</packaging>
  ...
</project>
```

The effect of this setting is to select the Maven bundle plug-in, **maven-bundle-plugin**, to perform packaging for this project. This setting on its own, however, has no effect until you explicitly add the bundle plug-in to your POM.

Add the bundle plug-in to your POM

To add the Maven bundle plug-in, copy and paste the following sample **plugin** element into the **project/build/plugins** section of your project's **pom.xml** file:

```
<project ... >
  ...
  <build>
    <defaultGoal>install</defaultGoal>
    <plugins>
      ...
      <plugin>
        <groupId>org.apache.felix</groupId>
        <artifactId>maven-bundle-plugin</artifactId>
        <version>2.3.7</version>
        <extensions>true</extensions>
        <configuration>
          <instructions>
            <Bundle-SymbolicName>${project.groupId}.${project.artifactId}</Bundle-
SymbolicName>
            <Import-Package>*</Import-Package>
          </instructions>
        </configuration>
      </plugin>
    </plugins>
  </build>
  ...
</project>
```

Where the bundle plug-in is configured by the settings in the **instructions** element.

Customize the bundle plug-in

For some specific recommendations on configuring the bundle plug-in for Apache CXF, see Section 6.3, “Packaging a Web Service in a Bundle”.

For an in-depth discussion of bundle plug-in configuration, in the context of the OSGi framework and versioning policy, see "Managing OSGi Dependencies".

Customize the JDK compiler version

It is almost always necessary to specify the JDK version in your POM file. If your code uses any modern features of the Java language—such as generics, static imports, and so on—and you have not customized the JDK version in the POM, Maven will fail to compile your source code. It is *not* sufficient to set the **JAVA_HOME** and the **PATH** environment variables to the correct values for your JDK, you must also modify the POM file.

To configure your POM file, so that it accepts the Java language features introduced in JDK 1.7, add the following **maven-compiler-plugin** plug-in settings to your POM (if they are not already present):

```
<project ... >
  ...
  <build>
    <defaultGoal>install</defaultGoal>
    <plugins>
      ...
      <plugin>
        <groupId>org.apache.maven.plugins</groupId>
        <artifactId>maven-compiler-plugin</artifactId>
        <configuration>
        <source>1.7</source>
        <target>1.7</target>
      </configuration>
    </plugin>
  </plugins>
 </build>
 ...
</project>
```

6.3. PACKAGING A WEB SERVICE IN A BUNDLE

Overview

This section explains how to modify an existing Maven project for a Apache CXF application, so that the project generates an OSGi bundle suitable for deployment in the Red Hat JBoss Fuse OSGi container. To convert the Maven project, you need to modify the project's POM file and the project's Spring XML file(s) (located in **META-INF/spring**).

Modifying the POM file to generate a bundle

To configure a Maven POM file to generate a bundle, there are essentially two changes you need to make: change the POM's package type to **bundle**; and add the Maven bundle plug-in to your POM. For details, see Section 6.1, "Generating a Bundle Project".

Mandatory import packages

In order for your application to use the Apache CXF components, you need to import their packages into the application's bundle. Because of the complex nature of the dependencies in Apache CXF, you cannot rely on the Maven bundle plug-in, or the **bnd** tool, to automatically determine the needed imports. You will need to explicitly declare them.

You need to import the following packages into your bundle:

```
javax.jws
javax.wsdl
javax.xml.bind
javax.xml.bind.annotation
javax.xml.namespace
javax.xml.ws
org.apache.cxf.bus
org.apache.cxf.bus.spring
org.apache.cxf.bus.resource
org.apache.cxf.configuration.spring
org.apache.cxf.resource
org.apache.cxf.jaxws
org.springframework.beans.factory.config
```

Sample Maven bundle plug-in instructions

Example 6.1, "Configuration of Mandatory Import Packages" shows how to configure the Maven bundle plug-in in your POM to import the mandatory packages. The mandatory import packages appear as a comma-separated list inside the **Import-Package** element. Note the appearance of the wildcard, *****, as the last element of the list. The wildcard ensures that the Java source files from the current bundle are scanned to discover what additional packages need to be imported.

Example 6.1. Configuration of Mandatory Import Packages

```
<project ... >
  ...
  <build>
    <plugins>
      <plugin>
        <groupId>org.apache.felix</groupId>
        <artifactId>maven-bundle-plugin</artifactId>
        <extensions>true</extensions>
        <configuration>
          <instructions>
            ...
            <Import-Package>
              javax.jws,
              javax.wsdl,
              javax.xml.bind,
              javax.xml.bind.annotation,
              javax.xml.namespace,
              javax.xml.ws,
              org.apache.cxf.bus,
              org.apache.cxf.bus.spring,
              org.apache.cxf.bus.resource,
              org.apache.cxf.configuration.spring,
              org.apache.cxf.resource,
              org.apache.cxf.jaxws,
              org.springframework.beans.factory.config,
              *
            </Import-Package>
            ...
          </instructions>
        </configuration>
      </plugin>
    </plugins>
  </build>
  ...
</project>
```

Add a code generation plug-in

A Web services project typically requires code to be generated. Apache CXF provides two Maven plug-ins for the JAX-WS front-end, which enable tyou to integrate the code generation step into your build. The choice of plug-in depends on whether you develop your service using the Java-first approach or the WSDL-first approach, as follows:

- *Java-first approach*—use the **cxf-java2ws-plugin** plug-in.
- *WSDL-first approach*—use the **cxf-codegen-plugin** plug-in.

OSGi configuration properties

The OSGi Configuration Admin service defines a mechanism for passing configuration settings to an OSGi bundle. You do not have to use this service for configuration, but it is typically the most convenient way of configuring bundle applications. Both Spring DM and Blueprint provide support for OSGi configuration, enabling you to substitute variables in a Spring XML file or a Blueprint file using values obtained from the OSGi Configuration Admin service.

For details of how to use OSGi configuration properties, see Section 6.4, "Configuring the Bundle Plug-In" and the section called "Add OSGi configurations to the feature" .

6.4. CONFIGURING THE BUNDLE PLUG-IN

Overview

A bundle plug-in requires very little information to function. All of the required properties use default settings to generate a valid OSGi bundle.

While you can create a valid bundle using just the default values, you will probably want to modify some of the values. You can specify most of the properties inside the plug-in's **instructions** element.

Configuration properties

Some of the commonly used configuration properties are:

- Bundle-SymbolicName
- Bundle-Name
- Bundle-Version
- Export-Package
- Private-Package
- Import-Package

Setting a bundle's symbolic name

By default, the bundle plug-in sets the value for the Bundle-SymbolicName property to *groupId* **+ "." +** *artifactId*, with the following exceptions:

- If *groupId* has only one section (no dots), the first package name with classes is returned.

  For example, if the group Id is **commons-logging:commons-logging**, the bundle's symbolic name is **org.apache.commons.logging**.

- If *artifactId* is equal to the last section of *groupId*, then *groupId* is used.

  For example, if the POM specifies the group ID and artifact ID as **org.apache.maven:maven**, the bundle's symbolic name is **org.apache.maven**.

- If *artifactId* starts with the last section of *groupId*, that portion is removed.

  For example, if the POM specifies the group ID and artifact ID as **org.apache.maven:maven-core**, the bundle's symbolic name is **org.apache.maven.core**.

To specify your own value for the bundle's symbolic name, add a **Bundle-SymbolicName** child in the plug-in's **instructions** element, as shown in Example 6.2.

Example 6.2. Setting a bundle's symbolic name

```
<plugin>
  <groupId>org.apache.felix</groupId>
  <artifactId>maven-bundle-plugin</artifactId>
  <configuration>
   <instructions>
     <Bundle-SymbolicName>${project.artifactId}</Bundle-SymbolicName>
     ...
    </instructions>
  </configuration>
</plugin>
```

Setting a bundle's name

By default, a bundle's name is set to **${project.name}**.

To specify your own value for the bundle's name, add a **Bundle-Name** child to the plug-in's **instructions** element, as shown in Example 6.3.

Example 6.3. Setting a bundle's name

```
<plugin>
  <groupId>org.apache.felix</groupId>
  <artifactId>maven-bundle-plugin</artifactId>
  <configuration>
   <instructions>
     <Bundle-Name>JoeFred</Bundle-Name>
     ...
    </instructions>
  </configuration>
</plugin>
```

Setting a bundle's version

By default, a bundle's version is set to **${project.version}**. Any dashes (**-**) are replaced with dots (**.**) and the number is padded up to four digits. For example, **4.2-SNAPSHOT** becomes **4.2.0.SNAPSHOT**.

To specify your own value for the bundle's version, add a **Bundle-Version** child to the plug-in's **instructions** element, as shown in Example 6.4.

Example 6.4. Setting a bundle's version

```
<plugin>
  <groupId>org.apache.felix</groupId>
  <artifactId>maven-bundle-plugin</artifactId>
  <configuration>
   <instructions>
```

```
      <Bundle-Version>1.0.3.1</Bundle-Version>
      ...
    </instructions>
  </configuration>
</plugin>
```

Specifying exported packages

By default, the OSGi manifest's **Export-Package** list is populated by all of the packages in your local Java source code (under **src/main/java**), *except* for the deault package, **.**, and any packages containing **.impl** or **.internal**.

IMPORTANT

If you use a **Private-Package** element in your plug-in configuration and you do not specify a list of packages to export, the default behavior includes only the packages listed in the **Private-Package** element in the bundle. No packages are exported.

The default behavior can result in very large packages and in exporting packages that should be kept private. To change the list of exported packages you can add an **Export-Package** child to the plug-in's **instructions** element.

The **Export-Package** element specifies a list of packages that are to be included in the bundle and that are to be exported. The package names can be specified using the ***** wildcard symbol. For example, the entry **com.fuse.demo.*** includes all packages on the project's classpath that start with com.fuse.demo.

You can specify packages to be excluded be prefixing the entry with **!**. For example, the entry **!com.fuse.demo.private** excludes the package com.fuse.demo.private.

When excluding packages, the order of entries in the list is important. The list is processed in order from the beginning and any subsequent contradicting entries are ignored.

For example, to include all packages starting with com.fuse.demo except the package com.fuse.demo.private, list the packages using:

```
!com.fuse.demo.private,com.fuse.demo.*
```

However, if you list the packages using com.fuse.demo.*,!com.fuse.demo.private, then com.fuse.demo.private is included in the bundle because it matches the first pattern.

Specifying private packages

If you want to specify a list of packages to include in a bundle *without* exporting them, you can add a **Private-Package** instruction to the bundle plug-in configuration. By default, if you do not specify a **Private-Package** instruction, all packages in your local Java source are included in the bundle.

IMPORTANT

If a package matches an entry in both the **Private-Package** element and the **Export-Package** element, the **Export-Package** element takes precedence. The package is added to the bundle and exported.

The **Private-Package** element works similarly to the **Export-Package** element in that you specify a list of packages to be included in the bundle. The bundle plug-in uses the list to find all classes on the project's classpath that are to be included in the bundle. These packages are packaged in the bundle, but not exported (unless they are also selected by the **Export-Package** instruction).

Example 6.5 shows the configuration for including a private package in a bundle

Example 6.5. Including a private package in a bundle

```
<plugin>
  <groupId>org.apache.felix</groupId>
  <artifactId>maven-bundle-plugin</artifactId>
  <configuration>
   <instructions>
     <Private-Package>org.apache.cxf.wsdlFirst.impl</Private-Package>
     ...
    </instructions>
  </configuration>
</plugin>
```

Specifying imported packages

By default, the bundle plug-in populates the OSGi manifest's **Import-Package** property with a list of all the packages referred to by the contents of the bundle.

While the default behavior is typically sufficient for most projects, you might find instances where you want to import packages that are not automatically added to the list. The default behavior can also result in unwanted packages being imported.

To specify a list of packages to be imported by the bundle, add an **Import-Package** child to the plug-in's **instructions** element. The syntax for the package list is the same as for the **Export-Package** element and the **Private-Package** element.

IMPORTANT

When you use the **Import-Package** element, the plug-in does not automatically scan the bundle's contents to determine if there are any required imports. To ensure that the contents of the bundle are scanned, you must place an * as the last entry in the package list.

Example 6.6 shows the configuration for specifying the packages imported by a bundle

Example 6.6. Specifying the packages imported by a bundle

```
<plugin>
  <groupId>org.apache.felix</groupId>
  <artifactId>maven-bundle-plugin</artifactId>
  <configuration>
   <instructions>
     <Import-Package>javax.jws,
         javax.wsdl,
         org.apache.cxf.bus,
         org.apache.cxf.bus.spring,
            org.apache.cxf.bus.resource,
            org.apache.cxf.configuration.spring,
            org.apache.cxf.resource,
            org.springframework.beans.factory.config,
            *
        </Import-Package>
        ...
      </instructions>
    </configuration>
  </plugin>
```

More information

For more information on configuring a bundle plug-in, see:

- "Managing OSGi Dependencies"
- Apache Felix documentation
- Peter Kriens' aQute Software Consultancy web site

CHAPTER 7. DEPLOYING AN OSGI BUNDLE

Abstract

Apache Karaf provides two different approaches for deploying a single OSGi bundle: hot deployment or manual deployment. If you need to deploy a collection of related bundles, on the other hand, it is recommended that you deploy them together as a *feature*, rather than singly (see Chapter 8, *Deploying Features*).

7.1. HOT DEPLOYMENT

Hot deploy directory

JBoss Fuse monitors JAR files in the ***InstallDir*/deploy** directory and hot deploys everything in this directory. Each time a JAR file is copied to this directory, it is installed in the runtime and also started. You can subsequently update or delete the JARs, and the changes are handled automatically.

For example, if you have just built the bundle, *ProjectDir*/**target/foo-1.0-SNAPSHOT.jar**, you can deploy this bundle by copying it to the *InstallDir*/**deploy** directory as follows (assuming you are working on a UNIX platform):

```
% cp ProjectDir/target/foo-1.0-SNAPSHOT.jar InstallDir/deploy
```

Hot undeploying a bundle

To undeploy a bundle from the hot deploy directory, simply delete the bundle file from the ***InstallDir*/deploy** directory *while the Apache Karaf container is running* .

IMPORTANT

The hot undeploy mechanism does *not* work while the container is shut down. If you shut down the Karaf container, delete the bundle file from **deploy**/, and then restart the Karaf container, the bundle will *not* be undeployed after you restart the container (you can, however, undeploy the bundle manually using the **osgi:uninstall** console command).

7.2. MANUAL DEPLOYMENT

Overview

You can manually deploy and undeploy bundles by issuing commands at the Red Hat JBoss Fuse console.

Installing a bundle

Use the **osgi:install** command to install one or more bundles in the OSGi container. This command has the following syntax:

```
osgi:install [-s] [--start] [--help] UrlList
```

Where *UrlList* is a whitespace-separated list of URLs that specify the location of each bundle to deploy. The following command arguments are supported:

-s

Start the bundle after installing.

--start

Same as **-s**.

--help

Show and explain the command syntax.

For example, to install and start the bundle, *ProjectDir*/**target/foo-1.0-SNAPSHOT.jar**, enter the following command at the Karaf console prompt:

```
osgi:install -s file:ProjectDir/target/foo-1.0-SNAPSHOT.jar
```

NOTE

On Windows platforms, you must be careful to use the correct syntax for the **file** URL in this command. See Section A.1, "File URL Handler" for details.

Uninstalling a bundle

To uninstall a bundle, you must first obtain its bundle ID using the **osgi:list** command. You can then uninstall the bundle using the **osgi:uninstall** command (which takes the bundle ID as its argument).

For example, if you have already installed the bundle named **A Camel OSGi Service Unit**, entering **osgi:list** at the console prompt might produce output like the following:

```
...
[ 181] [Resolved    ] [            ] [       ] [   60] A Camel OSGi Service Unit (1.0.0.SNAPSHOT)
```

You can now uninstall the bundle with the ID, **181**, by entering the following console command:

```
osgi:uninstall 181
```

URL schemes for locating bundles

When specifying the location URL to the **osgi:install** command, you can use any of the URL schemes supported by Red Hat JBoss Fuse, which includes the following scheme types:

- Section A.1, "File URL Handler" .
- .Section A.2, "HTTP URL Handler" .
- .Section A.3, "Mvn URL Handler" .

Redeploying bundles automatically using dev:watch

In a development environment—where a developer is constantly changing and rebuilding a bundle—it is typically necessary to re-install the bundle multiple times. Using the **dev:watch** command, you can instruct Karaf to monitor your local Maven repository and re-install a particular bundle automatically, as soon as it changes in your local Maven repository.

For example, given a particular bundle—with bundle ID, **751**—you can enable automatic redeployment by entering the command:

```
dev:watch 751
```

Now, whenever you rebuild and install the Maven artifact into your local Maven repository (for example, by executing **mvn install** in your Maven project), the Karaf container automatically re-installs the changed Maven artifact. For more details, see section "dev:watch, watch" in "Console Reference" .

IMPORTANT

Using the **dev:watch** command is intended for a development environment only. It is *not* recommended for use in a production environment.

7.3. LIFECYCLE MANAGEMENT

Bundle lifecycle states

Applications in an OSGi environment are subject to the lifecycle of its bundles. Bundles have six lifecycle states:

1. **Installed** — All bundles start in the installed state. Bundles in the installed state are waiting for all of their dependencies to be resolved, and once they are resolved, bundles move to the resolved state.

2. **Resolved** — Bundles are moved to the resolved state when the following conditions are met:

    - The runtime environment meets or exceeds the environment specified by the bundle.
    - All of the packages imported by the bundle are exposed by bundles that are either in the resolved state or that can be moved into the resolved state at the same time as the current bundle.
    - All of the required bundles are either in the resolved state or they can be resolved at the same time as the current bundle.

    IMPORTANT

    All of an application's bundles must be in the resolved state before the application can be started.

    If any of the above conditions ceases to be satisfied, the bundle is moved back into the installed state. For example, this can happen when a bundle that contains an imported package is removed from the container.

3. **Starting** — The starting state is a transitory state between the resolved state and the active state. When a bundle is started, the container must create the resources for the bundle. The container also calls the **start()** method of the bundle's bundle activator when one is provided.

4. **Active** — Bundles in the active state are available to do work. What a bundle does in the active state depends on the contents of the bundle. For example, a bundle containing a JAX-WS service provider indicates that the service is available to accept requests.

5. **Stopping** — The stopping state is a transitory state between the active state and the resolved state. When a bundle is stopped, the container must clean up the resources for the bundle. The container also calls the **stop()** method of the bundle's bundle activator when one is provided.

6. **Uninstalled** — When a bundle is uninstalled it is moved from the resolved state to the uninstalled state. A bundle in this state cannot be transitioned back into the resolved state or any other state. It must be explicitly re-installed.

The most important lifecycle states for application developers are the starting state and the stopping state. The endpoints exposed by an application are published during the starting state. The published endpoints are stopped during the stopping state.

Installing and resolving bundles

When you install a bundle using the **osgi:install** command (without the **-s** flag), the kernel installs the specified bundle and attempts to put it into the resolved state. If the resolution of the bundle fails for some reason (for example, if one of its dependencies is unsatisfied), the kernel leaves the bundle in the installed state.

At a later time (for example, after you have installed missing dependencies) you can attempt to move the bundle into the resolved state by invoking the **osgi:resolve** command, as follows:

```
osgi:resolve 181
```

Where the argument (**181**, in this example) is the ID of the bundle you want to resolve.

Starting and stopping bundles

You can start one or more bundles (from either the installed or the resolved state) using the **osgi:start** command. For example, to start the bundles with IDs, 181, 185, and 186, enter the following console command:

```
osgi:start 181 185 186
```

You can stop one or more bundles using the **osgi:stop** command. For example, to stop the bundles with IDs, 181, 185, and 186, enter the following console command:

```
osgi:stop 181 185 186
```

You can restart one or more bundles (that is, moving from the started state to the resolved state, and then back again to the started state) using the **osgi:restart** command. For example, to restart the bundles with IDs, 181, 185, and 186, enter the following console command:

```
osgi:restart 181 185 186
```

Bundle start level

A *start level* is associated with every bundle. The start level is a positive integer value that controls the order in which bundles are activated/started. Bundles with a low start level are started before bundles with a high start level. Hence, bundles with the start level, **1**, are started first and bundles belonging to the kernel tend to have lower start levels, because they provide the prerequisites for running most other bundles.

Typically, the start level of user bundles is 60 or higher.

Specifying a bundle's start level

Use the **osgi:bundle-level** command to set the start level of a particular bundle. For example, to configure the bundle with ID, **181**, to have a start level of **70**, enter the following console command:

```
osgi:bundle-level 181 70
```

System start level

The OSGi container itself has a start level associated with it and this *system start level* determines which bundles can be active and which cannot: only those bundles whose start level is *less than or equal* to the system start level can be active.

To discover the current system start level, enter **osgi:start-level** in the console, as follows:

```
JBossFuse:karaf@root> osgi:start-level
Level 100
```

If you want to change the system start level, provide the new start level as an argument to the **osgi:start-level** command, as follows:

```
osgi:start-level 200
```

7.4. TROUBLESHOOTING DEPENDENCIES

Missing dependencies

The most common issue that can arise when you deploy an OSGi bundle into the Red Hat JBoss Fuse container is that one or more dependencies are missing. This problem shows itself when you try to resolve the bundle in the OSGi container, usually as a side effect of starting the bundle. The bundle fails to resolve (or start) and a **ClassNotFound** error is logged (to view the log, use the **log:display** console command or look at the log file in the ***InstallDir*/data/log** directory).

There are two basic causes of a missing dependency: either a required feature or bundle is not installed in the container; or your bundle's **Import-Package** header is incomplete.

Required features or bundles are not installed

Evidently, all features and bundles required by your bundle must *already* be installed in the OSGi container, before you attempt to resolve your bundle. In particular, because Apache Camel has a modular architecture, where each component is installed as a separate feature, it is easy to forget to install one of the required components.

NOTE

Consider packaging your bundle as a feature. Using a feature, you can package your bundle together with all of its dependencies and thus ensure that they are all installed simultaneously. For details, see Chapter 8, *Deploying Features*.

Import-Package header is incomplete

If all of the required features and bundles are already installed and you are still getting a **ClassNotFound** error, this means that the **Import-Package** header in your bundle's **MANIFEST.MF** file is incomplete. The **maven-bundle-plugin** (see Section 6.2, "Modifying an Existing Maven Project") is a great help when it comes to generating your bundle's **Import-Package** header, but you should note the following points:

- Make sure that you include the wildcard, *, in the **Import-Package** element of the Maven bundle plug-in configuration. The wildcard directs the plug-in to scan your Java source code and automatically generates a list of package dependencies.

- The Maven bundle plug-in is *not* able to figure out dynamic dependencies. For example, if your Java code explicitly calls a class loader to load a class dynamically, the bundle plug-in does not take this into account and the required Java package will not be listed in the generated **Import-Package** header.

- If you define a Spring XML file (for example, in the **META-INF/spring** directory), the Maven bundle plug-in is *not* able to figure out dependencies arising from the Spring XML configuration. Any dependencies arising from Spring XML must be added manually to the bundle plug-in's **Import-Package** element.

- If you define a blueprint XML file (for example, in the **OSGI-INF/blueprint** directory), any dependencies arising from the blueprint XML file are *automatically resolved at run time*. This is an important advantage of blueprint over Spring.

How to track down missing dependencies

To track down missing dependencies, perform the following steps:

1. Perform a quick check to ensure that all of the required bundles and features are actually installed in the OSGi container. You can use **osgi:list** to check which bundles are installed and **features:list** to check which features are installed.

2. Install (but do not start) your bundle, using the **osgi:install** console command. For example:

```
JBossFuse:karaf@root> osgi:install MyBundleURL
```

3. Use the **dev:dynamic-import** console command to enable dynamic imports on the bundle you just installed. For example, if the bundle ID of your bundle is 218, you would enable dynamic imports on this bundle by entering the following command:

```
JBossFuse:karaf@root> dev:dynamic-import 218
```

   This setting allows OSGi to resolve dependencies using *any* of the bundles already installed in the container, effectively bypassing the usual dependency resolution mechanism (based on the **Import-Package** header). This is *not* recommemded for normal deployment, because it bypasses version checks: you could easily pick up the wrong version of a package, causing your application to malfunction.

4. You should now be able to resolve your bundle. For example, if your bundle ID is 218, enter the followng console command:

   ```
   JBossFuse:karaf@root> osgi:resolve 218
   ```

5. Assuming your bundle is now resolved (check the bundle status using **osgi:list**), you can get a complete list of all the packages wired to your bundle using the **package:imports** command. For example, if your bundle ID is 218, enter the following console command:

   ```
   JBossFuse:karaf@root> package:imports 218
   ```

   You should see a list of dependent packages in the console window (where the package names are highlighted in this example):

   ```
   Spring Beans (67): org.springframework.beans.factory.xml; version=3.0.5.RELEASE
   Web Services Metadata 2.0 (104): javax.jws; version=2.0.0
   Apache CXF Bundle Jar (125): org.apache.cxf.helpers; version=2.4.2.fuse-00-08
   Apache CXF Bundle Jar (125): org.apache.cxf.transport.jms.wsdl11; version=2.4.2.fuse-
   00-08
   ...
   ```

6. Unpack your bundle JAR file and look at the packages listed under the **Import-Package** header in the **META-INF/MANIFEST.MF** file. Compare this list with the list of packages found in the previous step. Now, compile a list of the packages that are missing from the manifest's **Import-Package** header and add these package names to the **Import-Package** element of the Maven bundle plug-in configuration in your project's POM file.

7. To cancel the dynamic import option, you must uninstall the old bundle from the OSGi container. For example, if your bundle ID is 218, enter the following command:

   ```
   JBossFuse:karaf@root> osgi:uninstall 218
   ```

8. You can now rebuild your bundle with the updated list of imported packages and test it in the OSGi container.

CHAPTER 8. DEPLOYING FEATURES

Abstract

Because applications and other tools typically consist of multiple OSGi bundles, it is often convenient to aggregate inter-dependent or related bundles into a larger unit of deployment. Red Hat JBoss Fuse therefore provides a scalable unit of deployment, the *feature*, which enables you to deploy multiple bundles (and, optionally, dependencies on other features) in a single step.

8.1. CREATING A FEATURE

Overview

Essentially, a feature is created by adding a new **feature** element to a special kind of XML file, known as a *feature repository*. To create a feature, perform the following steps:

1. the section called "Create a custom feature repository" .
2. the section called "Add a feature to the custom feature repository" .
3. the section called "Add the local repository URL to the features service" .
4. the section called "Add dependent features to the feature" .
5. the section called "Add OSGi configurations to the feature" .

Create a custom feature repository

If you have not already defined a custom feature repository, you can create one as follows. Choose a convenient location for the feature repository on your file system—for example, **C:\Projects\features.xml**—and use your favorite text editor to add the following lines to it:

```
<?xml version="1.0" encoding="UTF-8"?>
<features name="CustomRepository">
</features>
```

Where you must specify a name for the repository, *CustomRepository*, by setting the **name** attribute.

NOTE

In contrast to a Maven repository or an OBR, a feature repository does *not* provide a storage location for bundles. A feature repository merely stores an aggregate of references to bundles. The bundles themselves are stored elsewhere (for example, in the file system or in a Maven repository).

Add a feature to the custom feature repository

To add a feature to the custom feature repository, insert a new **feature** element as a child of the root **features** element. You must give the feature a name and you can list any number of bundles belonging to the feature, by inserting **bundle** child elements. For example, to add a feature named **example-camel-bundle** containing the single bundle, **C:\Projects\camel-bundle\target\camel-bundle-1.0-SNAPSHOT.jar**, add a **feature** element as follows:

```
<?xml version="1.0" encoding="UTF-8"?>
<features name="MyFeaturesRepo">
  <feature name="example-camel-bundle">
    <bundle>file:C:/Projects/camel-bundle/target/camel-bundle-1.0-SNAPSHOT.jar</bundle>
  </feature>
</features>
```

The contents of the **bundle** element can be any valid URL, giving the location of a bundle (see Appendix A, *URL Handlers*). You can optionally specify a **version** attribute on the feature element, to assign a non-zero version to the feature (you can then specify the version as an optional argument to the **features:install** command).

To check whether the features service successfully parses the new feature entry, enter the following pair of console commands:

```
JBossFuse:karaf@root> features:refreshUrl
JBossFuse:karaf@root> features:list
...
[uninstalled] [0.0.0              ] example-camel-bundle              MyFeaturesRepo
...
```

The **features:list** command typically produces a rather long listing of features, but you should be able to find the entry for your new feature (in this case, **example-camel-bundle**) by scrolling back through the listing. The **features:refreshUrl** command forces the kernel to reread all the feature repositories: if you did not issue this command, the kernel would not be aware of any recent changes that you made to any of the repositories (in particular, the new feature would not appear in the listing).

To avoid scrolling through the long list of features, you can **grep** for the **example-camel-bundle** feature as follows:

```
JBossFuse:karaf@root> features:list | grep example-camel-bundle
[uninstalled] [0.0.0              ] example-camel-bundle              MyFeaturesRepo
```

Where the **grep** command (a standard UNIX pattern matching utility) is built into the shell, so this command also works on Windows platforms.

Add the local repository URL to the features service

In order to make the new feature repository available to Apache Karaf, you must add the feature repository using the **features:addUrl** console command. For example, to make the contents of the repository, **C:\Projects\features.xml**, available to the kernel, you would enter the following console command:

```
features:addUrl file:C:/Projects/features.xml
```

Where the argument to **features:addUrl** can be specified using any of the supported URL formats (see Appendix A, *URL Handlers*).

You can check that the repository's URL is registered correctly by entering the **features:listUrl** console command, to get a complete listing of all registered feature repository URLs, as follows:

```
JBossFuse:karaf@root> features:listUrl
file:C:/Projects/features.xml
mvn:org.apache.ode/ode-jbi-karaf/1.3.3-fuse-01-00/xml/features
```

```
mvn:org.apache.felix.karaf/apache-felix-karaf/1.2.0-fuse-01-00/xml/features
```

Add dependent features to the feature

If your feature depends on other features, you can specify these dependencies by adding **feature** elements as children of the original **feature** element. Each child **feature** element contains the name of a feature on which the current feature depends. When you deploy a feature with dependent features, the dependency mechanism checks whether or not the dependent features are installed in the container. If not, the dependency mechanism automatically installs the missing dependencies (and any recursive dependencies).

For example, for the custom Apache Camel feature, **example-camel-bundle**, you can specify explicitly which standard Apache Camel features it depends on. This has the advantage that the application could now be successfully deployed and run, even if the OSGi container does not have the required features pre-deployed. For example, you can define the **example-camel-bundle** feature with Apache Camel dependencies as follows:

```
<?xml version="1.0" encoding="UTF-8"?>
<features name="MyFeaturesRepo">
  <feature name="example-camel-bundle">
    <bundle>file:C:/Projects/camel-bundle/target/camel-bundle-1.0-SNAPSHOT.jar</bundle>
    <feature version="6.3.0.redhat-xxx">camel-core</feature>
    <feature version="6.3.0.redhat-xxx">camel-spring-osgi</feature>
  </feature>
</features>
```

Specifying the **version** attribute is optional. When present, it enables you to select the specified version of the feature.

Add OSGi configurations to the feature

If your application uses the *OSGi Configuration Admin* service, you can specify configuration settings for this service using the **config** child element of your feature definition. For example, to specify that the **prefix** property has the value, **MyTransform**, add the following **config** child element to your feature's configuration:

```
<?xml version="1.0" encoding="UTF-8"?>
<features name="MyFeaturesRepo">
  <feature name="example-camel-bundle">
    <config name="org.fusesource.fuseesb.example">
      prefix=MyTransform
    </config>
  </feature>
</features>
```

Where the **name** attribute of the **config** element specifies the *persistent ID* of the property settings (where the persistent ID acts effectively as a name scope for the property names). The content of the **config** element is parsed in the same way as a Java properties file.

The settings in the **config** element can optionally be overridden by the settings in the Java properties file located in the ***InstallDir*/etc** directory, which is named after the persistent ID, as follows:

```
InstallDir/etc/org.fusesource.fuseesb.example.cfg
```

As an example of how the preceding configuration properties can be used in practice, consider the following Blueprint XML file that accesses the OSGi configuration properties:

```
<?xml version="1.0" encoding="UTF-8"?>
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0"
           xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
           xmlns:cm="http://aries.apache.org/blueprint/xmlns/blueprint-cm/v1.1.0">

    <!-- osgi blueprint property placeholder -->
    <cm:property-placeholder id="placeholder"
                             persistent-id="org.fusesource.fuseesb.example">
        <cm:default-properties>
            <cm:property name="prefix" value="DefaultValue"/>
        </cm:default-properties>
    </cm:property-placeholder>

    <bean id="myTransform" class="org.fusesource.fuseesb.example.MyTransform">
      <property name="prefix" value="${prefix}"/>
    </bean>

</blueprint>
```

When this Blueprint XML file is deployed in the **example-camel-bundle** bundle, the property reference, **${prefix}**, is replaced by the value, **MyTransform**, which is specified by the **config** element in the feature repository.

Automatically deploy an OSGi configuration

By adding a **configfile** element to a feature, you can ensure that an OSGi configuration file gets added to the ***InstallDir*/etc** directory at the same time that the feature is installed. This means that you can conveniently install a feature and its associated configuration at the same time.

For example, given that the **org.fusesource.fuseesb.example.cfg** configuration file is archived in a Maven repository at **mvn:org.fusesource.fuseesb.example/configadmin/1.0/cfg**, you could deploy the configuration file by adding the following element to the feature:

```
<configfile finalname="etc/org.fusesource.fuseesb.example.cfg">
  mvn:org.fusesource.fuseesb.example/configadmin/1.0/cfg
</configfile>
```

8.2. DEPLOYING A FEATURE

Overview

You can deploy a feature in one of the following ways:

- Install at the console, using **features:install**.
- Use hot deployment.
- Modify the boot configuration (first boot only!).

Installing at the console

After you have created a feature (by adding an entry for it in a feature repository and registering the feature repository), it is relatively easy to deploy the feature using the **features:install** console command. For example, to deploy the **example-camel-bundle** feature, enter the following pair of console commands:

```
JBossFuse:karaf@root> features:refreshUrl
JBossFuse:karaf@root> features:install example-camel-bundle
```

It is recommended that you invoke the **features:refreshUrl** command before calling **features:install**, in case any recent changes were made to the features in the feature repository which the kernel has not picked up yet. The **features:install** command takes the feature name as its argument (and, optionally, the feature version as its second argument).

NOTE

Features use a flat namespace. So when naming your features, be careful to avoid name clashes with existing features.

Uninstalling at the console

To uninstall a feature, invoke the **features:uninstall** command as follows:

```
JBossFuse:karaf@root> features:uninstall example-camel-bundle
```

NOTE

After uninstalling, the feature will still be visible when you invoke **features:list**, but its status will now be flagged as **[uninstalled]**.

Hot deployment

You can hot deploy *all* of the features in a feature repository simply by copying the feature repository file into the ***InstallDir*/deploy** directory.

As it is unlikely that you would want to hot deploy an entire feature repository at once, it is often more convenient to define a reduced feature repository or *feature descriptor*, which references only those features you want to deploy. The feature descriptor has exactly the same syntax as a feature repository, but it is written in a different style. The difference is that a feature descriptor consists only of references to existing features from a feature repository.

For example, you could define a feature descriptor to load the **example-camel-bundle** feature as follows:

```
<?xml version="1.0" encoding="UTF-8"?>
<features name="CustomDescriptor">
  <repository>RepositoryURL</repository>
  <feature name="hot-example-camel-bundle">
    <feature>example-camel-bundle</feature>
  </feature>
</features>
```

The repository element specifies the location of the custom feature repository, *RepositoryURL* (where you can use any of the URL formats described in Appendix A, *URL Handlers*). The feature, **hot-example-camel-bundle**, is just a reference to the existing feature, **example-camel-bundle**.

Hot undeploying a features file

To undeploy a features file from the hot deploy directory, simply delete the features file from the ***InstallDir*/deploy** directory *while the Apache Karaf container is running* .

IMPORTANT

The hot undeploy mechanism does *not* work while the container is shut down. If you shut down the Karaf container, delete the features file from **deploy/**, and then restart the Karaf container, the features will *not* be undeployed after you restart the container (you can, however, undeploy the features manually using the **features:uninstall** console command).

Adding a feature to the boot configuration

If you want to provision copies of Apache Karaf for deployment on multiple hosts, you might be interested in adding a feature to the boot configuration, which determines the collection of features that are installed when Apache Karaf boots up for the very first time.

The configuration file, **/etc/org.apache.karaf.features.cfg**, in your install directory contains the following settings:

```
...
#
# Comma separated list of features repositories to register by default
#
featuresRepositories=\
    mvn:org.apache.karaf.assemblies.features/standard/2.4.0.redhat-630187/xml/features,\
    mvn:org.apache.karaf.assemblies.features/spring/2.4.0.redhat-630187/xml/features,\
    mvn:org.apache.karaf.assemblies.features/enterprise/2.4.0.redhat-630187/xml/features,\
    mvn:org.apache.cxf.karaf/apache-cxf/3.1.5.redhat-630187/xml/features,\
    mvn:org.apache.camel.karaf/apache-camel/2.17.0.redhat-630187/xml/features,\
    mvn:org.apache.activemq/activemq-karaf/5.11.0.redhat-630187/xml/features-core,\
    mvn:io.fabric8/fabric8-karaf/1.2.0.redhat-630187/xml/features,\
    mvn:org.jboss.fuse/jboss-fuse/6.3.0.redhat-187/xml/features,\
    mvn:io.fabric8.patch/patch-features/1.2.0.redhat-630187/xml/features,\
    mvn:io.hawt/hawtio-karaf/1.4.0.redhat-630187/xml/features,\
    mvn:io.fabric8.support/support-features/1.2.0.redhat-630187/xml/features,\
    mvn:org.fusesource/camel-sap/6.3.0.redhat-187/xml/features,\
    mvn:org.switchyard.karaf/switchyard/2.1.0.redhat-630187/xml/core-features

#
# Comma separated list of features to install at startup
#
featuresBoot=\
    jasypt-encryption,\
    pax-url-classpath,\
    deployer,\
    config,\
    management,\
    fabric-cxf,\
        fabric,\
        fabric-maven-proxy,\
        patch,\
        transaction,\
        jms-spec;version=2.0,\
        mq-fabric,\
        swagger,\
        camel,\
        camel-cxf,\
        camel-jms,\
        camel-amq,\
        camel-blueprint,\
        camel-csv,\
        camel-ftp,\
        camel-bindy,\
        camel-jdbc,\
        camel-exec,\
        camel-jasypt,\
        camel-saxon,\
        camel-snmp,\
        camel-ognl,\
        camel-routebox,\
        camel-script,\
        camel-spring-javaconfig,\
        camel-jaxb,\
        camel-jmx,\
        camel-mail,\
        camel-paxlogging,\
        camel-rmi,\
        war,\
        fabric-redirect,\
        hawtio-offline,\
        support,\
        hawtio-redhat-fuse-branding,\
        jsr-311

featuresBlackList=\
        pax-cdi-openwebbeans,\
        pax-cdi-web-openwebbeans,\
        spring-struts,\
        cxf-bean-validation-java6,\
        pax-cdi-1.2-web,\
        pax-jsf-support,\
        camel-ignite,\
        camel-jetty8,\
        camel-ironmq,\
        camel-gae
```

This configuration file has two properties:

- **featuresRepositories**—comma separated list of feature repositories to load at startup.
- **featuresBoot**—comma separated list of features to install at startup.
- **featuresBlackList**—comma separated list of features that are prevented from being installed (to protect against unsupported or buggy features).

You can modify the configuration to customize the features that are installed as JBoss Fuse starts up. You can also modify this configuration file, if you plan to distribute JBoss Fuse with pre-installed features.

IMPORTANT

This method of adding a feature is only effective the *first time* a particular Apache Karaf instance boots up. Any changes made subsequently to the **featuresRepositories** setting and the **featuresBoot** setting are ignored, even if you restart the container.

You could force the container to revert back to its initial state, however, by deleting the complete contents of the **InstallDir/data/cache** (thereby losing all of the container's custom settings).

CHAPTER 9. DEPLOYING A PLAIN JAR

Abstract

This chapter explains how to deal with plain JAR files (typically libraries) that contain *no deployment metadata whatsoever*. That is, a plain JAR is neither a WAR, nor an OSGi bundle.

If the plain JAR occurs as a dependency of a bundle, you must add bundle headers to the JAR . If the JAR exposes a public API, typically the best solution is to convert the existing JAR into a bundle, enabling the JAR to be shared with other bundles. This chapter describes how to perform the conversion process automatically, using the open source Bnd tool.

For more information on Bnd tool, see Bnd tools website.

9.1. CONVERTING A JAR USING THE WRAP SCHEME

Overview

You also have the option of converting a JAR into a bundle using the **wrap** scheme, which can be prefixed to any existing URL format. The **wrap** scheme is also based on the Bnd utility.

Syntax

The **wrap** scheme has the following basic syntax:

```
wrap:LocationURL
```

The **wrap** scheme can prefix any URL that locates a JAR. The locating part of the URL, *LocationURL*, is used to obtain the (non-bundlized) JAR and the URL handler for the **wrap** scheme then converts the JAR automatically into a bundle.

NOTE

The **wrap** scheme also supports a more elaborate syntax, which enables you to customize the conversion by specifying a Bnd properties file or by specifying individual Bnd properties in the URL. Typically, however, the **wrap** scheme is used just with its default settings.

Default properties

Because the **wrap** scheme is based on the Bnd utility, it uses exactly the same default properties to generate the bundle as Bnd does—see ???.

Wrap and install

The following example shows how you can use a single console command to download the plain **commons-logging** JAR from a remote Maven repository, convert it into an OSGi bundle on the fly, and then install it and start it in the OSGi container:

```
JBossFuse:karaf@root> osgi:install -s wrap:mvn:commons-logging/commons-logging/1.1.1
```

Reference

The **wrap** scheme is provided by the Pax project, which is the umbrella project for a variety of open source OSGi utilities. For full documentation on the **wrap** scheme, see the Wrap Protocol reference page.

CHAPTER 10. OSGI BUNDLE TUTORIALS

Abstract

This chapter presents tutorials for Apache Camel and Apache CXF applications. Each tutorial describes how to generate, build, run, and deploy an application as an OSGi bundle.

10.1. GENERATING AND RUNNING AN EIP BUNDLE

Overview

This section explains how to generate, build, and run a complete Apache Camel example as an OSGi bundle, where the starting point code is generated with the help of a Maven archetype.

Prerequisites

In order to generate a project using an Red Hat JBoss Fuse Maven archetype, you must have the following prerequisites:

- *Maven installation*—Maven is a free, open source build tool from Apache. You can download the latest version from http://maven.apache.org/download.html (minimum is 3.x).
- *Internet connection*—whilst performing a build, Maven dynamically searches external repositories and downloads the required artifacts on the fly. In order for this to work, your build machine *must* be connected to the Internet.
- *fusesource Maven repository is configured*—in order to locate the archetypes, Maven's **settings.xml** file must be configured with the location of the **fusesource** Maven repository. For details of how to set this up, see the section called "Adding the Red Hat JBoss Fuse repository" .

Generating an EIP bundle

The **karaf-camel-cbr-archetype** archetype creates a router project, which is configured to deploy as a bundle. To generate a Maven project with the coordinates, **org.fusesource.example:camel-bundle**, enter the following command:

```
mvn archetype:generate \
  -DarchetypeGroupId=io.fabric8.archetypes \
  -DarchetypeArtifactId=karaf-camel-cbr-archetype \
  -DarchetypeVersion=1.2.0.redhat-630xxx \
  -DgroupId=org.fusesource.example \
  -DartifactId=camel-bundle \
  -Dversion=1.0-SNAPSHOT \
  -Dfabric8-profile=camel-bundle-profile
```

NOTE

The backslash character, \, indicates line continuation on Linux and UNIX operating systems. On Windows platforms, you must omit the backslash character and put all of the arguments on a single line.

The result of this command is a directory, ***ProjectDir*/camel-bundle**, containing the files for the generated bundle project.

Running the EIP bundle

To install and run the generated **camel-bundle** project, perform the following steps:

1. *Build the project*—open a command prompt and change directory to ***ProjectDir*/camel-bundle**. Use Maven to build the demonstration by entering the following command:

   ```
   mvn install
   ```

   If this command runs successfully, the ***ProjectDir*/camel-bundle/target** directory should contain the bundle file, **camel-bundle.jar** and the bundle will also be installed in the local Maven repository.

2. *Install prerequisite features (optional)*—by default, the **camel-core** feature and some related features are pre-installed in the OSGi container. But many of the Apache Camel components are *not* installed by default. To check which features are available and whether or not they are installed, enter the following console command:

   ```
   JBossFuse:karaf@root> features:list
   ```

   Apache Camel features are identifiable by the **camel-** prefix. For example, if one of your routes requires the HTTP component, you can make sure that it is installed in the OSGi container by issuing the following console command:

   ```
   JBossFuse:karaf@root> features:install camel-http
   ```

3. *Install and start the camel-bundle bundle* —at the Red Hat JBoss Fuse console, enter the following command to install the bundle from the local Maven repository (see Section A.3, "Mvn URL Handler"):

   ```
   JBossFuse:karaf@root> osgi:install -s mvn:org.fusesource.example/camel-bundle/1.0-
   SNAPSHOT
   ```

4. *Provide the route with file data to process* —after the route has started, you should find the following directory under your JBoss Fuse installation:

   ```
   InstallDir/work/cbr/input
   ```

   To initiate content routing in this example, copy the provided data files from the ***ProjectDir*/camel-bundle/src/main/fabric8/data** directory into the ***InstallDir*/work/cbr/input** directory.

5. *View the output*—after a second or two, the data files disappear from the **work/cbr/input** directory, as the route moves the data files into various sub-directories of the **work/cbr/output** directory.

6. *Stop the camel-bundle bundle* —to stop the **camel-bundle** bundle, you first need to discover the relevant bundle number. To find the bundle number, enter the following console command:

   ```
   JBossFuse:karaf@root> osgi:list
   ```

At the end of the listing, you should see an entry like the following:

```
[ 265] [Active     ] [Created     ] [       ] [   80] JBoss Fuse Quickstart: camel-cbr
(1.0.0.SNAPSHOT)
```

Where, in this example, the bundle number is 265. To stop this bundle, enter the following console command:

```
JBossFuse:karaf@root> osgi:stop 265
```

10.2. GENERATING AND RUNNING A WEB SERVICES BUNDLE

Overview

This section explains how to generate, build, and run a complete Apache CXF example as a *bundle* in the OSGi container, where the starting point code is generated with the help of a Maven archetype.

Prerequisites

In order to generate a project using a Red Hat JBoss Fuse Maven archetype, you must have the following prerequisites:

- *Maven installation*—Maven is an open source build tool from Apache. You can download the latest version from http://maven.apache.org/download.html (minimum is 3.x).
- *Internet connection*—whilst performing a build, Maven dynamically searches external repositories and downloads the required artifacts on the fly. In order for this to work, your build machine *must* be connected to the Internet.
- *fusesource Maven repository is configured*—in order to locate the archetypes, Maven's **settings.xml** file must be configured with the location of the **fusesource** Maven repository. For details of how to set this up, see the section called "Adding the Red Hat JBoss Fuse repository" .

Generating a Web services bundle

The **karaf-soap-archetype** archetype creates a project for building a Java-first JAX-WS application that can be deployed into the OSGi container. To generate a Maven project with the coordinates, **org.fusesource.example:cxf-code-first-bundle**, enter the following command:

```
mvn archetype:generate \
  -DarchetypeGroupId=io.fabric8.archetypes \
  -DarchetypeArtifactId=karaf-soap-archetype \
  -DarchetypeVersion=1.2.0.redhat-630xxx \
  -DgroupId=org.fusesource.example \
  -DartifactId=cxf-code-first-bundle \
  -Dversion=1.0-SNAPSHOT \
  -Dfabric8-profile=cxf-code-first-bundle-profile
```

> **NOTE**
>
> The backslash character, \, indicates line continuation on Linux and UNIX operating systems. On Windows platforms, you must omit the backslash character and put all of the arguments on a single line.

The result of this command is a directory, ***ProjectDir*/cxf-code-first-bundle**, containing the files for the generated bundle project.

Modifying the bundle instructions

Typically, you will need to modify the instructions for the Maven bundle plug-in in the POM file. In particular, the default **Import-Package** element generated by the **karaf-soap-archetype** archetype is not configured to scan the project's Java source files. In most cases, however, you would want the Maven bundle plug-in to perform this automatic scanning in order to ensure that the bundle imports all of the packages needed by your code.

To enable the **Import-Package** scanning feature, simply add the wildcard, *****, as the last item in the comma-separated list inside the **Import-Package** element, as shown in the following example:

Example 10.1. Import-Package Instruction with Wildcard

```
<project ... >
  ...
  <build>
    <plugins>
      <plugin>
        <groupId>org.apache.felix</groupId>
        <artifactId>maven-bundle-plugin</artifactId>
        <version>${version.maven-bundle-plugin}</version>
        <extensions>true</extensions>
        <configuration>
          <instructions>
            <Import-Package>javax.jws;version="[0,3)",
              javax.wsdl,
              javax.xml.namespace,
              org.apache.cxf.helpers,
              org.osgi.service.blueprint,
              io.fabric8.cxf.endpoint,
              org.apache.cxf.transport.http,
              *
            </Import-Package>
            <Import-Service>org.apache.aries.blueprint.NamespaceHandler;

osgi.service.blueprint.namespace=http://cxf.apache.org/transports/http/configuration</Import-
Service>
            <Export-Package>org.fusesource.example</Export-Package>
          </instructions>
        </configuration>
      </plugin>
    </plugins>
  </build>
  ...
</project>
```

Running the Web services bundle

To install and run the generated **cxf-code-first-bundle** project, perform the following steps:

1. *Build the project*—open a command prompt and change directory to ***ProjectDir*/cxf-code-first-bundle**. Use Maven to build the demonstration by entering the following command:

   ```
   mvn install
   ```

   If this command runs successfully, the ***ProjectDir*/cxf-code-first-bundle/target** directory should contain the bundle file, **cxf-code-first-bundle.jar**.

2. *Install and start the cxf-code-first-bundle bundle* —at the Red Hat JBoss Fuse console, enter the following command to install the bundle from your local Maven repository:

   ```
   JBossFuse:karaf@root> osgi:install -s mvn:org.fusesource.example/cxf-code-first-bundle/1.0-
   SNAPSHOT
   ```

3. *Test the Web serivce* —to test the Web service deployed in the previous step, you can use a web browser to query the service's WSDL. Open your favourite web browser and navigate to the following URL:

   ```
   http://localhost:8181/cxf/HelloWorld?wsdl
   ```

   When the web service receives the query, **?wsdl**, it returns a WSDL description of the running service.

4. *Stop the cxf-code-first-bundle bundle* —to stop the **cxf-code-first-bundle** bundle, you first need to discover the relevant bundle number. To find the bundle number, enter the following console command:

   ```
   JBossFuse:karaf@root> osgi:list
   ```

   At the end of the listing, you should see an entry like the following:

   ```
   [ 266] [Active     ] [Created     ] [       ] [   80] JBoss Fuse Quickstart: soap (1.0.0.SNAPSHOT)
   ```

   Where, in this example, the bundle number is 266. To stop this bundle, enter the following console command:

   ```
   JBossFuse:karaf@root> osgi:stop 266
   ```

PART III. WAR DEPLOYMENT MODEL

Abstract

The Web application ARchive (WAR) is a tried and tested model for packaging and deploying applications. This approach is simple and reliable, thought not as flexible as the OSGi bundle model.

CHAPTER 11. BUILDING A WAR

Abstract

This chapter describes how to build and package a WAR using Maven.

11.1. MODIFYING AN EXISTING MAVEN PROJECT

Overview

If you already have a Maven project and you want to modify it so that it generates a WAR, perform the following steps:

1. the section called “Change the package type to WAR” .
2. the section called “Customize the JDK compiler version” .
3. the section called “Store resources under webapp/WEB-INF” .
4. the section called “Customize the Maven WAR plug-in” .

Change the package type to WAR

Configure Maven to generate a WAR by changing the package type to **war** in your project's **pom.xml** file. Change the contents of the **packaging** element to **war**, as shown in the following example:

```
<project ... >
  ...
  <packaging>war</packaging>
  ...
</project>
```

The effect of this setting is to select the Maven WAR plug-in, **maven-war-plugin**, to perform packaging for this project.

Customize the JDK compiler version

It is almost always necessary to specify the JDK version in your POM file. If your code uses any modern features of the Java language—such as generics, static imports, and so on—and you have not customized the JDK version in the POM, Maven will fail to compile your source code. It is *not* sufficient to set the **JAVA_HOME** and the **PATH** environment variables to the correct values for your JDK, you must also modify the POM file.

To configure your POM file, so that it accepts the Java language features introduced in JDK 1.7, add the following **maven-compiler-plugin** plug-in settings to your POM (if they are not already present):

```
<project ... >
  ...
  <build>
    <defaultGoal>install</defaultGoal>
    <plugins>
      ...
      <plugin>
        <groupId>org.apache.maven.plugins</groupId>
        <artifactId>maven-compiler-plugin</artifactId>
        <configuration>
          <source>1.7</source>
          <target>1.7</target>
        </configuration>
      </plugin>
    </plugins>
  </build>
  ...
</project>
```

Store resources under webapp/WEB-INF

Resource files for the Web application are stored under the **/WEB-INF** directory in the standard WAR directory layout. In order to ensure that these resources are copied into the root of the generated WAR package, store the **WEB-INF** directory under ***ProjectDir*/src/main/webapp** in the Maven directory tree, as follows:

```
ProjectDir/
    pom.xml
    src/
        main/
            webapp/
                WEB-INF/
 web.xml
                    classes/
                    lib/
```

In particular, note that the **web.xml** file is stored at ***ProjectDir*/src/main/webapp/WEB-INF/web.xml**.

Customize the Maven WAR plug-in

It is possible to customize the Maven WAR plug-in by adding an entry to the **plugins** section of the **pom.xml** file. Most of the configuration options are concerned with adding additonal resources to the WAR package. For example, to include all of the resources under the **src/main/resources** directory (specified relative to the location of **pom.xml**) in the WAR package, you could add the following WAR plug-in configuration to your POM:

```
<project ...>
  ...
  <build>
    ...
    <plugins>
      <plugin>
        <artifactId>maven-war-plugin</artifactId>
     <version>2.1.1</version>
        <configuration>
          <!-- Optionally specify where the web.xml file comes from -->
          <webXml>src/main/webapp/WEB-INF/web.xml</webXml>
          <!-- Optionally specify extra resources to include -->
          <webResources>
            <resource>
            <directory>src/main/resources</directory>
            <targetPath>WEB-INF</targetPath>
            <includes>
              <include>**/*</include>
            </includes>
          </resource>
        </webResources>
      </configuration>
    </plugin>
    ...
  </plugins>
 </build>
</project>
```

The preceding plug-in configuration customizes the following settings:

webXml

Specifies where to find the **web.xml** file in the current Maven project, relative to the location of **pom.xml**. The default is **src/main/webapp/WEB-INF/web.xml**.

webResources

Specifies additional resource files that are to be included in the generated WAR package. It can contain the following sub-elements:

- **webResources/resource**—each resource elements specifies a set of resource files to include in the WAR.
- **webResources/resource/directory**—specifies the base directory from which to copy resource files, where this directory is specified relative to the location of **pom.xml**.
- **webResources/resource/targetPath**—specifies where to put the resource files in the generated WAR package.
- **webResources/resource/includes**—uses an Ant-style wildcard pattern to specify explicitly which resources should be *included* in the WAR.
- **webResources/resource/excludes**—uses an Ant-style wildcard pattern to specify explicitly which resources should be *excluded* from the WAR (exclusions have priority over inclusions).

For complete details of how to configure the Maven WAR plug-in, see http://maven.apache.org/plugins/maven-war-plugin/index.html.

NOTE

Do not use version 2.1 of the **maven-war-plugin** plug-in, which has a bug that causes two copies of the **web.xml** file to be inserted into the generated **.war** file.

Building the WAR

To build the WAR defined by the Maven project, open a command prompt, go to the project directory (that is, the directory containing the **pom.xml** file), and enter the following Maven command:

```
mvn install
```

The effect of this command is to compile all of the Java source files, to generate a WAR under the ***ProjectDir*/target** directory, and then to install the generated WAR in the local Maven repository.

11.2. BOOTSTRAPPING A CXF SERVLET IN A WAR

Overview

A simple way to bootstrap Apache CXF in a WAR is to configure **web.xml** to use the standard CXF servlet, **org.apache.cxf.transport.servlet.CXFServlet**.

Example

For example, the following **web.xml** file shows how to configure the CXF servlet, where all Web service addresses accessed through this servlet would be prefixed by **/services/** (as specified by the value of **servlet-mapping/url-pattern**):

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE web-app PUBLIC
  "-//Sun Microsystems, Inc.//DTD Web Application 2.3//EN"
  "http://java.sun.com/dtd/web-app_2_3.dtd">

<web-app>
  <display-name>cxf</display-name>
  <description>cxf</description>

  <servlet>
    <servlet-name>cxf</servlet-name>
    <display-name>cxf</display-name>
    <description>Apache CXF Endpoint</description>
    <servlet-class>org.apache.cxf.transport.servlet.CXFServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>

  <servlet-mapping>
    <servlet-name>cxf</servlet-name>
    <url-pattern>/services/*</url-pattern>
  </servlet-mapping>

  <session-config>
    <session-timeout>60</session-timeout>
  </session-config>

</web-app>
```

cxf-servlet.xml file

In addition to configuring the **web.xml** file, it is also necessary to configure your Web services by defining a **cxf-servlet.xml** file, which must be copied into the root of the generated WAR.

Alternatively, if you do not want to put **cxf-servlet.xml** in the default location, you can customize its name and location, by setting the **contextConfigLocation** context parameter in the **web.xml** file. For example, to specify that Apache CXF configuration is located in **WEB-INF/cxf-servlet.xml**, set the following context parameter in **web.xml**:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE web-app PUBLIC
  "-//Sun Microsystems, Inc.//DTD Web Application 2.3//EN"
  "http://java.sun.com/dtd/web-app_2_3.dtd">

<web-app>
    ...
  <context-param>
   <param-name>contextConfigLocation</param-name>
   <param-value>WEB-INF/cxf-servlet.xml</param-value>
  </context-param>
    ...
</web-app>
```

11.3. BOOTSTRAPPING A SPRING CONTEXT IN A WAR

Overview

You can bootstrap a Spring context in a WAR using Spring's ContextLoaderListener class.

Bootstrapping a Spring context in a WAR

For example, the following **web.xml** file shows how to boot up a Spring application context that is initialized by the XML file, **/WEB-INF/applicationContext.xml** (which is the location of the context file in the generated WAR package):

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<web-app version="2.4" xmlns="http://java.sun.com/xml/ns/j2ee"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://java.sun.com/xml/ns/j2ee http://java.sun.com/xml/ns/j2ee/web-
app_2_4.xsd">

    <display-name>Camel Routes</display-name>

    <!-- location of spring xml files -->
    <context-param>
        <param-name>contextConfigLocation</param-name>
        <param-value>/WEB-INF/applicationContext.xml</param-value>
    </context-param>

    <!-- the listener that kick-starts Spring -->
    <listener>
        <listener-class>org.springframework.web.context.ContextLoaderListener</listener-class>
    </listener>

</web-app>
```

Maven dependency

In order to access the **ContextLoaderListener** class from the Spring framework, you *must* add the following dependency to your project's **pom.xml** file:

```
        <dependency>
```

```
    <groupId>org.springframework</groupId>
    <artifactId>spring-web</artifactId>
    <version>${spring-version}</version>
</dependency>
```

Where the **spring-version** property specifies the version of the Spring framework you are using.

CHAPTER 12. DEPLOYING A WAR

Abstract

This chapter explains how to deploy a Web archive (WAR) file as a bundle in the OSGi container. Conversion to a bundle is performed automatically by the PAX War URL, which is based on the open source Bnd tool. The presence of a **web.xml** file in the bundle signals to the container that the bundle should be deployed as a Web application.

IMPORTANT

The information in this chapter pertains to deploying standard JEE WAR files into an OSGi container. For complex War files, those which combine components, such as Apache Camel and Spring, the easiest and most efficient way to deploy them into a JBoss Fuse container is to use JBoss Fuse on EAP. For details, see the JBoss Fuse on EAP documention listed under **Getting Started** and **Adminisration on JBoss EAP** on the Red Hat Customer Portal .

12.1. CONVERTING THE WAR USING THE WAR SCHEME

Overview

To convert a WAR file into a bundle suitable for deployment in the OSGi container, add the war: prefix to the WAR URL. The PAX War URL handler acts as a wrapper, which adds the requisite manifest headers to the WAR file.

Syntax

The **war** scheme has the following basic syntax:

```
war:LocationURL[?Options]
```

The location URL, *LocationURL*, can be any of the location URLs described in Appendix A, *URL Handlers* (for example, an **mvn:** or a **file:** URL). Options can be appended to the URL in the following format:

```
?Option=Value&Option=Value&...
```

Or if the **war** URL appears in an XML file:

```
?Option=Value&amp;Option=Value&amp;...
```

Prerequisite

The Apache Karaf **war** feature is required to convert and deploy WARs using the war: scheme. It can be installed from the container's command console using **features:install war**.

Deploying a WAR file

If the WAR file is stored in a Maven repository, you can deploy it into the OSGi container using the **osgi:install** command, taking a **war:mvn:** URL as its argument. For example, to deploy the wicket-example WAR file from a Maven repository, where the application should be accessible from the **wicket** Web application context, enter the following console command:

```
JBossFuse:karaf@root> install war:mvn:org.apache.wicket/wicket-examples/1.4.7/war?Web-
ContextPath=wicket
```

Alternatively, if the WAR file is stored on the filesystem, you can deploy it into the OSGi container by specifying a **war:file:** URL. For example, to deploy the WAR file, **wicket-example-1.4.6.war**, enter the following console command:

```
JBossFuse:karaf@root> install war:file://wicket-examples-1.4.7.war?Web-ContextPath=wicket
```

Accessing the Web application

The WAR file is automatically installed into a Web container, which listens on the TCP port 8181 by default, and the Web container uses the Web application context specified by the **Web-ContextPath** option. For example, the **wicket-example** WAR deployed in the preceding examples, would be accessible from the following URL:

```
http://localhost:8181/wicket
```

Default conversion parameters

The PAX War URL handler converts a WAR file to a special kind of OSGi bundle, which includes additional Manifest headers to support WAR deployment (for example, the **Web-ContextPath** Manifest header). By default, the deployed WAR is configured as an isolated bundle (neither importing nor exporting any packages). This mimics the deployment model of a WAR inside a J2EE container, where the WAR is completely self-contained, including all of the JAR files it needs.

For details of the default conversion parameters, see Table A.2, “Default Instructions for Wrapping a WAR File”.

Customizing the conversion parameters

The PAX War URL handler is layered over Bnd. If you want to customize the bundle headers in the Manifest file, you can either add a Bnd instruction as a URL option or you can specify a Bnd instructions file for the War URL handler to use—for details, see Section A.5, “War URL Handler” .

In particular, you might sometimes find it necessary to customize the entry for the **Bundle-ClassPath**, because the default value of **Bundle-ClassPath** does *not* include all of the resources in the WAR file (see Table A.2, “Default Instructions for Wrapping a WAR File”).

References

Support for running WARs in the OSGi container is provided by the PAX WAR Extender, which monitors each bundle as it starts and, if the bundle contains a **web.xml** file, automatically deploys the WAR in a Web container. The War Protocol page has the original reference documentation for the War URL handler.

12.2. CONFIGURING THE WEB CONTAINER

Overview

Red Hat JBoss Fuse automatically deploys WAR files into a Web container, which is implemented by the PAX Web library. You can configure the Web container through the OSGi Configuration Admin service.

Configuration file

The Web container uses the following configuration file:

```
EsbInstallDir/etc/org.ops4j.pax.web.cfg
```

You must create this file, if it does not already exist in the ***EsbInstallDir*/etc/** directory.

Customizing the HTTP port

By default, the Web container listens on the TCP port, 8181. You can change this value by editing the **etc/org.ops4j.pax.web.cfg** file and setting the value of the **org.osgi.service.http.port** property, as follows:

```
# Configure the Web container
org.osgi.service.http.port=8181
```

Enabling SSL/TLS security

The Web container is also used for deploying the Fuse Management Console. The instructions for securing the Web container with SSL/TLS are identical to the instructions for securing the Fuse Management Console with SSL/TLS. See chapter "Securing the Jetty HTTP Server" in "Security Guide" for details.

WARNING

If you are planning to enable SSL/TLS security, you must ensure that you explicitly disable the SSLv3 protocol, in order to safeguard against the Poodle vulnerability (CVE-2014-3566). For more details, see Disabling SSLv3 in JBoss Fuse 6.x and JBoss A-MQ 6.x.

Reference

The properties that you can set in the Web container's configuration file are defined by the PAX Web library. You can set the following kinds of property:

- Basic
- SSL
- JSP

PART IV. CDI DEPLOYMENT MODEL

Abstract

Contexts and Dependency Injection (CDI) is a dependency injection framework based entirely on the Java language (making use of Java annotations). Although originally developed for J2EE platforms (such as JBoss EAP), CDI is also supported in Apache Karaf. Pax CDI provides an adapter layer that makes it possible to integrate CDI applications in the OSGi container.

CHAPTER 13. CONTEXTS AND DEPENDENCY INJECTION (CDI)

13.1. INTRODUCTION TO CDI

13.1.1. About Contexts and Dependency Injection (CDI)

Contexts and Dependency Injection (CDI) 1.2 is a JSR specification, which defines a general-purpose dependency injection framework in the Java language. Although originally conceived for the Java EE platform, CDI can also be used in the context of an OSGi container, provided the requisite adapter layer (a combination of Pax CDI and JBoss Weld) is installed and enabled.

CDI 1.2 release is treated as a maintenance release of 1.1. Details about CDI 1.1 can be found in JSR 346: Contexts and Dependency Injection for Java™ EE 1.1.

JBoss Fuse includes Weld, which is the reference implementation of JSR-346:Contexts and Dependency Injection for Java™ EE 1.1.

Benefits of CDI
The benefits of CDI include:

- Simplifying and shrinking your code base by replacing big chunks of code with annotations.
- Flexibility, allowing you to disable and enable injections and events, use alternative beans, and inject non-CDI objects easily.
- Optionally, allowing you to include **beans.xml** in your **META-INF**/ or **WEB-INF**/ directory if you need to customize the configuration to differ from the default. The file can be empty.
- Simplifying packaging and deployments and reducing the amount of XML you need to add to your deployments.
- Providing lifecycle management via contexts. You can tie injections to requests, sessions, conversations, or custom contexts.
- Providing type-safe dependency injection, which is safer and easier to debug than string-based injection.
- Decoupling interceptors from beans.
- Providing complex event notification.

13.1.2. JBoss Weld CDI Implementation

Weld is the reference implementation of CDI, which is defined in JSR 346: Contexts and Dependency Injection for Java™ EE 1.1. Weld was inspired by Seam 2 and other dependency injection frameworks, and is included in JBoss Fuse.

13.2. USE CDI

13.2.1. Enable CDI in the Apache Karaf Container

CDI is *not* enabled by default in the Apache Karaf container. To enable CDI in Karaf, follow the instructions in Section 14.2, “Enabling Pax CDI”.

13.2.2. Use CDI to Develop an Application

Contexts and Dependency Injection (CDI) gives you tremendous flexibility in developing applications, reusing code, adapting your code at deployment or run-time, and unit testing. JBoss Fuse includes Weld, the reference implementation of CDI. These tasks show you how to use CDI in your enterprise applications.

13.2.2.1. Exclude Beans From the Scanning Process

One of the features of Weld, the JBoss Fuse implementation of CDI, is the ability to exclude classes in your archive from scanning, having container lifecycle events fired, and being deployed as beans. This is not part of the JSR-346 specification.

The following example has several <weld:exclude> tags:

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://java.sun.com/xml/ns/javaee"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xmlns:weld="http://jboss.org/schema/weld/beans"
     xsi:schemaLocation="
       http://java.sun.com/xml/ns/javaee http://docs.jboss.org/cdi/beans_1_0.xsd
       http://jboss.org/schema/weld/beans http://jboss.org/schema/weld/beans_1_1.xsd">

   <weld:scan>

     <!-- Don't deploy the classes for the swing app! -->
     <weld:exclude name="com.acme.swing.**" /> 1

     <!-- Don't include GWT support if GWT is not installed -->
     <weld:exclude name="com.acme.gwt.**"> 2
        <weld:if-class-available name="!com.google.GWT"/>
     </weld:exclude>

     <!--
        Exclude classes which end in Blether if the system property verbosity is set to low
        i.e.
         java ... -Dverbosity=low
     -->
     <weld:exclude pattern="^(.*)Blether$"> 3
        <weld:if-system-property name="verbosity" value="low"/>
     </weld:exclude>

    <!--
        Don't include JSF support if Wicket classes are present, and the viewlayer system
        property is not set
     -->
     <weld:exclude name="com.acme.jsf.**"> 4
        <weld:if-class-available name="org.apache.wicket.Wicket"/>
        <weld:if-system-property name="!viewlayer"/>
     </weld:exclude>
   </weld:scan>
</beans>
```

1 The first one excludes all Swing classes.

2 The second excludes Google Web Toolkit classes if Google Web Toolkit is not installed.

3 The third excludes classes which end in the string **Blether** (using a regular expression), if the system property verbosity is set to **low**.

4 The fourth excludes Java Server Faces (JSF) classes if Wicket classes are present and the viewlayer system property is not set.

The formal specification of Weld-specific configuration options can be found at http://jboss.org/schema/weld/beans_1_1.xsd.

13.2.2.2. Use an Injection to Extend an Implementation

You can use an injection to add or change a feature of your existing code.

The following example adds a translation ability to an existing class, and assumes you already have a Welcome class, which has a method **buildPhrase**. The **buildPhrase** method takes as an argument the name of a city, and outputs a phrase like "Welcome to Boston!".

Example: Inject a Translator Bean Into the Welcome Class

The following injects a hypothetical **Translator** object into the **Welcome** class. The **Translator** object can be an EJB stateless bean or another type of bean, which can translate sentences from one language to another. In this instance, the **Translator** is used to translate the entire greeting, without modifying the original **Welcome** class. The **Translator** is injected before the **buildPhrase** method is called.

```
public class TranslatingWelcome extends Welcome {

   @Inject Translator translator;

   public String buildPhrase(String city) {
      return translator.translate("Welcome to " + city + "!");
   }
   ...
}
```

13.2.3. Ambiguous or Unsatisfied Dependencies

Ambiguous dependencies exist when the container is unable to resolve an injection to exactly one bean.

Unsatisfied dependencies exist when the container is unable to resolve an injection to any bean at all.

The container takes the following steps to try to resolve dependencies:

1. It resolves the qualifier annotations on all beans that implement the bean type of an injection point.

2. It filters out disabled beans. Disabled beans are @Alternative beans which are not explicitly enabled.

In the event of an ambiguous or unsatisfied dependency, the container aborts deployment and throws an exception.

To fix an ambiguous dependency, see Use a Qualifier to Resolve an Ambiguous Injection .

13.2.3.1. Qualifiers

Qualifiers are annotations used to avoid ambiguous dependencies when the container can resolve multiple beans, which fit into an injection point. A qualifier declared at an injection point provides the set of eligible beans, which declare the same Qualifier.

Qualifiers have to be declared with a retention and target as shown in the example below.

Example: Define the @Synchronous and @Asynchronous Qualifiers

```
@Qualifier
@Retention(RUNTIME)
@Target({TYPE, METHOD, FIELD, PARAMETER})
public @interface Synchronous {}
```

```
@Qualifier
@Retention(RUNTIME)
@Target({TYPE, METHOD, FIELD, PARAMETER})
public @interface Asynchronous {}
```

Example: Use the @Synchronous and @Asynchronous Qualifiers

```
@Synchronous
public class SynchronousPaymentProcessor implements PaymentProcessor {
   public void process(Payment payment) { ... }
}
```

```
@Asynchronous
public class AsynchronousPaymentProcessor implements PaymentProcessor {
   public void process(Payment payment) { ... }
}
```

13.2.3.2. Use a Qualifier to Resolve an Ambiguous Injection

You can resolve an ambiguous injection using a qualifier. Read more about ambiguous injections at Ambiguous or Unsatisfied Dependencies.

The following example is ambiguous and features two implementations of Welcome, one which translates and one which does not. The injection needs to be specified to use the translating Welcome.

Example: Ambiguous injection

```
public class Greeter {
  private Welcome welcome;

  @Inject
  void init(Welcome welcome) {
    this.welcome = welcome;
  }
  ...
}
```

Resolve an Ambiguous Injection with a Qualifier

1. To resolve the ambiguous injection, create a qualifier annotation called @Translating:

```
@Qualifier
@Retention(RUNTIME)
@Target({TYPE,METHOD,FIELD,PARAMETERS})
public @interface Translating{}
```

2. Annotate your translating Welcome with the @Translating annotation:

```
@Translating
public class TranslatingWelcome extends Welcome {
    @Inject Translator translator;
    public String buildPhrase(String city) {
        return translator.translate("Welcome to " + city + "!");
    }
    ...
}
```

3. Request the translating Welcome in your injection. You must request a qualified implementation explicitly, similar to the factory method pattern. The ambiguity is resolved at the injection point.

```
public class Greeter {
  private Welcome welcome;
  @Inject
  void init(@Translating Welcome welcome) {
    this.welcome = welcome;
  }
  public void welcomeVisitors() {
    System.out.println(welcome.buildPhrase("San Francisco"));
  }
}
```

13.2.4. Managed Beans

Managed Beans are defined as container-managed objects with minimal programming restrictions, otherwise known by the acronym POJO (Plain Old Java Object). They support a small set of basic services, such as resource injection, lifecycle callbacks, and interceptors. Companion specifications, such as EJB and CDI, build on this basic model.

With very few exceptions, almost every concrete Java class that has a constructor with no parameters (or a constructor designated with the annotation **@Inject**) is a bean.

13.2.4.1. Types of Classes That are Beans

A managed bean is a Java class. The basic lifecycle and semantics of a managed bean are defined by the Managed Beans specification. You can explicitly declare a managed bean by annotating the bean class **@ManagedBean**, but in CDI you do not need to. According to the specification, the CDI container treats any class that satisfies the following conditions as a managed bean:

- It is not a non-static inner class.
- It is a concrete class, or is annotated **@Decorator**.

- It is not annotated with an EJB component-defining annotation or declared as an EJB bean class in **ejb-jar.xml**.
- It does not implement interface **javax.enterprise.inject.spi.Extension**.
- It has either a constructor with no parameters, or a constructor annotated with **@Inject**.

The unrestricted set of bean types for a managed bean contains the bean class, every superclass and all interfaces it implements directly or indirectly.

If a managed bean has a public field, it must have the default scope **@Dependent**.

13.2.4.2. Use CDI to Inject an Object Into a Bean

CDI is activated automatically if CDI components are detected in an application. If you wish to customize your configuration to differ from the default, you can include **META-INF/beans.xml** or **WEB-INF/beans.xml** to your deployment archive.

Inject Objects into Other Objects

1. To obtain an instance of a class, annotate the field with **@Inject** within your bean:

   ```
   public class TranslateController {
     @Inject TextTranslator textTranslator;
     ...
   ```

2. Use your injected object's methods directly. Assume that TextTranslator has a method **translate**:

   ```
   // in TranslateController class

   public void translate() {
     translation = textTranslator.translate(inputText);
   }
   ```

3. Use an injection in the constructor of a bean. You can inject objects into the constructor of a bean as an alternative to using a factory or service locator to create them:

   ```
   public class TextTranslator {

     private SentenceParser sentenceParser;
     private Translator sentenceTranslator;

     @Inject
     TextTranslator(SentenceParser sentenceParser, Translator sentenceTranslator) {
       this.sentenceParser = sentenceParser;
       this.sentenceTranslator = sentenceTranslator;
     }

     // Methods of the TextTranslator class
     ...
   }
   ```

4. Use the **Instance(<T>)** interface to get instances programatically. The **Instance** interface can return an instance of TextTranslator when parameterized with the bean type.

```
@Inject Instance<TextTranslator> textTranslatorInstance;
...
public void translate() {
   textTranslatorInstance.get().translate(inputText);
}
```

When you inject an object into a bean, all of the object's methods and properties are available to your bean. If you inject into your bean's constructor, instances of the injected objects are created when your bean's constructor is called, unless the injection refers to an instance that already exists. For instance, a new instance would not be created if you inject a session-scoped bean during the lifetime of the session.

13.2.5. Contexts and Scopes

A context, in terms of CDI, is a storage area that holds instances of beans associated with a specific scope.

A scope is the link between a bean and a context. A scope/context combination may have a specific lifecycle. Several pre-defined scopes exist, and you can create your own. Examples of pre-defined scopes are **@RequestScoped**, **@SessionScoped**, and **@ConversationScope**.

13.2.5.1. Available Contexts

Table 13.1. Available contexts

Context	Description
@Dependent	The bean is bound to the lifecycle of the bean holding the reference.
@ApplicationScoped	The bean is bound to the lifecycle of the application.
@RequestScoped	The bean is bound to the lifecycle of the request.
@SessionScoped	The bean is bound to the lifecycle of the session.
@ConversationScoped	The bean is bound to the lifecycle of the conversation. The conversation scope is between the lengths of the request and the session, and is controlled by the application.
Custom scopes	If the above contexts do not meet your needs, you can define custom scopes.

13.2.6. Bean Lifecycle

This task shows you how to save a bean for the life of a request.

The default scope for an injected bean is **@Dependent**. This means that the bean's lifecycle is dependent upon the lifecycle of the bean that holds the reference. Several other scopes exist, and you can define your own scopes. For more information, see "Contexts and Scopes".

Manage Bean Lifecycles

Annotate the bean with the desired scope:

```
@RequestScoped
@Named("greeter")
public class GreeterBean {
  private Welcome welcome;
  private String city; // getter & setter not shown
  @Inject   void init(Welcome welcome) {
    this.welcome = welcome;
  }
  public void welcomeVisitors() {
    System.out.println(welcome.buildPhrase(city));
  }
}
```

Your bean is saved in the context relating to the scope that you specify, and lasts as long as the scope applies.

13.2.6.1. Use a Producer Method

This task shows how to use producer methods to produce a variety of different objects that are not beans for injection.

Example: Use a producer method instead of an alternative, to allow polymorphism after deployment

The **@Preferred** annotation in the example is a qualifier annotation. For more information about qualifiers, see Qualifiers.

```
@SessionScoped
public class Preferences implements Serializable {
   private PaymentStrategyType paymentStrategy;
   ...
   @Produces @Preferred
   public PaymentStrategy getPaymentStrategy() {
       switch (paymentStrategy) {
           case CREDIT_CARD: return new CreditCardPaymentStrategy();
           case CHECK: return new CheckPaymentStrategy();
           default: return null;
       }
   }
}
```

The following injection point has the same type and qualifier annotations as the producer method, so it resolves to the producer method using the usual CDI injection rules. The producer method is called by the container to obtain an instance to service this injection point.

```
@Inject @Preferred PaymentStrategy paymentStrategy;
```

Example: Assign a scope to a producer method

The default scope of a producer method is **@Dependent**. If you assign a scope to a bean, it is bound to the appropriate context. The producer method in this example is only called once per session.

```
@Produces @Preferred @SessionScoped
```

```
public PaymentStrategy getPaymentStrategy() {
  ...
}
```

Example: Use an injection inside a producer method

Objects instantiated directly by an application cannot take advantage of dependency injection and do not have interceptors. However, you can use dependency injection into the producer method to obtain bean instances.

```
@Produces @Preferred @SessionScoped
public PaymentStrategy getPaymentStrategy(CreditCardPaymentStrategy ccps,
                                          CheckPaymentStrategy cps ) {
  switch (paymentStrategy) {
    case CREDIT_CARD: return ccps;
    case CHEQUE: return cps;
    default: return null;
  }
}
```

If you inject a request-scoped bean into a session-scoped producer, the producer method promotes the current request-scoped instance into session scope. This is almost certainly not the desired behavior, so use caution when you use a producer method in this way.

NOTE

The scope of the producer method is not inherited from the bean that declares the producer method.

Producer methods allow you to inject non-bean objects and change your code dynamically.

13.2.7. Named Beans

You can name a bean by using the **@Named** annotation. Naming a bean allows you to use it directly in Java Server Faces (JSF) and Expression Language (EL).

The **@Named** annotation takes an optional parameter, which is the bean name. If this parameter is omitted, the bean name defaults to the class name of the bean with its first letter converted to lower-case.

13.2.7.1. Use Named Beans

Configure Bean Names Using the @Named Annotation

1. Use the **@Named** annotation to assign a name to a bean.

```
@Named("greeter")
public class GreeterBean {
  private Welcome welcome;

  @Inject
  void init (Welcome welcome) {
    this.welcome = welcome;
  }
  public void welcomeVisitors() {
    System.out.println(welcome.buildPhrase("San Francisco"));
  }
}
```

In the example above, the default name would be **greeterBean** if no name had been specified.

2. In the context of Camel CDI, the named bean is automatically added to the registry and can be accessed from a Camel route, as follows:

```
from("direct:inbound").bean("greeter");
```

13.2.8. Alternative Beans

Alternatives are beans whose implementation is specific to a particular client module or deployment scenario.

By default, @Alternative beans are disabled. They are enabled for a specific bean archive by editing its **beans.xml** file.

Example: Defining Alternatives

This alternative defines a implementation of both @Synchronous PaymentProcessor and @Asynchronous PaymentProcessor, all in one:

```
@Alternative @Synchronous @Asynchronous

public class MockPaymentProcessor implements PaymentProcessor {

  public void process(Payment payment) { ... }

}
```

13.2.8.1. Override an Injection with an Alternative

You can use alternative beans to override existing beans. They can be thought of as a way to plug in a class which fills the same role, but functions differently. They are disabled by default.

This task shows you how to specify and enable an alternative.

Override an Injection

This task assumes that you already have a TranslatingWelcome class in your project, but you want to override it with a "mock" TranslatingWelcome class. This would be the case for a test deployment, where the true Translator bean cannot be used.

1. Define the alternative.

```
@Alternative
@Translating
public class MockTranslatingWelcome extends Welcome {
  public String buildPhrase(string city) {
    return "Bienvenue Ã  " + city + "!");
  }
}
```

2. Activate the substitute implementation by adding the fully-qualified class name to your **META-INF/beans.xml** or **WEB-INF/beans.xml** file.

```
<beans>
  <alternatives>
    <class>com.acme.MockTranslatingWelcome</class>
  </alternatives>
</beans>
```

The alternative implementation is now used instead of the original one.

13.2.9. Stereotypes

In many systems, use of architectural patterns produces a set of recurring bean roles. A stereotype allows you to identify such a role and declare some common metadata for beans with that role in a central place.

A stereotype encapsulates any combination of:

- Default scope
- A set of interceptor bindings

A stereotype can also specify either:

- All beans where the stereotypes are defaulted bean EL names
- All beans where the stereotypes are alternatives

A bean may declare zero, one, or multiple stereotypes. A stereotype is an @Stereotype annotation that packages several other annotations. Stereotype annotations may be applied to a bean class, producer method, or field.

A class that inherits a scope from a stereotype may override that stereotype and specify a scope directly on the bean.

In addition, if a stereotype has a **@Named** annotation, any bean it is placed on has a default bean name. The bean may override this name if the @Named annotation is specified directly on the bean. For more information about named beans, see Named Beans.

13.2.9.1. Use Stereotypes

Without stereotypes, annotations can become cluttered. This task shows you how to use stereotypes to reduce the clutter and streamline your code.

Example: Annotation clutter

```
@Secure
@Transactional
@RequestScoped
@Named
public class AccountManager {
  public boolean transfer(Account a, Account b) {
    ...
  }
}
```

Define and Use Stereotypes

1. Define the stereotype.

```
@Secure
@Transactional
@RequestScoped
@Named
@Stereotype
@Retention(RUNTIME)
@Target(TYPE)
public @interface BusinessComponent {
 ...
}
```

2. Use the stereotype.

```
@BusinessComponent
public class AccountManager {
  public boolean transfer(Account a, Account b) {
    ...
  }
}
```

13.2.10. Observer Methods

Observer methods receive notifications when events occur.

CDI also provides transactional observer methods, which receive event notifications during the before completion or after completion phase of the transaction in which the event was fired.

13.2.10.1. Transactional Observers

Transactional observers receive the event notifications before or after the completion phase of the transaction in which the event was raised. Transactional observers are important in a stateful object model because state is often held for longer than a single atomic transaction.

There are five kinds of transactional observers:

- IN_PROGRESS: By default, observers are invoked immediately.
- AFTER_SUCCESS: Observers are invoked after the completion phase of the transaction, but only if the transaction completes successfully.
- AFTER_FAILURE: Observers are invoked after the completion phase of the transaction, but only if the transaction fails to complete successfully.
- AFTER_COMPLETION: Observers are invoked after the completion phase of the transaction.
- BEFORE_COMPLETION: Observers are invoked before the completion phase of the transaction.

The following observer method refreshes a query result set cached in the application context, but only when transactions that update the Category tree are successful:

```
public void refreshCategoryTree(@Observes(during = AFTER_SUCCESS) CategoryUpdateEvent
event) { ... }
```

Assume we have cached a JPA query result set in the application scope:

```
import javax.ejb.Singleton;
import javax.enterprise.inject.Produces;

@ApplicationScoped @Singleton

public class Catalog {
  @PersistenceContext EntityManager em;
  List<Product> products;
  @Produces @Catalog
  List<Product> getCatalog() {
    if (products==null) {
      products = em.createQuery("select p from Product p where p.deleted = false")
        .getResultList();
    }
    return products;
  }
}
```

Occasionally a Product is created or deleted. When this occurs, we need to refresh the Product catalog. But we have to wait for the transaction to complete successfully before performing this refresh.

The bean that creates and deletes Products triggers events, for example:

```
import javax.enterprise.event.Event;

@Stateless

public class ProductManager {
  @PersistenceContext EntityManager em;
  @Inject @Any Event<Product> productEvent;
  public void delete(Product product) {
    em.delete(product);
    productEvent.select(new AnnotationLiteral<Deleted>(){}).fire(product);
  }

  public void persist(Product product) {
    em.persist(product);
    productEvent.select(new AnnotationLiteral<Created>(){}).fire(product);
  }
  ...
}
```

The Catalog can now observe the events after successful completion of the transaction:

```
import javax.ejb.Singleton;

@ApplicationScoped @Singleton
```

```
public class Catalog {
  ...
  void addProduct(@Observes(during = AFTER_SUCCESS) @Created Product product) {
    products.add(product);
  }

  void removeProduct(@Observes(during = AFTER_SUCCESS) @Deleted Product product) {
    products.remove(product);
  }

}
```

13.2.10.2. Fire and Observe Events

Example: Fire an event

The following code shows an event being injected and used in a method.

```
public class AccountManager {
  @Inject Event<Withdrawal> event;

  public boolean transfer(Account a, Account b) {
    ...
    event.fire(new Withdrawal(a));
  }
}
```

Example: Fire an event with a qualifier

You can annotate your event injection with a qualifier, to make it more specific. For more information about qualifiers, see Qualifiers.

```
public class AccountManager {
  @Inject @Suspicious Event <Withdrawal> event;

  public boolean transfer(Account a, Account b) {
    ...
    event.fire(new Withdrawal(a));
  }
}
```

Example: Observe an event

To observe an event, use the **@Observes** annotation.

```
public class AccountObserver {
  void checkTran(@Observes Withdrawal w) {
    ...
  }
}
```

You can use qualifiers to observe only specific types of events.

```
public class AccountObserver {
  void checkTran(@Observes @Suspicious Withdrawal w) {
    ...
  }
}
```

13.2.11. Interceptors

Interceptors allow you to add functionality to the business methods of a bean without modifying the bean’s method directly. The interceptor is executed before any of the business methods of the bean. Interceptors are defined as part of the Enterprise JavaBeans specification, which can be found at https://jcp.org/aboutJava/communityprocess/final/jsr318/index.html.

CDI enhances this functionality by allowing you to use annotations to bind interceptors to beans.

Interception points

- Business method interception: A business method interceptor applies to invocations of methods of the bean by clients of the bean.
- Lifecycle callback interception: A lifecycle callback interceptor applies to invocations of lifecycle callbacks by the container.
- Timeout method interception: A timeout method interceptor applies to invocations of the EJB timeout methods by the container.

13.2.11.1. Use Interceptors with CDI

CDI can simplify your interceptor code and make it easier to apply to your business code.

Without CDI, interceptors have two problems:

- The bean must specify the interceptor implementation directly.
- Every bean in the application must specify the full set of interceptors in the correct order. This makes adding or removing interceptors on an application-wide basis time-consuming and error-prone.

Example: Interceptors without CDI

```
@Interceptors({
  SecurityInterceptor.class,
  TransactionInterceptor.class,
  LoggingInterceptor.class
})
@Stateful public class BusinessComponent {
  ...
}
```

Use interceptors with CDI

1. Define the interceptor binding type:

```
@InterceptorBinding
@Retention(RUNTIME)
@Target({TYPE, METHOD})
public @interface Secure {}
```

2. Mark the interceptor implementation:

```
@Secure
@Interceptor
public class SecurityInterceptor {
  @AroundInvoke
  public Object aroundInvoke(InvocationContext ctx) throws Exception {
    // enforce security ...
    return ctx.proceed();
    }
}
```

3. Use the interceptor in your business code:

```
@Secure
public class AccountManager {
  public boolean transfer(Account a, Account b) {
    ...
  }
}
```

4. Enable the interceptor in your deployment, by adding it to **META-INF/beans.xml** or **WEB-INF/beans.xml**:

```
<beans>
  <interceptors>
    <class>com.acme.SecurityInterceptor</class>
    <class>com.acme.TransactionInterceptor</class>
  </interceptors>
</beans>
```

The interceptors are applied in the order listed.

13.2.12. Decorators

A decorator intercepts invocations from a specific Java interface, and is aware of all the semantics attached to that interface. Decorators are useful for modeling some kinds of business concerns, but do not have the generality of interceptors. A decorator is a bean, or even an abstract class, that implements the type it decorates, and is annotated with **@Decorator**. To invoke a decorator in a CDI application, it must be specified in the **beans.xml** file.

A decorator must have exactly one **@Delegate** injection point to obtain a reference to the decorated object.

Example: Example Decorator

```
@Decorator
public abstract class LargeTransactionDecorator implements Account {

  @Inject @Delegate @Any Account account;
  @PersistenceContext EntityManager em;

  public void withdraw(BigDecimal amount) {
    ...
    }

    public void deposit(BigDecimal amount);
      ...
    }
}
```

13.2.13. Portable Extensions

CDI is intended to be a foundation for frameworks, extensions, and for integration with other technologies. Therefore, CDI exposes a set of SPIs for the use of developers of portable extensions to CDI.

Extensions can provide the following types of functionality:

- Integration with Business Process Management engines
- Integration with third-party frameworks, such as Spring, Seam, GWT, or Wicket
- New technology based upon the CDI programming model

According to the JSR-346 specification, a portable extension can integrate with the container in the following ways:

- Providing its own beans, interceptors, and decorators to the container
- Injecting dependencies into its own objects using the dependency injection service
- Providing a context implementation for a custom scope
- Augmenting or overriding the annotation-based metadata with metadata from another source

13.2.14. Bean Proxies

Clients of an injected bean do not usually hold a direct reference to a bean instance. Unless the bean is a dependent object (scope @Dependent), the container must redirect all injected references to the bean using a proxy object.

A bean proxy, which can be referred to as client proxy, is responsible for ensuring the bean instance that receives a method invocation is the instance associated with the current context. The client proxy also allows beans bound to contexts, such as the session context, to be serialized to disk without recursively serializing other injected beans.

Due to Java limitations, some Java types cannot be proxied by the container. If an injection point declared with one of these types resolves to a bean with a scope other than @Dependent, the container aborts the deployment.

Certain Java types cannot be proxied by the container. These include:

- Classes that do not have a non-private constructor with no parameters
- Classes that are declared **final** or have a **final** method
- Arrays and primitive types

13.2.15. Use a Proxy in an Injection

A proxy is used for injection when the lifecycles of the beans are different from each other. The proxy is a subclass of the bean that is created at run-time, and overrides all the non-private methods of the bean class. The proxy forwards the invocation onto the actual bean instance.

In this example, the **PaymentProcessor** instance is not injected directly into **Shop**. Instead, a proxy is injected, and when the **processPayment()** method is called, the proxy looks up the current **PaymentProcessor** bean instance and calls the **processPayment()** method on it.

Example: Proxy Injection

```
@ConversationScoped
class PaymentProcessor
{
  public void processPayment(int amount)
  {
    System.out.println("I'm taking $" + amount);
  }
}

@ApplicationScoped
public class Shop
{

  @Inject
  PaymentProcessor paymentProcessor;

  public void buyStuff()
  {
    paymentProcessor.processPayment(100);
  }
}
```

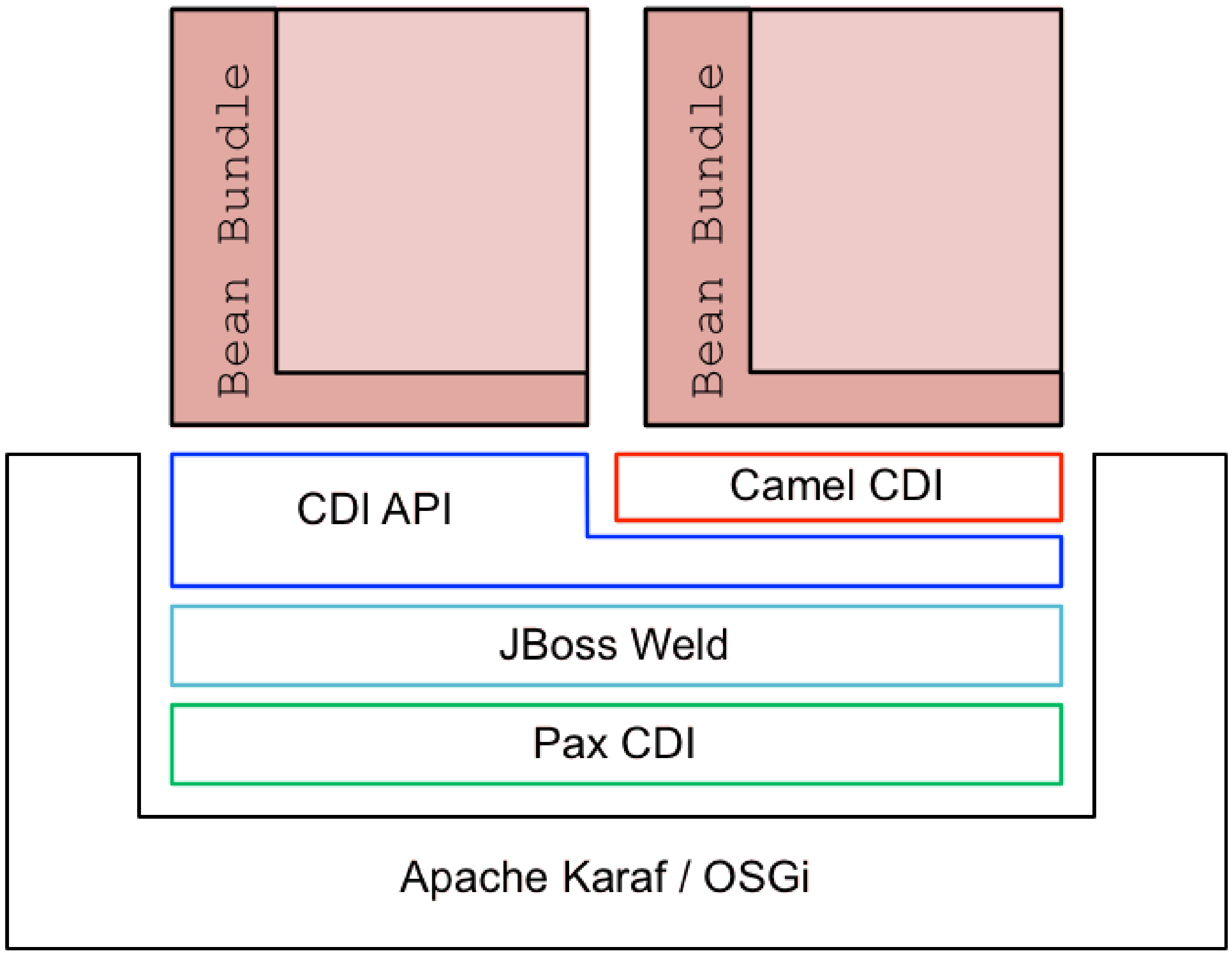
CHAPTER 14. PAX CDI AND OSGI SERVICES

14.1. PAX CDI ARCHITECTURE

Overview

Figure 14.1, "Pax CDI Architecture" gives an overview of the technology stack underlying Pax CDI.

Figure 14.1. Pax CDI Architecture



Pax CDI

Pax CDI is the integration layer that makes it possible to deploy a CDI container within the Apache Karaf OSGi container.

JBoss Weld

JBoss Weld provides the CDI implementation for the Pax CDI integration. JBoss Weld is the reference implementation for CDI and comes with its own extensive documentation, CDI Reference Implementation.

Bean bundle

A *bean bundle* is an OSGi bundle that has been enabled to use Pax CDI. A bundle cannot use CDI by default, it must be explicitly enabled to do so (see the section called "Requirements and capabilities").

CDI container

A CDI container effectively defines the scope for a collection of managed beans under CDI, which are capable of being published and injected within this scope. In the context of OSGi, a CDI container maps to a single bundle. That is, each bean bundle gets its own CDI container.

Camel CDI and other customizations

JBoss Fuse provides additional features that define CDI customizations (that is, non-standard CDI annotations) targeted at different aspects of middleware development. For example:

camel-cdi

Provides custom annotations for defining and injecting Camel contexts and routes. See Chapter 15, *Camel CDI*.

switchyard-cdi

Provides custom annotations for use with SwitchYard. For example, see the quickstart example under the following directory of your JBoss Fuse installation:

```
quickstarts/switchyard/camel-bus-cdi
```

For more information, see chapter "Service Implementations" in "SwitchYard Development Guide" .

cxf-jaxrs-cdi

Provides support for CDI in JAX-RS, as defined in the JAX-RS 2.0 Specification (see section 10.2.3).

deltaspike

Apache Deltaspike is a general-purpose collection of CDI customizations.

14.2. ENABLING PAX CDI

Overview

Pax CDI is *not* enabled by default in the Karaf container in JBoss Fuse, so you must enable it explicitly. There are two aspects of enabling Pax CDI in the Karaf container: first, installing the requisite Karaf features in the container; second, enabling CDI for a particular bundle, by adding the **Require-Capability** header to the bundle's manifest (turning the bundle into a *bean bundle*).

Pax CDI features

To make Pax CDI functionality available in the Karaf container, install the requisite Karaf features into your container. JBoss Fuse provides the following Karaf features for Pax CDI:

pax-cdi

Deploys the core components of Pax CDI. This feature must be combined with the **pax-cdi-weld** CDI implementation.

pax-cdi-weld

Deploys the JBoss Weld CDI implementation (which is the only CDI implementation supported on JBoss Fuse)

pax-cdi-web

Adds support for deploying a CDI application as a Web application (that is, deploying the CDI application into the Pax Web Jetty container). This enables support for the CDI features associated with servlet deployment, such as session-scoped beans, request-scoped beans, injection into servlets, and so on. This feature must be combined with the **pax-cdi-web-weld** feature (CDI implementation).

pax-cdi-web-weld

Deploys the JBoss Weld CDI implementation for Web applications.

Requirements and capabilities

CDI requires you to organize your Java code in a very specific way, so it cannot be enabled arbitrarily for any bundle. It only makes sense to enable CDI for each bundle that needs it, *not* for the entire container. Hence, it is necessary to use an OSGi extension mechanism that switches on the CDI capability on a bundle-by-bundle basis. The relevant OSGi mechanism is known as the *requirements and capabilities* mechanism.

The CDI *capability* is provided by the relevant Pax CDI packages (installed as Karaf features); and the CDI *requirement* is specified for each bundle by adding a **Require-Capability** bundle header to the bundle's manifest file. For example, to enable the base Pax CDI functionality, you would add the following **Require-Capability** header to the bundle's manifest file:

```
Require-Capability : osgi.extender; filter:="(osgi.extender=pax.cdi)"
```

A bundle that includes the preceding **Require-Capability** bundle header effectively becomes a bean bundle (a CDI enabled bundle).

How to enable Pax CDI in Apache Karaf

To enable Pax CDI in Apache Karaf, perform the following steps:

1. Add the required **pax-cdi** and **pax-cdi-weld** features to the Karaf container, as follows:

   ```
   JBossFuse:karaf@root> features:install pax-cdi pax-cdi-weld
   ```

2. When the Pax CDI features are installed in the Karaf container, this is *not* sufficient to enable CDI. You must also explicitly enable Pax CDI in each bundle that uses CDI (so that it becomes a *bean bundle*). To enable Pax CDI in a bundle, open the **pom.xml** file in your bundle's Maven project and add the following **Require-Capability** element to the configuration of the Maven bundle plug-in:

   ```
   <project ...>
     ...
     <build>
       <plugins>
         ...
         <plugin>
           <groupId>org.apache.felix</groupId>
           <artifactId>maven-bundle-plugin</artifactId>
           <extensions>true</extensions>
           <configuration>
   ```

```
          <instructions>
            <Bundle-SymbolicName>${project.groupId}.${project.artifactId}</Bundle-
SymbolicName>
            <Import-Package>*</Import-Package>
            <Require-Capability>
              osgi.extender; filter:="(osgi.extender=pax.cdi)"
            </Require-Capability>
          </instructions>
        </configuration>
      </plugin>
      ...
    </plugins>
  </build>
  ...
</project>
```

3. To access the CDI annotations in Java, you must add a dependency on the CDI API package. Edit your bundle's POM file, **pom.xml**, to add the CDI API package as a Maven dependency:

```
<project ...>
  ...
  <dependencies>
    ...
    <!-- CDI API -->
    <dependency>
      <groupId>javax.enterprise</groupId>
      <artifactId>cdi-api</artifactId>
      <version>${cdi-api-1.2-version}</version>
      <scope>provided</scope>
    </dependency>
    ...
  </dependencies>
  ...
</project>
```

4. Rebuild your bundle in the usual way for your Maven project. For example, using the command:

```
mvn clean install
```

5. Deploy the bundle to the Karaf container in the usual way (for example, using the **osgi:install** console command).

14.3. OSGI SERVICES EXTENSION

Overview

Pax CDI also provides an integration with OSGi services, enabling you to reference an OSGi service or to publish an OSGi service using CDI annotations. This capability is provided by the Pax CDI OSGi Services Extension, which is *not* enabled by default.

Enabling the OSGi Services Extension

To enable the Pax CDI OSGi Services Extension, you must include the following bundle header in the manifest file:

```
Require-Capability : org.ops4j.pax.cdi.extension; filter:="(extension=pax-cdi-extension)"
```

In a Maven project, you would normally add a **Require-Capability** element to the configuration of the Maven bundle plug-in. For example, to add both the Pax CDI Extender and the Pax CDI OSGi Services Extension to the bundle, configure your project's POM file, **pom.xml**, as follows:

```
<project ...>
  ...
  <build>
    <plugins>
      ...
      <plugin>
        <groupId>org.apache.felix</groupId>
        <artifactId>maven-bundle-plugin</artifactId>
        <extensions>true</extensions>
        <configuration>
          <instructions>
            <Bundle-SymbolicName>${project.groupId}.${project.artifactId}</Bundle-SymbolicName>
            <Import-Package>*</Import-Package>
            <Require-Capability>
              osgi.extender; filter:="(osgi.extender=pax.cdi)",
              org.ops4j.pax.cdi.extension; filter:="(extension=pax-cdi-extension)"
            </Require-Capability>
          </instructions>
        </configuration>
      </plugin>
      ...
    </plugins>
  </build>
  ...
</project>
```

Maven dependency for the OSGi Services extensions API

To access the OSGi Services annotations in your Java code, you need to add a dependency on the **pax-cdi-api** package. Edit your bundle's POM file, **pom.xml**, to add the Pax CDI API package as a Maven dependency:

```
<project ...>
  ...
  <dependencies>
    ...
    <!-- CDI API -->
    <dependency>
        <groupId>org.ops4j.pax.cdi</groupId>
        <artifactId>pax-cdi-api</artifactId>
        <version>1.0.0.RC1</version>
    </dependency>
    ...
  </dependencies>
  ...
</project>
```

■

Injecting an OSGi Service

You can inject an OSGi service into a field using the following annotation:

```
@Inject @OsgiService
private IceCreamService iceCream;
```

Pax CDI finds the OSGi service to inject by matching the type of the OSGi service to the type of the field.

Disambiguating OSGi Services

If there exists more than one OSGi service of a particular type, you can disambiguate the match by filtering on the OSGi service properties—for example:

```
@Inject @OsgiService(filter = "(&(flavour=chocolate)(lactose=false))")
private IceCreamService iceCream;
```

As usual for OSGi services, the properties filter is defined using LDAP filter syntax (see the section called “Matching service properties with a filter” for more details). For an example of how to set properties on an OSGi service, see the section called “Setting OSGi Service properties” .

Selecting OSGi Services at run time

You can reference an OSGi service dynamically by injecting it as follows:

```
@Inject
@OsgiService(dynamic = true)
private Instance<IceCreamService> iceCreamServices;
```

Calling **iceCreamServices.get()** will return an instance of the **IceCreamService** service at run time. With this approach, it is possible to reference an OSGi service that is created *after* your bean is created.

Publishing a bean as OSGi Service with singleton scope

You can publish an OSGi service with OSGi singleton scope (which is the default), as follows:

```
@OsgiServiceProvider
public class ChocolateService implements IceCreamService {
    ...
}
```

OSGi singleton scope means that the bean manager creates a single instance of the bean and returns that instance every time a bean instance is requested.

Publishing a bean as OSGi Service with prototype scope

You can publish an OSGi service with OSGi prototype scope, as follows:

```
@OsgiServiceProvider
@PrototypeScoped
```

```
public class ChocolateService implements IceCreamService {
    ...
}
```

OSGi prototype scope means that the bean manager creates a new bean instance every time a bean instance is requested.

Publishing a bean as OSGi Service with bundle scope

You can publish an OSGi service with bundle scope, as follows:

```
@OsgiServiceProvider
@BundleScoped
public class ChocolateService implements IceCreamService {
    ...
}
```

Bundle scope means that the bean manger creates a new bean instance for every client bundle. That is, the **@BundleScoped** beans are registered with an **org.osgi.framework.ServiceFactory**.

Setting OSGi Service properties

You can set properties on an OSGi service by annotating the service bean as follows:

```
@OsgiServiceProvider
@Properties({
    @Property(name = "flavour", value = "chocolate"),
    @Property(name = "lactose", value = "false")
})
public class ChocolateService implements IceCreamService {
    ...
}
```

Publishing an OSGi Service with explicit interfaces

You can explicitly specify the Java interfaces supported by an OSGi Service bean, as follows:

```
@OsgiServiceProvider(classes = {ChocolateService.class, IceCreamService.class})
public class ChocolateService implements IceCreamService {
    ...
}
```

CHAPTER 15. CAMEL CDI

15.1. BASIC FEATURES

Overview

The Camel CDI component provides auto-configuration for Apache Camel using CDI as the dependency injection framework, based on *convention-over-configuration*. It auto-detects Camel routes available in the application and provides beans for common Camel primitives like **Endpoint**, **ProducerTemplate** or **TypeConverter**. It implements standard Camel bean integration so that Camel annotations like **@Consume**, **@Produce** and **@PropertyInject** can be used seamlessly in CDI beans. Besides, it bridges Camel events (for example **RouteAddedEvent**, **CamelContextStartedEvent**, **ExchangeCompletedEvent**, ...) as CDI events and provides a CDI events endpoint that can be used to consume / produce CDI events from / to Camel routes.

How to enable Camel CDI in Apache Karaf

To enable Camel CDI in Apache Karaf, perform the following steps:

1. Add the required **pax-cdi**, **pax-cdi-weld**, and **camel-cdi** features to the Karaf container, as follows:

```
JBossFuse:karaf@root> features:install pax-cdi pax-cdi-weld camel-cdi
```

2. To enable Camel CDI in a bundle, open the **pom.xml** file in your bundle's Maven project and add the following **Require-Capability** element to the configuration of the Maven bundle plug-in:

```
<project ...>
  ...
  <build>
    <plugins>
      ...
      <plugin>
        <groupId>org.apache.felix</groupId>
        <artifactId>maven-bundle-plugin</artifactId>
        <extensions>true</extensions>
        <configuration>
          <instructions>
            <Bundle-SymbolicName>${project.groupId}.${project.artifactId}</Bundle-
SymbolicName>
            <Import-Package>*</Import-Package>
            <Require-Capability>
              osgi.extender; filter:="(osgi.extender=pax.cdi)",
              org.ops4j.pax.cdi.extension; filter:="(extension=camel-cdi-extension)"
            </Require-Capability>
          </instructions>
        </configuration>
      </plugin>
      ...
    </plugins>
  </build>
  ...
</project>
```

3. To access the CDI annotations in Java, you must add a dependency on the CDI API package and on the Camel CDI package. Edit your bundle's POM file, **pom.xml**, to add the CDI API package as a Maven dependency:

```
<project ...>
  ...
  <dependencies>
    ...
    <!-- CDI API -->
    <dependency>
      <groupId>javax.enterprise</groupId>
      <artifactId>cdi-api</artifactId>
      <version>${cdi-api-1.2-version}</version>
      <scope>provided</scope>
    </dependency>

    <!-- Camel CDI API -->
    <dependency>
      <groupId>org.apache.camel</groupId>
      <artifactId>camel-cdi</artifactId>
      <version>2.17.0.redhat-630xxx</version>
    </dependency>
    ...
  </dependencies>
  ...
</project>
```

4. Rebuild your bundle in the usual way for your Maven project. For example, using the command:

```
mvn clean install
```

5. Deploy the bundle to the Karaf container in the usual way (for example, using the **osgi:install** console command).

Auto-configured Camel context

Camel CDI automatically deploys and configures a **CamelContext** bean. That **CamelContext** bean is automatically instantiated, configured and started (resp. stopped) when the CDI container initialises (resp. shuts down). It can be injected in the application, for example:

```
@Inject
CamelContext context;
```

The default **CamelContext** bean is qualified with the built-in **@Default** qualifier, is scoped **@ApplicationScoped** and is of type **DefaultCamelContext**.

Note that this bean can be customised programmatically and other Camel context beans can be deployed in the application as well.

Auto-detecting Camel routes

Camel CDI automatically collects all the **RoutesBuilder** beans in the application, instantiates and add them to the **CamelContext** bean instance when the CDI container initialises. For example, adding a Camel route is as simple as declaring a class, for example:

```
class MyRouteBean extends RouteBuilder {

 @Override
    public void configure() {
        from("jms:invoices").to("file:/invoices");
    }
}
```

Note that you can declare as many **RoutesBuilder** beans as you want. Besides, **RouteContainer** beans are also automatically collected, instantiated and added to the **CamelContext** bean instance managed by Camel CDI when the container initialises.

Auto-configured Camel primitives

Camel CDI provides beans for common Camel primitives that can be injected in any CDI beans, for example:

```
@Inject
@Uri("direct:inbound")
ProducerTemplate producerTemplate;

@Inject
MockEndpoint outbound; // URI defaults to the member name, i.e. mock:outbound

@Inject
@Uri("direct:inbound")
Endpoint endpoint;

@Inject
TypeConverter converter;
```

Camel context configuration

If you just want to change the name of the default **CamelContext** bean, you can used the **@ContextName** qualifier provided by Camel CDI, for example:

```
@ContextName("camel-context")
class MyRouteBean extends RouteBuilder {

 @Override
    public void configure() {
        from("jms:invoices").to("file:/invoices");
    }
}
```

Else, if more customisation is needed, any **CamelContext** class can be used to declare a custom Camel context bean. Then, the **@PostConstruct** and **@PreDestroy** lifecycle callbacks can be done to do the customisation, for example:

```
@ApplicationScoped
class CustomCamelContext extends DefaultCamelContext {

    @PostConstruct
    void customize() {
        // Set the Camel context name
        setName("custom");
        // Disable JMX
        disableJMX();
    }

    @PreDestroy
    void cleanUp() {
        // ...
    }
}
```

Producer and disposer methods can also be used as well to customize the Camel context bean, for example:

```
class CamelContextFactory {

    @Produces
    @ApplicationScoped
    CamelContext customize() {
        DefaultCamelContext context = new DefaultCamelContext();
        context.setName("custom");
        return context;
    }

    void cleanUp(@Disposes CamelContext context) {
        // ...
    }
}
```

Similarly, producer fields can be used, for example:

```
@Produces
@ApplicationScoped
CamelContext context = new CustomCamelContext();

class CustomCamelContext extends DefaultCamelContext {

    CustomCamelContext() {
        setName("custom");
    }
}
```

This pattern can be used for example to avoid having the Camel context routes started automatically when the container initialises by calling the **setAutoStartup** method, for example:

```
@ApplicationScoped
class ManualStartupCamelContext extends DefaultCamelContext {

    @PostConstruct
    void manual() {
        setAutoStartup(false);
    }
}
```

Multiple Camel contexts

Any number of **CamelContext** beans can actually be declared in the application as documented above. In that case, the CDI qualifiers declared on these **CamelContext** beans are used to bind the Camel routes and other Camel primitives to the corresponding Camel contexts. From example, if the following beans get declared:

```
@ApplicationScoped
@ContextName("foo")
class FooCamelContext extends DefaultCamelContext {
}

@ApplicationScoped
@BarContextQualifier
class BarCamelContext extends DefaultCamelContext {
}

@ContextName("foo")
class RouteAdddedToFooCamelContext extends RouteBuilder {

 @Override
    public void configure() {
        // ...
    }
}

@BarContextQualifier
class RouteAdddedToBarCamelContext extends RouteBuilder {

 @Override
    public void configure() {
        // ...
    }
}

@ContextName("baz")
class RouteAdddedToBazCamelContext extends RouteBuilder {

 @Override
    public void configure() {
        // ...
    }
}

@MyOtherQualifier
class RouteNotAddedToAnyCamelContext extends RouteBuilder {

 @Override
    public void configure() {
        // ...
    }
}
```

The **RoutesBuilder** beans qualified with **@ContextName** are automatically added to the corresponding **CamelContext** beans by Camel CDI. If no such **CamelContext** bean exists, it gets automatically created, as for the **RouteAddedToBazCamelContext** bean. Note this only happens for the **@ContextName** qualifier provided by Camel CDI. Hence the **RouteNotAddedToAnyCamelContext** bean qualified with the user-defined **@MyOtherQualifier** qualifier does not get added to any Camel contexts. That may be useful, for example, for Camel routes that may be required to be added later during the application execution.

Since Camel version 2.17.0, Camel CDI is capable of managing any kind of **CamelContext** beans. In previous versions, it is only capable of managing beans of type **CdiCamelContext** so it is required to extend it.

The CDI qualifiers declared on the **CamelContext** beans are also used to bind the corresponding Camel primitives, for example:

```
@Inject
@ContextName("foo")
@Uri("direct:inbound")
ProducerTemplate producerTemplate;

@Inject
@BarContextQualifier
MockEndpoint outbound; // URI defaults to the member name, i.e. mock:outbound

@Inject
@ContextName("baz")
@Uri("direct:inbound")
Endpoint endpoint;
```

Configuration properties

To configure the sourcing of the configuration properties used by Camel to resolve properties placeholders, you can declare a **PropertiesComponent** bean qualified with **@Named("properties")**, for example:

```
@Produces
@ApplicationScoped
@Named("properties")
PropertiesComponent propertiesComponent() {
    Properties properties = new Properties();
    properties.put("property", "value");
    PropertiesComponent component = new PropertiesComponent();
    component.setInitialProperties(properties);
    component.setLocation("classpath:placeholder.properties");
    return component;
}
```

If you want to use DeltaSpike configuration mechanism you can declare the following **PropertiesComponent** bean:

```
@Produces
@ApplicationScoped
@Named("properties")
PropertiesComponent properties(PropertiesParser parser) {
    PropertiesComponent component = new PropertiesComponent();
    component.setPropertiesParser(parser);
    return component;
}
```

```
// PropertiesParser bean that uses DeltaSpike to resolve properties
static class DeltaSpikeParser extends DefaultPropertiesParser {
    @Override
    public String parseProperty(String key, String value, Properties properties) {
        return ConfigResolver.getPropertyValue(key);
    }
}
```

You can see the **camel-example-cdi-properties** example for a working example of a Camel CDI application using DeltaSpike configuration mechanism.

Auto-configured type converters

CDI beans annotated with the **@Converter** annotation are automatically registered into the deployed Camel contexts, for example:

```
@Converter
public class MyTypeConverter {

    @Converter
    public Output convert(Input input) {
        //...
    }
}
```

Note that CDI injection is supported within the type converters.

Lazy Injection / Programmatic Lookup

Available as of Camel 2.17

While the CDI programmatic model favors a type-safe resolution mechanism that occurs at application initialization time, it is possible to perform dynamic / lazy injection later during the application execution using the programmatic lookup mechanism.

Camel CDI provides for convenience the annotation literals corresponding to the CDI qualifiers that you can use for standard injection of Camel primitives. These annotation literals can be used in conjunction with the**javax.enterprise.inject.Instance** interface which is the CDI entry point to perform lazy injection / programmatic lookup.

For example, you can use the provided annotation literal for the **@Uri**qualifier to lazily lookup for Camel primitives, for example for **ProducerTemplate**beans:

```
@Any
@Inject
Instance<ProducerTemplate> producers;

ProducerTemplate inbound = producers
    .select(Uri.Literal.of("direct:inbound"))
    .get();
```

Or for **Endpoint** beans, for example:

```
@Any
@Inject
Instance<Endpoint> endpoints;

MockEndpoint outbound = endpoints
    .select(MockEndpoint.class, Uri.Literal.of("mock:outbound"))
    .get();
```

Similarly, you can use the provided annotation literal for the**@ContextName** qualifier to lazily lookup for **CamelContext** beans, for example:

```
@Any
@Inject
Instance<CamelContext> contexts;

CamelContext context = contexts
    .select(ContextName.Literal.of("foo"))
    .get();
```

You can also refined the selection based on the Camel context type, for example:

```
@Any
@Inject
Instance<CamelContext> contexts;

// Refine the selection by type
Instance<DefaultCamelContext> context = contexts.select(DefaultCamelContext.class);

// Check if such a bean exists then retrieve a reference
if (!context.isUnsatisfied())
    context.get();
```

Or even iterate over a selection of Camel contexts, for example:

```
@Any
@Inject
Instance<CamelContext> contexts;

for (CamelContext context : contexts)
    context.setUseBreadcrumb(true);
```

Injecting a Camel context from Spring XML

While CDI favors a type safe dependency injection mechanism, it may be useful to reuse existing Camel XML configurations by injecting them into a Camel CDI application. In other use cases, it might be handy to rely on the Camel XML DSL to configure its Camel context(s).

To inject by CDI a camelContext defined in Spring XML, you need to use the Java **@Resource** annotation, instead of the **@Inject @ContextName** annotations in the Camel CDI extension. For example,

```
...
public class RouteCaller {
    ...
```

```
@Resource(name = "java:jboss/camel/context/simple-context")
private CamelContext context;
...
```

The string **java:jboss/camel/context/simple-context** is the name of the deployed context registered in the JNDI registry. **simple-context** is the **xml:id** of the **camelContext** element in the Spring XML file.

IMPORTANT

Using the **@Inject @ContextName** annotations can result in the creation of a new camelContext instead of injecting the named context, which later causes endpoint lookups to fail.

15.2. CAMEL BEAN INTEGRATION

Camel annotations

As part of the Camel bean integration, Camel comes with a set of annotations that are seamlessly supported by Camel CDI. So you can use any of these annotations in your CDI beans, for example:

	Camel annotation	CDI equivalent

Configuration property	`@PropertyInject("key")`
	`String value;`
		If using DeltaSpike configuration mechanism:
		`@Inject`
		`@ConfigProperty(name = "key")`
		`String value;`
		See configuration properties for more details.

Producer template injection (default Camel context)	`@Produce(uri = "mock:outbound")`
	`ProducerTemplate producer;`
		`@Inject`
		`@Uri("direct:outbound")`
		`ProducerTemplate producer;`

Endpoint injection (default Camel context)	`@EndpointInject(uri = "direct:inbound")`
	`Endpoint endpoint;`
		`@Inject`
		`@Uri("direct:inbound")`
		`Endpoint endpoint;`

Endpoint injection (Camel context by name)	`@EndpointInject(uri = "direct:inbound", context = "foo")`
	`Endpoint contextEndpoint;`
		`@Inject`
		`@ContextName("foo")`
		`@Uri("direct:inbound")`
		`Endpoint contextEndpoint;`

Bean injection (by type)	`@BeanInject`
	`MyBean bean;`
		`@Inject`
		`MyBean bean;`

Bean injection (by name)	`@BeanInject("foo")`
	`MyBean bean;`
		`@Inject`
		`@Named("foo")`
		`MyBean bean;`

POJO consuming	`@Consume(uri =`
	`"seda:inbound")`
	`void consume(@Body`
	`String body) {`
	`    //...`
	`}`	

Bean component

You can refer to CDI beans, either by type or name, From the Camel DSL, for example with the Java Camel DSL:

```
class MyBean {
 //...
}

from("direct:inbound").bean(MyBean.class);
```

Or to lookup a CDI bean by name from the Java DSL:

```
@Named("foo")
class MyNamedBean {
 //...
}

from("direct:inbound").bean("foo");
```

Referring beans from Endpoint URIs

When configuring endpoints using the URI syntax you can refer to beans in the Registry using the **#** notation. If the URI parameter value starts with a **#** sign then Camel CDI will lookup for a bean of the given type by name, for example:

```
from("jms:queue:{{destination}}?
transacted=true&transactionManager=#jtaTransactionManager").to("...");
```

Having the following CDI bean qualified with **@Named("jtaTransactionManager")**:

```
@Produces
```

```
@Named("jtaTransactionManager")
PlatformTransactionManager createTransactionManager(TransactionManager transactionManager,
UserTransaction userTransaction) {
    JtaTransactionManager jtaTransactionManager = new JtaTransactionManager();
    jtaTransactionManager.setUserTransaction(userTransaction);
    jtaTransactionManager.setTransactionManager(transactionManager);
    jtaTransactionManager.afterPropertiesSet();
    return jtaTransactionManager;
}
```

15.3. CDI EVENTS IN CAMEL

Camel events to CDI events

Camel provides a set of management events that can be subscribed to for listening to Camel context, service, route and exchange events. Camel CDI seamlessly translates these Camel events into CDI events that can be observed using CDI observer methods, for example:

```
void onContextStarting(@Observes CamelContextStartingEvent event) {
    // Called before the default Camel context is about to start
}
```

When multiple Camel contexts exist in the CDI container, the Camel context bean qualifiers, like **@ContextName**, can be used to refine the observer method resolution to a particular Camel context as specified in observer resolution, for example:

```
void onRouteStarted(@Observes @ContextName("foo") RouteStartedEvent event) {
    // Called after the route 'event.getRoute()' for the Camel context 'foo' has started
}

void onContextStarted(@Observes @Manual CamelContextStartedEvent event) {
    // Called after the the Camel context qualified with '@Manual' has started
}
```

Similarly, the **@Default** qualifier can be used to observe Camel events for the *default* Camel context if multiples contexts exist, for example:

```
void onExchangeCompleted(@Observes @Default ExchangeCompletedEvent event) {
    // Called after the exchange 'event.getExchange()' processing has completed
}
```

In that example, if no qualifier is specified, the **@Any** qualifier is implicitly assumed, so that corresponding events for all the Camel contexts get received.

Note that the support for Camel events translation into CDI events is only activated if observer methods listening for Camel events are detected in the deployment, and that per Camel context.

CDI events endpoint

The CDI event endpoint bridges the CDI events with the Camel routes so that CDI events can be seamlessly observed / consumed (resp. produced / fired) from Camel consumers (resp. by Camel producers).

The **CdiEventEndpoint<T>** bean provided by Camel CDI can be used to observe / consume CDI events whose *event type* is **T**, for example:

```
@Inject
CdiEventEndpoint<String> cdiEventEndpoint;

from(cdiEventEndpoint).log("CDI event received: ${body}");
```

This is equivalent to writing:

```
@Inject
@Uri("direct:event")
ProducerTemplate producer;

void observeCdiEvents(@Observes String event) {
    producer.sendBody(event);
}

from("direct:event").log("CDI event received: ${body}");
```

Conversely, the **CdiEventEndpoint<T>** bean can be used to produce / fire CDI events whose *event type* is **T**, for example:

```
@Inject
CdiEventEndpoint<String> cdiEventEndpoint;

from("direct:event").to(cdiEventEndpoint).log("CDI event sent: ${body}");
```

This is equivalent to writing:

```
@Inject
Event<String> event;

from("direct:event").process(new Processor() {
    @Override
    public void process(Exchange exchange) {
        event.fire(exchange.getBody(String.class));
    }
}).log("CDI event sent: ${body}");
```

Or using a Java 8 lambda expression:

```
@Inject
Event<String> event;

from("direct:event")
    .process(exchange -> event.fire(exchange.getIn().getBody(String.class)))
    .log("CDI event sent: ${body}");
```

The type variable **T** (resp. the qualifiers) of a particular **CdiEventEndpoint<T>** injection point are automatically translated into the parameterized *event type* (resp. into the *event qualifiers*) for example:

```
@Inject
@FooQualifier
```

```
CdiEventEndpoint<List<String>> cdiEventEndpoint;

from("direct:event").to(cdiEventEndpoint);

void observeCdiEvents(@Observes @FooQualifier List<String> event) {
    logger.info("CDI event: {}", event);
}
```

When multiple Camel contexts exist in the CDI container, the Camel context bean qualifiers, like **@ContextName**, can be used to qualify the **CdiEventEndpoint<T>** injection points, for example:

```
@Inject
@ContextName("foo")
CdiEventEndpoint<List<String>> cdiEventEndpoint;
// Only observes / consumes events having the @ContextName("foo") qualifier
from(cdiEventEndpoint).log("Camel context (foo) > CDI event received: ${body}");
// Produces / fires events with the @ContextName("foo") qualifier
from("...").to(cdiEventEndpoint);

void observeCdiEvents(@Observes @ContextName("foo") List<String> event) {
    logger.info("Camel context (foo) > CDI event: {}", event);
}
```

Note that the CDI event Camel endpoint dynamically adds an observer method for each unique combination of *event type* and *event qualifiers* and solely relies on the container typesafe observer resolution, which leads to an implementation as efficient as possible.

Besides, as the impedance between the *typesafe* nature of CDI and the *dynamic* nature of the Camel component model is quite high, it is not possible to create an instance of the CDI event Camel endpoint via URIs. Indeed, the URI format for the CDI event component is:

```
cdi-event://PayloadType<T1,...,Tn>[?qualifiers=QualifierType1[,...[,QualifierTypeN]...]]
```

With the authority **PayloadType** (resp. the **QualifierType**) being the URI escaped fully qualified name of the payload (resp. qualifier) raw type followed by the type parameters section delimited by angle brackets for payload parameterized type. Which leads to *unfriendly* URIs, for example:

```
cdi-event://org.apache.camel.cdi.example.EventPayload%3Cjava.lang.Integer%3E?
qualifiers=org.apache.camel.cdi.example.FooQualifier%2Corg.apache.camel.cdi.example.BarQualifier
```

But more fundamentally, that would prevent efficient binding between the endpoint instances and the observer methods as the CDI container doesn't have any ways of discovering the Camel context model during the deployment phase.

15.4. OSGI INTEGRATION

Auto-configured OSGi integration

The Camel context beans are automatically adapted by Camel CDI so that they are registered as OSGi services and the various resolvers (like **ComponentResolver** and **DataFormatResolver**) integrate with the OSGi registry. That means that the Karaf Camel commands can be used to operate the Camel contexts auto-configured by Camel CDI, for example:

```
karaf@root()> camel:context-list
 Context        Status              Total #       Failed #     Inflight #   Uptime
 -------        ------              -------       --------     ----------   ------
 camel-cdi      Started                   1             0              0   1 minute
```

See the **camel-example-cdi-osgi** example, available in the list of camel examples for a working example of the Camel CDI OSGi integration.

PART V. OSGI SERVICE LAYER

Abstract

In Red Hat JBoss Fuse, the natural way to communicate between deployed bundles is to use *OSGi services*. An OSGi service exposes Java methods that can be invoked by other bundles in the container.

CHAPTER 16. OSGI SERVICES

Abstract

The OSGi core framework defines the *OSGi Service Layer*, which provides a simple mechanism for bundles to interact by registering Java objects as services in the *OSGi service registry*. One of the strengths of the OSGi service model is that *any* Java object can be offered as a service: there are no particular constraints, inheritance rules, or annotations that must be applied to the service class. This chapter describes how to deploy an OSGi service using the OSGi *blueprint container*.

16.1. THE BLUEPRINT CONTAINER

Abstract

The *blueprint container* is a dependency injection framework that simplifies interaction with the OSGi container. In particular, the blueprint container supports a configuration-based approach to using the OSGi service registry—for example, providing standard XML elements to import and export OSGi services.

16.1.1. Blueprint Configuration

Location of blueprint files in a JAR file

Relative to the root of the bundle JAR file, the standard location for blueprint configuration files is the following directory:

```
OSGI-INF/blueprint
```

Any files with the suffix, **.xml**, under this directory are interpreted as blueprint configuration files; in other words, any files that match the pattern, **OSGI-INF/blueprint/*.xml**.

Location of blueprint files in a Maven project

In the context of a Maven project, *ProjectDir*, the standard location for blueprint configuration files is the following directory:

```
ProjectDir/src/main/resources/OSGI-INF/blueprint
```

Blueprint namespace and root element

Blueprint configuration elements are associated with the following XML namespace:

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

The root element for blueprint configuration is **blueprint**, so a blueprint XML configuration file normally has the following outline form:

```
<?xml version="1.0" encoding="UTF-8"?>
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">
```

```
  ...
</blueprint>
```

NOTE

In the **blueprint** root element, there is no need to specify the location of the blueprint schema using an **xsi:schemaLocation** attribute, because the schema location is already known to the blueprint framework.

Blueprint Manifest configuration

There are a few aspects of blueprint configuration that are controlled by headers in the JAR's manifest file, **META-INF/MANIFEST.MF**, as follows:

- the section called “Custom Blueprint file locations” .
- the section called “Mandatory dependencies” .

Custom Blueprint file locations

If you need to place your blueprint configuration files in a non-standard location (that is, somewhere other than **OSGI-INF/blueprint/*.xml**), you can specify a comma-separated list of alternative locations in the **Bundle-Blueprint** header in the manifest file—for example:

```
Bundle-Blueprint: lib/account.xml, security.bp, cnf/*.xml
```

Mandatory dependencies

Dependencies on an OSGi service are mandatory by default (although this can be changed by setting the **availability** attribute to **optional** on a **reference** element or a **reference-list** element). Declaring a dependency to be mandatory means that the bundle cannot function properly without that dependency and the dependency must be available at all times.

Normally, while a blueprint container is initializing, it passes through a *grace period*, during which time it attempts to resolve all mandatory dependencies. If the mandatory dependencies cannot be resolved in this time (the default timeout is 5 minutes), container initialization is aborted and the bundle is not started. The following settings can be appended to the **Bundle-SymbolicName** manifest header to configure the grace period:

blueprint.graceperiod

If **true** (the default), the grace period is enabled and the blueprint container waits for mandatory dependencies to be resolved during initialization; if **false**, the grace period is skipped and the container does not check whether the mandatory dependencies are resolved.

blueprint.timeout

Specifies the grace period timeout in milliseconds. The default is 300000 (5 minutes).

For example, to enable a grace period of 10 seconds, you could define the following **Bundle-SymbolicName** header in the manifest file:

```
Bundle-SymbolicName: org.fusesource.example.osgi-client;
 blueprint.graceperiod:=true;
 blueprint.timeout:= 10000
```

The value of the **Bundle-SymbolicName** header is a semi-colon separated list, where the first item is the actual bundle symbolic name, the second item, **blueprint.graceperiod:=true**, enables the grace period and the third item, **blueprint.timeout:= 10000**, specifies a 10 second timeout.

16.1.2. Defining a Service Bean

Overview

Similarly to the Spring container, the blueprint container enables you to instantiate Java classes using a **bean** element. You can create all of your main application objects this way. In particular, you can use the **bean** element to create a Java object that represents an OSGi service instance.

Blueprint bean element

The blueprint **bean** element is defined in the blueprint schema namespace, **http://www.osgi.org/xmlns/blueprint/v1.0.0**. The blueprint **{http://www.osgi.org/xmlns/blueprint/v1.0.0}bean** element should not be confused with the Spring **{http://www.springframework.org/schema/beans}bean** element, which has a similar syntax but is defined in a different namespace.

NOTE

The Spring DM specification version 2.0 or later, allows you to mix both kinds of **bean** element under the **beans** root element, (as long as you define each **bean** elements using the appropriate namespace prefix).

Sample beans

The blueprint **bean** element enables you to create objects using a similar syntax to the conventional Spring **bean** element. One significant difference, however, is that blueprint constructor arguments are specified using the **argument** child element, in contrast to Spring's **constructor-arg** child element. The following example shows how to create a few different types of bean using blueprint's **bean** element:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <bean id="label" class="java.lang.String">
    <argument value="LABEL_VALUE"/>
  </bean>

  <bean id="myList" class="java.util.ArrayList">
    <argument type="int" value="10"/>
  </bean>

  <bean id="account" class="org.fusesource.example.Account">
    <property name="accountName" value="john.doe"/>
    <property name="balance" value="10000"/>
  </bean>

</blueprint>
```

Where the **Account** class referenced by the last bean example could be defined as follows:

```
package org.fusesource.example;

public class Account
{
    private String accountName;
    private int balance;

    public Account () { }

    public void setAccountName(String name) {
        this.accountName = name;
    }

    public void setBalance(int bal) {
        this.balance = bal;
    }
    ...
}
```

Differences between Blueprint and Spring

Althought the syntax of the blueprint **bean** element and the Spring **bean** element are similar, there are a few differences, as you can see from Table 16.1, "Comparison of Spring bean with Blueprint bean" . In this table, the XML tags (identifiers enclosed in angle brackets) refer to child elements of **bean** and the plain identifiers refer to attributes.

Table 16.1. Comparison of Spring bean with Blueprint bean

Spring DM Attributes/Tags	Blueprint Attributes/Tags
id	**id**
name/<alias>	*N/A*
class	**class**
scope	**scope=("singleton"|"prototype")**
lazy-init=("true"|"false")	**activation=("eager"|"lazy")**
depends-on	**depends-on**
init-method	**init-method**
destroy-method	**destroy-method**
factory-method	**factory-bean**
factory-bean	**factory-ref**

Spring DM Attributes/Tags	Blueprint Attributes/Tags
<constructor-arg>	**<argument>**
<property>	**<property>**

Where the default value of the blueprint **scope** attribute is **singleton** and the default value of the blueprint **activation** attribute is **eager**.

References

For more details on defining blueprint beans, consult the following references:

- Spring Dynamic Modules Reference Guide v2.0 (see the blueprint chapters).
- Section 121 *Blueprint Container Specification*, from the OSGi Compendium Services R4.2 specification.

16.1.3. Exporting a Service

Overview

This section describes how to export a Java object to the OSGi service registry, thus making it accessible as a service to other bundles in the OSGi container.

Exporting with a single interface

To export a service to the OSGi service registry under a single interface name, define a **service** element that references the relevant service bean, using the **ref** attribute, and specifies the published interface, using the **interface** attribute.

For example, you could export an instance of the **SavingsAccountImpl** class under the **org.fusesource.example.Account** interface name using the blueprint configuration code shown in Example 16.1, "Sample Service Export with a Single Interface" .

Example 16.1. Sample Service Export with a Single Interface

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <bean id="savings" class="org.fusesource.example.SavingsAccountImpl"/>

 <service ref="savings" interface="org.fusesource.example.Account"/>

</blueprint>
```

Where the **ref** attribute specifies the ID of the corresponding bean instance and the **interface** attribute specifies the name of the public Java interface under which the service is registered in the OSGi service registry. The classes and interfaces used in this example are shown in Example 16.2, "Sample Account Classes and Interfaces"

Example 16.2. Sample Account Classes and Interfaces

```
package org.fusesource.example

public interface Account { ... }

public interface SavingsAccount { ... }

public interface CheckingAccount { ... }

public class SavingsAccountImpl implements SavingsAccount
{
    ...
}

public class CheckingAccountImpl implements CheckingAccount
{
    ...
}
```

Exporting with multiple interfaces

To export a service to the OSGi service registry under multiple interface names, define a **service** element that references the relevant service bean, using the **ref** attribute, and specifies the published interfaces, using the **interfaces** child element.

For example, you could export an instance of the **SavingsAccountImpl** class under the list of public Java interfaces, **org.fusesource.example.Account** and **org.fusesource.example.SavingsAccount**, using the following blueprint configuration code:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">
  <bean id="savings" class="org.fusesource.example.SavingsAccountImpl"/>
  <service ref="savings">
    <interfaces>
      <value>org.fusesource.example.Account</value>
      <value>org.fusesource.example.SavingsAccount</value>
    </interfaces>
  </service>
  ...
</blueprint>
```

NOTE

The **interface** attribute and the **interfaces** element cannot be used simultaneously in the same **service** element. You must use either one or the other.

Exporting with auto-export

If you want to export a service to the OSGi service registry under *all* of its implemented public Java interfaces, there is an easy way of accomplishing this using the **auto-export** attribute.

For example, to export an instance of the **SavingsAccountImpl** class under all of its implemented public interfaces, use the following blueprint configuration code:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">
  <bean id="savings" class="org.fusesource.example.SavingsAccountImpl"/>
  <service ref="savings" auto-export="interfaces"/>
  ...
</blueprint>
```

Where the **interfaces** value of the **auto-export** attribute indicates that blueprint should register all of the public interfaces implemented by **SavingsAccountImpl**. The **auto-export** attribute can have the following valid values:

disabled

Disables auto-export. This is the default.

interfaces

Registers the service under all of its implemented public Java interfaces.

class-hierarchy

Registers the service under its own type (class) and under all super-types (super-classes), except for the **Object** class.

all-classes

Like the **class-hierarchy** option, but including all of the implemented public Java interfaces as well.

Setting service properties

The OSGi service registry also allows you to associate *service properties* with a registered service. Clients of the service can then use the service properties to search for or filter services. To associate service properties with an exported service, add a **service-properties** child element that contains one or more **beans:entry** elements (one **beans:entry** element for each service property).

For example, to associate the **bank.name** string property with a savings account service, you could use the following blueprint configuration:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0"
           xmlns:beans="http://www.springframework.org/schema/beans"
           ...>
  ...
  <service ref="savings" auto-export="interfaces">
    <service-properties>
      <beans:entry key="bank.name" value="HighStreetBank"/>
    </service-properties>
  </service>
  ...
</blueprint>
```

Where the **bank.name** string property has the value, **HighStreetBank**. It is possible to define service properties of type other than string: that is, primitive types, arrays, and collections are also supported. For details of how to define these types, see Controlling the Set of Advertised Properties. in the *Spring Reference Guide*.

NOTE

Strictly speaking, the **entry** element ought to belong to the blueprint namespace. The use of the **beans:entry** element in Spring's implementation of blueprint is non-standard.

Default service properties

There are two service properties that might be set automatically when you export a service using the **service** element, as follows:

- **osgi.service.blueprint.compname**—is always set to the **id** of the service's **bean** element, unless the bean is inlined (that is, the bean is defined as a child element of the **service** element). Inlined beans are always anonymous.
- **service.ranking**—is automatically set, if the ranking attribute is non-zero.

Specifying a ranking attribute

If a bundle looks up a service in the service registry and finds more than one matching service, you can use ranking to determine which of the services is returned. The rule is that, whenever a lookup matches multiple services, the service with the highest rank is returned. The service rank can be any non-negative integer, with **0** being the default. You can specify the service ranking by setting the **ranking** attribute on the **service** element—for example:

```
<service ref="savings" interface="org.fusesource.example.Account" ranking="10"/>
```

Specifying a registration listener

If you want to keep track of service registration and unregistration events, you can define a *registration listener* callback bean that receives registration and unregistration event notifications. To define a registration listener, add a **registration-listener** child element to a **service** element.

For example, the following blueprint configuration defines a listener bean, **listenerBean**, which is referenced by a **registration-listener** element, so that the listener bean receives callbacks whenever an **Account** service is registered or unregistered:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0" ...>
  ...
  <bean id="listenerBean" class="org.fusesource.example.Listener"/>

  <service ref="savings" auto-export="interfaces">
    <registration-listener
        ref="listenerBean"
        registration-method="register"
        unregistration-method="unregister"/>
  </service>
  ...
</blueprint>
```

Where the **registration-listener** element's **ref** attribute references the **id** of the listener bean, the **registration-method** attribute specifies the name of the listener method that receives the registration callback, and **unregistration-method** attribute specifies the name of the listener method that receives the unregistration callback.

The following Java code shows a sample definition of the **Listener** class that receives notifications of registration and unregistration events:

```
package org.fusesource.example;

public class Listener
{
    public void register(Account service, java.util.Map serviceProperties) {
        ...
    }

    public void unregister(Account service, java.util.Map serviceProperties) {
        ...
    }
}
```

The method names, **register** and **unregister**, are specified by the **registration-method** and **unregistration-method** attributes respectively. The signatures of these methods must conform to the following syntax:

- *First method argument*—any type T that is assignable from the service object's type. In other words, any supertype class of the service class or any interface implemented by the service class. This argument contains the service instance, unless the service bean declares the **scope** to be **prototype**, in which case this argument is **null** (when the scope is **prototype**, no service instance is available at registration time).

- *Second method argument*—must be of either **java.util.Map** type or **java.util.Dictionary** type. This map contains the service properties associated with this service registration.

16.1.4. Importing a Service

Overview

This section describes how to obtain and use references to OSGi services that have been exported to the OSGi service registry. Essentially, you can use either the **reference** element or the **reference-list** element to import an OSGi service. The key difference between these elements is *not* (as you might at first be tempted to think) that **reference** returns a single service reference, while **reference-list** returns a list of service references. Rather, the real difference is that the **reference** element is suitable for accessing *stateless* services, while the **reference-list** element is suitable for accessing *stateful* services.

Managing service references

The following models for obtaining OSGi services references are supported:

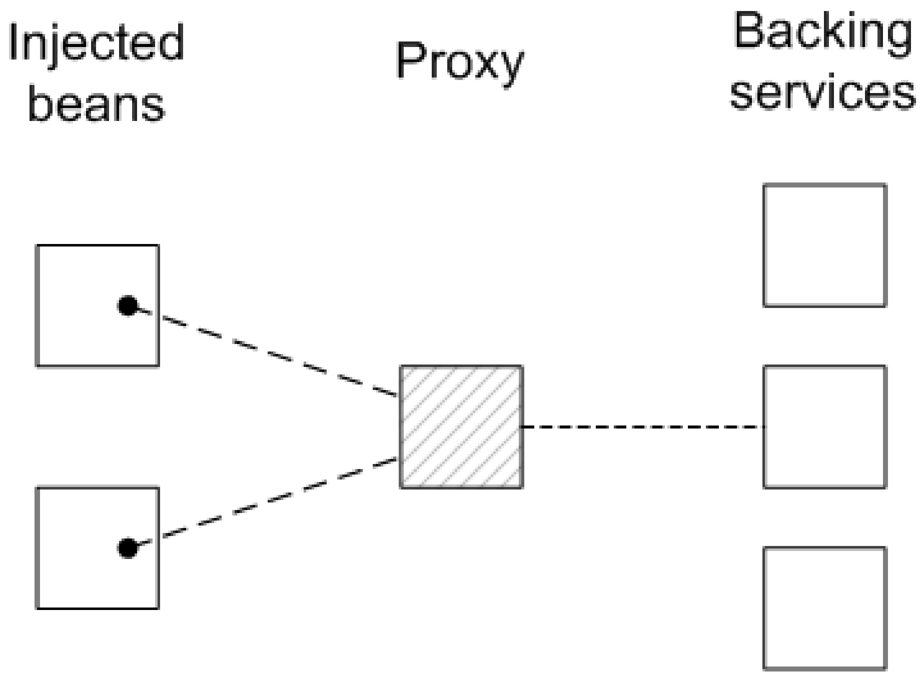
- the section called "Reference manager".

- the section called "Reference list manager".

Reference manager

A *reference manager* instance is created by the blueprint **reference** element. This element returns a single service reference and is the preferred approach for accessing *stateless* services. Figure 16.1, "Reference to Stateless Service" shows an overview of the model for accessing a stateless service using the reference manager.

Figure 16.1. Reference to Stateless Service



Beans in the client blueprint container get injected with a proxy object (the *provided object*), which is backed by a service object (the *backing service*) from the OSGi service registry. This model explicitly takes advantage of the fact that stateless services are interchangeable, in the following ways:

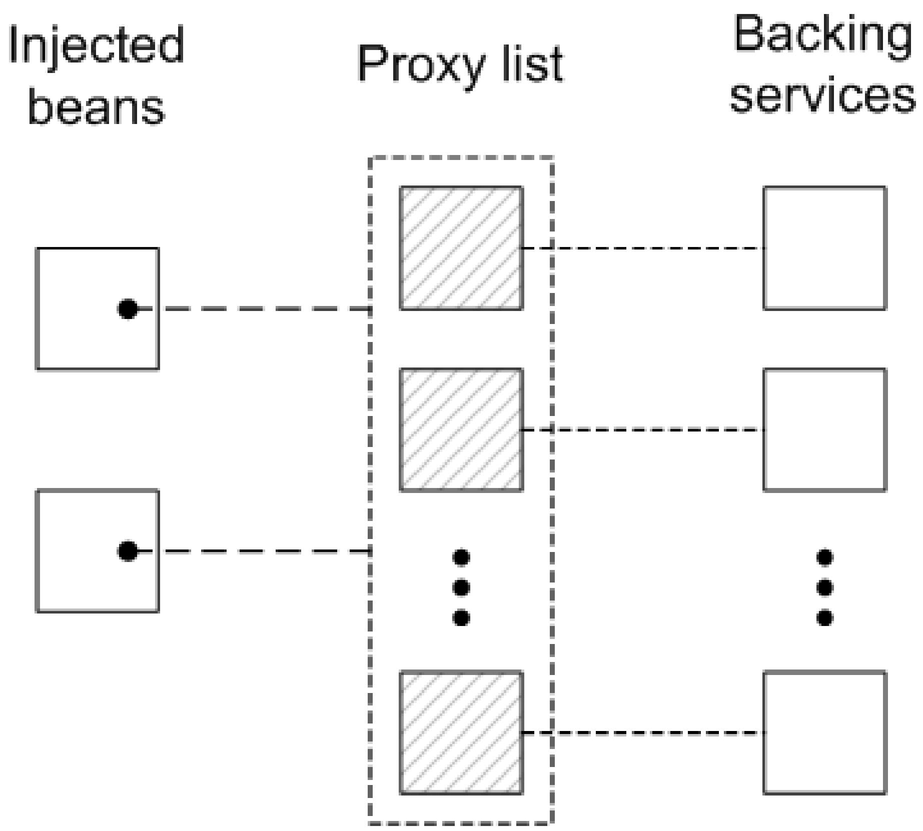
- If multiple services instances are found that match the criteria in the **reference** element, the reference manager can arbitrarily choose one of them as the backing instance (because they are interchangeable).
- If the backing service disappears, the reference manager can immediately switch to using one of the other available services of the same type. Hence, there is no guarantee, from one method invocation to the next, that the proxy remains connected to the same backing service.

The contract between the client and the backing service is thus *stateless*, and the client must *not* assume that it is always talking to the same service instance. If no matching service instances are available, the proxy will wait for a certain length of time before throwing the **ServiceUnavailable** exception. The length of the timeout is configurable by setting the **timeout** attribute on the **reference** element.

Reference list manager

A *reference list manager* instance is created by the blueprint **reference-list** element. This element returns a list of service references and is the preferred approach for accessing *stateful* services. Figure 16.2, “List of References to Stateful Services” shows an overview of the model for accessing a stateful service using the reference list manager.

Figure 16.2. List of References to Stateful Services



Beans in the client blueprint container get injected with a **java.util.List** object (the *provided object*), which contains a list of proxy objects. Each proxy is backed by a unique service instance in the OSGi service registry. Unlike the stateless model, backing services are *not* considered to be interchangeable here. In fact, the lifecycle of each proxy in the list is tightly linked to the lifecycle of the corresponding backing service: when a service gets registered in the OSGi registry, a corresponding proxy is synchronously created and added to the proxy list; and when a service gets unregistered from the OSGi registry, the corresponding proxy is synchronously removed from the proxy list.

The contract between a proxy and its backing service is thus *stateful*, and the client may assume when it invokes methods on a particular proxy, that it is always communicating with the *same* backing service. It could happen, however, that the backing service becomes unavailable, in which case the proxy becomes stale. Any attempt to invoke a method on a stale proxy will generate the **ServiceUnavailable** exception.

Matching by interface (stateless)

The simplest way to obtain a *stateles* service reference is by specifying the interface to match, using the **interface** attribute on the **reference** element. The service is deemed to match, if the **interface** attribute value is a super-type of the service or if the attribute value is a Java interface implemented by the service (the **interface** attribute can specify either a Java class or a Java interface).

For example, to reference a stateless **SavingsAccount** service (see Example 16.1, “Sample Service Export with a Single Interface”), define a **reference** element as follows:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <reference id="savingsRef"
           interface="org.fusesource.example.SavingsAccount"/>

  <bean id="client" class="org.fusesource.example.client.Client">
    <property name="savingsAccount" ref="savingsRef"/>
  </bean>

</blueprint>
```

Where the **reference** element creates a reference manager bean with the ID, **savingsRef**. To use the referenced service, inject the **savingsRef** bean into one of your client classes, as shown.

The bean property injected into the client class can be any type that is assignable from **SavingsAccount**. For example, you could define the **Client** class as follows:

```
package org.fusesource.example.client;

import org.fusesource.example.SavingsAccount;

public class Client {
    SavingsAccount savingsAccount;

    // Bean properties
    public SavingsAccount getSavingsAccount() {
        return savingsAccount;
    }

    public void setSavingsAccount(SavingsAccount savingsAccount) {
        this.savingsAccount = savingsAccount;
    }
    ...
}
```

Matching by interface (stateful)

The simplest way to obtain a *stateful* service reference is by specifying the interface to match, using the **interface** attribute on the **reference-list** element. The reference list manager then obtains a list of all the services, whose **interface** attribute value is either a super-type of the service or a Java interface implemented by the service (the **interface** attribute can specify either a Java class or a Java interface).

For example, to reference a stateful **SavingsAccount** service (see Example 16.1, "Sample Service Export with a Single Interface"), define a **reference-list** element as follows:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <reference-list id="savingsListRef"
                  interface="org.fusesource.example.SavingsAccount"/>

  <bean id="client" class="org.fusesource.example.client.Client">
    <property name="savingsAccountList" ref="savingsListRef"/>
  </bean>

</blueprint>
```

Where the **reference-list** element creates a reference list manager bean with the ID, **savingsListRef**. To use the referenced service list, inject the **savingsListRef** bean reference into one of your client classes, as shown.

By default, the **savingsAccountList** bean property is a list of service objects (for example, **java.util.List<SavingsAccount>**). You could define the client class as follows:

```
package org.fusesource.example.client;

import org.fusesource.example.SavingsAccount;

public class Client {
    java.util.List<SavingsAccount> accountList;

    // Bean properties
    public java.util.List<SavingsAccount> getSavingsAccountList() {
        return accountList;
    }

    public void setSavingsAccountList(
                java.util.List<SavingsAccount> accountList
    ) {
        this.accountList = accountList;
    }
    ...
}
```

Matching by interface and component name

To match both the interface and the component name (bean ID) of a *stateless* service, specify both the **interface** attribute and the **component-name** attribute on the **reference** element, as follows:

```
<reference id="savingsRef"
           interface="org.fusesource.example.SavingsAccount"
           component-name="savings"/>
```

To match both the interface and the component name (bean ID) of a *stateful* service, specify both the **interface** attribute and the **component-name** attribute on the **reference-list** element, as follows:

```
<reference-list id="savingsRef"
           interface="org.fusesource.example.SavingsAccount"
           component-name="savings"/>
```

Matching service properties with a filter

You can select services by matching service properties against a filter. The filter is specified using the **filter** attribute on the **reference** element or on the **reference-list** element. The value of the **filter** attribute must be an *LDAP filter expression* . For example, to define a filter that matches when the **bank.name** service property equals **HighStreetBank**, you could use the following LDAP filter expression:

```
(bank.name=HighStreetBank)
```

To match two service property values, you can use **&** conjunction, which combines expressions with a logical **and**.For example, to require that the **foo** property is equal to **FooValue** and the **bar** property is equal to **BarValue**, you could use the following LDAP filter expression:

```
(&(foo=FooValue)(bar=BarValue))
```

For the complete syntax of LDAP filter expressions, see section 3.2.7 of the *OSGi Core Specification*.

Filters can also be combined with the **interface** and **component-name** settings, in which case all of the specified conditions are required to match.

For example, to match a *stateless* service of **SavingsAccount** type, with a **bank.name** service property equal to **HighStreetBank**, you could define a **reference** element as follows:

```
<reference id="savingsRef"
           interface="org.fusesource.example.SavingsAccount"
           filter="(bank.name=HighStreetBank)"/>
```

To match a *stateful* service of **SavingsAccount** type, with a **bank.name** service property equal to **HighStreetBank**, you could define a **reference-list** element as follows:

```
<reference-list id="savingsRef"
           interface="org.fusesource.example.SavingsAccount"
           filter="(bank.name=HighStreetBank)"/>
```

Specifying whether mandatory or optional

By default, a reference to an OSGi service is assumed to be mandatory (see the section called "Mandatory dependencies"). It is possible, however, to customize the dependency behavior of a **reference** element or a **reference-list** element by setting the **availability** attribute on the element. There are two possible values of the **availability** attribute: **mandatory** (the default), means that the dependency *must* be resolved during a normal blueprint container initialization; and **optional**, means that the dependency need *not* be resolved during initialization.

The following example of a **reference** element shows how to declare explicitly that the reference is a mandatory dependency:

```
<reference id="savingsRef"
           interface="org.fusesource.example.SavingsAccount"
           availability="mandatory"/>
```

Specifying a reference listener

To cope with the dynamic nature of the OSGi environment—for example, if you have declared some of your service references to have **optional** availability—it is often useful to track when a backing service gets bound to the registry and when it gets unbound from the registry. To receive notifications of service binding and unbinding events, you can define a **reference-listener** element as the child of either the **reference** element or the **reference-list** element.

For example, the following blueprint configuration shows how to define a reference listener as a child of the reference manager with the ID, **savingsRef**:

```
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <reference id="savingsRef"
             interface="org.fusesource.example.SavingsAccount"
             >
    <reference-listener bind-method="onBind" unbind-method="onUnbind">
      <bean class="org.fusesource.example.client.Listener"/>
    </reference-listener>
  </reference>
  <bean id="client" class="org.fusesource.example.client.Client">
    <property name="savingsAcc" ref="savingsRef"/>
  </bean>

</blueprint>
```

The preceding configuration registers an instance of **org.fusesource.example.client.Listener** type as a callback that listens for **bind** and **unbind** events. Events are generated whenever the **savingsRef** reference manager's backing service binds or unbinds.

The following example shows a sample implementation of the **Listener** class:

```
package org.fusesource.example.client;

import org.osgi.framework.ServiceReference;

public class Listener {

    public void onBind(ServiceReference ref) {
        System.out.println("Bound service: " + ref);
    }

    public void onUnbind(ServiceReference ref) {
        System.out.println("Unbound service: " + ref);
    }

}
```

The method names, **onBind** and **onUnbind**, are specified by the **bind-method** and **unbind-method** attributes respectively. Both of these callback methods take an **org.osgi.framework.ServiceReference** argument.

16.2. PUBLISHING AN OSGI SERVICE

Overview

This section explains how to generate, build, and deploy a simple OSGi service in the OSGi container. The service is a simple *Hello World* Java class and the OSGi configuration is defined using a blueprint configuration file.

Prerequisites

In order to generate a project using the Maven Quickstart archetype, you must have the following prerequisites:

- *Maven installation*—Maven is a free, open source build tool from Apache. You can download the latest version from http://maven.apache.org/download.html (minimum is 2.0.9).

- *Internet connection*—whilst performing a build, Maven dynamically searches external repositories and downloads the required artifacts on the fly. In order for this to work, your build machine *must* be connected to the Internet.

Generating a Maven project

The **maven-archetype-quickstart** archetype creates a generic Maven project, which you can then customize for whatever purpose you like. To generate a Maven project with the coordinates, **org.fusesource.example:osgi-service**, enter the following command:

```
mvn archetype:create
-DarchetypeArtifactId=maven-archetype-quickstart
-DgroupId=org.fusesource.example
-DartifactId=osgi-service
```

The result of this command is a directory, ***ProjectDir*/osgi-service**, containing the files for the generated project.

NOTE

Be careful not *to choose a group ID for your artifact that clashes with the group ID of an existing product!* This could lead to clashes between your project's packages and the packages from the existing product (because the group ID is typically used as the root of a project's Java package names).

Customizing the POM file

You must customize the POM file in order to generate an OSGi bundle, as follows:

1. Follow the POM customization steps described in Section 6.1, "Generating a Bundle Project".

2. In the configuration of the Maven bundle plug-in, modify the bundle instructions to export the **org.fusesource.example.service** package, as follows:

```
<project ... >
  ...
  <build>
    ...
    <plugins>
      ...
      <plugin>
        <groupId>org.apache.felix</groupId>
        <artifactId>maven-bundle-plugin</artifactId>
        <extensions>true</extensions>
        <configuration>
          <instructions>
            <Bundle-SymbolicName>${pom.groupId}.${pom.artifactId}</Bundle-SymbolicName>
 <Export-Package>org.fusesource.example.service</Export-Package>
          </instructions>
        </configuration>
      </plugin>
    </plugins>
  </build>
  ...
</project>
```

Writing the service interface

Create the ***ProjectDir*/osgi-service/src/main/java/org/fusesource/example/service** sub-directory. In this directory, use your favorite text editor to create the file, **HelloWorldSvc.java**, and add the code from Example 16.3, "The HelloWorldSvc Interface" to it.

Example 16.3. The HelloWorldSvc Interface

```
package org.fusesource.example.service;

public interface HelloWorldSvc
{
    public void sayHello();
}
```

Writing the service class

Create the ***ProjectDir*/osgi-service/src/main/java/org/fusesource/example/service/impl** sub-directory. In this directory, use your favorite text editor to create the file, **HelloWorldSvcImpl.java**, and add the code from Example 16.4, "The HelloWorldSvcImpl Class" to it.

Example 16.4. The HelloWorldSvcImpl Class

```
package org.fusesource.example.service.impl;

import org.fusesource.example.service.HelloWorldSvc;


public class HelloWorldSvcImpl implements HelloWorldSvc {

    public void sayHello()
    {
        System.out.println( "Hello World!" );
    }

}
```

Writing the blueprint file

The blueprint configuration file is an XML file stored under the **OSGI-INF/blueprint** directory on the class path. To add a blueprint file to your project, first create the following sub-directories:

```
ProjectDir/osgi-service/src/main/resources
ProjectDir/osgi-service/src/main/resources/OSGI-INF
ProjectDir/osgi-service/src/main/resources/OSGI-INF/blueprint
```

Where the **src/main/resources** is the standard Maven location for all JAR resources. Resource files under this directory will automatically be packaged in the root scope of the generated bundle JAR.

Example 16.5, "Blueprint File for Exporting a Service" shows a sample blueprint file that creates a **HelloWorldSvc** bean, using the **bean** element, and then exports the bean as an OSGi service, using the **service** element.

Under the ***ProjectDir*/osgi-service/src/main/resources/OSGI-INF/blueprint** directory, use your favorite text editor to create the file, **config.xml**, and add the XML code from Example 16.5, "Blueprint File for Exporting a Service".

Example 16.5. Blueprint File for Exporting a Service

```
<?xml version="1.0" encoding="UTF-8"?>
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <bean id="hello" class="org.fusesource.example.service.impl.HelloWorldSvcImpl"/>

  <service ref="hello" interface="org.fusesource.example.service.HelloWorldSvc"/>

</blueprint>
```

Running the service bundle

To install and run the **osgi-service** project, perform the following steps:

1. *Build the project*—open a command prompt and change directory to ***ProjectDir*/osgi-service**. Use Maven to build the demonstration by entering the following command:

   ```
   mvn install
   ```

   If this command runs successfully, the ***ProjectDir*/osgi-service/target** directory should contain the bundle file, **osgi-service-1.0-SNAPSHOT.jar**.

2. *Install and start the osgi-service bundle*—at the Red Hat JBoss Fuse console, enter the following command:

   ```
   JBossFuse:karaf@root> osgi:install -s file:ProjectDir/osgi-service/target/osgi-service-1.0-
   SNAPSHOT.jar
   ```

   Where *ProjectDir* is the directory containing your Maven projects and the **-s** flag directs the container to start the bundle right away. For example, if your project directory is **C:\Projects** on a Windows machine, you would enter the following command:

   ```
   JBossFuse:karaf@root> osgi:install -s file:C:/Projects/osgi-service/target/osgi-service-1.0-
   SNAPSHOT.jar
   ```

   NOTE

   On Windows machines, be careful how you format the **file** URL—for details of the syntax understood by the **file** URL handler, see Section A.1, "File URL Handler".

3. *Check that the service has been created*—to check that the bundle has started successfully, enter the following Red Hat JBoss Fuse console command:

   ```
   JBossFuse:karaf@root> osgi:list
   ```

   Somewhere in this listing, you should see a line for the **osgi-service** bundle, for example:

```
[ 236] [Active     ] [Created     ] [       ] [   60] osgi-service (1.0.0.SNAPSHOT)
```

To check that the service is registered in the OSGi service registry, enter a console command like the following:

```
JBossFuse:karaf@root> osgi:ls 236
```

Where the argument to the preceding command is the **osgi-service** bundle ID. You should see some output like the following at the console:

```
osgi-service (236) provides:
----------------------------
osgi.service.blueprint.compname = hello
objectClass = org.fusesource.example.service.HelloWorldSvc
service.id = 272
----
osgi.blueprint.container.version = 1.0.0.SNAPSHOT
osgi.blueprint.container.symbolicname = org.fusesource.example.osgi-service
objectClass = org.osgi.service.blueprint.container.BlueprintContainer
service.id = 273
```

16.3. ACCESSING AN OSGI SERVICE

Overview

This section explains how to generate, build, and deploy a simple OSGi client in the OSGi container. The client finds the simple Hello World service in the OSGi registry and invokes the **sayHello()** method on it.

Prerequisites

In order to generate a project using the Maven Quickstart archetype, you must have the following prerequisites:

- *Maven installation*—Maven is a free, open source build tool from Apache. You can download the latest version from http://maven.apache.org/download.html (minimum is 2.0.9).
- *Internet connection*—whilst performing a build, Maven dynamically searches external repositories and downloads the required artifacts on the fly. In order for this to work, your build machine *must* be connected to the Internet.

Generating a Maven project

The **maven-archetype-quickstart** archetype creates a generic Maven project, which you can then customize for whatever purpose you like. To generate a Maven project with the coordinates, **org.fusesource.example:osgi-client**, enter the following command:

```
mvn archetype:create
-DarchetypeArtifactId=maven-archetype-quickstart
-DgroupId=org.fusesource.example
-DartifactId=osgi-client
```

The result of this command is a directory, ***ProjectDir*/osgi-client**, containing the files for the generated project.

NOTE

Be careful not *to choose a group ID for your artifact that clashes with the group ID of an existing product!* This could lead to clashes between your project's packages and the packages from the existing product (because the group ID is typically used as the root of a project's Java package names).

Customizing the POM file

You must customize the POM file in order to generate an OSGi bundle, as follows:

1. Follow the POM customization steps described in Section 6.1, “Generating a Bundle Project” .
2. Because the client uses the **HelloWorldSvc** Java interface, which is defined in the **osgi-service** bundle, it is necessary to add a Maven dependency on the **osgi-service** bundle. Assuming that the Maven coordinates of the **osgi-service** bundle are **org.fusesource.example:osgi-service:1.0-SNAPSHOT**, you should add the following dependency to the client's POM file:

```
<project ... >
  ...
  <dependencies>
    ...
    <dependency>
        <groupId>org.fusesource.example</groupId>
        <artifactId>osgi-service</artifactId>
        <version>1.0-SNAPSHOT</version>
    </dependency>
  </dependencies>
  ...
</project>
```

Writing the Blueprint file

To add a blueprint file to your client project, first create the following sub-directories:

```
ProjectDir/osgi-client/src/main/resources
ProjectDir/osgi-client/src/main/resources/OSGI-INF
ProjectDir/osgi-client/src/main/resources/OSGI-INF/blueprint
```

Under the ***ProjectDir*/osgi-client/src/main/resources/OSGI-INF/blueprint** directory, use your favorite text editor to create the file, **config.xml**, and add the XML code from Example 16.6, “Blueprint File for Importing a Service”.

Example 16.6. Blueprint File for Importing a Service

```
<?xml version="1.0" encoding="UTF-8"?>
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <reference id="helloWorld"
        interface="org.fusesource.example.service.HelloWorldSvc"/>
```

```
<bean id="client"
      class="org.fusesource.example.client.Client"
      init-method="init">
    <property name="helloWorldSvc" ref="helloWorld"/>
  </bean>

</blueprint>
```

Where the **reference** element creates a reference manager that finds a service of **HelloWorldSvc** type in the OSGi registry. The **bean** element creates an instance of the **Client** class and injects the service reference as the bean property, **helloWorldSvc**. In addition, the **init-method** attribute specifies that the **Client.init()** method is called during the bean initialization phase (that is, *after* the service reference has been injected into the client bean).

Writing the client class

Under the ***ProjectDir*/osgi-client/src/main/java/org/fusesource/example/client** directory, use your favorite text editor to create the file, **Client.java**, and add the Java code from Example 16.7, "The Client Class".

Example 16.7. The Client Class

```
package org.fusesource.example.client;

import org.fusesource.example.service.HelloWorldSvc;

public class Client {
    HelloWorldSvc helloWorldSvc;

    // Bean properties
    public HelloWorldSvc getHelloWorldSvc() {
        return helloWorldSvc;
    }

    public void setHelloWorldSvc(HelloWorldSvc helloWorldSvc) {
        this.helloWorldSvc = helloWorldSvc;
    }

    public void init() {
        System.out.println("OSGi client started.");
        if (helloWorldSvc != null) {
            System.out.println("Calling sayHello()");
            helloWorldSvc.sayHello();  // Invoke the OSGi service!
        }
    }

}
```

The **Client** class defines a getter and a setter method for the **helloWorldSvc** bean property, which enables it to receive the reference to the Hello World service by injection. The **init()** method is called during the bean initialization phase, after property injection, which means that it is normally possible to invoke the Hello World service within the scope of this method.

Running the client bundle

To install and run the **osgi-client** project, perform the following steps:

1. *Build the project*—open a command prompt and change directory to ***ProjectDir*/osgi-client**. Use Maven to build the demonstration by entering the following command:

   ```
   mvn install
   ```

   If this command runs successfully, the ***ProjectDir*/osgi-client/target** directory should contain the bundle file, **osgi-client-1.0-SNAPSHOT.jar**.

2. *Install and start the osgi-service bundle* —at the Red Hat JBoss Fuse console, enter the following command:

   ```
   JBossFuse:karaf@root> osgi:install -s file:ProjectDir/osgi-client/target/osgi-client-1.0-
   SNAPSHOT.jar
   ```

   Where *ProjectDir* is the directory containing your Maven projects and the **-s** flag directs the container to start the bundle right away. For example, if your project directory is **C:\Projects** on a Windows machine, you would enter the following command:

   ```
   JBossFuse:karaf@root> osgi:install -s file:C:/Projects/osgi-client/target/osgi-client-1.0-
   SNAPSHOT.jar
   ```

   NOTE

   On Windows machines, be careful how you format the **file** URL—for details of the syntax understood by the **file** URL handler, see Section A.1, “File URL Handler” .

3. *Client output*—f the client bundle is started successfully, you should immediately see output like the following in the console:

   ```
   Bundle ID: 239
   OSGi client started.
   Calling sayHello()
   Hello World!
   ```

16.4. INTEGRATION WITH APACHE CAMEL

Overview

Apache Camel provides a simple way to invoke OSGi services using the Bean language. This feature is automatically available whenever a Apache Camel application is deployed into an OSGi container and requires no special configuration.

Registry chaining

When a Apache Camel route is deployed into the OSGi container, the **CamelContext** automatically sets up a registry chain for resolving bean instances: the registry chain consists of the OSGi registry, followed by the blueprint (or Spring) registry. Now, if you try to reference a particular bean class or bean instance, the registry resolves the bean as follows:

1. Look up the bean in the OSGi registry first. If a class name is specified, try to match this with the interface or class of an OSGi service.

2. If no match is found in the OSGi registry, fall back on the blueprint registry (or the Spring registry, if you are using the Spring container).

Sample OSGi service interface

Consider the OSGi service defined by the following Java interface, which defines the single method, **getGreeting()**:

```
package org.fusesource.example.hello.boston;

public interface HelloBoston {
    public String getGreeting();
}
```

Sample service export

When defining the bundle that implements the **HelloBoston** OSGi service, you could use the following blueprint configuration to export the service:

```
<?xml version="1.0" encoding="UTF-8"?>
<blueprint xmlns="http://www.osgi.org/xmlns/blueprint/v1.0.0">

  <bean id="hello" class="org.fusesource.example.hello.boston.HelloBostonImpl"/>

  <service ref="hello" interface="org.fusesource.example.hello.boston.HelloBoston"/>

</blueprint>
```

Where it is assumed that the **HelloBoston** interface is implemented by the **HelloBostonImpl** class (not shown).

Invoking the OSGi service from Java DSL

After you have deployed the bundle containing the **HelloBoston** OSGi service, you can invoke the service from a Apache Camel application using the Java DSL. In the Java DSL, you invoke the OSGi service through the Bean language, as follows:

```
from("timer:foo?period=5000")
 .bean(org.fusesource.example.hello.boston.HelloBoston.class, "getGreeting")
  .log("The message contains: ${body}")
```

In the **bean** command, the first argument is the OSGi interface or class, which must match the interface exported from the OSGi service bundle. The second argument is the name of the bean method you want to invoke. For full details of the **bean** command syntax, see section "Bean Integration" in "Apache Camel Development Guide".

NOTE

When you use this approach, the OSGi service is implicitly imported. It is *not* necessary to import the OSGi service explicitly in this case.

Invoking the OSGi service from XML DSL

In the XML DSL, you can also use the Bean language to invoke the **HelloBoston** OSGi service, but the syntax is slightly different. In the XML DSL, you invoke the OSGi service through the Bean language, using the **method** element, as follows:

```
<beans ...>
  <camelContext xmlns="http://camel.apache.org/schema/spring">
    <route>
      <from uri="timer:foo?period=5000"/>
      <setBody>
        <method ref="org.fusesource.example.hello.boston.HelloBoston"
                method="getGreeting"/>
      </setBody>
      <log message="The message contains: ${body}"/>
    </route>
  </camelContext>
</beans>
```

NOTE

When you use this approach, the OSGi service is implicitly imported. It is *not* necessary to import the OSGi service explicitly in this case.

CHAPTER 17. JMS BROKER

Abstract

Red Hat JBoss Fuse supports the deployment of JMS brokers. By default, it deploys an Apache ActiveMQ JMS broker. It includes all of the required bundles to deploy additional Apache ActiveMQ instances by deploying a new broker configuration.

17.1. WORKING WITH THE DEFAULT BROKER

Abstract

Red Hat JBoss Fuse starts up with a message broker by default. You can use this broker as it is for your application, or you can update its configuration to suite the needs of your application.

Overview

When you deploy a Red Hat JBoss Fuse instance, whether as a standalone container or as a part of a fabric, the default behavior is for a Apache ActiveMQ instance to be started in the container. The default broker creates an Openwire port that listens on port **61616**. The broker remains installed in the container and activates whenever you restart the container.

Broker configuration

The default broker's configuration is controlled by two files:

- **etc/activemq.xml**—a standard Apache ActiveMQ configuration file that serves as a template for the default broker's configuration. It contains property place holders, specified using the syntax **${*propName*}**, that allow you to set the values of the actual property using the OSGi Admin service.
- **etc/io.fabric8.mq.fabric.server-broker.cfg**—the OSGi configuration file that specifies the values for the properties in the broker's template configuration file.

For details on how to edit the default broker's configuration see the JBoss A-MQ documentation.

Broker data

The default broker's data is stored in **data/activemq**. You can change this location using the **config** command to change the broker's data property as shown in Example 17.1, "Configuring the Default Broker's Data Directory".

Example 17.1. Configuring the Default Broker's Data Directory

```
JBossFuse:karaf@root> config:edit io.fabric8.mq.fabric.server.3e3d0055-1c5f-40e3-987e-
024c1fac1c3f
JBossFuse:karaf@root> config:propset data dataStore
JBossFuse:karaf@root> config:update
```

Disabling the default broker

If you do not want to use the default broker, you can disable it by removing its OSGi configuration file. There are two procedures to follow, depending on whether a Karaf container has been started:

If no Karaf container has been started:

- Delete **FUSE_HOME/etc/io.fabric8.mq.fabric.server-broker.cfg**.

If you have already started a Karaf container, use the following instructions whilst JBoss Fuse is running.

1. From the JBoss Fuse command console, list the JBoss Fuse brokers: **activemq:list**

   The result should look like this:

   ```
   brokerName = amq
   ```

2. List the configuration PID files: **config:list | grep io.fabric8.mq.fabric**

   The result will look like this:

   ```
   Pid:            io.fabric8.mq.fabric.server.cd4295e7-1db9-44b6-9118-69011a0f09a3
   FactoryPid:     io.fabric8.mq.fabric.server
     fabric.zookeeper.pid = io.fabric8.mq.fabric.server
     felix.fileinstall.filename = file:/home/username/product/fuse-630/jboss-fuse-6.3.0.redhat-
   187/etc/io.fabric8.mq.fabric.server-broker.cfg
     service.factoryPid = io.fabric8.mq.fabric.server
     service.pid = io.fabric8.mq.fabric.server.cd4295e7-1db9-44b6-9118-69011a0f09a3
   Pid:            io.fabric8.mq.fabric.standalone.server.4de976b1-2fae-4391-97d9-3a08876e39ab
   FactoryPid:     io.fabric8.mq.fabric.standalone.server
     felix.fileinstall.filename = file:/home/username/product/fuse-630/jboss-fuse-6.3.0.redhat-
   187/etc/io.fabric8.mq.fabric.server-broker.cfg
     mq.fabric.server.pid = io.fabric8.mq.fabric.server.cd4295e7-1db9-44b6-9118-69011a0f09a3
     service.factoryPid = io.fabric8.mq.fabric.standalone.server
     service.pid = io.fabric8.mq.fabric.standalone.server.4de976b1-2fae-4391-97d9-
   3a08876e39ab
   ```

3. Delete the configuration PID files labeled **Pid:** in the example above.

   ```
   config:delete io.fabric8.mq.fabric.server.cd4295e7-1db9-44b6-9118-69011a0f09a3
   config:delete io.fabric8.mq.fabric.standalone.server.4de976b1-2fae-4391-97d9-
   3a08876e39ab
   ```

   Note that your files will have the same names as those shown above until the last numeric portion of the the file name, which is a system generated ID for the broker. Replace the filenames in the instructions with your actual filename.

4. List the JBoss Fuse brokers again: **activemq:list**

   The deleted broker will not appear.

5. To permanently delete the default broker:

   Stop the JBoss Fuse instance.

Delete file **FUSE_HOME/etc/io.fabric8.mq.fabric.server-broker.cfg**.

Restart the JBoss Fuse instance and run the **activemq:list** command. The deleted broker will not appear.

17.2. JMS ENDPOINTS IN A ROUTER APPLICATION

Overview

The following example shows how you can integrate a JMS broker into a router application. The example generates messages using a timer; sends the messages through the **camel.timer** queue in the JMS broker; and then writes the messages to a specific directory in the file system.

Prerequisites

In order to run the sample router application, you need to have the **activemq-camel** feature installed in the OSGi container. The **activemq-camel** component is needed for defining Apache ActiveMQ-based JMS endpoints in Apache Camel. This feature is *not* installed by default, so you must install it using the following console command:

```
JBossFuse:karaf@root> features:install activemq-camel
```

You also need the **activemq** feature, but this feature is normally available, because Red Hat JBoss Fuse installs it by default.

TIP

Most of the Apache Camel components are *not* installed by default. Whenever you are about to define an endpoint in a Apache Camel route, remember to check whether the corresponding component feature is installed. Apache Camel component features generally have the same name as the corresponding Apache Camel component artifact ID, **camel-*ComponentName***.

Router configuration

Example 17.2, "Sample Route with JMS Endpoints" gives an example of a Apache Camel route defined using the Spring XML DSL. Messages generated by the timer endpoint are propagated through the JMS broker and then written out to the file system.

Example 17.2. Sample Route with JMS Endpoints

```
<?xml version="1.0"?>
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:camel="http://camel.apache.org/schema/spring">

  <bean id="activemq" class="org.apache.activemq.camel.component.ActiveMQComponent">
    <property name="brokerURL" value="tcp://localhost:61616"/>
  </bean>

  <camelContext xmlns="http://camel.apache.org/schema/spring">
    <route>
      <from uri="timer://MyTimer?fixedRate=true&amp;period=4000"/>
      <setBody><constant>Hello World!</constant></setBody>
      <to uri="activemq:camel.timer"/>
    </route>
    <route>
      <from uri="activemq:camel.timer"/>
      <to uri="file:C:/temp/sandpit/timer"/>
    </route>
  </camelContext>

</beans>
```

Camel activemq component

In general, it is necessary to create a custom instance of the Apache Camel **activemq** component, because you need to specify the connection details for connecting to the broker. The preceding example uses Spring syntax to instantiate the **activemq** bean which connects to the broker URL, **tcp://localhost:61616**. The broker URL must correspond to one of the transport connectors defined in the broker configuration file, **deploy/test-broker.xml**.

Sample routes

Example 17.2, "Sample Route with JMS Endpoints" defines two routes, as follows:

1. The first route uses a **timer** endpoint to generate messages at four-second intervals. The **setBody** element places a dummy string in the body of the message (which would otherwise be **null**). The messages are then sent to the **camel.timer** queue on the broker (the **activemq:camel.timer** endpoint).

   NOTE

   The **activemq** scheme in **activemq:camel.timer** is resolved by looking up **activemq** in the bean registry, which resolves to the locally instantiated bean with ID, **activemq**.

2. The second route pulls messages off the **camel.timer** queue and then writes the messages to the specified directory, **C:\temp\sandpit\timer**, in the file system.

Steps to run the example

To run the sample router application, perform the following steps:

1. Using your favorite text editor, copy and paste the router configuration from Example 17.2, "Sample Route with JMS Endpoints" into a file called **camel-timer.xml**.

   Edit the file endpoint in the second route, in order to change the target directory to a suitable location on your file system:

   ```
   <route>
     <from uri="activemq:camel.timer"/>
     <to uri="file:YourDirectoryHere!"/>
   </route>
   ```

2. Start up a local instance of the Red Hat JBoss Fuse runtime by entering the following at a command prompt:

   ```
   ./bin/fuse
   ```

3. Make sure the requisite features are installed in the OSGi container. To install the **activemq-camel** feature, enter the following command at the console:

   ```
   JBossFuse:karaf@root> features:install activemq-camel
   ```

   To ensure that the **activemq-broker** feature is *not* installed, enter the following command at the console:

   ```
   JBossFuse:karaf@root> features:uninstall activemq-broker
   ```

4. Use one of the following alternatives to obtain a broker instance for this demonstration:

   - *Use the default broker*—assuming you have not disabled the default broker, you can use it for this demonstration, because it is listening on the correct port, 61616.

   - *Create a new broker instance using the console*—if you prefer not to use the default broker, you can disable it (as described in Section 17.1, “Working with the Default Broker”) and then create a new JMS broker instance by entering the following command at the console:

     ```
     JBossFuse:karaf@root> activemq:create-broker --name test
     ```

     After executing this command, you should see the broker configuration file, **test-broker.xml**, in the ***InstallDir*/deploy** directory.

5. Hot deploy the router configuration you created in step 1. Copy the **camel-timer.xml** file into the ***InstallDir*/deploy** directory.

6. Within a few seconds, you should start to see files appearing in the target directory (which is **C:\temp\sandpit\timer**, by default). The file component automatically generates a unique filename for each message that it writes.

   It is also possible to monitor activity in the JMS broker by connecting to the Red Hat JBoss Fuse runtime's JMX port. To monitor the broker using JMX, perform the following steps:

   a. To monitor the JBoss Fuse runtime, start a JConsole instance (a standard Java utility) by entering the following command:

      ```
      jconsole
      ```

   b. Initially, a **JConsole: Connect to Agent** dialog prompts you to connect to a JMX port. From the **Local** tab, select the **org.apache.felix.karaf.main.Bootstrap** entry and click **Connect**.

   c. In the main JConsole window, click on the **MBeans** tab and then drill down to **org.apache.activemq|test|Queue** in the MBean tree (assuming that **test** is the name of your broker).

   d. Under the **Queue** folder, you should see the **camel.timer** queue. Click on the **camel.timer** queue to view statistics on the message throughput of this queue.

7. To shut down the router application, delete the **camel-timer.xml** file from the ***InstallDir*/deploy** directory *while the Karaf container is running* .

APPENDIX A. URL HANDLERS

Abstract

There are many contexts in Red Hat JBoss Fuse where you need to provide a URL to specify the location of a resource (for example, as the argument to a console command). In general, when specifying a URL, you can use any of the schemes supported by JBoss Fuse's built-in URL handlers. This appendix describes the syntax for all of the available URL handlers.

A.1. FILE URL HANDLER

Syntax

A file URL has the syntax, **file:***PathName*, where *PathName* is the relative or absolute pathname of a file that is available on the Classpath. The provided *PathName* is parsed by Java's built-in file *URL handler*. Hence, the *PathName* syntax is subject to the usual conventions of a Java pathname: in particular, on Windows, each backslash must either be escaped by another backslash or replaced by a forward slash.

Examples

For example, consider the pathname, **C:\Projects\camel-bundle\target\foo-1.0-SNAPSHOT.jar**, on Windows. The following example shows the *correct* alternatives for the file URL on Windows:

```
file:C:/Projects/camel-bundle/target/foo-1.0-SNAPSHOT.jar
file:C:\\Projects\\camel-bundle\\target\\foo-1.0-SNAPSHOT.jar
```

The following example shows some *incorrect* alternatives for the file URL on Windows:

```
file:C:\Projects\camel-bundle\target\foo-1.0-SNAPSHOT.jar        // WRONG!
file://C:/Projects/camel-bundle/target/foo-1.0-SNAPSHOT.jar      // WRONG!
file://C:\\Projects\\camel-bundle\\target\\foo-1.0-SNAPSHOT.jar  // WRONG!
```

A.2. HTTP URL HANDLER

Syntax

A HTTP URL has the standard syntax, **http:*Host*[:*Port*]/[*Path*][#*AnchorName*][?*Query*]**. You can also specify a secure HTTP URL using the **https** scheme. The provided HTTP URL is parsed by Java's built-in HTTP URL handler, so the HTTP URL behaves in the normal way for a Java application.

A.3. MVN URL HANDLER

Overview

If you use Maven to build your bundles or if you know that a particular bundle is available from a Maven repository, you can use the Mvn handler scheme to locate the bundle.

NOTE

To ensure that the Mvn URL handler can find local and remote Maven artifacts, you might find it necessary to customize the Mvn URL handler configuration. For details, see the section called “Configuring the Mvn URL handler” .

Syntax

An Mvn URL has the following syntax:

```
mvn:[repositoryUrl!]groupId/artifactId[/[version][/[packaging][/[classifier]]]]
```

Where *repositoryUrl* optionally specifies the URL of a Maven repository. The *groupId*, *artifactId*, *version*, *packaging*, and *classifier* are the standard Maven coordinates for locating Maven artifacts (see the section called “Maven coordinates”).

Omitting coordinates

When specifying an Mvn URL, only the *groupId* and the *artifactId* coordinates are required. The following examples reference a Maven bundle with the *groupId*, **org.fusesource.example**, and with the *artifactId*, **bundle-demo**:

```
mvn:org.fusesource.example/bundle-demo
mvn:org.fusesource.example/bundle-demo/1.1
```

When the *version* is omitted, as in the first example, it defaults to **LATEST**, which resolves to the latest version based on the available Maven metadata.

In order to specify a *classifier* value without specifying a *packaging* or a *version* value, it is permissible to leave gaps in the Mvn URL. Likewise, if you want to specify a *packaging* value without a *version* value. For example:

```
mvn:groupId/artifactId///classifier
mvn:groupId/artifactId/version//classifier
mvn:groupId/artifactId//packaging/classifier
mvn:groupId/artifactId//packaging
```

Specifying a version range

When specifying the *version* value in an Mvn URL, you can specify a version range (using standard Maven version range syntax) in place of a simple version number. You use square brackets—**[** and **]**—to denote inclusive ranges and parentheses—**(** and **)**—to denote exclusive ranges. For example, the range, **[1.0.4,2.0)**, matches any version, **v**, that satisfies **1.0.4 <= v < 2.0**. You can use this version range in an Mvn URL as follows:

```
mvn:org.fusesource.example/bundle-demo/[1.0.4,2.0)
```

Configuring the Mvn URL handler

Before using Mvn URLs for the first time, you might need to customize the Mvn URL handler settings, as follows:

1. the section called “Check the Mvn URL settings” .

2. the section called “Edit the configuration file” .
3. the section called “Customize the location of the local repository” .

Check the Mvn URL settings

The Mvn URL handler resolves a reference to a local Maven repository and maintains a list of remote Maven repositories. When resolving an Mvn URL, the handler searches first the local repository and then the remote repositories in order to locate the specified Maven artifiact. If there is a problem with resolving an Mvn URL, the first thing you should do is to check the handler settings to see which local repository and remote repositories it is using to resolve URLs.

To check the Mvn URL settings, enter the following commands at the console:

```
JBossFuse:karaf@root> config:edit org.ops4j.pax.url.mvn
JBossFuse:karaf@root> config:proplist
```

The **config:edit** command switches the focus of the **config** utility to the properties belonging to the **org.ops4j.pax.url.mvn** persistent ID. The **config:proplist** command outputs all of the property settings for the current persistent ID. With the focus on **org.ops4j.pax.url.mvn**, you should see a listing similar to the following:

```
   org.ops4j.pax.url.mvn.defaultRepositories = file:/path/to/JBossFuse/jboss-fuse-6.3.0.redhat-
xxx/system@snapshots@id=karaf.system,file:/home/userid/.m2/repository@snapshots@id=local,file:/pa
h/to/JBossFuse/jboss-fuse-6.3.0.redhat-xxx/local-repo@snapshots@id=karaf.local-
repo,file:/path/to/JBossFuse/jboss-fuse-6.3.0.redhat-xxx/system@snapshots@id=child.karaf.system
   org.ops4j.pax.url.mvn.globalChecksumPolicy = warn
   org.ops4j.pax.url.mvn.globalUpdatePolicy = daily
   org.ops4j.pax.url.mvn.localRepository = /path/to/JBossFuse/jboss-fuse-6.3.0.redhat-
xxx/data/repository
   org.ops4j.pax.url.mvn.repositories = http://repo1.maven.org/maven2@id=maven.central.repo,
https://maven.repository.redhat.com/ga@id=redhat.ga.repo,
https://maven.repository.redhat.com/earlyaccess/all@id=redhat.ea.repo,
https://repository.jboss.org/nexus/content/groups/ea@id=fuseearlyaccess
   org.ops4j.pax.url.mvn.settings = /home/fbolton/Programs/JBossFuse/jboss-fuse-6.3.0.redhat-
xxx/etc/maven-settings.xml
   org.ops4j.pax.url.mvn.useFallbackRepositories = false
   service.pid = org.ops4j.pax.url.mvn
```

Where the **localRepository** setting shows the local repository location currently used by the handler and the **repositories** setting shows the remote repository list currently used by the handler.

Edit the configuration file

To customize the property settings for the Mvn URL handler, edit the following configuration file:

```
InstallDir/etc/org.ops4j.pax.url.mvn.cfg
```

The settings in this file enable you to specify explicitly the location of the local Maven repository, remove Maven repositories, Maven proxy server settings, and more. Please see the comments in the configuration file for more details about these settings.

Customize the location of the local repository

In particular, if your local Maven repository is in a non-default location, you might find it necessary to configure it explicitly in order to access Maven artifacts that you build locally. In your **org.ops4j.pax.url.mvn.cfg** configuration file, uncomment the **org.ops4j.pax.url.mvn.localRepository** property and set it to the location of your local Maven repository. For example:

```
# Path to the local maven repository which is used to avoid downloading
# artifacts when they already exist locally.
# The value of this property will be extracted from the settings.xml file
# above, or defaulted to:
#     System.getProperty( "user.home" ) + "/.m2/repository"
#
org.ops4j.pax.url.mvn.localRepository=file:E:/Data/.m2/repository
```

Reference

For more details about the **mvn** URL syntax, see the original Pax URL Mvn Protocol documentation.

A.4. WRAP URL HANDLER

Overview

If you need to reference a JAR file that is not already packaged as a bundle, you can use the Wrap URL handler to convert it dynamically. The implementation of the Wrap URL handler is based on Peter Krien's open source Bnd utility.

Syntax

A Wrap URL has the following syntax:

```
wrap:locationURL[,instructionsURL][$instructions]
```

The *locationURL* can be any URL that locates a JAR (where the referenced JAR is *not* formatted as a bundle). The optional *instructionsURL* references a Bnd properties file that specifies how the bundle conversion is performed. The optional *instructions* is an ampersand, **&**, delimited list of Bnd properties that specify how the bundle conversion is performed.

Default instructions

In most cases, the default Bnd instructions are adequate for wrapping an API JAR file. By default, Wrap adds manifest headers to the JAR's **META-INF/Manifest.mf** file as shown in Table A.1, "Default Instructions for Wrapping a JAR".

Table A.1. Default Instructions for Wrapping a JAR

Manifest Header	Default Value
Import-Package	***;resolution:=optional**
Export-Package	All packages from the wrapped JAR.

Manifest Header	Default Value
Bundle-SymbolicName	The name of the JAR file, where any characters not in the set **[a-zA-Z0-9_-]** are replaced by underscore, _.

Examples

The following Wrap URL locates version 1.1 of the **commons-logging** JAR in a Maven repository and converts it to an OSGi bundle using the default Bnd properties:

```
wrap:mvn:commons-logging/commons-logging/1.1
```

The following Wrap URL uses the Bnd properties from the file, **E:\Data\Examples\commons-logging-1.1.bnd**:

```
wrap:mvn:commons-logging/commons-logging/1.1,file:E:/Data/Examples/commons-logging-1.1.bnd
```

The following Wrap URL specifies the **Bundle-SymbolicName** property and the **Bundle-Version** property explicitly:

```
wrap:mvn:commons-logging/commons-logging/1.1$Bundle-SymbolicName=apache-comm-
log&Bundle-Version=1.1
```

If the preceding URL is used as a command-line argument, it might be necessary to escape the dollar sign, **\$**, to prevent it from being processed by the command line, as follows:

```
wrap:mvn:commons-logging/commons-logging/1.1\$Bundle-SymbolicName=apache-comm-
log&Bundle-Version=1.1
```

Reference

For more details about the **wrap** URL handler, see the following references:

- The Bnd tool documentation, for more details about Bnd properties and Bnd instruction files.
- The original Pax URL Wrap Protocol documentation.

A.5. WAR URL HANDLER

Overview

If you need to deploy a WAR file in an OSGi container, you can automatically add the requisite manifest headers to the WAR file by prefixing the WAR URL with **war:**, as described here.

Syntax

A War URL is specified using either of the following syntaxes:

```
war:warURL
warref:instructionsURL
```

The first syntax, using the **war** scheme, specifies a WAR file that is converted into a bundle using the default instructions. The *warURL* can be any URL that locates a WAR file.

The second syntax, using the **warref** scheme, specifies a Bnd properties file, *instructionsURL*, that contains the conversion instructions (including some instructions that are specific to this handler). In this syntax, the location of the referenced WAR file does *not* appear explicitly in the URL. The WAR file is specified instead by the (mandatory) **WAR-URL** property in the properties file.

WAR-specific properties/instructions

Some of the properties in the **.bnd** instructions file are specific to the War URL handler, as follows:

WAR-URL

(Mandatory) Specifies the location of the War file that is to be converted into a bundle.

Web-ContextPath

Specifies the piece of the URL path that is used to access this Web application, after it has been deployed inside the Web container.

NOTE

Earlier versions of PAX Web used the property, **Webapp-Context**, which is now *deprecated*.

Default instructions

By default, the War URL handler adds manifest headers to the WAR's **META-INF/Manifest.mf** file as shown in Table A.2, "Default Instructions for Wrapping a WAR File" .

Table A.2. Default Instructions for Wrapping a WAR File

Manifest Header	Default Value
Import-Package	**javax.*,org.xml.*,org.w3c.***
Export-Package	No packages are exported.
Bundle-SymbolicName	The name of the WAR file, where any characters not in the set **[a-zA-Z0-9_-\.]** are replaced by period, **.**.
Web-ContextPath	No default value. But the *WAR extender* will use the value of **Bundle-SymbolicName** by default.

Manifest Header	Default Value
Bundle-ClassPath	In addition to any class path entries specified explicitly, the following entries are added automatically: • **.** • **WEB-INF/classes** • All of the JARs from the **WEB-INF/lib** directory.

Examples

The following War URL locates version 1.4.7 of the **wicket-examples** WAR in a Maven repository and converts it to an OSGi bundle using the default instructions:

```
war:mvn:org.apache.wicket/wicket-examples/1.4.7/war
```

The following Wrap URL specifies the **Web-ContextPath** explicitly:

```
war:mvn:org.apache.wicket/wicket-examples/1.4.7/war?Web-ContextPath=wicket
```

The following War URL converts the WAR file referenced by the **WAR-URL** property in the **wicket-examples-1.4.7.bnd** file and then converts the WAR into an OSGi bundle using the other instructions in the **.bnd** file:

```
warref:file:E:/Data/Examples/wicket-examples-1.4.7.bnd
```

Reference

For more details about the **war** URL syntax, see the original Pax URL War Protocol documentation.

APPENDIX B. OSGI BEST PRACTICES

Abstract

The combination of Maven and the OSGi framework provides a sophisticated framework for building and deploying enterprise applications. In order to use this framework effectively, however, it is necessary to adopt certain conventions and best practices. The practices described in this appendix are intended to optimize the manageability and scalability of your OSGi applications.

B.1. OSGI TOOLING

Overview

The following best practices are recommended for OSGi related tools and utilities:

- the section called "Use the Maven bundle plug-in to generate the Manifest" .
- the section called "Avoid using the OSGi API directly" .
- the section called "Prefer Blueprint over Spring-DM" .
- the section called "Use Apache Karaf features to group bundles together" .
- the section called "Use the OSGi Configuration Admin service" .
- the section called "Use PAX-Exam for testing" .

Use the Maven bundle plug-in to generate the Manifest

Even for a moderately sized bundle project, it is usually impractical to create and maintain a bundle Manifest by hand. The Maven bundle plug-in is the most effective tool for automating the generation of bundle Manifests in a Maven project. See Section B.2, "Building OSGi Bundles" .

Avoid using the OSGi API directly

Avoid using the OSGi Java API directly. Prefer a higher level technology, for example: Blueprint (from the OSGi Compendium Specification), Spring-DM, Declarative Services (DS), iPojo, and so on.

Prefer Blueprint over Spring-DM

The Blueprint container is now the preferred framework for instantiating, registering, and referencing OSGi services, because this container has now been adopted as an OSGi standard. This ensures greater portability for your OSGi service definitions in the future.

Spring Dynamic Modules (Spring-DM) provided much of the original impetus for the definition of the Blueprint standard, but should now be regarded as obsolescent. Using the Blueprint container does *not* prevent you from using the Spring framework: the latest version of Spring is compatible with Blueprint.

Use Apache Karaf features to group bundles together

When an application is composed of a large number of bundles, it becomes essential to group bundles together in order to deploy them efficiently. Apache Karaf *features* is a mechanism that is designed just for this purpose. It is easy to use and supported by a variety of different tools. See Chapter 8, *Deploying Features* for details.

Use the OSGi Configuration Admin service

The OSGi Configuration Admin service is the preferred mechanism for providing configuration properties to your application. This configuration mechanism enjoys better tooling support than other approaches. For example, in Red Hat JBoss Fuse the OSGi Configuration Admin service is supported in the following ways:

- Properties integrated with Spring XML files.
- Properties automatically read from configuration files, **etc/*persistendId*.cfg**
- Properties can be set in feature repositories.

Use PAX-Exam for testing

In order for testing to be really effective, you should run at least some of your tests in an OSGi container. This requires you to start an OSGi container, configure its environment, install prerequisite bundles, and install the actual test. Performing these steps manually for every test would make testing prohibitively difficult and time-consuming. Pax-Exam solves this problem by providing a testing framework that is capable of automatically initializing an OSGi container before running tests in the container.

B.2. BUILDING OSGI BUNDLES

Overview

The following best practices are recommended when building OSGi bundles using Maven:

- the section called “Use package prefix as the bundle symbolic name” .
- the section called “Artifact ID should be derived from the bundle symbolic name” .
- the section called “Always export packages with a version” .
- the section called “Use naming convention for private packages” .
- the section called “Import packages with version ranges” .
- the section called “Avoid importing packages that you export” .
- the section called “Use optional imports with caution” .
- the section called “Avoid using the Require-Bundle header” .

Use package prefix as the bundle symbolic name

Use your application's package prefix as the bundle symbolic name. For example, if all of your Java source code is located in sub-packages of **org.fusesource.fooProject**, use **org.fusesource.fooProject** as the bundle symbolic name.

Artifact ID should be derived from the bundle symbolic name

It makes sense to identify a Maven artifact with an OSGi bundle. To show this relationship as clearly as possible, you should use base the artifact ID on the bundle symbolic name. Two conventions are commonly used:

- *The artifact ID is identical to the bundle symbolic name* —this enables you to define the bundle symbolic name in terms of the artifact ID, using the following Maven bundle instruction:

  ```
  <Bundle-SymbolicName>${project.artifactId}</Bundle-SymbolicName>
  ```

- *The bundle symbolic name is composed of the group ID and the artifact ID, joined by a dot* —this enables you to define the bundle symbolic name in terms of the group ID and the artifact ID, using the following Maven bundle instruction:

  ```
  <Bundle-SymbolicName>${project.groupId}.${project.artifactId}</Bundle-SymbolicName>
  ```

NOTE

Properties of the form **project.*** can be used to reference the value of *any* element in the current POM. To construct the name of a POM property, take the XPath name of any POM element (for example, **project/artifactId**) and replace occurrences of / with the **.** character. Hence, **${project.artifactId}** references the **artifactId** element from the current POM.

Always export packages with a version

One of the key advantages of the OSGi framework is its ability to manage bundle versions and the possibility of deploying multiple versions of a bundle in the same container. In order to take advantage of this capability, however, it is essential that you associate a version with any packages that you export.

For example, you can configure the **maven-bundle-plugin** plug-in to export packages with the current artifact version (given by the **project.version** property) as follows:

```
<Export-Package>
  ${project.artifactId}*;version=${project.version}
</Export-Package>
```

Notice how this example exploits the convention that packages use the artifact ID, **project.artifactId**, as their package prefix. The combination of package prefix and wildcard, **${project.artifactId}***, enables you to reference all of the source code in your bundle.

Use naming convention for private packages

If you define any private packages in your bundle (packages that you do not want to export), it is recommended that you identify these packages using a strict naming convention. For example, if your bundle includes implementation classes that you do not want to export, you should place these classes in packages prefixed by **${project.artifactId}.impl** or **${project.artifactId}.internal**.

NOTE

If you do not specify any **Export-Package** instruction, the default behavior of the Maven bundle plug-in is to exclude any packages that contain a path segment equal to **impl** or **internal**.

To ensure that the private packages are *not* exported, you can add an entry of the form **!*PackagePattern*** to the Maven bundle plug-in's export instructions. The effect of this entry is to exclude any matching packages. For example, to exclude any packages prefixed by **${project.artifactId}.impl**, you could add the following instruction to the Maven bundle plug-in configuration:

```
<Export-Package>
  !${project.artifactId}.impl.*,
  ${project.artifactId}*;version=${project.version}
</Export-Package>
```

NOTE

The order of entries in the **Export-Package** element is significant. The first match in the list determines whether a package is included or excluded. Hence, in order for exclusions to be effective, they should appear at the *start* of the list.

Import packages with version ranges

In order to benefit from OSGi version management capabilities, it is important to restrict the range of acceptable versions for imported packages. You can use either of the following approaches:

- *Manual version ranges*—you can manually specify the version range for an imported package using the **version** qualifier, as shown in the following example:

  ```
  <Import-Package>
    org.springframework.*;version="[2.5,4)",
    org.apache.commons.logging.*;version="[1.1,2)",
    *
  </Import-Package>
  ```

  Version ranges are specified using the standard OSGi version range syntax, where square brackets—that is, **[** and **]**—denote inclusive ranges and parentheses—that is, **(** and **)**—denote exclusive ranges. Hence the range, **[2.5,4)**, means that the version, **v**, is restricted to the range, **2.5 <= v < 4**. Note the special case of a range written as a simple number—for example, **version="2.5"**, which is equivalent to the range, **[2.5,*infinity*)**.

- *Automatic version ranges*—if packages are imported from a Maven dependency and if the dependency is packaged as an OSGi bundle, the Maven bundle plug-in automatically adds the version range to the import instructions.

  The default behavior is as follows. If your POM depends on a bundle that is identified as version 1.2.4.8, the generated manifest will import version 1.2 of the bundle's exported packages (that is, the imported version number is truncated to the first two parts, major and minor).

  It is also possible to customize how imported version ranges are generated from the bundle dependency. When setting the **version** property, you can use the **${@}** macro (which returns the original export version) and the **${version}** macro (which modifies a version number) to generate a version range. For example, consider the following **version** settings:

  ***;version="${@}"**

  If a particular package has export version **1.2.4.8**, the generated import version resolves to **1.2.4.8**.

***;version="${version;==;${@}}"**

If a particular package has export version **1.2.4.8**, the generated import version resolves to **1.2**.

***;version="[${version;==;${@}},${version;=+;${@}})"**

If a particular package has export version **1.2.4.8**, the generated import version range resolves to **[1.2,1.3)**.

***;version="[${version;==;${@}},${version;+;${@}})"**

If a particular package has export version **1.2.4.8**, the generated import version range resolves to **[1.2,2)**.

The middle part of the version macro—for example, **==** or **=+**—formats the returned version number. The equals sign, **=**, returns the corresponding version part unchanged; the plus sign, **+**, returns the corresponding version part plus one; and the minus sign, **-**, returns the corresponding version part minus one. For more details, consult the Bnd documentation for the version macro and the -versionpolicy option.

NOTE

In practice, you are likely to find that the majority of imported packages can be automatically versioned by Maven. It is, typically, only occasionally necessary to specify a version manually.

Avoid importing packages that you export

Normally, it is not good practice to import the packages that you export (though there are exceptions to this rule). Here are some guidelines to follow:

- If the bundle is a pure library (providing interfaces and classes, but *not* instantiating any classes or OSGi services), do not import the packages that you export.
- If the bundle is a pure API (providing interfaces and abstract classes, but no implementation classes), do not import the packages that you export.
- If the bundle is a pure implementation (implementing and registering an OSGi service, but not providing any API), you do not need to export any packages at all.

  NOTE

  The registered OSGi service must be accessible through an API interface or class, but it is presumed that this API is provided in a *separate* API bundle. The implementation bundle therefore needs to import the corresponding API packages.

- A special case arises, if an implementation and its corresponding API are combined into the same bundle. In this case, the API packages must be listed amongst the export packages *and* amongst the import packages. This configuration is interpreted in a special way by the OSGi framework: it actually means that the API packages will either be exported *or* imported at run time (but not both).

  The reason for this special configuration is that, in a complex OSGi application, it is possible that an API package might be provided by more than one bundle. But you do not want multiple copies of an API to be exported into OSGi, because that can lead to technical problems like class cast exceptions. When a package is listed both in the exports and in the imports, the OSGi resolver proceeds as follows:

1. First of all, the resolver checks whether the package has already been exported from another bundle. If so, the resolver imports the package, but *does not export it*.

2. Otherwise, the resolver uses the local API package and exports this package, but it *does not import the package*.

Assuming you want to avoid importing the packages that you export, there are two alternative approaches you can take, as follows:

- *(Recommended)* The most effective way of suppressing the import of exported packages is to append the **-noimport:=true** setting to package patterns in the **Export-Package** instruction. For example:

  ```
  <Export-Package>
    ${project.artifactId}*;version=${project.version};-noimport:=true
  </Export-Package>
  ```

  The marked packages are now *not* imported, irrespective of what is contained in the **Import-Package** instruction.

- An alternative way of avoiding the import is to add one or more package exclusions to the Maven bundle plug-in's **Import-Package** element (this was the only possibility in earlier versions of the Maven bundle plug-in). For example, the following **Import-Package** element instructs the Maven bundle plug-in to exclude all packages prefixed by the artifact ID, **${project.artifactId}**:

  ```
  <Import-Package>
    !${project.artifactId}*,
    org.springframework.*;version="[2.5,4)",
    org.apache.commons.logging.*;version="[1.1,2)",
    *
  </Import-Package>
  ```

Use optional imports with caution

When an imported package is specified with *optional* resolution, this allows the bundle to be resolved *without* resolving the optional package. This affects the resolution order of the bundles which, in turn, can affect the runtime behavior. You should therefore be careful with optional imports, in case they have some unintended side effects.

A package is optional when it appears in the **Import-Package** manifest header with the **resolution:="optional"** setting appended to it. For example, the following example shows an **Import-Package** instruction for the Maven bundle plug-in that specifies an optional import:

```
<Import-Package>
  org.springframework.*;version="[2.5,4)",
  org.apache.commons.logging.*;version="[1.1,2)";resolution:="optional",
  *
</Import-Package>
```

Avoid using the Require-Bundle header

Avoid using the **Require-Bundle** header, if possible. The trouble with using the **Require-Bundle** header is that it *forces* the OSGi resolver to use packages from the specified bundle. Importing at the granularity of packages, on the other hand, allows the resolver to be more flexible, because there are fewer constraints: if a package is already available and resolved from another bundle, the resolver could use that package instead.

B.3. SAMPLE POM FILE

POM file

Example B.1, "Sample POM File Illustrating Best Practices" shows a sample POM that illustrates the best practices for building an OSGi bundle using Maven.

Example B.1. Sample POM File Illustrating Best Practices

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-
v4_0_0.xsd">

  <modelVersion>4.0.0</modelVersion>

  <groupId>org.fusesource</groupId>
  <artifactId>org.fusesource.fooProject</artifactId>
  <packaging>bundle</packaging>
  <version>1.0-SNAPSHOT</version>
  <name>A fooProject OSGi Bundle</name>
  <url>http://www.myorganization.org</url>

  <dependencies>...</dependencies>

  <build>
    <plugins>
      <plugin>
        <groupId>org.apache.felix</groupId>
        <artifactId>maven-bundle-plugin</artifactId>
        <configuration>
          <instructions>
            <Bundle-SymbolicName>${project.artifactId}</Bundle-SymbolicName>
            <Export-Package>
              !${project.artifactId}.impl.*,
              ${project.artifactId}*;version=${project.version};-noimport:=true
            </Export-Package>
            <Import-Package>
              org.springframework.*;version="[2.5,4)",
              org.apache.commons.logging.*;version="[1.1,2)",
              *
            </Import-Package>
          </instructions>
        </configuration>
      </plugin>
    </plugins>
  </build>

</project>
```

INDEX