Creating an application with dm Server

GreenPages: a demonstration

Christopher Frost
Ben Hale
Rob Harrop
Glyn Normington
Steve Powell
Andy Wilkinson

2.0.0.M2

Abstract

Spring application programmers are introduced to SpringSource® dm Server™ by installing dm Server and developing a small application called GreenPages. Despite its simplicity, GreenPages is designed to demonstrate many different dm Server features and to act as a template from which other modular applications can be built.

Table of Contents

Preface

This Guide explains how to install SpringSource® dm Server™ and the associated Eclipse™ tools and how to develop and test a small application.

It is intended for Spring application programmers and assumes little or no understanding of OSGi™ or SpringSource dm Server.

Questions about dm Server and SpringSource Tools Suite (or this Guide) may be posted to the dm Server Community Forums (http://forum.springframework.org/forumdisplay.php?f=53).

1. Concepts

SpringSource dm Server is a Java application server composed from a collection of modules which supports applications which are also composed from a collection of modules. These may be traditional Java web applications packaged as Web ARchive (`.war`) files as well as other modular applications.

This chapter introduces concepts necessary for developing dm Server applications. These concepts will become clearer as the GreenPages application is explored in later chapters.

1.1 OSGi concepts

Modules in dm Server are represented using a standard Java module system known as *OSGi*. Modules consist of programs and resources organised by Java package together with metadata which declares imported and exported packages. A module *exports* a package to make the corresponding programs and resources available for use by other modules. A module *imports* a package to use the corresponding programs and resources of another module.

Representing a program as a collection of modules makes it easier for the programmer to manage it and modify it and for teams of programmers to divide responsibilities between themselves. A module is similar to a Java class in this respect. Rules similar to those for organising data and programs into classes can be applied to organising applications into modules.

An industry consortium known as the *OSGi Alliance* (see the appendix Projects) develops the OSGi specification, reference implementation, and compliance tests. dm Server is built on the Equinox OSGi framework which is also the reference implementation for OSGi.

Bundles

Modules in OSGi are known as *bundles*. Each bundle conforms to the JAR file format and can contain Java classes, a manifest (in `META-INF/MANIFEST.MF`), and further resource files.

The OSGi framework enables bundles to be installed and run.

Bundles are identified by OSGi in two distinct ways: by *symbolic name* and by *bundle id*.

A bundle usually declares its *symbolic name* in its manifest, like this:

```
Bundle-SymbolicName: org.foo.bundle
```

Additionally, the OSGi framework assigns a number, known as a *bundle id*, to each bundle as it is installed. The OSGi framework itself resides in a bundle with bundle id `0`.

The dependencies between bundles are expressed statically in terms of packages and

dynamically in terms of services. A package is familiar to Java programmers. For example, a Java program may depend on a class `org.foo.X` and a bundle containing that program would either need to contain `org.foo.X` or depend on the package `org.foo`. Package dependencies are specified in the bundle manifest, for example:

```
Import-Package: org.foo
```

A bundle which provides a package for use by other bundles *must* export the package in its manifest. For example:

```
Export-Package: org.foo
```

The OSGi framework ensures that a given bundle's package dependencies can be *satisfied* before the bundle runs. This process is known as *resolution*.

After a bundle is resolved, its classes and resources are available for loading. In OSGi, bundles and their packages do not appear on the application classpath. Instead, each bundle has a class loader which loads its own classes and loads classes belonging to each of its imported packages by deferring to the bundle class loader that exported the package.

Life cycle

The OSGi framework manages the *life cycle* of each bundle. A bundle is first of all *install*ed and will be in the INSTALLED state. If a request is made to *start* the bundle, the OSGi framework *resolve*s the bundle and, if resolution was successful, will subsequently move the bundle to the ACTIVE state. If a request is made to *stop* the bundle, the OSGi framework will move the bundle back to the INSTALLED state. A request may then be made to *uninstall* the bundle.

While the bundle is INSTALLED or ACTIVE, it may be *updated* to pick up some changes. These changes are not detected by bundles which were depending on the bundle before it was updated. A "refresh packages" operation may be performed to ripple the changes out to those bundles. (See Services concepts.)

The life cycle of a bundle is best summarised as a state transition diagram. This diagram shows some more of the intermediate states of a bundle not described in the overview above:

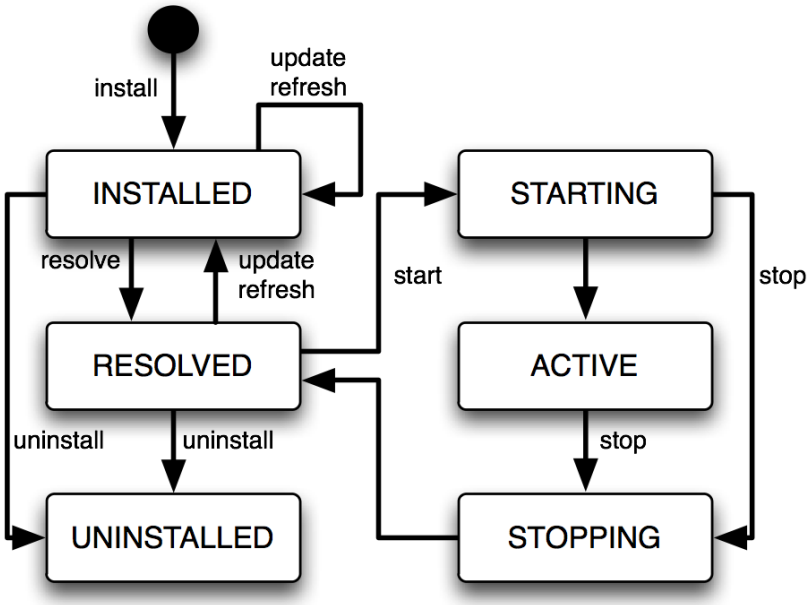


Figure 1.1. Bundle States

Services

Bundles may publish Java objects, known as *services*, to a registry managed by the OSGi framework. Other bundles running in the same OSGi framework can then find and use those services. Services are typically instances of some shared Java interface. A bundle which provides a service need not export the package containing the implementation class of the service.

For example, a bundle could export a package containing the interface `org.bar.SomeInterface`, thus:

```
Export-Package: org.bar
```

implement the interface with a class `SomeImpl`:

```
package org.bar.impl;

class SomeImpl implements SomeInterface {
        …
}
```

create an instance of `SomeImpl`and then publish this instance (as an instance of the interface `SomeInterface`).

OSGi specifies a number of standard services. For example, the *Package Admin* service provides the “refresh packages” life cycle operation mentioned above.

OSGi provides an *API* which can be used to publish and find services, but it is much simpler to use Spring DM to accomplish this. (See Spring DM concepts.)

Versioning

OSGi supports versioning of bundles, packages, and several other entities, and provides some mechanisms for managing these versions.

Version numbers

An OSGi *version number* consists of up to three numeric components or exactly three numeric components followed by a string component. The components are separated by a period ("`.`") and are called the *major*, *minor*, *micro*, and *qualifier* components, respectively. For example, the version `2.4.1.ga` has major component `2`, minor component `4`, micro component `1`, and a qualifier component `ga`. (There are restrictions on the characters that can appear in a qualifier. For example, letters, digits, underscores and hyphens are allowed; periods and commas are not.)

Trailing components may be omitted along with their . So, for example, the version numbers `2`, `2.0`, and `2.0.0` are all equal. This example demonstrates that `0` is assumed if a numeric component is omitted, and the empty string is assumed for an omitted qualifier.

Version ranges

Dependencies on bundles and packages have an associated *version range* which is specified using an interval notation: a square bracket "`[`" or "`]`" denotes an *inclusive* end of the range and a round bracket "`(`" or "`)`" denotes an *exclusive* end of the range. Where one end of the range is to be included and the other excluded, it is permitted to pair a round bracket with a square bracket. The examples below make this clear.

If a single version number is used where a version *range* is required this does *not* indicate a single version, but the range *starting* from that version and including all higher versions.

There are three common cases:

- A "strict" version range, such as `[1.2,1.2]`, which denotes one version and only that version.
- A "half-open" range, such as `[1.2,2)`, which has an inclusive lower limit and an exclusive upper limit, denoting all versions from version `1.2` up to version `2.0.0` *but not including version `2.0.0`*.
- An "unbounded" version range, such as `1.2`, which contains version `1.2` and all higher versions.

Versioning policies

A *versioning policy* is a way of using version numbers to indicate compatible and incompatible changes. OSGi does not mandate a particular versioning policy. Instead a specific versioning policy may be implemented using version ranges.

Strict and half-open version ranges are most useful in representing versioning policies. Unbounded version ranges can lead to problems as they assume that compatibility will be preserved indefinitely.

For example, a conservative versioning policy may assume that any change other than in the qualifier component of a version implies an incompatible change to the object. Such a policy would employ version ranges such as `[1.2.1.beta,1.2.2)` which accept any version from `1.2.1.beta` inclusive to `1.2.2` exclusive. For another example, a relaxed versioning policy may assume that only changes in the major component of a version denote an incompatible change. Such a policy would employ version ranges such as `[1.2,2)`.

Bundle version

Each bundle has a version. The bundle's version may be specified in the manifest using a `Bundle-Version` header:

```
Bundle-Version: 1.4.3.BUILD-20090302
```

If not specified the bundle version is assumed to be `0`.

Package version

Each exported package has a version. The exported package's version may be specified on the Export-Package manifest header. For example

```
Export-Package: org.foo;version="2.9",org.bar;version="1"
```

exports two packages: `org.foo`, at version `2.9.0` and `org.bar`, at version `1.0.0`.

If the version attribute is omitted the version is assumed to be `0`.

Each package *import* has a version *range*. The package import version range may be specified on the `Import-Package` manifest header. If interval notation is used, the version range must be enclosed in double quotes, for example:

```
Import-Package: org.foo;version="[2,3)",org.bar;version="[1,1]"
```

seeks to import a package `org.foo` in the range `[2.0.0,3.0.0)` and a package `org.bar` with the (exact) version `1.0.0`.

If a version range is not specified on an import, the range `0` is assumed, meaning that any version of this package would satisfy the import.

Bundle manifest version

Bundle manifests have a version which is `1` by default, indicating OSGi Release 3 semantics. dm Server is based on OSGi Release 4 and therefore expects bundle manifests to be at version `2`, indicating OSGi Release 4 semantics. (See the appendix Projects.) The bundle manifest's version should be specified on the Bundle-ManifestVersion manifest header, exactly as follows:

```
Bundle-ManifestVersion: 2
```

Manifest version

Manifests themselves also have a version which *must* be specified as `1.0`. This is not an OSGi definition but part of the JAR file specification (http://java.sun.com/javase/6/docs/technotes/guides/jar/jar.html).

```
Manifest-Version: 1.0
```

1.2 Spring DM concepts

Spring DM is a project which enables *services* to be published and consumed using descriptions written in XML. dm Server has Spring DM built-in.

The XML descriptions reside in files with extension `.xml` in the bundle's `META-INF/spring` sub-directory.

To publish a service, an `<osgi:service>` tag is used, specifying the implementation class of the service and the interface class to be used. Spring DM constructs an instance of the implementation class like any other Spring bean and then publishes that instance in the OSGi service registry under the interface when the bundle is started.

To consume a service, an `<osgi:reference>` tag is used and the service may be passed into other Spring beans using Spring's dependency injection facilities.

Spring DM automatically creates proxies for OSGi services so that the actual service object may come and go at runtime. If a service disappears, any proxies to the service will wait for the service to re-appear. This effect is known as *damping*.

When a bundle is started, Spring DM builds the application contexts specified by the XML descriptions, creates proxies for the specified services, and publishes the specified services to the OSGi service registry.

When a bundle is stopped, Spring DM retracts any services it published on behalf of the bundle and closes the bundle's application contexts. dm Server turns off damping of a service proxy

while the proxy's application context is being closed.

1.3 dm Server concepts

Several dm Server concepts are essential for developing an application.

PAR files

dm Server provides a way of grouping together a collection of OSGi bundles which comprise a single application. These bundles are placed in a JAR file with extension "`.par`". This is called a PAR file.

All the bundles in a PAR file are resolved together and so mutual dependencies are permitted.

At runtime a PAR file provides a *scope* in the sense that bundles inside the PAR file may depend on packages and services outside the PAR file, but bundles outside the PAR file may not depend on packages and services provided by the PAR file.

Deployment

PAR files or individual bundles are *deployed* into dm Server by dropping them into a "pickup" directory or using the Administration Console web application provided with dm Server. During deployment, the bundle or bundles are installed into OSGi, resolved together, and then started together.

Personalities

dm Server supports multiple application programming models known as *personalities*. Each bundle of an application has a personality. For example, a bundle providing a servlet has either the *web* or the *war* personality. Bundles which provide packages and services using the OSGi and Spring DM programming models have the *bundle* personality.

When a bundle is deployed into dm Server, personality-specific transformations are applied to the bundle's contents, including its manifest, and the bundle is made available for use in a personality-specific way. For example, a bundle with the web personality has some package imports added to its manifest and its servlet is automatically made available for dispatching from HTTP requests.

Module types

Web ARchive (`.war`) files are identified as having the `war` personality by the file extension. Bundles with a `.jar` extension could have any personality, so dm Server enables the personality to be specified using the `Module-Type` manifest header, for example:

```
Module-Type: web
```

The default `Module-Type` is `bundle`.

2. Installation

Before developing an application with dm Server, it is essential to install *dm Server*, the Eclipse *Integrated Development Environment* (IDE), the Eclipse-based *@sts@*, and a build system integrated with Eclipse. The present document uses *Apache Maven* and the Eclipse plugin *Q for Eclipse* to integrate the IDE with the build system.

2.1 Pre-requisites

Before proceeding, ensure that a Java™ Standard Edition Development Kit for Java 6 or later is installed and that the `JAVA_HOME` environment variable is set to the correct value.

To verify this, issue the command `"%JAVA_HOME%"\bin\java -version` from a command prompt on Windows or `$JAVA_HOME/bin/java -version` from a terminal window on UNIX and ensure that the command completes successfully and reports a Java version `1.6.x` (denoting Java 6) or greater.

Also issue the command `"%JAVA_HOME%"\bin\jar` to ensure that there is a means of extracting files from zip archives. If the `jar` command is unavailable, download and install a suitable zip program such as `7zip`, `gzip`, or `WinZip`. This is most relevant for Windows operating systems where the inbuilt zip extraction utility may mishandle long pathnames.

2.2 Installing dm Server

Although the steps are similar, the details of installing dm Server depend on the operating system.

First download the free *Community Edition* of dm Server from the dm Server download site (http://www.springsource.com/download/dmserver).

Installing dm Server on Windows™ operating systems

Unzip the download of dm Server to the root directory of a drive (this will avoid possible problems with long pathnames). Set an environment variable `%DMS_HOME%` to refer to the unzipped folder.

```
cd C:\
"%JAVA_HOME%"\bin\jar xf \path\to\springsource-dm-server-2.0.0.M2.zip
set DMS_HOME=C:\springsource-dm-server-2.0.0.M2
```

To verify the installation, issue the command: `"%DMS_HOME%"\bin\startup.bat` and ensure a message numbered `SPPM0002I` is displayed.

(Timestamps have been removed.)

```
main                    <SPKB0001I> Server starting.
main                    <SPOF0001I> OSGi telnet console available on port 2401.
main                    <SPKE0000I> Boot subsystems installed.
main                    <SPKE0001I> Base subsystems installed.
server-dm-10            <SPPM0000I> Installing profile 'web'.
server-dm-10            <SPPM0001I> Installed profile 'web'.
server-dm-8             <SPSC0001I> Creating HTTP/1.1 connector with scheme http on port 8080.
server-dm-8             <SPSC0001I> Creating HTTP/1.1 connector with scheme https on port 8443.
server-dm-8             <SPSC0001I> Creating AJP/1.3 connector with scheme http on port 8009.
server-dm-8             <SPSC0000I> Starting ServletContainer.
server-dm-10            <SPPM0002I> Server open for business with profile 'web'.
…
```

Shut down the server by pressing `Ctrl-C`.

Installing dm Server on UNIX™ operating systems

Unzip the download of dm Server to a suitable location on the file system, such as the home directory. (If the download was automatically unzipped by the operating system, simply move the unzipped directory to the chosen location.) Set an environment variable `$DMS_HOME` to refer to the unzipped folder.

```
mkdir /path/to/home/springsource
cd /path/to/home/springsource
unzip /path/to/springsource-dm-server-2.0.0.M2.zip
export DMS_HOME=/path/to/home/springsource/springsource-dm-server-2.0.0.M2
```

To verify the installation, use a terminal window to issue the command: `$DMS_HOME/bin/startup.sh` and ensure a message numbered `SPPM0002I` is displayed.

(Timestamps have been removed.)

```
main                    <SPKB0001I> Server starting.
main                    <SPOF0001I> OSGi telnet console available on port 2401.
main                    <SPKE0000I> Boot subsystems installed.
main                    <SPKE0001I> Base subsystems installed.
server-dm-3             <SPPM0000I> Installing profile 'web'.
server-dm-3             <SPPM0001I> Installed profile 'web'.
server-dm-5             <SPSC0001I> Creating HTTP/1.1 connector with scheme http on port 8080.
server-dm-5             <SPSC0001I> Creating HTTP/1.1 connector with scheme https on port 8443.
server-dm-5             <SPSC0001I> Creating AJP/1.3 connector with scheme http on port 8009.
server-dm-5             <SPSC0000I> Starting ServletContainer.
server-dm-3             <SPPM0002I> Server open for business with profile 'web'.
…
```

Shut down the server by pressing `Ctrl-C`.

2.3 Installing the SpringSource Tools Suite

The SpringSource Tools Suite is a development environment based on Eclipse that comes configured with all the plugins needed to work with the dm Server and OSGi. Although the steps are similar, the details of installing STS depend on the operating system.

Go to the STS download site (http://www.springsource.com/products/sts) and download the variant appropriate to the operating system STS is to be run on. At the time of writing version 2.0.2 is the latest stable release.

Installing STS on Windows™ operating systems

Unzip the download of STS to the root directory of a drive (this will avoid possible problems with long pathnames).

```
cd C:\
"%JAVA_HOME%"\bin\jar xf \path\to\springsource-tool-suite-2.0.2-e3.4-win32.zip
```

To verify the installation, run the `eclipse.exe` executable in the unzipped directory and check that STS displays a welcome panel.

Installing STS on UNIX™ operating systems

Unpack the download of STS to a suitable location on the file system, such as `/opt` or, if root access is not available, the home directory. (If the download was automatically unpacked by the operating system, simply move the unpacked directory to the chosen location.)

To verify the installation, run the STS executable (`Eclipse.app` on Mac OS X) in the unpacked directory and check that STS displays a welcome panel.

2.4 Installing Apache Maven

Apache Maven, or Maven for short, is a software project management and comprehension tool which uses a central *Project Object Model* (POM) to manage a project's build, reporting and documentation generation. The POM files (`pom.xml`) are included in the solution projects for GreenPages.

To install Maven, visit the Maven website (http://maven.apache.org) and follow the download instructions from there. This document has been written and tested with Maven version 2.0.6. The rest of the document assumes that the Maven commands (`mvn …`) are available from the command line.

3. Installing and exploring GreenPages

3.1 Introduction

GreenPages is a simple application that allow users to search an online email address directory. Each listing in the directory details the relevant email addresses and the name of the owner. GreenPages has only three screens: the search screen, the results screen and the listing detail screen.

In the search screen, users can enter search criteria to be matched against the listings in the directory. The result screen displays any listings that match the criteria entered by the user. The listing detail screen shows all the data known about a given listing.

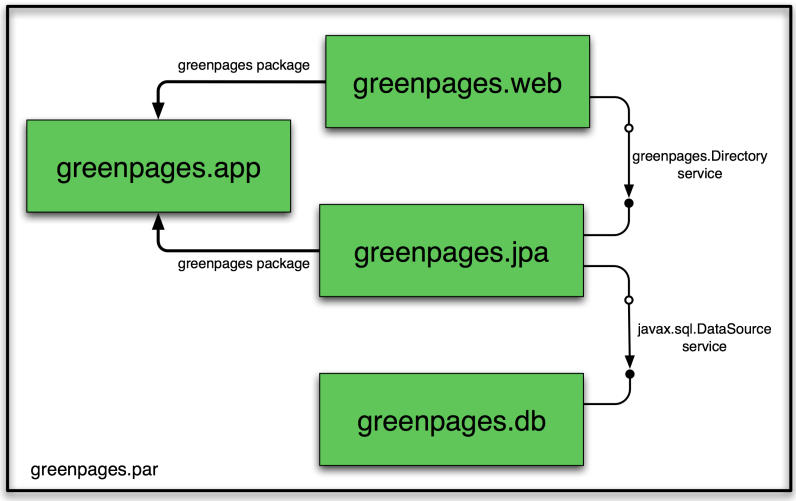
Despite its simplicity, GreenPages is designed to demonstrate many different dm Server features and to act as a template from which other modular applications can be built. In particular, GreenPages demonstrates:

- module dependencies with `Import-Package`,
- load-time weaving with JPA and AspectJ,
- bundle classpath scanning, and
- service export, lookup and injection.

In addition to demonstrating common dm Server features, GreenPages demonstrates integration with:

- Spring Framework 2.5;
- FreeMarker 2.3;
- EclipseLink 1.0.1;
- H2 1.0.71; and
- Commons DBCP 1.2.2.

The GreenPages application is packaged as a PAR file containing four modules.



The `greenpages.db` module provides access to an external database and publishes a `javax.sql.DataSource` service.

The `greenpages.app` module exports a `greenpages` package containing `Directory` and `Listing` interfaces.

The `greenpages.jpa` module imports the `greenpages` package and uses the `javax.sql.DataSource` service to access the external database and publishes its contents as a `greenpages.Directory` service.

The `greenpages.web` module imports the `greenpages` package and uses the `greenpages.Directory` service to respond to web requests.

3.2 Obtaining GreenPages

This document provides step-by-step instructions for building the GreenPages application with dm Server and the SpringSource Tools Suite. In addition, the complete application is available as a ZIP file that can be built and installed into dm Server.

To get the completed GreenPages application *and* the starter projects to build GreenPages by steps:

1. download the latest ZIP file from

```
http://www.springsource.com/download/community?project=SpringSource%20dm%20Server%20Samples
```

2. extract all the files from the ZIP file to a convenient directory (preserving the directory structure).

To extract the files on Windows:

```
mkdir c:\springsource\samples
cd c:\springsource\samples
jar xf c:\path\to\greenpages-1.0.1.RELEASE.zip
set GREENPAGES_HOME=c:\springsource\samples\greenpages-1.0.1.RELEASE
```

To extract the files on Unix systems:

```
mkdir -p /opt/springsource/samples
cd /opt/springsource/samples
unzip /path/to/greenpages-1.0.1.RELEASE.zip
export GREENPAGES_HOME=/opt/springsource/samples/greenpages-1.0.1.RELEASE
```

The environment variable `GREENPAGES_HOME` set here is not used by the projects, but is used as a shorthand in the instructions that follow.

The GreenPages zip file contains two main directories called `solution` and `start`. The `solution` directory contains the completed application which can be built and tested (as described below). The `start` directory contains the initial skeleton of the GreenPages application upon which the step-by-step creation instructions build.

To follow the step-by-step instructions start at Chapter 4, *The Web Module*.

3.3 Building and installing GreenPages

Building with Apache Maven

GreenPages uses Apache Maven as its primary build system. Each module of the application can be built separately and the entire application can built and assembled into a PAR file from a single location. To build the PAR file:

1. Make `$GREENPAGES_HOME/solution` the current directory.

2. Run the command `mvn package`. The first time this is run quite a lot of files will be downloaded from Maven repositories and SpringSource repositories. Subsequent runs will not need to do this.

3. Verify that the `greenpages-1.0.0.SNAPSHOT.par` file exists in `$GREENPAGES_HOME/greenpages/target`.

Building on Windows:

```
cd %GREENPAGES_HOME%\solution
mvn package
```

Building on UNIX:

```
cd $GREENPAGES_HOME/solution
mvn package
```

Installing dependencies into dm Server

Unlike traditional Java EE applications, GreenPages does not package all of its dependencies

inside its deployment unit. Instead, it relies on the mechanisms of OSGi to locate its dependencies at runtime. When running an OSGi application on dm Server, these dependencies can be loaded into memory as needed, but first they must be made available to dm Server.

The Maven build included with GreenPages uses the `dependency:copy-dependencies` plugin to gather all the artifacts that GreenPages depends on that are not supplied by the OSGi runtime. These dependencies can then be installed into the dm Server repository. Dependencies are gathered automatically during the `package` phase. These dependencies can be found in `$GREENPAGES_HOME/solution/greenpages/target/par-provided`. To install dependencies simply copy all the bundles from this directory into `$DMS_HOME/repository/bundles/usr`.

Installing dependencies on Windows:

```
cd %GREENPAGES_HOME%\solution\greenpages
copy target\par-provided\* %DMS_HOME%\repository\bundles\usr
```

Installing Dependencies on UNIX:

```
cd $GREENPAGES_HOME/solution/greenpages
cp target/par-provided/* $DMS_HOME/repository/bundles/usr
```

Starting and configuring the database

GreenPages uses the H2 database to store all its data. Before the application can be started, the database server must be started and the database populated with data.

1. Make `$GREENPAGES_HOME/db` the current directory.

2. Run the database startup script appropriate to the operating system.

3. Run the data population script appropriate to the operating system.

Starting and configuring the database on Windows:

```
cd %GREENPAGES_HOME%\db
run
data
```

Starting and configuring the database on UNIX:

```
cd $GREENPAGES_HOME/db
./run.sh &

./data.sh
```

After `./run.sh &` press Return to continue.

These instructions need only be run once to start a database server for H2; this will continue to run in the background. A browser window offering a connection to the database may open: this should be closed.

Installing and starting GreenPages PAR

To install the GreenPages PAR into dm Server and start it:

1. Copy the GreenPages PAR to the `$DMS_HOME/pickup` directory.
2. Start dm Server.
3. Verify that GreenPages starts correctly by checking in the dm Server output for the log message:

```
<SPDE0010I> Deployment of 'greenpages' version '1.0.0.SNAPSHOT' completed.
```

Installing and starting GreenPages on Windows:

```
cd %DMS_HOME%
copy %GREENPAGES_HOME%\solution\greenpages\target\greenpages-solution-1.0.0.SNAPSHOT.par pickup\
bin/startup.bat
```

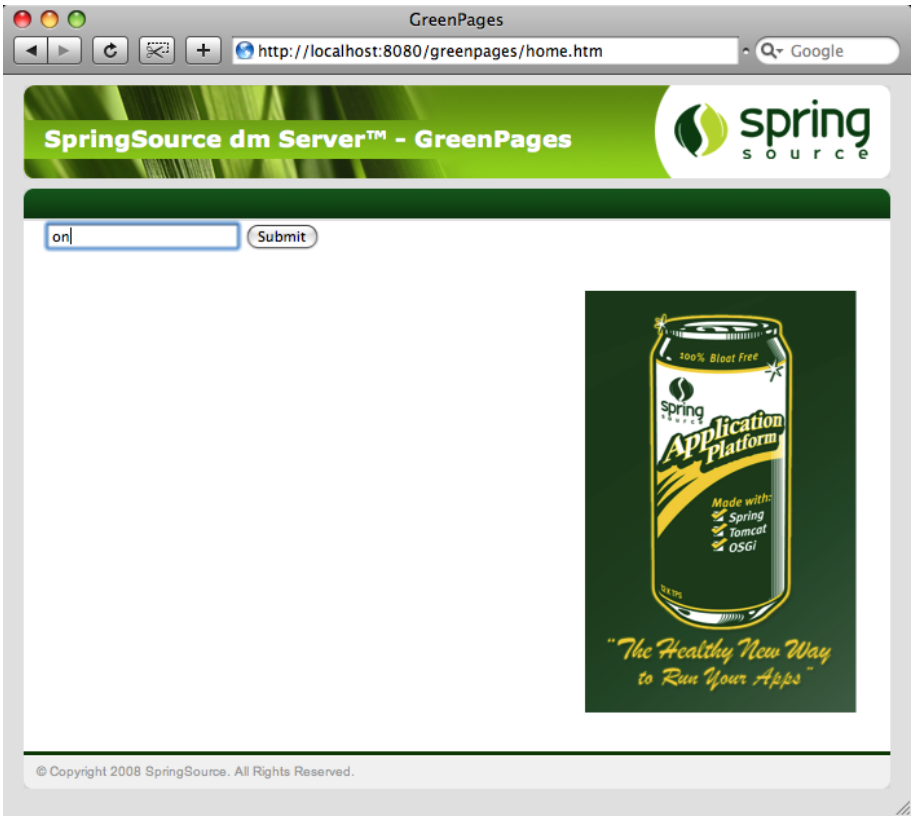
Installing and starting GreenPages on UNIX:

```
cd $DMS_HOME
cp $GREENPAGES_HOME/solution/greenpages/target/greenpages-solution-1.0.0.SNAPSHOT.par pickup/
bin/startup.sh
```

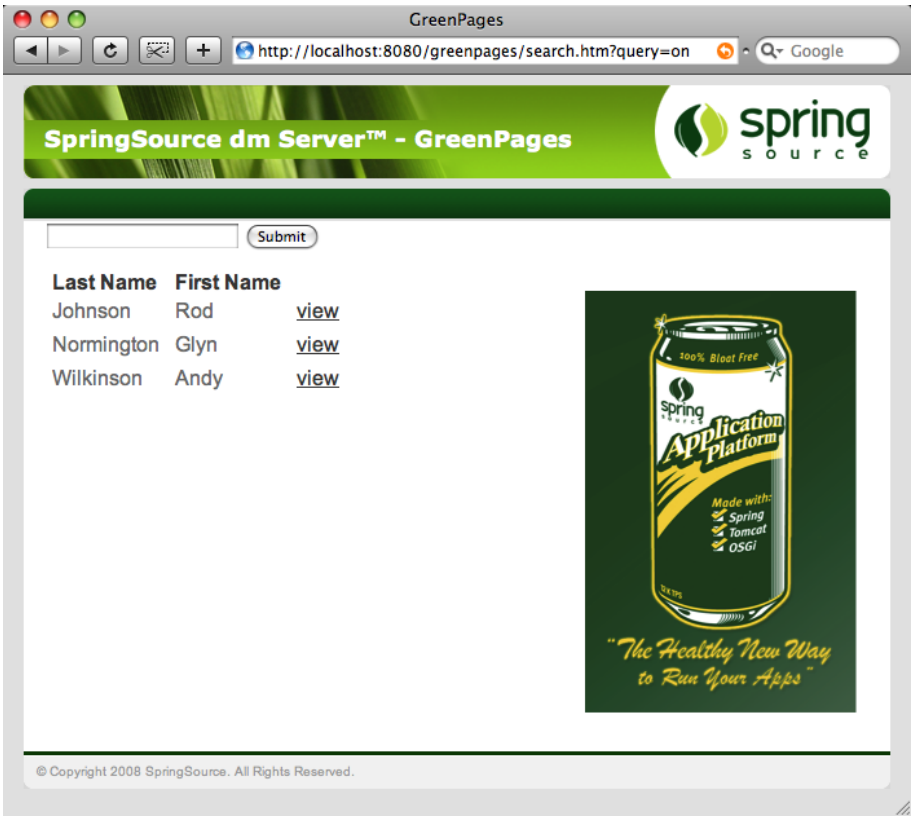
3.4 Browsing the GreenPages application

Once installed and started, the GreenPages application can be accessed with a web browser using the address http://localhost:8080/greenpages/home.htm.

From the home page, a search query can be entered into the search box:



After entering a query into the search box, the results page shows all the matches from the directory:



Clicking on a match in the search listing displays the full details for that listing:

3.5 Running GreenPages from Eclipse

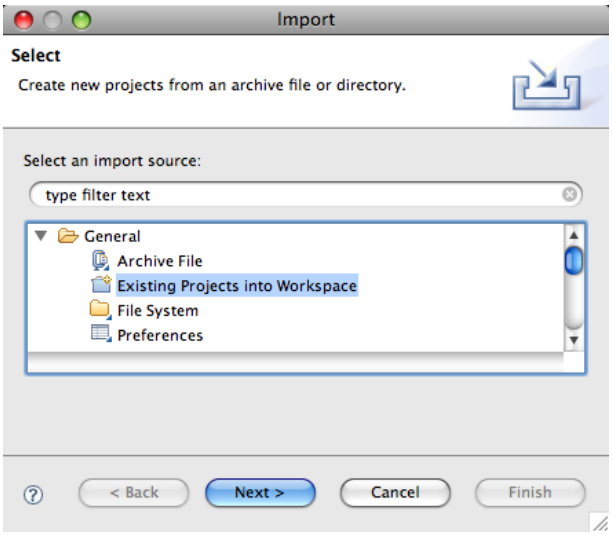
Using Eclipse and the dm Server tools, it is possible to run applications directly from the IDE. As changes are made to the application in the IDE, they can be automatically applied to the running application allowing for rapid feedback of changes in function.

Importing the GreenPages projects into Eclipse

Before the GreenPages application can be started from Eclipse, the projects need to be imported. To import the projects into Eclipse:

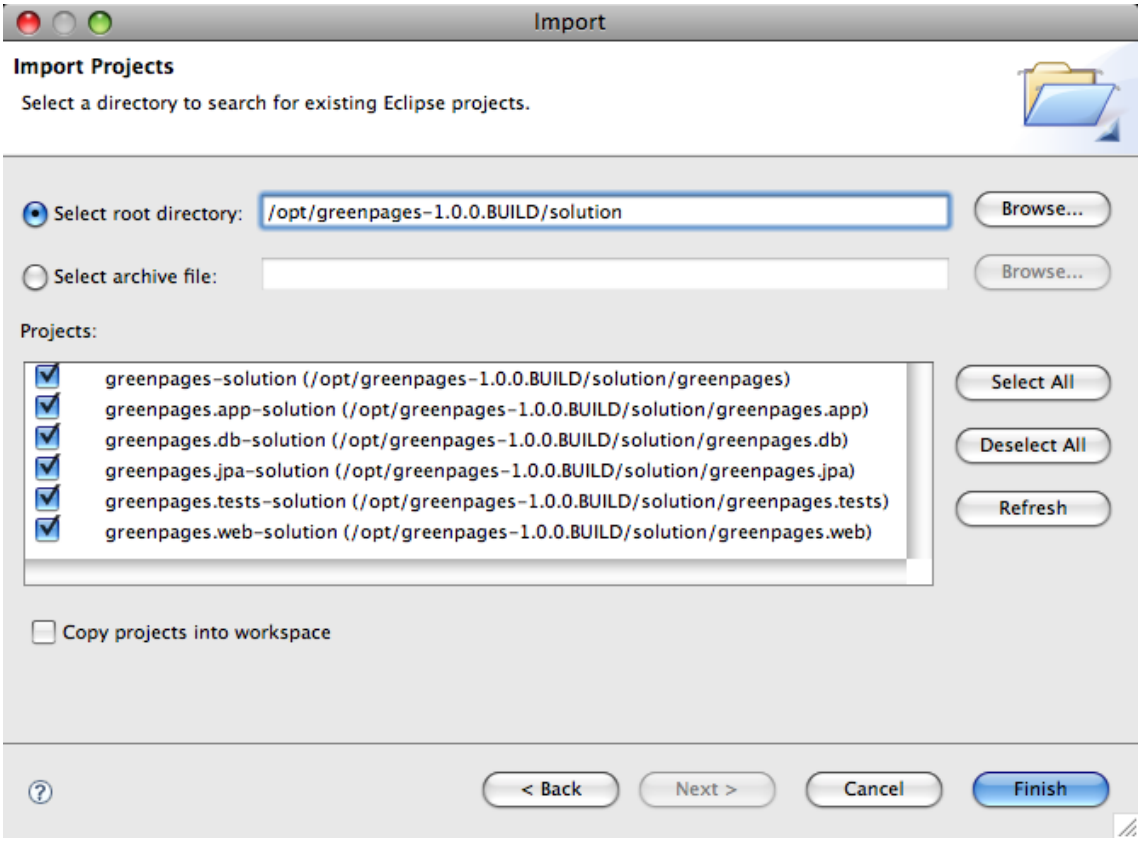
1. Open the Import Wizard using File → Import.

2. From the Import Wizard select General → Existing Projects into Workspace and click *Next*:

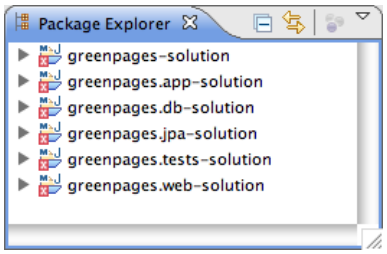


3. Click Browse… and select `$GREENPAGES_HOME/solution` as the root directory.

4. In the *Import Projects* window, select all the projects and click *Finish*:



5. Validate that the imported projects appear in Package Explorer:



There may be compilation errors at this stage.

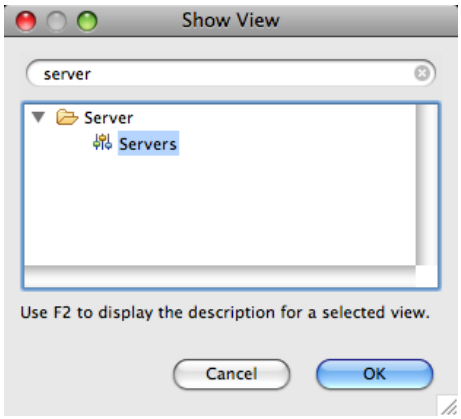
Configuring dm Server target runtime

Projects for dm Server are associated with a dm Server runtime environment in Eclipse. This is to allow launching and testing from within Eclipse, and also to allow classpath construction in Eclipse to mirror the dynamic classpath in the dm Server runtime.

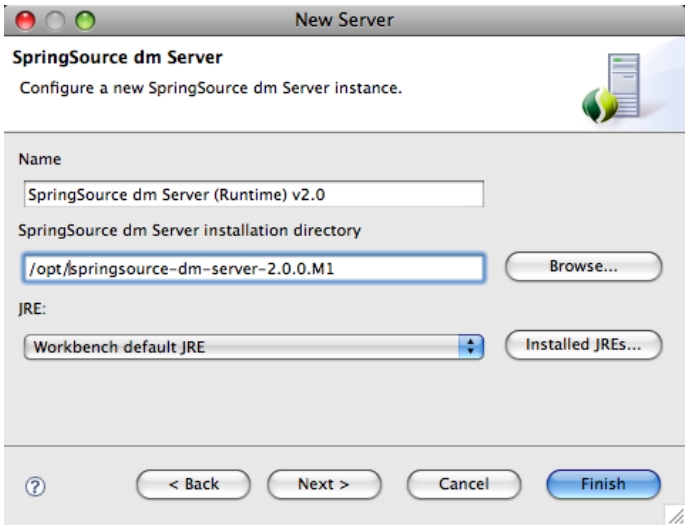
Compilation errors in the previous step will be resolved here.

To configure a dm Server runtime environment:

1. Open Window → Show View → Other….
2. In the *Show View* dialog choose Server → Servers to make the servers view visible:



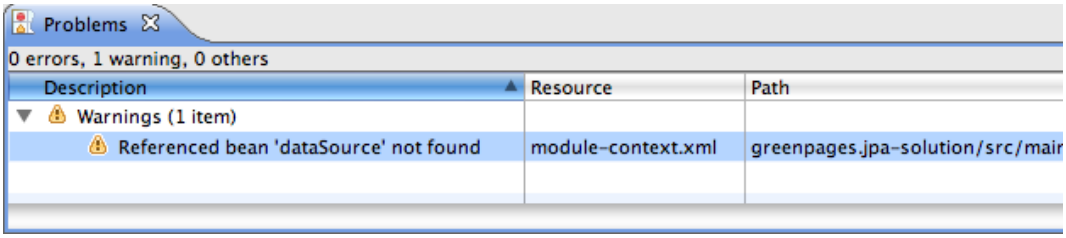
3. Right-click in the (empty) *Servers* view and select New → Server.
4. In the *New Server* dialog, choose SpringSource → SpringSource dm Server v1.0 and click *Next*.
5. Click Browse and select the `$DMS_HOME` directory. Click Finish to complete creation of the server:



6. Close and reopen all projects. Select all projects in *Package Explorer*. Right-click on the projects and choose Close Project and then Open Project.

It is possible that there remain spurious build errors from Eclipse (see the *Problems* view), in which case a project clean build may clear the problems. Select Project → Clean… from the main menu, and choose to *Clean all projects*. This process is known as the "Eclipse dance". It may be necessary to repeat this on a few projects.

Despite the dance steps outlined, there will remain a *Warning* like this:



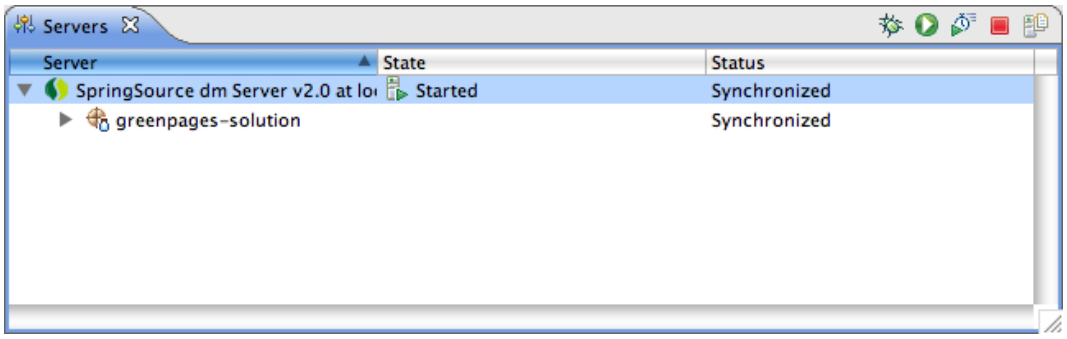
It is safe to ignore this warning.

Running GreenPages from within Eclipse

Now that GreenPages is successfully imported into Eclipse, the project can be run directly from within the IDE. Before doing so, remove a GreenPages PAR that may currently be deployed in dm Server.

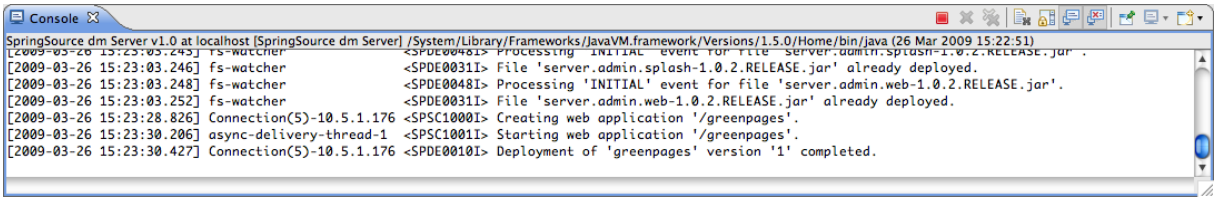
To run GreenPages from within Eclipse:

1. Drag the greeenpages PAR project from the Package Explorer onto the dm Server node in the Servers window:



2. To start dm Server from within Eclipse right-click on the dm Server node in the Servers window and choose Start.

3. Verify that GreenPages is installed correctly by checking for `<SPDE0010I> Deployment of 'greenpages' version '1' completed` in the Console window.



4. The Web Module

4.1 Introduction

In common with most Enterprise Java applications GreenPages uses a web-based interface for user interactions. The following steps show how to create the controller for the application, implement that controller using a service from the OSGi Service Registry, and deploy both bundles to the dm Server instance.

It is assumed that the instructions in Chapter 2, *Installation* have been followed already and that the GreenPages zip file has been downloaded and unzipped as described in Chapter 3, *Installing and exploring GreenPages*. Rather than working with the fully completed application a skeleton version of the projects (found in `$GREENPAGES_HOME/start`) is used to demonstrate how to build the application in stages.

4.2 GreenPages set up

Before beginning development, configure the development environment to work with the application. In the case of GreenPages this means Maven and Eclipse.

Setting up dm Server

The GreenPages application uses Maven for dependency management in Eclipse and for building at the command line. Since Maven downloads needed dependencies, it is helpful to tell dm Server to use the local Maven cache as a repository. In this step the dm Server configuration is modified to search the local Maven cache for bundles.

Open `$DMS_HOME/config/repository.config`. In this file add a new repository to the `repositories` section.

```
…
"libraries-usr" : {
  "type" : "external",
  "searchPattern" : "repository/libraries/usr/{library}"
},
"bundles-m2" : {
  "type" : "external",
  "searchPattern" : "${user.home}/.m2/repository/**/{bundle}"
}
```

Next add the `bundles-m2` repository to the `repositoryChain`.

```
"repositoryChain" : [
  "bundles-subsystems",
  "bundles-ext",
  "bundles-usr",
  "bundles-m2",
  "libraries-ext",
  "libraries-usr"
]
```

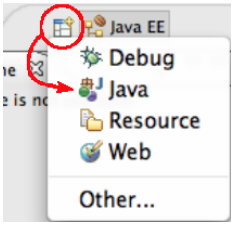
Errors in this configuration may cause the dm Server instance to fail to start later. Ensure that

this is entered correctly (cut and paste would be ideal) before proceeding.

When this is complete save the file and go to the next step.

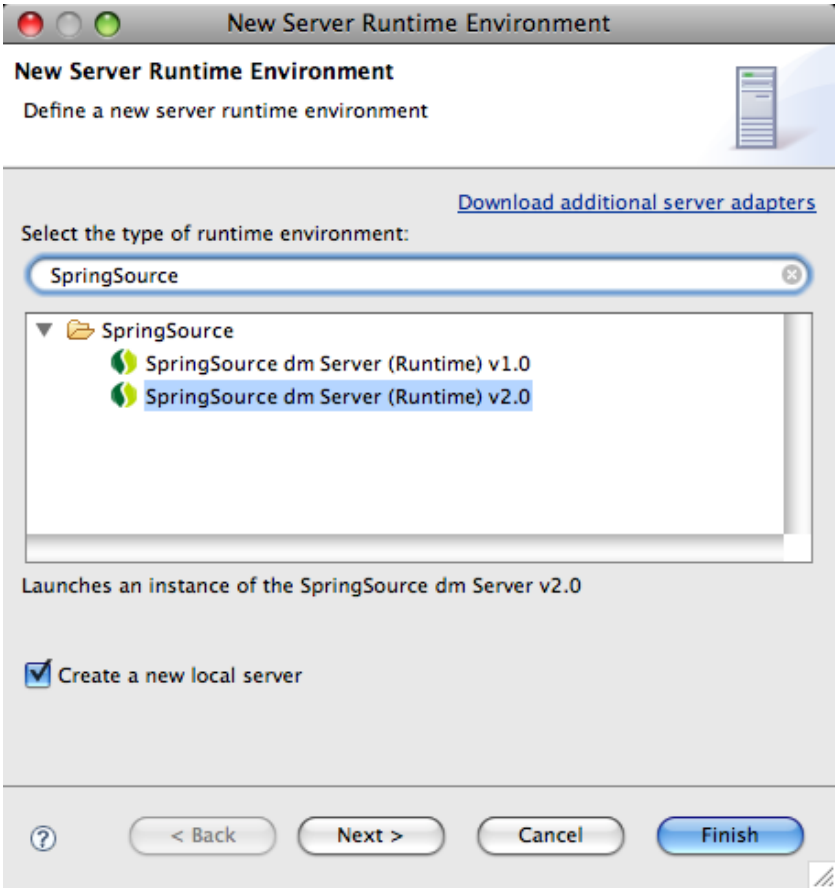
Setting up Eclipse

The following instructions are most easily followed using the Java perspective rather than the Java EE perspective. If not already in the Java perspective, switch to the Java perspective in Eclipse using the Open Perspective menu:

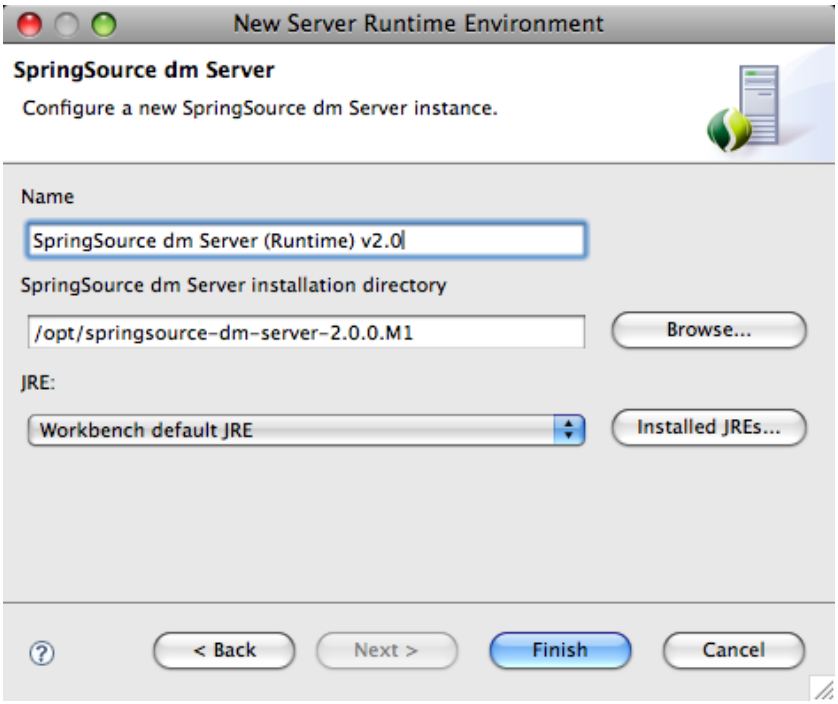


The GreenPages application also uses the SpringSource dm Server Tools. These tools integrate with the instance of dm Server that was modified earlier. In this step an instance of the dm Server runtime in Eclipse is created that the GreenPages application will integrate with.

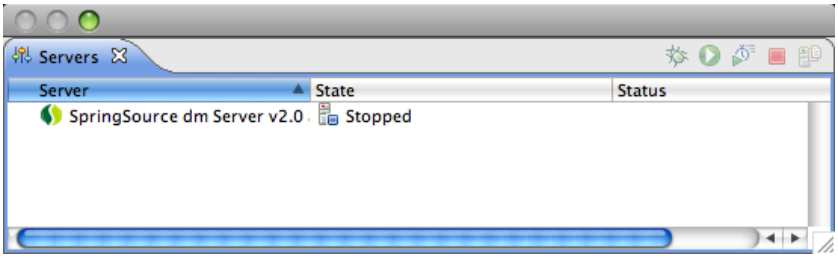
In Eclipse open Preferences → Server → Runtime Environments. Select *Add…* to create a new instance of the dm Server. In the dialog that opens, select the *SpringSource dm Server* runtime environment and check the box to create a new local server. When complete, press *Next*.



In the next dialog, set the *SpringSource dm Server installation directory* field to the value of `$DMS_HOME` and press *Finish*.



After returning to the *Preferences* window, press *OK* to return to Eclipse. The *Servers* view has opened and now shows an instance of *SpringSource dm Server* in it.



Proceed to the next step.

4.3 Creating a controller

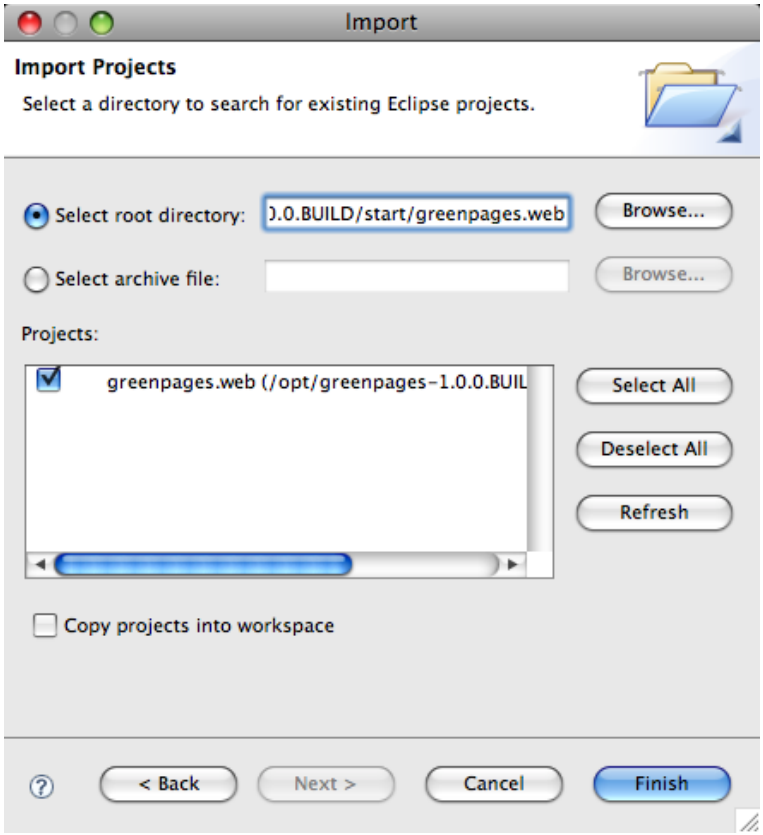
The GreenPages application uses Spring's @MVC style of web application development. A central type of this development style is the controller class.

Importing the `greenpages.web` project

The GreenPages application is divided up into a number of OSGi bundles that are represented as Eclipse projects. In this step the starting version of the `greenpages.web` project is imported.

Right-click in the *Package Explorer* view and select *Import…*. In the dialog that opens, choose General → Existing Projects into Workspace and select *Next*. In the following dialog set the *root directory* field to the value of `$GREENPAGES_HOME/start/greenpages.web` and press *Finish*.

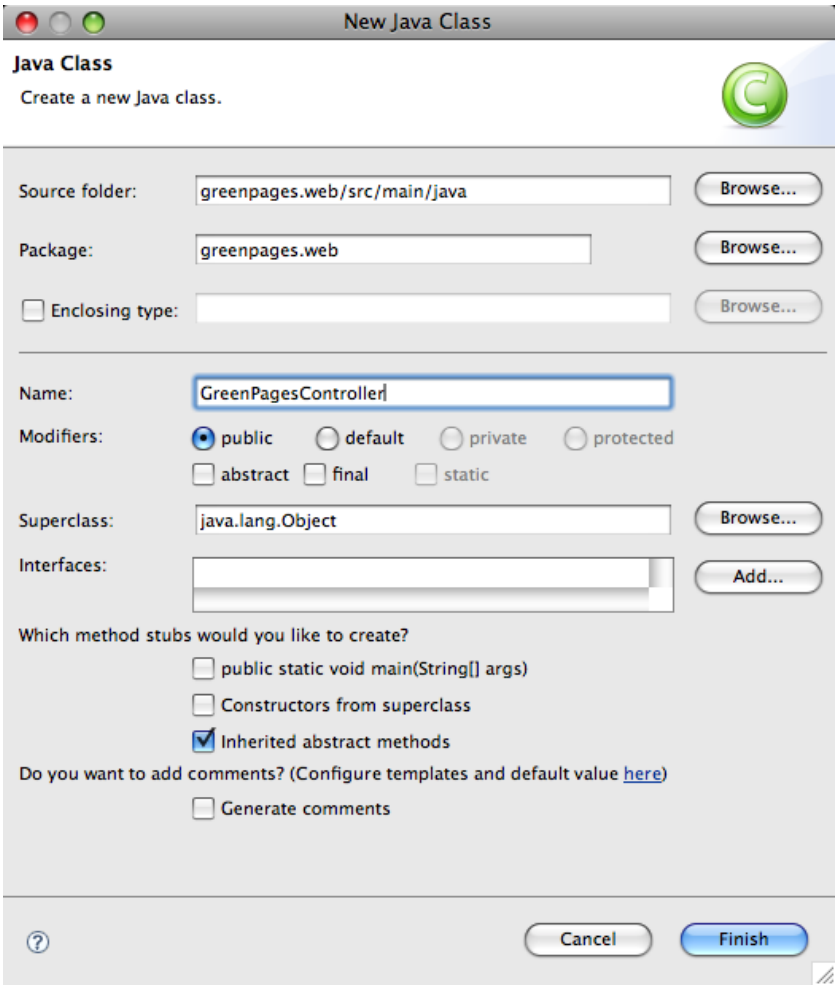
Initially this project will have compile failures in it; this is to be expected.



When Eclipse finishes importing the project, go to the next step.

Creating the controller class

Create a new `class` by right-clicking on the `greenpages.web` package in the `src/main/java` source folder and selecting New → Class. (If *Class* is not offered on the New menu, then the *Java* perspective may not be being used. Look for the *Class* option under *Other…* in the *Java* section.) Name the new class `GreenPagesController` and press *Finish*.



Next add the following code to the `GreenPagesController` class.

```
@Controller
public class GreenPagesController {

    @RequestMapping("/home.htm")
    public void home() {
    }
}
```

This will not compile. Eclipse will offer (as a *Quick Fix*) to insert imports for Spring Framework annotations `Controller` and `RequestMapping`; these should be accepted. After these changes, save the file and go to the next step.

Enable component scanning

Once the controller is written, Spring needs to be told to instantiate a bean of the controller type. In this step you enable Spring's component scanning to detect the `GreenPagesController` class.

Open the `META-INF/spring/module-context.xml` file in the `src/main/resources` source folder. In this file add the following line.

```
<context:component-scan base-package="greenpages.web"/>
```

When this is complete save the file and go to the next step.

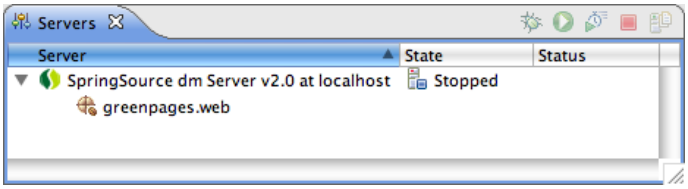
4.4 Deploying a bundle

During development time, it can be helpful to run an application inside of the deployment container. In the case of Greenpages, this means deploying the `greenpages.web` bundle to the SpringSource dm Server.

Deploying the `greenpages.web` bundle and starting the dm Server

The dm Server can be used while inside of Eclipse. In this step you will deploy the `greenpages.web` bundle and start the dm Server instance.

Drag the `greenpages.web` project from the *Package Explorer* and drop it on the dm Server instance in the *Servers* view. Expand the dm Server instance and the bundle will be shown as a child of the dm Server.



Right-click on the dm Server instance and select *Start*. If deployment has gone successfully the console will print `<SPDE0010I> Deployment of 'greenpages.web' version '1' completed.`

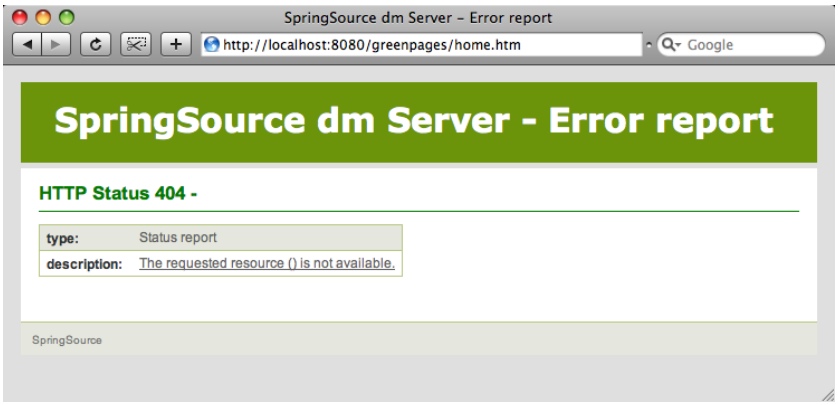
(If the server fails to start, re-check that the modifications to `server.config` were entered correctly in section the section called “Setting up dm Server”.)

When this message is displayed, leave the server instance running and go to the next step.

Creating web module metadata

The dm Server has special knowledge of the web application bundles. In this step web module metadata is added to the bundle and a web browser is used to navigate to it.

Open a web browser and navigate to http://localhost:8080/greenpages/home.htm. The link is not currently served by any bundle in the dm Server so there will be an error displayed:



To fix this issue the `greenpages.web` bundle must be declared to be a web module and a context path can be defined.

Open the `template.mf` file (at the top level under the `greenpages.web` project) and add (and save) the following entries (using the *template.mf pane* of the editor):

```
Module-Type: web
Web-ContextPath: greenpages
```

Be careful not to insert any blank lines or trailing spaces in this file.

Once added, right-click on the `greenpages.web` project and select Spring Tools → Run automatic generation of MANIFEST.MF file. This will use a tool called Bundlor to update the OSGi metadata in the `MANIFEST.MF` file. Once Bundlor has finished running, open the `META-INF/MANIFEST.MF` file in the `src/main/resources` source folder. It should look like the following:

```
Manifest-Version: 1.0
Bundle-Name: GreenPages Web
Bundle-Classpath: .
Web-ContextPath: greenpages
Import-Package: org.springframework.stereotype,org.springframework.web
 .bind.annotation,org.springframework.web.servlet.mvc.annotation,org.s
 pringframework.web.servlet.view.freemarker
Bundle-ManifestVersion: 2
Bundle-Vendor: SpringSource Inc.
Module-Type: web
Bundle-SymbolicName: greenpages.web
Export-Package: greenpages.web;version="1.0";uses:="org.springframewor
 k.stereotype,org.springframework.web.bind.annotation"
Bundle-Version: 1.0
```

By default, Bundlor generates `Import-Package` entries with no version range specified. In the absence of a version range, the OSGi default (of any version) is used. While this is very flexible it is generally a good idea to restrict an import by specifying a narrower range. This can be achieved by providing Bundlor with some additional information in the manifest template.

Add and save the following entry to the `template.mf` file:

```
Import-Template:
 org.springframework.*;version="[2.5.6.A, 3.0.0)"
```

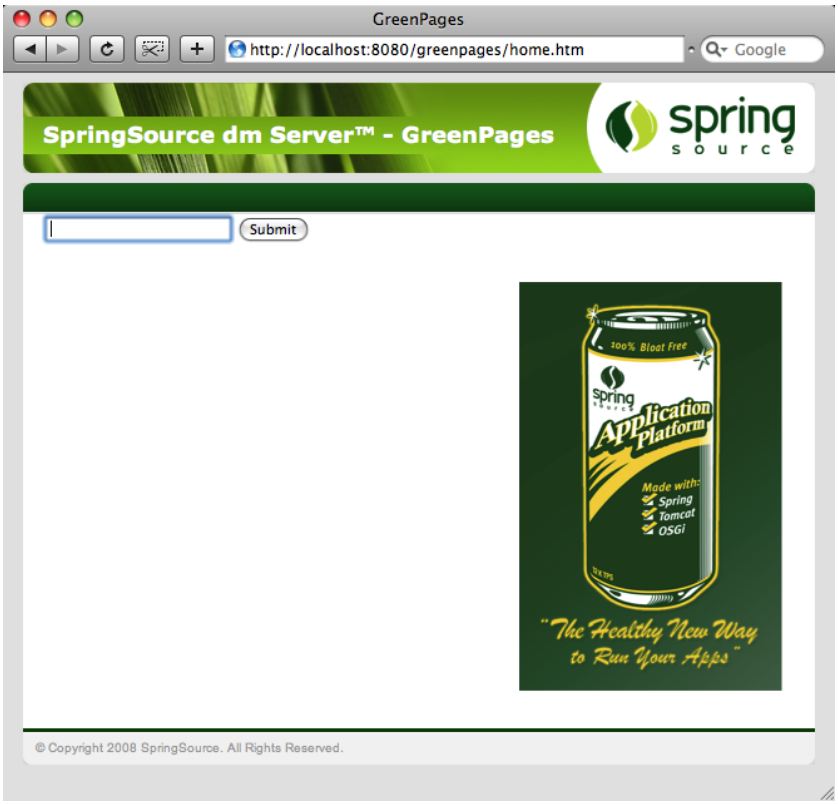
(Again, be careful not to leave trailing spaces on lines or insert blank lines in this file.)

Re-run the MANIFEST.MF generation as described earlier. In the `MANIFEST.MF` file the `Import-Package` entry should now have version ranges on each of its packages:

```
Import-Package: org.springframework.stereotype;version="[2.5.6.A, 3.0.
```

```
0)",org.springframework.web.bind.annotation;version="[2.5.6.A, 3.0.0)
",org.springframework.web.servlet.mvc.annotation;version="[2.5.6.A, 3
.0.0)",org.springframework.web.servlet.view.freemarker;version="[2.5.
6.A, 3.0.0)"
```

Behind the scenes the dm Server Tools have refreshed the deployed bundle as changes were made. Once again navigate to http://localhost:8080/greenpages/home.htm. This page now displays an entry field.



Put any characters into the entry field and press *Submit*. This should display a "404" page again, similar to before. This is because there is no search page (`search.htm`) to process this request yet. The next section will address this.

4.5 Creating a PAR

At the end of the previous step, the dm Server instance was started and the `greenpages.web` bundle deployed. This bundle shows a static home page but a search value causes an error. This error appears because the URL for that search was not serviced by the controller. The logic behind the search request is not in the `greenpages.web` project but in another project called `greenpages.app`. This section creates the `greenpages.app` project and then combines the two projects into a PAR so as to be able to deploy them together as a single unit.

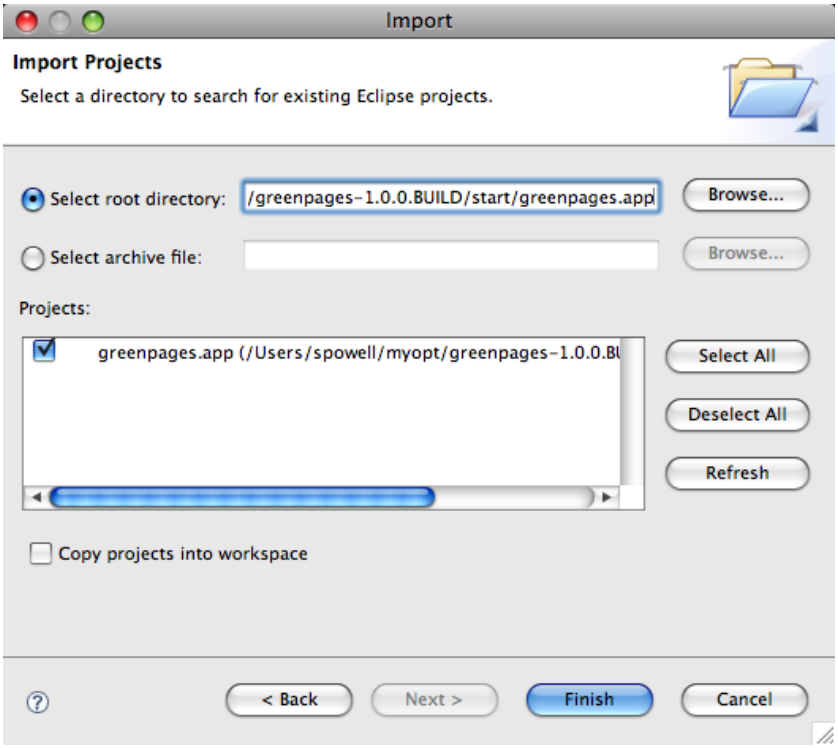
While executing these instructions it is not necessary to remove bundles from the dm Server instance, nor to stop the instance. As changes are made the bundle will be refreshed (or redeployed) and the server instance may report errors if the changes are incomplete. These may safely be ignored. Alternatively, the `greenpages.web` bundle can be removed from the dm

Server instance, or the server can be stopped while these changes are made.

Importing the `greenpages.app` project

In this step, the `greenpages.app` project is imported which contains the business interfaces (and stub implementations of these interfaces).

In the same way that the starting `greenpages.web` project was imported (in section the section called “Importing the greenpages.web project”) import the `$GREENPAGES_HOME/start/greenpages.app` project.



When Eclipse finishes importing the project, go to the next step.

Adding the controller implementation

The controller implementation will depend on the `Directory` and `Listing` interfaces found in the `greenpages.app` project. In this step, the implementation is added.

Open the `GreenPagesController` class. Add the following field and methods to the class:

```
@Autowired
private Directory directory;

@RequestMapping("/search.htm")
public List<Listing> search(@RequestParam("query") String query) {
  return this.directory.search(query);
}

@RequestMapping("/entry.htm")
public Listing entry(@RequestParam("id") int id) {
  return this.directory.findListing(id);
}
```

Add the (*Quick Fix*) suggested imports for the annotations `Autowired` and `RequestParam`, and choose the import for `List< >` from `java.util.List`.

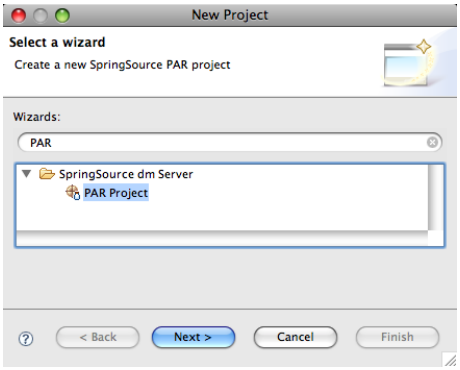
Eclipse will not be able to suggest import statements for the `Listing` and `Directory` types. This is because the `greenpages.web` and `greenpages.app` projects are not linked together and therefore cannot see each other's types.

Proceed to the next step.

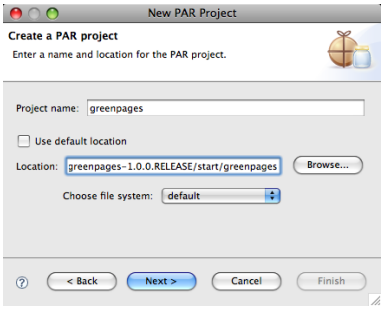
Creating a PAR project

In dm Server, applications consisting of multiple bundles can be packaged as part of a PAR. In this step a PAR project containing the `greenpages.web` and `greenpages.app` bundles is created and deployed to the server.

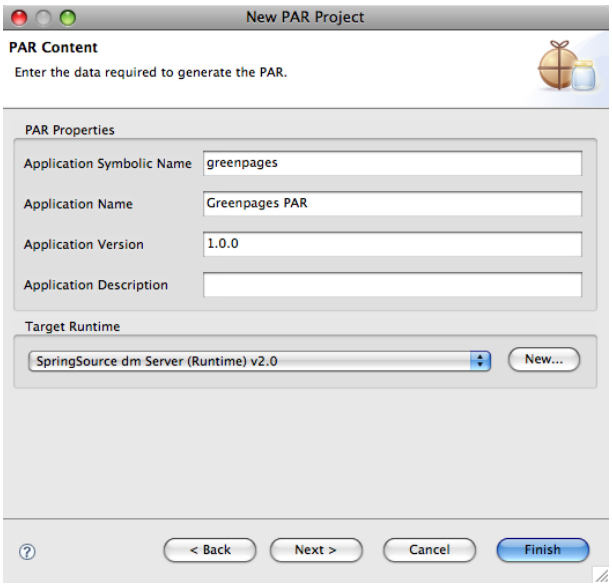
Right-click in the *Package Explorer* and select New → Project…. In the dialog that opens select SpringSource dm Server → PAR Project and press *Next*:



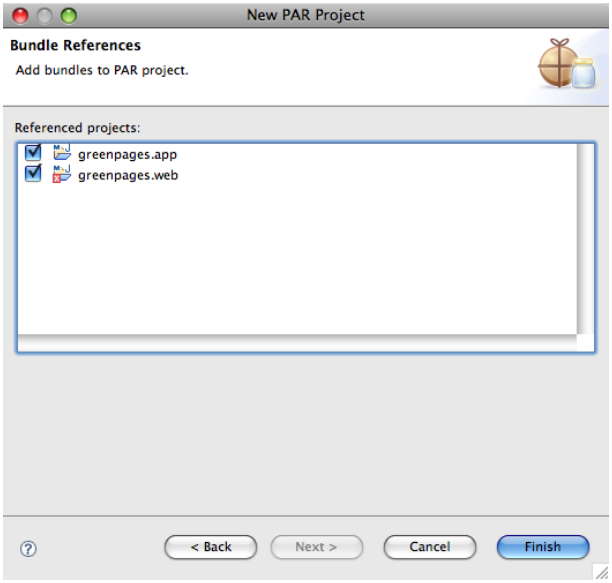
In the New PAR Project dialog, ensure the *Use default location* option is unchecked, name the project `greenpages`, set the location to `$GREENPAGES_HOME/start/greenpages` and press *Next*.



In the next dialog, some of the PAR properties are pre-populated. Ensure that the *Target Runtime* is set to *SpringSource dm Server (Runtime)* and press *Next*.

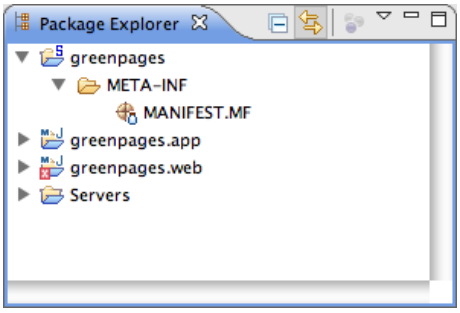


In the next dialog, select the `greenpages.app` and `greenpages.web` bundles so that they are contained in the PAR and press *Finish*.



`greenpages.web` still has errors these are soon to be fixed.

The package explorer view will now show the following:



PAR project creation is complete, go to the next section.

4.6 Referencing an OSGi Service

In an OSGi-based application, the business logic behind a controller is typically accessed through the OSGi Service Registry.

Exporting Packages

By default, Bundlor detects and exports all packages in a bundle. In this step Bundlor is told what to export from the `greenpages.app` bundle and which types from those packages to use in the `greenpages.web` bundle.

Add and save the following entry to the `template.mf` file in the `greenpages.app` project and then run the MANIFEST.MF generation on the project as explained in the section called “Creating web module metadata”.

```
Excluded-Exports:
 greenpages.internal
```

(As before, be careful not to leave trailing spaces on the ends of lines and not to add any blank lines to the file.)

Check that the package is no longer exported in the `greenpages.app` `MANIFEST.MF` file which should look like this:

```
Manifest-Version: 1.0
Bundle-Name: GreenPages Service
Bundle-Classpath: .
Import-Package: org.springframework.stereotype;version="[2.5.6.A,3.0.0)"
Bundle-ManifestVersion: 2
Bundle-Vendor: SpringSource Inc.
Bundle-SymbolicName: greenpages
Export-Package: greenpages;version="1.0"
Bundle-Version: 1.0
```

Once Bundlor has done this, go to the next step.

Referencing Projects and Packages

Now that the `greenpages.app` bundle exports the package that the `Directory` and `Listing` interfaces reside in, the `greenpages.web` bundle must import it. In this step you will update the Maven `pom.xml` file to depend on the `greenpages.app` bundle and import the package.

Open the `pom.xml` file in the `greenpages.web` project. In this file add the following entry (between the `<dependencies>` tags):

```
<dependency>
  <groupId>com.springsource.dmserver</groupId>
  <artifactId>greenpages.app</artifactId>
  <version>${project.version}</version>
</dependency>
```

Open the `GreenPagesController` class and import the `Listing` and `Directory` types. Eclipse should now offer these as a *Quick Fix*. The class should now compile cleanly.

The following imports should now have been added to the `GreenPagesController` class:

```
import java.util.List;

import greenpages.Directory;
import greenpages.Listing;

import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.stereotype.Controller;
import org.springframework.web.bind.annotation.RequestMapping;
import org.springframework.web.bind.annotation.RequestParam;
```

Add the following package clause to the `Import-Template` entry in the `template.mf` file in the `greenpages.web` project. When added run the MANIFEST.MF generation on the project as described in the section called “Creating web module metadata”.

```
greenpages.*;version="[1.0.0, 1.0.1)"
```

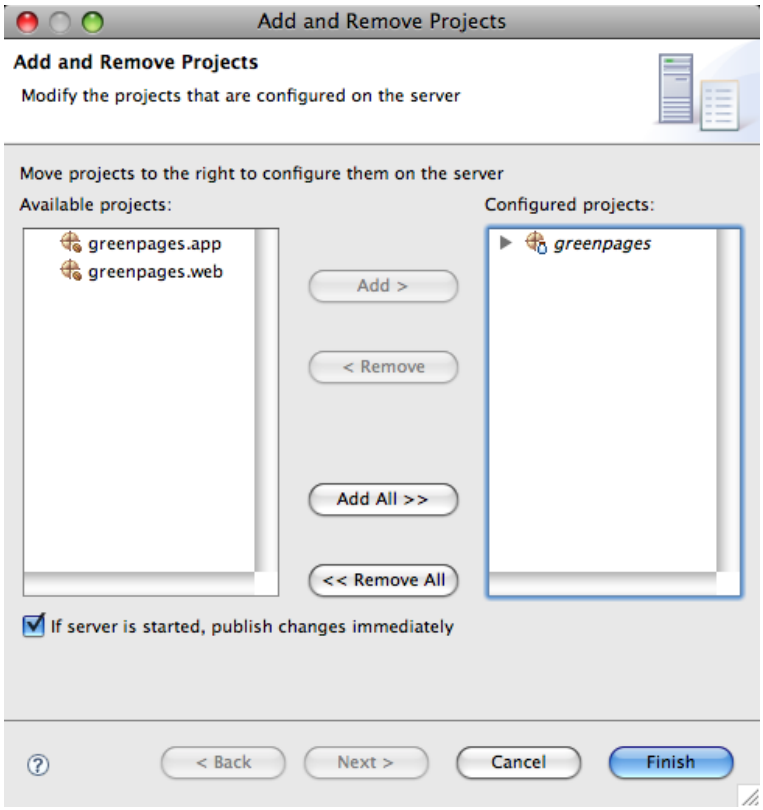
Be careful to include the “`.*`” in the package pattern.

Once Bundlor has finished, go to the next step.

Deploying a PAR

Currently the dm Server instance has a single web module bundle deployed. In this step, the `greenpages.web` bundle is undeployed and `greenpages` PAR is deployed.

Right-click on the dm Server in the *Servers* view, and select *Add and Remove Projects.…*. In the dialog that opens, remove the `greenpages.web` bundle and add the `greenpages` PAR to the server. When the configuration is complete, press *Finish*.



Eclipse automatically undeploys the `greenpages.web` bundle and deploys the `greenpages` PAR. When this happens, the deployment fails with an error. One of the exceptions in the exception list that is included is similar to:

```
Caused by: org.springframework.beans.factory.NoSuchBeanDefinitionException: No unique bean of type
    [greenpages.Directory] is defined: Unsatisfied dependency of type [interface greenpages.Directory]:
    expected at least 1 matching bean
```

This error is caused by there being no instance of `Directory` to inject into the controller. The next section will supply one.

Referencing an OSGi Service

There is no instance of `Directory` to be injected into the controller. In the GreenPages application, it is intended that this implementation is used through an interface in the OSGi *Service Registry*. Using a service in the Service Registry enables another bundle to provide an implementation without revealing the implementation or the provider to all clients of the service. dm Server supports the use of the Spring DM *namespace* for referencing elements in the OSGi Service Registry. This step adds an OSGi Service Reference to an implementation of the `Directory` interface.

In the `META-INF/spring/osgi-context.xml` file in the `greenpages.web` project add a reference to a `greenpages.Directory` instance in the OSGi service registry using the `<osgi:reference/>` tag as follows:

```
<osgi:reference id="directory" interface="greenpages.Directory"/>
```

The tools will automatically redeploy the `greenpages.web` bundle when the change to the bean definition has been saved. As the redploy happens, the following error will occur:

```
<SPCC0001W> Mandatory reference '&directory' in bundle
  'greenpages-1-greenpages.web' version '1.0.0' is waiting for service with filter
  '(&(objectClass=greenpages.Directory)(!(com.springsource.server.app.name=*)))'.
```

This error indicates that there is no provider of a `greenpages.Directory` in the Service Registry. The next step will address this.

The error is re-issued as the dm Server instance waits for the service to be supplied. After about five minutes the server will “time-out” and the deploy will be abandoned. This same error (and time-out) will occur each time the PAR is redeployed as each change is made.

Stop the server instance by right-clicking on the server in the *Servers* view and selecting *Stop*. This will avoid unnecessary delays as changes are made.

4.7 Publishing an OSGi Service

At the end of the previous step, a dependency was created on an OSGi Service Registry exposed instance of `greenpages.Directory`. The application would not start because no other bundle was contributing an instance of this service to the Service Registry.

Stop the server instance before proceeding.

Add Implementation

In this step Spring’s context scanning is added which will create an instance of the `DirectoryImpl` class.

Open the `greenpages.internal.DirectoryImpl` class in the `greenpages.app` project. Add the `@Component` annotation to the class:

```
@Component("directory")
public class DirectoryImpl implements Directory {
…
```

generating imports with Eclipse’s help if necessary.

Open the `META-INF/spring/module-context.xml` in the `greenpages.app` project. Add component scanning to this file:

```
<context:component-scan base-package="greenpages.internal"/>
```

When complete, go to the next step.

Publish OSGi Service

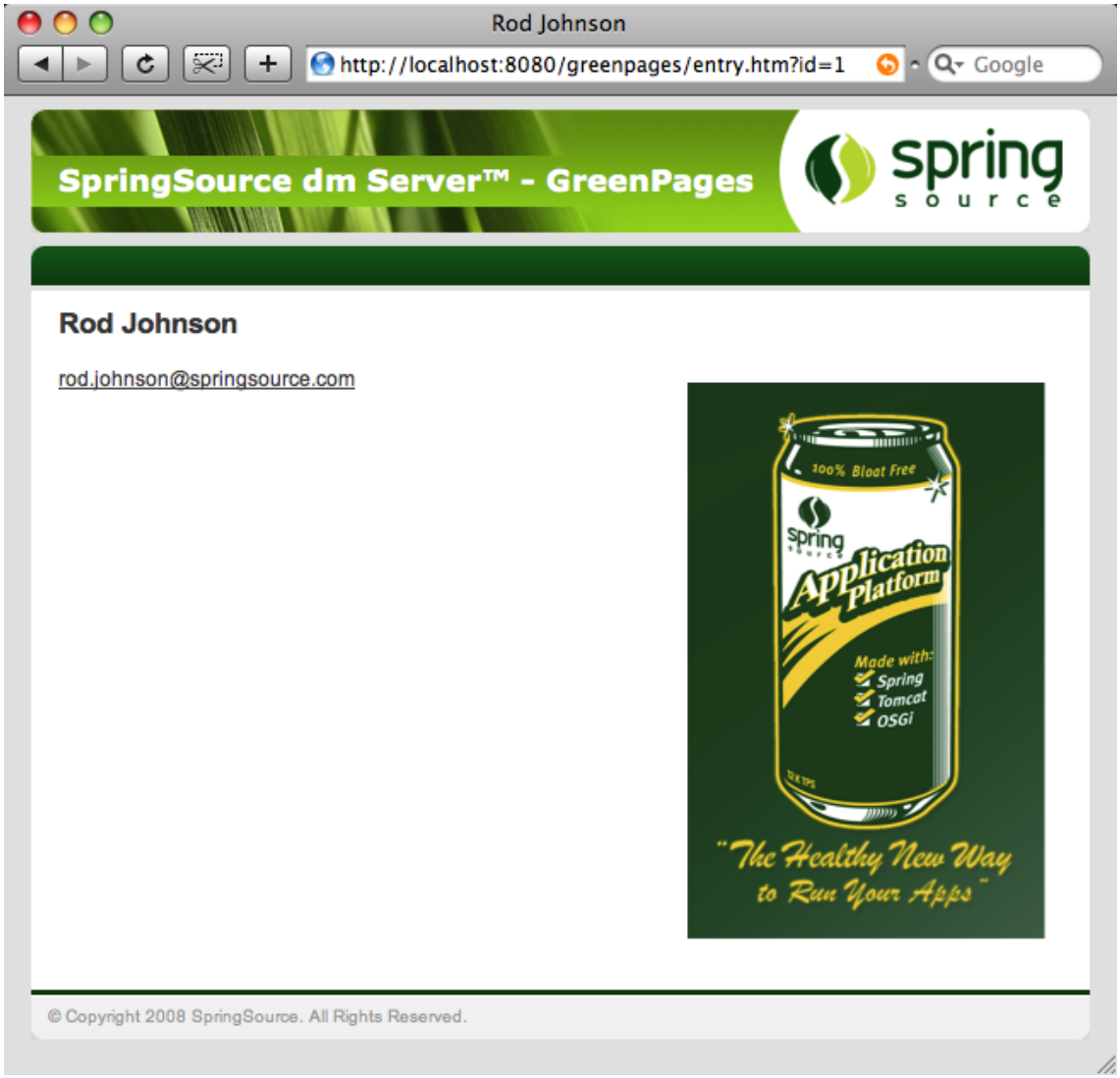
In this step the `DirectoryImpl` instance is published to the OSGi Service Registry.

Open the `META-INF/spring/osgi-context.xml` file. Add the `<osgi:service/>` tag to publish the `directory` bean with an interface of `greenpages.Directory`.

```
<osgi:service ref="directory" interface="greenpages.Directory"/>
```

A Working Web Application

Start (or restart) the dm Server instance from the `Servers` view. If the GreenPages PAR was not removed before, it will be automatically deployed, otherwise deploy it as before. There should be no errors reported. When GreenPages is deployed succesfully, open a web browser and navigate to http://localhost:8080/greenpages/home.htm. On the home page type `johnson` into the search field and press *Submit*. Unlike the previous attempt, this should return a list (of size 1) of search results. From here, select *view* to get the "detailed" listing.



This uses a stub implementation of the `Directory` interface which only knows about "Rod Johnson".

The web interface is complete enough. Go to the next chapter to see the middle tier implementation.

5. The Middle Tier

5.1 Introduction

GreenPages' middle-tier provides implementations of the `Directory` and `Listing` interfaces that can be used by the web module. The implementation will use EclipseLink JPA to access a database via a `DataSource` published in the OSGi service registry.

The database

The GreenPages application uses a very simple database that contains a single table. The table, named `LISTING`, consists of four columns:

LISTING_NUMBER	FIRST_NAME	LAST_NAME	EMAIL_ADDRESS

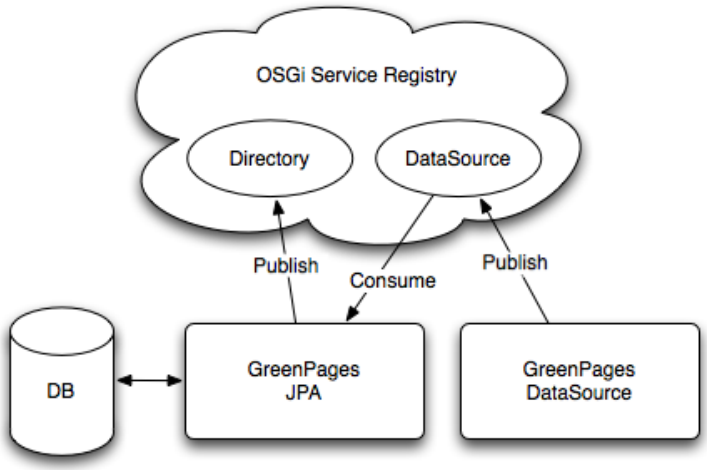
Scripts are provided with the sample source code (in `$GREENPAGES_HOME/db`) to start, create, and populate the database. These will be used during the creation of the middle tier.

Using JPA

The middle tier will provide JPA-based implementations of the `Directory` and `Listing` interfaces with the four attributes of a `Listing` (first name, last name, email address, and id) being mapped to the corresponding columns in the `LISTING`. JPA will be used to implement the queries that search the database and return `Listings`.

Structure

The middle tier consists of two bundles, `greenpages.jpa` that publishes a `Directory` implementation for consumption by the Web module, and `greenpages.db` to configure and publish the `DataSource` used to access the database.

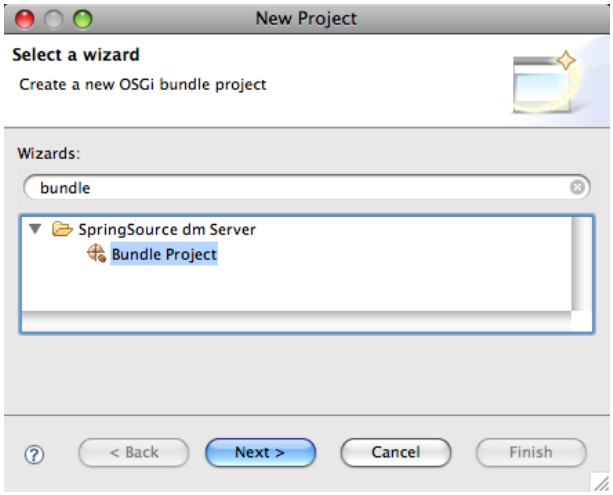


5.2 Creating the DataSource project

This section describes how to use the bundle project creation wizard to create a new `Bundle Project`. The project's Spring bean definition files will also be created using the Spring bean configuration file creation wizard.

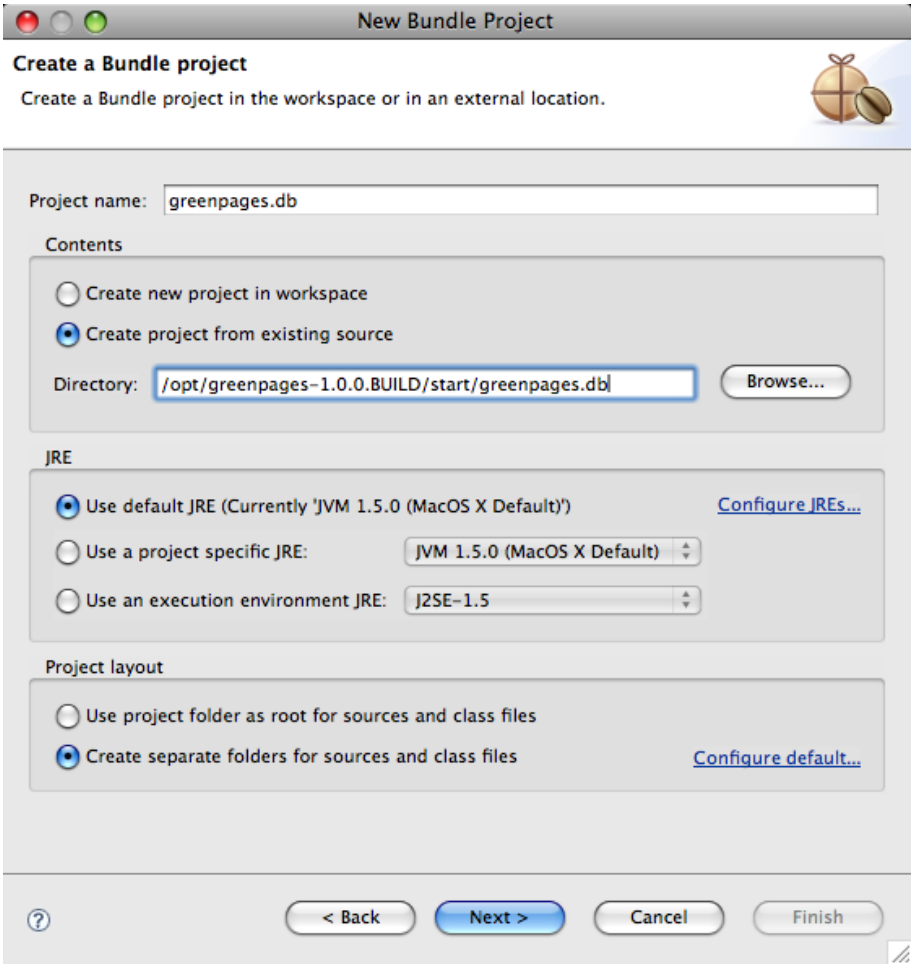
Creating a new Bundle Project

Create a new project by right-clicking in the *Package Explorer* view and selecting New → Project…. In the resulting dialog select SpringSource dm Server → Bundle Project and press *Next*:



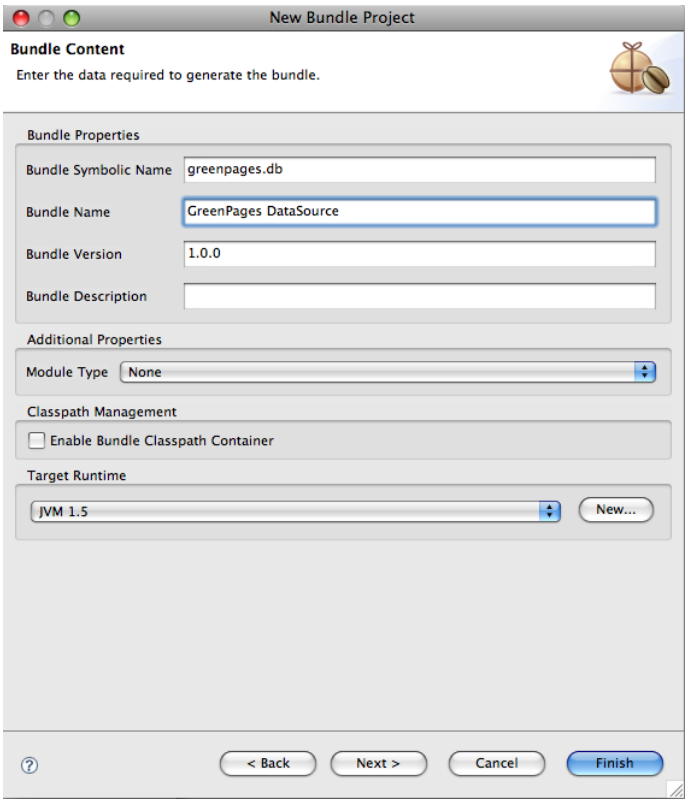
In the *New Bundle Project* dialog, name the project `greenpages.db`. Choose the create the project from an existing source location and specify a location that will place the new `greenpages.db` alongside the project skeletons that were imported into the workspace earlier. If the `start` directory of the GreenPages sample is being used this will be

`$GREENPAGES_HOME/start/greenpages.db`. Click *Next*.



In this page of the wizard, many of the *Bundle Properties* are already populated. The `Bundle-SymbolicName` is the name of the project. The `Bundle-Name` is derived from the `Bundle-SymbolicName`. The `Bundle-Version` is set to `1.0.0`, and there is no `Bundle-Description`.

Change the `Bundle-Name` to "`GreenPages DataSource`" to more accurately describe the bundle's purpose. An option to select a 'Bundle Classpath Container' is already selected. It should be de-selected, as a Maven Classpath container will be configured later. Lastly, check the target runtime JVM version is appropriately configured; it should specify a JVM version of 1.5 or later. Click *Finish*.



The `greenpages.db` project appears in the *Package Explorer* view.

Configuring the project's classpath container

Before a Maven Classpath Container can be added to the project, a `pom.xml` file must be created. Create a new file in the root of the `greenpages.db` project named `pom.xml` and add the following contents to it:

```
<?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">

        <parent>
                <groupId>com.springsource.dmserver</groupId>
                <artifactId>greenpages.parent</artifactId>
                <version>1.0.0.SNAPSHOT</version>
                <relativePath>../parent</relativePath>
        </parent>

        <modelVersion>4.0.0</modelVersion>
        <groupId>com.springsource.dmserver</groupId>
        <artifactId>greenpages.db</artifactId>
        <name>greenpages.db</name>
        <packaging>jar</packaging>

        <dependencies>
        </dependencies>

</project>
```

Save the file.

A Maven Classpath Container can now be added to the project. Right-click the `greenpages.db` project in the Package Explorer and select Maven 2 → Use Maven dependency management. Eclipse will perform some workspace building, and the

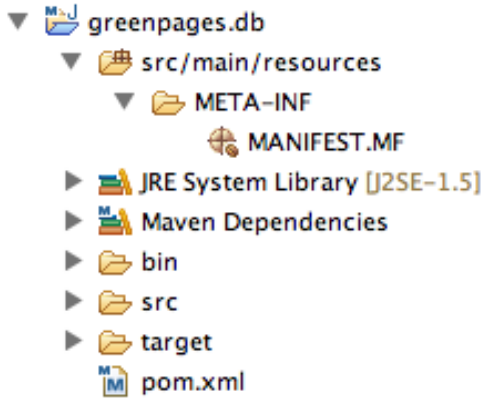
`greenpages.db` project will now be marked as a Maven project.

Configuring the source folders

The last part of the setup of the project is to configure its source folders. Return to the *Properties* dialog of the `greenpages.db` project (from the *Package Explorer* view). Select *Java Build Path* on the left-hand side and the *Source* tab on the right-hand side. Remove *both* of the pre-configured source folders by selecting them and clicking *Remove*.

Now click *Add folder* and then *Create new folder…*. Specify `src/main/resources` as the folder name and click *Finish*, then *OK* and *OK* again.

The final change to be made is to drag the `META-INF` folder from `src` to `src/main/resources`. Once these changes have been made the project will appear similar to the following in the *Package Explorer* view:



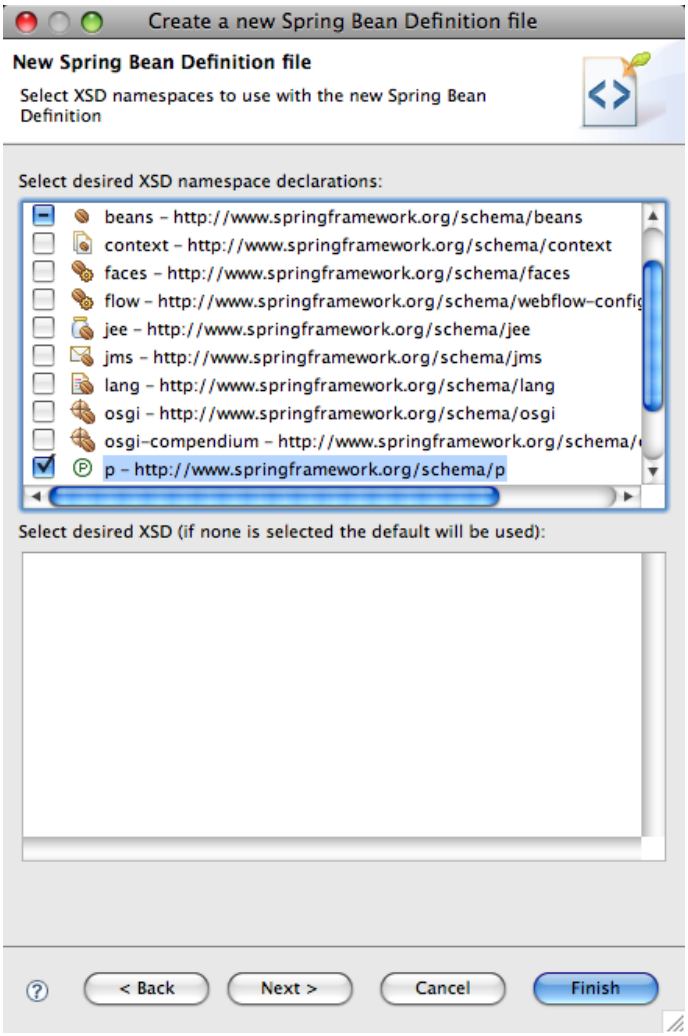
Configuring the DataSource

The DataSource bundle's main rôle is to configure and create a `DataSource` object and to publish this to the OSGi service registry. This will be done by creating a handful of Spring beans.

By default, Spring DM looks for application context files in a bundle's `META-INF/spring` directory. Create a new folder named `spring` in the `greenpages.db` project's `META-INF` folder. Having created the new folder, right-click it in the Package Explorer and select New → Spring Bean Configuration File. This will open the wizard for creating Spring bean configuration files.

In the wizard enter a `File name` of `module-context.xml` and click *Next*:

Add the *p - http://www.springframework.org/schema/p* namespace declaration to the pre-selected *beans* declaration and then click *Finish*.



Update the newly-created file (which is opened by Eclipse) to declare a bean that defines the `DataSource` object that will be used to access the GreenPages database. Do this by adding the following bean declaration:

```
    <bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource"
        p:driverClassName="org.h2.Driver"
        p:url="jdbc:h2:~/greenpages-db/greenpages"
        p:username="greenpages"
        p:password="pass"
        init-method="createDataSource"
        destroy-method="close" />
```

The new bean has introduced a dependency on Commons DBCP, which will cause an error to be reported by Eclipse.

This dependency must be recorded in the project's pom file. Open the pom file for `greenpages.db` and add the following dependency between the `<dependencies>` tags:

```
        <dependency>
            <groupId>org.apache.commons</groupId>
            <artifactId>com.springsource.org.apache.commons.dbcp</artifactId>
        </dependency>
```

Save the updated pom and then switch back to the editor for `module-context.xml`. Save the updated file and observe that the previously reported problem has now been resolved as

Commons DBCP is available on the classpath. (If this is not resolved automatically, it may be necessary to close and open the `greenpages.db` project in the *Package Explorer* view.)

Now that the `DataSource` bean is available, it can be published into the OSGi service registry.

Right-click the `spring` folder and select New → Spring Bean Configuration File. This time specify a name of `osgi-context.xml`, click *Next*, and add the `osgi` namespace declaration. Click *Finish* and then add the following to the new file to publish the `DataSource` as a service:

```
    <!--
        export the dataSource bean to the OSGi service registry under the
        DataSource interface
    -->
    <osgi:service ref="dataSource" interface="javax.sql.DataSource" />
```

Configuring Bundlor's manifest template

Bundlor uses a manifest *template* to control the contents of the generated manifest. Create a new file named `template.mf` in the root of the `greenpages.db` project. Open the existing `MANIFEST.MF` and switch to the `MANIFEST.MF` tab to view its source. Copy the contents. Switch to the editor for `template.mf`, switch to the `template.mf` tab and paste the contents from `MANIFEST.MF`. These entries will tell Bundlor what the resulting manifest's bundle symbolic name, bundle version, etc. should be. Save the updated template.

Still in the `template.mf` editor switch to the *Overview* tab and click *Update MANIFEST.MF* which is under the "Bundle Actions" section.

At this point Bundlor will scan the project to determine its dependencies. It will scan both `module-context.xml` and `osgi-context.xml` looking for references to classes. For each class to which it finds a reference, an import for the class's package will be added to the resulting manifest.

In this case, Bundlor will generate imports for both `javax.sql` and `org.apache.commons.dbcp`. The import for `org.apache.commons.dbcp` will result in an error as the package cannot be resolved. (`javax.sql` may also be unresolved.) The `greenpages.db` project needs to be associated with a dm Server instance which has the Commons DBCP bundle in its repository. This is achieved in the next step by adding the `greenpages.db` project to the GreenPages PAR, this will result in it inheriting the PAR project's targetted runtime configuration.

Double-click the `MANIFEST.MF` file in the `greenpages` project in the *Package Explorer* view. Switch to the `Dependencies` tab and click *Add…*. Select `greenpages.db` and click *OK*. Save the updated file. The problem concerning the `org.apache.commons.dbcp` dependency should now be resolved (along with any other resolution errors) and (if the server is running) the GreenPages application will be redeployed due to the addition of the `greenpages.db` module. Start the server if it is not already running and observe that this deployment fails.

The deployment will fail because the `org.h2.Driver` class that is referenced in the `DataSource` bean's definition in `module-context.xml` is not available to the bundle.

(Check for the exception `org.springframework.beans.factory.BeanCreationException` with text: "`Error creating bean with name 'dataSource' defined in URL [bundleentry://84/META-INF/spring/module-context.xml]: Invocation of init method failed; nested exception is org.apache.commons.dbcp.SQLNestedException: Cannot load JDBC driver class 'org.h2.Driver'`".)

There are a few cases where Bundlor will not identify a dependency on a class and, at the moment, this is one of them, although this is an area of Bundlor that is being improved all the time. Thankfully it's easy to add the required import by making a simple update to the template.

Open the editor for the `template.mf` file in the `greenpages.db` project and add the following `Import-Package` header and save the updated manifest:

```
Import-Package: org.h2;version="[1.0.71,1.0.71]"
```

Saving the manifest will trigger a redeployment (or click on *Update MANIFEST.MF* as before) which will fail if the H2 database is not available. (Refer to the section the section called "Starting and configuring the database" in Chapter 3, *Installing and exploring GreenPages* to run and configure the database.)

If the database is running the GreenPages application should correctly deploy. Although the application web front-end will run, the database contents is not visible, of course, because we are still running with the stub version of the `search` method on the controller. The implementation of the `Directory` service needs to be changed to exploit the database.

5.3 Building the JPA module

In this section the JPA module in GreenPages is created, building upon an existing skeleton. JPA and its metadata are configured, and a JPA-based Directory service implementation is published which is then consumed by the application's Web module.

Completing the JPA-based Directory implementation

The `greenpages.jpa` starter project provides the beginnings of a JPA-based implementation of `Directory` named `JpaDirectory`. Import the `greenpages.jpa` project from the `$GREENPAGES_HOME/start` directory.

Open the `JpaDirectory.java` source file in the `greenpages.jpa` package of `greenpages.jpa` project (under `src/main/java`).

The source file contains a Java Persistence Query Language (JPQL) search query that will be used to retrieves listings from the database and empty implementations of the `search` and `findListing` methods.

First add an `EntityManager` to it. Before the new field can be added, `EntityManager`

must be available on the classpath. Open the pom for `greenpages.jpa` and add the following dependency:

```
        <dependency>
            <groupId>javax.persistence</groupId>
            <artifactId>com.springsource.javax.persistence</artifactId>
        </dependency>
```

Now return to `JpaDirectory` and add the following field to the class along with an import for `javax.persistence.EntityManager` (which should be suggested by Eclipse):

```
    private EntityManager em;
```

This `EntityManager` can now be used to implement the `search` and `findListing` methods. Update the implementations of these two methods to match the following implementations and then save the updated class:

```
    public Listing findListing(int id) {
        return em.find(JpaListing.class, id);
    }

    @SuppressWarnings("unchecked")
    public List<Listing> search(String term) {
        return em.createQuery(SEARCH_QUERY).setParameter("term",
                "%" + term.toUpperCase() + "%").getResultList();
    }
```

(Warnings from Eclipse should now be absent.)

The application context now needs to be updated to create `JpaDirectory` and to create an `EntityManager` that can be injected into `JpaDirectory`.

Open `module-context.xml` in the `META-INF/spring` folder of the `greenpages.jpa`. Add the following beans that will create `JpaDirectory` and an `EntityManager`, enable load-time weaving that is required by JPA, and enable annotation-based configuration that will allow the `EntityManager` to be injected into `JpaDirectory`:

```
    <!--
        Activates a load-time weaver for the context. Any bean within the
        context that implements LoadTimeWeaverAware (such as
        LocalContainerEntityManagerFactoryBean) will receive a reference to
        the autodetected load-time weaver.
    -->
    <context:load-time-weaver aspectj-weaving="on" />

    <!-- JPA EntityManagerFactory -->
    <bean id="entityManagerFactory"
        class="org.springframework.orm.jpa.LocalContainerEntityManagerFactoryBean"
        p:dataSource-ref="dataSource">
        <property name="jpaVendorAdapter">
            <bean id="jpaVendorAdapter"
                class="org.springframework.orm.jpa.vendor.EclipseLinkJpaVendorAdapter"
                p:databasePlatform="org.eclipse.persistence.platform.database.HSQLPlatform"
                p:showSql="true" />
        </property>
    </bean>

    <!--
        Activates various annotations to be detected in bean classes: Spring's
        @Required and @Autowired, as well as JSR 250's @PostConstruct,
        @PreDestroy and @Resource (if available) and JPA's @PersistenceContext
        and @PersistenceUnit (if available).
    -->
    <context:annotation-config />

    <bean id="directory" class="greenpages.jpa.JpaDirectory" />
```

The addition of the new beans to the context has introduced a new dependency upon Spring's

ORM support and upon EclipseLink and its JPA implementation. Add the following dependencies to the pom file for `greenpages.jpa` and save it:

```
        <dependency>
            <groupId>org.springframework</groupId>
            <artifactId>org.springframework.spring-library</artifactId>
            <type>libd</type>
        </dependency>
        <dependency>
            <groupId>org.eclipse.persistence</groupId>
            <artifactId>com.springsource.org.eclipse.persistence</artifactId>
        </dependency>
        <dependency>
            <groupId>org.eclipse.persistence</groupId>
            <artifactId>com.springsource.org.eclipse.persistence.jpa</artifactId>
        </dependency>
```

Now switch back to `module-context.xml` for `greenpages.jpa` and observe that the errors relating to Spring's ORM types have now been resolved. Save `module-context.xml`.

The application context now contains a factory that will create an `EntityManager` and is configured for annotation-based configuration. The last step in completing `JpaDirectory` is to annotate the `EntityManager` field so that Spring will inject the `EntityManager` created by the factory into the field.

Open `JpaDirectory.java` again and add an annotation `@PersistenceContext` to the `EntityManager` field.

```
@PersistenceContext
private EntityManager em;
```

Eclipse will suggest an import for `javax.persistence.PersistenceContext`; accept this and save the file.

Providing the JPA metadata

JPA uses a file named `META-INF/persistence.xml` to describe persistence units. `persistence.xml` refers to a second file, typically named `META-INF/orm.xml`, to define entity mappings. In the case of GreenPages the `persistence.xml` file specifies a single persistence unit that points to the `greenpages.JpaListing` class. The specified mapping file (`META-INF/orm.xml`) tells the JPA implementation how to map `JpaListing` to the `LISTING` database table described above. (For more information on JPA consult the Documentation section in the appendix.)

Create a new file named `persistence.xml` in the `META-INF` folder of the `greenpages.jpa` project. Add the following contents to the new file and then save it:

```
<?xml version="1.0" encoding="UTF-8" ?>
<persistence xmlns="http://java.sun.com/xml/ns/persistence"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/persistence
                        http://java.sun.com/xml/ns/persistence/persistence_1_0.xsd"
    version="1.0">

    <persistence-unit name="GreenPages" transaction-type="RESOURCE_LOCAL">
        <class>greenpages.jpa.JpaListing</class>
    </persistence-unit>

</persistence>
```

Now create a new file named `orm.xml` in the same folder as `persistence.xml`. Add the following contents to the new file and then save it:

```
<?xml version="1.0" encoding="UTF-8" ?>
<entity-mappings xmlns="http://java.sun.com/xml/ns/persistence/orm"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/persistence/orm
                        http://java.sun.com/xml/ns/persistence/orm_1_0.xsd"
    version="1.0">
    <package>greenpages.jpa</package>
    <entity class="greenpages.jpa.JpaListing" name="Listing">
        <table name="LISTING" />
        <attributes>
            <id name="listingNumber">
                <column name="LISTING_NUMBER" />
                <generated-value strategy="TABLE" />
            </id>
            <basic name="firstName">
                <column name="FIRST_NAME" />
            </basic>
            <basic name="lastName">
                <column name="LAST_NAME" />
            </basic>
            <basic name="emailAddress">
                <column name="EMAIL_ADDRESS" />
            </basic>
        </attributes>
    </entity>
</entity-mappings>
```

Consuming the DataSource from the service registry

The `entityManagerFactory` bean that was added earlier depends upon a bean named `dataSource` which it will use to connect the `EntityManager` to the GreenPages database. The `greenpages.db` module already publishes a `DataSource` to the service registry. `greenpages.jpa` must now be updated to consume this `dataSource`.

Open `osgi-context.xml` in the `META-INF/spring` folder of the `greenpages.jpa` project and add the following:

```
    <!-- import the DataSource from the OSGi service registry -->
    <osgi:reference id="dataSource" interface="javax.sql.DataSource" />
```

This will result in a bean being created in the application context that is named `dataSource`. The bean will be of type `javax.sql.DataSource` and will be backed by a service found in the OSGi service registry that implements the `javax.sql.DataSource` interface.

Publishing the Directory implementation to the service registry

To make the JPA-based `Directory` implementation available to GreenPages' Web module it must be "published" to the OSGi service registry.

Open `osgi-context.xml` in the `META-INF/spring` folder of the `greenpages.jpa` project, add the following and then save the updated file:

```
    <!--
        export the directory bean to the OSGi service registry under the
        Directory interface
    -->
    <osgi:service ref="directory" interface="greenpages.Directory" />
```

Generating greenpages.jpa's manifest using Bundlor

Open the `template.mf` file in the root of the `greenpages.jpa` project and switch to the `template.mf` tab. Add the following entries to the template and save it.

```
Import-Bundle: com.springsource.org.eclipse.persistence;version="[1.0.0,1.0.0]",
 com.springsource.org.eclipse.persistence.jpa;version="[1.0.0,1.0.0]"
Import-Package: org.springframework.context.weaving;version="[2.5.6.A,3.0.0)",
 org.springframework.transaction.aspectj;version="[2.5.6.A,3.0.0)"
Excluded-Exports: greenpages.jpa
```

The `Excluded-Exports` header tells Bundlor that the `greenpages.jpa` should not be exported from the `greenpages.jpa` bundle.

The `Import-Package` entries for `org.springframework.context.weaving` and `org.springframework.transaction.aspectj` are needed as Bundlor cannot, yet, detect that these packages are required based on the contents of the bundle's application context.

Lastly, the `Import-Bundle` entries for EclipseLink and its JPA implementation are needed as Bundlor cannot, yet, detect that EclipseLink is the JPA implementation that is being used by GreenPages.

Switch to the *Overview* tab and click *Update MANIFEST.MF*. As with `greenpages.db` before, this update will result in some errors being reported in the manifest as the project is not associated with a targetted runtime. Double-click the `MANIFEST.MF` file in the `greenpages` project in the Package Explorer. Switch to the *Dependencies* tab and click *Add.…*. Select `greenpages.jpa` and click *OK*. Save the updated file. The problems in the manifest should now be resolved and the GreenPages application should be redeployed due to the addition of the `greenpages.jpa` module. This redeployment should succeed and it's now time to try the application again.

5.4 Trying out the JPA middle tier

Open a Web browser and navigate to `http://localhost/greenpages/home.htm`. Click the *Submit* button. Unfortunately the search will not return any results as the Web module is still using the stub `Directory` implementation provided by the `greenpages.app` module, rather than the JPA-based implementation that is provided by `greenpages.jpa`. This can be confirmed by using the OSGi console.

Open a command prompt and enter

```
telnet localhost 2401
```

At the resulting prompt, enter ss (for short status) and press return. This will return a list of all of the bundles currently running in dm Server. Something like this:

```
69      ACTIVE      com.springsource.server.web.dm_1.0.2.RELEASE
70      ACTIVE      org.springframework.web.servlet_2.5.6.A
71      ACTIVE      com.springsource.freemarker_2.3.12
72      ACTIVE      com.springsource.org.apache.commons.fileupload_1.2.0
73      ACTIVE      com.springsource.org.apache.commons.io_1.4.0
74      ACTIVE      org.springframework.context.support_2.5.6.A
75      ACTIVE      greenpages-1-greenpages-synthetic.context_1.0.0
```

```
76      ACTIVE      greenpages-1-greenpages_1.0.0
77      ACTIVE      greenpages-1-greenpages.db_1.0.0
78      ACTIVE      greenpages-1-greenpages.jpa_1.0.0
79      ACTIVE      greenpages-1-greenpages.web_1.0.0
80      ACTIVE      com.springsource.org.h2_1.0.71
81      ACTIVE      com.springsource.org.apache.commons.dbcp_1.2.2.osgi
82      ACTIVE      org.springframework.aspects_2.5.6.A
```

The bundle that is of primary interest is the Web module (`greenpages-1-greenpages.web_1.0.0`). In the example above this is bundle 79. Enter a command of `bundle <web-module-bundle-id>`, that is `bundle 79` for the case above. There will be several lines of output.

Towards the top of the generated output will be details of the services which are being used by the Web module:

```
  Services in use:
    {greenpages.Directory}={org.springframework.osgi.bean.name=directory,
        Bundle-SymbolicName=greenpages-1-greenpages,
        Bundle-Version=1.0, com.springsource.server.app.name=greenpages-1, service.id=129}
    {org.osgi.service.packageadmin.PackageAdmin}={service.ranking=2147483647,
        service.pid=0.com.springsource.server.osgi.framework.equinox.EquinoxOsgiFramework$LockEnforcingPackageAdmin,
        service.vendor=Eclipse.org, service.id=1}
    {org.xml.sax.EntityResolver}={service.id=32}
    {org.springframework.beans.factory.xml.NamespaceHandlerResolver}={service.id=31}
```

As can be seen in this output the `greenpages.Directory` service is being provided by a bundle with a symbolic name of `greenpages-1-greenpages`: the service is coming from the `greenpages.app` bundle, rather than the `greenpages.jpa` bundle.

The service which is being used by the Web module can be changed at runtime without having to restart the application or dm Server. This can be achieved changing `greenpages.app` so that it no longer publishes its `Directory` implementation. As a result of this `Directory` service no longer being available, the Web module will automatically switch to using the JPA-based implementation.

Open the `osgi-context.xml` file in the `META-INF/spring` folder of the `greenpages.app` project and comment out the publication of the directory service:

```
<!-- <osgi:service interface="greenpages.Directory" ref="directory"/> -->
```

Now save the updated file which will cause the application to be updated and refreshed on the server. Switch back to the Web browser and click *Submit* again.

This time eight results should be returned. Clicking on any of the *View* links will display the listing’s details. The application is now working. All that remains is to apply some best practices to the middle tier.

5.5 Applying best practices to the middle tier

While the application middle tier now works as required, it does not observe a few Spring-related best practices.

Using transactions

At the moment, the middle tier does not make any use of transactions. This isn't a problem while the database access methods are only running single queries, but could lead to problems in the future if the application is made more complex. Thankfully, adding the use of transactions to the middle tier is simple.

Open `module-context.xml` in the `META-INF/spring` folder of `greenpages.jpa`. Add the following bean definition to create a transaction manager and associate it with the context's `EntityManager`:

```
    <!--
        Transaction manager for a single JPA EntityManagerFactory (alternative to JTA)
    -->
    <bean id="transactionManager" class="org.springframework.orm.jpa.JpaTransactionManager"
        p:entityManagerFactory-ref="entityManagerFactory" />
```

(Save it, and the `greenpages.jpa` module will be refreshed.)

Next, Spring must be told to enable transaction management. In keeping with the use of annotation-based configuration for the `EntityManager`, annotation-based transaction configuration will also be used. Add the following to enable AspectJ-powered transaction demarcation for appropriately annotated beans:

```
    <!--
        Instruct Spring to perform declarative transaction management
        automatically on annotated classes.
    -->
    <tx:annotation-driven mode="aspectj" />
```

Save the updated file which will trigger (another) successful refresh of `greenpages.jpa`.

Lastly, `JpaDirectory` needs to be annotated so that it is identified as requiring Spring-based transaction management. Open `JpaDirectory.java` in `greenpages.jpa`. Annotate the class with `@Transactional` and add an import for `org.springframework.transaction.annotation.Transactional`, which Eclipse should suggest:

```
import org.springframework.transaction.annotation.Transactional;

@Transactional
final class JpaDirectory implements Directory {
…
```

Save the updated file triggering another successful refresh: `JpaDirectory` is now transactional.

Enabling exception translation

When using JPA, the standard exceptions are somewhat out of keeping with Spring's exception model. Spring provides support for automatically translating these exceptions into Spring's `DataAccessException` hierarchy.

Open `module-context.xml` for `greenpages.jpa` again and add the following bean

definition to add the exception translator to the application context:

```
    <!--
        Post-processor to perform exception translation on @Repository classes
        (from native exceptions such as JPA PersistenceExceptions to
        Spring&rsquo;s DataAccessException hierarchy).
    -->
    <bean class="org.springframework.dao.annotation.PersistenceExceptionTranslationPostProcessor" />
```

Save the updated file. The translation will only occur on classes that are annotated with Spring's `@Repository` stereotype annotation. `JpaDirectory` needs to have this annotation added to it complete the enabling of the exception translation.

Open `JpaDirectory.java` again, annotate the class with `@Repository` and add an import for `org.springframework.stereotype.Repository`:

```
import org.springframework.stereotype.Repository;

@Transactional
@Repository
final class JpaDirectory implements Directory {
```

Save the updated file.

At this point the redeploy of the GreenPages application may fail with an error similar to this:

```
<SPDE0100E> The class with name 'org.springframework.dao.annotation.PersistenceExceptionTranslationPostProcessor',
referenced by bean 'org.springframework.dao.annotation.PersistenceExceptionTranslationPostProcessor#0',
could not be loaded by class loader 'ServerBundleClassLoader: [bundle=greenpages-1-greenpages.jpa_1.0.0]':
…
```

which indicates that there is some package (`org.springframework.dao.annotation`) which is not available to the "`BundleClassLoader`" for bundle `greenpages-1-greenpages.jpa_1.0.0`. We should look in the `MANIFEST.MF` file for this bundle, and see that this package is not imported (in the `Import-Package` header). Since Bundlor generated this file (controlled by the template file `template.mf`) we should check that the manifest was re-generated on our last change.

Open `template.mf` in `greenpages.jpa` and, in the *Overview* pane, click on *Update MANIFEST.MF* in the *Bundle Actions* section. The `MANIFEST.MF` file is updated, and the application is redeployed, this time successfully. It might be worthwhile checking the option *Automatically update MANIFEST.MF in the background* on the `template.mf` *Overview* pane.

Versioning imports

By default, Bundlor generates `Import-Package` entries with no version range specified. In the absence of a version range, the OSGi default of "any version" is used. Whilst this is very flexible it's generally a good idea to restrict an import by specifying a narrower range. This can be achieved by providing Bundlor with some additional information in the manifest template.

Open `template.mf` for `greenpages.jpa` and add the following `Import-Template` header:

```
Import-Template: org.springframework.*;version="[2.5.6.A,3.0)",
 greenpages;version="[1.0,1.1)",
 javax.persistence;version="[1.0.0,1.0.0]"
```

This header tells Bundlor that all imports of `org.springframework` packages should be in the range `2.5.6.A` inclusive to `3.0` exclusive, that an import of the `greenpages` package should be in the range `1.0` inclusive to `1.1` exclusive, and that an import of `javax.persistence` should be at exactly version `1.0.0`.

Bundlor has also generated an import for the `javax.sql` package due to the `greenpages.jpa` module's use of `javax.sql.DataSource`. This class is provided by the JRE and as such is generally considered to be unversioned, that is it has the default OSGi version of zero. If version zero is *precisely* what is required then add the following to the `Import-Template` header:

```
,javax.sql;version="[0,0]"
```

but if "any" version is acceptable add the following instead:

```
,javax.sql;version="0"
```

Either of these will successfully allow GreenPages to deploy and work correctly. The difference is in the level of flexibility allowed with the external dependency, something which is probably irrelevant in this case, but with other package sources might be important.

Congratulations!

The GreenPages middle tier is now complete and observes some "best practice" development with Spring and OSGi.

6. Testing Greenpages

6.1 Introduction

Testing is one of the most important aspects of software development. Without testing it would be difficult to determine if a piece of code worked properly, changes would have undetected consequences, and the quality of products would generally be lower.

There are two major categories of testing generally recognised today: unit testing and integration testing. In the context of the GreenPages application, *unit testing* means testing a single class in isolation from other application code. This type of testing does not change at all when developing for dm Server.

In our application *integration testing* means testing an application or portion of an application with other code. This kind of testing does look a bit different when developing for dm Server. In most cases dm Server applications are made up of small bundles that consume services through the OSGi registry. In the following steps a single bundle and the entire GreenPages application will be integration tested outside the container.

6.2 Single bundle integration testing

One of the most common forms of integration testing is ensuring that the object relational mapping in an application is working properly. This kind of testing typically uses a data access object to retrieve data from a live database. In this step a test case for the `JpaDirectory` class is created.

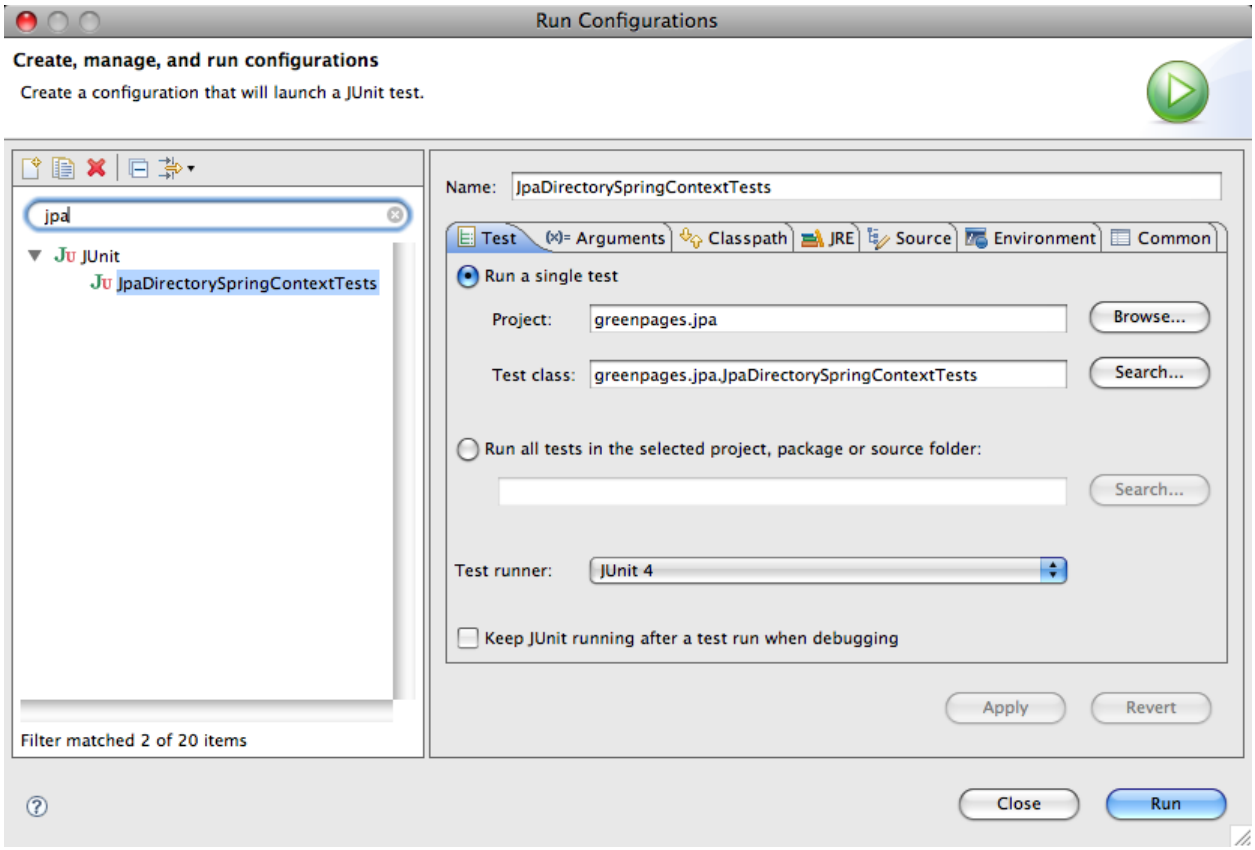
Open the `greenpages.jpa.JpaDirectorySpringContextTests` class in the `src/test/java` source folder of the `greenpages.jpa` project. This class contains a method that uses *JUnit* to test that a search completes correctly. Rather than instantiate this class directly in the test, the Spring Test Framework is used to instantiate and inject a `JpaDirectory` based on the `META-INF/spring/module-context.xml` file.

Add Spring Test Framework declarations to the test class. These declarations run the test with the `SpringJunit4ClassRunner` and configure the test with the `classpath:/META-INF/spring/module-context.xml` file:

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(locations = "classpath:/META-INF/spring/module-context.xml")
@TestExecutionListeners(value = DependencyInjectionTestExecutionListener.class)
public class JpaDirectorySpringContextTests {
…
```

Use Eclipse to suggest the necessary imports until there are no errors.

When this configuration is complete, click on the *Run* drop-down menu and select *Run Configurations…*. In the the dialog that opens select JUnit → JpaDirectorySpringContextTests and press *Run*.



This test run will fail because there is no `DataSource` bean to be injected; it is typically sourced from the OSGi service registry at runtime:

```
Caused by: org.springframework.beans.factory.NoSuchBeanDefinitionException:
    No bean named 'dataSource' is defined
```

The next step will correct this error.

6.3 Contributing OSGi sourced dependencies

In the previous step the `JpaDirectorySpringContextTests` test failed because it did not have a `DataSource` to be injected. In this step, you will instantiate an “in-process” database for testing and populate it with data.

Open the `test-context.xml` file in the `src/test/resources` `META-INF/spring` folder. In this file, define two beans; a `DataSource` and a `TestDataPopulator`. These two beans will provide a test `DataSource` complete with test data.

```
    <bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource"
        p:driverClassName="org.h2.Driver" p:url="jdbc:h2:.~/greenpages-db/greenpages"
        p:username="greenpages" p:password="pass" init-method="createDataSource"
        destroy-method="close" />

    <bean class="greenpages.jpa.TestDataPopulator" init-method="populate">
        <constructor-arg ref="dataSource" />
        <constructor-arg value="file:../../db/db.sql" />
    </bean>
```

Open the `JpaDirectorySpringContextTests` class and update the `ContextConfiguration` annotation to point at both the `module-context.xml` file and the `test-context.xml` file:

```
@ContextConfiguration(locations = {
        "classpath:/META-INF/spring/module-context.xml",
        "classpath:/META-INF/spring/test-context.xml" })
```

Once again use the `JpaDirectorySpringContextTests` JUnit profile to run the test class. Now that there is a `DataSource` being contributed, the test will pass

Proceed to the next step.

6.4 Multi bundle integration testing

Earlier a single bundle was integration tested by providing a test implementation of its `DataSource` dependency. When integration testing it is often a good idea to test the entire application outside of the container. In this step you will create a test case for the entire GreenPages application starting with the `GreenPagesController` class and descending all the way to a database.

Following the import instructions in the section called “Importing the greenpages.web project”, import the `$GREENPAGES_HOME/start/greenpages.tests` project. Initially this project will have compile failures in it; this is to be expected.

Since this project will be testing the GreenPages application as a whole, it needs to depend on the bundles that make up the application. Open its `pom.xml` file and add dependency declarations for the `greenpages.app`, `greenpages.jpa`, and `greenpages.web` bundles:

```
        <dependency>
            <groupId>com.springsource.dmserver</groupId>
            <artifactId>greenpages.app</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.springsource.dmserver</groupId>
            <artifactId>greenpages.jpa</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.springsource.dmserver</groupId>
            <artifactId>greenpages.web</artifactId>
            <version>${project.version}</version>
        </dependency>
```

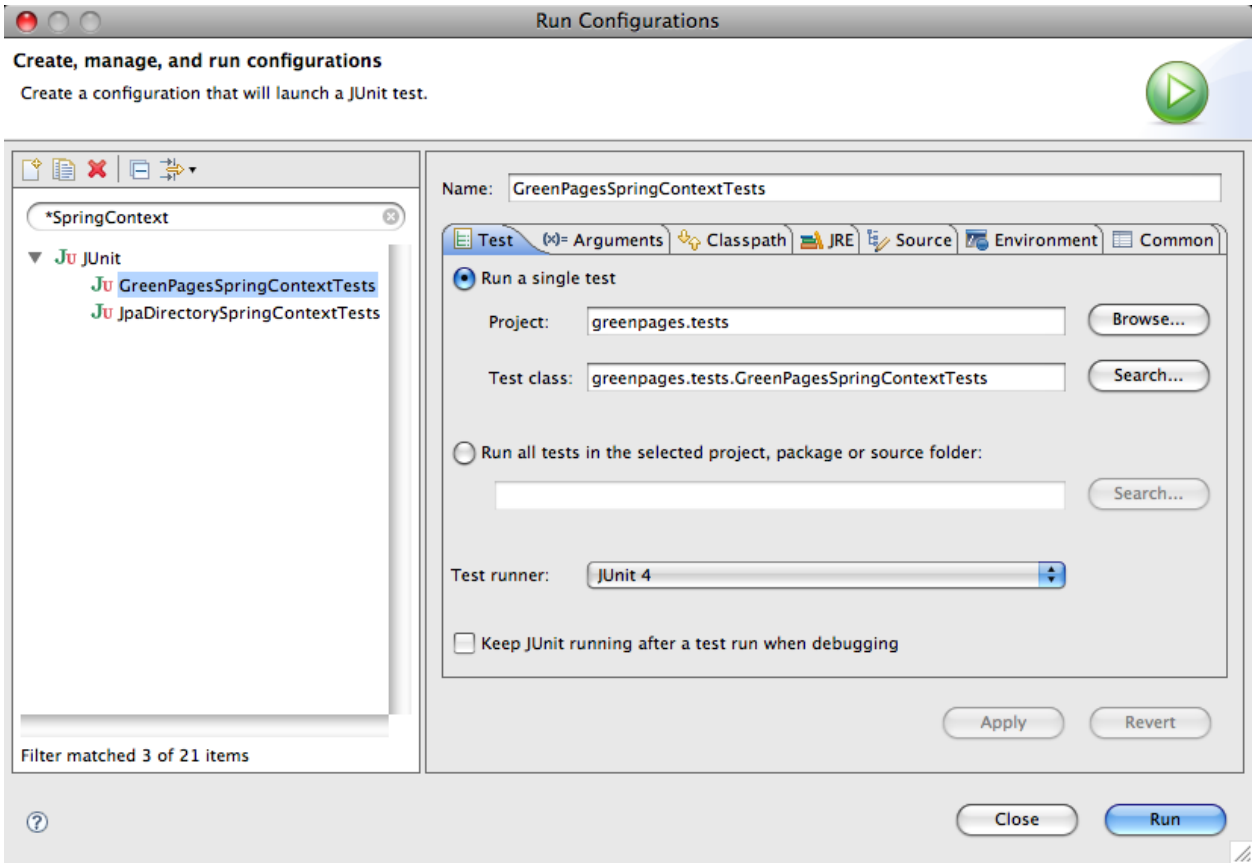
Open the `GreenPagesSpringContextTests` class (in `greenpages.tests`) and add the Spring Test Framework declarations. These declarations should run the test with the `SpringJunit4ClassRunner` and configure the test with the `classpath*:/META-INF/spring/module-context.xml` and `classpath:/META-INF/spring/test-context.xml` files. Note the use of `classpath*:` with respect to the `module-context.xml` path. This will cause Spring to look for files that match that path in all of the bundles on the classpath meaning that all the application beans will be instantiated:

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(locations = {
```

```
        "classpath*:/META-INF/spring/module-context.xml",
        "classpath:/META-INF/spring/test-context.xml" })
@TestExecutionListeners(value = DependencyInjectionTestExecutionListener.class)
public class GreenPagesSpringContextTests {
…
```

It may be necessary to update the `MANIFEST.MF` from the template overview pane, before Eclipse will suggest all the right imports here.

When this configuration is complete, click on the *Run* drop-down and select *Run Configurations…*. In the the dialog that opens select JUnit → GreenPagesSpringContextTests and press *Run*;



When this test is run, Spring creates an `ApplicationContext` that is built from the `module-context.xml` configuration files from all of the bundles. Because of this all of the internal dependencies are satisfied by the beans created directly by the bundles.

There are warnings output by this test concerning `log4j`:

```
log4j:WARN No appenders could be found for logger
                                (org.springframework.test.context.junit4.SpringJUnit4ClassRunner).
log4j:WARN Please initialize the log4j system properly.
```

These warnings are benign, and do not influence the tests in any way.

The next chapter constructs an automated build system that might be used to build GreenPages (and run its tests) outside of an interactive development environment.

7. Automated Build

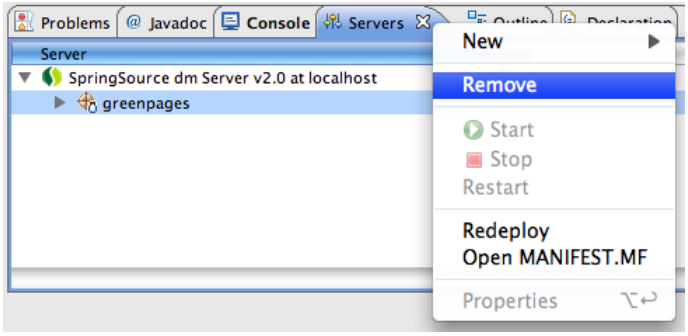
7.1 Introduction

One of the most important components in application development is the automated build. This permits application artifacts to be created outside of the developer's IDE. The application can be created and tested in a variety of environments including continuous integration.

7.2 Setting up for Automated Build

Before building and deploying from the command line, it is important to clean up the artifacts that Eclipse has deployed. In this section the GreenPages application will be undeployed within Eclipse and all of the GreenPages bundles built from the command line.

Right-click on the `greenpages` application in the `Servers` view and select *Remove*. Once this is complete close Eclipse: it is no longer needed.



Run the following command from a command prompt with the `$GREENPAGES_HOME/start` as the current directory. This will build the individual bundles that make up the GreenPages application:

```
mvn clean install
```

The first time this is run will cause Maven to download quite a few packages. It is likely also that this does not build successfully on the first try, due to warnings from Bundlor. These warnings are due to the lack of information regarding some of the packages required by `greenpages.db` and `greenpages.web`. For example the following warnings may be issued:

```
[WARNING] Bundlor Warnings:
[WARNING]     <SB0001W>: The import of package javax.sql does not specify a version.
[WARNING]     <SB0001W>: The import of package org.apache.commons.dbcp does not specify a version.
[INFO] ------------------------------------------------------------------------
[ERROR] BUILD ERROR
[INFO] ------------------------------------------------------------------------
[INFO] Bundle transformer returned warnings.
  Please fix manifest template at '/opt/greenpages-1.0.0.BUILD/start/greenpages.db/template.mf' and try again.
```

which indicate that there is no information in the `template.mf` file in the `greenpages.db`

project to inform Bundlor what version of these packages to generate in the `MANIFEST.MF` for that bundle.

To correct these problems add the following lines to the `template.mf` file for the `greenpages.db` bundle:

```
Import-Template: javax.sql;version="0",
 org.apache.commons.dbcp;version="0"
```

When the `mvn` command returns successfully, go to the next step.

7.3 Create POM

All of the projects except the PAR project have Maven POM files for building. In this step an initial POM file for the PAR is created.

Using a text editor create a file called `$GREENPAGES_HOME/start/greenpages/pom.xml`. Open this file and add the following skeleton to it.

```
<?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">

  <parent>
    <groupId>com.springsource.dmserver</groupId>
    <artifactId>greenpages.parent</artifactId>
    <version>1.0.0.SNAPSHOT</version>
    <relativePath>../parent</relativePath>
  </parent>

  <modelVersion>4.0.0</modelVersion>
  <groupId>com.springsource.dmserver</groupId>
  <artifactId>greenpages</artifactId>
  <name>GreenPages PAR</name>
  <packaging>par</packaging>

  <dependencies>
  </dependencies>

  <build>
    <plugins>
    </plugins>
  </build>

</project>
```

This skeleton defines a basic configuration with a parent POM. Notice that the `packaging` type is `par`. When you have created this file execute the following command from the `$GREENPAGES_HOME/start/greenpages` directory.

```
mvn clean package
```

This command returns an error indicating that Maven does not know how to build a PAR:

```
[INFO] ------------------------------------------------------------------------
[ERROR] BUILD ERROR
[INFO] ------------------------------------------------------------------------
[INFO] The plugin 'org.apache.maven.plugins:maven-par-plugin' does not exist
[INFO] or no valid version could be found
[INFO] ------------------------------------------------------------------------
```

The next step will correct this.

7.4 Adding the `par` plugin

Thorsten Maus (see Section A.2, “Documentation”) has developed a Maven plugin that builds a PAR file from a list of dependencies. In this step the Maven `par` plugin is added to properly build a PAR artifact type.

Add a `<pluginRepository/>` declaration to the `greenpages` POM file so that Maven can find the `par` plugin:

```
<pluginRepositories>
  <pluginRepository>
    <id>steademy</id>
    <name>Steademy repository</name>
    <url>http://repo.steademy.com/beta/maven2</url>
  </pluginRepository>
</pluginRepositories>
```

In the `<build><plugins>…</plugins></build>` section, add a plugin declaration for the `par` plugin.

```
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-par-plugin</artifactId>
  <version>0.2.0</version>
  <configuration>
    <fqn>true</fqn>
    <applicationSymbolicName>greenpages</applicationSymbolicName>
    <applicationVersion>${project.version}</applicationVersion>
    <applicationDescription>GreenPages PAR</applicationDescription>
    <applicationName>GreenPages PAR</applicationName>
  </configuration>
</plugin>
```

Declare the list of bundles to be packaged in the PAR as dependencies of the PAR project.

```
<dependency>
  <groupId>com.springsource.dmserver</groupId>
  <artifactId>greenpages.app</artifactId>
  <version>${project.version}</version>
</dependency>
<dependency>
  <groupId>com.springsource.dmserver</groupId>
  <artifactId>greenpages.jpa</artifactId>
  <version>${project.version}</version>
</dependency>
<dependency>
  <groupId>com.springsource.dmserver</groupId>
  <artifactId>greenpages.db</artifactId>
  <version>${project.version}</version>
</dependency>
<dependency>
  <groupId>com.springsource.dmserver</groupId>
  <artifactId>greenpages.web</artifactId>
  <version>${project.version}</version>
</dependency>
```

Run the following command.

```
mvn clean package
```

This command will now complete successfully and build a PAR into `target/`. Proceed to the next step.

```
[INFO] [par:par]
[INFO] assembling artifacts for par package
[INFO] greenpages
[INFO] artifact greenpages.app is copied with fully qualified name
                                                    com.springsource.dmserver.greenpages.app-1.0.0.SNAPSHOT
[INFO] artifact greenpages.jpa is copied with fully qualified name
```

```
                                                    com.springsource.dmserver.greenpages.jpa-1.0.0.SNAPSHOT
[INFO] artifact greenpages.db is copied with fully qualified name
                                                    com.springsource.dmserver.greenpages.db-1.0.0.SNAPSHOT
[INFO] artifact greenpages.web is copied with fully qualified name
                                                    com.springsource.dmserver.greenpages.web-1.0.0.SNAPSHOT
[INFO] added com.springsource.dmserver.greenpages.app-1.0.0.SNAPSHOT.jar
[INFO] added com.springsource.dmserver.greenpages.db-1.0.0.SNAPSHOT.jar
[INFO] added com.springsource.dmserver.greenpages.jpa-1.0.0.SNAPSHOT.jar
[INFO] added com.springsource.dmserver.greenpages.web-1.0.0.SNAPSHOT.jar
```

7.5 Adding the dependency plugin

Maven now successfully builds the PAR for your application. However, the dependecies of the PAR are not apparent. In this step the Maven `dependency` plugin is added to collect the transitive dependency graph for the PAR.

In the `<build><plugins>…</plugins></build>` section (after the `par` plugin declaration), add a plugin declaration for the `dependency` plugin.

```
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-dependency-plugin</artifactId>
  <executions>
    <execution>
      <id>copy-dependencies</id>
      <phase>package</phase>
      <goals>
        <goal>copy-dependencies</goal>
      </goals>
      <configuration>
        <outputDirectory>${project.build.directory}/par-provided</outputDirectory>
        <overWriteIfNewer>true</overWriteIfNewer>
        <excludeGroupIds>com.springsource.dmserver</excludeGroupIds>
      </configuration>
    </execution>
  </executions>
</plugin>
```

Run the following command.

```
mvn clean package
```

When the command has completed, it will have copied all of the PAR's dependencies into the `target/par-provided` directory. The output from Maven should include lines like these (these lines are wrapped for this document):

```
[INFO] [dependency:copy-dependencies {execution: copy-dependencies}]
[INFO] Copying com.springsource.javax.persistence-1.0.0.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.javax.persistence-1.0.0.jar
[INFO] Copying com.springsource.org.apache.commons.dbcp-1.2.2.osgi.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.org.apache.commons.dbcp-1.2.2.osgi.jar
[INFO] Copying com.springsource.org.apache.commons.pool-1.3.0.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.org.apache.commons.pool-1.3.0.jar
[INFO] Copying com.springsource.org.apache.log4j-1.2.15.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.org.apache.log4j-1.2.15.jar
[INFO] Copying com.springsource.org.eclipse.persistence-1.0.0.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.org.eclipse.persistence-1.0.0.jar
[INFO] Copying com.springsource.org.eclipse.persistence.antlr-1.0.0.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.org.eclipse.persistence.antlr-1.0.0.jar
[INFO] Copying com.springsource.org.eclipse.persistence.asm-1.0.0.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.org.eclipse.persistence.asm-1.0.0.jar
[INFO] Copying com.springsource.org.eclipse.persistence.jpa-1.0.0.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.org.eclipse.persistence.jpa-1.0.0.jar
[INFO] Copying com.springsource.freemarker-2.3.12.jar to
/opt/greenpages-1.0.0.BUILD/start/greenpages/target/par-provided/com.springsource.freemarker-2.3.12.jar
```

If the dependencies are produced, proceed to the next step.

7.6 Deploying the application

Maven can now build both the PAR application and the collection of dependencies required for the application. In this step the PAR and dependencies are copied to the dm Server and the PAR is started.

Copy the JARs in the `target/par-provided` directory into the `$DMS_HOME/repository/bundles/usr/` directory.

Copy the PAR (`greenpages-1.0.0.SNAPSHOT.par`) in the `target/` directory into the `$DMS_HOME/pickup` directory.

Start the dm Server. The server may issue warnings, for example:

```
<SPDE0010I> Deployment of 'greenpages' version '1.0.0.SNAPSHOT' completed.
```

Once deployment of the GreenPages application has completed, navigate to http://localhost:8080/greenpages/home.htm.

```
<SPDE0010I> Deployment of 'greenpages' version '1.0.0.SNAPSHOT' completed.
```

The GreenPages application has been built (and automatically tested) from the command line, with a complete dependency set generated for independent deployment.

The automated build procedure is to run `mvn clean install` from the base directory, generating the component bundles, and then to run `mvn clean package` from the `greenpages` directory to generate the par and produce all its dependencies.

Appendix A. Further Resources

A.1 Projects

a. SpringSource.org (http://www.springsource.org) — homepage for SpringSource dm Server and Spring Framework.

b. OSGi (http://www.osgi.org) — homepage for OSGi.

c. H2 Database (http://www.h2database.com — homepage for the H2 database.

d. FreeMarker (http://freemarker.sourceforge.net) — homepage for FreeMarker templating engine.

e. Commons DBCP (http://commons.apache.org/dbcp) — homepage for Commons DBCP.

f. Eclipse IDE (http://www.eclipse.org/eclipse) — homepage for Eclipse IDE.

g. EclipseLink (http://www.eclipse.org/eclipselink) — homepage for Ecli#pseLink JPA.

A.2 Documentation

a. SpringSource dm Server User's Guide (http://static.springsource.com/projects/dm-server/1.0.x/user-guide/html/).

b. SpringSource dm Server Programmer's Guide (http://static.springsource.com/projects/dm-server/1.0.x/programmer-guide/html/).

c. Spring DM Reference Guide (http://static.springframework.org/osgi/docs/1.1.3/reference/html/).

d. Spring Framework 2.5 documentation (http://static.springframework.org/spring/docs/2.5.x/reference/index.html).

e. FreeMarker documentation (http://freemarker.sourceforge.net/docs).

f. Eclipse IDE documentation (http://www.eclipse.org/documentation).

g. EclipseLink documentation wiki (http://wiki.eclipse.org/EclipseLink/UserManual).

h. Maven PAR plugin from Thorsten Maus (http://blog.steademy.com/2008/05/29/maven-par-plugin/).