

EclipseLink

Solutions Guide for EclipseLink

Release 2.4

December 2012

Beta Draft



Solutions Guide for EclipseLink

Copyright © 2012 by The Eclipse Foundation under the Eclipse Public License (EPL)

<http://www.eclipse.org/org/documents/epl-v10.php>

The initial contribution of this content was based on work copyrighted by Oracle and was submitted with permission.

Print date: December 7, 2012

This documentation is in prerelease status and is intended for demonstration and preliminary use only. It may not be specific to the hardware on which you are using the software.

Contents

Audience.....	vii
Related Documents	viii
Conventions	viii
New and Changed Features for Release 2.4	ix
1 Introduction	
1.1 About This Guide	1-1
1.2 What You Need to Know First	1-1
1.3 The Use Cases	1-2
2 Installing EclipseLink	
2.1 Installing EclipseLink for Java SE and Java EE Development)	2-1
2.2 Installing EclipseLink NoSQL (2.4 and Later)	2-2
2.3 Installing EclipseLink OSGi	2-2
3 Using EclipseLink with WebLogic Server	
3.1 Introduction to the Solution	3-2
3.2 Implementing the Solution	3-3
3.3 Additional Resources	3-16
4 Using EclipseLink with GlassFish Server	
4.1 Introduction to the Solution	4-1
4.2 Implementing the Solution	4-3
4.3 Additional Resources	4-10
5 Using EclipseLink with JBoss 7 Application Server	
5.1 Introduction to the Solution	5-1
5.2 Implementing the Solution	5-2
5.3 Additional Resources	5-5
6 Using EclipseLink with IBM WebSphere Application Server	
6.1 Introduction to the Solution	6-1
6.2 Implementing the Solution	6-2
6.3 Additional Resources	6-5

7	Migrating from Native EclipseLink	
7.1	Introduction to the Solution	7-1
7.2	Implementing the Solution	7-2
7.3	Additional Resources	7-10
8	Migrating from Hibernate to EclipseLink	
8.1	Introduction to the Solution	8-1
8.2	Main Tasks	8-2
8.3	Additional Resources	8-6
9	Migrating from Apache OpenJPA to EclipseLink	
9.1	Introduction to the Solution	9-1
9.2	Implementing the Solution	9-2
9.3	Additional Resources	9-10
10	Using Multiple Databases with a Composite Persistence Unit	
10.1	Introduction to the Solution	10-1
10.2	Implementing the Solution	10-3
10.3	Additional Resources	10-4
11	Scaling EclipseLink Applications in Clusters	
11.1	Introduction to the Solution	11-1
11.2	Implementing the Solution	11-2
11.3	Additional Resources	11-11
12	Providing Software as a Service	
12.1	Introduction to the Solution	12-1
12.2	Making JPA Entities Extensible	12-1
12.3	Making JAXB Beans Extensible	12-7
12.4	Using Multitenancy	12-14
12.5	Using an External Metadata Source	12-15
13	Tenant Isolation Using EclipseLink	
13.1	Introduction to the Solution	13-1
13.2	Using Single-Table Multi-Tenancy	13-2
13.3	Using Table-Per-Tenant Multi-Tenancy	13-10
13.4	Using VPD Multi-Tenancy	13-14
13.5	Additional Resources	13-16
14	Mapping JPA to XML	
14.1	Introduction to the Solution	14-2
14.2	Binding JPA Entities to XML	14-3
14.3	Mapping Simple Java Values to XML Text Nodes	14-14
14.4	Using XML Metadata Representation to Override JAXB Annotations	14-21

14.5	Using XPath Predicates for Mapping	14-22
14.6	Using Dynamic JAXB/MOXY	14-27
14.7	Additional Resources	14-32
15	Converting Objects to and from JSON Documents	
15.1	Introduction to the Solution	15-1
15.2	Implementing the Solution	15-2
15.3	Additional Resources	15-10
16	Testing EclipseLink JPA Outside a Container	
16.1	Understanding JPA Deployment	16-1
16.2	Configuring the persistence.xml File	16-2
16.3	Using a Property Map	16-3
16.4	Using Weaving	16-4
16.5	Additional Resources	16-5
17	Enhancing Performance	
17.1	Performance Features	17-1
17.2	Monitoring and Optimizing EclipseLink-Enable Applications	17-7
17.3	Additional Resources	17-12
18	Exposing JPA Entities Through RESTful Services Using EclipseLink Data Services	
18.1	Introduction to the Solution	18-1
18.2	Additional Resources	18-8
18.3	HTTP Request Reference for JPA-RS	18-8
	Entity Operations	18-9
	Entity Operations on Relationships	18-15
	Query Operations	18-19
	Single Result Queries	18-22
	Base Operations	18-23
	Metadata Operations	18-26
19	Using Caching with a Shared Database in a JPA Environment	
19.1	Introduction to the Solution	19-2
19.2	Implementing the Solution	19-3
19.3	Limitations on the Solution	19-6
19.4	Additional Resources	19-6
20	Using EclipseLink with NoSQL Databases	
20.1	Introduction to the Solution	20-1
20.2	Implementing the Solution	20-2
20.3	Additional Resources	20-7

21 Using EclipseLink with the Oracle Database

21.1	Introduction to the Solution	21-1
21.2	Implementing the Solution	21-2
21.3	Additional Resources	21-14

Preface

EclipseLink delivers a proven standards-based enterprise Java solution for all of your relational, XML, and JSON persistence requirements based on high performance and scalability, developer productivity, and flexibility in architecture and design.

Audience

A variety of engineers use EclipseLink. Users of EclipseLink are expected to be proficient in the use of technologies and services related to EclipseLink (for example, Java Persistence API). This guide does not include details about related common tasks, but focuses on EclipseLink functionality.

Users of this guide include:

- Developers who want to develop applications using any of the following technologies for persistence services:
 - Java Persistence API (JPA) 2.*n* plus EclipseLink JPA extensions
 - Java Architecture for XML Binding 2.*n* (JAXB) plus EclipseLink Object-XML extensions
 - EclipseLink Database Web Services (DBWS)

Developers should be familiar with the concepts and programming practices of Java Platform, Standard Edition (Java SE platform), and Java Platform, Enterprise Edition (Java EE platform).

Developers using EclipseLink JPA should be familiar with the concepts and programming practices of JPA 2.1, as specified in the Java Persistence Architecture 2.1 specification at <http://jcp.org/en/jsr/detail?id=338>.

Developers using EclipseLink Object-XML should be familiar with the concepts and programming practices of JAXB 2.0, as specified in the Java Architecture for XML Binding 2.0 specification at <http://jcp.org/aboutJava/communityprocess/pfd/jsr222/index.html>.

Developers using EclipseLink DBWS should be familiar with the concepts and programming practices of JAX-WS 2.0, as specified in the Java API for XML-Based Web Services 2.0 specification at <http://jcp.org/aboutJava/communityprocess/pfd/jsr222/index.html>.

- Administrators and deployers who want to deploy and manage applications using EclipseLink persistence technologies. These users should be familiar with basic operations of the chosen application server.

Related Documents

For more information, see the following documents:

- *EclipseLink Concepts*
- *Java Persistence API (JPA) Extensions Reference for EclipseLink*
- *Developing Persistence Architectures Using EclipseLink Database Web Services Developer's Guide*
- *Developing Persistence Architectures Using EclipseLink MOXy Developer's Guide*
- *Java API Reference for EclipseLink*
- EclipseLink Documentation Center at <http://www.eclipse.org/eclipselink/documentation/>

Conventions

The following text conventions are used in this guide:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
<i>italic</i>	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
<code>monospace</code>	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.
<code>bold monospace</code>	Bold monospace type is used in code examples to emphasize certain items.

What's New in This Guide

The following topics introduce the new and changed features of EclipseLink and other significant changes that are described in this guide, and provides pointers to additional information.

New and Changed Features for Release 2.4

EclipseLink Release 2.4 includes the following new and changed features that are documented in this book. This list does not necessarily include all new or changed features in this release. It only includes the new features that are documented in this book.

- Multi-tenancy, where multiple application tenants may share database tables and schemas. This allows applications to manage entities for multiple tenants in the same application. See [Chapter 13, "Tenant Isolation Using EclipseLink."](#)
- JSON bindings, for converting objects directly to and from JavaScript Object Notation (JSON). This can be useful when creating RESTful services, using JSON messages with Java API for RESTful Web Services (JAX-RS) services. See [Chapter 15, "Converting Objects to and from JSON Documents,"](#)
- RESTful persistence, where Java Persistence API (JPA) entities can be exposed through standards-based RESTful services such as JAX-RS, using either JSON or XML media. See [Chapter 18, "Exposing JPA Entities Through RESTful Services Using EclipseLink Data Services."](#)
- Support for TopLink Database Change Notification (DCN), which allows shared caching to be used in a JPA environment. DCN allows the database to notify TopLink of database changes. The changed objects are invalidated in the TopLink shared cache. Stale data can be discarded, even if other applications access the same data in the database. See [Chapter 19, "Using Caching with a Shared Database in a JPA Environment."](#)
- NoSQL database support, allowing objects to be mapped to non-relational (NoSQL) data sources. See [Chapter 20, "Using EclipseLink with NoSQL Databases,"](#).

Introduction

EclipseLink is a powerful and flexible Java persistence framework for storing Java objects in a data store such as relational or NoSQL database and for converting Java objects to XML or JSON documents. EclipseLink provides APIs and a run-time environment for implementing the persistence layer of Java Platform, Standard Edition (Java SE platform), and Java Platform, Enterprise Edition (Java EE platform) applications.

EclipseLink is an open source persistence framework from the Eclipse Foundation. For more information about the EclipseLink project, see "Eclipse Persistence Services Project (EclipseLink) home" at <http://www.eclipse.org/eclipselink/>. For the EclipseLink Documentation, Center see <http://www.eclipse.org/eclipselink/documentation/>.

1.1 About This Guide

This guide, *Solutions Guide for EclipseLink*, documents a number of scenarios, or use cases, that illustrate EclipseLink features and typical EclipseLink development processes. These are not tutorials that lead you step-by-step through every task required to complete a project. Rather, they document general processes and key details for solving particular problems and then provide links to other documentation for more information.

1.2 What You Need to Know First

To make good use of this guide, you should already be familiar with the following:

- The concepts and programming practices of the Java SE platform and the Java EE platform. In the current release, EclipseLink supports Java EE 6. For more information, see the following.

Java

- Java home page:
<http://www.oracle.com/us/technologies/java/index.html>
- Java EE 5 Tutorial:
<http://download.oracle.com/javaee/5/tutorial/doc/bnbpy.html>
- Java EE 6 Tutorial:
<http://download.oracle.com/javaee/6/tutorial/doc/bnbpy.html>
- Any of the thousands of books and websites devoted to Java.

Eclipse Integrated Development Environment

- Eclipse IDE: <http://www.eclipse.org/>
- If you are working with EclipseLink Java Persistence API (JPA), you should be familiar with the concepts and programming practices of JPA 2.1, as specified in the *Java Persistence API, Version 2.1* specification at <http://jcp.org/en/jsr/detail?id=338>.
- If you are working with EclipseLink MOXy, you should be familiar with the concepts and programming practices of JAXB 2.0, as specified in the *The Java Architecture for XML Binding (JAXB) 2.0* specification at <http://jcp.org/en/jsr/detail?id=222>.
- Developers using EclipseLink DBWS should be familiar with the concepts and programming practices of JAX-WS 2.0, as specified in the *Java API for XML-Based Web Services (JAX-WS) 2.0* specification at <http://jcp.org/en/jsr/detail?id=224>.
- Support for RESTful (Representational State Transfer) Web Services in the Java Platform at <http://jcp.org/en/jsr/detail?id=311>.

1.3 The Use Cases

The use cases documented in this guide are as follows:

- [Chapter 2, "Installing EclipseLink"](#) - How to download and install EclipseLink.
- [Chapter 3, "Using EclipseLink with WebLogic Server"](#) - How to use EclipseLink as the persistence provider for EclipseLink Java Persistence API (JPA) 2.x applications deployed to WebLogic Server.
- [Chapter 4, "Using EclipseLink with GlassFish Server"](#) - How to use EclipseLink as the persistence provider for EclipseLink Java Persistence Architecture (JPA) 2.x applications deployed to GlassFish Server.
- [Chapter 5, "Using EclipseLink with JBoss 7 Application Server"](#) - How to use TopLink as the persistence provider in JBoss 7 Application Server.
- [Chapter 6, "Using EclipseLink with IBM WebSphere Application Server"](#) - How to use TopLink as the persistence provider in IBM WebSphere Application Server.
- [Chapter 7, "Migrating from Native EclipseLink"](#) - How to how to migrate applications using native EclipseLink object-relational mapping (ORM) API to the current EclipseLink API.
- [Section 8, "Migrating from Hibernate to EclipseLink"](#) - How to migrate applications from using Hibernate JPA to using EclipseLink JPA.
- [Section 9, "Migrating from Apache OpenJPA to EclipseLink"](#) - How to migrate applications from using Apache OpenJPA to using EclipseLink JPA.
- [Chapter 10, "Using Multiple Databases with a Composite Persistence Unit"](#) - How to expose multiple persistence units (each with unique sets of entity types) as a single persistence context.
- [Chapter 11, "Scaling EclipseLink Applications in Clusters"](#) - How to configure EclipseLink applications to ensure scalability in clustered application server environments.
- [Chapter 12, "Providing Software as a Service"](#) - How to make JPA entities or JAXB beans extensible; how to use multi-tenancy; and how to use an external metadata source.

- [Chapter 13, "Tenant Isolation Using EclipseLink"](#) - How to support multiple application tenants who share data sources, including tables and schemas.
- [Chapter 14, "Mapping JPA to XML"](#) - How to map JPA entities to XML using EclipseLink MOXy.
- [Chapter 16, "Testing EclipseLink JPA Outside a Container"](#) - How to test your EclipseLink application outside the container.
- [Chapter 17, "Enhancing Performance"](#) - Getting the best performance out of EclipseLink.
- [Chapter 18, "Exposing JPA Entities Through RESTful Services Using EclipseLink Data Services"](#) - How to Expose Entities
- [Chapter 19, "Using Caching with a Shared Database in a JPA Environment"](#) - How to use EclipseLink Database Change Notification (DCN) for caching with a shared database in JPA.
- [Chapter 20, "Using EclipseLink with NoSQL Databases"](#) - How to use EclipseLink to map objects to non-relational (that is, no SQL) data sources.

Installing EclipseLink

This chapter tells how to install EclipseLink.

A Java Virtual Machine (JVM) compatible with JDK 1.5 (or higher) must be installed on the computer where you are installing EclipseLink.

EclipseLink is available in several distributions which are installed in a variety of ways, as described in the following sections:

- [Installing EclipseLink for Java SE and Java EE Development](#)
- [Installing EclipseLink NoSQL \(2.4 and Later\)](#)
- [Installing EclipseLink OSGi](#)

2.1 Installing EclipseLink for Java SE and Java EE Development

This section on EclipseLink installation is under development

Use the following procedures to install EclipseLink for Java SE and EE development. Before you proceed with the install, it is recommended that you back up any existing project data.

1. Set the following system environment variables before installing EclipseLink:
 - `JAVA_HOME` - Set `JAVA_HOME` to where you installed your Java SDK home directory. For example:
 - Windows example: `JAVA_HOME = C:\JDK`
 - UNIX example: `JAVA_HOME = ...:/usr/java/jdk`
 - `PATH` - Set `PATH` to include `JDK/bin` directory. For example:
 - Windows example: `PATH = C:\JDK\bin`
 - UNIX example: `PATH = ...:/usr/java/jdk/bin`
2. Download the EclipseLink install archive zip file from the EclipseLink downloads page at <http://www.eclipse.org/eclipselink/downloads/>. The zip file also includes EclipseLink Workbench, a graphical interface that allows you to configure descriptors and map your projects. It is a powerful tool if you are migrating from Oracle TopLink with classic or native ORM/OXM/EIS usage.
3. Unpack the downloaded zip file in the desired installation directory. When you unzip the file, you will find an `eclipselink` subdirectory, containing multiple subdirectories. This directory is your new `ECLIPSELINK_HOME` directory. For example:
 - Windows example: `ECLIPSELINK_HOME = <INSTALL_DIR>/eclipselink`

- UNIX example: `ECLIPSELINK_HOME = ...:/usr/el/INSTALL_DIR/eclipselink`
- 4. If you want to use EclipseLink Workbench, additional steps are required. See "Configuring the Workbench Environment" at http://wiki.eclipse.org/Using_Workbench_%28ELUG%29#Configuring_the_Workbench_Environment.

2.2 Installing EclipseLink NoSQL (2.4 and Later)

This section on EclipseLink installation is under development

Support for NoSQL databases is supported in EclipseLink by downloading and installing a separate zip file from <http://www.eclipse.org/eclipselink/downloads/>. Use this bundle in conjunction with `EclipseLink.jar` or the EclipseLink jpa bundles.

2.3 Installing EclipseLink OSGi

This section on EclipseLink installation is under development

Blah

2.3.1 Introduction

The Eclipse Plug-in Development Environment (PDE) provides tools to create, develop, test, debug, build and deploy Eclipse plug-ins, fragments, features, update sites and RCP products. PDE also provides comprehensive OSGi tooling. For more information about PDE, see "PDE" at <http://www.eclipse.org/pde/>.

REWRITE THIS:.....To use PDE, PDE must be installed on your computer. PDE ships with the Eclipse SDK and can be downloaded from the Eclipse project downloads page <http://www.eclipse.org/downloads/>. For installation instructions, see "Eclipse Installation" at <http://wiki.eclipse.org/Eclipse/Installation>.

If you already have an installation of Eclipse that does not include PDE (for example, Eclipse IDE for Java Developers), you can install it using the Install New Software wizard. Filter the results for "Eclipse plug-in development environment." PDE is listed as "Eclipse plug-in development environment" under the "General Purpose Tools" category.

EclipseLink OSGi bundles are made available both as a zip and via an Eclipse P2 update site. See the following for download and installation instructions.

- [Alternative 1: Install EclipseLink OSGi from the Zip File](#)
- [Alternative 2: Install EclipseLink OSGi in PDE from an Eclipse P2 Update Site](#)

2.3.2 Alternative 1: Install EclipseLink OSGi from the Zip File

To download and install the zip file distribution, do the following:

1. Download the EclipseLink OSGi bundle zip file from <http://www.eclipse.org/eclipselink/downloads/>.
2. Unpack the downloaded zip file in the desired installation directory. You can do either of the following:
 - Add the installation directory to a target platform.

- If you are developing in Eclipse with PDE, you can place the downloaded bundles into your `<ECLIPSE_HOME>\dropins` folder. However, the approach described in [Alternative 2: Install EclipseLink OSGi in PDE from an Eclipse P2 Update Site](#) is recommended.

2.3.3 Alternative 2: Install EclipseLink OSGi in PDE from an Eclipse P2 Update Site

To Install EclipseLink OSGi in PDE from an Eclipse P2 update site, do the following:

1. Start the Eclipse IDE.
2. From the Open 'Window>Preferences' and navigate to 'Plug-in Development>Target Platform'.
3. Select 'Add..' to create a new target platform definition.
4. Select 'Nothing' to start with an empty target and then click 'Next'.
5. On the 'Locations' tab select 'Add..'.
6. Select 'Software Site' and then click 'Next'.
7. Choose the Helios update site from the 'Work with:' drop down of P2 repositories.
8. Once the feature list has been populated, from the 'EclipseRT Target Platform Components' category check 'EclipseLink Target Components' and click 'Finish'.
9. Change the name of your new target platform to reflect its contents, e.g., 'EclipseLink 2.1'.
10. Finally, select your newly defined target as your default and click 'Ok'.

In the Plug-ins view of the Plug-in Development perspective you will see all of the bundles in your target platform. Note that bundles EclipseLink requires have also been downloaded and installed by P2, e.g., Equinox (org.eclipse.osgi).

2.3.4 EclipseLink OSGi Bundles

The following tables list the bundles included with EclipseLink OSGi.

Note: The names of the bundle files include suffixes with a release and build number. Those numbers vary depending upon the release you download.

Table 2–1 EclipseLink Core Functionality

Bundle	Description
org.eclipse.persistence.core	This bundle provides EclipseLink's core library. All other EclipseLink bundles (JPA, MOXy, SDO) are dependent on this bundle.
org.eclipse.persistence.asm	This bundle provides EclipseLink's version of the ASM library used for byte-code weaving in the core, JPA, SDO and MOXy bundles. It is required when using any of those bundles.

Table 2–1 (Cont.) EclipseLink Core Functionality

Bundle	Description
org.eclipse.persistence. .antlr	This bundle provides EclipseLink's version of the ANTLR library used for JPQL parsing in the JPA and core bundles. It is required when using JPA.
org.eclipse.persistence. .oracle	This bundle provides support for extended Oracle database features (Timestamp extensions, Spatial types, Oracle XML Parser, XDB, Advanced Queueing, XDK, Oracle LOBs).
javax.activation	These bundles contain classes from Java specification. They have been converted to bundle format so they can be used in OSGi. Depending on the OSGi environment whether the running OSGi Environment EclipseLink contains those versions of the libraries listed, these bundles may or may not be necessary.
javax.jms	
javax.mail	
javax.resource	
javax.servlet	
javax.transaction	
javax.xml.rpc	
javax.xml.soap	
javax.xml.stream	
javax.xml.ws	

Table 2–2 EclipseLink JPA

Bundle	Description
javax.persistence	This bundle contains versions of the javax.persistence and javax.persistence.spi classes that have been updated to be OSGi friendly. OSGi users must use this bundle for performing OSGi-based JPA.
org.eclipse.persistence. .jpa	This bundle supports JPA functionality along with Extended JPA support using EclipseLink's annotations, PU properties, and query hints. The bundle also supports partial and complete EclipseLink-ORM.XML extensions of JPA.
org.eclipse.persistence. .jpa.osgi	This bundle provides support for using JPA in OSGi
org.eclipse.persistence. .jpa.equinox	These bundles implement byte code weaving support when running on Equinox, the Eclipse implementation of the OSGi R4 core framework specification, including a set of bundles that implement various optional OSGi services and other infrastructure for running OSGi-based systems. For information about Equinox, see http://www.eclipse.org/equinox .
org.eclipse.persistence. .jpa.equinox.weaving	

Table 2–3 EclipseLink MOXy

Bundle	Description
org.eclipse.persistence. .moxy	This bundle supports JAXB 2.0 using annotations and XML mapping file.
javax.xml.bind	This bundle contains the specification classes and interfaces augmented with support for discovering JAXB provider services.

Table 2–4 EclipseLink SDO

Bundle	Description
org.eclipse.persistence. .sdo	This bundle supports Eclipse persistence SDO 2.1 classes.
commonj.sdo	This bundle provides common SDO 2.1 classes.

Using EclipseLink with WebLogic Server

This chapter introduces how EclipseLink can be used as the persistence provider for EclipseLink Java Persistence API (JPA) 2.0 applications deployed to Oracle WebLogic Server.

This chapter contains the following sections:

- [Section 3.1, "Introduction to the Solution"](#)
- [Section 3.2, "Implementing the Solution"](#)
- [Section 3.3, "Additional Resources"](#)

Use Case

WebLogic Server developers, administrators, and user want to take advantage of all the persistence services provided by EclipseLink.

Solution

While WebLogic Server can use other persistence providers and EclipseLink can be used with other application servers, using WebLogic Server with EclipseLink provides a number of advantages.

Components

- WebLogic Server 12c or later.
- A compliant Java Database Connectivity (JDBC) database including Oracle Database, Oracle Express, MySQL, and so on.
- While it is not required, you may want to use a Java EE integrated development environment (IDE) for convenience during development.

Samples

See the following EclipseLink samples for related information:

- http://wiki.eclipse.org/EclipseLink/Examples/JPA/WebLogic_Web_Tutorial
- http://wiki.eclipse.org/EclipseLink/Examples/JPA/WLS_AppScoped_DataSource
- <http://wiki.eclipse.org/EclipseLink/Examples/Distributed>

3.1 Introduction to the Solution

WebLogic Server is a scalable, enterprise-ready Java Platform, Enterprise Edition (Java EE platform) application server. WebLogic Server's complete implementation of the Java EE 6 specification provides a standard set of APIs for creating distributed Java applications that can access a wide variety of services, such as databases, messaging services, and connections to external enterprise systems. In addition to the Java EE implementation, WebLogic Server enables enterprises to deploy critical applications in a robust, secure, highly available, and scalable environment. These features allow enterprises to configure clusters of WebLogic Server instances to distribute load, and provide extra capacity in case of hardware or other failures. For more details about these and other WebLogic Server features, see *Introduction to WebLogic Server*.

3.1.1 Advantages to Using EclipseLink with WebLogic Server

While WebLogic Server can use other persistence providers and EclipseLink can be used with other application servers, using WebLogic Server with EclipseLink provides a number of advantages:

- EclipseLink is the default persistence provider for WebLogic Server domains, with support for JPA 2.1.
- The EclipseLink implementation of Java Architecture for XML Binding (JAXB) is the default JAXB implementation in WebLogic Server. EclipseLink fully implements JAXB and also includes other advanced features. By default, you can take advantage of EclipseLink JAXB in Java API for XML Web Services (JAX-WS) and Java API for RESTful Web Services (JAX-RS) applications.
- Oracle WebLogic Suite includes Oracle Coherence, which is a Java-based in-memory data-grid product that provides data caching, data replication, and distributed computing services. WebLogic Server and Coherence are tightly integrated and allow applications to use Coherence data caches. WebLogic Server applications can use EclipseLink Grid, which is an integration between EclipseLink and Coherence that allows EclipseLink to use Coherence as a level 2 (L2) cache and persistence layer for entities. How to use these integrations is beyond the scope of this guide. See *Oracle Coherence Developer's Guide* and *Integrating Oracle Coherence* for more information.

Note: You can also obtain Coherence as a separately licensed product to use WebLogic Server Standard Edition and WebLogic Server Enterprise Edition.

- EclipseLink logging integration in WebLogic Server provides a comprehensive, integrated logging infrastructure. See [Section 3.2.4, "Task 4: Use or Reconfigure the Logging Integration."](#)
- WebLogic Server supports Oracle Application Development Framework (Oracle ADF), an end-to-end Java EE framework, based on Struts and JavaServer Faces (JSF). Oracle ADF simplifies application development by providing infrastructure services and a visual and declarative development experience. EclipseLink and Oracle ADF together provide a complete Java EE application infrastructure. How to use Oracle ADF is beyond the scope of this guide. See *Oracle Fusion Middleware Fusion Developer's Guide for Oracle Application Development Framework*.
- WebLogic Server, EclipseLink, and Oracle ADF are all integrated with Oracle JDeveloper, Oracle's integrated development environment (IDE) that provides support for modeling, developing, debugging, optimizing, and deploying Java EE

applications, including applications that use EclipseLink as the persistence provider and that are deployed to WebLogic Server. How to use JDeveloper is beyond the scope of this guide. See

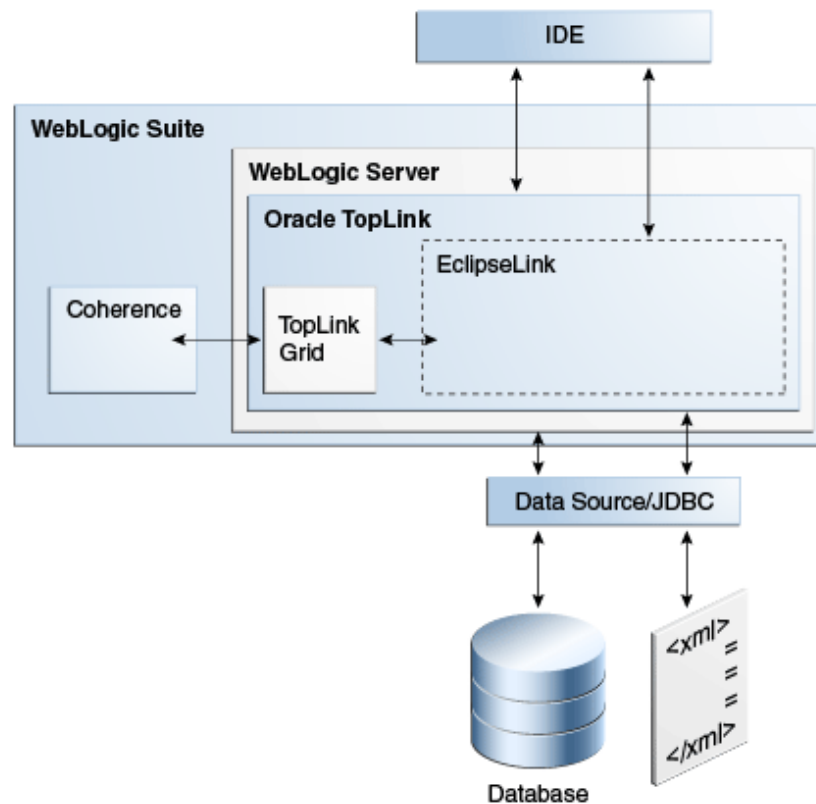
<http://www.oracle.com/technetwork/developer-tools/jdev/overview/index.html> for general information about JDeveloper. For information about JDeveloper tasks, see the JDeveloper online help in the JDeveloper IDE.

3.1.2 EclipseLink and Other Fusion Middleware Products

Figure 3–1 shows how WebLogic Server and EclipseLink are related to and used with other Oracle products. You might use the products together as follows:

- Use JDeveloper (or Oracle Enterprise Pack for Eclipse or NetBeans) to develop Java EE applications.
- Use EclipseLink as the persistence provider.
- Use WebLogic as the application server.
- Use the Oracle database for persisting data from EclipseLink JPA applications or XML for persisting data from EclipseLink MOXy applications.

Figure 3–1 Relationship of WebLogic Server, EclipseLink, and Related Products



3.2 Implementing the Solution

To run EclipseLink JPA applications in WebLogic Server, you must configure WebLogic Server and coordinate certain settings in it and in your application, as described in the following tasks.

- [Task 1: Prerequisites](#)

- Task 2: Update the Release of EclipseLink in WebLogic Server (Optional)
- Task 3: Configure JMX MBean Extensions in WebLogic Server
- Task 4: Use or Reconfigure the Logging Integration
- Task 5: Add Persistence to Your Java Application Using EclipseLink
- Task 6: Configure a Data Source
- Task 7: Extend the Domain to Use Advanced Oracle Database Features
- Task 8: Start WebLogic Server and Deploy the Application
- Task 9: Run the Application
- Task 10: Configure and Monitor Persistence Settings in WebLogic Server

3.2.1 Task 1: Prerequisites

This document is based on the following products and tools, although the principles apply to any supported database or development environment. It is assumed that the software is already installed, except where noted in later sections.

- WebLogic Server 12c or later.

For more information and downloads, see

<http://www.oracle.com/technetwork/middleware/weblogic/overview/index.html> on the Oracle Technology Network.

- Any compliant Java Database Connectivity (JDBC) database including Oracle Database, Oracle Express, MySQL, and so on.

For Oracle Database, see

<http://www.oracle.com/technetwork/database/enterprise-edition/overview/index.html>. For Oracle Database, Express Edition, see

<http://www.oracle.com/technetwork/database/express-edition/overview/index.html>. For MySQL, see

<http://www.oracle.com/us/products/mysql/index.html>.

- While it is not required, you may want to use a Java development environment (IDE) for convenience during development. For example JDeveloper, Oracle Enterprise Pack for Eclipse, and NetBeans all provide sophisticated Java EE development tools. Both JDeveloper and Oracle Enterprise Pack for Eclipse include embedded versions of WebLogic Server, although this guide describes a standalone instance of WebLogic Server.

For JDeveloper, see

<http://www.oracle.com/technetwork/developer-tools/jdev/downloads/index.html>. For Oracle Enterprise Pack for Eclipse, see

<http://www.oracle.com/technetwork/developer-tools/eclipse/overview/index.html>. For NetBeans, see

<http://www.oracle.com/us/products/tools/050845.html>.

3.2.2 Task 2: Update the Release of EclipseLink in WebLogic Server (Optional)

EclipseLink includes all the EclipseLink libraries, which provide the support for JPA, MOXy, DBWS, and other persistence and transformation services. The release of EclipseLink included in EclipseLink may not be the most current available from the Eclipse Foundation. However, you can upgrade the EclipseLink release by using the WebLogic Server filtering class loader and the shared library feature.

The `FilteringClassLoader` class provides a mechanism for configuring deployment descriptors to specify that certain packages are always loaded from the application, rather than being loaded by the system class loader. You can use this mechanism to specify that a newer release of EclipseLink be used by an application. For more information about filtering class loaders, see "Using a Filtering Classloader" in *Oracle Fusion Middleware Developing Applications for Oracle WebLogic Server*.

A shared library is a Java EE module that can be shared by multiple enterprise applications. A shared library is deployed to a WebLogic Server target, and it can then be referenced by applications. Upon deployment, WebLogic Server merges the contents of the shared library with the application. In addition, because shared libraries can be packaged as standard Java EE archives, any descriptors are also merged with the application at deployment. For more information about WebLogic Server shared libraries, see "Creating Shared Java EE Libraries and Optional Packages" in *Oracle Fusion Middleware Developing Applications for Oracle WebLogic Server*.

To update the release of EclipseLink used by applications deployed to WebLogic Server, do the following:

1. Download the `eclipselink-release_no.zip` file for the EclipseLink release you want from the EclipseLink website at <http://www.eclipse.org/eclipselink/downloads/index.php>.
2. Prepare the shared library as a standard Java EE Enterprise Archive (EAR), named, for example, `eclipselink-shared-lib.ear`, containing the following items:

```
META-INF/weblogic-application.xml
META-INF/application.xml
lib/eclipselink.jar
```

For more information about creating EARs, see "Creating and Configuring Web Applications" in *Oracle Fusion Middleware Developing Web Applications, Servlets, and JSPs for Oracle WebLogic Server*.

3. In the application's `weblogic-application.xml` descriptor file, add a `prefer-application-packages` element, with the subelement `<package-name>org.eclipse.persistence.*</package-name>`, as follows:
4. Create an `application.xml` file for the application. This file is necessary to support the runtime library merging. The minimum configuration is as follows:

```
<weblogic-application>
  <prefer-application-packages>
    <package-name>org.eclipse.persistence.*</package-name>
  </prefer-application-packages>
</weblogic-application>
```

```
<application>
  <display-name>eclipselink-shared-lib</display-name>
  <module>
    <java></java>
  </module>
</application>
```

5. Add the extension name, the specification version, and the implementation version to the EAR's `META-INF/MANIFEST.MF` file. For example, if you are using Apache Ant, you can do the following:

```
<target name="package" depends="prepare">
  <jar destfile="dist/${ant.project.name}.ear">
    <metainf dir="etc" includes="*.xml"/>
  </jar>
</target>
```

```
<manifest>
  <attribute name="Extension-Name" value="eclipselink"/>
  <attribute name="Specification-Version" value="2.0"/>
  <attribute name="Implementation-Version" value="2.2.0"/>
</manifest>
<fileset dir="build" includes="**/*"/>
</jar>
</target>
```

At deployment time, WebLogic Server uses the attributes as metadata for the deployed shared library.

The final EAR file should look like this:

```
META-INF/
META-INF/MANIFEST.MF
META-INF/application.xml
META-INF/weblogic-application.xml
lib/
lib/eclipselink.jar
```

6. Deploy the eclipselink-shared-lib.ear file to WebLogic Server. This results in a new library being available on the server, eclipselink#2.0@2.2.0.
7. In the weblogic-application.xml file of any applications that will use the updated release of EclipseLink, add a reference to the shared library, as follows:

```
<weblogic-application>
  <library-ref>
    <library-name>eclipselink</library-name>
    <specification-version>2.0</specification-version>
    <implementation-version>2.2.0</implementation-version>
  </library-ref>
</weblogic-application>
```

3.2.3 Task 3: Configure JMX MBean Extensions in WebLogic Server

WebLogic Server uses Java Management Extensions (JMX) MBeans to configure, monitor, and manage WebLogic Server resources. For EclipseLink applications, MBeans are used to monitor and configure aspects of persistence units and are also used for logging.

Note: When deployed to WebLogic Server, EclipseLink applications deploy MBeans when they connect to the database, not at deployment time.

For information about how MBeans are used in WebLogic Server, see *Oracle Fusion Middleware Developing Custom Management Utilities With JMX for Oracle WebLogic Server* and *Oracle Fusion Middleware Developing Manageable Applications With JMX for Oracle WebLogic Server*.

For information about EclipseLink logging in WebLogic Server, see [Section 3.2.4, "Task 4: Use or Reconfigure the Logging Integration."](#)

By default, when you deploy an EclipseLink application to WebLogic Server, the EclipseLink runtime deploys the following JMX MBeans to the WebLogic Server JMX service for each EclipseLink session:

- `org.eclipse.persistence.services.DevelopmentServices` - This class provides facilities for managing an EclipseLink session internal to EclipseLink over JMX.
- `org.eclipse.persistence.services.RuntimeServices` - This class provides facilities for managing an EclipseLink session external to EclipseLink over JMX.

Use the API that this JMX MBean exposes to access and configure your EclipseLink sessions at runtime, using JMX code that you write, or to integrate your EclipseLink application with a third-party JMX management application, such as JConsole.

To find out how to access information about custom MBeans, you must first enable anonymous lookup and then use a separate tool to access the MBean information.

To enable anonymous lookup in the WebLogic Server Administration Console, do the following:

1. If you have not already done so, in the Change Center of the Administration Console, click **Lock & Edit**.
2. In the left pane, select your domain to open the Settings page for your domain.
3. Expand **Security > General**.
4. Select **Anonymous Admin Lookup Enabled**.
5. To activate these changes, in the Change Center of the Administration Console, click **Activate Changes**.

For the information about accessing the MBean information using various tools, see "Accessing Custom MBeans," in *Oracle Fusion Middleware Developing Manageable Applications With JMX for Oracle WebLogic Server*.

For information about monitoring custom MBeans in the Administration Console, see "Monitor Custom MBeans" in *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*.

3.2.4 Task 4: Use or Reconfigure the Logging Integration

By default, EclipseLink logging is integrated into the WebLogic Server logging infrastructure. Details about how the integration works and how to override it are described in the following sections. For detailed information about WebLogic Server logging, see the following:

- *Oracle Fusion Middleware Using Logging Services for Application Logging for Oracle WebLogic Server*
- *Oracle Fusion Middleware Configuring Log Files and Filtering Log Messages for Oracle WebLogic Server*
- The logging topics in *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*

For information about configuring logging for JPA persistence units, see "How to Configure Logging" in the EclipseLink documentation at <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Logging>.

3.2.4.1 How the Logging Integration Works

By default, the WebLogic Server logging implementation is injected into the persistence context, which results in all EclipseLink logging messages being produced according to the WebLogic Server logging configuration.

As a result of this integration, EclipseLink logging levels are converted to WebLogic Server logging levels as shown in [Table 3-1](#).

Table 3–1 Mapping of EclipseLink Logging Levels to WebLogic Server Logging Levels

EclipseLink Logging Levels	WebLogic Server Logging Levels
ALL, FINEST, FINER, FINE	DEBUG
CONFIG	INFO
INFO	NOTICE
WARNING	WARNING
SEVERE	ALERT
OFF	OFF

WebLogic Server logging levels are mapped to EclipseLink levels as shown in [Table 3–2](#).

Table 3–2 Mapping of WebLogic Server Logging Levels to EclipseLink Logging Levels

WebLogic Server Logging Levels	EclipseLink Logging Levels
TRACE, DEBUG	FINEST
INFO	CONFIG
NOTICE	INFO
WARNING	WARNING
ERROR, CRITICAL, ALERT	SEVERE
EMERGENCY, OFF	OFF

3.2.4.2 Viewing Persistence Unit Logging Levels in the Administration Console

You can see the EclipseLink logging level defined for the persistence unit in the Administration Console, as described in [Section 3.2.10, "Task 10: Configure and Monitor Persistence Settings in WebLogic Server."](#) However, be aware that this logging level, set in the `persistence.xml` file, is overridden when the default WebLogic Server and EclipseLink logging integration is used. For information about overriding the integration, see [Section 3.2.4.3, "Overriding the Default Logging Integration."](#)

When the default integration is used, the Enterprise JavaBeans (EJB) logging options for persistence are mapped through and control EclipseLink's logging output in the Administration Console.

3.2.4.3 Overriding the Default Logging Integration

You set EclipseLink logging levels in the `persistence.xml` file. However, when you accept the default logging integration with WebLogic Server, those settings are ignored, and the logging configuration set in WebLogic Server is used. The EclipseLink logging levels are used only when you use the native EclipseLink logging implementation.

You can override the default logging integration by setting the `eclipselink.logging.logger` property name to a different setting. For example, to enable the default EclipseLink logging, set the `eclipselink.logging.logger` property as follows:

```
<property name="eclipselink.logging.logger" value="DefaultLogger"/>
```

You can also use a different logging implementation for EclipseLink messages, for example the `java.util.logging` package:

```
<property name="eclipselink.logging.logger" value="JavaLogger"/>
```

3.2.4.4 Configuring WebLogic Server to Expose EclipseLink Logging

If you use the native EclipseLink logging implementation, you can still display EclipseLink logging messages in the WebLogic Server domain's log files by configuring WebLogic Server to redirect Java Virtual Machine (JVM) output to the registered log destinations.

For more information and instructions for redirecting, see "Redirecting JVM Output" in *Oracle Fusion Middleware Configuring Log Files and Filtering Log Messages for Oracle WebLogic Server*. To set this option in the Administration Console, see "Redirect JVM output" in *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*.

3.2.4.5 Other Considerations

Other things to consider include the following:

- The message ID 2005000 is used for all EclipseLink log messages.
- Some logging messages handled by the WebLogic Server integrated logger may show up in the WebLogic Server console or the server log (depending on the settings of logging levels) during deployment, even though at runtime the application's entity manager factory will use only the EclipseLink logging infrastructure and only the EclipseLink logging settings.
- If you use a different release of EclipseLink than the release bundled in your WebLogic Server installation (by using a filtering class loader), then trying to use the default integrated logging can lead to errors, due to classloading conflicts. To work around this issue, explicitly set the `eclipselink.logging.logger` property to something other than the integrated WebLogic Server logger.

3.2.5 Task 5: Add Persistence to Your Java Application Using EclipseLink

Using EclipseLink JPA to provide persistence for an application is the fundamental task presumed by all the other tasks described in this chapter; yet the actual JPA programming practice is mostly outside the scope of this guide. WebLogic Server imposes no special requirements on your EclipseLink application, other than the details described in this chapter.

That is because EclipseLink is based on EclipseLink, the open source persistence project from the Eclipse Foundation. EclipseLink 2.*n* is the reference implementation of the *Java Persistence API, Version 2.0* specification. EclipseLink includes all of the EclipseLink Java Archive (JAR) files, plus additional Oracle tools and features. Therefore, you can take advantage of the full range of features and functionality provided by JPA and EclipseLink when using EclipseLink to add the persistence layer to your Java applications.

This chapter describes features, settings, and tasks that are specific to using EclipseLink (runtime and API) with WebLogic Server. For information about developing, packaging, and deploying a Java application using JPA, see the following:

- The EclipseLink project wiki at <http://wiki.eclipse.org/EclipseLink>
- The EclipseLink Documentation Center at http://wiki.eclipse.org/EclipseLink/Documentation_Center
- The *Java Persistence API, Version 2.0* specification at <http://jcp.org/en/jsr/detail?id=317>

- "Part V, Persistence" in "The Java EE 6 Tutorial" at <http://download.oracle.com/javaee/6/tutorial/doc/bnbpy.html>
- Any third-party book that describes programming Java applications using JPA

For more information about EclipseLink features and concepts, see [Chapter 1, "Introduction"](#) and *EclipseLink Concepts*.

For related WebLogic Server programming topics, see any book in the WebLogic Server documentation set, in particular the following:

- *Oracle Fusion Middleware Programming Enterprise JavaBeans, Version 3.0, for Oracle WebLogic Server*
- *Oracle Fusion Middleware Developing Applications for Oracle WebLogic Server*
- *Oracle Fusion Middleware Deploying Applications to Oracle WebLogic Server*
- *Oracle Fusion Middleware Programming JDBC for Oracle WebLogic Server*

3.2.6 Task 6: Configure a Data Source

In WebLogic Server, you configure database connectivity by adding JDBC data sources to WebLogic Server domains. Each WebLogic data source contains a pool of database connections. Applications look up the data source on the Java Naming and Directory Interface (JNDI) tree or in the local application context and then reserve a database connection with the `getConnection()` method. Data sources and their connection pools provide connection management processes to keep the system running efficiently.

For information about using JDBC with WebLogic Server, see the following:

- For complete documentation about working with JDBC in WebLogic Server, see *Oracle Fusion Middleware Configuring and Managing JDBC Data Sources for Oracle WebLogic Server*, in particular:
 - "Configuring WebLogic JDBC Resources"
 - "Configuring JDBC Data Sources"
- For information about working with JDBC data sources in the WebLogic Server Administration Console, see the topics under "Configure JDBC" in *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*.

3.2.6.1 Ways to Configure Data Sources for JPA Applications

You can configure data sources for JPA applications deployed to WebLogic Server in a variety of ways, including the following:

- [Configure a Globally Scoped JTA Data Source](#)
- [Configure an Application-Scoped JTA Data Source](#)
- [Configure a non-JTA Data Source and Manage Transactions in the Application](#)

3.2.6.2 Configure a Globally Scoped JTA Data Source

The most common data source configuration is a globally-scoped JNDI data source, using Java Transaction API (JTA) for transaction management, specified in the `persistence.xml` file. Configuration is straightforward, as shown in the following steps, and multiple applications can access the data source:

- [Create the Data Source in WebLogic Server](#)
- [Configure the `persistence.xml` File](#)

3.2.6.2.1 Create the Data Source in WebLogic Server To set up a globally scoped JNDI data source in the WebLogic Server Administration Console, do the following:

1. Create a new data source, as described in "Configure JDBC generic data sources" in *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*.

Note: EclipseLink is compatible with any WebLogic Server data source that can be accessed using standard JNDI data source lookup by name. These instructions describe the wizard for a generic data source.

2. Enter values in the Create a New JDBC data source wizard, according to your requirements. For more information, see "Create a JDBC Data Source" in *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*.

Important: The value used for **JNDI Name** (on the JDBC Datasource Properties page must be the same as the value used for the `<jta-data-source>` element in the `persistence.xml` file.

3. Configure connection pools, as described in "Configuring Connection Pool Features" in *Oracle Fusion Middleware Configuring and Managing JDBC Data Sources for Oracle WebLogic Server*. The connection pool configuration can affect EclipseLink's ability to handle concurrent requests from the application. Properties should be tuned in the same way any connection pool would be tuned to optimize resources and application responsiveness.

3.2.6.2.2 Configure the persistence.xml File In the `persistence.xml` file, specify that `transaction-type` is JTA, and provide the name of the data source in the `jta-data-source` element (prefaced by `jdbc/` or not), as shown in [Example 3-1](#):

Example 3-1 persistence.xml File With JNDI Data Source Using JTA

```
...
<persistence-unit name="example" transaction-type="JTA">
  <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
  <jta-data-source>JDBC Data Source-1</jta-data-source>
  <class>org.eclipse.persistence.example.jpa.server.business.Cell</class>

<class>org.eclipse.persistence.example.jpa.server.business.CellAttribute</class>
</persistence-unit>
```

3.2.6.3 Configure an Application-Scoped JTA Data Source

To configure an application-scoped data source that uses JTA for transaction management, perform the following steps:

1. ["Specify that the Data Source Is Application-Scoped"](#)
2. ["Add the JDBC Module to the WebLogic Server Application Configuration"](#)
3. ["Configure the JPA Persistence Unit to Use the JTA Data Source"](#)

3.2.6.3.1 Specify that the Data Source Is Application-Scoped To define an application-scoped data source, create a `name-jdbc.xml` JDBC module file and place it in the `META-INF` folder of the application's EAR file. In that file, add `<scope>Application</scope>` to the `jdbc-data-source-params` section, as shown in [Example 3-2](#).

Example 3-2 JDBC Data Source Defined in the `name-jdbc.xml` File

```
<jdbc-data-source ...>
...
  <jdbc-data-source-params>
    <jndi-name>SimpleAppScopedDS</jndi-name>
    <scope>Application</scope>
  </jdbc-data-source-params>
</jdbc-data-source>
```

Hint: You can create the framework for the `name-jdbc.xml` file by creating a globally scoped data source from the WebLogic Server Administration Console, as described in [Section 3.2.6.2, "Configure a Globally Scoped JTA Data Source,"](#) with these differences:

- Do not associate the data source with a server.
 - Add the `<scope>` element manually.
-

For more information about JDBC module configuration files and `jdbc-data-source` (including `<jdbc-driver-params>` and `<jdbc-connection-pool-params>`), see "Configuring WebLogic JDBC Resources" in *Oracle Fusion Middleware Configuring and Managing JDBC Data Sources for Oracle WebLogic Server*.

3.2.6.3.2 Add the JDBC Module to the WebLogic Server Application Configuration Add a reference to the JDBC module in the `/META-INF/weblogic-application.xml` application deployment descriptor in the EAR file, as shown in [Example 3-3](#). This registers the data source for use in the application.

Example 3-3 JDBC Module Defined in the `weblogic-application.xml` File

```
<wls:module>
  <wls:name>SimpleAppScopedDS</wls:name>
  <wls:type>JDBC</wls:type>
  <wls:path>META-INF/simple-jdbc.xml</wls:path>
</wls:module>
```

For more information about `weblogic-application.xml` application deployment descriptors, see "Understanding Application Deployment Descriptors" in *Oracle Fusion Middleware Deploying Applications to Oracle WebLogic Server* and "Enterprise Application Deployment Descriptor Elements" in *Oracle Fusion Middleware Developing Applications for Oracle WebLogic Server*.

3.2.6.3.3 Configure the JPA Persistence Unit to Use the JTA Data Source To make it possible for EclipseLink runtime to lazily look up an application-scoped data source, you must specify an additional data source property in the definition of the persistence unit in the `persistence.xml` file. For a JTA data source, add a fully qualified

javax.persistence.jtaDataSource property, with the value java:/app/jdbc/data_source_name, as shown in [Example 3-4](#).

The values of the <jta-data-source> and <javax.persistence.jtaDataSource> properties must match.

Example 3-4 JTA Data Source Definition in the persistence.xml File

```
<?xml version="1.0" encoding="windows-1252" ?>
<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" xmlns="http://java.sun.com/xml/ns/persistence">
  <persistence-unit name="employee" transaction-type="JTA">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <jta-data-source>java:/app/jdbc/SimpleAppScopedDS</jta-data-source>
    <properties>
      <property name="javax.persistence.jtaDataSource"
        value="java:/app/jdbc/SimpleAppScopedDS" />
    </properties>
  </persistence-unit>
</persistence>
```

3.2.6.4 Configure a non-JTA Data Source and Manage Transactions in the Application

To configure a non-JTA data source managed by the application, follow the procedures described in [Section 3.2.6.3, "Configure an Application-Scoped JTA Data Source,"](#) but configure the JPA persistence unit to use a non-JTA data source by specifying a not-JTA data source, as shown in [Example 3-5](#).

Example 3-5 non-JTA Data Source Definition in the persistence.xml File

```
<?xml version="1.0" encoding="windows-1252" ?>
<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" xmlns="http://java.sun.com/xml/ns/persistence">
  <persistence-unit name="employee" transaction-type="RESOURCE_LOCAL">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <non-jta-data-source>OracleDS</non-jta-data-source>
    <properties>
      <property name="javax.persistence.nonJtaDataSource"
        value="OracleDS" />
    </properties>
  </persistence-unit>
</persistence>
```

Write the code in your application to handle the transactions as described, for example, in "Transactions in EJB Applications" in *Oracle Fusion Middleware Programming JTA for Oracle WebLogic Server*.

3.2.6.5 Ensure the Settings Match

Certain settings in the data source configuration must match certain settings in the application's ejbModule/META-INF/persistence.xml file. For the data source configuration in WebLogic Server, you can check the settings in the configuration files or in the Administration Console.

In the Administration Console, review the settings as follows:

1. In the **Domain Structure** tree, expand **Services**, then select **Data Sources**.
2. On the Summary of JDBC Data Sources page, click the name of the data source.
3. On the **Settings for *data_source_name* > Configuration > General** page, find the value for **JNDI Name**, for example **localDS**. If you are using JTA, then the name must match `<jta-data-source>` in the `persistence.xml` file.
4. On the **Settings for *data_source_name* > Configuration > Connection Pool** page, review these settings:
 - The value for **URL** must match the `javax.persistence.jdbc.url` value in the `persistence.xml` file, for example, `jdbc:oracle:thin:@127.0.0.1:1521:XE`.
 - The value for **Driver Class Name** must match the `javax.persistence.jdbc.driver` value in the `persistence.xml` file, for example (for a JTA data source), `oracle.jdbc.xa.client.OracleXADataSource`.

Example 3–6 shows the values that must be shared in the domain's `config.xml` file and the application's `persistence.xml` file.

Example 3–6 Server Domain `config.xml` File

```
...
<domain...>
  <jdbc-system-resource>
    <name>localJTA</name>
    <target>AdminServer,ManagedServer_1,ManagedServer_2</target>
    <descriptor-file-name>jdbc/localJTA-4636-jdbc.xml</descriptor-file-name>
  </jdbc-system-resource>
</domain>
```

3.2.7 Task 7: Extend the Domain to Use Advanced Oracle Database Features

To fully support Oracle Spatial and Oracle XDB mapping capabilities (in both standalone WebLogic Server and the JDeveloper Integrated WebLogic Server), you must use the `toplink-spatial-template.jar` file and the `toplink-xdb-template.jar` file to extend the WebLogic Server domain to support Oracle Spatial and Oracle XDB, respectively.

To extend your WebLogic Server domain:

1. Download the `toplink-spatial-template.jar` (to support Oracle Spatial) and `toplink-xdb-template.jar` (to support Oracle XDB) files from:
 - <http://download.oracle.com/otn/java/toplink/111110/toplink-spatial-template.jar>
 - <http://download.oracle.com/otn/java/toplink/111110/toplink-xdb-template.jar>
2. Copy the files, as shown in [Table 3–3](#) and [Table 3–4](#).

Table 3–3 File to Support Oracle Spatial

File	From...	To...
<code>sdoapi.jar</code>	<code>ORACLE_DATABASE_HOME/md/jlib</code>	<code>WL_HOME/server/lib</code>

Table 3–4 Files to Support Oracle XDB

File	From...	To...
xdb.jar	ORACLE_DATABASE_HOME/rdbms/jlib	WL_HOME/server/lib
xml.jar	ORACLE_DATABASE_HOME/lib	WL_HOME/server/lib
xmlparserv2.jar	ORACLE_DATABASE_HOME/lib	WL_HOME/server/lib

3. Start the Config wizard (*WL_HOME/common/bin/config.sh* (or *.bat*)).
4. Select **Extend an existing WebLogic domain**.
5. Browse and select your WebLogic Server domain.
6. Select **Extend my domain using an existing extension template**.
7. Browse and select the required template JAR file (*toplink-spatial-template.jar* for Oracle Spatial, *toplink-xdb-template.jar* for Oracle XDB).
8. Complete the remaining pages of the wizard.

For information about using WebLogic Server domain templates, see *Oracle Fusion Middleware Domain Template Reference*.

3.2.8 Task 8: Start WebLogic Server and Deploy the Application

For information about deploying to WebLogic Server, see *Oracle Fusion Middleware Deploying Applications to Oracle WebLogic Server*. See also "Deploying Fusion Web Applications" in *Oracle Fusion Middleware Fusion Developer's Guide for Oracle Application Development Framework*.

3.2.9 Task 9: Run the Application

For instructions for starting a deployed application from the WebLogic Server Administration Console, see "Start and stop a deployed Enterprise application" in *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*.

3.2.10 Task 10: Configure and Monitor Persistence Settings in WebLogic Server

In the WebLogic Server Administration Console, you can configure a persistence unit and configure JTA and non-JTA data sources of a persistence unit, as follows:

1. If you have not already done so, in the Change Center of the Administration Console, click **Lock & Edit**.
2. In the left pane of the Administration Console, select **Deployments**.
3. In the right pane, select the application or module you want to configure.
4. Select **Configuration**.
5. Select **Persistence**.
6. Select the persistence unit that you want to configure from the table.
7. Review and edit properties on the configuration pages. For help on any page, click the **Help** link at the top of the Administration Console.

Properties that can be viewed include:

- Name
- Provider

- Description
- Transaction type
- Data cache time out
- Fetch batch size
- Default schema name
- Values of persistence unit properties defined in the `persistence.xml` file, for example, `eclipselink.session-name`, `eclipselink.logging.level`, and `eclipselink.target-server`

You can also set attributes related to the transactional and non-transactional data sources of a persistence unit, on the Data Sources configuration page.

8. To activate these changes, in the Change Center of the Administration Console, click **Activate Changes**.

For links to other help topics about working with persistence in the Administration Console, search for "Persistence" in the Table of Contents of *Oracle Fusion Middleware Oracle WebLogic Server Administration Console Online Help*.

3.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- Oracle WebLogic Server documentation, for example, *Oracle Fusion Middleware Introduction to Oracle WebLogic Server*
- *Java API Reference for EclipseLink*, including:
 - `org.eclipse.persistence`
 - `org.eclipse.persistence.jpa.PersistenceProvider`
 - `org.eclipse.persistence.services.mbean`

Using EclipseLink with GlassFish Server

This chapter describes how EclipseLink can be used as the persistence provider for EclipseLink Java Persistence API (JPA) 2.0 applications deployed to Oracle GlassFish Server.

This chapter contains the following sections:

- [Section 4.1, "Introduction to the Solution"](#)
- [Section 4.2, "Implementing the Solution"](#)
- [Section 4.3, "Additional Resources"](#)

Use Case

Users want to run applications that employ JPA on Oracle GlassFish Server.

Solution

The Oracle GlassFish platform provides full support for EclipseLink. Developers writing applications for the GlassFish Server platform can achieve full Java-to-data source integration that complies with the Java Persistence API (JPA) 2.0 specification. EclipseLink allows you to integrate Java applications with any data source, without compromising ideal application design or data integrity.

Components

- GlassFish Server 3.1.2.
- EclipseLink 12c Release 1 (12.1.2).
- EclipseLink software distribution 2.3.0.
- Any compliant JDBC database including Oracle Database, Oracle Database Express Edition, MySQL, and so on.
- While it is not required, you may want to use a Java EE integrated development environment (IDE) for convenience during development.

4.1 Introduction to the Solution

Oracle GlassFish Server is the reference implementation of the Java Platform, Enterprise Edition (Java EE platform) specification. Built using the GlassFish Server Open Source Edition, GlassFish Server delivers a flexible, lightweight, and production-ready Java EE platform.

GlassFish Server is part of the Oracle Fusion Middleware application grid portfolio of products and is ideally suited for applications requiring lightweight infrastructure with the most up-to-date implementation of the Java EE platform. GlassFish Server

complements Oracle WebLogic Server, which is designed to run the broader portfolio of Oracle Fusion Middleware and large-scale enterprise applications.

4.1.1 Advantages to Using EclipseLink with GlassFish Server

By adding EclipseLink support, developers writing applications for the GlassFish Server platform can achieve full Java-to-data source integration that complies with the Java Persistence API (JPA) 2.0 specification. EclipseLink allows you to integrate Java applications with any data source, without compromising ideal application design or data integrity. In addition, EclipseLink gives your GlassFish Server platform applications the ability to store (that is, *persist*) and retrieve business domain objects using a relational database or an XML data source as a repository.

While GlassFish Server can use other persistence providers and EclipseLink can be used with other application servers, using GlassFish Server with EclipseLink provides a number of advantages:

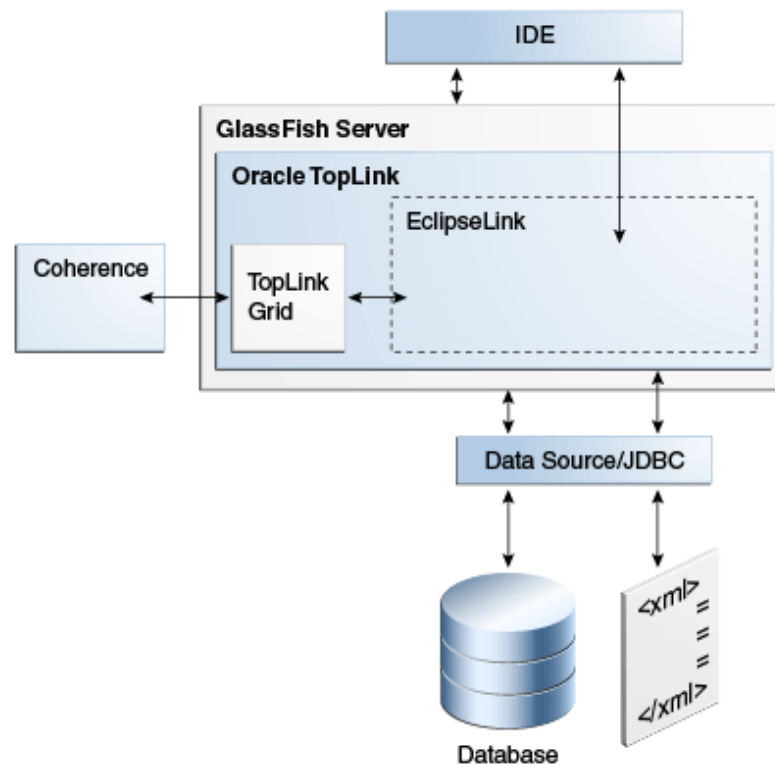
- EclipseLink is included in all GlassFish Server distributions and is the default JPA provider.
- EclipseLink logging integration in GlassFish Server provides a comprehensive, integrated logging infrastructure.
- EclipseLink MOXy is also included in GlassFish versions 3.1.2 and later. Although it is not the default JAXB implementation, it can be used in JAX-WS and JAX-RS applications. For more information, see:
<http://blog.bdoughan.com/2012/02/glassfish-312-is-full-of-moxy.html>
- GlassFish Server supports the Oracle Application Development Framework (Oracle ADF), an end-to-end Java EE framework, based on Struts and JavaServer Faces (JSF). Oracle ADF simplifies application development by providing infrastructure services and a visual and declarative development experience. EclipseLink and Oracle ADF together provide a complete Java EE application infrastructure. Oracle ADF is beyond the scope of this guide. See *Oracle Fusion Middleware Fusion Developer's Guide for Oracle Application Development Framework*.

4.1.2 Relationship of GlassFish Server and EclipseLink to Fusion Middleware Products

[Figure 4–1](#) illustrates how GlassFish Server and EclipseLink are related to and used with other Oracle products. The following are examples of using GlassFish Server and EclipseLink with other Oracle Middleware products:

- Use EclipseLink as the persistence provider.
- Use GlassFish as the application server.
- Use the Oracle database for persisting data.

Figure 4–1 GlassFish Server, EclipseLink and Other Products in the Oracle Fusion Middleware Stack



4.2 Implementing the Solution

To run EclipseLink JPA applications in GlassFish Server, you must configure the server and coordinate certain server and application settings. These are described in the following tasks.

- [Task 1: Prerequisites](#)
- [Task 2: Install GlassFish Server](#)
- [Task 3: Set Up the Data Source](#)
- [Task 4: Create the persistence.xml File](#)
- [Task 5: Set Up GlassFish Server for JPA](#)
- [Task 6: Create the Application](#)
- [Task 7: Deploy the Application to GlassFish Server](#)
- [Task 8: Run the Application](#)
- [Task 9: Monitor the Application](#)

4.2.1 Task 1: Prerequisites

This document is based on the following products and tools, although the principles apply to any supported database or development environment. It is assumed that the software is already installed, except where noted in later sections.

- GlassFish Server 3.1.2.

For more information and downloads, see

<http://www.oracle.com/technetwork/middleware/glassfish/overview/index.html> on the Oracle Technology Network.

- EclipseLink software distribution 2.4.1.

For more information and downloads, see

<http://www.eclipse.org/eclipselink/> on the EclipseLink website.

- Any compliant JDBC database including Oracle Database, Oracle Database Express Edition, MySQL, and so on.

For Oracle Database, see

<http://www.oracle.com/technetwork/database/enterprise-edition/overview/index.html>.

For Oracle Database Express Edition, see

<http://www.oracle.com/technetwork/database/express-edition/overview/index.html>.

For MySQL, see

<http://www.oracle.com/us/products/mysql/index.html>.

- While it is not required, you may want to use a Java EE integrated development environment (IDE) for convenience during development. For example, Oracle JDeveloper, Oracle Enterprise Pack for Eclipse, and NetBeans all provide sophisticated Java EE development tools.

For JDeveloper, see

<http://www.oracle.com/technetwork/developer-tools/jdev/downloads/index.html>.

For Oracle Enterprise Pack for Eclipse, see

<http://www.oracle.com/technetwork/developer-tools/eclipse/overview/index.html>.

For NetBeans, see

<http://www.oracle.com/us/products/tools/050845.html>.

4.2.2 Task 2: Install GlassFish Server

EclipseLink is included with the GlassFish Server distribution. You can find instructions for installing and configuring GlassFish Server at this URL:

http://docs.oracle.com/cd/E26576_01/index.htm

The EclipseLink modules appear as separate JAR files in the modules directory.

```
* \glassfish\modules
.
.
.
o org.eclipse.persistence.antlr.jar
o org.eclipse.persistence.asm.jar
o org.eclipse.persistence.core.jar
o org.eclipse.persistence.jpa.jar
o org.eclipse.persistence.jpa.modelgen.jar
o org.eclipse.persistence.moxy.jar
o org.eclipse.persistence.oracle.jar
.
.
.
```

Note:

- The `org.eclipse.persistence.oracle.jar` file is available with GlassFish and provides Oracle Database-specific functionality for EclipseLink. This file is used only for applications running against an Oracle Database.

Object-XML (also known as JAXB support, or *MOXy*) is a component that enables you to bind Java classes to XML schemas. This support is provided by the `org.eclipse.persistence.moxy.jar`.

4.2.3 Task 3: Set Up the Data Source

Configuring an Oracle database as a JDBC resource for a Java EE application involves the following steps:

1. [Integrate the JDBC Driver for Oracle Database into GlassFish Server](#)
2. [Create a JDBC Connection Pool for the Resource](#)
3. [Create the JDBC Resource](#)

4.2.3.1 Integrate the JDBC Driver for Oracle Database into GlassFish Server

To integrate the JDBC driver, copy its JAR file into the domain and then restart the domain and instances to make the driver available.

1. Copy the JAR file for the JDBC driver into the domain's `lib` subdirectory, for example:

```
cd /home/gfuser/glassfish3
cp oracle-jdbc-drivers/ojdbc6.jar glassfish/domains/domain1/lib
```

Note that you do not have to restart GlassFish Server; the drivers are picked up dynamically.

If the application uses Oracle Database-specific extensions provided by EclipseLink, then the driver must be copied to the `lib/ext` directory. For more information, see "Oracle Database Enhancements" in the *Oracle GlassFish Server Application Development Guide* at:

http://docs.oracle.com/cd/E26576_01/doc.312/e24930/jpa.htm#gigbi

2. You can use the GlassFish Server Administration Console or the command line to restart instances in the domain to make the JDBC driver available to the instances.

To use the GlassFish Server Administration Console:

In the GlassFish Server Administration Console, expand the **Cluster** node. Select the node for the cluster and on its General Information page, click the **Instances** tab. Select the instances you want to restart. For more information, see "To Start Clustered GlassFish Server Instances" in *GlassFish Server Administration Console Online Help*.

To start a standalone instance, expand the **Standalone Instances** node. For each instance that you are starting, select the instance in the Server Instances table. Click Start. The status of each instance is updated in the Server Instances table when the instance is started. For more information, see "To Start Standalone GlassFish Server Instances" in *GlassFish Server Administration Console Online Help*.

To use the command line:

Run the `restart-instance` subcommand to restart the instances. These commands assume that your instances are named `pmd-i1` and `pmd-i2`.

```
restart-instance pmd-i1
restart-instance pmd-i2
```

4.2.3.2 Create a JDBC Connection Pool for the Resource

You can create a JDBC connection pool from the GlassFish Server Administration Console or from the command line.

To use the GlassFish Server Administration Console:

In the GlassFish Server Administration Console, expand the **Common Tasks** node, then click the **Create New JDBC Connection Pool** button in the Common Tasks page. Specify the name of the pool, the resource type, the name of the database provider, the data source and driver class names, and other details. For more information, see "To Create a JDBC Connection Pool" in *GlassFish Server Administration Console Online Help*.

To use the command line:

1. Use the `create-jdbc-connection-pool` subcommand to create the JDBC connection pool, specifying the database connectivity values. In this command, note the use of two backslashes (`\\`) preceding the colons in the URL property value. These backslashes cause the colons to be interpreted as part of the property value instead of as separators between property-value pairs, for example:

```
create-jdbc-connection-pool
--datasourceclassname oracle.jdbc.pool.OracleDataSource
--restype javax.sql.DataSource
--property User=smith\\:Password=password\\:url=jdbc\\:oracle\\:thin\\:@node_
name.example.com\\:1521\\:smithdb
poolbvcallbackbmt
```

2. Verify connectivity to the database.

```
ping-connection-pool pool_name
```

4.2.3.3 Create the JDBC Resource

You can use the GlassFish Server Administration Console to create the JDBC resource or you can use the command line.

To use the GlassFish Server Administration Console:

In the GlassFish Server Administration Console, expand the **Resources** node, then the **JDBC** node, then the **JDBC Resources** node to open the JDBC Resources page. Provide a unique JNDI resource name and associate the resource with a connection pool. For more information, see "To Create a JDBC Resource" in the *GlassFish Server Administration Console Online Help*.

To use the command line:

Use the `create-jdbc-resource` subcommand to create the JDBC resource, and name it so that the application can discover it using JNDI lookup, for example:

```
create-jdbc-resource --connectionpoolid poolbvcallbackbmt jdbc/bvcallbackbmt
```

4.2.4 Task 4: Create the persistence.xml File

[Example 4-1](#) illustrates a sample `persistence.xml` file that specifies the default persistence provider for EclipseLink,

`org.eclipse.persistence.jpa.PersistenceProvider`. For more information about this file, see "About the Persistence Unit" in *EclipseLink Concepts*.

If you are using the default persistence provider, then you can specify additional database properties described in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

Several of the values you enter in the file must match the values you chose when you defined the cluster, connection, and connection pool properties in GlassFish Server, as follows:

JDBC Data Source Properties:

- **Name:** The name of the data source, which is typically the same as the JNDI name, for example `jdbc/bvcallbackbmt`.
- **JNDI Name:** The JNDI path to where this data source is bound. This must be the same name as the value for the `<jta-data-source>` element in `persistence.xml`, for example `jdbc/bvcallbackbmt`.
- **Database Type:** `Oracle`
- **Database Driver:** (default) Oracle's Driver (Thin XA) for Instance connections; Versions: 9.0.1 and later

Connection Properties:

- **Database Name:** The name of the database, for example, `XE` for Oracle Database Express Edition samples.
- **Host Name:** The IP address of the database server, for example `127.0.0.1` for a locally hosted database.
- **Port:** The port number on which your database server listens for connection requests, for example, `1521`, the default for Oracle Database Express Edition 11g.
- **Database User Name:** The database account user name used to create database connections, for example `hr` for Oracle Database Express Edition 11g samples.
- **Password:** Your password.

Select Targets:

- **Servers / Clusters:** Select the administration server, managed servers, or clusters to which you want to deploy the data source. You can choose one or more.

The sample `persistence.xml` file in [Example 4-1](#) highlights the properties defining the persistence provider, the JTA data source, and logging details. In this example, the logging level is set to `FINE`. At this level, SQL code generated by EclipseLink is logged to the `server.log` file. For more information about these properties, see:

- [Section 4.2.4.1, "Specify the Persistence Provider."](#)
- [Section 4.2.4.2, "Specify an Oracle Database."](#)
- [Section 4.2.4.3, "Specify Logging."](#)

Example 4-1 Sample `persistence.xml` File

```
<?xml version="1.0" encoding="UTF-8"?>
<persistence xmlns="http://java.sun.com/xml/ns/persistence" version="2.0">
  <persistence-unit name="pu1" transaction-type="JTA">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <jta-data-source>jdbc/bvcallbackbmt</jta-data-source>
    <properties>
      <property name="eclipselink.logging.level" value="FINE"/>
    </properties>
  </persistence-unit>
</persistence>
```

```
<property name="eclipselink.ddl-generation"
          value="drop-and-create-tables"/>
</properties>
</persistence-unit>
</persistence>
```

4.2.4.1 Specify the Persistence Provider

The persistence provider defines the implementation of JPA. It is defined in the provider element of the persistence.xml file. Persistence providers are vendor-specific. The persistence provider for EclipseLink is `org.eclipse.persistence.jpa.PersistenceProvider`.

4.2.4.2 Specify an Oracle Database

You specify the database connection details in the persistence.xml file. GlassFish Server uses the bundled Java DB (Derby) database by default, named `jdbc/___default`. To use a nondefault database, such as the Oracle Database, either specify a value for the `jta-data-source` element, or set the `transaction-type` element to `RESOURCE_LOCAL` and specify a value for the `non-jta-data-source` element.

If you are using the default persistence provider, `org.eclipse.persistence.jpa.PersistenceProvider`, then the provider attempts to automatically detect the database type based on the connection metadata. This database type is used to issue SQL statements specific to the detected database type. You can specify the optional `eclipselink.target-database` property to guarantee that the database type is correct.

For more information about specifying database properties in a persistence.xml file for GlassFish Server, see "Specifying the Database for an Application" in the *Oracle GlassFish Server Application Development Guide*, at:

http://docs.oracle.com/cd/E26576_01/doc.312/e24930/jpa.htm#gbwmj

4.2.4.3 Specify Logging

EclipseLink provides a logging utility even though logging is not part of the JPA specification. Hence, the information provided by the log is EclipseLink JPA-specific. With EclipseLink, you can enable logging to view the following information:

- Configuration details
- Information to facilitate debugging
- The SQL that is being sent to the database

You can specify logging in the persistence.xml file. EclipseLink logging properties let you specify the level of logging and whether the log output goes to a file or standard output. Because the logging utility is based on `java.util.logging`, you can specify a logging level to use.

The logging utility provides nine levels of logging control over the amount and detail of the log output. Use `eclipselink.logging.level` to set the logging level, for example:

```
<property name="eclipselink.logging.level" value="FINE"/>
```

By default, the log output goes to `System.out` or to the console. To configure the output to be logged to a file, set the property `eclipselink.logging.file`, for example:

```
<property name="eclipselink.logging.file" value="output.log"/>
```

EclipseLink's logging utility is pluggable, and several different logging integrations are supported, including `java.util.logging`. To enable `java.util.logging`, set the property `eclipselink.logging.logger`, for example:

```
<property name="eclipselink.logging.logger" value="JavaLogger"/>
```

While running inside GlassFish Server, EclipseLink is configured by GlassFish Server to use `JavaLogger` by default. The log is always redirected to the GlassFish Server `server.log` file. For more information, see "Setting Log Levels" in *Oracle GlassFish Server Administration Guide*, at:

http://docs.oracle.com/cd/E26576_01/doc.312/e24928/logging.htm#gklml

For more information about EclipseLink logging and the levels of logging available in the logging utility, see "Persistence Property Extensions Reference" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

4.2.5 Task 5: Set Up GlassFish Server for JPA

GlassFish Server Application Development Guide describes server-specific considerations on setting up GlassFish Server to run applications that employ JPA:

docs.oracle.com/cd/E26576_01/doc.312/e24930/jpa.htm

It provides more information about these topics:

- "Specifying the Database for an Application," for information about database connection properties
- "Specifying the Persistence Provider for an Application," for setting the default or non-default persistence provider for an application
- "Primary Key Generation Defaults," for the default persistence provider's primary key generation defaults
- "Automatic Schema Generation," for information on annotations and options to manage automatic schema generation
- "Restrictions and Optimizations," for restrictions and performance optimizations that affect using the Java Persistence API

4.2.6 Task 6: Create the Application

To create an application that uses EclipseLink as its JPA persistence provider, you may want to use a Java EE IDE for convenience during development. For example, JDeveloper, Oracle Enterprise Pack for Eclipse, and NetBeans provide sophisticated Java EE development tools, including support for EclipseLink. See "Key Tools" in *EclipseLink Concepts*.

For guidance in writing your application, see these topics from the "Configuring the Java Persistence Provider" chapter in *Oracle GlassFish Server Application Development Guide*, at:

docs.oracle.com/cd/E26576_01/doc.312/e24930/jpa.htm

4.2.7 Task 7: Deploy the Application to GlassFish Server

For information about deploying to GlassFish Server, see "Deploy Applications or Modules," "To Deploy an Enterprise Application," and "To Deploy a Web Application"

in *GlassFish Server Administration Console Online Help*. See also *Oracle GlassFish Server Application Deployment Guide*, at:

http://docs.oracle.com/cd/E26576_01/index.htm

4.2.8 Task 8: Run the Application

For instructions for starting a deployed application from the GlassFish Server Administration Console, see "Application Client Launch" and "To Launch an Application" in *GlassFish Server Administration Console Online Help*.

4.2.9 Task 9: Monitor the Application

GlassFish Server provides a monitoring service to track the health and performance of an application. For information about monitoring an application from the console, see the "Monitoring" and "Monitoring Data" topics in *GlassFish Server Administration Console Online Help*. For information about monitoring the application from the command line, see "Administering the Monitoring Service" in *Oracle GlassFish Server Administration Guide*, at:

http://docs.oracle.com/cd/E26576_01/doc.312/e24928/monitoring.htm

4.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- Oracle GlassFish Server Administration Guide
http://docs.oracle.com/cd/E26576_01/doc.312/e24928/toc.htm
- Oracle GlassFish Server Application Deployment Guide
http://docs.oracle.com/cd/E26576_01/doc.312/e24929/toc.htm
- Oracle GlassFish Server Application Development Guide
http://docs.oracle.com/cd/E26576_01/doc.312/e24930/toc.htm
- Oracle GlassFish Server 3.1.2 to 3.1.2.2 Documentation Library
http://docs.oracle.com/cd/E26576_01/index.htm

Using EclipseLink with JBoss 7 Application Server

This chapter introduces how EclipseLink can be used as the persistence provider for EclipseLink applications deployed to JBoss Application Server 7.1.

This chapter contains the following sections:

- [Section 5.1, "Introduction to the Solution"](#)
- [Section 5.2, "Implementing the Solution"](#)
- [Section 5.3, "Additional Resources"](#)

Use Case

EclipseLink can be used with a number of popular Java EE application servers, including JBoss Application Server.

Solution

Configure JBoss to use EclipseLink runtime, and deploy applications developed using EclipseLink APIs.

Components

- EclipseLink 2.4 or later.
- JBoss Application Server 7.x.
- A compliant Java Database Connectivity (JDBC) database, such as Oracle Database, Oracle Express, MySQL, the HSQL database embedded in JBoss Application Server, etc.

5.1 Introduction to the Solution

JBoss Application Server implements the Java Platform, Enterprise Edition (Java EE). JBoss 7 fully supports Java EE 6, while JBoss 6 officially supports only the Java EE 6 Web Profile.

By configuring JBoss to support EclipseLink, you can take advantage of EclipseLink's full support for Java Persistence API (JPA), Java Architecture for XML Binding (JAXB), including EclipseLink's extensions to those technologies, as well as EclipseLink Database Web Services (DBWS) to access to relational database artifacts via a Web service.

5.2 Implementing the Solution

To develop, deploy and run EclipseLink application in JBoss Application Server 7, you must create EclipseLink as a module of JBoss. You must also create other modules, such as a JDBC driver, etc., in order to run applications.

This section contains the following tasks for using EclipseLink with JBoss 7.1:

- [Task 1: Prerequisites](#)
- [Task 2: Configure EclipseLink as a Module in JBoss](#)
- [Task 3: Add ojdbc6.jar as a Module in JBoss](#)
- [Task 4: Create the Driver Definition and the Datasource](#)
- [Task 5: Create Users](#)
- [Task 6: Modify JBoss Properties](#)
- [Task 7: Other Requirements](#)
- [Task 8: Start JBoss](#)

5.2.1 Task 1: Prerequisites

Ensure that you have installed the following components:

- JBoss, version 7 or later. These instructions are based on JBoss release 7.1.1.
Download JBoss from <http://www.jboss.org/jbossas/downloads/>. The version of JBoss must be identified as "Certified Java EE6." Version 7.1.1 or later is recommended.
- EclipseLink 2.4 or later.
Download EclipseLink from <http://www.eclipse.org/eclipselink/downloads/>.
- Any compliant Java Database Connectivity (JDBC) database including Oracle Database, Oracle Express, MySQL, the HSQL database embedded in JBoss Application Server, and so on.

Note: Oracle XML DB (XDB) and JBoss Application Server both use port 8080 by default. If you have both available at the same URI, for example `localhost`, you must reconfigure one or the other to use a different port, for example 8081.

For the Oracle Database, see <http://www.oracle.com/technetwork/database/enterprise-edition/overview/index.html>. For the Oracle Database, Express Edition, see <http://www.oracle.com/technetwork/database/express-edition/overview/index.html>. For MySQL, see <http://www.oracle.com/us/products/mysql/index.html>. For information about the embedded HSQL database, see the JBoss documentation.

- While it is not required, you may want to use a Java development environment (IDE) for convenience during development. For example JDeveloper, Oracle Enterprise Pack for Eclipse, and NetBeans all provide sophisticated Java EE development tools that support EclipseLink.

For JDeveloper, see

<http://www.oracle.com/technetwork/developer-tools/jdev/downloads/index.html>. For Oracle Enterprise Pack for Eclipse, see

<http://www.oracle.com/technetwork/developer-tools/eclipse/overview/index.html>. For NetBeans, see

<http://www.oracle.com/us/products/tools/050845.html>.

5.2.2 Task 2: Configure EclipseLink as a Module in JBoss

To configure EclipseLink as a module in JBoss:

1. Create a directory as follows:

```
JBOSS_HOME\modules\org\eclipse\persistence\main
```

2. Copy eclipselink.jar to the directory created in step 1.
3. Create a module.xml file in the directory created in step 1, with the following content:

```
<module xmlns="urn:jboss:module:1.1" name="org.eclipse.persistence">
  <resources>
    <resource-root path="eclipselink.jar"/>
    <!-- Insert resources here -->
  </resources>
  <dependencies>
    <module name="javax.api"/>
    <module name="javax.persistence.api"/>
    <module name="javax.transaction.api"/>
    <module name="javax.validation.api"/>
    <module name="javax.xml.bind.api"/>
    <module name="org.antlr"/>
    <module name="org.apache.commons.collections"/>
    <module name="org.dom4j"/>
    <module name="org.javassist"/>
    <module name="org.jboss.logging"/>
    <module name="com.oracle.ojdbc6"/>
  </dependencies>
</module>
```

5.2.3 Task 3: Add ojdbc6.jar as a Module in JBoss

Add the Oracle thin driver ojdbc6.jar as a module within JBoss, as follows:

1. Create the module directory:

```
JBOSS_HOME\modules\com\oracle\ojdbc6\main
```

2. Copy ojdbc6.jar to the module directory created in step 2.
3. Create a module.xml file in the module directory created in step 2, with the following contents:

```
<module xmlns="urn:jboss:module:1.1" name="com.oracle.ojdbc6">
  <resources>
    <resource-root path="ojdbc6.jar"/>
    <!-- Insert resources here -->
  </resources>
  <dependencies>
    <module name="javax.api"/>
  </dependencies>
```

```
</module>
```

5.2.4 Task 4: Create the Driver Definition and the Datasource

Create the driver definition and create the datasource.

The following instructions tell how to configure JBoss for running in standalone mode, using the `standalone.xml` configuration file. For instructions on how to use `domain.xml` to configure JBoss for running in domain mode, see the JBoss documentation.

1. In the standalone configuration file `JBoss_HOME\standalone\configuration\standalone.xml`, find the following:

```
<subsystem xmlns="urn:jboss:domain:datasources:1.0">
```
2. In that section, configure the datasource. The following example shows a configuration for the Oracle Database, using the Oracle JDBC Thin driver. For instructions on configuring other datasources, see the JBoss documentation.

```
<subsystem xmlns="urn:jboss:domain:datasources:1.0">
  <datasources>
    <datasource jndi-name="java:/EclipseLinkDS"
      pool-name="EclipseLinkDS"
      enabled="true"
      jta="true"
      use-java-context="true"
      use-ccm="true">
      <connection-url>jdbc:oracle:thin:node_name.example.com:1521:TOPLINK</connection-url>
      <driver>oracle</driver>
      <transaction-isolation>TRANSACTION_READ_COMMITTED</transaction-isolation>
      <pool>
        <prefill>true</prefill>
        <use-strict-min>false</use-strict-min>
        <flush-strategy>FailingConnectionOnly</flush-strategy>
      </pool>
      <security>
        <user-name>Smith</user-name>
        <password>password</password>
      </security>
    </datasource>
    <driver name="oracle" module="com.oracle.ojdbc6">
      <xa-datasource-class>oracle.jdbc.OracleDriver</xa-datasource-class>
    </driver>
  </datasources>
</subsystem>
```

5.2.5 Task 5: Create Users

Starting with JBoss Application Server 7.1, you must create an Application User to get started, because remote access to the JNDI tree is secured by default, and you must provide login credentials. Therefore, at a minimum, you just create an Application User to be able to deploy an application to the server. If you want to use the JBoss administration console for administration tasks, for example to view the JNDI tree, you must also create an Administration User.

To create user credentials, use the JBoss `add-user.bat` utility, located in `JBoss_HOME\bin\`.

For more information about security in JBoss Application Server, refer to the JBoss documentation.

5.2.6 Task 6: Modify JBoss Properties

Modify JBoss properties, as follows:

```
## JBoss-7.x
server.factory=org.jboss.naming.remote.client.InitialContextFactory
java.naming.factory.url.pkgs=org.jboss.ejb.client.naming
server.depend=jboss-client.jar
jboss.server=${jboss.home}/standalone
server.lib=${jboss.home}/bin/client
server.url=remote://localhost:4447
server.user=usera
server.pwd=passworda
jboss.naming.client.ejb.context=true
```

5.2.7 Task 7: Other Requirements

1. Add `junit.jar` in the ear under the `\lib` directory.
2. Because of a classloading issue in JBoss, you must list all your entity classes in `persistence.xml`. You can use either `<class>` elements or a global `<exclude-unlisted-classes>false</exclude-unlisted-classes>` element.
3. Add both `jndi.properties` and `jboss-ejb-client.properties` in the client classpath.

5.2.8 Task 8: Start JBoss

Start JBoss by running `standalone.bat` (for a single-server configuration) or `domain.bat` file (in a clustered environment) in `JBOSS_HOME\bin\`.

For information on different ways to configure and start JBoss, see the JBoss documentation.

5.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- JBoss Community at <http://www.jboss.org>.

Using EclipseLink with IBM WebSphere Application Server

This chapter introduces how EclipseLink can be used as the persistence provider for EclipseLink applications deployed to IBM WebSphere Application Server.

This chapter contains the following sections:

- [Section 6.1, "Introduction to the Solution"](#)
- [Section 6.2, "Implementing the Solution"](#)
- [Section 6.3, "Additional Resources"](#)

Use Case

EclipseLink can be used with a number of popular Java EE application servers, including WebSphere Application Server.

Solution

Configure WebSphere to use EclipseLink runtime, and deploy applications developed using EclipseLink APIs.

Components

- EclipseLink 2.4 or later.
- WebSphere Application Server 7 or later. These instructions are based on WebSphere 8.5.
- A compliant Java Database Connectivity (JDBC) database, such as Oracle Database, Oracle Express, MySQL, the Derby database included in WebSphere Application Server, and so on.

6.1 Introduction to the Solution

WebSphere Application Server implements Java Platform, Enterprise Edition (Java EE). WebSphere V8.5 fully supports Java EE 6 and can support Java Platform, Standard Edition (Java SE) 7 via a plugin.

By configuring WebSphere support EclipseLink, you can create and deploy applications that take advantage of EclipseLink's full support for Java Persistence API (JPA), as well as EclipseLink's many extensions.

6.2 Implementing the Solution

To develop, deploy, and run EclipseLink applications in IBM WebSphere, you must add various modules including EclipseLink to WebSphere, and you must configure various aspects of WebSphere to support EclipseLink.

This section contains the following tasks for using EclipseLink with IBM WebSphere, Version 7 or later:

- [Task 1: Prerequisites](#)
- [Task 2: Configure Persistence Units](#)
- [Task 3: Configure the Server and the Application to Use EclipseLink](#)

6.2.1 Task 1: Prerequisites

Ensure that you have installed the following components:

- IBM WebSphere, Version 7 or later. These instructions are based on WebSphere, Version 8.5.

Obtain IBM WebSphere from

<http://www-01.ibm.com/software/webervers/appserv/was/>.

- EclipseLink 2.4 or later.

Download EclipseLink from

<http://www.eclipse.org/eclipselink/downloads/>.

You will use the following files:

- eclipselink.jar
- javax.persistence_ver_no.jar

6.2.2 Task 2: Configure Persistence Units

Configure persistence units to use EclipseLink (EclipseLink library) as the persistence provider and to use WebSphere as the target server.

[Example 6–1](#) shows a sample configuration for a container-managed persistence unit.

Example 6–1 Sample persistence.xml for a container-managed persistence unit

```
<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 persistence_1_0.xsd"
  version="1.0">
  <persistence-unit name="default" transaction-type="JTA">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <jta-data-source>jdbc/EclipseLinkDS</jta-data-source>
    <exclude-unlisted-classes>false</exclude-unlisted-classes>
    <properties>
      <property name="eclipselink.target-server" value="WebSphere_7"/>
      <property name="eclipselink.target-database"
        value="org.eclipse.persistence.platform.database.oracle.Oracle11Platform"/>
      <property name="eclipselink.validate-existence" value="true"/>
      <property name="eclipselink.weaving" value="true"/>
      <property name="eclipselink.logging.level" value="FINEST"/>
    </properties>
  </persistence-unit>
</persistence>
```

[Example 6-2](#) shows a sample configuration for an application-managed persistence unit.

Example 6-2 Sample persistence.xml for an application-managed persistence unit

```
<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 persistence_1_0.xsd" version="1.0">
  <persistence-unit name="default" transaction-type="RESOURCE_LOCAL">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <non-jta-data-source>jdbc/ELNonJTADS</non-jta-data-source>
    <exclude-unlisted-classes>false</exclude-unlisted-classes>
    <properties>
      <property name="eclipselink.target-server" value="WebSphere_7"/>
      <property name="eclipselink.target-database"
        value="org.eclipse.persistence.platform.database.oracle.Oracle11Platform"/>
      <property name="eclipselink.validate-existence" value="true"/>
      <property name="eclipselink.weaving" value="true"/>
      <property name="eclipselink.logging.level" value="FINEST"/>
    </properties>
  </persistence-unit>
</persistence>
```

Note the following about the two examples above:

- The eclipselink.target-server value WebSphere_7 is used for WebSphere Application Server version 7 and later.
- Specifying persistence_1_0.xsd" version="1.0" for the persistence schema version works with both JPA 1 and JPA 2. For a JPA 2.*n* -only application, you can change the version to persistence_2_0.xsd" version="2.*n*" (WebSphere's support for JPA 2 began in WebSphere Application Server 7.0.0.9).

6.2.3 Task 3: Configure the Server and the Application to Use EclipseLink

The following are typical scenarios for using EclipseLink with the application server:

- [Modify Server to Make EclipseLink Available Globally](#)
- [Package EclipseLink in the Application EAR](#)
- [Package EclipseLink in the WAR](#)

6.2.3.1 Modify Server to Make EclipseLink Available Globally

You can make EclipseLink available globally for both container-managed and application-managed persistence units in either of the following ways:

- [Option 1: Create a Global Shared Library \(Recommended\)](#)
- [Option 2: Add EclipseLink as a Server Library Extension](#)

Option 1: Create a Global Shared Library (Recommended)

1. Create a global shared library containing the following files:

- eclipselink.jar

Find this file in the `TOPLINK_INSTALLATION\oracle_common\modules\oracle.toplink_ver_no` directory created by the EclipseLink quick installer.

- xmlparserv2.jar

Find this file in the `TOPLINK_INSTALLATION\toplink\modules` directory created by the EclipseLink quick installer.

- If you use Oracle Database features such as `NCHAR`, `XMLTYPE`, and `MDSYS.SDO_GEOMETRY` with JPA, you must also include `xdb.jar` and `sdoapi.jar` in the shared library. Those files are available in your Oracle Database distribution.

See the WebSphere documentation for instructions on how to use WebSphere to facilitate the creation of shared libraries.

2. Associate the shared library with the application.

See the WebSphere documentation for instructions on how to use WebSphere to associate the shared library with an application.

Option 2: Add EclipseLink as a Server Library Extension

To add EclipseLink as a server library extension, copy `eclipselink.jar` and the other JAR file(s) listed in Option 1, above, to the `WAS_HOME\lib\ext` directory.

6.2.3.2 Package EclipseLink in the Application EAR

You can also implement container-managed persistence by adding `eclipselink.jar` in the application EAR, without making any modifications to the server configuration. In this case, the persistence unit is managed by `@PersistenceContext` entity manager proxy injection on a stateless session bean. The following instructions show an example of this approach.

1. Add `eclipselink.jar` to the application EAR in the following location:

`EAR_archive/APP-INF/lib/`

2. Add the path to the `eclipselink.jar` to the `ejbModule/META-INF/MANIFEST.MF` file(s) in your EJB JAR(s), as shown below:

```
Manifest-Version: 1.0
Class-Path: APP-INF/lib/eclipselink.jar
```

This is the manifest at the root of the entities' location, in this case as part of the `ejb.jar`.

3. Configure the class loader to load the classes with the application class loader first.
4. Deploy and start the application. See the IBM WebSphere documentation for instructions.

6.2.3.3 Package EclipseLink in the WAR

If you do not or cannot implement container-managed persistence, as described in the previous two scenarios, you can create an application managed entity manager. In this case, all library configuration and classloader scope changes must be done inside the EAR itself.

1. Add `eclipselink.jar` and `javax.persistence_ver_no.jar` to the web application archive (WAR) file in the following location:

`WAR_archive/WEB-INF/lib/`

2. Configure the class loader order for your application to load the classes with the application class loader first. See the WebSphere documentation for instructions on setting class loader order using the Administrative console.
3. Deploy and start the application. See the IBM WebSphere documentation for instructions.

6.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- WebSphere Application Server at
<http://www-01.ibm.com/software/webservers/appserv/was/>.

Migrating from Native EclipseLink

This chapter tells how to migrate applications using native EclipseLink object-relational mapping (ORM) APIs to the current EclipseLink APIs, which have been the core libraries in EclipseLink starting with EclipseLink 11g, Release 1 (11.1.1).

This chapter contains the following sections:

- [Section 7.1, "Introduction to the Solution"](#)
- [Section 7.2, "Implementing the Solution"](#)
- [Section 7.3, "Additional Resources"](#)

Use Case

A developer wants to upgrade an application that uses the older EclipseLink native ORM to use a current EclipseLink ORM implementation.

Solution

Follow the instructions in this chapter to upgrade the application.

Components

- EclipseLink 2.4 or later.
- (Optional) EclipseLink Workbench.

7.1 Introduction to the Solution

"Native" EclipseLink ORM refers to the API, configuration files, and tools for object-relational mapping that evolved in EclipseLink before the Java Persistence API (JPA) standardized an object-relational mapping API. Full JPA support was introduced in EclipseLink 10g (10.1.3.1.0), via EclipseLink Essentials. However, native EclipseLink continued to be supported.

Prior to the EclipseLink 11g (11.1.1) release, Oracle contributed the EclipseLink source code—including EclipseLink JPA and native EclipseLink—to the Eclipse Foundation, where it was used to form the basis of the open-source EclipseLink persistence services project. Then, in EclipseLink 11g Release 1 (11.1.1), Oracle started to include EclipseLink in EclipseLink, providing EclipseLink's core functionality.

EclipseLink developers using EclipseLink versions 11.1.1.0.0 through 11.1.1.6.0 have access to native EclipseLink ORM in either the proprietary Oracle `toplink.jar` or in the EclipseLink `eclipselink.jar`. In `toplink.jar`, the classes are in packages whose names start with `oracle.toplink.*`. In `eclipselink.jar`, those package names begin instead with `org.eclipselink.persistence..`

You can migrate applications that use `oracle.toplink.*` packages from `toplink.jar` to use `org.eclipselink.persistence.` packages from `eclipselink.jar`. The application functionality remains the same, but migrating to `eclipselink.jar` provides the most up-to-date code base. After migrating, you will have access to other EclipseLink features and will be better prepared to convert your application to use JPA or one of the other persistence services included in current versions of EclipseLink.

This chapter explains how to use the renaming tool that is packaged with stand-alone EclipseLink to easily change the package names in your application and how to perform other actions necessary to migrate to the current code base.

Note: Following the instructions in this chapter will update your application to use the current EclipseLink code base. Doing so retains the design and functionality of your application as originally implemented. However, these instructions do not describe how to convert a native EclipseLink-based application to use JPA or any of the other persistence services in current versions of EclipseLink. See the other EclipseLink documentation sources for that information.

7.2 Implementing the Solution

This section contains the following tasks:

- [Section 7.2.1, "Task 1: Prerequisites"](#)
- [Section 7.2.2, "Task 2: Replace Deprecated and Removed Native APIs"](#)
- [Section 7.2.3, "Task 3: Rename Packages"](#)
- [Section 7.2.4, "Task 4: Convert XML Configuration Files"](#)
- [Section 7.2.5, "Convert EclipseLink Workbench Projects"](#)

7.2.1 Task 1: Prerequisites

- EclipseLink 12c (12.1.2).

All EclipseLink downloads starting with 11g include the renaming tool discussed in this chapter.

Note: The renaming tool is not included with embedded versions of EclipseLink, for example in Oracle WebLogic Server or Oracle Glassfish. You must download the standalone EclipseLink installer.

Download EclipseLink from

<http://www.oracle.com/technetwork/middleware/toplink/downloads/index.html>. For installation instructions, see [Chapter 2, "Installing EclipseLink."](#)

- (Optional) EclipseLink Workbench. The EclipseLink Workbench is available in EclipseLink downloads. See the EclipseLink download page at <http://www.eclipse.org/eclipselink/downloads/>.

7.2.2 Task 2: Replace Deprecated and Removed Native APIs

APIs that were deprecated in releases before EclipseLink 11g Release 1 (11.1.1) were removed in EclipseLink and therefore are not included in current versions of

EclipseLink. If your application uses any of those deprecated APIs or any APIs that were already replaced or removed from EclipseLink, you must update the application to use current APIs.

The following sections lists the replaced and removed APIs, with suggested substitutions:

- [Section 7.2.2.1, "APIs Replaced,"](#)
- [Section 7.2.2.2, "Deprecated APIs,"](#)
- [Section 7.2.2.3, "Removed API,"](#)

Note: When suggested replacements are in `oracle.toplink.*` packages, you must also change the package names, as described in [Section 7.2.3, "Task 3: Rename Packages."](#)

7.2.2.1 APIs Replaced

The following tables list the APIs removed as of EclipseLink 11g Release 1 (11.1.1.1.). Use the replacement API listed in the tables.

- [Table 7–1, "changetracking \(oracle.toplink.descriptors.*\)"](#)
- [Table 7–2, "databaseaccess \(oracle.toplink.internal*\)"](#)
- [Table 7–3, "jdo \(oracle.toplink.*\)"](#)
- [Table 7–4, "mappings \(oracle.toplink.*\)"](#)
- [Table 7–5, "objectrelational \(oracle.toplink.*\)"](#)
- [Table 7–6, "oraclespecific \(oracle.toplink.*\)"](#)
- [Table 7–7, "publicinterface \(oracle.toplink.*\)"](#)
- [Table 7–8, "sdk \(oracle.toplink.*\)"](#)
- [Table 7–9, "entitymanager \(oracle.toplink.sessions.*\)"](#)
- [Table 7–10, "sessionconfiguration \(oracle.toplink.tools.*\)"](#)
- [Table 7–11, "xml \(oracle.toplink.*\)"](#)
- [Table 7–12, "XMLCommandConverter \(oracle.toplink.*\)"](#)
- [Table 7–13, "Remote Protocols \(oracle.toplink.*\)"](#)
- [Table 7–14, "EJB Mapping for BEA WebLogic 6.1"](#)
- [Table 7–15, "mappings \(oracle.toplink.*\)"](#)
- [Table 7–16, "descriptors \(oracle.toplink.*\)"](#)

Table 7–1 *changetracking (oracle.toplink.descriptors.*)*

Class Name	Method Name	Replacement APIs
ChangeTracker	getTopLinkPropertyChangeListener	<code>._persistence_getPropertyChangeListener</code>
ChangeTracker	setTopLinkPropertyChangeListener (PropertyChangeListener)	<code>._persistence_setPropertyChangeListener (PropertyChangeListener)</code>

Table 7–2 *databaseaccess (oracle.toplink.internal*)*

Class Name	Method Name	Replacement APIs
.*Platform	Whole class	oracle.toplink.platform.database.*Platform

Table 7–3 *jdo (oracle.toplink.*)*

Class Name	Method Name	Replacement APIs
.jdo	Whole package	None

Table 7–4 *mappings (oracle.toplink.*)*

Class Name	Method Name	Replacement APIs
TypeConversionMapping	Whole class	.mappings.converters.TypeConversionConverter
ObjectTypeMapping	Whole class	.mappings.converters.ObjectTypeConverter
SerializedObjectMapping	Whole class	.mappings.converters.SerializedObjectConverter

Table 7–5 *objectrelational (oracle.toplink.*)*

Class Name	Method Name	Replacement APIs
Oracle8Platform	Whole class	oracle.toplink.platform.database.oracle.Oracle8Platform

Table 7–6 *oraclespecific (oracle.toplink.*)*

Class Name	Method Name	Replacement APIs
.oraclespecific.NCharacter	Whole class	.platform.database.oracle.NCharacter
.oraclespecific.NClob	Whole class	.platform.database.oracle.NClob
.oraclespecific.NClob	Whole class	.platform.database.oracle.NClob
.oraclespecific.Oracle8Platform	Whole class	.platform.database.oracle.Oracle8Platform
.oraclespecific.Oracle9Specific ¹	Whole class	.platform.database.oracle.Oracle9Specific
.oraclespecific.TopLinkXMLType ²	Whole class	None

¹ oracle.toplink.oraclespecific.Oracle9Specific was moved to an internal package and renamed to oracle.toplink.internal.platform.database.oracle.Oracle9Specific. The replacement public API for oracle.toplink.oraclespecific.Oracle9Specific is oracle.toplink.platform.database.oracle.Oracle9Specific.

² oracle.toplink.oraclespecific.TopLinkXMLType was a miscellaneous class, which does not have a replacement API.

Table 7–7 *publicinterface (oracle.toplink.*)*

Class Name	Method Name	Replacement APIs
DatabaseRow	Whole class	.sessions.DatabaseRecord
DatabaseSession ¹	Whole class	.sessions.DatabaseSession
Descriptor	Whole class	.descriptors - ClassDescriptor, RelationalDescriptor
DescriptorEvent	Whole class	.descriptors.DescriptorEvent
DescriptorEventListener	Whole class	.descriptors - new interface will not extend old interface
DescriptorEventManager	Whole class	.descriptors
DescriptorQueryManager	Whole class	.descriptors

Table 7–7 (Cont.) publicinterface (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
InheritancePolicy	Whole class	.descriptors
Session ²	Whole class	.sessions.Session
UnitOfWork ³	Whole class	.sessions.UnitOfWork

¹ oracle.toplink.publicinterface.DatabaseSession was moved to an internal package and renamed to oracle.toplink.internal.sessions.DatabaseSessionImpl. The replacement public API for oracle.toplink.publicinterface.DatabaseSession is oracle.toplink.sessions.DatabaseSession.

² oracle.toplink.publicinterface.Session was moved to an internal package and renamed to oracle.toplink.internal.sessions.AbstractSessionImpl. The replacement public API for oracle.toplink.publicinterface.Session is oracle.toplink.sessions.Session.

³ oracle.toplink.publicinterface.UnitOfWork was moved to an internal package and renamed to oracle.toplink.internal.sessionl.UnitOfWorkImpl. The replacement public API for oracle.toplink.publicinterface.UnitOfWork is oracle.toplink.sessions.UnitOfWork.

Table 7–8 sdk (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
.sdk	Whole package	.eis

Table 7–9 entitymanager (oracle.toplink.sessions.*)

Class Name	Method Name	Replacement APIs
All classes	All methods	JPA: see Section 7.2.2.4.1, "JPA Persistence Provider Implementation,"

Table 7–10 sessionconfiguration (oracle.toplink.tools.*)

Class Name	Method Name	Replacement APIs
WASXMLLoader	All methods	None

Table 7–11 xml (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
.xml	Whole package	.ox
.xmlstream	Whole package	.ox
.xml.tools	Whole package	.ox
.xml.xerces	Whole package	.ox
.xml.zip	Whole package	.ox

Table 7–12 XMLCommandConverter (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
.remotecommand.XMLCommandConverter	Whole class	None
.transform.xml.XMLSource	Whole class	None
.transform.xml.XMLResult	Whole class	None

Table 7–12 (Cont.) XMLCommandConverter (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
.internal.localization.i18n.ExceptionLocalizationResource	"error_loading_resources"	None
.internal.localization.i18n.ExceptionLocalizationResource	"error_parsing_resources"	None
.internal.localization.i18n.ExceptionLocalizationResource	"unexpected_argument"	None

Table 7–13 Remote Protocols (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
.remote.corba.orbix	Whole package	None
.remote.corba.visibroker	Whole package	None
.remote.ejb	Whole package	None
.tools.sessionconfiguration.TopLinkSessionsFactory	References for any of JNDIClusteringService in orbix, visibroker and ejb packages.	None
.tools.sessionconfiguration.DTD2SessionConfigLoader	References for any of JNDIClusteringService in orbix, visibroker and ejb packages.	None
.tools.sessionconfiguration.model.clustering.VisibrokerCORBAJNDIClusteringConfig	Whole class	None
.tools.sessionconfiguration.model.clustering.OrbixCORBAJNDIClusteringConfig	Whole class	None
.tools.sessionconfiguration.model.clustering.EJBNDIClusteringConfig	Whole class	None
.tools.sessionconfiguration.XMLSessionConfigProject	References for any of JNDIClusteringService in orbix, visibroker and ejb packages.	None

Table 7–14 EJB Mapping for BEA WebLogic 6.1

Class Name	Method Name	Replacement APIs
toplink-cmp-bean_name.xml	None	A warning will be added at the beginning of: internal.ejb.cmp.wls11.CMPDeployer.readTypeSpecificData()

7.2.2.2 Deprecated APIs

The following tables list the APIs deprecated in the releases prior to EclipseLink 11g Release 1 (11.1.1) and therefore removed in that release, due to the substitution of EclipseLink libraries. Use the replacement API indicated.

Note: Because deprecated classes and moved classes have the same name, you may get compile errors if you use `import *` to import classes from both the old package and the new package. To avoid these errors, use `import` with a fully qualified package name.

- [Table 7–15, "mappings \(oracle.toplink.*\)"](#)
- [Table 7–16, "descriptors \(oracle.toplink.*\)"](#)

Table 7–15 mappings (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
OneToOneMapping	useJoining	ForeignReferenceMapping.setJoinFetch(int)

Table 7–16 descriptors (oracle.toplink.*)

Class Name	Method Name	Replacement APIs
ClassDescriptor	addMultipleTableForeignKeyField	addForeignKeyFieldForMultipleTable
ClassDescriptor	addMultipleTablePrimaryKeyField	addForeignKeyFieldForMultipleTable
ClassDescriptor	addMultipleTablePrimaryKeyFieldName	addForeignKeyFieldNameForMultipleTable
ClassDescriptor	addMultipleTableForeignKeyFieldName	addForeignKeyFieldNameForMultipleTable

7.2.2.3 Removed API

The following classes were removed in the release prior to EclipseLink 11g Release 1 (11.1.1):

- OTSTransactionController
- OTSSynchronizationListener
- OracleSequenceDefinition (use SequenceObjectDefinition instead)
- TimeTenSequenceDefinition (use SequenceObjectDefinition instead)

7.2.2.4 Miscellaneous API Changes

Other API changes include the following:

- [Section 7.2.2.4.1, "JPA Persistence Provider Implementation."](#)
- [Section 7.2.2.4.2, "Session Finalizers Disabled by Default."](#)
- [Section 7.2.2.4.3, "Vector and Hashtable Return Types Changed to List or Map."](#)

7.2.2.4.1 JPA Persistence Provider Implementation The persistence provider implementation in all TopLink releases since 11g (11.1.1) is packaged in `eclipselink.jar`. It replaces all previous implementations, for example:

- `toplink.jar`
- `toplink-essentials.jar`

7.2.2.4.2 Session Finalizers Disabled by Default In EclipseLink 11g (11.1.1) Technology Preview 3, session finalizers were disabled by default to improve performance. To enable session finalizers, use Session method `setIsFinalizersEnabled(true)`.

7.2.2.4.3 Vector and Hashtable Return Types Changed to List or Map Any Session or ClassDescriptor method that returns Vector or Hashtable will eventually be changed to return List or Map, respectively. To prepare for this change, cast Vector and Hashtable return types to List or Map, respectively. For example, although the Javadoc for ClassDescriptor method `getMappings` is `java.util.Vector`, you should cast the returned value to List:

```
List mappings = (List) descriptor.getMappings();
```

Other changes that now return Map include the following:

- `ClassDescriptor.getQueryKeys()`
- `ClassDescriptor.getProperties()`
- `DescriptorQueryManager.getQueries()`
- `EISInteraction.getProperties()`
- `Session.getProperties()`
- `Session.getQueries()`
- `getAttributesToAlwaysInclude()`
- `getSpecialOperations()`
- `getValuesToExclude()`s

7.2.3 Task 3: Rename Packages

Starting with EclipseLink 11g, Release 1 (11.1.1), all EclipseLink libraries are included in EclipseLink. EclipseLink provides the core EclipseLink functionality, which now includes support for JPA 2.x, JAXB, and other standards-based persistence services, as well as extensions to those standards. In addition, EclipseLink continues to support native EclipseLink APIs; however, all `oracle.toplink.*` packages are now renamed to `org.eclipse.persistence.*`.

To migrate your application to use the new code base, you must rename the packages in your code. To facilitate this, a package renamer tool is included with the EclipseLink installation. Use this tool on all of the following:

- project source code
- `project.xml` file
- `persistence.xml` file
- `sessions.xml` file

The package renamer is located in the `toplink_install_directory\toplink\utils\rename` directory. Windows and UNIX/LINUX scripts are included.

To run the package renamer using the scripts, do the following:

1. Find the `packageRename.cmd` (Windows) and `packageRename.sh` (UNIX/LINUX) scripts in `toplink_install_directory\toplink\utils\rename` directory.
2. Run either `packageRename.cmd` or `packageRename.sh` with the following arguments:
 - `sourceLocation` - The directory containing the files to rename.
 - `targetLocation` - The destination directory for the renamed files. The package renamer removes any existing Java and XML files, so it is advisable to specify an empty directory.

For example:

```
packageRename c:/mySourceLocation c:/myDestinationLocation
```


The package renamer performs a recursive directory search for Java and XML files to rename. The renamed version of each file is saved in the corresponding directory in the target location

7.2.4 Task 4: Convert XML Configuration Files

The package renamer can rename EclipseLink XML configuration files, but depending on the type of file, you may need to make additional changes.

7.2.4.1 Sessions XML

EclipseLink

You can continue to use `sessions.xml` files as is. For a more forward-compatible solution, run the renamer on your `sessions.xml` files.

7.2.4.2 Deployment XML

Deployment XML files from EclipseLink 10.1.3 and above can be read by EclipseLink 11.1.1 and later. You can continue to use those files or for a more forward compatible solution, run the renamer on these files and replace the version string in the "XML Header" with the following:

"Eclipse Persistence Services"

7.2.4.3 Persistence XML

To use EclipseLink as a persistence provider, you must run the renamer on your `persistence.xml` files. The renamer updates the persistence provider to be EclipseLink and also update any native EclipseLink specific properties to the EclipseLink equivalent.

7.2.4.4 ORM XML

The Object-Relational (ORM) XML configuration file (`orm.xml`) is not EclipseLink-dependant and does not need to be updated.

7.2.5 Convert EclipseLink Workbench Projects

In releases prior to EclipseLink 11g Release 1 (11.1.1), a graphical editing tool called Oracle TopLink Workbench was available for configuring descriptors and mapping your project. That tool is no longer available from Oracle, but a comparable tool, the Oracle TopLink Workbench is available from the Eclipse Foundation. You can convert old TopLink Workbench projects into EclipseLink Workbench projects and then use the output in current EclipseLink applications.

To convert your Oracle TopLink Workbench (.mwp) project to an EclipseLink Workbench project:

1. Use the package renamer (as described above) to migrate your Oracle TopLink Workbench project source.
2. Open the Oracle TopLink Workbench project with EclipseLink Workbench.
3. EclipseLink Workbench detects the project and displays a message asking if you want to save in the current version of the Workbench.
4. Click **Save Now** and select a new directory location in which to save the project.

7.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

-

Migrating from Hibernate to EclipseLink

This chapter describes how to migrate applications from using Hibernate JPA annotations and its native and proprietary API to using EclipseLink JPA. The migration involves converting Hibernate annotations to EclipseLink's native annotations, and converting native Hibernate API to EclipseLink JPA in the application code. Standard JPA annotations and API are left unchanged.

This chapter contains the following sections:

- [Section 8.1, "Introduction to the Solution"](#)
- [Section 8.2, "Main Tasks"](#)
- [Section 8.3, "Additional Resources"](#)

Use Case

A developer wants to migrate applications using Hibernate as the persistence provider to use EclipseLink instead.

Solution

Follow the instructions in this chapter to upgrade the application.

Components

EclipseLink 2.4 or later.

8.1 Introduction to the Solution

Hibernate is an object-relational mapping (ORM) tool for Java environments. It provides a framework for mapping Java objects to relational database artifacts, and Java data types to SQL data types. It also provides the ability to query the database and retrieve data.

For more information about Hibernate, see <http://www.hibernate.org>.

Reasons to Migrate

Reasons why you would want to migrate from Hibernate to EclipseLink include:

- **Performance and scalability:** EclipseLink's caching architecture allows you to minimize object creation and share instances. EclipseLink's caching supports single-node and clustered deployments.
- **Support for leading relation databases:** EclipseLink continues to support all leading relational databases with extensions specific to each. EclipseLink is also the best ORM solution for Oracle Database.

- **A comprehensive persistence solution:** While EclipseLink offers industry leading object-relational support, EclipseLink also uses its core mapping functionality to deliver Object-XML (JAXB), Service Data Object (SDO), and Database Web Services (DBWS). Depending on your requirements, you can use one or more of the persistence services based on the same core persistence engine.
- **JPA Support:** As the JPA 1.0 specification co-leads, Oracle and the EclipseLink team have been focused on delivering a JPA-compliant solution with supporting integration with Oracle JDeveloper, Oracle ADF, Spring, and the Eclipse IDE (Dali project). Oracle delivered the JPA 1.0 reference implementation and EclipseLink delivers the JPA 2.0 reference implementation.

8.2 Main Tasks

Complete these tasks to migrate an application that uses Hibernate as its persistence provider to EclipseLink.

- [Task 1: Convert the Hibernate Entity Annotation](#)
- [Task 2: Convert the Hibernate Custom Sequence Generator Annotation](#)
- [Task 3: Convert Hibernate Mapping Annotations](#)
- [Task 4: Modify the persistence.xml File](#)
- [Task 5: Convert Hibernate API to EclipseLink API](#)

8.2.1 Task 1: Prerequisites

EclipseLink 2.4 or later.

Download EclipseLink from

<http://www.eclipse.org/eclipselink/downloads/>.

8.2.2 Task 1: Convert the Hibernate Entity Annotation

The Hibernate entity annotation, defined by the `org.hibernate.annotations.Entity` class, adds additional metadata beyond what is defined by the JPA standard `@Entity` annotation.

[Example 8–1](#) illustrates a sample Hibernate entity annotation. The example uses the `selectBeforeUpdate`, `dynamicInsert`, `dynamicUpdate`, `optimisticLock`, and `polymorphism` attributes. Note that the Hibernate entity annotation also defines `mutable` and `persister` attributes, which are not used in this example.

Example 8–1 Sample Hibernate Entity Annotation

```
@org.hibernate.annotations.Entity(  
    selectBeforeUpdate = true,  
    dynamicInsert = true,  
    dynamicUpdate = true,  
    optimisticLock = OptimisticLockType.ALL,  
    polymorphism = PolymorphismType.EXPLICIT)
```

The following sections describe how EclipseLink handles selects, locks, polymorphism, and dynamic updates and inserts. For more information, see "EclipseLink/Examples/JPA/Migration/Hibernate/V3Annotations" in the EclipseLink documentation, at:

<http://wiki.eclipse.org/EclipseLink/Examples/JPA/Migration/Hibernate/V3Annotations>

8.2.2.1 Convert the `SelectBeforeUpdate`, `dynamicInsert` and `dynamicUpdate` Attributes

In Hibernate, the `selectBeforeUpdate` attribute specifies that Hibernate should never perform a SQL update unless it is certain that an object is actually modified. The `dynamicInsert` attribute specifies that the `INSERT` SQL statement should be generated at runtime and contain only the columns whose values are not null. The `dynamicUpdate` attribute specifies that the `UPDATE` SQL statement should be generated at runtime and can contain only those columns whose values have changed.

By default, EclipseLink will always insert all mapped columns and will update only the columns that have changed. If alternative operations are required, then the queries used for these operations can be customized by using Java code, SQL, or stored procedures.

8.2.2.2 Convert the `OptimisticLock` Attribute

In Hibernate, the `optimisticLock` attribute determines the optimistic locking strategy.

EclipseLink's optimistic locking functionality supports all of the Hibernate locking types and more. Table 8–1 translates locking types from Hibernate's `@Entity(optimisticLock)` attributes into EclipseLink locking policies. These policies can be configured either with the EclipseLink `@OptimisticLocking` annotation or in the EclipseLink `orm.xml` file. For more information, see `@OptimisticLocking`.

Table 8–1 Translating Hibernate's `OptimisticLock` to EclipseLink's `OptimisticLocking`

Hibernate's <code>OptimisticLock</code> Type	Description	EclipseLink <code>OptimisticLocking</code>
NONE	No optimistic locking	EclipseLink defaults to no optimistic locking.
VERSION	Use a column version	Use the JPA <code>@Version</code> annotation or the EclipseLink annotation: <code>@OptimisticLocking(type = OptimisticLockingType.VERSION_COLUMN)</code>
DIRTY	Changed columns are compared	Use the JPA <code>@Version</code> annotation or the EclipseLink annotation: <code>@OptimisticLocking(type = OptimisticLockingType.CHANGED_COLUMNS)</code>
ALL	All columns are compared	Use the EclipseLink annotation: <code>@OptimisticLocking(type = OptimisticLockingType.ALL_COLUMNS)</code>

Additionally, EclipseLink allows you to compare a specific set of selected columns using the `OptimisticLockingType.SELECTED_COLUMNS` annotation. This allows you to select the critical columns that should be compared if the `CHANGED` or `ALL` strategies do not meet your needs.

8.2.3 Task 2: Convert the Hibernate Custom Sequence Generator Annotation

In Hibernate, the `@GeneratedValue` annotation defines the identifier generation strategy. The `@GenericGenerator` allows you to define a Hibernate-specific ID generator. Example 8–2 illustrates a custom generator for sequence values.

Example 8–2 Custom Generator for Sequence Values

```
.  
.   
.   
@Id  
    @GeneratedValue(generator = "system-uuid")  
    @GenericGenerator(name = "system-uuid", strategy = "mypackage.UUIDGenerator")  
    public String getTransactionGuid()  
.   
.   
. 
```

In EclipseLink, a custom sequence generator can be implemented and registered by using the `@GeneratedValue` annotation. For more information, see "How to use Custom Sequencing (i.e., UUID)" in the EclipseLink documentation, at:

<http://wiki.eclipse.org/EclipseLink/Examples/JPA/CustomSequencing>

8.2.4 Task 3: Convert Hibernate Mapping Annotations

The following sections describe how to convert various Hibernate annotations to EclipseLink annotations.

8.2.4.1 Convert the `@ForeignKey` Annotation

In Hibernate, the `@ForeignKey` annotation allows you to define the name of the foreign key to be used during schema generation.

EclipseLink does generate reasonable names for foreign keys, but does not provide an annotation or `eclipselink-orm.xml` support for specifying the name to use. When migrating, the recommended solution is to have EclipseLink generate the schema (DDL) commands to a script file instead of directly on the database. The script can then be customized to use different names prior to being executed.

Note: The foreign key name is not used by EclipseLink at runtime, but is required if EclipseLink attempts to drop the schema. In this case, the drop script should be generated to a file and customized to match the foreign key names used during creation.

8.2.4.2 Convert the `@Cache` Annotation

In Hibernate, the `@Cache` annotation configures the caching of entities and relationships. Because EclipseLink uses an entity cache instead of a data cache, the relationships are automatically cached. In these cases, the `@Cache` annotation should be removed during migration.

When the `@Cache` annotation is used on an entity, its behavior is similar to the EclipseLink `@Cache` annotation. For more information about the `@Cache` annotation and equivalent `eclipselink-orm.xml` configuration values, see "Eclipse User Guide on JPA Extensions" in the EclipseLink documentation, at:

http://wiki.eclipse.org/Using_EclipseLink_JPA_Extensions_%28ELUG%29#Using_EclipseLink_JPA_Extensions_for_Entity_Caching

8.2.5 Task 4: Modify the persistence.xml File

The `persistence.xml` file is the deployment descriptor file for JPA persistence. It specifies the persistence units, and declares the managed persistence classes, the object-relational mapping, and the database connection details. [Example 8–3](#) illustrates a `persistence.xml` file for an application that uses Hibernate. Hibernate-specific values appear in bold font.

Example 8–3 Persistence File for an Application that Uses Hibernate

```
<persistence>
  <persistence-unit name="helloworld">
    <provider>org.hibernate.ejb.HibernatePersistence</provider>
    <jta-data-source>java:/DefaultDS</jta-data-source>
    <properties>
      <property name="hibernate.dialect"
value="org.hibernate.dialect.HSQLDialect"/>

```

8.2.5.1 Modified persistence.xml File

[Example 8–4](#) illustrates a `persistence.xml` file modified for an application that uses EclipseLink. Key differences include the value for the persistence provider. For EclipseLink, this value is `org.eclipse.persistence.jpa.PersistenceProvider`. The names of EclipseLink-specific properties are typically be prefixed by `eclipselink`, for example, `eclipselink.target-database`. EclipseLink-specific values appear in bold font.

Example 8–4 Persistence File Modified for EclipseLink

```
<xml version="1.0" encoding="UTF-8"?>
<persistence version="1.0" 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">
  <persistence-unit name="helloworld">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <jta-data-source>java:/DefaultDS</jta-data-source>
    <!-- Entities must be specified for EclipseLink weaving -->
    <class>Todo</class>
    <properties>
      <property name="eclipselink.ddl-generation" value="drop-and-create-tables"/>
      <property name="eclipselink.ddl-generation.output-mode" value="database"/>
      <property name="eclipselink.weaving" value="false"/>
      <property name="eclipselink.logging.level" value="FINE"/>
    </properties>
  </persistence-unit>
</persistence>
```

8.2.5.2 Drop and Create the Database

For production environments, you would usually have the schema set up on the database. The following properties defined in the persistence unit are more suitable for examples and demonstrations. These properties will instruct EclipseLink to automatically drop and create database tables. Any previously existing tables will be removed.

```
<property name="eclipselink.ddl-generation" value="drop-and-create-tables"/>
<property name="eclipselink.ddl-generation.output-mode" value="database"/>
```

8.2.6 Task 5: Convert Hibernate API to EclipseLink API

Table 8–2 describes the Hibernate classes that are commonly used in a JPA project and their equivalent EclipseLink (JPA) interfaces. All of the Hibernate classes are in the `org.hibernate` package. All of the JPA interfaces (and the `Persistence` class) are in the `javax.persistence` package.

For information about the EclipseLink API, see *Java API Reference for EclipseLink*.

Table 8–2 *Hibernate Classes and Equivalent JPA Interfaces*

org.hibernate	javax.persistence	Description
cfg.Configuration	Persistence	Provides a bootstrap class that configures the session factory (in Hibernate) or the entity manager factory (in JPA). It is generally used to create a single session (or entity manager) factory for the JVM.
SessionFactory	EntityManagerFactory	Provides APIs to open Hibernate sessions (or JPA entity managers) to process a user request. Generally, a session (or entity manager) is opened per thread processing client requests.
Session	EntityManager	Provides APIs to store and load entities to and from the database. It also provides APIs to get a transaction and create a query.
Transaction	EntityTransaction	Provides APIs to manage transactions.
Query	Query	Provides APIs to execute queries.

8.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- Hibernate at <http://www.hibernate.org>.
- "EclipseLink/Examples/JPA/Migration/Hibernate" in the EclipseLink documentation, at <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Migration/Hibernate>.

Migrating from Apache OpenJPA to EclipseLink

This chapter tells how to migrate applications using Apache OpenJPA to use EclipseLink instead.

This chapter contains the following sections:

- [Section 9.1, "Introduction to the Solution"](#)
- [Section 9.2, "Implementing the Solution"](#)
- [Section 9.3, "Additional Resources"](#)
- [Section 9.1, "Introduction to the Solution"](#)

Use Case

A developer wants to migrate applications using OpenJPA as the persistence provider to use EclipseLink instead.

Solution

Follow the instructions in this chapter to upgrade the application.

Components

EclipseLink 2.4 or later.

9.1 Introduction to the Solution

Apache OpenJPA is an open-source implementation of the Java Persistence API (JPA) specification. Both OpenJPA and EclipseLink implement standard JPA and also extend it to provide additional features. To migrate an OpenJPA application to EclipseLink, you must switch the persistence provider to EclipseLink and make certain modifications to the application, to account for the differences in OpenJPA and EclipseLink APIs.

Reasons to Migrate

Reasons why you would want to migrate from Hibernate to EclipseLink include:

- **Performance and scalability:** EclipseLink's caching architecture allows you to minimize object creation and share instances. EclipseLink's caching supports single-node and clustered deployments.
- **Support for leading relation databases:** EclipseLink continues to support all leading relational databases with extensions specific to each. EclipseLink is also the best ORM solution for Oracle Database.

- **A comprehensive persistence solution:** While EclipseLink offers industry leading object-relational support, EclipseLink also uses its core mapping functionality to deliver Object-XML (JAXB), Service Data Object (SDO), and Database Web Services (DBWS). Depending on your requirements, you can use one or more of the persistence services based on the same core persistence engine.
- **JPA Support:** As the JPA 1.0 specification co-leads, Oracle and the EclipseLink/EclipseLink team have been focused on delivering a JPA-compliant solution with supporting integration with Oracle JDeveloper, Oracle ADF, Spring, and the Eclipse IDE (Dali project). Oracle delivered the JPA 1.0 reference implementation and EclipseLink delivers the JPA 2.0 reference implementation.

9.2 Implementing the Solution

This section contains the following tasks:

- [Task 1: Prerequisites](#)
- [Task 2: Change the Provider and Persistence Unit Properties in persistence.xml](#)
- [Task 3: Convert Query Hint Names Used in Named and Dynamic Queries](#)
- [Task 4: Convert or Fix Nonstandard Mappings Available in OpenJPA](#)
- [Task 5: Convert from OpenJPA Extended Features](#)
- [Task 6: Take Advantage of EclipseLink Features](#)

9.2.1 Task 1: Prerequisites

EclipseLink 2.4 or later.

Download EclipseLink from

<http://www.eclipse.org/eclipselink/downloads/>.

9.2.2 Task 2: Change the Provider and Persistence Unit Properties in persistence.xml

Update the following properties in the persistence.xml file, as needed:

9.2.2.1 Provider

Set the JPA persistence provider to

`org.eclipse.persistence.jpa.PersistenceProvider`, to ensure that EclipseLink JPA is used as the provider, in case multiple providers exist in the target container.

```
<provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
```

Note: When using OpenJPA with Java SE, the provider resolver may continue to use OpenJPA, instead of the specified provider, if OpenJPA is encountered first on the classpath. If this happens, remove OpenJPA from the classpath of your application.

9.2.2.2 Persistence Unit Properties

Persistence unit properties are a standard mechanism for providing vendor-specific configuration. The following sections list OpenJPA persistence unit properties that must be replaced when migrating from OpenJPA to EclipseLink:

- [Section 9.2.2.2.1, "JDBC Properties"](#)

- [Section 9.2.2.2.2, "Caching Properties"](#)
- [Section 9.2.2.2.3, "Diagnostic Properties"](#)
- [Section 9.2.2.2.4, "Other Properties"](#)

Not all OpenJPA persistence unit properties have exact equivalents in EclipseLink, so you may have to consult the OpenJPA documentation and the EclipseLink documentation to determine a conversion strategy. For complete reference documentation on the EclipseLink extensions to standard JPA persistence properties, see "Persistence Property Extensions Reference" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*. For complete EclipseLink Javadoc, see *Java API Reference for EclipseLink*.

9.2.2.2.1 JDBC Properties JDBC properties are used to configure internal connection pooling typically used in Java SE or in containers where data sources are not available. [Table 9–1, "JDBC Persistence Unit Properties"](#) compares OpenJPA JDBC properties to the corresponding or related EclipseLink properties.

For information about the EclipseLink JDBC persistence properties, see "JDBC Configuration Options" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

Note: In JPA 2.0 several persistence unit properties for JDBC configuration were standardized. Therefore, beginning in EclipseLink 11.1.1.2, the equivalent EclipseLink properties were deprecated and replaced by the JPA 2.x standard ones. Both are shown in the **EclipseLink JPA Equivalent** column of [Table 9–1](#).

Table 9–1 JDBC Persistence Unit Properties

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.ConnectionDriverName</code>	The full class name of either the JDBC <code>java.sql.Driver</code> or a <code>javax.sql.DataSource</code> implementation to use to connect to the database.	EclipseLink 11.1.1.0 - 11.1.1.1: <code>eclipselink.jdbc.driver</code> EclipseLink 11.1.1.2 +: <code>javax.persistence.jdbc.driver</code>
<code>openjpa.ConnectionPassword</code>	The password for the user, specified in the <code>ConnectionUserName</code> property.	EclipseLink 11.1.1.0 - 11.1.1.1: <code>eclipselink.jdbc.password</code> EclipseLink 11.1.1.2 +: <code>javax.persistence.jdbc.password</code>
<code>openjpa.ConnectionURL</code>	The JDBC URL for the database.	EclipseLink 11.1.1.0 - 11.1.1.1: <code>eclipselink.jdbc.url</code> EclipseLink 11.1.1.2 +: <code>javax.persistence.jdbc.url</code>
<code>openjpa.ConnectionUserName</code>	The user name to use when connecting to the database.	EclipseLink 11.1.1.0 - 11.1.1.1: <code>eclipselink.jdbc.user</code> EclipseLink 11.1.1.2 +: <code>javax.persistence.jdbc.user</code>

Other JDBC issues to consider include:

- The OpenJPA properties containing "2," for example `openjpa.Connection2DriverName`, are for the unmanaged connection pool. EclipseLink uses the same information for both managed and unmanaged connections. If separate login information is required for unmanaged connections, it must be configured in code.

- Connection properties and custom connectors equivalent to OpenJPA connection factories are supported through `DatabaseLogin`, `DatabasePlatform`, and custom `Connectors`. These are generally not required with containers but can be configured using a `SessionCustomizer`, if needed.

9.2.2.2.2 Caching Properties EclipseLink uses its own shared entity caching feature instead of a data cache requiring a 3rd party implementation. [Table 9–2, "Caching Persistence Unit Properties"](#) compares OpenJPA caching properties to the corresponding or related EclipseLink properties.

Table 9–2 Caching Persistence Unit Properties

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.DataCache</code>	The data cache implementation to use for data caching.	Not Required
<code>openjpa.DataCacheManager</code>	The data cache manager to use for managing the system data caches.	Not Required
<code>openjpa.DataCacheTimeout</code>	The duration that data in the data cache is valid.	EclipseLink provides expiration and invalidation per entity cache, based on the time since it was read or on the time of day. Configure these by using a <code>@Cache</code> annotation on the entity. Alternatively, specify it in <code>eclipselink-orm.xml</code> .
<code>openjpa.QueryCache</code>	The query cache implementation to use for caching of queries loaded from the data store.	EclipseLink supports query result caching through the query hint <code>eclipselink.query-results-cache</code> .
<code>openjpa.QueryCompilationCache</code>	The map to use for caching data of compiled queries	EclipseLink automatically caches generated SQL strings and prepared statements. The size of these caches is configurable.

9.2.2.2.3 Diagnostic Properties [Table 9–3, "Diagnostic Properties"](#) compares the OpenJPA logging property to the corresponding EclipseLink property.

Table 9–3 Diagnostic Properties

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.Log</code>	The log factory to use for logging.	Use <code>eclipselink.logging.logger</code> .

9.2.2.2.4 Other Properties [Table 9–4, "Other Properties"](#) compares miscellaneous other OpenJPA properties to the corresponding or related EclipseLink properties.

Table 9–4 Other Properties

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.AutoClear</code>	When to clear instance state: on entering a datastore transaction or on entering any transaction.	
<code>openjpa.AutoDetach</code>	Events that cause managed instances to be detached.	Not applicable. Entities can be used with other entity managers as detached at any time. However, they are always considered managed relative to the reading entity manager, as long as it is open and the entity has not been serialized.
<code>openjpa.BrokerFactory</code>	The broker factory to use.	The EclipseLink <code>ServerSession</code> is equivalent to the OpenJPA <code>BrokerFactory</code> . Direct configuration in XML is not supported. Custom server session types are supported through API only.
<code>openjpa.BrokerImpl</code>	The broker type to use at runtime.	The EclipseLink <code>UnitOfWork</code> is equivalent to the OpenJPA <code>BrokerImpl</code> . The <code>UnitOfWork</code> type cannot be customized in JPA through XML
<code>openjpa.ClassResolver</code>	The class resolver to use to resolve class names.	Specify the EclipseLink <code>eclipselink.classloader</code> to be used. Alternatively, create a custom <code>ConversionManager</code> or <code>DatabasePlatform</code> to customize conversion routines.
<code>openjpa.Compatibility</code>	Options to ensure compatibility with previous OpenJPA releases.	Not required when migrating.
<code>openjpa.DetachState</code>	Determines which fields are part of the detached graph and related options.	Use the JPA 2.0 <code>EntityManager.detach()</code> method to detach an entity. Alternatively, use a <code>CopyGroup</code> to detach a specified set of attributes and nested attributes. Serializing a partial entity loaded with a <code>FetchGroup</code> causes it to serialize the attributes that were fetched only.
<code>openjpa.DynamicDataStructs</code>	Whether to dynamically generate customized structs to hold persistent data.	
<code>openjpa.FetchBatchSize</code>	The number of rows to fetch at a time when scrolling through a result set.	EclipseLink batching and joining depth and size is configurable on queries instead of globally.
<code>openjpa.FetchGroups</code>	Fetch groups to be loaded when retrieving objects from the datastore.	EclipseLink's default fetch group is determined by the <code>fetchType</code> on an entity's mappings but can be customized on individual queries using the <code>eclipselink.fetch-group</code> query hint.

Table 9–4 (Cont.) Other Properties

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.DetachState</code>	Determines which fields are part of the detached graph and related options.	EclipseLink determines detached state based on usage along with lazy loading configurations and dynamic fetch groups. Lazy relationships can always be retrieved until the entity is truly detached through serialization or copying.
<code>openjpa.FlushBeforeQueries</code>	Whether to flush changes made in the current transaction to the datastore before executing a query.	EclipseLink relies on the standard <code>FlushMode</code> as well as its support of in-memory querying to minimize the need to flush before executing a query. For large transactions consider using <code>eclipselink.flush-clear.cache</code> .
<code>openjpa.IgnoreChanges</code>	Avoid tracking changes	EclipseLink provides similar support using <code>@ReadOnly</code> as well as the <code>eclipselink.read-only</code> query hint. These take advantage of the shared cache.
<code>openjpa.Id</code>	Identifier for current configuration, for example, persistence unit name.	Equivalent to <code>eclipselink.session-name</code> property which simplifies looking up the underlying shared session in the native <code>SessionManager</code> singleton.
<code>openjpa.InverseManager</code>	Whether to consider changes to persistent objects made in the current transaction when evaluating queries.	
<code>openjpa.LockManager</code>	The lock manager to use to use for acquiring locks on persistent instances during transactions.	
<code>openjpa.LockTimeout</code>	Time to wait for an object lock before throwing an exception	
<code>openjpa.ManagedRuntime</code>	The managed runtime implementation to use to obtain a reference to the transaction manager in an enterprise environment.	This is generally supported in EclipseLink through the <code>eclipselink.target-server</code> configuration of the <code>ServerPlatform</code> , but you can configure it separately using a custom <code>ExternalTransactionController</code> .
<code>openjpa.Mapping</code>	Name of the object-to-datastore mapping to use.	
<code>openjpa.MaxFetchDepth</code>	The maximum depth of relations to traverse when eager fetching.	
<code>openjpa.MetadataFactory</code>	The metadata factory to use to store and retrieve metadata for persistent classes.	
<code>openjpa.Multithreaded</code>	Whether persistent instances and components other than the entity manager factory are accessed by multiple threads simultaneously.	
<code>openjpa.Optimistic</code>	Selects between optimistic and pessimistic (datastore) transactional modes.	

Table 9–4 (Cont.) Other Properties

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.OrphanedKeyAction</code>	The orphaned key action to invoke when OpenJPA discovers an orphaned datastore key.	
<code>openjpa.NontransactionalRead</code>	Whether the runtime allows data to be read outside of a transaction.	
<code>openjpa.NontransactionalWrite</code>	Whether persistent objects can be modified and whether persistence operations can be performed outside a transaction.	
<code>openjpa.ProxyManager</code>	The proxy manager to use for proxying mutable second class objects.	
<code>openjpa.RemoteCommitProvider</code>	The remote commit provider implementation to use for distributed event notification.	
<code>openjpa.RestoreState</code>	Whether to restore managed fields to their pretransaction values when rolled back.	
<code>openjpa.RetryClassRegistration</code>	Whether to defer registration instead of throwing an exception when a persistent class cannot be processed	
<code>openjpa.SavepointManager</code>	The savepoint manager to use for managing transaction savepoints.	
<code>openjpa.Sequence</code>	The kernel sequence implementation to use for the system sequence.	
<code>openjpa.TransactionMode</code>	The default transaction mode to use.	
<code>openjpa.WriteLockLevel</code>	The default level to use to lock objects changed during a non-optimistic transaction.	

9.2.3 Task 3: Convert Query Hint Names Used in Named and Dynamic Queries

JPA applications can include query hints, which define provider-specific behavior. These hints can be specified in annotations, ORM XML files, or application code. The query hint names are strings and therefore do not typically force compile time dependencies on the provider. However, the values for these hints may introduce dependencies.

[Table 9–5, "Query Hints"](#) compares OpenJPA query hint to the corresponding or related EclipseLink features.

Table 9–5 Query Hints

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.hint.OracleSelectHint</code>	Specifies an Oracle-specific query hint to be generated.	Use <code>eclipselink.sql.hint</code> to include a hint in the SQL for a query.
<code>openjpa.FetchPlan.ReadLockMode</code>	Values= READ or WRITE	Use JPA 2.0 <code>Query.setLockMode(LockModeType)</code> to set the lock mode.
<code>openjpa.hint.OptimizeResultCount</code>	Sets the size for a query result set.	Use <code>QueryHints.JDBC_FETCH_SIZE</code> to configure the JDBC fetch size for the queries result set.

Table 9–5 (Cont.) Query Hints

OpenJPA Property	Description	EclipseLink JPA Equivalent
<code>openjpa.FetchPlan.Isolation</code>	Specifies the isolation level using the SQL <code>WITH <isolation></code> clause for those databases that support it.	
<code>openjpa.FetchPlan.MaxFetchDepth</code>	The maximum depth of relations to traverse when eager fetching.	Specify <code>FetchGroup</code> depth using attributes, not numeric depth.
<code>openjpa.FetchPlan.FetchBatchSize</code>	The number of rows to fetch at once when scrolling through a result set.	Use <code>Query.setMaxResultsQueryHints.JDBC_MAX_ROWS</code> .
<code>openjpa.FetchPlan.LockTimeOut</code>	Time to wait to acquire a lock.	Use <code>QueryHints.PESSIMISTIC_LOCK_TIMEOUT</code> .
<code>openjpa.FetchPlan.EagerFetchMode</code>	Determines how to eager-fetch a field.	EclipseLink fetch group loading is done based on the attributes specified for the fetch group. In the case of the default <code>FetchGroup</code> , loading is based on the lazy configuration of the mappings.
<code>openjpa.FetchPlan.SubclassFetchMode</code>	Determines how to eager-fetch subclass data.	Fetch group attributes can be assigned to any mapped attribute in the target entity or its mapped parent classes.

9.2.4 Task 4: Convert or Fix Nonstandard Mappings Available in OpenJPA

Note: Using a JPA mapping tool such as Oracle JDeveloper or Oracle Enterprise Pack for Eclipse (OEPE) makes mapping entities easier and less error-prone. Such tools provide validation and configuration assistance to address many common mapping errors.

The following are some mapping scenarios you might encounter when migrating from OpenJPA to EclipseLink.

9.2.4.1 @Column in Relationship Mappings

When defining relationship mappings involving foreign keys (`@OneToOne` and `@ManyToOne`), JPA supports the specification of non-default column names using `@JoinColumn` and `@JoinColumns`. OpenJPA allows the specification of `@Column`. Since this has no defined meaning in JPA, EclipseLink throws a validation exception to assist customers in identifying this incorrect mapping configuration.

Solution

Convert all `@OneToOne` and `@ManyToOne` mappings that have an `@Column` configuration to use `@JoinColumn`. If the target class of the relationship has a composite identifier (primary key) you must use `@JoinColumns`.

If the relationship defined by the `@JoinColumn(s)` involves columns which are also mapped as identifiers (primary key columns), make sure they are mapped with `@Id` and that the duplicate mappings are properly mapped and managed in the entity class.

9.2.4.2 @Transient with Relationship Mappings

The JPA specification does not define whether mappings (`@Basic`, `@OneToOne`, `@ManyToOne`, `@OneToMany`, `@ManyToMany`, etc.) can be specified to be transient. While OpenJPA allows this, EclipseLink correctly throws an exception. Transient configuration on an attribute is intended to prevent default mappings from being applied when calculating the mappings for an entity. With default mappings, unmapped attributes are assumed to be mapped according to the specification. `@Transient` prevents these assumptions, which may not be the desired behavior.

Solution

Determine which configuration you want. If you want mapping, remove `@Transient`. If the intention was to avoid the default mapping, then either remove or comment out the mapping configuration.

9.2.5 Task 5: Convert from OpenJPA Extended Features

OpenJPA offers some extended functionality that goes beyond the JPA specification. The following sections describe these features and how you can migrate to the corresponding functionality in EclipseLink.

9.2.5.1 BigCollection

9.2.5.2 FetchPlan/Group

9.2.5.3 Inheritance Casting

9.2.5.4 Native SQL with POJO results

9.2.5.5 Detached (Serialized) entities & relationships

9.2.6 Task 6: Take Advantage of EclipseLink Features

After completing the conversion to EclipseLink JPA it is also very important to harness the additional features available. The most commonly used features include:

- **Caching** - Make sure you understand and optimize your cache configuration to work with your locking policies and the volatility of your underlying database tables:
 - Shared (L2) versus Isolated (EntityManager/TX)
 - Shared type, size, and expiration/invalidation
 - Cache coordination (where applicable)
- **Query Optimization** - Minimize the amount of data loaded and cached for greater performance and optimal cache usage:
 - Batch and Joined (multi-level) for graph retrieval

- Cache usage and refreshing
- Data projections for data loading on searches where full entities are not required
- Paged data/entity loading
- Fetch Groups
- **Weaving** - Ensure weaving is enabled for change tracking, lazy loading, and fetch groups capabilities .

9.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- Apache OpenJPA at <http://openjpa.apache.org>.

Using Multiple Databases with a Composite Persistence Unit

With EclipseLink, you can expose multiple persistence units (each with unique sets of entity types) as a single persistence context by using a *composite persistence unit*. Individual persistence units that are part of this composite persistence unit are called *composite member persistence units*.

This chapter contains the following sections:

- [Section 10.1, "Introduction to the Solution"](#)
- [Section 10.2, "Implementing the Solution"](#)
- [Section 10.3, "Additional Resources"](#)

Use Case

Users need to map expose multiple persistence units as a single persistence context within an application.

Solution

EclipseLink supports a "composite" persistence unit which can include multiple member persistence units.

Components

- EclipseLink 2.4 or later..
- Multiple databases

Sample

See the following EclipseLink examples for related information:

- <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Composite>

10.1 Introduction to the Solution

With a composite persistence unit, you can:

- Map relationships among any of the entities in multiple persistence units
- Access entities stored in multiple databases and different data sources
- Easily perform queries and transactions across the complete set of entities

[Example 10-1](#) shows how you can persist data from a single persistence context into two different databases:

Example 10–1 Using Multiple Databases

```

em.persist(new A(..));
em.persist(new B(..));
// You can insert A into database1 and insert B into database2.
// The two databases can be from different vendors.

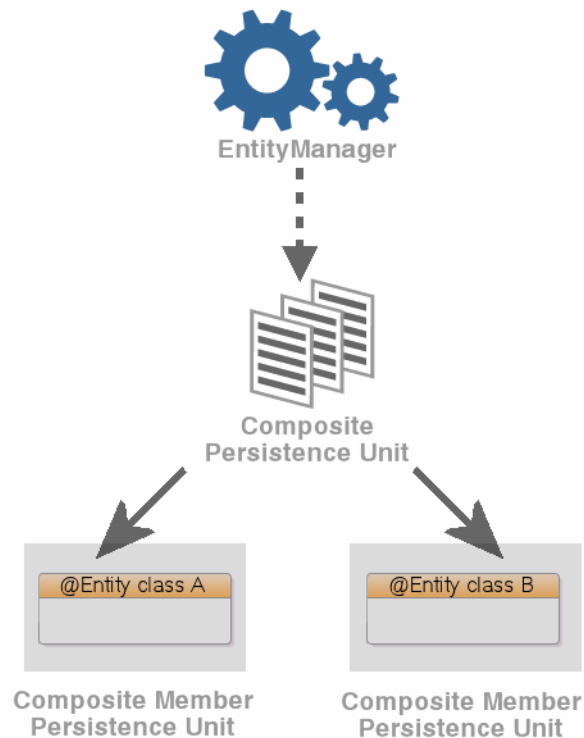
em.flush();

```

Figure 10–1 illustrates a simple composite persistence unit. The `EntityManager` passes the persistence unit to the `Persistence.createEntityManagerFactory` method and instantiates the composite persistence unit, which contains two composite member persistence units:

- Class **A** is mapped by a persistence unit named **memberPu1** located in the `member1.jar` file.
- Class **B** is mapped by a persistence unit named **memberPu2** located in the `member2.jar` file.

Figure 10–1 A Simple Composite Persistence Unit



10.1.1 Composite Persistence Unit Requirements

When using composite persistence units, note the following requirements:

- The name of each composite member persistence unit must be unique within the composite.
- The `transaction-type` and other properties that correspond to the entire persistence unit (such as target server, logging, transactions, and so on) should be defined in the composite persistence unit. If not, the transaction types, target

server information, and logging properties defined with composite members will be ignored.

10.2 Implementing the Solution

This section includes the following tasks:

- [Task 1: Configure the Composite Persistence Unit](#)
- [Task 2: Use Composite Persistence Units](#)
- [Task 3: Deploy Composite Persistence Units](#)

10.2.1 Task 1: Configure the Composite Persistence Unit

Because the composite persistence unit is a regular persistence element, it requires a `persistence.xml` file. [Example 10–2](#) illustrates a sample `persistence.xml` file.

Example 10–2 The `persistence.xml` File for a Composite Persistence Unit

```
<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 persistence_1_0.xsd"
version="1.0">
  <persistence-unit name="compositePu" transaction-type="JTA">
    <provider>
      org.eclipse.persistence.jpa.PersistenceProvider
    </provider>

    <jar-file>member1.jar</jar-file>
    <jar-file>member2.jar</jar-file>
    <properties>
      <property name="eclipselink.composite-unit" value="true"/>
      <property name="eclipselink.target-server" value="WebLogic_10"/>
    </properties>
  </persistence-unit>
</persistence>
```

Use the `<property name="eclipselink.composite-unit" value="true"/>` property to identify a persistence unit as a composite persistence unit.

Use the `<jar-file>` element to specify the JAR files containing the composite member persistence units. The composite persistence unit will contain all the composite member persistence units found in the JAR files specified.

10.2.2 Task 2: Use Composite Persistence Units

You can use a composite persistence unit as you would any other persistence unit; the `EntityManager` could be injected, as follows:

```
@PersistenceUnit(unitName="compositePu")
EntityManagerFactory entityManagerFactory;
```

```
@PersistenceUnit(unitName="compositePu")
EntityManager entityManager;
```

Or create it manually:

```
EntityManagerFactory entityManagerFactory =
Persistence.createEntityManagerFactory("compositePu", properties);
```

10.2.3 Task 3: Deploy Composite Persistence Units

To deploy multiple persistence units, deploy all of the JAR files (the composite persistence unit and its members) on the same class loader.

- When deploying to Oracle WebLogic Server, package the JAR files in an EAR file.
- When running as a standalone application, add the JAR files to the class path.

For important requirements, see [Section 10.1.1, "Composite Persistence Unit Requirements."](#)

10.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

For the following additional information about composite persistence units, see "[@CompositeMember](#)," "[composite.unit](#)," and "[composite-unit.member](#)" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*:

- Limitations of composite persistence units.
- Configuring composite member persistence units that contain dependencies.
- All persistence unit properties used by composite persistence units and composite member persistence units
- How to pass persistence unit properties to composite member persistence units with the `Persistence.createEntityManagerFactory` method, while creating a composite persistence unit `EntityManagerFactory`
- All entity manager properties used by composite persistence unit and composite member persistence units
- How to pass entity manager properties to composite member persistence units with the `emf.createEntityManager` method for the composite persistence unit `EntityManagerFactory`

10.3.1 Related Javadoc

For more information, see the following APIs in *Java API Reference for EclipseLink*:

- `PersistenceUnitProperties` class
- `Persistence.createEntityManager` class
- `EntityManagerFactory` interface

Scaling EclipseLink Applications in Clusters

This chapter provides instructions for configuring EclipseLink applications to ensure scalability in an application server cluster. The instructions are generic and can be applied to any application server cluster; however, additional content is provided for Oracle WebLogic Server and Oracle GlassFish Server. Consult your vendor's documentation as required.

This chapter contains the following sections:

- [Section 11.1, "Introduction to the Solution"](#)
- [Section 11.2, "Implementing the Solution"](#)
- [Section 11.3, "Additional Resources"](#)

Use Case

Applications must scale to meet client demand.

Solution

The implementation is achieved by using a cache, configuring cache coordination, and using data partitioning.

Components

- EclipseLink 12c Release 1 (12.1.2)
- Application Server that supports clustering
- Any compliant JDBC database

Sample

See [Section 11.3, "Additional Resources,"](#) for links to samples.

11.1 Introduction to the Solution

EclipseLink applications that are deployed to an application server cluster benefit from cluster scalability, load balancing, and failover. These capabilities ensure that EclipseLink applications are highly available and scale as application demand increases. EclipseLink applications are deployed the same way in application server clusters as they are in standalone server environments. However, additional planning and configuration is required to ensure cache consistency in an application server cluster.

EclipseLink uses a shared (L2) object cache that avoids database access for objects and their relationships. The cache is enabled by default and enhances application

performance. In an application server cluster, caching can result in consistency issues (such as stale data) because changes made on one server are not reflected on objects cached in other servers. Cache consistency is problematic only for objects that are frequently updated. Read-only objects are not affected by cache consistency. For more details about caching, see:

http://wiki.eclipse.org/EclipseLink/UserGuide/JPA/Basic_JPA_Development/Caching/Caching_Overview

Various options are available for addressing cache consistency:

- Use distributed caching. EclipseLink Grid is an integration between EclipseLink and Oracle Coherence that addresses many cache consistency issues that result from operating in a distributed environment. For details on EclipseLink Grid, see [Chapter 18, "Scaling JPA Applications Using TopLink Grid with Oracle Coherence."](#)
- Use cache coordination. Cache coordination is a feature that broadcasts changes between the servers in the cluster to update or invalidate changed objects.
- Use optimistic locking. Optimistic locking is a feature that prevents updates to stale objects, and triggers the objects to be invalidated in the cache.
- Refresh the cache. Refreshing a cache loads that latest data in the cache.
- Disable the shared cache or limit the cache to read-only objects.

11.2 Implementing the Solution

These tasks provide general instructions for ensuring that a EclipseLink application scales in an application server cluster. Complete the tasks prior to deploying an application.

This section contains the following tasks:

- [Task 1: Configure Cache Consistency](#)
- [Task 2: Ensure EclipseLink Is Enabled](#)
- [Task 3: Ensure All Application Servers Are Part of the Cluster](#)
- [Using Data Partitioning to Scale Data](#)

11.2.1 Task 1: Configure Cache Consistency

This task includes different configuration options that mitigate the possibility that an application might use stale data when deployed to an application server cluster. The cache coordination option is specifically designed for applications that are clustered; however, evaluate all the options and use them together (if applicable) to create a solution that results in the best application performance. Properly configuring a cache can, in some cases, eliminate the need to use cache coordination. For additional details on these options, see:

http://wiki.eclipse.org/Introduction_to_Cache_%28ELUG%29#Handling_Stale_Data

The following are the configuration options:

- [Disabling the Shared Cache](#)
- [Refreshing the Cache](#)
- [Setting Cache Expiration](#)

- [Setting Optimistic Locking](#)
- [Using Cache Coordination](#)

Note: Oracle provides a EclipseLink and Coherence integration that allows EclipseLink to use Coherence as the L2 cache. For details on EclipseLink Grid, see [Chapter 18, "Scaling JPA Applications Using TopLink Grid with Oracle Coherence."](#)

11.2.1.1 Disabling the Shared Cache

Disable the shared cache if an application does not require it. To disable the shared cache for all objects, use the `<shared-cache-mode>` element in the `persistence.xml` file. For example:

```
<shared-cache-mode>NONE</shared-cache-mode>
```

To selectively enable or disable the shared cache, use the `shared` attribute of the `@Cache` annotation when defining an entity. For example:

```
@Entity
@Cache(shared=false)
public class Employee {
}
```

11.2.1.2 Refreshing the Cache

Refreshing a cache reloads the cache from the database to ensure that an application is using current data. There are different ways to refresh a cache.

The `@Cache` annotation provides the `alwaysRefresh` and `refreshOnlyIfNewer` attributes which force all queries that go to the database to refresh the cache:

```
@Entity
@Cache(
    alwaysRefresh=true,
    refreshOnlyIfNewer=true)
public class Employee {
}
```

The `org.eclipse.persistence.jpa.JpaCache` interface includes several methods that remove stale objects if the cache is out of date:

- The `evictAll` method invalidates all of the objects in the cache.

```
em.getEntityManagerFactory().getCache().evictAll();
```
- The `evict` method invalidates specific classes.

```
em.getEntityManagerFactory().getCache().evict(MyClass);
```
- The `clear` method also refreshes a cache; however, clearing the cache can cause object identity issues if any one of the cached objects is in use. Use this method only if the application no longer has references to objects held in the cache.

The preceding methods are passive and refresh objects only the next time the cache is accessed. To actively refresh an object, use the `EntityManager.refresh` method. The method refreshes a single object at a time.

Any one of the following methods also refreshes a cache:

- `Session.refreshObject` method
- `DatabaseSession` and `UnitOfWork`: `refreshAndLockObject` methods
- `ObjectLevelReadQuery`: `refreshIdentityMapResult` and `refreshRemoteIdentityMapResult` methods

The `ClassDescriptor` class also provides methods that refresh a cache:

- `setShouldAlwaysRefreshCache`
- `setShouldAlwaysRefreshCacheOnRemote`
- `setShouldDisableCacheHits`
- `setShouldDisableCacheHitsOnRemote`
- `setShouldOnlyRefreshCacheIfNewerVersion`

Use these methods within the `addToDescriptor` method. For example:

```
public void addToDescriptor(ClassDescriptor descriptor) {
    descriptor.setShouldRefreshCacheOnRemote(true);
    descriptor.setShouldDisableCacheHitsOnRemote(true);
}
```

Last, use the `setHint` method to set a query hint that triggers the query to refresh the cache. For example:

```
Query query = em.createQuery("Select e from Employee e");
query.setHint("javax.persistence.cache.storeMode", "REFRESH");
```

11.2.1.3 Setting Cache Expiration

Cache expiration makes a cached object instance invalid after a specified amount of time. Any attempt to use the object causes the most up-to-date version of the object to be reloaded from the data source. Expiration can help ensure that an application is always using the most recent data. There are different ways to set expiration.

The `@Cache` annotation provides the `expiry` and `expiryTimeOfDay` attributes, which remove cache instances after a specific amount of time. The `expiry` attribute is entered in milliseconds. The default value if no value is specified is `-1`, which indicates that expiry is disabled. The `expiryTimeOfDay` attribute is an instance of the `org.eclipse.persistence.annotations.TimeOfDay` interface. The following example sets the object to expire after 5 minutes:

```
@Entity
@Cache(expiry=300000)
public class Employee {
}
```

At the descriptor level, use the `ClassDescriptor.setCacheInvalidationPolicy` method to set a `CacheInvalidationPolicy` instance. The following invalidation policies are available:

- `DailyCacheInvalidationPolicy`: The object is automatically flagged as invalid at a specified time of day.
- `NoExpiryCacheInvalidationPolicy`: The object can be flagged as invalid only by explicitly calling the `IdentityMapAccessor.invalidateObject` method.
- `TimeToLiveCacheInvalidationPolicy`: The object is automatically flagged as invalid after a specified time period has elapsed since the object was read.

11.2.1.4 Setting Optimistic Locking

Optimistic locking prevents one user from writing over another user's work. Locking is important when multiple servers or multiple applications access the same data and is relevant in both single-server and multiple-server environments. In a multiple-server environment, locking is still required if an application uses cache refreshing or cache coordination. There are different ways to set optimistic locking.

The `@OptimisticLocking` annotation specifies the type of optimistic locking to use when updating or deleting entities. Optimistic locking is supported on an `@Entity` or `@MappedSuperclass` annotation. The following policies are available and are set within the `type` attribute:

- `ALL_COLUMNS`: This policy compares every field in the table in the `WHERE` clause when performing an update or delete operation.
- `CHANGED_COLUMNS`: This policy compares only the changed fields in the `WHERE` clause when performing an update operation. A delete operation compares only the primary key.
- `SELECTED_COLUMNS`: This policy compares selected fields in the `WHERE` clause when performing an update or delete operation. The fields that are specified must be mapped and not be primary keys.
- `VERSION_COLUMN`: (Default) This policy allows a single version number to be used for optimistic locking. The version field must be mapped and not be the primary key. To automatically force a version field update on a parent object when its privately owned child object's version field changes, use the `cascaded` method set to `true`. The method is set to `false` by default.

At the descriptor level, configure optimistic locking by using the `ClassDescriptor.setOptimisticLockingPolicy` method to set an optimistic `FieldsLockingPolicy` instance. As with the annotation, the following policies are included:

- `AllFieldsLockingPolicy`: This policy compares every field in the table in the `WHERE` clause when performing an update or delete operation.
- `ChangedFieldsLockingPolicy`: This policy compares only the changed fields in the `WHERE` clause when doing an update. A delete operation only compares the primary key.
- `SelectedFieldsLockingPolicy`: This policy compares selected fields in the `WHERE` clause when performing an update or delete operation. The fields specified must be mapped and not be primary keys.
- `VersionLockingPolicy`: This policy allows a single version number to be used for optimistic locking. To automatically force a version field update on a parent object when its privately owned child object's version field changes, use the `VersionLockingPolicy.setIsCascaded` method set to `true`.
- `TimestampLockingPolicy`: This policy allows a single version timestamp to be used for optimistic locking.

11.2.1.5 Using Cache Coordination

Cache coordination synchronizes changes among distributed sessions. Cache coordination is most useful in application server clusters where maintaining consistent data for all applications is challenging. Moreover, cache consistency becomes increasingly more difficult as the number of servers within an environment increases.

Cache coordination works by broadcasting notifications of transactional object changes among sessions (ServerSession or persistence unit) in the cluster. Cache coordination is most useful for applications that are primarily read-based and when changes are performed by the same application operating with multiple, distributed sessions.

Cache coordination significantly minimizes stale data, but does not completely eliminate the possibility that stale data might occur. In addition, cache coordination reduces the number of optimistic lock exceptions encountered in distributed architectures, and reduces the number of failed or repeated transactions in an application. However, cache coordination in no way eliminates the need for an effective locking policy. To ensure the most current data, use cache coordination with optimistic or pessimistic locking; optimistic locking is preferred.

Cache coordination is supported over the Remote Method Invocation (RMI) and Java Message Service (JMS) protocols and is configured either declaratively by using persistence properties in a `persistence.xml` file or by using the cache coordination API. System properties that match the persistence properties are available as well.

For additional details on cache coordination see:

Java Persistence API (JPA) Extensions Reference for EclipseLink

11.2.1.5.1 Configuring JMS Cache Coordination Using Persistence Properties The following example demonstrates how to configure cache coordination in the `persistence.xml` file and uses JMS for broadcast notification. For JMS, provide a JMS topic JNDI name and topic connection factory JNDI name. The JMS topic should not be JTA-enabled and should not have persistent messages.

```
<property name="eclipselink.cache.coordination.protocol" value="jms" />
<property name="eclipselink.cache.coordination.jms.topic"
  value="jms/EmployeeTopic" />
<property name="eclipselink.cache.coordination.jms.factory"
  value="jms/EmployeeTopicConnectionFactory" />
```

Applications that run in a cluster generally do not require a URL because the topic provides enough to locate and use the resource. For applications that run outside the cluster, a URL is required. The following example is a URL for a WebLogic Server cluster:

```
<property name="eclipselink.cache.coordination.jms.host"
  value="t3://myserver:7001/" />
```

A user name and password for accessing the servers can also be set if required. For example:

```
<property name="eclipselink.cache.coordination.jndi.user" value="user" />
<property name="eclipselink.cache.coordination.jndi.password" value="password" />
```

11.2.1.5.2 Configuring RMI Cache Coordination Using Persistence Properties The following example demonstrates how to configure cache coordination in the `persistence.xml` file and uses RMI for broadcast notification:

```
<property name="eclipselink.cache.coordination.protocol" value="rmi" />
```

Applications that run in a cluster generally do not require a URL because JNDI is replicated and servers can look up each other. If an application runs outside of a cluster, or if JNDI is not replicated, then each server must provide its URL. This could be done through the `persistence.xml` file; however, different `persistence.xml` files (thus JAR or EAR) for each server is required, which is usually not desirable. A second

option is to set the URL programmatically using the cache coordination API. For more details, see ["Configuring Cache Coordination Using the Cache Coordination API"](#) on page 11-7. The final option is to set the URL as a system property on each application server. The following example sets the URL for a WebLogic Server cluster using a system property:

```
-Declipselink.cache.coordination.jms.host=t3://myserver:7001/
```

A user name and password for accessing the servers can also be set if required; for example:

```
<property name="eclipselink.cache.coordination.jndi.user" value="user" />
<property name="eclipselink.cache.coordination.jndi.password" value="password" />
```

RMI cache coordination can use either asynchronous or synchronous broadcasting notification; asynchronous is the default. Synchronous broadcasting ensures that all of the servers are updated before a request returns. The following example configures synchronous broadcasting.

```
<property name="eclipselink.cache.coordination.propagate-asynchronously"
value="false" />
```

If multiple applications on the same server or network use cache coordination, then a separate channel can be used for each application. For example:

```
<property name="eclipselink.cache.coordination.channel" value="EmployeeChannel" />
```

Last, if required, change the default RMI multicast socket address that allows servers to find each other. The following example explicitly configures the multicast settings:

```
<property name="eclipselink.cache.coordination.rmi.announcement-delay"
value="1000" />
<property name="eclipselink.cache.coordination.rmi.multicast-group"
value="239.192.0.0" />
<property name="eclipselink.cache.coordination.rmi.multicast-group.port"
value="3121" />
<property name="eclipselink.cache.coordination.packet-time-to-live" value="2" />
```

11.2.1.5.3 Configuring Cache Coordination Using the Cache Coordination API Use the `CommandManager` interface to programmatically configure cache coordination for a session. The following example configures RMI cache configuration:

```
Session.getCommandManager().setShouldPropagateAsynchronously(boolean)
```

```
Session.getCommandManager().getDiscoveryManager().
    setAnnouncementDelay()
    setMulticastGroupAddress()
    setMulticastPort()
    setPacketTimeToLive()
```

```
Session.getCommandManager().getTransportManager().
    setEncryptedPassword()
    setInitialContextFactoryName()
    setLocalContextProperties(Hashtable)
    setNamingServiceType() //passing in one of:
        TransportManager.JNDI_NAMING_SERVICE
        TransportManager.REGISTRY_NAMING_SERVICE
    setPassword()
    setRemoteContextProperties(Hashtable)
    setShouldRemoveConnectionOnError()
```

```
setUserName()
```

11.2.1.5.4 Setting Cache Synchronization Cache synchronization determines how notifications of object changes are broadcast among session members. The following synchronization options are available:

- `SEND_OBJECT_CHANGES`: (Default) This option broadcasts a list of changed objects including data about the changes. This data is merged into the receiving cache.
- `INVALIDATE_CHANGED_OBJECTS`: This option broadcasts a list of the identities of the objects that have changed. The receiving cache invalidates the objects rather than changing any of the data.
- `SEND_NEW_OBJECTS_WITH_CHANGES`: This option is the same as the `SEND_OBJECT_CHANGES` option except it also includes any newly created objects from the transaction.
- `NONE`: This option does no cache coordination.

The `@Cache` annotation `coordinationType` attribute is used to specify synchronization. For example:

```
@Entity
@Cache(CacheCoordinationType.SEND_NEW_OBJECTS_CHANGES)
public class Employee {
}
```

The `ClassDescriptor.setCacheSynchronizationType` method can also be used to specify synchronization. For example:

```
setCacheSynchronizationType() // passing in one of:
    ClassDescriptor.DO_NOT_SEND_CHANGES
    ClassDescriptor.INVALIDATE_CHANGED_OBJECTS
    ClassDescriptor.SEND_NEW_OBJECTS_WITH_CHANGES
    ClassDescriptor.SEND_OBJECT_CHANGES
```

11.2.2 Task 2: Ensure EclipseLink Is Enabled

Ensure that the EclipseLink JAR files are included on the classpath of each application server in the cluster to which the EclipseLink application is deployed and configure EclipseLink as the persistence provider. For detailed instructions about setting up EclipseLink with WebLogic Server and GlassFish Server, see [Chapter 3, "Using EclipseLink with WebLogic Server,"](#) and [Chapter 4, "Using EclipseLink with GlassFish Server,"](#) respectively.

11.2.3 Task 3: Ensure All Application Servers Are Part of the Cluster

Configure an application server cluster that includes each application server that hosts the EclipseLink application:

- For WebLogic Server clustering see *Oracle Fusion Middleware Using Clusters for Oracle WebLogic Server*.
- For GlassFish Server clustering, see:

http://download.oracle.com/docs/cd/E18930_01/html/821-2426/index.html

11.2.4 Using Data Partitioning to Scale Data

Data partitioning allows an application to scale its data across more than one database machine. Data partitioning is supported at the entity level to allow a different set of entity instances for the same class to be stored in a different physical database or different node within a database cluster. Both regular databases and clustered databases are supported. Data can be partitioned both horizontally and vertically.

Partitioning can be enabled on an entity, a relationship, a query, or a persistence unit. To configure data partitioning, use the `@Partitioned` annotation and one or more partitioning policy annotations. [Table 11–1](#) describes the partitioning policies

Table 11–1 Partitioning Policies

Annotation	Description
<code>@HashPartitioning</code>	Partitions access to a database cluster by the hash of a field value from the object, such as the object's ID, location, or tenant. The hash indexes into the list of connection pools/nodes. All write or read request for objects with that hash value are sent to the same server. If a query does not include the hash field as a parameter, it can be sent to all servers and unioned, or it can be left to the session's default behavior.
<code>@PinnedPartitioning</code>	Pins requests to a single connection pool/node. This allows for vertical partitioning.
<code>@RangePartitioning</code>	Partitions access to a database cluster by a field value from the object, such as the object's ID, location, or tenant. Each server is assigned a range of values. All write or read requests for objects with that value are sent to the same server. If a query does not include the field as a parameter, then it can either be sent to all servers and unioned, or left to the session's default behavior.
<code>@ReplicationPartitioning</code>	Sends requests to a set of connection pools/nodes. This policy is for replicating data across a cluster of database machines. Only modification queries are replicated.
<code>@RoundRobinPartitioning</code>	Sends requests in a round-robin fashion to the set of connection pools/nodes. This policy is used for load balancing read queries across a cluster of database machines. It requires that the full database be replicated on each machine, so it does not support partitioning. The data should either be read-only, or writes should be replicated.
<code>@UnionPartitioning</code>	Sends queries to all connection pools and unions the results. This is for queries or relationships that span partitions when partitioning is used, such as on a ManyToMany cross partition relationship.
<code>@ValuePartitioning</code>	Partitions access to a database cluster by a field value from the object, such as the object's location or tenant. Each value is assigned a specific server. All write or read requests for objects with that value are sent to the same server. If a query does not include the field as a parameter, then it can be sent to all servers and unioned, or it can be left to the session's default behavior.
<code>@Partitioning</code>	Partitions access to a database cluster by a custom partitioning policy. A class that extends the <code>PartitioningPolicy</code> class must be provided.

Partitioning policies are globally-named objects in a persistence unit and are reusable across multiple descriptors or queries. This improves the usability of the configuration, specifically with JPA annotations and XML.

The persistence unit properties support adding named connection pools in addition to the existing configuration for read/write/sequence. A named connection pool must be defined for each node in the database cluster.

If a transaction modifies data from multiple partitions, JTA should be used to ensure 2-phase commit of the data. An exclusive connection can also be configured in an `EntityManager` implementation to ensure only a single node is used for a single transaction.

The following example partitions the `Employee` data by location. The two primary sites, Ottawa and Toronto, are each stored on a separate database. All other locations are stored on the default database. Project is range partitioned by its ID. Each range of ID values are stored on a different database.

```
@Entity
@IdClass(EmployeePK.class)
@UnionPartitioning(
    name="UnionPartitioningAllNodes",
    replicateWrites=true)
@ValuePartitioning(
    name="ValuePartitioningByLOCATION",
    partitionColumn=@Column(name="LOCATION"),
    unionUnpartitionableQueries=true,
    defaultConnectionPool="default",
    partitions={
        @ValuePartition(connectionPool="node2", value="Ottawa"),
        @ValuePartition(connectionPool="node3", value="Toronto")
    })
@Partitioned("ValuePartitioningByLOCATION")
public class Employee {
    @Id
    @Column(name = "EMP_ID")
    private Integer id;

    @Id
    private String location;
    ...

    @ManyToMany(cascade = { PERSIST, MERGE })
    @Partitioned("UnionPartitioningAllNodes")
    private Collection<Project> projects;
    ...
}
```

The employee/project relationship is an example of a cross partition relationship. To allow the employees and projects to be stored on different databases a union policy is used and the join table is replicated to each database.

```
@Entity
@RangePartitioning(
    name="RangePartitioningByPROJ_ID",
    partitionColumn=@Column(name="PROJ_ID"),
    partitionValueType=Integer.class,
    unionUnpartitionableQueries=true,
    partitions={
        @RangePartition(connectionPool="default", startValue="0",
            endValue="1000"),
    })
```



```

        @RangePartition(connectionPool="node2", startValue="1000",
            endValue="2000"),
        @RangePartition(connectionPool="node3", startValue="2000")
    })
    @Partitioned("RangePartitioningByPROJ_ID")
    public class Project {
        @Id
        @Column(name="PROJ_ID")
        private Integer id;
        ...
    }

```

11.2.4.1 Clustered Databases and Oracle RAC

Some databases support clustering the database across multiple servers. Oracle Real Application Clusters (RAC) allows for a single database to span multiple different server nodes. Oracle RAC also supports table and node partitioning of data. A database cluster allows for any of the data to be accessed from any node in the cluster. However, it is generally more efficient to partition the data access to specific nodes, to reduce cross node communication. Partitioning can be used in conjunction with a clustered database to reduce cross node communication, and improve scalability. For details on using EclipseLink with Oracle RAC, see [Section 21.2.5, "Using EclipseLink with Oracle RAC."](#)

Adhere to the following requirements when using data partitioning with a database cluster:

- Partition policy should not enable replication, as database cluster makes data available to all nodes.
- Partition policy should not use unions, as database cluster returns the complete query result from any node.
- A `DataSource` and connection pool should be defined for each node in the cluster.
- The application's data access and data partitioning should be designed to have each transaction only require access to a single node.
- Usage of an exclusive connection for an `EntityManager` is recommended to avoid having multiple nodes in a single transaction and avoid 2-phase commit.

11.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

The following code sample and JavaDoc resources are available:

- Code Samples
 - <http://wiki.eclipse.org/EclipseLink/Examples/JPA/CacheCoordination>
 - <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Caching>
- See the following APIs in *Java API Reference for EclipseLink*.
 - `org.eclipse.persistence.annotations.OptimisticLocking`
 - `org.eclipse.persistence.annotations.Cache`
 - `org.eclipse.persistence.annotations.Partitioned`

- `org.eclipse.persistence.descriptors.ClassDescriptor`
- `org.eclipse.persistence.sessions.coordination`

Providing Software as a Service

This chapter provides instructions for creating shared Oracle EclipseLink applications that run in software as a service (SaaS) environments.

This chapter contains the following sections:

- [Section 12.1, "Introduction to the Solution"](#)
- [Section 12.2, "Making JPA Entities Extensible"](#)
- [Section 12.3, "Making JAXB Beans Extensible"](#)
- [Section 12.4, "Using Multitenancy"](#)
- [Section 12.5, "Using an External Metadata Source"](#)

Use Case

Users want to establish a SaaS environment, where applications are shared by multiple clients.

Solution

Employ EclipseLink SaaS features, such as extensibility, multi-tenancy, and external metadata sources.

Components

- EclipseLink 12c Release 1 (12.1.2)

12.1 Introduction to the Solution

The Oracle platform for SaaS includes EclipseLink, a part of Oracle Fusion Middleware. This allows you to build, deploy, and manage SaaS applications. With Oracle EclipseLink, you can manage persistence in cloud-enabled applications and services. EclipseLink provides flexible SaaS solutions that address multi-tenancy and extensibility while still maintaining high performance and scalability, making the persistence layer of these applications a critical component.

EclipseLink supports software as a service by supplying extensibility, multi-tenancy, and the ability to use external metadata sources.

12.2 Making JPA Entities Extensible

Use the `@VirtualAccessMethods` annotation to specify that an entity is extensible. By using virtual properties in an extensible entity, you can specify mappings external to

the entity. This allows you to modify the mappings without modifying the entity source file and without redeploying the entity's persistence unit.

Extensible entities are useful in a multi-tenant (or SaaS) architecture where a shared, generic application can be used by multiple clients (tenants). Tenants have private access to their own data, and to data shared with other tenants.

Using extensible entities, you can:

- Build an application where some mappings are common to all users and some mappings are user-specific.
- Add mappings to an application after it is made available to a customer (even post-deployment).
- Use the same `EntityManagerFactory` interface to work with data after mappings have changed.
- Provide an additional source of metadata to be used by an application.

12.2.1 Main Tasks for Creating and Supporting an Extensible JPA Entity

To create and support an extensible JPA entity:

- [Task 1: Configure the Entity](#)
- [Task 2: Design the Schema](#)
- [Task 3: Provide Additional Mappings](#)
- [Task 4: Configure Persistence Properties and the Data Repository](#)

12.2.1.1 Task 1: Configure the Entity

Configuring the entity consists of annotating the entity class with `@VirtualAccessMethods`, adding `get` and `set` methods for the property values, and adding a data structure to store the extended attributes and values.

12.2.1.1.1 Annotate the Entity Class with `@VirtualAccessMethods` Annotate the entity with `@VirtualAccessMethods` to specify that it is extensible and to define virtual properties.

[Table 12–1](#) describes the attributes available to the `@VirtualAccessMethods` annotation.

Table 12–1 Attributes for the `@VirtualAccessMethods` Annotation

Attribute	Description
<code>get</code>	<p>The name of the <code>getter</code> method to use for the virtual property. This method must take a single <code>java.lang.String</code> parameter and return a <code>java.lang.Object</code> parameter.</p> <p>Default: <code>get</code></p> <p>Required? No</p>
<code>set</code>	<p>The name of the <code>setter</code> method to use for the virtual property. This method must take a <code>java.lang.String</code> and a <code>java.lang.Object</code> parameter and return a <code>java.lang.Object</code> parameter.</p> <p>Default: <code>set</code></p> <p>Required? No</p>

12.2.1.1.2 Add `get` and `set` Methods to the Entity Add `get(String)` and `set(String, Object)` methods to the entity. The `get()` method returns a value by property name and the `set()` method stores a value by property name. The default names for these

methods are `get` and `set`, and they can be overridden with the `@VirtualAccessMethods` annotation.

EclipseLink weaves these methods if weaving is enabled, which provides support for lazy loading, change tracking, fetch groups, and internal optimizations. You must use the `get(String)` and `set(String, Object)` signatures, or else weaving will not work.

Note: Weaving is not supported when using virtual access methods with `OneToOne` mappings. If attempted, an exception will be thrown.

12.2.1.1.3 Add a Data Structure Add a data structure to store the extended attributes and values, that is, the virtual mappings. These can then be mapped to the database. See [Section 12.2.1.3, "Task 3: Provide Additional Mappings."](#)

A common way to store the virtual mappings is in a `Map` object (as shown in [Example 12–1](#)), but you can also use other strategies. For example you could store the virtual mappings in a directory system.

When using field-based access, annotate the data structure with `@Transient` so the structure cannot be used for another mapping. When using property-based access, `@Transient` is unnecessary.

[Example 12–1](#) illustrates an entity class that uses property access. The `@Transient` annotation is illustrated in bold font.

Example 12–1 Entity Class that Uses Property Access

```
@Entity
@VirtualAccessMethods
public class Customer{

    @Id
    private int id;
    ...

    @Transient
    private Map<String, Object> extensions;

    public <T> T get(String name) {
        return (T) extensions.get(name);
    }

    public Object set(String name, Object value) {
        return extensions.put(name, value);
    }
}
```

12.2.1.1.4 Use XML As an alternative to, or in addition to, using the `@VirtualAccessMethods` annotation, you can use the `<access>` and `<access-methods>` elements, for example:

```
<access>VIRTUAL</access>
<access-methods set-method="get" get-method="set"/>
```

12.2.1.2 Task 2: Design the Schema

Provide database tables with extra columns for storing flexible mapping data. For example, the following `Customer` table includes two predefined columns, `ID` and `NAME`, and three flexible columns, `FLEX_COL1`, `FLEX_COL2`, `FLEX_COL3`:

CUSTOMER table

- INTEGER ID
- VARCHAR NAME
- VARCHAR FLEX_COL1
- VARCHAR FLEX_COL2
- VARCHAR FLEX_COL3

You can then specify which of the FLEX columns should be used to persist an extended attribute, as described in "[Task 3: Provide Additional Mappings](#)".

12.2.1.3 Task 3: Provide Additional Mappings

To provide additional mappings, add the mappings with the column and access-methods attributes to the eclipselink-orm.xml file, for example:

```
<basic name="idNumber" attribute-type="String">
  <column name="FLEX_COL1" />
  <access-methods get-method="get" set-method="set" />
</basic>
```

12.2.1.4 Task 4: Configure Persistence Properties and the Data Repository

Configure persistence unit properties to indicate that the application should retrieve the flexible mappings from the eclipselink-orm.xml file. You can set persistence unit properties using the persistence.xml file or by setting properties on the EntityManagerFactory interface, as described in the following sections.

For more information about external mappings, see "External Mappings" in the EclipseLink documentation, at:

http://wiki.eclipse.org/EclipseLink/UserGuide/JPA/Advanced_JPA_Development/External_Mappings

12.2.1.4.1 Configure the persistence.xml File In the persistence.xml file, use the eclipselink.metadata-source property to use the default eclipselink-orm.xml file. Use the eclipselink.metadata-source.xml.url property to use a different file at the specified location, for example:

```
<property name="eclipseLink.metadata-source" value="XML" />
<property name="eclipseLink.metadata-source.xml.url" value="foo://bar" />
```

12.2.1.4.2 Configure EntityManagerFactory and the Metadata Repository Extensions are added at bootstrap time through access to a metadata repository. The metadata repository is accessed through a class that provides methods to retrieve the metadata it holds. EclipseLink includes a metadata repository implementation that supports XML repositories.

Specify the class to use and any configuration information for the metadata repository through persistence unit properties. The EntityManagerFactory interface integrates additional mapping information from the metadata repository into the metadata it uses to bootstrap.

You can provide your own implementation of the class to access the metadata repository. Each metadata repository access class must specify an individual set of properties to use to connect to the repository.

You can subclass either of the following classes:

- org.eclipse.persistence.internal.jpa.extensions.MetadataRepository

- `org.eclipse.persistence.internal.jpa.extensions.XMLMetadataRepository`

In the following example, the properties that begin with `com.foo` are subclasses defined by the developer.

```
<property name="eclipselink.metadata-source" value="com.foo.MetadataRepository"/>
<property name="com.foo.MetadataRepository.location" value="foo://bar"/>
<property name="com.foo.MetadataRepository.extra-data" value="foo-bar"/>
```

12.2.1.4.3 Refresh the Metadata Repository If you change the metadata and you want an `EntityManager` instance based on the new metadata, you must call the `refreshMetadata()` method on the `EntityManagerFactory` interface to refresh the data. The next `EntityManager` instance will be based on the new metadata.

The `refreshMetadata()` method takes a map of properties that can be used to override the properties previously defined for the `metadata-source` element.

12.2.2 Code Examples

[Example 12-2](#) illustrates the following:

- Field access is used for non-extension fields.
- Virtual access is used for extension fields, using defaults (`get(String)` and `set(String, Object)`).
- The `get(String)` and `set(String, Object)` methods will be woven, even if no mappings use them, because of the presence of `@VirtualAccessMethods`.
- Extensions are mapped in a portable way by specifying `@Transient`.

These items are illustrated in bold font.

Example 12-2 Virtual Access Using Default get and set Method Names

```
@Entity
@VirtualAccessMethods
public class Address {

    @Id
    private int id;

    @Transient
    private Map<String, Object> extensions;

    public int getId(){
        return id;
    }

    public <T> T get(String name) {
        return (T) extensions.get(name);
    }

    public Object set(String name, Object value) {
        return extensions.put(name, value);
    }
}
```

[Example 12-3](#) illustrates the following:

- Field access is used for non-extension fields.
- The `@VirtualAccessMethods` annotation overrides methods to be used for getting and setting.
- The `get(String)` and `set(String, Object)` methods will be woven, even if no mappings use them, because of the presence of `@VirtualAccessMethods`.
- Extensions are mapped in a portable way by specifying `@Transient`.
- The XML for extended mapping indicates which `get()` and `set()` method to use.

These items are illustrated in bold font.

Example 12–3 Overriding get and set Methods

```
@Entity
@VirtualAccessMethods(get="getExtension", set="setExtension")
public class Address {

    @Id
    private int id;

    @Transient
    private Map<String, Object> extensions;

    public int getId(){
        return id;
    }

    public <T> T getExtension(String name) {
        return (T) extensions.get(name);
    }

    public Object setExtension(String name, Object value) {
        return extensions.put(name, value);
    }

    ...

    <basic name="name" attribute-type="String">
        <column name="FLEX_1"/>
        <access-methods get-method="getExtension" set-method="setExtension"/>
    </basic>
```

Example 12–4 illustrates the following:

- Property access is used for non-extension fields.
- Virtual access is used for extension fields, using defaults (`get(String)` and `set(String, Object)`).
- The extensions are mapped in a portable way. `@Transient` is not required, because property access is used.
- The `get(String)` and `set(String, Object)` methods will be woven, even if no mappings use them, because of the presence of `@VirtualAccessMethods`.

These items are illustrated in bold font.

Example 12–4 Using Property Access

```
@Entity
@VirtualAccessMethods
```



```

public class Address {

    private int id;

    private Map<String, Object> extensions;

    @Id
    public int getId(){
        return id;
    }

    public <T> T get(String name) {
        return (T) extensions.get(name);
    }

    public Object set(String name, Object value) {
        return extensions.put(name, value);
    }

    ...

```

12.3 Making JAXB Beans Extensible

Use the `@XmlVirtualAccessMethods` annotation to specify that a JAXB bean is extensible. By using virtual properties in an extensible bean, you can specify mappings external to the bean. This allows you to modify the mappings without modifying the bean source file and without redeploying the bean's persistence unit.

In a multi-tenant (or SaaS) architecture, a single application runs on a server, serving multiple client organizations (tenants). Good multi-tenant applications allow per-tenant customizations. When these customizations are made to data, it can be difficult for the binding layer to handle them. JAXB is designed to work with domain models that have real fields and properties. EclipseLink Object-XML 2.3 (also known as *MOXy*) introduces the concept of virtual properties which can easily handle this use case. Virtual properties are defined by the Object-XML metadata file, and provide a way to extend a class without modifying the source.

This section has the following subsections:

- [Section 12.3.1, "Main Steps"](#)
- [Section 12.3.2, "Code Examples"](#)

12.3.1 Main Steps

To create and support an extensible JAXB bean:

- [Task 1: Configure the Bean](#)
- [Task 2: Provide Additional Mappings](#)

12.3.1.1 Task 1: Configure the Bean

Configuring the bean consists of annotating the bean class with the `@XmlVirtualAccessMethods`, adding get and set methods for the property values, and adding a data structure to store the extended attributes and values.

12.3.1.1.1 Annotate the Bean Class with `@XmlVirtualAccessMethods` Annotate the bean with `@XmlVirtualAccessMethods` to specify that it is extensible and to define virtual properties.

[Table 12–2](#) describes the attributes available to the `@XmlVirtualAccessMethods` annotation.

Table 12–2 Attributes for the `@XmlVirtualAccessMethods` Annotation

Attribute	Description
<code>get</code>	<p>The name of the getter method to use for the virtual property. This method must take a single <code>java.lang.String</code> parameter and return a <code>java.lang.Object</code>.</p> <p>Default: <code>get</code></p> <p>Required? No</p>
<code>set</code>	<p>The name of the setter method to use for the virtual property. This method must take a <code>java.lang.String</code> and a <code>java.lang.Object</code> parameter and return a <code>java.lang.Object</code> parameter.</p> <p>Default: <code>set</code></p> <p>Required? No</p>

12.3.1.1.2 Add get and set Methods to the Bean Add `get(String)` and `set(String, Object)` methods to the bean. The `get()` method returns a value by property name and the `set()` method stores a value by property name. The default names for these methods are `get` and `set`, and they can be overridden with the `@XmlVirtualAccessMethods` annotation.

EclipseLink weaves these methods if weaving is enabled, which provides support for lazy loading, change tracking, fetch groups, and internal optimizations.

12.3.1.1.3 Add a Data Structure Add a data structure to store the extended attributes and values, that is, the virtual mappings. These can then be mapped to the database. See ["Task 2: Provide Additional Mappings"](#).

A common way to store the virtual mappings is in a `Map`, but you can use other ways, as well. For example you could store the virtual mappings in a directory system.

When using field-based access, annotate the data structure with `@XmlTransient` so it cannot use it for another mapping. When using property-based access, `@XmlTransient` is unnecessary.

12.3.1.1.4 Use XML As an alternative to, or in addition to, using `@XmlVirtualAccessMethods`, you can use the `<access>` and `<access-methods>` elements, for example:

```
<access>VIRTUAL</access>
<access-methods set-method="get" get-method="set"/>
```

XML to enable virtual access methods using `get` and `set`:

```
<xml-virtual-access-methods/>
```

XML to enable virtual access methods using `put` instead of `set` (default):

```
<xml-virtual-access-methods set-method="put"/>
```

XML to enable virtual access methods using `retrieve` instead of `get` (default):

```
<xml-virtual-access-methods get-method="retrieve"/>
```

XML to enable virtual access methods using `retrieve` and `put` instead of `get` and `set` (default):

```
<xml-virtual-access-methods get-method="retrieve" set-method="put"/>
```

12.3.1.2 Task 2: Provide Additional Mappings

To provide additional mappings, add the mappings to the `eclipselink-oxm.xml` file, for example:

```
<xml-element java-attribute="idNumber"/>
```

12.3.2 Code Examples

The examples in this section illustrate how to use extensible JAXB beans. The example begins with the creation of a base class that other classes can extend. In this case the extensible classes are for `Customers` and `PhoneNumbers`. Mapping files are created for two separate tenants. Even though both tenants share several real properties, they will define virtual properties that are unique to their requirements.

12.3.2.1 Basic Setup

[Example 12–5](#) illustrates a base class, `ExtensibleBase`, which other extensible classes can extend. In the example, the use of the `@XmlTransient` annotation prevents `ExtensibleBase` from being mapped as an inheritance relationship. The real properties represent the parts of the model that will be common to all tenants. The per-tenant extensions will be represented as virtual properties.

Example 12–5 A Base Class for Extensible Classes

```
package examples.virtual;

import java.util.HashMap;
import java.util.Map;

import javax.xml.bind.annotation.XmlTransient;
import org.eclipse.persistence.oxm.annotations.XmlVirtualAccessMethods;

@XmlTransient
@XmlVirtualAccessMethods(setMethod="put")
public class ExtensibleBase {

    private Map<String, Object> extensions = new HashMap<String, Object>();

    public <T> T get(String property) {
        return (T) extensions.get(property);
    }

    public void put(String property, Object value) {
        extensions.put(property, value);
    }
}
```

[Example 12–6](#) illustrates the definition of a `Customer` class. The `Customer` class is extensible because it inherits from a domain class that has been annotated with `@XmlVirtualAccessMethods`.

Example 12–6 An Extensible Customer Class

```
package examples.virtual;

import javax.xml.bind.annotation.XmlRootElement;
```

```
@XmlElement
public class Customer extends ExtensibleBase {

    private String firstName;
    private String lastName;
    private Address billingAddress;

    public String getFirstName() {
        return firstName;
    }

    public void setFirstName(String firstName) {
        this.firstName = firstName;
    }

    public String getLastName() {
        return lastName;
    }

    public void setLastName(String lastName) {
        this.lastName = lastName;
    }

    public Address getBillingAddress() {
        return billingAddress;
    }

    public void setBillingAddress(Address billingAddress) {
        this.billingAddress = billingAddress;
    }

}
```

[Example 12-7](#) illustrates an Address class. It is not necessary for every class in your model to be extensible. In this example, the Address class does not have any virtual properties.

Example 12-7 A Nonextensible Address Class

```
package examples.virtual;

public class Address {

    private String street;

    public String getStreet() {
        return street;
    }

    public void setStreet(String street) {
        this.street = street;
    }

}
```

[Example 12-8](#) illustrates a PhoneNumber class. Like Customer, PhoneNumber will be an extensible class.

Example 12–8 An Extensible PhoneNumber Class

```

package examples.virtual;

import javax.xml.bind.annotation.XmlValue;

public class PhoneNumber extends ExtensibleBase {

    private String number;

    @XmlValue
    public String getNumber() {
        return number;
    }

    public void setNumber(String number) {
        this.number = number;
    }

}

```

12.3.2.2 Define the Tenants

The examples in this section define two separate tenants. Even though both tenants share several real properties, the corresponding XML representation can be quite different due to virtual properties.

Tenant 1

The first tenant is an online sporting goods store that requires the following extensions to its model:

- Customer ID
- Customer's middle name
- Shipping address
- A collection of contact phone numbers
- Type of phone number (that is, home, work, or cell)

The metadata for the virtual properties is supplied through Object-XML's XML mapping file. Virtual properties are mapped in the same way as real properties. Some additional information is required, including type (since this cannot be determined through reflection), and for collection properties, a container type. The virtual properties defined below for Customer are `middleName`, `shippingAddress`, and `phoneNumbers`. For `PhoneNumber`, the virtual property is the `type` property.

[Example 12–9](#) illustrates the `binding-tenant1.xml` mapping file.

Example 12–9 Defining Virtual Properties for Tenant 1

```

<?xml version="1.0"?>
<xml-bindings
  xmlns="http://www.eclipse.org/eclipselink/xsds/persistence/oxm"
  package-name="examples.virtual">
  <java-types>
    <java-type name="Customer">
      <xml-type prop-order="firstName middleName lastName billingAddress
shippingAddress phoneNumbers"/>
      <java-attributes>
        <xml-attribute

```

```

        java-attribute="id"
        type="java.lang.Integer"/>
    <xml-element
        java-attribute="middleName"
        type="java.lang.String"/>
    <xml-element
        java-attribute="shippingAddress"
        type="examples.virtual.Address"/>
    <xml-element
        java-attribute="phoneNumbers"
        name="phoneNumber"
        type="examples.virtual.PhoneNumber"
        container-type="java.util.List"/>
    </java-attributes>
</java-type>
<java-type name="PhoneNumber">
    <java-attributes>
        <xml-attribute
            java-attribute="type"
            type="java.lang.String"/>
        </java-attributes>
    </java-type>
</java-types>
</xml-bindings>

```

The get and set methods are used on the domain model to interact with the real properties and the accessors defined on the `@XmlVirtualAccessMethods` annotation are used to interact with the virtual properties. The normal JAXB mechanisms are used for marshal and unmarshal operations. [Example 12–10](#) illustrates the `Customer` class code for tenant 1 to obtain the data associated with virtual properties.

Example 12–10 Tenant 1 Code to Provide the Data Associated with Virtual Properties

```

...
Customer customer = new Customer();

//Set Customer's real properties
customer.setFirstName("Jane");
customer.setLastName("Doe");

Address billingAddress = new Address();
billingAddress.setStreet("1 Billing Street");
customer.setBillingAddress(billingAddress);

//Set Customer's virtual 'middleName' property
customer.put("middleName", "Anne");

//Set Customer's virtual 'shippingAddress' property
Address shippingAddress = new Address();
shippingAddress.setStreet("2 Shipping Road");
customer.put("shippingAddress", shippingAddress);

List<PhoneNumber> phoneNumbers = new ArrayList<PhoneNumber>();
customer.put("phoneNumbers", phoneNumbers);

PhoneNumber workPhoneNumber = new PhoneNumber();
workPhoneNumber.setNumber("555-WORK");
//Set the PhoneNumber's virtual 'type' property
workPhoneNumber.put("type", "WORK");
phoneNumbers.add(workPhoneNumber);

```

```

PhoneNumber homePhoneNumber = new PhoneNumber();
homePhoneNumber.setNumber("555-HOME");
//Set the PhoneNumber's virtual 'type' property
homePhoneNumber.put("type", "HOME");
phoneNumbers.add(homePhoneNumber);

Map<String, Object> properties = new HashMap<String, Object>();
properties.put(JAXBContextFactory.ECLIPSELINK_OXM_XML_KEY,
"examples/virtual/binding-tenant1.xml");
JAXBContext jc = JAXBContext.newInstance(new Class[] {Customer.class,
Address.class}, properties);

Marshaller marshaller = jc.createMarshaller();
marshaller.setProperty(Marshaller.JAXB_FORMATTED_OUTPUT, true);
marshaller.marshal(customer, System.out);
...

```

[Example 12-11](#) illustrates the XML output from the Customer class for tenant 1.

Example 12-11 XML Output from the Customer Class for Tenant 1

```

<?xml version="1.0" encoding="UTF-8"?>
<customer>
  <firstName>Jane</firstName>
  <middleName>Anne</middleName>
  <lastName>Doe</lastName>
  <billingAddress>
    <street>1 Billing Street</street>
  </billingAddress>
  <shippingAddress>
    <street>2 Shipping Road</street>
  </shippingAddress>
  <phoneNumber type="WORK">555-WORK</phoneNumber>
  <phoneNumber type="HOME">555-HOME</phoneNumber>
</customer>

```

Tenant 2

The second tenant is a streaming media provider that offers on-demand movies and music to its subscribers. It requires a different set of extensions to the core model:

- A single contact phone number

For this tenant, the mapping file is also used to customize the mapping of the real properties.

[Example 12-12](#) illustrates the binding-tenant2.xml mapping file.

Example 12-12 Defining Virtual Properties for Tenant 2

```

<?xml version="1.0"?>
<xml-bindings
  xmlns="http://www.eclipse.org/eclipselink/xsds/persistence/oxm"
  package-name="examples.virtual">
  <xml-schema namespace="urn:tenant1" element-form-default="QUALIFIED"/>
  <java-types>
    <java-type name="Customer">
      <xml-type prop-order="firstName lastName billingAddress phoneNumber"/>
      <java-attributes>
        <xml-attribute java-attribute="firstName"/>
        <xml-attribute java-attribute="lastName"/>

```

```
        <xml-element java-attribute="billingAddress" name="address"/>
        <xml-element
            java-attribute="phoneNumber"
            type="examples.virtual.PhoneNumber"/>
    </java-attributes>
</java-type>
</java-types>
</xml-bindings>
```

[Example 12-13](#) illustrates the tenant 2 Customer class code to obtain the data associated with virtual properties.

Example 12-13 Tenant 2 Code to Provide the Data Associated with Virtual Properties

```
...
Customer customer = new Customer();
customer.setFirstName("Jane");
customer.setLastName("Doe");

Address billingAddress = new Address();
billingAddress.setStreet("1 Billing Street");
customer.setBillingAddress(billingAddress);

PhoneNumber phoneNumber = new PhoneNumber();
phoneNumber.setNumber("555-WORK");
customer.put("phoneNumber", phoneNumber);

Map<String, Object> properties = new HashMap<String, Object>();
properties.put(JAXBContextFactory.ECLIPSELINK_OXM_XML_KEY,
"examples/virtual/binding-tenant2.xml");
JAXBContext jc = JAXBContext.newInstance(new Class[] {Customer.class,
Address.class}, properties);

Marshaller marshaller = jc.createMarshaller();
marshaller.setProperty(Marshaller.JAXB_FORMATTED_OUTPUT, true);
marshaller.marshal(customer, System.out);
...
```

[Example 12-14](#) illustrates the XML output from the Customer class for tenant 2.

Example 12-14 XML Output from the Customer Class for Tenant 2

```
<?xml version="1.0" encoding="UTF-8"?>
<customer xmlns="urn:tenant1" firstName="Jane" lastName="Doe">
    <address>
        <street>1 Billing Street</street>
    </address>
    <phoneNumber>555-WORK</phoneNumber>
</customer>
```

12.4 Using Multitenancy

A key element to implementing SaaS is the ability for multiple application tenants to use a shared schema ******EXPAND****** while ensuring that the tenant works only on its own data.

- Single-table multi-tenancy uses a single table for all application tenants and differentiates application tenants based on tenant discriminator columns with specific application context values.

- Table-per-tenant multitenancy *****COMPLETE*****
- VPD multitenancy *****COMPLETE*****

For information about multi-tenancy, see [Chapter 13, "Tenant Isolation Using EclipseLink."](#)

12.5 Using an External Metadata Source

With EclipseLink, you can store your mapping information in a metadata source that is external to the running application. Because the mapping information is retrieved when the application creates the persistence unit, you can dynamically override or extend mappings in a deployed application.

12.5.1 Using the eclipselink-orm.xml File Externally

With EclipseLink, you can use the `eclipselink-orm.xml` file to support advanced mapping types and options. This file can override the standard JPA `orm.xml` mapping configuration file.

12.5.2 Main Tasks

To use an external metadata source for your mapping information, perform the following tasks:

- [Task 1: Configure the Persistence Unit](#)
- [Task 2: Configure the Server](#)

12.5.2.1 Task 1: Configure the Persistence Unit

You can configure your persistence unit to use the external metadata by:

- [Accessing a Fixed Location](#)
- [Accessing an Application Context-Based Location](#)

12.5.2.1.1 Accessing a Fixed Location The easiest way to access an external file, such as the `eclipselink-orm.xml` file with additional mapping information, is by making the file available from a fixed URL on the web server.

Use the `eclipselink.metadata-source.xml.url` property, as shown in [Example 12–15](#), to specify the location.

Example 12–15 Fixed Location

```
<property name="eclipselink.metadata-source" value="XML"/>
<property name="eclipselink.metadata-source.xml.url"
value="http://myserverlocation/" />
```

12.5.2.1.2 Accessing an Application Context-Based Location For more complex requirements, such as providing tenant-specific extensions in a multi-tenant application, you can specify the location of the external metadata based on the application context.

Implement the `MetadataSource` interface, as shown in [Example 12–16](#), to specify the location.

Example 12–16 Fixed Location

```
<property name="eclipselink.metadata-source" value="mypackage.MyMetadataSource"/>
<property name="eclipselink.metadata-source.xml.url" value="foo://bar"/>
```

[Example 12–17](#) illustrates how to return a specific mapping file, based on the tenant.

Example 12–17 Tenant-specific Mapping File

```
public class AdminMetadataSource extends XMLMetadataSource {

    @Override
    public XMLEntityMappings getEntityMappings(Map<String, Object> properties,
        ClassLoader classLoader, SessionLog log) {
        String leagueId = (String) properties.get(LEAGUE_CONTEXT);
        properties.put(PersistenceUnitProperties.METADATA_SOURCE_XML_URL,
            "http://myserverlocation/rest/" + leagueId + "/orm");
        return super.getEntityMappings(properties, classLoader, log);
    }
}
```

12.5.2.2 Task 2: Configure the Server

To access the metadata file, the server must provide URL access to the mapping file by using any of the following:

- Static file serving
- A server-based solution with its own mapping file or a mapping file built on-demand from stored mapping information
- some other web technology.

12.5.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

For additional information about JPA deployment, see the following sections of the JPA Specification (<http://jcp.org/en/jsr/detail?id=317>):

- Section 7.2, "Bootstrapping in Java SE Environments"
- Chapter 7, "Container and Provider Contracts for Deployment and Bootstrapping"

12.5.3.1 Related Javadoc

For more information, see the following APIs in *Oracle Fusion Middleware Java API Reference for EclipseLink*:

- `PersistenceUnitProperties` class

Tenant Isolation Using EclipseLink

With EclipseLink, you can develop a single application and then deploy it for different clients, or "tenants," with varying degrees of application and data isolation and of tenant-specific functionality. For example, a large company may develop a single payroll application to be used by multiple divisions. Each division has access to its own data and to shared data, but they cannot see any other division's data.

This chapter contains the following sections:

- [Section 13.1, "Introduction to the Solution"](#)
- [Section 13.2, "Using Single-Table Multi-Tenancy"](#)
- [Section 13.3, "Using Table-Per-Tenant Multi-Tenancy"](#)
- [Section 13.4, "Using VPD Multi-Tenancy"](#)
- [Section 13.5, "Additional Resources"](#)

Use Case

Multiple application clients must share data sources, with private access to their data, for example in a Software as a Service (SaaS) environment.

Solution

Decide on a strategy for tenant isolation; then use EclipseLink's tenant isolation features to implement the strategy.

Components

- EclipseLink 2.4 or later.
- A compliant Java Database Connectivity (JDBC) database, such as Oracle Database, Oracle Express, or MySQL.

13.1 Introduction to the Solution

EclipseLink offers considerable flexibility in how you can design and implement features for isolating tenants. Possibilities include the following:

Application Isolation options

- Separate container/server
- Separate application within the same container/server
- Separate entity manager factory and shared cache within the same application
- Shared entity manager factory with tenant isolation at the entity manager

Data isolation options

- Separate database
- Separate schema/tablespace
- Separate tables
- Shared table with row isolation
- Query filtering
- Oracle Virtual Private Database (VPD)

EclipseLink includes the following options for providing multi-tenancy in the data source:

- **Single-table multi-tenancy** allows tenants to share tables. Each tenant has its own rows, identified by discriminator columns, and those rows are invisible to other tenants. See [Using Single-Table Multi-Tenancy](#).
- With **table-per-tenant** multi-tenancy, each tenant has its own table or tables, identified by table tenant discriminators, and those tables are invisible to other users. See [Using Table-Per-Tenant Multi-Tenancy](#).
- With **(VDP)** multi-tenancy, tenants use a VDP database, which provides the functionality to support multiple tenants sharing the same table. See [Using VPD Multi-Tenancy](#).

EclipseLink further provides tenant-specific extensions through extensible entities using extensible entities and `MetadataSource`. For information about those features, see [Chapter 12, "Providing Software as a Service."](#)

13.2 Using Single-Table Multi-Tenancy

With single-table multi-tenancy, any table (`Table` or `SecondaryTable`) to which an entity or mapped superclass maps can include rows for multiple tenants. Access to tenant-specific rows is restricted to the specified tenant.

Tenant-specific rows are associated with the tenant by using tenant discriminator columns. The discriminator columns are used with application context values to limit what a persistence context can access.

The results of queries on the mapped tables are limited to the tenant discriminator value(s) provided as property values. This applies to all insert, update, and delete operations on the table. When multi-tenant metadata is applied at the mapped superclass level, it is applied to all subentities unless they specify their own multi-tenant metadata.

Note: In the context of single-table multi-tenancy, “single-table” means multiple tenants can share a single table, and each tenant’s data is distinguished from other tenants’ data via the discriminator column(s). It is possible to use multiple tables with single-table multi-tenancy; but in that case, an entity’s persisted data is stored in multiple tables, and multiple tenants can share all the tables.

13.2.1 Main Tasks for Using Single-Table Multi-Tenancy

The following tasks provide instructions for using single-table multi-tenancy:

- [Task 1: Prerequisites](#)

- [Task 2: Enable Single-Table Multi-Tenancy](#)
- [Task 3: Specify Tenant Discriminator Columns](#)
- [Task 4: Perform Operations and Queries](#)
- [Task 5: Use Single-Table Multi-Tenancy in an Inheritance Hierarchy](#)

13.2.1.1 Task 1: Prerequisites

To implement and use single-table multi-tenancy, you need:

- EclipseLink 2.4 or later.
Download EclipseLink from <http://www.eclipse.org/eclipselink/downloads/>.
- Any compliant Java Database Connectivity (JDBC) database, including Oracle Database, Oracle Database Express Edition (Oracle Database XE), or MySQL. These instructions are based on Oracle Database XE 11g Release 2.

For the certification matrix, see

13.2.1.2 Task 2: Enable Single-Table Multi-Tenancy

Single-table multi-tenancy can be enabled declaratively using the `@Multitenant` annotation, in an Object Relational Mapping (ORM) XML file using the `<multitenant>` element, or by using annotations and XML together.

13.2.1.2.1 Using the `@Multitenant` Annotation To use the `@Multitenant` annotation, include it with an `@Entity` or `@MappedSuperclass` annotation. For example:

```
@Entity
@Table(name="EMP")
@Multitenant(SINGLE_TABLE)
public class Employee {
}
```

Note: Single-table is the default multi-tenancy type, so `SINGLE_TABLE` does not have to be included in `@Multitenant`.

Note: The `@Table` annotation is not required, because the discriminator column is assumed to be on the primary table. However, if the discriminator column is defined on a secondary table, you must identify that table using `@SecondaryTable`.

13.2.1.2.2 Using the `<multitenant>` Element To use the `<multitenant>` element, include the element within an `<entity>` element. For example:

```
<entity class="model.Employee">
  <multitenant type="SINGLE_TABLE">
    ...
  </multitenant>
  ...
</entity>
```

13.2.1.3 Task 3: Specify Tenant Discriminator Columns

Discriminator columns are used together with an associated application context to indicate which rows in a table an application tenant can access.

Tenant discriminator columns can be specified declaratively using the `@TenantDiscriminatorColumn` annotation or in an object-relational (ORM) XML file using the `<tenant-discriminator-column>` element.

The following characteristics apply to discriminator columns:

- Tenant discriminator column(s) must always be used with `@Multitenant` (or `<multitenant>` in the ORM XML file). You cannot specify the tenant discriminator column(s) only.
- The tenant discriminator column is assumed to be on the primary table unless another table or secondary table is explicitly specified.
- On persist, the values of tenant discriminator columns are populated from their associated context properties.
- When a multi-tenant entity is specified, the tenant discriminator column can default. Its default values are:
 - Name = `TENANT_ID` (the database column name)
 - Context property = `tenant.id` (the context property used to populate the database column)
- Tenant discriminator columns are application definable. That is, the discriminator column is not tied to a specific column for each shared entity table. You can use `TENANT_ID`, `T_ID`, etc.
- There is no limit on the number of tenant discriminator columns an application can define.
- Any name can be used for a discriminator column.
- Generated schemas can include specified tenant discriminator columns.
- Tenant discriminator columns can be mapped or unmapped:
 - When a tenant discriminator column is mapped, its associated mapping attribute must be marked as read only. With this restriction in place, a tenant discriminator column cannot be part of the entity identifier; it can only be part of the primary key specification on the database.
 - Both mapped and unmapped properties are used to form the additional criteria when issuing a `SELECT` query.

13.2.1.3.1 Use the `@TenantDiscriminatorColumn` Annotation To use the `@TenantDiscriminatorColumn` annotation, include it with `@Multitenant` annotation on an entity or mapped superclass, and optionally include the `name` and `contextProperty` attributes. If you do not specify these attributes, the defaults `name = "TENANT-ID"` and `contextProperty = "eclipselink.tenant-id"` are used.

For example:

```
@Entity
@Multitenant(SINGLE_TABLE)
@TenantDiscriminatorColumn(name = "TENANT", contextProperty = "multitenant.id")
public class Employee {
}
```

To specify multiple tenant discriminator columns, include multiple `@TenantDiscriminatorColumn` annotations within the `@TenantDiscriminatorColumns` annotation, and include the table where the column is located if it is not located on the primary table. For example:

```
@Entity
@Table(name = "EMPLOYEE")
@SecondaryTable(name = "RESPONSIBILITIES")
@Multitenant(SINGLE_TABLE)
@TenantDiscriminatorColumns({
    @TenantDiscriminatorColumn(name = "TENANT_ID",
        contextProperty = "employee-tenant.id", length = 20)
    @TenantDiscriminatorColumn(name = "TENANT_CODE",
        contextProperty = "employee-tenant.code", discriminatorType = STRING,
        table = "RESPONSIBILITIES")
})
public Employee() {
    ...
}
```

13.2.1.3.2 Use the <tenant-discriminator-column> Element To use the `<tenant-discriminator-column>` element, include the element within a `<multitenant>` element and optionally include the name and context-property attributes. If you do not specify these attributes, the defaults `name = "TENANT-ID"` and `contextProperty = "eclipselink.tenant-id"` are used.

For example:

```
<entity class="model.Employee">
    <multitenant>
        <tenant-discriminator-column name="TENANT"
            context-property="multitenant.id"/>
    </multitenant>
    ...
</entity>
```

To specify multiple columns, include additional `<tenant-discriminator-column>` elements, and include the table where the column is located if it is not located on the primary table. For example:

```
<entity class="model.Employee">
    <multitenant type="SINGLE_TABLE">
        <tenant-discriminator-column name="TENANT_ID"
            context-property="employee-tenant.id" length="20"/>
        <tenant-discriminator-column name="TENANT_CODE"
            context-property="employee-tenant.id" discriminator-type="STRING"
            table="RESPONSIBILITIES"/>
    </multitenant>
    <table name="EMPLOYEE"/>
    <secondary-table name="RESPONSIBILITIES"/>
    ...
</entity>
```

13.2.1.3.3 Map Tenant Discriminator Columns Tenant discriminator columns can be mapped to a primary key or to another column. The following example maps the tenant discriminator column to the primary key on the table during DDL generation:

```
@Entity
```

```
@Table(name = "ADDRESS")
@Multitenant
@TenantDiscriminatorColumn(name = "TENANT", contextProperty = "tenant.id",
    primaryKey = true)
public Address() {
    ...
}
```

To have the tenant discriminator column mapped to the primary key as part of the object entity, the column must be mapped. For example:

```
@Id
@Column("TENANT")
public int tenant;
```

The following example uses the ORM XML file to map the tenant discriminator column to a primary key:

```
<entity class="model.Address">
    <multitenant>
        <tenant-discriminator-column name="TENANT"
            context-property="multitenant.id" primary-key="true"/>
    </multitenant>
    <table name="ADDRESS"/>
    ...
</entity>
```

The following example maps the tenant discriminator column to another column named AGE:

```
@Entity
@Table(name = "Player")
@Multitenant
@TenantDiscriminatorColumn(name = "AGE", contextProperty = "tenant.age")
public Player() {
    ...

    @Basic
    @Column(name="AGE", insertable="false", updatable="false")
    public int age;
}
```

The following example uses the ORM XML file to map the tenant discriminator column to another column named AGE:

```
<entity class="model.Player">
    <multitenant>
        <tenant-discriminator-column name="AGE" context-property="tenant.age"/>
    </multitenant>
    <table name="PLAYER"/>
    ...
    <attributes>
        <basic name="age" insertable="false" updatable="false">
            <column name="AGE"/>
        </basic>
        ...
    </attributes>
    ...
</entity>
```


13.2.1.3.4 Define Persistence Unit and Entity Mappings Defaults In addition to configuring discriminator columns at the entity and mapped superclass levels, you can also configure them at the persistence-unit-defaults and entity-mappings levels to provide defaults. Defining the metadata at these levels follows similar JPA metadata defaulting and overriding rules.

Specify default tenant discriminator column metadata at the persistence-unit-defaults level in the ORM XML file. When defined at this level, the defaults apply to all entities of the persistence unit that have specified a multi-tenant type of `SINGLE_TABLE` minus those that specify their own tenant discriminator metadata. For example:

```
<xsd:complexType name="persistence-unit-defaults">
  ...
  <xsd:sequence>
    ...
    <xsd:element name="tenant-discriminator-column"
      type="orm:tenant-discriminator-column"
      minOccurs="0" maxOccurs="unbounded"/>
    ...
  </xsd:sequence>
</xsd:complexType>
```

You can also specify tenant discriminator column metadata at the entity-mappings level in the ORM XML file. A setting at this level overrides a persistence unit default and applies to all entities with a multi-tenant type of `SINGLE_TABLE` of the mapping file, minus those that specify their own tenant discriminator metadata. For example:

```
<xsd:element name="entity-mappings">
  ...
  <xsd:sequence>
    ...
    <xsd:element name="tenant-discriminator-column"
      type="orm:tenant-discriminator-column" minOccurs="0"
      maxOccurs="unbounded"/>
    ...
  </xsd:sequence>
</xsd:complexType>
```

13.2.1.4 Configure Context Properties and Caching Scope

Runtime context properties are used in conjunction with the multi-tenancy configuration on an entity (or mapped superclass) to implement the multi-tenancy strategy. For example, the tenant ID assigned to a tenant discriminator column for an entity is used at runtime (via an entity manager) to restrict access to data, based on that tenant's ownership of (or access to) the rows and tables of the database.

At runtime, multi-tenancy properties can be specified in a persistence unit definition or passed to a create entity manager factory call.

The order of precedence for tenant discriminator column properties is as follows:

1. EntityManager
2. EntityManagerFactory
3. Application context (when in a Java EE container)

For example, to set the configuration on a persistence unit in `persistence.xml`:

```
<persistence-unit name="multitenant">
  ...
```

```
<properties>
  <property name="tenant.id" value="707"/>
  ...
</properties>
</persistence-unit>
```

Alternatively, to set the properties programmatically:

```
HashMap properties = new HashMap();
properties.put("tenant.id", "707");
...
EntityManager em = Persistence.createEntityManagerFactory("multi-tenant",
    properties).createEntityManager();
```

Note: Swapping tenant IDs during a live `EntityManager` is not allowed.

13.2.1.4.1 Configure a Shared Entity Manager By default, tenants share the entity manager factory. A single application instance with a shared `EntityManagerFactory` for a persistence unit can be responsible for handling requests from multiple tenants.

The following example shows a shared entity manager factory configuration:

```
EntityManager em = createEntityManager(MULTI_TENANT_PU);
em.getTransaction().begin();
em.setProperty(EntityManagerProperties.MULTITENANT_PROPERTY_DEFAULT, "my_id");
```

When using a shared entity manager factory, the L2 cache is by default not shared, and therefore multi-tenant entities have an `ISOLATED` cache setting.

To share the cache, set the `eclipselink.multitenant.tenants-share-cache` property to `true`. This results in multi-tenant entities having a `PROTECTED` cache setting.

Caution: Queries that use the cache may return data from other tenants when using the `PROTECTED` setting.

13.2.1.4.2 Configure a Non-Shared Entity Manager To create an entity manager factory that is not shared, set the `eclipselink.multitenant.tenants-share-emf` property to `false`.

When the entity manager factory is not shared, you must use the `eclipselink.session-name` property to provide a unique session name, as shown in the following example. This ensures that a unique server session and cache are provided for each tenant. This provides full caching capabilities. For example,

```
HashMap properties = new HashMap();
properties.put("tenant.id", "707");
properties.put("eclipselink.session-name", "multi-tenant-707");
...
EntityManager em = Persistence.createEntityManagerFactory("multitenant",
    properties).createEntityManager();
```

Another example:

```
HashMap properties = new HashMap();
properties.put(PersistenceUnitProperties.MULTITENANT_SHARED_EMF, "false");
properties.put(PersistenceUnitProperties.SESSION_NAME,
```

```
"non-shared-emf-for-this-emp");
properties.put(PersistenceUnitProperties.MULTITENANT_PROPERTY_DEFAULT, "this-emp");
...
EntityManager em = Persistence.createEntityManagerFactory("multi-tenant-pu",
properties).createEntityManager();
```

An example in the persistence unit definition:

```
<persistence-unit name="multi-tenant-pu">
...
<properties>
  <property name="eclipselink.multitenant.tenants-share-emf" value="false"/>
  <property name="eclipselink.session-name"
    value="non-shared-emf-for-this-emp"/>
  <property name="eclipselink.tenant-id" value="this-emp"/>
...
</properties>
</persistence-unit>
```

13.2.1.4.3 Configure an Entity Manager When configuring properties at the level of the entity manager, you must specify the caching strategies, because the same server session can be used for each tenant. For example, you can set up an isolation level (L1 cache) to ensure no shared tenant information exists in the L2 cache. These settings are set when creating the entity manager factory.

```
HashMap tenantProperties = new HashMap();
properties.put("tenant.id", "707");

HashMap cacheProperties = new HashMap();
properties.put("eclipselink.cache.shared.Employee", "false");
properties.put("eclipselink.cache.size.Address", "10");
properties.put("eclipselink.cache.type.Contract", "NONE");
...
EntityManager em = Persistence.createEntityManagerFactory("multitenant",
    cacheProperties).createEntityManager(tenantProperties);
...
```

13.2.1.5 Task 4: Perform Operations and Queries

The tenant discriminator column is used at runtime through entity manager operations and querying. The tenant discriminator column and value are supported through the following entity manager operations:

- `persist()`
- `find()`
- `refresh()`

The tenant discriminator column and value are supported through the following queries:

- Named queries
- Update all
- Delete all

Note: Multi-tenancy is not supported through named native queries. To use named native queries in a multi-tenant environment, manually handle any multi-tenancy issues directly in the query. In general, it is best to avoid named native queries in a multi-tenant environment.

13.2.1.6 Task 5: Use Single-Table Multi-Tenancy in an Inheritance Hierarchy

Inheritance strategies are configured by specifying the inheritance type (`@javax.persistence.Inheritance`). Single-table multi-tenancy can be used in an inheritance hierarchy, as follows:

- Multi-tenant metadata can be applied only at the root level of the inheritance hierarchy when using a `SINGLE_TABLE` or `JOINED` inheritance strategy.
- You can also specify multi-tenant metadata within a `TABLE_PER_CLASS` inheritance hierarchy. In this case, every entity has its own table, with all its mapping data (which is not the case with `SINGLE_TABLE` or `JOINED` strategies). Consequently, in the `TABLE_PER_CLASS` strategy, some entities of the hierarchy may be multi-tenant, while others may not be. The other inheritance strategies can only specify multi-tenancy at the root level, because you cannot isolate an entity to a single table to build only its type.

13.3 Using Table-Per-Tenant Multi-Tenancy

Table-per-tenant multi-tenancy allows multiple tenants of an application to isolate their data in one or more tenant-specific tables. Multiple tenants' tables can be in a shared schema, identified using a prefix or suffix naming pattern; or they can be in separate, tenant-specific schemas. Table-per-tenant entities can be mixed with other multi-tenant type entities within the same persistence unit.

The table-per-tenant multi-tenant type is used in conjunction with:

- A tenant table discriminator that specifies the type of discriminator (schema or name with prefix or suffix)
- A tenant ID to identify the user (configured per entity manager or at the entity manager factory, if isolating the table-per-tenant per the persistence unit.)

A single application instance with a shared `EntityManagerFactory` for a persistence unit can be responsible for handling requests from multiple tenants.

Alternatively, separate `EntityManagerFactory` instances can be used for each tenant. (This is required when using extensions per tenant.) In this case, tenant-specific schema and table names are defined in an `eclipselink-orm.xml` configuration file. A `MetadataSource` must be registered with a persistence unit. The `MetadataSource` is used to support additional persistence unit metadata provided from outside the application.

For information about `MetadataSource`, see [Section 12.5, "Using an External Metadata Source."](#) See also `metadata-source` in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

The table-per-tenant multi-tenant type enables individual tenant table(s) to be used at the entity level. A tenant context property must be provided on each entity manager after a transaction has started.

- The table(s) (`Table` and `SecondaryTable`) for the entity are individual tenant tables based on the tenant context. Relationships within an entity that uses a join or a collection table are also assumed to exist within the table-per-tenant context.

- Multi-tenant metadata can only be applied at the root level of the inheritance hierarchy when using a `SINGLE_TABLE` or `JOINED` inheritance strategy. Multi-tenant metadata can be specified in a `TABLE_PER_CLASS` inheritance hierarchy

13.3.1 Main Tasks for Using Table-Per-Tenant Multi-Tenancy

The following tasks provide instructions for using table-per-tenant multi-tenancy:

- [Task 1: Prerequisites](#)
- [Task 2: Enable Table-Per-Tenant Multi-Tenancy](#)
- [Task 3: Specify Tenant Table Discriminator](#)
- [Task 4: Specify a Context Property at Runtime](#)

13.3.1.1 Task 1: Prerequisites

To implement and use table-per-tenant multi-tenancy, you need:

- EclipseLink 2.4 or later.
Download EclipseLink from <http://www.eclipse.org/eclipselink/downloads/>.
- Any compliant Java Database Connectivity (JDBC) database, including Oracle Database, Oracle Database Express Edition (Oracle Database XE), or MySQL. These instructions are based on Oracle Database XE 11g Release 2.
For the certification matrix, see

13.3.1.2 Task 2: Enable Table-Per-Tenant Multi-Tenancy

Table-per-tenant multi-tenancy can be enabled declaratively using the `@Multitenant` annotation; or in an Object Relational Mapping (ORM) XML file using the `<multitenant>` element, or using annotations and XML together.

13.3.1.2.1 Using the `@Multitenant` and `@TenantTableDiscriminator` Annotations To use the `@Multitenant` annotation, include the annotation with an `@Entity` or `@MappedSuperclass` annotation and include the `TABLE_PER_TENANT` attribute.

For example:

```
@Entity
@Multitenant(TABLE_PER_TENANT
...)
public class Employee {
}
```

The `TABLE_PER_TENANT` attribute states that clients have a dedicated table or tables (Table and SecondaryTable) associated with the entity.

13.3.1.2.2 Using the `<multitenant>` Element To use the `<multitenant>` element, include the element within an `<entity>` element. For example:

```
<entity class="model.Employee">
  <multitenant type="TABLE_PER_TENANT">
    ...
  </multitenant>
  ...
</entity>
```

13.3.1.3 Task 3: Specify Tenant Table Discriminator

The tenant table discriminator describes the type of table discriminator to use in a table-per-tenant multi-tenancy strategy. The tenant table discriminator is identified by a property. You can define your own identifier or use the default property:

```
org.eclipse.persistence.config.PersistenceUnitProperties.MULTITENANT_
PROPERTY_DEFAULT = "eclipselink.tenant-id"
```

The tenant table discriminator can be specified at the entity or mapped superclass level, and it must always be accompanied with a `Multitenant (TABLE_PER_TENANT)` specification. It is not sufficient to specify only a tenant table discriminator.

The tenant table discriminator is used together with an associated application context to indicate which table or tables an application tenant can access.

13.3.1.3.1 Using the `@TenantTableDiscriminator` Annotation Use the `@TenantTableDiscriminator` annotation to specify which tables are associated with which tenants. The tenant table discriminator must include a type and a context property:

- Use the type attribute to identify what type of discriminator to use:
 - Use `PREFIX` to apply the tenant table discriminator as a prefix to all multi-tenant tables.
 - Use `SUFFIX` to apply the tenant table discriminator as a suffix to all multi-tenant tables.
 - Use `SCHEMA` to apply the tenant table discriminator as a schema to all multi-tenant tables. This strategy requires appropriate database provisioning.
- Use the contextProperty attributes to identify the user. The value of the context property is a tenant ID that identifies the user. This can be configured for an entity manager or, if you want to isolate the table-per-tenant per persistence unit, an entity manager factory.

For example:

```
@Entity
@Table(name="EMP")
@Multitenant(TABLE_PER_TENANT)
@TenantTableDiscriminator(type=SCHEMA, contextProperty="eclipselink-tenant.id")
public class Employee {
    ...
}
```

13.3.1.3.2 Using the `<tenant-table-discriminator>` Element To use the `<tenant-table-discriminator>` element, include the element within a `<multitenant>` element and include the name and context-property attributes. For example:

```
<entity class="Employee">
  <multitenant type="TABLE_PER_TENANT">
    <tenant-table-discriminator type="SCHEMA"
      context-property="eclipselink-tenant.id"/>
  </multitenant>
  <table name="EMP">
    ...
  </table>
</entity>
```

13.3.1.3.3 Define Persistence Unit and Entity Mappings Defaults In addition to configuring tenant table discriminators at the entity and mapped superclass levels, you can also

configure them at the persistence-unit-defaults and entity-mappings levels to provide defaults. Defining the metadata at these levels follows similar JPA metadata defaulting and overriding rules. Configure these settings as described in [Section 13.2.1.3.4, "Define Persistence Unit and Entity Mappings Defaults,"](#) but substitute table-tenant-discriminator for tenant-discriminator-column.

13.3.1.4 Task 4: Specify a Context Property at Runtime

At runtime, specify the context property using a persistence unit definition passed to an entity manager factory or set on an individual entity manager. For example:

```
<persistence-unit name="multitenant">
    ...
    <properties>
        <property name="tenant.id" value="707"/>
    ...
    </properties>
</persistence-unit>
```

To specify a context property at runtime programmatically:

```
HashMap properties = new HashMap();
properties.put(PersistenceUnitProperties.MULTITENANT_PROPERTY_DEFAULT, "707");
EntityManager em = Persistence.createEntityManagerFactory("multitenant-pu",
    properties).createEntityManager();
```

An entity manager property definition follows:

```
EntityManager em =
    Persistence.createEntityManagerFactory("multitenant-pu").createEntityManager();
em.beginTransaction();
em.setProperty("other.tenant.id.property", "707");
em.setProperty(EntityManagerProperties.MULTITENANT_PROPERTY_DEFAULT, "707");
...
```

13.3.1.5 Task 5: Perform Operations and Queries

The tenant discriminator column is used at runtime through entity manager operations and querying. The tenant discriminator column and value are supported through the following entity manager operations:

- `persist()`
- `find()`
- `refresh()`

The tenant discriminator column and value are supported through the following queries:

- Named queries
- Update all
- Delete all

Note: Multi-tenancy is not supported through named native queries. To use named native queries in a multi-tenant environment, manually handle any multi-tenancy issues directly in the query. In general, it is best to avoid named native queries in a multi-tenant environment.

13.4 Using VPD Multi-Tenancy

A Virtual Private Database (VPD) uses security controls to restrict access to database objects based on various parameters.

For example, the Oracle Virtual Private Database supports security policies that control database access at the row and column level. Oracle VPD adds a dynamic `WHERE` clause to SQL statements issued against the table, view, or synonym to which the security policy was applied.

Oracle Virtual Private Database enforces security directly on the database tables, views, or synonyms. Because security policies are attached directly to these database objects, and the policies are automatically applied whenever a user accesses data, there is no way to bypass security.

When a user directly or indirectly accesses a table, view, or synonym that is protected with an Oracle Virtual Private Database policy, Oracle Database dynamically modifies the SQL statement of the user. This modification creates a `WHERE` condition (called a predicate) returned by a function implementing the security policy. Oracle Virtual Private Database modifies the statement dynamically, transparently to the user, using any condition that can be expressed in or returned by a function. Oracle Virtual Private Database policies can be applied to `SELECT`, `INSERT`, `UPDATE`, `INDEX`, and `DELETE` statements.

When using EclipseLink VPD multitancy, the database handles the tenant filtering on all `SELECT`, `UPDATE` and `DELETE` queries.

To use EclipseLink VPD multi-tenancy, you must first configure VPD in the database and then specify multi-tenancy on the entity or mapped superclass, as shown in the following example, using `@Multitenant` and `@TenantDiscriminatorColumn`:

13.4.1 Main Tasks for Using VPD Multi-Tenancy

The following tasks provide instructions for using VPD multi-tenancy with Oracle Virtual Private Database:

- [Task 1: Prerequisites](#)
- [Task 2: Configure the Virtual Private Database](#)
- [Task 3: Identify the Client in the Context](#)
- [Task 4: Configure the Entity or Mapped Superclass](#)
- [Task 5: Disable Criteria Generation](#)
- [Task 6: Configure persistence.xml](#)

13.4.1.1 Task 1: Prerequisites

To implement and use VPD multi-tenancy, you need:

- EclipseLink 2.4 or later.
Download EclipseLink from <http://www.eclipse.org/eclipselink/downloads/>.
- Any compliant Java Database Connectivity (JDBC) database that supports VPD, for example, Oracle Virtual Private Database.

For the certification matrix, see

13.4.1.2 Task 2: Configure the Virtual Private Database

In this example, an Oracle Virtual Private Database is configured with a policy and a stored procedure. The policy is a call to the database that tells the database to use a stored function to limit the results of a query. In this example, the function is called `ident_func`, and it is run whenever a `SELECT`, `UPDATE` or `DELETE` is performed on the `SCOTT.TASK` table. The policy is created as follows:

```
CALL DBMS_RLS.ADD_POLICY ('SCOTT', 'TASK', 'todo_list_policy', 'SCOTT', 'ident_
func', 'select, update, delete');
```

The function defined below is used by VPD to limit the data based on the identifier that is passed in to the connection. The function uses the `USER_ID` column in the table to limit the rows. The rows are limited, based on what is set in the `client_identifier` variable in the `userenv` context.

```
CREATE OR REPLACE FUNCTION ident_func (p_schema IN VARCHAR2 DEFAULT NULL, p_object
IN VARCHAR2 DEFAULT NULL)
RETURN VARCHAR2
AS
BEGIN
    RETURN 'USER_ID = sys_context(''userenv'', ''client_identifier'');
```

13.4.1.3 Task 3: Identify the Client in the Context

In the application, use a `postAcquireExclusiveConnection` event to identify the client to the database. The following code sets the `client_identifier` variable in the `userenv` context to the value in the `tenant.id` property:

```
public void postAcquireExclusiveConnection(SessionEvent event) {
    SQLCall call = new SQLCall("CALL DBMS_SESSION.SET_IDENTIFIER('" +
event.getSession().getProperty("tenant.id") + "')");
    event.getSession().executeNonSelectingCall(call);
}
```

Use `preReleaseExclusiveConnection` to clear the `IDENTIFIER`:

```
public void preReleaseExclusiveConnection(SessionEvent event) {
    SQLCall call = new SQLCall("CALL DBMS_SESSION.CLEAR_IDENTIFIER()");
    event.getSession().executeNonSelectingCall(call);
}
```

13.4.1.4 Task 4: Configure the Entity or Mapped Superclass

As described above, VPD is configured to use the `USER_ID` column to limit access to rows. Therefore, you must tell EclipseLink to auto-populate the `USER_ID` column on inserts. The following code uses EclipseLink multi-tenancy and specifies that the client identifier is passed in to the entity managers using a property called `tenant.id`. Because the filtering is done by VPD on the database, you must turn off caching on this entity to avoid leakage across users.

```
@Entity
@Multitenant
@TenantDiscriminatorColumn(name = "USER_ID", contextProperty = "tenant.id")
@Cacheable(false)

public class Task implements Serializable {
    ...
    ...
}
```

13.4.1.5 Task 5: Disable Criteria Generation

When single-table and table-per-tenant multi-tenancy are enabled, a client identifier is auto appended to any generated SQL. However, when VPD is used to limit the access to data, the auto-appending of the identifier should be turned off.

Beginning with EclipseLink 12c Release 1 (12.1.2), disable criteria generation as follows:

```
@Multitenant(includeCriteria=false)
@TenantDiscriminatorColumn(name = "USER_ID", contextProperty = "tenant.id")
```

13.4.1.6 Task 6: Configure persistence.xml

Add the following properties to persistence.xml.

Include the following to set and clear the VPD identifier:

```
<property name="eclipselink.session-event-listener" value="example.VPDSessionEventAdapter" />
```

Include the following to provide one connection per entity manager:

```
<property name="eclipselink.jdbc.exclusive-connection.mode" value="Always" />
```

Include the following to allow native queries to be runnable from EclipseLink. This is required for creating VPD artifacts:

```
<property name="eclipselink.jdbc.allow-native-sql-queries" value="true" />
</properties>
```

For example:

```
<properties>
  <property name="eclipselink.session-event-listener" value="example.VPDSessionEventAdapter" />
  <property name="eclipselink.jdbc.exclusive-connection.mode" value="Always" />
  <property name="eclipselink.jdbc.allow-native-sql-queries" value="true" />
  ...
</properties>
```

13.5 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- Code Samples
 - <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Multitenant>
 - <http://wiki.eclipse.org/EclipseLink/Examples/MySports>
- See the following in *Java Persistence API (JPA) Extensions Reference for EclipseLink.*
 - "@Multitenant"
 - "@TenantDiscriminatorColumn"
 - "@TenantDiscriminatorColumns"
 - "@TenantTableDiscriminator"

Mapping JPA to XML

This chapter describes how to use JPA with the Java Architecture for XML Binding (JAXB)—the Java EE standard for mapping POJOs (Plain Old Java Objects) to XML—and its Mapping Objects to XML (MOXy) extensions to map JPA entities to XML. Mapping JPA entities to XML is useful when you want to create a data access service with Java API for RESTful Web Services (JAX-RS), Java API for XML Web Services (JAX-WS), or Spring.

This chapter contains the following topics:

- [Section 14.1, "Introduction to the Solution"](#)
- [Section 14.2, "Binding JPA Entities to XML"](#)
- [Section 14.3, "Mapping Simple Java Values to XML Text Nodes"](#)
- [Section 14.4, "Using XML Metadata Representation to Override JAXB Annotations"](#)
- [Section 14.5, "Using XPath Predicates for Mapping"](#)
- [Section 14.6, "Using Dynamic JAXB/MOXy"](#)

Use Case

Users need to map JPA entities to XML.

Solution

EclipseLink provides support for the JAXB standard through EclipseLink MOXy extensions.

Components

- EclipseLink 12c Release 1 (12.1.2).
- XML document

Sample

See the following EclipseLink and JAXB examples for related information:

- <http://wiki.eclipse.org/EclipseLink/Examples/MOXy>
- <http://java.sun.com/developer/technicalArticles/WebServices/jaxb/index.html>

14.1 Introduction to the Solution

This chapter demonstrates some typical techniques for mapping JPA entities to XML. Working with the examples that follow requires some understanding of such high-level JPA-to-XML mapping concepts, such as JAXB, MOXy, XML binding, and how to override JAXB annotations. The following sections will give you a basic understanding of these concepts:

- [Section 14.1.1, "Understanding XML Binding"](#)
- [Section 14.1.2, "Understanding JAXB"](#)
- [Section 14.1.3, "Understanding MOXy"](#)
- [Section 14.1.4, "Understanding an XML Data Representation"](#)

14.1.1 Understanding XML Binding

XML binding is how you represent information in an XML document as an object in computer memory. This allows applications to access the data in the XML from the object rather than using the Domain Object Model (DOM), the Simple API for XML (SAX) or the Streaming API for XML (StAX) to retrieve the data from a direct representation of the XML itself. When binding, JAXB applies a tree structure to the graph of JPA entities. Multiple tree representations of a graph are possible and will depend on the root object chosen and the direction the relationships are traversed.

You can find examples of XML binding with JAXB in [Section 14.2, "Binding JPA Entities to XML"](#).

14.1.2 Understanding JAXB

JAXB is a Java API that allows a Java program to access an XML document by presenting that document to the program in a Java format. This process, called binding, represents information in an XML document as an object in computer memory. In this way, applications can access the data in the XML from the object rather than using the Domain Object Model (DOM) or the Streaming API for XML (SAX) to retrieve the data from a direct representation of the XML itself. Usually, an XML binding is used with JPA entities to create a data access service by leveraging a JAX-WS or JAX-RS implementation. Both of these Web Service standards use JAXB as the default binding layer. This service provides a means to access data exposed by JPA across computers, where the client computer might or might not be using Java.

JAXB uses an extended set of annotations to define the binding rules for Java-to-XML mapping. These annotations are subclasses of the `javax.xml.bind.*` packages in the EclipseLink API. For more information about these annotations, see *Java API Reference for EclipseLink*.

For more information about JAXB, see "Java Architecture for XML Binding (JAXB)" at: <http://www.eclipse.org/eclipselink/moxy.php>

14.1.3 Understanding MOXy

MOXy is EclipseLink's JAXB implementation. It allows you to map a POJO model to an XML schema, greatly enhancing your ability to create JPA-to-XML mappings. MOXy supports all the standard JAXB annotations in the `javax.xml.bind.annotation` package plus has its own extensions in the `org.eclipse.persistence.oxm.annotations` package. You can use these latter annotations in conjunction with the standard annotations to extend the utility of JAXB. Because MOXy represents the optimal JAXB implementation, you still

implement it whether or not you explicitly use any of its extensions. MOXy offers these benefits:

- It allows you to map your own classes to your own XML schema, a process called "Meet in the Middle Mapping". This avoids static coupling of your mapped classes with a single XML schema,
- It offers specific features, such as Xpath-based mapping, JSON binding, and compound key mapping and mapping relationships with back-pointers to address critical JPA-to-XML mapping issues.
- It allows you to map your existing JPA models to industry standard schema.
- It allows you to combine MOXy mappings and EclipseLink's persistence framework to interact with your data through JCA.
- It offers superior performance in several scenarios.

For more information about MOXy, see the MOXy FAQ at:

<http://wiki.eclipse.org/EclipseLink/FAQ/WhatIsMOXy>

14.1.4 Understanding an XML Data Representation

Annotations are not always the most effective way to map JPA to XML. For example, you would not use JAXB if:

- You want to specify metadata for a third-party class but do not have access to the source.
- You want to map an object model to multiple XML schemas, because JAXB rules preclude applying more than one mapping by using annotations.
- Your object model already contains too many annotations—for example, from such services as JPA, Spring, JSR-303, and so on—and you want to specify the metadata elsewhere.

Under these and similar circumstances, you can use an XML data representation by exposing the `eclipselink_oxm.xml` file.

XML metadata works in two modes:

- It adds to the metadata supplied by annotations. This is useful when:
 - Annotations define version one of the XML representation, and you use XML metadata to tweak the metadata for future versions.
 - You use the standard JAXB annotations, and use the XML metadata for the MOXy extensions. In this way you don't introduce new compile time dependencies in the object model.
- It completely replaces the annotation metadata, which is useful when you want to map to different XML representations.

To see how to use XML data representation, see [Section 14.4, "Using XML Metadata Representation to Override JAXB Annotations"](#)

14.2 Binding JPA Entities to XML

The following examples demonstrate how to bind JPA entities to XML by using JAXB annotations. For more information about binding, see [Section 14.1.1, "Understanding XML Binding"](#) for more information about JAXB, see [Section 14.1.2, "Understanding JAXB"](#)

- [Section 14.2.1, "Binding JPA Relationships to XML"](#)
- [Section 14.2.2, "Binding Compound Primary Keys to XML"](#)
- [Section 14.2.3, "Binding Embedded ID Classes to XML"](#)

14.2.1 Binding JPA Relationships to XML

The following exercise demonstrate show to use JAXB to derive an XML representation from a set of JPA entities, a process called "binding" (read about XML binding in [Section 14.2, "Binding JPA Entities to XML"](#)). These examples will show how to bind two common JPA relationships:

- Privately-owned relationships
- Shared reference relationships

to map an `Employee` entity to that employee's phone number, address, and department.

14.2.1.1 Task 1: Define the Accessor Type and Import Classes

Since all of the following examples use the same accessor type, `FIELD`, define it at the package level by using the JAXB annotation `@XmlAccessorType`. At this point, you would also import the necessary classes:

```
@XmlAccessorType(XmlAccessType.FIELD)
package com.example.model;

import javax.xml.bind.annotation.XmlAccessType;
import javax.xml.bind.annotation.XmlAccessorType;
```

14.2.1.2 Task 2: Map Privately-Owned Relationships

A "privately-owned" relationship occurs when the target object is only referenced by a single source object. This type of relationship can be either one-to-one and embedded or one-to-many.

This Task shows how to create bi-directional mappings for both of these types of relationships between the `Employee` entity and the `Address` and `PhoneNumber` entities.

14.2.1.2.1 Mapping a One-to-One and Embedded Relationship

The JPA `@OneToOne` and `@Embedded` annotations indicate that only one instance of the source entity is able to refer to the same target entity instance. This example shows how to map the `Employee` entity to the `Address` entity and back. This is considered a one-to-one mapping because the employee can be associated with only one address. Since this relationship is bi-directional—that is, `Employee` points to `Address`, which must point back to `Employee`—it uses the EclipseLink extension `@XmlInverseReference` to represent the back-pointer.

To create the one-to-one and embedded mapping:

1. Ensure that the accessor type `FIELD` has been defined at the package level, as described in [Section 14.2.1.1, "Task 1: Define the Accessor Type and Import Classes"](#).
2. Map one direction of the relationship, in this case, the `employee` property on `Address`, by inserting the `@OneToOne` annotation in the `Employee` entity:

```
@OneToOne(mappedBy="resident")
private Address residence;
```

The `mappedBy` argument indicates that the relationship is owned by the `resident` field.

3. Map the return direction—that is, the address property on `Employee`—by inserting the `@OneToOne` and `@XmlInverseMapping` annotations into the `Address` entity:

```
@OneToOne
@JoinColumn(name="E_ID")
@XmlInverseReference(mappedBy="residence")
private Employee resident;
```

The `mappedBy` field indicates that this relationship is owned by the `residence` field. `@JoinColumn` identifies the column that will contain the foreign key.

The entities should look like those shown in [Example 14–1](#) and [Example 14–2](#).

14.2.1.2.2 Mapping a One-to-Many Relationship The JPA `@OneToMany` annotation indicates that a single instance of the source entity can refer to multiple instances of the same target entity. For example, one employee can have multiple phone numbers, such as a land line, a mobile number, a desired contact number, and an alternative workplace number. Each different number would be an instance of the `PhoneNumber` entity and a single `Employee` entity could point to each instance.

This Task maps the employee to one of that employee's phone numbers and back. Since the relationship between `Employee` and `PhoneNumber` is bi-directional, the example again uses the EclipseLink extension `@XmlInverseReference` to map the back-pointer.

To create a one-to-many mapping:

1. Ensure that the accessor type `FIELD` has been defined at the package level, as described in [Section 14.2.1.1, "Task 1: Define the Accessor Type and Import Classes"](#).
2. Map one direction of the relationship, in this case, the employee property on `PhoneNumber`, by inserting the `@OneToMany` annotation in the `Employee` entity:

```
@OneToMany(mappedBy="contact")
private List<PhoneNumber> contactNumber;
```

The `mappedBy` field indicates that this relationship is owned by the `contact` field.

3. Map the return direction—that is, the phone number property on `Employee`—by inserting the `@ManyToOne` and `@XmlInverseMapping` annotations into the `PhoneNumber` entity:

```
@ManyToOne
@JoinColumn(name="E_ID", referencedColumnName = "E_ID")
@XmlInverseReference(mappedBy="contactNumber")
private Employee contact;
```

The `mappedBy` field indicates that this relationship is owned by the `contactNumber` field. The `@JoinColumn` annotation identifies the column that will contain the foreign key (`name="E_ID"`) and the column referenced by the foreign key (`referencedColumnName = "E_ID"`).

The entities should look like those shown in [Example 14–1](#) and [Example 14–3](#).

14.2.1.3 Task 3: Map the Shared Reference Relationship

A shared reference relationship occurs when target objects are referenced by multiple source objects. For example, a business might be segregated into multiple

departments, such as IT, human resources, finance, and so on. Each of these departments has multiple employees of differing job descriptions, pay grades, locations, and so on. Managing departments and employees requires shared reference relationships.

Since a shared reference relationship cannot be safely represented as nesting in XML, we use key relationships. In order to leverage the ID fields on JPA entities, you need to use the EclipseLink JAXB `@XmlID` annotation on non-String fields and properties and `@XmlIDREF` on string fields and properties.

This section contains examples that show how to map a many-to-one shared reference relationship and a many-to-many shared reference relationship.

14.2.1.3.1 Mapping a Many-to-One Shared Reference Relationship In a many-to-one mapping, one or more instances of the source entity are able to refer to the same target entity instance. This example demonstrates how to map an employee to one of that employee's multiple phone numbers.

To map a many-to-one shared reference relationship:

1. Ensure that the accessor type `FIELD` has been defined at the package level, as described in [Section 14.2.1.1, "Task 1: Define the Accessor Type and Import Classes"](#).
2. Map one direction of the relationship, in this case the phone number property on `Employee`, by inserting the `@ManyToOne` annotation in the `PhoneNumber` entity:

```
@ManyToOne
@JoinColumn(name="E_ID", referencedColumnName = "E_ID")
@XmlIDREF
private Employee contact;
```

The `@JoinColumn` annotation identifies the column that will contain the foreign key (`name="E_ID"`) and the column referenced by the foreign key (`referencedColumnName = "E_ID"`). The `@XmlIDREF` annotation indicates that this will be the primary key for the corresponding table.

3. Map the return direction—that is, the employee property on `PhoneNumber`—by inserting the `@OneToMany` and `@XmlInverseReference` annotations into the `Address` entity:

```
@OneToMany(mappedBy="contact")
@XmlInverseReference(mappedBy="contact")
private List<PhoneNumber> contactNumber;
```

The `mappedBy` field for both annotations indicates that this relationship is owned by the `contact` field.

The entities should look like those shown in [Example 14–1](#) and [Example 14–3](#).

14.2.1.3.2 Mapping a Many-to-Many Shared Reference Relationship The `@ManyToMany` annotation indicates that one or more instances of the source entity are able to refer to one or more target entity instances. Since the relationship between `Department` and `Employee` is bi-directional, this example again uses the EclipseLink's `@XmlInverseReference` annotation to represent the back-pointer.

To map a many-to-many shared reference relationship, do the following:

1. Ensure that the accessor type `FIELD` has been defined at the package level, as described in [Section 14.2.1.1, "Task 1: Define the Accessor Type and Import Classes"](#).

2. Create a Department entity by inserting the following code:

```
@Entity
public class Department {
```

3. Under this entity define the many-to-many relationship and the entity's join table by inserting the following code:

```
@ManyToMany
@JoinTable(name="DEPT_EMP", joinColumns =
    @JoinColumn(name="D_ID", referencedColumnName = "D_ID"),
    inverseJoinColumns = @JoinColumn(name="E_ID",
        referencedColumnName = "E_ID"))
```

This code creates a join table called DEPT_EMP and identifies the column that will contain the foreign key (name="E_ID") and the column referenced by the foreign key (referencedColumnName = "E_ID"). Additionally, it identifies the primary table on the inverse side of the association.

4. Complete the initial mapping—in this case, the Department property employee—and make it a foreign key for this entity by inserting the following code:

```
@XmlIDREF
private List<Employee> member;
```

5. In the Employee entity created in [Section 14.2.1.2.1, "Mapping a One-to-One and Embedded Relationship"](#), specifying that eId is the primary key for JPA (@Id annotation), and for JAXB (@XmlID annotation) by inserting the following code:

```
@Id
@Column(name="E_ID")
@XmlID
private BigDecimal eId;
```

6. Still within the Employee entity, complete the return mapping by inserting the following code:

```
@ManyToMany(mappedBy="member")
@XmlInverseReference(mappedBy="member")
private List<Department> team;
```

The entities should look like those shown in [Example 14–1](#) and [Example 14–4](#).

14.2.1.4 JPA Entities

Once the mappings are created, the entities should look like those in the following examples:

- [Example 14–1, "Employee Entity"](#)
- [Example 14–2, "Address Entity"](#)
- [Example 14–3, "PhoneNumber Entity"](#)
- [Example 14–4, "Department Entity"](#)

Note: In order to save space, package names, import statements, and the get/set methods have been omitted from the code examples. All examples use standard JPA annotations.

Example 14–1 Employee Entity

```
@Entity
public class Employee {

    @Id
    @Column(name="E_ID")
    private BigDecimal eId;

    private String name;

    @OneToOne(mappedBy="resident")
    private Address residence;

    @OneToMany(mappedBy="contact")
    private List<PhoneNumber> contactNumber;

    @ManyToMany(mappedBy="member")
    private List<Department> team;

}
```

Example 14–2 Address Entity

```
@Entity
public class Address {

    @Id
    @Column(name="E_ID", insertable=false, updatable=false)
    private BigDecimal eId;

    private String city;

    private String street;

    @OneToOne
    @JoinColumn(name="E_ID")
    private Employee resident;

}
```

Example 14–3 PhoneNumber Entity

```
@Entity
@Table(name="PHONE_NUMBER")
public class PhoneNumber {

    @Id
    @Column(name="P_ID")
    private BigDecimal pId;

    @ManyToOne
    @JoinColumn(name="E_ID", referencedColumnName = "E_ID")
    private Employee contact;

    private String num;

}
```

Example 14–4 Department Entity

```

@Entity
public class Department {

    @Id
    @Column(name="D_ID")
    private BigDecimal dId;

    private String name;

    @ManyToMany
    @JoinTable(name="DEPT_EMP", joinColumns =
        @JoinColumn(name="D_ID", referencedColumnName = "D_ID"),
        inverseJoinColumns = @JoinColumn(name="E_ID",
            referencedColumnName = "E_ID"))
    private List<Employee> member;

}

```

14.2.2 Binding Compound Primary Keys to XML

When a JPA entity has compound primary keys, you can bind it by using JAXB annotations and certain EclipseLink extensions, as shown in the following example.

14.2.2.1 Task1: Define the XML Accessor Type

Define the accessor type as `FIELD`, as described in [Section 14.2.1.1, "Task 1: Define the Accessor Type and Import Classes"](#)

14.2.2.2 Task 2: Create the Target Object

To create the target object, do the following:

1. Create an `Employee` entity with a composite primary key class called `EmployeeID` to map to multiple fields or properties of the entity:

```

@Entity
@IdClass({EmployeeId.class})
public class Employee {

```

2. Specify the first primary key, `eId`, of the entity and map it to a column:

```

    @Id
    @Column(name="E_ID")
    @XmlID
    private BigDecimal eId;

```

3. Specify the second primary key, `country`. In this instance, you need to use `@XmlKey` to identify the primary key because only one property—`eId`—can be annotated with the `@XmlID`.

```

    @Id
    @XmlKey
    private String country;

```

The `@XmlKey` annotation marks a property as a key that will be referenced by using a key-based mapping via the `@XmlJoinNode` annotation in the source object. This is similar to the `@XmlKey` annotation except it doesn't require the property be bound to the schema type ID. This is a typical application of the `@XmlKey` annotation.

4. Create a many-to-one mapping of the `Employee` property on `PhoneNumber` by inserting the following code:

```
@OneToMany(mappedBy="contact")
@XmlInverseReference(mappedBy="contact")
private List<PhoneNumber> contactNumber;
```

The `Employee` entity should look like [Example 14-5](#)

Example 14-5 Employee Entity with Compound Primary Keys

```
@Entity
@IdClass(EmployeeId.class)
public class Employee {

    @Id
    @Column(name="E_ID")
    @XmlID
    private BigDecimal eId;

    @Id
    @XmlKey
    private String country;

    @OneToMany(mappedBy="contact")
    @XmlInverseReference(mappedBy="contact")
    private List<PhoneNumber> contactNumber;

}

public class EmployeeId {
    public BigDecimal eId;
    public String country;

    public EmployeeId(BigDecimal eId, String country) {
        this.eId = eId;
        this.country = country;;
    }

    public boolean equals(Object other) {
        if (other instanceof EmployeeId) {
            final EmployeeId otherEmployeeId = (EmployeeId) other;
            return (otherEmployeeId.eId.equals(eId) &&
otherEmployeeId.country.equals(country));
        }

        return false;
    }
}
```

14.2.2.3 Task 3: Create the Source Object

This Task creates the source object, the `PhoneNumber` entity. Because the target object has a compound key, we need to use the EclipseLink's `@XmlJoinNodes` annotation to set up the mapping.

To create the source object:

1. Create the `PhoneNumber` entity:

```
@Entity
```

```
public class PhoneNumber {
```

2. Create a many-to-one relationship and define the join columns:

```
@ManyToOne
@JoinColumns({
    @JoinColumn(name="E_ID", referencedColumnName = "E_ID"),
    @JoinColumn(name="E_COUNTRY", referencedColumnName = "COUNTRY")
})
```

3. Set up the mapping by using the EclipseLink's @XmlJoinNodes annotation

```
@XmlJoinNodes( {
    @XmlJoinNode(xmlPath="contact/id/text()",
        referencedXmlPath="id/text()"),
    @XmlJoinNode(xmlPath="contact/country/text()",
        referencedXmlPath="country/text()")
})
```

4. Define the contact property:

```
private Employee contact;

}
```

The target object should look like [Example 14–6](#).

Example 14–6 *PhoneNumber Entity*

```
@Entity
public class PhoneNumber {

    @ManyToOne
    @JoinColumns({
        @JoinColumn(name="E_ID", referencedColumnName = "E_ID"),
        @JoinColumn(name="E_COUNTRY", referencedColumnName = "COUNTRY")
    })
    @XmlJoinNodes( {
        @XmlJoinNode(xmlPath="contact/id/text()", referencedXmlPath="id/text()"),
        @XmlJoinNode(xmlPath="contact/country/text()", referencedXmlPath="country/text()")
    })
    private Employee contact;

}
```

14.2.3 Binding Embedded ID Classes to XML

An embedded ID defines a separate `Embeddable` Java class to contain the entity's primary key. It is defined through the `@EmbeddedId` annotation. The embedded ID's `Embeddable` class must define each id attribute for the entity using basic mappings. All attributes in the embedded ID's `Embeddable` are assumed to be part of the primary key. This exercise shows how to derive an XML representation from a set of JPA entities using JAXB when a JPA entity has an embedded ID class.

14.2.3.1 Task1: Define the XML Accessor Type

Define the XML accessor type as `FIELD`, as described in [Section 14.2.1.1, "Task 1: Define the Accessor Type and Import Classes"](#)

14.2.3.2 Task 2: Create the Target Object

The target object is an entity called `Employee` and contains the mapping for an employee's contact phone number. Creating this target object requires implementing a `DescriptorCustomizer` interface, so you must include EclipseLink's `@XmlCustomizer` annotation. Also, since the relationship is bidirectional, you must also implement the `@XmlInverseReference` annotation.

To create the target object:

1. Create the `Employee` entity. Use the `@IdClass` annotation to specify that the `EmployeeId` class will be mapped to multiple properties of the entity.

```
@Entity
@IdClass(EmployeeId.class)
public class Employee {
}
```

2. Define the `id` property and make it embeddable.

```
@EmbeddedId
@XmlPath(".");
private EmployeeId id;
```

3. Define a one-to-many mapping—in this case, the `employee` property on `PhoneNumber`. Because the relationship is bi-directional, use `@XmlInverseReference` to define the return mapping. Both of these relationships will be owned by the `contact` field, as indicated by the `mappedBy` argument.

```
@OneToMany(mappedBy="contact")
@XmlInverseReference(mappedBy="contact")
private List<PhoneNumber> contactNumber;
```

The completed target object should look like [Example 14-7](#).

Example 14-7 Employee Entity as Target Object

```
@Entity
@IdClass(EmployeeId.class)
@XmlCustomizer(EmployeeCustomizer.class)
public class Employee {

    @EmbeddedId
    private EmployeeId id;

    @OneToMany(mappedBy="contact")
    @XmlInverseReference(mappedBy="contact")
    private List<PhoneNumber> contactNumber;

}
```

14.2.3.3 Task 3: Create the Source Object

The source object in this example has a compound key, so you must mark the field `@XmlTransient` to prevent a key from being mapped by itself. Use EclipseLink's `@XmlCustomizer` annotation to set up the mapping.

To create the source object, do the following:

1. Create the `PhoneNumber` entity.

```
@Entity
public class PhoneNumber {
```

```
}
```

2. Create a many-to-one mapping and define the join columns.

```
@ManyToOne
@JoinColumns({
    @JoinColumn(name="E_ID", referencedColumnName = "E_ID"),
    @JoinColumn(name="E_COUNTRY", referencedColumnName = "COUNTRY")
})
```

3. Define the XML nodes for the mapping, using the EclipseLink `@XmlJoinNodes` annotation extension. If the target object had a *single* ID, you would use the `@XmlIDREF` annotation.

```
@XmlJoinNodes( {
    @XmlJoinNode(xmlPath="contact/id/text()", referencedColumnName="id/text()"),
    @XmlJoinNode(xmlPath="contact/country/text()",
referencedXmlPath="country/text()")
})
private Employee contact;
```

The completed `PhoneNumber` class should look like [Example 14–8](#).

Example 14–8 *PhoneNumber* Class as Source Object

```
@Entity
public class PhoneNumber {

    @ManyToOne
    @JoinColumns({
        @JoinColumn(name="E_ID", referencedColumnName = "E_ID"),
        @JoinColumn(name="E_COUNTRY", referencedColumnName = "COUNTRY")
    })
    @XmlJoinNodes( {
        @XmlJoinNode(xmlPath="contact/id/text()", referencedColumnName="id/text()"),
        @XmlJoinNode(xmlPath="contact/country/text()",
referencedXmlPath="country/text()")
    })
    private Employee contact;

}
```

14.2.3.4 Task 5: Implement the `DescriptorCustomizer` as `PhoneNumberCustomizer` Class

Code added in Task 4 indicated the need to create the `XMLObjectReferenceMappings` to the new values. This requires to implementing the `DescriptorCustomizer` as the `PhoneNumberCustomizer` and adding the multiple key mappings. To do this:

1. Implement `DescriptorCustomizer` as `PhoneNumberCustomizer`. Be sure to import `org.eclipse.persistence.oxm.mappings.XMLObjectReferenceMapping`:

```
import org.eclipse.persistence.oxm.mappings.XMLObjectReferenceMapping;

public class PhoneNumberCustomizer implements DescriptorCustomizer {
```

2. In the `customize` method, update the following mappings:

- `contactMapping.setAttributeName` to `"contact"`.
- `contactMapping.addSourceToTargetKeyFieldAssociation` to `"contact/@eID", "eId/text()"`.

- `contactMapping.addSourceToTargetKeyFieldAssociation` to `"contact/@country", "country/text()"`.

`PhoneNumberCustomizer` should look like [Example 14–9](#).

Example 14–9 *PhoneNumberCustomizer with Updated Key Mappings*

```
import org.eclipse.persistence.config.DescriptorCustomizer;
import org.eclipse.persistence.descriptors.ClassDescriptor;
import org.eclipse.persistence.oxm.mappings.XMLObjectReferenceMapping;

public class PhoneNumberCustomizer implements DescriptorCustomizer {

    public void customize(ClassDescriptor descriptor) throws Exception {
        XMLObjectReferenceMapping contactMapping = new XMLObjectReferenceMapping();
        contactMapping.setAttributeName("contact");
        contactMapping.setReferenceClass(Employee.class);
        contactMapping.addSourceToTargetKeyFieldAssociation("contact/@eID", "eID/text()");
        contactMapping.addSourceToTargetKeyFieldAssociation("contact/@country", "country/text()");
        descriptor.addMapping(contactMapping);
    }
}
```

14.2.4 Using the EclipseLink XML Binding Document

As demonstrated in the preceding examples, EclipseLink implements the standard JAXB annotations to map JPA entities to an XML representation. You can also express metadata by using the EclipseLink XML Bindings document. Not only can you use XML bindings to separate your mapping information from your actual Java class but you can also use it for more advanced metadata tasks such as:

- Augmenting or overriding existing annotations with additional mapping information.
- Specifying all mapping information externally, without using any Java annotations.
- Defining your mappings across multiple Bindings documents.
- Specifying "virtual" mappings that do not correspond to concrete Java fields

For more information about using the XML Bindings document, see XML Bindings in the JAXB/MOXY documentation at

http://wiki.eclipse.org/EclipseLink/UserGuide/MOXY/Runtime/XML_Bindings.

14.3 Mapping Simple Java Values to XML Text Nodes

This section demonstrates several ways to map simple Java values directly to XML text nodes. It includes the following examples:

- [Mapping a Value to an Attribute](#)
- [Mapping a Value to a Text Node](#)

14.3.1 Mapping a Value to an Attribute

This example maps the `id` property in the Java object `Customer` to its XML representation as an attribute of the `<customer>` element. The XML will be based on the schema in [Example 14–10](#).

Example 14–10 Example XML Schema

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

    <xsd:element name="customer" type="customer-type"/>

    <xsd:complexType name="customer-type">
        <xsd:attribute name="id" type="xsd:integer"/>
    </xsd:complexType>

</xsd:schema>
```

The following procedures demonstrate how to map the `id` property from the Java object and, alternately, how to represent the value in EclipseLink's Object-to-XML Mapping (OXM) metadata format.

14.3.1.1 Mapping from the Java Object

The key to creating this mapping from a Java object is the `@XmlAttribute` JAXB annotation, which maps the field to the XML attribute. To create this mapping:

1. Create the object and import `javax.xml.bind.annotation.*`:

```
package example;

import javax.xml.bind.annotation.*;
```

2. Declare the `Customer` class and use the `@XmlRootElement` annotation to make it the root element. Set the XML accessor type to `FIELD`:

```
@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
```

3. Map the `id` property in the `Customer` class as an attribute:

```
    @XmlAttribute
    private Integer id;
```

The object should look like [Example 14–11](#).

Example 14–11 Customer Object with Mapped id Property

```
package example;

import javax.xml.bind.annotation.*;

@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
    @XmlAttribute
    private Integer id;

    ...
}
```

14.3.1.2 Defining the Mapping in OXM Metadata Format

If you want to represent the mapping in EclipseLink's OXM metadata format, you need to use the XML tags defined in the `eclipselink-oxm.xml` file and populate them with the appropriate values, as shown in [Example 14–12](#).

Example 14–12 Mapping id as an Attribute in OXM Metadata Format

```

...
<java-type name="Customer">
  <xml-root-element name="customer"/>
  <java-attributes>
    <xml-attribute java-attribute="id"/>
  </java-attributes>
</java-type>
...

```

For more information about the OXM metadata format, see [Section 14.4, "Using XML Metadata Representation to Override JAXB Annotations"](#).

14.3.2 Mapping a Value to a Text Node

EclipseLink makes it easy for you to map values from a Java object to various kinds of XML text nodes; for example, to simple text nodes, text nodes in a simple sequence, in a subset, or by position. These mappings are demonstrated in the following examples:

- [Mapping a Value to a Simple Text Node](#)
- [Mapping Values to a Text Node in a Simple Sequence](#)
- [Mapping a Value to a Text Node in a Sub-element](#)
- [Mapping Values to a Text Node by Position](#)

14.3.2.1 Mapping a Value to a Simple Text Node

You can map a value from a Java object either by using JAXB annotations in the Java object or, alternately, by representing the mapping in EclipseLink's OXM metadata format.

14.3.2.1.1 Mapping by Using JAXB Annotations Assuming the associated schema defines an element called `<phone-number>` which accepts a string value, you can use the `@XmlValue` annotation to map a string to the `<phone-number>` node. Do the following:

1. Create the object and import `javax.xml.bind.annotation.*`:


```
package example;

import javax.xml.bind.annotation.*;
```
2. Declare the `PhoneNumber` class and use the `@XmlRootElement` annotation to make it the root element with the name `phone-number`. Set the XML accessor type to `FIELD`:


```
@XmlRootElement(name="phone-number")
@XmlAccessorType(XmlAccessType.FIELD)
public class PhoneNumber {
```
3. Insert the `@XmlValue` annotation on the line before the `number` property in the `Customer` class to map this value as an attribute:

```

    @XmlValue
    private String number;
```

The object should look like [Example 14–13](#).

Example 14–13 PhoneNumber Object with Mapped number Property

```
package example;
```

```
import javax.xml.bind.annotation.*;

@XmlRootElement(name="phone-number")
@XmlAccessorType(XmlAccessType.FIELD)
public class PhoneNumber {
    @XmlValue
    private String number;

    ...
}
```

14.3.2.1.2 Defining the Mapping in OXM Metadata Format If you want to represent the mapping in EclipseLink's OXM metadata format, you need to use the XML tags defined in the `eclipselink-oxm.xml` file and populate them with the appropriate values, as shown in [Example 14-14](#).

Example 14-14 Mapping number as an Attribute in OXM Metadata Format

```
...
<java-type name="PhoneNumber">
  <xml-root-element name="phone-number"/>
  <java-attributes>
    <xml-value java-attribute="number"/>
  </java-attributes>
</java-type>
...
```

14.3.2.2 Mapping Values to a Text Node in a Simple Sequence

You can map a sequence of values, for example a customer's first and last name, as separate elements either by using JAXB annotations or by representing the mapping in EclipseLink's OXM metadata format. The following procedures illustrate how to map values for a customers' first names and last names

14.3.2.2.1 Mapping by Using JAXB Annotations Assuming the associated schema defines the following elements:

- `<customer>` of the type `customer-type`, which itself is defined as a `complexType`.
- Sequential elements called `<first-name>` and `<last-name>`, both of the type `string`.

you can use the `@XmlElement` annotation to map values for a customer's first and last name to the appropriate XML nodes. To do so:

1. Create the object and import `javax.xml.bind.annotation.*`:

```
package example;

import javax.xml.bind.annotation.*;
```

2. Declare the `Customer` class and use the `@XmlRootElement` annotation to make it the root element. Set the XML accessor type to `FIELD`:

```
@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
```

3. Define the `firstname` and `lastname` properties and annotate them with the `@XmlElement` annotation. Use the `name=` argument to customize the XML element

name (if you do not explicitly set the name with `name=`, the XML element will match the Java attribute name; for example, here the `<first-name>` element combination would be specified `<firstName> </firstName>` in XML).

```
@XmlElement(name="first-name")
private String firstName;

@XmlElement(name="last-name")
private String lastName;
```

The object should look like [Example 14–15](#).

Example 14–15 Customer Object Mapping Values to a Simple Sequence

```
package example;

import javax.xml.bind.annotation.*;

@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
    @XmlElement(name="first-name")
    private String firstName;

    @XmlElement(name="last-name")
    private String lastName;

    ...
}
```

14.3.2.2 Defining the Mapping in OXM Metadata Format If you want to represent the mapping in EclipseLink's OXM metadata format, you need to use the XML tags defined in the `eclipselink-oxm.xml` file and populate them with the appropriate values, as shown in [Example 14–16](#).

Example 14–16 Mapping Sequential Attributes in OXM Metadata Format

```
...
<java-type name="Customer">
  <xml-root-element name="customer"/>
  <java-attributes>
    <xml-element java-attribute="firstName" name="first-name"/>
    <xml-element java-attribute="lastName" name="last-name"/>
  </java-attributes>
</java-type>
...
```

14.3.2.3 Mapping a Value to a Text Node in a Sub-element

You can map values from a Java object to text nodes that are nested as a subelement in the XML document by using JAXB annotations or by representing the mapping in EclipseLink's OXM metadata format. For example, if you want to populate `<first-name>` and `<last-name>` elements, which are sub-elements of a `<personal-info>` element under a `<customer>` root, you could use the following procedures to achieve these mappings.

14.3.2.3.1 Mapping by Using JAXB Annotations Assuming the associated schema defines the following elements:

- `<customer>` of the type `customer-type`, which itself is defined as a `complexType`.

- `<personal-info>`
- Sub-elements of `<personal-info>` called `<first-name>` and `<last-name>`, both of the type string

you can use JAXB annotations to map values for a customer's first and last name to the appropriate XML sub-element nodes. Because this example goes beyond a simple element name customization and actually introduces new XML structure, it uses EclipseLink's `@XPath` annotation. To achieve this mapping:

1. Create the object and import `javax.xml.bind.annotation.*` and `org.eclipse.persistence.oxm.annotations.*`.

```
package example;

import javax.xml.bind.annotation.*;
import org.eclipse.persistence.oxm.annotations.*;
```

2. Declare the `Customer` class and use the `@XmlRootElement` annotation to make it the root element. Set the XML accessor type to `FIELD`:

```
@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
```

3. Define the `firstName` and `lastName` properties.
4. Map the `firstName` and `lastName` properties to the sub-elements defined by the XML schema by inserting the `@XPath` annotation on the line immediately preceding the property declaration. For each annotation, define the mapping by specifying the appropriate XPath predicate:

```
    @XPath("personal-info/first-name/text()")
    private String firstName;

    @XPath("personal-info/last-name/text()")
    private String lastName;
```

The object should look like [Example 14–17](#).

Example 14–17 Customer Object Mapping Properties to Sub-elements

```
package example;

import javax.xml.bind.annotation.*;
import org.eclipse.persistence.oxm.annotations.*;

@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
    @XPath("personal-info/first-name/text()")
    private String firstName;

    @XPath("personal-info/last-name/text()")
    private String lastName;

    ...
}
```

14.3.2.3.2 Defining the Mapping in OXM Metadata Format If you want to represent the mapping in EclipseLink's OXM metadata format, you need to use the XML tags

defined in the `eclipselink-oxm.xml` file and populate them with the appropriate values, as shown in [Example 14–18](#).

Example 14–18 Mapping Attributes as Sub-elements in OXM Metadata Format

```
...
<java-type name="Customer">
  <xml-root-element name="customer"/>
  <java-attributes>
    <xml-element java-attribute="firstName" xml-path="personal-info/first-name/text()"/>
    <xml-element java-attribute="lastName" xml-path="personal-info/last-name/text()"/>
  </java-attributes>
</java-type>
...
```

14.3.2.4 Mapping Values to a Text Node by Position

When multiple nodes have the same name, map their values from the Java object by specifying their position in the XML document. Do this by using mapping the values to the *position* of the attribute rather than the attribute's name. You can do this either by using JAXB annotations or by representing the mapping in EclipseLink's OXM metadata format. In the following example, XML contains two `<name>` elements; the first occurrence of name should represent the Customer's first name, the second name their last name.

14.3.2.4.1 Mapping by Using JAXB Annotations Assuming an XML schema that defines the following attributes:

- `<customer>` of the type `customer-type`, which itself is specified as a `complexType`
- `<name>` of the type `String`

this example again uses the JAXB `@XmlPath` annotation to map a customer's first and last names to the appropriate `<name>` element. It also uses the `@XmlType(propOrder)` annotation to ensure that the elements are always in the proper positions. To achieve this mapping:

1. Create the object and import `javax.xml.bind.annotation.*` and `org.eclipse.persistence.oxm.annotations.XmlPath`.


```
package example;

import javax.xml.bind.annotation.*;
import org.eclipse.persistence.oxm.annotations.XmlPath;
```
2. Declare the `Customer` class and insert the `@XmlType(propOrder)` annotation with the arguments `"firstName"` followed by `"lastName"`. Insert the `@XmlRootElement` annotation to make `Customer` the root element and set the XML accessor type to `FIELD`:

```
@XmlRootElement
@XmlType(propOrder={"firstName", "lastName"})
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
```

3. Define the properties `firstName` and `lastName` with the type `String`.
4. Map the properties `firstName` and `lastName` to the appropriate position in the XML document by inserting the `@XmlPath` annotation with the appropriate XPath predicates.

```
    @XmlPath("name[1]/text()")
```

```
private String firstName;

@XmlPath("name[2]/text()")
private String lastName;
```

The predicates, "name[1]/text()" and "name[2]/text()" indicate the <name> element to which that specific property will be mapped; for example, "name[1]/text" will map the firstName property to the first <name> element.

The object should look like [Example 14-19](#).

Example 14-19 Customer Object Mapping Values by Position

```
package example;

import javax.xml.bind.annotation.*;

import org.eclipse.persistence.oxm.annotations.XmlPath;

@XmlRootElement
@XmlType(propOrder={"firstName", "lastName"})
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
    @XmlPath("name[1]/text()")
    private String firstName;

    @XmlPath("name[2]/text()")
    private String lastName;

    ...
}
```

For more information about using XPath predicates, see [Section 14.5, "Using XPath Predicates for Mapping"](#).

14.4 Using XML Metadata Representation to Override JAXB Annotations

In addition to using Java annotations, EclipseLink provides an XML mapping configuration file called `eclipselink-oxm.xml` that you can use in place of or to override JAXB annotations in the source with an XML representation of the metadata. In addition to allowing all of the standard JAXB mapping capabilities it also includes advanced mapping types and options.

An XML metadata representation is useful when:

- You cannot modify the domain model because, for example, it come from a third party).
- You do not want to introduce compile dependencies on JAXB APIs (if you are using a version of Java that predates Java SE 6).
- You want to apply multiple JAXB mappings to a domain model (you are limited to one representation with annotations).
- Your object model already contains so many annotations from other technologies that adding more would make the class unreadable.

This section demonstrates how to use `eclipselink-oxm.xml` to override JAXB annotations

Note: While using this mapping file enables many advanced features, it might prevent you from porting it to other JAXB implementations

14.4.1 Task 1: Define Advanced Mappings in the XML

First, update the XML mapping file to expose the `eclipselink_oxm_2_3.xsd` schema. [Example 14-20](#) shows how to modify the `<xml-bindings>` element in the mapping file to point to the correct namespace and leverage the schema. Each Java package can have one mapping file.

Example 14-20 Updating XML Binding Information in the Mapping File

```
<?xml version="1.0"?>
<xml-bindings
  xmlns="http://www.eclipse.org/eclipselink/xsds/persistence/oxm"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.eclipse.org/eclipselink/xsds/persistence/oxm
http://www.eclipse.org/eclipselink/xsds/eclipselink_oxm_2_4.xsd"
  version="2.4">
</xml-bindings>
```

14.4.2 Task 2: Configure Usage in JAXBContext

Next, pass the mapping file to `JAXBContext` in your object:

1. Specify the externalized metadata by inserting this code:

```
Map<String, Object> properties = new HashMap<String, Object>(1);
properties.put(JAXBContextProperties.OXM_METADATA_SOURCE,
  "org/example/oxm.xml");
JAXBContext.newInstance("org.example", aClassLoader, properties);
```

2. Create the properties object to pass to the `JAXBContext`. For this example:

```
Map<String, Object> properties = new HashMap<String, Object>();
properties.put(JAXBContextFactory.ECLIPSELINK_OXM_XML_KEY, metadata);
```

3. Create the `JAXBContext`. For this example:

```
JAXBContext.newInstance("example.order:example.customer", aClassLoader,
properties);
```

14.4.3 Task 3: Specify the MOXy as the JAXB Implementation

You must use MOXy as your JAXB implementation. To do so, do the following:

1. Open a `jaxb.properties` file and add the following line:

```
javax.xml.bind.context.factory=org.eclipse.persistence.jaxb.JAXBContextFactory
```

2. Copy the `jaxb.properties` file to the package that contains your domain classes.

14.5 Using XPath Predicates for Mapping

This section demonstrates how the EclipseLink MOXy API uses XPath predicates to define an expression that specifies the XML element's name. An XPath predicate is an expression that defines a specific object-to-XML mapping. As shown in previous examples, by default, JAXB will use the Java field name as the XML element name.

This section contains the following subsections:

- [Section 14.5.1, "Understanding XPath Predicates"](#)
- [Section 14.5.2, "Mapping Based on Position"](#)
- [Section 14.5.3, "Mapping Based on an Attribute Value"](#)
- [Section 14.5.4, "'Self' Mappings"](#)

14.5.1 Understanding XPath Predicates

As described above, an XPath predicate is an expression that defines a specific object-to-XML mapping when standard annotations

are not sufficient. For example, the following snippet of XML shows a `<data>` element with two `<node>` sub-elements. If you wanted to create this mapping in a Java object, you would need to specify an XPath predicate for each `<node>` sub-element; for example, `Node[2]` in the following Java:

```
<java-attributes>
  <xml-element java-attribute="node" xml-path="node[1]/ABC"/>
  <xml-element java-attribute="node" xml-path="node[2]/DEF"/>
</java-attributes>
```

would match the second occurrence of the node element ("`DEF`") in the following XML:

```
<?xml version="1.0" encoding="UTF-8"?>
<data>
  <node>ABC</node>
  <node>DEF</node>

```

Thus, by using the XPath predicate, you can use the same attribute name for a different attribute value.

14.5.2 Mapping Based on Position

This mapping technique is described in [Section 14.3.2.4, "Mapping Values to a Text Node by Position"](#).

14.5.3 Mapping Based on an Attribute Value

Beginning with EclipseLink MOXy 2.3, you can also map to an XML element based on an Attribute value. In this exercise, you will annotate the JPA entity to render the XML document shown in [Example 14-21](#). Note that all of the XML elements are named `node` but are differentiated by the value of their `name` attribute.

Example 14-21

```
<?xml version="1.0" encoding="UTF-8"?>
<node>
  <node name="first-name">Bob</node>
  <node name="last-name">Smith</node>
  <node name="address">
    <node name="street">123 A Street</node>
  </node>
  <node name="phone-number" type="work">555-1111</node>
  <node name="phone-number" type="cell">555-2222</node>
</node>
```

To attain this mapping, you need to declare three classes, `Name`, `Address`, and `PhoneNumber` and then use an XPath in the form of `element-name[@attribute-name='value']` to map each Java field.

14.5.3.1 Task 1: Create the Customer Entity

To create the Customer class entity:

1. Import the necessary JPA packages by adding the following code:

```
import javax.xml.bind.annotation.*;

import org.eclipse.persistence.oxm.annotations.XmlPath;
```

2. Declare the Customer class and use the `@XmlRootElement` annotation to make it the root element. Set the XML accessor type to `FIELD`:

```
@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
```

3. Declare local to the Customer class these properties:

- `firstName` (String type)
- `lastName` (String)
- `Address` (Address)

For each property, set the XPath predicate by preceding the property declaration with the annotation `@XmlPath(element-name[@attribute-name='value'])`; for example, for `firstName`, you would set the XPath predicate with this statement:

```
@XmlPath("node[@name='first-name']/text()")
```

4. Also local to the Customer class, declare the `phoneNumber` property as a `List<PhoneNumber>` type and assign it the value `new ArrayList<PhoneNumber>()`.

The Customer class should look like the snippet in [Example 14-22](#).

Example 14-22 Customer Object Mapping to an Attribute Value

```
package example;

import javax.xml.bind.annotation.*;

import org.eclipse.persistence.oxm.annotations.XmlPath;

@XmlRootElement(name="node")
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {

    @XmlPath("node[@name='first-name']/text()")
    private String firstName;

    @XmlPath("node[@name='last-name']/text()")
    private String lastName;

    @XmlPath("node[@name='address']")
    private Address address;

    @XmlPath("node[@name='phone-number']")
    private List<PhoneNumber> phoneNumbers = new ArrayList<PhoneNumber>();
```

```
...
}
```

14.5.3.2 Task 2: Create the Address Entity

To create the Address class, do the following:

1. Import the necessary JPA packages by adding the following code:

```
import javax.xml.bind.annotation.*;

import org.eclipse.persistence.xml.annotations.XmlPath;
```

2. Declare the Address class and set the XML accessor type to FIELD:

```
@XmlAccessorType(XmlAccessType.FIELD)
public class Address {
```

This instance does not require the `@XmlRootElement` annotation as in the previous Tasks because the Address class is root not a root element in the XML document.

3. Declare local to the Address class the String property street. Set the XPath predicate by preceding the property declaration with the annotation

```
@XmlPath("node[@name='street']/text()")
```

The Address class should look like [Example 14–23](#).

Example 14–23 Address Object Mapping to an Attribute Value

```
package example;

import javax.xml.bind.annotation.*;

import org.eclipse.persistence.xml.annotations.XmlPath;

@XmlAccessorType(XmlAccessType.FIELD)
public class Address {

    @XmlPath("node[@name='street']/text()")
    private String street;

    ...
}
```

14.5.3.3 Task 3: Create the PhoneNumber Entity

To create the PhoneNumber entity:

1. Import the necessary JPA packages by adding the following code:

```
import javax.xml.bind.annotation.*;

import org.eclipse.persistence.xml.annotations.XmlPath;
```

2. Declare the PhoneNumber class and use the `@XmlRootElement` annotation to make it the root element. Set the XML accessor type to FIELD:

```
@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer {
```

3. Create the type and string properties and define their mapping as attributes under the PhoneNumber root element by using the `@XmlAttribute` annotation.

```
@XmlAttribute
private String type;

@XmlValue
private String number;
```

The PhoneNumber object should look like [Example 14-24](#).

Example 14-24 PhoneNumber Object Mapping to an Attribute Value

```
package example;

import javax.xml.bind.annotation.*;

@XmlAccessorType(XmlAccessType.FIELD)
public class PhoneNumber {

    @XmlAttribute
    private String type;

    @XmlValue
    private String number;

    ...
}
```

14.5.4 "Self" Mappings

A "self" mapping occurs on one-to-one mappings when you set the target object's XPath to "." (dot) so the data from the target object appears inside the source object's XML element. This exercise uses the example in [Section 14.5.3, "Mapping Based on an Attribute Value"](#) to map the Address information to appear directly under the customer element and not wrapped in its own element.

To create the self mapping:

1. Repeat Tasks 1 and 2 in [Section 14.5.3.1, "Task 1: Create the Customer Entity"](#).
2. Declare local to the Customer class these properties:
 - firstName (String type)
 - lastName (String)
 - Address (Address)
3. For the firstName and lastName properties, set the XPath annotation by preceding the property declaration with the annotation `@XPath(element-name[@attribute-name='value'])`; for example, for firstName, you would set the XPath predicate with this statement:

```
@XPath("node[@name='first-name']/text()")
```

4. For the address property, set @XPath to "." (dot):

```
@XPath(".")
private Address address;
```

5. Also local to the Customer class, declare the `phoneNumber` property as a `List<PhoneNumber>` type and assign it the value `new ArrayList<PhoneNumber>()`.

The rendered XML for the Customer entity would look like [Example 14–25](#).

Example 14–25 XML Node with Self-Mapped Address Element

```
<?xml version="1.0" encoding="UTF-8"?>
<node>
  <node name="first-name">Bob</node>
  <node name="last-name">Smith</node>
  <node name="street">123 A Street</node>
  <node name="phone-number" type="work">555-1111</node>
  <node name="phone-number" type="cell">555-2222</node>
</node>
```

14.6 Using Dynamic JAXB/MOXY

Dynamic JAXB/MOXY allows you to bootstrap a `JAXBContext` from a variety of metadata sources and use familiar JAXB APIs to marshal and unmarshal data, without requiring compiled domain classes. This is an enhancement over static JAXB, because now you can update the metadata without having to update and recompile the previously-generated Java source code.

The benefits of using dynamic JAXB/MOXY entities are:

- Instead of using actual Java classes (for example, `Customer.class`, `Address.class`, and so on), the domain objects are subclasses of the `DynamicEntity`.
- Dynamic entities offer a simple `get (propertyName) /set (propertyName, propertyValue)` API to manipulate their data.
- Dynamic entities have an associated `DynamicType`, which is generated in-memory, when the metadata is parsed.

The following Tasks demonstrate how to use dynamic JAXB:

- [Task 1: Bootstrap a Dynamic JAXBContext from an XML Schema](#)
- [Task 2: Create Dynamic Entities and Marshal Them to XML](#)
- [Task 3: Unmarshal the Dynamic Entities from XML](#)

14.6.1 Task 1: Bootstrap a Dynamic JAXBContext from an XML Schema

This example demonstrates how to bootstrap a dynamic `JAXBContext` from an XML Schema.

14.6.1.1 Bootstrapping from an XML Schema

Use the `DynamicJAXBContextFactory` to create a dynamic `JAXBContext`. [Example 14–26](#) to bootstrap a `DynamicJAXBContext` from the `customer.xsd` schema ([Example 14–27](#)) by using `createContextFromXSD()`.

Example 14–26 Specifying the Input Stream and Creating the DynamicJAXBContext

```
import java.io.FileInputStream;

import org.eclipse.persistence.jaxb.dynamic.DynamicJAXBContext;
import org.eclipse.persistence.jaxb.dynamic.DynamicJAXBContextFactory;

public class Demo {
```

```
public static void main(String[] args) throws Exception {
    FileInputStream xsdInputStream = new FileInputStream("src/example/customer.xsd");
    DynamicJAXBContext jaxbContext =
        DynamicJAXBContextFactory.createContextFromXSD(xsdInputStream, null, null, null);
}
```

The first parameter represents the XML schema itself and must be in one of the following forms: `java.io.InputStream`, `org.w3c.dom.Node`, or `javax.xml.transform.Source`.

14.6.1.2 The XML Schema

[Example 14-27](#) shows the `customer.xsd` schema that represents the metadata for the dynamic JAXBContext you are bootstrapping.

Example 14-27 Sample XML Schema Document

```
<xsd:schema
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns="http://www.example.org"
  targetNamespace="http://www.example.org"
  elementFormDefault="qualified">

  <xsd:complexType name="address">
    <xsd:sequence>
      <xsd:element name="street" type="xsd:string" minOccurs="0"/>
      <xsd:element name="city" type="xsd:string" minOccurs="0"/>
    </xsd:sequence>
  </xsd:complexType>

  <xsd:element name="customer">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element name="name" type="xsd:string" minOccurs="0"/>
        <xsd:element name="address" type="address" minOccurs="0"/>
      </xsd:sequence>
    </xsd:complexType>
  </xsd:element>

</xsd:schema>
```

14.6.1.3 Handling Schema Import/Includes

To bootstrap `DynamicJAXBContext` from an XML schema that contains imports of other schemas, you need to configure an `org.xml.sax.EntityResolver` to resolve the locations of the imported schemas and pass the `EntityResolver` to `DynamicJAXBContextFactory`.

The following example shows two schema documents, `customer.xsd` ([Example 14-28](#)) and `address.xsd` ([Example 14-29](#)). You can see that `customer.xsd` imports `address.xsd` by using the statement:

```
<xsd:import namespace="http://www.example.org/address" schemaLocation="address.xsd"/>
```

Example 14-28 customer.xsd

```
<?xml version="1.0" encoding="UTF-8"?>
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:add="http://www.example.org/address"
  xmlns="http://www.example.org/customer"
  targetNamespace="http://www.example.org/customer"
```

```

elementFormDefault="qualified">

<xsd:import namespace="http://www.example.org/address" schemaLocation="address.xsd"/>

<xsd:element name="customer">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="name" type="xsd:string" minOccurs="0"/>
      <xsd:element name="address" type="add:address" minOccurs="0"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>

</xsd:schema>

```

Example 14–29 address.xsd

```

<?xml version="1.0" encoding="UTF-8"?>
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns="http://www.example.org/address"
  targetNamespace="http://www.example.org/address"
  elementFormDefault="qualified">

  <xsd:complexType name="address">
    <xs:sequence>
      <xs:element name="street" type="xs:string"/>
      <xs:element name="city" type="xs:string"/>
    </xs:sequence>
  </xsd:complexType>

</xsd:schema>

```

14.6.1.4 Implementing and Passing an EntityResolver

If you want to bootstrap `DynamicJAXBContext` from the `customer.xsd` schema, you need to pass an entity resolver. Do the following:

1. To resolve the locations of the imported schemas, you need to implement an `EntityResolver` by supplying the code shown in [Example 14–30](#).

Example 14–30 Implementing an EntityResolver

```

class MyEntityResolver implements EntityResolver {

    public InputSource resolveEntity(String publicId, String systemId) throws SAXException,
    IOException {
        // Imported schemas are located in ext\appdata\xsd\

        // Grab only the filename part from the full path
        String filename = new File(systemId).getName();

        // Now prepend the correct path
        String correctedId = "ext/appdata/xsd/" + filename;

        InputSource is = new InputSource(ClassLoader.getResourceAsStream(correctedId));
        is.setSystemId(correctedId);

        return is;
    }
}

```

```
}
```

2. After you implement your `DynamicJAXBContext`, pass the `EntityResolver`, as shown in [Example 14-31](#).

Example 14-31 Passing in the Entityresolver

```
FileInputStream xsdInputStream = new FileInputStream("src/example/customer.xsd");
DynamicJAXBContext jaxbContext =
    DynamicJAXBContextFactory.createContextFromXSD(xsdInputStream, new MyEntityResolver(), null,
    null);
```

14.6.1.5 Error Handling

You might see the following exception when importing another schema:

Internal Exception: org.xml.sax.SAXParseException: schema_reference.4: Failed to read schema document '<imported-schema-name>', because 1) could not find the document; 2) the document could not be read; 3) the root element of the document is not <xsd:schema>.

To work around this exception, disable XJC's schema correctness check by setting the `noCorrectnessCheck` Java property. You can set this property one of two ways:

- From within the code, by adding this line:

```
System.setProperty("com.sun.tools.xjc.api.impl.s2j.SchemaCompilerImpl.noCorrectnessCheck", "true")
```

- From the command line, by using this command:

```
-Dcom.sun.tools.xjc.api.impl.s2j.SchemaCompilerImpl.noCorrectnessCheck=true
```

14.6.1.6 Specifying a ClassLoader

Use your application's current class loader as the `classLoader` parameter. This parameter verifies that specified classes exist before new `DynamicTypes` are generated. In most cases you can pass `null` for this parameter and use `Thread.currentThread().getContextClassLoader()` instead.

14.6.2 Task 2: Create Dynamic Entities and Marshal Them to XML

This example shows how to create dynamic entities and marshal them to XML.

14.6.2.1 Creating the Dynamic Entities

Use the `DynamicJAXBContext` to create instances of `DynamicEntity`. The entity and property names correspond to the class and property names—in this case, the `customer` and `address`—that would have been generated if you had used static JAXB.

Example 14-32 Creating the Dynamic Entity

```
DynamicEntity customer = jaxbContext.newDynamicEntity("org.example.Customer");
customer.set("name", "Jane Doe");

DynamicEntity address = jaxbContext.newDynamicEntity("org.example.Address");
address.set("street", "1 Any Street").set("city", "Any Town");
customer.set("address", address);
```


14.6.2.2 Marshalling the Dynamic Entities to XML

The marshaller obtained from the `DynamicJAXBContext` is a standard marshaller and can be used normally to marshal instances of `DynamicEntity`.

Example 14–33 Standard Dynamic JAXB Marshaller

```
Marshaller marshaller = jaxbContext.createMarshaller();
marshaller.setProperty(Marshaller.JAXB_FORMATTED_OUTPUT, true);
marshaller.marshal(customer, System.out);
```

[Example 14–34](#) shows the resultant XML document:

Example 14–34 Updated XML Document Showing <address> Element and Its Attributes

```
<?xml version="1.0" encoding="UTF-8"?>
<customer xmlns="www.example.org">
  <name>Jane Doe</name>
  <address>
    <street>1 Any Street</street>
    <city>Any Town</city>
  </address>
</customer>
```

14.6.3 Task 3: Unmarshal the Dynamic Entities from XML

In this example shows how to unmarshal from XML the dynamic entities you created in [Task 2: Create Dynamic Entities and Marshal Them to XML](#). The XML in reference is shown in [Example 14–34](#).

14.6.3.1 Unmarshal DynamicEntities from XML

The `Unmarshaller` obtained from the `DynamicJAXBContext` is a standard unmarshaller, and can be used normally to unmarshal instances of `DynamicEntity`.

Example 14–35 Standard Dynamic JAXB Unmarshaller

```
FileInputStream xmlInputStream = new FileInputStream("src/example/dynamic/customer.xml");
Unmarshaller unmarshaller = jaxbContext.createUnmarshaller();
DynamicEntity customer = (DynamicEntity) unmarshaller.unmarshal(xmlInputStream);
```

14.6.3.2 Get Data from the Dynamic Entity

Next, specify which data in the dynamic entity to obtain. Specify this value by using `System.out.println()` and passing in the entity name. `DynamicEntity` offers property-based data access; for example, `get("name")` instead of `getName()`:

```
System.out.println(customer.<String>get("name"));
```

14.6.3.3 Use DynamicType to Introspect Dynamic Entity

Instances of `DynamicEntity` have a corresponding `DynamicType`, which you can use to introspect the `DynamicEntity`, as shown in [Example 14–36](#).

Example 14–36

```
DynamicType addressType = jaxbContext.getDynamicType("org.example.Address");

DynamicEntity address = customer.<DynamicEntity>get("address");
for(String propertyName: addressType.getPropertiesNames()) {
    System.out.println(address.get(propertyName));
}
```

}

14.7 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- *Developing Persistence Architectures Using EclipseLink MOXy Developer's Guide*

Converting Objects to and from JSON Documents

This chapter describes how Oracle TopLink MOXy supports the ability to convert objects to and from JSON (JavaScript Object Notation). This feature is useful when creating RESTful services; JAX-RS services can accept both XML and JSON messages.

This chapter contains the following sections:

- [Section 15.1, "Introduction to the Solution"](#)
- [Section 15.2, "Implementing the Solution"](#)
- [Section 15.3, "Additional Resources"](#)

Use Case

Users need to convert objects to and from JSON documents.

Solution

EclipseLink provides JSON support through the EclipseLink MOXy implementation.

Components

- EclipseLink 12c Release 1 (12.1.2).
- JSON documents

Sample

See the following EclipseLink samples for related information:

- <http://wiki.eclipse.org/EclipseLink/Examples/MOXy>
- http://wiki.eclipse.org/EclipseLink/Examples/MOXy/JSON_Metadata
- http://wiki.eclipse.org/EclipseLink/Examples/MOXy/MOXy_JSON_Provider

15.1 Introduction to the Solution

TopLink supports all MOXy object-to-XML options when reading and writing JSON, including:

- TopLink's advanced and extended mapping features (in addition to the JAXB specification)
- Storing mappings in external bindings files

- Creating dynamic models with Dynamic JAXB
- Building extensible models that support multitenant applications

15.2 Implementing the Solution

This section contains the following tasks for converting objects to and from JSON documents.

- [Task 1: Marshalling and Unmarshalling JSON Documents](#)
- [Task 2: Specifying JSON Bindings](#)
- [Task 3: Specifying JSON Data Types](#)
- [Task 4: Supporting Attributes](#)
- [Task 5: Supporting no Root Element](#)
- [Task 6: Using Collections](#)
- [Task 7: Mapping Root-Level Collections](#)
- [Task 8: Wrapping XML Values](#)

15.2.1 Task 1: Marshalling and Unmarshalling JSON Documents

Use the `eclipselink.media-type` property on your JAXB Marshaller or Unmarshaller to produce and use JSON documents with your application, as shown in [Example 15–1](#).

Example 15–1 Marshalling and Unmarshalling

```
...

Marshaller m = jaxbContext.createMarshaller();
m.setProperty("eclipselink.media-type", "application/json");

Unmarshaller u = jaxbContext.createUnmarshaller();
u.setProperty("eclipselink.media-type", "application/json");

...
```

You can also specify the `eclipselink.media-type` property in the Map of the properties used when you create the `JAXBContext`, as shown in [Example 15–2](#).

Example 15–2 Using a Map

```
import org.eclipse.persistence.jaxb.JAXBContextProperties;
import org.eclipse.persistence.xml.MediaType;

Map<String, Object> properties = new HashMap<String, Object>();
properties.put("eclipselink.media-type", "application/json");

JAXBContext ctx = JAXBContext.newInstance(new Class[] { Employee.class },
properties);
Marshaller jsonMarshaller = ctx.createMarshaller();
Unmarshaller jsonUnmarshaller = ctx.createUnmarshaller();
```

When specified in a Map, the Marshaller and Unmarshaller created from the `JAXBContext` will automatically use the specified media type.

You can also configure your application to use JSON documents by using the `MarshallerProperties`, `UnmarshallerProperties`, and `MediaType` constants, as shown in [Example 15-3](#).

Example 15-3 Using `MarshallerProperties` and `UnmarshallerProperties`

```
import org.eclipse.persistence.jaxb.MarshallerProperties;
import org.eclipse.persistence.jaxb.UnmarshallerProperties;
import org.eclipse.persistence.oxm.MediaType;

m.setProperty(MarshallerProperties.MEDIA_TYPE, MediaType.APPLICATION_JSON);
u.setProperty(UnmarshallerProperties.MEDIA_TYPE, MediaType.APPLICATION_JSON);
...
```

15.2.2 Task 2: Specifying JSON Bindings

[Example 15-4](#) shows a basic JSON binding that does not require compile time dependencies in addition to those required for normal JAXB usage. This example shows how to unmarshal JSON from a `StreamSource` into the user object `SearchResults`, add a new `Result` to the collection, and then marshal the new collection to `System.out`.

Example 15-4 Using Basic JSON Binding

```
package org.example;

import org.example.model.Result;
import org.example.model.SearchResults;

import java.util.Date;

import javax.xml.bind.JAXBContext;
import javax.xml.bind.JAXBElement;
import javax.xml.bind.Marshaller;
import javax.xml.bind.Unmarshaller;
import javax.xml.transform.stream.StreamSource;

public class Demo {

    public static void main(String[] args) throws Exception {
        JAXBContext jc = JAXBContext.newInstance(SearchResults.class);

        Unmarshaller unmarshaller = jc.createUnmarshaller();
        unmarshaller.setProperty("eclipseLink.media-type", "application/json");
        StreamSource source = new
StreamSource("http://search.twitter.com/search.json?q=jaxb");
        JAXBElement<SearchResults> jaxbElement = unmarshaller.unmarshal(source,
SearchResults.class);

        Result result = new Result();
        result.setCreatedAt(new Date());
        result.setFromUser("bsmith");
        result.setText("You can now use EclipseLink JAXB (MOXy) with JSON :)");
        jaxbElement.getValue().getResults().add(result);

        Marshaller marshaller = jc.createMarshaller();
        marshaller.setProperty(Marshaller.JAXB_FORMATTED_OUTPUT, true);
```

```

        marshaller.setProperty("eclipselink.media-type", "application/json");
        marshaller.marshal(jaxbElement, System.out);
    }
}

```

You can also write MOXy External Bindings files as JSON documents. [Example 15–5](#) shows how to use `bindings.json` to map **Customer** and **PhoneNumber** classes to JSON.

Example 15–5 Using External Bindings

```

{
  "package-name" : "org.example",
  "xml-schema" : {
    "element-form-default" : "QUALIFIED",
    "namespace" : "http://www.example.com/customer"
  },
  "java-types" : {
    "java-type" : [ {
      "name" : "Customer",
      "xml-type" : {
        "prop-order" : "firstName lastName address phoneNumbers"
      },
      "xml-root-element" : {},
      "java-attributes" : {
        "xml-element" : [
          {"java-attribute" : "firstName", "name" : "first-name"},
          {"java-attribute" : "lastName", "name" : "last-name"},
          {"java-attribute" : "phoneNumbers", "name" : "phone-number"}
        ]
      }
    }, {
      "name" : "PhoneNumber",
      "java-attributes" : {
        "xml-attribute" : [
          {"java-attribute" : "type"}
        ],
        "xml-value" : [
          {"java-attribute" : "number"}
        ]
      }
    } ]
  }
}

```

[Example 15–6](#) shows how to use the JSON file (created in [Example 15–5](#)) when bootstrapping a `JAXBContext`.

Example 15–6 Using JSON to Bootstrap a JAXBContext

```

Map<String, Object> properties = new HashMap<String, Object>(2);
properties.put("eclipselink-oxm-xml", "org/example/binding.json");
properties.put("eclipselink.media-type", "application/json");
JAXBContext context = JAXBContext.newInstance("org.example",
Customer.class.getClassLoader(), properties);

Unmarshaller unmarshaller = context.createUnmarshaller();
StreamSource json = new StreamSource(new File("src/org/example/input.json"));
...

```

15.2.3 Task 3: Specifying JSON Data Types

JSON does not use attributes; anything mapped with a `@XmlAttribute` annotation will be marshalled as an element. By default, TopLink triggers *both* the attribute and element events, thereby allowing either the mapped attribute or element to handle the value.

You can override this behavior by using the `JSON_ATTRIBUTE_PREFIX` property to specify an attribute prefix, as shown in [Example 15-7](#). TopLink prepends the prefix to the attribute name during marshal and will recognize it during unmarshal.

In the example below the number field is mapped as an attribute with the prefix @.

Example 15-7 Using a Prefix

```
jsonUnmarshaller.setProperty(UnmarshallerProperties.JSON_ATTRIBUTE_PREFIX, "@");
jsonMarshaller.setProperty(MarshallerProperties.JSON_ATTRIBUTE_PREFIX, "@");
```

```
{
  "phone" : {
    "area-code" : "613",
    "@number" : "1234567"
  }
}
```

You can also set the `JSON_ATTRIBUTE_PREFIX` property in the Map used when creating the `JAXBContext`, as shown in [Example 15-8](#). Allmarshallers and unmarshallers created from the context will use the specified prefix.

Example 15-8 Setting a Prefix in a Map

```
Map<String, Object> properties = new HashMap<String, Object>();
properties.put(JAXBContextProperties.JSON_ATTRIBUTE_PREFIX, "@");

JAXBContext ctx = JAXBContext.newInstance(new Class[] { Phone.class },
properties);
```

15.2.4 Task 4: Supporting Attributes

JSON does not use attributes; anything mapped with a `@XmlAttribute` annotation will be marshalled as an element. By default, TopLink triggers *both* the attribute and element events, thereby allowing either the mapped attribute or element to handle the value.

You can override this behavior by using the `JSON_ATTRIBUTE_PREFIX` property to specify an attribute prefix, as shown in [Example 15-7](#). TopLink prepends the prefix to the attribute name during marshal and will recognize it during unmarshal.

In the example below the number field is mapped as an attribute with the prefix @.

Example 15-9 Using a Prefix

```
jsonUnmarshaller.setProperty(UnmarshallerProperties.JSON_ATTRIBUTE_PREFIX, "@");
jsonMarshaller.setProperty(MarshallerProperties.JSON_ATTRIBUTE_PREFIX, "@");
```

```
{
  "phone" : {
    "area-code" : "613",
    "@number" : "1234567"
  }
}
```

You can also set the `JSON_ATTRIBUTE_PREFIX` property in the Map used when creating the `JAXBContext`, as shown in [Example 15–10](#). All marshallers and unmarshallers created from the context will use the specified prefix.

Example 15–10 Setting a Prefix in a Map

```
Map<String, Object> properties = new HashMap<String, Object>();
properties.put(JAXBContextProperties.JSON_ATTRIBUTE_PREFIX, "@");

JAXBContext ctx = JAXBContext.newInstance(new Class[] { Phone.class },
properties);
```

15.2.5 Task 5: Supporting no Root Element

`TopLink` supports JSON documents without a root element. By default, if no `@XmlRootElement` annotation exists, the marshalled JSON document will not have a root element. You can override this behavior (that is omit the root element from the JSON output, even if the `@XmlRootElement` is specified) by setting the `JSON_INCLUDE_ROOT` property when marshalling a document, as shown in [Example 15–11](#).

Example 15–11 Marshalling no Root Element Documents

```
marshaller.setProperty(MarshallerProperties.JSON_INCLUDE_ROOT, false);
```

When unmarshaling a document with no root elements, you should set the `JSON_INCLUDE_ROOT` property as shown in [Example 15–12](#).

Example 15–12 Unmarshalling no Root Element Documents

```
unmarshaller.setProperty(UnmarshallerProperties.JSON_INCLUDE_ROOT, false);
JAXBElement<SearchResults> jaxbElement = unmarshaller.unmarshal(source,
SearchResults.class);
```

Note: If the document has no root element, you must specify the class to unmarshal to.

15.2.6 Task 5 Using Namespaces

Because JSON does not use namespaces, by default all namespaces and prefixes are ignored when marshaling and unmarshaling. In some cases, this may be an issue if you have multiple mappings with the same local name – there will be no way to distinguish between the mappings.

With `TopLink`, you can supply a Map of namespace-to-prefix (or an instance of `NamespacePrefixMapper`) to the `Marshaller` and `Unmarshaller`. The namespace prefix

will appear in the marshalled document prepended to the element name. TopLink will recognize the prefix during an unmarshal operation and the resulting Java objects will be placed in the proper namespaces.

[Example 15–13](#) shows how to use the `NAMESPACE_PREFIX_MAPPER` property.

Example 15–13 Using Namespaces

```
Map<String, String> namespaces = new HashMap<String, String>();
namespaces.put("namespace1", "ns1");
namespaces.put("namespace2", "ns2");
jsonMarshaller.setProperty(MarshallerProperties.NAMESPACE_PREFIX_MAPPER,
namespaces);
jsonUnmarshaller.setProperty(UnmarshallerProperties.JSON_NAMESPACE_PREFIX_MAPPER,
namespaces);
```

The `MarshallerProperties.NAMESPACE_PREFIX_MAPPER` applies to *both* XML and JSON; `UnmarshallerProperties.JSON_NAMESPACE_PREFIX_MAPPER` is a *JSON-only* property. XML unmarshalling can obtain the namespace information directly from the document.

When JSON is marshalled, the namespaces will be given the prefix from the Map separated by a dot (.):

```
{
  "ns1.employee" : {
    "ns2.id" : 123
  }
}
```

The dot separator can be set to any custom character by using the `JSON_NAMESPACE_SEPARATOR` property. Here, a colon (:) will be used instead:

```
jsonMarshaller.setProperty(MarshallerProperties.JSON_NAMESPACE_SEPARATOR, ':');
jsonUnmarshaller.setProperty(UnmarshallerProperties.JSON_NAMESPACE_SEPARATOR,
':');
```

15.2.7 Task 6: Using Collections

By default, when marshalling to JSON, TopLink marshals empty collections as `[]`, as shown in [Example 15–14](#).

Example 15–14 Marshalling Empty Collections

```
{
  "phone" : {
    "myList" : [ ]
  }
}
```

Use the `JSON_MARSHAL_EMPTY_COLLECTIONS` property to override this behavior (so that empty collections are not marshalled at all).

```
jsonMarshaller.setProperty(MarshallerProperties.JSON_MARSHAL_EMPTY_COLLECTIONS,
Boolean.FALSE) ;
```

```
{
```

```
        "phone" : {  
        }  
    }  
}
```

15.2.8 Task 7: Mapping Root-Level Collections

If you use the `@XmlRootElement(name="root")` annotation to specify a root level, the JSON document can be marshaled as:

```
marshaller.marshal(myListOfRoots, System.out);
```

```
[ {  
  "root" : {  
    "name" : "aaa"  
  }  
}, {  
  "root" : {  
    "name" : "bbb"  
  }  
} ]
```

Because the root element *is* present in the document, you can unmarshal it using:

```
unmarshaller.unmarshal(json);
```

If the class *does not* have an `@XmlRootElement` (or if `JSON_INCLUDE_ROOT = false`), the marshal would produce:

```
[ {  
  "name": "aaa"  
}, {  
  "name": "bbb"  
} ]
```

Because the root element *is not* present, you must indicate the class to unmarshal to:

```
unmarshaller.unmarshal(json, Root.class);
```

15.2.9 Task 8: Wrapping XML Values

JAXB supports one or more `@XmlAttributes` on `@XmlValue` classes, as shown in [Example 15-15](#).

Example 15-15 Using @XmlAttributes

```
public class Phone {  
  
    @XmlValue  
    public String number;  
  
    @XmlAttribute  
    public String areaCode;  
  
    public Phone() {  
        this("", "");  
    }  
}
```

```

    public Phone(String num, String code) {
        this.number = num;
        this.areaCode = code;
    }
}

```

To produce a valid JSON document, TopLink uses a value wrapper, as shown in [Example 15-16](#).

Example 15-16 Using a value Wrapper

```

{
  "employee" : {
    "name" : "Bob Smith",
    "mainPhone" : {
      "areaCode" : "613",
      "value" : "555-5555"
    },
    "otherPhones" : [ {
      "areaCode" : "613",
      "value" : "123-1234"
    }, {
      "areaCode" : "613",
      "value" : "345-3456"
    } ]
  }
}

```

By default, TopLink uses **value** as the name of the wrapper. Use the `JSON_VALUE_WRAPPER` property to customize the name of the value wrapper, as shown in [Example 15-17](#).

Example 15-17 Customizing the Name of the Value Wrapper

```

jsonMarshaller.setProperty(MarshallerProperties.JSON_VALUE_WRAPPER, "$");
jsonUnmarshaller.setProperty(UnmarshallerProperties.JSON_VALUE_WRAPPER, "$");

```

Would produce:

```

{
  "employee" : {
    "name" : "Bob Smith",
    "mainPhone" : {
      "areaCode" : "613",
      "$" : "555-5555"
    },
    "otherPhones" : [ {
      "areaCode" : "613",
      "$" : "123-1234"
    }, {
      "areaCode" : "613",
      "$" : "345-3456"
    } ]
  }
}

```

You can also specify the `JSON_VALUE_WRAPPER` property in the Map of the properties used when you create the `JAXBContext`, as shown in [Example 15-18](#).

Example 15–18 Using a Map

```
Map<String, Object> properties = new HashMap<String, Object>();
properties.put(JAXBContextProperties.JSON_VALUE_WRAPPER, "$");

JAXBContext ctx = JAXBContext.newInstance(new Class[] { Employee.class },
properties);
Marshaller jsonMarshaller = ctx.createMarshaller();
Unmarshaller jsonUnmarshaller = ctx.createUnmarshaller();
```

When specified in a Map, the Marshallers and Unmarshallers created from the JAXBContext will automatically use the specified value wrapper.

15.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- *Developing Persistence Architectures Using EclipseLink MOXy Developer's Guide*

Testing EclipseLink JPA Outside a Container

With EclipseLink, you can use the persistence unit JAR file to test your application outside the container (for instance, in applications for the Java Platform, Standard Edition (Java SE platform)).

This chapter contains the following sections:

- [Section 16.1, "Understanding JPA Deployment"](#)
- [Section 16.2, "Configuring the persistence.xml File"](#)
- [Section 16.3, "Using a Property Map"](#)
- [Section 16.4, "Using Weaving"](#)
- [Section 16.5, "Additional Resources"](#)

Use Case

Users need to use EclipseLink both inside and outside the container (such as applications for the Java SE platform).

Solution

This solution highlights the primary differences when using EclipseLink outside a container.

Components

- EclipseLink 12c Release 1 (12.1.2).
- An application server (such as Oracle WebLogic Server, IBM WebSphere, or Glassfish)

16.1 Understanding JPA Deployment

When deploying outside of a container, use the `createEntityManagerFactory` method of the `javax.persistence.Persistence` class to create an entity manager factory. This method accepts a `Map` of properties and the name of the persistence unit. The properties that you pass to this method are combined with those specified in the `persistence.xml` file. They may be additional properties or they may override the value of a property that you specified previously in the `persistence.xml` file.

Tip: This is a convenient way to set properties obtained from program input, such as the command line.

16.1.1 Using EntityManager

The `EntityManager` is the access point for persisting an entity bean, loading it from the database. Usually, the Java Persistence API (JPA) container manages interaction with the data source. However, if you are using a JTA data source for your JPA persistence unit, then you can access the JDBC connection from the Java EE program container's data source. You must include the connection information to the `persistence.xml` file because the managed data source is not available.

With EclipseLink, you also have access to the EclipseLink extensions to the `EntityManager`.

16.2 Configuring the persistence.xml File

The `persistence.xml` file is the deployment descriptor file for persistence using JPA. It specifies the persistence units and declares the managed persistence classes, the object/relation mapping, and the database connection details.

16.2.1 Main Tasks

To configure the `persistence.xml` file, the following tasks:

- [Task 1: Use the persistence.xml File](#)
- [Task 2: Instantiate EntityManagerFactory](#)

16.2.1.1 Task 1: Use the persistence.xml File

[Example 16–1](#) illustrates a `persistence.xml` file for a Java SE platform configuration (that is, outside a container).

Example 16–1 A persistence.xml File Specifying the Java SE Platform Configuration

```
<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 persistence_1_0.xsd"
version="1.0">
  <persistence-unit name="my-app" transaction-type="RESOURCE_LOCAL">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <exclude-unlisted-classes>false</exclude-unlisted-classes>
    <properties>
      <property name="javax.persistence.jdbc.driver"
value="oracle.jdbc.OracleDriver"/>
      <property name="javax.persistence.jdbc.url"
value="jdbc:oracle:thin:@localhost:1521:orcl"/>
      <property name="javax.persistence.jdbc.user" value="scott"/>
      <property name="javax.persistence.jdbc.password" value="tiger"/>
    </properties>
  </persistence-unit>
</persistence>
```

16.2.1.2 Task 2: Instantiate EntityManagerFactory

An `EntityManagerFactory` provides an efficient way to construct `EntityManager` instances for a database. You can instantiate the `EntityManagerFactory` for the application (illustrated in [Example 16–1](#)) by using:

```
Persistence.createEntityManagerFactory("my-app");
```

16.3 Using a Property Map

You can use a property map to override the default persistence properties and use container deployment.

16.3.1 Main Tasks

To use a property map, perform the following steps:

- [Task 1: Configure the persistence.xml File](#)
- [Task 2: Configure the Bootstrapping API](#)
- [Task 3: Instantiate the EntityManagerFactory](#)

16.3.1.1 Task 1: Configure the persistence.xml File

[Example 16–2](#) illustrates a persistence.xml file that uses container deployment.

Example 16–2 A persistence.xml File Specifying the Java SE Platform Configuration, for use with a Property Map

```
<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 persistence_1_0.xsd"
version="1.0">
    <persistence-unit name="employee" transaction-type="RESOURCE_LOCAL">
        <non-jta-data-source>jdbc/MyDS</non-jta-data-source>
    </persistence-unit>
</persistence>
```

Note: There is no data source available when tested outside a container.

16.3.1.2 Task 2: Configure the Bootstrapping API

To test the persistence unit shown in [Example 16–2](#) outside the container, you must use the Java SE platform bootstrapping API. [Example 16–3](#) contains sample code that illustrates this bootstrapping.

Example 16–3 Sample Configuration

```
import static org.eclipse.persistence.config.PersistenceUnitProperties.*;

...

Map properties = new HashMap();

// Ensure RESOURCE_LOCAL transactions is used.
properties.put(TRANSACTION_TYPE,
    PersistenceUnitTransactionType.RESOURCE_LOCAL.name());

// Configure the internal connection pool
properties.put(JDBC_DRIVER, "oracle.jdbc.OracleDriver");
properties.put(JDBC_URL, "jdbc:oracle:thin:@localhost:1521:ORCL");
properties.put(JDBC_USER, "scott");
properties.put(JDBC_PASSWORD, "tiger");

// Configure logging. FINE ensures all SQL is shown
```

```
properties.put(LOGGING_LEVEL, "FINE");
properties.put(LOGGING_TIMESTAMP, "false");
properties.put(LOGGING_THREAD, "false");
properties.put(LOGGING_SESSION, "false");

// Ensure that no server-platform is configured
properties.put(TARGET_SERVER, TargetServer.None);
```

16.3.1.3 Task 3: Instantiate the EntityManagerFactory

An `EntityManagerFactory` provides an efficient way to construct `EntityManager` instances for a database. You can instantiate the `EntityManagerFactory` for the application (illustrated in [Example 16-3](#)) by using:

```
Persistence.
createEntityManagerFactory("unitName", "Properties");
```

16.4 Using Weaving

Weaving is a technique of manipulating the byte-code of compiled Java classes.

EclipseLink uses weaving to enhance Plain Old Java Object (POJO) classes and JPA entities with many features such lazy loading, change tracking, fetch groups, and internal optimizations.

16.4.1 How to Disable or Enable Weaving in a Java SE Environment

In a Java SE environment weaving is not enabled by default. This can affect LAZY One-To-One, Many-To-One and Basic relationships. It also has a major effect on performance and disable attribute change tracking.

To enable weaving in Java SE, the EclipseLink agent must be used when starting the Java VM.

```
java -javaagent:eclipselink.jar
```

Spring could also be used to allow JPA weaving in Java SE.

Static weaving can also be used, by including the following persistence property,

```
<property name="eclipselink.weaving" value="static"/>
```

16.4.2 How to Disable or Enable Weaving in a Java EE Environment

In a Java EE environment weaving is enabled by default (on any JEE EJB 3.0 fully compliant application server, such as Weblogic, Websphere, and Glassfish. JBoss does not allow weaving so you must use static weaving or Spring).

To disable weaving the weaving persistence unit property can be used,

```
<property name="eclipselink.weaving" value="false">
```

For more information on weaving see "weaving" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

16.5 Additional Resources

For additional information about JPA deployment, see the following sections of the JPA Specification (<http://jcp.org/en/jsr/detail?id=317>):

- Section 7.2, "Bootstrapping in Java SE Environments"
- Chapter 7, "Container and Provider Contracts for Deployment and Bootstrapping"

16.5.1 Related Javadoc

For more information, see the following APIs in *Java API Reference for EclipseLink*:

- `PersistenceUnitProperties` class
- `EntityManagerFactory` interface
- `JpaEntityManager` interface

Enhancing Performance

This chapter describes EclipseLink performance features and how to monitor and optimize EclipseLink-enabled applications.

This chapter contains the following sections:

- [Section 17.1, "Performance Features"](#)
- [Section 17.2, "Monitoring and Optimizing EclipseLink-Enable Applications"](#)

Use Case

Users want to improve the performance of their EclipseLink-enabled application.

Solution

EclipseLink provides many configuration options that can improve performance, such as caching. In addition, there are ways to improve the performance of specific functions, such as using Join Fetching for queries.

Components

- EclipseLink 12c Release 1 (12.1.2).

Sample

See the following EclipseLink samples for related information:

- <http://wiki.eclipse.org/EclipseLink/Performance>
- <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Performance>
- <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Monitoring>

17.1 Performance Features

EclipseLink includes a number of performance features that make it the industry's best performing and most scalable JPA implementation. These features include:

- [Object Caching](#)
- [Querying](#)
- [Mapping](#)
- [Transactions](#)
- [Database](#)
- [Tools](#)

17.1.1 Object Caching

The EclipseLink cache is an in-memory repository that stores recently read or written objects based on class and primary key values. The cache helps improve performance by holding recently read or written objects and accessing them in-memory to minimize database access.

Caching allows you to:

- Set how long the cache lives and the time of day, a process called cache invalidation.
- Configure cache types (Weak, Soft, SoftCache, HardCache, Full) on a per entity basis.
- Configure cache size on a per entity basis.
- Coordinate clustered caches.

17.1.1.1 Caching Annotations

EclipseLink defines these entity caching annotations:

- `@Cache`
- `@TimeOfDay`
- `@ExistenceChecking`

EclipseLink also provides a number of persistence unit properties that you can specify to configure the EclipseLink cache (see "Persistence Property Extensions Reference" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*). These properties might compliment or provide an alternative to the usage of annotations.

17.1.1.2 Using the @Cache Annotation

EclipseLink uses identity maps to cache objects in order to enhance performance, as well as maintain object identity. You can control the cache and its behavior by using the `@Cache` annotation in your entity classes. [Example 17–1](#) shows how to implement this annotation.

Example 17–1 Using the @Cache Annotation

```
@Entity
@Table(name="EMPLOYEE")
@Cache (
    type=CacheType.WEAK,
    isolated=false,
    expiry=600000,
    alwaysRefresh=true,
    disableHits=true,
    coordinationType=INVALIDATE_CHANGED_OBJECTS
)
public class Employee implements Serializable {
    ...
}
```

For more information about object caching and using the `@Cache` annotation, see "`@Cache`" in the *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.2 Querying

The scope of a query, the amount of data returned, and how that data is returned can all affect the performance of a EclipseLink-enabled application. EclipseLink query mechanisms enhance query performance by providing these features:

- [Read-only Queries](#)
- [Join Fetching](#)
- [Batch Reading](#)
- [Fetch Size](#)
- [Pagination](#)
- [Cache Usage](#)

This section describes how these features improve performance.

17.1.2.1 Read-only Queries

EclipseLink uses the `eclipselink.read-only` hint, `QueryHint (@QueryHint)` to retrieve read-only results back from a query. On nontransactional read operations, where the requested entity types are stored in the shared cache, you can request that the shared instance be returned instead of a detached copy.

For more information about read-only queries, see the documentation for the read-only hint in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.2.2 Join Fetching

Join Fetching enhances performance by enabling the joining and reading of the related objects in the same query as the source object. Enable Join Fetching by using the `@JoinFetch` annotation, as shown in [Example 17-2](#). This example shows how the `@JoinFetch` annotation specifies the `Employee` field `managedEmployees`.

Example 17-2 Enabling JoinFetching

```
@Entity
public class Employee implements Serializable {
    ...
    @OneToMany(cascade=ALL, mappedBy="owner")
    @JoinFetch(value=OUTER)
    public Collection<Employee> getManagedEmployees() {
        return managedEmployees;
    }
    ...
}
```

For more details on Join Fetching, see "`@JoinFetch`" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.2.3 Batch Reading

The `eclipselink.batch` hint supplies EclipseLink with batching information so subsequent queries of related objects can be optimized in batches instead of being retrieved one-by-one or in one large joined read. Batch reading is more efficient than joining because it avoids reading duplicate data. Batching is only allowed on queries that have a single object in their select clause.

17.1.2.4 Fetch Size

If you have large queries that return a large number of objects you can improve performance by reducing the number database hits required to satisfy the selection criteria. To do this, use the `The eclipselink.jdbc.fetch-size` hint. This hint specifies the number of rows that should be fetched from the database when more rows are required (depending on the JDBC driver support level). Most JDBC drivers default to a fetch size of 10, so if you are reading 1000 objects, increasing the fetch size to 256 can significantly reduce the time required to fetch the query's results. The optimal fetch size is not always obvious. Usually, a fetch size of one half or one quarter of the total expected result size is optimal. Note that if you are unsure of the result set size, incorrectly setting a fetch size too large or too small can decrease performance.

17.1.2.5 Pagination

Slow paging can result in significant application overhead; however, EclipseLink includes a variety of solutions for improving paging results; for example, you can:

- Configure the first and maximum number of rows to retrieve when executing a query.
- Perform a query on the database for all of the ID values that match the criteria and then use these values to retrieve specific sets.
- Configure EclipseLink to return a `ScrollableCursor` object from a query by using query hints. This returns a database cursor on the query's result set and allows the client to scroll through the results page by page.

For details on improving paging performance, see "How to use EclipseLink Pagination" in the EclipseLink online documentation, at:

http://wiki.eclipse.org/EclipseLink/Examples/JPA/Pagination#How_to_use_EclipseLink_Pagination

17.1.2.6 Cache Usage

EclipseLink uses a shared cache mechanism that is scoped to the entire persistence unit. When operations are completed in a particular persistence context, the results are merged back into the shared cache so that other persistence contexts can use them. This happens regardless of whether the entity manager and persistence context are created in Java SE or Java EE. Any entity persisted or removed using the entity manager will always be kept consistent with the cache.

You can specify how the query should interact with the EclipseLink cache by using the `eclipselink.cache-usage` hint. For more information, see "cache usage" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.3 Mapping

Mapping performance is enhanced by these features:

- [Indirection \("Lazy Loading"\)](#)
- [Read-Only Objects](#)
- [Weaving](#)

This section describes these features.

17.1.3.1 Read-Only Objects

When you declare a class read-only, clones of that class are neither created nor merged greatly improving performance. You can declare a class as read-only within the context of a unit of work by using the `addReadOnlyClass()` method.

- To configure a read-only class for a single unit of work, specify that class as the argument to `addReadOnlyClass()`:

```
myUnitOfWork.addReadOnlyClass(B.class);
```

- To configure multiple classes as read-only, add them to a vector and specify that vector as the argument to `addReadOnlyClass()`:

```
myUnitOfWork.addReadOnlyClasses(myVectorOfClasses);
```

For more information about using read-only objects to enhance performance, see "[@ReadOnly](#)" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.3.2 Weaving

Weaving is a technique of manipulating the byte-code of compiled Java classes. The EclipseLink JPA persistence provider uses weaving to enhance both JPA entities and Plain Old Java Object (POJO) classes for such things as lazy loading, change tracking, fetch groups, and internal optimizations.

Weaving can be performed either dynamically at runtime, when entities are loaded, or statically at compile time by post-processing the entity `.class` files. By default, EclipseLink uses dynamic weaving whenever possible. This includes inside an Java EE 5/6 application server and in Java SE when the EclipseLink agent is configured. Dynamic weaving is recommended as it is easy to configure and does not require any changes to a project's build process

For details on how to use weaving to enhance application performance, see "weaving" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.4 Transactions

To optimize performance during data transactions, use change tracking. Change tracking allows you to tune the way EclipseLink detects changes that occur during a transaction. You should choose the strategy based on the usage and data modification patterns of the entity type as different types may have different access patterns and hence different settings, and so on.

Enable change tracking by using the `@ChangeTracking` annotation, as shown in [Example 17-3](#).

Example 17-3 Enabling Change Tracking

```
@Entity
@Table(name="EMPLOYEE")
@ChangeTracking(OBJECT) (
public class Employee implements Serializable {
    ...
}
```

For more details on change tracking, see "[@ChangeTracking](#)" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.5 Database

Database performance features in EclipseLink include:

- [Connection Pooling](#)
- [Parameterized SQL and Statement Caching](#)
- [Batch Writing](#)

This section describes these features.

17.1.5.1 Connection Pooling

Establishing a connection to a data source can be time-consuming, so reusing such connections in a connection pool can improve performance. EclipseLink uses connection pools to manage and share the connections used by server and client sessions. This feature reduces the number of connections required and allows your application to support many clients.

By default, EclipseLink sessions use internal connection pools. These pools allow you to optimize the creation of read connections for applications that read data only to display it and only infrequently modify data. They also allow you to use Workbench to configure the default (write) and read connection pools and to create additional connection pools for object identity or any other purpose.

In addition to internal connection pools, you can also configure EclipseLink to use any of these types of connection pools:

- External connection pools; you must use this type of connection pool to integrate with external transaction controller (JTA).
- Default (write) and read connection pools;
- Sequence connection pools; Use these types of pools when your application requires table sequencing (that is, non-native sequencing) and you are using an external transaction controller.
- Application-specific connection pools; These are connection pools that you can create and use for any application purpose, provided you are using internal EclipseLink connection pools in a session.

For more information about using connection pools with EclipseLink, see the following topics in *EclipseLink Concepts*:

- "Understanding Connections"
- "Understanding Connection Pools"

17.1.5.2 Parameterized SQL and Statement Caching

Parameterized SQL can prevent the overall length of an SQL query from exceeding the statement length limit that your JDBC driver or database server imposes. Using parameterized SQL along with prepared statement caching can improve performance by reducing the number of times the database SQL engine parses and prepares SQL for a frequently called query.

By default, EclipseLink enables parameterized SQL but not prepared statement caching. You should enable statement caching either in EclipseLink when using an internal connection pool or in the data source when using an external connection pool and want to specify a statement cache size appropriate for your application.

To enable parameterized SQL, add this line to the `persistence.xml` file that is in the same path as your domain classes:


```
<property name="eclipselink.jdbc.bind-parameters" value="true"/>
```

To disable parameterized SQL, change value= to false.

For more information about using parameterized SQL and statement caching, see "jdbc.bind-parameters" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.5.3 Batch Writing

Batch writing helps optimize transactions with multiple write operations. Batch writing is enabled by using the EclipseLink JDBC extension batch-writing. You set one of the following parameter this property into the session at deployment time:

- JDBC; Use JDBC batch writing.
- Buffered; Do not use either JDBC batch writing nor native platform batch writing.
- Oracle-JDBC; Use both JDBC batch writing and Oracle native platform batch writing and use `OracleJDBC` in your property map.
- None; Disable batch writing.

For more information about batch writing, see "jdbc.batch-writing" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.1.6 Tools

EclipseLink provides monitoring and optimization tools, as described in [Section 17.2, "Monitoring and Optimizing EclipseLink-Enable Applications"](#).

17.2 Monitoring and Optimizing EclipseLink-Enable Applications

The most important challenge to performance tuning is knowing what to optimize. To improve the performance of your application, identify the areas of your application that do not operate at peak efficiency. This section contains information about these subjects:

- [Performance Optimization Recommendations and Tips](#)
- [Task 1: Measure EclipseLink Performance with the EclipseLink Profiler](#)
- [Task 2: Identify Sources of Application Performance Problems](#)
- [Task 3: Modify Poorly-Performing Application Components](#)
- [Task 4: Measure Performance Again](#)

17.2.1 Performance Optimization Recommendations and Tips

EclipseLink provides a diverse set of features to measure and optimize application performance. You can enable or disable most features in the descriptors or session, making any resulting performance gains global. Performance considerations are present at every step of the development cycle. Although this implies an awareness of performance issues in your design and implementation, it does not mean that you should expect to achieve the best possible performance in your first pass.

For example, if optimization complicates the design, leave it until the final development phase. You should still plan for these optimizations from your first iteration, to make them easier to integrate later.

The most important concept associated with tuning your EclipseLink application is the idea of an iterative approach. The most effective way to tune your application is to do the following tasks:

- [Task 1: Measure EclipseLink Performance with the EclipseLink Profiler.](#)
- [Task 2: Identify Sources of Application Performance Problems.](#)
- [Task 3: Modify Poorly-Performing Application Components.](#)
- [Task 4: Measure Performance Again.](#)

17.2.2 Task 1: Measure EclipseLink Performance with the EclipseLink Profiler

The EclipseLink performance profiler helps you identify performance problems by logging performance statistics for every executed query in a given session.

The EclipseLink performance profiler logs the following information to the log file.

Table 17–1 Information Logged by the EclipseLink Performance Profiler

Information Logged	Description
Query Class	Query class name.
Domain Class	Domain class name.
Total Time	Total execution time of the query, including any nested queries (in milliseconds).
Local Time	Execution time of the query, excluding any nested queries (in milliseconds).
Number of Objects	The total number of objects affected.
Number of Objects Handled per Second	How many objects were handled per second of transaction time.
Logging	the amount of time spent printing logging messages (in milliseconds).
SQL Prepare	The amount of time spent preparing the SQL script (in milliseconds).
SQL Execute	The amount of time spent executing the SQL script (in milliseconds).
Row Fetch	The amount of time spent fetching rows from the database (in milliseconds)
Cache	The amount of time spent searching or updating the object cache (in milliseconds)
Object Build	The amount of time spent building the domain object (in milliseconds)
query Prepare	the amount of time spent to prepare the query prior to execution (in milliseconds)
SQL Generation	the amount of time spent to generate the SQL script before it is sent to the database (in milliseconds)

17.2.2.1 Enabling the EclipseLink Profiler

The EclipseLink performance profiler is an instance of `org.eclipse.persistence.tools.profiler.PerformanceProfiler` class. To enable it, add the following line to the `persistence.xml` file:

```
<property name="eclipselink.profiler" value="PerformanceProfiler.logProfiler"/>
```

In addition to enabling the EclipseLink profiler, The `PerformanceProfiler` class public API also provides the functionality describes in [Table 17-2](#):

Table 17-2 Additional PerformanceProfiler Functionality

To...	Use...
Disable the profiler	<code>dontLogProfile</code>
Organize the profiler log into a summary of all the individual operation profiles including operation statistics like the shortest time of all the operations that were profiled, the total time of all the operations, the number of objects returned by profiled queries, and the total time that was spent in each kind of operation that was profiled	<code>logProfileSummary</code>
Organize the profiler log into a summary of all the individual operation profiles by query	<code>logProfileSummaryByQuery</code>
Organize the profiler log into a summary of all the individual operation profiles by class.	<code>logProfileSummaryByClass</code>

17.2.2.2 Accessing and Interpreting Profiler Results

You can see profiling results by opening the profile log in a text reader, such as Notepad.

The profiler output file indicates the health of a EclipseLink-enabled application.

[Example 17-4](#) shows an sample of the EclipseLink profiler output.

Example 17-4 Performance Profiler Output

```
Begin Profile of{
ReadAllQuery(com.demos.employee.domain.Employee)
Profile(ReadAllQuery,# of obj=12, time=139923809,sql execute=21723809,
prepare=49523809, row fetch=39023809, time/obj=11623809,obj/sec=8)
} End Profile
```

[Example 17-4](#) shows the following information about the query:

- `ReadAllQuery(com.demos.employee.domain.Employee)`: specific query profiled, and its arguments.
- `Profile(ReadAllQuery`: start of the profile and the type of query.
- `# of obj=12`: number of objects involved in the query.
- `time=139923809`: total execution time of the query (in milliseconds).
- `sql execute=21723809`: total time spent executing the SQL statement.
- `prepare=49523809`: total time spent preparing the SQL statement.
- `row fetch=39023809`: total time spent fetching rows from the database.
- `time/obj=11623809`: number of nanoseconds spent on each object.
- `obj/sec=8`: number of objects handled per second.

17.2.3 Task 2: Identify Sources of Application Performance Problems

Areas of the application where performance problems could occur include the following:

- Identifying General Performance Optimization

- Schema
- Mappings and Descriptors
- Sessions
- Cache
- Data Access
- Queries
- Unit of Work
- Application Server and Database Optimization

[Task 3: Modify Poorly-Performing Application Components](#) provides some guidelines for dealing with problems in each of these areas.

17.2.4 Task 3: Modify Poorly-Performing Application Components

For each source of application performance problems listed in [Section 17.2.3, "Task 2: Identify Sources of Application Performance Problems"](#), you can try specific workarounds, as described in this section.

17.2.4.1 Identifying General Performance Optimizations

Avoid overriding EclipseLink default behavior unless your application requires it.

Some of these defaults are suitable for a development environment; you should change these defaults to suit your production environment. These defaults may include:

- Batch writing – See "jdbc.batch-writing" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.
- Statement caching – See "jdbc.cache-statements" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.
- Read and write connection pool size – See "connection-pool" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.
- Session cache size – See "maintain-cache" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

Use the Workbench rather than manual coding. These tools are not only easy to use: the default configuration they export to deployment XML (and the code it generates, if required) represents best practices optimized for most applications.

17.2.4.2 Schema

Optimization is an important consideration when you design your database schema and object model. Most performance issues occur when the object model or database schema is too complex, as this can make the database slow and difficult to query. This is most likely to happen if you derive your database schema directly from a complex object model.

To optimize performance, design the object model and database schema together. However, allow each model to be designed optimally: do not require a direct one-to-one correlation between the two.

Possible ways to optimize the schema include:

- Aggregating two tables into one
- Splitting one table into many

- Using a collapsed hierarchy
- Choosing one out of many

See "Data Storage Schema" in *EclipseLink Concepts* for additional information.

17.2.4.3 Mappings and Descriptors

If you find performance bottlenecks in your mapping and descriptors, try these solutions:

- Always use indirection (lazy loading). It is not only critical in optimizing database access, but also allows EclipseLink to make several other optimizations including optimizing its cache access and unit of work processing. See "cache-usage" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.
- Avoid using method access in your EclipseLink mappings, especially if you have expensive or potentially dangerous side-effect code in your get or set methods; use the default direct attribute access instead. See "Using Method or Direct Field Access" in the *EclipseLink Concepts*.
- Avoid using the existence checking option `checkCacheThenDatabase` on descriptors, unless required by the application. The default existence checking behavior offers better performance. See "@ExistenceChecking" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.
- Avoid expensive initialization in the default constructor that EclipseLink uses to instantiate objects. Instead, use lazy initialization or use an EclipseLink instantiation policy to configure the descriptor to use a different constructor. See "@InstantiationCopyPolicy" in *Java Persistence API (JPA) Extensions Reference for EclipseLink*.

17.2.4.4 Cache

You can often improve performance through caching, even in a clustered environment by implementing cache coordination. Cache coordination allows multiple, possibly distributed instances of a session to broadcast object changes among each other so that each session's cache can be kept up-to-date. For detailed information about optimizing cache behavior, see "Understanding Caching" in *EclipseLink Concepts* and the following examples:

- <http://wiki.eclipse.org/EclipseLink/Examples/JPA/Caching>
- <http://wiki.eclipse.org/EclipseLink/Examples/JPA/CacheCoordination>
- <http://wiki.eclipse.org/EclipseLink/Examples/JPA/DCN>

17.2.4.5 Data Access

Depending on the type of data source your application accesses, EclipseLink offers a variety of `Login` options that you can use to tune the performance of low level data reads and writes. For optimizing higher-level data reads and writes, "Understanding Data Access" in *EclipseLink Concepts* offers several techniques to improve data access performance for your application. These techniques show you how to:

- Optimize JDBC driver properties.
- Optimize data format.
- Use batch writing for optimization.
- Use Outer-Join Reading with Inherited Subclasses.

- Use Parameterized SQL (Parameter Binding) and Prepared Statement Caching for Optimization.

17.2.4.6 Queries

EclipseLink provides an extensive query API for reading, writing, and updating data. "Understanding EclipseLink Queries" in *EclipseLink Concepts* offers several techniques to improve query performance for your application. These techniques show you how to:

- Use parameterized SQL and prepared statement caching for optimization.
- Use named queries for optimization.
- Use batch and join reading for optimization.
- Use partial object queries and fetch groups for optimization.
- Use read-only queries for optimization.
- Use JDBC fetch size for optimization.
- Use censored streams and scrollable cursors for optimization.
- Use result set pagination for optimization.

It also includes links to read and write optimization examples.

17.2.4.7 Application Server and Database Optimization

To optimize the application server and database performance, consider these techniques:

- Configuring your application server and database correctly can have a big impact on performance and scalability. Ensure that you correctly optimize these key components of your application in addition to your EclipseLink application and persistence.
- For your application or Java EE server, ensure your memory, thread pool and connection pool sizes are sufficient for your server's expected load, and that your JVM has been configured optimally.
- Ensure that your database has been configured correctly for optimal performance and its expected load.

17.2.5 Task 4: Measure Performance Again

Finally, after identifying possible performance bottlenecks and taking some action on them, rerun your application, again with the profiler enabled (see [Section 17.2.2.1, "Enabling the EclipseLink Profiler"](#)). Review the results and, if more action is required, follow the procedures outlined in [Section 17.2.4, "Task 3: Modify Poorly-Performing Application Components"](#).

17.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

-

Exposing JPA Entities Through RESTful Services Using EclipseLink Data Services

This chapter introduces EclipseLink Data Services (TLDS), with its support for exposing JPA persistence units through RESTful services.

This chapter contains the following sections:

- [Section 18.1, "Introduction to the Solution"](#)
- [Section 18.2, "Additional Resources"](#)
- [Section 18.3, "HTTP Request Reference for JPA-RS"](#)

Use Case

Expose persistent data model and application logic over REST for the development of Thin Server Architecture (TSA) clients including HTML5/JavaScript and mobile technologies.

Solution

Use Java Persistence API for RESTful Web Services (JPA-RS) to expose entities using a RESTful service, without writing JAX-RS code.

Components

- A Java EE application server with the following:
 - EclipseLink 2.4 or later.
 - Support for Java API for RESTful Web Services (JAX-RS) 1.0, for example Jersey.
- A compliant Java Database Connectivity (JDBC) database, such as Oracle Database, Oracle Express, or MySQL

18.1 Introduction to the Solution

Representational State Transfer (REST) defines a set of architectural principles for distributed systems, in which Web Services are viewed as resources. Those resources are identified by URIs and can be addressed and transferred using the HTTP protocol. REST can be used with a number of technologies, including JPA. HTTP methods are used to access and perform operations on resources.

You can use the Java API for RESTful Web Services (JAX-RS) to develop applications that use the REST architecture, by using annotations to define resources and the actions that can be performed on those resources. The "RESTful Service Example" at

wiki.eclipse.org/EclipseLink/Examples/REST/GettingStarted gives an example using this approach to interact with JPA persistence units.

However, EclipseLink provides an API that makes it easier to implement REST, without the need to use JAX-RS directly. EclipseLink Java Persistence API for RESTful Web Services (JPA-RS) can be used to interact with JPA persistence units and EJB session bean methods without explicitly writing JAX-RS code, thus providing a simple way to expose these Java EE capabilities through REST.

JPA-RS is made available via a web fragment, which extends the capabilities of a web application. The REST functionality is made available by including the JPA-RS jar in the WEB-INF/lib folder of a web application.

JPA-RS runtime provides access to all persistence units packaged in the same application that it is running in as well as any dynamic persistence unit that is provisioned within it.

18.1.1 Implementing the Solution

This section contains the following tasks for exposing JPA entities using JPA-RS:

- [Step 1: Prerequisites](#)
- [Step 2: Create and Configure the Application](#)
- [Step 3: Understand JPA-RS URI Basics](#)
- [Step 4: Issue Client Calls for Operations on the Persistence Unit](#)
- [Step 5: Represent Entities Using JPA, JAXB, or JSON](#)
- [Step 6: Implement Security](#)

18.1.1.1 Step 1: Prerequisites

To implement and use EclipseLink JPA-RS, you need:

- Either of the following Java EE application servers:
 - Oracle WebLogic Server 12c Release 1 (12.1.2) or later.
 - Glassfish Server 3.1.2 or later.

These servers include:

- EclipseLink 2.4 or later, configured as the persistence provider.
- Jersey, the reference implementation of the Java API for RESTful Web Services (JAX-RS) 1.0.
- The `org.eclipse.persistence.jpars_version.jar` file. This file is included in the EclipseLink distributions from the Eclipse foundation, at <http://www.eclipse.org/eclipselink/downloads/>:
 - In the installer distribution, the file is located in `eclipselink\jlib\jpa\`.
 - In the bundles distribution, the file is located with the other bundles.
- Any compliant Java Database Connectivity (JDBC) database, including Oracle Database, Oracle Database Express Edition (Oracle Database XE), or MySQL. These instructions are based on Oracle Database XE 11g Release 2.

For the certification matrix, see

18.1.1.2 Step 2: Create and Configure the Application

JPA-RS is designed to function with a standard JPA application, with little extra work required beyond enabling JPA-RS, as described below:

1. Develop an application using one or more standard JPA persistence units, package it in a WAR/EAR file, and deploy it normally.

Note: Weaving is required for several features to work: providing relationships as links, editing relationships, and dealing with lazy x-1 relationships. Either deploy to a Java EE compliant server or statically weave your classes.

Lazy x-1 relationships are only supported when using the JPA RS default mapping strategy, which returns those mappings as links by using read-only mappings for the JSON/XML support and providing the links through a weaved attribute.

2. Include the JPA-RS servlet in the EAR/WAR containing the application. (For instructions on downloading, see [Step 1: Prerequisites](#))

Note: The JPA-RS JAR file includes a `web-fragment.xml` file that identifies the JPA-RS servlet and defines the root URI for the RESTful service.

Add the `org.eclipse.persistence.jpars_version_no.jar` file to the WAR/EAR containing the application, under `WEB-INF/lib`.

18.1.1.3 Step 3: Understand JPA-RS URI Basics

URIs used for making HTTP calls for JPA-RS follow these standard patterns:

- The base URL for JPA-RS for an application is:
`http://server:port/application-name/persistence/`
- For base operations on the persistence unit, add the persistence unit name:
`/persistence/{unit-name}`
- For specific types of operations, add the type of operation, for example:
 - Entity operations: `/persistence/{unit-name}/entity`
 - Query operations: `/persistence/{unit-name}/query`
 - Single result query operations:
`/persistence/{unit-name}/querySingleResult`
 - Metadata operations: `/persistence/{unit-name}/metadata`

For complete documentation on how to construct these URIs, see [Section 18.3, "HTTP Request Reference for JPA-RS."](#)

18.1.1.4 Step 4: Issue Client Calls for Operations on the Persistence Unit

Clients use HTTP calls to perform operations on persistence units in a deployed application. The requirements and options for constructing the calls are described [Section 18.3, "HTTP Request Reference for JPA-RS."](#)

18.1.1.4.1 Specify Media Format in the Header This REST interface can handle both XML and JSON representations of data. The caller is responsible for using HTTP header values to indicate the format of the content:

- `Content-Type = application/json` indicates that the content being sent is JSON
- `Content-Type = application/xml` indicates that the content being sent is XML
- `Accept = application/json` indicates that the expected format of the result is JSON
- `Accept = application/xml` indicates that the expected format of the result is XML

If no header value is specified, JSON is used by default. If `Content-type` is specified and `Accept` is not specified, the returned format matches the `Content-type` passed in.

Note: In many REST utilities, the `Accept` value is defaulted to `application/xml`. In those cases, you must configure this value explicitly, if you want JSON.

18.1.1.4.2 Configure Web Caching (Optional) EclipseLink provides internal caching, but you can also cache the results from REST URI calls. The results can be cached at various points between the initiating server and the user, including the browser. This caching is determined by URI structure and the HTTP header information in the response from the REST calls. Generally only `GET` call responses are cached, so these must be addressed carefully to ensure the proper caching information is provided and the correct information is returned.

18.1.1.4.3 About Logging Messages related to JPA-RS operations are logged to a logger called `org.eclipse.persistence.jpars`. Most messages are logged at the `FINE` level. Exception stacks are logged at `FINER`.

Messages related to operations within `EntityManagers`, `EntityManagerFactory`s and `JAXBContext`s are logged in the same manner as other EclipseLink logging.

18.1.1.5 Step 5: Represent Entities Using JPA, JAXB, or JSON

Entities in JPA-RS are represented in two ways:

- **As JPA Entities** - The mappings of the JPA entities must be represented in the typical EclipseLink JPA fashion, using either annotations or XML files. These mappings are used to interact with the data source.
- **As JAXB/JSON** - No specific mapping information is required when using JAXB/JSON. By default, JPA-RS uses the JAXB defaults (defined in the JAXB specification) to map to JAXB/JSON. You can optionally provide JAXB annotations on the classes to alter the way the objects are mapped. Additionally, the persistence unit property `eclipselink.jpa-rs.xml` can be specified in a persistence unit's `persistence.xml` to specify XML-defined JAXB mappings.

18.1.1.5.1 Relationships In general, JAXB default mappings are sufficient to allow information exchange using JSON/JAXB. There are, however, some special cases when dealing with relationships.

Bidirectional Relationships and Cycles

Bidirectional relationships are typical in JPA and are easy to represent in a database using foreign keys. They are more difficult to represent in a XML or JSON document using standard JAXB. However, the EclipseLink JAXB implementation provides a way

to define an inverse relationship. Inverse relationships are not directly written to XML or JSON but are populated when the XML or JSON is unmarshalled. *The way this is handles is as follows:*

JPA bidirectional relationships are defined to have an owning side and a non-owning side. JPA mapping provides a `mapped-by` attribute that defines which is which. JPA-RS defaults the owning side to be an inverse relationship. As a result, when an object with an owned-relationship is read or written, that relationship is ignored.

Consider the following pseudo-code:

```
@Entity
ClassA{

    @Id
    int id

    @OneToOne
    myB

}

@Entity
ClassB{

    @Id
    int id

    @OneToOne (mappedby="myB")
    myA

}
```

If the objects are identified as follows...

- A1 with id=1 and myB = B1
- B1 with id=11 and myA = A1

...the following JSON cooresponds to those objects:

```
A {
  id:1
}

B {
  id:11
  myA: {
    id: 1
  }
}
```

Cycles can be difficult to detect, and JPA-RS requires that you provide JAXB mappings. That allows EclipseLink to resolve cycles in the cases where they can cause problems. In general, issues arise only when you try to create a group of new objects that include a cycle. To avoid problems in such cases, choose one of the mappings in the cycle and map it as `XMLTransient`.

Pass By Reference, Pass By Value

JPA-RS allows relationship objects to be passed either by value or by reference.

To pass an object by value, create typical JSON or XML that represents the object. The following JSON passes `myA` by value:

```
B {
  id:11
  myA {
    id: 1
  }
}
```

To pass an object by reference, use a `link`. The link represents the JPA-RS call necessary to get that object. The following JSON passes `myA` by reference:

```
B {
  id:11
  myA {
    _link:{
      href: "http://localhost:8080/app/persistence/pu/entity/A/1"
      method: "GET"
      rel: "self"
    }
  }
}
```

Lists can mix and match items represented by reference and by value.

JPA-RS read operations currently return all relationships by reference.

18.1.1.5.2 Sample JSON The following example shows JSON that can be sent to JPA-RS in a regular-expression-like syntax:

```
<code>
{
  numericAttribute: 1
  stringAttribute: "auction1"
  dateAttribute: 12-09-16
  singleRelatedItem: RELATED_ITEM?
  listRelatedItem:
  {
    RELATED_ITEM*
  }
}
```

RELATED_ITEM =

```
{
  numericAttribute: 11
  stringAttribute: "myName"
}
```

OR

```
_link {
  rel="self",
  href=LINK_HREF,
  method="GET"
}
```

The following JSON represents an entity called `StaticAuction` with several directly mapped fields and a collection of an entity called `Bid`.

```
{
```

```

    "description": "Auction 1",
    "endPrice": 0,
    "id": 2,
    "image": "auction1.jpg",
    "name": "A1",
    "sold": false,
    "startPrice": 100,
    "_relationships": [(1)
    {
      "_link": {
        "href":
"http://localhost:8080/eclipselink.jpars.test/persistence/auction-static/entity/St
aticAuction/2/bids",
        "rel": "bids"
      }
    },
    "bids": [(2)
    {
      "_link": {
        "href":
"http://localhost:8080/eclipselink.jpars.test/persistence/auction-static/entity/St
aticBid/5",
        "method": "GET",
        "rel": "self"
      }
    },
    {
      "_link": {
        "href":
"http://localhost:8080/eclipselink.jpars.test/persistence/auction-static/entity/St
aticBid/6",
        "method": "GET",
        "rel": "self"
      }
    }
  ]
}

```

18.1.1.5.3 Sample XML XML representation mimics the JSON representation. The following is sample XML for an entity called `StaticAuction`, with several directly mapped attributes and a list of an entity called `Bid`.

```

<staticAuction xmlns:atom="http://www.w3.org/2005/Atom">
  <description>Auction 1</description>
  <endPrice>0.0</endPrice>
  <id>2</id>
  <image>auction1.jpg</image>
  <name>A1</name>
  <sold>>false</sold>
  <startPrice>100.0</startPrice>
  <_relationships>
    <_link
href="http://localhost:8080/eclipselink.jpars.test/persistence/auction-static/enti
ty/StaticAuction/2/bids" rel="bids" />
  </_relationships>
  <bids>
    <_link
href="http://localhost:8080/eclipselink.jpars.test/persistence/auction-static/enti

```

```
ty/StaticBid/5" method="GET" rel="self" />
    </bids>
    <bids>
        <_link
href="http://localhost:8080/eclipselink.jpars.test/persistence/auction-static/enti
ty/StaticBid/6" method="GET" rel="self" />
    </bids>
</staticAuction>
```

18.1.1.6 Step 6: Implement Security

Secure JPA-RS through typical REST security mechanisms.

18.2 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- "Building RESTful Web Services with JAX-RS" in The Java EE 6 Tutorial at <http://docs.oracle.com/javaee/6/tutorial/doc/giepu.html>.
- "RESTful Service Example" at wiki.eclipse.org/EclipseLink/Examples/REST/GettingStarted.
- JSR 311: JAX-RS: The Java API for RESTful Web Services" at <http://jcp.org/en/jsr/detail?id=311>
- Jersey project at <http://jersey.java.net/>.

18.3 HTTP Request Reference for JPA-RS

The following types of RESTful operations can be used with JPA via HTTP when using JPA-RS.

- [Entity Operations](#)
- [Entity Operations on Relationships](#)
- [Query Operations](#)
- [Base Operations](#)
- [Metadata Operations](#)

Entity Operations

Entity operations are those performed against a specific entity type within the persistence unit.

The base URI for entity operations is as follows:

`/persistence/{unit-name}/entity/{type}/*`

The `{type}` value refers to the type name (descriptor alias).

Supported entity operations are:

- [FIND](#)
- [PERSIST](#)
- [MERGE](#)
- [DELETE](#)

FIND

HTTP Request Syntax

GET /persistence/{unit-name}/entity/{type}/{id} *hints*

where:

- {id} is a string
- *hints* are specified using HTTP query parameters, with the key being the name of the EclipseLink query hint

Example

GET http://localhost:8080/persistence/ExamplePU/entity/Foo/1

Produces

JSON or XML

Response

- OK, with a payload containing the entity
- NOT_FOUND if the entity does not exist

Usage

The `EntityManager.find` API is as follows:

```
public <T> T find(Class<T> entityClass, Object primaryKey);  
public <T> T find(Class<T> entityClass, Object primaryKey, Map<String, Object> properties);
```

Hints specified in the request are put into the `properties`. For example, see ["Refresh,"](#) below.

Composite Keys

Composite keys are supported. The `+` character is reserved and therefore cannot be used in fields that represent keys. Composite keys are separated using the `+` character and should be specified in an order corresponding to the Java default sorting of the attribute names.

For example, consider an entity `Phone`, with attributes `extB=123` and `extA=321`. The URL to find the entity is:

http://localhost:8080/persistence/ExamplePU/entity/Phone/321+123

The 321 comes before the 123 because `extA` comes before `extB` when sorted in Java.

Result Caching

Default EclipseLink and HTTP caching is enabled and configured through standard means.

Refresh

The `EntityManager.refresh` operation can be invoked using the `find` with the query hint for `Refresh`.

Attributes

Navigating into the attributes of an entity (for example, to get the Address entity associated with an employee in a single URL) is supported to one level, for example:

`/persistence/{unit-name}/entity/{type}/{id}/{relationship}` will work

while

`/persistence/{unit-name}/entity/{type}/{id}/{relationship}/{index}/{relationship2}` will not

PERSIST

HTTP Request Syntax

```
PUT /persistence/{unit-name}/entity/{type}
```

Example

```
PUT http://localhost:8080/persistence/ExamplePU/entity/Foo
```

Consumes

JSON or XML

Payload

Entity

Produces

JSON or XML

Response

Payload containing the entity returned by the persist operation

Usage

PUT is required to be idempotent. As a result, it will fail if called with an object that expects the server to provide an ID field. Typically this will occur if the metadata specifies a generated key and the field that contains that key is unpopulated.

MERGE

HTTP Request Syntax

```
POST /persistence/{unit-name}/entity/{type}
```

Example

```
POST http://localhost:8080/persistence/ExamplePU/entity/Foo
```

Consumes

JSON or XML

Payload

Entity

Produces

JSON or XML

Response

Payload containing the entity returned by the merge operation.

Merge takes an object graph and makes it part of the persistence context through comparison. It compares the object and all related objects to the ones that already exist and issues INSERTs, UPDATES, and DELETES to put the object in the persistence context.

DELETE

HTTP Request Syntax

`DELETE /persistence/{unit-name}/entity/{type}{id}`

where {id} is defined using HTTP query parameters

Example

`DELETE http://localhost:8080/persistence/ExamplePU/entity/Foo?id=1`

Response

OK

Entity Operations on Relationships

The base URI for relationship operations is as follows:

`/persistence/{unit-name}/entity/{entity}/{id}/{relationship}`

Supported relationship operations are:

- [READ](#)
- [ADD](#)
- [REMOVE](#)

READ

Use this operation to get the values of a relationship.

HTTP Request Syntax

```
GET /persistence/{unit-name}/entity/{type}/{id}/{relationship}
```

where:

- {id} is a string.
- {relationship} is the JPA name of the relationship.

Example

```
GET  
http://localhost:8080/persistence/ExamplePU/entity/Foo/1/myRelationship
```

Produces

JSON or XML

Response

- OK, Payload containing an entity or a list of entities.
- NOT_FOUND if the entity does not exist

ADD

Use this operation to add to a list or replace the value of an x-1 relationship.

HTTP Request Syntax

```
POST /persistence/{unit-name}/entity/{type}/{id}/{relationship}{partner}
```

Examples

For unidirectional relationships, {partner} is not required, for example:

```
POST
http://localhost:8080/persistence/ExamplePU/entity/Foo/1/myRelationship
```

For bi-directional relationships, you must provide the name of the attribute that makes up the opposite side of the relationship. For example, to update an Auction.bid where the opposite side of the relationship is Bid.auction, use the following:

```
POST
http://localhost:8080/persistence/ExamplePU/entity/Foo/1/myRelationship;partner=bid
```

Consumes

JSON or XML

Payload

Entity with the new value.

Note: Relationship objects can be passed by value or by reference. See "[Pass By Reference, Pass By Value](#)" on page 18-5.

Produces

JSON or XML

Response

Payload containing the entity with the added element

REMOVE

Use this operation to remove a specific entity from the list or a null on an x-1 relationship.

HTTP Request Syntax

```
DELETE /persistence/{unit-name}/entity/{type}/{id}/{relationship}
```

Example

```
DELETE  
http://localhost:8080/persistence/ExamplePU/entity/Foo/1/myRelationship
```

Consumes

JSON or XML

Payload

The entity to be removed

Note: Relationship objects can be passed by value or by reference. See "[Pass By Reference, Pass By Value](#)" on page 18-5.

Produces

JSON or XML

Response

- OK
- Payload containing the entity with the removed element

Query Operations

The base URI for query operations is as follows:

GET /persistence/{unit-name}/query/{name}{params}

The following query operations are supported:

Named queries doing reads can be run two ways in JPA. Both are supported in the REST API. They are:

- [Query Returning List of Results](#)
- [Update/Delete Query](#)

Query Returning List of Results

HTTP Request Syntax

GET /persistence/{unit-name}/query/{name} *parameters hints*

where:

- *parameters* are specified using HTTP matrix parameters
- *hints* are specified using HTTP query parameters and with the key being the name of the EclipseLink query hint

Examples

GET

http://localhost:8080/persistence/ExamplePU/query/Foo.findByName;name=myname

GET

http://localhost:8080/persistence/ExamplePU/query/Foo.findByName;name=myname?eclipselink.jdbc.max-results=500

Produces

JSON or XML

Response

A payload containing a list of entities.

Update/Delete Query

HTTP Request Syntax

POST /persistence/{unit-name}/query/{name} *parameters hints*

where:

- *parameters* are specified using HTTP matrix parameters
- *hints* are specified using HTTP query parameters and with the key being the name of the EclipseLink query hint

Examples

POST

http://localhost:8080/persistence/ExamplePU/query/Foo.deleteAllByName;name=myname

POST

http://localhost:8080/persistence/ExamplePU/query/Foo.updateName;name=myname?eclipselink.jdbc.max-results=500

Produces

application/octet-stream

Response

A payload containing the number of entities updated or deleted

Single Result Queries

HTTP Request Syntax

GET /persistence/{unit-name}/querySingleResult/{name} *parameters hints*

where:

- *parameters* are specified using HTTP matrix parameters
- *hints* are specified using HTTP query parameters and with the key being the name of the EclipseLink query hint

Example

```
GET
http://localhost:8080/persistence/ExamplePU/querySingleResult/Foo.findByName;name=myname
```

Produces

JSON or XML

Response

A payload containing an entity

Base Operations

Base operations are:

- [List Existing Persistence Units](#)
- [Call a Session Bean](#)

List Existing Persistence Units

HTTP Request Syntax

```
GET /persistence
```

Example

```
GET http://localhost:8080/persistence/
```

Produces

JSON

Response

A payload containing a list of persistence unit names and links to metadata about them. For example,

```
[
  {
    "rel": "auction",
    "type": "application/json",
    "href": "http://localhost:8080/Model/jpa-rs/auction/metadata"
  },
  {
    "rel": "DataAppLibraryPU",
    "type": "application/json",
    "href": "http://localhost:8080/Model/jpa-rs/DataAppLibraryPU/metadata"
  }
]
```

Call a Session Bean

HTTP Request Syntax

POST /persistence

where the payload is a `SessionBeanCall` JSON or XML object containing the following information:

- `jndiName` - The JNDI name of the `SessionBean`
- `methodName` - The name of the `SessionBean` method to call
- `context` - (optional) The JPA RS context to use to unmarshall parameters and marshall return values. If not provided, return values are returned as is
- `parameters` - A list of parameter Object with the following information
 - `typeName` - The name of the java class of the parameter, or the name of the entity type in JPA RS
 - `value` - The value of the parameter

Note: To support the security of an application, it is recommended that you disable this URL pattern by default. Only enable specific patterns that allow calling beans that are designed to be called.

Produces

- Produces `*/*` for entities in XML or JSON
- For queries that return single fields, returns the type associated with the field

Response

- `NOT_FOUND` if the context is not found or the session bean cannot be found on lookup
- `OK` when successful, with a payload containing the return value of a `SessionBean` method

Metadata Operations

The following metadata operations are supported:

- [List Types in a Persistence Unit](#)
- [List Queries in a Persistence Unit](#)
- [Describe a Specific Entity](#)

List Types in a Persistence Unit

HTTP Request Syntax

```
GET /persistence/{unit-name}/metadata
```

Example

```
GET http://localhost:8080/persistence/ExamplePU/metadata
```

Produces

JSON

Response

- OK, with a payload containing a list of types, with links to more detailed metadata for example,

```
{
  "persistence-unit-name": "auction",
  "types": [
    {
      "rel": "User",
      "type": "application/json",
      "href": "http://localhost:8080/Model/jpa-rs/auction/metadata/entity/User"
    },
    {
      "rel": "Auction",
      "type": "application/json",
      "href": "http://localhost:8080/Model/jpa-rs/auction/metadata/entity/Auction"
    },
    {
      "rel": "Bid",
      "type": "application/json",
      "href": "http://localhost:8080/Model/jpa-rs/auction/metadata/entity/Bid"
    }
  ]
}
```

- NOT_FOUND if the persistence unit is not found

List Queries in a Persistence Unit

HTTP Request Syntax

```
GET /persistence/{unit-name}/metadata/query
```

Example

```
GET http://localhost:8080/persistence/ExamplePU/metadata/query
```

Produces

JSON

Response

- OK with a payload containing a list of all available queries, for example,

```
[
  {
    "query-name": "User.all",
    "reference-type": "jpars.app.auction.model.User",
    "jpql": "SELECT u from User u",
    "link-template": {
      "rel": "execute",
      "method": "get",
      "href":
"http://localhost:8080/Model/jpa-rs/auction/query/User.all/{parameters}"
    }
  },
  {
    "query-name": "User.updateName",
    "reference-type": "jpars.app.auction.model.User",
    "jpql": "UPDATE User u SET u.name = :name WHERE u.id = :id",
    "link-template": {
      "rel": "execute",
      "method": "post",
      "href":
"http://localhost:8080/Model/jpa-rs/auction/query/User.updateName/{parameters}"
    }
  }
]
```
- NOT_FOUND if persistence unit is not found

Describe a Specific Entity

HTTP Request Syntax

```
GET /persistence/{unit-name}/metadata/entity/ type
```

Example

```
GET http://localhost:8080/persistence/ExamplePU/metadata/entity/MyEntity
```

Produces

```
JSON
```

Response

- OK, with a payload containing details about the entity and available operations on it, for example,

```
{
  "name": "User",
  "type": "jpars.app.auction.model.User",
  "link-templates": [
    {
      "rel": "find",
      "type": "application/json",
      "method": "get",
      "href":
"http://localhost:8080/Model/jpa-rs/auction/entity/Bid/{primaryKey}"
    },
    {
      "rel": "persist",
      "type": "application/json",
      "method": "put",
      "href": "http://localhost:8080/Model/jpa-rs/auction/entity/Bid"
    },
    {
      "rel": "update",
      "type": "application/json",
      "method": "post",
      "href": "http://localhost:8080/Model/jpa-rs/auction/entity/Bid"
    },
    {
      "rel": "delete",
      "type": "application/json",
      "method": "delete",
      "href":
"http://localhost:8080/Model/jpa-rs/auction/entity/Bid/{primaryKey}"
    }
  ],
  "attributes": [
    {
      "name": "id",
      "type": "java.lang.Integer"
    },
    {
      "name": "name",
      "type": "java.lang.String"
    }
  ]
},
```

```
"queries": [  
  {  
    "query-name": "User.all",  
    "reference-type": "jpars.app.auction.model.User",  
    "jpql": "SELECT u from User u"  
  },  
  {  
    "query-name": "User.updateName",  
    "reference-type": "jpars.app.auction.model.User",  
    "jpql": "UPDATE User u SET u.name = :name WHERE u.id = :id"  
  }  
]  
}
```

- NOT_FOUND if the persistence unit is not found

Using Caching with a Shared Database in a JPA Environment

This chapter describes EclipseLink Database Change Notification (DCN), which allows you to use caching with a shared database in JPA.

This chapter contains the following sections:

- [Section 19.1, "Introduction to the Solution"](#)
- [Section 19.2, "Implementing the Solution"](#)
- [Section 19.3, "Limitations on the Solution"](#)
- [Section 19.4, "Additional Resources"](#)

Use Case

Users want to use a shared cache with their JPA application, however, external applications update the same database data, or the cache is in a clustered environment. The cache may retain stale data.

Solution

EclipseLink provides an API which allows the database to notify EclipseLink of database changes. The changed objects can then be invalidated in the EclipseLink shared cache. Stale data can be discarded, even if other applications access the same data in the database.

Components

- Oracle 11gR2 (11.2) (or higher) database
- EclipseLink 12c Release 1 (12.1.2), specifically:
 - EclipseLink library: `eclipselink.jar`
 - JDBC library: `ojdbc6.jar`
 - JPA library: `persistence.jar`

Sample

For sample files that illustrate the use of Database Change Notification and shared caching in an application that uses JPA, see "EclipseLink/Examples/JPA/DCN" in the EclipseLink documentation.

<http://wiki.eclipse.org/EclipseLink/Examples/JPA/DCN>

19.1 Introduction to the Solution

EclipseLink provides a shared (L2) object cache that can reduce database access for objects and their relationships. This cache is enabled by default which is normally not a problem, unless the contents of the database are modified directly by other applications, or by the same application on other servers in a clustered environment. This may result in stale data in the cache.

If the contents of the database are modified, then a mechanism is needed to ensure that the contents of the cache are synchronized with the database. That mechanism is provided by EclipseLink Database Change Notification. DCN allows shared caching to be used in the JPA environment.

Note: Database Change Notification extends the functionality provided by the Oracle Database Continuous Query Notification feature. For more information, see "Continuous Query Notification" in *Oracle Database JDBC Developer's Guide*.

EclipseLink Database Change Notification extends the functionality provided by the Oracle Database Continuous Query Notification. One of the features of Continuous Query Notification is that it allows database events to be raised when rows in a table are modified.

To detect modifications, EclipseLink DCN uses the ROWID to inform of row level changes in the primary table. EclipseLink includes the ROWID in all queries for a DCN-enabled class. EclipseLink also selects the object's ROWID after an insert operation. EclipseLink maintains a cache index on the ROWID, in addition to the object's Id. EclipseLink also selects the database transaction ID once for each transaction to avoid invalidating the cache on the server that is processing the transaction.

EclipseLink DCN is enabled through the `OracleChangeNotificationListener` (`org.eclipse.persistence.platform.database.oracle.dcn.OracleChangeNotificationListener`) listener class. This listener integrates with Oracle JDBC to receive database change events. To enable the listener, specify the full path to the `OracleChangeNotificationListener` class as the value of the `eclipselink.cache.database-event-listener` property in the `persistence.xml` file.

By default, all entities in the domain are registered for change notification. However, you can selectively disable change notification for certain classes by tagging them in the Java files with the `databaseChangeNotificationType` (`org.eclipse.persistence.annotations.DatabaseChangeNotificationType`) attribute of the `Cache` annotation. The value of this attribute determines the type of database change notification an entity should use. The default value of the `databaseChangeNotificationType` attribute is `Invalidate`. To disable change notification for a class, set the value of the attribute to `None`.

The `databaseChangeNotificationType` attribute is relevant only if the persistence unit has been configured with a database event listener, such as the `OracleChangeNotificationListener` class, that receives database change events. This allows the EclipseLink cache to be invalidated or updated from database changes.

Oracle strongly suggests that you use optimistic locking (writes on stale data will fail and automatically invalidate the cache) in your transactions. If you include an `@Version` annotation in your entity, then the version column in the primary table will always be updated, and the object will always be invalidated.

19.2 Implementing the Solution

This section contains the following tasks to enable shared caching in a JPA environment:

- [Task 1: Setup the Database and Tables](#)
- [Task 2: Grant User Permissions](#)
- [Task 3: Set the Classpath](#)
- [Task 4: Identify Classes that will Participate in Change Notification](#)
- [Task 5: Add the Database Event Listener](#)
- [Task 6: Edit the Java Files](#)

19.2.1 Task 1: Setup the Database and Tables

The solution presumes that you are working with an Oracle 11gR2 (11.2) or higher database that contains the tables that you are interested in.

19.2.2 Task 2: Grant User Permissions

Among other permissions, the database user must be granted the `CHANGE NOTIFICATION` privilege. To do this, you must have a DBA privilege, such as `SYS`, or have your database administrator apply it:

```
grant change notification to user
```

The following example illustrates granting the change notification privilege to user.

```
...
define user="SCOTT"
define pass="tiger"
grant create session, alter session to &user
/
grant resource, connect to &user
/
grant select any dictionary to &user
/
grant select any table to &user
/
grant change notification to &user
/
...
```

19.2.3 Task 3: Set the Classpath

Ensure that the `eclipselink.jar` EclipseLink library, the `ojdbc6.jar` JDBC library, the `persistence.jar` JPA library, and the domain classes are present on the classpath.

19.2.4 Task 4: Identify Classes that will Participate in Change Notification

By default, all entities in the domain will participate in change notification. There are several different ways to limit the entities that will participate. For example, the entity classes can be indicated by the `<entity class ...>` element in the `orm.xml` file, indicated with the `<exclude-unlisted-classes>` element in the `persistence.xml` file, or contained in a JAR file.

Note: The `<exclude-unlisted-classes>` element is not intended for use in the Java SE environment.

Entity classes can also be excluded by using a `Cache` annotation attribute in the Java files. For more information, see [Section 19.2.6.2, "Exclude Classes from Change Notification \(Optional\)."](#)

Another way to identify the entity classes is to use the `<class>` element in the `persistence.xml` file. The following example indicates that the `Order`, `OrderLine`, and `Customer` classes in the `model` package will participate in change notification. For an example of a complete `persistence.xml` file, see [Example 19–1](#).

```
...
<class>model.Order</class>
<class>model.OrderLine</class>
<class>model.Customer</class>
...
```

19.2.5 Task 5: Add the Database Event Listener

Use the `eclipselink.cache.database-event-listener` property to identify the database event listener. The `org.eclipse.persistence.platform.database.oracle.dcn.OracleChangeNotificationListener` class is the listener for EclipseLink Database Change Notification. This allows the EclipseLink cache to be invalidated by database events.

The following example illustrates the `eclipselink.cache.database-event-listener` property configured with the `OracleChangeNotificationListener` class. For an example of a complete `persistence.xml` file, see [Example 19–1](#).

```
...
  <properties>
    <property name="eclipselink.cache.database-event-listener"
value="org.eclipse.persistence.platform.database.oracle.dcn.OracleChangeNotificati
onListener"/>
  </properties>
...
```

[Example 19–1](#) illustrates an example of a complete `persistence.xml` file. The classes that will participate in change notification are the `Order`, `OrderLine`, and `Customer` classes from the `model` package. The `eclipselink.cache.database-event-listener` property is set to the full path of the `OracleChangeNotificationListener` class.

Note: A `<provider>` tag is optional if running in a container where EclipseLink/EclipseLink is the default provider.

Example 19–1 Sample *persistence.xml* File

```
<?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
persistence_2_0.xsd"
  version="2.0">
  <persistence-unit name="acme" transaction-type="RESOURCE_LOCAL">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <class>model.Order</class>
```



```

        <class>model.OrderLine</class>
        <class>model.Customer</class>
        <exclude-unlisted-classes>false</exclude-unlisted-classes>
        <properties>
            <property name="eclipselink.cache.database-event-listener"
value="org.eclipse.persistence.platform.database.oracle.dcn.OracleChangeNotificati
onListener"/>
        </properties>
    </persistence-unit>
</persistence>

```

19.2.6 Task 6: Edit the Java Files

Typically, to participate in change notification, no changes are needed to the Java classes which correspond to database tables. However, setting optimistic locking with the `@Version` annotation is strongly suggested.

If you want to exclude classes that are listed in the persistence unit, you can tag them in the Java files. EclipseLink tracks changes only to the primary table. If you want changes to secondary tables to also be tracked, you can indicate this in the Java files.

19.2.6.1 Set Optimistic Locking

Oracle strongly suggests that you use optimistic locking: writes on stale data will fail and automatically invalidate the cache. Include an `@Version` annotation in your entity; the version column in the primary table will always be updated, and the older version of the object will always be invalidated.

In [Example 19–2](#) the `@Version` annotation is defined for the entity `Customer`. Note that getters and setters are defined for the version variable.

Example 19–2 Defining the @Version Annotation

```

...
@Entity
@Table(name="DBE_CUSTOMER")
public class Customer implements Serializable {
    @Id
    @GeneratedValue(generator="CUST_SEQ")
    @TableGenerator(name="CUST_SEQ")
    private long id;

    @Version
    private long version;

    ...

    public long getVersion() {
        return version;
    }

    public void setVersion(long version) {
        this.version = version;
    }
    ...
}

```

19.2.6.2 Exclude Classes from Change Notification (Optional)

Use the `databaseChangeNotificationType` attribute of the `Cache` annotation to identify the classes for which you do not want change notifications. To exclude a class

from change notification, set the attribute to `DatabaseChangeNotificationType.NONE`, as illustrated in the following example.

```
...
@Entity
@Cache(databaseChangeNotificationType=DatabaseChangeNotificationType.NONE)
public class Order {
...

```

19.2.6.3 Track Changes in Secondary Tables (Optional)

EclipseLink tracks changes only to the primary table. If any updates occur in a secondary table, EclipseLink will not invalidate the object. If you want changes to secondary tables to be tracked as well, add the `@Version` annotation to the entity.

Oracle DCN listens only for events from the primary table. It does not track changes in secondary tables, or relationships tables. The reason for this is that Oracle DCN only tracks the `ROWID`, so there is no correlation from the `ROWID` of the primary, secondary and relationship tables. Thus, to receive events when a secondary or relationship table changes, the version in the primary table must change so that the event is returned.

19.3 Limitations on the Solution

EclipseLink Database Change Notification has the following limitations:

- Changes to an object's secondary tables will not trigger it to be invalidate unless a `@Version` annotation is used and updated in the primary table.
- Changes to an object's `OneToMany`, `ManyToMany`, and `ElementCollection` relationships will not trigger it to be invalidate, unless an `@Version` annotation is used and updated in the primary table.

19.4 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- "Continuous Query Notification" in *Oracle Database JDBC Developer's Guide*.
- "EclipseLink/Examples/JPA/DCN"—This page describes an example of cache sharing in a JPA environment that employs DCN. Sample files and instructions for running the example are included. See the EclipseLink documentation:

<http://wiki.eclipse.org/EclipseLink/Examples/JPA/DCN>

Using EclipseLink with NoSQL Databases

This chapter describes how Oracle TopLink supports the ability to map objects to NoSQL database systems such as internet databases, object databases, XML databases, and even legacy databases.

This chapter contains the following sections:

- [Section 20.1, "Introduction to the Solution"](#)
- [Section 20.2, "Implementing the Solution"](#)
- [Section 20.3, "Additional Resources"](#)

Use Case

Users need to use EclipseLink with NoSQL data sources.

Solution

EclipseLink provides support for multiple NoSQL data sources. This solution illustrates using Oracle NoSQL and MongoDB.

Components

- EclipseLink 12c Release 1 (12.1.2).
- NoSQL datasource.
- JCA Adapter.

Sample

See the following EclipseLink samples for related information:

- <http://wiki.eclipse.org/EclipseLink/Examples/JPA/NoSQL>

20.1 Introduction to the Solution

EclipseLink supports access to NoSQL data through the JavaEE Connector Architecture. You must use a JCA adapter (provided by EclipseLink, a third party, or custom built).

Most NoSQL data is hierarchical in form so using embeddable objects is common. Some NoSQL adaptors support XML data, so NoSQL mapped objects can use XML mappings when mapping to XML.

20.2 Implementing the Solution

This section contains the following tasks for converting objects to and from JSON documents.

- [Task 1: Prerequisites](#)
- [Task 2: Mapping the Data](#)
- [Task 3: Defining IDs](#)
- [Task 4: Defining Mappings](#)
- [Task 5: Using Locking](#)
- [Task 6: Defining Queries](#)
- [Task 7: Connecting to the Database](#)

20.2.1 Task 1: Prerequisites

20.2.2 Task 2: Mapping the Data

You can configure mappings to NoSQL data with the EclipseLink `@NoSQL` annotation and `<no-sql>` XML element. The `@NoSQL` annotation defines the class as mapping to non-relational data. You can use `@NoSQL` with JPA Entity or Embeddable classes.

The `@NoSQL` annotation allows you to specify the `dataType` and `dataFormat` of the data. The `dataType` will vary, depending on your NoSQL datasource:

- For MongoDB, `dataType` is the collection name that the JSON documents are stored to.
- For Oracle NoSQL, `dataType` is the first part of the major key value.

The `dataFormat` depends on the type structure (data format) of data being stored.

- For MongoDB, use `MAPPED` for its structured database.
- For Oracle NoSQL, use `MAPPED` (for key/value data) or `XML` (for a single XML document).

[Example 20–1](#) illustrates how to use `@NoSQL` with `@Entity` and `@Embeddable` classes.

Example 20–1 Using @NoSql Annotation with JSON

```
@Entity
@NoSQL(dataType="orders", dataFormat=DataFormatType.MAPPED)
public class Order {
    @Id
    @GeneratedValue
    @Field(name="_id")
    private long id;
    @Basic
    @Field(name="description")
    private String description;
    @Embedded
    @Field(name="deliveryAddress")
    private Address deliveryAddress
    @ElementCollection
    @Field(name="orderLines")
```

```

    private List<OrderLine> orderLines;
    @ManyToOne
    @JoinField(name="customerId")
    private Customer customer;
}

@Embeddable
@NoSQL(dataFormat=DataFormatType.MAPPED)
public class OrderLine {
    @Field(name="lineNumber")
    private int lineNumber;
    @Field(name="itemName")
    private String itemName;
    @Field(name="quantity")
    private int quantity;
}

```

20.2.3 Task 3: Defining IDs

With EclipseLink, you can use any field (or set of fields) as your ID when using a non-relational database, just like any other relational Entity. You can use a *natural ID* (that is, assigned by the application) or a *generated ID* (that is, assigned by EclipseLink).

MongoDB also requires an `_id` field in every document. If no `_id` field is present, Mongo will automatically generate and assign the `_id` field using an OID (object identifier), which is similar to a UUID (universally unique identifier).

- To use a natural ID as the Mongo ID, simply name the field as `_id` by using the `@Field` (or `@Column`) annotation without any of the relational details.

For example:

```

@Field(name="_id")
private long id;

```

- To use the generated Mongo OID as your ID, simply include `@Id`, `@GeneratedValue`, and `@Field(name="_id")` annotations in the object's ID field mapping.

The `@GeneratedValue` tells EclipseLink to use the Mongo OID to generate this ID value. To use a UUID instead of the Mongo OID, use the `@UUIDGenerator` annotation.

Note: MongoDB does not support `@SequenceGenerator` or `@TableGenerator` nor the `IDENTITY`, `TABLE`, and `SEQUENCE` generation types.

The ID of the Mongo OID or UUID is not a numerical value; you must map it as a `String` or `byte[]`.

For example:

```

@Id
@GeneratedValue
@Field(name="_id")

```

```
private String id;
```

20.2.4 Task 4: Defining Mappings

With non-relational databases, EclipseLink maps objects to structured data such as XML or JSON. NoSQL supports embedded data and embedded collections. NoSQL supports all existing JPA mapping annotations and XML, including embedded data and embedded collections. If you do not define a mapping annotation (or XML) for an attribute EclipseLink uses the default mapping.

Basic Mappings

Because the NoSQL defaults follow the JPA defaults, most simple mappings do not require any configuration. Field names used in the Mongo BSON document will mirror the object attribute names (in uppercase). To use a different BSON field name, use the `@Field` annotation.

Note: Do not use `@Column` or `@JoinColumn`. Instead use `@Field` and `@JoinField`. Additionally, the `@JoinTable` and `@CollectionTable` annotations are not supported or required.

Embedded Values

Use the `@Embedded` annotation to persist embedded values and the `@ElementCollection` annotation for embedded collections. Because all data is stored in the XML document, no separate table (that is, `@CollectionTable`) is needed. Additionally, because embedded objects are nested in the document and do not require unique field names, the `@AttributeOverride` attribute is not needed.

Note: Normally, you will not need to use the `@Embedded` annotation, since it will default correctly.

However, EclipseLink does not default `@ElementCollection` mappings, therefore you must include that annotation.

Relationships

You should use the relationship annotations (such as `@OneToOne`, `@ManyToOne`, `@OneToMany` and `@ManyToMany`) only with *external* relationships. Relationships *within* the document should use the [Embedded Values](#).

EclipseLink fully supports external relationships to other documents by using a foreign key. The ID of the target object is stored in the source object's document. For a collection, a collection of IDs is stored. Use the `@JoinField` annotation to define the name of the foreign key field in the BSON document.

Note: EclipseLink does not support the `mappedBy` option for relationships with non-relational databases, as the foreign keys would need to be stored on both sides.

You can also define a relationship mapping by using a query. However you must use a `DescriptorCustomizer` instead of an annotation.

Example 20–2 Sample Mappings

```

@Basic
private String description;
@Basic
private double totalCost = 0;
@Embedded
private Address billingAddress;
@Embedded
private Address shippingAddress;
@ElementCollection
private List<OrderLine> orderLines = new ArrayList<OrderLine>();
@ManyToOne(fetch=FetchType.LAZY)
private Customer customer;

```

20.2.5 Task 5: Using Locking

Locking support is dependent on the NoSQL platform. Some NoSQL platforms may offer support for optimistic version locking.

- Oracle NoSQL – Locking is not supported.
- MongoDB – Version locking is supported.

Note: MongoDB does not support transactions. If a lock error occurs during a transaction, any objects that have been previously written will not be rolled back.

If the NoSQL platform does not support locking, you can use the `@Version` annotation (as shown in [Example 20–3](#)) to validate objects on `merge()` operations.

Example 20–3 Using @Version

```

@Version
private long version;
...

```

20.2.6 Task 6: Defining Queries

Querying in NoSQL is dependent on the NoSQL platform. Some NoSQL data-sources may support dynamic querying through their own query language, others may not support querying at all.

20.2.6.1 JPQL Queries

The Java Persistence Query Language (JPQL) is the query language defined by JPA. JPQL can be used for reading (`SELECT`), as well as bulk updates (`UPDATE`) and deletes (`DELETE`). You can use JPQL in a `NamedQuery` (through annotations or XML) or in dynamic queries using the `EntityManager.createQuery()` API.

- Oracle NoSQL – Supports `find()` and JPQL and Criteria by Id or with no `WHERE` clause.
- MongoDB – Supports JPQL and Criteria queries, with some restrictions: joins, sub-selects, group by and certain database functions are not supported.

Example 20–4 Oracle NoSQL JPQL Examples**Example 20–5 MongoDB JPQL Examples**

```
Query query = em.createQuery("Select o from Order o where o.totalCost > 1000");
List<Order> orders = query.getResultList();
```

```
Query query = em.createQuery("Select o from Order o where o.description like 'Pinball%'");
List<Order> orders = query.getResultList();
```

```
Query query = em.createQuery("Select o from Order o join o.orderLines l where l.description = :desc");
query.setParameter("desc", "shipping");
List<Order> orders = query.getResultList();
```

```
Query query = em.createQuery("Select o.totalCost from Order o");
List<BigDecimal> orders = query.getResultList();
```

20.2.6.2 Native Queries

Native SQL queries are not translated, and passed directly to the database. SQL queries can be used for advanced queries that require database specific syntax.

Although native SQL queries are not supported with NoSQL, some NoSQL platforms have their own, native query language. EclipseLink supports JPA native queries using that language.

- MongoDB – Supports JPA native queries by using the MongoDB native command language.

Example 20–6 Oracle NoSQL Native Query**Example 20–7 MongoDB Native Query**

```
Query query = em.createNativeQuery("db.ORDER.findOne({'_id':'" + oid + "'})",
Order.class);
Order order = (Order)query.getSingleResult();
```

20.2.7 Task 7: Connecting to the Database

EclipseLink connects to NoSQL databases through the persistence.xml file. Use the <eclipselink.target-database> property to define the specific NoSQL platform. You must also define a connection with the <eclipselink.nosql.connection-spec> property. Additional connection values (such as the db, port, and host can also be defined.

Note: To connect to a cluster of Mongo databases, enter a comma-separated list of values for the host and port.

Example 20–8 Oracle NoSQL persistence.xml Example

Example 20–9 MongoDB persistence.xml Example

```
<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 persistence_2_0.xsd"
version="2.0">
    <persistence-unit name="acme" transaction-type="RESOURCE_LOCAL">
        <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
        <exclude-unlisted-classes>false</exclude-unlisted-classes>
        <properties>
            <property name="eclipselink.target-database"
value="org.eclipse.persistence.nosql.adapters.mongo.MongoPlatform"/>
            <property name="eclipselink.nosql.connection-spec"
value="org.eclipse.persistence.nosql.adapters.mongo.MongoConnectionSpec"/>
            <property name="eclipselink.nosql.property.mongo.port" value="27017,
27017"/>
            <property name="eclipselink.nosql.property.mongo.host" value="host1,
host2"/>
            <property name="eclipselink.nosql.property.mongo.db" value="acme"/>
        </properties>
    </persistence-unit>
</persistence>
```

20.3 Additional Resources

See the following resources for more information about the technologies and tools used to implement the solutions in this chapter:

- *Developing Persistence Architectures Using EclipseLink MOXy Developer's Guide*
- *Java Persistence API (JPA) Extensions Reference for EclipseLink*
- EclipseLink Extensions Incubator:
<http://wiki.eclipse.org/EclipseLink/Development/Incubator/Platformform>

Using EclipseLink with the Oracle Database

This chapter provides instructions for understanding and using EclipseLink features that are designed specifically to support the Oracle Database platform.

This chapter contains the following sections:

- [Introduction to the Solution](#)
- [Implementing the Solution](#)
- [Additional Resources](#)

Use Case

EclipseLink offers a persistence solution that is designed to work with any database. However, applications that plan to use the Oracle Database platform can take advantage of enhanced support for the Oracle Database.

Solution

The solution is achieved by using various EclipseLink APIs and Oracle products. Applications choose to implement different EclipseLink APIs based on the Oracle Database feature or products being used.

Components

The solution requires EclipseLink and Oracle Database. Additional Oracle Database and Middleware products are required depending on the features that an application chooses to use.

21.1 Introduction to the Solution

EclipseLink includes enhanced support for the Oracle Database platform. Applications that have standardized on the Oracle Database can take advantage of this support to gain ease-of-use, increase performance and scalability, and enhance security. EclipseLink includes support for native Oracle JDBC-specific APIs, PL/SQL, Oracle Real Application Clusters (RAC), Oracle Virtual Private Database, Oracle Proxy Authentication, and Oracle Spatial and Graph. Refer to the Oracle Database documentation for details on these technologies.

Much of the Oracle Database platform support is contained in the `org.eclipse.persistence.platform.database.oracle*` package. For details on the APIs, see *Java API Reference for EclipseLink*.

21.2 Implementing the Solution

The solution in this section is organized according to technology. The organization allows developers to easily understand the different parts of the solution and choose specific parts to implement.

This section includes the following topics:

- [Using Oracle Platform-Specific APIs](#)
- [Using Oracle PL/SQL With EclipseLink](#)
- [Using Oracle Virtual Private Database](#)
- [Using Oracle Proxy Authentication](#)
- [Using EclipseLink with Oracle RAC](#)
- [Using Oracle Spatial and Graph](#)

21.2.1 Using Oracle Platform-Specific APIs

Oracle Database platform support is provided in the `org.eclipse.persistence.platform.database.OraclePlatform` class, the `org.eclipse.persistence.platform.database.oracle*` packages, and the `org.eclipse.persistence.mappings.xml.xdb` package for Oracle XML Database support. For details on the API, see *Java API Reference for EclipseLink*. For details on specific Oracle SQL types, see *Oracle Database JDBC Java API Reference*.

The following support is provided for the Oracle Database:

- Batch writing with optimistic locking
- Native SQL for `byte[]`, `Date`, `Time`, `Timestamp` and `Calendar`
- Support for `BLOB` and `CLOB` database types using Oracle JDBC specific `LOBLocator` for large values

Note: For non-Oracle thin JDBC drivers or applications environments where the thin driver is wrapped, it is possible to turn off `LOBLocator` usage using `setShouldUseLocatorForLOBWrite(boolean)` on the platform instance.

- Native support for outer join syntax `(+) =`
- Native Sequencing (`SELECT SEQ_NAME.NEXTVAL FROM DUAL`)
- Native SQL/`ROWNUM` support for `MaxRows` and `FirstResult` filtering.
- Hierarchical selects (`connect by prior`)
- Returning clause
- Custom expression functions (`REGEXP_LIKE`, `LOCATE`, `ATAN2`, `LOG`, `CONCAT`, `SYSDATE` (`Date`, `Time`, `Today`), `EXCEPT`)
- PLSQL data types, stored functions, stored procedure syntax for invoking and parameter passing, output parameters and output cursors. See [Section 21.2.2, "Using Oracle PL/SQL With EclipseLink."](#)
- Timestamp query for use in optimistic locking using `SYSDATE` and `SYSTIMESTAMP`
- Multi-byte support of `NCHAR`, `NSTRING`, and `NCLOB`

- Support of `TIMESTAMP`, `TIMESTAMP``TZ`, and `TIMESTAMP``PLTZ`
- Oracle XML Database support of `XMLType` field and custom XSQL functions (`extract`, `extractValue`, `existsNode`, `isFragment`, `getStringVal`, and `getNumberVal`)
- XDK XML parser
- Flashback Querying in Historical Sessions
- Object-relational Mappings (`ReferenceMapping`, `StructureMapping`, `NestedTableMapping`, `ArrayMapping`, `ObjectArrayMapping`)
- Oracle AQ
- Oracle Real Application Clusters. See [Section 21.2.5, "Using EclipseLink with Oracle RAC."](#)
- Virtual Private Database (VPD), including Oracle Label Security. [Section 21.2.3, "Using Oracle Virtual Private Database."](#)
- Proxy Authentication. See [Section 21.2.4, "Using Oracle Proxy Authentication."](#)

21.2.2 Using Oracle PL/SQL With EclipseLink

EclipseLink includes APIs for use with Oracle PL/SQL. The APIs are located in the `org.eclipse.persistence.platform.database.oracle.plsql` package and the `org.eclipse.persistence.platform.database.oracle.annotations` package.

This Section contains the following topics:

- [Executing an Oracle PL/SQL Stored Function](#)
- [Handling PL/SQL arguments for Oracle Stored Procedures](#)

21.2.2.1 Executing an Oracle PL/SQL Stored Function

Oracle PL/SQL stored functions can be used to return complex PL/SQL data-types such as `RECORD` types and `TABLE` types. PL/SQL types are not supported by Oracle JDBC, so these types must be translated to Oracle `OBJECT` types and `VARRAY` types. `OBJECT` types are returned as `java.sql.Struct` and `VARRAY` as `java.sql.Array` types in JDBC.

Executing PL/SQL stored functions or procedures requires defining mirror `OBJECT` and `VARRAY` types for the `RECORD` and `TABLE` types. `OBJECT` types can be mapped to classes annotated with either `@Entity` or `@Embeddable` using the `@Struct` annotation. Typically, classes annotated with `@Embeddable` are used, unless the `OBJECT` type defines an `Id` and can be stored in a table. Nested `OBJECT` and `VARRAY` types are mapped using the `@Structure` and `@Array` annotations.

Use the `PLSQLStoredFunctionCall` class or the `@NamedPLSQLStoredFunctionQuery` annotation to call a stored function using PL/SQL types. The `PLSQLStoredProcedureCall` class and the `@NamedPLSQLStoredProcedureQuery` annotation also exist for stored procedures. Use the `StoredFunctionCall` class, the `@NamedStoredFunctionQuery` annotation, the `StoredProcedureCall` class, and the `@NamedStoredProcedureQuery` annotation for stored functions and procedure that do not return complex PL/SQL types.

21.2.2.1.1 Main Tasks To execute an Oracle PL/SQL stored function:

- [Task 1: Create an Oracle Stored Function That Returns a PL/SQL Record Type](#)
- [Task 2: Define an Object Type Mirror](#)

- [Task 3: Define a Java Class Mapping The OBJECT Type](#)
- [Task 4: Execute a PL/SQL Stored Function Using JpaEntityManager](#)
- [Task 5: Define a Stored Function Using @NamedPLSQLStoredFunctionQuery](#)
- [Task 6: Use the Stored Function in a Query](#)

21.2.2.1.2 Task 1: Create an Oracle Stored Function That Returns a PL/SQL Record Type

```
CREATE OR REPLACE PACKAGE EMP_PKG AS
TYPE EMP_REC IS RECORD (F_NAME VARCHAR2(30), L_NAME VARCHAR2(30),
    SALARY NUMBER(10,2));
FUNCTION GET_EMP RETURN EMP_REC;
END EMP_PKG;

CREATE OR REPLACE PACKAGE BODY EMP_PKG AS
FUNCTION GET_EMP RETURN EMP_REC AS
    P_EMP EMP_REC;
BEGIN P_EMP.F_NAME := 'Bob'; P_EMP.L_NAME := 'Smith'; P_EMP.SALARY := 30000;
RETURN P_EMP;
END;
END EMP_PKG;
```

21.2.2.1.3 Task 2: Define an Object Type Mirror

```
CREATE OR REPLACE TYPE EMP_TYPE AS OBJECT (F_NAME VARCHAR2(30),
    L_NAME VARCHAR2(30), SALARY NUMBER(10,2))
```

21.2.2.1.4 Task 3: Define a Java Class Mapping The OBJECT Type

```
@Embeddable
@Struct(name="EMP_TYPE", fields={"F_NAME", "L_NAME", "SALARY"})
public class Employee {
    @Column(name="F_NAME")
    private String firstName;
    @Column(name="L_NAME")
    private String lastName;
    @Column(name="SALARY")
    private BigDecimal salary;
    ...
}
```

21.2.2.1.5 Task 4: Execute a PL/SQL Stored Function Using JpaEntityManager

```
import javax.persistence.Query;
import org.eclipse.persistence.platform.database.oracle.plsql.
    PLSQLStoredFunctionCall;
import org.eclipse.persistence.queries.ReadAllQuery;

DataReadQuery databaseQuery = new DataReadQuery();
databaseQuery.setResultType(DataReadQuery.VALUE);
PLSQLrecord record = new PLSQLrecord();
record.setTypeName("EMP_PKG.EMP_REC");
record.setCompatibleType("EMP_TYPE");
record.setJavaType(Employee.class);
record.addField("F_NAME", JDBCTypes.VARCHAR_TYPE, 30);
record.addField("L_NAME", JDBCTypes.VARCHAR_TYPE, 30);
record.addField("SALARY", JDBCTypes.NUMERIC_TYPE, 10, 2);
```

```

PLSQLStoredFunctionCall call = new PLSQLStoredFunctionCall(record);
call.setProcedureName("EMP_PKG.GET_EMP");
databaseQuery.setCall(call);

Query query = ((JpaEntityManager)entityManager.getDelegate()).
    createQuery(databaseQuery);
Employee result = (Employee)query.getSingleResult();

```

21.2.2.1.6 Task 5: Define a Stored Function Using @NamedPLSQLStoredFunctionQuery

```

@NamedPLSQLStoredFunctionQuery(name="getEmployee", functionName="EMP_PKG.GET_EMP",
    returnParameter=@PLSQLParameter(name="RESULT", databaseType="EMP_PKG.EMP_REC"))
@Embeddable
@Struct(name="EMP_TYPE", fields={"F_NAME", "L_NAME", "SALARY"})
@PLSQLRecord(name="EMP_PKG.EMP_REC", compatibleType="EMP_TYPE",
    javaType=Employee.class, fields={@PLSQLParameter(name="F_NAME"),
@PLSQLParameter(name="L_NAME"), @PLSQLParameter(name="SALARY",
    databaseType="NUMERIC_TYPE")})

public class Employee {
    ...
}

```

21.2.2.1.7 Task 6: Use the Stored Function in a Query

```

Query query = entityManager.createNamedQuery("getEmployee");
Employee result = (Employee)query.getSingleResult();

```

21.2.2.2 Handling PL/SQL arguments for Oracle Stored Procedures

The standard way of handling a stored procedure is to build an instance of the `StoredProcedureCall` class. However, the arguments must be compatible with the JDBC specification. To handle Oracle PL/SQL arguments (for example, `BOOLEAN`, `PLS_INTEGER`, `PL/SQL record`, and so on), use the `PLSQLStoredProcedureCall` class.

Note: the `PLSQLStoredProcedureCall` class is only supported on Oracle8 or higher.

21.2.2.2.1 Using the `PLSQLStoredProcedureCall` Class The following example demonstrates handling PL/SQL arguments using the `PLSQLStoredProcedureCall` class. The example is based on the following target procedure:

```
PROCEDURE bool_in_test(x IN BOOLEAN)
```

Example of Using the `PLSQLStoredProcedureCall` Class

```

import java.util.List;
import java.util.ArrayList;
import org.eclipse.persistence.logging.SessionLog;
import org.eclipse.persistence.platform.database.jdbc.JDBCTypes;
import org.eclipse.persistence.platform.database.oracle.Oracle10Platform;
import org.eclipse.persistence.platform.database.oracle.OraclePLSQLTypes;
import org.eclipse.persistence.platform.database.oracle.PLSQLStoredProcedureCall;
import org.eclipse.persistence.queries.DataModifyQuery;
import org.eclipse.persistence.sessions.DatabaseLogin;
import org.eclipse.persistence.sessions.DatabaseSession;

```

```
import org.eclipse.persistence.sessions.Project;
import org.eclipse.persistence.sessions.Session;

public class TestClass {

    public static String DATABASE_USERNAME = "username";
    public static String DATABASE_PASSWORD = "password";
    public static String DATABASE_URL = "jdbc:oracle:thin:@localhost:1521:ORCL";
    public static String DATABASE_DRIVER = "oracle.jdbc.driver.OracleDriver";

    public static void main(String[] args) {
        Project project = new Project();
        DatabaseLogin login = new DatabaseLogin();
        login.setUserName(DATABASE_USERNAME);
        login.setPassword(DATABASE_PASSWORD);
        login.setConnectionString(DATABASE_URL);
        login.setDriverClassName(DATABASE_DRIVER);
        login.setDatasourcePlatform(new Oracle10Platform());
        project.setDatasourceLogin(login);
        Session s = project.createDatabaseSession();
        s.setLogLevel(SessionLog.FINE);
        ((DatabaseSession)s).login();

        PLSQLStoredProcedureCall call = new PLSQLStoredProcedureCall();
        call.setProcedureName("bool_in_test");
        call.addNamedArgument("X", OraclePLSQLTypes.PLSQLBoolean);
        DataModifyQuery query = new DataModifyQuery();
        query.addArgument("X");
        query.setCall(call);
        List queryArgs = new ArrayList();
        queryArgs.add(Integer.valueOf(1));
        s.executeQuery(query, queryArgs);
    }
}
```

The following log excerpt shows the target procedure being invoked from an anonymous PL/SQL block:

```
...
[EclipseLink Info]: 2007.11.23 01:03:23.890--DatabaseSessionImpl(15674464)--
  Thread(Thread[main,5,main])-- login successful
[EclipseLink Fine]: 2007.11.23 01:03:23.968--DatabaseSessionImpl(15674464)--
  Connection(5807702)--Thread(Thread[main,5,main])--
DECLARE
    X_TARGET BOOLEAN := SYS.SQLJUTL.INT2BOOL(:1);
BEGIN
    bool_in_test(X=>X_TARGET);
END;
bind => [:1 => 1]
```

Note: Notice the conversion of the Integer to a PL/SQL BOOLEAN type in the DECLARE stanza (as a similar conversion is used for OUT BOOLEAN arguments).

21.2.2.2.2 Mixing JDBC Arguments With Non JDBC Arguments A Stored Procedure may have a mix of regular and non JDBC arguments. Use the `PLSQLStoredProcedureCall` class when at least one argument is a non JDBC type. In addition, some additional information may be required for the JDBC type (length, scale or precision) because the

target procedure is invoked from an anonymous PL/SQL block. The example is based on the following target procedure:

```
PROCEDURE two_arg_test(x IN BOOLEAN, y IN VARCHAR)
```

Example of Mixing JDBC Arguments With NonJDBC Arguments

```
import org.eclipse.persistence.platform.database.jdbc.JDBCTypes;
...
PLSQLStoredProcedureCall call = new PLSQLStoredProcedureCall();
call.setProcedureName("two_arg_test");
call.addNamedArgument("X", OraclePLSQLTypes.PLSQLBoolean);
call.addNamedArgument("Y", JDBCTypes.VARCHAR_TYPE, 40);
DataModifyQuery query = new DataModifyQuery();
query.addArgument("X");
query.addArgument("Y");
query.setCall(call);
List queryArgs = new ArrayList();
queryArgs.add(Integer.valueOf(0));
queryArgs.add("test");
boolean worked = false;
String msg = null;
s.executeQuery(query, queryArgs);
```

The following log excerpt shows the target procedure being invoked from an anonymous PL/SQL block:

```
[EclipseLink Fine]: 2007.11.23 02:54:46.109--DatabaseSessionImpl(15674464)--
Connection(5807702)--Thread(Thread[main,5,main])--
DECLARE
  X_TARGET BOOLEAN := SYS.SQLJUTL.INT2BOOL(:1);
  Y_TARGET VARCHAR(40) := :2;
BEGIN
  two_arg_test(X=>X_TARGET, Y=>Y_TARGET);
END;
bind => [:1 => 0, :2 => test]
```

21.2.2.2.3 Handling IN and OUT Arguments The following example demonstrates a stored procedure that contain both IN and OUT arguments and is based on the following target procedure:

```
PROCEDURE two_arg_in_out(x OUT BINARY_INTEGER, y IN VARCHAR) AS
BEGIN
  x := 33;
END;
```

Example of Handling IN and OUT Arguments

```
import static org.eclipse.persistence.platform.database.oracle.OraclePLSQLTypes.
  BigInteger;
...
PLSQLStoredProcedureCall call = new PLSQLStoredProcedureCall();
call.setProcedureName("two_arg_in_out");
call.addNamedOutputArgument("X", OraclePLSQLTypes.BigInteger);
call.addNamedArgument("Y", JDBCTypes.VARCHAR_TYPE, 40);
DataReadQuery query = new DataReadQuery();
query.setCall(call);
query.addArgument("Y");
List queryArgs = new ArrayList();
```

```
queryArgs.add("testsdfsdfasdfsdfsdfsdfsdfsdfsdfsdfsdfs");
boolean worked = false;
String msg = null;
List results = (List)s.executeQuery(query, queryArgs);
DatabaseRecord record = (DatabaseRecord)results.get(0);
BigDecimal x = (BigDecimal)record.get("X");
if (x.intValue() != 33) {
    System.out.println("wrong x value");
}
```

The following log excerpt shows the target procedure being invoked from an anonymous PL/SQL block:

```
[EclipseLink Fine]: 2007.11.23 03:15:25.234--DatabaseSessionImpl(15674464)--
Connection(5807702)--Thread(Thread[main,5,main])--
DECLARE
    Y_TARGET VARCHAR(40) := :1;
    X_TARGET BINARY_INTEGER;
BEGIN
    two_arg_in_out(X=>X_TARGET, Y=>Y_TARGET);
    :2 := X_TARGET;
END;
bind => [:1 => testsdfsdfasdfsdfsdfsdfsdfsdfsdfsdfsdfs, X => :2]
```

Note: The order in which arguments are bound at runtime must be altered. Anonymous PL/SQL blocks must process the ordinal markers (:1,:2) for all the IN arguments first, then the OUT arguments. Inside the block, the arguments are passed in the correct order for the target procedure, but the bind order is managed in the DECLARE stanza and after the target procedure has been invoked.

21.2.2.2.4 Handling IN OUT Arguments Anonymous PL/SQL blocks cannot natively handle IN OUT arguments. The arguments must be split into two parts: an IN-half and an OUT-half. The following example demonstrates a stored procedure that handles IN OUT arguments and is based on the following target procedure:

```
PROCEDURE two_args_inout(x VARCHAR, y IN OUT BOOLEAN) AS
BEGIN
    y := FALSE;
END;
```

Example of Handling IN OUT Arguments

```
...
PLSQLStoredProcedureCall call = new PLSQLStoredProcedureCall();
call.setProcedureName("two_args_inout");
call.addNamedArgument("X", JDBCTypes.VARCHAR_TYPE, 20);
call.addNamedInOutArgument("Y", OraclePLSQLTypes.PLSQLBoolean);
DataReadQuery query = new DataReadQuery();
query.addArgument("X");
query.addArgument("Y");
query.setCall(call);
List queryArgs = new ArrayList();
queryArgs.add("test");
queryArgs.add(Integer.valueOf(1));
List results = (List)s.executeQuery(query, queryArgs);
DatabaseRecord record = (DatabaseRecord)results.get(0);
```

```

Integer bool2int = (Integer)record.get("Y");
if (bool2int.intValue() != 0) {
    System.out.println("wrong bool2int value");
}

```

The following log excerpt shows the target procedure being invoked from an anonymous PL/SQL block:

```

[EclipseLink Fine]: 2007.11.23 03:39:55.000--DatabaseSessionImpl(25921812)--
    Connection(33078541)--Thread(Thread[main,5,main])--
DECLARE
    X_TARGET VARCHAR(20) := :1;
    Y_TARGET BOOLEAN := SYS.SQLJUTL.INT2BOOL(:2);
BEGIN
    two_args_inout(X=>X_TARGET, Y=>Y_TARGET);
    :3 := SYS.SQLJUTL.BOOL2INT(Y_TARGET);
END;
bind => [:1 => test, :2 => 1, Y => :3]

```

Note: The Y argument is split in two using the :2 and :3 ordinal markers.

21.2.3 Using Oracle Virtual Private Database

EclipseLink supports Oracle Virtual Private Database (VPD). Oracle VPD is a server-enforced, fine-grained access control mechanism. Oracle VPD ties a security policy to a table by dynamically appending SQL statements with a predicate to limit data access at the row level. You can create your own security policies, or use Oracle's custom implementation called Oracle Label Security (OLS). For details about Oracle VPD, see *Oracle Database Security Guide*. For details about Oracle Label Security, see *Oracle Label Security Administrator's Guide*.

For details about using Oracle VPD with Multitenancy, see [Section 13.4, "Using VPD Multi-Tenancy."](#)

To use the Oracle Database VPD feature in a EclipseLink application, an isolated cache should be used. Any entity that maps to a table that uses Oracle VPD should have the descriptor configured as isolated. In addition, you typically use exclusive connections.

To support Oracle VPD, you must implement session event handlers that are invoked during the persistence context's life cycle. The session event handler you must implement depends on whether or not you are using Oracle Database proxy authentication.

Oracle VPD with Oracle Database Proxy Authentication

By using Oracle Database proxy authentication, you can set up Oracle VPD support entirely in the database. That is, rather than session event handlers to execute SQL, the database performs the required setup in an after login trigger using the proxy session_user.

For details on using Oracle proxy authentication, see [Section 21.2.4, "Using Oracle Proxy Authentication."](#)

Oracle VPD Without Oracle Database Proxy Authentication

If you are not using Oracle Database proxy authentication, implement session event handlers for the following session events:

- `postAcquireExclusiveConnection`: used to perform Oracle VPD setup at the time a dedicated connection is allocated to an isolated session and before the isolated session user uses the connection to interact with the database.
- `preReleaseExclusiveConnection`: used to perform Oracle VPD cleanup at the time the isolated session is released and after the user is finished interacting with the database.

In the implementation of these handlers, you can obtain the required user credentials from the associated session's properties.

21.2.4 Using Oracle Proxy Authentication

JPA and EclipseLink are typically used in a middle tier/server environment with a shared connection pool. A connection pool allows database connections to be shared to avoid the cost of reconnecting to the database. Typically, the user logs into the application but does not have their own database login as a shared login is used for the connection pool. The provides a mechanism to set a proxy user on an existing database connection. This allows for a shared connection pool to be used, but to also gives the database a user context.

Oracle proxy authentication is configured using the following persistence unit properties on an `EntityManager` object:

- `"eclipselink.oracle.proxy-type"` :
`oracle.jdbc.OracleConnection.PROXYTYPE_USER_NAME, PROXYTYPE_CERTIFICATE, PROXYTYPE_DISTINGUISHED_NAME`
- `oracle.jdbc.OracleConnection.PROXY_USER_NAME` : *user_name*
- `oracle.jdbc.OracleConnection.PROXY_USER_PASSWORD` : *password*
- `oracle.jdbc.OracleConnection.PROXY_DISTINGUISHED_NAME`
- `oracle.jdbc.OracleConnection.PROXY_CERTIFICATE`
- `oracle.jdbc.OracleConnection.PROXY_ROLES`

Note: This connection is only used for writing by default; reads still use the shared connection pool. To force reads to also use the connection, the `eclipselink.jdbc.exclusive-connection.mode` property should be set to `Always`, but this depends on if the application wishes to audit writes or reads as well. The `eclipselink.jdbc.exclusive-connection.is-lazy` property configures whether the connection should be connected up front, or only when first required. If only writes are audited, then lazy connections allow for the cost of creating a new database connection to be avoided unless a write occurs.

21.2.4.1 Main Tasks:

To setup proxy authentication, create an `EntityManager` object and set the persistence unit properties. Three examples are provided:

Task: Audit Only Writes

To configure proxy authentication when auditing only writes:

```
Map properties = new HashMap();
properties.put("eclipselink.oracle.proxy-type",
    oracle.jdbc.OracleConnection.PROXYTYPE_USER_NAME);
```

```
properties.put(oracle.jdbc.OracleConnection.PROXY_USER_NAME, user);
properties.put(oracle.jdbc.OracleConnection.PROXY_USER_PASSWORD, password);
properties.put("eclipselink.jdbc.exclusive-connection.mode", "Transactional");
properties.put("eclipselink.jdbc.exclusive-connection.is-lazy", "true");
EntityManager em = factory.createEntityManager(properties);
```

Task: Audit Reads and Writes

To configure proxy authentication when auditing reads and writes:

```
Map properties = new HashMap();
properties.put("eclipselink.oracle.proxy-type",
    oracle.jdbc.OracleConnection.PROXYTYPE_USER_NAME);
properties.put(oracle.jdbc.OracleConnection.PROXY_USER_NAME, user);
properties.put(oracle.jdbc.OracleConnection.PROXY_USER_PASSWORD, password);
properties.put("eclipselink.jdbc.exclusive-connection.mode", "Always");
properties.put("eclipselink.jdbc.exclusive-connection.is-lazy", "false");
EntityManager em = factory.createEntityManager(properties);
```

Task: Configure Proxy Authentication in Java EE Applications

If a JEE and JTA managed entity manager is used, specifying a proxy user and password can be more difficult, as the entity manager and JDBC connection is not under the applications control. The persistence unit properties can still be specified on an EntityManager object as long as this is done before establishing a database connection.

If using JPA 2.0, the setProperty API can be used:

```
em.setProperty("eclipselink.oracle.proxy-type",
    oracle.jdbc.OracleConnection.PROXYTYPE_USER_NAME);
em.setProperty(oracle.jdbc.OracleConnection.PROXY_USER_NAME, user);
em.setProperty(oracle.jdbc.OracleConnection.PROXY_USER_PASSWORD, password);
em.setProperty("eclipselink.jdbc.exclusive-connection.mode", "Always");
em.setProperty("eclipselink.jdbc.exclusive-connection.is-lazy", "false");
```

Otherwise, the getDelegate API can be used:

```
Map properties = new HashMap();
properties.put("eclipselink.oracle.proxy-type",
    oracle.jdbc.OracleConnection.PROXYTYPE_USER_NAME);
properties.put(oracle.jdbc.OracleConnection.PROXY_USER_NAME, user);
properties.put(oracle.jdbc.OracleConnection.PROXY_USER_PASSWORD, password);
properties.put("eclipselink.jdbc.exclusive-connection.mode", "Always");
properties.put("eclipselink.jdbc.exclusive-connection.is-lazy", "false");
((org.eclipse.persistence.internal.jpa.EntityManagerImpl)em.getDelegate()).
    setProperties(properties);
```

21.2.4.2 Caching and security

By default, EclipseLink maintains a shared (L2) object cache. This is fine for auditing, but if Oracle VPD or user based security is used to prevent the reading of certain tables/classes, then the cache may need to be disabled for these secure classes. To disable the shared cache, see ["Disabling the Shared Cache"](#) on page 11-3.

If the database user is used to check security for reads, then set the eclipselink.jdbc.exclusive-connection.mode property to Isolated to only use the user connection for reads for the classes whose shared cache has been disabled (isolated).

21.2.4.3 Using Oracle Virtual Private Database for Row-Level Security

The Oracle Virtual Private Database (VPD) feature allows for row level security within the Oracle database. Typically, database security only allows access privileges to be assigned per table. Row level security allows different users to have access to different rows within each table.

The Oracle proxy authentication features in EclipseLink can be used to support Oracle VPD. The proxy user allows for the row level security to be checked. When using Oracle VPD, it is also important to disable shared caching for the secured objects as these objects should not be shared. To disable the shared cache, see ["Disabling the Shared Cache"](#) on page 11-3.

21.2.5 Using EclipseLink with Oracle RAC

Oracle Real Application Clusters (RAC) extends the Oracle Database so that you can store, update, and efficiently retrieve data using multiple database instances on different servers at the same time. Oracle RAC provides the software that manages multiple servers and instances as a single group. Applications use Oracle RAC features to maximize connection performance and availability and to mitigate down-time due to connection problems. Applications have different availability and performance requirements and implement Oracle RAC features accordingly. For details on Oracle RAC, see the *Oracle Real Application Clusters Administration and Deployment Guide*.

The Oracle Database and the Oracle WebLogic Server both provide connection pool implementations that can create connections to a RAC database and take advantage of various Oracle RAC features. The features include Fast Connection Failover (FCF), Run-Time Connection Load Balancing (RCLB), and connection affinity. In WebLogic Server, applications create JDBC data sources (Multi Data Source or GridLink Data Source) to connect to a RAC-enabled database. Standalone applications use the Universal Connection Pool (UCP) JDBC connection pool API (`ucp.jar`) to create data sources. Both connection pool implementations require the Oracle Notification Service library (`ons.jar`). This library is the primary means by which the connection pools register for, and listen to, RAC events. For those new to these technologies, refer to the *Oracle Universal Connection Pool for JDBC Developer's Guide* and the *Oracle Fusion Middleware Configuring and Managing JDBC Data Sources for Oracle WebLogic Server*.

This section assumes that you have an Oracle JDBC driver and Oracle RAC-enabled database. Make sure that the RAC-enabled database is operational and that you know the connection URL. In addition, download the database Oracle Client software that contains the `ons.jar` file. The `ucp.jar` file is included with the Oracle Database.

21.2.5.1 Accessing a RAC-Enabled database from Java EE Applications

The tasks in this section are used to connect to a RAC-enabled database from a persistence application implemented in Oracle WebLogic Server.

21.2.5.1.1 Task 1: Configure a Multi Data Source or GridLink Data Source Refer to [Chapter 3, "Using EclipseLink with WebLogic Server,"](#) and *Oracle Fusion Middleware Configuring and Managing JDBC Data Sources for Oracle WebLogic Server* for details about configuring a data source in WebLogic Server for Oracle RAC.

21.2.5.1.2 Task 2: Configure the Persistence Unit Edit the `persistence.xml` file and include the name of the data source within a persistence unit configuration. For example:

```
<persistence-unit name="OrderManagement">
  <jta-data-source>jdbc/MyOrderDB</jta-data-source>
```

```
...
</persistence-unit>
```

21.2.5.1.3 Task 3: Include the Required JARs Ensure that the `ons.jar` is in the WebLogic Server classpath.

21.2.5.2 Accessing a RAC-Enabled Database from Standalone Applications

The tasks in this section are used to connect to a RAC database from a standalone persistence application. The tasks demonstrate how to use UCP data sources which are required for advanced RAC features.

21.2.5.2.1 Task 1: Create a UCP Data Source A UCP data source is used to connect to a RAC database. The data source can specify advanced RAC configuration. For details on using advanced RAC features with UCP, see *Oracle Universal Connection Pool for JDBC Developer's Guide*. The following example creates a data source and enables FCF and configures ONS.

```
PoolDataSource datasource = PoolDataSourceFactory.getPoolDataSource();
datasource.setONSConfiguration("nodes=host1:4200,host2:4200");
datasource.setFastConnectionFailoverEnabled(true);
datasource.setConnectionFactoryClassName("oracle.jdbc.pool.OracleDataSource");
datasource.setURL("jdbc:oracle:thin:@DESCRIPTION=
    (LOAD_BALANCE=on)
    (ADDRESS=(PROTOCOL=TCP) (HOST=host1) (PORT=1521))
    (ADDRESS=(PROTOCOL=TCP) (HOST=host2) (PORT=1521))
    (ADDRESS=(PROTOCOL=TCP) (HOST=host3) (PORT=1521))
    (ADDRESS=(PROTOCOL=TCP) (HOST=host4) (PORT=1521))
    (CONNECT_DATA=(SERVICE_NAME=service_name)))");
```

Applications that do not require the advanced features provided by RAC and UCP can connect to a RAC-enabled database using the native connection pool in EclipseLink. In this case, edit the `persistence.xml` file for your applications and add the RAC URL connection string for a persistence unit. For example:

```
<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
    persistence_1_0.xsd" version="1.0">
  <persistence-unit name="my-app" transaction-type="RESOURCE_LOCAL">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <exclude-unlisted-classes>false</exclude-unlisted-classes>
    <properties>
      <property name="javax.persistence.jdbc.driver"
        value="oracle.jdbc.OracleDriver"/>
      <property name="javax.persistence.jdbc.url"
        value="jdbc:oracle:thin@(DESCRIPTION= "+ " (LOAD_BALANCE=on) "+
          " (ADDRESS=(PROTOCOL=TCP) (HOST=rac_node) (PORT=1521)) "+
          " (ADDRESS=(PROTOCOL=TCP) (HOST=racnode2) (PORT=1521)) "+
          " (CONNECT_DATA=(SERVICE_NAME=service_name))) "/>
      <property name="javax.persistence.jdbc.user" value="user_name"/>
      <property name="javax.persistence.jdbc.password" value="password"/>
    </properties>
  </persistence-unit>
</persistence>
```

To use the persistence unit, instantiate an `EntityManagerFactory` as follows:

```
Persistence.createEntityManagerFactory("my-app");
```

21.2.5.2.2 Task 2: Use the UCP Data Source To use the UCP data source, instantiate an `EntityManagerFactory` and pass in the data source as follows:

```
Map properties = new HashMap();
properties.add("javax.persistence.nonJtaDataSource", datasource);
Persistence.createEntityManagerFactory(properties);
```

21.2.5.2.3 Task 3: Include the Required JARs Ensure that both `ucp.jar` and `ons.jar` are in the application classpath.

21.2.6 Using Oracle Spatial and Graph

EclipseLink provides added support for querying Oracle Spatial and Graph data in the Oracle Database. Oracle Spatial and Graph is used to location-enable applications. It provides advanced features for spatial data and analysis and for physical, logical, network, and social and semantic graph applications. The spatial features provide a schema and functions that facilitate the storage, retrieval, update, and query of collections of spatial features in an Oracle database. For details about developing Oracle Spatial and Graph applications, see *Oracle Spatial and Graph Developer's Guide*. To use Oracle Spatial and Graph within WebLogic Server, see [Chapter 3.2.7, "Task 7: Extend the Domain to Use Advanced Oracle Database Features,"](#)

EclipseLink applications can construct expressions that use Oracle Spatial and Graph operators. See the `org.eclipse.persistence.expressions.spatial` API for details. For Example:

```
ExpressionBuilder builder = new ExpressionBuilder();
Expression withinDistance = SpatialExpressions.withinDistance(myJGeometry1,
    myJGeometry2, "DISTANCE=10");
session.readAllObjects(GeometryHolder.class, withinDistance);
```

The above expression requires a `oracle.spatial.geometry.JGeometry` object. Use the EclipseLink

`org.eclipse.persistence.platform.database.oracle.converters.JGeometryConverter` converter to convert the `JGeometry` object as it is read and written from the Oracle database. The `JGeometryConverter` object must be added to the Oracle Database platform either with the `addStructConverter(StructConverter)` method or specified in the `sessions.xml` file. The `JGeometry` type must also be available on the classpath.

The following example demonstrates how to use the FUNCTION JPA extension to perform Oracle Spatial queries. For details on the FUNCTION extension, see *Java Persistence API (JPA) Extensions Reference for EclipseLink*:

```
SELECT a FROM Asset a, Geography geo WHERE geo.id = :id AND a.id IN :id_list AND
    FUNCTION('ST_INTERSECTS', a.geometry, geo.geometry) = 'TRUE'

SELECT s FROM SimpleSpatial s WHERE FUNCTION('MDSYS.SDO_RELATE', s.jGeometry,
    :otherGeometry, :params) = 'TRUE' ORDER BY s.id ASC
```

21.3 Additional Resources

See the following links for additional resources about the solutions discussed in this chapter.

- [Java API Reference for EclipseLink](#)
- [Java Persistence API \(JPA\) Extensions Reference for EclipseLink](#)
- [Oracle Database JDBC Java API Reference](#)

- *Oracle Database PL/SQL Language Reference*
- *Oracle Database Security Guide*
- *Oracle Label Security Administrator's Guide*
- *Oracle Fusion Middleware Configuring and Managing JDBC Data Sources for Oracle WebLogic Server*
- *Oracle Real Application Clusters Administration and Deployment Guide*
- *Oracle Universal Connection Pool for JDBC Developer's Guide*
- *Oracle Spatial and Graph Developer's Guide*

