Oracle® Application Server

Migrating from WebSphere

10*g* Release 3 (10.1.3.1.0)

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Oracle Application Server Migrating from WebSphere, 10*g* Release 3 (10.1.3.1.0)

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Preface

This guide provides information on how to migrate from WebSphere to Oracle Application Server. This preface contains the following topics:

Audience

Oracle Application Server Migrating from WebSphere is intended for administrators, developers, and others who are responsible for migrating from WebSphere to Oracle Application Server.

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Organization

The following chapters make up this guide:

Chapter 1, "Overview"

This chapter provides you with an overview of the J2EE platform, application servers, and OracleAS. In addition, it provides you with an understanding of what is involved in migrating from WebSphere 3.5.3 to OracleAS.

Chapter 2, "Comparison of Oracle Application Server and WebSphere Features"

This chapter provides a comparison between Oracle Corporation's implementation of Sun Microsystems' J2EE platform and component specifications and that of IBM's.

Chapter 3, "Migrating Servlets"

This chapter provides you with an overview of Sun Microsystems' Java Servlet technology and its implementation in OracleAS. In addition, the issues involved in migrating servlets from WebSphere 3.5.3 to OracleAS are presented.

Chapter 4, "Migrating JSPs"

This chapter provides you with an overview of Sun Microsystems' JavaServer Pages (JSP) technology and its implementation in OracleAS. In addition, the issues involved in migrating JSP pages from WebSphere 3.5.3 to OracleAS are presented.

Chapter 5, "Migrating Enterprise Java Beans"

This chapter provides you with an overview of Sun Microsystems' Enterprise JavaBeans (EJB) architecture and its implementation in OracleAS. In addition, the issues involved in migrating EJB components from WebSphere 3.5.3 to OracleAS are presented.

Chapter 6, "Migrating JDBC Applications"

This chapter provides you with an overview of Sun Microsystems' JDBC technology and its implementation in OracleAS. In addition, the issues involved in migrating database access code from WebSphere 3.5.3 to OracleAS are presented.

Appendix A, "Migrating from WebSphere 4.0"

This chapter provides the migration strategy and tips for migrating applications from WebSphere Advanced Edition 4.0 to Oracle Application Server.

Related Documents

For more information, see these Oracle resources:

- Oracle Application Server Documentation Library
- Oracle Application Server Platform-Specific Documentation on Oracle Application Server Disk 1

Printed documentation is available for sale in the Oracle Store at

http://oraclestore.oracle.com/

To download free release notes, installation documentation, white papers, or other collateral, please visit the Oracle Technology Network (OTN). You must register online before using OTN; registration is free and can be done at

http://otn.oracle.com/membership/

If you already have a username and password for OTN, then you can go directly to the documentation section of the OTN Web site at

http://otn.oracle.com/documentation/

For additional information, see:

- http://ibm.com/ for more information on WebSphere
- http://java.sun.com/ for more information on J2EE

Conventions

The following text conventions are used in this document:

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

1 Overview

This chapter provides an overview of the J2EE platform, application servers, and Oracle Application Server. In addition, it provides an understanding of what is involved in migrating from WebSphere Advanced Edition 3.5.3 to Oracle Application Server 10*g* Release 3 (10.1.3.1.0).

This chapter contains the following topics:

1.1 Overview of J2EE

The application server market is evolving rapidly. In particular, the most significant development over the last few years is the emergence of Sun Microsystems' Java 2 Platform, Enterprise Edition (J2EE) Specification that promises to create a level of cross-vendor standardization.

The J2EE platform and component specifications define, among other things, a standard platform for developing and deploying multi-tier, web-based enterprise applications.

J2EE provides a solution to the problems encountered by companies moving to a multi-tier computing model. The problems addressed include reliability, scalability, security, application deployment, transaction processing, web interface design, and timely software development. It builds upon the Java 2 Platform, Standard Edition (J2SE) to enable Sun Microsystems' "Write Once, Run Anywhere" paradigm for multi-tier computing. J2EE includes the components in the following table:

Table 1–1 J2EE Architecture Components

Component	Description
J2EE Application Model	An application model for developing multi-tier, thin client services.
J2EE Platform	A platform for hosting J2EE applications.

Table 1–1 (Cont.) J2EE Architecture Components

Component	Description
J2EE Compatibility Test Suite	A compatibility test suite for verifying that a J2EE platform product meets the requirements set forth in the J2EE platform and component specifications.
J2EE Reference Implementation	A reference implementation of the J2EE platform.

1.1.1 What is the J2EE Application Model?

The J2EE application model is a multi-tier application model. Application components are managed in the middle tier by containers. A container is a standard runtime environment that provides services, including life cycle management, deployment, and security services, to application components. This container-based model separates business logic from system infrastructure.

1.1.2 What is the J2EE Platform?

The J2EE platform consists of a runtime environment and a standard set of services that provide the necessary functionality for developing multi-tiered, web-based enterprise applications. The following two tables list the J2EE platform components and services:

Table 1–2 J2EE Runtime Application Components

Component	Description
Application clients	A Java program, typically used for GUIs, that executes on a desktop computer.
Applets	A component of a Java program that typically executes in a web browser.
Servlets	A Java program, used to generate dynamic content, that executes on a web server.
Java Server Page (JSP)	A technology used to return dynamic content to a client, typically a web browser.
Enterprise Java Bean (EJB)	An applications architecture for component-based distributed computing
Containers	A runtime environment that provides services for application components, including life cycle management, deployment, and security services.
Resource Manager Drivers	A system-level component that enables network connectivity to external data sources.
Database	A set of related files used to store business data and accessible through the JDBC API.

Table 1–3 J2EE Standard Services

Service	Description
HTTP	The standard protocol used on the Internet to send and receive messages between web servers and browsers.
HTTPS	A security protocol used on the Internet to send and receive messages between web servers and browsers.
Java Transaction API (JTA)	An API that allows applications and application servers to access transactions.

Table 1–3 (Cont.) J2EE Standard Services

Service	Description
RMI-IIOP	RMI: A protocol that enables Java objects to communicate remotely with other Java objects. IIOP: A protocol that enables browsers and servers to exchange things other than text. RMI-IIOP is a version of RMI that uses the CORBA IIOP protocol
JavaIDL	A standard language for interface specification primarily used for CORBA object interface definition.
JDBC	An API that provides connectivity between databases and the J2EE platform.
Java Message Service (JMS)	An API that enables the use of enterprise messaging systems.
Java Naming and Directory Interface (JNDI)	An API that provides directory and naming services.
JavaMail	An API that provides the ability to send and receive e-mail.
JavaBeans Activation Framework (JAF)	An API required by the JavaMail API.

1.2 What is an Application Server?

An application server is software that runs between web-based client programs and back-end databases and legacy applications. Application servers help separate system complexity from business logic, enabling developers to focus on solving business problems. Application servers reduce the size and complexity of client programs by enabling these programs to share capabilities and resources in an organized and efficient way.

Application servers provide benefits in the areas of usability, flexibility, scalability, maintainability, and interoperability.

1.3 Overview of Oracle Application Server

Oracle Application Server is a comprehensive, integrated application server that provides all of the infrastructure and functionality needed to run any e-business. All development teams face a similar set of challenges—the need to rapidly deliver web sites and applications that run fast over any network and on every device; while providing business intelligence to support operational adjustments and strategic decisions. Oracle Application Server enables teams to address all of these e-business challenges.

Oracle Application Server has generated a great deal of interest in the application server market, and many organizations are embracing it to deploy their web-based enterprise applications.

Oracle Application Server offers the only integrated infrastructure to develop and deploy web sites and applications. It provides a complete J2EE platform for developing enterprise Java applications. It enables developers to develop web applications in any language including Java, Perl, PL/SQL, XML, and Oracle Forms. It enables the reduction of development and deployment costs through a single, unified platform for Java, XML, and SQL.

The J2EE server implementation in Oracle Application Server is called Oracle Containers for J2EE (OC4J). OC4J is J2EE 1.3 compliant and runs on the standard JDK

version 1.4, which is installed with the product (JDK 1.3 is supported). It is lightweight, provides high performance and scalability, and is simple to deploy and manage. OC4J can be deployed in standalone mode, which is ideal for development environments or with Application Server Control Console to provide enterprise-level monitoring and management facilities.

1.3.1 J2EE Application Migration Challenges

The varying degrees of compliance to J2EE standards can make migrating applications from one application server to another a daunting task. Some of the challenges in migrating J2EE applications from one application server to another are:

- Though in theory any J2EE application can be deployed on any J2EE-compliant application server, in practice this is not strictly true.
- Lack of knowledge of the implementation details of the given J2EE application.
- Ambiguity in the meaning of 'J2EE-compliant' (usually, this means the application server has J2EE-compliant features, not code-level compatibility with the J2EE specification).
- The number of vendor-supplied extensions to the J2EE standards in use, which differ in deployment methods and reduce portability of Java code from one application server to another. (For example, there are Websphere-specific libraries associated with servlet engines, EJB containers, and JDBC and JNDI interfaces).
- Differences in clustering, load balancing, and failover implementations among application servers. These differences are sparsely documented, and are thus an even bigger challenge to the migration process.

These challenges make the migration work unpredictable and difficult to reliably plan and schedule. This document addresses the challenges in migrating your applications from WebSphere to Oracle Application Server, providing an approach to migration with solutions based on the J2EE version 1.3 specification.

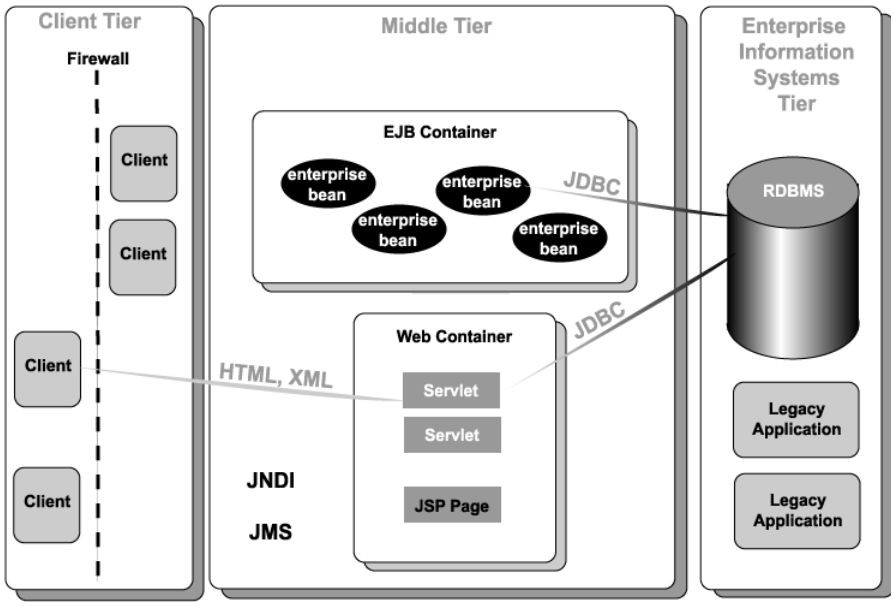
1.4 J2EE Application Architecture

The J2EE platform provides a multi-tiered distributed application model. Central to the J2EE component-based development model is the concept of containers. Containers are standardized runtime environments that provide specific services to components. Thus, Enterprise Java Beans (EJB) developed for a specific purpose in any organization can expect generic services such as transaction and EJB life cycle management to be available on any J2EE platform from any vendor.

Containers also provide standardized access to enterprise information systems; for example, providing database access through the JDBC API. Containers also provide a mechanism for selecting application behavior at assembly or deployment time.

As shown in Figure 1–1, the J2EE application architecture is a multi-tiered application model. In the middle tier, components are managed by containers; for example, J2EE Web containers invoke servlet behavior, and EJB containers manage life cycle and transactions for EJBs. The container-based model separates business logic from system infrastructure.

Figure 1–1 J2EE Architecture



1.5 Migration Issues

Given the inherent challenges outlined above, it is helpful to examine the applications to be migrated in terms of the following before quantifying the migration effort.

- Portability
- Dependence on Vendor Specific Implementation
- Deviations from the J2EE Specification

1.5.1 Portability

Code may not be portable because it contains embedded references to vendor- specific extensions to the J2EE specification. In such cases, runtime exceptions, (for example, "class not found") may occur when applications are migrated and run from one J2EE-compliant application server to another. In addition, some J2EE application servers still support deprecated APIs and others are strictly compliant to the J2EE specifications. WebSphere contains extentions to servlets, JSPs, EJBs, JNDI, and JDBC. In such cases, evaluating code and planning for its modification may be a significant part of the migration effort.

1.5.2 Dependence on Vendor Specific Implementation

If WebSphere-specific services are in use, migration of those components becomes difficult or unfeasible. These components may need to be redesigned and reimplemented, instead of being identified as migration candidates. This guide does not address complete redesign toward J2EE specifications. For example, applications using Component Broker (IBM ORB) services, CICS or Encina transaction monitors, MQSeries or DB2 libraries are not candidates for migration as defined in this guide.

1.5.3 Deviations from the J2EE Specification

Different application server vendors have different levels of support for J2EE standards, and some variations in behavior. For example, WebSphere Advanced Edition 3.5.3 supports pre-J2EE 1.3 specifications, but Oracle Application Server fully supports J2EE 1.3. This fact raises issues with servlet, EJB, JNDI, and security migration. This guide addresses those issues and explains how to migrate to Oracle Application Server without major code changes.

1.5.4 Migration Approach

Our approach for this guide is to document our experiences with migrating components and/or example applications from WebSphere Advanced Edition 3.5.3 to Oracle Application Server 10*g* Release 3 (10.1.3.1.0). Guidelines for migrating from WebSphere Advanced Edition 4.0 to Oracle Application Server 10*g* Release 3 (10.1.3.1.0) is discussed in Appendix A, "Migrating from WebSphere 4.0".

We selected some of the examples shipped with WebSphere for this migration excercise.We tested these samples with WebSphere and migrated them to Oracle Application Server. In doing so, we exposed and documented specific migration issues not identified in the product documentation. As described in "J2EE Application Migration Challenges" these issues exist because WebSphere Advanced Edition 3.5.3 does not support J2EE 1.3 specifications, and because WebSphere-specific API extensions are used.

1.5.5 Migration Tool

The Oracle JDeveloper Application Migration Assistant (AMA) is a tool developed by Oracle to simplify the process of migrating applications to the Oracle platform. The tool provides code navigation and progress reporting to guide you through migrating from WebSphere to Oracle Application Server.

The AMA tool is installed as a plug-in to Oracle JDeveloper. It uses regular expressions to identify code in your application files that may require modification to work on the Oracle platform. These regular expressions are contained in an XML file called search rules file. AMA can analyze your WebSphere application and generate an analysis report that summarizes project statistics, allows navigation between review items, and provides comprehensive status tracking for your migration changes. AMA is customizable by providing an extensible API that allows additional search rules files to be written and tailored for your specific application.

Oracle provides a number of search rules files through the AMA Search Rules Exchange (http://otn.oracle.com/tech/migration/exchange.html). In addition to writing your own, you can download and use any of these search rules files.

To download the tool and for more information on it, go to http://otn.oracle.com/tech/migration/ama

1.6 Using this Guide

This guide details the migration of components from WebSphere Advanced Edition 3.5.3 to Oracle Application Server. While it does not claim to be an exhaustive source of solutions for every possible configuration, it provides solutions for some of the migration issues listed above, which will surface, along with others, in your migration effort. The information in this guide helps you to assess the WebSphere applications and plan and execute their migration to Oracle Application Server. The material in this guide supports these high-level tasks:

- Survey the components according to the issues listed above
- Identify migration candidates
- Prepare the migration environment and tools
- Migrate and test the candidate components

Note: In this document, unless otherwise specified, any reference to WebSphere without a version number implies reference to WebSphere Advanced Edition 3.5.3.

2

Oracle Application Server and WebSphere Features

WebSphere 3.5.3 and Oracle Application Server are created from entirely different architectures. WebSphere is based on the IBM SanFrancisco Java application framework and its Component Broker, both of which predate J2EE standards. Oracle Application Server has a new lightweight, robust J2EE container that supports the J2EE 1.3 standard APIs.

This chapter identifies major differences between WebSphere and Oracle Application Server in terms of overall product offering, architecture, clustering and load balancing, J2EE support, and development and deployment tools.

2.1 Application Server Comparison

This section describes and compares the WebSphere and Oracle Application Server products.

2.1.1 WebSphere

For WebSphere 3.5.3, IBM sells several technologies under the WebSphere marketing umbrella. The WebSphere Application Server is the core of the WebSphere extended family of products, of which there are three versions, described in the following three sections:

2.1.1.1 Websphere Standard Edition

WebSphere Standard Edition is a servlet/JSP container layer that runs on top of an HTTP server. It works with a number of popular HTTP servers, including IBM HTTP Server, Microsoft IIS, and Netscape iPlanet server. WebSphere Standard Edition supports static HTML pages, servlets, JavaServer Pages, and XML.

2.1.1.2 WebSphere Advanced Edition

WebSphere Standard Edition is a servlet/JSP container layer that runs on top of an HTTP server. It works with a number of popular HTTP servers, including IBM HTTP Server, Microsoft IIS, and Netscape iPlanet server. WebSphere Standard Edition supports static HTML pages, servlets, JavaServer Pages, and XML.

2.1.1.3 WebSphere Enterprise Edition

WebSphere Advanced Edition contains all the features of Standard Edition, and also includes:

- Full support for the Enterprise JavaBeans™ (EJB) component model

- Workload management (WLM) features to support multiple servers within a single administrative domain

In WebSphere Enterprise Edition, Component Broker serves both EJBs and CORBA objects. TXSeries provides a a pure transactional environment, for applications that don't require an EJB/component-based/object-oriented programming model. Depending on your requirements, you could use either or both.

2.1.2 Oracle Application Server

Like WebSphere, Oracle Application Server is a platform-independent J2EE application server that can host multi-tier, web-enabled enterprise applications for the Internet and intranets, and which is accessible from browser and standalone clients. It includes Oracle Containers for J2EE (OC4J) a lightweight, scalable J2EE container written in Java, and is J2EE 1.3 certified. OC4J provides support for the following:

- Servlets 2.4
- JSP 2.0
- EJB 2.1 and 3.0 (Complete EJB 3.0 andJPA implementation)
- JNDI 1.2
- JavaMail 1.2
- JAF 1.0.1
- JAXP 1.2
- JCA 1.5
- JAAS 1.0
- JMS 1.1
- JTA 1.0
- JDBC 3.0
- JMX 1.2

Oracle Application Server is designed specifically to run large-scale, distributed Java enterprise applications, including Internet commerce sites, enterprise portals and high volume transactional applications. It adds considerable value beyond the J2EE standards in areas critical to the implementation of real world applications, providing an entire suite of integrated solutions that encompass:

- Web services
- Business intelligence
- Management and security
- E-business integration
- Support for wireless clients
- Enterprise portals
- Performance caching

To enable these solutions to be implemented in a reliable and scalable infrastructure, Oracle Application Server can be deployed in a redundant architecture using clustering mechanisms. The sections"Architecture Comparison" and "High Availability and Load Balancing" in this chapter detail the components in and characteristics of Oracle Application Server.

2.2 Architecture Comparison

This section describes and compares the architectures of WebSphere and Oracle Application Server.

2.2.1 WebSphere Components

The WebSphere Advanced Edition 3.5.3 consists of the following components:

2.2.1.1 IBM HTTP Server

IBM's HTTP Server is the Apache HTTP Server (with official product support) with SSL capability implemented by IBM, and IBM tools for managing keys, certificates, and such. The public key technology that SSL uses is patented and requires tracking for licensing purposes. The SSL support is part of IBM's value-add on top of the Apache HTTP Server open source distribution. Neither Apache nor the IBM HTTP Server provide servlet support out-of-the-box.

2.2.1.2 Web Server Plug-in

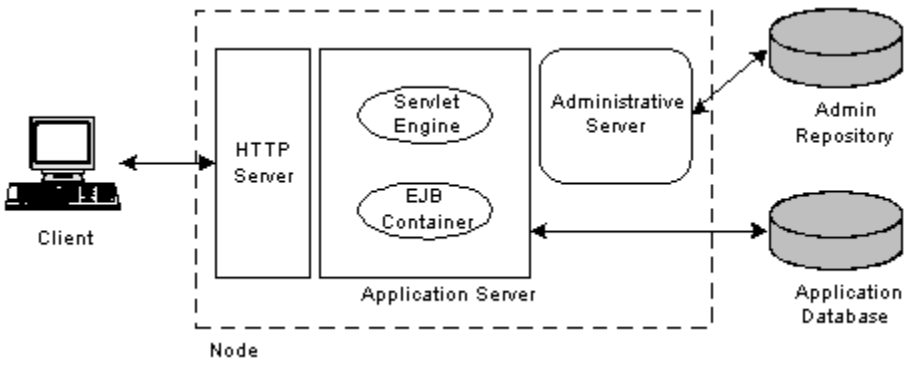
The Web Server Plug-in is a module that runs within the web server, using its native APIs, and forwards requests to the WebSphere Application Server. When you install WebSphere, the installation program installs a hook into the web server that intercepts HTTP requests that target a servlet (it examines the incoming URL to determine whether it is a servlet request), and redirects those requests to the servlet engine for processing. Static content is still handled solely by the HTTP Server.

2.2.1.3 Adminstrative Server

The Administrative Server must be running on every node that runs a WebSphere Application Server component. It performs the following functions:

- Starting, stopping and monitoring all configured application servers.
- Providing a location service daemon (LSD).
- Providing a persistence name server (PNS).
- Providing a security server.
- Providing a watchdog process to restart the Administrative Server in case of failure.

Figure 2–1 WebSphere Application Server Components.



The WebSphere Application Server version 3.5.x requires an Administrative Server Repository. The Administrative Server Repository is a relational database containing configuration information. This database is used to store setup, configuration, and state information about the WebSphere Application Server.

Before starting the Administrative Server, WebSphere Application Server checks for the existence of an Administrative Server Repository, which contains descriptive information about the resources that are configured to run on each node in the domain, for example, the names of application servers, the node each server is running on, the enterprise beans installed in each server, and the current state of each server.

The Administrative Server Repository enables the system administrator to manage the domain from any machine, because all configuration information is stored in a central location. Each Administrative Server has a central view of resource configuration information about the domain. When the administrator modifies a resource configuration, the changes are seen by all administrative servers.

2.2.1.4 Application Server

In WebSphere, an Application Server is the process that runs servlet and EJB-based applications, providing both the servlet run-time components (Servlet Engine, Web applications) and EJB run-time (EJB container). Like the Administrative Server, each WebSphere Application Server runs in its own Java Virtual Machine (JVM).

2.2.2 Oracle Application Server Components and Concepts

This section describes components and several concepts that are specific to Oracle Application Server.

See Also:

Oracle Application Server Concepts

Oracle Application Server Administrator's Guide

Oracle Application Server Containers for J2EE User's Guide

An OracleAS instance is a runtime occurrence of an installation of Oracle Application Server. An Oracle Application Server installation corresponds to an "Oracle Home" where the Oracle Application Server files are installed. Each Oracle Application Server installation can provide only one OracleAS instance at runtime. A physical node can have multiple "Oracle Homes", and hence, can have more than one Oracle Application Server installation and OracleAS instance.

Each OracleAS instance consists of several interoperating components that enable Oracle Application Server to service user requests in a reliable and scalable manner. The components are:

2.2.2.1 Oracle HTTP Server

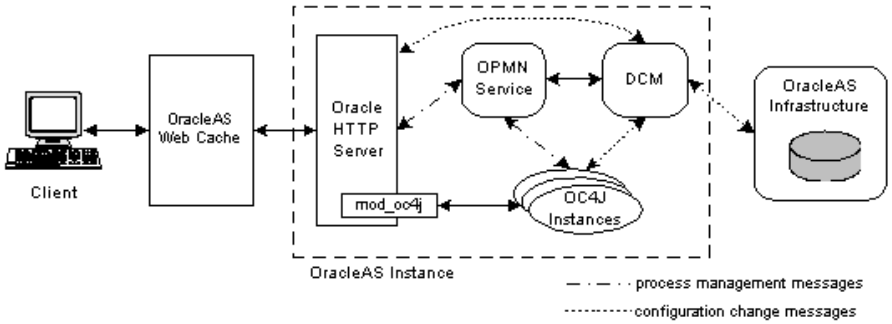
OracleAS contains two listeners: The Oracle HTTP Server (based on the Apache open source project) and the listener that is part of OC4J, which runs in a separate thread of execution. Each OracleAS instance has one Oracle HTTP Server.

The OC4J listener listens to requests coming from the `mod_oc4j` module of the Oracle HTTP Server and forwards them to the appropriate OC4J instance. From a functional viewpoint, the Oracle HTTP Server acts as a proxy server to OC4J, wherein all servlet or JSP requests are redirected to OC4J instances.

`mod_oc4j` communicates with the OC4J listener using the Apache JServ Protocol version 1.3 (AJP 1.3). `mod_oc4j` works with the Oracle HTTP Server as an Apache module. The OC4J listener can also accept HTTP and RMI requests, in addition to AJP 1.3 requests.

The following diagram depicts Oracle HTTP Server and other Oracle Application Server runtime components in a single instance of OracleAS:

Figure 2–2 Oracle Application Server Component Relationships



2.2.2.2 OC4J Instance

An OC4J instance is a logical instantiation of the OC4J implementation in Oracle Application Server. This implementation is based on Java 2 Enterprise Edition (J2EE) and written entirely in Java. It executes on the standard Java Development Kit (JDK) 1.4 Java Virtual Machine, which is installed with OracleAS (JDK 1.3 is also supported). It has a lower disk and memory footprint than previous Oracle Application Server Java environments and competitive Java application servers. Note that each OC4J instance can consist of more than one JVM process where each process can be executing multiple J2EE containers. The number of JVM processes can be specified for each OC4J instance using the Oracle Enterprise Manager 10*g* Application Server Control Console GUI.

Oracle Application Server allows several OC4J instances to be clustered together for scalability and high availibility purposes. When OC4J instances are clustered together, they have the same configuration and applications deployed amongst them. A more in-depth discussion on clustering is found in the section "High Availability and Load Balancing".

2.2.2.3 Oracle Process Manager and Notification Server (OPMN)

Each OracleAS instance has an OPMN server which performs monitoring and process management functions within that instance. This service communicates messages between the components in an OracleAS instance to enable startup, death-detection and recovery of components. This communication extends to other OPMN services in other OracleAS instances belonging to the same cluster as well, thereby allowing other instances in a cluster to be aware of active OC4J and Oracle HTTP Server processes in other OracleAS instances (in the same cluster).

The OPMN service also communicates and interfaces with Application Server Control Console to provide a consolidated interface for monitoring, configurating, and managing Oracle Application Server. Oracle Application Server components, Oracle HTTP Server, OC4J instances, and Distributed Configuration Manager (described below), use a subscribe-publish messaging mechanism to communicate with the

OPMN service. For failover and availibility, the process that implements the OPMN service has a shadow process that restarts the OPMN process if it fails.

2.2.2.4 Distributed Configuration Management (DCM)

In order to manage and track configuration changes in the various components in each OracleAS instance, a DCM process exists in each OracleAS instance to perform those tasks. Each configuration change made to any of the components in a OracleAS instance is communicated to the DCM. DCM in turn takes note of the change and records it in the Oracle Application Server Metadata Repository in the Infrastructure database. This repository contains the configuration information for all the OracleAS instances connected to it through their respective DCMs. All OracleAS instances connecting to the same infrastructure repository in this way belong to the same OracleAS Farm. If any of the OracleAS instances fail, the configuration information can be retrieved from the repository for purposes of restarting the instance.

Each DCM also communicates with the OPMN in their respective instances to send notification events on changes in repository data. This allows OPMN to make the corresponding adjustments to the Oracle Application Server components.

2.2.2.5 Oracle Application Server Web Cache

OracleAS provides a caching solution with the unique capability to cache both static and dynamically generated web content. Oracle Web Cache significantly improves the performance and scalability of heavily loaded Oracle Application Server web sites by reducing the number of round trips to the web server. In addition, it provides a number of features to ensure consistent and predictable responses. These features include page fragment caching, dynamic content assembly, web server load balancing, Web Cache clustering, and failover. Oracle Web Cache can be used as a load balancer for OracleAS instances in a cluster. Oracle Web Cache can itself be deployed in its own cluster. For more information, refer to the *Oracle Application Server Web Cache Administrator's Guide*..

2.2.2.6 Oracle Enterprise Manager 10*g* Application Server Control Console

Oracle Enterprise Manager 10*g* Application Server Control Console provides a web-based interface for managing Oracle Application Server components and applications. Using the Application Server Control Console, you can do the following:

- monitor OracleAS components, OracleAS middle tier and Infrastructure instances, OracleAS middle tier clusters, and deployed J2EE applications and their components
- configure Oracle Application Server components, instances, clusters, and deployed applications
- operate OracleAS components, instances, clusters, and deployed applications
- manage security for OracleAS components and deployed applications

For more information on Oracle Enterprise Manager and its two frameworks, see the Oracle Enterprise Manager 10g documentation.

> **See Also:** *Oracle Application Server Administrator's Guide* - provides descriptions on Application Server Control Console and instructions on how to use it.

2.2.2.7 Oracle Application Server Infrastructure

In Oracle Application Server 10g, the role of the Infrastructure is expanded from earlier versions. It provides a completely integrated framework for the development and deployment of enterprise applications. An OracleAS Infrastructure installation type provides centralized product metadata, security services, management services, and configuration and data repositories for the OracleAS middle tier. By integrating the Infrastructure services required by the middle tier, time and effort required to develop enterprise applications are reduced. In turn, the total cost of developing and deploying these applications is reduced, and the deployed applications are more reliable.

The OracleAS Infrastructure provides the following overall services:

- **Product Metadata Service**

  OracleAS Infrastructure stores all application server metadata required by OracleAS middle tier instances. This data is stored in an Oracle database, thereby leveraging the robustness of the database to provide a reliable, scalable, and easy-to-manage metadata repository.

- **Security Service**

  The security service provides a consistent security model and identity management for all applications deployed on OracleAS. The service enables centralized authentication using single sign-on, web-based administration, and centralized storage of user authentication credentials. The Oracle Internet Directory is used as the underlying repository for this service.

- **Management Service**

  This service is used by Oracle Enterprise Manager and DCM to manage and administer OracleAS middle tier instances and the OracleAS Infrastructure. It is also used to administer clustering services for the middle tier. Oracle Enterprise Manager reduces the total administrative cost by centralizing the management of deployed J2EE applications through the OracleAS Console, which provides web pages for unified administration of OracleAS.

  The components in OracleAS Infrastructure which implement the above services are:

  - Oracle Application Server Metadata Repository
  - Oracle Identity Management

2.2.2.7.1 Oracle Application Server Metadata Repository

Oracle Application Server metadata and customer or application data can coexist in the Oracle Application Server Metadata Repository, the difference is in which applications are allowed to access them.

The Oracle Application Server Metadata Repository stores three main types of metadata corresponding to the three main Infrastructure services described earlier in this section. These types of metadata are:

- management metadata
- security metadata
- product metadata

Table 2–1 shows the Oracle Application Server components that store and use these types of metadata during application deployment.

Table 2–1 Metadata and Infrastructure Components

Type of Metadata	Infrastructure Components Involved
Product metadata (includes demo data)	Oracle Application Server Metadata Repository
Identity Management metadata	Oracle Single Sign-On, Oracle Internet Directory, Oracle Application Server Certificate Authority
Management metadata	Distributed Configuration Management, Oracle Enterprise Manager

Oracle Application Server Metadata Repository is needed for all application deployments except for those using the J2EE and Web Cache install option. Oracle Application Server provides three middle tier installation options:

- **J2EE and Web Cache:** Installs Oracle HTTP Server, OC4J, Oracle Web Cache, Web Services, Datatags, and Oracle Enterprise Manager 10*g* Application Server Control Console.
- **Portal and Wireless:** Installs all components of J2EE and Oracle Web Cache, plus UDDI, Oracle Application Server Portal, Oracle Application Server Syndication Services, Oracle Ultra Search, and Oracle Application Server Wireless.
- **Business Intelligence and Forms:** Installs all components of J2EE and Oracle Web Cache, Oracle Application Server Portal, and Oracle Application Server Wireless, plus Oracle Application Server Forms Services, Oracle Reports, Oracle Business Intelligence Discoverer, and Oracle Application Server Personalization.

  Integration components, such as Oracle Application Server Business Activity Monitoring, Oracle Application Server Integration InterConnect, and Oracle Workflow are installed on top of any of these middle tier install options.

  The DCM component enables middle tier management, and stores its metadata in the Metadata Repository for both the Portal and Wireless and the Business Intelligence and Forms install options. For the J2EE and Web Cache installation type, by default, DCM uses a file-based repository. If you choose to associate the J2EE and Web Cache installation type with an Infrastructure, the file-based repository is moved into the Metadata Repository.

> **See Also:** *Oracle Application Server 10g Installation Guide* for information on the OracleAS installation details.

2.2.2.7.2 Oracle Identity Management

Oracle Identity Management provides an infrastructure for the security lifecycle of applications and entities in Oracle Application Server. The components that make up Identity Management are:

- *Oracle Internet Directory*

  Oracle Internet Directory is Oracle's implementation of a directory service using the Lightweight Directory Access Protocol (LDAP) version 3. It runs as an application on the Oracle database and utilizes the database's high performance, scalability, and high availability.

  Oracle Internet Directory provides a centralized repository for creating and managing users for the rest of the Oracle Application Server components such as OC4J, Oracle Application Server Portal, or Oracle Application Server Wireless. Central management of user authorization and authentication enables users to be

defined centrally in Oracle Internet Directory and shared across all Oracle Application Server components.

Oracle Internet Directory is provided with a Java-based management tool (Oracle Directory Manager), a Web-based administration tool (Oracle Delegated Administration Services) for trusted proxy-based administration, and several command-line tools. Oracle Delegated Administration Services provide a means of provisioning end users in the Oracle Application Server environment by delegated administrators who are not the Oracle Internet Directory administrator. It also allows end users to modify their own attributes.

Oracle Internet Directory also enables Oracle Application Server components to synchronize data about users and group events, so that those components can update any user information stored in their local application instances.

- *Oracle Virtual Directory*

  Oracle Virtual Directory facilitates the integration of applications into existing identity infrastructures. Oracle Virtual Directory accomplishes this integration without requiring changes to exisiting directories or user repositories, allowing enterprises to deploy these services quickly without having to deal with the issues of data ownership and representation. Oracle Virtual Directory can also provide multiple application centric views of directory information optimized for the specific needs of individual applications.

2.3 High Availability and Load Balancing

This section defines and describes clustering and load balancing and their importance to application server operation, it compares the methods for high availability (mainly through clustering) and load balancing used in WebSphere and Oracle Application Server.

2.3.1 WebSphere Support for High Availability and Load Balancing

WebSphere provides clustering and load balancing support through its Administrative Console, with cloning and workload management services.

2.3.1.1 Clustering in WebSphere

Clustering is implemented in WebSphere through cloning, available in the Administration system. Cloning enables you to create multiple copies of an application server, based on a server that you have already configured.

The clone has the same structure and attributes as the application server on which it is based, but it is not associated with any node, and does not correspond to any real server process running on any node.

WebSphere Application Server supports cloning for servlet engines, Web applications, and servlets for workload management, load balancing, and failover. The servlets, EJBs, and Web resources are shared by the clones, but each clone uses its own JVM to run the application code. This provides identical, yet independent processes for the application to run in.

2.3.1.2 Load Balancing in WebSphere

The workload management service improves the scalability of the application server environment by grouping multiple application servers into application server groups. Clients then access these application server groups as if they were a single server, and the workload management service distributes the workload among the application

servers in the application server groups. An application server can belong to only one application server group. WebSphere workload management supports load balancing for stateless servlets and stateless session beans, and provides a failover mechanism for stateful servlets and stateful session beans.

Servlet load balancing is performed by a servlet redirector. The servlet redirector runs on the Web server in front of the application servers. The redirector balances workload across the servlet engines running in multiple application servers behind the Web server. When a web server HTTP session asks to invoke a servlet, the redirector transfers the request to a servlet engine.

The EJB component workload manager balances the load between Java objects (servlets to EJB components, EJB components to EJB components and stand-alone Java clients to EJB components). For example, when a servlet needs data or begins a transaction through an EJB component, the EJB component workload manager transfers the request to an EJB container (an instance of WebSphere Application Server) or a remote EJB handler.

2.3.2 Oracle Application Server Support for High Availability and Load Balancing

Oracle Application Server is designed with several high availability and load balancing mechanisms. These mechanisms ensure that failover and scalability are achieved at the Infrastructure and middle tier levels. For failover, clusters of similar OracleAS components can be created. These clusters offer redundancy for similar components.

This section describes the clustering and load balancing concepts and capabilities of applicable components in Oracle Application Server.

See Also: *Oracle Application Server High Availability Guide*

2.3.2.1 Oracle Application Server Instance

The Oracle Application Server architecture supports high availability in the middle tier that in many cases can prevent unplanned down time for deployed applications. This section provides an overview of the architecture of an Oracle Application Server instance and shows some of the mid-tier high availability features.

Within each Oracle Application Server instance, the following features provide high availability within the instance, and for any clusters that the instance is a part of:

- Process Monitoring – Using the Oracle Process Manager and Notification Server system provides for process death detection and process restarting in the event that problems are detected for monitored processes.
- Configuration Cloning – Using the Distributed Configuration Management features that uses a Oracle Application Server Metadata Repository for configuration information provides distributed and managed configuration for Oracle Application Server instances and for Oracle Application Server instances that are part of a cluster.
- Data Replication – Using OC4J instances with OC4J islands that provide Web application level stateful session replication, and using EJB sessions, data is replicated across processes within an Oracle Application Server instance and across different Oracle Application Server instances that may reside on different hosts when using Oracle Application Server Clusters. This allows stateful session based applications to remain available even when processes within an Oracle Application Server instance become unavailable or fail.

- Smart Routing – Oracle Web Cache and Oracle HTTP Server (`mod_oc4j`) provide configurable and intelligent routing for incoming requests. Requests are routed only to processes and components that `mod_oc4J` determines to be alive, through communication with the Oracle Process Manager and Notification Server system.

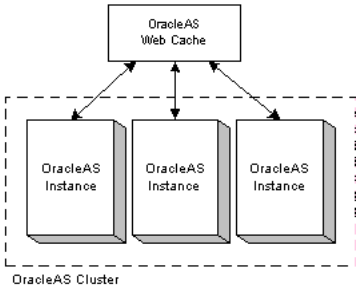
2.3.2.2 Oracle Application Server Clusters (Middle Tier)

An Oracle Application Server Cluster (OracleAS Cluster) is made up of one or more OracleAS instances (see Figure 2–3). All OracleAS instances in the cluster have the same configuration. The first OracleAS instance to join a cluster has its configuration replicated to the second and later instances when they join. In addition to the configuration, deployed OC4J applications are also replicated to the newer instances. Information for the replicated configuration and applications is retrieved from the OracleAS Metadata Repository used by the cluster.

Within each cluster, there is no mechanism to load balance or failover the OracleAS instances. That is, there is no internal mechanism in the cluster to load balance or failover requests to the Oracle HTTP Server component in the instances. A separate load balancer such as Oracle Web Cache or hardware load balancing product can be used to load balance the OracleAS instances in the cluster and failover the Oracle HTTP Server instances in the cluster.

Several OracleAS Clusters and standalone OracleAS instances can be further grouped into an OracleAS Farm. The clusters and instances in this farm share the same OracleAS Metadata Repository. For further information on OracleAS Farms, refer to the *Oracle Application Server Administrator's Guide*

Figure 2–3 An OracleAS Cluster Using OracleAS Web Cache for Load Balancing



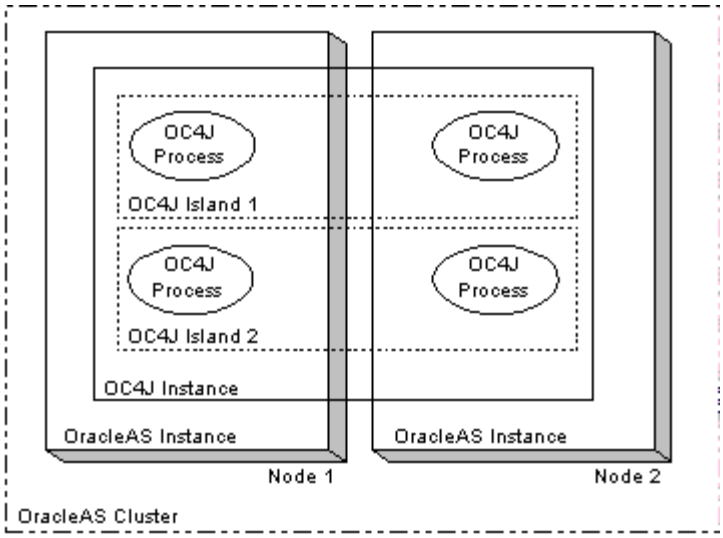
2.3.2.3 OC4J Islands

An important function of clustering technology in Oracle Application Server is that of reducing multicast traffic. With every server sharing its session state with every other server in the cluster, a lot of CPU cycles is consumed as overhead to replicate the session state across all nodes in the cluster.Oracle Application Server solves this problem by introducing the concept of OC4J islands, where OC4J processes (JVMs) in an OracleAS Cluster can be sub-grouped into islands. Session state of applications is replicated only to OC4J processes belonging to the same island rather than all OC4J processes in the OracleAS Cluster. Hence, state is replicated to a smaller number of processes. OC4J islands are typically configured to span across physical nodes, thereby allowing failover of application state if a node goes down.

Consider an OracleAS Cluster with four OC4J processes running in two nodes, two processes per node (see Figure 2–4). When the state of an application changes, which could occur at every request from the same client, multicast messages are sent between all four processes to update the state of that application in each process. If these four processes were to be divided into two islands of two processes across two nodes, state

replication of the application would only have to occur between processess within the same island. Multicast messages would be required only between the two processes in the island instead of four, reducing replication overhead by half. As a result, network traffic and CPU cycles are reduced.

Figure 2–4 OC4J Islands



When configuring OC4J islands, you can specify the number of OC4J processes for each node that belong to each island. By doing so, you can increase or decrease the number of processes based on the capabilities of the hardware and operating system of each node. For instructions on how to configure OracleAS Clusters and OC4J islands, refer to *Oracle Application Server High Availability Guide*.

2.3.2.4 Stateful Session EJB with High Availability Using EJB Clustering

Using OC4J, stateful session EJBs can be configured to provide state replication across OC4J processes running within an application server instance or across an OracleAS Cluster. This EJB replication configuration provides high availability for stateful session EJBs by using multiple OC4J processes to run instances of the same stateful session EJB.

> **Note:** Use of EJB replication (EJB clusters) for high availability is independent of OracleAS Clusters and can involve multiple application server instances installed across nodes that are or are not part of OracleAS Clusters.

EJB clusters provide high availability for stateful session EJBs. They allow for failover of these EJBs across multiple OC4J processes that communicate over the same multicast address. Thus, when stateful session EJBs use replication, this can protect against process and node failures and can provide for high availability of stateful session EJBs running on Oracle Application Server.

See Also:

- *Oracle Application Server High Availability Guide*
- *Oracle Application Server Containers for J2EE User's Guide*
- *Oracle Containers for J2EE Enterprise JavaBeans Developer's Guide*

2.3.2.4.1 JNDI NamespaceReplication When EJB clustering is enabled, JNDI namespace replication is also enabled between the OC4J instances in an OracleAS Cluster. New bindings to the JNDI namespace in one OC4J instance are propagated to other OC4J instances in the OracleAS Cluster. Rebindings and unbindings are not replicated.

The replication is done outside the scope of OC4J islands. In other words, multiple islands in an OC4J instance have visibility into the same replicated JNDI namespace.

See Also: *Oracle Containers for J2EE Services Guide*

2.3.2.5 Java Object Cache

Oracle Application Server Java Object Cache provides a distributed cache that can serve as a high availability solution for applications deployed to OC4J. The Java Object Cache is an in-process cache of Java objects that can be used on any Java platform by any Java application. It allows applications to share objects across requests and across users, and coordinates the life cycle of the objects across processes.

Java Object Cache enables data replication among OC4J processes even if they do not belong to the same OC4J island, application server instance, or Oracle Application Server Cluster.

By using Java Object Cache, performance can be improved since shared Java objects are cached locally, regardless of which application produces the objects. This also improves availability; in the event that the source for an object becomes unavailable, the locally cached version will still be available.

2.3.2.6 Oracle Web Cache Clusters

Two or more Oracle Web Cache instances can be clustered together to create a single logical cache. Physically, the cache can be distributed amongst several nodes. If one node fails, a remaining node in the same cluster can fulfill the requests serviced by the failed node. The failure is detected by the remaining nodes in the cluster who take over ownership of the cacheable content of the failed member. The load balancing mechanism in front of the Oracle Web Cache cluster, for example, a hardware load balancing appliance, redirects the requests to the live Oracle Web Cache nodes.

Oracle Web Cache clusters also add to the availability of OracleAS instances. By caching static and dynamic content in front of the OracleAS instances, requests can be serviced by Oracle Web Cache reducing the need for the requests to be fulfilled by OracleAS instances, particularly for Oracle HTTP Servers. The load and stress on OracleAS instances is reduced, thereby increasing availability of the components in the instances.

Oracle Web Cache can also perform a stateless or stateful load balancing role for Oracle HTTP Servers. Load balancing is done based on the percentage of the available capacity of each Oracle HTTP Server, or, in other words, the weighted available capacity of each Oracle HTTP Server. If the weighted available capacity is equal for several Oracle HTTP Servers, Oracle Web Cache uses roundrobin to distribute the load. Refer to *Oracle Application Server Web Cache Administrator's Guide* for the formula to calculate weighted available capacity.

In the case of failure of a Oracle HTTP Server, Oracle Web Cache redistributes the load to the remaining Oracle HTTP Servers and polls the failed server intermittently until it comes back online. Thereafter, Oracle Web Cache recalculates the load distribution with the revived Oracle HTTP Server in scope.

See Also: *Oracle Application Server Web Cache Administrator's Guide*

2.3.2.7 Oracle Application Server Infrastructure High Availability Solutions

Several solutions exist to enable high availability for the OracleAS Infrastructure. These solutions allow for intrasite failover. They are:

2.3.2.7.1 Oracle Application Server Cold Failover Clusters The cold failover cluster solution offers a two-node hardware cluster, which are identically configured. One node is active while the other is passive. A hardware interconnect exists between both nodes, which run with an operating system that has clustering features. Both of these nodes access a common shared storage. A single logical IP address is also shared between the two nodes. (A unique physical IP address also exists for each node. But only the single logical IP address is visible and used by the middle tier to access the Infrastructure on the cold failover cluster.

During OracleAS Infrastructure installation, the "Oracle Home" for the installation is installed on the shared storage together with the database files. During operation, only one node is mounted on the shared storage at any one time. In the event that the active node fails, the clustering software of the passive node detects the failure and "takes over" the logical IP address. The passive node becomes the active node, mounts the shared storage, and services requests from the middle tier.

The cold failover cluster nodes can also be installed with the middle tier. In this scenario, the nodes are active-active for the middle tier and active-passive for the Infrastructure.

See Also: *Oracle Application Server High Availability Guide*

2.3.2.7.2 Oracle Application Server Active Clusters While the cold failover cluster offers an active-passive availability configuration for the Infrastructure, the Oracle Application Server Active Clusters (OracleAS Active Clusters) solution offers active-active availability. The OracleAS Active Clusters solution is based on Oracle9*i* Real Application Clusters technology. It allows more than two nodes to be active in a cluster. The underlying hardware used for each node also utilizes hardware cluster technology. But the IP address take over mechanism is not used. Instead, a hardware load balancer appliance is configured in front of the OracleAS Active Clusters nodes to load balance requests to them. This load balancer has a logical IP name and address, which are used by the middle tier to access the Infrastructure. Oracle Net connections bypass this hardware load balancer by using an address list of nodes in the cluster. Both the hardware load balancer appliance and Oracle Net manage the failover of requests to active nodes if a node fails.

See Also: *Oracle Application Server High Availability Guide*

2.4 J2EE Support Comparison

This section outlines the differences in the level of support of J2EE specifications between WebSphere and Oracle Application Server.

2.4.1 WebSphere J2EE Support

WebSphere 3.5.3 is a J2EE server, but is not fully J2EE 1.2 compliant. It supports the following J2EE API specifications:

- Servlet 2.1 (and partial support for Servlet 2.2)
- JSPs - supports 0.91 and 1.0
- EJBs 1.0+
- JTA 1.0
- JNDI 1.2
- JDBC 2.0
- JMS 1.0

WebSphere is not fully J2EE compliant, since it provides custom extensions to J2EE standards and includes non-standard packages for supporting J2EE features, such as servlet filtering and chaining, security, connection pooling and data access beans, and deployment descriptors. An application using these extensions and packages requires code-level changes in order to migrate to Oracle Application Server or any other J2EE-compliant application server.

2.4.2 Oracle Application Server J2EE Support

Oracle Containers for J2EE (OC4J) is fully certified with J2EE 1.3. Table 2–2 lists the J2EE technologies and the level of support provided by Oracle Application Server and WebSphere:

Table 2–2 J2EE Technology Support

J2EE Technology	Version Supported by WebSphere 3.5.3	Version Supported by Oracle Application Server 10*g* Release 3 (10.1.3.1.0)
JDK	1.2.2	1.4 and 1.3
Servlets	2.1+	2.4
JSPs	1.0	2.0
EJBs	1.0+	2.1 and 3.0 (Complete EJB 3.0 and JPA implementation)
JDBC	2.0	3.0
JNDI	1.2	1.2
JTA	1.0	1.0
JMS	1.0	1.1
JavaMail	None	1.2
JAF	None	1.0.1
JAXP	1.0.1	1.2
JCA	1.0	1.5
JAAS	1.0	1.0

Note: Oracle Application Server OC4J is installed with JDK 1.4.1. However, OC4J can also work with JDK 1.3.x for this version, 10*g* Release 3 (10.1.3.1.0), of Oracle Application Server.

In addition to supporting these standards, Oracle Application Server provides a well-thought-out, integrated architecture for building real world J2EE applications, including implementation of standard deployment archives: JAR files for EJBs, Web Archives (WARs) for servlets and JSPs, and Enterprise Archives (EARs) for applications. This ensures smooth server interoperability.

2.5 Java Development and Deployment Tools

This section compares the Java tools included with WebSphere and Oracle Application Server.

2.5.1 WebSphere Development and Deployment Tools

The WebSphere development environment, tools, and system administration console are described below.

2.5.1.1 WebSphere Development Tools

VisualAge for Java is is IBM's integrated development environment (IDE) for building J2EE applications. VisualAge for Java offers remote debugging support for JSP pages and other server-side Java logic. A new Servlet SmartGuide generates servlets, JSP components, and HTML prototypes, so that developers can quickly test their code inside the IDE before deploying to a production server. Integration with IBM WebSphere Studio allows for quick addition of content to prototypes, increasing productivity for programmers and web developers. VisualAge also comes with Persistence Builder, a standalone object-relational mapper tool.

2.5.1.2 WebSphere Studio

The WebSphere Studio provides a tool set for creating, managing and debugging multiplatform Web applications. It includes the following functionality:

- Visual Page Designer for Java Server Pages (JSP), HTML and DHTML
- Wizards to create database applications, queries, JavaBeans and servlets
- Deployment of EJBs, servlets and web applications

2.5.1.3 WebSphere Administrative Console

The WebSphere Administrative Console provides a GUI for managing the WebSphere domain. A WebSphere domain consists of one or more WebSphere instances (where each instance runs one or more applications). The Administrative Console connects to one of the Administrative servers running in the domain and can be used change to the configuration or run-time state on any machine in a domain. The Administrative Console is used to manage the administrative repository, deploy applications and configure applications.

2.5.2 Oracle Application Server Development and Deployment Tools

This section describes development and deployment tools for creating J2EE applications. The tools are part of the Oracle Developer Suite.

2.5.2.1 Oracle Application Server Development Tools

Application developers can use the tools in Oracle JDeveloper to build J2EE compliant applications for deployment on OC4J. JDeveloper is a component in Oracle Internet Developer Suite, a full-featured, integrated development environment for creating multi-tier Java applications. It enables you to develop, debug, and deploy Java client applications, dynamic HTML applications, web and application server components and database stored procedures based on industry-standard models. For creating multi-tier Java applications, JDeveloper has the following features:

- Oracle Business Components for Java (Datatags)
- Web application development
- Java client application development
- Java in the database
- Component-Based Development with JavaBeans
- Simplified database access
- Visual Integrated Development Environment
- Complete J2EE 1.3 support
- Automatic generation of .ear files, .war files, EJB JAR file, and deployment descriptors.

You can build applications with Oracle JDeveloper and deploy them manually, using Application Server Control Console. Also note that you are not restricted to using JDeveloper to build applications; you can deploy applications built with IBM VisualAge or Borland JBuilder on OC4J.

Note: In addition to JDeveloper, Oracle TopLink, an object-relational mapping tool, also comes with Oracle Application Server. For more information, see *Oracle TopLink Developer's Guide*.

2.5.2.2 Assembly Tools

Oracle Application Server provides a number of assembly tools to configure and package J2EE Applications. The output from these tools is compliant with J2EE standards and is not specific to OC4J. These include:

- A WAR file assembly tool to assemble JSP, servlets, tag libraries and static content into WAR files.
- An EJB assembler, which packages an EJB home, remote interface, deployment descriptor, and the EJB into a standard JAR file.
- An EAR File assembly tool, which assembles WAR Files and EJB JARs into standard EAR files.
- A tag library assembly tool, which assembles JSP tag libraries into standard JAR files.

2.5.2.3 Administration Tools

Oracle Application Server also provides two different administration facilities to configure, monitor, and administer OC4J.

- A graphical management console, integrated with Oracle Enterprise Manager 10*g* Application Server Control Console, which provides a single point of administration across OracleAS Clusters, Farms, and OC4J containers.
- A command line tool for performing administrative tasks locally or remotely from a command prompt. Oracle Enterprise Manager 10*g* Application Server Control Console is the preferred administration environment over the command line tool as Application Server Control Console provides a more integrated set of administration services.

3

Migrating Servlets

This chapter discusses key servlet features and APIs, WebSphere support for servlet APIs and its extensions to standards, and OC4J support for servlet APIs. It also includes a step-by-step migration path for servlets deployed on WebSphere to Oracle Application Server OC4J container.

3.1 Overview of the Java Servlet API

A servlet is an instance of a Java class running in a web container and servlet engine. Servlets are used for generating dynamic web pages. Servlets receive and respond to requests from web clients, usually via the HTTP protocol.

Servlets have several advantages over traditional CGI programming:

- Each servlet does not run in a separate process. This removes the overhead of creating a new process for each request.
- A servlet stays in memory between requests. A CGI program (and probably also an extensive runtime system or interpreter) needs to be loaded and started for each CGI request.
- There is only a single instance which answers all requests concurrently. This saves memory and allows a servlet to easily manage persistent data.
- A servlet can be run by a servlet engine in a restrictive sandbox (similar to how an applet runs in a web browser's sandbox), which allows for secure use of servlets.
- Servlets are scalable, providing support for a multi-application server configuration. Servlets also enable data caching, database access, and data sharing with other servlets, JSP files and (in some environments) Enterprise JavaBeans.

The servlet API is specified in two Java extension packages: `javax.servlet` and `javax.servlet.http`. Most servlets, however, extend one of the standard implementations of that interface, namely `javax.servlet.GenericServlet` and `javax.servlet.http.HttpServlet`. Of these, the classes and interfaces in `javax.servlet` are protocol independent, while `javax.servlet.http` contain classes specific to HTTP.

The servlet API provides support in four categories:

- Servlet life cycle management
- Access to servlet context
- Utility classes
- HTTP-specific support classes

identifies the servlet API classes according to the purpose they serve.

Table 3–1 Servlet API Classes

Purpose	Class or Interface
Servlet implementation	`javax.servlet.Servlet`
	`javax.servlet.SingleThreadModel`
	`javax.servlet.GenericServlet`
	`javax.servlet.httpServlet`
Servlet configuration	`javax.servlet.ServletConfig`
Servlet exceptions	`javax.servlet.ServletException`
	`javax.servlet.UnavailableException`
Request/response	`javax.servlet.ServletRequest`
	`javax.servlet.ServletResponse`
	`javax.servlet.ServletInputStream`
	`javax.servlet.ServletOutputStream`
	`javax.servlet.http.HttpServletRequest`
	`javax.servlet.http.HttpServletResponse`
Session tracking	`javax.servlet.http.HttpSession`
	`javax.servlet.http.HttpSessionBindingListner`
	`javax.servlet.http.HttpSessionBindingEvent`
	`javax.servlet.http.Cookie`
Servlet context	`javax.servlet.ServletContext`
Servlet collaboration	`javax.servlet.RequestDispatcher`

3.1.1 Servlet Lifecycle

Servlets run on the web server platform as part of the same process as the web server itself. The web server is responsible for initializing, invoking, and destroying each servlet instance. A web server communicates with a servlet through a simple interface, `javax.servlet.Servlet`.

This interface consists of three main methods

- `init()`
- `service()`
- `destroy()`

and two ancillary methods:

- `getServletConfig()`
- `getServletInfo()`

3.1.1.1 The `init()` Method

When a servlet is first loaded, its `init()` method is invoked, and begins initial processing such as opening files or establishing connections to servers. If a servlet has been permanently installed in a server, it is loaded when the server starts.

Otherwise, the server activates a servlet when it receives the first client request for the services provided by the servlet. The `init()` method is guaranteed to finish before any other calls are made to the servlet, such as a call to the `service()` method. The

`init()` method is called only once; it is not called again unless the servlet is reloaded by the server.

The `init()` method takes one argument, a reference to a `ServletConfig` object, which provides initialization arguments for the servlet. This object has a method `getServletContext()` that returns a `ServletContext` object, which contains information about the servlet's environment.

3.1.1.2 The `service()` Method

The `service()` method is the heart of the servlet. Each request from a client results in a single call to the servlet's `service()` method. The `service()` method reads the request and produces the response from its two parameters:

- A `ServletRequest` object with data from the client. The data consists of name/value pairs of parameters and an `InputStream`. Several methods are provided that return the client's parameter information. The `InputStream` from the client can be obtained via the `getInputStream()` method. This method returns a `ServletInputStream`, which can be used to get additional data from the client. If you are interested in processing character-level data instead of byte-level data, you can get a `BufferedReader` instead with `getReader()`.
- A `ServletResponse` represents the servlet's reply back to the client. When preparing a response, the method `setContentType()` is called first to set the MIME type of the reply. Next, the method `getOutputStream()` or `getWriter()` can be used to obtain a `ServletOutputStream` or `PrintWriter`, respectively, to send data back to the client.

There are two ways for a client to send information to a servlet. The first is to send parameter values and the second is to send information via the `InputStream` (or `Reader`). Parameter values can be embedded into a URL. The `service()` method's job is simple--it creates a response for each client request sent to it from the host server. However, note that there can be multiple service requests being processed simultaneously. If a service method requires any outside resources, such as files, databases, or some external data, resource access must be thread-safe.

3.1.1.3 The `destroy()` Method

The `destroy()` method is called to allow the servlet to clean up any resources (such as open files or database connections) before the servlet is unloaded. If no clean-up operations are required, this can be an empty method.

The server waits to call the `destroy()` method until either all service calls are complete, or a certain amount of time has passed. This means that the `destroy()` method can be called while some longer-running `service()` methods are still running. It is important that you write your `destroy()` method to avoid closing any necessary resources until all `service()` calls have completed.

3.1.2 Session Tracking

HTTP is a stateless protocol, which means that every time a client requests a resource, the protocol opens a separate connection to the server, and the server doesn't preserve the context from one connection to another; each transaction is isolated. However, most web applications aren't stateless. Robust Web applications need to interact with with the user, remember the nature of the user's requests, make data collected about the user in one request available to the next request from the same user. A classic example would be the shopping cart application, from internet commerce. The Servlet API provides techniques for identifying a session and associating data with it, even over multiple connections. These techniques include the following:

- Cookies
- URL rewriting
- Hidden form fields

To eliminate the need for manually managing the session information within application code (regardless of the technique used), you use the `HttpSession` class of the Java Servlet API. The `HttpSession` interface allows servlets to:

- View and manage information about a session
- Preserve information across multiple user connections, to include multiple page requests as well as connections

3.1.2.1 Cookies

Cookies are probably the most common approach for session tracking. Cookies store information about a session in a human-readable file on the client's machine. Subsequent sessions can access the cookie to extract information. The server associates a session ID from the cookie with the data from that session. This becomes more complicated when there are multiple cookies involved, when a decision must be made about when to expire the cookie, and when many unique session identifiers are needed. Also, a cookie has a maximum size of 4K, and no domain can have more than 20 cookies. Cookies pose some privacy concerns for users. Some people don't like that a program can store and retrieve information from their local disk, and disable cookies or delete them altogether. Therefore, they are not dependable as a sole mechanism for session tracking.

3.1.2.2 URL rewriting

The URL rewriting technique works by appending data to the end of each URL that identifies a session. The server associates the identifier with data it has stored about the session. The URL is constructed using an HTTP GET, and may include a query string containing pairs of parameters and values. For example:

```
http://www.server.com/getPreferences?uid=username&bgcolor=red&fgcolor=blue.
```

3.1.2.3 Hidden form fields in HTML

Hidden form fields are another way to store information about the session. The hidden data can be retrieved later by using the `HTTPServletRequest` object. When a form is submitted, the data is included in the GET or POST. A note of caution though: form fields can be used only on dynamically generated pages,so their use is limited. And there are security holes: people can view the HTML source to see the stored data.

3.1.3 The `HttpSession` object

No matter the technique(s) used to collect session data, it must be stored somewhere. The `HttpSession` object can be used to store the session data from a servlet and associate it with a user.

The basic steps for using the `HttpSession` object are:

1. Obtain a session object
2. Read or write to it
3. Terminate the session by expiring it, or allowing it to expire on its own

A session persists for a certain time period, up to forever, depending on the value set in the servlet. A unique session ID is used to track multiple requests from the same

client to the server. Persistence is valid within the context of the Web application, which may encompass multiple servlets. A servlet can access an object stored by another servlet; the object is distinguished by name and is considered bound to the session. These objects (called attributes when set and get methods are performed on them) are available to other servlets within the scope of a request, a session, or an application.

Servlets are used to maintain state between requests, which is cumbersome to implement in traditional CGI and many CGI alternatives. Only a single instance of the servlet is created, and each request simply results in a new thread calling the servlet's service method (which calls `doGet` or `doPost`). So, shared data simply has to be placed in a regular instance variable (field) of the servlet. Thus,the servlet can access the appropriate ongoing calculation when the browser reloads the page and can keep a list of the N most recently requested results, returning them immediately if a new request specifies the same parameters as a recent one. Of course, the normal rules that require authors to synchronize multithreaded access to shared data still apply to servlets.

Servlets can also store persistent data in the `ServletContext` object, available through the `getServletContext` method. `ServletContext` has `setAttribute` and `getAttribute` methods that enable storage of arbitrary data associated with specified keys. The difference between storing data in instance variables and storing it in the `ServletContext` is that the `ServletContext` is shared by all servlets in the servlet engine or in the Web application.

3.1.4 J2EE Web Applications

A Web application, as defined in the servlet specification, is a collection of servlets, JavaServer Pages (JSPs), Java utility classes and libraries, static documents such as HTML pages, images , client side applets, beans, and classes, and other Web resources that are set up in such a way as to be portably deployed across any servlet-enabled Web server. A Web application can be contained in entirety within a single archive file and deployed by placing the file into a specific directory.

3.1.4.1 Web Application Archive (WAR)

Web application archive files have the extension `.war`. WAR files are `.jar` files (created using the `jar` utility) saved with an alternate extension. The JAR format allows JAR files to be stored in compressed form and have their contents digitally signed. The `.war` file extension was chosen over `.jar` to distinguish them for certain operations. An example of a WAR file listing is shown below:

```
index.html
howto.jsp
feedback.jsp
images/banner.gif
images/jumping.gif
WEB-INF/web.xml
WEB-INF/lib/jspbean.jar
WEB-INF/classes/MyServlet.class
WEB-INF/classes/com/mycorp/frontend/CorpServlet.class
WEB-INF/classes/com/mycorp/frontend/SupportClass.class
```

On install, a WAR file can be mapped to any URI prefix path on the server. The WAR file then handles all requests beginning with that prefix. For example, if the WAR file above were installed under the prefix `/demo`, the server would use it to handle all requests beginning with `/demo`. A request for `/demo/index.html` would serve the

index.html file from the WAR file. A request for /demo/howto.jsp or /demo/images/banner.gif would also serve content from the WAR file.

3.1.4.2 About the WEB-INF directory

The WEB-INF directory is special. The files in it are not served directly to the client; instead, they contain Java classes and configuration information for the Web application. The directory behaves like a JAR file's META-INF directory; it contains meta-information about the archive contents. The WEB-INF/classes directory contains the class files for the Web application's servlets and supporting classes. WEB-INF/lib contains classes stored in JAR files. For convenience, web server class loaders automatically look to WEB-INF/classes and WEB-INF/lib for their classes—no extra install steps are necessary.

The servlets under WEB-INF in the example Web application listing can be invoked using URIs like /demo/servlet/MyServlet and /demo/servlet/com.mycorp.frontend.CorpServlet.

Note that every request for this application begins with /demo, even requests for servlets.

The web.xml file in the WEB-INF directory defines descriptors for a Web Application. This file contains configuration information about the Web application in which it resides and is used to register your servlets, define servlet initialization parameters, register JSP tag libraries, define security constraints, and other Web Application parameters .

3.1.5 Differences between Servlet 2.0, 2.1 and 2.2

The Servlet API in the J2EE specification is continously evolving. In a span of two years Servlet API 2.0 , 2.1, 2.2 has been published; the most recent version as of this writing is Servlet API 2.3. The fundamental architecture of servlets has not changed much, so most of the API is still relevant. However, there are enhancements and some new functionality, and some APIs have been deprecated.

This section covers the major differences between Servlet API 2.0 , 2.1 ,2.2 and 2.3 draft specification.

3.1.5.1 Highlights of the Java Servlet API 2.1

The Servlet 2.1 API highlights include:

- A request dispatcher wrapper for each resource (servlet)

  A request dispatcher is a wrapper for resources that can process HTTP requests (such as servlets andJSPs) and files related to those resources (such as static HTML and GIFs). The servlet engine generatesa single request dispatcher for each servlet or JSP when it is instantiated. The request dispatcher receives client requests and dispatches the request to the resource.

- A servlet context for each application

  In Servlet API 2.0, the servlet engine generated a single servlet context that was shared by all servlets. The Servlet API 2.1 provides a single servlet context per application, which facilitates partitioning applications. As explained in the description of the application programming model, applications on the same virtual host can access each other's servlet context.

- Deprecated HTTP session context

The Servlet API 2.0 `HttpSessionContext` interface grouped all of the sessions for a Web server into a single session context. Using the session context interface methods, a servlet could get a list of the session IDs for the session context and get the session associated with an ID. As a security safeguard, this interface has been deprecated in the Servlet API 2.1. The interface methods have been redefined to return `null`.

3.1.5.2 New Features in the Java Servlet API 2.2

The Servlet API 2.2 specification changed the term 'servlet engine', replacing it with 'servlet container'. This change is indicative of the Java Servlet API is now a required API of the Java 2 Platform, Enterprise Edition (J2EE) specification and, throughout J2EE's terminology, container is preferred over engine. Servlet API 2.2 introduced the following new features:

- Web Applications (as discussed above)
- References to external data sources, such as JNDI. Enables adding resources into the JNDI lookup table, such as database connections. Allows the resources to be located by servlets using a simple name lookup.
- Parameter information for the application (initiallization parameters for the application).
- Registered servlet names. Provides a place to register servlets and give them names. Previously, each server had a different process for registering servlets, making deployment difficult.
- Servlet initialization parameters. Enables passing parameters to servlets parameters at initialization time. This is a new, standard way to accomplish what used to be a server dependent process.
- Servlet load order. Specifies which servlets are preloaded, and in what order.
- Security constraints. Dictate which pages must be protected, and by what mechanism. Include built-in form-based authentication.

3.1.5.3 Servlet API 2.3

The Servlet API 2.3 leaves the core of servlets relatively untouched. Additions and changes include:

- JDK 1.2 or later is required
- A filter mechanism has been created
- Application lifecycle events have been added
- Additional internationalization support has been added
- The technique to express inter-JAR dependencies has been formalized
- Rules for class loading have been clarified
- Error and security attributes have been added
- The HttpUtils class has been deprecated
- Several DTD behaviors have been expanded and clarified

3.1.5.4 Filters and Servlet Chaining

Filtering support is provided as a part of the Servlet 2.3 API. WebSphere Advanced Edition 3.5.3 achieves similar filtering functionality with a WebSphere-specific package. OC4J supports the Java servlet 2.3 filtering specification.

Filtering is a method of loading and invoking servlets in a web server. Both local and remote servlets can be part of a servlet chain (defined below). There are restrictions, however, on chaining the local internal servlets, and these restrictions are specific to the J2EE container used. For example, in WebSphere, if an internal servlet is used in a chain, it must be the first servlet in the chain. Internal servlets include: `file` servlet, `pageCompile` servlet, `ssInclude` servlet, and `template` servlet.

3.1.5.5 Servlet Chains

For some requests, a chain of ordered servlets can be invoked rather than just one servlet. The input from the browser is sent to the first servlet in the chain and the output from the last servlet in the chain is the response sent back to the browser. Each servlet in the chain receives inputs from, and transmits outputs to, the servlet before and after it, respectively. A chain of servlets can be triggered for an incoming request by using:

- Servlet aliasing to indicate a chain of servlets for a request
- MIME types to trigger the next servlet in the chain

3.1.6 WebSphere Servlet API Support

WebSphere versions 3.5.2 and 3.5.3 maintain compatibility with existing applications while simultaneously supporting the Java Servlet API 2.2 specification. But this support is partial, and you can choose only one. To ensure compatibility, a new option was added to servlet container properties in the Administrative console. This new option, the Select Servlet Engine Mode, is located on the Servlet Engine Properties view. The Select Servlet Engine Mode option toggles between the following two different 'runtime' modes:

3.1.6.1 WebSphere Advanced Edition 3.5.3 Compatibility Mode

This mode maintains behavior with existing WebSphere Application Server v3.5 and v3.5.1 applications at the expense of full compliance with the Java Servlet API 2.2 specification. In compatibility mode, the servlet engine is Servlet 2.2 specification level compliant, except for the method and behavior changes noted below. This capability is provided to allow existing WebSphere Advanced Edition v3.5 and v3.5.1 applications to successfully execute until they are migrated to fully compliant Servlet 2.2 level applications.

3.1.6.2 Full Servlet 2.2 Compliance Mode

This mode maintains compliance with the Java Servlet API 2.2 specification at the expense of compatibility with existing WebSphere Application Server v3.5 and v3.5.1 applications.

The default mode is the Compatibility Mode. You select the desired mode using the Administrative Console, Servlet Engine General tab.

3.1.6.3 Servlet 2.2 API Support

WebSphere Advanced Edition 3.5.3 has partial support for the Servlet 2.2 API. The supported API features are:

- Response Buffering
- Multiple Error page support
- Welcome File Lists
- New request mapping logic

- Session Timeout per web application
- Mime mapping table per web application
- Request Dispatchers by name
- Request Dispatchers by relative path
- Duplicate Header support (`addHeader()`, `getHeaders(name)` APIs)
- Initialization parameters on a web application
- Internationalization improvements (`getLocale()`, `getLocales()`)
- New APIs `getServletName()`

The following Servlet 2.2 API features are not supported:

- J2EE Security Roles
  - Security deployment information in `web.xml`
  - `isUserInRole()`
  - `getUserPrincipal()` API
- J2EE-style Form Login
- J2EE References
  - EJB reference
  - Resource Reference
  - Environment Reference
  - Environment Entry
  - Refrence deployment information in `web.xml`
  - Security deployment information in `web.xml`

3.1.6.4 WebSphere Extensions to the Servlet API

The WebSphere Application Server includes its own packages that extends and adds to the Java Servlet API. The extensions and additions are provided to manage session state, create personalized Web pages, generate better servlet error reports, and access databases.

The Application Server API packages and classes are:

- `com.ibm.servlet.personalization.sessiontracking`

  Records the referral page that led a visitor to a web site, tracks the visitor's position within the site, and associates user identification with the session. IBM has also added session clustering support to the API.

- `com.ibm.websphere.servlet.session.IBMSession` interface

  Extends `HttpSession` for session support and increases Web administrators' control in a session cluster environment.

- `com.ibm.servlet.personalization.userprofile` package

  Provides an interface for maintaining detailed information about web visitors and incorporate it in your applications, so that you can provide a personalized user experience. This information stored it in a database.

- `com.ibm.websphere.userprofile` package

User profile enhancements.

- `com.ibm.websphere.servlet.error.ServletErrorReport` class

  Enables the application to provide more detailed and tailored messages to the client when errors occur.

- `com.ibm.websphere.servlet.event` package

  Provides listener interfaces for notifications of application lifecycle events, servlet lifecycle events, and servlet errors. The package also includes an interface for registering listeners.

- `com.ibm.websphere.servlet.filter` package

  Provides classes that support servlet chaining. The package includes the `ChainerServlet`, the `ServletChain` object, and the `ChainResponse` object.

- `com.ibm.websphere.servlet.request` package

  Provides an abstract class, `HttpServletRequestProxy`, for overloading the servlet engine's `HttpServletRequest` object. The overloaded request object is forwarded to another servlet for processing. The package also includes the `ServletInputStreamAdapter` class for converting an `InputStream` into a `ServletInputStream` and proxying all method calls to the underlying `InputStream`.

- `com.ibm.websphere.servlet.response` package

  Provides an abstract class, `HttpServletResponseProxy`, for overloading the servlet engine's `HttpServletResponse` object. The overloaded response object is forwarded to another servlet for processing. The package includes the `ServletOutputStreamAdapter` class for converting an `OutputStream` into a `ServletOutputStream` and proxying all method calls to the underlying `OutputStream`.

  The package also includes the `StoredResponse` object that is useful for caching a servlet response that contains data that is not expected to change for a period of time, for example, a weather forecast.

3.1.7 Oracle Application Server Servlet API Suport

Oracle Application Server OC4J is a fully compliant implementation of the Java Servlets 2.2 and 2.3 specifications. As such, standard Java Servlets 2.2 code will work correctly. WebSphere 3.5.3, on the other hand, has partial support for the Java Servlets 2.2 specification as described above. In particular, the security support remains at the Servlet 2.1 level, and there is no support for J2EE references that would normally be defined in the `web.xml` file associated with the Web application. There is also no direct support for J2EE Web Applications.

Because of these differences in API support and WebSphere extensions, an application may require code level changes before it can be migrated if it uses extensions or deprecated method calls. Since WebSphere does not support J2EE deployment descriptors, existing applications must be packaged into the J2EE Web Application structure before deployment on Oracle Application Server OC4J.

3.1.8 Migrating Standalone Servlets to OC4J

We migrated example servlets provided with WebSphere Advanced Edition 3.5.3. Some of these examples were not migrated because they used WebSphere-specific

extensions. For example, we did not migrate `AbstractLoginServlet` because it uses a single sign-on package specific to WebSphere.

We migrated these servlets (located in in `WebSphereInstallHome/Servlets`):

- Custom Login Servlet
- HelloWorldServlet
- SessionServlet

In addition to these, we migrated packaged Web Applications that use WebSphere-specific deployment descriptors.

These examples were migrated without code changes. All that was required was to place these servlets in

<ORACLE_HOME>`/j2ee/home/default-web-app/WEB-INF/classes` in UNIX

or

<ORACLE_HOME>`\j2ee\home\default-web-app\WEB-INF\classes` in NT.

The OC4J servlet container loads these servlets automatically. You can invoke these servlets from a browser using an URL similar to `http://`*<hostname>*`:7777/j2ee/servlet/HelloWorldServlet`.

WebSphere provides another way of deploying standalone servlets (that is, servlets that require initialization parameters and configuration information). These servlets are deployed in WebSphere using a deployment descriptor whose name is the name of the servlet and ends with `.servlet`. This WebSphere-specific deployment descriptor must be migrated to the J2EE Web application deployment descriptor before it can be deployed in OC4J.

Example 3–1 SnoopServlet.servlet Deployment Descriptor

```
<servlet>
  <name>snoop</name>
  <description>snoop servlet</description>
  <code>SnoopServlet</code>
  <servlet-path>/servlet/snoop/*</servlet-path>
  <servlet-path>/servlet/snoop2/*</servlet-path>
  <init-parameter>
    <name>param1</name>
    <value>test-value1</value>
  </init-parameter>
  <autostart>false</autostart>
</servlet>
```

3.1.8.1 Sample `.servlet` file: `SnoopServlet.servlet`

The Snoop Servlet can be migrated by placing its `.class` file in *<ORACLE_HOME>*`/j2ee/home/default-web-app/WEB-INF/classes` in UNIX or *<ORACLE_HOME>*`\j2ee\home\default-web-app\WEB-INF\classes` in NT

and editing `web.xml` located in the following directory:

UNIX:
<ORACLE_HOME>`/j2ee/home/default-web-app/WEB-INF`

NT:
<ORACLE_HOME>`\j2ee\home\default-web-app\WEB-INF`

The migrated SnoopServlet deployment descriptor looks like:

```
<web-app>
  <servlet>
    <servlet-name>snoop</servlet-name>
    <description>snoop servlet</description>
    <servlet-class>SnoopServlet</servlet-class>
    <servlet-path>/servlet/snoop/*</servlet-path>
    <servlet-path>/servlet/snoop2/*?/servlet-path?
    <init-param>
      <param-name>param1</param-name>
      <param-value>test-value1</param-value>
    </init-param>
    <autostart>false</autostart>
  </servlet>
</web-app>
```

3.1.9 Migrating Cluster-Aware applications to OC4J

Clustering and load balancing are two key features of an enterprise application server. These features make the application server available, fault tolerant, and scalable. The load balancer replicates state of an individual node to the cluster of instances so that if a node fails, the state information is preserved elsewhere. The cluster configuration provided by OC4J accomplishes the following:

- Maximizes use of resources

  If an application cannot make full use of a machine's resources, OC4J can help make more efficient useof the processing power.

- Maximize throughput

  OC4J can dramatically increase the number of requests an application can serve concurrently.

- Minimize risks of single points of failure

  OC4J builds redundancy into your configuration. If one instance fails, others can continue to process requests.

WebSphere and Oracle Application Server OC4J both provide clustering and load balancing session failover. OC4J also supports HTTP tunneling of RMI requests and responses without clustering. If you have a cluster-aware application running on WebSphere, it can be migrated to an OC4J instance (a set of OC4J processes, equivalent to a cluster).

The OC4J configuration incorporates the concept of islands. An island is a set of OC4J processes that have uniform application configuration and replicated application state. An island is a subset of processes within an OC4J instance.

3.1.9.1 Configuring an OC4J Island (in OC4J standalone mode)

Note: The instructions in this section show you how to configure a island manually. This can be done in a development environment where OC4J is running in standalone mode. If you are configuring an island in an OracleAS Cluster, **use the Oracle Enterprise Manager 11 Application Server Control Console web pages or the dcmctl command line utility**. Information on using these can be found in *Oracle Application Server Administrator's Guide* and *Oracle Application Server Containers for J2EE User's Guide*

The following steps explain how to configure an OC4J island:

1. Install your web application on all of the nodes in your cluster.
   a. First, make sure that the nodes you are using in your cluster have the same web application installed. If you do not want to install the application in two places, you can place it on a shared drive that both servers access.
   b. Start all your nodes and check that the web-applications are working correctly on all of them.
2. Set up your web-application to replicate its state to the cluster.
   a. Edit the `orion-web.xml` deployment descriptor for the web application, located at the following directory:

      UNIX:
      `<ORACLE_HOME>/j2ee/home/application-deployments/application-name/web-app-name/`

      NT:
      `<ORACLE_HOME>\j2ee\home\application-deployments\application-name\web-app-name\`

   b. If you want to add clustering for all web applications in the site, edit the `orion-web.xml` of the global web application located at the following directory:

      UNIX:
      `<ORACLE_HOME>/j2ee/home/config/global-web-application.xml`

      NT:
      `<ORACLE_HOME>\j2ee\home\config\global-web-application.xml`

      Add the following to the main body of the `<orion-web-app>` tag:

      ```
      <cluster-config/>
      ```

3. Optional: Specify the multicast host and IP address on which to transmit and receive cluster data.
4. Optional: Specify the port on which to transmit and receive cluster data.
5. Specify the ID (number) of the node to identify itself within the cluster. The default is localhost.
6. Optional: Repeat steps 4, 5 and 6 for all the nodes in your cluster.

   The `HTTPSession` data will now be replicated (as long as it is serializable, or an EJB reference). Note, however, that if the EJBs are located on a server that goes down, the references might become invalid. The `ServletContext` data is also replicated.

Note: It is important to understand that load balancing, in this case, is implemented for the web-component, not the EJB (EJBs have a different way of load balancing using client stubs). When using multiple islands, you may want to use different multicast IP addresses, to enable smart routing of multicast packets in your network, and just send traffic on certain IP addresses to certain servers.

---

7. Configure your islands.

   Islands are connected to a certain site rather than to a web-application. To configure an island:

   a. Edit the `web-site.xml` file for the website your web application is deployed on (for example, `default-web-site.xml` if you are clustering the default Web site). Add the following to the `<web-site>` tag:

      ```
      cluster-island="1"
      ```

      If your cluster has more than one island, you will specify different island values for the servers that belong to different islands. State is shared only within an island.

   b. Specify the host the Web site is serving using the `host="<hostname/ip address>"` attribute in the `<web-site>` tag.

8. Tell the servers about the load balancer. In the same file, the `web-site.xml` for your web site, you also specify where the load balancer for the site is located.

   a. In the main body of the `<website>` tag, add:

      ```
      <frontend host="balancer_hostname" port="balancer_port" />
      ```

      where `balancer_hostname` and `balancer_port` are the hostname and port of the server that will be running the load balancer.

9. In the `/WEB-INF/web.xml` or NT equivalent of your application, put in the tag

   ```
   </distributable>
   ```

   This tag indicates that the application is distributable (a feature of the J2EE 1.2 specification).

10. Access the load balancer's host and port with a browser. You will notice how the request is sent to a server. If you request the same page again from the same client, your request will probably be sent to the same server again, but if you request the same page from different clients, you will see that the client requests get balanced.

    To test the state replication, you can try accessing the servlet in the following directory:

    UNIX:
    <ORACLE_HOME>`/j2ee/home/servlet/SessionServlet`

    NT:
    <ORACLE_HOME>`\j2ee\home\servlet\SessionServlet`

    Make the request once, and check which server becomes the primary server for the session. Stop that server and make the request again. The desired result is that the request is part of the same session as before but on a different node. And, the counter is updated correctly.

3.1.9.2 How OC4J Island Works (in OC4J standalone mode)

For all of the islands, there is a single load balancer OC4J instance that dispatches requests to the application clones.

- If a new request is made from an IP address that has not connected to the site before, and has no session associated with it, it is sent to a random OC4J instance. If more than one island in the cluster is capable of serving the same site, an island is chosen at random. Thereafter, a random node is picked within the selected island.

- All state replication occurs within the island of this selected node. If a request is made from an IP address that has connected to to the website before, the request will be sent to the same server as the previous request (unless the configuration specifies that requests not be routed based on IP address).
- By default, load balancing is based on client, not on request. In other words, statistically speaking, default load balancing is expected to send off an equal number of clients to each node in the island. Note that an equal number of clients to nodes in the island does not equate to an equal number of requests to the server, since each client makes a different number of requests.
- To make load balancing request based, you can use the "`dontuseIP`" switch, a powerful feature of OC4J islands.
- If a request is made within a keep-alive socket, the request will get sent to the same server as the previous request, unless you have specified that keep-alives should not be used (`-dontUseKeepalives` as command line option or `use-keepalives="false"` in `load-balancer.xml`.
- If a request is made from a user in a session, the request is sent to the primary server for that session. If the primary server for the session does not respond, the request will be sent to another server in the same island. Since the state has been replicated, the other server has the same user state.

4

Migrating Java Server Pages

This chapter describes how to migrate JavaServer Pages (JSPs) from WebSphere to Oracle Application Server OC4J. The JSP API, and the details of the WebSphere extensions and the different JSP engines it supports are discussed. The process of migrating JSPs from WebSphere to Oracle Application Server is outlined at the end of the chapter. This chapter contains the following topics:

4.1 Overview of Java Server Pages

JavaServer Pages is a technology specified by Sun Microsystems as a method of generating dynamic content from an application running on a web server. This technology, which is closely coupled with Java servlet technology, allows you to include Java code snippets and calls to external Java components within the HTML code (or other markup code, such as XML) of your Web pages.

A JSP page is translated into a Java servlet before being executed (typically on demand, but sometimes in advance). As a servlet, it processes HTTP requests and generates responses. JSP technology offers a more convenient way to code the servlet instead of embedding HTML tags in the servlets. Furthermore, JSP pages are fully interoperable with servlets—that is, JSP pages can include output from a servlet or forward output to a servlet, and servlets can include output from a JSP page or forward to a JSP page.

4.1.1 Parts of a JSP Page

A JSP page typically consists of the following:

- Directives - imports and and interfaces
- Declarations - class-wide variables and methods
- Expressions - return value substitution
- Scriptlets - inline Java code

Each is described below.

4.1.1.1 Directives

Directives are compile-time control tags. They allow you to customize how your JSP pages are compiled to Java servlets. There are three types of directives:

4.1.1.1.1 Page A page directive is placed at the top of a JSP page. Its attributes apply to the entire page.

Example:

```
<%@ page language="java" import="com.mycom.*" buffer="16k" %>
```

4.1.1.1.2 Taglib A taglib directive extends the set of tags recognized by the JSP processor. It requires two attributes, uri and prefix.

Example:

```
<%@ taglib uri="tag-lib-uri" prefix="tag-prefix" %>
```

The uri attribute contains the location of the tag library TLD (Tag Library Descriptor) file.

The prefix attribute specifies the tag prefix you want to use for your custom tag.

Example:

```
<%@ taglib uri="/WEB-INF/tlds/myapp.tld" prefix="custom" %>
```

4.1.1.1.3 Include The include directive enables you to insert the content of another file into the JSP page at compilation time. Its syntax is as follows:

```
<%@ include file="localOrAbsoluteURL" %>
```

During compilation the content of the file specified in the file attribute will be added to the current JSP page.

4.1.2 What is a JSP container?

A JSP container is software that stores the JSP files and servlets, converts JSP files into servlets, compiles the servlets, and runs them (creating HTML). The exact make-up of a JSP container varies from implementation to implementation, but it will consist of a servlet or collection of servlets. The JSP container is executed by a servlet container.

The JSP container creates and compiles a servlet from each JSP file. The container produces two files for each JSP file:

- A `.java` file, which contains the Java language code for the servlet
- A `.class` file, which is the compiled servlet

The JSP container puts the `.java` and the `.class` file in a path specific to the container. The `.java` and the `.class` file have the same filename. Each container uses a naming convention for the generated `.java` and `.class` files. For example, WebSphere generates files named `_simple_xjsp.java` and `_simple_xjsp.class` from the JSP file `simple.jsp`.

4.1.3 Life Cycle of a JSP Page

1. The user requests the JSP page through a URL ending with a `.jsp` file name.
2. Upon noting the `.jsp` file name extension in the URL, the servlet container of the Web server invokes the JSP container.
3. The JSP container locates the JSP page and translates it if this is the first time it has been requested.

   Translation includes producing servlet code in a `.java` file and then compiling the `.java` file to produce a servlet `.class` file.

4. The servlet class generated by the JSP translator subclasses a class (provided by the JSP container) that implements the `javax.servlet.jsp.HttpJspPage` interface.
5. The servlet class is referred to as the page implementation class. This document will refer to instances of page implementation classes as JSP page instances.

4.2 WebSphere Support for the JSP API

WebSphere Advanced Edition 3.5.3 supports JSP 0.91, JSP 1.0, and, in its latest service pack, JSP 1.1. However, the support is not backward compatible.

WebSphere specifies two modes of operation for JSPs: Compatibility mode and Compliance mode. In Compatibility mode, you can choose compatibility with JSP 1.0 or JSP 0.91. For example, if you choose compatibility mode with JSP 0.91 you cannot use features of JSP 1.0 or JSP 1.1. In compliance mode, your applications are compliant with JSP 1.1.

These modes of JSP are necessary because WebSphere provides a JSP processor for each supported level of the JSP specification. Each of these JSP processors is a servlet that can be added to a web application to handle all JSP requests specific to the web application. The JSP processor used is dependent on the web application. If a web application includes JSPs of version 1.0, WebSphere loads the JSP processors for JSP 1.0. These is specified as a part of your web application.

Table 4–1 JSP Processors

JSP Processor	Processor Servlet Name	Class Name
JSP 1.0	`JSPServlet`	`com.sun.jsp.runtime.JspServlet in jsp10.jar`
JSP 0.91	`PageCompileServlet`	`com.ibm.servlet.jsp.http.pagecompile. PageCompileServletinibmwebas.jar`

4.2.1 WebSphere-Specific Features

WebSphere provides several JSP features which are available in WebSphere only. These are:

4.2.1.1 Batch JSP Compiler

WebSphere provides a batch JSP compiler, enabling faster responses to requests for the JSP files. The process of batch compilation is different for JSP 0.91 and JSP 1.0.

4.2.1.2 HTML Template Extensions in JSP 0.91

WebSphere has built-in extensions for JSPs called HTML templates for variable data. These extensions are supported by the WebSphere JSP engine and are useful for generating tabular data.These template extensions consist of three additional tags:

- `<INSERT>` - This tag enables developers to insert a value based on a property name and an object specifier. This object can be a bean name or reference to a object in request object.
- `<REPEAT>` - This tag enables developers to write a "`for`" loop in a JSP page, as a HTML element, without embedding Java code. For example, a database query resulting in a variable result set can be iterated using a `<REPEAT>` tag instead of a embedded Java "`for`" loop. A `<REPEAT>` tag can contain a block of HTML tagging that in turn contains the `<INSERT>` tags, and the HTML tags for formatting

content. The <REPEAT> tag iterates from the start value to the end value until either the end value is reached or an ArrayIndexOutofBoundsException is thrown. The output of a <REPEAT> block is buffered until the block completes. If an exception is thrown before a block completes, no output is written for that block.

- <BEAN> - This tag enables the developer to reference a bean in the JSP.

JSP also has tags for database connect, query, and modify: <DBCONNECT>, <DBQUERY> and <DBMODIFY>. The functionality of these tags has not changed in JSP 1.0 other than being moved to a new tag library, tsx, with names <tsx:dbconnect>, <tsx:dbquery>, and <tsx:dbmodify> respectively.

4.2.1.3 WebSphere Extensions to JSP 1.0

WebSphere Advanced Edition 3.5.3 provides several extensions to the base APIs. The extensions are categorized as tags for variable data and tags for database access.

Tags for variable data:

- <tsx:repeat> - This tag is similar to the <REPEAT> tag described above, useful in creating HTML tables.
- <tsx:getProperty> - This tag is an extension of the Sun JSP tag <jsp:getProperty>. It is similar to <jsp:getProperty>, and adds the ability to introspect a database bean that was created using the extension <tsx:dbquery> or <tsx:dbmodify>.

Tags for database access:

(These tags are useful for making database connections from a JSP and then use that connection to query or update the database. The user ID and password for the database connection can be provided by the user at request-time or hard coded within the JSP file.)

- <tsx:dbconnect> - This tag enables the JSP page to make a database connection through JDBC. dbconnect tags are not used directly to establish a database connection. Instead, the <tsx:dbquery> and <tsx:dbmodify> tags are used to reference a <tsx:dbconnect> in the same JSP file and establish the connection to the database. Note that this is different from what is done at the application server level, where you setup a set of datasources.
- <tsx:userid> and <tsx:passwd> - These tags enable the JSP page to accept user input for the values and then add that data to the request object. The request object can be accessed by a JSP file, for example, Account.jsp, that requests the database connection.These two tags should be used in within a <tsx:dbconnect> tag.
- <tsx:dbquery> - This tag is used to establish a connection to a database using information specified in the <tsx:dbconnect> tag in the same JSP file, and query the database and return the result set. This caches the result set in a results object. At the end of the operation it closes the connection.
- <tsx:dbmodify>:<tsx:dbconnect> - This tag is used to open a new connection to a database and then update the database tables. This tag is also similar to <tsx:dbquery> in that it obtains database connnection information, and at the end of the operation closes the connection.

4.2.2 OC4J JSP Features

Oracle Application Server provides one of the fastest JSP engines on the market. It also provides several value-added features and enhancements such as support for globalization and SQLJ. If you are familiar with Oracle9*i*AS 1.0.2.2, the first release of Oracle Application Server to include OC4J, there were two JSP containers: a container developed by Oracle and formerly known as OracleJSP and a container licensed from Ironflare AB and formerly known as the "Orion JSP container".

In Oracle Application Server 10*g*, these have been integrated into a single JSP container, referred to as the "OC4J JSP container". This new container offers the best features of both previous versions, runs efficiently as a servlet in the OC4J servlet container, and is well integrated with other OC4J containers. The integrated container primarily consists of the OracleJSP translator and the Orion container runtime running with a new simplified dispatcher and the OC4J 1.0.2.2 core runtime classes. The result is one of the fastest JSP engines on the market with additional functionality over the standard JSP specifications.

OC4J JSP provides extended functionality through custom tag libraries and custom JavaBeans and classes that are generally portable to other JSP environments:

- Extended types implemented as JavaBeans that can have a specified scope
- `JspScopeListener` for event handling
- Integration with XML and XSL through custom tags
- Data-access JavaBeans
- The Oracle JSP Markup Language (JML) custom tag library, which reduces the level of Java proficiency required for JSP development
- OC4J JSP includes connection pooling tags, XML tags, EJB tags, file access tags, email tags, caching tags, OracleAS Personalization tags, OracleAS Ultrasearch tags, and a custom tag library for SQL functionality.
- JESI (Edge Side Includes for Java) tags and Web Object Cache tags and API that work with content delivery network edge servers to provide an intelligent caching solution for web content (see the following sub-sections).

> **See Also:** *Oracle Containers for J2EE JSP Tag Libraries and Utilities Reference* for detailed information on custom JSP tag libraries.

The OC4J JSP container also offers several important features such as the ability to switch modes for automatic page recompilation and class reloading, JSP instance pooling, and tag handler instance pooling.

4.2.2.1 Edge Side Includes for Java (JESI) Tags

OC4J provides fine-grained control allowing developers to cache fragments of JSP pages down to each individual tag - these can be cached in OracleAS Web Cache and are automatically invalidated and refreshed when a JSP changes. The technology behind this is Edge Side Includes (ESI), a W3C standard XML schema/markup language that allows dynamic content to be cached in a Web cache or to be assembled in an edge network. By caching this dynamic content, it reduces the need to execute JSPs or Servlets, thereby improving performance, off loading the application servers, and reducing latency. JESI (JSP to ESI) tags are layered on top of an Edge Side Includes (ESI) framework to provide ESI caching functionality in a JSP application. JESI tags enable the user to break down dynamic content of JSP pages into cacheable components or fragments.

4.2.2.2 Web Object Cache Tags

The Web Object Cache is an Oracle Application Server feature that allows Web applications written in Java to capture, store, reuse, post-process, and maintain the partial and intermediate results generated by JSPs or Servlets. For programming interfaces, it provides a tag library (for use in JSP pages) and a Java API (for use in Servlets). Cached objects might consist of HTML or XML fragments, XML DOM objects, or Java serializable objects. By caching these objects in memory, various operations can be carried out on the cached objects including:

- Applying a different XSLT based on user profile or device characteristics on the stored XML
- Re-using a cached object outside HTTP, such as SMTP to send e-mail to clients.

4.2.2.3 Oracle JDeveloper and OC4J JSP Container

Oracle JDeveloper is integrated with the OC4J JSP container to support the full JSP application development cycle - editing, source-level debugging, and running JSP pages. It also provides an extensive set of data-enabled and web-enabled JavaBeans, known as JDeveloper web beans and a JSP element wizard which offers a convenient way to add predefined web beans to a page. JDeveloper also provides a distinct feature that is very popular with developers. It allows you to set breakpoints within JSP page source and can follow calls from JSP pages into JavaBeans. This is much more convenient than manual debugging techniques, such as adding print statements within the JSP page to output state into the response stream for display on browser or to the server log.

4.3 Migrating from WebSphere JSP 0.91

This section explains how to migrate WebSphere JSP 0.91 files to OC4J.

4.3.1 The <REPEATGROUP> Tag

1. If you are migrating JSP 0.91 files that contain <REPEATGROUP> tags, you must change these tags. This tag is used for repeating a block of HTML, for data that is already logically grouped in the database.
2. Replace the <SERVLET> tag with the <jsp:include> tag.

   For example, change the following:

   ```
   <SERVLET CODE="com.samples.test.TestServlet"></SERVLET>
   ```

   to

   ```
   <jsp:include page="/servlet/com.samples.test.TestServlet" />
   ```

3. Replace the WebSphere <BEAN> tag with the <jsp:useBean> tag.

   The example below shows the <BEAN> tag migrated to the JSP standard tag:

   ```
   <BEAN NAME="AccountDBBean"
   TYPE="com.test.AccountDBBean"
   CREATE="YES"
   INTROSPECT="YES"
   SCOPE="request">
   <PARAM NAME="userID" VALUE="wsdemo">
   </BEAN>
   ```

   Migrating to OC4J, the above is replaced by:

```
<jsp:useBean
id="AccountDBBean"
type="com.test.AccountDBBean"
class="com.test.AccountDBBea"
scope="request"/>

<jsp:setProperty
name="AccountDBBean"
property="userID"
value="wasdemo" />
```

- Note that the explicit attribute of `CREATE="YES"` is removed. This is because, if the bean with the name specified by the id attribute is not found within the specified scope, then an instance of bean will be created according to the class attribute. The JSP `NAME` attribute corresponds to the JSP 1.0 id attribute. It is no longer an `INTROSPECT` attribute. (The JSP 0.91 scope of requests and sessions carries over to JSP 1.0.)
- The `class` attribute is not necessary if the bean already exists within the specified scope . But if the class attribute is not specified and the bean is not in the specified scope an error will occur when creating a new instance of the bean.

4. Set the bean properties.

   In JSP 0.91, the `<PARAM>` tag is used within the `<BEAN>` tag to specify properties for the bean. In JSP 1.0, you must use the `<jsp:setProperty>` tag outside of the `<jsp:useBean>` tag. You can link to the property settings of an existing bean using the name attribute within `<jsp:setProperty>` and specifying the bean identified by the id attribute in `<jsp:useBean>`. A similar way to obtain bean property values can be achieved using the tag `<jsp:getProperty>`.

4.4 Migrating WebSphere Extensions to OC4J

There are two ways to migrate JSPs that use any WebSphere-specific custom tags defined in the `tsx` tag library to OC4J.

- If there are many pages, and it is tedious to modify all the JSP files, you can use the WebSphere tag library and deploy it on on OC4J.
- Edit the JSP source files, using the OCJ JSP tag library wherever possible.

Following are code examples showing how to migrate WebSphere JSP extensions to OC4J using the Oracle JSP Markup Language (JML) tag library.

4.4.1 `<REPEAT>` or `<tsx:repeat>` tag:

These tags are provided by WebSphere for looping over a HTML block a specified number of times, as an altenative to writing a Java "`for`" loop within a JSP page. The Oracle JML tag library has a `<jml:for>` tag with the same functionality. The syntax for this tag is:

```
<jml:for id = " loopVariable"
    from = "<%= jspExpression %>"
    to = "<%= jspExpression %>" >
    ... body of for tag (executed once at each value of range, inclusive)...
</jml:for>
```

which is similar to the WebSphere `<tsx:repeat>`:

```
<tsx:repeat index=name start=start_index end=end_index >
</tsx:repeat>
```

The differences are:

- The `id` variable in the `<jml:for>` tag holds the current value in the range and is local in scope to the tag, whereas the index variable is global in scope to the JSP page.
- `from` and `to` in `<jml:for>` are mandatory in OC4J JSP. In WebSphere, `start` and `end` are optional.

See Also:

Oracle Containers for J2EE Support for JavaServer Pages Developer's Guide

Oracle Containers for J2EE JSP Tag Libraries and Utilities Reference

5

Migrating Enterprise Java Beans

This chapter provides an overview of Sun Microsystems' Enterprise JavaBeans (EJB) architecture and its implementation in Oracle Application Server. In addition, the issues involved in migrating EJB components from WebSphere Advanced Edition 3.5.3 to Oracle Application Server are presented.

5.1 Overview of Enterprise JavaBeans

Enterprise JavaBeans (EJB) is the standard server-side component architecture for developing and deploying object-oriented Java applications. It enables developers to quickly and easily build distributed applications.

A major goal of the EJB architecture is to provide component portability at both the source code level and the binary code level.

EJB components, called enterprise beans, are server-side components, written in Java, that typically contain the business logic of an application. The different types of enterprise beans are summarized in Table 5–1.

Table 5–1 Types of EJBs

Type of Enterprise Bean	Description
Session bean	A component created to provide a service on behalf of a single client; it lives only for the duration of a single client/server session.
Entity bean	A component representing data maintained in a data store; it can persist as long as the data it represents.

Although the EJB architecture does provide for component portability, certain implementation-specific aspects of an EJB component remain non-portable. These include:

- Deployment of enterprise beans
- Runtime support for deployed enterprise beans
- Container-managed persistence of entity beans

5.2 EJB Migration Considerations

One of the goals of the EJB initiative is to deliver component portability between different environments not only at source-code level, but also at a binary level, to ensure portability of compiled, packaged components. While it is true that EJB does offer an appreciable amount of portability, there are still a number of non-portable,

implementation-specific aspects that need to be addressed when migrating components from one application server to another. Typically, an EJB component requires low-level interfaces with the container in the form of stubs and skeleton classes that will probably always need to be container implementation-specific. In effect, a clear partitioning between portable and non-portable elements of an EJB component can be drawn from the EJB 1.1 specification:

- Portable EJB elements include:
  - The actual component implementation classes and interfaces (bean class, and remote, and home interfaces).
  - The assembly and deployment descriptor that describes generic component properties such as JNDI names and transactional attributes.
  - Security attributes
- Implementation-specific elements include:
  - Low-level helper implementation classes (stubs and skeletons) to interface with the host container.
  - Object-relational mapping definitions for CMP entity beans, including search logic for custom finder methods that are declared in an implementation-specific format proprietary to each application server.
  - Every component has a set of properties that require systematic configuration at deployment time. For example, mapping of security roles declared in an EJB component to actual users and groups is a task that is systematically performed at deployment-time, first, because mappings may not be known in advance, and secondly, because there are dependencies on the structure and population of the user directory on the target deployment server.
  - There are issues specific to migration from WebSphere to OC4J that arise from different levels of EJB standards support, and WebSphere-specific extensions to APIs. WebSphere Advanced Edition 3.5.3 supports the EJB 1.0 specification, OC4J supports EJB 2.0.

The following sections describe EJB specifications, session beans, and entity beans, transactions and concurrency, the WebSphere support for these APIs and WebSphere extensions, the difference between OC4J and WebSphere in the EJB containers and finally the migration path to OC4J.

5.3 EJB Functionality and Components

In brief, the goal of EJB technology surpasses the basic Java object model by integrating new functionality important for enterprise systems:

- Automatic management of object life cycle (instantiation, destruction, and activation)
- Object security: who can use which object and how
- Object persistence: how objects are stored on a long-term basis
- Transaction behavior of the objects
- Distribution: how can remote applications access objects
- Scalability: by implementing various technologies

From a developer's point of view, an EJB is presented as a group of files that brings together:

- Java classes
- Java interfaces,
- Deployment information,
- Metadata

5.3.1 The EJB Server

EJB servers manage low-level system resources, allocating resources to the containers as they are needed. The EJB Server hosts and provides a runtime environment for the EJB containers. Containers are transparent to the client—there is no client API to manipulate the container, and there is no way for a client to tell in which container an enterprise bean is deployed. However, the EJB container and the EJB servers are not clearly separated constructs. The EJB specification only defines a bean-container contract and does not define a container-server contract.

5.3.2 EJB container

The EJB container is a specialized service in which enterprise beans are deployed. EJB containers insulate the deployed enterprise beans from the underlying EJB server and provide a standard application programming interface (API) between the beans and the container. This specialized service manages their life cycle, transactions, security, naming, persistence, and so on, according to a specific contract and constrained model delineated by the EJB specification. To do this, the container uses the generic services provided by the server.

5.3.3 EJB Specification Roles

The Enterprise JavaBeans specification identifies the following roles that are associated with a specific task in the development of distributed applications.

5.3.3.1 Enterprise Bean Provider

Typically an expert in the application domain; for example, in the financial or telecommunications industry. The bean provider implements the business task without being concerned about the distribution, transaction, security, and other non-business aspects of the application.

5.3.3.2 Application Assembler

This is also a domain expert. The application assembler composes an application from various prefabricated building blocks (that is, enterprise beans) and adds other components such as GUI clients, applets, and servlets to complete the application. While composing an application, an assembler is only concerned with the interfaces to enterprise beans, but not with their implementation.

5.3.3.3 Deployer

The deployer is specialized in the installation of applications. The deployer adapts an application, composed of a number of enterprise beans, to a target operation environment by modifying the properties of the enterprise beans. The deployer's tasks include, for example, the setting of transaction and security policies, specifying JNDI names by setting the appropriate properties in the deployment descriptor, and integration with enterprise management software.

5.3.3.4 EJB Server Provider

Typically a vendor with expertise in distributed infrastructures and services. The server provider implements a platform, which facilitates the development of distributed applications and provides a runtime environment for them. This role can also provide specialized containers that wrap a certain class of legacy applications or systems.

5.3.3.5 EJB Container Provider

An expert in distributed systems, transactions, and security. A container is a runtime system for one or multiple enterprise beans. It provides the glue between enterprise beans and the EJB server. A container can be both, prefabricated code as well as a tool that generates code specific for a particular enterprise bean. A container also provides tools for the deployment of an enterprise bean and hooks into the application for monitoring and management.

5.3.3.6 System Administrator

The system administrator is concerned with a deployed application. The administrator monitors the running application and takes appropriate action in the case of abnormal behavior of the application. The administrator ensures that the hardware and network hosting the application is maintained and serviceable for the duration of the application's availability. Typically, an administrator uses enterprise management tools that are connected to the application by the deployer through the hooks provided by the container.

5.3.4 Session Beans

A session bean is an object that executes on behalf of a single client. The container creates the session bean instance in response to a remote task request from a client. A session bean has one client; in a sense, a session bean represents its client in the EJB server. Session beans can also be transaction-aware--they can update shared data in an underlying database, but they do not directly represent the shared database data. The life of a session bean is transient and relatively short-lived. Typically, the session bean lives for as long as its client maintains the session "conversation". When the client terminates, the session bean is no longer associated to that client. A session bean is considered transient because the session bean instance is removed should the container crash, and the client must reestablish a new session object to continue.

There are two types of session beans: Stateful Session Beans (SFSB) and Stateless Session Beans (SLSB). Both of these beans must implement `javax.ejb.SessionBean`. However their life cycles are different within a EJB container.

5.3.4.1 Stateful Session Beans

A session bean typically maintains the state of the interaction or conversation with its client--that is, the session bean holds information about the client across method invocations and for the duration of the client session. A session bean that maintains its state is called a stateful session bean. When the client ends its interaction with the session bean, the session ends and the bean no longer maintains the state values.

5.3.4.1.1 The Life Cycle of Stateful Session Beans

A session bean's lifecycle begins when a client invokes a `create()` method defined in the bean's home interface. In response to this method invocation, the container does the following:

1. Creates a new memory object for the session bean instance.
2. Invokes the session bean's `setSessionContext()` method. This method passes the session bean instance a reference to a session context interface that can be used by the instance to obtain container services and get information about the caller of a client-invoked method.
3. Invokes the session bean's `ejbCreate()` method corresponding to the `create()` method called by the EJB client.

5.3.4.1.2 Ready State

After a session bean instance is created, it moves to the ready state of its lifecycle. In this state, EJB clients can invoke the bean's business methods defined in the remote interface. The actions of the container in this state are determined by whether a method is invoked transactionally or non-transactionally.

5.3.4.1.3 Transactional Method Invocations

When a client invokes a transactional business method, the session bean instance is associated with a transaction. After a bean instance is associated with a transaction, it remains associated until that transaction completes. Furthermore, an error results if an EJB client attempts to invoke another method on the same bean instance and invoking that method causes the container to associate the bean instance with another transaction or with no transaction. The container then invokes the following methods:

1. The `afterBegin()` method if the session bean implements the `SessionSynchronization` interface.
2. The business method in the bean class that corresponds to the business method defined in the bean's remote interface and called by the EJB client.
3. The bean instance's `beforeCompletion()` method, if the session bean implements the `SessionSynchronization` interface.

The transaction service then attempts to commit the transaction, resulting either in a commit or a roll back. When the transaction completes, the container invokes the bean's `afterCompletion()` method (if the bean implements the `SessionSynchronization` interface), passing the completion status of the transaction (either commit or rollback) to the `afterCompletion()` method.

If a rollback occurs, a stateful session bean can roll back its conversational state to the values contained in the bean instance prior to beginning the transaction. Stateless session beans do not maintain a conversational state, so they do not need to be concerned about rollbacks.

5.3.4.1.4 Non-transactional Method Invocations

When a client invokes a nontransactional business method, the container simply invokes the corresponding method in the bean class.

5.3.4.1.5 Pooled State

The container has a sophisticated algorithm for managing which enterprise bean instances are retained in memory. When a container determines that a stateful session bean instance is no longer required in memory, it invokes the bean instance's `ejbPassivate()` method and moves the bean instance into a reserve pool. A stateful session bean instance cannot be passivated (deactivated) when it is associated with a transaction.

If a client invokes a method on a passivated instance of a stateful session bean, the container activates the instance by restoring the instance's state and then invoking the bean instance's `ejbActivate()` method. When this method returns, the bean instance is again in the ready state.

Because every stateless session bean instance of a particular type is the same as every other instance of that type, stateless session bean instances are not passivated or activated. These instances exist in a ready state at all times until their removal.

5.3.4.1.6 Removal

The lifecycle of a stateful session bean ends when an enterprise bean client or the container calls a `remove()` method defined in the bean's home interface or remote interface. In response to this method invocation, the container calls the bean instance's `ejbRemove()` method. The container can end stateless session beans by this method, or it can pool them for later use.

A container can implicitly call a remove method on an instance after the lifetime of the EJB object has expired. The lifetime of a session EJB object is set in the deployment descriptor with the timeout attribute.

5.3.4.2 Stateless Session Beans

A session bean may also be a stateless session bean. A stateless session bean does not maintain information or state for its client. A client may invoke a method of a stateless session bean to accomplish some objective, but the bean will hold values in its instance variables only for the duration of the method call. The stateless session bean does not retain these values (or state) when the method completes. Thus, all instances of stateless session beans are identical except when they are in the midst of a method invocation. As a result, stateless session beans can support multiple clients. The container can maintain a pool of stateless bean instances, and it can assign any instance to any client.

5.3.4.2.1 The Life Cycle of a Stateless Session Bean

The stateless session bean's life cycle has two states:

- The does-not-exist state.
- The method-ready pool state.

When a bean instance is in the does-not-exist state, this means that it has not yet been instantiated. When a bean instance is instantiated by the container and is ready to serve client requests, it is in the method-ready pool state. The container moves a stateless session bean from the does-not-exist state to the method-ready pool state by performing the following three operations:

1. Invoke the `Class.newInstance()` method on the stateless bean class.
2. Invoke the `SessionBean.setSessionContext(SessionContext context)` method on the bean instance.
3. `ejbCreate()` method is invoked on the bean instance.

5.3.5 Entity Beans

An entity bean represents an object view of persistent data maintained in a domain model, as well as methods that act on that data. To be more specific, an entity bean maps to a record in your domain model. In a relational database context, one bean exists for each row in a table. A primary key identifies each entity bean. Entity beans

are created by using an object factory `create()` method. Access to entity beans may be shared by more than one client--multiple clients can simultaneously access an entity bean. Entities access and update the underlying data within the context of a transaction so that data integrity is maintained. Entity beans are also implicitly persistent as an EJB object can manage its own persistence or delegate its persistence to its container. Based on the type of persistence in entity beans are divided into two types:

5.3.5.1 Container-managed Persistence (CMP) Entity Beans

Container Managed Persistence (CMP) allows developers to build EJB components without having to directly deal with persistence during development. For CMP Entity Beans, the EJB container is responsible for persisting the state of the entity beans and synchronization of instance fields within the persistence store (the database). This means that the container would, for example, manage both generating and executing SQL code to read and write to the database. Because it is container-managed, the implementation is independent of the data source. All container-managed fields need to be specified in the deployment descriptor for the persistence to be automatically handled by the container. CMP Entity Beans are wrappers for persistent data, commonly in the form of relational database tables with additional support for transaction control and security.

5.3.5.2 Bean-managed Persistence (BMP) Entity Beans

For BMP Entity Beans, the entity bean is directly responsible for persisting its own state and the container does not need to generate any database calls. Each BMP EJB is responsible for storing and retrieving its own state from a backing store in response to specific "hook" messages (like `ejbLoad()` and `ejbStore()`) that are sent to it at appropriate times during its lifecycle. Consequently, this implementation is less adaptable than CMP as the persistence needs to be hard-coded into the bean.

5.3.5.3 The Entity Beans Life Cycle

An entity bean is considered to be long-lived and its state is persistent. It lives as long as the data remains in the database, rather than for the life of the application or server process. An entity bean survives the crash of the EJB container. Once an enterprise bean is deployed into a container, clients can create and use instances of that bean as required. Within the container, instances of an enterprise bean go through a defined life cycle. The events in an enterprise bean's life cycle are derived from actions initiated by either the client or the container. The life cycle of entity beans has three states:

5.3.5.3.1 Does-not-exist State

At this stage, no instances of the bean exist. An entity bean instance's life cycle begins when the container creates that instance. After creating a new entity bean instance, the container invokes the instance's `setEntityContext()` method. This method passes to the bean instance a reference to an entity context interface that can be used by the instance to obtain container services and to retrieve information about the caller of the client-invoked method.

5.3.5.3.2 Pooled State

Once an entity bean instance is created, it is placed in a pool of available instances of the specified entity bean class. While the instance is in this pool, it is not associated with a specific `EJBObject`. Every instance of the same enterprise bean class in this pool is identical. While an instance is in this pooled state, the container can use it to invoke any of the bean's finder methods.

5.3.5.3.3 Ready State

When a client needs to work with a specific entity bean instance, the container picks an instance from the pool and associates it with the `EJBObject` initialized by the client. An entity bean instance is moved from the pooled to the ready state if there are no available instances in the ready state.

There are two events that cause an entity bean instance to be moved from the pooled state to the ready state:

- When a client invokes the `create()` method in the bean's home interface to create a new and unique entity of the entity bean class (and a new record in the data source). As a result of this method invocation, the container calls the bean instance's `ejbCreate()` and `ejbPostCreate()` methods. The new `EJBObject` is associated with the bean instance.
- When a client invokes a finder method to manipulate an existing instance of the entity bean class (associated with an existing record in the data source). In this case, the container calls the bean instance's `ejbActivate()` method to associate the bean instance with the existing `EJBObject`.

When an enterprise bean instance is in the ready state, the container can invoke the instance's `ejbLoad()` and `ejbStore()` methods to synchronize the data in the instance with the corresponding data in the data source. In addition, the client can invoke the bean instance's business methods when the instance is in this state. All interactions required to handle an entity bean instance's business methods in the appropriate transactional (or non-transactional) manner are handled by the container, unless the EJB developer wrote the bean to handle these interactions itself. When a container determines that an entity bean instance in the ready state is no longer required, it moves the instance to the pooled state. This transition to the pooled state results from either of the following events:

- When the container invokes the `ejbPassivate()` method.
- When the client invokes a `remove()` method on the `EJBObject` associated with the bean instance or on the EJB home object. When the `remove()` method is called, the underlying entity is removed permanently from the data source.

The state that an entity bean represents is shared and transactional. In contrast, if a session bean has state, it must be private and conversational.

5.3.6 Object-relational (O-R) Mapping and Persistence

The problem of persistence is complex, and many research projects are being carried out on this subject. One of the important points to remember is that at runtime, objects (EJBs) are not isolated entities but referenced mutually. Therefore, the problem of persistence does not concern isolated objects, but complex object graphs. There are many questions to answer. How can an object graph in memory be projected on a disk and vice versa? How can synchronization problems between the graph on disk and the graph in memory be resolved? How do you go about loading in memory only the parts of the graph being used at a given moment? How can the graph be saved in a relational database (object-relational mapping technologies)?

The EJB specification attempts to render container-managed persistence with a clean separation between an entity bean and its persistent representation. That is, a separation between the data logic methods (such as the logic in an entity bean to add two fields together) and JDBC. The reason this separation is valuable is that the persistent representation of an entity bean (such as changing from a relational database to an object database) can be modified without affecting the entity bean logic.

To achieve this clean separation, container-managed persistent entity bean classes must be written to be devoid of any JDBC or other persistence logic. The container then generates the JDBC by subclassing your entity bean class. The generated subclass inherits from your entity bean class. Thus, all container-managed persistent entity beans are each broken up into two classes: the superclass (which the user writes, and contains the entity bean data logic) and the subclass (which the container generates, and contains the persistence logic). With these two classes, a clean separation of entity bean logic and persistent representation is achieved. The actual entity bean is a combination of the superclass and the subclass.

5.3.7 EJB Transactions and Concurrency

A transaction is a set of statements that must be processed as a single unit. Transactions must have four properties recalled with the acronym ACID: Atomicity, Consistency, Isolation and Durability.

- Atomicity is "all or nothing" operation wherein, for example, a transaction consisting of a debit to one account and a credit to another is not committed unless both operations are successful. Typically, atomicity is provided by the database management system.
- Consistency reflects the state of the system. A system is always consistent based upon the state invariants and transactions give the opportunity to write code that checks the consistency of the state.
- Isolation keeps operations on shared data invisible across transactions.
- Durability guarantees the effect of completed transaction are permanent and are not lost.

The EJB specification describes the creation of applications that enforce transactional consistency on the data manipulated by the enterprise beans. However, unlike other specifications that support distributed transactions, the EJB specification does not require enterprise bean and EJB client developers to write any special code to use transactions. Instead, the container manages transactions based on two deployment descriptor attributes associated with the EJB module and the enterprise bean. EJB application developers are freed to deal with the business logic of their applications.

A J2EE 1.3 compliant EJB container should support flat transactions, the most common kind of transctions. A flat transaction cannot have any child (nested) transactions. These are the only transaction types supported by EJBs.

5.3.7.1 The Java Transaction API(JTA)

The JTA APIs specifies start and end transactions.

```
interface javax.transaction.UserTransaction
{
  public abstract void begin();
  public abstract void commit();
  public abstract void rollback();
  public abstract void setRollbackOnly();
  public abstract int getStatus();
  public abstract void setTransactionTimeout(int);
}

interface javax.transaction.Status
{
  public static final int STATUS_ACTIVE;
  public static final int STATUS_MARKED_ROLLBACK;
```

```
  public static final int STATUS_PREPARED;
  public static final int STATUS_COMMITTED;
  public static final int STATUS_ROLLEDBACK;
  public static final int STATUS_UNKNOWN;
  public static final int STATUS_NO_TRANSACTION;
  public static final int STATUS_PREPARING;
  public static final int STATUS_COMMITTING;
  public static final int STATUS_ROLLING_BACK;
}
```

The JTA `UserTransaction` interface is actually an interface to the application server's transaction manager. It is the public API exposed by the transaction manager. To get a reference to this, you must look up the interface using JNDI, just like you use JNDI to lookup EJB homes, JDBC drivers, etc. The application server must publish the JTA under "`java:comp/UserTransaction`".

```
Context ctx = new InitialContext(...);
  javax.transaction.UserTransaction userTran =
         (javax.transaction.UserTransaction) PortableRemoteObject.narrow(
                          ctx.lookup("javax.transaction.UserTransaction"),
                          javax.transaction.UserTransaction.class);
```

5.3.7.2 Transaction Boundaries

Transaction boundaries mark the beginning and end of transactions. The application developer chooses the boundaries. The J2EE specification mentions three ways of controlling transactional boundaries: programmatically inside bean code (bean-managed transactions), programmatically from client code (client-managed transactions), and declaratively inside deployment descriptors (container-managed transactions).

5.3.7.3 Client-Managed Transactions

A Java client can use the `javax.transaction.UserTransaction` interface to explicitly demarcate transaction boundaries. The client program obtains the `javax.transaction.UserTransaction` interface using the JNDI API.The EJB specification does not imply that the `javax.transaction.UserTransaction` is available to all Java clients. The J2EE specification specifies the client environments in which the `javax.transaction.UserTransaction` interface is available.

5.3.7.4 Container-Managed Transactions (CMT)

Whenever a client invokes an enterprise bean, the container interposes on the method invocation. The interposition allows the container to control transaction demarcation declaratively through the transaction attributes set in the deployment descriptor.

For example, if an enterprise bean method is configured with the "Required" transaction attribute, the container behaves as follows: if the client request is not associated with a transaction context, the container automatically initiates a transaction whenever a client invokes an enterprise bean method that requires a transaction context. If the client request contains a transaction context, the container includes the enterprise bean method in the client transaction.

An entity bean must always be designed with container-managed transaction demarcation. For entity beans using container-managed persistence, transaction isolation is managed by the data access classes that are generated by the container provider's tools. The tools must ensure that the management of the isolation levels performed by the data access classes will not result in conflicting isolation level requests for a resource manager within a transaction.

5.3.7.5 Bean Managed Transactions (BMT)

The enterprise bean with bean-managed transaction demarcation must be a session bean. An instance that starts a transaction must complete the transaction before it starts another new transaction. A session bean can use the `EJBContext` and the `javax.transaction.UserTransaction` object to programmatically demarcate transactions. For session beans with bean-managed transaction demarcation, the bean code can specify the desirable isolation level programmatically in the enterprise bean's methods using the resource manager specific API. For example, the bean provider can use the `java.sql.Connection.setTransactionIsolation(...)` method to set the appropriate isolation level for database access.

For transactions, a session bean can either use container-managed transactions or bean-managed transactions. Entity beans must use container-managed transactions. Whether an enterprise bean uses bean-managed or container-managed transaction demarcation, the burden of implementing transaction management is on the EJB container and server provider.

5.3.8 Transaction Isolation and Concurrency

The transaction isolation attribute tells the container how to limit concurrent reads in a database. The EJB 1.1 specification removed the guidelines for managing transaction isolation levels for beans with container-managed transaction demarcation. But since bean deployers still require mechanisms to govern EJB concurrency, WebSphere continues to support it along with other mechanisms discussed in the next section.

Using CMP, different databases need different SQL statements while trying to acquire a read/write lock at the "database" level as opposed to optimistic/pessimistic concurrency or locking at the container/bean level. For example, MS-SQL Server needs a "`SELECT ... AT ISLOLATION SERIALIZABLE`", Oracle needs a "`SELECT ... FOR UPDATE`" as a method of acquiring 'locks' or, in other words, at a transaction isolation level '`Serializable`' to prevent dirty/unrepeatable/phantom reads. Hence, it is difficult to use generic SQL clauses in conjunction with transactions and locks at the database level without resorting to vendor-specific clauses.

The need is for a simple time stamp/versioning mechanism in EJB 1.1 (even EJB 2.0 seems to imply that acquiring a read/write lock at the database level is up to the EJB vendor, which vendors may or may not provide). All that the time stamp and versioning do is compare versions when the client sends data over for modification. The reading could have been done by different clients in different transactions. If another client tries to update the same data in the entity bean instance, the version numbers will not match if the data has been updated by another client, and an exception can be raised that effectively tells the client to 'refresh' the information, that is, get the data again to see what might have changed since the client first requested it for modification. This is analogous to performing an "`Update <table> set <fields> where <fields> = <fields_read_at_transaction_start>`". The only difference is that the above technique works across transactions, that is, it prevents a client from overwriting committed changes made by another client.

Session beans that use bean-managed transaction have transaction attributes associated with each method of the bean. The attribute value tells the container how it must manage the transactions that involve this bean. There are six different transaction attributes that can be associated with each method of a bean. This association is done at deployment time by the application assembler or deployer.

EJB supports distributed flat transactions. The distribution mechanism makes it possible to involve bean objects on multiple EJB servers or to update data in multiple databases in a single transaction. Every client method invocation on a bean is

supervised by the bean's container, which makes it possible to manage the transactions according to the transaction attributes that are specified in the corresponding bean's deployment descriptor.

A particular transaction attribute can be associated with an entire bean and apply to all its methods or just to an individual method. The scope of a transaction is defined by the transaction context that is shared by the participating bean objects.

5.3.9 EJB Caching

EJB containers allow smart caching of entity beans, which allow some operations to occur in memory rather than at database level. Caching conserves system resources used in making a database connection by eliminating database accesses to unchanged data. There are three caching options available for the container in committing a transaction:

Option A: The container caches a readily available instance between transactions, which has explicit access to the state of the object in the persistent storage. That is, each instance of the EJB will be held in memory. This option is supported by WebSphere and OC4J but should only be used in a single node system. Neither WebSphere nor OC4J enforce this restriction, hence, it is the bean deployer's responsibility to ensure that this restriction is satisfied. This means that the beans using this option will only be used within a single container. It is thus the responsibility of all clients of that bean to always direct their requests to the one bean instance within that specific container.

Option B: The container caches the instance between transactions which does not have access to the persistent object state. This option is not supported by WebSphere nor OC4J.

Option C: The container does not cache the instance between transactions. An entity bean's state is read once per transaction at the beginning of each transaction- even if the value did not change from the last time it was read. The instance is returned to the pool after the transaction is completed. This is the default option supported by WebSphere and OC4J and should be used in multiple node configurations.

5.4 WebSphere 3.5.x Support for the EJB API

WebSphere supports EJB 1.0 specification with some additional features. WebSphere supports:

- Container-managed persistence (CMP)
- Uses `javax.transaction.UserTransaction`
- Restricts bean-managed transactions to session beans (as required by EJB 1.1 specification)

WebSphere Advanced Edition 3.5.3 does not support these EJB 1.1 features:

- XML deployment descriptors
- Use of JNDI within EJB environment:
  - Lookup of home interfaces via EJB references and links defined in the EJB's environment
  - The new `HomeHandle` class and the associated API changes to `EJBHome`
- Use of the `javax.security.Principal` interface

WebSphere and VisualAge for Java extend the EJB specification with the following features:

- Access beans: Simplify client application using EJBs
- Association: Support relationship between CMP beans
- Inheritance: Support polymorphism and reuse

5.4.1 Read-only Methods

The EJB specification does not provide a standard mechanism to let the container check if the bean's state has changed within a unit of work. The specification assumes that all beans accessed during a transaction are "dirty," and must have their state written back to the persistent store at the end of a transaction. WebSphere provides an extension to the EJB specification with the const method flag in the deployment descriptor of entity beans. It lets the developer tell the container which methods are const or read-only, in other words, it doesn't change the state of the bean. For these methods, the EJB container does not call `ejbLoad` at the end of the method call.

5.4.2 EJB Finder-Helper Interface

WebSphere uses a concept called a “FinderHelper” to define the finder logic for CMP entity beans. The following finder logic is required for each finder method (other than the `findByPrimaryKey` method) contained in the home interface of an entity bean with CMP:

- The logic must be defined in a public interface named *<Name>*`BeanFinderHelper`, where *<Name>* is the name of the enterprise bean (for example, `AccountBeanFinderHelper`).
- The logic must be contained in a `String` constant named *<findMethodName>*`QueryString`, where *<findMethodName>* is the name of the finder method. The `String` constant can contain zero or more question marks (?) that are replaced from left to right with the value of the finder method’s arguments when that method is invoked.

Example 5–1 Finder Helper Interface

```
Public interface AccountBeanFinderHelper
{
  String findLargeAccountsQueryString ="select * from
                                    ejb.accountbeantblwhere balance > ?";
}
```

This file contains one static `java.lang.String` field for each finder method declared in the EJB home interface. The strings are initialized with SQL queries executed dynamically when bean instances are retrieved in a finder method. Note that this file is specific to the WebSphere application server.

5.4.3 CMP in WebSphere

The CMP model in WebSphere allows a set of entity EJBs to be read from a relational database in the `findXXX()` method with only a single SQL `SELECT` call. This is much more efficient then the BMP case, which requires N+1 SQL calls to accomplish the same task.

5.4.4 Transactions

WebSphere supports two-phase commits for distributed transactions for Oracle , DB2, and Sybase and MQ Series. Distributed transaction support is also provided for Oracle

and Microsoft SQL Server using the Merant drivers in addition to the existing support for DB2 and Sybase. WebSphere 3.5.3 also supports distributed transactions over EJBs and JMS.

WebSphere never passivates an active bean, that is, a bean participating in a transaction. WebSphere will throw a ROLLBACK exception back to the client.

WebSphere also makes the `UserTransaction` interface available to Java clients including servlets, JSPs, and standalone programs.

5.4.5 EJB Inheritance

WebSphere provides EJB inheritance similar to Java class inheritance.This EJB inheritance model is specific to the IBM EJB development environment. This is an extension of the EJB specification. In EJB inheritance, an enterprise bean inherits properties, such as CMP fields and association roles, methods, and method-level control descriptor attributes from another enterprise bean that resides in the same EJB group.

5.4.6 Distributed Exceptions

Support for chaining distributed exceptions is provided by the `com.ibm.websphere.exception` Java package. The following classes and interfaces make up this package

- `DistributedException`
- `DistributedExceptionEnabled`
- `DistributedExceptionInfo`
- `ExceptionInstantiationException`

5.4.7 Access Beans

An access bean adapts an enterprise bean to the JavaBeans programming model by hiding the home and remote interfaces from the access bean user (that is, an EJB client developer). This is specific to IBM WebSphere environment. These access beans are packaged in `com.ibm.ivj.ejb.access`. There are three types of access beans:

- A Java bean wrapper

  This facilitates either a session or entity bean to be used like a standard Java bean. It hides the enterprise bean home and remote interfaces from you. Each Java bean wrapper that you create extends the `com.ibm.ivj.ejb.access.AccessBean` class.

- Copy helper

  A copy helper is similar to Java bean wrapper, but it also incorporates a single copy helper object that contains a local copy of attributes from a remote entity bean. A user program can retrieve the entity bean attributes from the local copy helper object that resides in the access bean, which eliminates the need to access the attributes from the remote entity bean.

- Rowset

  A rowset access bean has all of characteristics of both the Java bean wrapper and copy helper access beans. However, instead of a single copy helper object, it contains multiple copy helper objects. Each copy helper object corresponds to a single enterprise bean instance.

5.4.8 Associations Between Enterprise Beans

WebSphere supports one-to-one and one-to-many associations for CMP beans. The generated code is specific to WebSphere and VisualAge for Java environment specific.

In the EJB 1.1 specification, the application would have been required to throw an `EJBException`, but this has not yet been implemented in WebSphere Advanced Edition 3.5.3.

6

Migrating JDBC Applications

This chapter introduces the JDBC (Java Database Connectivity) API and describes how to connect to, and access data from, a database with WebSphere Advanced Edition 3.5.3. It also discusses ways of migrating WebSphere applications to Oracle Containers for J2EE (OC4J). The topics in this chapter are:

6.1 The JDBC API

The JDBC API enables Java programs to create sessions, execute SQL statements, and retrieve results from relational databases, providing vendor-independent access to relational data. The JDBC specification delivers a call-level SQL interface for Java that is based on the X/Open SQL call level interface specification.

The JDBC API consists of four major components: JDBC drivers, connections, statements, and a result set. Database vendors deliver only the driver, which should comply with JDBC specifications (for a complete description, see "Database Drivers" on page 6-2). The connection, statement, and result set components are in the JDBC API package (that is, the `java.sql` package).

The JDBC API provides interface classes for working with these components:

- The `java.sql.Driver` and `java.sql.DriverManager` for managing JDBC drivers
- The `java.sql.Connection` for using connections
- The `java.sql.Statement`, for constructing and executing SQL statements
- The `java.sql.ResultSet` for processing the results

The JDBC 2.0 API includes many new features in the `java.sql` package as well as the new Standard Extension package, `javax.sql` Features in the `java.sql` package include support for SQL3 data types, scrollable result sets, programmatic updates, and batch updates.

The new JDBC standard extension APIs, an integral part of Enterprise JavaBeans (EJB) technology, allows you to write distributed transactions that use connection pooling and connect to virtually any tabular data source, including files and spreadsheets.

When you write a JDBC application, the only driver-specific information required is the database URL. You can build a JDBC application so that it derives the URL information at runtime. Using the database URL, a user name, and password, your application first requests a `java.sql.Connection` from the `DriverManager`.

A typical JDBC program follows this process:

1. Load the database driver, using the driver's class name

2. Obtain the connection, using the JDBC URL for connection
3. Create and execute statements
4. Use result sets to navigate through the results
5. Close the connection

6.2 Database Drivers

JDBC defines standard API calls to a specified JDBC driver, a piece of software that performs the actual data interface commands. The driver is considered the lower level JDBC API. The interfaces to the driver are database client calls, or database network protocol commands that are serviced by a database server.

Depending on the interface type, there are four types of JDBC drivers that translate JDBC API calls:

- Type 1, JDBC-ODBC bridge: Translates calls into ODBC API calls.
- Type 2, Native API driver: Translates calls into database native API calls. As this driver uses native APIs, it is vendor dependent. The driver consists of two parts: a Java language part that performs the translation and a set of native API libraries.
- Type 3, Network Protocol: Translates calls into DBMS-independent network protocol calls. The database server interprets these network protocol calls into specific DBMS operations.
- Type 4, Native Protocol: Translates calls into DBMS native network protocol calls. The database server converts these calls into DBMS operations.

6.2.1 The `DriverManager` Class

Using different drivers, a Java program can create several connections to several different databases. To manage driver operations, JDBC provides a driver manager class, the `java.sql.DriverManager`, which loads drivers and creates new database connections.

6.2.1.1 Registering JDBC Drivers

The `DriverManager` registers any JDBC driver that is going to be used. If a Java program issues a JDBC operation on a non-registered driver, JDBC raises a "`No Suitable Driver`" exception.

There are several ways to register a driver:

- Register the driver explicitly by using

  `DriverManager.registerDriver(`*`driver-instance`*`)`

  where *`driver-instance`* is an instance of the JDBC driver class.

- Load the driver class by using

  `Class.forName(`*`driver-class`*`)`

  where *driver-class* is the JDBC driver class.This loads the driver into the Java Virtual Machine. When loaded, each driver must register itself implicitly by using the `DriverManager.registerDriver` method.

  For example, to register the DB2 JDBC Type 2 driver in the `COM.ibm.db2.jdbc.app` package, you can use either:

```
DriverManager.registerDriver(new COM.ibm.db2.jdbc.app.DB2Driver());
```

or

```
Class.forName("COM.ibm.db2.jdbc.app.DB2Driver");
```

For an Oracle database:

```
DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver ());
```

or

```
Class.forName("oracle.jdbc.driver.OracleDriver")
```

A J2EE server implicitly loads the driver based on the JDBC driver configuration, so no client-specific code is needed to load the driver. The JNDI (Java Naming and Directory Interface) tree provides the datatsource object reference.

WebSphere Advanced Edition 3.5.3 supports DB2, Informix, Microsoft SQL Server, Oracle, Sybase, Versant, and others. However, WebSphere does not support the Oracle thick JDBC driver. To use the Oracle thick JDBC driver, configure the data sources in Oracle Containers for J2EE (OC4J), as described in "Configuring Data Sources". OC4J will automatically load the driver classes during server startup.

Note: If you use the Type 3 JDBC driver (`COM.ibm.db2.jdbc.app.DB2Driver - jdcb:db2:DBNAME`), you must install the DB2 CAE (Client Application Enabler) and then catalog the remote database. OC4J will treat the cataloged database as a local database.

6.2.2 The `DataSource` Class

The JDBC 2.0 specification introduced the `java.sql.Datasource` class to make the JDBC program 100% portable. In this version, the vendor-specific connection URL and machine and port dependencies were removed. This version also discourages using `java.sql.DriverManager`, `Driver`, and `DriverPropertyInfo` classes. The data source facility provides a complete replacement for the previous JDBC `DriverManager` facility. Instead of explictly loading the driver manager classes into the runtime of client applications, the centralized JNDI service lookup obtains the `java.sql.Datasource` object. The `Datasource` object can also be used to connect to the database.

According to the JDBC 2.0 API specification, a data source is registered under the JDBC subcontext or one of its child contexts. The JDBC context itself is registered under the root context. A `Datasource` object is a connection factory to a data source. WebSphere and OC4J both support the JDBC 2.0 `DataSource` API.

6.2.3 Configuring Data Sources

In WebSphere, you configure data sources using the Administrative Console to specify the data source name, database name, and JDBC URL string. This information is stored in a repository database.

OC4J uses flat files to configure data sources for all of its deployed applications. data sources are specified in the following descriptor file:

UNIX:
<ORACLE_HOME>`/j2ee/home/config/data-sources.xml`

NT:
<*ORACLE_HOME*>\j2ee\home\config\data-sources.xml

Following is a sample data source configuration for an Oracle database. Each data source in `data-sources.xml` (`xa-location`, `ejb-location` and `pooled-location`) must be unique.

```
<data-source
class="com.evermind.sql.DriverManagerDataSource"
name="Oracle"
url="jdbc:oracle:thin@node2058.oracle.com:1521:orcl"
xa-location="jdbc/xa/OracleXADS"
ejb-location="jdbc/OracleDS"
pooled-location="jdbc/OraclePoolDS"
connection-driver="oracle.jdbc.driver.OracleDriver"
username="scott"
password="tiger"
schema="database-schemas/oracle.xml"
inactivity-timeout="30"
max-connections="20"
/>
```

Table 6–1 describes all of the configuration parameters in `data-sources.xml`. (Not all of the parameters are shown in the example above).

Table 6–1 data-sources.xml file

Parameter	Description
`class`	Class name of the data source
`connection-driver`	Class name of the JDBC driver
`connection-retry-interval`	Number of seconds to wait before retrying a failed connection. The default is 1.
`ejb-location`	JNDI path for binding an EJB-aware, pooled version of this data source; this version will participate in container-managed transactions. This is the type of data source to use from within EJBs and similar objects. This parameter only applies to a `ConnectionDataSource`.
`inactivity-timeout`	Number of seconds unused connections will be cached before being closed.
`location`	JNDI path for binding this data source.
`max-connect-attempts`	Number of times to retry a failed connection. The default is 3.
`max-connections`	Maximum number of open connections for pooling data sources.
`min-connections`	Minimum number of open connections for pooling data sources. The default is zero.
`name`	Displayed name of the data source.
`password`	User password for accessing the data source (optional).
`pooled-location`	JNDI path for binding a pooled version of this data source. This parameter only applies to a `ConnectionDataSource`.
`schema`	Relative or absolute path to a database-schema file for the database connection.
`source-location`	Underlying data source of this specialized data source.
`url`	JDBC URL for this data source (used by some data sources that deal with `java.sql.Connections`)

Table 6–1 (Cont.) data-sources.xml file

Parameter	Description
username	User name for accessing the data source (optional).
wait-timeout	Number of seconds to wait for a free connection if all connections are used. Default is 60.
xa-location	JNDI path for binding a transactional version of this data source. This parameter only applies to a ConnectionDataSource.
xa-source-location	Underlying XADataSource of this specialized data source (used by OrionCMTDataSource)

Note that WebSphere does not support subcontexts. For example, you cannot specify xa/OracleXADS, where xa is subcontext under the JDBC context. Morever, in WebSphere, the JDBC context is implicit, and you don't specify it (as you specify it explicitly for OC4J, in data-sources.xml). However, both WebSphere and OC4J automatically bind the data sources for you.

6.2.4 Configuring OC4J with DB2 Database

If you are using DB2 as your database, you need to create an additional file, db2.xml, in the following directory to define DB2 as a data source:

UNIX:
<ORACLE_HOME>/OC4J/j2ee/home/config/database-schema

NT:
<ORACLE_HOME>\OC4J\j2ee\home\config\database-schema

Below is an example of the schema file db2.xml:

```
<?xml version="1.0"?>
<!DOCTYPE database-schema PUBLIC "-//Evermind//- Database schema"
"http://www.orionserver.com/dtds/database-schemas.dtd">
<database-scheme name="DB2" not-null="not null" null="default null"
  primary-key="primary key">
  <type-mapping type="java.lang.String" name="varchar(255)" />
  <type-mapping type="int" name="integer" />
  <type-mapping type="long" name="bigint" />
  <type-mapping type="float" name="double" />
  <type-mapping type="double" name="double" />
  <type-mapping type="byte" name="smallint" />
  <type-mapping type="char" name="smallint" />
  <type-mapping type="short" name="smallint" />
  <type-mapping type="boolean" name="char(1)" />
  <type-mapping type="java.util.Date" name="timestamp" />
  <type-mapping type="java.io.Serializable" name="blob(1 M)" />
  <disallowed-field name="add" />
  <disallowed-field name="admin" />
  <disallowed-field name="wvarchar" />
</database-scheme>
```

The following is an example of a corresponding data-sources.xml file with the db2.xml file specified:

```
<data-source
name="Default data-source"
class="com.evermind.sql.ConnectionDataSource"
location="jdbc/DefaultDS"
pooled-location="jdbc/DefaultPooledDS"
```

```
xa-location="jdbc/xa/DefaultXADS"
ejb-location="jdbc/DefaultEJBDS"
url="jdbc:db2:dbTest"
connection-driver="COM.ibm.db2.jdbc.app.DB2Driver"
username="myUserName"
password="myPwd"
inactivity-timeout="30"
schema="database-schemas/db2.xml"
/>
```

6.2.5 Obtaining a Data Source Object

Obtaining a data source object involves binding to the JNDI initial context and doing a lookup for the subcontext `jdbc/sampleDB`. To do this, you have to get a handle to the intial context `javax.naming.InitialContext`. `IntialContext` is the root context of the JNDI namespace. `InitialContext` has two constructors:

- A default constructor that takes no parameters
- A constructor that takes one parameter, `java.util.Properties` or `java.util.HashTable`

For OC4J, you must change your code to use the constructor that takes a parameter. The following code example illustrates this:

```
//WebSphere Code
try
{
  java.util.Properties parms = new java.util.Properties();
  parms.setProperty(Context.INITIAL_CONTEXT_FACTORY,
                                "com.ibm.ejs.ns.jndi.CNInitialContextFactory");
  javax.naming.Context ctx = new javax.naming.InitialContext(parms);
  javax.sql.DataSource ds = (javax.sql.DataSource)ctx.lookup("jdbc/SampleDB");
  java.sql.Connection conn = ds.getConnection();

  // process the results
  ...
}
```

To migrate from WebSphere, you must change the class that implements the initial context factory (`Context.INITIAL_CONTEXT_FACTORY`) of the JNDI tree:

from the WebSphere-specific class:

```
com.ibm.ejs.ns.jndi.CNInitialContextFactory
```

to the OC4J-specific class:

```
com.evermind.server.ApplicationClientInitialContextFactory
```

6.3 Connection Pooling

Most web-based resources, such as servlets and application servers, access information in a database. Each time a resource attempts to access a database, it must establish a connection to the database using system resources to create the connection, maintain it, and release it when it is no longer in use. The resource overhead is particularly high for web-based applications due to the frequency and volume of web users connecting and disconnecting. Often, more resources are consumed in connecting and disconnecting than in executing the business logic.

Connection pooling enables you to control connection resource usage by spreading the connection overhead across many user requests. A connection pool is a cached set of connection objects that multiple clients can share when they need to access a database resource. The resources to create the connections in the pool are expended only once for a specified number of connections. The connections are left open and re-used by many client requests instead of each client request consuming resources to create and close its own connection. Connection pooling improves overall performance in the following ways:

- Reducing the load on the middle-tier server
- Minimizing resource usage by having session-wide create and close operations
- Eliminating bottlenecks caused by socket and file descriptor limitations and 'n' user license limitations

The JDBC 2.0 specification allows you to define a pool of JDBC database connections, with the following objectives:

- Maximize the availability of connections to resources
- Minimize the idle connections in the pool
- Return orphan connections to the pool and make them available for reuse by other servlets or application servers.

To meet these objectives, you should perform the following:

1. Set the maximum connection pool size property equal to the maximum number of concurrently active user requests expected.
2. Set the minimum connection pool size property equal to the minimum number of concurrently active user requests expected.

The connection pooling properties ensure that as the number of user requests decreases, unused connections are gradually removed from the pool. Likewise, as the number of user requests begins to grow, new connections are created. The balance of connections is maintained so that connection re-use is maximized and connection creation overhead minimized. You can also use connection pooling to control the number of concurrent database connections.

6.3.1 Migrating WebSphere Connection Pooling to Oracle Application Server

WebSphere Advanced Edition 3.5.3 provides two options for accessing database connections:

- Connection pooling (model based on JDBC 2.0)
- Connection manager (model based on JDBC 1.0)

6.3.1.1 Migrating from WebSphere JDBC 2.0 connection pooling:

WebSphere implements JDBC 2.0 connection pooling and data source objects using the following packages.

```
import com.ibm.db2.jdbc.app.stdext.javax.sql.*;
import com.ibm.ejs.dbm.jdbcext.*;
```

To migrate from the WebSphere JDBC 2.0 connection to OC4J you must replace these import packages with `javax.sql.*` .

An application component that obtains two or more connections to the same database manager (using either the same data source or different data source) must use data

sources with JTA-enabled drivers. For more information, refer to *Oracle Application Server Containers for J2EE User's Guide*.

6.4 IBM Extensions

WebSphere provides the following extension packages for data access. Applications using these packages require code level changes for migration.

6.4.1 Data Access Beans

WebSphere Advanced Edition 3.5.3 also provides data access beans (in addition to access beans for EJBs) which offer a set of features for working with relational database queries and result sets. The `com.ibm.db` package contains the data access JavaBean classes. The classes are in the `databeans.jar` file (found in the `lib` directory under the application server root install directory). You will need this JAR file in your classpath in order to compile a servlet using the data access JavaBeans.

If you have lot of code using data access beans that need to be migrated to OC4J, then put `databeans.jar` in the classpath of OC4J. However, Oracle recommends that you migrate to JDBC 2.0 APIs.

6.4.2 Connection Pool Manager

As mentioned, IBM WebSphere 3.5.x still supports connection pooling with a proprietary connection pool manager. Oracle recommends that you develop connection pooling using IBM's standard extensions for JDBC 2.0.

A

Migrating from WebSphere 4.0

This appendix outlines the migration strategy from WebSphere Advanced Edition 4.0 to Oracle Application Server and has the following topics:

A.1 Feature Differences Between WebSphere Advanced Edition 3.5.3 and 4.0

WebSphere Advanced Edition 4.0 is an evolution of the 3.5.x version in several areas including J2EE specification support up to J2EE 1.2 for 4.0. Table A–1 summarizes the evolved features. The information in the table provides a general reference for what you can reuse from the other chapters in this book for your migration tasks from WebSphere Advanced Edition 4.0 to Oracle Application Server 10g Release 3.

Table A–1 Summary of WebSphere 3.5.x and 4.0 feature differences

WebSphere Advanced Edition 3.5.x	WebSphere Advanced Edition 4.0
Policy-based authorization	J2EE roles-based authorization - method invocation permissions for enterprise beans can now be assigned to users through their respective roles. Roles are specified in an application's deployment descriptors.
JSP 1.0	JSP 1.1
Servlet 2.1	Servlet 2.2
EJB 1.0	EJB 1.1
Presentation layer separation - HTML and CGI requests are served by a separate product. No implementation of J2EE Web Application concept.	J2EE Web Application support (support for `.war` files)
`ServiceInitializer` interface	`CustomService` interface - Similar to the `ServiceInitializer` interface except that `CustomService` does not pass in the context for the services to use for registration binding.
Connection Manager V2.0	Connection pooling - JDBC 2.0 or data access beans is used for connection pooling.

JNDI context interface used:
`com.ibm.ejs.ns.jndi.`
`CNInitialContextFactory`
	New JNDI context interface used:
	`com.ibm.websphere.naming.`
	`WsnInitialContextFactory`

XML4J V2.0.15 parser	XML4J V3.1.1 parser
`.servlet` file support	Servlet extensions are bundled in `.war` file.

Table A–1 (Cont.) Summary of WebSphere 3.5.x and 4.0 feature differences

WebSphere Advanced Edition 3.5.x	WebSphere Advanced Edition 4.0
Open Servlet Engine (OSE) remote and servlet redirector support for remote request invocations.	HTTP transport plug-ins to communicate between web server and application server.

A.2 J2EE Specification Differences Between WebSphere Advanced Edition 4.0 and Oracle Application Server

WebSphere Advanced Edition 4.0 advances on the J2EE specification support from WebSphere Advanced Edition 3.x. It has more comparable features with Oracle Application Server in the J2EE specification levels. Table A–2 compares the specification levels supported by Oracle Application Server 10g Release 3 and WebSphere Advanced Edition 4.0.

Table A–2 Summary of Oracle Application Server and WebSphere Advanced Edition 4.0 feature differences

J2EE Specification	WebSphere Advanced Edition 4.0	Oracle Application Server 10g Release 3
JDK	1.2.2 and 1.3	1.4 and 1.3
Servlet	2.2	2.3
JSP	1.1	1.2
EJB	1.1	2.0
JDBC	2.0	2.0 Extension
JNDI	1.2	1.2
JTA	1.0	1.0
JMS	1.0	1.0

A.3 Migrating WebSphere 4.0 Servlets to Oracle Application Server

WebSphere 4.0 is compliant with Servlet 2.2 specifications. It has proprietary mechanisms to enable servlet chaining and filtering and is not fully Servlet 2.3-compliant. The WebSphere 3.5.3 compatibility mode is not available. With those points in mind and not taking Servlet 2.3 features into consideration, migrating WebSphere Advanced Edition 4.0 servlets to OC4J servlets should be straightforward as both products support the same level of specifications (Servlets 2.2). However, the following possible incompatibilities should be noted and resolved if applicable to your servlets:

- WebSphere Specific Servlet Extensions
- WebSphere-Specific Deployment Descriptors
- Deprecated 3.5.3 API (Supported in WebSphere 4.0)

A.3.1 WebSphere Specific Servlet Extensions

The servlet extensions from WebSphere Advanced Edition 3.5.3 are still available in WebSphere Advanced Edition 4.0. Information in the section "WebSphere Extensions to the Servlet API" on page 3-9 is still valid when these extensions are used. If your servlets use any of these extensions, they need to be re-written to conform with the standard Servlet 2.2 or 2.3 API in order to run in OC4J.

A.3.2 WebSphere-Specific Deployment Descriptors

WebSphere Advanced Edition uses non-J2EE compliant deployment descriptors. WebSphere 4.0's Application Assembly Tool generates additional descriptor files in addition to the standard J2EE files. These are the DDL and XMI files used to store binding and WebSphere-specific extension information.

Since these files apply to WebSphere-specific extensions, they are redundant in Oracle Application Server and need not be migrated. Ensure that other WebSphere-specific extensions are not implemented in the migrated application before deploying in Oracle Application Server.

A.3.3 Deprecated 3.5.3 API (Supported in WebSphere 4.0)

If your servlets deployed in WebSphere 4.0 use the 3.5.3 deprecated API shown in the following table, you need to re-write them to use the equivalent Servlet 2.2 API as follows:

Table A–3 Deprecated 3.5.3 API and their Servlet 2.2 replacement

WebSphere 3.5.3 (supported in 4.0)	Servlet 2.2
`getValue()`	`getAttribute()`
`getValueNames()`	`getAttributeNames()`
`removeValue()`	`removeAttribute()`
`putValue()`	`setAttribute()`

A.4 Migrating WebSphere 4.0 JSPs to Oracle Application Server

WebSphere Advanced Edition 4.0 and Oracle Application Server 10g Release 3 both support JSP 1.1 (with Oracle Application Server supporting 1.2 as well). Therefore, JSP migration between the two products should be straightforward. In general, the rules and processes that apply when migrating JSPs from WebSphere Advanced Edition 3.x to Oracle Application Server can also be applied here. This is especially true for variations deviating from the JSP 1.1 specifications. These are related to the "tsx" family of tags. In OC4J, these should be replaced with OC4J JML tags. Refer to the section "Migrating WebSphere Extensions to OC4J" on page 4-7 for more information.

A.5 Migrating WebSphere 4.0 EJBs to Oracle Application Server

WebSphere Advanced Edition 4.0 complies with EJB 1.1. Oracle Application Server is compliant with EJB 2.0. Hence, migrating EJBs from WebSphere 3.5.3 to Oracle Application Server requires upgrading EJBs to EJB 2.0 specifications level.

Oracle strongly recommends that you archive your EJBs in a EAR file with any web applications and deploy that file using Oracle Enterprise Manager 10g Application Server Control Console or `dcmctl` to ensure that appropriate stubs are generated by Oracle Application Server. Copying EJB classes and their WebSphere-compiled stubs manually is not recommended.

Oracle is investigating the EJB migration process further and will update this document and information in the Oracle Technology Network website (*http://otn.oracle.com*).

A.6 Other Considerations

In addition to the migration points above, the following should also be observed:

A.6.1 Dynamic Fragment Cache

Dynamic Fragment Cache is a performance enhancement feature in WebShpere that caches the output of servlets and JSPs. This feature intercepts calls to the `service` method of servlets and determines if the calls can be serviced by its cache. For servlets or JSPs to use this feature, they have to use the `com.ibm.websphere.servlet.cache` package. When migrating to Oracle Application Server, ensure that this package is removed and any related code modified. For caching functionality in Oracle Application Server, consider using Oracle Application Server Web Cache and its Edge Side Includes for Java (JESI) technology.

A.6.2 Data Access and Sources

WebSphere 4.0 provides the `com.ibm.db` package as a substitute for the standard JDBC package `java.sql`. When migrating to Oracle Application Server, replace usage of `com.ibm.db` with `java.sql` (standard JDBC 2.0 package is recommended). If your application and components also use IBM data access beans, follow the guidelines in "Data Access Beans" on page 6-8.

In WebSphere 4.0, all data sources must be created using `com.ibm.websphere.advanced.cm.factory.DataSourceFactory`. To migrate to Oracle Application Server, data sources can be obtained using the JDBC 2.0 `java.sql.Datasource`, which is a connection factory to a data source. A `Datasource` object can be obtained by looking it up in the JNDI namespace. Refer to "The DataSource Class" on page 6-3 for more information.

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