The J2EE™ Tutorial

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Preface

THE Java Tutorial has been an indispensable resource for many programmers learning the Java programming language. This tutorial hopes to serve the same role for developers encountering the Java™ 2 Platform, Enterprise Edition (J2EE™) for the first time. It follows an example-oriented focus similar to the Java Tutorial.

Who Should Use This Tutorial

This tutorial is intended for programmers interested in developing and deploying J2EE applications. It covers the main component technologies comprising the J2EE platform and describes how to develop J2EE components and deploy them on the J2EE SDK.

This tutorial is not intended for J2EE server or tool vendors. It does not explain how to implement the J2EE architecture, nor does it explain the internals of the J2EE SDK. The J2EE specifications describe the J2EE architecture and can be downloaded from:

```
http://java.sun.com/j2ee/docs.html#specs
```

About the Examples

This tutorial includes many complete, working examples.

Prerequisites for the Examples

To understand the examples you will need a good knowledge of the Java programming language, SQL, and relational database concepts. The following topics in the Java Tutorial are particularly relevant:

Topic	Java Tutorial
JDBC™	`http://java.sun.com/docs/books/tutorial/jdbc`
Threads	`http://java.sun.com/docs/books/tutorial/essential/threads`
JavaBeans™	`http://java.sun.com/docs/books/tutorial/javabeans`
Security	`http://java.sun.com/docs/books/tutorial/security1.2`

Downloading the Examples

If you are viewing this online, and you want to build and run the examples, you need to download the tutorial bundle from:

```
http://java.sun.com/j2ee/download.html#tutorial
```

Once you have installed the bundle, the example source code is in the `j2eetutorial/examples/src` directory, with subdirectories `ejb` for enterprise bean technology examples, `web` for web technology examples, and `connector` for connector technology examples. For most of the examples, the bundle also includes J2EE application EAR files, which are located in the `j2eetutorial/examples/ears` directory.

How to Build and Run the Examples

This tutorial documents the J2EE SDK version 1.3. To build, deploy, and run the examples you need a copy of the J2EE SDK 1.3 and the J2SE™ SDK 1.3.1 (earlier versions were called JDK). You can download the J2EE SDK from:

```
http://java.sun.com/j2ee/download.html#sdk
```

and the J2SE 1.3.1 from:

```
http://java.sun.com/j2se/1.3/
```

The examples are distributed with a configuration file for version 1.3 of `ant` a portable make tool. The `ant` utility is hosted by the Jakarta project at the Apache Software Foundation. You can download `ant` from:

```
http://jakarta.apache.org/builds/jakarta-ant/release/v1.3/bin
```

To build the examples:

1. Download and install the J2SE SDK 1.3.1, J2EE SDK 1.3, and `ant`.
2. The installation instructions for the J2SE SDK, J2EE SDK, and `ant` explain how to set the required environment variables. Verify that the environment variables have been set to the values noted in the following table.

Environment Variable	Value
`JAVA_HOME`	The location of the J2SE SDK installation.
`J2EE_HOME`	The location of the J2EE SDK installation.
`ANT_HOME`	The location of the `ant` installation.
`PATH`	Should include the `bin` directories of the J2EE SDK and `ant` installations.

3. Go to the `j2eetutorial/examples/src` directory.
4. Execute `ant` *`target`*. For example, to build all the examples, execute `ant all` or to build the web layer examples, execute `ant web`. The build process deposits the output into the directory `j2eetutorial/examples/build`.

Related Information

This tutorial provides a concise overview of how to use the central component technologies in the J2EE platform. For more information about these technologies, see:

Component Technology	**Web Site**
Enterprise JavaBeans™ (EJB™)	`http://java.sun.com/products/ejb`
Java Servlet	`http://java.sun.com/products/servlets`
JavaServer Pages™ (JSP™)	`http://java.sun.com/products/jsp`

The J2EE platform includes a wide variety of APIs that this tutorial only briefly touches on. Some of these technologies have their own tutorials:

API	**Tutorial**
Java Message Service (JMS)	`http://java.sun.com/products/jms/tutorial/`
Java Naming and Directory Interface™ (JNDI)	`http://java.sun.com/products/jndi/tutorial/`
Extensible Markup Language (XML)	`http://java.sun.com/xml/tutorial_intro.html`

For complete information on these topics see:

API	**Web Site**
XML	`http://java.sun.com/xml`
J2EE Connector	`http://java.sun.com/j2ee/connector`

API	Web Site
JavaMail™	`http://java.sun.com/products/javamail`
JMS	`http://java.sun.com/products/jms`
JNDI	`http://java.sun.com/products/jndi`
JDBC™	`http://java.sun.com/products/jdbc`

Once you have become familiar with the J2EE technologies described in this tutorial, you may be interested in guidelines for architecting J2EE applications. The J2EE BluePrints illustrate best practices for developing and deploying J2EE applications. You can obtain the J2EE BluePrints from:

`http://java.sun.com/j2ee/blueprints`

How to Print This Tutorial

To print this tutorial, follow these steps:

- Ensure that Adobe Acrobat Reader is installed on your system.
- Download the PDF version of this book from `http://java.sun.com/j2ee/download.html#tutorial`.
- Click the printer icon in Adobe Acrobat Reader.

Typographical Conventions

The following table lists the typographical conventions used in this tutorial.

Font Style	Uses
italic	Emphasis, titles, first occurrence of terms
`monospace`	URLs, code examples, file names, command names, programming language keywords
`italic monospace`	Programming variables, variable file names

Acknowledgments

The J2EE tutorial team would like to thank the J2EE SDK team for their technical advice and enthusiasm.

We would also like to thank our manager Jim Inscore for his support and steadying influence.

The chapters on web components use an example and some material that first appeared in the servlet trail of the Java Tutorial. The chapter on custom tags describes a template tag library that first appeared in the J2EE Blueprints.

Overview

by Monica Pawlan

TODAY, more and more developers want to write distributed transactional applications for the enterprise and leverage the speed, security, and reliability of server-side technology. If you are already working in this area, you know that in today's fast-moving and demanding world of e-commerce and information technology, enterprise applications have to be designed, built, and produced for less money, with greater speed, and with fewer resources than ever before.

To reduce costs and fast-track enterprise application design and development, the Java™ 2 Platform, Enterprise Edition (J2EE™) technology provides a component-based approach to the design, development, assembly, and deployment of enterprise applications. The J2EE platform gives you a multitiered distributed application model, the ability to reuse components, integrated XML-based data interchange, a unified security model, and flexible transaction control. Not only can you deliver innovative customer solutions to market faster than ever, but your platform-independent J2EE component-based solutions are not tied to the products and APIs of any one vendor. Vendors and customers enjoy the freedom to choose the products and components that best meet their business and technological requirements.

This tutorial takes an examples-based approach to describing the features and functionalities available in J2EE SDK version 1.3. Whether you are a new or an experienced enterprise developer, you should find the examples and accompanying text a valuable and accessible knowledge base for creating your own enterprise solutions.

If you are new to J2EE applications development, this chapter is a good place to start. Here you will learn the J2EE architecture, become acquainted with important terms and concepts, and find out how to approach J2EE application programming, assembly, and deployment.

Distributed Multitiered Applications

The J2EE platform uses a multitiered distributed application model. This means application logic is divided into components according to function, and the various application components that make up a J2EE application are installed on different machines depending on which tier in the multitiered J2EE environment the application component belongs. Figure 1 shows two multitiered J2EE applications divided into the tiers described in the bullet list below. The J2EE application parts shown in Figure 1 are presented in J2EE Application Components (page 29).

- Client tier components run on the client machine
- Web tier components run on the J2EE server
- Business tier components run on the J2EE server
- Enterprise information system (EIS) tier software runs on the EIS server

While a J2EE application can consist of the three or four tiers shown in Figure 1, J2EE multitiered applications are generally considered to be three-tiered applications because they are distributed over three different locations: client machines, J2EE server machine, and the database or legacy machines at the back-end. Three-tiered applications that run in this way extend the standard two-tiered client and server model by placing a multithreaded application server between the client application and back-end storage.

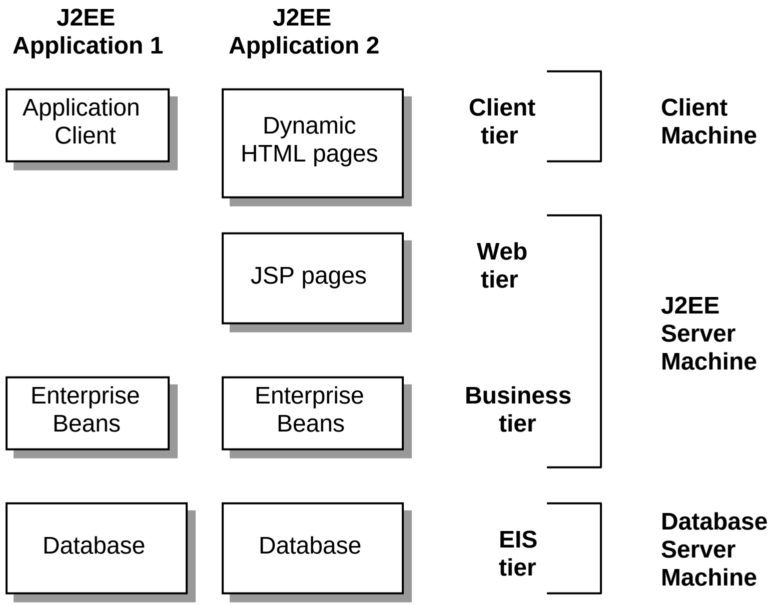


Figure 1 Multitiered Applications

J2EE Application Components

J2EE applications are made up of components. A J2EE component is a self-contained functional software unit that is assembled into a J2EE application with its related classes and files and communicates with other components. The J2EE specification defines the following J2EE components:

- Application clients and applets are client components.
- Java Servlet and JavaServer Pages™ (JSP™) technology components are web components.
- Enterprise JavaBeans™ (EJB™) components (enterprise beans) are business components.

J2EE components are written in the Java programming language and compiled in the same way as any program in the language. When you work with the J2EE platform, the difference is that J2EE components are assembled into a J2EE application, verified that they are well-formed and in compliance with the J2EE specification, and deployed to production where they are run and managed by the J2EE server.

Client Components

A J2EE application can be web-based or non-web-based. An application client executes on the client machine for a non-web-based J2EE application, and a web browser downloads web pages and applets to the client machine for a web-based J2EE application.

Application Clients

An application client runs on a client machine and provides a way for users to handle tasks such as J2EE system or application administration. It typically has a graphical user interface created from Swing or Abstract Window Toolkit (AWT) APIs, but a command-line interface is certainly possible.

Application clients directly access enterprise beans running in the business tier. However, if the J2EE application client requirements warrant it, an application client can open an HTTP connection to establish communication with a servlet running in the web tier.

Web Browsers

The user's web browser downloads static or dynamic Hypertext Markup Language (HTML), Wireless Markup Language (WML), or Extensible Markup Language (XML) web pages from the web tier. Dynamic web pages are generated by servlets or pages created with JavaServer Pages (JSP) technology pages running in the web tier.

Applets

A web page downloaded from the web tier can include an embedded applet. An applet is a small client application written in the Java programming language that executes in the Java VM installed in the web browser. However, client systems will likely need Java Plug-in and possibly a security policy file so the applet can successfully execute in the web browser.

JSP pages are the preferred API for creating a web-based client program because no plug-ins or security policy files are needed on the client systems. Also, JSP pages enable cleaner and more modular application design because they provide a way to separate applications programming from web page design. This means personnel involved in web page design do not need to understand Java programming language syntax to do their jobs.

Applets that run in other network-based systems such as handheld devices or car phones can render Wireless Markup Language (WML) pages generated by a JSP page or servlet running on the J2EE server. The WML page is delivered over Wireless Application Protocol (WAP) and the network configuration requires a gateway to translate WAP to HTTP and back again. The gateway translates the WAP request coming from the handheld device to an HTTP request for the J2EE server, and then translates the HTTP server response and WML page to a WAP server response and WML page for display on the handheld device.

JavaBeans™ Component Architecture

The client tier might also include a component based on the JavaBeans™ component architecture (JavaBeans component) to manage the data flow between an application client or applet and components running on the J2EE server. JavaBeans components are not considered J2EE components by the J2EE specification.

JavaBeans components written for the J2EE platform have instance variables and `get` and `set` methods for accessing the data in the instance variables. JavaBeans components used in this way are typically simple in design and implementation, but should conform to the naming and design conventions outlined in the JavaBeans component architecture.

J2EE Server Communications

Figure 2 shows the various elements that can make up the client tier. The client communicates with the business tier running on the J2EE server either directly, or as in the case of a client running in a browser, by going through JSP pages or servlets running in the web tier.

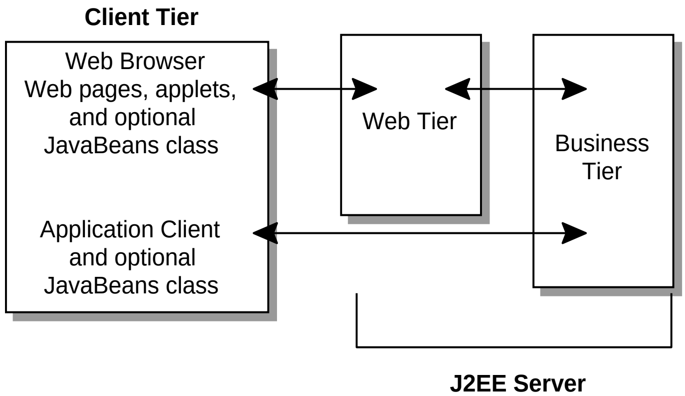


Figure 2 Server Communications

Thin Clients

A thin client is a lightweight and typically browser-based interface to the application. Thin clients do not do things like query databases, execute complex business rules, or connect to legacy applications. When you use a thin client, heavyweight operations like these are off-loaded to web or enterprise beans executing on the J2EE server where they can leverage the security, speed, services, and reliability of J2EE server-side technologies.

Your J2EE application uses a thin browser-based client or thick application client. In deciding which one to use, you should be aware of the tradeoffs between keeping functionality on the client and close to the user (thick client) and off-loading as much functionality as possible to the server (thin client). The more functionality you offload to the server, the easier it is to distribute, deploy, and manage the application; however, keeping more functionality on the client can make for a better *perceived* user experience.

Web Components

J2EE web components can be either JSP pages or servlets. Servlets are Java programming language classes that dynamically process requests and construct responses. JSP pages are text-based documents that execute as servlets, but allow a more natural approach to creating static content.

Static HTML pages and applets are bundled with web components during application assembly, but are not considered web components by the J2EE specification. Server-side utility classes can also be bundled with web components, and like HTML pages, are not considered web components.

Like the client tier and as shown in Figure 3, the web tier might include a JavaBeans object to manage the user input and send that input to enterprise beans running in the business tier for processing.

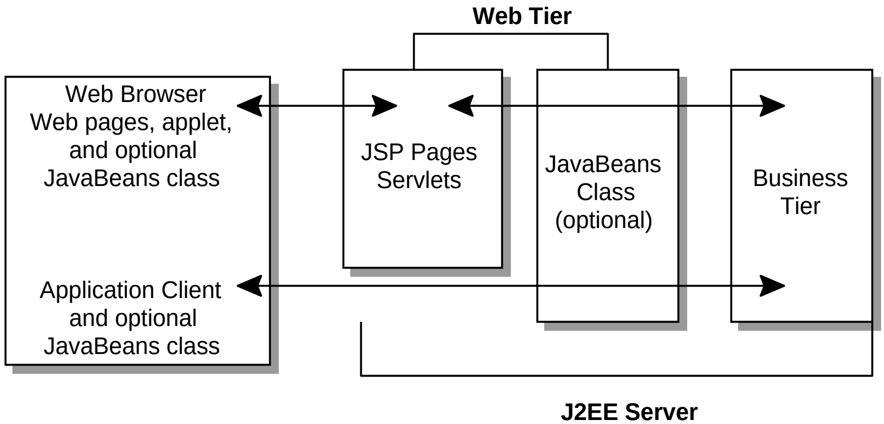


Figure 3 Web Tier and J2EE Application

Business Components

Business code, which is logic that solves or meets the needs of a particular business domain such as banking, retail, or finance, is handled by enterprise beans running in the business tier. Figure 4 shows how an enterprise bean receives data from client programs, processes it (if necessary), and sends it to the enterprise information system tier for storage. An enterprise bean also retrieves data from storage, processes it (if necessary), and sends it back to the client program.

There are three kinds of enterprise beans: session beans, entity beans, and message-driven beans. A session bean represents a transient conversation with a client. When the client finishes executing, the session bean and its data are gone. In contrast, an entity bean represents persistent data stored in one row of a database table. If the client terminates or if the server shuts down, the underlying services ensure the entity bean data is saved.

A message-driven bean combines features of a session bean and a Java Message Service (JMS) message listener, allowing a business component to receive JMS messages asynchronously. This tutorial describes entity beans and session beans.

For information on message-driven beans, see the Java Message Service Tutorial, which is online at:

```
http://java.sun.com/products/jms/tutorial/index.html
```

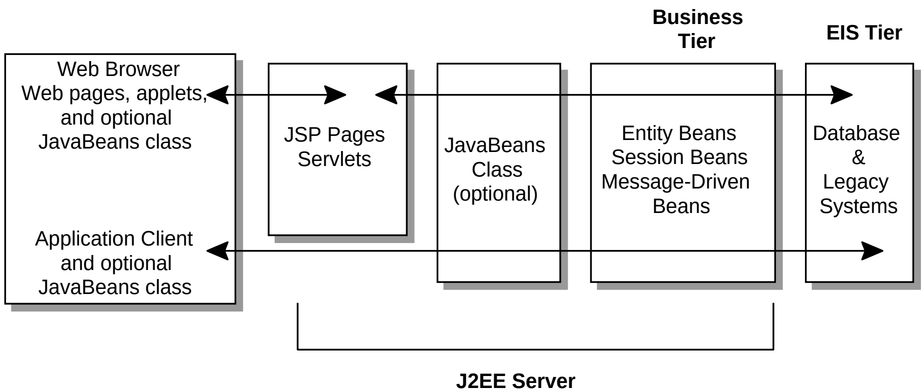


Figure 4 Business and EIS Tiers

Enterprise Information System Tier

The enterprise information system tier handles enterprise information system software, and includes enterprise infrastructure systems such as enterprise resource planning (ERP), mainframe transaction processing, database systems, and other legacy information systems. J2EE application components might need access to enterprise information systems for database connectivity, for example.

J2EE Architecture

Normally, thin-client multitiered applications are hard to write because they involve many lines of intricate code to handle transaction and state management, multithreading, resource pooling, and other complex low-level details. The component-based and platform-independent J2EE architecture makes J2EE applications easy to write because business logic is organized into reusable components and the J2EE server provides underlying services in the form of a container for every component type. Because you do not have to develop these services yourself, you are free to concentrate on solving the business problem at hand.

Containers and Services

Containers are the interface between a component and the low-level platform-specific functionality that supports the component. Before a web, enterprise bean, or application client component can be executed, it must be assembled into a J2EE application and deployed into its container.

The assembly process involves specifying container settings for each component in the J2EE application and for the J2EE application itself. Container settings customize the underlying support provided by the J2EE server, which include services such as security, transaction management, Java Naming and Directory Interface™ (JNDI) lookups, and remote connectivity. Here are some of the highlights:

- The J2EE security model lets you configure a web component or enterprise bean so system resources are accessed only by authorized users.
- The J2EE transaction model lets you specify relationships among methods that make up a single transaction so all methods in one transaction are treated as a single unit.
- JNDI lookup services provide a unified interface to multiple naming and directory services in the enterprise so application components can access naming and directory services.
- The J2EE remote connectivity model manages low-level communications between clients and enterprise beans. After an enterprise bean is created, a client invokes methods on it as if it were in the same virtual machine.

The fact that the J2EE architecture provides configurable services means that application components within the same J2EE application can behave differently based on where they are deployed. For example, an enterprise bean can have security settings that allow it a certain level of access to database data in one production environment and another level of database access in another production environment.

The container also manages non-configurable services such as enterprise bean and servlet life cycles, database connection resource pooling, data persistence, and access to the J2EE platform APIs described in J2EE APIs (page 41). Although data persistence is a non-configurable service, the J2EE architecture lets you override container-managed persistence by including the appropriate code in your enterprise bean implementation when you want more control than the default container-managed persistence provides. For example, you might use bean-managed persistence to implement your own finder (search) methods or to create a customized database cache.

Container Types

The deployment process installs J2EE application components in the following types of J2EE containers. The J2EE components and container addressed in this tutorial are shown in Figure 5.

- An Enterprise JavaBeans (EJB) container manages the execution of all enterprise beans for one J2EE application. Enterprise beans and their container run on the J2EE server.
- A web container manages the execution of all JSP page and servlet components for one J2EE application. Web components and their container run on the J2EE server.
- An application client container manages the execution of all application client components for one J2EE application. Application clients and their container run on the client machine.
- An applet container is the web browser and Java Plug-in together running on the client machine.

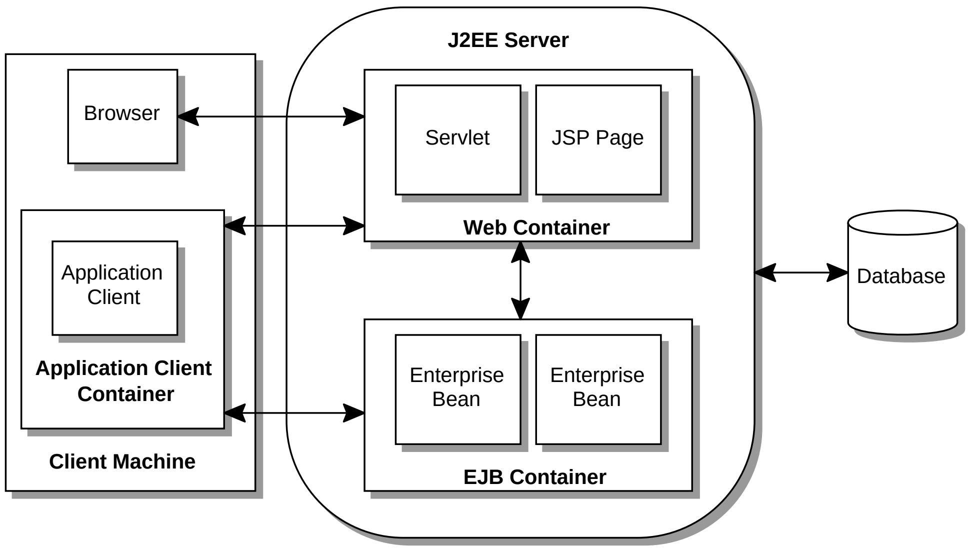


Figure 5 J2EE Server and Containers

Packaging

J2EE components are packaged separately and bundled into a J2EE application for deployment. Each component, its related files such as GIF and HTML files or server-side utility classes, and a deployment descriptor (DD), are assembled into a module and added to the J2EE application. A J2EE application is composed of one or more enterprise bean, web, or application client component modules. The final enterprise solution can use one J2EE application or be made up of two or more J2EE applications depending on design requirements

A J2EE application and each of its modules has its own deployment descriptor. A deployment descriptor is an Extensible Markup Language (XML) text-based file with an `.xml` extension that describes a component's deployment settings. An enterprise bean module deployment descriptor, for example, declares transaction attributes and security authorizations for an enterprise bean. Because deployment descriptor information is declarative, it can be changed without modifying the bean source code. At run time, the J2EE server reads the deployment descriptor and acts upon the component accordingly.

A J2EE application with all of its modules is delivered in an Enterprise ARchive (EAR) file. An EAR file is a standard JAR file with an `.ear` extension. In the GUI version of the J2EE SDK application deployment tool, you create an EAR file first and add JAR and WAR files to the EAR. If you use the command line packager tools, however, you create the Java ARchive (JARs) and Web ARchive (WAR) files first and create the EAR. The J2EE SDK tools are described in Tools (page 45).

- Each EJB JAR file contains its deployment descriptor, related files, and the `.class` files for the enterprise bean.
- Each application client JAR file contains its deployment descriptor, related files, and the `.class` files for the application client.
- Each WAR file contains its deployment descriptor, related files, and the `.class` files for the servlet or `.jsp` files for a JSP page.

Using modules and EAR files makes it possible to assemble a number of different J2EE applications using some of the same components. No extra coding is needed; it is just a matter of assembling various J2EE modules into J2EE EAR files.

Development Roles

Reusable modules make it possible to divide the application development and deployment process into distinct roles so different people or companies can perform different parts of the process.

The first two roles involve purchasing and installing the J2EE product and tools. Once software is purchased and installed, J2EE components can be developed by application component providers, assembled by application assemblers, and deployed by application deployers. In a large organization, each of these roles might be executed by different individuals or teams. This division of labor works because each of the earlier roles outputs a portable file that is the input for a subsequent role. For example, in the application component development phase, an enterprise bean software developer delivers EJB JAR files. In the application assembly role, another developer combines these EJB JAR files into a J2EE application and saves it in an EAR file. In the application deployment role, a system administrator at the customer site uses the EAR file to install the J2EE application into a J2EE server.

The different roles are not always executed by different people. If you work for a small company, for example, or if you are prototyping a sample application, you might perform the tasks in every phase.

J2EE Product Provider

The J2EE product provider is the company that designs and makes available for purchase the J2EE platform, APIs, and other features defined in the J2EE specification. Product providers are typically operating system, database system, application server, or web server vendors who implement the J2EE platform according to the Java 2 Platform, Enterprise Edition Specification.

Tool Provider

The tool provider is the person or company who creates development, assembly, and packaging tools used by component providers, assemblers, and deployers. See Tools (page 45) for information on the tools available with J2EE SDK version 1.3.

Application Component Provider

The application component provider is the company or person who creates web components, enterprise beans, applets, or application clients for use in J2EE applications.

Enterprise Bean Creation

A software developer performs the following tasks to deliver an EJB JAR file that contains the enterprise bean:

- Writes and compiles the source code
- Specifies the deployment descriptor
- Bundles the `.class` files and deployment descriptor into an EJB JAR file

Web Component Creation

A web designer (JSP pages) or software developer (servlets) performs the following tasks to deliver a WAR file containing the web component.

- Writes and compiles servlet source code
- Writes JSP and HTML files
- Specifies the deployment descriptor for the web component
- Bundles the `.class`, `.jsp`, `.html`, and deployment descriptor files in the WAR file

J2EE Application Client Creation

A software developer performs the following tasks to deliver a JAR file containing the J2EE application client.

- Writes and compiles the source code
- Specifies the deployment descriptor for the client
- Bundles the `.class` files and deployment descriptor into the JAR file

Application Assembler

The application assembler is the company or person who gets application component JAR files from component providers and assembles them into a J2EE application EAR file. The assembler or deployer can edit the deployment descriptor directly or use tools that correctly add XML tags according to interactive selections. A software developer performs the following tasks to deliver an EAR file containing the J2EE application.

- Assembles EJB JAR and web components (WAR) files created in the previous phases into a J2EE application (EAR) file.
- Specifies the deployment descriptor for the J2EE application.
- Verifies that the contents of the EAR file are well-formed and comply with the J2EE specification.

Application Deployer and Administrator

The company or person who configures and deploys the J2EE application, administers the computing and networking infrastructure where J2EE applications run, and oversees the runtime environment. Duties include such things as setting transaction controls and security attributes, and specifying connections to databases.

During configuration, the deployer follows instructions supplied by the application component provider to resolve external dependencies, specify security settings, and assign transaction attributes. During installation, the deployer moves the application components to the server, and generates the container-specific classes and interfaces.

A deployer/system administrator performs the following tasks to install and configure a J2EE application.

- Adds the J2EE application (EAR) file created in the preceding phase to the J2EE server.
- Configures the J2EE application for the operational environment by modifying the deployment descriptor of the J2EE application.
- Verifies that the contents of the EAR file are well-formed and comply with the J2EE specification.
- Deploys (installs) the J2EE application EAR file into the J2EE server.

Reference Implementation Software

The J2EE SDK is a non-commercial operational definition of the J2EE platform and specification made freely available by Sun Microsystems for demonstrations, prototyping, and educational use. It comes with the J2EE application server, web server, relational database, J2EE APIs, and complete set of development and deployment tools. You can download the J2EE SDK from the web:

```
http://java.sun.com/j2ee/download.html#sdk
```

- Product providers use the J2EE SDK to determine what their implementations must do under a given set of application conditions, and to run the J2EE Compatibility Test Suite to test that their J2EE products fully comply with the specification.
- Application component developers run their J2EE applications on the J2EE SDK to verify that applications are fully portable across all J2EE products and tools.

Web Server

The web server provides services to one or more web containers. For example, a web container typically relies on a web server to provide HTTP message handling. A J2EE implementation is not required to support a particular type of web server, which means the web server supported by different J2EE products can vary.

Database Access

The relational database provides persistent storage for application data. A J2EE implementation is not required to support a particular type of database which means the database supported by different J2EE products can vary. See the Release Notes included with the J2EE SDK download for a list of the databases currently supported by the reference implementation.

J2EE APIs

The Java 2 Platform, Standard Edition (J2SE™) SDK is required to run the J2EE SDK and provides core APIs for writing J2EE components, core development tools, and the Java virtual machine. The J2EE SDK provides the following APIs to be used in J2EE applications.

Enterprise JavaBeans Technology 2.0

An enterprise bean is a body of code with fields and methods to implement modules of business logic. You can think of an enterprise bean as a building block that can be used alone or with other enterprise beans to execute business logic on the J2EE server.

There are three kinds of enterprise beans: session beans, entity beans, and message-driven beans as described in Business Components (page 33). You do not have to write any SQL code or use the JDBC™ API directly to perform database access operations with an entity bean. The EJB container handles this for you. However, if you override the default container-managed persistence for any reason, you will need to use the JDBC API. Also, if you choose to have a session bean access the database, you have to use the JDBC API.

JDBC™ 2.0 API

The JDBC API lets you invoke SQL commands from Java programing language methods. You use the JDBC API in an enterprise bean when you override the default container-managed persistence or have a session bean access the database. With container-managed persistence, database access operations are handled by the container and your enterprise bean implementation contains no JDBC code or SQL commands. You can also use the JDBC API from a servlet or JSP page to access the database directly without going through an enterprise bean.

The JDBC API has two parts: an application-level interface used by the application components to access a database, and a service provider interface to attach a JDBC driver to the J2EE platform.

Java Servlet Technology 2.3

Java Servlet technology lets you define HTTP-specific servlet classes. A servlet class extends the capabilities of servers that host applications accessed by way of a request-response programming model. Although servlets can respond to any type of request, they are commonly used to extend the applications hosted by web servers.

JavaServer Pages (JSP) Technology 1.2

JSP pages technology lets you put snippets of servlet code directly into a text-based document. A JSP page is a text-based document that contains two types of text: static template data which can be expressed in any text-based format such as HTML, WML, and XML, and JSP elements that determine how the page constructs dynamic content.

Java Message Service (JMS) 1.0

The JMS API is a messaging standard that allows J2EE application components to create, send, receive, and read messages. It enables distributed communication that is loosely coupled, reliable, and asynchronous. For more information on JMS see the online Java Message Service Tutorial:

```
http://java.sun.com/products/jms/tutorial/index.html
```

Java Transaction API (JTA) 1.0

The JTA API provides a standard demarcation interface for demarcating transactions. The J2EE architecture provides a default auto commit to handle transaction commits and roll backs. An auto commit means any other applications viewing data will see the updated data after each database read or write operation. However, if your application performs two separate database access operations that depend on each other, you will want to use the JTA API to demarcate where the entire transaction, including both operations, begins, rolls back, and commits.

JavaMail™ Technology 1.2

Many Internet applications need to send email notifications so the J2EE platform includes the JavaMail API with a JavaMail service provider that application components can use to send Internet mail. The JavaMail API has two parts: an application-level interface used by the application components to send mail, and a service provider interface.

JavaBeans Activation Framework 1.0

The JavaBeans Activation Framework is included because JavaMail uses it. It provides standard services to determine the type of an arbitrary piece of data, encapsulate access to it, discover the operations available on it, and create the appropriate JavaBean component to perform those operations.

Java API for XML Processing (JAXP) 1.1

XML is a language for representing and describing text-based data so the data can be read and handled by any program or tool that uses XML APIs. Programs and tools can generate XML files that other programs and tools can read and handle.

For example, a J2EE application can use XML to produce reports, and different companies that receive the reports can handle the data in a way that best suits their needs. One company might put the XML data through a program to translate the XML to HTML so it can post the reports to the web, another company might put the XML data through a tool to create a marketing presentation, and yet another company might read the XML data into its J2EE application for processing.

J2EE Connector Architecture 1.0

The J2EE Connector Architecture is used by J2EE tools vendors and system integrators to create resource adapters that support access to enterprise information systems that can be plugged into any J2EE product. A resource adapter is a software component that allows J2EE application components to access and interact with the underlying resource manager. Because a resource adapter is specific to its resource manager, there is typically a different resource adapter for each type of database or enterprise information system.

Java Authentication and Authorization Service (JAAS) 1.0

The Java Authentication and Authorization Service (JAAS) provides a way for a J2EE application to authenticate and authorize a specific user or group of users to run it.

JAAS is a Java programing language version of the standard Pluggable Authentication Module (PAM) framework that extends the Java 2 platform security architecture to support user-based authorization.

Simplified Systems Integration

The J2EE platform is a platform-independent and full systems integration solution that creates an open marketplace in which every vendor can sell to every customer. Such a marketplace encourages vendors to compete, not by trying to lock customers into their technologies, but by trying to outdo each other by providing products and services that benefit customers such as better performance, better tools, or better customer support.

The J2EE APIs enable systems and applications integration as follows:

- Unified application model across tiers with enterprise beans.
- Simplified response and request mechanism with JSP pages and servlets.
- Reliable security model with JAAS API.
- XML-based data interchange integration with the JAXP API.
- Simplified interoperability with the J2EE Connector Architecture.
- Easy database connectivity with the JDBC API.
- Enterprise application integration with message-driven beans and the JMS, JTS, and JNDI APIs.

You can learn more about using the J2EE platform to build integrated business systems by reading *J2EE Technology in Practice*.

```
http://java.sun.com/j2ee/inpractice/aboutthebook.html
```

Tools

The J2EE reference implementation provides an application deployment tool and an array of scripts for assembling, verifying, and deploying J2EE applications and managing your development and production environments. See J2EE™ SDK Tools (page 449) for a discussion of the tools.

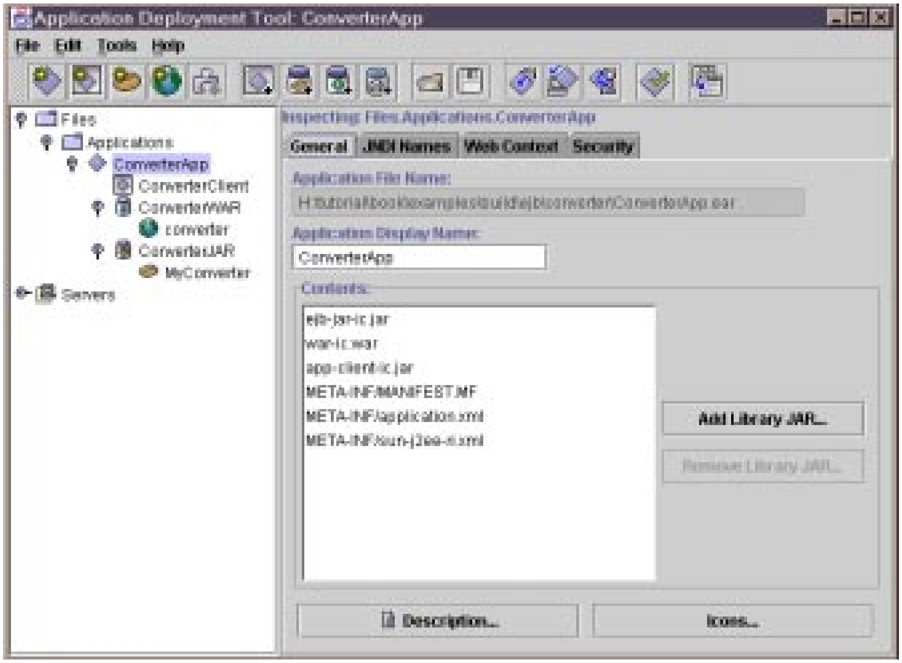
Application Deployment Tool

The J2EE reference implementation provides an application deployment tool for assembling, verifying, and deploying J2EE applications. There are two versions: command-line and GUI.

The GUI tool includes wizards for

- Packaging, configuring, and deploying J2EE applications
- Packaging and configuring enterprise beans
- Packaging and configuring web components
- Packaging and configuring application clients
- Packaging and configuring resource adaptors

In addition, configuration information can be set for each component and module type in the tabbed inspector panels.



Scripts

Table 1 lists the scripts included with the J2EE reference implementation that let you perform operations from the command line.

Table 1 J2EE Scripts

Script	Description
`j2ee`	Start and stop the J2EE server.
`cloudscape`	Start and stop the default database.
`cloudIJ`	Run the interactive SQL tool. This is an unsupported tool.
`j2eeadmin`	Add JDBC drivers, JMS destinations, and connection factories for various resources.
`keytool`	Create public and private keys and generate X509 self-signed certificates.
`realmtool`	Import certificate files. Add J2EE users to and remove J2EE users from the authentication and authorization list for a J2EE application.
`packager`	Package J2EE application components into EAR, EJB JAR, application client JAR, and WAR files.
`verifier`	Verify that EAR, EJB JAR, application client JAR, and WAR files are well-formed and comply with the J2EE specification.
`runclient`	Run a J2EE application client.
`cleanup`	Remove all deployed applications from the J2EE server.

Getting Started

by Dale Green

THIS chapter shows you how to develop, deploy, and run a simple client-server application that consists of an currency conversion enterprise bean and two clients: a J2EE™ application client and a web client that consists of a JSP page.

Setting Up

Before you start developing the example application, you should follow the instructions in this section.

Getting the Example Code

The source code for components is in the `j2eetutorial/examples/src/ejb/converter` directory created when you unzip the tutorial bundle. If you are viewing this online, you need to download the tutorial bundle from:

```
http://java.sun.com/j2ee/download.html#tutorial
```

Getting the Build Tool (ant)

To build the example code you'll need copies of the J2EE SDK and `ant`, a portable make tool. For more information, see How to Build and Run the Examples (page xxiii).

Checking the Environment Variables

The installation instructions for the J2EE SDK and `ant` explain how to set the required environment variables. Please verify that the environment variables have been set to the values noted in the following table.

Table 2 Required Environment Variables

Environment Variable	Value
`JAVA_HOME`	The location of the J2SE™ SDK installation.
`J2EE_HOME`	The location of the J2EE™ SDK installation.
`ANT_HOME`	The location of the `ant` installation.
`PATH`	Should include the `bin` directory of the J2EE SDK installation and the `ant` installation.

Starting the J2EE™ Server

To launch the J2EE server, open a terminal window and type this command:

```
j2ee -verbose
```

Although optional, the `verbose` option is useful for debugging. To stop the server, type the following command:

```
j2ee -stop
```

Starting the deploytool

The deploytool has two modes: command-line and GUI. The instructions in this chapter refer to the GUI version. To start the `deploytool` GUI, open a terminal window and type this command:

```
deploytool
```

To view the tool's context-sensitive help, press `f1`.

Creating the J2EE™ Application

The sample application contains three J2EE components: an enterprise bean, a J2EE application client, and a web component. Before building these components, you will create a new J2EE application called `ConverterApp` and will store it in a file named `ConverterApp.ear`.

1. In the `deploytool`, select File -> New-> Application.
2. Click Browse.
3. In the file chooser, navigate to `j2eetutorial/examples/src/ejb/converter`.
4. In the File Name field enter `ConverterApp`.
5. Click New Application.
6. Click OK.

Creating the Enterprise Bean

An enterprise bean is a server-side component that contains the business logic of an application. At run time, the application clients execute the business logic by invoking the enterprise bean's methods. The enterprise bean in our example is a stateless session bean called `ConverterEJB`. The source code for the `ConverterEJB` bean is in the `j2eetutorial/examples/src/ejb/converter` directory.

Coding the Enterprise Bean

The enterprise bean in this example requires the following code:

- Remote interface
- Home interface
- Enterprise bean class

Coding the Remote Interface

A remote interface defines the business methods that a client may call. The business methods are implemented in the enterprise bean code. The source code for the `Converter` remote interface follows.

```
import javax.ejb.EJBObject;
import java.rmi.RemoteException;

public interface Converter extends EJBObject {

public double dollarToYen(double dollars)
       throws RemoteException;
public double yenToEuro(double yen) throws RemoteException;
}
```

Coding the Home Interface

A home interface defines the methods that allow a client to create, find, or remove an enterprise bean. The `ConverterHome` interface contains a single create method, which returns an object of the remote interface type. Here is the source code for the `ConverterHome` interface:

```
import java.io.Serializable;

import java.rmi.RemoteException;
import javax.ejb.CreateException;
import javax.ejb.EJBHome;

public interface ConverterHome extends EJBHome {

   Converter create() throws RemoteException, CreateException;
}
```

Coding the Enterprise Bean Class

The enterprise bean class for this example is called `ConverterBean`. This class implements the two business methods, `dollarToYen` and `yenToEuro`, that the `Converter` remote interface defines. The source code for the `ConverterBean` class follows.

```
import java.rmi.RemoteException;
import javax.ejb.SessionBean;
import javax.ejb.SessionContext;

public class ConverterBean implements SessionBean {

   public double dollarToYen(double dollars) {

        return dollars * 121.6000;
}

   public double yenToEuro(double yen) {
```

```
        return yen * 0.0077;
}

    public ConverterBean() {}
    public void ejbCreate() {}
    public void ejbRemove() {}
    public void ejbActivate() {}
    public void ejbPassivate() {}
    public void setSessionContext(SessionContext sc) {}
}
```

Compiling the Source Files

Now you are ready to compile the remote interface (`Converter.java`), home interface (`ConverterHome.java`), and the enterprise bean class (`ConverterBean.java`):

1. In a terminal window, go to the `j2eetutorial/examples/`**`src`** directory.
2. Type the following command:

```
ant converter
```

This command compiles the source files for the enterprise bean and the J2EE application client. It places the resulting class files in the `j2eetutorial/examples/`**`build`**`/ejb/converter` directory. For more information about `ant`, see How to Build and Run the Examples (page xxiii).

Note: When compiling the code, the preceding `ant` task includes the `j2ee.jar` file in the classpath. This file resides in the `lib` directory of your J2EE SDK installation. If you plan on using other tools to compile the source code for J2EE components, make sure that the classpath includes the `j2ee.jar` file.

Packaging the Enterprise Bean

In this section you will run the New Enterprise Bean Wizard of the `deploytool` to perform these tasks:

- Create the bean's deployment descriptor.
- Package the deployment descriptor and the bean's classes in an EJB JAR file.
- Insert the EJB JAR file into the application's `ConverterApp.ear` file.

To start the New Enterprise Bean Wizard, select File->New-> Enterprise Bean. The wizard displays the following dialog boxes.

1. Introduction Dialog Box
   a. Read this explanatory text for an overview of the wizard's features.
   b. Click Next.
2. EJB JAR Dialog Box
   a. Select the Create new JAR File in Application button.
   b. In the combo box, select ConverterApp.
   c. In the JAR Display Name field enter `ConverterJAR`.
   d. Click Edit.
   e. In the tree under Available Files, locate the `j2eetutorial/examples/build/ejb/converter` directory. (If the `converter` directory is many levels down in the tree, you can simplify the tree view by entering all or part of the `converter` directory's path name in the Starting Directory field.)
   f. Select the following classes from the Available Files tree and click Add: `Converter.class`, `ConverterBean.class`, `ConverterHome.class`. (You may also drag and drop these class files to the Contents text area.)
   g. Click OK.
   h. Click Next.
3. General Dialog Box
   a. Under Bean Type, select the Session radio button.
   b. Select the Stateless radio button.
   c. In the Enterprise Bean Class combo box, select ConverterBean.
   d. In the Enterprise Bean Name field, enter `ConverterEJB`.
   e. In the Remote Home Interface combo box, select ConverterHome.
   f. In the Remote Interface combo box, select Converter.
   g. Click Next.
4. Transaction Management Dialog Box

   Because you may skip the remaining dialog boxes, click Finish.

Creating the J2EE™ Application Client

A J2EE application client is a program written in the Java™ programming language. At run time, the client program executes in a different virtual machine (VM) than the J2EE server.

The J2EE application client in this example requires two different JAR files. The first JAR file is for the J2EE component of the client. This JAR file contains the client's deployment descriptor and its class files. When you run the New Application Client wizard, the `deploytool` automatically creates the JAR file and stores it in the application's EAR file. Defined by the *J2EE Specification*, the JAR file is portable across all compliant J2EE servers.

The second JAR file contains stub classes that are required by the client program at run time. These stub classes enable the client to access the enterprise beans that are running in the J2EE server. Because this second JAR file is not covered by the *J2EE Specification*, it is implementation-specific, intended only for the J2EE SDK.

The J2EE application client source code is in `j2eetutorial/examples/src/ejb/converter/ConverterClient.java`. You already compiled this code along with the enterprise bean code in the section, Compiling the Source Files (page 54).

Coding the J2EE Application Client

The `ConverterClient.java` source code illustrates the basic tasks performed by the client of an enterprise bean:

- Locating the home interface
- Creating an enterprise bean instance
- Invoking a business method

Locating the Home Interface

The `ConverterHome` interface defines life-cycle methods such as `create`. Before the `ConverterClient` can invoke the `create` method, it must instantiate an object whose type is `ConverterHome`. This is a three-step process:

1. Create a JNDI naming context. See About JNDI Naming (page 72) for background on naming contexts.

```
Context initial = new InitialContext();
```

2. Retrieve the object bound to the name `ejb/SimpleConverter`.

```
Object objref = initial.lookup
   ("java:comp/env/ejb/SimpleConverter");
```

3. Narrow the reference to a `ConverterHome` object.

```
ConverterHome home =
   (ConverterHome) PortableRemoteObject.narrow(objref,
       ConverterHome.class);
```

Creating an Enterprise Bean Instance

To create the bean instance, the client invokes the `create` method on the `ConverterHome` object. The `create` method returns an object whose type is `Converter`. The remote `Converter` interface defines the business methods of the bean that the client may call. When the client invokes the `create` method, the EJB container instantiates the bean and then invokes the `ConverterBean.ejbCreate` method. The client invokes the `create` method as follows:

```
Converter currencyConverter = home.create();
```

Invoking a Business Method

Calling a business method is easy—you simply invoke the method on the `Converter` object. The EJB container will invoke the corresponding method on the `ConverterEJB` instance that is running on the server. The client invokes the `dollarToYen` business method in the following line of code.

```
double amount = currencyConverter.dollarToYen(100.00);
```

ConverterClient Source Code

The full source code for the `ConverterClient` program follows.

```
import javax.naming.Context;
import javax.naming.InitialContext;
import javax.rmi.PortableRemoteObject;
import Converter;
import ConverterHome;

public class ConverterClient {

   public static void main(String[] args) {

       try {
```

```
            Context initial = new InitialContext();
            Object objref = initial.lookup
                ("java:comp/env/ejb/SimpleConverter");
            ConverterHome home =
                (ConverterHome)PortableRemoteObject.narrow(
                objref, ConverterHome.class);
            Converter currencyConverter = home.create();

            double amount =
                currencyConverter.dollarToYen(100.00);
            System.out.println(String.valueOf(amount));
            amount = currencyConverter.yenToEuro(100.00);
            System.out.println(String.valueOf(amount));

            currencyConverter.remove();

         } catch (Exception ex) {
            System.err.println(“Caught an unexpected
exception!”);
            ex.printStackTrace();
         }
    }
}
```

Compiling the Application Client

The application client files are compiled at the same time as the enterprise bean files, as described in Compiling the Source Files (page 54).

Packaging the J2EE Application Client

To package an application client component, you run the New Application Client Wizard of the `deploytool`. During this process, the wizard puts the client files into a JAR file and then adds the JAR file to the application's `ConverterApp.ear` file.

To start the New Application Client Wizard, select File->New->Application Client. The wizard displays the following dialog boxes.

1. Introduction Dialog Box:
   a. Read this explanatory text for an overview of the wizard's features.
   b. Click Next.
2. JAR File Contents Dialog Box
   a. In the combo box, select ConverterApp.

   b. Click Edit.
   c. In the tree under Available Files, locate the `j2eetutorial/examples/build/ejb/converter` directory.
   d. Select the ConverterClient.class file and click Add.
   e. Click OK.
   f. Click Next.

3. General Dialog Box:
   a. In the Main Class combo box, select ConverterClient.
   b. Verify that the entry in the Display Name field is ConverterClient.
   c. In the Callback Handler Class combo box, select container-managed authentication.
   d. Click Next.
   e. Click Finish.

Specifying the Application Client's Enterprise Bean Reference

When it invokes the `lookup` method, the ConverterClient refers to an enterprise bean:

```
Object objref = initial.lookup
    ("java:comp/env/ejb/SimpleConverter");
```

You specify this reference as follows:

1. In the tree, select ConverterClient.
2. Select the EJB Refs tab.
3. Click Add.
4. In the Coded Name column enter `ejb/SimpleConverter`.
5. In the Type column, select Session.
6. In the Interfaces column, select Remote.
7. In the Home Interface column enter `ConverterHome`.
8. In the Local/Remote Interface column enter `Converter`.

Creating the Web Client

The web client is contained in the JSP page `j2eetutorial/examples/src/ejb/converter/index.jsp`. A JSP page is a text-based document that contains static template data, which can be expressed in any text-based format such as HTML, WML, and XML and JSP elements, which construct dynamic content.

Coding the Web Client

The statements (highlighted below) for locating the home interface, creating an enterprise bean instance, and invoking a business method are nearly identical to those of the J2EE application client. The parameter of the `lookup` method is the only difference; the motivation for using a different name is discussed in Specifying the JNDI Name (page 63).

The classes needed by the client are declared with a JSP directive (enclosed within the `<%@ %>` characters). Because locating the home interace and creating the enterprise bean are performed only once, they appear in a JSP declaration (enclosed within the `<%! %>` characters), that contains the initialization method, `jspInit`, of the JSP page. The declaration is followed by standard HTML markup for creating a form with an input field. A scriptlet (enclosed within the `<% %>` characters) retrieves a parameter from the request and converts it to a double. Finally, JSP expressions (enclosed within `<%= %>` characters) invoke the enterprise bean's business methods and insert the result into the stream of data returned to the client.

```
<%@ page import="Converter,ConverterHome,javax.ejb.*,
javax.naming.*, javax.rmi.PortableRemoteObject,
java.rmi.RemoteException" %>
<%!
   private Converter converter = null;
   public void jspInit() {
        try {
             InitialContext ic = new InitialContext();
             Object objRef = ic.lookup("
                  java:comp/env/ejb/TheConverter");
             ConverterHome home =
             (ConverterHome)PortableRemoteObject.narrow(
             objRef, ConverterHome.class);
             converter = home.create();
        } catch (RemoteException ex) {
             ...
        }
```

```
    }
    ...
%>
<html>
<head>
    <title>Converter</title>
</head>

<body bgcolor="white">
<h1><center>Converter</center></h1>
<hr>
<p>Enter an amount to convert:</p>
<form method="get">
<input type="text" name="amount" size="25">
<br>
<p>
<input type="submit" value="Submit">
<input type="reset" value="Reset">
</form>
<%
    String amount = request.getParameter("amount");
   if ( amount != null && amount.length() > 0 ) {
       Double d = new Double (amount);
%>
   <p><%= amount %> dollars are
       <%= converter.dollarToYen(d.doubleValue()) %>  Yen.
   <p><%= amount %> Yen are
       <%= converter.yenToEuro(d.doubleValue()) %>  Euro.
<%
    }
%>
</body>
</html>
```

Compiling the Web Client

The J2EE server automatically compiles web clients that are JSP pages. If the web client were a servlet, you would have to recompile it.

Packaging the Web Client

To package a web component, you run the New Web Component Wizard of the `deploytool`. During this process, the wizard puts the client files into a WAR file and then adds the WAR file to the application's `ConverterApp.ear` file.

To start the New Web Component Wizard, select File->New->Web Component. The wizard displays the following dialog boxes.

1. Introduction Dialog Box:
   a. Read this explanatory text for an overview of the wizard's features.
   b. Click Next.
2. WAR File Dialog Box
   a. Select Create New WAR File in Application.
   a. In the combo box, select ConverterApp.
   b. In the WAR Display Name field, enter `ConverterWAR`.
   c. Click Edit.
   d. In the tree under Available Files, locate the `j2eetutorial/examples/build/ejb/converter` directory.
   e. Select index.jsp and click Add.
   f. Click OK.
   g. Click Next.
3. Choose Component Type Dialog Box
   a. Select the JSP radio button.
   b. Click Next.
4. Component General Properties Dialog Box
   a. In the JSP Filename combo box, select index.jsp.
   b. Click Finish.

Specifying the Web Client's Enterprise Bean Reference

When it invokes the `lookup` method, the web client refers to an enterprise bean:

```
Object objref = initial.lookup
   ("java:comp/env/ejb/TheConverter");
```

You specify this reference as follows:

1. In the tree, select ConverterWAR.
2. Select the EJB Refs tab.
3. Click Add.

4. In the Coded Name column enter `ejb/TheConverter`.
5. In the Type column, select Session.
6. In the Interfaces column, select Remote.
7. In the Home Interface column enter `ConverterHome`.
8. In the Local/Remote Interface column enter `Converter`.

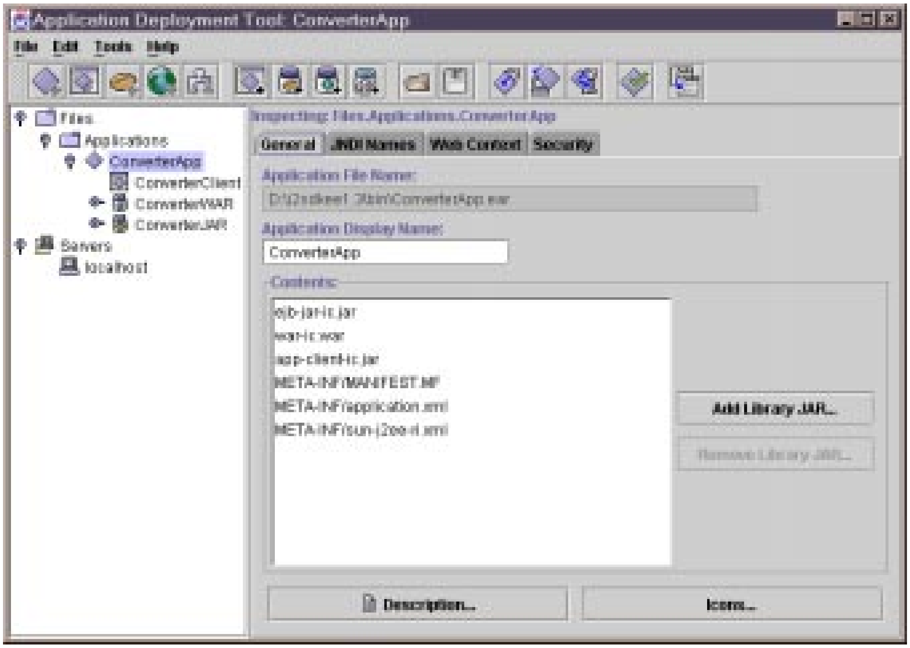
Specifying the JNDI Name

Although the J2EE application client and the web client access the same enterprise bean, their code refers to the bean by different names. The J2EE application client refers to the bean as `SimpleConverter`, but the web client refers to it as `TheConverter`. These references are in the parameters of the `lookup` calls. In order for the `lookup` method to retrieve the bean, you must map the references in the code to the bean's JNDI name. Although this mapping adds a level of indirection, it decouples the clients and the beans, making it easier to assemble applications from J2EE components. For more information, see About JNDI Naming (page 72).

To map the bean references in the clients to the JNDI name of the bean, follow these steps:

1. In the tree, select ConverterApp.
2. Select the JNDI Names tab.
3. To specify a JNDI name for the bean, in the Application table locate the ConverterEJB component and enter `MyConverter` in the JNDI Name column.
4. To map the references, in the References table enter `MyConverter` in the JNDI Name for each row.

The following screen shot shows what the JNDI Names tab should look like after you've performed the preceding steps.



Deploying the J2EE™ Application

Now that the J2EE application contains the components, it is ready for deployment.

1. Select the ConverterApp application.
2. Select Tools->Deploy.
3. In the Introduction dialog box, confirm that ConverterApp is shown for the Object to Deploy and `localhost` for the Target Server.
4. Select the checkbox labelled Return Client Jar.
5. In the text field that appears, enter the full path name for the file `ConverterAppClient.jar` so that it will reside in the `j2eetutorial/examples/src/ejb/converter` subdirectory. The `ConverterAppClient`.jar file contains the stub classes that enable remote access to the `ConverterEJB` bean.
6. Click Next.
7. In the JNDI Names dialog box, verify the names you entered in the previous section.

8. Click Next.
9. In the WAR Context Root dialog box, enter `converter` in the Context Root field. When you run the web client, the `converter` context root will be part of the URL.
10. Click Next.
11. In the Review dialog box, click Finish.
12. In the Deployment Progress dialog box, click OK when the deployment completes.

Running the J2EE™ Application Client

1. In a terminal window, go to the `j2eetutorial/examples/src/ejb/converter` directory.
2. Verify that this directory contains the `ConverterApp.ear` and `ConverterAppClient.jar` files.
3. Set the APPCPATH environment variable to `ConverterAppClient.jar`.
4. Type the following command (on a single line):

```
runclient -client ConverterApp.ear -name ConverterClient
-textauth
```

5. The client container prompts you to login. Enter `guest` for the user name and `guest123` for the password.
6. In the terminal window, the client displays these lines:

```
Binding name:‘java:comp/env/ejb/SimpleConverter‘
12160.0
0.77
Unbinding name:‘java:comp/env/ejb/SimpleConverter‘
```

Running the Web Client

To run the web client point your browser at the following URL. Replace *<host>* with the name of the host running the J2EE server. If your browser is running on the same host as the J2EE server, you may replace *<host>* with `localhost`.

```
http://<host>:8000/converter
```

You should see the following after entering `100` in the input field and clicking Submit:

Modifying the J2EE™ Application

Since the J2EE SDK is intended for experimentation, it supports iterative development. Whenever you make a change to a J2EE application, you must redeploy the application.

Modifying a Class File

To modify a class file in an enterprise bean, you change the source code, recompile it, and redeploy the application. For example, suppose that you want to change the exchange rate in the `dollarToYen` business method of the `ConverterBean` class:

1. Edit the `ConverterBean.java` source file.
2. Recompile `ConverterBean.java` by typing `ant converter`.
3. In the `deploytool`, select Tools->Update and Redeploy. The `deploytool` replaces the old class file in `ConverterApp.ear` with the new one and then redeploys the application.

Adding a File

To add a file to the EJB JAR or WAR of the application, you would perform these steps:

1. Select the JAR or WAR in the tree.
2. Select the General tab.
3. Click Edit.
4. In the tree of the Available Files field, locate the file and click Add.
5. Click OK
6. From the main toolbar, select Tools->Update and Redeploy.

Modifying the Web Client

To modify the web client, you simply edit the JSP page and select Tools->Update and Redeploy.

Modifying a Deployment Setting

To modify a deployment setting of `ConverterApp`, you edit the appropriate field in a tabbed pane and redeploy the application. For example, to change the JNDI name of the `ConverterBean` from `ATypo` to `MyConverter`, you would follow these steps:

1. In the `deploytool`, select ConverterApp in the tree.
2. Select the JNDI Names tab.
3. In the JNDI Name field, enter `MyConverter`.
4. From the main toolbar, select File->Save.
5. Select Tools->Update and Redeploy.

Common Problems and Their Solutions

Cannot Start the J2EE Server

Naming and Directory Service Port Conflict

Symptom: When you start the J2EE server with the `-verbose` option, it displays these lines:

```
J2EE server listen port: 1050
RuntimeException: Could not initialize server. . .
```

Solution: Another process is using port 1050. If the J2EE server is already running, you can stop it by typing `j2ee -stop`. If some other program is using the port, then you can change the default port number (1050) by editing the `config/orb.properties` file of your J2EE SDK installation.

For more information about default port numbers, see the *Configuration Guide* in the documentation download bundle of the J2EE SDK.

Web Service Port Conflict

Symptom: When you start the J2EE server with the `-verbose` option, it displays these lines:

```
LifecycleException: HttpConnector[8000].open:
java.net.BindException: Address in use. . .
```

Solution: Another process is using port 8000. You can change the default port number (8000) by editing the `config/web.properties` file of your J2EE SDK installation.

Incorrect XML Parser

Symptom: When you start the J2EE server with the `-verbose` option, it displays these lines:

```
Exception in thread "main"
javax.xml.parsers.FactoryConfigurationError:
org.apache.xerces.jaxp.SAXParserFactoryImpl at . . .
```

Solution: Remove the `jre/lib/jaxp.properties` file from your J2SE installation.

Compilation Errors

Ant Cannot Locate the Build File

Symptom: When you type `ant converter`, these messages appear:

```
Buildfile: build.xml does not exist!
Build failed.
```

Solution: Before running `ant`, go the `j2eetutorial/examples/src` directory. If you want to run `ant` from your current directory, then you must specify the build file on the command line. For example, on Windows you would type this command on a single line:

```
ant -buildfile C:\j2eetutorial\examples\src\build.xml
converter
```

The Compiler Cannot Resolve Symbols

Symptom: When you type `ant converter`, the compiler reports many errors, including these:

```
cannot resolve symbol
. . .
BUILD FAILED
. . .
Compile failed, messages should have been provided
```

Solution: Make sure that you've set the J2EE_HOME environment variable correctly. See Checking the Environment Variables (page 51).

Deployment Errors

The Incorrect XML Parser Is In Your Classpath

Symptom: The error displayed has the following text:

```
. . .
[]java.rmi.RemoteException:Error saving/opening

Deployment Error:Bad mapping of key{0}  class{1},
not found: com.sum.enterprise.deployment.xml.ApplicationNode
```

Solution: Remove the `jaxp.jar` file from the `jre/lib/ext` directory of your J2SE installation. This JAR file contains XML parsing routines that are incompatible with the J2EE server. If you do not have a `jaxp.jar` file, then perhaps your classpath refers to the XML routines of a Tomcat installation. In this case, you should remove that reference from your classpath.

J2EE Application Client Runtime Errors

The Client Throws an Exception

Symptom: The client reports this exception:

```
java.lang.NoClassDefFoundError:converter.ConverterHome
```

Solution: Make sure that you set APPCPATH to the path of the client jar you returned when you deployed the application.

The Client Cannot Find ConverterApp.ear

Symptom: The client reports this exception:

```
IOException: ConverterApp.ear does not exist
```

Solution: Ensure that the `ConverterApp.ear` file exists and that you've specified it with the `-client` option:

```
runclient -client ConverterApp.ear -name ConverterClient
```

You created the `ConverterApp.ear` file in the section, Creating the J2EE™ Application (page 52). See also, Running the J2EE™ Application Client (page 65).

The Client Cannot Find the ConverterClient Component

Symptom: The client displays this line:

```
No application client descriptors defined for: . . .
```

Solution: Verify that you've created the ConverterClient component and that you've specified it for the `-name` option of the `runclient` command. You created the ConverterClient component in the section, Packaging the J2EE Application Client (page 58).

The Login Failed

Symptom: After you login, the client reports displays this line:

```
Incorrect login and/or password
```

Solution: At the login prompts, enter `guest` as the user name and `guest123` as the password.

The J2EE Application Has Not Been Deployed

Symptom: The client reports the following exception:

```
NameNotFoundException. Root exception is org.omg.CosNaming. . .
```

Solution: Deploy the application. For instructions, see Deploying the J2EE™ Application (page 64).

The JNDI Name is Incorrect

Symptom: The client reports the following exception:

```
NameNotFoundException. Root exception is org.omg.CosNaming. . .
```

Solution: In the JNDI Names tabbed pane of the `ConverterApp`, make sure that the JNDI names for the `ConverterBean` and the `ejb/SimpleConverter` match. Edit the appropriate JNDI Name field and then redeploy the application.

Web Client Runtime Errors

The Web Context in the URL is Incorrect

Symptom: The browser reports that the page cannot be found (HTTP 404).

Solution: Verify that the web context (`converter`) in the URL matches the one you specified in the Component General Properties dialog box in the section, Packaging the Web Client (page 61). The case (upper or lower) of the web context *is* significant.

The J2EE Application Has Not Been Deployed

Symptom: The browser reports that the page cannot be found (HTTP 404).

Solution: Deploy the application.

The JNDI Name is Incorrect

Symptom: When you click Submit on the web page, the browser reports that `A Servlet Exception Has Occurred`.

Solution: In the JNDI Names tabbed pane of the `ConverterApp`, make sure that the JNDI names for the `ConverterBean` and the `ConverterWAR` match. Edit the appropriate JNDI Name field and then redeploy the application.

Detecting Problems With the Verifier Tool

The `verifier` tool can detect inconsistencies in deployment descriptors and method signatures. These inconsistencies often cause deployment or runtime errors. From the `deploytool`, you can run the GUI version of the `verifier` tool by selecting Tools-> Verifier. You can also run a stand-alone GUI or command-line version of the `verifier` tool. For more information, see the J2EE™ SDK Tools (page 449).

Comparing Your EAR Files With Ours

For most of the examples, the download bundle of the tutorial includes J2EE application EAR files, which are located in the `j2eetutorial/examples/ears` directory.

When All Else Fails

If none of these suggestions fixes the problem, you can uninstall the application and clean out the server's repository by running the `cleanup` script. You'll also need to shutdown and restart the server:

```
j2ee -stop
cleanup
j2ee -verbose
```

About JNDI Naming

J2EE naming services provide application clients, enterprise beans, and Web components with access to a JNDI naming environment. A *naming environment* allows a component to be customized without the need to access or change the component's source code. A container implements the component's environment, and provides it to the component as a JNDI *naming context*.

J2EE components locate their environment naming contexts using JNDI interfaces. A component creates a `javax.naming.InitialContext` object and looks up the environment naming context in `InitialContext` under the name `java:comp/env`. A component's naming environment is stored directly in the environment naming context, or in any of its direct or indirect *subcontexts*.

A J2EE component can access named system-provided and user-defined objects. The names of system-provided objects, such as JTA `UserTransaction` objects, are stored in the environment naming context, `java:comp/env`. The J2EE platform allows a component to name user-defined objects, such as enterprise beans, environment entries, JDBC `DataSource` objects, and message connections. An object should be named within a subcontext of the naming environment according to the type of the object. For example, enterprise beans are named within the subcontext `java:comp/env/ejb` and JDBC `DataSource` references in the subcontext `java:comp/env/jdbc`.

Enterprise Beans

by Dale Green

ENTERPRISE beans are the J2EE™ components that implement Enterprise JavaBeans™ (EJB™) technology. Enterprise beans run in the EJB container, a runtime environment within the J2EE server. (See Figure 5.) Although transparent to the application developer, the EJB container provides system-level services such as transactions to its enterprise beans. These services enable you to quickly build and deploy enterprise beans, which form the core of transactional J2EE applications.

What is an Enterprise Bean?

Written in the Java™ programming language, an enterprise bean is a server-side component that encapsulates the business logic of an application. The business logic is the code that fulfills the purpose of the application. In an inventory control application, for example, the enterprise beans might implement the business logic in methods called `checkInventoryLevel` and `orderProduct`. By invoking these methods, remote clients can access the inventory services provided by the application.

Benefits of Enterprise Beans

For several reasons, enterprise beans simplify the development of large, distributed applications.

First, because the EJB container provides system-level services to enterprise beans, the bean developer can concentrate on solving business problems. The EJB container—not the bean developer—is responsible for system-level services such as transaction management and security authorization.

Second, because the beans—and not the clients—contain the application's business logic, the client developer can focus on the presentation of the client. The client developer does not have to code the routines that implement business rules or access databases. As a result, the clients are thinner, a benefit that is particularly important for clients that run on small devices.

Third, because enterprise beans are portable components, the application assembler can build new applications from existing beans. These applications can run on any compliant J2EE server.

When To Use Enterprise Beans

You should consider using enterprise beans if your application has any of these requirements:

- The application must be scalable. To accommodate a growing number of users, you may need to distribute an application's components across multiple machines. Not only can the enterprise beans of an application run on different machines, but their location will remain transparent to the clients.
- Transactions are required to ensure data integrity. Enterprise beans support transactions, the mechanisms that manage the concurrent access of shared objects.
- The application will have a variety of clients. With just a few lines of code, remote clients can easily locate enterprise beans. These clients can be thin, various, and numerous.

Types of Enterprise Beans

The following table summarizes the three different types of enterprise beans. The following sections discuss each type in more detail.

Table 3 Summary of Enterprise Bean Types

Enterprise Bean Type	Purpose
Session	Performs a task for a client.
Entity	Represents a business entity object that exists in persistent storage.
Message-Driven	Acts as a listener for the Java™ Message Service API, processing messages asynchronously.

What is a Session Bean?

A session bean represents a single client inside the J2EE server. To access an application that is deployed on the server, the client invokes the session bean's methods. The session bean performs work for its client, shielding the client from complexity by executing business tasks inside the server.

As its name suggests, a session bean is similar to an interactive session. A session bean is not shared—it may have just one client, in the same way that an interactive session may have just one user. Like an interactive session, a session bean is not persistent. (That is, its data is not saved to a database.) When the client terminates, its session bean appears to terminate and is no longer associated with the client.

For code samples, see the chapter, Bean-Managed Persistence Examples (page 109).

State Management Modes

There are two types of session beans: stateful and stateless.

Stateful Session Beans

The state of an object consists of the values of its instance variables. In a stateful session bean, the instance variables represent the state of a unique client-bean session. Because the client interacts ("talks") with its bean, this state is often called the conversational state.

The state is retained for the duration of the client-bean session. If the client removes the bean or terminates, the session ends and the state disappears. This transient nature of the state is not a problem, however, because when the conversation between the client and the bean ends there is no need to retain the state.

Stateless Session Beans

A stateless session bean does not maintain a conversational state for a particular client. When a client invokes the method of a stateless bean, the beans's instance variables may contain a state, but only for the duration of the invocation. When the method is finished, the state is no longer retained. Except during method invocation, all instances of a stateless bean are equivalent, allowing the EJB container to assign an instance to any client.

Because stateless session beans can support multiple clients, they can offer better scalability for applications that require large numbers of clients. Typically, an application requires fewer stateless session beans than stateful session beans to support the same number of clients.

At times, the EJB container may write a stateful session bean out to secondary storage. However, stateless session beans are never written out to secondary storage. Therefore, stateless beans may offer better performance than stateful beans.

When to Use Session Beans

In general, you should use a session bean under the following circumstances:

- At any given time, only one client has access to the bean instance.
- The state of the bean is not persistent, existing only for a short period of time (perhaps a few hours).

Stateful session beans are appropriate if any of the following conditions are true:

- The bean's state represents the interaction between the bean and a specific client.
- The bean needs to hold information about the client across method invocations.
- The bean mediates between the client and the other components of the application, presenting a simplified view to the client.
- Behind the scenes, the bean manages the work flow of several enterprise beans. For an example, see the `AccountControllerEJB` in the The Duke's Bank Application (page 407).

To improve performance, you might choose a stateless session bean if it has any of these traits:

- The bean's state has no data for a specific client.
- In a single method invocation, the bean performs a generic task for all clients. For example, you might use a stateless session bean to send an email that confirms an online order.
- The bean fetches from a database a set of read-only data that is often used by clients. Such a bean, for example, could retrieve the table rows that represent the products that are on sale this month.

What is an Entity Bean?

An entity bean represents a business object in a persistent storage mechanism. Some examples of business objects are customers, orders, and products. In the J2EE SDK, the persistent storage mechanism is a relational database. Typically, each entity bean has an underlying table in a relational database, and each instance of the bean corresponds to a row in that table.

For code examples of entity beans, please refer to these chapters:

- Bean-Managed Persistence Examples (page 109)
- Container-Managed Persistence Examples (page 143)

What Makes Entity Beans Different From Session Beans

Entity beans differ from session beans in several ways. Entity beans are persistent, allow shared access, have primary keys, and may participate in relationships with other entity beans.

Persistence

Because the state of an entity bean is saved in a storage mechanism, it is persistent. Persistence means that the entity bean's state exists beyond the lifetime of the application or the J2EE server process. If you've worked with databases, you're familiar with persistent data. The data in a database is persistent because it still exists even after you shut down the database server or the applications it services.

There are two types of persistence for entity beans: bean-managed and container-managed. With bean-managed persistence, the entity bean code that you write contains the calls that access the database. If your bean has container-managed persistence, the EJB container automatically generates the necessary database access calls. The code that you write for the entity bean does not include these calls. For additional information, see Container-Managed Persistence (page 81).

Shared Access

Entity beans may be shared by multiple clients. Because the clients might want to change the same data, it's important that entity beans work within transactions. Typically, the EJB container provides transaction management. In this case, you specify the transaction attributes in the bean's deployment descriptor.

You do not have to code the transaction boundaries in the bean—the container marks the boundaries for you. See Transactions (page 331) for more information.

Primary Key

Each entity bean has a unique object identifier. A customer entity bean, for example, might be identified by a customer number. The unique identifier, or primary key, enables the client to locate a particular entity bean. For more information see Entity Bean Class (page 110).

Relationships

Like a table in a relational database, an entity bean may be related to other entity beans. For example, in a college enrollment application the `StudentEJB` and `CourseEJB` beans would be related because students enroll in classes.

You implement relationships differently for entity beans with bean-managed-persistence and those with container-managed-persistence. With bean-managed persistence, the code that you write implements the relationships. But with container-managed persistence, the EJB container takes care of the relationships for you. For this reason, relationships in entity beans with container-managed persistence are often referred to as container-managed relationships.

Container-Managed Persistence

The term container-managed persistence means that the EJB container handles all database access required by the entity bean. The bean’s code contains no database access (SQL) calls. As a result, the bean’s code is not tied to a specific persistent storage mechanism (database). Because of this flexibility, even if you redeploy the same entity bean on different J2EE servers that use different databases, you won’t need to modify or recompile the bean’s code. In short, your entity beans are more portable.

In order to generate the data access calls, the container needs information that you provide in the entity bean’s abstract schema.

Abstract Schema

Part of an entity bean’s deployment descriptor, the abstract schema defines the bean’s persistent fields and relationships. The term “abstract” distinguishes this schema from the physical schema of the underlying datastore. In a relational database, for example, the physical schema is made up of structures such as tables and columns.

You specify the name of an abstract schema in the deployment descriptor. This name is referenced by queries written in the Enterprise JavaBeans™ Query Language (EJB™ QL). For an entity bean with container-managed persistence, you must define an EJB QL query for every finder method (except `findByPrimaryKey`). The EJB QL query determines the query that is executed by the EJB container when the finder method is invoked. To learn more about EJB QL, see the chapter, Enterprise JavaBeans™ Query Language (page 183).

You'll probably find it helpful to sketch the abstract schema before writing any code. The following figure represents a simple abstract schema that describes the relationships between three entity beans. These relationships are discussed further in the sections that follow.

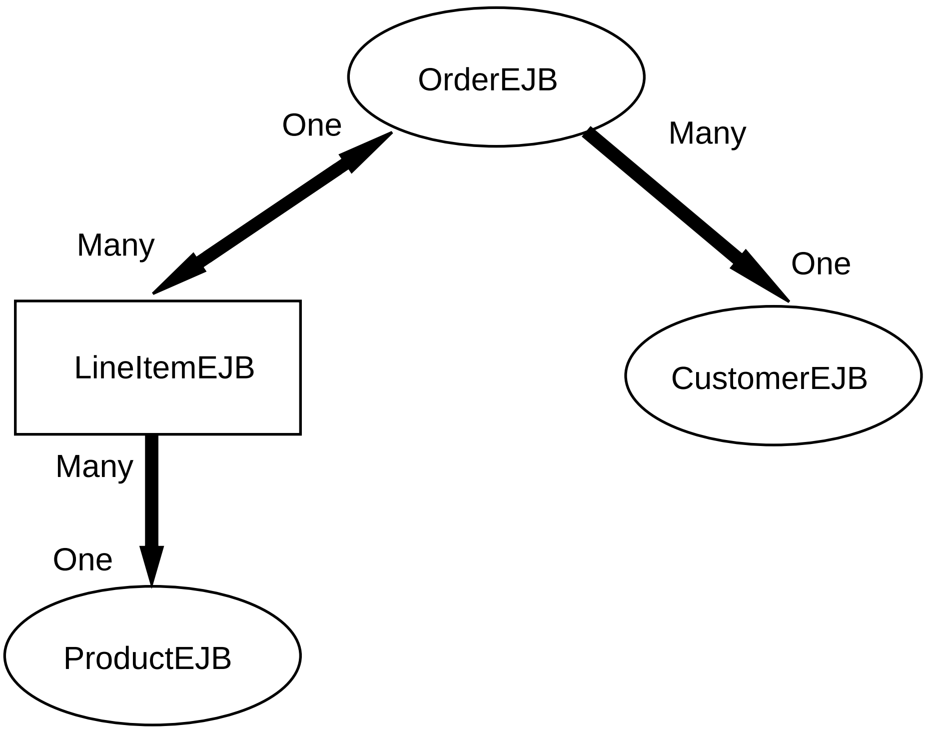


Figure 6 A High-Level View of an Abstract Schema

Persistent Fields. The persistent fields of an entity bean are stored in the underlying datastore. Collectively, these fields constitute the state of the bean. At runtime, the EJB container automatically synchronizes this state with the database. During deployment, the container typically maps the entity bean to a database table and the persistent fields to the table's columns.

A `CustomerEJB` bean, for example, might have persistent fields such as `firstName`, `lastName`, `phone`, and `emailAddress`. In container-managed persistence, these fields are virtual. You declare them in the abstract schema, but you do not code them as instance variables in the entity bean class. Instead, the persistent fields are identified in the code by access methods (getters and setters).

Relationship Fields. A relationship field is like a foreign key in a database table—it identifies a related bean. Like a persistent field, a relationship field is virtual and is defined in the enterprise bean class with access methods. But unlike a persistent field, a relationship field does not represent the bean's state. Relationship fields are discussed further in Direction in Container-Managed Relationships (page 83).

Multiplicity in Container-Managed Relationships

There are four types of multiplicities:

One-to-One - Each entity bean instance is related to a single instance of another entity bean. For example, to model a physical warehouse in which each storage bin contains a single widget, the `StorageBinEJB` and `WidgetEJB` beans would have a one-to-one relationship.

One-to-Many - An entity bean instance may be related to multiple instances of the other entity bean. A sales order, for example, can have multiple line items. In the order application, an `OrderEJB` bean would have a one-to-many relationship with the `LineItemEJB` beans.

Many-to-One - Multiple instances of an entity bean may be related to a single instance of the other entity bean. This multiplicity is the opposite of one-to-many. In the example mentioned in the previous paragraph, from the perspective of the `LineItemEJB` bean the relationship to the `OrderEJB` bean is many-to-one.

Many-to-Many - The entity bean instances may be related to multiple instances of each other. For example, in college each course has many students and every student may take several courses. Therefore, in an enrollment application, the `CourseEJB` and `StudentEJB` beans would have a many-to-many relationship.

Direction in Container-Managed Relationships

The direction of a relationship may be either bidirectional or unidirectional.

In a bidirectional relationship, each entity bean has a relationship field that refers to the other bean. Through the relationship field, an entity bean's code can access its related object. If an entity bean has a relative field, then we often say that it "knows" about its related object. For example, if an `OrderEJB` bean knows what `LineItemEJB` beans it has and if each `LineItemEJB` bean knows what `OrderEJB` bean it belongs to, then they have a bidirectional relationship.

In a unidirectional relationship, only one entity bean has a relationship field that refers to the other. For example, a `LineItemEJB` bean would have a relationship field that identifies a `ProductEJB` bean, but the `ProductEJB` bean would not have a relationship field for the `LineItemEJB` bean. In other words, the `LineItemEJB` bean knows about the `ProductEJB` bean, but the `ProductEJB` bean doesn't know which `LineItemEJB` beans refer to it.

EJB QL queries often navigate across relationships. The direction of a relationship determines whether a query can navigate from one bean to another. For example, a query may navigate from the `LineItemEJB` bean to the `ProductEJB` bean, but may not navigate in the opposite direction. For the `OrderEJB` and `LineItemEJB` beans, a query could navigate in both directions, since these two beans have a bidirectional relationship.

When To Use Entity Beans

You should probably use an entity bean under the following conditions:

- The bean represents a business entity, not a procedure. For example, `CreditCardEJB` would be an entity bean, but `CreditCardVerifierEJB` would probably be a session bean.
- The bean's state must be persistent. If the bean instance terminates or if the J2EE server is shut down, the bean's state still exists in persistent storage (a database).

What is a Message-Driven Bean?

Note: This section contains text from the Java™ Message Service Tutorial. Because message-driven beans rely on Java Message Service (JMS) technology, to fully understand how these beans work you should consult the tutorial at this URL:

`http://java.sun.com/products/jms/tutorial/index.html`

A message-driven bean is an enterprise bean that allows J2EE applications to process messages asynchronously. It acts as a JMS message listener, which is similar to an event listener except that it receives messages instead of events. The messages may be sent by any J2EE component—an application client, another enterprise bean, or a Web component—or by a JMS application or system that does not use J2EE technology.

Message-driven beans currently process only JMS messages, but in the future they may be used to process other kinds of messages.

For a code sample, see the chapter, A Message-Driven Bean Example (page 173).

What Makes Message-Driven Beans Different From Session and Entity Beans

The most visible difference between message-driven beans and session and entity beans is that clients do not access message-driven beans through interfaces. Interfaces are described in the section Defining Client Access With Interfaces (page 86). Unlike a session or entity bean, a message-driven bean has only a bean class.

In several respects, a message-driven bean resembles a stateless session bean:

- A message-driven bean's instances retain no data or conversational state for a specific client.
- All instances of a message-driven bean are equivalent, allowing the EJB container to assign a message to any message-driven bean instance. The container can pool these instances to allow streams of messages to be processed concurrently.
- A single message-driven bean can process messages from multiple clients.

The instance variables of the message-driven bean instance can contain some state across the handling of client messages—for example, a JMS API connection, an open database connection, or an object reference to an enterprise bean object.

When a message arrives, the container calls the message-driven bean's `onMessage` method to process the message. The `onMessage` method normally casts the message to one of the five JMS message types and handles it in accordance with the application's business logic. The `onMessage` method may call helper methods, or it may invoke a session or entity bean to process the information in the message or to store it in a database.

A message may be delivered to a message-driven bean within a transaction context, so that all operations within the `onMessage` method are part of a single transaction. If message processing is rolled back, the message will be redelivered. For more information see Transactions (page 331).

When to Use Message-Driven Beans

Session beans and entity beans allow you to send JMS messages and to receive them synchronously, but not asynchronously. To avoid tying up server resources, you may prefer not to use blocking synchronous receives in a server-side component. To receive messages asynchronously, use a message-driven bean.

Defining Client Access With Interfaces

Note: The material in this section applies only to session and entity beans, not to message-driven beans. Because they have a different programming model, message-driven beans do not have interfaces that define client access.

A client may access a session or an entity bean only through the methods defined in the bean's interfaces. These interfaces define the client's view of a bean. All other aspects of the bean—method implementations, deployment descriptor settings, abstract schemas, database access calls—are hidden from the client.

Well designed interfaces simplify the development and maintenance of J2EE applications. Not only do clean interfaces shield the clients from any complexities in the EJB tier, but they allow the beans to change internally without affecting the clients. For example, even if you change your entity beans from bean-managed to container-managed persistence, you won't have to alter the client code. But if you were to change the method definitions in the interfaces, then you might have to modify the client code as well. Therefore, to isolate your clients from possible changes in the beans, it is important that you design the interfaces carefully.

When you design a J2EE application, one of the first decisions you make is the type of client access allowed by the enterprise beans: remote or local.

Remote Access

A remote client of an enterprise bean has the following traits:

- It may run on a different machine and a different Java™ Virtual Machine (JVM) than the enterprise bean it accesses. (It is not required to run on a different JVM.)
- It can be a web component, a J2EE application client, or another enterprise bean.
- To a remote client, the location of the enterprise bean is transparent.

To create an enterprise bean with remote access, you must code a remote interface and a home interface. The remote interface defines the business methods that are specific to the bean. For example, the remote interface of a `BankAccountEJB` bean might have business methods named `debit` and credit. The home interface defines the bean's life-cycle methods—`create` and `remove`. For entity beans, the home interface also defines finder methods and home methods. Finder methods are used to locate entity beans. Home methods are business methods that are invoked on all instances of an entity bean class. The following figure shows how the interfaces control the client's view of an enterprise bean.

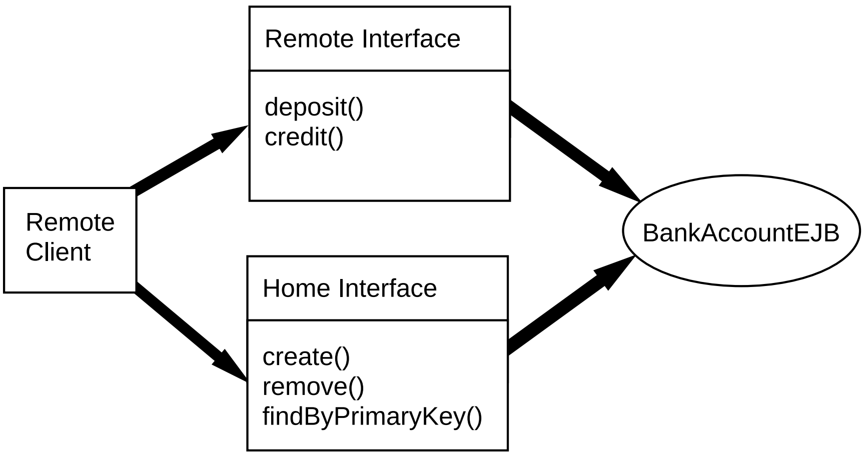


Figure 7 Interfaces for an Enterprise Bean With Remote Access

Local Access

A local client has these characteristics:

- It must run in the same JVM as the enterprise bean it accesses.
- It may be a web component or another enterprise bean.
- To the local client, the location of the enterprise bean it accesses is not transparent.

- It is often an entity bean that has a container-managed relationship with another entity bean.

To build an enterprise bean that allows local access, you must code the local interface and the local home interface. The local interface defines the bean's business methods and the local home interface defines its life-cycle and finder methods.

Local Interfaces and Container-Managed Relationships

If an entity bean is the target of a container-managed relationship, then it must have local interfaces. The direction of the relationship determines whether or not a bean is the target. In Figure 6, for example, the `ProductEJB` bean is the target of a unidirectional relationship with the `LineItemEJB` bean. Because the `LineItemEJB` accesses the `ProductEJB` locally, the `ProductEJB` must have the local interfaces. The `LineItemEJB` also needs local interfaces—not because of its relationship with the ProductEJB—but because it is the target of a relationship with the `OrderEJB`. And because the relationship between the `LineItemEJB` and `OrderEJB` is bidirectional, both beans must have local interfaces.

Because they require local access, entity beans that participate in a container-managed relationship must reside in the same EJB container. The primary benefit of this locality is increased performance—local calls are usually faster than remote calls.

Deciding on Remote or Local Access

The decision on whether to allow local or remote access depends on the following factors:

- Container-Managed Relationships

  If an entity bean is the target of a container-managed relationship, it must use local access.

- Tight or Loose Coupling of Related Beans

  Tightly coupled beans depend on one another. For example, a completed sales order must have one or more line items, which cannot exist without the order to which they belong. The `OrderEJB` and `LineItemEJB` beans that model this relationship are tightly coupled.

Tightly coupled beans are good candidates for local access. Since they fit together as a logical unit, they probably call each other often and would benefit from the increased performance that is possible with local access.

• Type of Client

If an enterprise bean is accessed by J2EE application clients, then it should allow remote access. In a production environment, these clients almost always run on different machines than the J2EE server.

If an enterprise bean's clients are web components or other enterprise beans, then the type of access depends on how you want to distribute your components.

• Component Distribution

J2EE applications are scalable because their server-side components can be distributed across multiple machines. In a distributed application, for example, the web components may run on a different server than the enterprise beans they access. In this distributed scenario, the enterprise beans should allow remote access.

If you aren't sure which type of access an enterprise bean should have, then choose remote access. This decision gives you more flexibility—in the future you can distribute your components to accommodate growing demands on your application.

Although uncommon, it is possible for an enterprise bean to allow both remote and local access. Such a bean would require both remote and local interfaces.

Performance and Access

Because of factors such as network latency, remote calls may be slower than local calls. On the other hand, if you distribute components among different servers, you might improve the application's overall performance. Both of these statements are generalizations; actual performance can vary in different operational environments. Nevertheless, you should keep in mind how your application design might impact performance.

Method Parameters and Access

The type of access affects the parameters of the bean methods that are called by clients. The following topics apply not only to method parameters, but also to method return values.

Isolation

An argument in a remote call is passed by value; it is a copy of an object. But an argument in a local call is passed by reference, just like a normal method call in the Java programming language.

The parameters of remote calls are more isolated than those of local calls. With remote calls, the client and bean operate on different copies of a parameter object. If the client changes the value of the object, the value of the copy in the bean does not change. This layer of isolation can help protect the bean if the client accidentally modifies the data.

In a local call, both the client and the bean may modify the same object. In general, you should not rely on this side-effect of local calls. Perhaps some day you will want to distribute your components, replacing the local calls with remote ones.

Granularity of Accessed Data

Because remote calls are likely to be slower than local calls, the parameters in remote methods should be relatively coarse-grained. Since a coarse-grained object contains more data than a fine-grained one, fewer access calls are required.

For example, suppose that a `CustomerEJB` is accessed remotely. This bean would have a single getter method that returns a `CustomerDetails` object, which encapsulates all of the customer's information. But if the `CustomerEJB` is to be accessed locally, it could have a getter method for each instance variable: `getFirstName`, `getLastName`, `getPhoneNumber`, and so forth. Since local calls are fast, the multiple calls to these finer-grained getter methods would not significantly degrade performance.

The Contents of an Enterprise Bean

To develop an enterprise bean, you must provide the following files:

- Deployment descriptor - An XML file that specifies information about the bean such as its persistence type and transaction attributes. The `deploytool` creates the deployment descriptor when you step through the New Enterprise Bean Wizard.
- Enterprise bean class - Implements the methods defined in the following interfaces.
- Interfaces - The remote and home interfaces are required for remote access. For local access, the local and local home interfaces are required.

See Defining Client Access With Interfaces (page 86). (Please note that these interfaces are not used by message-driven beans.)

- Helper classes - Other classes needed by the enterprise bean class, such as exception and utility classes.

You package the files in the preceding list into an EJB JAR file, the module that stores the enterprise bean. An EJB JAR file is portable and may be used for different applications. To assemble a J2EE application, you package one or more modules—such as EJB JAR files—into an EAR file, the archive file that holds the application. When you deploy the EAR file that contains the bean's EJB JAR file, you also deploy the enterprise bean onto the J2EE server.

The Life Cycles of Enterprise Beans

An enterprise bean goes through various stages during its lifetime, or life cycle. Each type of enterprise bean— session, entity, or message-driven— has a different life cycle.

The descriptions that follow refer to methods that are explained along with the code examples in the next two chapters. If you are new to enterprise beans, you should skip this section and try out the code examples first.

The Stateful Session Bean Life Cycle

Figure 8 illustrates the stages that a session bean passes through during its lifetime. The client initiates the life cycle by invoking the `create` method.The EJB container instantiates the bean and then invokes the `setSessionContext` and `ejbCreate` methods in the session bean. The bean is now ready to have its business methods invoked.

While in the ready stage, the EJB container may decide to deactivate, or passivate, the bean by moving it from memory to secondary storage. (Typically, the EJB container uses a least-recently-used algorithm to select a bean for passivation.) The EJB container invokes the bean's `ejbPassivate` method immediately before passivating it. If a client invokes a business method on the bean while it is in the passive stage, the EJB container activates the bean, moving it back to the ready stage, and then calls the bean's `ejbActivate` method.

At the end of the life cycle, the client invokes the remove method and the EJB container calls the bean's `ejbRemove` method. The bean's instance is ready for garbage collection.

Your code controls the invocation of only two life cycle methods—the `create` and `remove` methods in the client. All other methods in Figure 8 are invoked by the EJB container. The `ejbCreate` method, for example, is inside the bean class, allowing you to perform certain operations right after the bean is instantiated. For instance, you may wish to connect to a database in the `ejbCreate` method. See Resource Connections (page 369) for more information.

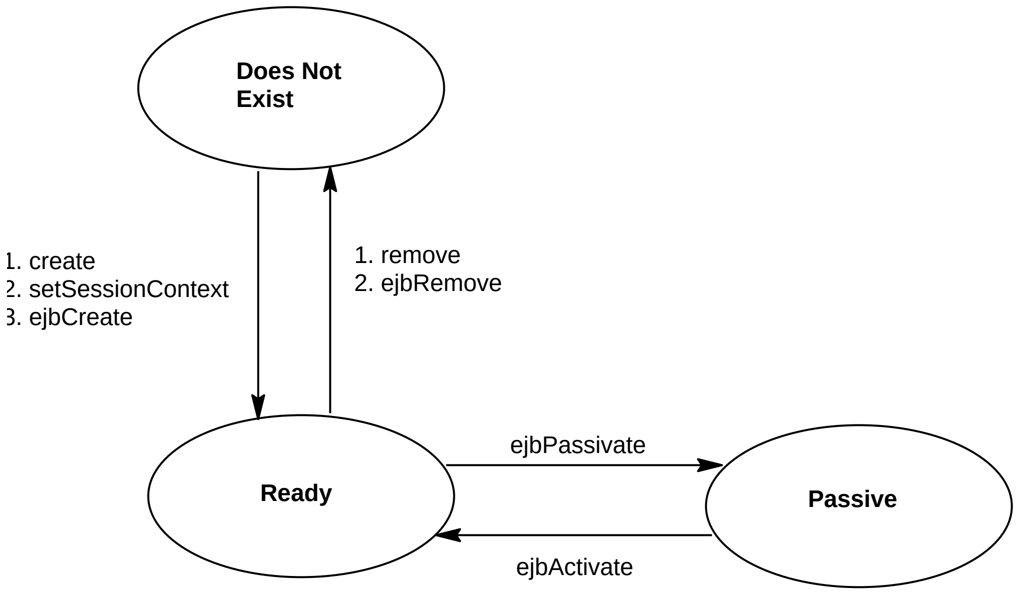


Figure 8 Life Cycle of a Stateful Session Bean

The Stateless Session Bean Life Cycle

Because a stateless session bean is never passivated, its life cycle has just two stages: non-existent and ready for the invocation of business methods. Figure 9 illustrates the stages of a stateless session bean.

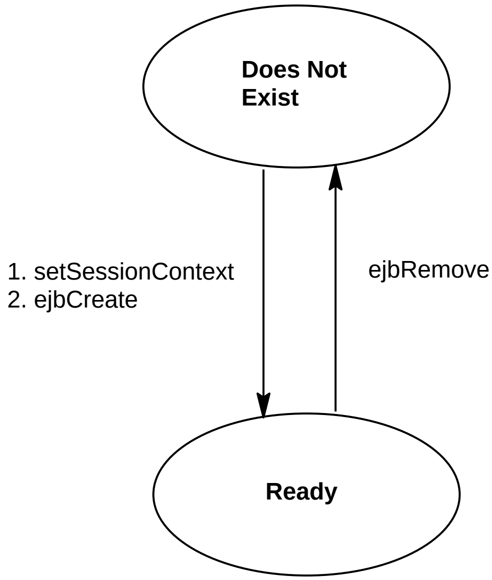


Figure 9 Life Cycle of a Stateless Session Bean

The Entity Bean Life Cycle

Figure 10 shows the stages that an entity bean passes through during its lifetime. After the EJB container creates the instance, it calls the `setEntityContext` method of the entity bean class. The `setEntityContext` method passes the entity context to the bean.

After instantiation, the entity bean moves to a pool of available instances. While in the pooled stage, the instance is not associated with any particular EJB object identity. All instances in the pool are identical. The EJB container assigns an identity to an instance when moving it to the ready stage.

There are two paths from the pooled stage to the ready stage. On the first path, the client invokes the `create` method, causing the EJB container to call the `ejbCreate` and `ejbPostCreate` methods. On the second path, the EJB container invokes the `ejbActivate` method. While in the ready stage, an entity bean's business methods may be invoked.

There are also two paths from the ready stage to the pooled stage. First, a client may invoke the `remove` method, which causes the EJB container to call the `ejbRemove` method. Second, the EJB container may invoke the `ejbPassivate` method.

At the end of the life cycle, the EJB container removes the instance from the pool and invokes the `unsetEntityContext` method.

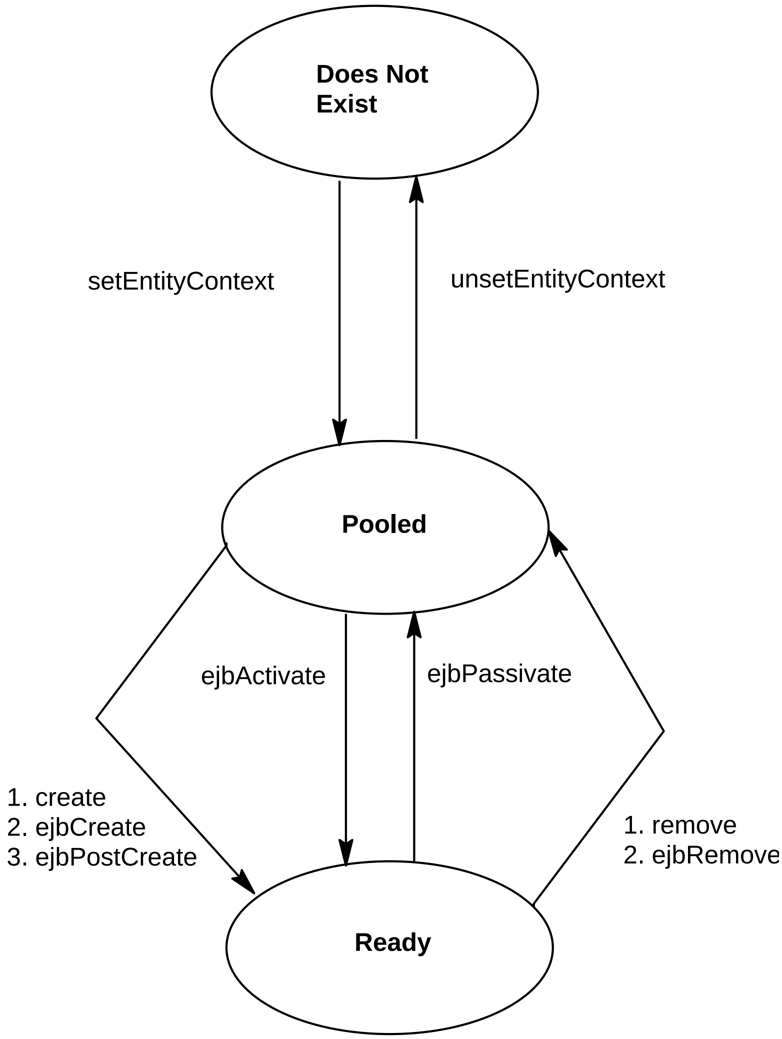


Figure 10 Life Cycle of an Entity Bean

In the pooled state, an instance is not associated with any particular EJB object identity. With bean-managed persistence, when the EJB container moves an instance from the pooled state to the ready state, it does not automatically set the primary key. Therefore, the `ejbCreate` and `ejbActivate` methods must set the primary key. If the primary key is incorrect, the `ejbLoad` and `ejbStore` methods cannot synchronize the instance variables with the database. In the AccountEJB example, the ejbCreate method assigns the primary key from one of the input parameters. The ejbActivate method sets the primary key (id) as follows:

```
id = (String)context.getPrimaryKey();
```

In the pooled state, the values of the instance variables are not needed. You can make these instance variables eligible for garbage collection by setting them to null in the ejbPasssivate method.

The Message-Driven Bean Life Cycle

Figure 11 illustrates the stages in the life cycle of a message-driven bean.

The EJB container usually creates a pool of message-driven bean instances. For each instance, the EJB container instantiates the bean and performs these tasks:

1. It calls the setMessageDrivenContext method to pass the context object to the instance.
2. It calls the instance's ejbCreate method.

Like a stateless session bean, a message-driven bean is never passivated, and it has only two states: nonexistent and ready to receive messages.

At the end of the life cycle, the container calls the ejbRemove method. The bean's instance is ready for garbage collection.

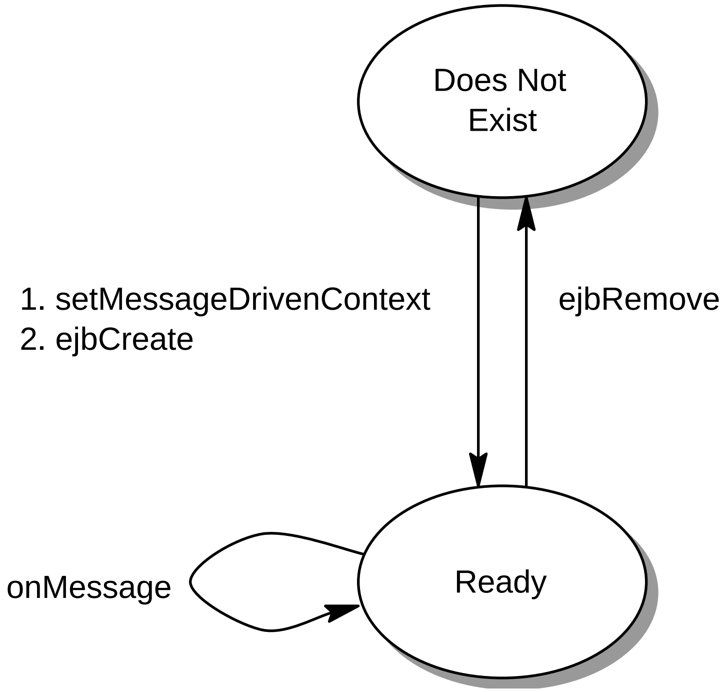


Figure 11 Life Cycle of a Message-Driven Bean

A Session Bean Example

by Dale Green

SESSION beans are powerful because they extend the reach of your clients into remote servers—yet they're easy to build. In Getting Started (page 49), you built a stateless session bean named `ConverterEJB`. This chapter examines the source code of a stateful session bean called `CartEJB`.

The CartEJB Example

The `CartEJB` bean represents a shopping cart in an online book store. The bean's client may add a book to the cart, remove a book, or retrieve the cart's contents. To construct the `CartEJB` bean, you need the following code:

- Session bean class (`CartBean`)
- Home interface (`CartHome`)
- Remote interface (`Cart`)

All session beans require a session bean class. All enterprise beans that permit remote access must have a home and remote interface. To meet the needs of a specific application, an enterprise bean may also need some helper classes. The `CartEJB` session bean uses two helper classes, `BookException` and `IdVerifier`, which are discussed in the section, Helper Classes (page 104).

Source Code. The source code for this example is in the `j2eetutorial/examples/src/ejb/cart` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant cart`. A sample `CartApp.ear` file is in the `j2eetutorial/examples/ears` directory.

Session Bean Class

The session bean class for this example is called `CartBean`. Like any session bean, the `CartBean` class must meet these requirements:

- It implements the `SessionBean` interface.
- The class is defined as public.
- The class cannot be defined as `abstract` or `final`.
- It implements one or more `ejbCreate` methods.
- It implements the business methods.
- It contains a `public` constructor with no parameters.
- It must not define the `finalize` method.

The source code for the `CartBean` class follows:

```
import java.util.*;
import javax.ejb.*;

public class CartBean implements SessionBean {

   String customerName;
```

```
 String customerId;
 Vector contents;

public void ejbCreate(String person) throws CreateException {

    if (person == null) {
      throw new CreateException("Null person not allowed.");
    }
    else {
       customerName = person;
    }

    customerId = "0";
    contents = new Vector();
 }

 public void ejbCreate(String person, String id)
   throws CreateException {

    if (person == null) {
      throw new CreateException("Null person not allowed.");
    }
    else {
       customerName = person;
    }

    IdVerifier idChecker = new IdVerifier();
    if (idChecker.validate(id)) {
       customerId = id;
    }
    else {
       throw new CreateException("Invalid id: " + id);
    }

    contents = new Vector();
 }

 public void addBook(String title) {

    contents.addElement(title);
 }

 public void removeBook(String title) throws BookException {

    boolean result = contents.removeElement(title);
    if (result == false) {
       throw new BookException(title + " not in cart.");
    }
```

```
    }

    public Vector getContents() {
       return contents;
    }

    public CartBean() {}
    public void ejbRemove() {}
    public void ejbActivate() {}
    public void ejbPassivate() {}
    public void setSessionContext(SessionContext sc) {}

}
```

The SessionBean Interface

The `SessionBean` interface extends the `EnterpriseBean` interface, which in turn extends the `Serializable` interface. The `SessionBean` interface declares the `ejbRemove`, `ejbActivate`, `ejbPassivate`, and `setSessionContext` methods. The `CartBean` class doesn't use these methods, but it must implement them because they're declared in the `SessionBean` interface. Consequently, these methods are empty in the `CartBean` class. Later sections explain when you might use these methods.

The ejbCreate Methods

Because an enterprise bean runs inside an EJB container, a client cannot directly instantiate the bean. Only the EJB container can instantiate an enterprise bean. During instantiation, the example program performs these steps:

1. The client invokes a `create` method on the home object:

```
Cart shoppingCart = home.create("Duke DeEarl","123");
```

2. The EJB container instantiates the enterprise bean.
3. The EJB container invokes the appropriate `ejbCreate` method in `CartBean`:

```
public void ejbCreate(String person, String id)
   throws CreateException {

   if (person == null) {
     throw new CreateException("Null person not allowed.");
   }
   else {
      customerName = person;
```

```
    }

    IdVerifier idChecker = new IdVerifier();
    if (idChecker.validate(id)) {
       customerId = id;
    }
    else {
       throw new CreateException("Invalid id: " + id);
    }

    contents = new Vector();
}
```

Typically, an `ejbCreate` method initializes the state of the enterprise bean. The preceding `ejbCreate` method, for example, initializes the `customerName` and `customerId` variables with the arguments passed by the `create` method.

An enterprise bean must have one or more `ejbCreate` methods. The signatures of the methods must meet the following requirements:

- The access control modifier must be `public`.
- The return type must be `void`.
- If the bean allows remote access, the arguments must be legal types for Java RMI.
- The modifier cannot be `static` or `final`.

The `throws` clause may include the `javax.ejb.CreateException` and other exceptions that are specific to your application. The `ejbCreate` method usually throws a `CreateException` if an input parameter is invalid.

Business Methods

The primary purpose of a session bean is to run business tasks for the client. The client invokes business methods on the remote object reference that is returned by the `create` method. From the client's perspective, the business methods appear to run locally, but they actually run remotely in the session bean. The following code snippet shows how the `CartClient` program invokes the business methods:

```
Cart shoppingCart = home.create("Duke DeEarl", "123");
. . .
shoppingCart.addBook("The Martian Chronicles");
shoppingCart.removeBook("Alice In Wonderland");
bookList = shoppingCart.getContents();
```

The `CartBean` class implements the business methods in the following code:

```
public void addBook(String title) {

   contents.addElement(new String(title));
}

public void removeBook(String title) throws BookException {

   boolean result = contents.removeElement(title);
   if (result == false) {
      throw new BookException(title + " not in cart.");
   }
}

public Vector getContents() {
   return contents;
}
```

The signature of a business method must conform to these rules:

- The method name must not conflict with one defined by the EJB architecture. For example, you cannot call a business method `ejbCreate` or `ejbActivate`.
- The access control modifier must be `public`.
- If the bean allows remote access, the arguments and return types must be legal types for Java RMI.
- The modifier must not be `static` or `final`.

The `throws` clause may include exceptions that you define for your application. The `removeBook` method, for example, throws the `BookException` if the book is not in the cart.

To indicate a system-level problem, such as the inability to connect to a database, a business method should throw the `javax.ejb.EJBException`. When a business method throws an `EJBException`, the container wraps it in a `RemoteException`, which is caught by the client. The container will not wrap application exceptions such as `BookException`. Because `EJBException` is a subclass of `RuntimeException`, you do not need to include it in the `throws` clause of the business method.

Home Interface

A home interface extends the `EJBHome` interface. For a session bean, the purpose of the home interface is to define the create methods that a remote client may invoke. The `CartClient` program, for example, invokes this `create` method:

```
Cart shoppingCart = home.create("Duke DeEarl", "123");
```

Every `create` method in the home interface corresponds to an `ejbCreate` method in the bean class. The signatures of the `ejbCreate` methods in the `CartBean` class follow:

```
public void ejbCreate(String person) throws CreateException
. . .
public void ejbCreate(String person, String id)
   throws CreateException
```

Compare the `ejbCreate` signatures with those of the `create` methods in the `CartHome` interface:

```
import java.io.Serializable;
import java.rmi.RemoteException;
import javax.ejb.CreateException;
import javax.ejb.EJBHome;

public interface CartHome extends EJBHome {
    Cart create(String person) throws RemoteException,
                                      CreateException;
    Cart create(String person, String id) throws
RemoteException, CreateException;
}
```

The signatures of the `ejbCreate` and `create` methods are similar, but differ in important ways. The rules for defining the signatures of the `create` methods of a home interface follow:

- The number and types of arguments in a `create` method must match those of its corresponding `ejbCreate` method.
- The arguments and return type of the `create` method must be valid RMI types.
- A `create` method returns the remote interface type of the enterprise bean. (But an `ejbCreate` method returns void.)
- The `throws` clause of the `create` method must include the `java.rmi.RemoteException` and the `javax.ejb.CreateException`.

Remote Interface

The remote interface, which extends javax.ejb.EJBObject, defines the business methods that a remote client may invoke. Here is the source code for the Cart remote interface:

```
import java.util.*;
import javax.ejb.EJBObject;
import java.rmi.RemoteException;

public interface Cart extends EJBObject {

   public void addBook(String title) throws RemoteException;
   public void removeBook(String title) throws BookException,
                                                  RemoteException;
   public Vector getContents() throws RemoteException;
}
```

The method definitions in a remote interface must follow these rules:

- Each method in the remote interface must match a method implemented in the enterprise bean class.
- The signatures of the methods in the remote interface must be identical to the signatures of the corresponding methods in the enterprise bean class.
- The arguments and return values must be valid RMI types.
- The throws clause must include the java.rmi.RemoteException.

Helper Classes

The CartEJB bean has two helper classes: BookException and IdVerifier. The BookException is thrown by the removeBook method and the IdVerifier validates the customerId in one of the ejbCreate methods. Helper classes must reside in the EJB JAR file that contains the enterprise bean class.

Running the CartEJB Example

1. Start the J2EE server and the deploytool. For instructions, see Setting Up (page 50).
2. In the deploytool open the j2eetutorial/examples/ears/CartApp.ear file (File->Open).

3. Deploy the `CartApp` application (Tools->Deploy). In the Introduction dialog box, make sure that you select the Return Client JAR checkbox. For detailed instructions, see Deploying the J2EE™ Application (page 64).
4. Run the application:
   a. In a terminal window, go to the `j2eetutorial/examples/ears` directory.
   b. Set the `APPCPATH` environment variable to `CartAppClient.jar`.
   c. Type the following command:

```
runclient -client CartApp.ear -name CartClient -textauth
```

   d. At the login prompts, enter `guest` for the user name and `guest123` for the password.

Other Enterprise Bean Features

The topics that follow apply to both session and entity beans.

Accessing Environment Entries

Stored in an enterprise bean's deployment descriptor, an environment entry is a name-value pair that allows you to customize the bean's business logic without changing its source code. An enterprise bean that calculates discounts, for example, might have an environment entry named "Discount Percent." Before deploying the bean's application, you could assign "Discount Percent" a value of .05 on the Environment tabbed pane of the `deploytool`. When you run the application, the enterprise bean fetches the .05 value from its environment.

In the following code example, the `applyDiscount` method uses environment entries to calculate a discount based on the purchase amount. First, the method locates the environment naming context by invoking `lookup` with the `java:comp/env` parameter. Then it calls `lookup` on the environment to get the values for the "Discount Level" and "Discount Percent" names. For example, if you assign a value of .05 to the "Discount Percent" name in the `deploytool`, the code will assign .05 to the `discountPercent` variable. The `applyDiscount` method, which follows, is in the `CheckerBean` class. The source code for this example is in `j2eetotorial/examples/src/ejb/checker`. A sample `CheckerApp.ear` file is in the `j2eetutorial/examples/ears` directory.

```
public double applyDiscount(double amount) {

      try {

         double discount;

         Context initial = new InitialContext();
         Context environment =
           (Context)initial.lookup("java:comp/env");

         Double discountLevel =
            (Double)environment.lookup("Discount Level");
         Double discountPercent =
            (Double)environment.lookup("Discount Percent");

         if (amount >= discountLevel.doubleValue()) {
            discount = discountPercent.doubleValue();
         }
         else {
            discount = 0.00;
         }

         return amount * (1.00 - discount);

      } catch (NamingException ex) {
           throw new EJBException("NamingException: " +
              ex.getMessage());
      }
   }
```

Comparing Enterprise Beans

A client can determine if two stateful session beans are identical by invoking the `isIdentical` method:

```
bookCart = home.create("Bill Shakespeare");
videoCart = home.create("Lefty Lee");
. . .
if (bookCart.isIdentical(bookCart)) {
   // true . . . }
if (bookCart.isIdentical(videoCart)) {
   // false . . . }
```

Because stateless session beans have the same object identity, the `isIdentical` method always returns `true` when used to compare them.

To determine if two entity beans are identical, the client can invoke the `isIdentical` method, or it can fetch and compare the beans's primary keys:

```
String key1 = (String)accta.getPrimaryKey();
String key2 = (String)acctb.getPrimaryKey();

if (key1.compareTo(key2) == 0)
   System.out.println("equal");
```

Passing an Enterprise Bean's Object Reference

Suppose that your enterprise bean needs to pass a reference to itself to another bean. You might want to pass the reference, for example, so that the second bean can call the first bean's methods. You can't pass the `this` reference because it points to the bean's instance, which is running in the EJB container. Only the container may directly invoke methods on the bean's instance. Clients access the instance indirectly by invoking methods on the object whose type is the bean's remote interface. It is the reference to this object (the bean's remote reference) that the first bean would pass to the second bean.

A session bean obtains its remote reference by calling the `getEJBObject` method of the `SessionContext` interface. An entity bean would call the `getEJBObject` method of the `EntityContext` interface. These interfaces provide beans with access to the instance contexts maintained by the EJB container. Typically, the bean saves the context in the `setSessionContext` method. The following code fragment shows how a session bean might use these methods.

```
public class WagonBean implements SessionBean {

   SessionContext context;
   . . .
   public void setSessionContext(SessionContext sc) {
      this.context = sc;
   }
   . . .
   public void passItOn(Basket basket) {
   . . .
      basket.copyItems(context.getEJBObject());
   }
   . . .
```

Bean-Managed Persistence Examples

by Dale Green

DATA is at the heart of most business applications. In J2EE™ applications, entity beans represent the business objects that are stored in a database. For entity beans with bean-managed persistence, you must write the code for the database access calls. Although writing this code is an additional responsibility, you will have more control over how the entity bean accesses a database.

This chapter discusses the coding techniques for entity beans with bean-managed persistence. For conceptual information on entity beans, please see What is an Entity Bean? (page 80).

The SavingsAccountEJB Example

The entity bean illustrated in this section represents a simple bank account. The state of the `SavingsAccountEJB` bean is stored in the `savingsaccount` table of a relational database. The `savingsaccount` table is created by the following SQL statement:

```
CREATE TABLE savingsaccount
   (id VARCHAR(3)
    CONSTRAINT pk_savingsaccount PRIMARY KEY,
    firstname VARCHAR(24),
    lastname  VARCHAR(24),
    balance   DECIMAL(10,2));
```

The `SavingsAccountEJB` example requires the following code:

- Entity bean class (`SavingsAccountBean`)
- Home interface (`SavingsAccountHome`)
- Remote interface (`SavingsAccount`)

This example also makes use of the following classes:

- A helper class named `InsufficientBalanceException`.
- A client class called `SavingsAccountClient`.

Source Code. The source code for this example is in the `j2eetutorial/examples/src/ejb/savingsaccount` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant savingsaccount`. A sample `SavingsAccountApp.ear` file is in the `j2eetutorial/examples/ears` directory.

Entity Bean Class

The sample entity bean class is called `SavingsAccountBean`. As you look through its code, note that it meets the requirements of any entity bean with bean-managed persistence. First of all, it implements the following:

- `EntityBean` interface
- zero or more `ejbCreate` and `ejbPostCreate` methods
- Finder methods
- Business methods
- Home methods

In addition, an entity bean class with bean-managed persistence has these requirements:

- The class is defined as `public`.
- The class cannot be defined as `abstract` or `final`.
- It contains an empty constructor.
- It does not implement the `finalize` method.

The EntityBean Interface

The `EntityBean` interface extends the `EnterpriseBean` interface, which extends the `Serializable` interface. The `EntityBean` interface declares a number of methods, such as `ejbActivate` and `ejbLoad`, which you must implement in your entity bean class. These methods are discussed later sections.

The ejbCreate Method

When the client invokes a create method, the EJB container invokes the corresponding `ejbCreate` method. Typically, an `ejbCreate` method in an entity bean performs the following tasks:

- Inserts the entity state into the database
- Initializes the instance variables
- Returns the primary key

The `ejbCreate` method of `SavingsAccountBean` inserts the entity state into the database by invoking the private `insertRow` method, which issues the SQL `INSERT` statement. Here is the source code for the `ejbCreate` method:

```
public String ejbCreate(String id, String firstName,
       String lastName, double balance)
       throws CreateException {

       if (balance < 0.00) {
          throw new CreateException
             (“A negative initial balance is not allowed.”);
       }

       try {
          insertRow(id, firstName, lastName, balance);
       } catch (Exception ex) {
           throw new EJBException(“ejbCreate: “ +
              ex.getMessage());
       }
```

```
      this.id = id;
      this.firstName = firstName;
      this.lastName = lastName;
      this.balance = balance;

      return id;
   }
```

Although the SavingsAccountBean class has just one ejbCreate method, an enterprise bean may contain multiple ejbCreate methods. For an example, see the CartEJB.java source code in the j2eetutorial/examples/src/ejb/cart directory.

When writing an ejbCreate method for an entity bean, be sure to follow these rules:

- The access control modifier must be public.
- The return type must be the primary key.
- The arguments must be legal types for Java RMI.
- The method modifier cannot be final or static.

The throws clause may include the javax.ejb.CreateException and exceptions that are specific to your application. An ejbCreate method usually throws a CreateException if an input parameter is invalid. If an ejbCreate method cannot create an entity because another entity with the same primary key already exists, it should throw a javax.ejb.DuplicateKeyException (a subclass of CreateException). If a client receives a CreateException or a DuplicateKeyException, it should assume that the entity was not created.

The state of an entity bean may be directly inserted into the database by an application that is unknown to the J2EE server. For example, a SQL script might insert a row into the savingsaccount table. Although the entity bean for this row was not created by an ejbCreate method, the bean can be located by a client program.

The ejbPostCreate Method

For each ejbCreate method, you must write an ejbPostCreate method in the entity bean class. The EJB container invokes ejbPostCreate immediately after it calls ejbCreate. Unlike the ejbCreate method, the ejbPostCreate method can invoke the getPrimaryKey and getEJBObject methods of the EntityContext interface. For more information on the getEJBObject method, see Passing an Enterprise Bean's Object Reference (page 107). Often, your ejbPostCreate methods will be empty.

The signature of an `ejbPostCreate` must meet the following requirements:

- The number and types of arguments must match a corresponding `ejbCreate` method.
- The access control modifier must be `public`.
- The method modifier cannot be `final` or `static`.
- The return type must be `void`.

The throws clause may include the `javax.ejb.CreateException` and exceptions that are specific to your application.

The ejbRemove Method

A client deletes an entity bean by invoking the `remove` method. This invocation causes the EJB client to call the `ejbRemove` method, which deletes the entity state from the database. In the `SavingsAccountBean` class, the `ejbRemove` method invokes a private method named `deleteRow`, which issues a SQL `DELETE` statement. The `ejbRemove` method is short:

```
public void ejbRemove() {
    try {
        deleteRow(id);
    catch (Exception ex) {
        throw new EJBException("ejbRemove: " +
        ex.getMessage());
    }
}
```

If the `ejbRemove` method encounters a system problem, it should throw the `javax.ejb.EJBException`. If it encounters an application error, it should throw a `javax.ejb.RemoveException`. For a comparison of system and application exceptions, see the section, Handling Exceptions (page 139).

An entity bean may also be removed directly by a database deletion. For example, if a SQL script deletes a row that contains an entity bean state, then that entity bean is removed.

The ejbLoad and ejbStore Methods

If the EJB container needs to synchronize the instance variables of an entity bean with the corresponding values stored in a database, it invokes the `ejbLoad` and `ejbStore` methods. The `ejbLoad` method refreshes the instance variables from the database, and the `ejbStore` method writes the variables to the database. The client may not call `ejbLoad` and `ejbStore`.

If a business method is associated with a transaction, the container invokes ejbLoad before the business method executes. Immediately after the business method executes, the container calls ejbStore. Because the container invokes ejbLoad and ejbStore, you do not have to refresh and store the instance variables in your business methods. The SavingsAccountBean class relies on the container to synchronize the instance variables with the database. Therefore, the business methods of SavingsAccountBean should be associated with transactions.

If the ejbLoad and ejbStore methods cannot locate an entity in the underlying database, they should throw the javax.ejb.NoSuchEntityException. This exception is a subclass of EJBException. Because EJBException is a subclass of RuntimeException, you do not have to include it in the throws clause. When NoSuchEntityException is thrown, the EJB container wraps it in a RemoteException before returning it to the client.

In the SavingsAccountBean class, ejbLoad invokes the loadRow method, which issues a SQL select statement and assigns the retrieved data to the instance variables. The ejbStore method calls the storeRow method, which stores the instance variables in the database with a SQL UPDATE statement. Here is the code for the ejbLoad and ejbStore methods:

```
public void ejbLoad() {
      try {
         loadRow();
       } catch (Exception ex) {
           throw new EJBException("ejbLoad: " +
              ex.getMessage());
       }
   }

public void ejbStore() {
      try {
         storeRow();
       } catch (Exception ex) {
           throw new EJBException("ejbLoad: " +
              ex.getMessage());
       }
   }
```

The Finder Methods

The finder methods allow clients to locate entity beans. The SavingsAccountClient program locates entity beans with three finder methods:

```
SavingsAccount jones = home.findByPrimaryKey("836");
...
Collection c = home.findByLastName("Smith");
...
Collection c = home.findInRange(20.00, 99.00);
```

For every finder method available to a client, the entity bean class must implement a corresponding method that begins with the prefix `ejbFind`. The `SavingsAccountBean` class, for example, implements the `ejbFindByLastName` method as follows:

```
public Collection ejbFindByLastName(String lastName)
   throws FinderException {

   Collection result;

   try {
      result = selectByLastName(lastName);
    } catch (Exception ex) {
        throw new EJBException("ejbFindByLastName " +
           ex.getMessage());
    }
    return result;
}
```

The finder methods that are specific to your application, such as `ejbFindByLastName` and `ejbFindInRange`, are optional—but the `ejbFindByPrimaryKey` method is required. As its name infers, the `ejbFindByPrimaryKey` method accepts as an argument the primary key, which it uses to locate an entity bean. In the `SavingsAccountBean` class, the primary key is the `id` variable. Here is the code for the `ejbFindByPrimaryKey` method:

```
public String ejbFindByPrimaryKey(String primaryKey)
   throws FinderException {

   boolean result;

   try {
      result = selectByPrimaryKey(primaryKey);
    } catch (Exception ex) {
        throw new EJBException("ejbFindByPrimaryKey: " +
           ex.getMessage());
    }

   if (result) {
      return primaryKey;
```

```
      }
      else {
         throw new ObjectNotFoundException
            ("Row for id " + primaryKey + " not found.");
      }
   }
```

The `ejbFindByPrimaryKey` method may look strange to you, because it uses a `primaryKey` for both the method argument and return value. However, remember that the client does not call `ejbFindByPrimaryKey` directly. It is the EJB container that calls the `ejbFindByPrimaryKey` method. The client invokes the `findByPrimaryKey` method, which is defined in the home interface.

The following list summarizes the rules for the finder methods that you implement in an entity bean class with bean-managed persistence:

- The `ejbFindByPrimaryKey` method must be implemented.
- A finder method name must start with the prefix `ejbFind`.
- The access control modifier must be `public`.
- The method modifier cannot be `final` or `static`.
- The arguments and return type must be legal types for Java RMI.
- The return type must be the primary key or a collection of primary keys.

The `throws` clause may include the `javax.ejb.FinderException` and exceptions that are specific to your application. If a finder method returns a single primary key and the requested entity does not exist, the method should throw the `javax.ejb.ObjectNotFoundException` (a subclass of `FinderException`). If a finder method returns a collection of primary keys and it does not find any objects, it should return an empty collection.

The Business Methods

The business methods contain the business logic that you want to encapsulate within the entity bean. Usually, the business methods do not access the database, allowing you to separate the business logic from the database access code. The `SavingsAccountBean` class contains these business methods:

```
public void debit(double amount)
      throws InsufficientBalanceException {

      if (balance - amount < 0) {
          throw new InsufficientBalanceException();
      }
      balance -= amount;
```

```
}

public void credit(double amount) {

       balance += amount;
}

public String getFirstName() {

       return firstName;
}

public String getLastName() {

       return lastName;
}

public double getBalance() {

       return balance;
}
```

The `SavingsAccountClient` program invokes the business methods as follows:

```
SavingsAccount duke = home.create("123", "Duke", "Earl", 0.00);
duke.credit(88.50);
duke.debit(20.25);
double balance = duke.getBalance();
```

The requirements for the signature of a business method are the same for both session and entity beans:

- The method name must not conflict with a method name defined by the EJB architecture. For example, you cannot call a business method `ejbCreate` or `ejbActivate`.
- The access control modifier must be `public`.
- The method modifier cannot be `final` or `static`.
- The arguments and return types must be legal types for Java RMI.

The `throws` clause may include the exceptions that you define for your application. The `debit` method, for example, throws the `InsufficientBalanceException`. To indicate a system-level problem, a business method should throw the `javax.ejb.EJBException`.

Database Calls

The following table summarizes the database access calls in the `SavingsAccountBean` class:

Table 4 SQL Statements in `SavingsAccountBean`

Method	SQL Statement
`ejbCreate`	`INSERT`
`ejbFindByPrimaryKey`	`SELECT`
`ejbFindByLastName`	`SELECT`
`ejbFindInRange`	`SELECT`
`ejbLoad`	`SELECT`
`ejbRemove`	`DELETE`
`ejbStore`	`UPDATE`

The business methods of the `SavingsAccountBean` class are absent from the preceding table because they do not access the database. Instead, these business methods update the instance variables, which are written to the database when the EJB container calls `ejbStore`. Another developer may have chosen to access the database in the business methods of the `SavingsAccountBean` class. This choice is one of those design decisions that depend on the specific needs of your application.

Before accessing a database you must connect to it. For more information, see the section, Resource Connections (page 369).

Home Interface

The home interface defines the methods that allow a client to create and find an entity bean. The `SavingsAccountHome` interface follows:

```
import java.util.Collection;
import java.rmi.RemoteException;
import javax.ejb.*;

public interface SavingsAccountHome extends EJBHome {
```

```
    public SavingsAccount create(String id, String firstName,
        String lastName, double balance)
        throws RemoteException, CreateException;

    public SavingsAccount findByPrimaryKey(String id)
        throws FinderException, RemoteException;

    public Collection findByLastName(String lastName)
        throws FinderException, RemoteException;

    public Collection findInRange(double low, double high)
        throws FinderException, RemoteException;
}
```

Each `create` method in the home interface must conform to these requirements:

- It has the same number and types of arguments as its matching `ejbCreate` method in the enterprise bean class.
- It returns the remote interface type of the enterprise bean.
- The `throws` clause includes the exceptions specified by the `throws` clause of the corresponding `ejbCreate` and `ejbPostCreate` methods.
- The throws clause contains the `java.rmi.RemoteException` and the `javax.ejb.CreateException`.

Every finder method in the home interface corresponds to a finder method in the entity bean class. The name of a finder method in the home interface begins with `find`, whereas the corresponding name in the entity bean class begins with `ejbFind`. For example, the `SavingsAccountHome` class defines the `findByLastName` method, and the `SavingsAccountBean` class implements the `ejbFindByLastName` method. The rules for defining the signatures of the finder methods of a home interface follow:

- The number and types of arguments must match those of the corresponding method in the entity bean class.
- The return type is the entity bean's remote interface type, or a collection of those types.
- The exceptions in the `throws` clause include those of the corresponding method in the entity bean class.
- The `throws` clause contains the `javax.ejb.FinderException` and the `javax.ejb.RemoteException`.

Remote Interface

The remote interface extends `javax.ejb.EJBObject` and defines the business methods that a client may invoke. Here is the `SavingsAccount` remote interface:

```
import javax.ejb.EJBObject;
import java.rmi.RemoteException;

public interface SavingsAccount extends EJBObject {

    public void debit(double amount)
        throws InsufficientBalanceException, RemoteException;

    public void credit(double amount)
        throws RemoteException;

    public String getFirstName()
        throws RemoteException;

    public String getLastName()
        throws RemoteException;

    public double getBalance()
        throws RemoteException;
}
```

The requirements for the method definitions in a remote interface are the same for both session and entity beans:

- Each method in the remote interface must match a method in the enterprise bean class.
- The signatures of the methods in the remote interface must be identical to the signatures of the corresponding methods in the enterprise bean class.
- The arguments and return values must be valid RMI types.
- The throws clause must include `java.rmi.RemoteException`.

Running the SavingsAccountEJB Example

Setting Up the Database

The instructions that follow explain how to use the `SavingsAccountEJB` example with a Cloudscape database. The Cloudscape software is included with the J2EE SDK download bundle.

1. From the command-line prompt, run the Cloudscape database server by typing `cloudscape -start`. (When you are ready to shut down the server, type `cloudscape -stop`.)
2. Create the `savingsaccount` database table.

    a. Go to the `j2eetutorial/examples/src` directory

    b. Type `ant create-savingsaccount-table`.

You may also run this example with databases other than Cloudscape. (See the *Release Notes* of the J2EE SDK for a list of supported databases.) If you are using one of these other databases, you may run the `j2eetutorial/examples/src/ejb/sql/savingsaccount.sql` script to create the `savingsaccount` table.

Deploying the Application

1. In the `deploytool` open the `j2eetutorial/examples/ears/SavingsAccountApp.ear` file (File->Open).
2. Deploy the `SavingsAccountApp` application (Tools->Deploy). In the Introduction dialog box, make sure that you select the Return Client JAR checkbox. For detailed instructions, see Deploying the J2EE™ Application (page 64).

Running the Client

1. In a terminal window, go to the `j2eetutorial/examples/ears` directory.
2. Set the `APPCPATH` environment variable to `SavingsAccountAppClient.jar`.
3. Type the following command on a single line:

```
   runclient -client SavingsAccountApp.ear -name
SavingsAccountClient -textauth
```

4. At the login prompts, enter `guest` for the user name and `guest123` for the password.

5. The client should display the following lines:

```
balance = 68.25
balance = 32.53
456: 44.77
730: 19.53
268: 100.06
836: 32.53
456: 44.77
```

Deploytool Tips for Entity Beans With Bean-Managed Persistence

An earlier chapter, Getting Started (page 49), gave step-by-step instructions for creating and packaging a session bean. To build an entity bean you follow the same procedures, but with the following exceptions.

1. In the New Enterprise Bean Wizard, specify the bean's type and persistent management.
   a. In the General dialog box, select the Entity radio button.
   b. In the Entity Settings dialog box, select the radio button for Bean-Managed Persistence.
2. In the Resource Refs Tabbed Pane, specify the resource factories referenced by the bean. These settings enable the bean to connect to the database. For instructions, see Deploytool Tips for Resource References (page 370).
3. Before you deploy the bean, verify that the JNDI names are correct.
   a. Select the application from the tree.
   b. Select the JNDI Names tab.

Mapping Table Relationships For Bean-Managed Persistence

In a relational database, tables can be related by common columns. The relationships between the tables affect the design of their corresponding entity beans.

The entity beans discussed in this section are backed up by tables with the following types of relationships:

- One-to-One relationships
- One-to-Many relationships
- Many-to-Many relationships

One-to-One Relationships

In a one-to-one relationship, each row in a table is related to a single row in another table. For example, in a warehouse application a `storagebin` table might have a one-to-one relationship with a `widget` table. This application would model a physical warehouse where each storage bin contains one type of widget and each widget resides in one storage bin.

Figure 12 illustrates the `storagebin` and `widget` tables. Because the `storagebinid` uniquely identifies a row in the `storagebin` table, it is that table's primary key. The `widgetid` is the primary key of the `widget` table. The two tables are related because the `widgetid` is also a column in the `storagebin` table. By referring to the primary key of the `widget` table, the `widgetid` in the `storagebin` table identifies which widget resides in a particular storage bin in the warehouse. Because the `widgetid` of the `storagebin` table refers to the primary key of another table, it is called a foreign key. (The figure denotes a primary key with PK and a foreign key with FK.)

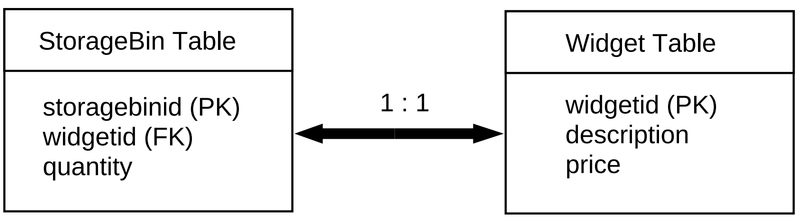


Figure 12 One-to-One Table Relationship

A dependent (child) table includes a foreign key that matches the primary key of the referenced (parent) table. The values of the foreign keys in the `storagebin` (child) table depend on the primary keys in the `widget` (parent) table. For example, if the `storagebin` table has a row with a `widgetid` of 344, then the widget table should also have a row whose `widgetid` is 344.

When designing a database application, you may choose to enforce the dependency between the parent and child tables. There are two ways to enforce such a dependency: by defining a referential constraint in the database or by performing checks in the application code. The `storagebin` table has a referential constraint named `fk_widgetid`:

```
CREATE TABLE storagebin
   (storagebinid VARCHAR(3)
    CONSTRAINT pk_storagebin PRIMARY KEY,
    widgetid VARCHAR(3),
    quantity INTEGER,
    CONSTRAINT fk_widgetid
    FOREIGN KEY (widgetid)
     REFERENCES widget(widgetid));
```

Source Code. The source code for the following example is in the `j2eetutorial/examples/src/ejb/storagebin` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant storagebin`. A sample `StorageBinApp.ear` file is in the `j2eetutorial/examples/ears` directory.

The `StorageBinBean` and `WidgetBean` classes illustrate the one-to-one relationship of the `storagebin` and `widget` tables. The `StorageBean` class contains variables for each column in the `storagebin` table, including the foreign key, `widgetId`:

```
private String storageBinId;
private String widgetId;
private int quantity;
```

The `ejbFindByWidgetId` method of the `StorageBean` class returns the `storageBinId` that matches a given `widgetId`:

```
public String ejbFindByWidgetId(String widgetId)
   throws FinderException {

   String storageBinId;

   try {
      storageBinId = selectByWidgetId(widgetId);
    } catch (Exception ex) {
        throw new EJBException("ejbFindByWidgetId: " +
           ex.getMessage());
    }
```

```
        if (storageBinId == null) {
           throw new ObjectNotFoundException
              ("Row for widgetId " + widgetId + " not found.");
        }
        else {
           return storageBinId;
        }
     }
```

The `ejbFindByWidgetId` method locates the widgetId by querying the database in the `selectByWidgetId` method:

```
     private String selectByWidgetId(String widgetId)
        throws SQLException {

        String storageBinId;

        String selectStatement =
              "select storagebinid " +
              "from storagebin where widgetid = ? ";
        PreparedStatement prepStmt =
              con.prepareStatement(selectStatement);
        prepStmt.setString(1, widgetId);

        ResultSet rs = prepStmt.executeQuery();

        if (rs.next()) {
           storageBinId = rs.getString(1);
        }
        else {
           storageBinId = null;
        }

        prepStmt.close();
        return storageBinId;
     }
```

To find out which storage bin a widget resides in, the `StorageBinClient` program calls the `findByWidgetId` method:

```
     String widgetId = "777";
     StorageBin storageBin =
        storageBinHome.findByWidgetId(widgetId);
     String storageBinId = (String)storageBin.getPrimaryKey();
     int quantity = storageBin.getQuantity();
```

Running the StorageBinEJB Example

1. Create the `storagebin` database table:
   a. Go to the `j2eetutorial/examples/src` directory.
   b. Type `ant create-storagebin-table`.
2. Deploy the `StorageBinApp.ear` file (located in the `j2eetutorial/examples/ears` directory).
3. Run the client:
   a. Go to the `j2eetutorial/examples/ears` directory.
   b. Set the `APPCPATH` environment variable to `StorageBinAppClient.jar`.
   c. Type the following command on a single line:

```
runclient -client StorageBinApp.ear -name StorageBinClient
-textauth
```

   d. At the login prompts, enter `guest` for the user name and `guest123` for the password.

One-to-Many Relationships

If the primary key in a parent table matches multiple foreign keys in a child table, then the relationship is one-to-many. This relationship is common in database applications. For example, an application for a sports league might access a `team` table and a `player` table. Each team has multiple players and each player belongs to a single team. Every row in the child table (`player`), has a foreign key identifying the player's team. This foreign key matches the `team` table's primary key.

The sections that follow describe how you might implement one-to-many relationships in entity beans. When designing such entity beans, you must decide whether both tables are represented by entity beans, or just one.

A Helper Class for the Child Table

Not every database table needs to be mapped to an entity bean. If a database table doesn't represent a business entity, or if it stores information that is contained in another entity, then the table should be represented with a helper class. In an online shopping application, for example, each order submitted by a customer can have multiple line items. The application stores the information in the database tables shown by the following figure.

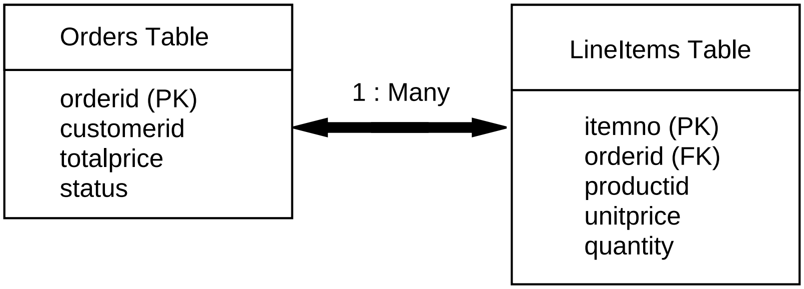


Figure 13 One-to-Many Relationship: Order and Line Items

Not only does a line item belong to an order, it does not exist without the order. Therefore, the `lineitems` table should be represented with a helper class and not with an entity bean. Using a helper class in this case is not required, but doing so might improve performance because a helper class uses fewer system resources than an entity bean.

Source Code. The source code for the following example is in the `j2eetutorial/examples/src/ejb/order` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant order`. A sample `OrderApp.ear` file is in the `j2eetutorial/examples/ears` directory.

The `LineItem` and `OrderBean` classes show how to implement a one-to-many relationship with a helper class (`LineItem`). The instance variables in the `LineItem` class correspond to the columns in the `lineitems` table. The `itemNo` variable matches the primary key for the `lineitems` table and the `orderId` variable represents the table's foreign key. Here is the source code for the `LineItem` class:

```
public class LineItem implements java.io.Serializable {

   String productId;
   int quantity;
   double unitPrice;
   int itemNo;
   String orderId;


   public LineItem(String productId, int quantity,
     double unitPrice, int itemNo, String orderId) {

      this.productId = productId;
```

```
        this.quantity = quantity;
        this.unitPrice = unitPrice;
        this.itemNo = itemNo;
        this.orderId = orderId;
    }

    public String getProductId() {
        return productId;
    }

    public int getQuantity() {
        return quantity;
    }

    public double getUnitPrice() {
        return unitPrice;
    }

    public int getItemNo() {
        return itemNo;
    }

    public String getOrderId() {
        return orderId;
    }
}
```

The `OrderBean` class contains an `ArrayList` variable named `lineItems`. Each element in the `lineItems` variable is a `LineItem` object. The `lineItems` variable is passed to the `OrderBean` class in the `ejbCreate` method. For every `LineItem` object in the `lineItems` variable, the `ejbCreate` method inserts a row into the `lineitems` table. It also inserts a single row into the `orders` table. The code for the `ejbCreate` method follows:

```
public String ejbCreate(String orderId, String customerId,
    String status, double totalPrice, ArrayList lineItems)
    throws CreateException {

    try {
       insertOrder(orderId, customerId, status, totalPrice);
       for (int i = 0; i < lineItems.size(); i++) {
          LineItem item = (LineItem)lineItems.get(i);
          insertItem(item);
       }
    } catch (Exception ex) {
        throw new EJBException("ejbCreate: " +
           ex.getMessage());
```

```
    }

    this.orderId = orderId;
    this.customerId = customerId;
    this.status = status;
    this.totalPrice = totalPrice;
    this.lineItems = lineItems ;

    return orderId;
}
```

The `OrderClient` program creates and loads an `ArrayList` of `LineItem` objects. The program passes this `ArrayList` to the entity bean when it invokes the `create` method:

```
ArrayList lineItems = new ArrayList();
lineItems.add(new LineItem("p23", 13, 12.00, 1, "123"));
lineItems.add(new LineItem("p67", 47, 89.00, 2, "123"));
lineItems.add(new LineItem("p11", 28, 41.00, 3, "123"));
. . .
Order duke = home.create("123", "c44", "open",
   totalItems(lineItems), lineItems);
```

Other methods in the `OrderBean` class also access both database tables. The `ejbRemove` method, for example, deletes not only a row from the `orders` table, but also deletes all corresponding rows in the `lineitems` table. The `ejbLoad` and `ejbStore` methods synchronize the state of an `OrderEJB` instance, including the `lineItems` `ArrayList`, with the `orders` and `lineitems` tables.

The `ejbFindByProductId` method enables clients to locate all orders that have a particular line item. This method queries the `lineitems` table for all rows with a particular `productId`. The method returns a `Collection` of `productId` String objects. The `OrderClient` program iterates through the `Collection` and prints the primary key of each order:

```
Collection c = home.findByProductId("p67");
Iterator i=c.iterator();
while (i.hasNext()) {
   Order order = (Order)i.next();
   String id = (String)order.getPrimaryKey();
   System.out.println(id);
 }
```

Running the OrderEJB Example

1. Create the `orders` database table:
   a. Go to the `j2eetutorial/examples/src` directory.
   b. Type `ant create-order-table`.
2. Deploy the `OrderApp.ear` file (located in the `j2eetutorial/examples/ears` directory).
3. Run the client:
   a. Go to the `j2eetutorial/examples/ears` directory.
   b. Set the `APPCPATH` environment variable to `OrderAppClient.jar`.
   c. Type the following command on a single line:

```
runclient -client OrderApp.ear -name OrderClient
-textauth
```

   d. At the login prompts, enter `guest` for the user name and `guest123` for the password.

An Entity Bean for the Child Table

You should consider building an entity bean for a child table under the following conditions:

- The information in the child table is not dependent on the parent table.
- The business entity of the child table could exist without that of the parent table.
- The child table might be accessed by another application that does not access the parent table.

These conditions exist in the following scenario. Suppose that each sales representative in a company has multiple customers and that each customer has only one sales representative. The company tracks its sales force with a database application. In the database, each row in the `salesrep` table (parent) matches multiple rows in the `customer` table (child). Figure 14 illustrates this relationship

.

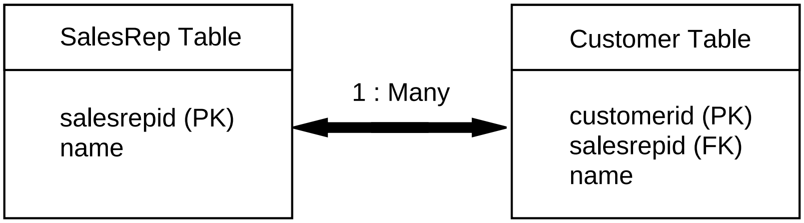


Figure 14 One-to-Many Relationship: Sales Representative and Customers

The `SalesRepBean` and `CustomerBean` entity bean classes implement the one-to-many relationship of the of `sales` and `customer` tables.

Source Code. The source code for this example is in the `j2eetutorial/examples/src/ejb/salesrep` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant salesrep`. A sample `SalesRepApp.ear` file is in the `j2eetutorial/examples/ears` directory.

The `SalesRepBean` class contains a variable named `customerIds`, which is an `ArrayList` of `String` elements. These `String` elements identify which customers belong to the sales representative. Because the `customerIds` variable reflects this relationship, the `SalesRepBean` class must keep the variable up to date.

The `SalesRepBean` class instantiates the `customerIds` variable in the `setEntityContext` method, not in `ejbCreate`. The container invokes `setEntityContext` just once—when it creates the bean instance—ensuring that `customerIds` is instantiated just once. Because the same bean instance can assume different identities during its life cycle, instantiating `customerIds` in `ejbCreate` might cause multiple and unnecessary instantiations. Therefore, the `SalesRepBean` class instantiates the `customerIds` variable in `setEntityContext`:

```
public void setEntityContext(EntityContext context) {

   this.context = context;
   customerIds = new ArrayList();

   try {
      makeConnection();
      Context initial = new InitialContext();
      Object objref =
        initial.lookup("java:comp/env/ejb/Customer");
```

```
        customerHome =
          (CustomerHome)PortableRemoteObject.narrow(objref,
           CustomerHome.class);
    } catch (Exception ex) {
         throw new EJBException("setEntityContext: " +
            ex.getMessage());
    }
}
```

Invoked by the `ejbLoad` method, `loadCustomerIds` is a private method that refreshes the `customerIds` variable. There are two approaches when coding a method such as `loadCustomerIds`: fetch the identifiers from the `customer` database table or get them from the `CustomerEJB` entity bean. Fetching the identifiers from the database might be faster, but exposes the code in the `SalesRepBean` class to the `CustomerEJB` bean's underlying database table. In the future, if you were to change the `CustomerEJB` bean's table (or move the bean to a different J2EE server), then you might need to change the `SalesRepBean` code. But if the `SalesRepBean` class gets the identifiers from the `CustomerEJB` entity bean, no coding changes would be required. The two approaches present a trade-off: performance versus flexibility. The `SalesRepEJB` example opts for flexibility, loading the `customerIds` variable by calling the `findSalesRep` and `getPrimaryKey` methods of the `CustomerEJB` bean. Here is the code for the `loadCustomerIds` method:

```
private void loadCustomerIds() {

    customerIds.clear();

    try {
        Collection c = customerHome.findBySalesRep(salesRepId);
        Iterator i=c.iterator();

        while (i.hasNext()) {
            Customer customer = (Customer)i.next();
            String id = (String)customer.getPrimaryKey();
            customerIds.add(id);
        }

    } catch (Exception ex) {
        throw new EJBException("Exception in loadCustomerIds: " +
            ex.getMessage());
    }
}
```

If a customer's sales representative changes, the client program updates the database by calling the `setSalesRepId` method of the `CustomerBean` class. The next time a business method of the `SalesRepBean` class is called, the `ejbLoad` method invokes `loadCustomerIds`, which refreshes the `customerIds` variable. (To ensure that `ejbLoad` is invoked before each business method, set the transaction attributes of the business methods to Required.) For example, the `SalesRepClient` program changes the `salesRepId` for a customer named Mary Jackson:

```
Customer mary = customerHome.findByPrimaryKey("987");
mary.setSalesRepId("543");
```

The `salesRepId` 543 identifies a sales representative named Janice Martin. To list all of Janice's customers, the `SalesRepClient` program invokes the `getCustomerIds` method, iterates through the ArrayList of identifiers, and locates each `CustomerEJB` bean by calling its find`ByPrimaryKey` method:

```
SalesRep janice = salesHome.findByPrimaryKey("543");
ArrayList a = janice.getCustomerIds();
i = a.iterator();

while (i.hasNext()) {
   String customerId = (String)i.next();
   Customer customer =
customerHome.findByPrimaryKey(customerId);
   String name = customer.getName();
   System.out.println(customerId + ": " + name);
}
```

Running the SalesRepEJB Example

1. Create the database tables:
   a. Go to the `j2eetutorial/examples/src` directory.
   b. Type `ant create-salesrep-table`.
2. Deploy the `SalesRepApp.ear` file (located in the `j2eetutorial/examples/ears` directory).
3. Run the client:
   a. Go to the `j2eetutorial/examples/ears` directory.
   b. Set the `APPCPATH` environment variable to `SalesRepAppClient.jar`.
   c. Type the following command on a single line:

```
runclient -client SalesRepApp.ear -name SalesRepClient
-textauth
```

d. At the login prompts, enter `guest` for the user name and `guest123` for the password.

Many-to-Many Relationships

In a many-to-many relationship, each entity may be related to multiple occurrences of the other entity. For example, a college course has many students and each student may take several courses. In a database, this relationship is represented by a cross reference table containing the foreign keys. In Figure 15, the cross reference table is the `enrollment` table. (PK indicates a primary key and FK a foreign key.)

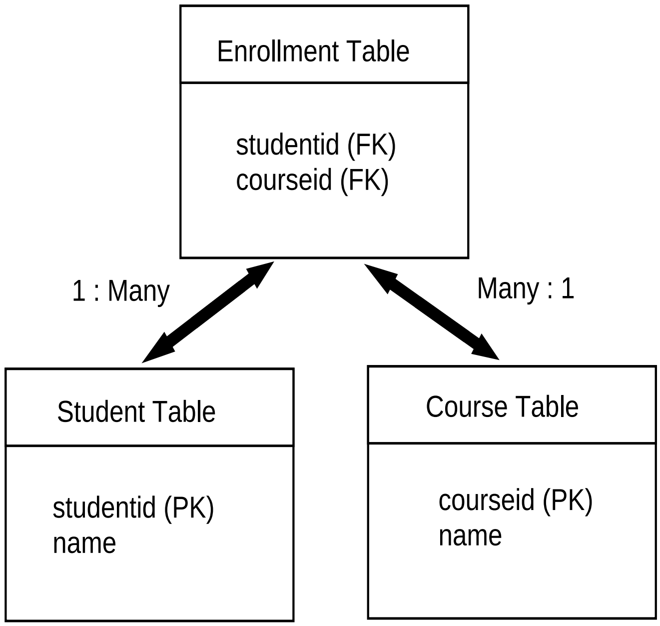


Figure 15 Many-to-Many Relationship: Students and Courses

These tables are accessed by the `StudentBean`, `CourseBean`, and `EnrollerBean` classes.

Source Code. The source code for this example is in the `j2eetutorial/examples/src/ejb/enroller` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant enroller`. A sample `EnrollerApp.ear` file is in the `j2eetutorial/examples/ears` directory.

The `StudentBean` and `CourseBean` classes are complementary. Each class contains an `ArrayList` of foreign keys. The `StudentBean` class, for example, contains an `ArrayList` named `courseIds`, which identifies the courses the student is enrolled in. Likewise, the `CourseBean` class contains an `ArrayList` named `studentIds`.

The `ejbLoad` method of the `StudentBean` class adds elements to the `courseIds` `ArrayList` by calling `loadCourseIds`, a private method. The `loadCourseIds` method gets the course identifiers from the `EnrollerEJB` session bean. The source code for the `loadCourseIds` method follows:

```
private void loadCourseIds() {

   courseIds.clear();

   try {
      Enroller enroller = enrollerHome.create();
      ArrayList a = enroller.getCourseIds(studentId);
      courseIds.addAll(a);

   } catch (Exception ex) {
       throw new EJBException("Exception in loadCourseIds: " +
          ex.getMessage());
   }
}
```

Invoked by the `loadCourseIds` method, the `getCourses` method of the `EnrollerBean` class queries the `enrollment` table:

```
select courseid from enrollment
where studentid = ?
```

Only the `EnrollerBean` class accesses the `enrollment` table. Therefore, the `EnrollerBean` class manages the student-course relationship represented in the `enrollment` table. If a student enrolls in a course, for example, the client calls the `enroll` business method, which inserts a row:

```
insert into enrollment
values (studentid, courseid)
```

If a student drops a course, the `unEnroll` method deletes a row:

```
delete from enrollment
where studentid = ? and courseid = ?
```

And if a student leaves the school, the `deleteStudent` method deletes all rows in the table for that student:

```
delete from enrollment
where student = ?
```

The `EnrollerBean` class does not delete the matching row from the `student` table. That action is performed by the `ejbRemove` method of the `StudentBean` class. To ensure that both deletes are executed as a single operation, they should belong to the same transaction. SeeTransactions (page 331) for more information.

Running the EnrollerEJB Example

1. Create the database tables:
   a. Go to the `j2eetutorial/examples/src` directory.
   b. Type `ant create-enroller-table`.
2. Deploy the `EnrollerApp.ear` file (located in the `j2eetutorial/examples/ears` directory).
3. Run the client:
   a. Go to the `j2eetutorial/examples/ears` directory.
   b. Set the `APPCPATH` environment variable to `EnrollerAppClient.jar`.
   c. Type the following command on a single line:

   ```
   runclient -client EnrollerApp.ear -name EnrollerClient
   -textauth
   ```

   d. At the login prompts, enter `guest` for the user name and `guest123` for the password.

Primary Key Class

You specify the primary key class in the entity bean's deployment descriptor. In most cases, your primary key class will be a `String`, an `Integer`, or some other class that belongs to the `java` package.

Creating a Primary Key Class

For some entity beans, you will need to define your own primary key class. For example, if the bean has a composite primary key (that is, composed of multiple fields) then you must create a primary key class. In the following primary key class, the `productId` and `vendorId` fields together uniquely identify an entity bean:

```
public class ItemKey implements java.io.Serializable {

   public String productId;
   public String vendorId;

   public ItemKey() { };

   public ItemKey(String productId, String vendorId) {

     this.productId = productId;
     this.vendorId = vendorId;
   }

   public String getProductId() {

      return productId;
   }

   public String getVendorId() {

      return vendorId;
   }

   public boolean equals(Object other) {

      if (other instanceof ItemKey) {
         return (productId.equals(((ItemKey)other).productId)
               && vendorId.equals(((ItemKey)other).vendorId));
      }

      return false;
   }

   public int hashCode() {

      return productId.hashCode();
   }
}
```

Class Requirements

For bean-managed persistence, a primary key class must meet these requirements:

- The access control modifier of the class is `public`.
- All fields are declared as `public`.
- The class has a public default constructor.
- The class implements the `hashCode()` and `equals(Object other)` methods.
- The class is serializable.

The Primary Key Class and Bean-Managed Persistence

With bean-managed persistence, the `ejbCreate` method assigns the input parameters to instance variables and then returns the primary key class:

```
public ItemKey ejbCreate(String productId, String vendorId,
   String description) throws CreateException {

   if (productId == null || vendorId == null) {
      throw new CreateException(
               “The productId and vendorId are required.”);
   }

   this.productId = productId;
   this.vendorId = vendorId;
   this.description = description;

   return new ItemKey(productId, vendorId);
}
```

The `ejbFindByPrimaryKey` verifies the existence of the database row for the given primary key:

```
public ItemKey ejbFindByPrimaryKey(ItemKey primaryKey)
   throws FinderException {

   try {
      if (selectByPrimaryKey(primaryKey))
         return primaryKey;
   ...
}
```

```
private boolean selectByPrimaryKey(ItemKey primaryKey)
   throws SQLException {

   String selectStatement =
         “select productid “ +
         “from item where productid = ? and vendorid = ?”;
   PreparedStatement prepStmt =
         con.prepareStatement(selectStatement);
   prepStmt.setString(1, primaryKey.getProductId());
   prepStmt.setString(2, primaryKey.getVendorId());
   ResultSet rs = prepStmt.executeQuery();
   boolean result = rs.next();
   prepStmt.close();
   return result;
}
```

Getting the Primary Key

A client can fetch the primary key of an entity bean by invoking the `getPrimaryKey` method of the `EJBObject` class:

```
SavingsAccount account;
...
String id = (String)account.getPrimaryKey();
```

The entity bean retrieves its own primary key by calling the `getPrimaryKey` method of the `EntityContext` class:

```
EntityContext context;
...
String id = (String) context.getPrimaryKey();
```

Handling Exceptions

The exceptions thrown by enterprise beans fall into two categories: system and application.

A system exception indicates a problem with the services that support an application. Examples of these problems include the following: a database connection cannot be obtained, a SQL insert fails because the database is full, a `lookup` method cannot find the desired object. If your enterprise bean encounters a system-level problem, it should throw a `javax.ejb.EJBException`. The container will wrap the `EJBException` in a `RemoteException`, which it passes back to the client. Because the `EJBException` is a subclass of the `RuntimeException`, you do not have to specify it in the `throws` clause of the method declaration. If a system exception is thrown, the EJB container might destroy the bean instance. Therefore, a system exception cannot be handled by the bean's client program; it requires intervention by a system administrator.

An application exception signals an error in the business logic of an enterprise bean. There are two types of application exceptions: customized and predefined. A customized exception is one that you've coded yourself, such as the `InsufficentBalanceException` thrown by the `debit` business method of the `SavingsAccountEJB` example. The `javax.ejb` package includes several predefined exceptions that are designed to handle common problems. For example, an `ejbCreate` method should throw a `CreateException` to indicate an invalid input parameter. When an enterprise bean throws an application exception, the container does not wrap it in another exception. The client should be able to handle any application exception it receives.

If a system exception occurs within a transaction, the EJB container rolls back the transaction. However, if an application exception is thrown within a transaction, the container does not roll back the transaction.

The following table summarizes the exceptions of the `javax.ejb` package. All of these exceptions are application exceptions, except for the `NoSuchEntityException` and the `EJBException`, which are system exceptions.

Table 5 Exceptions

Method Name	**Exception It Throws**	**Reason for Throwing**
`ejbCreate`	`CreateException`	An input parameter is invalid.
`ejbFindByPrimaryKey (and other finder methods that return a single object)`	`ObjectNotFoundException (subclass of FinderException)`	The database row for the requested entity bean is cannot be found.
`ejbRemove`	`RemoveException`	The entity bean's row cannot be deleted from the database.
`ejbLoad`	`NoSuchEntityException`	The database row to be loaded cannot be found.

Table 5 Exceptions (Continued)

Method Name	Exception It Throws	Reason for Throwing
`ejbStore`	`NoSuchEntityException`	The database row to be updated cannot be found.
`(all methods)`	`EJBException`	A system problem has been encountered.

Container-Managed Persistence Examples

by Dale Green

AN entity bean with container-managed persistence offers important advantages to the bean developer. First, the EJB™ container handles all database storage and retrieval calls. The container also manages the relationships between the entity beans. Because of these services, you don't have to code the database access calls in the entity bean. Instead, you specify settings in the bean's deployment descriptor. Not only does this approach save you time, but it makes the bean portable across various database servers.

This chapter focuses on the source code and deployment settings for an example called `RosterApp`, an application that features entity beans with container-managed persistence. If you are unfamiliar with the terms and concepts mentioned in this chapter, please consult the section, Container-Managed Persistence (page 81).

Overview of the RosterApp Application

The `RosterApp` application maintains the team rosters for players in sports leagues. The application has five components. The `RosterAppClient` component is a J2EE™ application client that accesses the `RosterEJB` session bean through the bean's remote interfaces. The `RosterEJB` bean accesses three entity beans—`PlayerEJB`, `TeamEJB`, and `LeagueEJB`—through their local interfaces.

The entity beans use container-managed persistence and relationships. The `TeamEJB` and `PlayerEJB` beans have a bidirectional, many-to-many relationship. In a bidirectional relationship, each bean has a relationship field whose value identifies the related bean instance. The multiplicity of the TeamEJB-PlayerEJB relationship is many-to-many: Players who participate in more than one sport belong to multiple teams and each team has multiple players. The `LeagueEJB` and `TeamEJB` beans also have a bidirectional relationship, but the multiplicity is one-to-many: A league has many teams but a team can belong to just one league.

Figure 16 shows the components and relationships of the `RosterApp` application. The dotted lines represent the access gained through invocations of the JNDI `lookup` method. The solid lines represent the container-managed relationships.

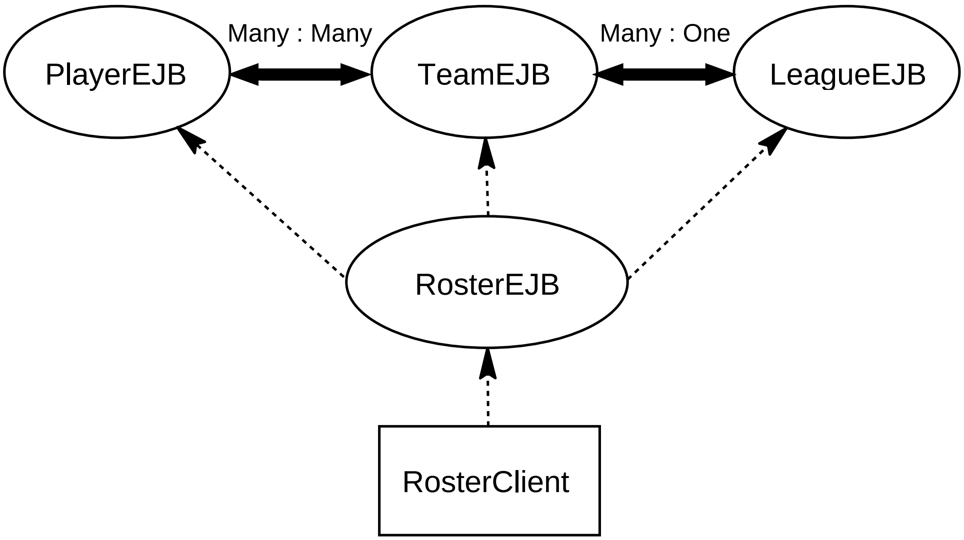


Figure 16 RosterApp J2EE™ Application

The PlayerEJB Code

The `PlayerEJB` entity bean represents a player in a sports league. Like any entity bean with container-managed persistence, the `PlayerEJB` bean needs the following code:

- Entity Bean Class (`PlayerBean`)
- Local Home Interface (`LocalPlayerHome`)
- Local Interface (`LocalPlayer`)

Source Code. The source code for this example is in the `j2eetutorial/examples/src/ejb/cmproster` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant cmproster`. A sample `RosterApp.ear` file is in the `j2eetutorial/examples/ears` directory.

Entity Bean Class

For container-managed persistence, the code of the entity bean class must meet the several syntax requirements. First, the class must be defined as `public` and `abstract`. Also, the class must implement the following:

- The `EntityBean` interface
- Zero or more `ejbCreate` and `ejbPostCreate` methods
- The get and set access methods, defined as `abstract`, for the persistent and relationship fields
- Any select methods, defining them as `abstract`
- The home methods
- The business methods.

The entity bean class must not implement these methods:

- The finder methods
- The `finalize` method

Differences Between Container-Managed and Bean-Managed Code

Because it contains no calls to access the database, an entity bean with container-managed persistence requires a lot less code than one with bean-managed persistence. For example, the `PlayerBean.java` source file discussed in this chapter is much smaller than the `SavingsAccountBean.java` code documented in the Bean-Managed Persistence Examples (page 109) chapter. The following table compares the code of the two types entity beans.

Table 6 Coding Differences Between Persistent Types

Difference	Container-Managed	Bean-Managed
class definition	abstract	not abstract
database access calls	generated by tools	coded by developer
persistent state	represented by virtual persistent fields	coded as instance variables
access methods for persistent and relationship fields	required	none

Table 6 Coding Differences Between Persistent Types (Continued)

Difference	Container-Managed	Bean-Managed
findByPrimaryKey method	handled by container	coded by developer
customized finder methods	handled by container, but the developer must define the EJB QL queries	coded by developer
select methods	handled by container	none

Access Methods

An entity bean with container-managed persistence has persistent and relationship fields. These fields are virtual, so you do not code them in the class as instance variables. Instead, you specify them in the bean's deployment descriptor. To permit access to the fields, you define abstract get and set methods in the entity bean class.

Access Methods for Persistent Fields. The EJB container automatically performs the database storage and retrieval of the bean's persistent fields. The deployment descriptor of the `PlayerEJB` bean specifies the following persistent fields:

- `playerId` (primary key)
- `name`
- `position`
- `salary`

The `PlayerBean` class defines the access methods for the persistent fields as follows:

```
public abstract String getPlayerId();
public abstract void setPlayerId(String id);

public abstract String getName();
public abstract void setName(String name);

public abstract String getPosition();
```

```
public abstract void setPosition(String position);

public abstract double getSalary();
public abstract void setSalary(double salary);
```

The name of an access method begins with `get` or `set`, followed by the capitalized name of the persistent or relationship field. For example, the accessor methods for the `salary` field are `getSalary` and `setSalary`. This naming convention is similar to that of JavaBeans™ components.

Access Methods for Relationship Fields. In the `RosterApp` application, since a player can belong to multiple teams, a `PlayerEJB` instance may be related to many `TeamEJB` instances. To specify this relationship, the deployment descriptor of the `PlayerEJB` defines a relationship field named `teams`. In the `PlayerBean` class, the access methods for the `teams` relationship field are as follows:

```
public abstract Collection getTeams();
public abstract void setTeams(Collection teams);
```

Select Methods

A select method is similar to a finder method in the following ways:

- A select method queries a database and returns objects.
- The deployment descriptor specifies an EJB QL query for a select method.
- The entity bean class does not implement the select method.

However, a select method differs significantly from a finder method:

- A select method can return persistent fields or the home interfaces of related entity beans. A finder method can return only the home interface (or a collection thereof) that defines it.
- Since it is not exposed in any of the local or remote interfaces, a select method cannot be invoked by a client. It may be invoked only by the methods implemented within the entity bean class. A select method is usually invoked by a business method.
- A select method is defined in the entity bean class. For bean-managed persistence, a finder method is defined in the entity bean class, but for container-managed persistence it is not.

The `PlayerBean` class defines these select methods:

```
public abstract Collection ejbSelectLeagues(LocalPlayer player)
    throws FinderException;

public abstract Collection ejbSelectSports(LocalPlayer player)
    throws FinderException;
```

The signature for a select method must follow these rules:

- The prefix of the method name must be `ejbSelect`.
- The access control modifier must be `public`.
- The method must be declared as `abstract`.
- The throws clause must include the `javax.ejb.FinderException`.

Business Methods

Since clients cannot invoke select methods, the `PlayerBean` class wraps them in the `getLeagues` and `getSports` business methods:

```
public Collection getLeagues() throws FinderException {

     LocalPlayer player =
         (team.LocalPlayer)context.getEJBLocalObject();
     return ejbSelectLeagues(player);
}

public Collection getSports() throws FinderException {

     LocalPlayer player =
         (team.LocalPlayer)context.getEJBLocalObject();
     return ejbSelectSports(player);
}
```

Entity Bean Methods

Because the container handles persistence, the life-cycle methods in the `PlayerBean` class are nearly empty.

The `ejbCreate` method initializes the bean instance by assigning the input arguments to the persistent fields. After the `ejbCreate` method completes, the container inserts a row into the database. Here is the source code for the `ejbCreate` method:

```
public String ejbCreate (String id, String name,
    String position, double salary) throws CreateException {

    setPlayerId(id);
```

```
        setName(name);
        setPosition(position);
        setSalary(salary);
        return id;
    }
```

Except for a debug statement, the `ejbRemove` method in the `PlayerBean` class is empty. The container invokes `ejbRemove` right before it deletes the database row.

The `ejbPostCreate` method must have the same input parameters and return type as the `ejbCreate` method. If you want to set a relationship field to initialize the bean instance, you should do so in the `ejbPostCreate` method. You may not set a relationship field in the `ejbCreate` method.

The container automatically synchronizes the state of the entity bean with the database. After the container loads the bean's state from the database, it invokes the `ejbLoad` method. In like manner, before storing the state in the database, the container invokes the `ejbStore` method.

Local Home Interface

The local home interface defines the `create`, finder, and home methods that may be invoked by local clients.

The syntax rules for a `create` method follow:

- The name begins with `create`.
- It has the same number and types of arguments as its matching `ejbCreate` method in the entity bean class.
- It returns the local interface type of the entity bean.
- The `throws` clause includes the exceptions specified by the `throws` clause of the corresponding `ejbCreate` method.
- The throws clause contains the `javax.ejb.CreateException`.

These rules apply for a finder method:

- The name begins with `find`.
- The return type is the entity bean's local interface type, or a collection of those types.
- The `throws` clause contains the `javax.ejb.FinderException`.
- The `findByPrimaryKey` method must be defined.

An excerpt of the `LocalPlayerHome` interface follows:

```
package team;

import java.util.*;
import javax.ejb.*;

public interface LocalPlayerHome extends EJBLocalHome {

    public LocalPlayer create (String id, String name,
        String position, double salary)
        throws CreateException;

    public LocalPlayer findByPrimaryKey (String id)
        throws FinderException;

    public Collection findByPosition(String position)
        throws FinderException;
     . . .
    public Collection findByLeague(LocalLeague league)
        throws FinderException;
    . . .
  }
```

Local Interface

This interface defines the business and access methods that a local client may invoke. The `PlayerBean` class implements two business methods: `getLeagues` and `getSports`. It also defines several get and set access methods for the persistent and relationship fields. The set methods are hidden from the bean's clients because they are not defined in the `LocalPlayer` interface. However, the get methods are exposed to the clients by the interface:

```
package team;

import java.util.*;
import javax.ejb.*;

public interface LocalPlayer extends EJBLocalObject {

    public String getPlayerId();
    public String getName();
    public String getPosition();
    public double getSalary();
    public Collection getTeams();
```

```
    public Collection getLeagues() throws FinderException;
    public Collection getSports() throws FinderException;
}
```

A Guided Tour of the RosterApp Settings

This section introduces you to the settings of the deployment descriptors for entity beans with container-managed persistence and relationships. As this tour guides you through the `deploytool` screens, it discusses the highlights of the tabbed panes and dialog boxes that appear.

To begin our tour, please run the `deploytool` and open the `RosterApp.ear` file, which is in the `j2eetutorial/examples/ears` directory.

RosterApp

To view the deployment settings for the application, select the `RosterApp` node in the tree view.

General Tabbed Pane (RosterApp)

The Contents field displays the files contained in the `RosterApp.ear` file, including the two EJB JAR files (`team-ejb.jar`, `roster-ejb.jar`) and the J2EE application client JAR file (`roster-ac.jar`).

JNDI Names Tabbed Pane (RosterApp)

The Application table lists the JNDI names for the enterprise beans in the `RosterApp` application.

The References table has two entries. The EJB Ref entry maps the coded name (`ejb/SimpleRoster`) in the `RosterClient` to the JNDI name of the `RosterEJB` session bean. The Resource entry specifies the JNDI name for the database that is accessed by the entity beans contained in the `TeamJAR` module.

RosterClient

To view this client, expand the `RosterApp` node by clicking its adjacent key icon in the tree view. Next, select `RosterClient`.

JAR File Tabbed Pane (Roster Client)

The Contents field shows the files contained by the roster-ac.jar file: two XML files (the deployment descriptors) and a single class file (RosterClient.class).

EJB Refs Tabbed Pane (Roster Client)

The RosterClient accesses a single bean, the RosterEJB session bean. Because this access is remote, the value in the Interfaces column is Remote and the value for the Local/Remote Interface column is the bean's remote interface (roster.Roster).

RosterJAR

In the tree view, select RosterJAR. This JAR file contains the RosterEJB session bean.

General Tabbed Pane (RosterJAR)

The Contents field lists three packages of class files. The roster package contains the class files required for the RosterEJB—the session bean class, remote interface, and home interface. The team package includes the local interfaces for the entity beans accessed by the RosterEJB session bean. The util package holds the utility classes for this application.

RosterEJB

In the tree view, expand the RosterJAR node and select RosterEJB.

General Tabbed Pane (RosterEJB). This tabbed pane shows that RosterEJB is a stateful session bean with remote access. Since it allows no local access, the Local Interfaces fields are empty.

EJB Refs Tabbed Pane (RosterEJB). The RosterEJB session bean accesses three entity beans: PlayerEJB, TeamEJB, and LeagueEJB. Because this access is local, the entries in the Interfaces columns are defined as Local. The Home Interface column lists the local home interfaces of the entity beans. The Local/Remote Interfaces column displays the local interfaces of the entity beans.

To view the runtime deployment settings, select a row in the table. For example, when you select the row with the Coded Name of ejb/SimpleLeague, the LeagueEJB name appears in the Enterprise Bean Name Field. If a component references a local entity bean, then you must enter the name of the referenced bean in the Enterprise Bean Name field.

TeamJAR

In the tree view, select the `TeamJAR` node. This JAR file contains the three related entity beans: `LeagueEJB`, `TeamEJB`, and `PlayerEJB`.

General Tabbed Pane (TeamJAR)

The Contents field shows two packages of class files: `team` and `util`. The `team` package has the entity bean classes, local interfaces, and local home interfaces for all three entity beans. The `util` package contains utility classes.

Relationships Tabbed Pane (TeamJAR)

On this tabbed pane you define the relationships between entity beans with container-managed persistence. The Container Managed Relationships table summarizes two relationships: TeamEJB-PlayerEJB and LeagueEJB-TeamEJB. In the TeamEJB-PlayerEJB relationship, the `TeamEJB` bean is designated as EJB A and the `PlayerEJB` bean as EJB B. (This designation is arbitrary—we could have assigned `PlayerEJB` to EJB A and `TeamEJB` to EJB B.)

Edit Relationship Dialog Box (TeamJAR). To view this dialog box, on the Relationships tab select a row and click Edit. For example, to view the TeamEJB-PlayerEJB relationship, select the row in which the EJB A value is `Team` and then click Edit.

TeamEJB-PlayerEJB Relationship

The Multiplicity combo box offers four choices. For this relationship, the Many to Many choice should be selected because a team has many players and a player can belong to more than one team.

The information in the Enterprise Bean A box defines the `TeamEJB` bean's side of the relationship. The Field Referencing Bean B combo box displays the relationship field (`players`) in TeamEJB. This field corresponds to the relationship access methods in the `TeamBean.java` source code:

```
public abstract Collection getPlayers();
public abstract void setPlayers(Collection players);
```

The selection of the Field Type combo box is `java.util.Collection`, which matches the `players` type in the access methods. The `players` type is a multivalued object (`Collection`) because on the `TeamEJB` side of the relationship the multiplicity is many. (The type is a `Collection` instead of a `Set` because a `Collection` does not allow duplicates—a player cannot belong to the same team more than once.)

The TeamEJB-PlayerEJB relationship is bidirectional—each bean has a relationship field that identifies the related bean. If this relationship were unidirectional, then one of the beans would not have a relationship field identifying the other bean. For the bean without the relationship field, the value of the Field Referencing combo box would be `<none>`.

LeagueEJB-TeamEJB Relationship

In the Edit Relationship dialog box, the Multiplicity choice should be One to Many. This choice indicates that a single league has multiple teams.

For the `LeagueEJB`, the relationship field is `teams` and for the `TeamEJB` it is `league`. Because the `TeamEJB` is on the multiple side of the relationship, the `teams` field is a `Collection`. In contrast, since the `LeagueEJB` is on the single side of the relationship, the `league` field is a single-valued object, a `LocalLeague`. The `TeamBean.java` code defines the league relationship field with these access methods:

```
public abstract LocalLeague getLeague();
public abstract void setLeague(LocalLeague players);
```

For the `TeamEJB` (Enterprise Bean B), the Delete When Bean A is Deleted checkbox is selected. Because of this selection, when a `LeagueEJB` instance is deleted the related `TeamEJB` instances are automatically deleted. This type of deletion, in which one deletion triggers another, is called a *cascade delete*. For the `LeagueEJB`, the corresponding checkbox is disabled: If you delete a team, you don't want to automatically delete the league because there may be other teams in that league. In general, if a bean is on the multiple side of a relationship, the other bean cannot be automatically deleted.

PlayerEJB

In the tree view, expand the `TeamJAR` node and select the `PlayerEJB` entity bean.

General Tabbed Pane (PlayerEJB). This tab shows the enterprise bean class and interfaces. Since `PlayerEJB` entity bean uses container-managed persistence, it has local interfaces. It does not have remote interfaces because it does not allow remote access.

Entity Tabbed Pane (PlayerEJB). The radio buttons at the top define the bean's persistence type. For the `PlayerEJB`, bean this type is container-managed persistence, version 2.0. Since version 1.0 did not support relationships, it is not recommended. These version numbers identify a particular release of the *Enterprise JavaBeans™ Specification,* not the J2EE SDK software.

The Fields To Be Persisted box lists the persistent and relationship fields defined by the access methods in the `PlayerBean.java` code. The checkboxes for the persistent fields must be selected, but those for the relationship fields must not be selected. The `PlayerEJB` bean has one relationship field: `teams`.

The Abstract Schema Name is `Player`, a name that represents the relationships and persistent fields of the `PlayerEJB` entity bean. This abstract name is referenced in the `PlayerEJB` bean's Enterprise JavaBeans™ (EJB™ QL) queries. For more information on EJB QL, see the chapter, Enterprise JavaBeans™ Query Language (page 183).

Finder/Select Methods Dialog Box (PlayerEJB). To open this dialog box, on the Entity tabbed pane click Finder/Select Methods.

This dialog box enables you to view and edit the EJB QL queries for a bean's finder and select methods. For example, to list the finder methods defined in the `LocalPlayerHome` interface, select the Local Finders radio button. When you select the finder method, its EJB QL query appears in an editable text field.

Entity Deployment Settings Dialog Box (PlayerEJB). To view this dialog box, in the Entity tabbed pane click Deployment Settings.

In this dialog box, you define the runtime settings of an entity bean with container-managed persistence. These runtime settings are specific to the J2EE™ SDK; other implementations of the J2EE platform may take a different approach.

In the J2EE SDK, the bean's persistent fields are stored in a relational database table. In the checkboxes of the Database Table box, you specify whether or not the server automatically creates or drops the table. If you want to save the data in your table between deployments, then make sure that the Delete Table checkbox is not selected. Otherwise, every time you undeploy the bean, the table will be deleted.

The J2EE server accesses the database by issuing SQL calls. In an entity bean with container-managed persistence, you do not code these calls. The `deploytool` creates the SQL calls automatically when you click the Generate Default SQL button. To view the SQL statement for a finder method, for example, select the Local Finder radio button and then select an entry in the Method list. You may modify a SQL statement by editing the text in the SQL Query field.

For the finder and select methods, the corresponding EJB QL query is also displayed. When you click Generate Default SQL, the `deploytool` translates the EJB QL queries into SQL calls. If you change an EJB QL query, you should click the Generate Default SQL button again.

To view the SQL `CREATE TABLE` statement, for example, click the Container Methods radio button and then select the createTable entry in the Method list. The `CREATE TABLE` statement defines column names for the bean's persistent fields and specifies a primary key constraint for `playerId`, the bean's primary key field.

When the EJB container creates a new `PlayerEJB` instance, it issues a SQL `INSERT` statement. To examine this statement, select createRow from the Method list. In the `INSERT` statement, the parameters in the `values` clause correspond to the arguments of the `create` method that is defined in the `LocalPlayerHome` interface:

```
public LocalPlayer create (String id, String name,
    String position, double salary) throws CreateException;
```

Database Deployment Settings Dialog Box (PlayerEJB). To access this dialog box, on the Entity tabbed pane click Deployment Settings. On the Deployment Settings dialog box that appears, click Database Settings. The Deployment Settings dialog box with the Database Settings label should appear.

It is important that you set the JNDI name of the database. (If it is not set, the bean cannot connect to the database.) For this example, the Database JNDI Name field should be `jdbc/Cloudscape`. The User Name and Password fields are blank because they are not required for Cloudscape.

Method Invocations in RosterApp

To show how the various components interact, this section describes the sequence of method invocations that occur for particular functions. The source code for the components is in the `j2eetutorial/examples/src/ejb/cmproster` directory.

Creating a Player

1. RosterClient

The `RosterClient` invokes the `createPlayer` business method of the `RosterEJB` session bean. In the following line of code, the type of the `myRoster` object is `Roster`, the remote interface of the `RosterEJB` bean. The argument of the `createPlayer` method is a `PlayerDetails` object, which encapsulates information about a particular player.

```
myRoster.createPlayer(new PlayerDetails("P1", "Phil Jones",
    "goalkeeper", 100.00));
```

2. RosterEJB

The `createPlayer` method of the `RosterEJB` session bean creates a new instance of the `PlayerEJB` entity bean. Because the access to `PlayerEJB` bean is local, the `create` method is defined in the local home interface, `LocalPlayerHome`. The type of the `playerHome` object is `LocalPlayerHome`. Here is the source code for the `createPlayer` method:

```
public void createPlayer(PlayerDetails details) {

try {
        LocalPlayer player = playerHome.create(details.getId(),
            details.getName(), details.getPosition(),
            details.getSalary());
    } catch (Exception ex) {
         throw new EJBException(ex.getMessage());
    }
}
```

3. PlayerEJB

The `ejbCreate` method assigns the input arguments to the bean's persistent fields by calling the set access methods. After invoking the `ejbCreate` method, the container saves the persistent fields in the database by issuing a SQL `INSERT` statement. The code for the `ejbCreate` method follows.

```
public String ejbCreate (String id, String name,
    String position,double salary) throws CreateException {

    setPlayerId(id);
    setName(name);
```

```
        setPosition(position);
        setSalary(salary);
        return id;
    }
```

Adding a Player To a Team

1. RosterClient

The `RosterClient` calls the `addPlayer` business method of the `RosterEJB` bean. The `P1` and `T1` parameters are the primary keys of the `PlayerEJB` and `TeamEJB` instances, respectively.

```
myRoster.addPlayer("P1", "T1");
```

2. RosterEJB

The `addPlayer` method performs two steps. First, it calls `findByPrimaryKey` to locate the `PlayerEJB` and `TeamEJB` instances. Second, it invokes the `addPlayer` business method of the `TeamEJB` bean. Here is the source code for the `addPlayer` method of the `RosterEJB` session bean:

```
public void addPlayer(String playerId, String teamId) {

    try {
        LocalTeam team = teamHome.findByPrimaryKey(teamId);
        LocalPlayer player =
            playerHome.findByPrimaryKey(playerId);
        team.addPlayer(player);
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }
}
```

3. TeamEJB

The `TeamEJB` entity bean has a relationship field named `players`, a `Collection` that represents the players that belong to the team. The access methods for the `players` relationship field are as follows:

```
public abstract Collection getPlayers();
public abstract void setPlayers(Collection players);
```

The `addPlayer` method of the `TeamEJB` bean invokes the `getPlayers` access method to fetch the `Collection` of related `LocalPlayer` objects. Next, the addPlayer method invokes the add method of the Collection interface. Here is the source code for the addPlayer method:

```
public void addPlayer(LocalPlayer player) {
    try {
        Collection players = getPlayers();
        players.add(player);
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }
}
```

Removing a Player

1. RosterClient

To remove player P4, the client would invoke the removePlayer method of the RosterEJB session bean:

```
myRoster.removePlayer("P4");
```

2. RosterEJB

The removePlayer method locates the PlayerEJB instance by calling findByPrimaryKey and then invokes the remove method on the instance. This invocation signals the container to delete the row in the database that corresponds to the PlayerEJB instance. The container also removes the item for this instance from the players relationship field in the TeamEJB entity bean. By this removal, the container automatically updates the TeamEJB-PlayerEJB relationship. Here is the removePlayer method of the RosterEJB session bean:

```
public void removePlayer(String playerId) {
    try {
        LocalPlayer player =
            playerHome.findByPrimaryKey(playerId);
        player.remove();
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }
}
```

Dropping a Player From a Team

1. RosterClient

To drop player P2 from team T1, the client would call the dropPlayer method of the RosterEJB session bean:

```
myRoster.dropPlayer("P2", "T1");
```

2. RosterEJB

The dropPlayer method retrieves the PlayerEJB and TeamEJB instances by calling their findByPrimaryKey methods. Next, it invokes the dropPlayer business method of the TeamEJB entity bean. The dropPlayer method of the RosterEJB bean follows:

```
public void dropPlayer(String playerId, String teamId) {

    try {
        LocalPlayer player =
            playerHome.findByPrimaryKey(playerId);
        LocalTeam team = teamHome.findByPrimaryKey(teamId);
        team.dropPlayer(player);
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }
}
```

3. TeamEJB

The dropPlayer method updates the TeamEJB-PlayerEJB relationship. First, the method retrieves the Collection of LocalPlayer objects that correspond to the players relationship field. Next, it drops the target player by calling the remove method of the Collection interface. Here is the dropPlayer method of the TeamEJB entity bean:

```
public void dropPlayer(LocalPlayer player) {

  try {
        Collection players = getPlayers();
        players.remove(player);
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }
}
```

Getting the Players Of a Team

1. RosterClient

The client can fetch a team's players by calling the `getPlayersOfTeam` method of the `RosterEJB` session bean. This method returns an `ArrayList` of `PlayerDetails` objects. A `PlayersDetails` object contains four variables—`playerId`, `name`, `position`, and `salary`—which are copies of the `PlayerEJB` persistent fields. The `RosterClient` calls the `getPlayersOfTeam` method as follows:

```
playerList = myRoster.getPlayersOfTeam("T2");
```

2. RosterEJB

The `getPlayersOfTeam` method of the `RosterEJB` session bean locates the `LocalTeam` object of the target team by invoking the `findByPrimaryKey` method. Next, the `getPlayersOfTeam` method calls the `getPlayers` method of the `TeamEJB` entity bean. Here is the source code for the `getPlayersOfTeam` method:

```
public ArrayList getPlayersOfTeam(String teamId) {

    Collection players = null;

    try {
        LocalTeam team = teamHome.findByPrimaryKey(teamId);
        players = team.getPlayers();
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }

    return copyPlayersToDetails(players);
}
```

The `getPlayersOfTeam` method returns the `ArrayList` of `PlayerDetails` objects that is generated by the `copyPlayersToDetails` method:

```
private ArrayList copyPlayersToDetails(Collection players) {

     ArrayList detailsList = new ArrayList();
     Iterator i = players.iterator();

     while (i.hasNext()) {
         LocalPlayer player = (LocalPlayer) i.next();
         PlayerDetails details =
             new PlayerDetails(player.getPlayerId(),
```

```
                    player.getName(), player.getPosition(),
                    player.getSalary());
            detailsList.add(details);
        }

        return detailsList;
    }
```

3. TeamEJB

The `getPlayers` method of the `TeamEJB` entity bean is an access method of the `players` relationship field:

```
public abstract Collection getPlayers();
```

This method is exposed to local clients because it is defined in the local interface, `LocalTeam`:

```
public Collection getPlayers();
```

When invoked by a local client, a get access method returns a reference to the relationship field. If the local client alters the object returned by a get access method, it also alters the value of the relationship field inside the entity bean. For example, a local client of the `TeamEJB` entity bean could drop a player from a team as follows:

```
LocalTeam team = teamHome.findByPrimaryKey(teamId);
Collection players = team.getPlayers();
players.remove(player);
```

If you want to prevent a local client from modifying a relationship field in this manner, then you should take the approach described in the next section.

Getting a Copy of a Team's Players

In contrast to the methods discussed in the preceding section, the methods in this section demonstrate the following techniques:

- Filtering the information passed back to the remote client
- Preventing the local client from directly modifying a relationship field

1. RosterClient

If you wanted to hide the salary of a player from a remote client, you would require the client to call the `getPlayersOfTeamCopy` method of the `RosterEJB` session bean. Like the getPlayersOfTeam method, the getPlayersOfTeamCopy method returns an ArrayList of PlayerDetails objects. However, the objects returned by getPlayersOfTeamCopy are different—their salary variables have been set to zero. The RosterClient calls the getPlayersOfTeamCopy method as follows:

```
playerList = myRoster.getPlayersOfTeamCopy("T5");
```

2. RosterEJB

Unlike the getPlayersOfTeam method, the getPlayersOfTeamCopy method does not invoke the getPlayers access method that is exposed in the LocalTeam interface. Instead, the getPlayersOfTeamCopy method retrieves a copy of the player information by invoking the getCopyOfPlayers business method that is defined in the LocalTeam interface. As a result, the getPlayersOfTeamCopy method cannot modify the players relationship field of the TeamEJB bean. Here is the source code for the getPlayersOfTeamCopy method of the RosterEJB bean:

```
public ArrayList getPlayersOfTeamCopy(String teamId) {

    ArrayList playersList = null;

    try {
        LocalTeam team = teamHome.findByPrimaryKey(teamId);
        playersList = team.getCopyOfPlayers();
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }

    return playersList;
}
```

3. TeamEJB

The getCopyOfPlayers method of the TeamEJB bean returns an ArrayList of PlayerDetails objects. To create this ArrayList, the method iterates through the Collection of related LocalPlayer objects and copies information to the variables of the PlayerDetails objects. The method copies the values of the PlayerEJB bean's persistent fields—except for the salary field, which it sets to zero. As a result, a player's salary is hidden from a client that invokes the getPlayersOfTeamCopy method. The source code for the getCopyOfPlayers of the TeamEJB bean follows:

```
public ArrayList getCopyOfPlayers() {

    ArrayList playerList = new ArrayList();
    Collection players = getPlayers();

    Iterator i = players.iterator();
    while (i.hasNext()) {
        LocalPlayer player = (LocalPlayer) i.next();
        PlayerDetails details =
            new PlayerDetails(player.getPlayerId(),
            player.getName(), player.getPosition(), 0.00);
        playerList.add(details);
    }

    return playerList;
}
```

Finding the Players By Position

1. RosterClient

The client starts the procedure by invoking the `getPlayersByPosition` method of the `RosterEJB` session bean:

```
playerList = myRoster.getPlayersByPosition("defender");
```

2. RosterEJB

The `getPlayersByPosition` method retrieves the `players` list by invoking the `findByPosition` method of the `PlayerEJB` entity bean:

```
public ArrayList getPlayersByPosition(String position) {

   Collection players = null;

    try {
        players = playerHome.findByPosition(position);
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }

    return copyPlayersToDetails(players);
}
```

3. PlayerEJB

The `LocalPlayerHome` interface defines the `findByPosition` method:

```
public Collection findByPosition(String posistion)
    throws FinderException;
```

Because the PlayerEJB entity bean uses container-managed persistence, the entity bean class (PlayerBean) does not implement its finder methods. To specify the queries associa1ted with the finder methods, EJB QL queries must be defined in the bean's deployment descriptor. For example, the findByPosition method has this EJB QL query:

```
SELECT DISTINCT OBJECT(p) FROM Player p
WHERE p.position = ?1
```

The deploytool translates the EJB QL query into an SQL SELECT statement. At runtime, when the container invokes the findByPosition method it will execute the SQL SELECT statement.

For details about EJB QL, please refer to the chapter, Enterprise JavaBeans™ Query Language (page 183). To learn how to view and edit an EJB QL query in the deploytool, see Finder/Select Methods Dialog Box (PlayerEJB) (page 156).

Getting the Sports of a Player

1. RosterClient

The client invokes the getSportsOfPlayer method of the RosterEJB session bean:

```
sportList = myRoster.getSportsOfPlayer("P28");
```

2. RosterEJB

The getSportsOfPlayer method returns an ArrayList of String objects that represent the sports of the specified player. It constructs the ArrayList from a Collection returned by the getSports business method of the PlayerEJB. bean. Here is the source code for the getSportsOfPlayer method of the RosterEJB bean:

```
public ArrayList getSportsOfPlayer(String playerId) {

ArrayList sportsList = new ArrayList();
    Collection sports = null;

    try {
        LocalPlayer player =
```

```
            playerHome.findByPrimaryKey(playerId);
        sports = player.getSports();
    } catch (Exception ex) {
        throw new EJBException(ex.getMessage());
    }

    Iterator i = sports.iterator();
    while (i.hasNext()) {
        String sport = (String) i.next();
        sportsList.add(sport);
    }
    return sportsList;
}
```

3. PlayerEJB

The `getSports` method is a wrapper for the `ejbSelectSports` method. Since the parameter of the `ejbSelectSports` method is of type `LocalPlayer`, the `getSports` method passes along a reference to the entity bean instance. The `PlayerBean` class implements the `getSports` method as follows:

```
public Collection getSports() throws FinderException {

     LocalPlayer player =
         (team.LocalPlayer)context.getEJBLocalObject();
     return ejbSelectSports(player);
}
```

The `PlayerBean` class defines the `ejbSelectSports` method:

```
public abstract Collection ejbSelectSports(LocalPlayer player)
    throws FinderException;
```

The bean's deployment descriptor specifies the following EJB QL query for the `ejbSelectSports` method:

```
SELECT DISTINCT t.league.sport
FROM Player p, IN (p.teams) AS t
WHERE p = ?1
```

Before deploying the `PlayerEJB` entity bean, you run the `deploytool` to generate SQL `SELECT` statements for the bean's EJB QL queries. Because the `PlayerEJB` bean uses container-managed persistence, when the `ejbSelectSports` method is invoked the EJB container will execute its corresponding SQL `SELECT` statement.

Running the RosterApp Example

Setting Up

1. In a terminal window, start the Cloudscape database server.

```
cloudscape -start
```

2. In another terminal window, start the J2EE server.

```
j2ee -verbose
```

3. Run the `deploytool`.

```
deploytool
```

Deploying the Application

1. In the `deploytool`, open the `RosterApp.ear` file.
   a. Choose File->Open from the main menu.
   b. In the Open Object dialog box, navigate to the `j2eetutorial/examples/ears` directory.
   c. Select the `RosterApp.ear` file.
   d. Click Open Object.
2. Deploy the application.
   a. In the deploytool, select `RosterApp` from the tree view.
   b. Choose Tools->Deploy from the main menu.
   c. In the Introduction dialog box, select the Return Client JAR checkbox.
   d. In the Client JAR File Name field, make sure that the file is called `RosterAppClient.jar` and that its path refers to the `j2eetutorial/examples/ears` directory.
   e. Click Next until the Review dialog box appears.
   f. Click Finish.

Running the Client

1. In a terminal window, go to the `j2eetutorial/examples/ears` directory.
2. Set the `APPCPATH` environment variable to `RosterAppClient.jar`.

3. Type the following command:

```
runclient -client RosterApp.ear -name RosterClient -textauth
```

4. At the login prompts, enter `guest` for the user name and `guest123` for the password.

Deploytool Tips for Entity Beans With Container-Managed Persistence

The Getting Started (page 49) chapter covered the basic steps for building and packaging enterprise beans. This section highlights the tasks in the `deploytool` that are needed for entity beans with container-managed persistence. The examples referenced in this section are from A Guided Tour of the RosterApp Settings (page 152).

Specifying the Bean's Type

In the New Enterprise Bean Wizard, specify the bean's type and persistent management.

1. In the Edit Contents dialog box, add all of the classes required by the entity bean and by its related beans.
2. In the General dialog box, select the Entity radio button.
3. In the General dialog box, specify the local interfaces of the entity bean. (If the bean also has remote interfaces, you specify them as well.)
4. In the Entity Settings dialog box, select the radio button for Container-Managed Persistence (2.0). You may skip the other settings in this dialog and enter them later in the Entity tabbed pane.

Selecting the Persistent Fields and Abstract Schema Name

In the Entity tabbed pane, enter the field information and the abstract schema name.

1. In the Fields To Be Persisted list, select the fields that will be saved in the database. The names of the persistent fields are determined by the access methods defined in the entity bean code.

2. Enter values in the Primary Key Class and Primary Key Field Name fields. The primary key uniquely identifies the entity bean.
3. In the Abstract Schema Name field, enter a name that represents the entity bean. This name will be referenced in the EJB QL queries.

Example: Entity Tabbed Pane (PlayerEJB) (page 156)

Defining EJB QL Queries for Finder and Select Methods

You specify these settings in the Finder/Select Methods dialog box.

1. To open this dialog box, go to the Entity tabbed pane and click Finder/Select Methods.
2. To display a set of finder or select methods, click one of the radio buttons under the Show label.
3. To specify an EJB QL query, choose the name of the finder or select method from the Method list and then enter the query in the field labelled EJB QL Query.

Example: Finder/Select Methods Dialog Box (PlayerEJB) (page 156)

Generating SQL and Specifying Table Creation

In the deploytool, the various Deployment Settings dialog boxes enable you to enter information needed by the server at runtime. These settings are specific to the J2EE SDK implementation.

1. To open this Deployment Settings dialog box, go to the Entity tabbed pane and click Deployment Settings.
2. With container-managed persistence, the container can automatically create or delete the database table used by the entity bean. If you've loaded test data into the table, you may want to de-select the checkboxes in the Database Table box.
3. To translate the EJB QL queries into SQL SELECT statements, click Generate Default SQL. If this button is disabled, you must first specify the database settings.

Example: Entity Deployment Settings Dialog Box (PlayerEJB) (page 156)

Specifying the Database JNDI Name, User Name, and Password

You make these settings In the Database Settings dialog box.

1. To open this dialog box, go to the Entity tabbed pane and click Deployment Settings. In the Deployment Settings dialog box, click Database Settings.
2. Enter a value in the Database JNDI Name field. The examples in this book use the jdbc/Cloudscape JNDI name.
3. The Cloudscape databases shipped with the J2EE SDK does not require a user name or password. So, if your bean connects to the Cloudscape database, you may leave the User Name and Password fields blank. To connect to other types of databases, you may need to enter values into these fields.

Example: Database Deployment Settings Dialog Box (PlayerEJB) (page 157)

Defining Relationships

The Relationships tabbed pane enables you to define relationships between entity beans that reside in the same EJB JAR file.

1. Before you create a relationship between two entity beans, you must first create both beans with the New Enterprise Bean wizard.
2. To display the Relationships tabbed pane, select the EJB JAR in the tree view and then select the Relationships tab.
3. To add or edit a relationship, go the Relationships tabbed pane and click the appropriate button.
4. The Add (or Edit) Relationship dialog box appears. (The Add Relationship and Edit Relationship dialog boxes are identical.)

Example: Edit Relationship Dialog Box (TeamJAR) (page 154)

A Message-Driven Bean Example

by Dale Green and Kim Haase

SINCE message-driven beans are based on the Java™ Message Service (JMS) technology, in order to understand the example in this chapter you should already be familiar with basic JMS concepts such as queues and messages. The best place to learn about these concepts is the Java™ Message Service Tutorial:

```
http://java.sun.com/products/jms/tutorial/index.html
```

This chapter describes the source code of a simple message-driven bean example. Before proceeding, you should read the basic conceptual information in What is a Message-Driven Bean? (page 84).

Example Application Overview

This application has the following components:

- `SimpleMessageClient` - A J2EE™ application client that sends several messages to a queue.
- `SimpleMessageEJB` - A message-driven bean that asynchronously receives and processes the messages that are sent to the queue.

Figure 16 illustrates the structure of this application. The application client sends messages to the queue, which was created administratively using the `j2eeadmin` command. The JMS provider (in this, case the J2EE™ server) delivers the messages to the instances of the message-driven bean, which then processes the messages.

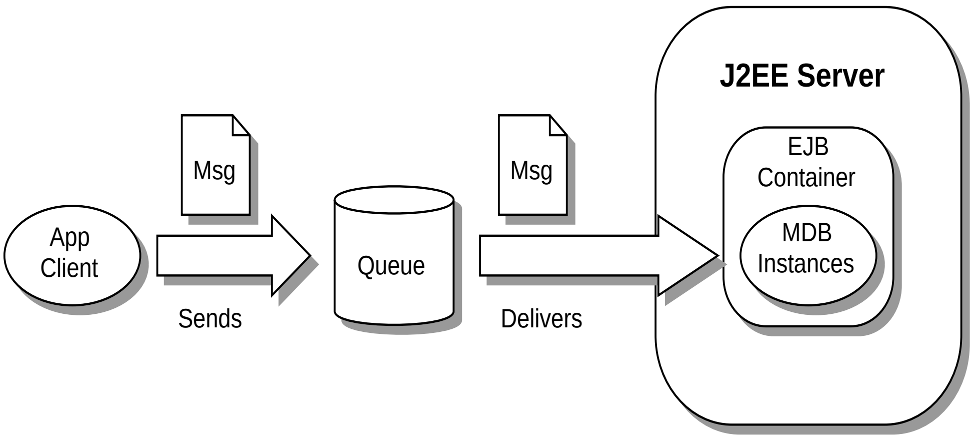


Figure 17 The `SimpleMessageApp` Application

Source Code. The source code for this application is in the `j2eetutorial/examples/src/ejb/simplemessage` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant simple-`

message. A sample SimpleMessageApp.ear file is in the j2eetutorial/examples/ears directory.

The J2EE™ Application Client

The SimpleMessageClient sends messages to the queue that the SimpleMessageBean listens to. The client starts out by locating the connection factory and queue:

```
queueConnectionFactory = (QueueConnectionFactory)
    jndiContext.lookup
    ("java:comp/env/jms/MyQueueConnectionFactory");
queue = (Queue)
     jndiContext.lookup("java:comp/env/jms/QueueName");
```

Next, the client creates the queue connection, session, and sender:

```
queueConnection =
    queueConnectionFactory.createQueueConnection();
queueSession =
    queueConnection.createQueueSession(false,
    Session.AUTO_ACKNOWLEDGE);
queueSender = queueSession.createSender(queue);
```

Finally, the client sends several messages to the queue:

```
message = queueSession.createTextMessage();

for (int i = 0; i < NUM_MSGS; i++) {
     message.setText("This is message " + (i + 1));
     System.out.println("Sending message: " +
         message.getText());
     queueSender.send(message);
}
```

The Message-Driven Bean Class

The code for the `SimpleMessageEJB` class illustrates the requirements of a message-driven bean class:

- It implements the `MessageDrivenBean` and `MessageListener` interfaces.
- The class is defined as public.
- The class cannot be defined as `abstract` or `final`.
- It implements one `onMessage` method.
- It implements one `ejbCreate` method and one `ejbRemove` method.
- It contains a `public` constructor with no arguments.
- It must not define the `finalize` method.

Unlike session and entity beans, message-driven beans do not have the remote or local interfaces that define client access. Client components do not locate message-driven beans and invoke methods on them. Although message-driven beans do not have business methods, they may contain helper methods that are invoked internally by the `onMessage` method.

The onMessage Method

When the queue receives a message, the EJB™ container invokes the `onMessage` method of the message-driven bean. In the `SimpleMessageBean` class, the `onMessage` method casts the incoming message to a `TextMessage` and displays the text:

```
public void onMessage(Message inMessage) {
    TextMessage msg = null;

    try {
        if (inMessage instanceof TextMessage) {
            msg = (TextMessage) inMessage;
            System.out.println
                ("MESSAGE BEAN: Message received: "
                + msg.getText());
        } else {
            System.out.println
                ("Message of wrong type: "
                + inMessage.getClass().getName());
        }
    } catch (JMSException e) {
        e.printStackTrace();
        mdc.setRollbackOnly();
```

```
        } catch (Throwable te) {
            te.printStackTrace();
        }
    }
```

The ejbCreate and ejbRemove Methods

The signatures of these methods have the following requirements:

- The access control modifier must be `public`.
- The return type must be `void`.
- The modifier cannot be `static` or `final`.
- The `throws` clause must not define any application exceptions.
- It has no arguments.

In the `SimpleMessageBean` class, the `ejbCreate` and `ejbRemove` methods are empty.

Running the SimpleMessageEJB Example

Starting the J2EE™ Server

To view the output of the message-driven bean, you must start the server in verbose mode:

```
j2ee -verbose
```

Creating the Queue

1. Create the queue with the `j2eeadmin` command:

```
j2eeadmin -addJmsDestination MyQueue queue
```

2. Verify that the queue was created:

```
j2eeadmin -listJmsDestination
```

Deploying the Application

1. In the `deploytool` open the `j2eetutorial/examples/ears/SimpleMessageApp.ear` file (File->Open).

2. Deploy the `SimpleMessageApp` application (Tools->Deploy). In the Introduction dialog box, make sure that you select the Return Client JAR checkbox. For detailed instructions, see Deploying the J2EE™ Application (page 64).

Running the Client

1. In a terminal window, go to the `j2eetutorial/examples/ears` directory.
2. Set the `APPCPATH` environment variable to `SimpleMessageAppClient.jar`.
3. Type the following command on a single line:

```
runclient -client SimpleMessageApp.ear -name
SimpleMessageClient -textauth
```

4. At the login prompts, enter `j2ee` for the user name and `j2ee` for the password.
5. The client displays these lines:

```
Sending message: This is message 1
Sending message: This is message 2
Sending message: This is message 3
```

6. In the terminal window in which you've started the `j2ee` server (in `-verbose` mode), the following lines should be displayed:

```
MESSAGE BEAN: Message received: This is message 1
MESSAGE BEAN: Message received: This is message 2
MESSAGE BEAN: Message received: This is message 3
```

Deploytool Tips for Message-Driven Beans

The Getting Started (page 49) chapter covered the basic steps for building and packaging enterprise beans. This section describes the tasks in the `deploytool` that are that are necessary for message-driven beans. To view an example in `deploytool`, open the `j2eetutorial/examples/ears/SimpleMessageApp.ear` file and select the SimpleMessageEJB bean from the tree view.

Specifying the Bean's Type and Transaction Management

You specify the type when you create the bean with the New Enterprise Bean wizard.

1. To start the wizard, select File->New->Enterprise Bean.
2. In the General dialog box of the wizard, select the Message-Driven radio button.
3. In the Transaction Management dialog box, you may select either the Bean-Managed or Container-Managed radio button. If you select the Bean-Managed button, then in step (4.) of the next section, you may select the acknowledgement type.

Setting the Message-Driven Bean's Characteristics

You may specify these settings in two places:

- The Message-Driven Bean Settings dialog box of the New Enterprise Bean wizard
- The Message tabbed pane of the bean

These settings are as follows:

1. For the Destination Type, select either the Queue or Topic radio button. A queue uses the point-to-point messaging domain and may have at most one consumer. A topic uses the publish-subscribe messaging domain; it may have zero, one, or many consumers.
2. In the Destination combo box, select the JNDI name of the destination that you have created administratively. For an example, see Creating the Queue (page 177). The destination is either a `Queue` or a `Topic` object; it represents the source of incoming messages and the target of outgoing messages.
3. In the Connection Factory combo box, select the appropriate object, either a QueueConnectionFactory or a TopicConnectionFactory. These objects produce the connections through which J2EE components access the messaging service.
4. If you've specified bean-managed transactions, then you may select the acknowledgement type— either Auto-Acknowledge or Duplicates-OK— from the Acknowledgement combo box. The Auto-Acknowledge type instructs the session to automatically acknowledge that the bean has con-

sumed the message. The Duplicates-OK type instructs the session to lazily acknowledge the delivery of messages; this type may result in duplicate messages but it reduces session overhead.

5. In the JMS Message Selector field, you may enter a statement that filters the messages received by the bean.

Deploytool Tips for JMS Clients

For more information on JMS clients, please see the Java™ Message Service Tutorial:

`http://java.sun.com/products/jms/tutorial/index.html`

Setting the Resource References

1. In the tree view, select the client's node.
2. Select the Resource Refs tab.
3. Click Add.
4. In the Coded Name field, enter the name matches the parameter of the `lookup` method in the client's code. For example, if the `lookup` parameter is `java:comp/env/jms/MyQueueConnectionFactory`, the Coded Name should be `jms/QueueConnectionFactory`.
5. In the Type field, select the connection factory class that matches the destination type.
6. In the Authentication field, in most cases you will select Container. You would select Application if your code explicitly logs on to the messaging service.
7. In the Sharable field, make sure the checkbox is selected. This choice allows the container to optimize connections.
8. Enter strings in the User Name and Password fields. The authentication service of the J2EE SDK will prompt you for these fields when you run the client.

Setting the Resource Environment References

1. Select the Resource Env. Refs tab.
2. Click Add.

3. In the Coded Name field, enter a name that matches the parameter of the `lookup` call that locates the queue or topic. For example, if the `lookup` parameter is `java:comp/env/jms/QueueName`, the Coded Name should be `jms/QueueName`.
4. In the Type field, select the class that matches the destination type.

Specifying the JNDI Names

1. In the tree view, select the application's node.
2. Select the JNDI Names tab and enter the appropriate names. For example, the `SimpleMessageApp` discussed in this chapter uses the JNDI names shown in the following table.

Table 7 JNDI Names for the `SimpleMessageApp`

Component or Reference Name	JNDI Name
SimpleMessageEJB	jms/MyQueue
jms/MyQueueConnectionFactory	jms/QueueConnectionFactory
jms/QueueName	jms/MyQueue

Enterprise JavaBeans™ Query Language

by Dale Green

THE Enterprise JavaBeans™ Query Language (EJB™ QL) defines the queries for the finder and select methods of an entity bean with container-managed persistence. A subset of SQL92, EJB QL has extensions that allow navigation over the relationships defined in an entity bean's abstract schema. The scope of an EJB QL query spans the abstract schemas of related entity beans that are packaged in the same EJB JAR file.

You define EJB QL queries in the deployment descriptor of the entity bean. Typically, a tool will translate these queries into the target language of the underlying data store. Because of this translation, entity beans with container-managed persistence are portable—their code is not tied to a specific type of data store.

This chapter relies on the material presented in earlier chapters. For conceptual information, see Container-Managed Persistence (page 81). For code examples, see Container-Managed Persistence Examples (page 143).

Terminology

The following list defines some of the terms referred to in this chapter:

- *abstract schema* - The part of an entity bean's deployment descriptor that defines the bean's persistent fields and relationships.
- *abstract schema name* - A logical name that is referenced in EJB QL queries. You specify an abstract schema name for each entity bean with container-managed persistence.
- *abstract schema type* - All EJB QL expressions evaluate to a type. If the expression is an abstract schema name, by default its type is the local home interface of the entity bean for which the abstract schema name is defined.
- *Backus-Naur Form (BNF)* - A notation that describes the syntax of high-level languages. The syntax diagrams in this chapter are in BNF notation.
- *Navigation* - The traversal of relationships in an EJB QL expression. The navigation operator is a period.
- *Path expression* - An expression that navigates to a related entity bean.
- *persistent field* - A virtual field of an entity bean with container-managed persistence, it is stored in a database.
- *relationship field* - A virtual field of an entity bean with container-managed persistence, it identifies a related entity bean.

Simplified Syntax

This section briefly describes the syntax of EJB QL so that you can quickly move on to the Example Queries (page 185). When you are ready to learn about the syntax in more detail, see Full Syntax (page 191).

An EJB QL query has three clauses: `SELECT`, `FROM`, and `WHERE`. The `SELECT` and `FROM` clauses are required, but the `WHERE` clause is optional. Here is the high-level BNF syntax of an EJB QL query:

```
EJB QL :: = select_clause from_clause [where_clause]
```

The `SELECT` clause defines the types of the objects or values returned by the query. A return type is either a local interface, a remote interface, or a persistent field.

The `FROM` clause defines the scope of the query by declaring one or more identification variables, which may be referenced in the `SELECT` and `WHERE` clauses. An identification variable represents one of the following elements:

- The abstract schema name of an entity bean
- A member of a collection that is the multiple side of a one-to-many relationship

The `WHERE` clause is a conditional expression that restricts the objects or values retrieved by the query. Although optional, most queries have a `WHERE` clause.

Example Queries

The following queries are from the `PlayerEJB` entity bean of the `RosterApp` J2EE™ application, which is documented in the chapter, Container-Managed Persistence Examples (page 143). To see the relationships between the beans of the `RosterApp`, see Figure 16 (page 145).

Simple Finder Queries

If you are unfamiliar with EJB QL, these simple queries are a good place to start.

Example 1

```
SELECT OBJECT(p)
FROM Player p
```

Data Retrieved: All players.

Finder Method: `findall()`

Description: The `FROM` clause declares an identification variable named `p`, omitting the optional keyword `AS`. If the `AS` keyword were included, the clause would be written as follows:

```
FROM Player AS p
```

The `Player` element is the abstract schema name of the `PlayerEJB` entity bean. Because the bean defines the `findall` method in the `LocalPlayerHome` interface, the objects returned by the query have that interface's type.

See Also: Identification Variables (page 195)

Example 2

```
SELECT DISTINCT OBJECT(p)
FROM Player p
WHERE p.position = ?1
```

Data Retrieved: The players with the position specified by the finder method's parameter.

Finder Method: `findByPosition(String position)`

Description: In a `SELECT` clause, the `OBJECT` keyword must precede a stand-alone identification variable such as `p`. The `DISTINCT` keyword eliminates duplicate values.

The `WHERE` clause restricts the players retrieved by checking their `position`, a persistent field of the `PlayerEJB` entity bean. The `?1` element denotes the input parameter of the `findByPosition` method.

See Also: Input Parameters (page 200)

DISTINCT and OBJECT Keywords (page 209)

Example 3

```
SELECT DISTINCT OBJECT(p)
FROM Player p
WHERE p.position = ?1 AND p.name = ?2
```

Data Retrieved: The players with the specified position and name.

Finder Method: `findByPositionAndName(String position, String name)`

Description: The `position` and `name` elements are persistent fields of the `PlayerEJB` entity bean. The `WHERE` clause compares the values of these fields with the parameters of the `findByPositionAndName` method. EJB QL denotes an input parameter with a question mark followed by an integer. The first input parameter is `?1`, the second is `?2`, and so forth.

Finder Queries That Navigate to Related Beans

In EJB QL, an expression can traverse—or navigate—to related beans. These expressions are the primary difference between EJB QL and SQL. EJB QL navigates to related beans, whereas SQL joins tables.

Example 4

```
SELECT DISTINCT OBJECT(p)
FROM Player p, IN (p.teams) AS t
WHERE t.city = ?1
```

Data Retrieved: The players whose teams belong to the specified city.

Finder Method: `findByCity(String city)`

Description: The `FROM` clause declares two identification variables: `p` and `t`. The `p` variable represents the `PlayerEJB` entity bean and the `t` variable represents the related `TeamEJB` beans. The declaration for `t` references the previously declared `p` variable. The `IN` keyword signifies that `teams` is a collection of related beans. The `p.teams` expression navigates from a `PlayerEJB` bean to its related `TeamEJB` beans. The period in the `p.teams` expression is the navigation operator.

In the `WHERE` clause, the period preceding the `city` persistent variable is a delimiter, not a navigation operator. Strictly speaking, expressions can navigate to relationship fields (related beans), but not to persistent fields. To access a persistent field, an expression uses the period as a delimiter.

Expressions may not navigate (or further qualify) beyond relationship fields that are collections. In the syntax of an expression, a collection-valued field is a terminal symbol. Because the `teams` field is a collection, the `WHERE` clause cannot specify `p.teams.city`—an illegal expression.

See Also: Path Expressions (page 197)

Example 5

```
SELECT DISTINCT OBJECT(p)
FROM Player p, IN (p.teams) AS t
WHERE t.league = ?1
```

Data Retrieved: The players that belong to the specified league.

Finder Method: `findByLeague(LocalLeague league)`

Description: The expressions in this query navigate over two relationships. The `p.teams` expression navigates the `PlayerEJB-TeamEJB` relationship and the `t.league` expression navigates the `TeamEJB-LeagueEJB` relationship.

In the other examples, the input parameters are `String` objects, but in this example the parameter is an object whose type is a `LocalLeague` interface. This type matches the `league` relationship field in the comparison expression of the `WHERE` clause.

Example 6

```
SELECT DISTINCT OBJECT(p)
FROM Player p, IN (p.teams) AS t
WHERE t.league.sport = ?1
```

Data Retrieved: The players who participate in the specified sport.

Finder Method: `findBySport(String sport)`

Description: The `sport` persistent field belongs to the `LeagueEJB` bean. To reach the `sport` field, the query must first navigate from the `PlayerEJB` bean to the `TeamEJB` bean (`p.teams`) and then from the `TeamEJB` bean to the `LeagueEJB` bean (`t.league`). Because the `league` relationship field is not a collection, it may be followed by the `sport` persistent field.

Finder Queries With Other Conditional Expressions

Every `WHERE` clause must specify a conditional expression, of which there are several kinds. In the previous examples, the conditional expressions are comparison expressions that test for equality. The following examples demonstrate some of the other kinds of conditional expressions. For descriptions of all conditional expressions, see WHERE Clause (page 200).

Example 7

```
SELECT OBJECT(p)
FROM Player p
WHERE p.teams IS EMPTY
```

Data Retrieved: All players who do not belong to a team.

Finder Method: `findNotOnTeam()`

Description: The `teams` relationship field of the `PlayerEJB` bean is a collection. If a player does not belong to a team, then the `teams` collection is empty and the conditional expression is `TRUE`.

See Also: Empty Collection Comparison Expressions (page 204)

Example 8

```
SELECT DISTINCT OBJECT(p)
FROM Player p
WHERE p.salary BETWEEN ?1 AND ?2
```

Data Retrieved: The players whose salaries fall within the range of the specified salaries.

Finder Method: `findBySalaryRange(double low, double high)`

Description: This `BETWEEN` expression has three arithmetic expressions: a persistent field (`p.salary`) and the two input parameters (`?1`, `?2`). The following expression is equivalent to the `BETWEEN` expression:

```
p.salary >= ?1 AND p.salary <= ?2
```

See also: BETWEEN Expressions (page 202)

Example 9

```
SELECT DISTINCT OBJECT(p1)
FROM Player p1, Player p2
WHERE p1.salary > p2.salary AND p2.name = ?1
```

Data Retrieved: All players whose salaries are higher than the salary of the player with the specified name.

Finder Method: `findByHigherSalary(String name)`

Description: The FROM clause declares two identification variables (p1, p2) of the same type (Player). Two identification variables are needed because the WHERE clause compares the salary of one player (p2) with that of the other players (p1).

See Also: Identification Variables (page 195)

Select Queries

The queries in this selection are for select methods. Unlike finder methods, a select method may return persistent fields or other entity beans.

Example 10

```
SELECT DISTINCT t.league
FROM Player p, IN (p.teams) AS t
WHERE p = ?1
```

Data Retrieved: The leagues that the specified player belongs to.

Select Method: ejbSelectLeagues(LocalPlayer player)

Description: The return type of this query is the abstract schema type of the LeagueEJB entity bean. This abstract schema type maps to the LocalLeague-Home interface. Because the expression t.league is not a stand-alone identification variable, the OBJECT keyword is omitted.

See Also: SELECT Clause (page 207)

Example 11

```
SELECT DISTINCT t.league.sport
FROM Player p, IN (p.teams) AS t
WHERE p = ?1
```

Data Retrieved: The sports that the specified player participates in.

Select Method: ejbSelectSports(LocalPlayer player)

Description: This query returns a String named sport, which is a persistent field of the LeagueEJB entity bean.

Full Syntax

This section discusses the EJB QL syntax, as defined in the *Enterprise JavaBeans™ Specification*. Much of the following material paraphrases or directly quotes the *Enterprise JavaBeans™ Specification*.

BNF Grammar of EJB QL

Here is the entire BNF diagram for EJB QL:

```
EJB QL ::= select_clause from_clause [where_clause]

from_clause ::= FROM identification_variable_declaration
    [, identification_variable_declaration]*

identification_variable_declaration ::=
    collection_member_declaration |
    range_variable_declaration

collection_member_declaration ::=
    IN (collection_valued_path_expression) [AS] identifier

range_variable_declaration ::=
    abstract_schema_name [AS] identifier

single_valued_path_expression ::=
    {single_valued_navigation |
    identification_variable}.cmp_field |
    single_valued_navigation

single_valued_navigation ::=
    identification_variable.[single_valued_cmr_field.]*
    single_valued_cmr_field

collection_valued_path_expression ::=
    identification_variable.[single_valued_cmr_field.]*
    collection_valued_cmr_field

select_clause ::= SELECT [DISTINCT]
    {single_valued_path_expression |
    OBJECT(identification_variable)}

where_clause ::= WHERE conditional_expression

conditional_expression ::= conditional_term |
    conditional_expression OR conditional_term
```

```
conditional_term ::= conditional_factor |
    conditional_term AND conditional_factor

conditional_factor ::= [ NOT ] conditional_test

conditional_test :: = conditional_primary

conditional_primary ::=
    simple_cond_expression | (conditional_expression)

simple_cond_expression ::=
    comparison_expression |
    between_expression |
    like_expression |
    in_expression |
    null_comparison_expression |
    empty_collection_comparison_expression |
    collection_member_expression

between_expression ::=
    arithmetic_expression [NOT] BETWEEN
    arithmetic_expression AND arithmetic_expression

in_expression ::=
    single_valued_path_expression
    [NOT] IN (string_literal [, string_literal]* )

like_expression ::=
    single_valued_path_expression
    [NOT] LIKE pattern_value [ESCAPE escape-character]

null_comparison_expression ::=
    single_valued_path_expression IS [NOT] NULL

empty_collection_comparison_expression ::=
    collection_valued_path_expression IS [NOT] EMPTY

collection_member_expression ::=
    {single_valued_navigation | identification_variable |
    input_parameter}
    [NOT] MEMBER [OF] collection_valued_path_expression

comparison_expression ::=
    string_value { =|<>} string_expression |
    boolean_value { =|<>} boolean_expression} |
    datetime_value { = | <> | > | < } datetime_expression |
    entity_bean_value { = | <> } entity_bean_expression |
```

```
    arithmetic_value comparison_operator
    single_value_designator

arithmetic_value ::= single_valued_path_expression |
    functions_returning_numerics

single_value_designator ::= scalar_expression

comparison_operator ::=
    = | > | >= | < | <= | <>

scalar_expression ::= arithmetic_expression

arithmetic_expression ::= arithmetic_term |
    arithmetic_expression { + | - } arithmetic_term

arithmetic_term ::= arithmetic_factor |
    arithmetic_term { * | / } arithmetic_factor

arithmetic_factor ::= { + |- } arithmetic_primary

arithmetic_primary ::= single_valued_path_expression |
    literal | (arithmetic_expression) |
    input_parameter | functions_returning_numerics

string_value ::= single_valued_path_expression |
    functions_returning_strings

string_expression ::= string_primary | input_expression

string_primary ::= single_valued_path_expression | literal |
    (string_expression) | functions_returning_strings

datetime_value ::= single_valued_path_expression

datetime_expression ::= datetime_value | input_parameter

boolean_value ::= single_valued_path_expression

boolean_expression ::= single_valued_path_expression |
   literal | input_parameter

entity_bean_value ::=
    single_valued_navigation | identification_variable

entity_bean_expression ::= entity_bean_value | input_parameter

functions_returning_strings ::=
```

```
        CONCAT(string_expression, string_expression) |
        SUBSTRING(string_expression, arithmetic_expression,
        arithmetic_expression)

    functions_returning_numerics::=
        LENGTH(string_expression) |
        LOCATE(string_expression,
        string_expression[, arithmetic_expression]) |
        ABS(arithmetic_expression) |
        SQRT(arithmetic_expression)
```

BNF Symbols

Table 8 describes the BNF symbols used in the preceding diagram.

Table 8 BNF Symbol Summary

Symbol	Description
::=	the element to the left of the symbol is defined by the constructs on the right
*	the preceding construct may occur zero or more times
{...}	the constructs within the curly braces are grouped together
[...]	the constructs within the square brackets are optional
|	an exclusive OR
BOLDFACE	a keyword (although capitalized in the BNF diagram, keywords are not case sensitive)
whitespace	a whitespace character can be a space, horizontal tab, or form feed

FROM Clause

The `FROM` clause defines the domain of the query by declaring identification variables. Here is the syntax of the `FROM` clause:

```
from_clause ::= FROM identification_variable_declaration
    [, identification_variable_declaration]*
```

```
identification_variable_declaration ::=
    collection_member_declaration |
    range_variable_declaration

collection_member_declaration ::=
    IN (collection_valued_path_expression) [AS] identifier

range_variable_declaration ::=
    abstract_schema_name [AS] identifier
```

Identifiers

An identifier is a sequence of one or more characters. The first character must be a valid first character (letter, $, _) in an identifier of the Java™ programming language (hereafter in this chapter called simply "Java"). Each subsequent character in the sequence must be a valid non-first character (letter, digit, $, _) in a Java identifier. (For details, see the J2SE™ API documentation of the `isJavaIdentifierStart` and `isJavaIdentifierPart` methods of the `Character` class.) The question mark (?) is a reserved character in EJB QL and cannot be used in an identifier. Unlike a Java variable, an EJB QL identifier is not case sensitive.

An identifier cannot be the same as an EJB QL keyword:

```
AND       MEMBER
AS        NOT
BETWEEN   NULL
DISTINCT  OBJECT
EMPTY     OF
FALSE     OR
FROM      SELECT
IN        TRUE
IS        UNKNOWN
LIKE      WHERE
```

EJB QL keywords are also reserved words in SQL. In the future, the list of EJB QL keywords may expand to include other reserved SQL words. The *Enterprise JavaBeans™ Specification* recommends that you not use other reserved SQL words for EJB QL identifiers.

Identification Variables

An identification variable is an identifier declared in the `FROM` clause. Although the `SELECT` and `WHERE` clauses may reference identification variables, they cannot declare them. All identification variables must be declared in the `FROM` clause.

Since an identification variable is an identifier, it has the same naming conventions and restrictions as an identifier. For example, an identification variable is not case sensitive and it cannot be the same as an EJB QL keyword. (See the previous section for more naming rules.) Also, within a given EJB JAR file an identifier name must not match the name of any entity bean or abstract schema.

The `FROM` clause may contain multiple declarations, separated by commas. A declaration may reference another identification variable that has been previously declared (to the left). In the following `FROM` clause, the variable `t` references the previously declared variable `p`:

```
FROM Player p, IN (p.teams) AS t
```

Even if an identification variable is not used in the `WHERE` clause, its declaration can affect the results of the query. For an example, compare the next two queries. This query returns all players, whether or not they belong to a team:

```
SELECT OBJECT(p)
FROM Player p
```

In contrast, because the next query declares the `t` identification variable, it fetches all players that belong to a team:

```
SELECT OBJECT(p)
FROM Player p, IN (p.teams) AS t
```

The following query returns the same results as the preceding query, but the `WHERE` clause makes it easier to read:

```
SELECT OBJECT(p)
FROM Player p
WHERE p.teams IS NOT EMPTY
```

An identification variable always designates a reference to a single value, whose type is that of the expression used in the declaration. There are two kinds of declarations: range variable and collection member.

Range Variable Declarations

To declare an identification variable as an abstract schema type, you specify a range variable declaration. In other words, an identification variable can range over the abstract schema type of an entity bean. In the following example, an identification variable named `p` represents the abstract schema named `Player`:

```
FROM Player p
```

A range variable declaration may include the optional AS operator:

```
FROM Player AS p
```

In most cases, to obtain objects a query navigates through the relationships with path expressions. But for those objects that cannot be obtained by navigation, you can use a range variable declaration to designate a starting point (or “root”).

If the query compares multiple values of the same abstract schema type, then the FROM clause must declare multiple identification variables for the abstract schema:

```
FROM Player p1, Player p2
```

For a sample of such a query, see Example 9 (page 189).

Collection Member Declarations

In a one-to-many relationship, the multiple side consists of a collection of entity beans. An identification variable may represent a member of this collection. To access a collection member, the path expression in the variable’s declaration navigates through the relationships in the abstract schema. (For more information on path expressions, see the following section.) Because a path expression may be based on another path expression, the navigation can traverse across several relationships. See Example 6 (page 188).

A collection member declaration must include the IN operator, but it may omit the optional AS operator.

In the following example, the entity bean represented by the abstract schema named Player has a relationship field called teams. The identification variable named t represents a single member of the teams collection.

```
FROM Player p, IN (p.teams) AS t
```

Path Expressions

Path expressions are important constructs in the syntax of EJB QL, for several reasons. First, they define navigation paths through the relationships in the abstract schema. These path definitions affect both the scope and the results of a query. Second, they may appear in any of the three main clauses of an EJB QL query (SELECT, WHERE, FROM). Finally, although much of EJB QL is a subset of SQL, path expressions are extensions not found in SQL.

Syntax

There are two types of path expressions: single-valued and collection-valued. Here is the syntax for path expressions:

```
single_valued_path_expression ::=
    {single_valued_navigation |
    identification_variable}.cmp_field |
    single_valued_navigation

single_valued_navigation ::=
    identification_variable.[single_valued_cmr_field.]*
    single_valued_cmr_field

collection_valued_path_expression ::=
    identification_variable.[single_valued_cmr_field.]*
    collection_valued_cmr_field
```

In the preceding diagram, the `cmp_field` element represents a persistent field and the `cmr_field` element designates a relationship field. The term `single_valued` qualifies the relationship field as the single side of a one-to-one or one-to-many relationship; the term `collection_valued` designates it as the multiple (collection) side of a relationship.

The period (.) in a path expression serves two functions. If a period precedes a persistent field, it is a delimiter between the field and the identification variable. If a period precedes a relationship field, it is a navigation operator.

Examples

In the following query, the WHERE clause contains a single-valued expression. The `p` is an identification variable and the `salary` is a persistent field of `Player`.

```
SELECT DISTINCT OBJECT(p)
FROM Player p
WHERE p.salary BETWEEN ?1 AND ?2
```

The WHERE clause of the next example also contains a single-valued expression. The `t` is an identification variable, the `league` is a single-valued relationship field, and the `sport` is a persistent field of `league`.

```
SELECT DISTINCT OBJECT(p)
FROM Player p, IN (p.teams) AS t
WHERE t.league.sport = ?1
```

In the next query, the `WHERE` clause contains a collection-valued expression. The `p` is an identification variable and the `teams` designates a collection-valued relationship field.

```
SELECT DISTINCT OBJECT(p)
FROM Player p
WHERE p.teams IS EMPTY
```

Expression Types

The type of an expression is the type of the object represented by the ending element, which can be either of the following:

- persistent field
- single-valued relationship field
- collection-valued relationship field

For example, the type of the expression `p.salary` is a `double` because the terminating persistent field (`salary`) is a `double`.

In the expression `p.teams`, the terminating element is a collection-valued relationship field (`teams`). This expression's type is a collection of the abstract schema type named `Team`. Because `Team` is the abstract schema name for the `TEAMEJB` entity bean, this type maps to the bean's local home interface, `LocalTeamHome`. For more information the type mapping of abstract schemas, see Return Types (page 208).

Navigation

A path expression enables the query to navigate to related entity beans. The terminating elements of an expression determine whether navigation is allowed. If an expression contains a single-valued relationship field, the navigation may continue to an object that is related to the field. However, an expression cannot navigate beyond a persistent field or a collection-valued relationship field. For example, the expression `p.teams.league.sport` is illegal, since `teams` is a collection-valued relationship field. To reach the `sport` field, the `FROM` clause could define an identification variable named `t` for the `teams` field:

```
FROM Player AS p, IN (p.teams) t
WHERE t.league.sport = 'soccer'
```

WHERE Clause

The WHERE clause specifies a conditional expression that limits the values returned by the query. The query returns all corresponding values in the data store for which the conditional expression is TRUE. Although usually specified, the WHERE clause is optional. If the WHERE clause is omitted, then the query returns all values. The high-level syntax for the WHERE clause follows:

```
Where_clause ::= WHERE conditional_expression
```

Literals

There are three kinds of literals: string, numeric, and boolean.

String Literals. A string literal is enclosed in single quotes:

```
'Duke'
```

If a string literal contains a single quote, you indicate the quote with two single quotes:

```
'Duke''s'
```

Like a Java String, a string literal in EJB QL uses the Unicode character encoding.

Numeric Literals. There are two types of numeric literals: exact and approximate.

An exact numeric literal is a numeric value without a decimal point, such as 65, -233, +12. Using the Java integer syntax, exact numeric literals support numbers in the range of a Java long.

An approximate numeric literal is a numeric value in scientific notation, such as 57., -85.7, +2.1. Using the syntax of the Java floating point literal, approximate numeric literals support numbers in the range of a Java double.

Boolean Literals. A boolean literal is either TRUE or FALSE. These keywords are not case sensitive.

Input Parameters

An input parameter is designated by a question mark (?) followed by an integer. For example, the first input parameter is ?1, the second is ?2, and so forth.

The following rules apply to input parameters:

- They can be used only in a WHERE clause.
- Their use is restricted to a single-valued path expression within a conditional expression.
- They must be numbered, starting with the integer 1.
- The number of input parameters in the WHERE clause must not exceed the number of input parameters in the corresponding finder or select method.
- The type of an input parameter in the WHERE clause must match the type of the corresponding argument in the finder or select method.

Conditional Expressions

A WHERE clause consists of a conditional expression, which is evaluated from left to right within a precedence level. You may change the order of evaluation with parentheses.

Here is the syntax of a conditional expression:

```
conditional_expression ::= conditional_term |
    conditional_expression OR conditional_term

conditional_term ::= conditional_factor |
    conditional_term AND conditional_factor

conditional_factor ::= [ NOT ] conditional_test

conditional_test :: = conditional_primary

conditional_primary ::=
    simple_cond_expression | (conditional_expression)

simple_cond_expression ::=
    comparison_expression |
    between_expression |
    like_expression |
    in_expression |
    null_comparison_expression |
    empty_collection_comparison_expression |
    collection_member_expression
```

Operators and Their Precedence

Table 9 lists the EJB QL operators in order of decreasing precedence.

Table 9 EJB QL Operator Precedence

Type	Precedence Order
Navigation	. (a period)
Arithmetic	+ - (unary) * / (multiplication and division) + - (addition and subtraction)
Comparison	= > >= < <= <> (not equal)
Logical	NOT AND OR

BETWEEN Expressions

A BETWEEN expression determines whether an arithmetic expression falls within a range of values. The syntax of the BETWEEN expression follows:

```
between_expression ::=
    arithmetic_expression [NOT] BETWEEN
    arithmetic_expression AND arithmetic_expression
```

These two expressions are equivalent:

```
p.age BETWEEN 15 AND 19
p.age >= 15 AND p.age <= 19
```

The following two expressions are also equivalent:

```
p.age NOT BETWEEN 15 AND 19
p.age < 15 OR p.age > 19
```

If an arithmetic expression has a NULL value, then the value of the BETWEEN expression is unknown.

IN Expressions

An IN expression determines whether or not a string belongs to a set of string literals. Here is the syntax of the IN expression:

```
in_expression ::=
    single_valued_path_expression
    [NOT] IN (string_literal [, string_literal]* )
```

The single-valued path expression must have a String value. If the single-valued path expression has a NULL value, then the value of the IN expression is unknown.

In the following example, if the country is 'UK' the expression is TRUE. If the country is 'Peru' it is FALSE.

```
o.country IN ('UK', 'US', 'France')
```

LIKE Expressions

A LIKE expression determines whether a wildcard pattern matches a string. Here is the syntax:

```
like_expression ::=
    single_valued_path_expression
    [NOT] LIKE pattern_value [ESCAPE escape-character]
```

The single-valued path expression must have a String value. If this value is NULL, then the value of the LIKE expression is unknown. The pattern value is a string literal that may contain wildcard characters. The underscore (_) wildcard character represents any single character. The percent (%) wildcard character represents zero or more characters. The ESCAPE clause specifies an escape-character for the wildcard characters in the pattern value.

Table 10 shows some sample LIKE expressions. The TRUE and FALSE columns indicate the value of the LIKE expression for a single-valued path expression.

Table 10 LIKE Expression Examples

Expression	TRUE	FALSE
address.phone LIKE '12%3'	'123' '12993'	'1234'
asentence.word LIKE 'l_se'	'lose'	'loose'
aword.underscored LIKE '_%' ESCAPE '\'	'_foo'	'bar'
address.phone NOT LIKE '12%3'	1234	'123' '12993'

NULL Comparison Expressions

A NULL comparison expression tests whether a single-valued path expression has a NULL value. Usually, this expression is used to test whether or not a single-valued relationship has been set. If a path expression contains a NULL value during evaluation, it returns a NULL value. Here is the syntax of a NULL comparison expression:

```
null_comparison_expression ::=
    single_valued_path_expression IS [NOT] NULL
```

Empty Collection Comparison Expressions

An empty collection comparison expression tests whether a collection-valued path expression has no elements. In other words, it tests whether or not a collection-valued relationship has been set. Here is the syntax:

```
empty_collection_comparison_expression ::=
    collection_valued_path_expression IS [NOT] EMPTY
```

If the collection-valued path expression is NULL, then the empty collection comparison expression has a NULL value.

Collection Member Expressions

The collection member expression determines whether a value is a member of a collection. The value and the collection members must have the same type. The expression syntax follows:

```
collection_member_expression ::=
    {single_valued_navigation | identification_variable |
    input_parameter}
    [NOT] MEMBER [OF] collection_valued_path_expression
```

If the collection-valued path expression is unknown, then the collection member expression is unknown. If the collection-valued path expression designates an empty collection, then the collection member expression is `FALSE`.

Functional Expressions

EJB QL includes several string and arithmetic functions, which are listed in the following tables. In Table 11, the `start` and `length` arguments are of type `int`. They designate positions in the `String` argument. In Table 12, the `number` argument may be either an `int`, a `float`, or a `double`.

Table 11 String Expressions

Function Syntax	**Return Type**
CONCAT(String, String)	String
SUBSTRING(String, start, length)	String
LOCATE(String, String [, start])	int
LENGTH(String)	int

Table 12 Arithmetic Expressions

Function Syntax	**Return Type**
ABS(number)	int, float, or double
SQRT(double)	double

NULL Values

If the target of a reference is not in the persistent store, then the target is NULL. For conditional expressions containing NULL, EJB QL uses the semantics defined by SQL92. Briefly, these semantics are as follows:

- If a comparison or arithmetic operation has an unknown value, it yields a NULL value.
- If a path expression contains a NULL value during evaluation, it returns a NULL value.
- The IS NULL test converts a NULL persistent field or a single-valued relationship field to TRUE. The IS NOT NULL test converts them to FALSE.
- Boolean operators and conditional tests use the three-valued logic defined by the following tables.

Table 13 AND Operator Logic

AND	T	F	U
T	T	F	U
F	F	F	F
U	U	F	U

Table 14 OR Operator Logic

OR	T	F	U
T	T	T	T
F	T	F	U
U	T	U	U

Table 15 NOT Operator Logic

NOT	
T	F

Table 15 NOT Operator Logic (Continued)

NOT	
F	T
U	U

Table 16 Conditional Test

Conditional Test	**T**	**F**	**U**
expression IS TRUE	T	F	F
expression IS FALSE	F	T	F
expression IS UNKNOWN	F	F	T

Equality Semantics

In EJB QL, only values of the same type can be compared. However, this rule has one exception: Exact and approximate numeric values can be compared. In such a comparison, the required type conversion adheres to the rules of Java numeric promotion.

EJB QL treats compared values as if they were Java types, not as if they represented types in the underlying data store. For example, if a persistent field could be either an integer or a `NULL`, then it must be designated as an `Integer` object, not as an `int` primitive. This designation is required because a Java object can be `NULL` but a primitive cannot.

Two strings are equal only if they contain the same sequence of characters. Trailing blanks are significant; for example, the strings `'abc'` and `'abc   '` are not equal.

Two entity beans of the same abstract schema type are equal only if their primary keys have the same value.

SELECT Clause

The `SELECT` clause defines the types of the objects or values returned by the query. The `SELECT` clause has the following syntax:

```
select_clause ::= SELECT [DISTINCT]
    {single_valued_path_expression |
    OBJECT(identification_variable)}
```

Return Types

The return type defined by the SELECT clause must match that of the finder or select method for which the query is defined.

For finder method queries, the return type of the SELECT clause is the abstract schema type of the entity bean that defines the finder method. This abstract schema type maps to the type of the interface (or a collection thereof) that specifies the finder method. If the bean's remote home interface defines the finder method, then the return type is the remote interface (or a collection of remote interfaces). Likewise, if the local home interface defines the finder method, the return type is the local home interface (or a collection). For example, the LocalPlayerHome interface of the PlayerEJB entity bean defines the findall method:

```
public Collection findAll() throws FinderException;
```

The EJB QL query of the findall method returns a collection of LocalPlayerHome interface types:

```
SELECT OBJECT(p)
FROM Player p
```

For select method queries, the return type of the SELECT clause may be one of the following:

- The abstract schema of the entity bean that contains the select method.
- The abstract schema of a related entity bean

  (By default, each of these abstract schema types map to the local home interface of the entity bean. Although uncommon, in the deployment descriptor you may override the default mapping by specifying a remote home interface.)
- A persistent field

The PlayerEJB entity bean, for example, implements the ejbSelectSports method, which returns a collection of String objects for sport. The sport is a persistent field of the LeagueEJB entity bean. See Example 11 (page 190).

A SELECT clause cannot specify a collection-valued expression. For example, the SELECT clause p.teams is invalid because teams is a collection. However, the

SELECT clause in the following query is valid because the t is a single element of the teams collection:

```
SELECT t
FROM Player p, IN (p.teams) AS t
```

DISTINCT and OBJECT Keywords

The DISTINCT keyword eliminates duplicate return values. If the method of the query returns a java.util.Collection—which allows duplicates—to eliminate duplicates you must specify the DISTINCT keyword. However, if the method returns a java.util.Set, the DISTINCT keyword is redundant because a java.util.Set may not contain duplicates.

The OBJECT keyword must precede a stand-alone identification variable, but it must not precede a single-valued path expression. If an identification variable is part of a single-valued path expression, it is not stand-alone.

EJB QL Restrictions

EJB QL has a few restrictions:

- Comments are not allowed.
- Date and time values are in milliseconds and use a Java long. A date or time literal should be an integer literal. To generate a millisecond value, you may use the java.util.Calendar class.
- Currently, container-managed persistence does not support inheritance. For this reason, two entity beans of different types cannot be compared.

Web Components

by Stephanie Bodoff

WHEN a web-based client such as a browser communicates with a J2EE application, it does so through server-side objects called web components. There are two types of web components: Java™ Servlets and JavaServer Pages™ (JSP™) pages. Servlets are Java programming language classes that dynamically process requests and construct responses. JSP pages are text-based documents that execute as servlets, but allow a more natural approach to creating static content. While servlets and JSP pages can be used interchangeably, each has its strengths. Servlets are best suited to managing the control functions of an application, such as dispatching requests, and handling non-textual data. JSP pages are more appropriate for generating text-based markup such as HTML, SVG, WML, and XML.

This chapter describes the packaging, configuration, and deployment procedures common to servlets and JSP pages. Subsequent chapters, Java Servlet Technology (page 225) and JavaServer Pages™ Technology (page 261), cover how to develop the web components. Many features of JSP technology are determined by Java Servlet technology so you should familiarize yourself with that material, even if you do not intend to write servlets.

Most web-based J2EE clients use the HTTP protocol and support for HTTP is a major aspect of web components. For a brief summary of HTTP protocol features see HTTP Overview (page 447).

Web Component Life Cycle

The J2EE platform provides many supporting services that enhance the capabilities of web components and make them easier to develop. However, because it must take into account these services, the process for creating and running a web component is different than that of traditional stand-alone Java classes.

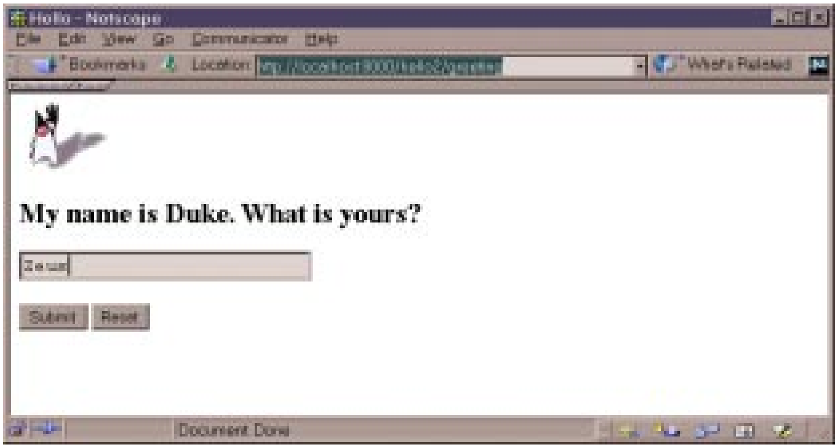
Web components run within an environment called a *web container.* The web container provides services such as request dispatching, security, concurrency, and life cycle management. It also gives web components access to the J2EE platform APIs such as naming, transactions, and email. Before it can be executed, a web component must be installed (or *deployed)* into a web container.

Certain aspects of web component behavior can be configured when it is packaged and deployed. The configuration information is maintained in a text file in XML format called a *web application deployment descriptor.* When you package and deploy web components using the J2EE SDK `deploytool`, it automatically generates or updates the deployment descriptor based on data that you enter in `deploytool` wizards and inspectors. You can also manually create a deployment descriptor according to the schema described in the Java Servlet specification.

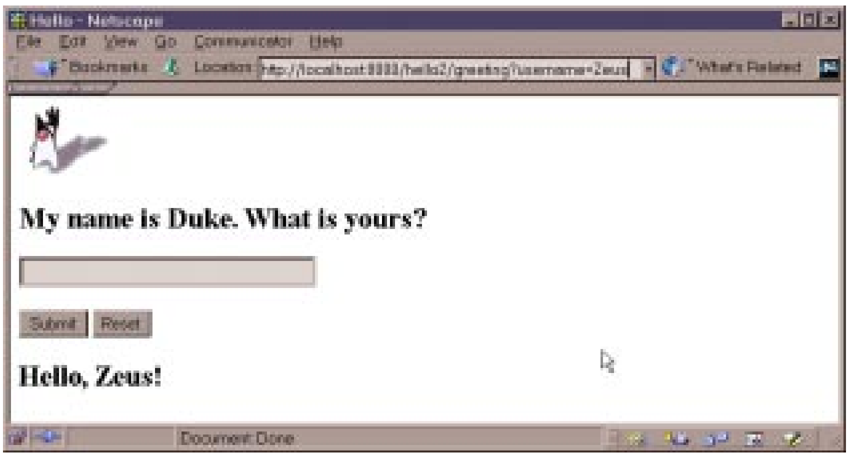
The process for creating, deploying, and executing a web component can be summarized as follows:

1. Develop the web component code (including possibly a deployment descriptor).
2. Package the web component along with any static resources (for example, images) referenced by the component.
3. Deploy the application.
4. Access a URL that references the web component.

These steps are expanded on in the following sections and are illustrated with a Hello, World style application. This application allows a user to enter a name into an HTML form:



and then displays a greeting after the name is submitted:



The Hello application contains two web components that generate the greeting and the response. This tutorial has two versions of this application: a servlet version called `Hello1App` in which the components are implemented by two servlet classes, `GreetingServlet.java` and `ResponseServlet.java` and a JSP version called `Hello2App` in which the components are implemented by two JSP pages, `greeting.jsp` and `response.jsp`. The two versions are used to illustrate the tasks involved in packaging and deploying a J2EE application that contains web components.

Packaging Web Components

You add web components to a J2EE application in a package called a *web application archive* (WAR), which is a JAR similar to the package used for Java class libraries. A WAR usually contains other resources besides web components, including:

- Server-side utility classes (database beans, shopping carts, and so on).
- Static web resources (HTML, image, and sound files, and so on)
- Client-side classes (applets and utility classes)

A WAR has a specific hierarchical directory structure. The top-level directory of a WAR is the *document root* of the application. The document root is where JSP pages, client-side classes and archives, and static web resources are stored.

The document root contains a subdirectory called `WEB-INF`, which contains the following files and directories:

- `web.xml` - the web application deployment descriptor
- Tag library descriptor files (see Tag Library Descriptors (page 306)).
- `classes` - a directory that contains server-side classes: servlet, utility classes, and JavaBeans components.
- `lib` - a directory that contains JAR archives of libraries (tag libraries and any utility libraries called by server-side classes).

You can also create application-specific subdirectories (that is , package directories) in either the document root or the `WEB-INF/classes` directory.

Note: When you add classes and archives to a WAR, `deploytool` automatically packages them in the `WEB-INF` subdirectory. This is correct for web components and server-side utility classes, but incorrect for client-side classes such as applets and any archives accessed by applets. To put client-side classes and archives in the correct location you must “drag” them to the document root after you have added them to the archive.

Creating a WAR

When you add the first web component to a J2EE application, `deploytool` automatically creates a new WAR to contain the component. A later section describes how to add a web component.

You can also manually create a WAR in three ways:

- With the `packager` tool distributed with the J2EE SDK. This tool is described in Packager (page 455).
- With the `war` task of the `ant` portable build tool. `Ant` is used to build the J2EE Tutorial examples. The example application described in The Example JSP Pages (page 265) uses ant to create the WAR.
- With the JAR tool distributed with the J2SE. If you arrange your application development directory in the structure required by the WAR format, it is straightforward to create a web application archive file in the required format. You simply execute the following command in the top-level directory of the application:

```
jar cvf archiveName.war .
```

Note that in order to use any of these methods, you must also manually create a deployment descriptor in the correct format.

Adding a WAR to a J2EE Application

If you manually create a WAR or you obtain a WAR from another party, you can add it to an existing J2EE application as follows:

1. Select a J2EE application.
2. Select File->Add->Web WAR.
3. Navigate to the directory containing the WAR, select the WAR, and click Add Web WAR.

See The Example JSP Pages (page 265) for an example.

You can also add a WAR to a J2EE application using the `packager` tool. The Duke’s Bank application described in Building, Deploying, and Running the Application (page 435) uses `packager`.

Adding a Web Component to a WAR

The following procedure describes how to create and add the web component in the `Hello1App` application to a WAR. Although the web component wizard solicits WAR and component-level configuration information when you add the component, this chapter describes how to add the component and provide configuration information at a later time using application, WAR, and web component inspectors:

1. Go to `j2eetutorial/examples/src` and build the example by running `ant hello1`. For detailed instructions, see About the Examples (page xxii)).
2. Create a J2EE application called `Hello1App`.
   a. Select File->New->Application.
   b. Click Browse.
   c. In the file chooser, navigate to `j2eetutorial/examples/src/web/hello1`.
   d. In the File Name field, enter `Hello1App` .
   e. Click New Application.
   f. Click OK.
3. Create the WAR and add the `GreetingServlet` web component and all the of the `Hello1App` application content.
   a. Invoke the web component wizard by selecting File->New->Web Component.
   b. In the combo box labelled Create New WAR File in Application select Hello1App. Enter `Hello1WAR` in the field labeled WAR Display Name.
   c. Click Edit to add the content files.
   d. In the Edit Contents dialog, navigate to `j2eetutorial/examples/build/web/hello1`. Select GreetingServlet.class, ResponseServlet.class, and duke.waving.gif, and click Add. Click OK.
   e. Click Next.
   f. Select the servlet radio button.
   g. Click Next.
   h. Select GreetingServlet from the Servlet Class combo box.
   i. Click Finish.

4. Add the `ResponseServlet` web component.
   a. Invoke the web component wizard by selecting File->New->Web Component.
   b. In the combo box labelled Add to Existing WAR File select Hello1WAR.
   c. Click Next.
   d. Select the servlet radio button.
   e. Click Next.
   f. Select ResponseServlet from the Servlet Class combo box.
   g. Click Finish.

Note: You can add JSP pages to a WAR without creating a new web component for each page. You simply select the WAR, click Edit to edit the contents of the WAR, and add the pages. The JSP version of the Hello, World application, described in Updating Web Components (page 222), shows how to do this. If you choose this method, you will not be able to specify alias paths (described in Specifying an Alias Path (page 220)) for the pages.

Configuring Web Components

The following sections describe the web component configuration parameters that you will usually want to specify. Configuration parameters are specified at three levels: application, WAR, and component. A number of security parameters can be applied at the WAR and component levels. For information on security parameters, see Security (page 349).

Application-Level Configuration

Context Root

A *context root* is a path that gets mapped to the document root of a J2EE application. If the entry URL of an application is the same as the base of the web server's URL namespace (for example `http://<host>:8000`), the context root is an empty string. If your application's context root is `catalog`, then a request URL such as `http://<host>:8000/catalog/index.html` will retrieve the file `index.html` from the application's document root.

To specify the context root for the `Hello1App` application in `deploytool`,

1. Select Hello1App.
2. Select the Web Context tab
3. Enter `hello1` in the Context Root field.

WAR-Level Configuration

The following sections give generic procedures for specifying WAR-level configuration information. For some specific examples, see The Example Servlets (page 227).

Context Parameters

The web components in a WAR share an object that represents their web context (see Accessing the Web Context (page 253)). To specify initialization parameters that are passed to the context,

1. Select the WAR.
2. Select the Context tab.
3. Click Add.

References to Environment Entries, Enterprise Beans, Resource Environment Entries, or Resources

If your web components reference environment entries, enterprise beans, resource environment entries, or resources such as databases, you must declare the references as follows:

1. Select the WAR.
2. Select the Environment, Enterprise Bean Refs, Resource Env. Refs or Resource Refs tab.
3. Click Add in the panel to add a new reference.

Event Listeners

To add an event listener class (described in Handling Servlet Life Cycle Events (page 232)),

1. Select the WAR.
2. Select the Event Listeners tab.
3. Click Add.
4. Select the listener class from the new field in the Event Listener Classes panel.

Error Mapping

You can specify a mapping between the status code returned in an HTTP response or a Java programming language exception returned by any web component and another web component or resource (see Handling Errors (page 234)). To set up the mapping,

1. Select the WAR.
2. Select the File Refs tab.
3. Click Add in the Error Mapping panel.
4. Enter the HTTP status code (see HTTP Responses (page 448)) or fully-qualified class name of an exception in the Error/Exception field.
5. Enter the name of a resource to be invoked when the status code or exception is returned. The name should have a leading '`/`'.

Note: You can also define error pages for a JSP page contained in a WAR. If error pages are defined for both the WAR and a JSP page, the JSP page's error page takes precedence.

Filter Mapping

A web container uses filter mapping declarations to decide which filters to apply to a request, and in what order (see Filtering Requests and Responses (page 243)). The container matches the request URI to a servlet as described in Specifying an Alias Path (page 220). To determine which filters to apply, it matches filter mapping declarations by servlet name or URL pattern. The order in which filters are invoked is the order in which filter mapping declarations that match a request URI for a servlet appear in the filter mapping list.

You specify a filter mapping in the `deploytool` as follows:

1. Select the WAR.
2. Select the Filter Mapping tab.
3. Add a filter
   a. Click Edit Filter List.
   b. Click Add.
   c. Select the filter class.
   d. Enter a filter name.
   e. Add any filter initialization parameters.
   f. Click OK.
4. Map the filter
   a. Click Add.
   b. Select the filter name.
   c. Select the target type. A filter can be mapped to a specific servlet or to all servlets that match a given URL pattern.
   d. Specify the target. If the target is a servlet, select the servlet from the drop-down list. If the target is a URL pattern, enter the pattern.

Component-Level Configuration

Initialization Parameters

To specify parameters that are passed to the web component when it is initialized,

1. Select the web component.
2. Select the Init. Parameters tab.
3. Click Add to add a new parameter and value.

Specifying an Alias Path

When a request is received by a web container it must determine which web component should handle the request. It does so by mapping the URL path contained in the request to a web component. A URL path contains the context root (described in Context Root (page 217)) and an *alias* path:

```
http://<host>:8000/context root/alias path
```

Before a servlet can be accessed, the web container must have least one alias path for the component. The alias path must start with a '`/`' and end with a string or a wildcard expression with an extension (`*.jsp` for example). Since Web containers automatically map an alias path that ends with `*.jsp`, you do not have to specify an alias path for a JSP page unless you wish to refer to the page by a name other than its file name. In the example discussed in Updating Web Components (page 222), the page `greeting.jsp` has an alias, `/greeting`, but the page `response.jsp` is referenced by its file name within `greeting.jsp`.

You set up the mappings for the servlet version of the Hello application using the web component inspector as follows:

1. Select the GreetingServlet web component.
2. Select the Aliases tab.
3. Click Add to add a new mapping.
4. Type `/greeting` in the aliases list.
5. Select the ResponseServlet web component.
6. Click Add.
7. Type `/response` in the aliases list.

Deploying Web Components

The next step after you have created, packaged, and configured a J2EE application containing web components is to deploy the application. To deploy the `Hello1App` application,

1. Select Hello1App.
2. Select Tools->Deploy.
3. Select a Target Server.
4. Click Finish.

Executing Web Components

A web component is executed when a web browser is pointed at a URL that is mapped to the component. Once you have deployed the `Hello1App` application, you can run it by pointing a browser at:

```
http://<host>:8000/hello1/greeting
```

Replace *<host>* with the name of the host running the J2EE server. If your browser is running on the same host as the J2EE server, you may replace *<host>* with `localhost`.

Updating Web Components

During development, you will often need to make changes to web components. To update a servlet you modify the source file, recompile the servlet class, update the component in the WAR, and redeploy the application. Except for the compilation step, you update a JSP page in the same way.

To try this feature, first build, package, and deploy the JSP version of the Hello application:

1. Go to `j2eetutorial/examples/src` and build the example by running `ant hello2`.
2. Create a J2EE application called `Hello2App`.
   a. Select File->New->Application.
   b. In the file chooser, navigate to `j2eetutorial/examples/src/web/hello2`.
   c. In the File Name field, enter `Hello2App` .
   d. Click New Application.
   e. Click OK.
3. Create the WAR and add the `greeting` web component and all of the `Hello2App` application content.
   a. Invoke the web component wizard by selecting File->New->Web Component.
   b. In the combo box labelled Create New WAR File in Application select Hello2App. Enter `Hello2WAR` in the field labeled WAR Display Name.
   c. Click Edit to add the content files.
   d. In the Edit Contents dialog, navigate to `examples/build/web/hello2`. Select greeting.jsp, response.jsp, and duke.waving.gif, and click Add. Click OK.
   e. Click Next.
   f. Select the JSP radio button.
   g. Click Next.
   h. Select greeting.jsp from the JSP Filename combo box.

   i. Click Finish.

4. Add the alias /greeting for the greeting web component.
5. Specify the context root hello2.
6. Deploy Hello2App.
7. Execute the application by pointing a web browser at http://<host>:8000/hello2/greeting. Replace <*host*> with the name of the host running the J2EE server.

Now modify one of the JSP files. For example, you could replace the contents of response.jsp with:

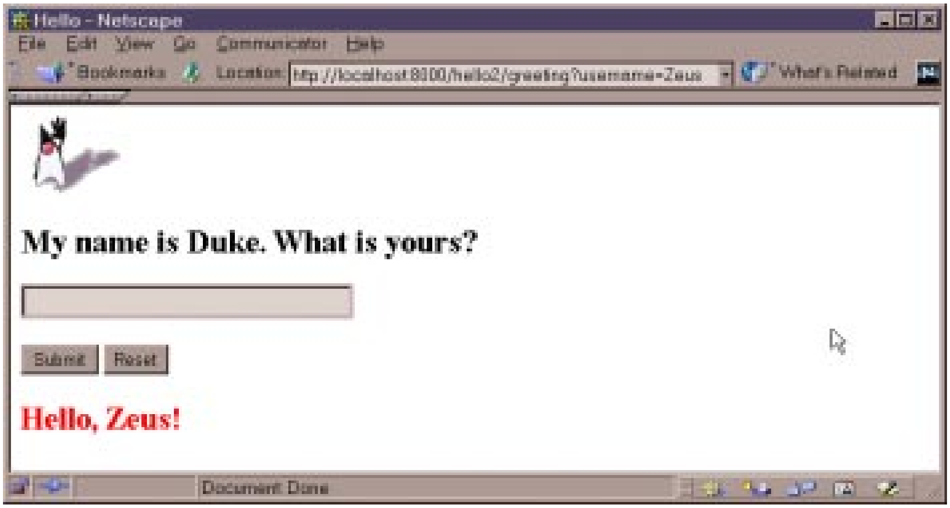
```
<h2><font color="red">Hello, <%=username%>!</font></h2>
```

To update the file in the WAR and redeploy the application:

1. Select Hello2App.
2. Select Tools->Update Files. A message should appear indicating that response.jsp has changed and reminding you to save the application.
3. Dismiss the message.
4. Select File->Save.You can skip this step if you leave the box labeled Save object before deploying in step 5.
5. Deploy the Hello2App.

You can also perform steps 2. through 5. by selecting Tools->Update and Redeploy.

When you execute the application, the color of the greeting should be red:



Java Servlet Technology

by Stephanie Bodoff

AS soon as the web began to be used for delivering services, service providers recognized the need for dynamic content. Applets, one of the earliest attempts towards this goal, focused on using the client platform to deliver dynamic user experiences. At the same time, developers also investigated using the server platform for this purpose. Initially, CGI scripts were the main technology used to generate dynamic content. Though widely used, CGI scripting technology has a number of shortcomings including platform-dependence and lack of scalability. To address these limitations, Java Servlet technology was created as a portable way to provide dynamic, user-oriented content.

What is a Servlet?

A servlet is a Java programming language class used to extend the capabilities of servers that host applications accessed via a request-response programming model. Although servlets can respond to any type of request, they are commonly used to extend the applications hosted by web servers. For such applications, Java Servlet technology defines HTTP-specific servlet classes.

The `javax.servlet` and `javax.servlet.http` packages provide interfaces and classes for writing servlets. All servlets must implement the `Servlet` interface, which defines life cycle methods.

When implementing a generic service, you can use or extend the `GenericServlet` class provided with the Java Servlet API. The `HttpServlet` class provides methods, such as `doGet` and `doPost`, for handling HTTP-specific services.

This chapter focuses on writing servlets that generate responses to HTTP requests. Some knowledge of the HTTP protocol is assumed; if you are unfamiliar with this protocol, you can get a brief introduction to HTTP in HTTP Overview (page 447).

The Example Servlets

To illustrate servlet capabilities, this chapter uses an example application called Duke's Bookstore. The source for the application is located in the `j2eetutorial/examples/src/web/bookstore1` directory created when you unzip the tutorial bundle (see Downloading the Examples (page xxii)). As shown in Table 17, each bookstore function is provided by a servlet. Different sections use the servlets to illustrate various tasks. For example, `BookDetailsServlet` illustrates how to handle HTTP GET requests and `CatalogServlet` shows you how to track session information.

Table 17 Duke's Bookstore Example Servlets

Function	**Servlet**
Enter the bookstore	`BookStoreServlet`
Create the bookstore banner	`BannerServlet`
Browse the bookstore catalog	`CatalogServlet`
Put a book in a shopping cart	`CatalogServlet and BookDetailsServlet`
Get detailed information on a specific book	`BookDetailsServlet`
Display the shopping cart	`ShowCartServlet`
Remove one or more books from the shopping cart	`ShowCartServlet`
Buy the books in the shopping cart	`CashierServlet`
Receive an acknowledgement for the purchase	`ReceiptServlet`

The data for the bookstore application is maintained in a Cloudscape database and is accessed through the helper class `database.BookDB`. The `database` package also contains the class `BookDetails` which represents a book. The shopping cart and shopping cart items are represented by the classes `cart.ShoppingCart` and `cart.ShoppingCartItem`.

To build, deploy, and run the example:

1. Go to `j2eetutorial/examples/src` and build the example by running `ant bookstore1` (See How to Build and Run the Examples (page xxiii)).
2. Start the `j2ee` server.
3. Start `deploytool`.
4. Start the Cloudscape database server by running `cloudscape -start`.
5. Load the bookstore data into the database by running `ant create-web-db`.
6. Create a J2EE application called `Bookstore1App`.
   a. Select File->New->Application.
   b. In the file chooser, navigate to `j2eetutorial/examples/src/web/bookstore1`.
   c. In the File Name field, enter `Bookstore1App` .
   d. Click New Application.
   e. Click OK.
7. Create the WAR and add the `BannerServlet` web component and all of the Duke's Bookstore content to the `Bookstore1App` application.
   a. Select File->New->Web Component.
   b. Click the Create New WAR File in Application radio button and select Bookstore1App from the combo box. Enter `Bookstore1WAR` in the field labeled WAR Display Name.
   c. Click Edit to add the content files.
   d. In the Edit Archive Contents dialog box, navigate to `j2eetutorial/examples/build/web/bookstore1`. Select BannerServlet.class, BookStoreServlet.class, BookDetailsServlet.class, CatalogServlet.class, ShowCartServlet.class, CashierServlet.class, and ReceiptServlet.class. Click Add. Add index.jsp, errorpage.html and duke.books.gif. Add the cart, database, exception, filters, listeners, messages, and util packages. Click OK.
   e. Click Next.
   f. Select the servlet radio button.
   g. Click Next.
   h. Select BannerServlet from the Servlet Class combo box.
   i. Click Next twice.

   j. In the Component Aliases panel click Add and then type `/banner` in the alias field.
   k. Click Finish.

8. Add each of the web components listed in Table 18. For each servlet, click the Add to Existing WAR File radio button and select Bookstore1WAR from the combo box. Since the WAR contains all of the servlet classes, you do not have to add any more content.

Table 18 Duke's Bookstore Web Components

Web Component Name	Servlet Class	Component Alias
`BookStoreServlet`	`BookStoreServlet`	`/enter`
`CatalogServlet`	`CatalogServlet`	`/catalog`
`BookDetailsServlet`	`BookDetailsServlet`	`/bookdetails`
`ShowCartServlet`	`ShowCartServlet`	`/showcart`
`CashierServlet`	`CashierServlet`	`/cashier`
`ReceiptServlet`	`ReceiptServlet`	`/receipt`

9. Add a resource reference for the Cloudscape database.
   a. Select Bookstore1WAR.
   b. Select the Resource Refs tab.
   c. Click Add.
   d. Select javax.sql.DataSource from the Type column
   e. Enter `jdbc/BookDB` in the Coded Name field.
   f. Enter `jdbc/Cloudscape` in the JNDI Name field.

10. Add the listener class `listeners.ContextListener` (described in Handling Servlet Life Cycle Events (page 232)).
   a. Select the Event Listeners tab.
   b. Click Add.
   c. Select the listeners.ContextListener class from drop down field in the Event Listener Classes panel.

11. Add an error page (described in Handling Errors (page 234)).
    a. Select the File Refs tab.
    b. Click Add in the Error Mapping panel.
    c. Enter `exception.BookNotFoundException` in the Error/Exception field.
    d. Enter `/errorpage.html` in the Resource to be Called field.
    e. Repeat for `exception.BooksNotFoundException` and `javax.servlet.UnavailableException`.
12. Add the filters `filters.HitCounterFilter` and `filters.OrderFilter` (described in Filtering Requests and Responses (page 243)).
    a. Select the Filter Mapping tab.
    b. Click Edit Filter List.
    c. Click Add.
    d. Select filters.HitCounterFilter from the Filter Class column.
    e. Select `HitCounterFilter` from the Display Name column.
    f. Click Add.
    g. Select filters.OrderFilter from the Filter Class column.
    h. Select OrderFilter from the Display Name column.
    i. Click OK.
    j. Click Add.
    k. Select HitCounterFilter from the Filter Name column.
    l. Select Servlet from the Target Type column.
    m. Select BookStoreServlet from the Target column.
    n. Repeat for OrderFilter. The target type is Servlet and the target is ReceiptServlet.
13. Enter the context root.
    a. Select `Bookstore1`App.
    b. Select the Web Context tab.
    c. Enter bookstore1.
14. Deploy the application.
    a. Select Tools->Deploy.
    b. Click Finish.
15. Open the bookstore URL `http://<host>:8000/bookstore1/enter`.

Troubleshooting

Common Problems and Their Solutions (page 67) (in particular Web Client Runtime Errors (page 71)) lists some reasons why a web application can fail. In addition, Duke's Bookstore returns the following exceptions:

- `BookNotFoundException` - if a book can't be located in the bookstore database. This will occur if you haven't loaded the bookstore database with data by running `ant create-web-db` or if the Cloudscape server hasn't been started or it has crashed.
- `BooksNotFoundException` - if the bookstore data can't be retrieved. This will occur if you haven't loaded the bookstore database with data by running `ant create-web-db` or if the Cloudscape server hasn't been started or it has crashed.
- `UnavailableException` - if a servlet can't retrieve the web context attribute representing the bookstore. This will occur if you haven't added the listener class to the application.

Since we have specified an error page, you will see the message `The application is unavailable. Please try later`. If you don't specify an error page, the web container generates a default page containing the message `A Servlet Exception Has Occurred` and a stack trace that can help diagnose the cause of the exception. If you use the `errorpage.html`, you will have to look in the web container's log to determine the cause of the exception. Web log files reside in the directory:

```
$J2EE_HOME/<logs>/<host>/web
```

and are named `catalina.<date>.log`.

The `<logs>` element is the directory specified by the `log.directory` entry in the `default.properties` file. The default value is `logs`. The `<host>` element is the name of the computer. See the *Configuration Guide* provided with the J2EE SDK for more information about J2EE SDK log files.

Servlet Life Cycle

The life cycle of a servlet is controlled by the container in which the servlet has been deployed. When a request is mapped to a servlet, the container performs the following steps:

1. If an instance of the servlet does not exist, the container:
   a. Loads the servlet class
   b. Instantiates an instance of the servlet class
   c. Initializes the servlet instance by calling the `init` method. Initialization is covered in Initializing a Servlet (page 237).
2. Invokes the `service` method, passing a request and response object. Service methods are discussed in Writing Service Methods (page 238).

If the container needs to remove the servlet, it finalizes the servlet by calling the servlet's `destroy` method. Finalization is discussed in Finalizing a Servlet (page 257).

Handling Servlet Life Cycle Events

You can monitor and react to events in a servlet's life cycle by defining listener objects whose methods get invoked when life cycle events occur. To use these listener objects you must

- Define the listener class
- Specify the listener class

Defining The Listener Class

You define a listener class as an implementation of a listener interface. Table 19 lists the events that can be monitored and the corresponding interface that must be implemented. When a listener method is invoked it is passed an event that contains information appropriate to the event. For example, the methods in the

`HttpSessionListener` interface are passed an `HttpSessionEvent`, which contains an `HttpSession`.

Table 19 Servlet Life Cycle Events

Object	Event	Listener Interface and Event Class
Web context (See Accessing the Web Context (page 253))	Initialization and destruction	`javax.servlet.ServletContextListener` and `ServletContextEvent`
	Attribute added, removed, or replaced	`javax.servlet.ServletContextAttributesListener` and `ServletContextAttributeEvent`
Session (See Maintaining Client State (page 254))	Creation, invalidation, and timeout	`javax.servlet.http.HttpSessionListener` and `HttpSessionEvent`
	Attribute added, removed, or replaced	`javax.servlet.http.HttpSessionAttributesListener` and `HttpSessionBindingEvent`

The `listeners.ContextListener` class creates and removes the database helper and counter objects used in the Duke's Bookstore application. The methods retrieve the web context object from `ServletContextEvent` and then store (and remove) the objects as servlet context attributes.

```
import database.BookDB;
import javax.servlet.*;
import util.Counter;

public final class ContextListener
   implements ServletContextListener {
   private ServletContext context = null;
   public void contextInitialized(ServletContextEvent event) {
       context = event.getServletContext();
       try {
           BookDB bookDB = new BookDB();
           context.setAttribute("bookDB", bookDB);
       } catch (Exception ex) {
           System.out.println(
               "Couldn't create database: "
               + ex.getMessage());
```

```
            }
            Counter counter = new Counter();
            context.setAttribute("hitCounter", counter);
            context.log("Created hitCounter"
                + counter.getCounter());
            counter = new Counter();
            context.setAttribute("orderCounter", counter);
            context.log("Created orderCounter"
                 + counter.getCounter());
        }

        public void contextDestroyed(ServletContextEvent event) {
            context = event.getServletContext();
            BookDB bookDB = context.getAttribute(
                "bookDB");
            bookDB.remove();
            context.removeAttribute("bookDB");
            context.removeAttribute("hitCounter");
            context.removeAttribute("orderCounter");
        }
    }
```

Specifying Event Listener Classes

You specify a listener class for a WAR in the `deploytool` Event Listeners inspector (see Event Listeners (page 219)).

Handling Errors

Any number of exceptions can occur when a servlet is executed. The web container will generate a default page containing the message `A Servlet Exception Has Occurred` when an exception occurs, but you can also specify that the container should return a specific error page for a given exception. You specify error pages for a WAR in the `deploytool` File Refs inspector (Error Mapping (page 219)).

Sharing Information

Web components, like most objects, usually work with other objects to accomplish their tasks. There are several ways they can do this. They can use private helper objects (for example, JavaBeans components), they can share objects that are attributes of a public scope, and they can invoke other web resources. The Java Servlet technology mechanisms that allow a web component to invoke other web resources are described in Invoking Other Web Resources (page 250).

Scope Objects

Collaborating web components share information via objects maintained as attributes of four scope objects. These attributes are accessed with the `[get|set]Attribute` methods of the class representing the scope. Table 20 lists the scope objects.

Table 20 Scope Objects

Scope Object	Class	Accessible From
web context	`javax.servlet.ServletContext`	Web components within a Web context. See Accessing the Web Context (page 253).
session	`javax.servlet.http.HttpSession`	Web components handling a request that belongs to the session. See Maintaining Client State (page 254).
request	subtype of `javax.servlet.ServletRequest`	Web components handling the request.
page	`javax.servlet.jsp.PageContext`	The JSP page that creates the object. See JavaServer Pages™ Technology (page 261).

Figure 18 shows the scoped attributes maintained by the Duke's Bookstore application.

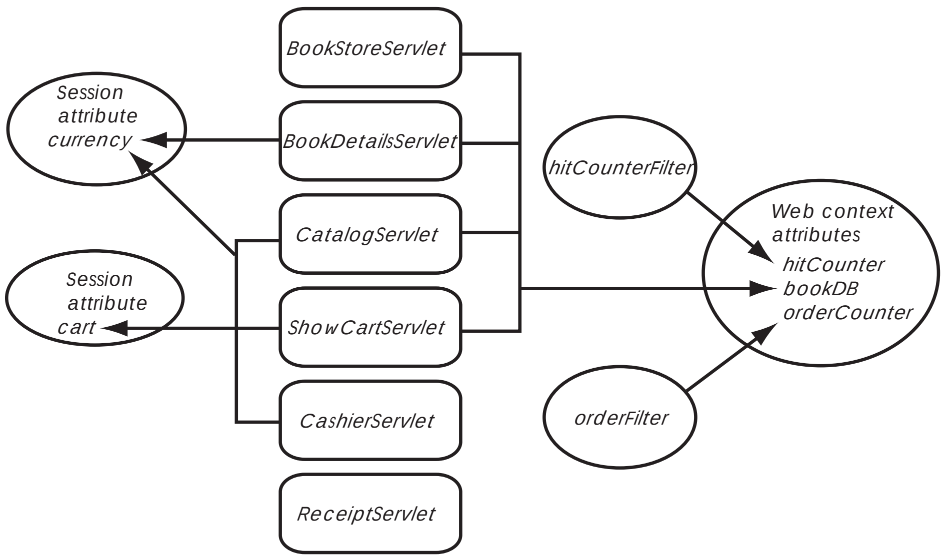


Figure 18 Duke's Bookstore Scoped Attributes

Controlling Concurrent Access to Shared Resources

In a multithreaded server, it is possible for shared resources to be accessed concurrently. Besides scope object attributes, shared resources include in-memory data such as instance or class variables and external objects such as files, database connections, and network connections. Concurrent access can arise in several situations:

- Multiple web components accessing objects stored in the web context
- Multiple web components accessing objects stored in a session
- Multiple threads within a web component accessing instance variables. A web container will typically create a thread to handle each request. If you want to ensure that a servlet instance handles only one request at a time, a servlet can implement the `SingleThreadModel` interface. If a servlet implements this interface, you are guaranteed that no two threads will execute concurrently in the servlet's service method. A web container can implement this guarantee by synchronizing access to a single instance of the servlet, or by maintaining a pool of web component instances and dispatching each new request to a free instance. This interface does not prevent synchronization problems that result from web components accessing shared resources such as static class variables or external objects.

When resources can be accessed concurrently, they can be used in an inconsistent fashion. To prevent this, you must control the access using the synchronization techniques described in the Threads lesson in the Java Tutorial.

In the previous section we showed five scoped attributes shared by more than one servlet: `bookDB`, `cart`, `currency`, `hitCounter`, and `orderCounter`. It is not necessary to control access to the `bookDB` attribute because it is only set during application startup. However, the cart, currency, and counters can be set and read by multiple multithreaded servlets. To prevent these objects from being used inconsistently, access is controlled by synchronized methods. For example, here is the `util.Counter` class:

```
public class Counter {
   private int counter;
   public Counter() {
       counter = 0;
   }
   public synchronized int getCounter() {
       return counter;
   }
   public synchronized int setCounter(int c) {
       counter = c;
       return counter;
   }
   public synchronized int incCounter() {
       return(++counter);
   }
}
```

Initializing a Servlet

After the web container loads and instantiates the servlet class and before it delivers requests from clients, the web container initializes the servlet. You can customize this process to allow the servlet to read persistent configuration data, initialize resources, and perform any other one-time activities by overriding the `init` method of the `Servlet` interface. A servlet that cannot complete its initialization process should throw `UnavailableException`.

All the servlets that access the bookstore database (`BookStoreServlet`, `CatalogServlet`, `BookDetailsServlet`, and `ShowCartServlet`) initialize a variable in their `init` method that points to the database helper object created by the web context listener:

```
public class CatalogServlet extends HttpServlet {
   private BookDB bookDB;
   public void init() throws ServletException {
       bookDB = (BookDB)getServletContext().
           getAttribute("bookDB");
       if (bookDB == null) throw new
           UnavailableException("Couldn't get database.");
   }
}
```

Writing Service Methods

The service provided by a servlet is implemented in the `service` method of a `GenericServlet`, the `do`*`Method`* methods (where *`Method`* can take the value `Get`, `Delete`, `Options`, `Post`, `Put`, `Trace`) of an `HttpServlet`, or any other protocol-specific methods defined by a class that implements the `Servlet` interface. In the rest of this chapter, the term “service method” will be used for any method in a servlet class that provides a service to a client.

The general pattern for a service method is to extract information from the request, access external resources, and then populate the response based on that information.

For HTTP servlets, the correct procedure for populating the response is to first fill in the response headers, then retrieve an output stream from the response, and finally write any body content to the output stream. Response headers must always be set before a `PrintWriter` or `ServletOutputStream` is retrieved because the HTTP protocol expects to receive all headers before body content. The next two sections describe how to get information from requests and generate responses.

Getting Information From Requests

A request contains data passed between a client and the servlet. All requests implement the `ServletRequest` interface. This interface defines methods for accessing the following information:

- Parameters, which are typically used to convey information between clients and servlets
- Object-valued attributes, which are typically used to pass information between the servlet container and a servlet or between collaborating servlets
- Information about the protocol used to communicate the request and the client and server involved in the request
- Information relevant to localization

For example, in `CatalogServlet` the identifier of the book that a customer wishes to purchase is included as a parameter to the request. The following code fragment illustrates how to use the `getParameter` method to extract the identifier:

```
String bookId = request.getParameter("Add");
if (bookId != null) {
   BookDetails book = bookDB.getBookDetails(bookId);
```

You can also retrieve an input stream from the request and manually parse the data. To read character data, use the `BufferedReader` object returned by the request's `getReader` method. To read binary data, use the `ServletInputStream` returned by `getInputStream`.

HTTP servlets are passed an HTTP request object, `HttpServletRequest`, which contains the request URL, HTTP headers, query string, and so on.

An HTTP request URL contains the following parts:

```
http://[host]:[port][request path]?[query string]
```

The request path is further composed of the following elements:

- **Context path:** A concatenation of `'/'` with the context root of the servlet's J2EE application.
- **Servlet path:** The path section that corresponds to the component alias that activated this request. This path starts with a `'/'`.

- **Path info:** The part of the request path that is not part of the context path or the servlet path.

Table 22 gives some examples of how the URL will be broken down if the context path is /catalog, and the aliases are as listed in Table 21:

Table 21 Aliases

Pattern	Servlet
/lawn/*	LawnServlet
/*.jsp	JSPServlet

Table 22 Request Path Elements

Request Path	Servlet Path	Path Info
/catalog/lawn/index.html	/lawn	/index.html
/catalog/help/feedback.jsp	/help/feedback.jsp	null

Query strings are composed of a set of parameters and values. Individual parameters are retrieved from a request with the getParameter method. There are two ways to generate query strings:

- A query string can explicitly appear in a web page. For example, an HTML page generated by the CatalogServlet could contain the link Add To Cart. CatalogServlet extracts the parameter named Add as follows:

```
String bookId = request.getParameter("Add");
```

- A query string is appended to a URL when a form with a GET HTTP method is submitted. In the Duke's Bookstore application, CashierServlet generates a form, a user name input to the form is appended to the URL that maps to ReceiptServlet, and ReceiptServlet extracts the user name using the getParameter method.

Constructing Responses

A response contains data passed between a server and the client. All responses implement the `ServletResponse` interface. This interface defines methods that allow you to:

- Retrieve an output stream to use to send data to the client. To send character data, use the `PrintWriter` returned by the response's `getWriter` method. To send binary data in a MIME body response, use the `ServletOutputStream` returned by `getOutputStream`. To mix binary and text data, for example, to create a multipart response, use a `ServletOutputStream` and manage the character sections manually.
- Indicate the content type (for example, `text/html`), being returned by the response. A registry of content type names is kept by IANA at:

```
ftp://ftp.isi.edu/in-notes/iana/assignments/media-types
```

- Indicate whether to buffer output. By default, any content written to the output stream is immediately sent to the client. Buffering allows content to be written before anything is actually sent back to the client, thus providing the servlet with more time to set appropriate status codes and headers or forward to another web resource.
- Set localization information.

HTTP response objects, `HttpServletResponse`, also have fields representing HTTP headers such as

- Status codes, which are used to indicate the reason of a request is not satisfied.
- Cookies, which are used to store application-specific information at the client. Sometimes cookies are used to maintain an identifier for tracking a user's session (see Maintaining Client State (page 254)).

In Duke's Bookstore, `BookDetailsServlet` generates an HTML page that displays information about a book which the servlet retrieves from a database. The servlet first sets response headers: the content type of the response and the buffer size. The servlet buffers the page content because the database access can generate an exception that would cause forwarding to an error page. By buffering the response, the client will not see a concatenation of part of a Duke's Bookstore page with the error page should an error occur. The `doGet` method then retrieves a `PrintWriter` from the response.

For filling in the response, the servlet first dispatches the request to `BannerServlet`, which generates a common banner for all the servlets in the application. This process is discussed in Including the Content of Another Resource in the Response (page 250). Then the servlet retrieves the book identifier from a request parameter and uses the identifier to retrieve information about the book from the bookstore database. Finally the servlet generates HTML markup that describes the book information and commits the response to the client by calling the `close` method on the `PrintWriter`.

```
public class BookDetailsServlet extends HttpServlet {
    public void doGet (HttpServletRequest request,
            HttpServletResponse response)
            throws ServletException, IOException {
        // set headers before accessing the Writer
        response.setContentType("text/html");
        response.setBufferSize(8192);
        PrintWriter out = response.getWriter();

        // then write the response
        out.println("<html>" +
        "<head><title>+
        messages.getString("TitleBookDescription")
        +</title></head>");

        // Get the dispatcher; it gets the banner to the user
        RequestDispatcher dispatcher =
            getServletContext().
            getRequestDispatcher("/banner");
        if (dispatcher != null)
            dispatcher.include(request, response);

        //Get the identifier of the book to display
        String bookId = request.getParameter("bookId");
        if (bookId != null) {
            // and the information about the book
            try {
                BookDetails bd =
                    bookDB.getBookDetails(bookId);
                ...
                //Print out the information obtained
                out.println("<h2>" + bd.getTitle() + "</h2>" +
                ...
            } catch (BookNotFoundException ex) {
                response.resetBuffer();
                throw new ServletException(ex);
            }
        }
```

```
            out.println("</body></html>");
            out.close();
        }
    }
```

BookDetailsServlet generates a page that looks like:

Filtering Requests and Responses

A filter is an object that can transform the header and/or content of a request or response. Filters differ from web components in that they usually do not themselves create a response. Instead, a filter provides functionality that can be "attached" to any kind of web resource. As a consequence, a filter should not have any dependencies on a web resource for which it is acting as a filter so that it can be composable with more than one type of web resource. The main tasks that a filter can perform are:

- Query the request and act accordingly
- Block the request and response pair from passing any further.
- Modify the request headers and data. You do this by providing a customized version of the request.
- Modify the response headers and data. You do this by providing a customized version of the response.
- Interact with external resources

Applications of filters include authentication, logging, image conversion, data compression, encryption, tokenizing streams, XML transformations, and so on.

You can configure a web component to be filtered by a chain of zero, one, or more filters in a specific order. This chain is specified when the web application containing the component is deployed and instantiated when a web container loads the component.

In summary, the tasks involved in using filters include:

- Programming the filter
- Programming customized requests and responses
- Specifying the filter chain for each servlet

Programming Filters

The filtering API is defined by the `Filter`, `FilterChain`, and `FilterConfig` interfaces in the `javax.servlet` package. You define a filter by implementing the `Filter` interface. The most important method in this interface is the `doFilter` method, which is passed request, response, and filter chain objects. This method can perform the following actions:

- Examine the request headers
- Customize the request object if it wishes to modify request headers or data
- Customize the response object if it wishes to modify response headers or data
- Invoke the next entity in the filter chain. If the current filter is the last filter in the chain that ends with the target web component or static resource, the next entity is the resource at the end of the chain; otherwise, it is the next filter that was configured in the WAR. It invokes the next entity by calling the `doFilter` method on the chain object (passing in the request and

response it was called with, or the wrapped versions it may have created). Alternatively, it can choose to block the request by not making the call to invoke the next entity. In the latter case, the filter is responsible for filling out the response.

- Examine response headers after it has invoked the next filter in the chain
- Throw an exception to indicate an error in processing

In addition to `doFilter`, you must implement the `init` and `destroy` methods. The `init` method is called by the container when the filter is instantiated. If you wish to pass initialization parameters to the filter you retrieve them from the `FilterConfig` object passed to `init`.

The Duke's Bookstore application uses the filters `HitCounterFilter` and `OrderFilter` to increment and log the value of a counter when the entry and receipt servlets are accessed.

In the `doFilter` method, both filters retrieve the servlet context from the filter configuration object so that they can access the counters stored as context attributes. After the filters have completed application-specific processing, they invoke `doFilter` on the filter chain object passed into the original `doFilter` method. The elided code is discussed in the next section.

```
public final class HitCounterFilter implements Filter {
   private FilterConfig filterConfig = null;

   public void init(FilterConfig filterConfig)
        throws ServletException {
        this.filterConfig = filterConfig;
   }
   public void destroy() {
        this.filterConfig = null;
   }
   public void doFilter(ServletRequest request,
        ServletResponse response, FilterChain chain)
        throws IOException, ServletException {
        if (filterConfig == null)
             return;
        StringWriter sw = new StringWriter();
        PrintWriter writer = new PrintWriter(sw);
        Counter counter = (Counter)filterConfig.
             getServletContext().
             getAttribute("hitCounter");
        writer.println();
        writer.println("===============");
        writer.println("The number of hits is: " +
             counter.incCounter());
```

```
            writer.println("==============");
            // Log the resulting string
            writer.flush();
            filterConfig.getServletContext().
                log(sw.getBuffer().toString());
            ...
            chain.doFilter(request, wrapper);
            ...
        }
    }
```

Programming Customized Requests and Responses

There are many ways for a filter to modify a request or response. For example, a filter could add an attribute to the request or insert data in the response. In the Duke's Bookstore example, `HitCounterFilter` inserts the value of the counter into the response.

A filter that modifies a response must usually capture the response before it is returned to the client. The way to do this is to pass the servlet that generates the response a stand-in stream. The stand-in stream prevents the servlet from closing the original response stream when it completes and allows the filter to modify the servlet's response.

In order to pass this stand-in stream to the servlet, the filter creates a response "wrapper" that overrides the `getWriter` or `getOutputStream` method to return this stand-in stream. The wrapper is passed to the `doFilter` method of the filter chain. Wrapper methods default to calling through to the wrapped request or response object. This approach follows the well-known Wrapper or Decorator pattern described in *Design Patterns, Elements of Reusable Object-Oriented Software*. The following sections describe how the hit counter filter described earlier and other types of filters use wrappers.

To override request methods, you wrap the request in an object that extends `ServletRequestWrapper` or `HttpServletRequestWrapper`. To override response methods, you wrap the response in an object that extends `ServletResponseWrapper` or `HttpServletResponseWrapper`.

`HitCounterFilter` wraps the response in a `CharResponseWrapper`. The wrapped response is passed to the next object in the filter chain, which is `BookStoreServlet`. `BookStoreServlet` writes its response into the stream created by `CharResponseWrapper`. When `chain.doFilter` returns, `HitCounterFilter` retrieves the servlet's response from `PrintWriter` and writes it to a buffer. The filter inserts the value of the counter into the buffer, resets the content length header of the response, and finally writes the contents of the buffer to the response stream.

```
PrintWriter out = response.getWriter();
CharResponseWrapper wrapper = new CharResponseWrapper(
   (HttpServletResponse)response);
chain.doFilter(request, wrapper);
CharArrayWriter caw = new CharArrayWriter();
caw.write(wrapper.toString().substring(0,
   wrapper.toString().indexOf("</body>")-1));
caw.write("<p>\n<center><center>" +
   messages.getString("Visitor") + "<font color='red'>" +
   counter.getCounter() + "</font><center>");
caw.write("\n</body></html>");
response.setContentLength(caw.toString().length());
out.write(caw.toString());
out.close();

public class CharResponseWrapper extends
   HttpServletResponseWrapper {
   private CharArrayWriter output;
   public String toString() {
       return output.toString();
   }
   public CharResponseWrapper(HttpServletResponse response){
       super(response);
       output = new CharArrayWriter();
   }
   public PrintWriter getWriter(){
       return new PrintWriter(output);
   }
}
```

Figure 19 shows the entry page for Duke’s Bookstore with the hit counter.

Figure 19 Duke's Bookstore

Specifying Filter Mappings

A web container uses filter mappings to decide how to apply filters to web resources. A filter mapping matches a filter to a web component by name or to web components and static resources by URL pattern. The filters are invoked in the order that filter mappings appear in the filter mapping list of a WAR. You specify a filter mapping list for a WAR in the `deploytool` Filter Mapping inspector (see Filter Mapping (page 219)).

Table 23 contains the filter mapping list for the Duke's Bookstore application. The filters are matched by servlet name and each filter chain contains only one filter.

Table 23 Duke's Bookstore Filter Mapping List

Servlet Name	Filter
`BookStoreServlet`	`HitCounterFilter`

Table 23 Duke's Bookstore Filter Mapping List (Continued)

Servlet Name	Filter
ReceiptServlet	OrderFilter

You can map a filter to one or more web resource and you can map more than one filter to a web resource. This is illustrated in Figure 20, where filter F1 is mapped to web resources W1, W2, and W3, filter F2 is mapped to W2, and filter F3 is mapped to W1 and W2.

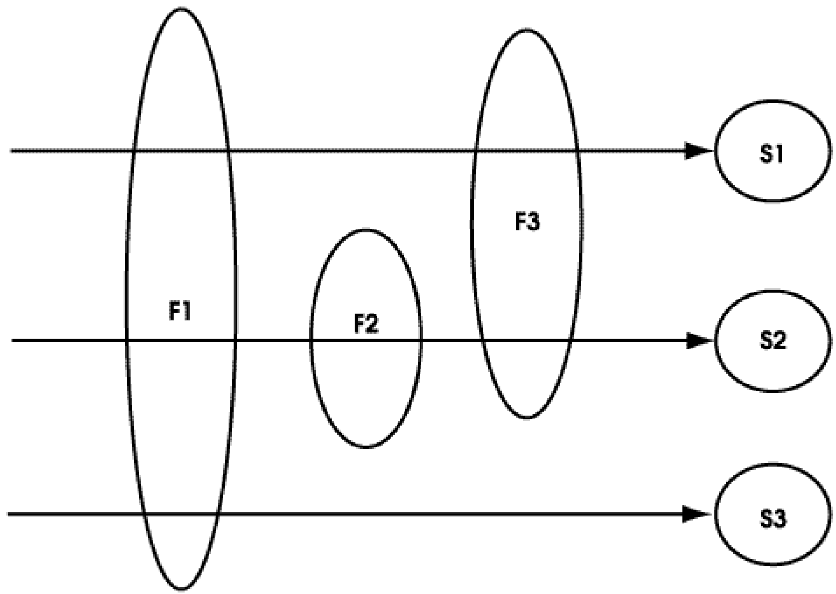


Figure 20 Filter to Servlet Mapping

Recall that a filter chain is one of the objects passed to the `doFilter` method of a filter. This chain is formed indirectly via filter mappings. The order of the filters in the chain is the same as the order that filter mappings appear in the web application deployment descriptor.

When a URL is mapped to web resource W1, the web container invokes the `doFilter` method of F1. The `doFilter` method of each filter in W1's filter chain is invoked by the preceding filter in the chain via the `chain.doFilter` method. Since W1's filter chain contains filters F1 and F3, F1's call to `chain.doFilter` invokes the `doFilter` method of filter F3. When F3's `doFilter` method completes, control returns to F1's `doFilter` method.

Invoking Other Web Resources

Web components can invoke other web resources in two ways: indirect and direct.

A web component indirectly invokes another web resource when it embeds a URL that points to another web component in content returned to a client. In the Duke's Bookstore application, most web components contain embedded URLs that point to other web components. For example, `ReceiptServlet` indirectly invokes the `CatalogServlet` through the embedded URL `/bookstore1/catalog`.

A web component can also directly invoke another resource while it is executing. There are two possibilities: it can include the content of another resource, or it can forward a request to another resource.

To invoke a resource available on the server that is running a web component, you must first obtain a `RequestDispatcher` using the `getRequestDispatcher("URL")` method.

You can get a `RequestDispatcher` from either a request or the web context, however, the two methods have slightly different behavior. The method takes the path to the requested resource as an argument. A request can take a relative path (that is, one that does not begin with a `'/'`), but the web context requires an absolute path. If the resource is not available, or if the server has not implemented a `RequestDispatcher` object for that type of resource, `getRequestDispatcher` will return null. Your servlet should be prepared to deal with this condition.

Including the Content of Another Resource in the Response

It is often useful to include content of another resource, for example, banner content or copyright information, in the response returned from a web component. To include the content of another resource, invoke the `include` method of a `RequestDispatcher`:

```
include(request, response);
```

If the resource is static, the `include` method enables programmatic server-side includes. If the resource is a web component, the effect of the method is to send the request to the included web component, execute the web component, and then include the result of the execution in the response from the containing servlet. An included web component has access to the request object, but it is limited in what it can do with the response object:

- It can write to the body of and commit a response.
- It cannot set headers or call any method (for example, `setCookie`) that affects the headers of the response.

The banner for the Duke's Bookstore application is generated by `BannerServlet`. Note that both `doGet` and `doPost` methods are implemented because `BannerServlet` can be dispatched from either method in a calling servlet.

```
public class BannerServlet extends HttpServlet {
   public void doGet (HttpServletRequest request,
        HttpServletResponse response)
        throws ServletException, IOException {

        PrintWriter out = response.getWriter();
        out.println("<body bgcolor=\"#ffffff\">" +
        "<center>" + "<hr> <br>  " + "<h1>" +
        "<font size=\"+3\" color=\"#CC0066\">Duke's </font>" +
        <img src=\"" + request.getContextPath() +
        "/duke.books.gif\">" +
        "<font size=\"+3\" color=\"black\">Bookstore</font>" +
        "</h1>" + "</center>" + "<br>   <hr> <br> ");
   }
   public void doPost (HttpServletRequest request,
        HttpServletResponse response)
        throws ServletException, IOException {

        PrintWriter out = response.getWriter();
        out.println("<body bgcolor=\"#ffffff\">" +
        "<center>" + "<hr> <br>  " + "<h1>" +
        "<font size=\"+3\" color=\"#CC0066\">Duke's </font>" +
        <img src=\"" + request.getContextPath() +
        "/duke.books.gif\">" +
        "<font size=\"+3\" color=\"black\">Bookstore</font>" +
        "</h1>" + "</center>" + "<br>   <hr> <br> ");
   }
}
```

Each servlet in the Duke's Bookstore application includes the result from BannerServlet with the following code:

```
RequestDispatcher dispatcher =
   getServletContext().getRequestDispatcher("/banner");
if (dispatcher != null)
   dispatcher.include(request, response);
}
```

Transferring a Control to Another Web Component

In some applications you might want to have one web component do preliminary processing of a request and another component generate the response. For example, you might want to partially process a request and then transfer to another component depending on the nature of the request.

To transfer control to another web component, you invoke the `forward` method of a `RequestDispatcher`. When a request is forwarded, the request URL is set to the path of the forwarded page. If the original URL is required for any processing you can save it as a request attribute. The `Dispatcher` servlet, used by a version of the Duke's Bookstore application described in A Template Tag Library (page 324), saves the path information from the original URL, retrieves a `RequestDispatcher` from the request, and then forwards to the JSP page `template.jsp`.

```
public class Dispatcher extends HttpServlet {
   public void doGet(HttpServletRequest request,
        HttpServletResponse response) {
        request.setAttribute("selectedScreen",
             request.getServletPath());
        RequestDispatcher dispatcher = request.
             getRequestDispatcher("/template.jsp");
        if (dispatcher != null)
             dispatcher.forward(request, response);
   }
   public void doPost(HttpServletRequest request,
   ...
}
```

The `forward` method should be used to give another resource responsibility for replying to the user. If you have already accessed a `ServletOutputStream` or `PrintWriter` object within the servlet, you cannot use this method; it throws an `IllegalStateException`.

Accessing the Web Context

The context in which web components execute is an object that implements the `ServletContext` interface. You retrieve the web context with the `getServletContext` method. The web context provides methods for accessing:

- Initialization parameters
- Resources associated with the web context
- Object-valued attributes
- Logging capabilities

The web context is used by the Duke's Bookstore filters `filters.HitCounterFilter` and `OrderFilter` discussed in Filtering Requests and Responses (page 243). The filters store a counter as a context attribute. Recall from Controlling Concurrent Access to Shared Resources (page 236) that the counter's access methods are synchronized to prevent incompatible operations by servlets that are running concurrently. A filter retrieves the counter object with the context's `getAttribute` method. The incremented value of the counter is recorded with the context's `log` method.

```
public final class HitCounterFilter implements Filter {
   private FilterConfig filterConfig = null;
   public void doFilter(ServletRequest request,
       ServletResponse response, FilterChain chain)
       throws IOException, ServletException {
       ...
       StringWriter sw = new StringWriter();
       PrintWriter writer = new PrintWriter(sw);
       ServletContext context = filterConfig.
           getServletContext();
       Counter counter = (Counter)context.
           getAttribute("hitCounter");
       ...
       writer.println("The number of hits is: " +
           counter.incCounter());
       ...
       context.log(sw.getBuffer().toString());
       ...
   }
}
```

Maintaining Client State

Many applications require a series of requests from a client to be associated with one another. For example, the Duke's Bookstore application saves the state of a user's shopping cart across requests. Web-based applications are responsible for maintaining such state, called a *session*, because the HTTP protocol is stateless. To support applications that need to maintain state, Java Servlet technology provides an API for managing sessions and allows several mechanisms for implementing sessions.

Accessing a Session

Sessions are represented by an `HttpSession` object. You access a session by calling the `getSession` method of a request object. This method returns the current session associated with this request, or, if the request does not have a session, creates one. Since `getSession` may modify the response header (if cookies are the session tracking mechanism), it needs to be called before you retrieve a `PrintWriter` or `ServletOutputStream`.

Associating Attributes with a Session

You can associate object-valued attributes with a session by name. Such attributes are accessible by any web component that belongs to the same web context *and* is handling a request that is part of the same session.

The Duke's Bookstore application stores a customer's shopping cart as a session attribute. This allows the shopping cart to be saved between requests and also allows cooperating servlets to access the cart. `CatalogServlet` adds items to the cart, `ShowCartServlet` displays, deletes items from, and clears the cart, and `CashierServlet` retrieves the total cost of the books in the cart.

```
public class CashierServlet extends HttpServlet {
   public void doGet (HttpServletRequest request,
       HttpServletResponse response)
       throws ServletException, IOException {

       // Get the user's session and shopping cart
       HttpSession session = request.getSession();
       ShoppingCart cart =
           (ShoppingCart)session.
```

```
        getAttribute("cart");
...
// Determine the total price of the user's books
double total = cart.getTotal();
```

Notifying Objects That Are Added To a Session

Recall that your application can notify web context and session listener objects of servlet life cycle events (Handling Servlet Life Cycle Events (page 232)). You can also notify objects of certain events related to their association with a session:

- When the object is added to or removed from a session. To receive this notification, your object must implement the `javax.http.HttpSessionBindingListener` interface.
- When the session to which the object is attached will be passivated and/or activated. A session will be passivated and activated when it is moved between VMs or saved to and restored from persistent storage. To receive this notification, your object must implement the `javax.http.HttpSessionActivationListener` interface.

Session Management

Since there is no way for an HTTP client to signal that it no longer needs a session, each session has an associated time-out so that its resources can be reclaimed. The time-out period can be accessed with a session's `[get|set]MaxInactiveInterval` methods. You can also set the time-out period in `deploytool`:

1. Select the WAR.
2. Select the General tab.
3. Enter the time-out period in the Advanced box.

To ensure that an active session is not timed-out, you should periodically access the session in service methods because this resets the session's time-to-live counter.

When a particular client interaction is finished, you use the session's `invalidate` method to delete a session on the server side. The session data is removed and when a new request is made to the servlet, a new session will be created.

The bookstore application's `ReceiptServlet` is the last servlet to access a client's session, so it has responsibility for invalidating the session:

```
public class ReceiptServlet extends HttpServlet {
   public void doPost(HttpServletRequest request,
                   HttpServletResponse response)
                   throws ServletException, IOException {
       // Get the user's session and shopping cart
       HttpSession session = request.getSession();
       // Payment received -- invalidate the session
       session.invalidate();
       ...
```

Session Tracking

A web container can use several methods to associate a session with a user, all of which involve passing an identifier between the client and server. The main methods require the client to accept cookies or the web component to rewrite any URL that is returned to the client.

If your application makes use of session objects, you must ensure that session tracking is enabled by allowing the application to rewrite a URL whenever the client turns off cookies. You do this by calling the response's `encodeURL(URL)` method on all URLs returned by a servlet. This method includes the session ID in the URL only if cookies are disabled; otherwise it returns the URL unchanged.

The `doGet` method of `ShowCartServlet` encodes the three URLs at the bottom of the shopping cart display page as follows:

```
out.println("<p>   <p><strong><a href=\"" +
   response.encodeURL(request.getContextPath() + "/catalog") +
       "\">" + messages.getString("ContinueShopping") +
       "</a>      " +
       "<a href=\"" +
   response.encodeURL(request.getContextPath() + "/cashier") +
       "\">" + messages.getString("Checkout") +
       "</a>      " +
       "<a href=\"" +
   response.encodeURL(request.getContextPath() +
       "/showcart?Clear=clear") +
       "\">" + messages.getString("ClearCart") +
       "</a></strong>");
```

If cookies are turned off, the session is encoded in the Check Out URL as follows:

```
http://localhost:8080/bookstore1/cashier;
   jsessionid=c0o7fszeb1
```

If cookies are turned on, the URL is simply:

```
http://localhost:8080/bookstore1/cashier
```

Finalizing a Servlet

When a servlet container determines that a servlet should be removed from service (for example, when a container wants to reclaim memory resources, or when it is being shut down) it calls the `destroy` method of the `Servlet` interface. In this method you release any resources the servlet is using and save any persistent state. The following `destroy` method releases the database object created in the `init` method described in Initializing a Servlet (page 237):

```
public void destroy() {
   bookDB = null;
}
```

All of a servlet's `service` methods should be complete when a servlet is removed. The server tries to ensure this completion by calling the `destroy` method only after all service requests have returned or after a server-specific grace period, whichever comes first.

If your servlet has potentially long-running service requests, use the techniques described below to:

- Keep track of how many threads are currently running the `service` method
- Provide a clean shutdown by having the `destroy` method notify long-running threads of the shutdown and wait for them to complete
- Have the long-running methods poll periodically to check for shutdown and, if necessary, stop working, clean up, and return

Tracking Service Requests

To track service requests, include in your servlet class a field that counts the number of service methods that are running. The field should have synchronized access methods to increment, decrement, and return its value.

```
public ShutdownExample extends HttpServlet {
   private int serviceCounter = 0;
   ...
   //Access methods for serviceCounter
   protected synchronized void enteringServiceMethod() {
```

```
            serviceCounter++;
        }
        protected synchronized void leavingServiceMethod() {
            serviceCounter--;
        }
        protected synchronized int numServices() {
            return serviceCounter;
        }
    }
```

The `service` method should increment the service counter each time the method is entered and should decrement the counter each time the method returns. This is one of the few times that your `HttpServlet` subclass should override the `service` method. The new method should call `super.service` to preserve all of the original `service` method's functionality.

```
    protected void service(HttpServletRequest req,
                           HttpServletResponse resp)
                           throws ServletException,IOException {
        enteringServiceMethod();
        try {
            super.service(req, resp);
        } finally {
            leavingServiceMethod();
        }
    }
```

Providing a Clean Shutdown

To ensure a clean shutdown, your `destroy` method should not release any shared resources until all of the service requests have completed. One part of doing this is to check the service counter. Another part is to notify the long-running methods that it is time to shut down. For this notification another field is required. The field should have the usual access methods.

```
    public ShutdownExample extends HttpServlet {
        private boolean shuttingDown;
        ...
        //Access methods for shuttingDown
        protected setShuttingDown(boolean flag) {
            shuttingDown = flag;
        }
        protected boolean isShuttingDown() {
            return shuttingDown;
        }
    }
```

An example of the `destroy` method using these fields to provide a clean shutdown follows:

```
public void destroy() {
    /* Check to see whether there are still service methods /*
    /* running, and if there are, tell them to stop. */
    if (numServices() > 0) {
        setShuttingDown(true);
    }

    /* Wait for the service methods to stop. */
    while(numServices() > 0) {
        try {
            Thread.sleep(interval);
        } catch (InterruptedException e) {
        }
    }
}
```

Creating Polite Long-Running Methods

The final step to provide a clean shutdown is to make any long-running methods behave politely. Methods that might run for a long time should check the value of the field that notifies them of shutdowns and should interrupt their work, if necessary.

```
public void doPost(...) {
    ...
    for(i = 0; ((i < lotsOfStuffToDo) &&
        !isShuttingDown()); i++) {
        try {
            partOfLongRunningOperation(i);
        } catch (InterruptedException e) {
            ...
        }
    }
}
```

JavaServer Pages™ Technology

by Stephanie Bodoff

JAVASERVER Pages™ (JSP™) technology allows you to easily create web content that has both static and dynamic components. JSP technology projects all the dynamic capabilities of Java Servlet technology but provides a more natural approach to creating static content. The main features of JSP technology are:

- A language for developing JSP pages, which are text-based documents that describe how to process a request and construct a response
- Constructs for accessing server-side objects
- Mechanisms for defining extensions to the JSP language

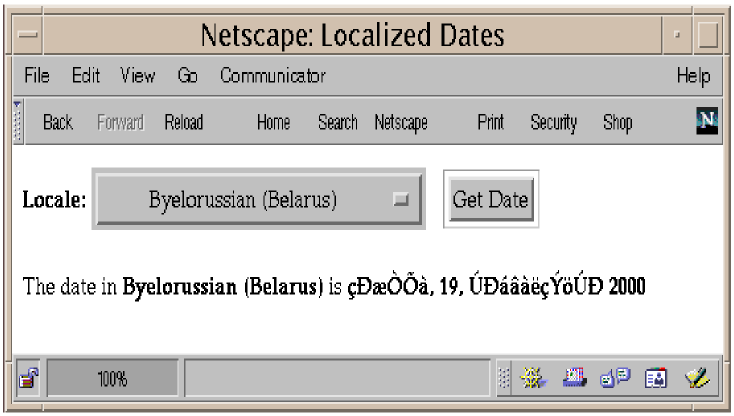
JSP technology also contains API that is used by developers of web containers, but this API is not covered in this chapter.

What is a JSP Page?

A JSP page is a text-based document that contains two types of text: static template data, which can be expressed in any text-based format such as HTML, SVG, WML, and XML, and JSP elements, which construct dynamic content. A syntax card and reference for the JSP elements is available at:

```
http://java.sun.com/products/jsp/technical.html#syntax
```

The following web page is a form that allows you to select a locale and displays the date in a manner appropriate to the locale.



The source for this example is in the `j2eetutorial/examples/src/web/date` directory created when you unzip the tutorial bundle. The JSP page `index.jsp` used to create the form appears below; it is a typical mixture of static HTML markup and JSP elements. If you have developed web pages, you are probably familiar with the HTML document structure statements (`<head>`, `<body>`, and so on) and the HTML statements that create a form `<form>` and a menu `<select>`.

The highlighted lines in the example contain the following types of JSP constructs:

- Directives (<**@page ... %**>) import classes in the `java.util` package and the `MyLocales` class, and set the content type returned by the page.
- The **`jsp:useBean`** element creates an object containing a collection of locales and initializes a variable that point to that object.
- Scriptlets (**`<% ... %>`**) retrieve the value of the `locale` request parameter, iterate over a collection of locale names, and conditionally insert HTML text into the output.
- Expressions (**`<%= ... %>`**) insert the value of the locale name into the response.
- The **`jsp:include`** element sends a request to another page (`date.jsp`) and includes the response in the response from the calling page.

```
<%@ page import="java.util.*,MyLocales" %>
<%@ page contentType="text/html; charset=ISO-8859-5" %>
<html>
<head><title>Localized Dates</title></head>
<body bgcolor="white">
<jsp:useBean id="locales" scope="application"
   class="MyLocales"/>
<form name="localeForm" action="index.jsp" method="post">
<b>Locale:</b>
<select name=locale>
<%
   String selectedLocale = request.getParameter("locale");
   Iterator i = locales.getLocaleNames().iterator();
   while (i.hasNext()) {
        String locale = (String)i.next();
        if (selectedLocale != null &&
             selectedLocale.equals(locale)) {
%>
             <option selected><%=locale%></option>
<%
        } else {
%>
             <option><%=locale%></option>
<%
        }
   }
%>
</select>
<input type="submit" name="Submit" value="Get Date">
```

```
</form>
<jsp:include page="date.jsp"/>
</body>
</html>
```

To build, deploy, and execute this JSP page:

1. Go to `j2eetutorial/examples/src` and build the example by executing `ant date` (see How to Build and Run the Examples (page xxiii)).
2. Create a J2EE application called `DateApp`.
    a. Select File->New->Application.
    b. In the file chooser, navigate to `j2eetutorial/examples/src/web/date`.
    c. In the File Name field, enter `DateApp` .
    d. Click New Application.
    e. Click OK.
3. Create the WAR and add the web components to the `DateApp` application.
    a. Select File->New->Web Component.
    b. Select DateApp from the Create new WAR File in Application combo box.
    c. Enter `DateWAR` in the WAR Display Name field.
    d. Click Edit.
    e. Navigate to `j2eetutorial/examples/build/web/date`. Select index.jsp, date.jsp, MyDate.class and MyLocales.class and click Add, then click Finish.
    f. Click Next.
    g. Click JSP in the Web Component radio box, then click Next.
    h. Select index.jsp from the JSP Filename combo box. Click Finish.
4. Enter the context root.
    a. Select DateApp.
    b. Select the Web Context tab.
    c. Enter `date`.
5. Deploy the application.
    a. Select Tools->Deploy.
    b. Click Finish.

6. Invoke the URL `http://<host>:8000/date` in a browser.

You will see a combo box whose entries are locales. Select a locale and click Get Date. You will see the date expressed in a manner appropriate for that locale.

The Example JSP Pages

To illustrate JSP technology, this chapter rewrites each servlet in the Duke's Bookstore application introduced in The Example Servlets (page 227) as a JSP page:

Table 24 Duke's Bookstore Example JSP Pages

Function	**JSP Pages**
Enter the bookstore	`bookstore.jsp`
Create the bookstore banner	`banner.jsp`
Browse the books offered for sale	`catalog.jsp`
Put a book in a shopping cart	`catalog.jsp` and `bookdetails.jsp`
Get detailed information on a specific book	`bookdetails.jsp`
Display the shopping cart	`showcart.jsp`
Remove one or more books from the shopping cart	`showcart.jsp`
Buy the books in the shopping cart	`cashier.jsp`
Receive an acknowledgement for the purchase	`receipt.jsp`

The source for the application is located in the `j2eetutorial/examples/src/web/bookstore2` directory created when you unzip the tutorial bundle (see Downloading the Examples (page xxii)). The data for the bookstore application is still maintained in a Cloudscape database. However, two changes are made to the database helper object `database.BookDB`:

- The database helper object is rewritten to conform to JavaBeans component design patterns as described in JavaBeans™ Components in JSP™ Pages (page 285). This change is made so that JSP pages can access the helper object using JSP language elements specific to JavaBeans components.

- Instead of accessing the bookstore database directly, the helper object goes through an enterprise bean. The advantage of using an enterprise bean is that the helper object is no longer responsible for connecting to the database; this job is taken over by the enterprise bean. Furthermore, because the EJB container maintains the pool of database connections, an enterprise bean can get a connection quicker than the helper object. The relevant interfaces and classes for the enterprise bean are the `database.BookDBEJBHome` home interface, `database.BookDBEJB` remote interface, and the `database.BookDBEJB` implementation class, which contains all the JDBC calls to the database.

The implementation of the database helper object follows. The bean has two instance variables: the current book and a reference to the database enterprise bean.

```
public class BookDB {
   private String bookId = "0";
   private BookDBEJB database = null;

   public BookDB () throws Exception {
   }
   public void setBookId(String bookId) {
       this.bookId = bookId;
   }
   public void setDatabase(BookDBEJB database) {
       this.database = database;
   }
   public BookDetails getBookDetails()
       throws Exception {
       try {
           return (BookDetails)database.
                   getBookDetails(bookId);
       } catch (BookNotFoundException ex) {
           throw ex;
       }
   }
   ...
}
```

Finally, this version of the example uses an applet to generate a dynamic digital clock in the banner. See Including an Applet (page 281) for a description of the JSP element that generates HTML for downloading the applet.

To build, deploy, and run the example:

1. Go to `j2eetutorial/examples/src` and build the example by running `ant bookstore2`.
2. Start the `j2ee` server.
3. Start `deploytool`.
4. Start the Cloudscape database by executing `cloudscape -start`.
5. If you have not already created the bookstore database, run `ant create-web-db`.
6. Create a J2EE application called `Bookstore2App`.
   a. Select File->New->Application.
   b. In the file chooser, navigate to `j2eetutorial/examples/src/web/bookstore2`.
   c. In the File Name field, enter `Bookstore2App` .
   d. Click New Application.
   e. Click OK.
7. Add `Bookstore2WAR` WAR to the `Bookstore2App` application.
   a. Select File->Add->Web WAR.
   b. In the Add Web WAR dialog, navigate to `j2eetutorial/examples/build/web/bookstore2`. Select bookstore2.war. Click Add Web WAR.
8. Add the `BookDBEJB` enterprise bean to the application.
   a. Select File->New Enterprise Bean or the New Enterprise Bean button.
   b. Select Bookstore2App from Create New JAR File in Application combo box.
   c. Type `BookDBJAR` in the JAR Display Name field.
   d. Click Add to add the content files. Navigate to the `j2eetutorial/examples/build/web/ejb` directory and add the database and exception packages. Click Next.
   e. Chose Session and Stateless for the Bean Type.
   f. Select database.BookDBEJBImpl for Enterprise Bean Class.
   g. In the Remote Interfaces box, select database.BookDBEJBHome for Remote Home Interface and database.BookDBEJB for Remote Interface.
   h. Enter BookDBEJB for Enterprise Bean Name.
   i. Click Next and then click Finish.

9. Add a resource reference for the Cloudscape database to the `BookDBEJB`.
   a. Select the BookDBEJB enterprise bean.
   b. Select the Resource Refs tab.
   c. Click Add.
   d. Select javax.sql.DataSource from the Type column
   e. Enter `jdbc/BookDB` in the Coded Name field.
   f. Enter `jdbc/Cloudscape` in the JNDI Name field.
10. Save BookDBJAR.
    a. Select BookDBJAR.
    b. Select File-Save As.
    c. Navigate to the directory `examples/build/web/ejb`.
    d. Enter `bookDB.jar` in the File name field.
    e. Click Save EJB JAR As.
11. Add a reference to the enterprise bean `BookDBEJB`.
    a. Select Bookstore2WAR.
    b. Select the EJB Refs tab.
    c. Click Add.
    d. Enter `ejb/BookDBEJB` in the Coded Name column.
    e. Enter Session in the Type column.
    f. Select Remote in the Interfaces column.
    g. Enter database.`BookDBEJBHome` in the Home Interface column.
    h. Enter database.`BookDBEJB` in the Local/Remote Interface column.
12. Specify the JNDI Names
    a. Select Bookstore2App.
    b. In the Application table, locate the EJB component and enter `BookD-BEJB` in the JNDI Name column.
    c. In the References table, locate the EJB Ref, and enter `BookDBEJB` in the JNDI Name column.
    d. In the References table, locate the Resource component and enter `jdbc/Cloudscape` in the JNDI Name column.
13. Enter the context root.
    a. Select the Web Context tab.
    b. Enter bookstore2.

14. Deploy the application.
    a. Select Tools->Deploy.
    b. Click Finish.
15. Open the bookstore URL `http://<host>:8000/bookstore2/enter`.

See Troubleshooting (page 231) for help with diagnosing common problems.

The Life Cycle of a JSP Page

A JSP page services requests as a servlet. Thus, the life cycle and many of the capabilities of JSP pages (in particular the dynamic aspects) are determined by Java Servlet technology and much of the discussion in this chapter refers to functions described in Java Servlet Technology (page 225).

When a request is mapped to a JSP page, it is handled by a special servlet that first checks whether the JSP page's servlet is older than the JSP page. If it is, it translates the JSP page into a servlet class and compiles the class. During development, one of the advantages of JSP pages over servlets is that the "build" process is performed automatically.

Translation and Compilation

During the translation phase each type of data in a JSP page is treated differently. Template data is transformed into code that will emit the data into the stream that returns data to the client. JSP elements are treated as follows:

- Directives are used to control how the web container translates and executes the JSP page.
- Scripting elements are inserted into the JSP page's servlet class. See JSP Scripting Elements (page 276) for details.
- Elements of the form `<jsp:XXX ... />` are converted into method calls to JavaBeans components or invocations of the Java Servlet API.

For a JSP page named *pageName*, the source for a JSP page's servlet is kept in the file:

```
J2EE_HOME/repository/host/web/context root/_0002fpageName_jsp.java
```

For example, the source for the index page (named `index.jsp`) for the `date` localization example discussed at the beginning the chapter would be named:

```
J2EE_HOME/repository/host/web/date/_0002findex_jsp.java
```

Both the translation and compilation phases can yield errors that are only observed when the page is requested for the first time. If an error occurs while the page is being translated (for example, if the translator encounters a malformed JSP element), the server will return a `ParseException` and the servlet class source file will be empty or incomplete. The last incomplete line will give a pointer to the incorrect JSP element.

If an error occurs while the JSP page is being compiled (for example, due to a syntax error in a scriptlet), the server will return a `JasperException` and a message that includes the name of the JSP page's servlet and the line where the error occurred.

Once the page has been translated and compiled, the JSP page's servlet for the most part follows the servlet life cycle described in Servlet Life Cycle (page 232):

1. If an instance of the JSP page's servlet does not exist, the container:
   a. Loads the JSP page's servlet class
   b. Instantiates an instance of the servlet class
   c. Initializes the servlet instance by calling the `jspInit` method
2. Invokes the `_jspService` method, passing a request and response object.

If the container needs to remove the JSP page's servlet, it calls the `jspDestroy` method.

Execution

You can control various JSP page execution parameters using `page` directives. The directives that pertain to buffering output and handling errors are discussed here. Other directives are covered in the context of specific page authoring tasks throughout the chapter.

Buffering

When a JSP page is executed, output written to the response object is automatically buffered. You can adjust the size of the buffer with the following page directive:

```
<%@ page buffer="none|xxxkb" %>
```

A larger buffer allows more content to be written before anything is actually sent back to the client, thus providing the JSP page with more time to set appropriate status codes and headers or forward to another web resource. A smaller buffer decreases server memory load and allows the client to start receiving data more quickly.

Handling Errors

Any number of exceptions can arise when a JSP page is executed. To specify that the web container should forward control to an error page if an exception occurs, include the following `page` directive at the beginning of your JSP page:

```
<%@ page errorPage="file_name" %>
```

The Duke's Bookstore application page `initdestroy.jsp` contains the directive

```
<%@ page errorPage="errorpage.jsp"%>
```

The beginning of `errorpage.jsp` indicates that it is serving as an error page with the following page directive:

```
<%@ page isErrorPage="true|false" %>
```

This directive makes the exception object (of type `javax.servlet.jsp.JspException`) available to the error page, so that you can retrieve, interpret, and possibly display information about the cause of the exception in the error page.

Note: You can also define error pages for the WAR that contains a JSP page. If error pages are defined for both the WAR and a JSP page, the JSP page's error page takes precedence.

Initializing and Finalizing a JSP Page

You can customize the initialization process to allow the JSP page to read persistent configuration data, initialize resources, and perform any other one-time activities by overriding the `jspInit` method of the `JspPage` interface. You release resources using the `jspDestroy` method. The methods are defined using JSP declarations, discussed in Declarations (page 276).

The bookstore example page `initdestroy.jsp` defines the `jspInit` method to retrieve or create an enterprise bean `database.BookDBEJB` that accesses the bookstore database and store a reference to the bean in `bookDBEJB`. The enterprise bean is created using the techniques described in Getting Started (page 49).

```
private BookDBEJB bookDBEJB;
public void jspInit() {
   bookDBEJB =
        (BookDB)getServletContext().
            getAttribute("bookDBEJB");
   if (bookDBEJB == null) {
        try {
            InitialContext ic = new InitialContext();
            Object objRef = ic.lookup(
                "java:comp/env/ejb/BookDBEJB");
            BookDBEJBHome home =
                (BookDBEJBHome)PortableRemoteObject.
                    narrow(objRef,
                    database.BookDBEJBHome.class);
            bookDBEJB = home.create();
            getServletContext().setAttribute("bookDBEJB",
            bookDBEJB);
        } catch (RemoteException ex) {
            System.out.println(
                "Couldn't create database bean." +
                ex.getMessage());
        } catch (CreateException ex) {
            System.out.println(
                "Couldn't create database bean." +
                ex.getMessage());
        } catch (NamingException ex) {
            System.out.println(
                "Unable to lookup home: " +
                "java:comp/env/ejb/BookDBEJB."+
                ex.getMessage());
        }
   }
}
```

When the JSP page is removed from service, the `jspDestroy` method releases the `BookDBEJB` variable.

```
public void jspDestroy() {
   bookDBEJB = null;
}
```

Since the enterprise bean is shared between all the JSP pages, it should be initialized when the application is started, instead of in each JSP page. Java Servlet technology provides application life cycle events and listener classes for this purpose. As an exercise, you can move the code that manages the creation of the enterprise bean to a context listener class. See Handling Servlet Life Cycle Events (page 232) for the context listener that initializes the Java Servlet version of the bookstore application.

Creating Static Content

You create static content in a JSP page by simply writing it as if you were creating a page that consists only of that content. Static content can be expressed in any text-based format such as HTML, WML, and XML. The default format is HTML. If you want to use a format other than HTML you include a `page` directive with the `contentType` attribute set to the format type at the beginning of your JSP page. For example, if you want a page to contain data expressed in the wireless markup language (WML), you need to include the following directive:

```
<%@ page contentType="text/vnd.wap.wml"%>
```

A registry of content type names is kept by IANA at:

```
ftp://ftp.isi.edu/in-notes/iana/assignments/media-types
```

Creating Dynamic Content

You create dynamic content by accessing Java programming language objects from within scripting elements.

Using Objects Within JSP Pages

You can access a variety of objects, including enterprise beans and JavaBeans components, within a JSP page. JSP technology automatically makes some objects available and you can also create and access application-specific objects.

Implicit Objects

Implicit objects are created by the web container and contain information related to a particular request, page, or application. Many of the objects are defined by the Java Servlet technology underlying JSP technology and are discussed at length in Java Servlet Technology (page 225). Table 25 summarizes the implicit objects.

Table 25 Implicit Objects

Variable	Class	Description
`application`	`javax.servlet.ServletContext`	The context for the JSP page's servlet and any web components contained in the same application. See Accessing the Web Context (page 253).
`config`	`javax.servlet.ServletConfig`	Initialization information for the JSP page's servlet.
`exception`	`java.lang.Throwable`	Accessible only from an error page. See Handling Errors (page 271).
`out`	`javax.servlet.jsp.JspWriter`	The output stream.
`page`	`java.lang.Object`	The instance of the JSP page's servlet processing the current request. Not typically used by JSP page authors.
`pageContext`	`javax.servlet.jsp.PageContext`	The context for the JSP page. Provides a single API to manage the various scoped attributes described in Sharing Information (page 234). This API is used extensively when implementing tag handlers (see Tag Handlers (page 305)).
`request`	subtype of `javax.servlet.ServletRequest`	The request triggering the execution of the JSP page. See Getting Information From Requests (page 239).
`response`	subtype of `javax.servlet.ServletResponse`	The response to be returned to the client. Not typically used by JSP page authors.
`session`	`javax.servlet.http.HttpSession`	The session object for the client. See Accessing the Web Context (page 253).

Application-Specific Objects

When possible, application behavior should be encapsulated in objects so that page designers can focus on presentation issues. Objects can be created by developers who are proficient in the Java programming language and accessing databases and other services. There are four ways to create and use objects within a JSP page:

- Instance and class variables of the JSP page's servlet class are created in *declarations* and accessed in *scriptlets* and *expressions*.
- Local variables of the JSP page's servlet class are created and used in *scriptlets* and *expressions*.
- Attributes of scope objects (see Scope Objects (page 235)) are created and used in *scriptlets* and *expressions*.
- JavaBeans components can be created and accessed using streamlined JSP elements. These elements are discussed in the chapter JavaBeans™ Components in JSP™ Pages (page 285). You can also create a JavaBeans component in a declaration or scriptlet and invoke the methods of a JavaBeans component in a scriptlet or expression.

Declarations, scriptlets, and expressions are described in JSP Scripting Elements (page 276).

Shared Objects

The conditions affecting concurrent access to shared objects described in Sharing Information (page 234) apply to objects accessed from JSP pages that run as multithreaded servlets. You can indicate how a web container should dispatch multiple client requests with the following `page` directive:

```
<%@ page isThreadSafe="true|false" %>
```

When `isThreadSafe` is set to `true`, the web container may choose to dispatch multiple concurrent client requests to the JSP page. This is the *default* setting. If using `true`, you must ensure that you properly synchronize access to any shared objects defined at the page level. This includes objects created within declarations, JavaBeans components with page scope, and attributes of the `page` scope object.

If `isThreadSafe` is set to `false`, requests are dispatched one at a time, in the order they were received and access to page level objects does not have to be controlled. However, you still must ensure that access to attributes of the `application` or `session` scope objects and JavaBeans components with application or session scope is properly synchronized.

JSP Scripting Elements

JSP scripting elements are used to create and access objects, define methods, and manage the flow of control. Since one of the goals of JSP technology is to separate static template data from the code needed to dynamically generate content, very sparing use of JSP scripting is recommended. Much of the work that requires the use of scripts can be eliminated by using custom tags, described in Extending the JSP Language (page 283).

JSP technology allows a container to support any scripting language that can call Java objects. If you wish to use a scripting language other than the default, `java`, you must specify it in a `page` directive at the beginning of a JSP page:

```
<%@ page language="scripting language" %>
```

Since scripting elements are converted to programming language statements in the JSP page's servlet class, you must import any classes and packages used by a JSP page. If the page language is `java`, you import a class or package with the `page` directive:

```
<%@ page import="packagename.*, fully_qualified_classname" %>
```

For example, bookstore example page `showcart.jsp` imports the classes needed to implement the shopping cart with the following directive:

```
<%@ page import="java.util.*, cart.*" %>
```

Declarations

A declaration is used to declare variables and methods in a page's scripting language. The syntax for a declaration is:

```
<%! scripting language declaration %>
```

When the scripting language is the Java programming language, variables and methods in JSP declarations become declarations in the JSP page's servlet class.

The bookstore example page `initdestroy.jsp` defines an instance variable named `bookDBEJB` and the initialization and finalization methods `jspInit` and `jspDestroy` discussed earlier in a declaration:

```
<%!
   private BookDBEJB bookDBEJB;

   public void jspInit() {
```

```
        ...
    }
    public void jspDestroy() {
        ...
    }
%>
```

Scriptlets

A scriptlet is used to contain any code fragment that is valid for the scripting language used in a page. The syntax for a scriptlet is:

```
<%
    scripting language statements
%>
```

When the scripting language is set to `java`, a scriptlet is transformed into a Java programming language statement fragment and is inserted into the service method of the JSP page's servlet. A programming language variable created within a scriptlet is accessible from anywhere within the JSP page.

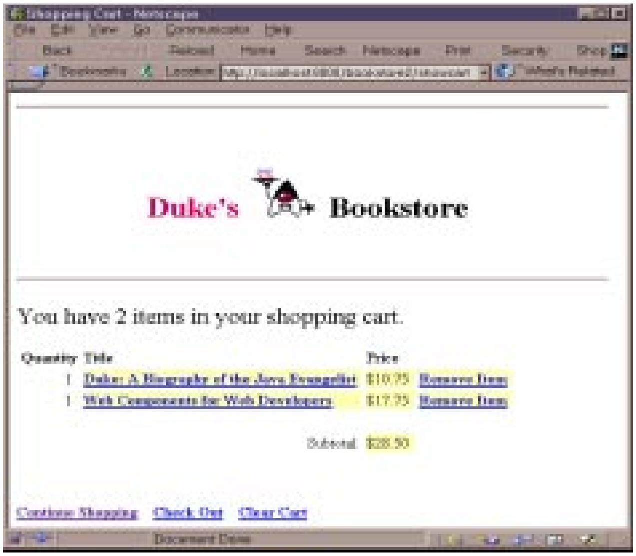
The JSP page `showcart.jsp` contains a scriptlet that retrieves an iterator from the collection of items maintained by a shopping cart and sets up a construct to loop through all the items in the cart. Inside the loop, the JSP page extracts properties of the book objects and formats them using HTML markup. Since the `while` loop opens a block, the HTML markup is followed by a scriptlet that closes the block.

```
<%
    Iterator i = cart.getItems().iterator();
    while (i.hasNext()) {
        ShoppingCartItem item =
            (ShoppingCartItem)i.next();
        BookDetails bd = (BookDetails)item.getItem();
%>

        <tr>
        <td align="right" bgcolor="#ffffff">
        <%=item.getQuantity()%>
        </td>
        <td bgcolor="#ffffaa">
        <strong><a href="
        <%=request.getContextPath()%>/bookdetails?bookId=
        <%=bd.getBookId()%>"><%=bd.getTitle()%></a></strong>
        </td>
        ...
```

```
<%
   // End of while
   }
%>
```

The output appears below:



Expressions

A JSP expression is used to insert the value of a scripting language expression, converted into a string, into the data stream returned to the client. When the scripting language is the Java programming language, an expression is transformed into a statement that converts the value of the expression into a `String` object and inserts it into the implicit `out` object.

The syntax for an expression is:

```
<%= scripting language expression %>
```

Note that a semicolon is not allowed within a JSP expression, even if the same expression has a semicolon when you use it within a scriptlet.

The following scriptlet retrieves the number of items in a shopping cart:

```
<%
   // Print a summary of the shopping cart
   int num = cart.getNumberOfItems();
   if (num > 0) {
%>
```

Expressions are then used to insert the value of `num` into the output stream and determine the appropriate string to include after the number:

```
<font size="+2">
<%=messages.getString("CartContents")%> <%=num%>
<%=(num==1 ? <%=messages.getString("CartItem")%> :
<%=messages.getString("CartItems")%>)%></font>
```

Including Content in a JSP Page

There are two mechanisms for including content from another source in a JSP page: the `include` directive and the `jsp:include` element.

The `include` directive is processed when the JSP page is *translated* into a servlet class. The effect of the directive to the insert the text contained in another file, either static content or another JSP page, in the including JSP page. You would probably use the `include` directive to include banner content, copyright information, or any chunk of content that you might want to reuse in another page. The syntax for the `include` directive is:

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

For example, all the bookstore application pages include the file `banner.jsp` containing the banner content with the following directive:

```
<%@ include file="banner.jsp" %>
```

In addition, the pages `bookstore.jsp`, `bookdetails.jsp`, `catalog.jsp`, and `showcart.jsp` include JSP elements that create and destroy a database bean with the element:

```
<%@ include file="initdestroy.jsp" %>
```

Because you must statically put an `include` directive in each file that reuses the resource referenced by the directive, this approach has its limitations. For a more flexible approach to building pages out of content chunks, see A Template Tag Library (page 324).

The `include` element is processed when a JSP page is *executed*. The `include` action allows you to include either a static or dynamic file in a JSP file. The results of including static and dynamic files are quite different. If the file is static, its content is inserted into the calling JSP file. If the file is dynamic, the request is sent to the included JSP page, the included page is executed, and then the result is included in the response from the calling JSP page. The syntax for the `jsp:include` element is:

```
<jsp:include page="includedPage" />
```

The `date` application introduced at the beginning of this chapter includes the page that generates the display of the localized date with the following element:

```
<jsp:include page="date.jsp"/>
```

Transferring Control to Another Web Component

The mechanism for transferring control to another web component from a JSP page uses the functionality provided by the Java Servlet API as described in Transferring a Control to Another Web Component (page 252). You access this functionality from a JSP page with the `jsp:forward` element:

```
<jsp:forward page="/main.jsp" />
```

Note that if any data has already been returned to a client, the `jsp:forward` element will fail with an `IllegalStateException`.

Param Element

When an `include` or `forward` element is invoked, the original request object is provided to the target page. If you wish to provide additional data to that page, you can append parameters to the request object with the `param` element:

```
<jsp:include page="..." >
   <jsp:param name=”param1” value="value1"/>
</jsp:include>
```

Including an Applet

You can include an applet or JavaBeans component in a JSP page using the `jsp:plugin` element. This element generates HTML that contains the appropriate client browser dependent constructs (`<object>` or `<embed>`) that will result in the download of the Java Plugin software (if required) and client-side component and subsequent execution of an client-side component. The syntax for the `jsp:plugin` element follows:

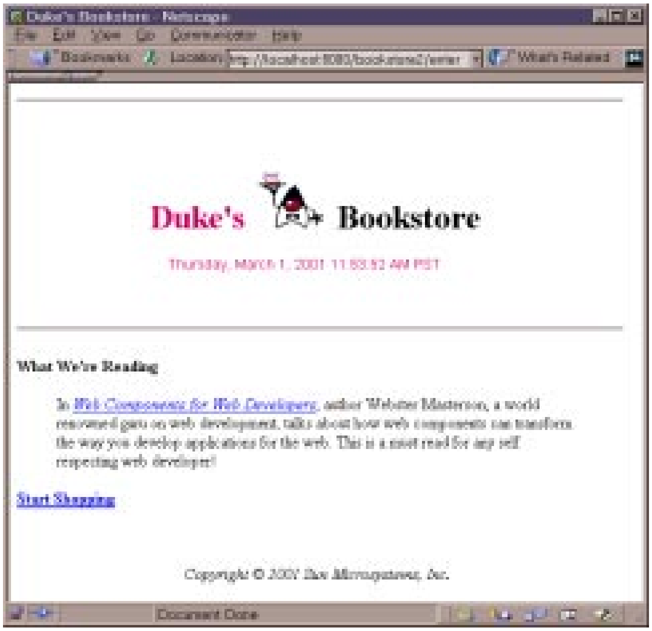
```
<jsp:plugin
   type="bean|applet"
   code="objectCode"
   codebase="objectCodebase"
   { align="alignment" }
   { archive="archiveList" }
   { height="height" }
   { hspace="hspace" }
   { jreversion="jreversion" }
   { name="componentName" }
   { vspace="vspace" }
   { width="width" }
   { nspluginurl="url" }
   { iepluginurl="url" } >
   { <jsp:params>
      { <jsp:param name="paramName" value= paramValue" /> }+
   </jsp:params> }
   { <jsp:fallback> arbitrary_text </jsp:fallback> }
</jsp:plugin>
```

The `jsp:plugin` tag is replaced by either an `<object>` or `<embed>` tag, as appropriate for the requesting client. The attributes of the jsp:plugin tag provide configuration data for the presentation of the element as well as the version of the plugin required. The `nspluginurl` and `iepluginurl` attributes specify the URL where the plugin can be downloaded.

The `jsp:param` elements indicate parameters to the applet or JavaBeans component. The `jsp:fallback` element indicates the content to be used by the client browser if the plugin cannot be started (either because `<object>` or `<embed>` is not supported by the client or due to some other problem).

If the plugin can start but the applet or JavaBeans component cannot be found or started, a plugin-specific message will be presented to the user, most likely a popup window reporting a `ClassNotFoundException`.

The Duke’s Bookstore page `banner.jsp` that creates the banner displays a dynamic digital clock generated by `DigitalClock`:



The `jsp:plugin` element used to download the applet follows:

```
<jsp:plugin
   type="applet"
   code="DigitalClock.class"
   codebase="/bookstore2"
   jreversion="1.3"
   align="center" height="25" width="300"
   nspluginurl="http://java.sun.com/products/plugin/1.3.0_01
       /plugin-install.html"
   iepluginurl="http://java.sun.com/products/plugin/1.3.0_01
       /jinstall-130_01-win32.cab#Version=1,3,0,1" >
   <jsp:params>
       <jsp:param name="language"
           value="<%=request.getLocale().getLanguage()%>" />
       <jsp:param name="country"
           value="<%=request.getLocale().getCountry()%>" />
       <jsp:param name="bgcolor" value="FFFFFF" />
       <jsp:param name="fgcolor" value="CC0066" />
   </jsp:params>
```

```
        <jsp:fallback>
            <p>Unable to start plugin.</p>
        </jsp:fallback>
    </jsp:plugin>
```

Extending the JSP Language

You can perform a wide variety of dynamic processing tasks including accessing databases, using enterprise services such as email and directories, and flow control with JavaBeans components in conjunction with scriptlets. One of the drawbacks of scriptlets however, is that they tend to make JSP pages more difficult to maintain. Alternatively, JSP technology provides a mechanism, called *custom tags*, that allows you to encapsulate dynamic functionality in objects that are accessed through extensions to the JSP language. Custom tags bring the benefits of another level of componentization to JSP pages.

For example, recall the scriptlet used to loop through and display the contents of the Duke's Bookstore shopping cart:

```
<%
    Iterator i = cart.getItems().iterator();
    while (i.hasNext()) {
        ShoppingCartItem item =
            (ShoppingCartItem)i.next();
        ...
%>
        <tr>
        <td align="right" bgcolor="#ffffff">
        <%=item.getQuantity()%>
        </td>
        ...
<%
    }
%>
```

An `iterate` custom tag eliminates the code logic and manages the scripting variable `item` that references elements in the shopping cart:

```
<logic:iterate id="item"
    collection="<%=cart.getItems()%>"
    <tr>
    <td align="right" bgcolor="#ffffff">
```

```
        <%=item.getQuantity()%>
        </td>
        ...
    </logic:iterate>
```

Custom tags are packaged and distributed in a unit called a *tag library*. The syntax of custom tags is the same as that used for the JSP elements, namely `<prefix:tag>`, but for custom tags, the prefix is defined by the *user* of the tag library and the tag is defined by the *tag developer*. Custom Tags in JSP™ Pages (page 295) explains how to use and develop custom tags.

JavaBeans™ Components in JSP™ Pages

by Stephanie Bodoff

JAVABEANS components are Java classes that can be easily reused and composed together into applications. Any Java class that follows certain design conventions can be a JavaBeans component.

JavaServer Pages™ technology directly supports using JavaBeans components with JSP language elements. You can easily create and initialize beans and get and set the values of their properties. This chapter provides basic information about JavaBeans components and the JSP language elements for accessing JavaBeans components in your JSP pages. For further information about the JavaBeans component model see `http://java.sun.com/products/javabeans`.

JavaBeans Component Design Conventions

JavaBeans component design conventions govern the properties of the class, and the public methods that give access to the properties.

A JavaBeans component property can be:

- Read/write, read-only, or write-only.
- Simple, which means it contains a single value, or indexed, which means it represents an array of values.

There is no requirement that a property be implemented by an instance variable; the property must simply be accessible using public methods that conform to certain conventions:

- For each readable property, the bean must have a method of the form: `PropertyClass getProperty() { ... }`
- For each writable property, the bean must have a method of the form: `setProperty(PropertyClass pc) { ... }`

In addition to the property methods, a JavaBeans component must define a constructor that takes no parameters.

The `Duke's Bookstore` application JSP pages `enter.jsp`, `bookdetails.jsp`, `catalog.jsp`, `showcart.jsp` use the `database.BookDB` and `database.BookDetails` JavaBeans components. `BookDB` provides a JavaBeans component front end to the enterprise bean `BookDBEJB`. Both beans are used extensively by bean-oriented custom tags (see Tags That Define Scripting Variables (page 314)). The JSP pages `showcart.jsp` and `cashier.jsp` use `cart.ShoppingCart` to represent a user's shopping cart.

The JSP pages `catalog.jsp`, `showcart.jsp`, and `cashier.jsp` use the `util.Currency` JavaBeans component to format currency in a locale-sensitive manner. The bean has two writable properties, `locale` and `amount`, and one readable property, `format`. The `format` property does not correspond to any instance variable, but returns a function of the `locale` and `amount` properties.

```
public class Currency {
   private Locale locale;
   private double amount;
   public Currency() {
      locale = null;
      amount = 0.0;
```

```
    }
    public void setLocale(Locale l) {
        locale = l;
    }
    public void setAmount(double a) {
        amount = a;
    }
    public String getFormat() {
        NumberFormat nf =
            NumberFormat.getCurrencyInstance(locale);
        return nf.format(amount);
    }
}
```

Why Use a JavaBeans Component?

A JSP page can create and use any type of Java programming language object within a declaration or scriptlet. The following scriptlet creates the bookstore shopping cart and stores it as a session attribute:

```
<%
    ShoppingCart cart = (ShoppingCart)session.
        getAttribute("cart");
    // If the user has no cart, create a new one
    if (cart == null) {
        cart = new ShoppingCart();
        session.setAttribute("cart", cart);
    }
%>
```

If the shopping cart object conforms to JavaBeans conventions, JSP pages can use JSP elements to create and access the object. For example, the `Duke's Bookstore` pages `bookdetails.jsp`, `catalog.jsp`, and `showcart.jsp` replace the scriptlet with the much more concise JSP `useBean` element:

```
<jsp:useBean id="cart" class="cart.ShoppingCart"
    scope="session"/>
```

Creating and Using a JavaBeans Component

You declare that your JSP page will use a JavaBeans component using either one of the following formats:

```
<jsp:useBean id="beanName"
   class="fully_qualified_classname" scope="scope"/>
```

or

```
<jsp:useBean id="beanName"
   class="fully_qualified_classname" scope="scope">
   <jsp:setProperty .../>
</jsp:useBean>
```

The second format is used when you want to include `jsp:setProperty` statements, described in the next section, for initializing bean properties.

The `jsp:useBean` element declares that the page will use a bean that is stored within and accessible from the specified scope, which can be `application`, `session`, `request` or `page`. If no such bean exists, the statement creates the bean and stores it as an attribute of the scope object (see Scope Objects (page 235)). The value of the `id` attribute determines the *name* of the bean in the scope and the *identifier* used to reference the bean in other JSP elements and scriptlets.

Note: In JSP Scripting Elements (page 276) we mentioned that you must you must import any classes and packages used by a JSP page. This rule is slightly altered if the class is only referenced by `useBean` elements. In these cases, you must only import the class if the class is in the unnamed package. For example, in What is a JSP Page? (page 262), the page `index.jsp` imports the `MyLocales` class. However, in the Duke's Bookstore example, all classes are contained in packages, and so are not explicitly imported.

The following element creates an instance of `Currency` if none exists, stores it as an attribute of the `session` object, and makes the bean available throughout the session by the identifier `currency`:

```
<jsp:useBean id="currency" class="util.Currency"
   scope="session"/>
```

Setting JavaBeans Component Properties

There are two ways to set JavaBeans component properties in a JSP page:

- With the jsp:setProperty element
- With a scriptlet: <%= *beanName*.set*PropName*(*value*) %>

The syntax of the jsp:setProperty element depends on the source of the property value. Table 26 summarizes the various ways to set a property of a JavaBeans component using the jsp:setProperty element:

Table 26 Setting JavaBeans Component Properties

Value Source	Element Syntax
String constant	<jsp:setProperty name="*beanName*" property="*propName*" value="*string constant*"/>
Request parameter	<jsp:setProperty name="*beanName*" property="*propName*" param="*paramName*"/>
Request parameter name matches bean property	<jsp:setProperty name="*beanName*" property="*propName*"/> <jsp:setProperty name="*beanName*" property="*"/>
Expression	<jsp:setProperty name="*beanName*" property="*propName*" value="<%= *expression* %>"/>

1. *beanName* must be the same as that specified for the id attribute in a useBean element.
2. There must be a *setPropName* method in the JavaBeans component.
3. *paramName* must be a request parameter name.

A property set from a constant or request parameter must have a type listed in Table 27. Since both a constant and request parameter are strings, the web container automatically converts the value to the property's type; the conversion applied is shown in the table. String values can be used to assign values to a property that has a PropertyEditor class. When that is the case, the setAsText(String) method is used. A conversion failure arises if the method throws an `IllegalArgumentException`. The value assigned to an indexed property must be an array, and the rules just described apply to the elements.

Table 27 Valid Value Assignments

Property Type	**Conversion on String Value**
Bean Property	Uses `setAsText(`*`string-literal`*`)`
`boolean` or `Boolean`	As indicated in `java.lang.Boolean.valueOf(String)`
`byte` or `Byte`	As indicated in `java.lang.Byte.valueOf(String)`
`char` or `Character`	As indicated in `java.lang.String.charAt(0)`
`double` or `Double`	As indicated in `java.lang.Double.valueOf(String)`
`int` or `Integer`	As indicated in `java.lang.Integer.valueOf(String)`
`float` or `Float`	As indicated in `java.lang.Float.valueOf(String)`
`long` or `Long`	As indicated in `java.lang.Long.valueOf(String)`
`short` or `Short`	As indicated in `Short.valueOf(String)`
Object	new `String(`*`string-literal`*`)`

You would use a runtime expression to set the value of a property whose type is a compound Java programming language type. Recall from Expressions (page 278) that a JSP expression is used to insert the value of a scripting language expression, converted into a `String`, into the stream returned to the client. When used within a `setProperty` element, an expression simply returns its value; *no* automatic conversion is performed. As a consequence, the type returned from an expression must match or be castable to the type of the property.

The `Duke's Bookstore` application demonstrates how to use the `setProperty` element and a scriptlet to set the current book for the database helper bean. For example, `bookstore3/bookdetails.jsp` uses the form:

```
<jsp:setProperty name="bookDB" property="bookId"/>
```

while `bookstore2/bookdetails.jsp` uses the form:

```
<% bookDB.setBookId(bookId) %>
```

The following fragments from the page `bookstore3/showcart.jsp` illustrate how to initialize a currency bean with a `Locale` object and amount determined by evaluating request-time expressions. Because the first initialization is nested in a `useBean` element, it is only executed when the bean is created.

```
<jsp:useBean id="currency" class="util.Currency"
   scope="session">
   <jsp:setProperty name="currency" property="locale"
       value="<%= request.getLocale() %>"/>
</jsp:useBean>

<jsp:setProperty name="currency" property="amount"
   value="<%=cart.getTotal()%>"/>
```

Retrieving JavaBeans Component Properties

There are several ways to retrieve JavaBeans component properties. Two of the methods convert the value of the property into a `String` and insert the value into the current implicit `out` object: the `jsp:getProperty` element and an expression:

- `<jsp:getProperty name="`*`beanName`*`" property="`*`propName`*`"/>`
- `<%= `*`beanName`*`.get`*`PropName`*`() %>`

For both methods, *`beanName`* must be the same as that specified for the `id` attribute in a `useBean` element and there must be a `get`*`PropName`* method in the JavaBeans component.

If you need to retrieve the value of a property without converting it and inserting it into the out object, you must use a scriptlet:

```
<% Object o = beanName.getPropName(); %>
```

Note the differences between the expression and the scriptlet; the expression has an ‘=’ after the opening ‘%’ and does not terminate with a semicolon, as does the scriptlet.

The `Duke’s Bookstore` application demonstrates how to use both forms to retrieve the formatted currency from the currency bean and insert it into the page. For example, `bookstore3/showcart.jsp` uses the form:

```
<jsp:getProperty name="currency" property="format"/>
```

while `bookstore2/showcart.jsp` uses the form:

```
<%= currency.getFormat() %>
```

The `Duke's Bookstore` application page `bookstore2/showcart.jsp` uses the following scriptlet to retrieve the number of books from the shopping cart bean and open a conditional insertion of text into the output stream:

```
<%
   // Print a summary of the shopping cart
   int num = cart.getNumberOfItems();
   if (num > 0) {
%>
```

Although scriptlets are very useful for dynamic processing, using custom tags (see Custom Tags in JSP™ Pages (page 295)) to access object properties and perform flow control is considered to be a better approach. For example, `bookstore3/showcart.jsp` replaces the scriptlet with the following custom tags:

```
<bean:define id="num" name="cart" property="numberOfItems" />
<logic:greaterThan name="num" value="0" >
```

Figure 21 summarizes where various types of objects are stored and how those objects can be accessed from a JSP page. Objects created by the `jsp:useBean` tag are stored as attributes of the scope objects and can be accessed by `jsp:[get|set]Property` tags and in scriptlets and expressions. Objects created in declarations and scriptlets are stored as variables of the JSP page's servlet class and can be accessed in scriptlets and expressions.

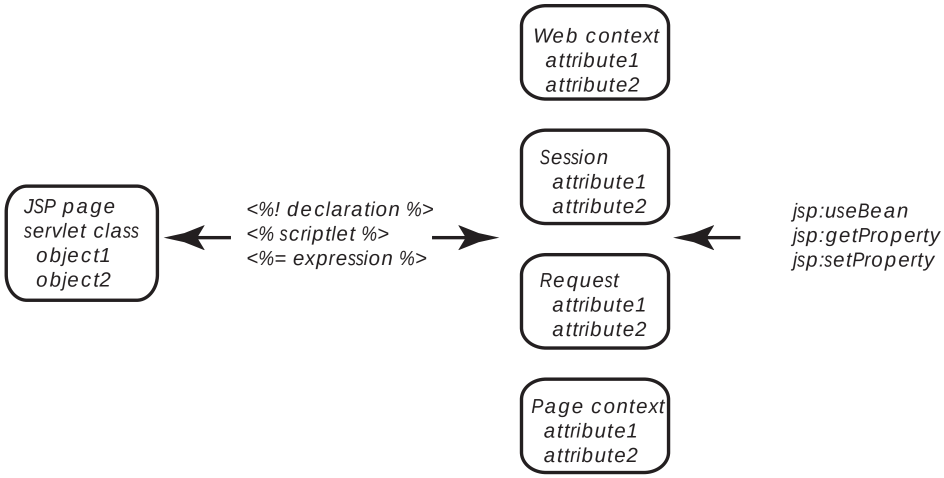


Figure 21 Accessing Objects From a JSP Page

Custom Tags in JSP™ Pages

by Stephanie Bodoff

THE standard JSP tags for invoking operations on JavaBeans™ components and performing request dispatching simplify JSP page development and maintenance. JSP technology also provides a mechanism for encapsulating other types of dynamic functionality in *custom tags*, which are extensions to the JSP language. Custom tags are usually distributed in the form of a *tag library*, which defines a set of related custom tags and contains the objects that implement the tags.

Some examples of tasks that can be performed by custom tags include operations on implicit objects, form processing, accessing databases and other enterprise services such as email and directories, and flow control. JSP tag libraries are created by developers who are proficient at the Java programming language and expert in accessing data and other services and used by web application designers who can focus on presentation issues rather than being concerned with how to access enterprise services. As well as encouraging division of labor between library developers and library users, custom tags increase productivity by encapsulating recurring tasks so that they can be reused across more than one application.

Tag libraries are receiving a great deal of attention in the JSP technology community. For more information about tag libraries and pointers to some freely-available libraries see `http://java.sun.com/products/jsp/taglibraries.html`.

What is a Custom Tag?

A custom tag is a user-defined JSP language element. When a JSP page containing a custom tag is translated into a servlet, the tag is converted to operations on an object called a *tag handler*. The web container then invokes those operations when the JSP page's servlet is executed.

Custom tags have a rich set of features. They can

- Be customized via attributes passed from the calling page.
- Access all the objects available to JSP pages.
- Modify the response generated by the calling page.
- Communicate with each other. You can create and initialize a JavaBeans component, create a variable that refers to that bean in one tag, and then use the bean in another tag.
- Be nested within one another, allowing for complex interactions within a JSP page.

The Example JSP Pages

This chapter describes the tasks involved in using and defining tags. The chapter illustrates the tasks with excerpts from the JSP version of the Duke's Bookstore application discussed in JavaServer Pages™ Technology (page 261) rewritten to take advantage of two tag libraries: Struts and tutorial-template. The third section in the chapter, Examples (page 320), describes two tags in detail: the `iterate` tag from Struts and the set of tags in the tutorial-template tag library.

The Struts tag library provides a framework for building internationalized web applications that implement the Model-View-Controller design pattern. Struts includes a comprehensive set of utility custom tags for handling:

- HTML forms
- Templates
- JavaBeans components
- Logic processing

The Duke's Bookstore application uses tags from the Struts `bean` and `logic` sublibraries.

The tutorial-template tag library defines a set of tags for creating an application template. The template is a JSP page, with place holders for the parts that need to change with each screen. Each of these place holders is referred to as a parameter of the template. For example, a simple template could include a title parameter for the top of the generated screen and a body parameter to refer to a JSP page for the custom content of the screen. The template is created with a set of nested tags—`definition`, `screen`, and `parameter`—that are used to build a table of screen definitions for Duke's Bookstore and an `insert` tag to insert parameters from the table into the screen.

Figure 22 shows the flow of a request through the Duke's Bookstore web components:

- `template.jsp` which determines the structure of each screen. It uses the `insert` tag to compose a screen from subcomponents.
- `screendefinitions.jsp` which defines the subcomponents used by each screen. All screens have the same banner, but different title and body content (specified by the JSP Pages column in Table 24).
- `Dispatcher`, a servlet, processes requests and forwards to `template.jsp`.

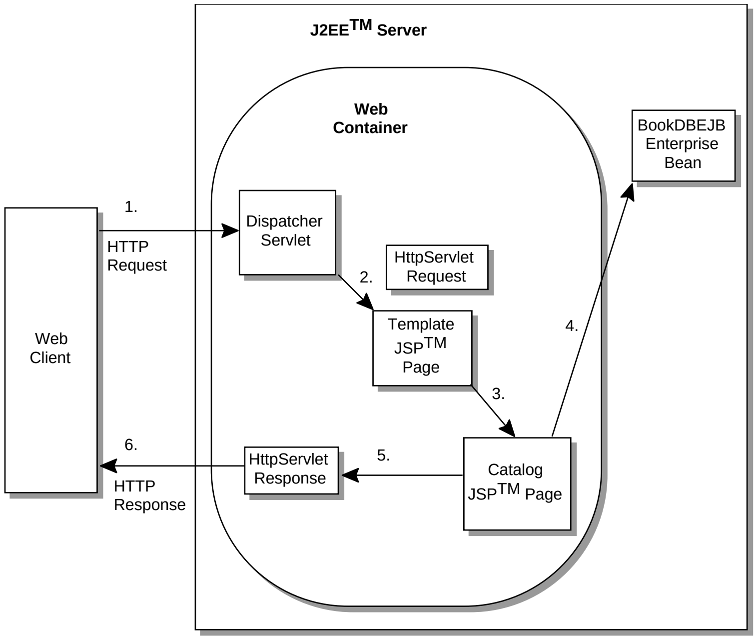


Figure 22 Request Flow Through Duke's Bookstore Components

The source for the Duke's Bookstore application is located in the `j2eetutorial/examples/src/web/bookstore3` directory created when you unzip the tutorial bundle (see Downloading the Examples (page xxii)). To build, deploy, and run the example:

1. Go to `j2eetutorial/examples/src` and build the application by executing `ant bookstore3` (see How to Build and Run the Examples (page xxiii)).
2. Download and unpack Struts version 1.0 from

   ```
   http://jakarta.apache.org/builds/jakarta-struts/
   release/v1.0/
   ```

   Copy `struts-bean.tld`, `struts-logic.tld`, and `struts.jar` from `jakarta-struts-1.0/lib` to `examples/build/web/bookstore3`.
3. Start the `j2ee` server.
4. Start `deploytool`
5. Start the Cloudscape database by executing `cloudscape -start`.

6. If you have not already created the bookstore database, run `ant create-web-db`.
7. Create a J2EE application called `Bookstore3App`.
   a. Select File->New Application.
   b. In the file chooser, navigate to `j2eetutorial/examples/src/web/bookstore3`.
   c. In the File Name field, enter `Bookstore3App` .
   d. Click New Application.
   e. Click OK.
8. Create the WAR and add the `DispatcherServlet` web component and all of the Duke's Bookstore content to `Bookstore3App`.
   a. Select File->New->Web Component.
   b. Click the Create New WAR File in Application radio button and select Bookstore3App from the combo box. Enter `Bookstore3WAR` in the field labeled WAR Display Name.
   c. Click Edit to add the content files. In the Edit Contents dialog, navigate to `j2eetutorial/examples/build/web/bookstore3`. Select Dispatcher.class and click Add. Add the JSP pages banner.jsp, bookstore.jsp, bookdetails.jsp, catalog.jsp, showcart.jsp, cashier.jsp, receipt.jsp, initdestroy.jsp, index.jsp, template.jsp, screendefinitions.jsp, and errorpage.jsp. Add duke.books.gif, struts-bean.tld, struts-logic.tld, tutorial-template.tld, and struts.jar. Add the cart, database, messages, taglib, and util packages. Click OK.
   d. Click Next.
   e. Select the servlet radio button.
   f. Click Next.
   g. Select Dispatcher from the Servlet class combo box.
   h. Click Next twice.
   i. In the Component Aliases panel click Add and then type `/enter` in the alias field. Repeat to add the aliases `/catalog`, `/bookdetails`, `/showcart`, `/cashier`, and `/receipt`.
   j. Click Finish.
9. Add the BookDBEJB enterprise bean that you created in The Example JSP Pages (page 265).
   a. Select File->Add->EJB JAR.
   b. Navigate to the directory `examples/build/web/ejb`.

c. Select `bookDB.jar`.

d. Click Add EJB JAR.

10. Add a reference to the enterprise bean `BookDBEJB`.

a. Select Bookstore3WAR.

b. Select the EJB Refs tab.

c. Click Add.

d. Enter `ejb/BookDBEJB` in the Coded Name column.

e. Enter Session in the Type column.

f. Select Remote in the Interfaces column.

g. Enter database.`BookDBEJBHome` in the Home Interface column.

h. Enter database.`BookDBEJB` in the Local/Remote Interface column.

11. Add the tag library URI to location mappings (see Declaring Tag Libraries (page 301)):

a. Select the File Refs tab

b. Click the Add button in the JSP Tag Libraries subpanel.

c. Enter the relative URI `/tutorial-template` in the Coded Reference field.

d. Enter the absolute location `/WEB-INF/tutorial-template.tld` in the Tag Library field.

e. Repeat for `/struts-bean` to `/WEB-INF/struts-bean.tld` and `/struts-logic` to `/WEB-INF/struts-logic.tld`.

12. Specify the JNDI Names

a. Select Bookstore3App.

b. In the Application table, locate the EJB component and enter `BookDBEJB` in the JNDI Name column.

c. In the References table, locate the EJB Ref, and enter `BookDBEJB` in the JNDI Name column.

d. In the References table, locate the Resource component and enter `jdbc/Cloudscape` in the JNDI Name column.

13. Enter the context root.

a. Select the Web Context tab.

b. Enter bookstore3.

14. Deploy the application.

a. Select Tools->Deploy.

b. Click Finish.

15.Open the bookstore URL `http://<host>:8000/bookstore3/enter`.

See Troubleshooting (page 231) for help with diagnosing common problems.

Using Tags

This section describes how a page author specifies that a JSP page is using a tag library and introduces the different types of tags.

Declaring Tag Libraries

You declare that a JSP page will use tags defined in a tag library by including a `taglib` directive in the page before any custom tag is used:

```
<%@ taglib uri="/WEB-INF/tutorial-template.tld" prefix="tt" %>
```

The `uri` attribute refers to a URI that uniquely identifies the TLD, described in Tag Library Descriptors (page 306). This URI can be direct or indirect. The `prefix` attribute defines the prefix that distinguishes tags defined by a given tag library from those provided by other tag libraries.

Tag library descriptor filenames must have the extension `.tld`. TLD files are stored in the `WEB-INF` directory of the WAR or in a subdirectory of `WEB-INF`. You can reference a TLD directly and indirectly.

The following `taglib` directive directly references a TLD filename:

```
<%@ taglib uri="/WEB-INF/tutorial-template.tld" prefix="tt" %>
```

This `taglib` directive uses a short logical name to indirectly reference the TLD:

```
<%@ taglib uri="/tutorial-template" prefix="tt" %>
```

1. A logical name must be mapped to an absolute location in the web application deployment descriptor. To map the logical name `/tutorial-template` to the absolute location `/WEB-INF/tutorial-template.tld`,Select Bookstore3WAR.
2. Select the File Refs tab
3. Click the Add button in the JSP Tag Libraries subpanel.

4. Enter the relative URI /tutorial-template in the Coded Reference field.
5. Enter the absolute location /WEB-INF/tutorial-template.tld in the Tag Library field.

Types of Tags

JSP custom tags are written using XML syntax. They have a start tag and end tag, and possibly a body:

```
<tt:tag>
   body
</tt:tag>
```

A custom tag with no body is expressed as follows:

```
<tt:tag />
```

Simple Tags

A simple tag contains no body and no attributes:

```
<tt:simple />
```

Tags With Attributes

A custom tag can have attributes. Attributes are listed in the start tag and have the syntax `attr="value"`. Attribute values serve to customize the behavior of a custom tag just as parameters are used to customize the behavior of a method.

You specify the types of a tag's attributes in a tag library descriptor, (see Tag Library Descriptors (page 306)).

You can set an attribute value from a `String` constant or a runtime expression. The conversion process between the constants and runtime expressions and attribute types follows the rules described for JavaBeans component properties in Setting JavaBeans Component Properties (page 289).

The attributes of the Struts `logic:present` tag determine whether the body of the tag is evaluated. In the following example, an attribute specifies a request parameter named `Clear`:

```
<logic:present parameter="Clear">
```

The Duke's Bookstore application page `catalog.jsp` uses a runtime expression to set the value of the attribute that determines the collection of books over which the Struts `logic:iterate` tag iterates:

```
<logic:iterate collection="<%=bookDB.getBooks()%>"
   id="book" type="database.BookDetails">
```

Tags With Bodies

A custom tag can contain custom and core tags, scripting elements, HTML text, and tag-dependent body content between the start and end tag.

In the following example, the Duke's Bookstore application page `showcart.jsp` uses the Struts `logic:present` tag to clear the shopping cart and print a message if the request contains a parameter named `Clear`:

```
<logic:present parameter="Clear">
   <% cart.clear(); %>
   <font color="#ff0000" size="+2"><strong>
   You just cleared your shopping cart!
   </strong><br> <br></font>
</logic:present>
```

Choosing Between Passing Information as Attributes or Body

As shown in the last two sections, it is possible to pass a given piece of data as an attribute of the tag or to the tag's body. Generally speaking, any data that is a simple string or can be generated by evaluating a simple expression is best passed as an attribute.

Tags That Define Scripting Variables

A tag can define a variable that can be used in scripts within a page. The following example illustrates how to define and use a scripting variable that contains an object returned from a JNDI lookup. Examples of such objects include enterprise beans, transactions, databases, environment entries, and so on:

```
<tt:lookup id="tx" type="UserTransaction"
   name="java:comp/UserTransaction" />
<% tx.begin(); %>
```

In the Duke's Bookstore application, several pages use bean-oriented tags from Struts to define scripting variables. For example, `bookdetails.jsp` uses the `bean:parameter` tag to create the `bookId` scripting variable and set it to value of the `bookId` request parameter. The `jsp:setProperty` statement also sets the bookId property of the bookDB object to the value of the bookId request parameter. The bean:define tag retrieves the value of the bookstore database property bookDetails and defines the result as the scripting variable book:

```
<bean:parameter id="bookId" name="bookId" />
<jsp:setProperty name="bookDB" property="bookId"/>
<bean:define id="book" name="bookDB" property="bookDetails"
   type="database.BookDetails"/>
<h2><jsp:getProperty name="book" property="title"></h2>
```

Cooperating Tags

Tags can cooperate with each other through shared objects.

In the following example, tag1 creates an object called obj1, which is then reused by tag2.

```
<tt:tag1 attr1="obj1" value1="value" />
<tt:tag2 attr1="obj1" />
```

In the next example, an object created by the enclosing tag of a group of nested tags is available to all inner tags. Since the object is not named, the potential for naming conflicts is reduced. The following example illustrates how a set of cooperating nested tags would appear in a JSP page.

```
<tt:outerTag>
   <tt:innerTag />
</tt:outerTag>
```

The Duke's Bookstore page template.jsp uses a set of cooperating tags to define the screens of the application. These tags are described in A Template Tag Library (page 324).

Defining Tags

To define a tag, you need to:

- Develop a tag handler and helper classes for the tag
- Declare the tag in a tag library descriptor (TLD)

This section describes the properties of tag handlers and TLDs and explains how to develop tag handlers and library descriptor elements for each type of tag introduced in the previous section.

Tag Handlers

A *tag handler* is an object invoked by a web container to evaluate a custom tag during the execution of the JSP page that references the tag. Tag handlers must implement either the `Tag` or `BodyTag` interface. Interfaces can be used to take an existing Java object and make it a tag handler. For newly created handlers, you can use the `TagSupport` and `BodyTagSupport` classes as base classes. These classes and interfaces are contained in the `javax.servlet.jsp.tagext` package.

Tag handler methods defined by the `Tag` and `BodyTag` interfaces are called by the JSP page's servlet at various points during the evaluation of the tag. When the start tag of a custom tag is encountered, the JSP page's servlet calls methods to initialize the appropriate handler and then invokes the handler's `doStartTag` method. When the end tag of a custom tag is encountered, the handler's `doEndTag` method is invoked. Additional methods are invoked in between when a tag handler needs to interact with the body of the tag. For further information, see How Is a Tag Handler Invoked? (page 329). In order to provide a tag handler implementation, you must implement the methods, summarized in Table 28, that are invoked at various stages of processing the tag.

Table 28 Tag Handler Methods

Tag Handler Type	Methods
Simple	`doStartTag, doEndTag, release`
Attributes	`doStartTag, doEndTag, set/getAttribute1...N, release`
Body, Evaluation and No Interaction	`doStartTag, doEndTag, release`
Body, Iterative Evaluation	`doStartTag, doAfterBody, doEndTag, release`
Body, Interaction	`doStartTag, doEndTag, release, doInitBody, doAfterBody, release`

A tag handler has access to an API that allows it to communicate with the JSP page. The entry point to the API is the page context object (`javax.serv-`

let.jsp.PageContext) through which a tag handler can retrieve all the other implicit objects (request, session, and application) accessible from a JSP page.

Implicit objects can have named attributes associated with them. Such attributes are accessed using [set|get]Attribute methods.

If the tag is nested, a tag handler also has access to the handler (called the *parent*) associated with the enclosing tag.

A set of related tag handler classes (a tag library) is usually packaged and deployed as a JAR archive.

Tag Library Descriptors

A *tag library descriptor* (TLD) is an XML document that describes a tag library. A TLD contains information about a library as a whole and about each tag contained in the library. TLDs are used by a web container to validate the tags and by JSP page development tools.

TLD filenames must have the extension .tld. TLD files are stored in the WEB-INF directory of the WAR file or a subdirectory of WEB-INF. When you add a TLD to a WAR using deploytool,

A TLD must begin with an XML document prolog that specifies the version of XML and the document type definition (DTD):

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<!DOCTYPE taglib PUBLIC "-//Sun Microsystems, Inc.//DTD JSP Tag
Library 1.2//EN"
"http://java.sun.com/dtd/web-jsptaglibrary_1_2.dtd">
```

The J2EE SDK version 1.3 can understand 1.1 and 1.2 version DTDs. However, this chapter documents the 1.2 version because you should use the newer version in any tag libraries that you develop. The template library TLD, tutorial-template.tld, conforms to the 1.2 version. The Struts library TLDs conform to the 1.1 version of the DTD, which has fewer elements and uses slightly different names for some of the elements.

The root of a TLD is the `taglib` element. The subelements of `taglib` are listed in Table 29:

Table 29 `taglib` Subelements

Element	Description
`tlib-version`	The tag library's version.
`jsp-version`	The JSP specification version the tag library requires.
`short-name`	Optional name that could be used by a JSP page authoring tool to create names with a mnemonic value.
`uri`	A URI that uniquely identifies the tag library.
`display-name`	Optional name intended to be displayed by tools.
`small-icon`	Optional small-icon that can be used by tools.
`large-icon`	Optional large-icon that can be used by tools.
`description`	Optional tag-specific information.
`listener`	See Listener Element (page 307).
`tag`	See Tag Element (page 307).

Listener Element

A tag library can specify some classes that are event listeners (see Handling Servlet Life Cycle Events (page 232)). The listeners are listed in the TLD as `listener` elements and the web container will instantiate the listener classes and register them in a way analogous to listeners defined at the WAR level. Unlike WAR-level listeners, the order in which the tag library listeners are registered is undefined. The only subelement of the `listener` element is the `listener-class` element, which must contain the fully-qualified name of the listener class.

Tag Element

Each tag in the library is described by giving its name and the class of its tag handler, information on the scripting variables created by the tag, and information on the tag's attributes. Scripting variable information can be given directly in the TLD or through a tag extra info class (see Tags That Define Scripting

Variables (page 314)). Each attribute declaration contains an indication of whether the attribute is required or not, whether its value can be determined by request-time expressions, and the type of the attribute (see Tags With Attributes (page 309)).

A tag is specified in a TLD in a `tag` element. The subelements of tag are listed in Table 30:

Table 30 `tag` Subelements

Element	Description
`name`	The unique tag name.
`tag-class`	The fully-qualified name of the tag handler class.
`tei-class`	Optional subclass of `javax.servlet.jsp.tagext.TagExtraInfo`. See TagExtraInfo Class (page 317).
`body-content`	The body content type. See Body-content Element (page 309) and Body-content Element (page 314).
`display-name`	Optional name intended to be displayed by tools.
`small-icon`	Optional small-icon that can be used by tools.
`large-icon`	Optional large-icon that can be used by tools.
`description`	Optional tag-specific information.
`variable`	Optional scripting variable information. See Variable Element (page 316).
`attribute`	Tag attribute information. See Attribute Element (page 310).

The following sections will describe the methods and TLD elements that you need to develop for each type of tag introduced in Using Tags (page 301).

Simple Tags

Tag Handlers

The handler for a simple tag must implement the `doStartTag` and `doEndTag` methods of the `Tag` interface. The `doStartTag` method is invoked when the start tag is encountered. This method returns SKIP_BODY because a simple tag has no body. The doEndTag method is invoked when the end tag is encountered. The doEndTag method needs to return EVAL_PAGE if the rest of the page needs to be evaluated; otherwise it should return SKIP_PAGE.

The simple tag discussed in the first section:

```
<tt:simple />
```

would be implemented by the following tag handler:

```
public SimpleTag extends TagSupport {
   public int doStartTag() throws JspException {
        try {
             pageContext.getOut().print("Hello.");
        } catch (Exception ex) {
             throw new JspTagException("SimpleTag: " +
                  ex.getMessage());
        }
        return SKIP_BODY;
   }
   public int doEndTag() {
        return EVAL_PAGE;
   }
}
```

Body-content Element

Tags without bodies must declare that their body content is empty using the body-content element:

```
<body-content>empty</body-content>
```

Tags With Attributes

Defining Attributes in a Tag Handler

For each tag attribute, you must define a property and get and set methods that conform to the JavaBeans architecture conventions in the tag handler. For example, the tag handler for the Struts logic:present tag

```
<logic:present parameter="Clear">
```

contains the following declaration and methods:

```
protected String parameter = null;
public String getParameter() {
   return (this.parameter);
}
public void setParameter(String parameter) {
   this.parameter = parameter;
}
```

Note that if your attribute is named `id`, and your tag handler inherits from the `TagSupport` class, you do not need to define the property and set and get methods as these are already defined by `TagSupport`.

A tag attribute whose value is a `String` can name an attribute of one of the implicit objects available to tag handlers. An implicit object attribute would be accessed by passing the tag attribute value to the `[set|get]Attribute` method of the implicit object. This is a good way to pass scripting variable names to a tag handler where they are associated with objects stored in the page context (See Tags That Define Scripting Variables (page 314)).

Attribute Element

For each tag attribute you must specify whether the attribute is required, whether the value can be determined by an expression, and optionally, the type of the attribute. For static values the type is always `java.lang.String`. If the `rtexprvalue` element is `true` or `yes`, then the `type` element defines the return type expected from any expression specified as the value of the attribute.

```
<attribute>
   <name>attr1</name>
   <required>true|false|yes|no</required>
   <rtexprvalue>true|false|yes|no</rtexprvalue>
   <type>fully-qualified_type</type>
</attribute>
```

If a tag attribute is not required, a tag handler should provide a default value.

The `tag` element for the `logic:present` tag declares that `parameter` attribute is not required (because the tag can also test for the presence of other entities such as bean properties), and that its value can be set by a runtime expression.

```
<tag>
   <name>present</name>
   <tag-class>org.apache.struts.taglib.
       logic.PresentTag</tag-class>
   <body-content>JSP</body-content>
   ...
   <attribute>
       <name>parameter</name>
       <required>false</required>
       <rtexprvalue>true</rtexprvalue>
   </attribute>
   ...
</tag>
```

Attribute Validation

The documentation for a tag library should describe valid values for tag attributes. When a JSP page is translated, a web container will enforce any constraints contained in the TLD element for each attribute.

The attributes passed to a tag can also be validated at translation time with the `isValid` method of a class derived from `TagExtraInfo`. This class is also used to provide information about scripting variables defined by the tag (see Tags That Define Scripting Variables (page 314)).

The `isValid` method is passed the attribute information in a `TagData` object, which contains attribute-value tuples for each of the tag's attributes. Since the validation occurs at translation time, the value of an attribute that is computed at request time will be set to `TagData.REQUEST_TIME_VALUE`.

The tag `<tt:twa attr1="value1"/>` has the following TLD `attribute` element:

```
<attribute>
   <name>attr1</name>
   <required>true</required>
   <rtexprvalue>true</a>
</attribute
```

This declaration indicates that the value of `attr1` can be determined at runtime.

The following `isValid` method checks that the value of `attr1` is a valid boolean value. Note that since the value of `attr1` can be computed at runtime, `isValid` must check whether the tag user has chosen to provide a runtime value.

```
public class TwaTEI extends TagExtraInfo {
   public boolean isValid(Tagdata data) {
       Object o = data.getAttribute("attr1");
       if (o != null && o != TagData.REQUEST_TIME_VALUE) {
           if (o.toLowerCase().equals("true") ||
               o.toLowerCase().equals("false") )
               return true;
           else
               return false;
       }
       else
           return true;
   }
}
```

Tags With Bodies

Tag Handlers

A tag handler for a tag with a body is implemented differently depending on whether the tag handler needs to interact with the body or not. By interact, we mean that the tag handler reads or modifies the contents of the body.

Tag Handler Does Not Interact With the Body. If the tag handler does not need to interact with the body, the tag handler should implement the `Tag` interface (or be derived from `TagSupport`). If the body of the tag needs to be evaluated, the `doStartTag` method needs to return `EVAL_BODY_INCLUDE`; otherwise it should return `SKIP_BODY`.

If a tag handler needs to iteratively evaluate the body it should implement the `IterationTag` interface or be derived from `TagSupport`. It should return `EVAL_BODY_AGAIN` from the `doStartTag` and `doAfterBody` methods if it determines that the body needs to be evaluated again.

Tag Handler Interacts With the Body. If the tag handler needs to interact with the body, the tag handler must implement `BodyTag` (or be derived from `BodyTagSupport`). Such handlers typically implement the `doInitBody` and the `doAfterBody` methods. These methods interact with body content passed to the tag handler by the JSP page's servlet.

A body content supports several methods to read and write its contents. A tag handler can use the body content's `getString` or `getReader` methods to extract information from the body and the `writeOut(out)` method to write the body contents to an out stream. The writer supplied to the `writeOut` method is obtained using the tag handler's `getPreviousOut` method. This method is used to ensure that a tag handler's results are available to an enclosing tag handler.

If the body of the tag needs to be evaluated, the `doStartTag` method needs to return `EVAL_BODY_BUFFERED`; otherwise it should return `SKIP_BODY`.

`doInitBody` Method

The `doInitBody` method is called after the body content is set but before it is evaluated. You generally use this method to perform any initialization that depends on the body content.

`doAfterBody` Method

The `doAfterBody` method is called *after* the body content is evaluated.

Like the `doStartTag` method, `doAfterBody` must return an indication of whether to continue evaluating the body. Thus, if the body should be evaluated again, as would be the case if you were implementing an iteration tag, `doAfterBody` should return `EVAL_BODY_BUFFERED`; otherwise `doAfterBody` should return `SKIP_BODY`.

`release` Method

A tag handler should reset its state and release any private resources in the `release` method.

The following example reads the content of the body (which contains an SQL query) and passes it to a object that executes the query. Since the body does not need to be reevaluated, `doAfterBody` returns `SKIP_BODY`.

```
public class QueryTag extends BodyTagSupport {
   public int doAfterBody() throws JspTagException {
        BodyContent bc = getBodyContent();
        // get the bc as string
        String query = bc.getString();
        // clean up
        bc.clearBody();
        try {
             Statement stmt = connection.createStatement();
             result = stmt.executeQuery(query);
        } catch (SQLException e) {
             throw new JspTagException("QueryTag: " +
                  e.getMessage());
        }
        return SKIP_BODY;
   }
}
```

Body-content Element

For tags that have a body, you must specify the type of the body content:

```
<body-content>JSP|tagdependent</body-content>
```

Body content containing custom and core tags, scripting elements, and HTML text is categorized as `JSP`. This is the value declared for the Struts `logic:present` tag. All other types of body content, for example, SQL statements passed to the query tag, would be labeled `tagdependent`.

Note that the value of the `body-content` element does not affect the interpretation of the body by the tag handler; the element is only intended to be used by an authoring tool for rendering the body content.

Tags That Define Scripting Variables

Tag Handlers

A tag handler is responsible for creating and setting the object referred to by the scripting variable into a context accessible from the page. It does this by using the `pageContext.setAttribute(name, value, scope)` or `pageContext.setAttribute(name, value)` methods. Typically an attribute passed to the custom tag specifies the `name` of the scripting variable object; this name can be retrieved by invoking the attribute's get method described in Defining Attributes in a Tag Handler (page 309).

If the value of the scripting variable is dependent on an object present in the tag handler's context it can retrieve the object using the `pageContext.getAttribute(name, scope)` method.

The usual procedure is that the tag handler retrieves a scripting variable, performs some processing on the object, and then sets the scripting variable's value using the `pageContext.setAttribute(name, object)` method.

The scope that an object can have is summarized in Table 31. The scope constrains the accessibility and lifetime of the object.

Table 31 Scope of Objects

Name	Accessible From	Lifetime
`page`	Current page	Until the response has been sent back to the user or the request is passed to a new page
`request`	Current page and any included or forwarded pages	Until the response has been sent back to the user
`session`	Current request and any subsequent request from the same browser (subject to session lifetime).	The life of the user's session
`application`	Current and any future request from the same web application	The life of the application

Providing Information About the Scripting Variable

The example described in Tags That Define Scripting Variables (page 303) defines a scripting variable `book` that is used for accessing book information:

```
<bean:define id="book" name="bookDB" property="bookDetails"
   type="database.BookDetails"/>
<font color="red" size="+2">
   <%=messages.getString("CartRemoved")%>
   <strong><jsp:getProperty name="book"
            property="title"/></strong>
<br> <br>
</font>
```

When the JSP page containing this tag is translated, the web container generates code to synchronize the scripting variable with the object referenced by the variable. In order to do the code generation, the web container requires certain information about the scripting variable:

- Variable name
- Variable class
- Whether the variable refers to a new or existing object.

- The availability of the variable.

There are two ways to provide this information: by specifying the `variable` TLD subelement or by defining a tag extra info class and including the `tei-class` element in the TLD. Using the `variable` element is simpler, but slightly less flexible.

Variable Element. The `variable` element has the following subelements:

- `name-given` - The variable name as a constant
- `name-from-attribute` The name of an attribute whose translation-time value will give the name of the variable.

One of `name-given` or `name-from-attribute` is required. The following subelements are optional:

- `variable-class` Fully-qualified name of the class of the variable. `java.lang.String` is the default.
- `declare` - Whether the variable refers to a new object. `True` is the default.
- `scope` - The scope of the scripting variable defined. `NESTED` is default. Table 32 describes the availability of the scripting variable and the methods where the value of the variable must be set or reset.

Table 32 Scripting Variable Availability

Value	Availability	Methods
`NESTED`	Between the start tag and the end tag.	In `doInitBody` and `doAfterBody` for a tag handler implementing `BodyTag`; otherwise in `doStartTag`.
`AT_BEGIN`	From the start tag until the end of the page.	In `doInitBody`, `doAfterBody`, and `doEndTag` for a tag handler implementing `BodyTag`; otherwise in `doStartTag` and `doEndTag`.
`AT_END`	After the end tag until the end of the page.	In `doEndTag`.

The implementation of the Struts `bean:define` tag conforms to the JSP specification version 1.1, which requires you to define a tag extra info class. The JSP specification version 1.2 adds the `variable` element. You could define the following `variable` element for the `bean:define` tag:

```
<tag>
   <variable>
       <name-from-attribute>id</name-from-attribute>
       <variable-class>database.BookDetails</variable-class>
       <declare>true</declare>
       <scope>AT_BEGIN</scope>
   </variable>
</tag>
```

TagExtraInfo Class. You define a tag extra info class by extending the class `javax.servlet.jsp.TagExtraInfo`. A `TagExtraInfo` must implement the `getVariableInfo` method to return an array of `VariableInfo` objects containing the following information:

- Variable name
- Variable class
- Whether the variable refers to a new object
- The availability of the variable

The web container passes a parameter called `data` to the `getVariableInfo` method that contains attribute-value tuples for each of the tag's attributes. These attributes can be used to provide the `VariableInfo` object with a scripting variable's name and class.

The Struts tag library provides information about the scripting variable created by the `bean:define` tag in the `DefineTei` tag extra info class. Since the name (`book`) and class (`database.BookDetails`) of the scripting variable are passed in as tag attributes, they can be retrieved with the `data.getAttributeString` method and used to fill in the `VariableInfo` constructor. To allow the scripting variable `book` to be used in the rest of the page, the scope of `book` is set to be `AT_BEGIN`.

```
public class DefineTei extends TagExtraInfo {
   public VariableInfo[] getVariableInfo(TagData data) {
   String type = data.getAttributeString("type");
       if (type == null)
           type = "java.lang.Object";
       return new VariableInfo[] {
           new VariableInfo(data.getAttributeString("id"),
               type,
               true,
               VariableInfo.AT_BEGIN)
       };
   }
}
```

The fully-qualified name of the tag extra info class defined for a scripting variable must be declared in the TLD in the `tei-class` subelement of the `tag` element. Thus, the `tei-class` element for `DefineTei` would be:

```
<tei-class>org.apache.struts.taglib.bean.DefineTagTei
</tei-class>
```

Cooperating Tags

Tags cooperate by sharing objects. JSP technology supports two styles of object sharing.

The first style requires that a shared object be named and stored in the page context (one of the implicit objects accessible to both JSP pages and tag handlers). To access objects created and named by another tag, a tag handler uses the `pageContext.getAttribute(name, scope)` method.

In the second style of object sharing, an object created by the enclosing tag handler of a group of nested tags is available to all inner tag handlers. This form of object sharing has the advantage that it uses a private namespace for the objects, thus reducing the potential for naming conflicts.

To access an object created by an enclosing tag, a tag handler must first obtain its enclosing tag with the static method `TagSupport.findAncestorWithClass(from, class)` or the `TagSupport.getParent` method. The former method should be used when a specific nesting of tag handlers cannot be guaranteed. Once the ancestor has been retrieved, a tag handler can access any statically or dynamically created objects. Statically created objects are members of the parent. Private objects can also be created dynamically created. Such objects can be stored in a tag handler with the `setValue` method and retrieved with the `getValue method`.

The following example illustrates a tag handler that supports both the named and private object approaches to sharing objects. In the example, the handler for a query tag checks whether an attribute named `connection` has been set in the `doStartTag` method. If the connection attribute has been set, the handler retrieves the connection object from the page context. Otherwise, the tag handler first retrieves the tag handler for the enclosing tag, and then retrieves the connection object from that handler.

```
public class QueryTag extends BodyTagSupport {
   private String connectionId;
   public int doStartTag() throws JspException {
       String cid = getConnection();
```

```
        if (cid != null) {
        // there is a connection id, use it
            connection =(Connection)pageContext.
                getAttribute(cid);
        } else {
            ConnectionTag ancestorTag =
                (ConnectionTag)findAncestorWithClass(this,
                    ConnectionTag.class);
            if (ancestorTag == null) {
                throw new JspTagException("A query without
                    a connection attribute must be nested
                    within a connection tag.");
            }
            connection = ancestorTag.getConnection();
        }
    }
}
```

The query tag implemented by this tag handler could be used in either of the following ways:

```
<tt:connection id="con01" ....> ... </tt:connection>
<tt:query id="balances" connection="con01">
   SELECT account, balance FROM acct_table
       where customer_number = <%= request.getCustno()%>
</tt:query>

<tt:connection ...>
   <x:query id="balances">
       SELECT account, balance FROM acct_table
           where customer_number = <%= request.getCustno()%>
   </x:query>
</tt:connection>
```

The TLD for the tag handler must indicate that the connection attribute is optional with the following declaration:

```
<tag>
   ...
   <attribute>
       <name>connection</name>
       <required>false</required>
   </attribute>
</tag>
```

Examples

The custom tags described in this section demonstrate solutions to two recurring problems in developing JSP applications: minimizing the amount of Java programming in JSP pages and ensuring a common look and feel across applications. In doing so, they illustrate many of the styles of tags discussed in the first section.

An Iteration Tag

Constructing page content that is dependent on dynamically generated data often requires the use of flow control scripting statements. By moving the flow control logic to tag handlers, flow control tags reduce the amount of scripting needed in JSP pages.

The Struts logic:`iterate` tag retrieves objects from a collection stored in a JavaBeans component and assigns them to a scripting variable. The body of the tag retrieves information from the scripting variable. While elements remain in the collection, the `iterate` tag causes the body to be reevaluated.

JSP Page

Two Duke's Bookstore application pages, `catalog.jsp` and `showcart.jsp`, use the `logic:iterate` tag to iterate over collections of objects. An excerpt from `catalog.jsp` is shown below. The JSP page initializes the `iterate` tag with a collection (named by the `property` attribute) of the `bookDB` bean. The `iterate` tag sets the `book` scripting variable on each iteration over the collection. The `bookId` property of the `book` variable is exposed as another scripting variable. Properties of both variables are used to dynamically generate a table containing links to other pages and book catalog information.

```
<logic:iterate name="bookDB" property="books"
   id="book" type="database.BookDetails">
   <bean:define id="bookId" name="book" property="bookId"
       type="java.lang.String"/>

   <tr>
   <td bgcolor="#ffffaa">
   <a href="<%=request.getContextPath()%>
       /bookdetails?bookId=<%=bookId%>">
       <strong><jsp:getProperty name="book"
       property="title"/> </strong></a></td>

   <td bgcolor="#ffffaa" rowspan=2>
```

```
        <jsp:setProperty name="currency" property="amount"
            value="<%=book.getPrice()%>"/>
        <jsp:getProperty name="currency" property="format"/>
         </td>

        <td bgcolor="#ffffaa" rowspan=2>
        <a href="<%=request.getContextPath()%>
            /catalog?Add=<%=bookId%>">
             <%=messages.getString("CartAdd")%>
             </a></td></tr>

        <tr>
        <td bgcolor="#ffffff">
          <%=messages.getString("By")%> <em>
            <jsp:getProperty name="book"
                property="firstName"/> 
            <jsp:getProperty name="book"
                property="surname"/></em></td></tr>
    </logic:iterate>
```

Tag Handler

The implementation of the Struts `logic:iterate` tag conforms to JSP version 1.1 specification capabilities, which requires you to extend the `BodyTagSupport` class. The JSP version 1.2 specification adds features (described in Tag Handler Does Not Interact With the Body (page 312)) that simplify programming tags that iteratively evaluate their body. The following discussion is based on an implementation that uses these features.

The `logic:iterate` tag supports initializing the collection in a several ways: from a collection provided as a tag attribute or from a collection that is a bean or a property of a bean. Our example uses the latter method. Most of the code in `doStartTag` is concerned with constructing an iterator over the collection object. The method first checks if the handler's collection property is set and if not, proceeds to checking the bean and property attributes. If the `bean` and `property` attributes are both set, the `doStartTag` calls a utility method that uses JavaBeans introspection methods to retrieve the collection. Once the collection object is determined, the method constructs the iterator.

If the iterator contains more elements, `doStartTag` sets the value of the scripting variable to the next element and then indicates that the body should be evaluated; otherwise it ends the iteration by returning `SKIP_BODY`.

After the body has been evaluated, the `doAfterBody` method retrieves the body content and writes it to the out stream. The body content object is then cleared in preparation for another body evaluation. If the iterator contains more elements, doAfterBody again sets the value of the scripting variable to the next element and returns EVAL_BODY_AGAIN to indicate that the body should be evaluated again. This causes the re-execution of doAfterBody. When there are no remaining elements, doAfterBody terminates the process by returning SKIP_BODY.

```
public class IterateTag extends TagSupport {
   protected Iterator iterator = null;
   protected Object collection = null;
   protected String id = null;
   protected String name = null;
   protected String property = null;
   protected String type = null;
   public int doStartTag() throws JspException {
      Object collection = this.collection;
      if (collection == null) {
         try {
            Object bean = pageContext.findAttribute(name);
            if (bean == null) {
               ... throw an exception
            }
            if (property == null)
               collection = bean;
            else
               collection =
                  PropertyUtils.
                     getProperty(bean, property);
            if (collection == null) {
               ... throw an exception
            }
         } catch
            ... catch exceptions thrown
               by PropertyUtils.getProperty
         }
      }
      // Construct an iterator for this collection
      if (collection instanceof Collection)
         iterator = ((Collection) collection).iterator();
      else if (collection instanceof Iterator)
         iterator = (Iterator) collection;
         ...
      }
      // Store the first value and evaluate,
      // or skip the body if none
      if (iterator.hasNext()) {
         Object element = iterator.next();
         pageContext.setAttribute(id, element);
         return (EVAL_BODY_AGAIN);
```

```
        } else
            return (SKIP_BODY);
}
    public int doAfterBody() throws JspException {
        if (bodyContent != null) {
            try {
                JspWriter out = getPreviousOut();
                out.print(bodyContent.getString());
                bodyContent.clearBody();
            } catch (IOException e) {
                ...
            }
        }
        if (iterator.hasNext()) {
            Object element = iterator.next();
            pageContext.setAttribute(id, element);
            return (EVAL_BODY_AGAIN);
        } else
            return (SKIP_BODY);
        }
    }
}
```

Tag Extra Info Class

Information about the scripting variable is provided in the `IterateTei` tag extra info class. The name and class of the scripting variable are passed in as tag attributes and used to fill in the `VariableInfo` constructor.

```
public class IterateTei extends TagExtraInfo {
    public VariableInfo[] getVariableInfo(TagData data) {
    String type = data.getAttributeString("type");
    if (type == null)
        type = "java.lang.Object";

    return new VariableInfo[] {
        new VariableInfo(data.getAttributeString("id"),
            type,
            true,
            VariableInfo.AT_BEGIN)
        };
    }
}
```

A Template Tag Library

A template provides a way to separate the common elements that are part of each screen from the elements that change with each screen of an application. Putting all the common elements together into one file makes it easier to maintain and enforce a consistent look and feel in all the screens. It also makes development of individual screens easier since the designer can focus on portions of a screen that are specific to that screen while the template takes care of the common portions.

The template is a JSP page, with place holders for the parts that need to change with each screen. Each of these place holders is referred to as a parameter of the template. For example, a simple template could include a title parameter for the top of the generated screen and a body parameter to refer to a JSP page for the custom content of the screen.

The template uses a set of nested tags—`definition`, `screen`, and `parameter`—to define a table of screen definition for an application screen and an `insert` tag to insert parameters from a screen definition into the application screen.

JSP Page

The template for the Duke's Bookstore example, `template.jsp`, is shown below. This page includes a JSP page that creates the screen definition and then uses the `insert` tag to insert parameters from the definition into the application screen.

```
<%@ taglib uri="/tutorial-template.tld" prefix="tt" %>
<%@ page errorPage="errorpage.jsp" %>
<%@ include file="screendefinitions.jsp" %><html>
   <head>
        <title>
            <tt:insert definition="bookstore"
                parameter="title"/>
        </title>
   </head>
        <tt:insert definition="bookstore"
            parameter="banner"/>
        <tt:insert definition="bookstore"
            parameter="body"/>
   </body>
</html>
```

`screendefinitions.jsp` creates a screen definition based on a request attribute `selectedScreen`:

```
<tt:definition name="bookstore"
   screen="<%= (String)request.
       getAttribute(\"selectedScreen\") %>">
   <tt:screen id="/enter">
       <tt:parameter name="title"
           value="Duke's Bookstore" direct="true"/>
       <tt:parameter name="banner"
           value="/banner.jsp" direct="false"/>
       <tt:parameter name="body"
           value="/bookstore.jsp" direct="false"/>
   </tt:screen>
   <tt:screen id="/catalog">
       <tt:parameter name="title"
       value="<%=messages.getString("TitleBookCatalog")%>"
       direct="true"/>
       ...
</tt:definition>
```

The template is instantiated by the `Dispatcher` servlet. `Dispatcher` first gets the requested screen and stores as an attribute of the request. This is necessary because when the request is forwarded to `template.jsp`, the request URL doesn't contain the original request (for example, `/bookstore3/catalog`), but instead reflects the path (`/bookstore3/template.jsp`) of the forwarded page. Finally the servlet dispatches the request to `template.jsp`:

```
public class Dispatcher extends HttpServlet {
   public void doGet(HttpServletRequest request,
           HttpServletResponse response) {
       request.setAttribute("selectedScreen",
           request.getServletPath());
       RequestDispatcher dispatcher =
           request.getRequestDispatcher("/template.jsp");
       if (dispatcher != null)
           dispatcher.forward(request, response);
   }
   public void doPost(HttpServletRequest request,
               HttpServletResponse response) {
       request.setAttribute("selectedScreen",
           request.getServletPath());
       RequestDispatcher dispatcher =
           request.getRequestDispatcher("/template.jsp");
       if (dispatcher != null)
           dispatcher.forward(request, response);
   }
}
```

Tag Handlers

The template tag library contains four tag handlers—`DefinitionTag`, `ScreenTag`, `ParameterTag`, and `InsertTag`—that demonstrate the use of cooperating tags. `DefinitionTag`, `ScreenTag`, and `ParameterTag` comprise a set of nested tag handlers that share public and private objects. `DefinitionTag` creates a public named object called `definition` that is used by `InsertTag`.

In `doStartTag`, `DefinitionTag` creates a public object named `screens` that contains a hash table of screen definitions. A screen definition consists of a screen identifier and a set of parameters associated with the screen.

```
public int doStartTag() {
   HashMap screens = null;
   screens = (HashMap) pageContext.getAttribute("screens");
   if (screens == null)
        pageContext.setAttribute("screens", new HashMap(),
            pageContext.APPLICATION_SCOPE);
   return EVAL_BODY_INCLUDE;
}
```

The table of screen definitions is filled in by `ScreenTag` and `ParameterTag` from text provided as attributes to these tags. Table 33 shows the contents of the screen definitions hash table for the Duke’s Bookstore application.

Table 33 Screen Definitions

Screen Id	Title	Banner	Body
/enter	Duke’s Bookstore	/banner.jsp	/bookstore.jsp
/catalog	Book Catalog	/banner.jsp	/catalog.jsp
/bookdetails	Book Description	/banner.jsp	/bookdetails.jsp
/showcart	Your Shopping Cart	/banner.jsp	/showcart.jsp
/cashier	Cashier	/banner.jsp	/cashier.jsp
/receipt	Receipt	/banner.jsp	/receipt.jsp

In `doEndTag`, `DefinitionTag` creates a public object of class `Definition`, selects a screen definition from the `screens` object based on the URL passed in the request, and uses it to initialize the `Definition` object.

```
public int doEndTag()throws JspTagException {
   try {
       Definition definition = new Definition();
       Hashtable screens = null;
       ArrayList params = null;
       TagSupport screen = null;
       screens = (HashMap)
           pageContext.getAttribute("screens",
               pageContext.APPLICATION_SCOPE);
       if (screens != null)
           params = (ArrayList) screens.get(screenId);
       else
           ...
       if (params == null)
           ...
       Iterator ir = null;
       if (params != null)
           ir = params.iterator();
       while ((ir != null) && ir.hasNext())
           definition.setParam((Parameter) ir.next());
           // put the definition in the page context
       pageContext.setAttribute(
           definitionName, definition);
   } catch (Exception ex) {
       ex.printStackTrace();
   }
   return EVAL_PAGE;
}
```

If the URL passed in the request is `/enter`, the `Definition` contains the items from the first row of Table 33:

Title	Banner	Body
`Duke's Bookstore`	`/banner.jsp`	`/bookstore.jsp`

The definition for the URL `/enter` is shown in Table 34. The definition specifies that the value of the `Title` parameter, Duke's Bookstore, should be inserted directly into the output stream, but the values of `Banner` and `Body` should be dynamically included.

Table 34 Screen Definition for URL `/enter`

Parameter Name	Parameter Value	isDirect
title	Duke's Bookstore	true
banner	/banner.jsp	false
body	/bookstore.jsp	false

`InsertTag` uses the `Definition` to insert parameters of the screen definition into the response. In the `doStartTag` method it retrieves the definition object from the page context.

```
public int doStartTag() {
   // get the definition from the page context
   definition = (Definition) pageContext.
        getAttribute(definitionName);
   // get the parameter
   if (parameterName != null && definition != null)
        parameter = (Parameter)definition.
             getParam(parameterName);
   if (parameter != null)
        directInclude = parameter.isDirect();
   return SKIP_BODY;
}
```

The `doEndTag` method inserts the parameter value. If the parameter is direct, it is directly inserted into the response; otherwise the request is sent to the parameter and the response is dynamically included into the overall response.

```
public int doEndTag()throws JspTagException {
   try {
        if (directInclude && parameter != null)
             pageContext.getOut().print(parameter.getValue());
        else {
             if ((parameter != null) &&
                  (parameter.getValue() != null))
                  pageContext.include(parameter.getValue());
```

```
        }
    } catch (Exception ex) {
        throw new JspTagException(ex.getMessage());
    }
    return EVAL_PAGE;
}
```

How Is a Tag Handler Invoked?

The `Tag` interface defines the basic protocol between a tag handler and JSP page's servlet. It defines the life cycle and the methods to be invoked when the start and end tags are encountered.

The JSP page's servlet invokes the `setPageContext`, `setParent`, and attribute setting methods before calling `doStartTag`. The JSP page's servlet also guarantees that `release` will be invoked on the tag handler before the end of the page.

Here is a typical tag handler method invocation sequence:

```
ATag t = new ATag();
t.setPageContext(...);
t.setParent(...);
t.setAttribute1(value1);
t.setAttribute2(value2);
t.doStartTag();
t.doEndTag();
t.release();
```

The `BodyTag` interface extends `Tag` by defining additional methods that let a tag handler access its body. The interface provides three new methods:

`setBodyContent` - creates body content and adds to tag handler

`doInitBody` - called before evaluation of tag body

`doAfterBody` - called after evaluation of tag body

A typical invocation sequence is:

```
t.doStartTag();
out = pageContext.pushBody();
t.setBodyContent(out);
// perform any initialization needed after body content is set
t.doInitBody();
t.doAfterBody();
// while doAfterBody returns EVAL_BODY_BUFFERED we
// iterate body evaluation
```

```
...
t.doAfterBody();
t.doEndTag();
t.pageContext.popBody();
t.release();
```

Transactions

by Dale Green

A typical enterprise application accesses and stores information in one or more databases. Because this information is critical for business operations, it must be accurate, current, and reliable. Data integrity would be lost if multiple programs were allowed to simultaneously update the same information. Also, it would be lost if a system that failed while processing a business transaction were to leave the affected data only partially updated. By preventing both of these scenarios, software transactions ensure data integrity. Transactions control the concurrent access of data by multiple programs. In the event of a system failure, transactions make sure that after recovery the data will be in a consistent state.

Note: Currently, this chapter discusses transactions only for enterprise beans. Subsequent versions will also discuss transactions for web components.

What is a Transaction?

To emulate a business transaction, a program may need to perform several steps. A financial program, for example, might transfer funds from a checking account to a savings account with the steps listed in the following pseudo-code.

```
begin transaction
   debit checking account
   credit savings account
   update history log
commit transaction
```

Either all three of these steps must complete, or none of them at all. Otherwise, data integrity is lost. Because the steps within a transaction are a unified whole, a *transaction* is often defined as an indivisible unit of work.

A transaction can end in two ways: with a commit or a rollback. When a transaction commits, the data modifications made by its statements are saved. If a statement within a transaction fails, the transaction rolls back, undoing the effects of all statements in the transaction. In the pseudo-code, for example, if a disk drive crashed during the `credit` step, the transaction rolls back and undoes the data modifications made by the `debit` statement. Although the transaction failed, data integrity is intact because the accounts still balance.

In the preceding pseudo-code, the `begin` and `commit` statements mark the boundaries of the transaction. When deploying an enterprise bean, you determine how the boundaries are set by specifying either container-managed or bean-managed transactions.

Container-Managed Transactions

In an enterprise bean with container-managed transactions, the EJB™ container sets the boundaries of the transactions. You can use container-managed transactions with both session and entity beans. Container-managed transactions simplify development because the enterprise bean code does not explicitly mark the transaction's boundaries. The code does not include statements that begin and end the transaction.

Typically, the container begins a transaction immediately before an enterprise bean method starts. It commits the transaction just before the method exits. Each method can be associated with a single transaction. Nested or multiple transactions are not allowed within a method.

Container-managed transactions do not require all methods to be associated with transactions. When deploying a bean, you specify which of the bean's methods are associated with transactions by setting the transaction attributes.

Transaction Attributes

A transaction attribute controls the scope of a transaction. Figure 23 illustrates why controlling the scope is important. In the diagram, method-A begins a transaction and then invokes method-B of Bean-2. When method-B executes, does it run within the scope of the transaction started by method-A or does it execute with a new transaction? The answer depends on the transaction attribute of method-B.

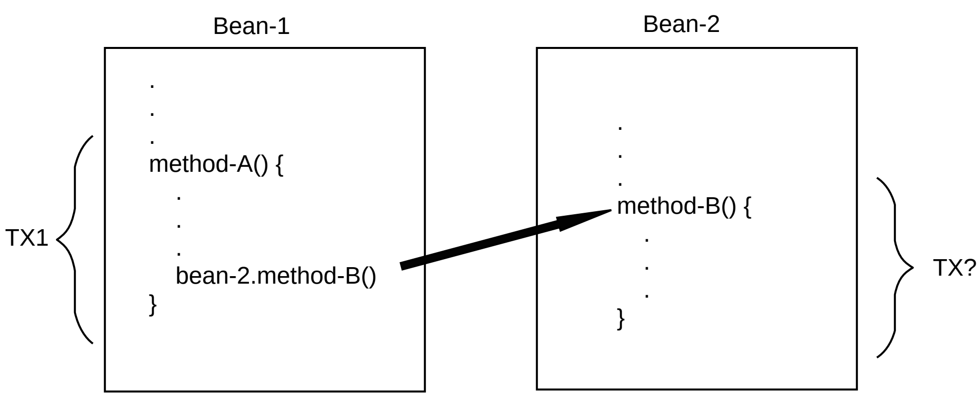


Figure 23 Transaction Scope

Transaction Attribute Values

A transaction attribute may have one of the following values:

- Required
- RequiresNew
- Mandatory
- NotSupported
- Supports

- Never

Required

If the client is running within a transaction and it invokes the enterprise bean's method, the method executes within the client's transaction. If the client is not associated with a transaction, the container starts a new transaction before running the method.

The Required attribute will work for most transactions. Therefore, you may want to use it as a default, at least in the early phases of development. Because transaction attributes are declarative, you can easily change them at a later time.

RequiresNew

If the client is running within a transaction and it invokes the enterprise bean's method, the container takes the following steps:

1. Suspends the client's transaction
2. Starts a new transaction
3. Delegates the call to the method
4. Resumes the client's transaction after the method completes
5. If the client is not associated with a transaction, the container starts a new transaction before running the method.

You should use the RequiresNew attribute when you want to ensure that the method always runs within a new transaction.

Mandatory

If the client is running within a transaction and it invokes the enterprise bean's method, the method executes within the client's transaction. If the client is not associated with a transaction, the container throws the `TransactionRequiredException`.

Use the Mandatory attribute if the enterprise bean's method must use the transaction of the client.

NotSupported

If the client is running within a transaction and it invokes the enterprise bean's method, the container suspends the client's transaction before invoking the method. After the method has completed, the container resumes the client's transaction.

If the client is not associated with a transaction, the container does not start a new transaction before running the method.

Use the NotSupported attribute when you want to ensure that the method will never run within a transaction generated by the container.

Supports

If the client is running within a transaction and it invokes the enterprise bean's method, the method executes within the client's transaction. If the client is not associated with a transaction, the container does not start a new transaction before running the method.

Because the transactional behavior of the method may vary, you should use the Supports attribute with caution.

Never

If the client is running within a transaction and it invokes the enterprise bean's method, the container throws a `RemoteException`. If the client is not associated with a transaction, the container does not start a new transaction before running the method.

Summary of Transaction Attributes

Table 35 summarizes the effects of the transaction attributes. Both the T1 and T2 transactions are controlled by the container. A T1 transaction is associated with the client that calls a method in the enterprise bean. In most cases, the client is another enterprise bean. A T2 transaction is started by the container just before the method executes.

In the last column, the word "none" means that the business method does not execute within a transaction controlled by the container. However, the database calls in such a business method might be controlled by the transaction manager of the DBMS.

Table 35 Transaction Attributes and Scope

Transaction Attribute	Client's Transaction	Business Method's Transaction
Required	none	T2
	T1	T1

Table 35 Transaction Attributes and Scope (Continued)

Transaction Attribute	Client's Transaction	Business Method's Transaction
RequiresNew	none	T2
	T1	T2
Mandatory	none	error
	T1	T1
NotSupported	none	none
	T1	none
Supports	none	none
	T1	T1
Never	none	none
	T1	error

Setting Transaction Attributes

Because transaction attributes are stored in the deployment descriptor, they can be changed during several phases of J2EE™ application development: enterprise bean creation, application assembly, and deployment. However, as an enterprise bean developer, it is your responsibility to specify the attributes when creating the bean. The attributes should be modified only by an application developer who is assembling components into larger applications. Do not expect the person who is deploying the J2EE™ application to specify the transaction attributes.

You can specify the transaction attributes for the entire enterprise bean or for individual methods. If you've specified one attribute for a method and another for the bean, the attribute for the method takes precedence. When specifying attributes for individual methods, the requirements for session and entity beans vary. Session beans need the attributes defined for business methods, but do not allow them for the create methods. Entity beans require transaction attributes for the business, `create`, `remove`, and finder methods.

Rolling Back a Container-Managed Transaction

There are two ways to roll back a container-managed transaction. First, if a system exception is thrown, the container will automatically roll back the transaction. Second, by invoking the `setRollbackOnly` method of the `EJBContext` interface, the bean method instructs the container to roll back the transaction. If the bean throws an application exception, the roll back is not automatic, but may be initiated by a call to `setRollbackOnly`. for For a description of system and application exceptions, see Handling Exceptions (page 139).

Source Code. The source code for the following example is in the `j2eetutorial/examples/src/ejb/bank` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant bank`. To create the database tables, type `ant create-bank-table`. A sample `BankApp.ear` file is in the `j2eetutorial/examples/ears` directory.

The `transferToSaving` method of the `BankEJB` example illustrates the `setRollbackOnly` method. If a negative checking balance occurs, `transferToSaving` invokes `setRollBackOnly` and throws an application exception (`InsufficientBalanceException`). The `updateChecking` and `updateSaving` methods update database tables. If the updates fail, these methods throw a `SQLException` and the `transferToSaving` method throws an `EJBException`. Because the `EJBException` is a system exception, it causes the container to automatically roll back the transaction. Here is the code for the `transferToSaving` method:

```
public void transferToSaving(double amount) throws
   InsufficientBalanceException  {

   checkingBalance -= amount;
   savingBalance += amount;

   try {
      updateChecking(checkingBalance);
      if (checkingBalance < 0.00) {
         context.setRollbackOnly();
         throw new InsufficientBalanceException();
      }
      updateSaving(savingBalance);
   } catch (SQLException ex) {
       throw new EJBException
          ("Transaction failed due to SQLException: "
          + ex.getMessage());
   }
}
```

When the container rolls back a transaction, it always undoes the changes to data made by SQL calls within the transaction. However, only in entity beans will the container undo changes made to instance variables. (It does so by automatically invoking the entity bean's `ejbLoad` method, which loads the instance variables from the database.) When a rollback occurs, a session bean must explicitly reset any instance variables changed within the transaction. The easiest way to reset a session bean's instance variables is by implementing the `SessionSynchonization` interface.

Synchronizing a Session Bean's Instance Variables

The `SessionSynchonization` interface, which is optional, allows you to synchronize the instance variables with their corresponding values in the database. The container invokes the `SessionSynchonization` methods—`afterBegin`, `beforeCompletion`, and `afterCompletion`—at each of the main stages of a transaction.

The `afterBegin` method informs the instance that a new transaction has begun. The container invokes `afterBegin` immediately before it invokes the business method. The `afterBegin` method is a good place to load the instance variables from the database. The `BankBean` class, for example, loads the `checkingBalance` and `savingBalance` variables in the `afterBegin` method:

```
public void afterBegin() {

   System.out.println("afterBegin()");
   try {
      checkingBalance = selectChecking();
      savingBalance = selectSaving();
   } catch (SQLException ex) {
       throw new EJBException("afterBegin Exception: " +
           ex.getMessage());
   }
}
```

The container invokes the `beforeCompletion` method after the business method has finished, but just before the transaction commits. The `beforeCompletion` method is the last opportunity for the session bean to roll back the transaction (by calling `setRollbackOnly`). If it hasn't already updated the database with the values of the instance variables, the session bean may do so in the `beforeCompletion` method.

The `afterCompletion` method indicates that the transaction has completed. It has a single `boolean` parameter, whose value is `true` if the transaction was committed and false if it was rolled back. If a rollback occurred, the session bean can refresh its instance variables from the database in the afterCompletion method:

```
public void afterCompletion(boolean committed) {

   System.out.println("afterCompletion: " + committed);
   if (committed == false) {
      try {
         checkingBalance = selectChecking();
         savingBalance = selectSaving();
      } catch (SQLException ex) {
         throw new EJBException("afterCompletion SQLException:
            " + ex.getMessage());
      }
   }
}
```

Methods Not Allowed in Container-Managed Transactions

You should not invoke any method that might interfere with the transaction boundaries set by the container. The list of prohibited methods follows:

- The commit, setAutoCommit, and rollback methods of java.sql.Connection
- The getUserTransaction method of javax.ejb.EJBContext
- Any method of javax.transaction.UserTransaction

You may, however, use these methods to set boundaries in bean-managed transactions.

Bean-Managed Transactions

In a bean-managed transaction, the session bean code invokes methods that mark the boundaries of the transaction. An entity bean may not have bean-managed transactions; it must use container-managed transactions instead. Although beans with container-managed transactions require less coding, they have one limitation: When a method is executing, it can be associated with either a single transaction or no transaction at all. If this limitation will make coding your session bean difficult, you should consider using bean-managed transactions.

The following pseudo-code illustrates the kind of fine-grained control you can obtain with bean-managed transactions. By checking various conditions, the pseudo-code decides whether to start and stop different transactions within the business method.

```
begin transaction
...
update table-a
...
if (condition-x)
   commit transaction
else if (condition-y)
   update table-b
   commit transaction
else
   rollback transaction
   begin transaction
   update table-c
   commit transaction
```

When coding a bean-managed transaction, you must decide whether to use JDBC or JTA transactions. The sections that follow discuss the techniques and merits of both approaches.

JDBC Transactions

A *JDBC transaction* is controlled by the transaction manager of the DBMS. You may want to use JDBC transactions when wrapping legacy code inside a session bean. To code a JDBC transaction, you invoke the `commit` and `rollback` methods of the `javax.sql.Connection` interface. The beginning of a transaction is implicit. A transaction begins with the first SQL statement that follows the most recent `commit`, `rollback`, or `connect` statement. (This rule is generally true, but may vary with DBMS vendor.)

Source Code. The source code for the following example is in the `j2eetutorial/examples/src/ejb/warehouse` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant bank`. To create the database tables, type `ant create-warehouse-table`. A sample `WarehouserApp.ear` file is in the `j2eetutorial/examples/ears` directory.

The following code is from the `WarehouseEJB` example, a session bean that uses the `Connection` interface's methods to delimit bean-managed transactions. The `ship` method starts by invoking `setAutoCommit` on the `Connection` object named con. This invocation tells the DBMS not to automatically commit every SQL statement. Next, the ship method calls routines that update the order_item and inventory database tables. If the updates succeed, the transaction is committed. But if an exception is thrown, the transaction is rolled back.

```
public void ship (String productId, String orderId, int
quantity) {

   try {
      con.setAutoCommit(false);
      updateOrderItem(productId, orderId);
      updateInventory(productId, quantity);
      con.commit();
   } catch (Exception ex) {
       try {
          con.rollback();
          throw new EJBException("Transaction failed: " +
             ex.getMessage());
       } catch (SQLException sqx) {
           throw new EJBException("Rollback failed: " +
              sqx.getMessage());
       }
   }
}
```

JTA Transactions

JTA is the abbreviation for the Java™ Transaction API. This API allows you to demarcate transactions in a manner that is independent of the transaction manager implementation. The J2EE SDK implements the transaction manager with the Java Transaction Service (JTS). But your code doesn't call the JTS methods directly. Instead, it invokes the JTA methods, which then call the lower-level JTS routines.

A *JTA transaction* is controlled by the J2EE transaction manager. You may want to use a JTA transaction because it can span updates to multiple databases from different vendors. A particular DBMS's transaction manager may not work with heterogeneous databases. However, the J2EE transaction manager does have one limitation—it does not support nested transactions. In other words, it cannot start a transaction for an instance until the previous transaction has ended.

Source Code. The source code for the following example is in the j2eetutorial/examples/src/ejb/teller directory. To compile the code, go to the j2eetutorial/examples/src directory and type ant teller. To create the database tables, type `ant create-bank-teller`. A sample `TellerApp.ear` file is in the `j2eetutorial/examples/ears` directory.

To demarcate a JTA transaction, you invoke the `begin`, `commit`, and `rollback` methods of the `UserTransaction` interface. The following code, taken from the `TellerBean` class, demonstrates the `UserTransaction` methods. The `begin` and `commit` invocations delimit the updates to the database. If the updates fail, the code invokes the `rollback` method and throws an `EJBException`.

```
public void withdrawCash(double amount) {

   UserTransaction ut = context.getUserTransaction();

   try {
      ut.begin();
      updateChecking(amount);
      machineBalance -= amount;
      insertMachine(machineBalance);
      ut.commit();
   } catch (Exception ex) {
       try {
          ut.rollback();
       } catch (SystemException syex) {
           throw new EJBException
              ("Rollback failed: " + syex.getMessage());
       }
       throw new EJBException
          ("Transaction failed: " + ex.getMessage());
    }
}
```

Returning Without Committing

In a stateless session bean with bean-managed transactions, a business method must commit or roll back a transaction before returning. However, a stateful session bean does not have this restriction.

In a stateful session bean with a JTA transaction, the association between the bean instance and the transaction is retained across multiple client calls. Even if each business method called by the client opens and closes the database connection, the association is retained until the instance completes the transaction.

In a stateful session bean with a JDBC transaction, the JDBC connection retains the association between the bean instance and the transaction across multiple calls. If the connection is closed, the association is not retained.

Methods Not Allowed in Bean-Managed Transactions

Do not invoke the `getRollbackOnly` and `setRollbackOnly` methods of the `EJBContext` interface. These methods should be used only in container-managed transactions. For bean-managed transactions you invoke the `getStatus` and `rollback` methods of the `UserTransaction` interface.

Summary of Transaction Options

The decision tree in Figure 24 shows the different approaches to transaction management that you may take. Your first choice depends on whether the enterprise bean is an entity or a session bean. An entity bean must use container-managed transactions. With container-managed transactions, you specify the transaction attributes in the deployment descriptor and you roll back a transaction with the `setRollbackOnly` method of the `EJBContext` interface. A session bean may have either container-managed or bean-managed transactions. There are two types of bean-managed transactions: JDBC and JTA transactions. You delimit JDBC transactions with the `commit` and `rollback` methods of the `Connection` interface. To demarcate JTA transactions, you invoke the `begin`, `commit`, and `rollback` methods of the `UserTransaction` interface.

In a session bean with bean-managed transactions, it is possible to mix JDBC and JTA transactions. This practice is not recommended, however, because it could make your code difficult to debug and maintain.

If you're unsure about how to set up transactions in an enterprise bean, here's a tip: In the deployment descriptor specify container-managed transactions. Then, set the Required transaction attribute for the entire bean. This approach will work most of the time.

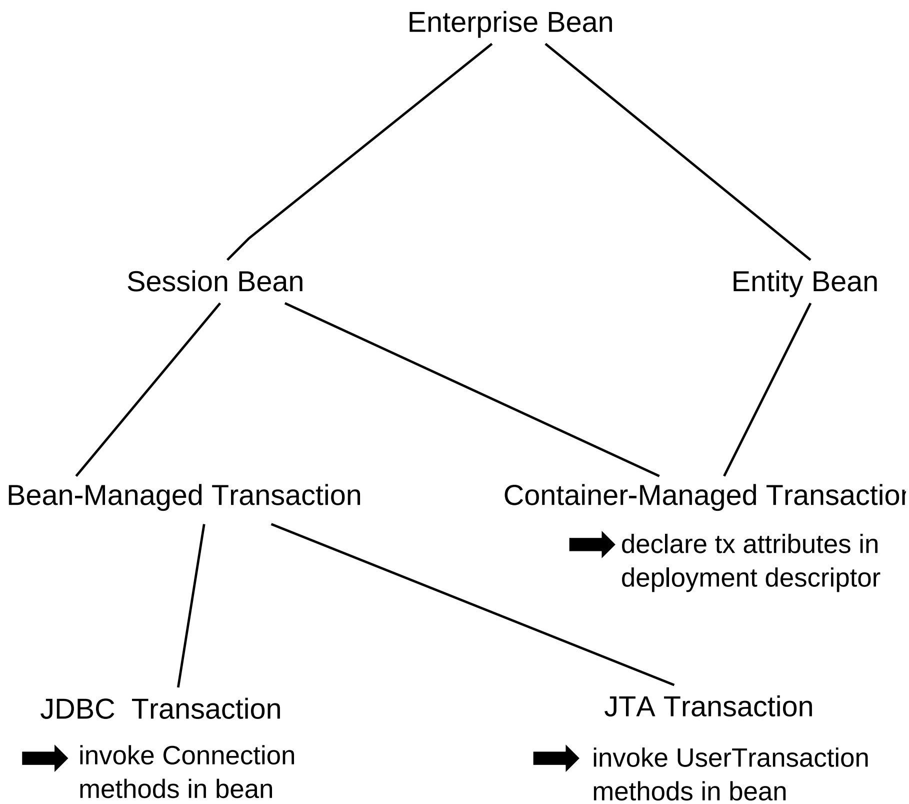


Figure 24 Options in Specifying Transactions

Transaction Timeouts

For container-managed transactions, you control the transaction timeout interval by setting the value of the `transaction.timeout` property in the `config/default.properties` file. For example, you would set the timeout value to 5 seconds as follows:

```
transaction.timeout=5
```

With this setting, if the transaction has not completed within 5 seconds, the EJB container manager rolls it back.

When J2EE is first installed, the timeout value is set to 0:

```
transaction.timeout=0
```

If the value is 0, the transaction will not time out.

Only enterprise beans with container-managed transactions are affected by the `transaction.timeout` property. For enterprise beans with bean-managed, JTA transactions, you invoke the `setTransactionTimeout` method of the `UserTransaction` interface.

Isolation Levels

Transactions not only ensure the full completion (or rollback) of the statements that they enclose, they also isolate the data modified by the statements. The *isolation level* describes the degree to which the data being updated is visible to other transactions.

Suppose that a transaction in one program updates a customer's phone number, but before the transaction commits another program reads the same phone number. Will the second program read the updated and uncommitted phone number or will it read the old one? The answer depends on the isolation level of the transaction. If the transaction allows other programs to read uncommitted data, performance may improve because the other programs don't have to wait until the transaction ends. But there's a tradeoff—if the transaction rolls back, another program might read the wrong data.

You cannot modify the isolation level of entity beans with container-managed persistence. These beans use the default isolation level of the DBMS, which is usually `READ_COMMITTED`.

For entity beans with bean-managed persistence and for all session beans, you can set the isolation level programmatically with the API provided by the underlying DBMS. A DBMS, for example, might allow you to permit uncommitted reads by invoking the `setTransactionIsolation` method:

```
Connection con;
...
con.setTransactionIsolation(TRANSACTION_READ_UNCOMMITTED);
```

Do not change the isolation level in the middle of a transaction. Usually, such a change causes the DBMS software to issue an implicit commit. Because the isolation levels offered by DBMS vendors may vary, you should check the DBMS documentation for more information.

Updating Multiple Databases

The J2EE transaction manager controls all enterprise bean transactions except for bean-managed JDBC transactions. The J2EE transaction manager allows an enterprise bean to update multiple databases within a transaction. The figures that follow show two scenarios for updating multiple databases in a single transaction.

In Figure 25, the client invokes a business method in Bean-A. The business method begins a transaction, updates Database-X, updates Database-Y, and invokes a business method in Bean-B. The second business method updates Database-Z and returns control to the business method in Bean-A, which commits the transaction. All three database updates occur in the same transaction.

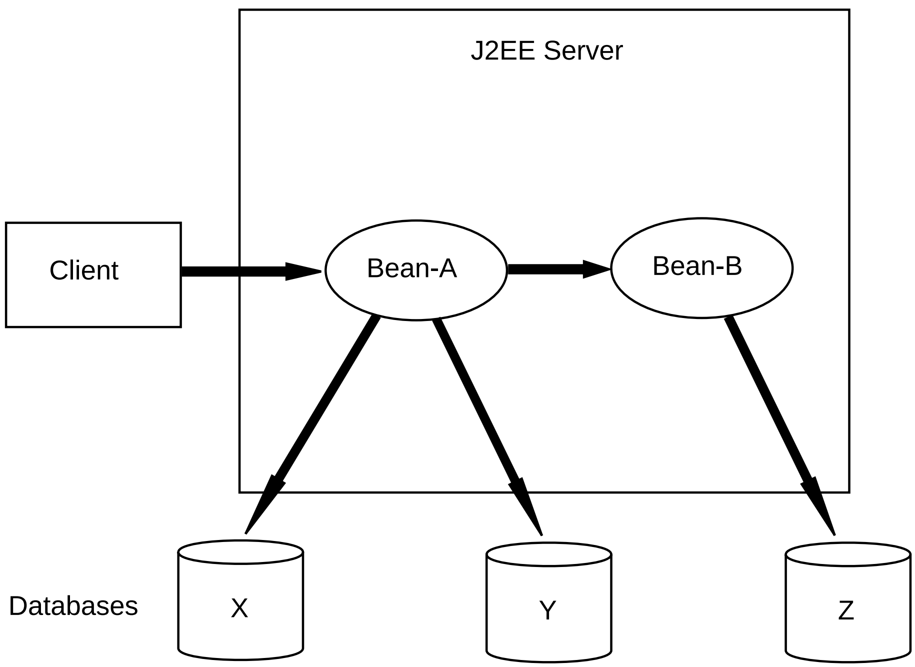


Figure 25 Updating Multiple Databases

In Figure 26, the client calls a business method in Bean-A, which begins a transaction and updates Database-X. Then, Bean-A invokes a method in Bean-B, which resides in a remote J2EE server. The method in Bean-B updates Database-Y. The transaction managers of the J2EE servers ensure that both databases are updated in the same transaction.

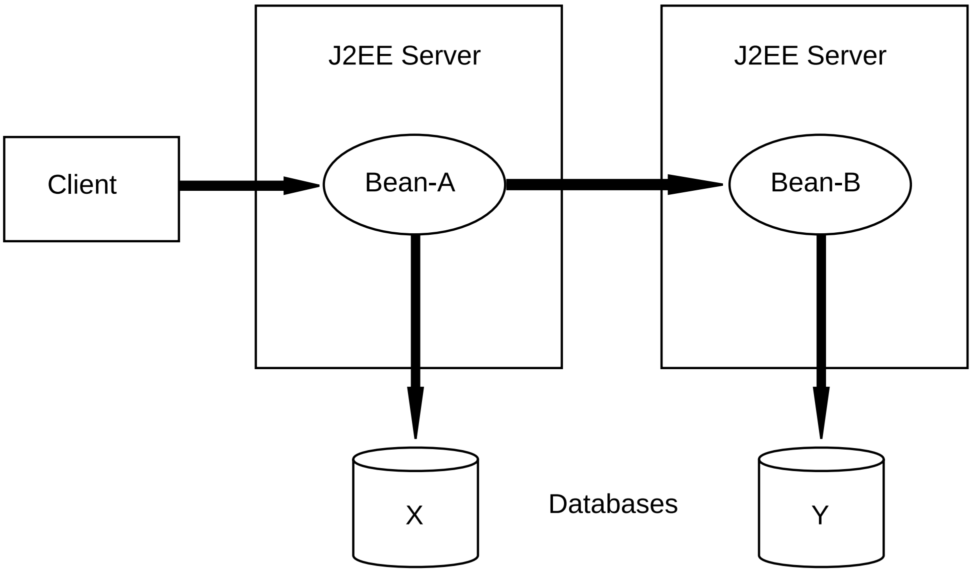


Figure 26 Updating Multiple Databases Across J2EE Servers

Security

by Eric Jendrock

The J2EE application programming model insulates developers from mechanism-specific implementation details of application security. J2EE provides this insulation in a way that enhances the portability of applications, allowing them to be deployed in diverse security environments.

J2EE applications are made up of components that can be deployed into different containers. These components are used to build a multi-tier enterprise application. The goal of the J2EE security architecture is to achieve end-to-end security by securing each tier.

The tiers can contain both protected and unprotected resources. Often, you need to protect resources to ensure that only authorized users have access. *Authorization* provides controlled access to protected resources. However, authorization is based on *identification* and *authentication*. Identification is a process that enables recognition of an entity by a system, while authentication is a process that verifies the identity of a user, device, or other entity in a computer system, usually as a prerequisite to allowing access to resources in a system.

Authorization is not required to access unprotected resources. Because authorization is built upon authentication, authentication is also not needed to access unprotected resources. Accessing a resource without authentication is referred to as *unauthenticated* or *anonymous* access.

The J2EE platform defines declarative contracts between those who develop and assemble application components and those who configure applications in operational environments. In the context of application security, application providers are required to declare the security requirements of their applications in a way that these requirements can be satisfied during application configuration. The *declarative security mechanisms* used an application are expressed in a declarative syntax in a document called a deployment descriptor. An application deployer then employs container-specific tools to map the application requirements that are in a deployment descriptor to security mechanisms that are implemented by J2EE containers. The J2EE SDK provides this functionality with the `deploytool`.

Some applications, however, have special security requirements that cannot be expressed using declarative security mechanisms. For example, an application might make authorization decisions based on the time of day, the parameters of a call, or the internal state of an enterprise bean or web component. Another application might restrict access based on user information stored in a database. If your application has such special security requirements, you may want to take advantage of *programmatic security mechanisms* that are available in the web, EJB, and EIS-tiers.

Declaring Roles

When you design an enterprise bean, you should keep in mind what kinds of users will access the bean. For example, an Account enterprise bean might be accessed by customers, bank tellers, and branch managers. Each of these user categories is called a *security role*, an abstract logical grouping of users that is defined by the person who is assembling the application. When an application is deployed, the roles will be mapped to security identities in the operational environment.

A J2EE group also represents a category of users, but it has a different scope than a role. A J2EE group is designated for the entire J2EE server, whereas a role covers only a specific application in a J2EE server.

To create a role for an application, you declare it for the EJB JAR file or for the web component WAR file that is contained in the application. For example, to create a role for an enterprise bean, follow this procedure in the `deploytool` utility:

1. In the tree view, select the enterprise bean's EJB JAR file or the web component's WAR file.
2. In the Roles tabbed pane, click Add.
3. In the table, enter values for the Name and Description fields.

Declaring Role References

A security role is an application-specific logical grouping of users, classified by common traits such as customer profile or job title. When an application is deployed, roles are mapped to security identities, such as principals or groups, in the operational environment.

A security role reference references a security role name. This security role reference is linked to the security role name that is defined for an assembled application.

To add a security role reference, you use `deploytool`:

1. Select the enterprise bean in the tree view.
2. Select the Security tabbed pane.
3. In the Role Names Referenced in Code pane, click the Add button.
4. Enter the name of the security role reference in the Coded Name column.

5. Click Edit Roles if the security role name to which you want to map is not listed in the Role Name column.
6. Select the security role name that maps to the coded name from the drop-down menu in the Role Name column.
7. Indicate the methods to which the role has access by selecting the appropriate checkboxes in the Method permissions panel.
8. Click on the folded paper icon to add a description for an object.
9. In the Description dialog box, enter a description.
10. Click OK to accept the description or Cancel to cancel the description.

Linking Role References to Roles

You should declare the coded name (Customer) in the Security dialog box of the New Enterprise Bean wizard of the deploytool. When you are ready to deploy the application, link the coded name with a role name. For example, to link the Customer coded name with the Buyer role name, you would do the following:

1. In the tree view select the enterprise bean.
2. Select the Security tabbed pane.
3. If the Customer entry does not appear in the Coded Name column of the Role Names Referenced in Code section, click Add and enter Customer in that column.
4. If the Buyer role name is not listed in the Method Permissions table, click Edit Roles and add Buyer in the Editing Roles dialog box.
5. Go to the table at the top of the Security tabbed pane and locate the row that lists Customer in the Coded Name column. In that row, select Buyer from the Role Name combo box.

Because a coded name is linked to a role name, you can change the role name at a later time without having to change the coded name. For example, if you were to change the role name from Buyer to Shopper, you don’t need to change the Customer name in the code. However, you do need to relink the Customer coded name to the Shopper role name.

Web-Tier Security

The following sections address authenticating users and protecting resources in the web tier.

Protecting Web-Tier Resources

You can protect web resources by specifying a security constraint. A security constraint determines who is authorized to access a web resource collection. Security constraints can be defined using the deploy tool. (described in Controlling Access to Web Resources (page 353)).

If you try to access a protected web resource as an unauthenticated user, the web container will try to authenticate you. The container will only accept the request after you have proven your identity to the container and have been granted permission to access the resource.

Controlling Access to Web Resources

To control access to a web resource, you use the deploytool to specify a security constraint:

1. Select the web component in the tree view.
2. Select the Security tabbed pane.
3. Click the Add button in the Security Constraints section of the screen.
4. Click the Edit button adjacent to the Web Resource Collection field to add a web resource collection to the security constraint. the web resource collection describes a URL pattern and HTTP method pair that refer to the resources that need to be protected.
5. Click the Edit button adjacent to the Authorized Roles field to add one or more roles to the security constraint. You are specifying the set of roles that are allowed to access the web resource collection.

Authenticating Users

When you try to access a protected web-tier resource, the web container activates the authentication mechanism that has been configured for that resource. You can configure the following authentication mechanisms for a resource:

- HTTP basic authentication
- Form-based authentication
- Client certificate authentication

Basic Authentication

If you specify *HTTP basic authentication,* the web server will authenticate a user by using the user name and password obtained from the web client.

Form-Based Authentication

If you specify *form-based authentication*, you can customize the login screen and error pages that are presented to the end user by an HTTP browser.

Neither HTTP basic authentication nor form-based authentication are secure, since the content of the user dialog is sent as plain text, and the target server is not authenticated.

Client Certificate Authentication

If you specify *client certificate authentication*, the web server will authenticate the client using a X.509 certificate. Client-certificate authentication is a more secure method of authentication than either basic or form-based authentication. It uses HTTP over SSL, in which the server and, optionally, the client authenticate each other with Public Key Certificates.

Configuring A Web Resource's Authentication Mechanism

To configure the authentication mechanism that a web resource will use:

1. Select the web component in the tree view. The Web Component inspector will be displayed.
2. Select the Security tab.
3. Choose one of the following authentication mechanisms from the User Authentication Method pulldown menu:
   - Basic
   - Form Based
   - Client Certificate
   - None

   a. If you chose Basic authentication, you must enter `Default` in the Realm name field.

   b. If you chose Form Based authentication, you must fill in the Login Page and Error Page fields. The error page is displayed when the user cannot be logged in.

Using SSL to Enhance the Confidentiality of HTTP Basic and Form-Based Authentication

Passwords are not protected for confidentiality with HTTP basic or form-based authentication. To overcome this limitation, you can run these authentication protocols over an SSL-protected session and ensure that all message content is protected for confidentiality.

To configure HTTP basic or form-based authentication over SSL:

1. Select the web component in the tree view. The Web Component inspector will be displayed.
2. From the Security tabbed pane, make sure that Basic or Form Based have been selected in the User Authentication Method menu pulldown.
3. Click on the Add button in the Security constraint section.
4. Click on the Security constraint that was added.
5. Select CONFIDENTIAL in the Network Security Requirement menu pull-down.

Using Programmatic Security in the Web-Tier

Programmatic security is used by security aware applications when declarative security alone is not sufficient to express the security model of the application. Programmatic security consists of the following methods of the `HttpServletRequest` interface:

- `getRemoteUser`
- `isUserInRole`
- `getUserPrincipal`

You can use the `getRemoteUser` method to determine the user name with which the client authenticated. The `isUserInRole` method is used to determine if a user is in a specific security role. The `getUserPrincipal` method returns a `java.security.Pricipal` object.

These APIs allow servlets to make business logic decisions based on the logical role of the remote user. They also allow the servlet to determine the principal name of the current user.

Unprotected Web-Tier Resources

Many applications feature unprotected web-tier content, which any caller can access without authentication. In the web tier, unrestricted access is provided simply by not configuring an authentication mechanism.

EJB-Tier Security

The following sections describe declarative and programmatic security mechanisms that can be used to protect resources in the EJB-tier. The protected resources include methods of enterprise beans that are called from the application clients, web components, or other enterprise beans.

You can protect EJB-tier resources by doing the following:

- Declaring method permissions
- Mapping roles to J2EE users and groups

Declaring Method Permissions

After you've defined the roles, you can define the method permissions of an enterprise bean. Method permissions indicate which roles are allowed to invoke which methods.

You use `deploytool` to specify method permissions by mapping roles to methods:

1. Select the enterprise bean in the tree view.
2. Select the Security tabbed pane.
3. In the Method Permissions table, select a role's checkbox if that role should be allowed to invoke a method.

Mapping Roles to J2EE Users and Groups

When you are developing an enterprise bean, you should know the roles of your users, but you probably won't know exactly who the users will be. That's perfectly all right, because after your bean has been deployed, the administrator of the J2EE server will map the roles to the J2EE users (or groups) of the default realm. In the Account bean example, the administrator might assign the user Sally to the Manager role, and the users Bob, Ted, and Clara to the Teller role.

Using `deploytool`, the administrator maps roles to J2EE users and groups by following these steps:

1. In the tree view, select the J2EE application.
2. In the Security tabbed pane, select the appropriate role from the Role Name list.
3. Click Add.

4. In the Users dialog box, select the users and groups that should belong to the role. (See Managing J2EE Users and Groups (page 364) for information about creating users and groups with `deploytool`.)

Using Programmatic Security in the EJB-Tier

Programmatic security in the EJB-tier consists of the `getCallerPrincipal` and the `isCallerInRole` methods. You can use the `getCallerPrincipal` method to determine the caller of the enterprise bean and the `isCallerInRole` method to determine the caller's role.

Determining the Caller of the Enterprise Bean

The `getCallerPrincipal` method of the `EJBContext` interface returns the `java.security.Principal` object that identifies the caller of the enterprise bean. (In this case, a principal is the same as a user.) In the following example, the `getUser` method of an enterprise bean returns the name of the J2EE user that invoked it:

```
public String getUser() {
   return context.getCallerPrincipal().getName();
}
...
public void setSessionContext(SessionContext context) {
   this.context = context;
}
```

Determining the Caller's Role

You can determine whether an enterprise bean's caller belongs to a particular role by invoking the `isCallerInRole` method:

```
boolean result = context.isCallerInRole("Customer");
```

Unprotected EJB-Tier Resources

In the EJB-tier, you can provide unrestricted access to resources by mapping at least one role, which is permitted access to the resource, to the universal set of users independent of authentication.

By default, the J2EE SDK assigns the ANYONE role to a method. The `guest` user, which is anonymous and unauthenticated, belongs to the ANYONE role. Therefore, if you do not map the roles, any user may invoke the methods of an enterprise bean.

Application Client-Tier Security

Authentication requirements for J2EE application clients are the same as the requirements for other J2EE components. Access to protected resources in either the EJB-tier or the web-tier require user authentication while access to unprotected resources do not.

In order to authenticate the user, an application client container interacts with the user to collect the authentication data needed to authenticate the user. A default user interface for the interaction is provided by a container. However, you can specify your own user interface by providing a class that implements the `javax.security.auth.callback.CallbackHandler` interface and specifying the class name using the `deploytool` utility.

`CallbackHandlers` are implemented in an application-dependent fashion. For example, implementations for an application with a graphical user interface (GUI) could pop up windows to prompt for requested information. An implementation could also choose to obtain requested information from an alternate source without asking the end user.

Underlying security services make requests for different types of information by passing individual Callbacks to the `CallbackHandler`. The `CallbackHandler` implementation decides how to retrieve and display information depending on the Callbacks passed to it. For example, if the underlying service needs a username and password to authenticate a user, it uses a `NameCallback` and `PasswordCallback`. The `CallbackHandler` can then choose to prompt for a username then a password, or to prompt for both in a single window.

Specifying the Application Client's CallbackHandler

To specify a `CallbackHandler` for an application client, use the `deploytool` utility:

1. Select the application client JAR file in the tree view.
2. From the `CallbackHandler` Class menu, select the `CallbackHandler` class that will be used as an interface to gather user authentication data.

EIS-Tier Security

In the EIS-tier, an application component requests a connection to an EIS resource. As part of this connection, EIS may require a sign-on to the resource.

The application component provider has two choices for the design of the EIS sign on. The two sign-on approaches are:

1. With the container-managed sign-on approach, the application component lets the container take the responsibility of configuring and managing the EIS sign on. The container determines the username and password for establishing a connection to an EIS instance.
2. With the component-managed sign-on approach, the application component code manages EIS sign-on by including code that performs the sign-on process to an EIS.

The type of sign-on can be chosen by the component provider using the deploytool.

Configuring Sign-On

You can configure the type of sign-on using the `deployment` utility as shown below:

1. Select the component from the tree.
2. Select the Resource Refs tab.
3. Click Add.
4. In the Authentication combo box, select one of the following:
    a. Container – for Container Managed Sign-On.
    b. Application – for Component Managed Sign-On

Container-Managed Sign-On

With container-managed sign-on, an application component does not have to pass any security information for signing-on to the resource to the `getConnection()` method. The security information is supplied by the container as shown in the example below.

```
// Business Method in an application component
Context initctx = new InitialContext();
// perform JNDI lookup to obtain a connection factory
javax.resource.cci.ConnectionFactory cxf =
(javax.resource.cci.ConnectionFactory)initctx.lookup(
“java:comp/env/eis/MainframeCxFactory”);
```

```
// Invoke factory to obtain a connection. The security
// information is not passed in the getConnection method
javax.resource.cci.Connection cx = cxf.getConnection();
...
```

Component-Managed Sign-On

With component-managed sign-on, an application component is responsible for passing the security information that is needed for signing-on to the resource to the `getConnection()` method. Security information could be username, password, for example, as shown in the example below.

```
// Method in an application component
Context initctx = new InitialContext();

// perform JNDI lookup to obtain a connection factory
javax.resource.cci.ConnectionFactory cxf =
     (javax.resource.cci.ConnectionFactory)initctx.lookup(
       “java:comp/env/eis/MainframeCxFactory”);

// Invoke factory to obtain a connection
com.myeis.ConnectionSpecImpl properties = //..

// get a new ConnectionSpec
properties.setUserName(“...”);
properties.setPassword(“...”);
javax.resource.cci.Connection cx =
  cxf.getConnection(properties);
...
```

Configuring Resource Adapter Security

In addition to configuring the sign-on, you must also configure the resource adapter security.

To add security to a resource adapter, complete the following steps:

1. Locate the resource adapter RAR file in the tree view.
2. Select the Security tabbed pane. In the Authentication Mechanisms panel, select the authentication mechanisms that this resource adapter supports:
   - Password: A user and password is required to connect to an EIS.
   - Kerberos Version 5.0: The resource adapter supports the Kerberos authentication mechanism. See the Kerberos specification for details.

You can select no mechanism, one mechanism, or multiple mechanisms. If you do not select a mechanism, standard security authentication will not be supported as part of the security contract.

3. Select Reauthentication Supported if the resource adapter supports performing reauthentication on an existing physical connection. Reauthentication will be performed when an application server calls the `getConnection()` method with a security context that is different than the one that was used to establish the connection.
4. In the Security Permissions panel, click the Add button to add a security permission that your resource adapter needs to access system resources in your operational environment. Specify only permissions that are not included in the default set, which are listed in section 11.2 in the Connector specification.
5. For each security permission, click the rightmost column labelled with a folded paper to enter a description for the permission.

To delete a security permission, select the permission in the table and click Delete.

Propagating Security Identity

When you design an enterprise bean, you can specify a security identity that will be used when methods on another enterprise bean are invoked from within the first bean. You can choose one of the following:

- Use the security identity with which the first bean is running to call the methods on the second bean.
- Use a specific identity to call the methods on the second bean.

You can use the `deploytool` utility to select the type of security identity that is propagated.

Configuring an Enterprise Bean to Use Propagated Security Identities

To force an enterprise bean to use the security identity with which the first bean is running, use the `deploytool` utility:

1. Select the target enterprise bean in the tree view.
2. Select the Security tabbed pane.

3. In the Security Identity pane, select the Use Caller ID radio button.

To force an enterprise bean to use a security identity other than that with which the first bean is running, use the `deploytool` utility:

1. Select the target enterprise bean in the tree view.
2. Select the Security tabbed pane.
3. In the Security Identity pane, select the Run As Specified Role option.
4. If you chose Run As Specified Role in the Security dialog, you can select the user from that role. To do this, select Deployment Settings.
5. From Run as Specified User, select the user name that the client will use to invoke the enterprise bean's methods.
6. Click OK when you are done.

Client Authentication to an Enterprise Bean

You can configure a bean to force the caller of the bean to authenticated. You may want to do this for the following reasons:

- An application component on an application client container access a protected method on a bean that requires the application component to be authenticated.
- If a caller is being propagated from the calling container, then client authentication can be used to establish trust with the calling container

Each of these cases is described below.

Trust Between Containers

When an enterprise bean is designed so that either the original caller identity or a designated identity is used to call a target bean, the target bean will receive the propagated identity only; it will not receive any authentication data. There is no way for the target container to authenticate the propagated security identity. However, since the security identity is used in authorization checks (for example, method permissions or with the `isCallerInRole()` method), it is vitally important that the security identity be authentic. Since there is no authentication data available to authenticate the propagated identity, the target must trust that the calling container has propagated an authenticated security identity. You can establish this trust between containers by following the procedures shown in Configuring Client Authentication (page 363).

Configuring Client Authentication

You can use the `deploytool` utility to choose the authentication method that is used to authenticate the EJB client:

1. Select the target enterprise bean in the tree view.
2. Select the Security tabbed pane.
3. Select Deployment Settings to display the Security Deployment Settings dialog.
4. Select the SSL Required checkbox to enable SSL.
5. In the Client Authentication pane, select Certificate as the method by which the server expects the client to authenticate itself to the server.
6. Click OK when you are done.

J2EE Users, Realms, and Groups

A J2EE user is similar to an operating system user. Typically, both types of users represent people. However, these two types of users are not the same. The J2EE authentication service has no knowledge of the user and password you provide when you log on to the operating system. The J2EE authentication service is not connected to the security mechanism of the operating system. The two security services manage users that belong to different realms.

A *realm* is a collection of users that are controlled by the same authentication policy. The J2EE authentication service governs users in two realms: certificate and default.

Certificates are used with the HTTPS protocol to authenticate web browser clients. To verify the identity of a user in the certificate realm, the authentication service verifies a X509 certificate. For step-by-step instructions, see Setting Up a Server Certificate (page 365). The common name field of the X509 certificate is used as the principal name.

In most cases, the J2EE authentication service verifies user identity by checking the default realm. This realm is used for the authentication of all clients except for web browser clients that use the HTTPS protocol and certificates.

A J2EE user of the default realm may belong to J2EE group. (A user in the certificate realm may not.) A *group* is a category of users, classified by common traits such as job title or customer profile. For example, most customers of an e-commerce application might belong to the `CUSTOMER` group, but the big spenders would belong to the `PREFERRED` group. Categorizing users into groups makes it easier to control the access of large numbers of users. A previous section, EJB-Tier Security (page 356), discusses controlling user access to enterprise beans.

Managing J2EE Users and Groups

This section shows how to use the `deploytool` utility to do the following:

- Display all users in the default realm
- Add a user to the default realm
- Add a user to the certificate realm
- Remove a user
- Add a group to the default realm. You cannot add a group to the certificate realm.
- Remove a group from the default realm

To display all users in the default or certificate realm:

1. In the tree view, click on the server to which you want to add users and/or groups.
2. From the Tools menu, select Server Configuration to display the Configuration Installation screen.
3. Under J2EE Server in the tree view, select Users.
4. Select the realm (Default or Certificate).

To add a user to the default realm:

1. Click Add User.
2. Enter username and password in the appropriate fields.
3. In the Group Membership panel, select the group to which the user you are adding will belong. To select multiple groups, repeat this step.

To add a new group to the default realm:

1. Click Edit Groups.
2. From the Groups window, click Add.
3. Select the line you just added and enter the name of the group to add.
4. Press OK when done.

To add remove a group from the default realm:

1. Click Edit Groups.
2. From the Groups window, select the group to remove.

3. Press Delete.
4. Press Yes when prompted.
5. Press OK when done.

To add a new user to the certificate realm:

1. Select the Certificate realm.
2. Click Add User.
3. Select the directory where the certificate is located.
4. Select the certificate filename.
5. Press OK when done.

When you have finished these modifications, you must stop and restart the J2EE server.

Setting Up a Server Certificate

Certificates are used with the HTTPS protocol to authenticate web browser clients. The HTTPS service of the J2EE server will not run unless a server certificate has been installed. To set up a J2EE server certificate, follow these steps:

1. Generate a key pair and a self-signed certificate.

   The `keytool` utility enables you to create the certificate. The `keytool` utility that ships with the J2EE SDK has the same syntax as the one that ships with the Java™ Platform, Standard Edition. However, the J2EE SDK version programmatically adds a Java™ Cryptographic Extension provider that has implementations of RSA algorithms. This provider enables you to import RSA signed certificates.

   To generate the certificate, run the `keytool` utility as follows, substituting `<certificate-alias>` with the alias of your certificate:

   ```
   keytool -genkey -keyalg RSA -alias <certificate-alias>
   ```

2. The `keytool` utility prompts you for the following information:
   a. Keystore password—The default value of this password is `changeit`. You can change the password by editing the `config/auth.properties` file.
   b. First and last name—Enter the fully-qualified name of your server. This fully-qualified name includes the host name and the domain name.

   c. Organizational unit—Enter the appropriate value.
   d. Organization—Enter the appropriate value.
   e. City or locality—Enter the appropriate value.
   f. State or province—Enter the unabbreviated name.
   g. Two-letter country code—For the USA, the two-letter country code is US.
   h. Key password for alias—Do not enter a password. Press Return.

3. Import the certificate.

   If your certificate will be signed by a Certification Authority (CA) other than Verisign, you must import the CA certificate. Otherwise, you may skip this step. (Even if your certificate will be signed by verisign Test CA, you must import it.)

   To import the certificate, perform these tasks:

   a. Request the CA certificate from your CA. Store the certificate in a file.
   b. To install the CA certificate in the Java™ 2 Platform, Standard Edition, run the `keytool` utility as follows. (You must have the required permissions to modify the `$JAVA_HOME/jre/lib/security/cacerts` file.)

```
keytool -import -trustcacerts -alis <ca-cert-alias>
   -file <ca-cert-filename>
```

4. Generate a Certificate Signing Request (CSR).

```
keytool -certreq -sigalg MD5withRSA -alias <cert-alias>
 -file <csr-filename>
```

5. Send the contents of the `<csr-filename>` for signing.

   If you are using Verisign CA, go to `http://digitalid.verisign.com/`. Verisign will send the signed certificate in email. Store this certificate in a file.

6. Import the signed certificate that you recieved in email into the server:

```
keytool -import -alias <cert-alias> -file <signed-cert-file>
```

Configuring J2SE Security Policy Files

The J2EE server policy file is named `server.policy`. It resides in the `$J2EE_HOME/lib/security` directory. The J2EE application client policy file, `client.policy`, resides in the same directory.

For more information on setting up security policy files to grant required permissions, see Security in JDK 1.2.

Resource Connections

by Dale Green

BOTH enterprise beans and web components can access a wide variety of resources, including databases, mail sessions, Java™ Message Service objects, and URLs. The J2EE™ platform provides mechanisms that allow you to access all of these resources in a similar manner. This chapter describes how to get connections to several types of resources. Although the code samples in this chapter are from enterprise beans, they will also work in web components.

JNDI Names and Resource References

First, let's define these terms.

JNDI is the acronym for the Java™ Naming and Directory Interface API. J2EE components locate objects by invoking the JNDI `lookup` method.

A *JNDI name* is a people-friendly name for an object. These names are bound to their objects by the naming and directory service that is provided by the J2EE server. Because J2EE components access this service through the JNDI API, we usually refer to an object's people-friendly name as its JNDI name.

A *connection factory* is an object that produces connection objects that enable a J2EE component to access to a resource.

A r*esource reference* is an element in a deployment descriptor that identifies the component's coded name for the resource. More specifically, the coded name identifies a connection factory for the resource.

Although both the coded and the JNDI name identify the same connection factory, they are different. This approach to naming requires that you map the two names before deployment, but it also decouples components from resources. Because of this decoupling, if at a later time the component needs to access a different resource, you don't have to change the name in the code. This flexibility also makes it easier for you to assemble J2EE applications from pre-existing components.

Deploytool Tips for Resource References

The instructions that follow refer to the entity bean described in the section, The SavingsAccountEJB Example (page 110). The `SavingsAccountEJB` code is in the `j2eetutorial/examples/src/ejb/savingsaccount` directory. A sample `SavingsAccountApp.ear` file is in the `j2eetutorial/examples/ears` directory.

Specifying a Resource Reference

1. In the `deploytool`, select the component from the tree.
2. Select the Resource Refs tab.
3. Click Add.
4. In the Coded Name field, enter `jdbc/SavingsAccountDB`.

   The `SavingsAccountBean` code refers to the database as follows:

   ```
   private String dbName = "java:comp/env/jdbc/SavingsAccountDB";
   ```

   The `java:comp/env` prefix is the JNDI subcontext for the component. Because this subcontext is implicit in the Coded Name field, you don't need to include it there.
5. In the Type combo box, select javax.sql.DataSource. A `DataSource` object is a factory for database connections.

6. In the Authentication combo box, select Container.
7. If you want other enterprise beans to share the connections acquired from the `DataSource`, select the Sharable checkbox.

Mapping a Resource Reference to a JNDI Name

1. Select the J2EE application from the tree.
2. Select the JNDI Names tab.
3. In the References table, select the row containing the resource reference. For the `SavingsAccountEJB` example, the resource reference is `jdbc/SavingsAccountDB`, the name you entered in the Coded Name field of the Resource Refs tab.
4. In the row you just selected, enter the JNDI name. For the `SavingsAccountEJB` example, you would enter `jdbc/Cloudscape` in the JNDI Name field.

When it starts up, the J2EE server reads information from a configuration file and adds JNDI database names such as `jdbc/Cloudscape` to the name space. To edit the configuration file, select Tools->Server Configuration and go to the Data Sources node. For information about configuring JDBC drivers, see the *Configuration Guide* of the J2EE SDK.

Database Connections for Enterprise Beans

The persistence type of an enterprise bean determines whether or not you code the connection routine. You must code the connection for enterprise beans that access a database and do not have container-managed persistence. Such beans include entity beans with bean-managed persistence and session beans. For entity beans with container-managed persistence, the `deploytool` generates the connect routines for you.

Coded Connections

How to Connect

The code examples in this section are from the `SavingsAccountBean` class, which connects to the database with the following steps:

1. Specify the database name.

```
private String dbName = "java:comp/env/jdbc/SavingsAccountDB";
```

2. Obtain the `DataSource` associated with the logical name.

```
InitialContext ic = new InitialContext();
DataSource ds = (DataSource) ic.lookup(dbName);
```

3. Get the `Connection` from the `DataSource`.

```
Connection con =  ds.getConnection();
```

When To Connect

When coding an enterprise bean, you must decide how long it will retain the connection. Generally you have two choices: either hold the connection for the lifetime of the bean, or only during each database call. Your choice determines the method (or methods) in which your bean connects to a database.

Longterm Connections. You can design an enterprise bean that holds a database connection for its entire lifetime. Because the bean connects and disconnects just once, its code is slightly easier to write. But there's a tradeoff—other components may not acquire the connection. Session and entity beans issue the lifelong connections in different methods.

Session Beans:

The EJB™ container invokes the `ejbCreate` method at the beginning of a session bean's life cycle and invokes the `ejbRemove` method at the end. To retain a connection for the lifetime of a session bean, you connect to the database in `ejbCreate` and disconnect in `ejbRemove`. If the session bean is stateful, you must also connect in `ejbActivate` and disconnect in `ejbPassivate`. A stateful session bean requires these additional calls because the EJB container may passivate the bean during its lifetime. During passivation, a stateful session bean is saved in secondary storage, but a database connection may not be saved in this manner. Because a stateless session bean cannot be passivated, it does not require the additional calls in `ejbActivate` and `ejbPassivate`. For more information on activation and passivation, see The Stateful Session Bean Life Cycle (page 91). For an example of a stateful session bean with a longterm connection, see the `TellerBean.java` code in the `j2eetutorial/examples/ejb/teller` directory.

Entity Beans With Container-Managed Persistence:

After instantiating an entity bean and moving it to the pooled stage, the EJB container invokes the `setEntityContext` method. Conversely, the EJB container invokes the `unsetEntityContext` method when the entity bean leaves the pooled stage and becomes eligible for garbage collection. To retain a database connection for its entire life span, an entity bean connects in the `setEntityContext` method and disconnects in the `unsetEntityContext` method. To see a diagram of the life cycle see Figure 10 in the section, The Entity Bean Life Cycle (page 93). For an example of an entity bean with a longterm connection, see the `SavingsAccountBean.java` code in the `j2eetutorial/examples/ejb/savingsaccount` directory.

Shortterm Connections. Briefly held connections allow many components to share the same connection. Because the EJB container manages a pool of database connections, enterprise beans can quickly obtain and release the connections. For example, a business method might connect to a database, insert a row, and then disconnect.

In a session bean, a business method that connects to a database should be transactional. The transaction will help maintain data integrity.

Deploytool Tips for Specifying Database Users and Passwords

The instructions in this section do not apply to entity beans with container-managed persistence. For those entity beans, see the instructions in Specifying the Database JNDI Name, User Name, and Password (page 171).

To connect to the Cloudscape database bundled with this release, you do not specify a database user and password; authentication is performed by a separate service. For more information about authentication, see the chapter on Security (page 349).

However, some types of databases do require a user and password during connection. For these databases, if the `getConnection` call has no parameters, you must specify the database user and password with the `deploytool`. To specify these values, perform these steps:

1. Select the enterprise bean in the tree view.
2. Select the Resource Refs tabbed pane.
3. Select the appropriate row in the table labelled, “Resource Factories Referenced in Code,” and enter the database user name and password in the fields at the bottom.

If you wish to obtain the database user and password programmatically, you do not need to specify them with the `deploytool`. In this case, you include the database user and password in the arguments of the `getConnection` method:

```
con = dataSource.getConnection(dbUser, dbPassword);
```

Connection Pooling

The EJB container maintains the pool of database connections. This pool is transparent to the enterprise beans. When an enterprise bean requests a connection, the container fetches one from the pool and assigns it to the bean. Because the time-consuming connection has already been made, the bean quickly gets a connection. The bean may release the connection after each database call, since it can rapidly get another connection. And because such a bean holds the connection for a short time, the same connection may be shared sequentially by many beans.

Mail Session Connections

If you've ever ordered a product from a web site, you've probably received an email confirming your order. The `ConfirmerBean` class demonstrates how to send email from an enterprise bean.

Source Code. The source code for this example is in the `j2eetutorial/examples/src/ejb/confirmer` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant confirmer`. A sample `ConfirmerApp.ear` file is in the `j2eetutorial/examples/ears` directory.

In the `sendNotice` method of the `ConfirmerBean` class, the `lookup` method returns a `Session` object, which represents a mail session. Like a database connection, a mail session is a resource. As with any resource, you must link the coded name (`TheMailSession`) with a JNDI name. Using the `Session` object as an argument, the `sendNotice` method creates an empty `Message` object. After calling several `set` methods on the `Message` object, `sendNotice` invokes the `send` method of the `Transport` class to send the message on its way. The source code for the `sendNotice` method follows:

```
public void sendNotice(String recipient) {

   try {
       Context initial = new InitialContext();
       Session session =
         (Session) initial.lookup(
         "java:comp/env/TheMailSession");

       Message msg = new MimeMessage(session);
       msg.setFrom();

       msg.setRecipients(Message.RecipientType.TO,
```

```
            InternetAddress.parse(recipient, false));

        msg.setSubject("Test Message from ConfirmerBean");

        DateFormat dateFormatter =
          DateFormat.getDateTimeInstance(
          DateFormat.LONG, DateFormat.SHORT);

        Date timeStamp = new Date();

       String messageText = "Thank you for your order." + `\n' +
           "We received your order on " +
           dateFormatter.format(timeStamp) + ".";

        msg.setText(messageText);
        msg.setHeader("X-Mailer", mailer);
        msg.setSentDate(timeStamp);

        Transport.send(msg);

    } catch(Exception e) {
        throw new EJBException(e.getMessage());
    }
}
```

Running the ConfirmerEJB Example

Deploying the Application

1. In the `deploytool` open the `j2eetutorial/examples/ears/Confirmer-App.ear` file (File->Open).
2. In the Resource Refs tab of the bean, specify the resource reference for the mail session with the values in the following table.

Table 36 Resource Refs for the `ConfirmerEJB` Example

Field Name	Value
`Coded Name`	`TheMailSession`
`Type`	`javax.mail.Session`
`Authentication`	`Application`
`From`	`(your email address)`

Table 36 Resource Refs for the `ConfirmerEJB` Example

Field Name	Value
Host	(mail server host)
User Name	(your UNIX or Windows user name)

3. Deploy the `SavingsAccountApp` application (Tools->Deploy). In the Introduction dialog box, make sure that you select the Return Client JAR checkbox.

Running the Client

1. In a terminal window, go to the `j2eetutorial/examples/ears` directory.
2. Set the `APPCPATH` environment variable to `ConfirmerAppClient.jar`.
3. Type the following command on a single line, replacing `<recipient>` with the email address of the person who will receive the message.

```
runclient -client ConfirmerApp.ear -name ConfirmerAppClient
-textauth <recipient>
```

4. At the login prompts, enter `guest` for the user name and `guest123` for the password.

Trouble-Shooting

If the application cannot connect to the mail server it will generate this exception:

```
javax.mail.MessagingException: Could not connect to SMTP host
```

To fix this problem, make sure that the mail server is running and that you've entered the correct name for the mail server host in the Resource Refs tab of the `deploytool`.

URL Connections

A Uniform Resource Locator (URL) specifies the location of a resource on the Web. The `HTMLReaderBean` class shows how to connect to a URL from within an enterprise bean.

Source Code. The source code for this example is in the `j2eetutorial/examples/src/ejb/htmlreader` directory. To compile the code, go to the `j2eetutorial/examples/src` directory and type `ant htmlreader`. A sample `HTMLReaderApp.ear` file is in the `j2eetutorial/examples/ears` directory.

The `getContents` method of the `HTMLReaderBean` class returns a `String` that contains the contents of an HTML file. This method looks up the `java.net.URL` object associated with a coded name (`url/MyURL`), opens a connection to it, and then reads its contents from an `InputStream`. Before deploying the application, you must map the coded name (`url/MyURL`) to a JNDI name (a URL string). Here is the source code for the `getContents` method:

```
public StringBuffer getContents() throws HTTPResponseException
{

   Context context;
   URL url;
   StringBuffer buffer;
   String line;
   int responseCode;
   HttpURLConnection connection;
   InputStream input;
   DataInputStream dataInput;

   try {
      context = new InitialContext();
      url = (URL)context.lookup("java:comp/env/url/MyURL");
      connection = (HttpURLConnection)url.openConnection();
      responseCode = connection.getResponseCode();
   } catch (Exception ex) {
       throw new EJBException(ex.getMessage());
   }

   if (responseCode != HttpURLConnection.HTTP_OK) {
      throw new HTTPResponseException("HTTP response code: " +
         String.valueOf(responseCode));
   }

   try {
      buffer = new StringBuffer();
      input = connection.getInputStream();
      dataInput = new DataInputStream(input);
      while ((line = dataInput.readLine()) != null) {
         buffer.append(line);
         buffer.append(`\n');
      }
   } catch (Exception ex) {
```

```
            throw new EJBException(ex.getMessage());
        }

        return buffer;
    }
```

Running the HTMLReaderEJB Example

Deploying the Application

1. In the deploytool open the j2eetutorial/examples/ears/HTMLReaderApp.ear file (File->Open).
2. Deploy the HTMLReaderApp application (Tools->Deploy). In the Introduction dialog box, make sure that you select the Return Client JAR checkbox.

Running the Client

1. In a terminal window, go to the j2eetutorial/examples/ears directory.
2. Set the APPCPATH environment variable to HTMLReaderAppClient.jar.
3. Type the following command on a single line:

```
runclient -client HTMLReaderApp.ear -name
HTMLReaderClient -textauth
```

4. At the login prompts, enter guest for the user name and guest123 for the password.
5. The client displays the contents of the index.html file that resides in the public_html directory of your J2EE SDK installation.

Connecting Beyond the Firewall

To connect to a URL outside of your firewall, you must perform these tasks:

1. Stop the J2EE server.
2. In the bin/j2ee script, add the following options to the PROPS environment variable. The <port> is the proxy's port number and <host> is the name of your proxy host.

```
-Dhttp.proxyPort=<port> -Dhttp.proxyHost=<host>
```

3. In the lib/security/Server.policy file, find the following line:

```
permission java.net.SocketPermission “*:0-65535”, “connect”;
```

Edit the line so that it appears as follows:

```
permission java.net.SocketPermission “*”, “connect”;
```

4. Start the J2EE server.

J2EE™ Connector Technology

by Dale Green and Beth Stearns

THE other chapters in this book are intended for business application developers, but this chapter is for advanced users such as system integrators and tools developers. The examples in this chapter demonstrate the J2EE™ Connector Technology by accessing relational databases. However, this technology is not a substitute for the JDBC API. Business application developers should continue to use the JDBC™ API to access relational databases.

The J2EE Connector Technology enables J2EE components such as enterprise beans to interact with enterprise information systems (EIS). EIS software includes various types of systems: enterprise resource planning (ERP), mainframe transaction processing, non-relational database, among others. The J2EE Connector Technology simplifies the integration of diverse EIS systems. Each EIS requires just one implementation of the J2EE Connector Technology. Because an implementation adheres to the *J2EE Connector Specification*, it is portable across all compliant J2EE servers.

About Resource Adapters

A resource adapter is a J2EE component that implements the J2EE Connector Technology for a specific EIS. It is through the resource adapter that a J2EE application communicates with an EIS. (See Figure 27.)

Stored in a RAR (Resource adapter ARchive) file, a resource adapter may be deployed on any J2EE server, much like the EAR file of a J2EE application. A RAR file may be contained in an EAR file or it may exist as a separate file.

A resource adapter is analogous to a JDBC driver. Both provide a standard API through which an application can access a resource that is outside of the J2EE server. For a resource adapter, the outside resource is an EIS; for a JDBC driver, it is a DBMS. Resource adapters and JDBC drivers are rarely created by application developers. In most cases, both types of software are built by vendors who sell products such as tools, servers, or integration software.

Resource Adapter Contracts

Figure 27 shows the two types of contracts implemented by a resource adapter. The application contract defines the API through which a J2EE component such as an enterprise bean accesses the EIS. This API is the only view that the component has of the EIS. The resource adapter itself and its system contracts are transparent to the J2EE component.

The system contracts link the resource adapter to important services—connection, transaction, and security—that are managed by the J2EE server.

The connection management contract supports connection pooling, a technique that enhances application performance and scalability. Connection pooling is transparent to the application, which simply obtains a connection to the EIS.

Because of the transaction management contract, calls to the EIS may be enclosed in a XA transactions. XA transactions are global—they may contain calls to multiple EISs, databases, and enterprise bean business methods. Although often appropriate, XA transactions are not mandatory. Instead, an application may use local transactions, which are managed by the individual EIS, or it may use no transactions at all.

To protect the information in an EIS, the security management contract provides these mechanisms: authentication, authorization, and secure communication between the J2EE server and the EIS.

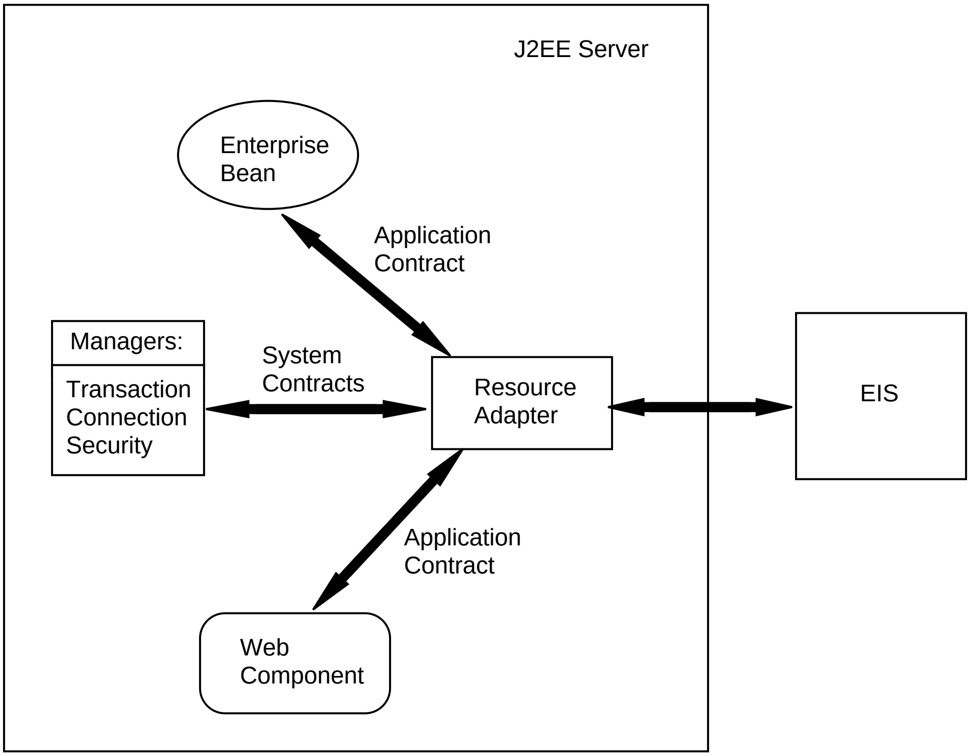


Figure 27 Accessing an EIS Through a Resource Adapter

Administering Resource Adapters

Installing a resource adapter is a two-step process:

1. Deploy the RAR file containing the resource adapter onto a server.

The following command, for example, deploys a sample black box resource adapter onto the local host. (For Windows, in the following commands omit the backslash character, change `$J2EE_HOME` to `%J2EE_HOME%`, and enter the entire command on a single line.)

```
deploytool -deployConnector \
   $J2EE_HOME/lib/connector/cciblackbox-tx.rar \
   localhost
```

2. Add a connection factory for the resource adapter.

Suppose that you wanted to add a connection factory for the resource adapter in the `cciblackbox-tx.rar` file. The JNDI name of the connection factory will be `eis/MyCciBlackBoxTx`. To override the default value of the property named `ConnnectionURL`, you specify the URL of a database. (A property is a name-value pair used to configure a connection factory.) To add the connection factory, you might enter the following `j2eeadmin` command:

```
j2eeadmin -addConnectorFactory \
   eis/MyCciBlackBoxTx \
   cciblackbox-tx.rar \
   -props \
   ConnectionURL=jdbc:oracle:thin:@myhost:1521:ACCTDB
```

For the full syntax of the `deploytool` and `j2eeadmin` commands, see J2EE™ SDK Tools (page 449). These commands also list and remove resource adapters and connection factories.

To list the resource adapters that have been deployed:

```
deploytool -listConnectors localhost
```

To list the connection factories that have been added:

```
j2eeadmin -listConnectorFactory
```

To uninstall the resource adapter deployed in step 1:

```
deploytool -undeployConnector cciblackbox-tx.rar localhost
```

To remove the connection factory added in step 2:

```
j2eeadmin -removeConnectorFactory eis/MyCciBlackBoxTx
```

The Black Box Resource Adapters

The J2EE SDK includes several black box resource adapters for performing end-to-end and compatibility testing. The underlying EIS of these adapters is a relational DBMS. The client API is the JDBC 2.0 API and the `javax.sql.DataSource` interface. Underneath, the black box adapters use JDBC drivers to communicate with relational databases. For more information, see Configuring JDBC™ Drivers (page 387).

Note: Although the black box adapters use JDBC, resource adapters are not meant to replace JDBC for accessing relational databases. The black box adapters are for testing purposes only. Because they use JDBC, they can be plugged into existing tests that also use JDBC.

Transaction Levels

The black box resource adapters reside in the `$J2EE_HOME/lib/connector` (Unix) or `%J2EE_HOME%\lib\connector` (Windows) subdirectory. The following table lists the blackbox RAR files and the different transaction levels that they support:

Table 37 Black Box Transaction Levels

File	Transaction Level
`blackbox-notx.rar`	`NO_TRANSACTION`
`blackbox-tx.rar`	`LOCAL_TRANSACTION`
`blackbox-xa.rar`	`XA_TRANSACTION`
`cciblackbox-tx.rar`	`LOCAL_TRANSACTION`
`cciblackbox-xa.rar`	`XA_TRANSACTION`

For the `XA_TRANSACTION` level, the underlying JDBC driver must support the XA requirements as defined by the JDBC 2.0 API.

Properties

A resource adapter may contain properties, name-value pairs containing information specific to the resource adapter and its underlying EIS. These properties are defined in the deployment descriptor of each blackbox RAR file. Because the EIS of a blackbox adapter is a relational database, the properties contain information required for connecting to a database. Table 38 lists the properties of the black box adapter files. Table 39 shows the default values for the black box properties.

Table 38 Black Box Properties

File	Property Name	Description
`blackbox-notx.rar`	`ConnectionURL`	URL of database
`blackbox-tx.rar`	`ConnectionURL`	URL of database
`blackbox-xa.rar`	`XADataSourceName`	JNDI name of `XADataSource`
`cciblackbox-tx.rar`	`ConnectionURL`	URL of database
`cciblackbox-xa.rar`	`XADataSourceName`	JNDI name of `XADataSource`

Table 39 Default Values for Black Box Properties

Property Name	Description
ConnectionURL	`jdbc:cloudscape:rmi:CloudscapeDB;create=true`
XADataSourceName	`jdbc/XACloudscape_xa`

To override a default property value, you set the value when adding a connection factory with the `j2eeadmin` command. See the section, Administering Resource Adapters (page 383).

Configuring JDBC™ Drivers

If you are running the black box adapters against a Cloudscape database, you may skip this section. If you are using a database other than Cloudscape, you should perform the steps that follow.

The Non-XA Black Box Adapters

1. Set the JDBC driver class. Use the `j2eeadmin` tool with the `-addJdbcDriver` option and specify the driver class name. The syntax for this option is:

```
j2eeadmin -addJdbcDriver <class name>
```

2. Edit the `bin/userconfig.sh` (UNIX) or `bin\userconfig.bat` (Windows) file, setting the J2EE_CLASSPTH variable to the location of the JDBC driver classes.
3. Restart the J2EE server.

The XA Black Box Adapters

1. Set the `XADatasource` property. With the `j2eeadmin` tool and the `-addJdbcXADatasource` option, specify the JNDI name and class name for the `XADatasource` property. Optionally, you may specify the XA user name and password and you may override the default property value. The syntax follows:

```
j2eeadmin -addJdbcXADatasource <jndi name> <class name>
   [<xa user name> <xa password>]
   [-props (<name>=<value>)+]
```

   The preceding command results in two data sources. One is a `DataSource` object with the specified JNDI name from which the J2EE application gets a `Connection` instance. The other is an `XADatasource` object whose JNDI name is the `<jndi-name>` parameter appended with two underscores and `xa` (`<jndi-name>__xa`). Behind the scenes, the `DataSource` uses the `XADataSource` to create connections.

2. Restart the J2EE server.

Resource Adapter Tutorial

This tutorial shows you how to deploy the black box resource adapter stored in the `blackbox-tx.rar` file. To test the resource adapter, you will modify the `examples/src/ejb/savingsaccount/SavingsAccountBean.java` file so that it accesses the Cloudscape database through the resource adapter. The `SavingsAccountBean.java` file is also used in another example; see Running the SavingsAccountEJB Example (page 121)

Setting Up

1. Start the J2EE server.

```
j2ee -verbose
```

2. Follow the instructions in the section, Setting Up the Database (page 121).

Deploying the Resource Adapter

1. Deploy a black box resource adapter that is packaged in the `blackbox-tx.rar` file.

UNIX:

```
deploytool -deployConnector \
$J2EE_HOME/lib/connector/blackbox-tx.rar localhost
```

Windows:

(Enter the following command on a single line.)

```
deploytool -deployConnector
%J2EE_HOME%\lib\connector\blackbox-tx.rar localhost
```

2. Add a connection factory for the resource adapter. The JNDI name for the connection factory is `eis/MyBlackBoxTx`.

UNIX:

```
j2eeadmin -addConnectorFactory \
eis/MyBlackBoxTx blackbox-tx.rar
```

Windows:

(Enter the following command on a single line.)

```
j2eeadmin -addConnectorFactory
eis/MyBlackBoxTx blackbox-tx.rar
```

3. Verify that the resource adapter has been deployed.

```
deploytool -listConnectors localhost
```

The `deploytool` displays these lines:

```
Installed connector(s):
Connector Name: blackbox-tx.rar

Installed connection factories:
Connection Factory JNDI Name: eis/MyBlackBoxTx
```

Testing the Resource Adapter

1. If you are new to the J2EE SDK, you should first read the instructions in Getting Started (page 49).
2. Locate the `SavingsAccountBean.java` source code, which resides in the `j2eetutorial/examples/src/ejb/savingsaccount` directory.
3. Edit the SavingsAccountBean`.java` source code, changing the value assigned to the `dbName` variable as follows:

```
private String dbName = "java:comp/env/MyEIS";
```

4. Compile the source code in the `savingsaccount` directory:
   a. Go to j2eetutorial`/examples/src.`
   b. Type `ant savingsaccount`.
5. Replace the new `SavingsAccountBean.class` file in the existing `SavingsAccountApp.ear` file.
   a. In the GUI deploytool, open the `j2eetutorial/examples/ears/SavingsAccountApp.ear` file.
   b. On the General tabbed pane of the SavingsAccountJAR, click Edit.
   c. In the Available Files field, locate the `j2eetutorial/examples/build/ejb/SavingsAccountBean.class` file.
   d. Drag and drop the `SavingnsAccountBean.class` file from the Available Files field to the Contents field.
   e. Click OK.

6. Change the resource factory reference.
   a. Select the Resource Refs tabbed pane of the SavingsAccountEJB.
   b. Select the item whose Coded Name entry is `jdbc/SavingsAccountDB`.
   c. Click Delete.
   d. Click Add.
   e. Enter the values specified in the following table.

Table 40 Resource References Values

Field	**Value**
`Coded Name`	`MyEIS`
`Type`	`javax.sql.DataSource`
`Authentication`	`Container`
`JNDI Name`	`eis/MyBlackBoxTx`

The `eis/MyBlackBoxTx` JNDI name matches the name of the connection factory that you added in step 2 of Deploying the Resource Adapter (page 388). The MyEIS value of the Coded Name field corresponds to this line in the `SavingsAccountBean.java` source code:

```
private String dbName = "java:comp/env/MyEIS";
```

Although it is included in the source code, the `java:comp/env/` subcontext is implicit in the Coded Name field of the Resource Refs tabbed pane.

7. Save the SavingsAccountApp (File->Save).
8. Deploy the SavingsAccountApp.
   a. Select Tools->Deploy.
   b. In the Introduction dialog box, select Return Client Jar.

c. In the JNDI Names dialog box, verify that the JNDI names in the following table have been specified.

Table 41 JNDI Names

Component or Reference Name	JNDI Name
SavingsAccountEJB	MySavingsAccount
MyEIS	eis/MyBlackBoxTx
ejb/SimpleSavingsAccount	MySavingsAccount

9. To run the application, follow the directions in Running the Client (page 121).

Common Client Interface (CCI)

This section describes how components use the Connector architecture Common Client Interface (CCI) API and a resource adapter to access data from an EIS.

Overview of the CCI

Defined by the J2EE Connector Specification, the CCI defines a set of interfaces and classes whose methods allow a client to perform typical data access operations. Our example `CoffeeEJB` session bean includes methods that illustrate how to use the CCI, in particular, the following CCI interfaces and classes:

- `ConnectionFactory`: Provides an application component with a `Connection` instance to an EIS.
- Connection- Represents the connection to the underlying EIS.
- `ConnectionSpec`: Provides a means for an application component to pass connection request-specific properties to the `ConnectionFactory` when making a connection request.
- `Interaction`: Provides a means for an application component to execute EIS functions, such as database stored procedures.
- `InteractionSpec`: Holds properties pertaining to an application component's Interaction with an EIS.
- `Record`: The superclass for the different kinds of record instances. Record instances may be `MappedRecord`, `IndexedRecord`, or `ResultSet` instances, which all inherit from the Record `interface`.
- `RecordFactory`: Provides an application component with a `Record` instance.
- `IndexedRecord`: Represents an ordered collection of `Record` instances based on the `java.util.List` interface.

A client or application component that uses the CCI to interact with an underlying EIS does so in a prescribed manner. The component must establish a connection to the EIS's resource manager, and it does so using the `ConnectionFactory`. The `Connection` object represents the actual connection to the EIS and it is used for subsequent interactions with the EIS.

The component performs its interactions with the EIS, such as accessing data from a specific table, using an `Interaction` object. The application component defines the `Interaction` object using an `InteractionSpec` object. When the application component reads data from the EIS (such as from database tables) or writes to those tables, it does so using a particular type of `Record` instance, either a `MappedRecord`, `IndexedRecord`, or `ResultSet` instance. Just as the `ConnectionFactory` creates `Connection` instances, a `RecordFactory` creates `Record` instances.

Our example shows how a session bean uses a resource adapter to add and read records in a relational database. The example shows how to invoke stored procedures, which are business logic functions stored in a database and specific to an enterprise's operation. Stored procedures consist of SQL code to perform operations related to the business needs of an organization. They are kept in the database and can be invoked when needed, just as you might invoke a Java™ method. In addition to showing how to use the CCI to invoke stored procedures, we'll also explain how to pass parameters to stored procedures and how to map the parameter data types from SQL to those of the Java programming language.

Programming with the CCI

The code for the following example is in the `examples/src/connector/cci` directory.

To illustrate how to use a CCI resource adapter, we've written a session bean and a client of that bean. These pieces of code illustrate how clients invoke the different CCI methods that resource adapters built on CCI might make available. Our example uses the two sample CCI-specific resource adapters: `cciblackbox_tx.rar` and `cciblackbox_xa.rar`.

The `Coffee` session bean is much like any other session bean. It has a home interface (`CoffeeHome`), a remote interface (`Coffee`), and an implementation class (`CoffeeEJB`). To keep things simple, we've called the client `CoffeeClient`.

Let's start with the session bean interfaces and classes. The home interface, `CoffeeHome`, is like any other session bean home interface. It extends `EJBHome` and defines a `create` method to return a reference to the `Coffee` remote interface.

The `Coffee` remote interface defines the bean's two methods that may be called by a client.

```
public void insertCoffee(String name, int quantity)
throws RemoteException;
public int getCoffeeCount() throws RemoteException;
```

Now let's examine the `CoffeeEJB` session bean implementation class to see how it uses the CCI.

To begin with, notice that `CoffeeEJB` imports the `javax.resource` CCI interfaces and classes, along with the `javax.resource.ResourceException`, and the sample `cciblackbox` classes.

```
import javax.resource.cci.*;
import javax.resource.ResourceException;
import com.sun.connector.cciblackbox.*;
Obtaining a Database Connection
```

Prior to obtaining a database connection, the session bean does some set up work in its `setSessionContext` method. (See the following code example.) Specifically, the `setSessionContext` method sets the user and password values, and instantiates a `ConnectionFactory`. These values and objects remain available to the other session bean methods.

(In this and subsequent code examples, the numbers in the left margin correspond to the explanation that follows the code.)

```
    public void setSessionContext(SessionContext sc) {
         try {
             this.sc = sc;
1            Context ic = new InitialContext();
2            user = (String) ic.lookup(“java:comp/env/user”);
             password = (String) ic.lookup
                (“java:comp/env/password”);
3            cf = (ConnectionFactory) ic.lookup
                (“java:comp/env/CCIEIS”);
         } catch (NamingException ex) {
             ex.printStackTrace();
         }
     }
```

1. Establish a JNDI `InitialContext`.
2. Use the JNDI `InitialContext.lookup` method to find the user and password values.
3. Use the `lookup` method to locate the `ConnectionFactory` for the CCI black box resource adapter and obtain a reference to it.

`CoffeeEJB` uses its private method `getCCIConnection` method to establish a connection to the underlying resource manager or database. A client of the `Coffee` session bean cannot invoke this method directly. Rather, the session bean uses this method internally to establish a connection to the database. The following code uses the CCI to establish a database connection.

```
     private Connection getCCIConnection() {
         Connection con = null;
         try {
1            ConnectionSpec spec =
                 new CciConnectionSpec(user, password);
2            con = cf.getConnection(spec);
         } catch (ResourceException ex) {
```

```
            ex.printStackTrace();
        }
        return con;
    }
```

1. Instantiate a new `CciConnectionSpec` object with the user and password values obtained by the `setSessionContext` method. The `CciConnectionSpec` class is the implementation of the `ConnectionSpec` interface.
2. Call the `ConnectionFactory.getConnection` method to obtain a connection to the database. (The reference to the `ConnectionFactory` was obtained in the `setSessionContext` method.) Use the `CciConnectionSpec` object to pass the required properties to the `ConnectionFactory`. The `getConnection` method returns a `Connection` object.

The `CoffeeEJB` bean also includes a private method, `closeCCIConnection`, to close a connection. The method invokes the `Connection` object's `close` method from within a `try/catch` block. Like the `getCCIConnection` method, this is a private method intended to be called from within the session bean.

```
private void closeCCIConnection(Connection con) {
    try {
        con.close();
    } catch (ResourceException ex) {
        ex.printStackTrace();
    }
}
```

Database Stored Procedures

The sample CCI black box adapters call database stored procedures. It is important to understand stored procedures before delving into how to read or write data using the sample CCI black box adapters. The methods of these sample CCI adapters do not actually read data from a database or update database data. Instead, these sample CCI adapters enable you to invoke database stored procedures, and it is the stored procedures that actually read or write to the database.

A stored procedure is a business logic method or function that is stored in a database and is specific for the enterprise's business. Typically, stored procedures consist of SQL code, though in certain cases (such as with Cloudscape) they may consist of code written in the Java™ programming language. Stored procedures perform operations related to the business needs of an organization. They are kept in the database and applications can invoke them when needed.

Stored procedures are typically SQL statements. Our example calls two stored procedures: COUNTCOFFEE and INSERTCOFFEE. The COUNTCOFFEE procedure merely counts the number of coffee records in the Coffee table, as follows:

```
SELECT COUNT(*) FROM COFFEE
```

The INSERTCOFFFEE procedure adds a record with two values, passed to the procedure as parameters, to the same Coffee table, as follows:

```
INSERT INTO COFFEE VALUES (?,?)
```

Mapping to Stored Procedure Parameters

When you invoke a stored procedure from your application component you may have to pass argument values to the procedure. For example, when you invoke the INSERTCOFFEE procedure, you pass it two values for the Coffee record elements. Likewise, you must be prepared to receive values that a stored procedure returns.

The stored procedure, in turn, passes its set of parameters to the database management system (DBMS) to carry out its operation and may receive values back from the DBMS. Database stored procedures specify, for each of their parameters, the SQL type of the parameter value and the mode of the parameter. Mode can be input (IN), output (OUT), or both input and output (INOUT). An input parameter only passes data in to the DBMS while an output parameter only receives data back from the DBMS. A INOUT parameter accepts both input and output data.

When you use the CCI execute method to invoke a database stored procedure you also create an instance of an InputRecord, provided that you're passing a parameter to the stored procedure and the stored procedure you're executing returns data (possibly an OutputRecord instance). The InputRecord and OutputRecord are instances of the supported Record types: IndexedRecord, MappedRecord, or ResultSet. In our example, we instantiate an InputRecord and an OutputRecord that are both IndexedRecord instances.

Note: The CCI black box adapters only support IndexedRecord types.

The InputRecord maps the IN and INOUT parameters for the stored procedure, while the OutputRecord maps the OUT and INOUT parameters. Each element of an input or output record corresponds to a stored procedure parameter. That is, there is an entry in the InputRecord for each IN and INOUT parameter declared in the stored procedure. Not only does the `InputRecord` have the same number of elements as the procedure's input parameters, they are declared in the same order as in the procedure's parameter list. The same holds true for the `OutputRecord`, though its list of elements matches only the `OUT` and `INOUT` parameters.

For example, suppose you have a stored procedure `X` that declares three parameters. The first parameter is an `IN` parameter, the second is an `OUT` parameter, and the third is an `INOUT` parameter. The following figure shows how the elements of an `InputRecord` and an `OutputRecord` map to this stored procedure.

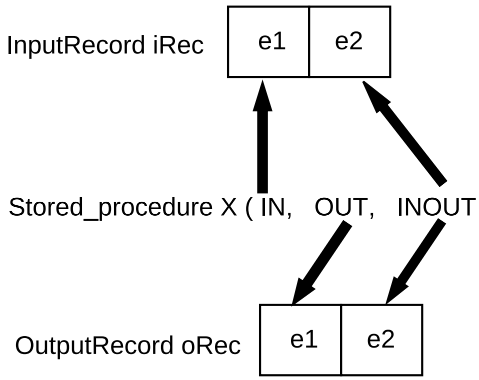


Figure 28 Mapping Stored Procedure Parameters to CCI Record Elements

When you use the CCI black box adapter, you designate the parameter type and mode in the same way, though the underlying Oracle or Cloudscape DBMS declare the mode differently. Oracle designates the parameter's mode in the stored procedure declaration, along with the parameter's type declaration. For example, an Oracle `INSERTCOFFEE` procedure declares its two `IN` parameters as follows:

```
procedure INSERTCOFFEE (name IN VARCHAR2, qty IN INTEGER)
```

An Oracle `COUNTCOFFEE` procedure declares its parameter `N` as an `OUT` parameter:

```
procedure COUNTCOFFEE (N OUT INTEGER)
```

Cloudscape, which declares stored procedures using standard a Java method signature, indicates an `IN` parameter using a single value and an `INOUT` parameter as an array. The method's return value is the `OUT` parameter. For example, Cloudscape declares the `IN` parameters (`name` and `qty`) for `insertCoffee` and the `OUT` parameter (the method's return value) for `countCoffee` as follows:

```
public static void insertCoffee(String name, int qty)
public int countCoffee()
```

If `qty` were an `INOUT` parameter, then Cloudscape would declares it as:

```
public static void insertCoffee(String name, int[] qty)
```

Oracle would declare it as:

```
procedure INSERTCOFFEE (name IN VARCHAR2, qty INOUT INTEGER)
```

You must also map the SQL type of each value to its corresponding Java type. Thus, if the SQL type is integer, then the `InputRecord` or `OutputRecord` element must be defined as a `Integer` object. If the SQL type is a `VARCHAR`, then the Java type must be a `String` object. Thus, when you add the element to the `Record`, you declare it to be an object of the proper type. For example, add an integer and a string element to an `InputRecord` as follows:

```
iRec.add (new Integer (intval));
iRec.add (new String ("Mocha Java"));
```

Note: The *JDBC Specification* defines the SQL to Java type mapping.

Reading Database Records

The `getCoffeeCount` method of `CoffeeEJB` illustrates how to use the CCI to read records from a database table. This method does not directly read the database records itself; instead, it invokes a procedure stored in the database called `COUNTCOFFEE`. It is the stored procedure that actually reads the records in the database table.

The CCI provides interfaces for three types of records: `IndexedRecord`, `MappedRecord`, and `ResultSet`. These three record types inherit from the base interface, `Record`. They differ only in how they map the record elements within the record. Our example uses `IndexedRecord`, which is the only record type currently supported. `IndexedRecord` holds its record elements in an ordered, indexed collection based on `java.util.List`. As a result, we use an `Iterator` object to access the individual elements in the list.

Let's begin by looking at how the `getCoffeeCount` method uses the CCI to invoke a database stored procedure. Again, note that the numbers in the margin to the left of the code correspond to the explanation after the code example.

```
        public int getCoffeeCount() {
            int count = -1;
            try {
1               Connection con = getCCIConnection();
2               Interaction ix = con.createInteraction();
3               CciInteractionSpec iSpec =
                   new CciInteractionSpec();
4               iSpec.setSchema(user);
                iSpec.setCatalog(null);
                iSpec.setFunctionName("COUNTCOFFEE");
5               RecordFactory rf = cf.getRecordFactory();
6               IndexedRecord iRec =
                   rf.createIndexedRecord("InputRecord");
7               Record oRec = ix.execute(iSpec, iRec);
8               Iterator iterator =
                   ((IndexedRecord)oRec).iterator();
9               while(iterator.hasNext()) {
                    Object obj = iterator.next();
                    if(obj instanceof Integer) {
                        count = ((Integer)obj).intValue();
                    }
                    else if(obj instanceof BigDecimal) {
                        count = ((BigDecimal)obj).intValue();
                    }
                }
10              closeCCIConnection(con);
            }catch(ResourceException ex) {
                ex.printStackTrace();
            }
            return count;
        }
```

1. Obtain a connection to the database.
2. Create a new `Interaction` instance. The `getCoffeeCount` method creates a new `Interaction` instance because it is this object that enables the session bean to execute EIS functions such as invoking stored procedures.
3. Instantiate a `CciInteractionSpec` object. The session bean must pass certain properties to the `Interaction` object, such as schema name, catalog name, and the name of the stored procedure. It does this by instantiating a `CciInteractionSpec` object. The `CciInteractionSpec` is the implementation class for the `InteractionSpec` interface, and it holds properties

required by the `Interaction` object to interact with an EIS instance. (Note that our example uses a Cloudscape database, which does not require a catalog name.)

4. Set values for the `CciInteractionSpec` instance's fields. The session bean uses the `CciInteractionSpec` methods `setSchema`, `setCatalog`, and `setFunctionName` to set the required values into the instance's fields.Our example passes `COUNTCOFFEE` to `setFunctionName` because this is the name of the stored procedure it intends to invoke.
5. The `getCoffeeCount` method uses the `ConnectionFactory` to obtain a reference to a `RecordFactory` so that it can create an `IndexedRecord` instance. We obtain an `IndexedRecord` (or a `MappedRecord` or a `ResultSet`) using a `RecordFactory`.
6. Invoke the `createIndexedRecord` method of `RecordFactory`. This method creates a new `IndexedRecord` using the name `InputRecord`, which is passed to it as an argument.
7. The `getCoffeeCount` method has completed the required set-up work and it can invoke the stored procedure `COUNTCOFFEE`. It does this using the `Interaction` instance's `execute` method. Notice that it passes two objects to the `execute` method: the `InteractionSpec` object, whose properties reference the `COUNTCOFFEE` stored procedure, and the `IndexedRecord` object, which the method expects to be an input `Record`. The `execute` method returns an output `Record` object.
8. The `getCoffeeCount` method uses an `Iterator` to retrieve the individual elements from the returned `IndexedRecord`. It casts the output `Record` object to an `IndexedRecord`. `IndexedRecord` contains an iterator method that it inherits from `java.util.List`.
9. Retrieve each element in the returned record object using the `iterator.hasNext` method. Each extracted element is an `Object`, and the bean evaluates whether it is an integer or decimal value and processes it accordingly.
10. Close the connection to the database.

Inserting Database Records

The `CoffeeEJB` session bean implements the `insertCoffee` method to add new records into the `Coffee` database table. This method invokes the `INSERTCOFFEE` stored procedure, which inserts a record with the values (`name` and `qty`) passed to it as arguments.

The `insertCoffee` method shown here illustrates how to use the CCI to invoke a stored procedure that expects to be passed argument values. This example shows the code for the `insertCoffee` method and is followed by an explanation.

```
     public void insertCoffee(String name, int qty) {
         try {
1            Connection con = getCCIConnection();
2            Interaction ix = con.createInteraction();
3            CciInteractionSpec iSpec =
                new CciInteractionSpec();
4            iSpec.setFunctionName(“INSERTCOFFEE”);
             iSpec.setSchema(user);
             iSpec.setCatalog(null);
5            RecordFactory rf = cf.getRecordFactory();
6            IndexedRecord iRec =
                rf.createIndexedRecord(“InputRecord”);
7            boolean flag = iRec.add(name);
             flag = iRec.add(new Integer(qty));
8            ix.execute(iSpec, iRec);
9            closeCCIConnection(con);
         }catch(ResourceException ex) {
             ex.printStackTrace();
         }
     }
```

1. Establish a connection to the database.
2. Create a new `Interaction` instance for the connection so that the bean can execute the database's stored procedures.
3. Instantiate a `CciInteractionSpec` object so that the bean can pass the necessary properties—schema name, catalog name, stored procedure name—to the `Interaction` object. The `CciInteractionSpec` class implements the `InteractionSpec` interface and it holds properties that the `Interaction` object requires to communicate with the database instance.
4. Set the required values into the new `CciInteractionSpec` instance's fields, using the instance's `setSchema`, `setCatalog`, and `setFunctionName` methods. Our example passes `INSERTCOFFEE` to `setFunctionName` and the `user` to `setSchema`.
5. Obtain a reference to a `RecordFactory` using the `ConnectionFactory` objects's `getRecordFactory` method.
6. Invoke the `RecordFactory` object's `createIndexedRecord` method to create a new `IndexedRecord` with the name `InputRecord`.
7. Use the `IndexedRecord` `add` method to set the values for the two elements in the new record. Call the `add` method once for each element. Our exam-

ple sets the first record element to the `name` value and the second element to the `qty` value. Notice that `qty` is set to an `Integer` object when passed to the `add` method. The `CoffeeEJB` session bean is now ready to add the new record to the database.

8. Call the `Interaction` instance's execute method to invoke the stored procedure `INSERTCOFFEE`. Just as we did when invoking the `COUNTCOFFEE` procedure, we pass two objects to the execute method: the `InteractionSpec` object with the correctly set properties for the `INSERTCOFFEE` stored procedure and the `IndexedRecord` object representing an input `Record`. The `execute` method is not expected to return anything in this case.
9. Close the connection to the database.

Writing a CCI Client

A client application that relies on a CCI resource adapter is very much like any other J2EE client that uses enterprise bean methods. Our `CoffeeClient` application uses the methods of the `CoffeeEJB` session bean to access the `Coffee` table in the underlying database. `CoffeeClient` invokes the `Coffee.getCoffeeCount` method to read the `Coffee` table records and the `Coffee.insertCoffee` method to add records to the table.

CCI Tutorial

This tutorial shows you how to deploy and test the sample CCI black box adapter with the code described in the preceding sections. This code has been packaged into a J2EE application EAR file named `CoffeeApp.ear`, which is located in the `j2eetutorial/examples/ears` directory. The source code is in `j2eetutorial/examples/src/connector/cci`. To compile the source code, go to the `j2eetutorial/examples/src` directory and type `ant cci`.

Deploying the Resource Adapter

1. Use the `deploytool` utility to deploy the CCI black box resource adapter. Specify the name of the resource adapter's RAR file (`cciblackbox-tx.rar`), plus the name of the server (`localhost`).

   UNIX:

   ```
   deploytool -deployConnector \
   $J2EE_HOME/lib/connector/cciblackbox-tx.rar localhost
   ```

   Windows:

(Note that this command and all subsequent Windows commands must be entered on a single line.)

```
deploytool -deployConnector
%J2EE_HOME%\lib\connector\cciblackbox-tx.rar localhost
```

2. Next, add a connection factory for the deployed CCI adapter. The connection factory supplies a data source connection for the adapter. Use `j2eeadmin` to create the connection factory, specifying the adapter's JNDI name plus the server name. Here, we add a connection factory for our CCI adapter whose JNDI name is `eis/CciBlackBoxTx` on the server `localhost`.

UNIX:

```
j2eeadmin -addConnectorFactory \
eis/CciBlackBoxTx cciblackbox-tx.rar
```

Windows:

```
j2eeadmin -addConnectorFactory
eis/CciBlackBoxTx cciblackbox-tx.rar
```

3. Verify that the resource adapter has been deployed.

```
deploytool -listConnectors localhost
```

The `deploytool` utility displays these lines:

```
Installed connector(s):
    Connector Name: cciblackbox-tx.rar
Installed connection factories:
    Connection Factory JNDI name: eis/CciBlackBoxTx
```

Setting Up the Database

Cloudscape:

1. Create the stored procedure.
   a. To compile the stored procedure, go to the `j2eetutorial/examples/src` directory and type `ant procs`. This command will put the `Procs.class` file in the `j2eetutorial/examples/build/connector/procs` directory.
   b. Locate the `bin/userconfig.sh` (UNIX) or `bin\userconfig.bat` (Windows) file in your J2EE SDK installation. Edit the file so that the

   `J2EE_CLASSPATH` variable points to the directory that contains the `Procs.class` file.

   c. Restart the Cloudscape server.

   d. Go to the `j2eetutorial/examples/src` directory and type `ant create-procs-alias`. This command creates aliases for the methods in `Procs.class`. Cloudscape uses method aliases to simulate stored procedures.

2. To create the `Coffee` table, go to the j2eetutorial/`examples/src` directory and type `ant create-coffee-table`.

Oracle:

1. Start the database server.
2. Run the `j2eetutorial/examples/src/connector/sql/oracle.sql` script, which creates both the stored procedures and the `Coffee` table.

Browsing the CoffeeApp Application

1. In the GUI `deploytool`, open the `j2eetutorial/examples/ears/CoffeeApp.ear` file.
2. Select the Resource Refs tabbed pane of the CoffeeBean component and note the following:
   - The Coded Name of `CCIEIS` corresponds to the following line in the `CoffeeEJB.java` source code:

```
cf = (ConnectionFactory) ic.lookup("java:comp/env/CCIEIS");
```

   - The JNDI Name of `eis/CciBlackBoxTx` matches the name of the connection factory you added in step 2 of Deploying the Resource Adapter (page 402).
   - The User Name and Password fields contain dummy values (XXX), since this EAR file was tested with a Cloudscape database. For other types of databases, you may be required to insert actual values in these fields. For these databases, you should also insert actual values on the Env. Entries tabbed pane of the CoffeeBean.
3. Select the JNDI Names tabbed pane of the CoffeeApp. Note that the CCIEIS value in the Reference Name field has been mapped to the eis/CciBlackBoxTx value in the JNDI Name field.

Deploying and Running the CoffeeApp Application

1. Deploy the application.
   a. In the GUI `deploytool`, select Tools->Deploy.
   b. In the Introduction dialog box, select Return Client Jar.
2. In a terminal window, go to the `j2eetutorial/examples/ears` directory.
3. Set the `APPCPATH` environment variable to the name of the stub client JAR file: `CoffeeAppClient.jar`.
4. Run the client.

```
runclient -client CoffeeApp.ear -name CoffeeClient
-textauth
```

5. At the login prompts, enter `guest` as the user name and `guest123` as the password.
6. The client should display the following lines:

```
Coffee count = 0
Inserting 3 coffee entries...
Coffee count = 3
```

The Duke's Bank Application

by Stephanie Bodoff, Dale Green, and Monica Pawlan

THIS chapter describes the Duke's Bank application, an online banking application with two clients: a J2EE application client used by administrators to manage customers and accounts; and a web client used by customers to access account histories and perform transactions. The clients access the customer, account, and transaction information maintained in a database through enterprise beans. The Duke's Bank application demonstrates how all the component technologies—enterprise beans, application clients, and web components—presented in this tutorial are put together to provide a simple but functional application. Figure 29 gives a high-level view of the how the components interact.

The rest of this chapter looks at each of the component types in detail and concludes with a discussion of how to build, deploy, and run the application.

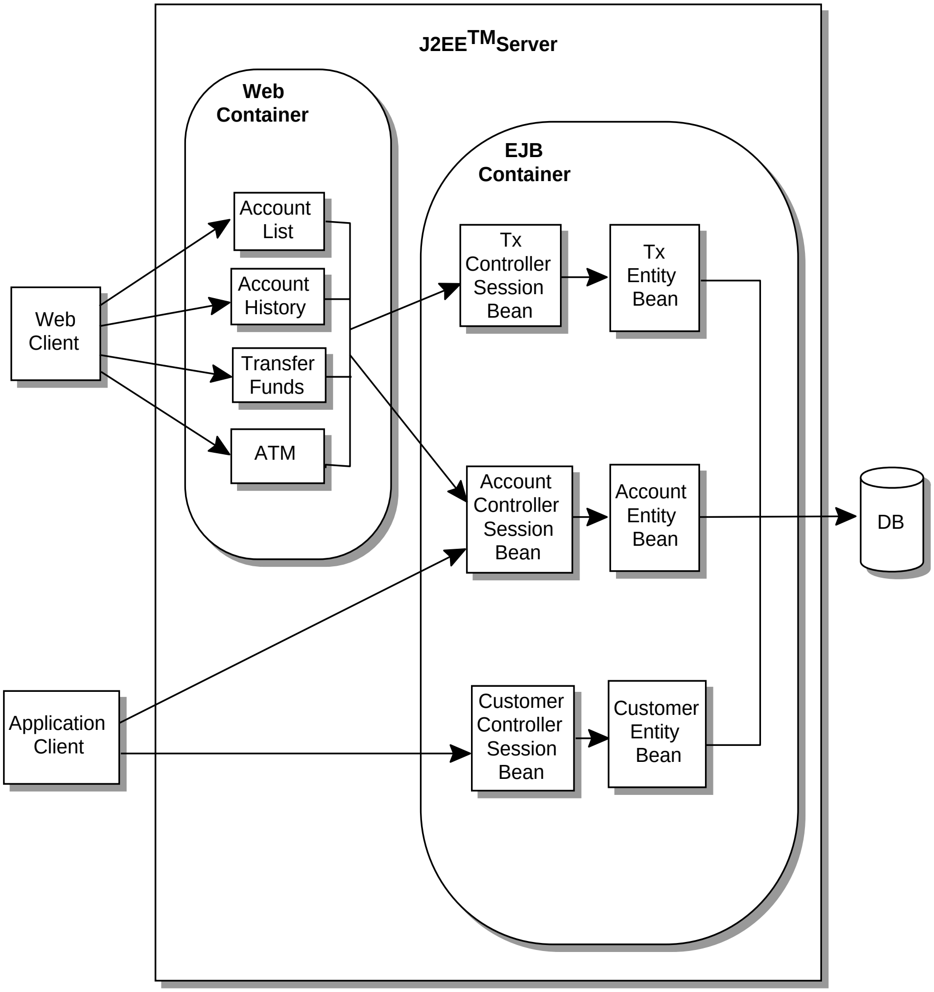


Figure 29 Duke's Bank Application

Enterprise Beans

Figure 30 shows the access paths between the clients, enterprise beans, and database tables. The end-user clients (web and J2EE application components) may access only the session beans. Within the enterprise bean tier, the session beans are clients of the entity beans. On the back-end of the application, the entity beans access the database tables that store the entity states.

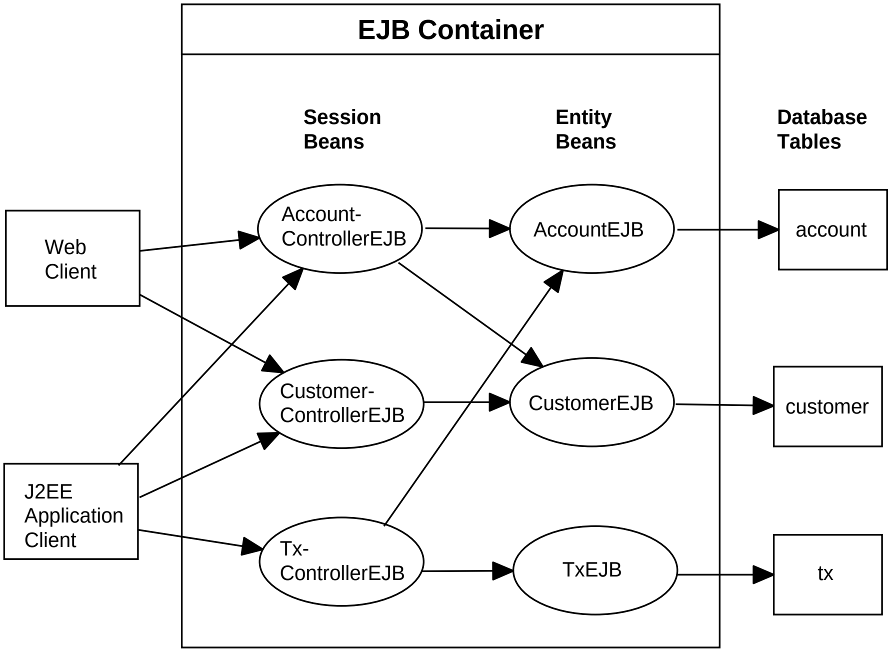


Figure 30 Enterprise Beans in the Duke's Bank Application

Source Code. The source code for these enterprise beans is in the `j2eetutorial/bank/src/com/sun/ebank/ejb` subdirectory of the tutorial.

Naming Conventions for Enterprise Beans

Because enterprise beans are composed of multiple parts, it's useful to follow a naming convention for your applications. The following table summarizes the conventions for the enterprise beans of the Duke's Bank application. (The DD abbreviation means that the item is an element in the bean's deployment descriptor.)

Table 42 Naming Conventions for Enterprise Beans

Item	Syntax	Example
enterprise bean name (DD)	`<name>EJB`	`AccountEJB`
EJB JAR display name (DD)	`<name>JAR`	`AccountJAR`
enterprise bean class	`<name>Bean`	`AccountBean`
home interface	`<name>Home`	`AccountHome`
remote interface	`<name>`	`Account`

Session Beans

The Duke's Bank application has three session beans: `AccountControllerEJB`, `CustomerControllerEJB`, and `TxControllerEJB`. ("Tx" stands for a business "transaction" such as transferring funds.) These session beans provide a client's view of the application's business logic. Hidden from the clients are the server-side routines that implement the business logic, access databases, manage relationships, and perform error checking.

AccountControllerEJB

The business methods of the `AccountControllerEJB` session bean perform tasks that fall into the following categories.

Methods that Create and Remove Entity Beans.

- `createAccount`
- `removeAccount`

The `createAccount` and `removeAccount` methods of the `AccountControllerEJB` session bean call the `create` and `remove` methods of the `AccountEJB` entity bean. The `createAccount` and `removeAccount` methods throw application exceptions to indicate invalid method arguments. The `createAccount` method throws a `IllegalAccountTypeException` if the type argument is neither `Checking`, `Savings`, `Credit`, nor `Money Market`. The `createAccount` method also verifies that the specified customer exists by invoking the `findByPrimaryKey` of the CustomerEJB entity bean. If the result of this verification is false, the createAccount method throws a CustomerNotFoundException.

Methods that Manage the Account-Customer Relationship.

- addCustomerToAccount
- removeCustomerFromAccount

The AccountEJB and CustomerEJB entity beans have a many-to-many relationship. A bank account may be jointly held by more than one customer, and a customer may have multiple accounts. Because the entity beans use bean-managed persistence, there are several ways to manage this relationship. For more information, see Mapping Table Relationships For Bean-Managed Persistence (page 122).

In the Duke's Bank application, the addCustomerToAccount and removeCustomerFromAccount methods of the AccountControllerEJB manage the account-customer relationship. The addCustomerToAccount method, for example, starts by verifying that the customer exists. To create the relationship, the addCustomerToAccount method inserts a row into the customer_account_xref database table. In this cross reference table, each row contains the customerId and accountId of the related entities. To remove a relationship, the removeCustomerFromAccount method deletes a row from the customer_account_xref table. If a client calls the removeAccount method, then all rows for the specified accountId are removed from the customer_account_xref table.

Methods that Get the Account Information.

- getAccountsOfCustomer
- getDetails

The AccountControllerEJB session bean has two getter methods. The getAccountsOfCustomer method returns all of the accounts of a given customer by invoking the findByCustomer method of the AccountEJB entity bean. Instead of implementing a getter method for every instance variable, the AccountControllerEJB has a getDetails method that returns an object (AccountDetails) that encapsulates the entire state of an AccountEJB. Because it can invoke a single method to retrieve the entire state, the client avoids the overhead associated with multiple remote calls.

CustomerControllerEJB

Because it is the AccountControllerEJB that manages the customer-account relationship, the CustomerControllerEJB is the simpler of these two session beans. A client creates a CustomerEJB entity bean by invoking the createCustomer method of the CustomerControllerEJB session bean. To remove a customer, the client calls the removeCustomer method, which not only invokes the remove method of CustomerEJB, but also deletes from the customer_account_xref table all rows that identify the customer.

The CustomerControllerEJB has two methods that return multiple customers: getCustomersOfAccount and getCustomersOfLastName. These methods call the corresponding finder methods—findbyAccountId and findByLastName—of CustomerEJB.

TxControllerEJB

The TxControllerEJB session bean handles bank transactions. In addition to its getter methods, getTxsOfAccount and getDetails, the TxControllerEJB has several methods that change the balances of the bank accounts:

- withdraw
- deposit
- makeCharge
- makePayment
- transferFunds

These methods access an AccountEJB entity bean to verify the account type and to set the new balance. The withdraw and deposit methods are for non-credit accounts, whereas the makeCharge and makePayment methods are for credit accounts. If the type method argument does not match the account, these methods throw an IllegalAccountTypeException. If a withdrawal were to result in a negative balance, then the withdraw method throws and InsufficientFundsException. If a credit charge attempts to exceed the account's credit line, the makeCharge method throws an InsufficientCreditException.

The transferFunds method also checks the account type and new balance; if necessary, it throws the same exceptions as the withdraw and makeCharge methods. The transferFunds method subtracts from the balance of one AccountEJB instance and adds the same amount to another instance. Because both of these steps must complete, the transferFunds method has a Required transaction attribute. If either step fails, the entire operation is rolled back and the balances remain unchanged.

Entity Beans

For each business entity represented in our simple bank, the Duke's Bank application has a matching entity bean:

- `AccountEJB`
- `CustomerEJB`
- `TxEJB`

The purpose of these beans is to provide an object view of these database tables: `account`, `customer`, and `tx`. For each column in a table, the corresponding entity bean has an instance variable. Because they use bean-managed persistence, the entity beans contain the SQL statements that access the tables. For example, the `create` method of the `CustomerEJB` entity bean calls the SQL `insert` command.

Unlike the session beans, the entity beans do not validate method parameters (except for the primary key parameter of `ejbCreate`). During the design phase, we decided that the session beans would check the parameters and throw the application exceptions, such as `CustomerNotInAccountException` and `IllegalAccountTypeException`. Consequently, if some other application were to include these entity beans, its session beans would also have to validate the method parameters.

Helper Classes

The EJB JAR files include several helper classes that are used by the enterprise beans. The source code for these classes is in the `j2eetutorial/bank/src/com/sun/ebank/util` subdirectory. The following table briefly describes the helper classes.

Table 43 Helper Classes for the Application's Enterprise Beans

Class Name	Description
`AccountDetails`	Encapsulates the state of an `AccountEJB` instance. Returned by the `getDetails` methods of `AccountControllerEJB` and `AccountEJB`.

Table 43 Helper Classes for the Application's Enterprise Beans (Continued)

Class Name	Description
`CodedNames`	Defines the strings that are the logical names in the calls of the lookup method. (For example: `java:comp/env/ejb/account`) The `EJB-Getter` class references these strings.
`CustomerDetails`	Encapsulates the state of an `CustomerEJB` instance. Returned by the getDetails methods of `CustomerControllerEJB` and `CustomerEJB`.
`DBHelper`	Provides methods that generate the next primary keys. (For example: `getNextAccountId`).
`Debug`	Has simple methods for printing a debugging message from an enterprise bean. These messages appear on the stdout of the J2EE server if it's run with the `-verbose` option.
`DomainUtil`	Contains validation methods: `getAccountTypes`, `checkAccountType`, `isCreditAccount`.
`EJBGetter`	Has methods that locate (by invoking lookup) and return home interfaces. (For example: `getAccountControllerHome`)
`TxDetails`	Encapsulates the state of an `TxEJB` instance. Returned by the `getDe-tails` methods of `TxControllerEJB` and `TxEJB`.

Database Tables

A database table of the Duke's Bank application may be categorized by its purpose:

- Representing business entities
- Holding the next primary key

Tables Representing Business Entities

Figure 31 shows relationships between the database tables. The `customer` and `account` tables have a many-to-many relationship: A customer may have several bank accounts and each account may be owned by more than one customer. This many-to-many relationship is implemented by the cross reference table named `customer_account_xref`. The `account` and `tx` tables have a one-to-many relationship: A bank account may have many transactions, but each transaction refers to a single account.

Figure 31 makes use of several abbreviations. PK stands for "primary key," the value that uniquely identifies a row in a table. FK is an abbreviation for "foreign key," which is the primary key of the related table. Tx is short for "transaction," such as a deposit or withdrawal.

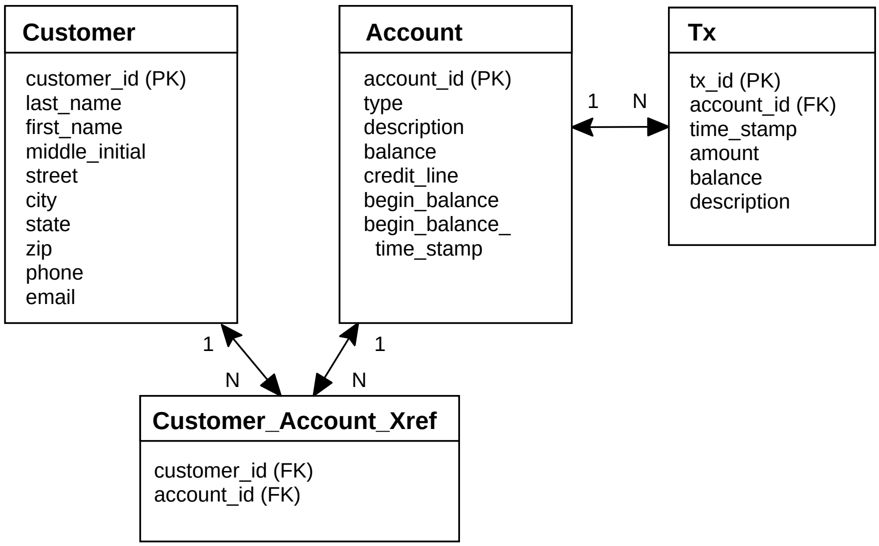


Figure 31 Database Tables in the Duke's Bank Application

Tables that Hold the Next Primary Key

These tables have the following names:

- `next_account_id`
- `next_customer_id`
- `next_tx_id`

Each of these tables has a single column named `id`. The value of the `id` is the next primary key that is passed to the `create` method of an entity bean. For example, before it creates a new `AccountEJB` entity bean, the `AccountControllerEJB` session bean must obtain a unique key by invoking the `getNextAccountId` method of the `DBHelper` class. The `getNextAccountId` method reads the `id` from the `next_account_id` table, increments the `id` value in the table, and then returns the `id`.

Securing the Enterprise Beans

In the J2EE platform, you can protect an enterprise bean by specifying the security roles that can access its methods (see EJB-Tier Security (page 356)). In the Duke's Bank application, two roles are defined—`BankCustomer` and `BankAdmin`—because two categories of operations are defined by the enterprise beans.

A user in the `BankAdmin` role is allowed to perform administrative functions, such as creating or removing an account, adding a customer to or removing a customer from an account, setting a credit line, setting an initial balance, etc. A user in the `BankCustomer` role is allowed to deposit, withdraw, transfer funds, make charges and payments, list transactions that have occurred in the account, etc. Notice that there is no overlap in functions that users in either role can perform.

Access to these functions was restricted to the appropriate role by setting method permissions on selected methods of the `CustomerControllerEJB`, `AccountControllerEJB`, and `TxControllerEJB` enterprise beans. For example, by allowing users in the `BankAdmin` role only to access the createAccount method in the `AccountControllerEJB` enterprise bean, you have denied users in the BankCustomer role or any other role permission to create bank accounts. To see the method permissions that have been set, start the deploytool utility and locate the `CustomerControllerEJB`, `AccountControllerEJB`, and `TxControllerEJB` enterprise beans in the tree view. Then select the Security tabbed pane and examine the method permissions that have been set for each bean's methods.

Application Client

Sometimes, enterprise applications use a standalone client application for handling tasks such as system or application administration. For example, the Duke's Bank application uses an application client to manually administer customers and accounts. This capability is useful in the event the site becomes inaccessible for any reason or a customer prefers to communicate things like changes to account information by phone.

A J2EE application client is a standalone program launched from the command line or desktop, and accesses enterprise beans running on the J2EE application server.

The application client shown in Figure 32 handles basic customer and account administration for the banking application through a Swing user interface.

Figure 32 Application Client

The bank administrator can perform any of the following functions by making menu selections.

Customer administration:

- View customer information
- Add a new customer to the database
- Update customer information
- Find customer ID

Account administration:

- Create a new account
- Add a new customer to an existing account
- View account information
- Remove an account from the database

Error and informational messages appear in the left panel under `Application Message Watch:` and data is entered and displayed in the right panel.

The Classes and their Relationships

The J2EE application client is divided into the following three classes. Their relationship is depicted in Figure 33.

- `BankAdmin` builds the initial user interface, creates the `EventHandle` object, and provides methods for the `EventHandle` and `DataModel` objects to call to update the user interface.
- `EventHandle` listens for button clicks by the user, takes action based on which button the user clicks, creates the `DataModel` object, calls methods in the `DataModel` object to write data to and read data from the underlying database, and calls methods in the `BankAdmin` object to update the user interface when actions complete.
- `DataModel` retrieves data from the user interface, performs data checks, writes valid data to and reads stored data from the underlying database, and calls methods in the `BankAdmin` object to update the user interface based on the success of the database read or write operation.

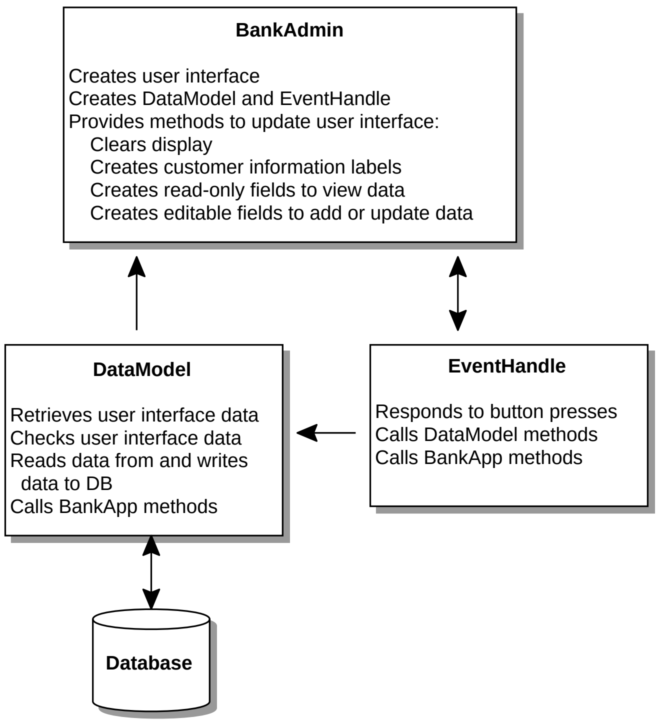


Figure 33 Relationships among Classes

BankAdmin Class

The `BankAdmin` class, which creates the user interface, is the class with the `main` method, and provides `protected` methods for the other `BankAdmin` application classes to call.

Main Method

The `main` method creates instances of the `BankAdmin` and `EventHandle` classes. The application client is internationalized and so the `currentLocale` an variable passed to the `BankAdmin` constructor contains the language and country codes for the Java virtual machine. In the event the Java virtual machine is localized for United States English, the language code is `en`, meaning English and the country code is `US`, meaning United States. In other words, mean the Java virtual machine is localized for United States English as opposed to Australian or United Kingdom English.

The `main` method lets you display the application client in another language. All you have to do is add a properties file to the application with the translations for the language you want to use, update and redeploy the application, and invoke it with the appropriate language and country codes. For example, the application client is distributed with a resource bundle named `AdminMessages_es.properties` that contains Spanish translations. To use this bundle, invoke the application like this:

```
runclient -client BankApp.ear -name BankAdmin es
```

See Running the J2EE Application Client (page 445) above for more information on the `runclient` command, and Internationalization (page 421) for more information on internationalization.

```
public static void main(String args[]) {
   String language, country;
   if(args.length == 1) {
       language = new String(args[0]);
       currentLocale = new Locale(language, "");
   } else if(args.length == 2) {
       language = new String(args[0]);
       country = new String(args[1]);
       currentLocale = new Locale(language, country);
   } else
       currentLocale = Locale.getDefault();
   frame = new BankAdmin(currentLocale);
   frame.setTitle(messages.getString("CustAndAccountAdmin"));
   WindowListener l = new WindowAdapter() {
```

```
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        };
        frame.addWindowListener(l);
        frame.pack();
        frame.setVisible(true);
        ehandle = new EventHandle(frame, messages);
        System.exit(0);
        }
    }
```

Constructor

The `BankAdmin` constructor creates the initial user interface, which consists of a menu bar and two panels. The menu bar contains the customer and account menus, the left panel contains a message area, and the right panel is a data display or update area. The internationalization code creates a `ResourceBundle` from the `currentLocale`.

```
//Constructor
public BankAdmin(Locale currentLocale) {
    //Internationalization setup
    messages = ResourceBundle.getBundle("AdminMessages",
    currentLocale);
```

Internationalization

In an internationalized program, strings are read from a properties file that contains translations for the language in use in the form of key and value pairs. So, instead of creating strings directly in your code, you create a `ResourceBundle` that indicates the file where the translations are, and read the translations (values) from that file using the corresponding key. To give you an idea how the key and value pairs are constructed in the properties file, here are the first few lines from the `MessagesBundle.properties` file for the example.

```
ViewCust=View Customer Information
CreateCust=Create New Customer
UpdateCust=Update Customer Information
```

Instead of creating the View Customer Information menu item in your code like this:

```
view = new JButton("View Customer Information")
```

You do it like this:

```
view = new JButton(messages.getString("ViewCust"))
```

In this example, `ViewCust` is the key in the `AdminMessages.properties` file with a corresponding value of `View Customer Information`. This approach makes it easy to localize application text to the language spoken by the majority of its users.

Class Methods

The `BankAdmin` class provides methods that other objects call when they need to update the user interface. These methods are as follows:

- `clearMessages` clears the application messages that appear in the left panel
- `resetPanelTwo` resets the right panel when the user selects OK to signal the end of a data `view or update operation.`
- `createPanelTwoActLabels` creates labels for account fields when account information is either viewed or updated.
- `createActFields` creates account fields when account information is either viewed or updated.
- `createPanelTwoCustLabels` creates labels for customer fields when customer information is either viewed or updated.
- `createCustFields` creates customer fields when account information is either viewed or updated.
- `addCustToActFields` creates labels and fields for when an add customer to account operation is invoked.
- `makeRadioButtons` makes radio buttons for selecting the account type when a new account is created.
- `getDescription` makes the radio button labels that describe each available account type.

EventHandle Class

The `EventHandle` class implements the `ActionListener` interface, which provides a method interface for handling action events. Like all other interfaces in the Java programming language, `ActionListener` defines a set of methods, but does not implement their behavior. Instead, you provide the implementations because they take application-specific actions.

Constructor

The constructor receives an instance of the `ResourceBundle` and `BankAdmin` classes and assigns them to its private instance variable so the `EventHandle` object has access to the application client's localized text and can update the user interface as needed. Lastly, the constructor calls the `hookupEvents` method to create the inner classes to listen for and handle action events.

```
public EventHandle(BankAdmin frame, ResourceBundle messages) {
    this.frame = frame;
    this.messages = messages;
    this.dataModel = new DataModel(frame, messages);
    //Hook up action events
    hookupEvents();
}
```

actionPerformed Method

The `ActionListener` interface has only one method, the `actionPerformed` method. This method handles action events generated by the `BankAdmin` user interface when users create a new account. Specifically, it sets the account description when a bank administrator selects an account type radio button and sets the current balance to the beginning balance for new accounts when a bank administrator presses the Return key in the beginning balance field.

hookupEvents Method

The `EventHandle` class uses inner classes to handle menu and button press events. An inner class is a class nested or defined inside another class. Using inner classes in this way modularizes the code making it easier to read and maintain. `EventHandle` inner classes manage the following application client operations:

- View Customer Information
- Create New Customer
- Update Customer Information
- Find Customer ID by Last Name
- View Account Information
- Create New Account
- Add Customer to Account
- Remove Account
- Clear data on cancel button press

- Process data on OK button press

DataModel Class

The DataModel class provides methods for reading data from the database, writing data to the database, retrieving data from the user interface, and checking that data before it is written to the database.

Constructor

The constructor receives an instance of the BankAdmin class and assigns it to its private instance variable so the DataModel object can display error messages in the user interface when its checkActData, checkCustData, or writeData method detects errors. It also receives an instance of the ResourceBundle class and assigns it to its private instance variable so the DataModel object has access to the application client's localized text.

Because the DataModel class interacts with the database, the constructor also has the code to establish connections with the remote interfaces for the CustomerController and AccountController enterprise beans, and to use their remote interfaces to create an instance of the CustomerController and AccountController enterprise beans.

```
//Constructor
public DataModel(BankAdmin frame, ResourceBundle messages) {
   this.frame = frame;
   this.messages = messages;
//Look up and create CustomerController bean
    try {
       CustomerControllerHome customerControllerHome =
           EJBGetter.
           getCustomerControllerHome();
       customer = customerControllerHome.create();
    } catch (Exception NamingException) {
       NamingException.printStackTrace();
    }
//Look up and create AccountController bean
    try {
       AccountControllerHome accountControllerHome =
           EJBGetter.getAccountControllerHome();
       account = accountControllerHome.create();
    } catch (Exception NamingException) {
       NamingException.printStackTrace();
    }
}
```

Methods

The getData method retrieves data from the user interface text fields and uses the String.trim method to remove extra control characters such as spaces and returns. Its one parameter is a JTextfield so any instance of the JTextfield class can be passed in for processing.

```
private String getData(JTextField component) {
    String text, trimmed;
    if(component.getText().length() > 0) {
       text = component.getText();
       trimmed = text.trim();
       return trimmed;
    } else {
       text = null;
       return text;
    }
}
```

The checkCustData method stores customer data retrieved by the getData method, but first checks the data to be sure all required fields have data, the middle initial is no longer than one character, and the state is no longer than two characters. If everything checks out, the writeData method is called. If there are errors, they are printed to the user interface in the BankAdmin object. The checkActData method uses a similar model to check and store account data.

The createCustInf and createActInf methods are called by the EventHandle class to refresh the Panel 2 display in the event of a view, update, or add action event.

- Create Customer Information
    - For a view or update event, the createCustInf method gets the customer information for the specified customer from the database and passes it to the createCustFields method in the BankAdmin class. A Boolean variable is used to determine whether the createCustFields method should create read-only fields for a view event or writable fields for an update event.
    - For create event, the createCustInf method calls the createCustFields method in the BankAdmin class with null data and a Boolean

variable to create empty editable fields for the user to enter customer data.

- Create Account Information
    - For a view or update event, the `createActInf` method gets the account information for the specified account from the database and passes it to the `createActFields` method in the `BankAdmin` class. A Boolean variable is used to determine whether the `createActFields` method should create read-only fields for a view event or writable fields for an update event.
    - For a create event, the `createActInf` method calls the `createActFields` method in the `BankAdmin` class with null data and a Boolean variable to create empty editable fields for the user to enter customer data.
    - Adding a customer to an account or removing an account events operate directly on the database without creating any user interface components.

Web Client

The web client is used by customers to access account information and perform operations on accounts. Table 44 lists the functions the client supports, the URLs used to access the functions, and the components that implement the functions.

Table 44 Web Client

Function	URL Aliases	JSP Pages	JavaBeans Component
Home page	`/main`	`main.jsp`	

Log on/off the application	`/logon`
	`/logonError`
	`/logoff`
		`logon.jsp`
		`logonError.jsp`
		`logoff.jsp`	

List account	`/accountList`	`accountList.jsp`	
List the history of an account	`/accountHist`	`accountHist.jsp`	`AccountHistoryBean`

Transfer funds between accounts	`/transferFunds`
	`/transferAck`
	`/transferError`
		`transferFunds.jsp`
		`transferAck.jsp`
		`transferError.jsp`
			`TransferBean`

Table 44 Web Client (Continued)

Function	URL Aliases	JSP Pages	JavaBeans Component
Withdraw and deposit funds	`/atm` `/atmAck`	`atm.jsp` `atmAck.jsp`	`ATMBean`

Figure 34 shows an example account history screen.

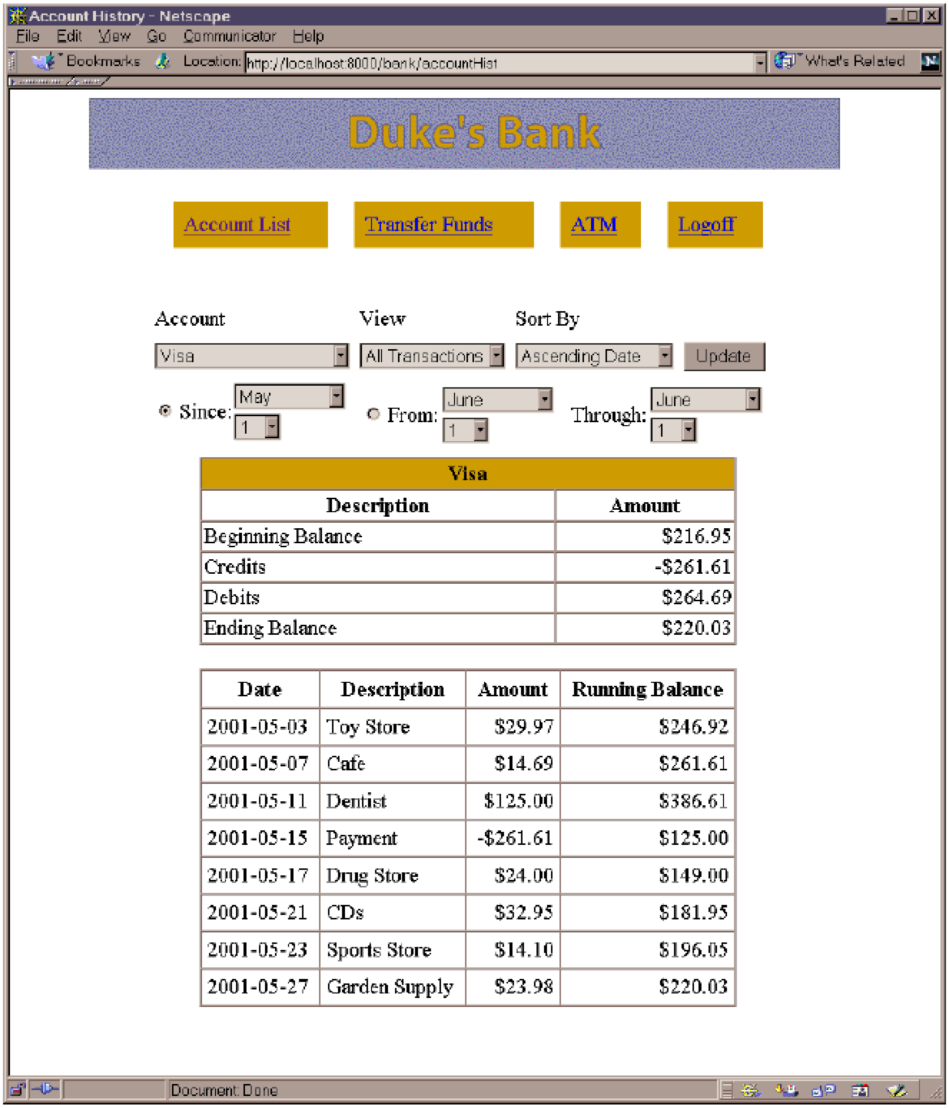


Figure 34 Account History

Design Strategies

The main job of the JSP pages in the Duke's Bank application is presentation. A strategy for developing maintainable JSP pages is to minimize the amount of scripting embedded in the pages. In order to achieve this, most dynamic processing tasks are delegated to enterprise beans, custom tags, and JavaBeans components.

In the Duke's Bank application, the JSP pages use enterprise beans to handle interactions with the database. In addition, the JSP pages rely heavily on JavaBeans components for interactions with the enterprise beans. In the Duke's Bookstore application presented in the chapters on web components, the `BookDB` JavaBeans component acted as a front end to a database or a facade to the interface provided by an enterprise bean. In the Duke's Bank application, `TransferBean` plays the same role. However, the other JavaBeans components have much richer functionality. `ATMBean` invokes enterprise bean methods and sets acknowledgement strings according to customer input and `AccountHistoryBean` massages the data returned from the enterprise beans in order to present the view of the data required by the customer.

The web client uses a template mechanism implemented by custom tags (discussed in A Template Tag Library (page 324)) to maintain a common look across all the JSP pages. The template mechanism consists of three components:

- `template.jsp` determines the structure of each screen. It uses the `insert` tag to compose a screen from subcomponents.
- `screendefinitions.jsp` defines the subcomponents used by each screen. All screens have the same banner, but different title and body content (specified by the JSP Pages column in Table 44).
- `Dispatcher`, a servlet, processes requests and forwards to `template.jsp`.

Finally, the web client uses three logic tags—`iterate`, `equal`, and `notEqual`—from the Struts tag library discussed in The Example JSP Pages (page 296) to perform flow control.

Web Client Life Cycle

Initializing the Client Components

Responsibility for managing the enterprise beans used by the web client rests with the `BeanManager` class. It creates customer, account, and transaction controller enterprise beans and provides methods for retrieving the beans.

When instantiated, `BeanManager` retrieves the home interface for each bean from the helper class `EJBGetter` and creates an instance by calling the `create` method of the home interface. Because this is an application-level function, `BeanManager` itself is created and stored as an context attribute by a `ContextListener` (see Handling Servlet Life Cycle Events (page 232)) when the client is first initialized.

```
public class BeanManager {
   private CustomerController custctl;
   private AccountController acctctl;
   private TxController txctl;
   public BeanManager() {
       if (custctl == null) {
           try {
               CustomerControllerHome home =
                   EJBGetter.getCustomerControllerHome();
               custctl = home.create();
           } catch (RemoteException ex) {
               System.out.println("...");
           } catch (CreateException ex) {
               System.out.println();
           } catch (NamingException ex) {
               System.out.println();
       }
   }
   public CustomerController getCustomerController() {
       return custctl;
   }
   ...
}

public final class ContextListener
   implements ServletContextListener {
   private ServletContext context = null;
   ...
   public void contextInitialized(ServletContextEvent event) {
       this.context = event.getServletContext();
       context.setAttribute("beanManager", new
BeanManager());
       context.log("contextInitialized()");
   }
   ...
}
```

Request Processing

All requests for the URLs listed in Table 44 are mapped to the `dispatcher` web component, which is implemented by the `Dispatcher` servlet. When a request is delivered to `Dispatcher` it:

1. Retrieves and saves the incoming request URL in the request attribute `selectedScreen`. This is because the URL will be modified when the request is later forwarded to the application's template page.
2. Creates a JavaBeans component and store the bean as a request attribute.
3. Parses and validate the request parameters. If a parameter is invalid, `Dispatcher` may reset the request alias to an error page. Otherwise it initializes the JavaBeans component.
4. Calls the `populate` method of the JavaBeans component. This method retrieves data from the enterprise beans and processes the data according to options specified by the customer.
5. Forwards the request to `template.jsp`.

```
public class Dispatcher extends HttpServlet {
   public void doPost(HttpServletRequest request,
       HttpServletResponse response) {
   ...
   String selectedScreen = request.getServletPath();

   request.setAttribute("selectedScreen", selectedScreen);
   BeanManager beanManager = getServletContext().getAttribute(
       "beanManager");
   ...
   if (selectedScreen.equals("/accountHist")) {
       ...
   } else if (selectedScreen.equals("/transferAck")) {
       String fromAccountId =
           request.getParameter("fromAccountId");
       String toAccountId =
           request.getParameter("toAccountId");
       if ( (fromAccountId == null) || (toAccountId == null) ){
           request.setAttribute(
               "selectedScreen", "/transferError");
       } else {
           TransferBean transferBean = new TransferBean();
           request.setAttribute("transferBean",
               transferBean);
           transferBean.setFromAccountId(fromAccountId);
           transferBean.setToAccountId(toAccountId);
           try {
```

```
                    transferBean.
                        setTransferAmount((Double.valueOf(
                    request.getParameter("transferAmount"))).
                        doubleValue());
                } catch (NumberFormatException e) {
                }
                transferBean.setBeanManager(beanManager);
                transferBean.populate();
            }
            ...
            try {
            request.getRequestDispatcher("/template.jsp").
                forward(request, response);
            } catch(Exception e) {
            }
        }
    }
```

As mentioned earlier, `template.jsp` generates the response by including the responses from subcomponents. If the request is a GET, the body subcomponent usually retrieves data from the enterprise bean directly; otherwise it retrieves data from the JavaBeans component initialized by `Dispatcher`.

Figure 35 summarizes the interaction between these components:

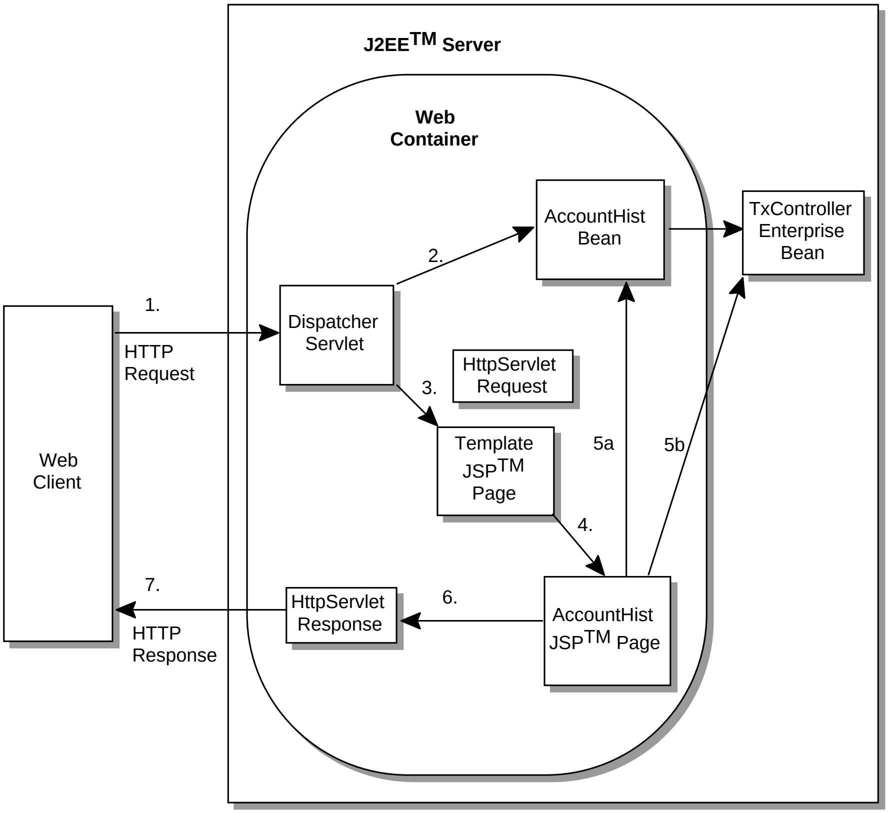


Figure 35 Web Component Interaction

Securing the Web Client

In the J2EE platform, a web component is protected from anonymous access by specifying which security roles can access the component (see Controlling Access to Web Resources (page 353)). This is known as an authorization constraint. The web container guarantees that only certain users can access the component. In order for the web container to enforce the authorization constraint, the application must also specify a means for users to identify themselves (described in Authenticating Users (page 353)) and the web container must support mapping a role to a user.

In the Duke's Bank web client, all of the URLs listed in Table 44 are restricted to the security role `BankCustomer`. The application requires users to identify themselves via the form-based login mechanism. When a customer tries to access a web client URL, and has not been authenticated, the web container displays the form-based login URL `/logon`, which is mapped to the JSP page `logon.jsp`. This page contains a form that requires a customer to enter an identifier and password. The web container retrieves this information, maps it to a security role, and verifies that the role matches that specified in the authorization constraint. Note that in order for the web container to check the validity of the authentication information, and perform the mapping, you must perform these two steps when you deploy the application:

- Add the customer's group, ID, and password to the default realm of the container (see J2EE Users, Realms, and Groups (page 363)).
- Map the `BankCustomer` role to the customer *or* customer's group (see Mapping Roles to J2EE Users and Groups (page 356)).

Once the customer has been authenticated, the identifier provided by the customer is used as a key to identify the customer's accounts. The identifier is retrieved from the request as follows:

```
<% ArrayList accounts =
beanManager.getAccountController().getAccountsOfCustomer(
   request.getUserPrincipal().getName()); %>
```

Internationalization

Like the application client, the web client uses resource bundles to map display keys to locale-specific strings. `Dispatcher` retrieves the locale (set by a browser language preference) from the request and then opens the appropriate resource bundle:

```
ResourceBundle messages = (ResourceBundle)session.
   getAttribute("messages");
   if (messages == null) {
        Locale locale=request.getLocale();
        messages = ResourceBundle.getBundle("WebMessages",
             locale);
        session.setAttribute("messages", messages);
   }
```

Each JSP page first retrieves the resource bundle from the session:

```
<% ResourceBundle messages =
(ResourceBundle)session.getAttribute("messages"); %>
```

and then looks up any string that it needs in the bundle. For example, here is how `accountHist.jsp` generates the headings for the transactions table:

```
<td><b><%=messages.getString("TxDate")%></b></td>
<td><b><%=messages.getString("TxDescription")%></b></td>
<td><b><%=messages.getString("TxAmount")%></b></td>
<td><b><%=messages.getString("TxRunningBalance")%></b></td>
```

Building, Deploying, and Running the Application

To build the Duke's Bank application, you must have downloaded and unzipped the tutorial bundle as described in Downloading the Examples (page xxii). When you install the bundle, the Duke's Bank application files are placed in the following directory structure of the `j2eetutorial` directory:

```
/bank
   /dd - deployment descriptors
       account-ejb.xml
       app-client.xml
       customer-ejb.xml
       runtime-ac.xml
       runtime-app.xml
       tx-ejb.xml
       web.xml
   /src
       /com - component classes
           /sun/ebank/appclient
           /sun/ebank/ejb
           /sun/ebank/web
       /web - JSP pages, images
   /sql - database scripts
       db-create-table.sql
       db-insert.sql
```

To simplify the packaging and deployment of the Duke's Bank application, the tutorial bundle includes deployment descriptors, source code, and a `build.xml` file that contains the automated `ant` tasks. If you haven't run `ant` yet, please see How to Build and Run the Examples (page xxiii).

After you compile the source code, the resulting class files will reside in the `j2eetutorial/bank/build` subdirectory. When you package the components and the application, the resulting archive files are placed in the `j2eetutorial/bank/jar` subdirectory.

Adding Groups and Users to the Realm

In order to run the application and web clients you must add groups and users to the default security realm. To create the `Customer` and `Admin` groups, add the user `200` to the `Customer` group, and add the user `admin` to the `Admin` group in `deploytool`:

1. Select Tools->Server Configuration
2. In the tree, select the Users node.
3. Make sure that Default is selected in the Realm combo box.
4. Click Add User.
5. Click Edit Groups.
6. Click Add.
7. Enter `Customer`.
8. Click Add.
9. Enter `Admin`.
10. Click OK.
11. Enter `200` for User Name: and `j2ee` for Password:
12. Select the `Customer` group from the Available Groups list.
13. Click Add.
14. Click Apply.
15. Enter `admin` for User Name and `j2ee` for Password.
16. Select the Admin Group from the Available Groups list.
17. Click Add.
18. Click OK.

You can also use the `realmtool` command line utility:

1. `realmtool -addGroup Customer`
2. `realmtool -add 200 j2ee Customer`
3. `realmtool -addGroup Admin`
4. `realmtool -add admin j2ee Admin`

Starting the J2EE Server, Deploy Tool, and Database

J2EE Server

1. If the J2EE server is running, stop it:

```
j2ee -stop
```

2. Restart the server:

```
j2ee -verbose
```

Deploytool

After the J2EE server reports "startup complete," run the `deploytool`:

1. If the `deploytool` is already running, reconnect to the J2EE server:
   a. File->Add Server
   b. In the Add Server dialog box, enter `localhost` in the Server Name field.
   c. Click OK.
2. If the `deploytool` is not running, launch it from the command line:

```
deploytool
```

Cloudscape

Start the Cloudscape database server:

```
cloudscape -start
```

Compiling the Enterprise Beans

In a different window, go to the `j2eetutorial/bank` subdirectory of the tutorial distribution and execute

```
ant compile-ejb
```

Packaging the Enterprise Beans

To package the enterprise beans execute

```
ant package-ejb
```

This command packages the class files and the deployment descriptors into these EJB JAR files:

```
account-ejb.jar
customer-ejb.jar
tx-ejb.jar
```

The JAR files are in the `j2eetutorial/bank/jar` subdirectory.

Compiling the Web Client

To compile the web client, go to the `j2eetutorial/bank` directory of the tutorial distribution and execute

```
ant compile-web
```

Packaging the Web Client

The web client uses the Struts tag library discussed in The Example JSP Pages (page 296). Before you can package the web client you must download and install Struts version 1.0 from

```
http://jakarta.apache.org/builds/jakarta-struts/release/v1.0/
```

Copy `struts-logic.tld` and `struts.jar` from `jakarta-struts-1.0/lib` to `j2eetutorial/bank/jar`. Then change to the `j2eetutorial/bank` directory and execute

```
ant package-web
```

This command packages the servlet class, JSP pages, JavaBeans component classes, tag libraries and the web application deployment descriptor into `web-client.war` and puts this file in `j2eetutorial/bank/jar`.

Compiling the J2EE Application Client

To compile the application client, go to the `j2eetutorial/bank` subdirectory and execute

```
ant compile-ac
```

Packaging the J2EE Application Client

From the `j2eetutorial/bank` directory, execute these commands:

1. `ant package-ac`. This command creates `app-client.jar` in `j2eetutorial/bank/jar`.
2. `ant setruntime-ac`. This command adds a runtime deployment descriptor (`j2eetutorial/bank/dd/runtime-ac.xml`) to `app-client.jar`.

Packaging the EAR

You create the Duke's Bank enterprise archive file by going to the `j2eetutorial/bank` directory and running the following commands:

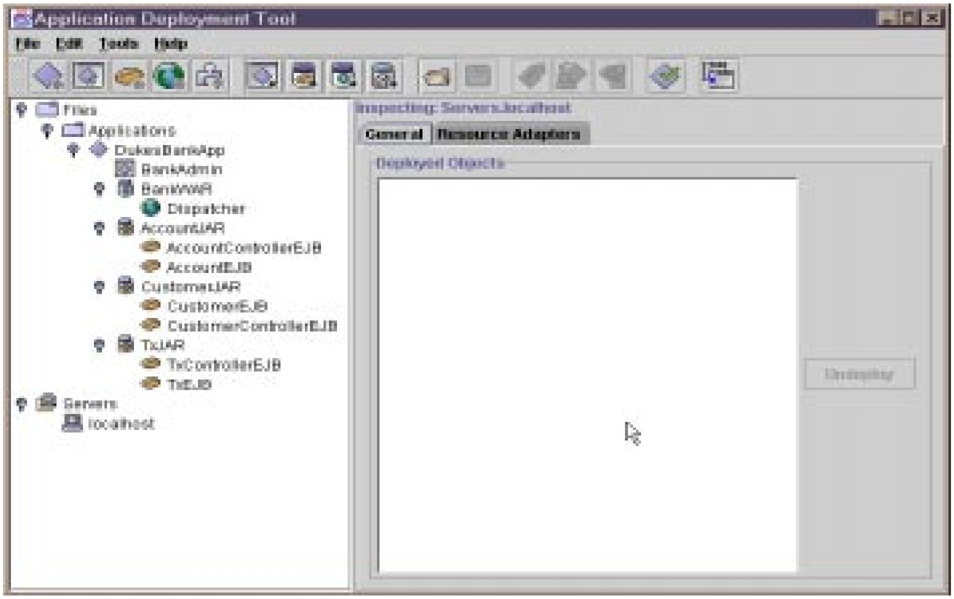
1. `ant assemble-app`. This command creates `DukesBankApp.ear` in `j2eetutorial/bank/jar`.
2. `ant setruntime-app`. This command adds a runtime deployment descriptor (`j2eetutorial/bank/dd/runtime-app.xml`) to `DukesBankApp.ear`.

Opening the EAR

In `deploytool`, open the EAR as follows:

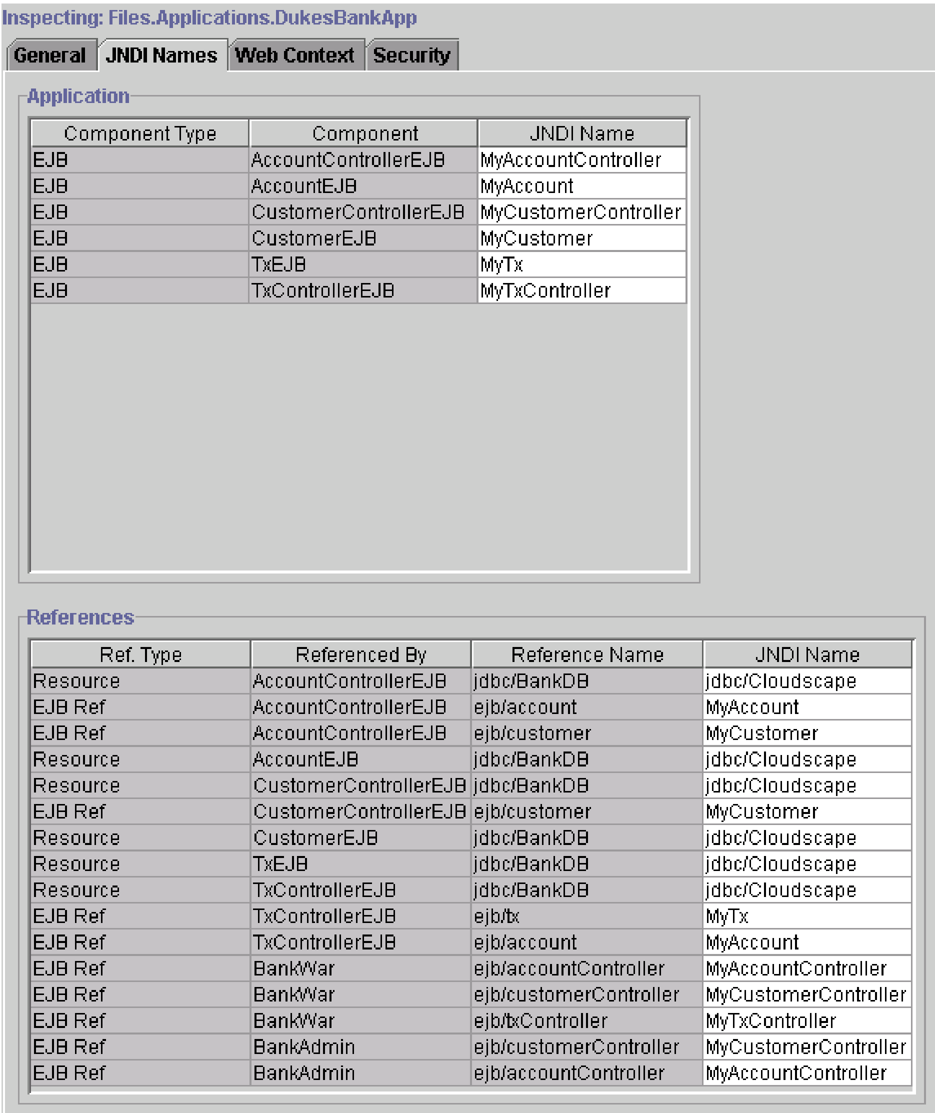
1. Select File ->Open.
2. Go to the `j2eetutorial/bank/jar` subdirectory.
3. Select `DukesBankApp.ear`.
4. Click Open Object.

You should see the following in deploytool:



Reviewing JNDI Names

With `DukesBankApp` selected, click the JNDI Names tab. The JNDI Name column is shown in Figure 36. The order may be a little different on your own display. An explanation of these mappings immediately follows.



Component Type	Component	JNDI Name
EJB	AccountControllerEJB	MyAccountController
EJB	AccountEJB	MyAccount
EJB	CustomerControllerEJB	MyCustomerController
EJB	CustomerEJB	MyCustomer
EJB	TxEJB	MyTx
EJB	TxControllerEJB	MyTxController

Ref. Type	Referenced By	Reference Name	JNDI Name
Resource	AccountControllerEJB	jdbc/BankDB	jdbc/Cloudscape
EJB Ref	AccountControllerEJB	ejb/account	MyAccount
EJB Ref	AccountControllerEJB	ejb/customer	MyCustomer
Resource	AccountEJB	jdbc/BankDB	jdbc/Cloudscape
Resource	CustomerControllerEJB	jdbc/BankDB	jdbc/Cloudscape
EJB Ref	CustomerControllerEJB	ejb/customer	MyCustomer
Resource	CustomerEJB	jdbc/BankDB	jdbc/Cloudscape
Resource	TxEJB	jdbc/BankDB	jdbc/Cloudscape
Resource	TxControllerEJB	jdbc/BankDB	jdbc/Cloudscape
EJB Ref	TxControllerEJB	ejb/tx	MyTx
EJB Ref	TxControllerEJB	ejb/account	MyAccount
EJB Ref	BankWar	ejb/accountController	MyAccountController
EJB Ref	BankWar	ejb/customerController	MyCustomerController
EJB Ref	BankWar	ejb/txController	MyTxController
EJB Ref	BankAdmin	ejb/customerController	MyCustomerController
EJB Ref	BankAdmin	ejb/accountController	MyAccountController

Figure 36 JNDI Names

A JNDI name is the name the J2EE server uses to look up enterprise beans and resources. When you look up an enterprise bean, you supply statements similar to those shown below. The actual lookup takes place three lines down where the getCustomerControllerHome method of com.sun.ebank.utilEJBGetter is called. EJBGetter is a utility class that retrieves a coded JNDI name from com.sun.ebank.util.CodedNames.

In this example, the application client is looking up the coded name for the CustomerController remote interface:

```
try {
   customerControllerHome =
       EJBGetter.getCustomerControllerHome();
   customer = customerControllerHome.create();
} catch (Exception NamingException) {
   NamingException.printStackTrace();
}

public static CustomerHome getCustomerHome() throws
NamingException {
   InitialContext initial = new InitialContext();
   Object objref = initial.lookup(
       CodedNames.CUSTOMER_EJBHOME);
```

BankAdmin (the display name for the main class for the application client) references ejb/customerController, which is the coded name defined in CodedNames for the CustomerController remote interface.

The JNDI name is stored in the J2EE application deployment descriptor and the J2EE server uses it to look up the CustomerControllerEJB. In Figure 36 you see that CustomerControllerEJB is mapped to the same JNDI name as is ejb/customerController. It does not matter what the JNDI name is, as long as it is the same name for the remote interface lookup as you use for its corresponding bean. So, looking at the table, you can say that the application client (BankAdmin) looks up the CustomerController remote interface, which uses the JNDI name of MyCustomerController, and the J2EE server uses the MyCustomerController JNDI name to find the corresponding CustomerControllerEJB object.

The other rows in the table have the mappings for the other enterprise beans. All of these beans are stored in the JAR files you added to the J2EE application during assembly. Their implementations have coded names for looking up either other enterprise beans or the database driver.

The JNDI name for the database driver is `jdbc/Cloudscape`. This name is the default coded name supplied in a configuration file of your J2EE SDK installation. For more information, see the *Configuration Guide* of the J2EE SDK.

Mapping the Security Roles to Groups

To map the `BankAdmin` role to the `Admin` group and the `BankCustomer` role to the `Customer` group:

1. In `deploytool`, select DukesBankApp.
2. In the Security tabbed pane, select the `BankAdmin` role from the Role Name list.
3. Click Add.
4. In the Users dialog box, select the `Admin` group in the Group Name list.
5. Click OK.
6. In the Security tabbed pane, select the `BankCustomer` role from the Role Name list.
7. Click Add.
8. In the Users dialog box, select the `Customer` group in the Group Name list.
9. Click OK.
10. From the main menu, select File->Save.

Figure 37 shows the `BankCustomer` role selected and the `Customer` group to which it is mapped.

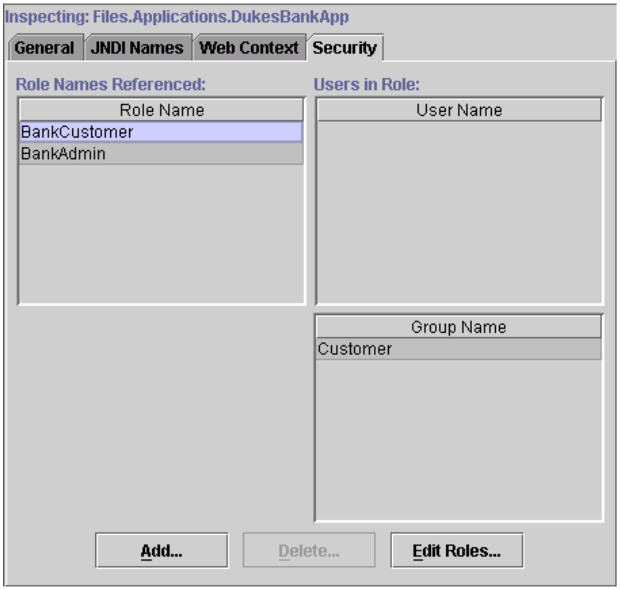


Figure 37 BankCustomer Role Mapped to Customer Group

Deploying the J2EE Application

To deploy the application:

1. Select the DukesBankApp application.
2. Select Tools->Deploy.
3. Select the checkbox labeled Return Client Jar. By default, the directory for the returned jar file is the that same as where the EAR file is stored. The default name of the client JAR file is the application name with `Client.jar` appended: `DukesBankAppClient.jar`.
4. Click Finish.

Creating the Bank Database

You have to create and enter data into the appropriate tables so that the enterprise beans have something to read from and write to the database. To create and populate the database tables, in a terminal window go to the `j2eetutorial/bank` directory and type the following commands:

1. `ant db-create-table`

2. `ant db-insert`

Running the J2EE Application Client

To launch and test the application client:

1. In a terminal window, go to `j2eetutorial/bank/jar`.
2. Set the `APPCPATH` environment variable to `DukesBankAppClient.jar`.
3. To run the English version of the client, execute the following command:

```
runclient -client DukesBankApp.ear -name BankAdmin
```

4. To run the Spanish version, include the `es` language code:

```
runclient -client DukesBankApp.ear -name BankAdmin es
```

The `DukesBankApp.ear` parameter is the name of the J2EE application EAR file, and the `BankAdmin` parameter is the display name of the application client.

5. At the login prompts, type in `admin` for the user name and `j2ee` for the password. The next thing you should see is the application shown in Figure 38.

Figure 38 BankAdmin J2EE Application Client

Running the Web Client

To run the web client:

1. Open the bank URL `http://<host>:8000/bank/main` in a web browser. If your J2EE server is running on the same host as your web browser, replace <*host*> with `localhost`. To see the Spanish version of the application, set your browser language preference to any Spanish dialect.
2. The application will display the login page. Enter `200` for the customer ID and `j2ee` for the password. Click Submit.
3. Select an application function: Account List, Transfer Funds, ATM, or Logoff. Once you have a list of accounts, you can get an account history by selecting an account link.

Note: The first time you select a new page, particularly a complicated page like an account history, it takes some time to display because the J2EE server must translate the page into a servlet class and compile and load the class.

If you select Account List, you will see the screen shown in Figure 39.

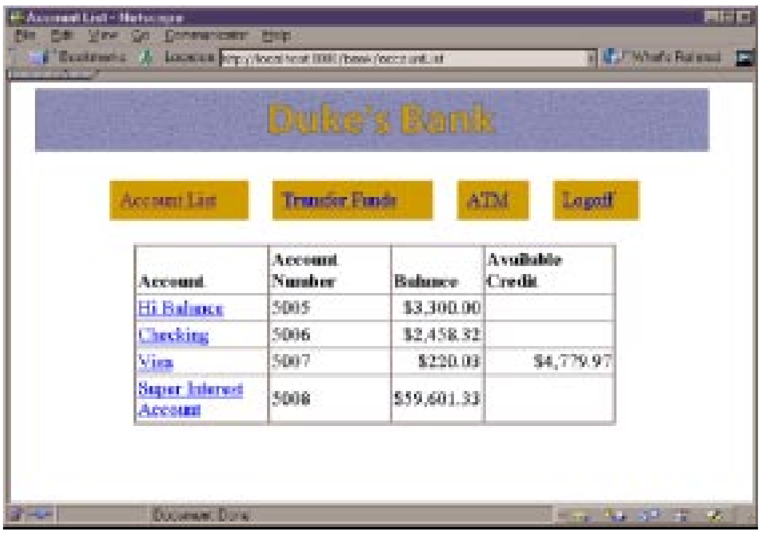


Figure 39 Account List

HTTP Overview

by Stephanie Bodoff

Most web-based J2EE clients use the HTTP protocol to communicate with a J2EE server. HTTP defines the requests that a client can send to a server and responses that the server can send in reply. Each request contains a URL, which is a string that identifies a web component or a static object such as an HTML page or image file.

The J2EE server converts an HTTP request to an HTTP request object and delivers it to the web component identified by the request URL. The web component fills in an HTTP response object, which the server converts to an HTTP response and sends to the client.

This appendix provides some introductory material on the HTTP protocol. For further information on this protocol, see the Internet RFCs: HTTP/1.0 - RFC 1945, HTTP/1.1 - RFC 2616, which can be downloaded from

```
http://www.rfc-editor.org/rfc.html
```

HTTP Requests

An HTTP request consists of a request method, a request URL, header fields, and a body. HTTP 1.1 defines the following request methods:

- GET - retrieves the resource identified by the request URL.
- HEAD - returns the headers identified by the request URL.
- POST - sends data of unlimited length to the web server.
- PUT - stores a resource under the request URL.
- DELETE - removes the resource identified by the request URL.

- OPTIONS - returns the HTTP methods the server supports.
- TRACE - returns the header fields sent with the TRACE request.

HTTP 1.0 includes only the GET, HEAD, and POST methods. Although J2EE servers are only required to support HTTP 1.0, in practice many servers, including the J2EE SDK, support HTTP 1.1.

HTTP Responses

An HTTP response contains a result code, header fields, and a body.

The HTTP protocol expects the result code and all header fields to be returned before any body content.

Some commonly used status codes include:

- 404 - indicates that the requested resource is not available.
- 401 - indicates that the request requires HTTP authentication.
- 500 - indicates an error inside the HTTP server which prevented it from fulfilling the request.
- 503 - indicates that the HTTP server is temporarily overloaded, and unable to handle the request.

J2EE™ SDK Tools

THE J2EE™ SDK includes the following tools:

J2EE Administration Tool

The j2eeadmin tool is a command-line script that enables you to add and remove these resources: JDBC™ drivers and data sources, JMS destinations and connection factories, and resource adapter connection factories.

Table 45 j2eeadmintool Options

Option	Description
-addConnectorFactory <jndi-name> [<app-name>:] <rar-filename> [<xa-user-name> <xa-password>] [-props (<name>=<value>)+]	Adds a connection factory with the specified <jndi-name>. The connection factory is contained in the RAR file specified by <rar-filename>. The <rar-filename> must be the base name of the file; it cannot include any prefix ending in / (Unix) or \ (Windows). If the RAR file is contained in an EAR file, then the name of the J2EE application name must be specified by <app-name>, followed by a colon. Optionally, a user name and password for the factory may be specified. Also optional is the -props flag, followed by one or more name-value pairs that specify properties for this factory. To prevent the shell from interpreting characters in the values, enclose the values in single or double quotes.
-addJdbcDriver <class-name>	Adds the JDBC driver specified by its fully-qualified <class-name>. You must also update the J2EE_CLASSPATH environment variable in the file bin\userconfig.bat. Then you must restart the J2EE server.
-addJdbcDatasource <jndi-name> <url>	Adds the JDBC DataSource with the specified <jndi-name> and <url>.
-addJdbcXADatasource <jndi-name> <class-name> [<xa-user-name> <xa-password>] [-props (<name>=<value>)+]	Adds the JDBC XADataSource with the specified <jndi-name> and fully-qualified <class-name>. Optionally, a user name and password for the DataSource may be specified. Also optional is the -props flag, followed by one or more name-value pairs that specify properties for this DataSource.
-addJmsDestination <jndi-name> (queue|topic)	Adds a JMS destination with the specified <jndi-name> and declares the destination as either a queue or topic.

Table 45 `j2eeadmintool` Options (Continued)

Option	Description
`-addJmsFactory <jndi-name> (queue|topic) [-props (<name>=<value>)+]`	Adds a JMS connection factory with the specified `<jndi-name>` and destination type, either queue or topic. Optionally, one or more properties may be specified with name-value pairs.
`-list<resource-type>`	Lists resources of the specified `<resource-type>`, either: `ConnectorFactory`, `JdbcDriver`, `JdbcDatasource`, `JdbcXADatasource`, `JmsDestination`, or `JmsFactory`. There is no space between `-list` and `<resource-type>`.
`-remove<resource-type> <jndi-name>`	Removes the resource of the specified `<resource-type>` and `<jndi-name>`. (See the description of `-list` for the allowed `<resource-type>` elements.)
`-removeAll<resource-type>`	Removes all resources of the specified `<resource-type>`. (See the description of `-list` for the allowed `<resource-type>` elements.)

Cleanup Tool

The `cleanup` tool is a command-line script that removes all deployed applications from your J2EE server. It will not delete the component files (JAR, WAR, EAR).

Note: Use this utility with care!

Cloudscape Server

The enterprise code examples in this manual have been tested with the Cloudscape DBMS, which is included in the J2EE SDK.

Starting Cloudscape

Before your enterprise beans can access a Cloudscape database, you must run the Cloudscape server from the command line:

```
cloudscape -start
```

You should see output similar to the following:

```
Mon Aug 09 11:50:30 PDT 1999: [RmiJdbc]
COM.cloudscape.core.JDBCDriver registered in DriverManager
Mon Aug 09 11:50:30 PDT 1999: [RmiJdbc] Binding . . ..
Mon Aug 09 11:50:30 PDT 1999: [RmiJdbc] No installation of
RMI Security Manager...
Mon Aug 09 11:50:31 PDT 1999: [RmiJdbc] RmiJdbcServer
bound in rmi registry
```

Stopping Cloudscape

To stop the server type the following command:

```
cloudscape -stop
```

You should see output similar to the following:

```
Attempting to shutdown RmiJdbc server
RmiJdbc Server RmiAddr is: //buzz/RmiJdbcServer
WARNING: Shutdown was successful!
```

Note: If you stop the server with Control-c, files will not be closed properly. When the server is started the next time, it must perform recovery by rolling back non-committed transactions and possibly applying the forward log.

Running the Interactive SQL Tool

The Cloudscape product includes a text-based, interactive tool called `ij`. (This tool is not supported by Sun Microsystems, Inc.) You can run the `ij` tool by typing this command:

```
cloudscape -isql
```

Within the tool, each command you type must end in a semicolon. The commands in the next example display all rows from the `orders` table, execute a SQL script named `myscript.sql`, and end the tool session:

```
ij> select * from orders;
ij> run ‘myscript.sql’;
ij> exit;
```

The following example runs a SQL script from the command line:

```
cloudscape -isql < myscript.sql
```

This command lists the names of all user tables in the database:

```
ij> select tablename from sys.systables
    where tabletype = ‘T’;
```

The next example displays the column names of the orders table:

```
ij> select columnname from sys.syscolumns
    where referenceid =
           (select tableid from sys.systables
            where tablename = ’orders’);
```

Before you deploy an entity bean with container-managed persistence, you use the `deploytool` to generate the bean’s SQL statements. Because the table names in these SQL statements are case-sensitive, you must enclose them in double quotes:

```
ij> select * from “TeamBeanTable”;
```

For more information on the `ij` tool, please refer to the online documentation on the Cloudscape web site:

```
http://www.cloudscape.com
```

Cloudscape Server Configuration

The default database used by the Cloudscape server is named `CloudscapeDB`. This database will reside in the `cloudscape` directory of your J2EE SDK installation. The `CloudscapeDB` database will be created automatically the first time it is accessed. The driver for the Cloudscape server is already configured in the `config/default.properties` file. No further changes by you are necessary.

Deployment Tool

The `deploytool` utility has two versions: GUI and command-line.

The GUI version enables you to package components and to deploy applications. If you run the `deploytool` script with no options, the GUI version is launched.

The GUI version includes online help information that is context sensitive. To access a help topic for a particular dialog box or tabbed pane, press f1.

The command-line version of the tool enables you to deploy and undeploy applications. To package components from the command line, use the `packager` tool.

Table 46 `deploytool` Options

Option	Description
`-deploy <ear-filename> <server-name> [<client-stub-jar>]`	Deploys the J2EE application contained in the EAR file specified by `<ear-filenamme>` onto the J2EE server running on the machine specified by `<server-name>`. Optionally, a JAR file for a stand-alone Java application client may be created by specifying `<client-stub-jar>`.
`-deployConnector <rar-filename> <server-name>`	Deploys the resource adapter contained in the RAR file specified by `<rar-filename>` onto the J2EE server running on the machine specified by `<server-name>`.
`-listApps <server-name>`	Lists the J2EE applications that are deployed on the J2EE server running on the machine specified by `<server-name>`.
`-listConnectors <server-name>`	Lists the resource adapters that are deployed on the J2EE server running on the machine specified by `<server-name>`.
`-undeployConnector <rar-filename> <server-name>`	Undeploys the resource adapter contained in the file specified by `<rar-filename>` from the J2EE server running on the machine specified by `<server-name>`.
`-uninstall <app-name> <server-name>`	Undeploys the J2EE application whose name is `<app-name>` from the J2EE server running on the machine specified by `<server-name>`.
`-help`	Displays options.
`-ui`	Runs GUI version (default).

J2EE Server

To launch the J2EE server, run the `j2ee` script from the command-line prompt.

Table 47 `j2ee` Options

Option	Description
`-verbose`	Redirects all logging output to the current shell.
`-version`	Displays the version number.
`-stop`	Stops the J2EE server.

To run the HTTPS service of the J2EE server, you must install a server certificate. For instructions, see the Security chapter.

Key Tool

The `keytool` utility creates public and private keys and generates X509 self-signed certificates. The J2EE SDK version of the `keytool` utility has the same options as the version distributed with the J2SE SDK. However, the J2EE version programmatically adds a Java Cryptographic Extension provider that has implementations of RSA algorithms (licensed from RSA Data Security). For more information, see the Security chapter.

Packager

The `packager` tool is a command-line script that enables you to package J2EE components. This tool is for advanced users who do not want to use the `deploytool` to package J2EE components. With the `packager`, you can create the following component packages:

- EJB JAR file
- Web Application WAR file
- Application Client JAR file
- J2EE Application EAR file

- Resource Adapter RAR file

The `packager` tool also enables you to set the runtime deployment information of an application EAR file.

Note: To make them easier to read, the examples that follow contain line breaks within the commands. When typing these commands, do not include the line breaks.

EJB JAR File

Syntax

```
packager -ejbJar <root-directory> <file-list>
<ejb-dd> <ejb-jar>
```

Example

The following command packages the three `Hello` classes, and the `hello-jar.xml` deployment descriptor into the `HelloEJB.jar` file:

```
packager -ejbJar /home/duke/classes/
HelloHome.class:HelloEJB.class:HelloRemote.class
hello-jar.xml HelloEJB.jar
```

Web Application WAR File

Syntax

```
packager -webArchive
[-classpath <root-directory> [-classFiles <file-list>]]
<content-root> [-contentFiles <file-list>] <web-dd> <web-war>
```

Example

The following command packages helper classes and JSP™ pages into the `bookstore2.war` file:

```
packager -webArchive -classpath .
-classFiles
   cart\ShoppingCart.class:cart\ShoppingCartItem.class:
   database\BookDB.class:util\Currency.class
.
-contentFiles
```

```
    banner.jsp:bookdetails.jsp:bookstore.jsp:cashier.jsp:
    catalog.jsp:DigitalClock.class:duke.books.gif:
    errorpage.jsp:initdestroy.jsp:receipt.jsp:showcart.jsp
web.xml bookstore2.war
```

Application Client JAR File

Syntax

```
packager -applicationClient <root-directory> <file-list>
<main-class> <appclient-dd> <appclient-jar>
```

Example

The following command creates the `appClient.jar` file:

```
packager  -applicationClient classes
hola:hello/HelloUtil.class
package.Main client.xml appClient.jar
```

J2EE Application EAR File

Syntax

```
packager -enterpriseArchive <file-only-list>
[-alternativeDescriptorEntries <file-only-list>]
[-libraryJars <file-list>] <app-name> <app-ear>
```

Example

In the following command, the optional `-alternativeDescriptorEntries` flag allows you to specify the external descriptor entry name of each component as you wish it to appear in the EAR file:

```
packager -enterpriseArchive
myWeb.war:myEJB.jar:appClient.ear
-alternativeDescriptorEntries
myWeb/web.xml:myEjb/myEjb.xml:client/client.xml
myAppName myApp.ear
```

Specifying the Runtime Deployment Descriptor

The preceding example specified the `-enterpriseArchive` flag to create a portable J2EE application EAR file. This file is portable because you can import it into any J2EE environment that conforms to the *J2EE Specification*. Although you can import the file into the deploytool, you cannot deploy it on the J2EE server until it contains a runtime deployment descriptor. This deployment descriptor is an XML file that contains information such as the JNDI names of the application's enterprise beans.

Syntax

```
-setRuntime <app-ear>|<appclient-jar> <runtime.xml>
[-o <output-file>]
```

Example

In the following command, the -setRuntime flag instructs the packager to insert the runtime deployment descriptor (sun-j2ee-ri.xml) into the myApp.ear file:

```
packager -setRuntime MyApp.ear sun-j2ee-ri.xml
```

The next command copies MyApp.ear to OtherApp.ear, inserts the deployment descriptor into OtherApp.ear file, and leaves MyApp.ear unchanged.

```
packager -setRuntime MyApp.ear sun-j2ee-ri.xml -o OtherApp.ear
```

To obtain an example of the runtime deployment descriptor, extract it from an EAR file that you've already deployed:

```
jar -xvf SomeApp.ear
```

The DTD of the runtime deployment descriptor is in the lib/dtds/sun-j2ee-ri-dtd file of your J2EE SDK installation.

Note: The runtime deployment descriptor (sun-j2ee-ri.xml) is not required by the *J2EE Specification*. This descriptor is unique to the J2EE SDK and may change in future releases.

Resource Adapter RAR File

Syntax

```
packager -connector <root-directory> file1:file2
ra.xml myConnector.rar
```

Example

In this example, the `jar` command packages the files under the `com` directory into `myfiles.jar`. The packager command creates a RAR file named `theConnector.rar` that contains `myfiles.jar` and the `myra.xml` deployment descriptor:

```
jar -cvf myadapter.jar com
packager -connector . myadapter.jar myra.xml theConnector.rar
```

Realm Tool

The `realmtool` utility is a command-line script that enables you to add and remove J2EE users and to import certificate files.

Table 48 `realmtool` Options

Option	Description
`-show`	Lists the realm names.
`-list <realm-name>`	Lists the users in the specified realm. This release has two realms: `default` and `certificate`.
`-add <username password group[,group]>`	Adds the specified user to the `default` realm.
`-addGroup <group>`	Adds a group to the `default` realm.
`-import <certificate-file> -alias <alias>`	Adds a user to the `certificate` realm by importing a file containing an X509 certificate.
`-remove <realm-name username>`	Removes a user from the specified realm.
`-removeGroup <group>`	Removes a group.

Examples

To display all users in the default realm, type this command:

```
realmtool -list default
```

To add a user to the default realm you specify the `-add` flag. The following command will add a user named robin who is protected by the password red, and will include robin in the bird and wing groups:

```
realmtool -add robin red bird,wing
```

To add a user to the certificate realm, you import a file containing the X509 certificate that identifies the user:

```
realmtool -import certificate-file
```

To remove a user you specify the `-remove` flag. For example, to remove a user named sparrow from the default realm, you would type the following command:

```
realmtool -remove default sparrow
```

To add a group to the default realm you specify the `-addGroup` flag. The following command adds the wing group:

```
realmtool -addGroup wing
```

(You cannot add a group to the certificate realm.)

To remove a group from the default realm, you specify the `-removeGroup` flag:

```
realmtool -removeGroup wing
```

Runclient Script

To run a J2EE application client, you execute the runclient script from a command-line prompt.

Syntax

```
runclient -client <appjar> [-name <name>] [-textauth]
[-Dj2eelogin.name=guest -Dj2eelogin.password=guest123]
[app-args]
```

Table 49 runclient Options

Option	Description
-client <appjar>	The J2EE application EAR file.
-name <name>	The display name of the J2EE application client component.
-textauth	Causes the client container to prompt for the user name and password are from the command line, not from a pop-up window.
-Dj2eelogin.name=guest -Dj2eelogin.password=guest123	Prevents the client container from prompting for the user name and password.
<app-args>	Any arguments required by the J2EE application.

Example

Before executing the runclient command, you must set the APPCPATH environment variable to the name of the client JAR stub file that is generated during deployment. The following example shows how to set APPCPATH on a Windows machine. The runclient command that follows launches a client named FabulousClient. The J2EE application of this client resides in the FabulousApp.ear file.

```
set APPCPATH=FabulousAppClient.jar
runclient -client FabulousApp.ear -name FabulousClient
```

Remote Access

If the J2EE application client will reside on a different machine than the J2EE server, before executing `runclient` you must do the following:

- Copy the EAR file to the remote client's machine.
- Copy the client JAR stub file to the remote client's machine.
- Set the `APPCPATH` environment variable to the name of the client JAR stub file.
- Set the `VMARGS` environment variable to the following value:

```
-Dorg.omg.CORBA.ORBInitialHost=<remote-host>
```

  For example, if the remote host were named `murphy` you would set the `VMARGS` variable on a Windows machine as follows:

```
set VMARGS=-Dorg.omg.CORBA.ORBInitialHost=murphy
```

Verifier

The `verifier` tool validates J2EE archive files (EAR, WAR, JAR).

You can run `verifier` three ways:

- From within the `deploytool` GUI
- As a command-line utility
- As a stand-alone GUI utility

To run `verifier` from within the `deploytool` GUI, choose Verifier from the Tools menu. The following sections explain how to run the verifier the other two ways.

Command-Line Verifier

The command-line verifier has the following syntax:

```
verifier [options] <filename>
```

The `filename` argument is the name of a J2EE component file. The following table lists the options.

Table 50 `verifier` Options

Syntax	Description
`-v`	Displays a verbose version of output.
`-o <output-file>`	Writes the results to the specified `<output-file>`, overriding the default `Results.txt` file
`-u`	Runs the stand-alone GUI version.
`-<report-level>`	Determines whether warnings or failures are reported. The `<report-level>` may be either `a`, `w`, or `f`: `a` (all results) `w` (warnings only) `f` (failures only) By default, only warnings and failures are reported.

Stand-Alone GUI Verifier

To run the stand-alone GUI verifier, follow these steps:

1. From the command-line prompt, type:

```
verifier -u
```

2. To select a file for verification, click Add.
3. Select the radio button to indicate the report level:
   - All Results
   - Failures Only
   - Failures and Warnings Only
4. Click OK.
5. The verifier lists the details in the lower portion of the screen.

Glossary

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

abstract schema
The part of an entity bean's deployment descriptor that defines the bean's persistent fields and relationships.

abstract schema name
A logical name that is referenced in Enterprise JavaBeans™ (EJB QL) queries.

access control
The methods by which interactions with resources are limited to collections of users or programs for the purpose of enforcing integrity, confidentiality, or availability constraints.

ACID
The acronym for the four properties guaranteed by transactions: atomicity, consistency, isolation, and durability.

activation
The process of transferring an enterprise bean from secondary storage to memory. (See passivation.)

applet
A component that typically executes in a web browser, but can execute in a variety of other applications or devices that support the applet programming model.

applet container
A container that includes support for the applet programming model.

Application Component Provider
A vendor that provides the Java classes that implement components' methods, JSP page definitions, and any required deployment descriptors.

Application Assembler
A person that combines components and modules into deployable application units.

application client
A first-tier client component that executes in its own Java virtual machine. Application clients have access to some (JNDI, JDBC, RMI-IIOP, JMS) J2EE platform APIs.

application client container
A container that supports application client components.

application client module
A software unit that consists of one or more classes and an application client deployment descriptor.

authentication
The process by which an entity proves to another entity that it is acting on behalf of a specific identity. The J2EE platform requires three types of authentication: basic, form-based, and mutual, and supports digest authentication.

authorization
The process by which access to a method or resource is determined. Authorization in the J2EE platform depends upon the determination of whether the principal associated with a request through authentication is in a given security role. A security role is a logical grouping of users defined by an Application Component Provider or Assembler. A Deployer maps security roles to security identities. Security identities may be principals or groups in the operational environment.

authorization constraint
An authorization rule that determines who is permitted to access a web resource collection.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

basic authentication
An authentication mechanism in which a web server authenticates an entity with a user name and password obtained using the web client's built-in authentication mechanism.

bean-managed persistence

Data transfer between an entity bean's variables and a resource manager managed by the entity bean.

bean-managed transaction

A transaction whose boundaries are defined by an enterprise bean.

business logic

The code that implements the functionality of an application. In the Enterprise JavaBeans model, this logic is implemented by the methods of an enterprise bean.

business method

A method of an enterprise bean that implements the business logic or rules of an application.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

callback methods

Component methods called by the container to notify the component of important events in its life cycle.

caller

Same as caller principal.

caller principal

The principal that identifies the invoker of the enterprise bean method.

cascade delete

A deletion that triggers another deletion. A cascade delete may be specified for an entity bean with container-managed persistence.

client certificate authentication

An authentication mechanism in which a client uses a X.509 certificate to establish its identity.

commit

The point in a transaction when all updates to any resources involved in the transaction are made permanent.

component

An application-level software unit supported by a container. Components are configurable at deployment time. The J2EE platform defines four types of components: enterprise beans, web components, applets, and application clients.

component contract

The contract between a component and its container. The contract includes: life cycle management of the component, a context interface that the instance uses to obtain various information and services from its container, and a list of services that every container must provide for its components.

connection

See resource manager connection.

connection factory

See resource manager connection factory.

connector

A standard extension mechanism for containers to provide connectivity to enterprise information systems. A connector is specific to an enterprise information system and consists of a resource adapter and application development tools for enterprise information system connectivity. The resource adapter is plugged in to a container through its support for system-level contracts defined in the connector architecture.

Connector architecture

An architecture for integration of J2EE products with enterprise information systems. There are two parts to this architecture: a resource adapter provided by an enterprise information system vendor and the J2EE product that allows this resource adapter to plug in. This architecture defines a set of contracts that a resource adapter has to support to plug in to a J2EE product, for example, transactions, security, and resource management.

container

An entity that provides life cycle management, security, deployment, and runtime services to components. Each type of container (EJB, web, JSP, servlet, applet, and application client) also provides component-specific services.

container-managed persistence

Data transfer between an entity bean's variables and a resource manager managed by the entity bean's container.

container-managed transaction

A transaction whose boundaries are defined by an EJB container. An entity bean must use container-managed transactions.

context attribute

An object bound into the context associated with a servlet.

conversational state

The field values of a session bean plus the transitive closure of the objects reachable from the bean's fields. The transitive closure of a bean is defined in terms of the serialization protocol for the Java programming language, that is, the fields that would be stored by serializing the bean instance.

CORBA

Common Object Request Broker Architecture. A language independent, distributed object model specified by the Object Management Group.

create method

A method defined in the home interface and invoked by a client to create an enterprise bean.

credentials

The information describing the security attributes of a principal.

CSS

Cascading Style Sheet. A stylesheet used with HTML and XML documents to add a style to all elements marked with a particular tag, for the direction of browsers or other presentation mechanisms.

CTS

Compatibility Test Suite. A suite of compatibility tests for verifying that a J2EE product complies with the J2EE platform specification.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

delegation

An act whereby one principal authorizes another principal to use its identity or privileges with some restrictions.

Deployer

A person who installs modules and J2EE applications into an operational environment.

deployment

The process whereby software is installed into an operational environment.

deployment descriptor

An XML file provided with each module and application that describes how they should be deployed. The deployment descriptor directs a deployment tool to deploy a module or application with specific container options and describes specific configuration requirements that a Deployer must resolve.

destination

A JMS administered object that encapsulates the identity of a JMS queue or topic. See point-to-point messaging system, publish/subscribe messaging system.

digest authentication

An authentication mechanism in which a web client authenticates to a web server by sending the server a message digest along its HTTP request message. The digest is computed by employing a one-way hash algorithm to a concatenation of the HTTP request message and the client's password. The digest is typically much smaller than the HTTP request, and doesn't contain the password.

distributed application

An application made up of distinct components running in separate runtime environments, usually on different platforms connected via a network. Typical distributed applications are two-tier (client-server), three-tier (client-middleware-server), and multitier (client-multiple middleware-multiple servers).

DOM

Document Object Model. A tree of objects with interfaces for traversing the tree and writing an XML version of it, as defined by the W3C specification.

DTD

Document Type Definition. A description of the structure and properties of a class of XML files.

durable subscription

In a JMS publish/subscribe messaging system, a subscription that continues to exist whether or not there is a current active subscriber object. If there is no active subscriber, JMS retains the subscription's messages until they are received by the subscription or until they expire.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

EAR file

A JAR archive that contains a J2EE application.

EJB™

See Enterprise JavaBeans.

EJB container

A container that implements the EJB component contract of the J2EE architecture. This contract specifies a runtime environment for enterprise beans that includes security, concurrency, life cycle management, transaction, deployment, naming, and other services. An EJB container is provided by an EJB or J2EE server.

EJB Container Provider

A vendor that supplies an EJB container.

EJB context

An object that allows an enterprise bean to invoke services provided by the container and to obtain the information about the caller of a client-invoked method.

EJB home object

An object that provides the life cycle operations (create, remove, find) for an enterprise bean. The class for the EJB home object is generated by the container's deployment tools. The EJB home object implements the enterprise bean's home interface. The client references an EJB home object to perform life cycle operations on an EJB object. The client uses JNDI to locate an EJB home object.

EJB JAR file

A JAR archive that contains an EJB module.

EJB module

A software unit that consists of one or more enterprise beans and an EJB deployment descriptor.

EJB object

An object whose class implements the enterprise bean's remote interface. A client never references an enterprise bean instance directly; a client always references an EJB object. The class of an EJB object is generated by a container's deployment tools.

EJB server

Software provides services to an EJB container. For example, an EJB container typically relies on a transaction manager that is part of the EJB server to perform the two-phase commit across all the participating resource managers. The J2EE architecture assumes that an EJB container is hosted by an EJB server from the same vendor, so does not specify the contract between these two entities. An EJB server may host one or more EJB containers.

EJB Server Provider

A vendor that supplies an EJB server.

enterprise bean

A component that implements a business task or business entity and resides in an EJB container; either an entity bean, session bean, or message-driven bean.

enterprise information system

The applications that comprise an enterprise's existing system for handling company-wide information. These applications provide an information infrastructure for an enterprise. An enterprise information system offers a well defined set of services to its clients. These services are exposed to clients as local and/or remote interfaces. Examples of enterprise information systems include: enterprise resource planning systems, mainframe transaction processing systems, and legacy database systems.

enterprise information system resource

An entity that provides enterprise information system-specific functionality to its clients. Examples are: a record or set of records in a database system, a business object in an enterprise resource planning system, and a transaction program in a transaction processing system.

Enterprise Bean Provider

An application programmer who produces enterprise bean classes, remote and home interfaces, and deployment descriptor files, and packages them in an EJB JAR file.

Enterprise JavaBeans™ (EJB™)

A component architecture for the development and deployment of object-oriented, distributed, enterprise-level applications. Applications written using the Enterprise JavaBeans architecture are scalable, transactional, and secure.

Enterprise JavaBeans Query Language (EJB QL)

Defines the queries for the finder and select methods of an entity bean with container-managed persistence. A subset of SQL92, EJB QL has extensions that allow navigation over the relationships defined in an entity bean's abstract schema.

entity bean

An enterprise bean that represents persistent data maintained in a database. An entity bean can manage its own persistence or it can delegate this function to its container. An entity bean is identified by a primary key. If the container in which an entity bean is hosted crashes, the entity bean, its primary key, and any remote references survive the crash.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

filter

An object that can transform the header and/or content of a request or response. Filters differ from web components in that they usually do not themselves create responses but rather they modify or adapt the requests for a resource, and modify or adapt responses from a resource. A filter should not have any dependencies on a web resource for which it is acting as a filter so that it can be composable with more than one type of web resource.

finder method
A method defined in the home interface and invoked by a client to locate an entity bean.

form-based authentication
An authentication mechanism in which a web container provides an application-specific form for logging in.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

group
A collection of principals within a given security policy domain.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

handle
An object that identifies an enterprise bean. A client may serialize the handle, and then later deserialize it to obtain a reference to the enterprise bean.

home interface
One of two interfaces for an enterprise bean. The home interface defines zero or more methods for managing an enterprise bean. The home interface of a session bean defines create and remove methods, while the home interface of an entity bean defines create, finder, and remove methods.

home handle
An object that can be used to obtain a reference of the home interface. A home handle can be serialized and written to stable storage and deserialized to obtain the reference.

HTML
Hypertext Markup Language. A markup language for hypertext documents on the Internet. HTML enables the embedding of images, sounds, video streams, form fields, references to other objects with URLs and basic text formatting.

HTTP
Hypertext Transfer Protocol. The Internet protocol used to fetch hypertext objects from remote hosts. HTTP messages consist of requests from client to server and responses from server to client.

HTTPS
HTTP layered over the SSL protocol.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

impersonation

An act whereby one entity assumes the identity and privileges of another entity without restrictions and without any indication visible to the recipients of the impersonator's calls that delegation has taken place. Impersonation is a case of simple delegation.

IDL

Interface Definition Language. A language used to define interfaces to remote CORBA objects. The interfaces are independent of operating systems and programming languages.

IIOP

Internet Inter-ORB Protocol. A protocol used for communication between CORBA object request brokers.

initialization parameter

A parameter that initializes the context associated with a servlet.

ISV

Independent Software Vendor.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

J2EE™

See Java 2 Platform, Enterprise Edition.

J2ME™

See Java 2 Platform, Micro Edition.

J2SE™

See Java 2 Platform, Standard Edition.

J2EE application

Any deployable unit of J2EE functionality. This can be a single module or a group of modules packaged into an .ear file with a J2EE application deployment descriptor. J2EE applications are typically engineered to be distributed across multiple computing tiers.

J2EE product

An implementation that conforms to the J2EE platform specification.

J2EE Product Provider

A vendor that supplies a J2EE product.

J2EE server
The runtime portion of a J2EE product. A J2EE server provides EJB and/or web containers.

JAR Java ARchive
A platform-independent file format that permits many files to be aggregated into one file.

Java™ 2 Platform, Enterprise Edition (J2EE)
An environment for developing and deploying enterprise applications. The J2EE platform consists of a set of services, application programming interfaces (APIs), and protocols that provide the functionality for developing multitiered, web-based applications.

Java™ 2 Platform, Micro Edition (J2SE)
A highly optimized Java runtime environment targeting a wide range of consumer products, including pagers, cellular phones, screenphones, digital set-top boxes and car navigation systems.

Java™ 2 Platform, Standard Edition (J2SE)
The core Java technology platform.

Java™ 2 SDK, Enterprise Edition (J2EE SDK)
Sun's implementation of the J2EE platform. This implementation provides an operational definition of the J2EE platform.

Java™ Message Service (JMS)
An API for using enterprise messaging systems such as IBM MQ Series, TIBCO Rendezvous, and so on.

Java Naming and Directory Interface™ (JNDI)
An API that provides naming and directory functionality.

Java™ Transaction API (JTA)
An API that allows applications and J2EE servers to access transactions.

Java™ Transaction Service (JTS)
Specifies the implementation of a transaction manager which supports JTA and implements the Java mapping of the OMG Object Transaction Service (OTS) 1.1 specification at the level below the API.

JavaBeans™ component
A Java class that can be manipulated in a visual builder tool and composed into applications. A JavaBeans component must adhere to certain property and event interface conventions.

Java IDL

A technology that provides CORBA interoperability and connectivity capabilities for the J2EE platform. These capabilities enable J2EE applications to invoke operations on remote network services using the OMG IDL and IIOP.

JavaMail™

An API for sending and receiving email.

JavaServer Pages™ (JSP™)

An extensible web technology that uses template data, custom elements, scripting languages, and server-side Java objects to return dynamic content to a client. Typically the template data is HTML or XML elements, and in many cases the client is a web browser.

JDBC™

An API for database-independent connectivity between the J2EE platform and a wide range of data sources.

JMS

See Java Message Service.

JMS administered object

A preconfigured JMS object (a resource manager connection factory or a destination) created by an administrator for the use of JMS clients and placed in a JNDI namespace.

JMS application

One or more JMS clients that exchange messages.

JMS client

A Java language program that sends and/or receives messages.

JMS provider

A messaging system that implements the Java Message Service as well as other administrative and control functionality needed in a full-featured messaging product.

JMS session

A single-threaded context for sending and receiving JMS messages. A JMS session can be non-transacted, locally transacted, or participating in a distributed transaction.

JNDI

See Java Naming and Directory Interface.

JSP

See JavaServer Pages.

JSP action

A JSP element that can act on implicit objects and other server-side objects or can define new scripting variables. Actions follow the XML syntax for elements with a start tag, a body and an end tag; if the body is empty it can also use the empty tag syntax. The tag must use a prefix.

JSP action, custom

An action described in a portable manner by a tag library descriptor and a collection of Java classes and imported into a JSP page by a `taglib` directive. A custom action is invoked when a JSP page uses a custom tag.

JSP action, standard

An action that is defined in the JSP specification and is always available to a JSP file without being imported.

JSP application

A stand-alone web application, written using the JavaServer Pages technology, that can contain JSP pages, servlets, HTML files, images, applets, and JavaBeans components.

JSP container

A container that provides the same services as a servlet container and an engine that interprets and processes JSP pages into a servlet.

JSP container, distributed

A JSP container that can run a web application that is tagged as distributable and is spread across multiple Java virtual machines that might be running on different hosts.

JSP declaration

A JSP scripting element that declares methods, variables, or both in a JSP file.

JSP directive

A JSP element that gives an instruction to the JSP container and is interpreted at translation time.

JSP element

A portion of a JSP page that is recognized by a JSP translator. An element can be a directive, an action, or a scripting element.

JSP expression

A scripting element that contains a valid scripting language expression that is evaluated, converted to a `String`, and placed into the implicit `out` object.

JSP file

A file that contains a JSP page. In the Servlet 2.2 specification, a JSP file must have a .jsp extension.

JSP page

A text-based document using fixed template data and JSP elements that describes how to process a request to create a response.

JSP scripting element

A JSP declaration, scriptlet, or expression, whose tag syntax is defined by the JSP specification, and whose content is written according to the scripting language used in the JSP page. The JSP specification describes the syntax and semantics for the case where the language page attribute is "java".

JSP scriptlet

A JSP scripting element containing any code fragment that is valid in the scripting language used in the JSP page. The JSP specification describes what is a valid scriptlet for the case where the language page attribute is "java".

JSP tag

A piece of text between a left angle bracket and a right angle bracket that is used in a JSP file as part of a JSP element. The tag is distinguishable as markup, as opposed to data, because it is surrounded by angle brackets.

JSP tag library

A collection of custom tags identifying custom actions described via a tag library descriptor and Java classes.

JTA

See Java Transaction API.

JTS

See Java Transaction Service.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

life cycle

The framework events of a component's existence. Each type of component has defining events which mark its transition into states where it has varying availability for use. For example, a servlet is created and has its `init` method called by its container prior to invocation of its service method by clients or other servlets who require its functionality. After the call of its `init` method it has the data and readiness for its intended use. The servlet's `destroy` method is called by its container prior to the ending of its existence so that processing associated with winding up may be done, and resources may be released. The `init` and `destroy` methods in this example are callback methods. Similar considerations apply to all J2EE component types: enterprise beans, web components (servlets or JSP pages), applets, and application clients.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

message
In the Java Message Service, an asynchronous request, report, or event that is created, sent, and consumed by an enterprise application, not by a human. It contains vital information needed to coordinate enterprise applications, in the form of precisely formatted data that describes specific business actions.

MessageConsumer
An object created by a JMS session that is used for receiving messages sent to a destination.

MessageProducer
An object created by a JMS session that is used for sending messages to a destination.

message-driven bean
An enterprise bean that is an asynchronous message consumer. A message-driven bean has no state for a specific client, but its instance variables may contain state across the handling of client messages, including an open database connection and an object reference to an EJB object. A client accesses a message-driven bean by sending messages to the destination for which the message-driven bean is a message listener.

method permission
An authorization rule that determines who is permitted to execute one or more enterprise bean methods.

module
A software unit that consists of one or more J2EE components of the same container type and one deployment descriptor of that type. There are three types of modules: EJB, web, and application client. Modules can be deployed as stand-alone units or assembled into an application.

mutual authentication
An authentication mechanism employed by two parties for the purpose of proving each other's identity to one another.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

naming context
: A set of associations between unique, atomic, people-friendly identifiers and objects.

naming environment
: A mechanism that allows a component to be customized without the need to access or change the component's source code. A container implements the component's naming environment, and provides it to the component as a JNDI naming context. Each component names and accesses its environment entries using the `java:comp/env` JNDI context. The environment entries are declaratively specified in the component's deployment descriptor.

non-JMS client
: A messaging client program that uses a message system's native client API instead of the Java Message Service.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

ORB
: Object Request Broker. A library than enables CORBA objects to locate and communicate with one another.

OS principal
: A principal native to the operating system on which the J2EE platform is executing.

OTS
: Object Transaction Service. A definition of the interfaces that permit CORBA objects to participate in transactions.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

passivation
: The process of transferring an enterprise bean from memory to secondary storage. (See activation.)

persistence
: The protocol for transferring the state of an entity bean between its instance variables and an underlying database.

persistent field
: A virtual field of an entity bean with container-managed persistence, it is stored in a database.

POA

Portable Object Adapter. A CORBA standard for building server-side applications that are portable across heterogeneous ORBs.

point-to-point message system

A messaging system built around the concept of message queues. Each message is addressed to a specific queue; clients extract messages from the queue(s) established to hold their messages.

principal

The identity assigned to an user as a result of authentication.

privilege

A security attribute that does not have the property of uniqueness and that may be shared by many principals.

primary key

An object that uniquely identifies an entity bean within a home.

publish/subscribe message system

A messaging system in which clients address messages to a specific node in a content hierarchy. Publishers and subscribers are generally anonymous and may dynamically publish or subscribe to the content hierarchy. The system takes care of distributing the messages arriving from a node's multiple publishers to its multiple subscribers.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

queue

See point-to-point messaging system.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

RAR

A JAR archive that contains a resource adapter.

realm

See security policy domain. Also, a string, passed as part of an HTTP request during basic authentication, that defines a protection space. The protected resources on a server can be partitioned into a set of protection spaces, each with its own authentication scheme and/or authorization database.

re-entrant entity bean

An entity bean that can handle multiple simultaneous, interleaved, or nested invocations which will not interfere with each other.

Reference Implementation

See Java 2 SDK, Enterprise Edition.

relationship field

A virtual field of an entity bean with container-managed persistence, it identifies a related entity bean.

remote interface

One of two interfaces for an enterprise bean. The remote interface defines the business methods callable by a client.

remove method

Method defined in the home interface and invoked by a client to destroy an enterprise bean.

resource adapter

A system-level software driver that is used by an EJB container or an application client to connect to an enterprise information system. A resource adapter is typically specific to an enterprise information system. It is available as a library and is used within the address space of the server or client using it. A resource adapter plugs in to a container. The application components deployed on the container then use the client API (exposed by adapter) or tool generated high-level abstractions to access the underlying enterprise information system. The resource adapter and EJB container collaborate to provide the underlying mechanisms—transactions, security, and connection pooling—for connectivity to the enterprise information system.

resource manager

Provides access to a set of shared resources. A resource manager participates in transactions that are externally controlled and coordinated by a transaction manager. A resource manager is typically in different address space or on a different machine from the clients that access it. Note: An enterprise information system is referred to as resource manager when it is mentioned in the context of resource and transaction management.

resource manager connection

An object that represents a session with a resource manager.

resource manager connection factory

An object used for creating a resource manager connection.

RMI

Remote Method Invocation. A technology that allows an object running in one Java virtual machine to invoke methods on an object running in a different Java virtual machine.

RMI-IIOP

A version of RMI implemented to use the CORBA IIOP protocol. RMI over IIOP provides interoperability with CORBA objects implemented in any language if all the remote interfaces are originally defined as RMI interfaces.

role (development)

The function performed by a party in the development and deployment phases of an application developed using J2EE technology. The roles are: Application Component Provider, Application Assembler, Deployer, J2EE Product Provider, EJB Container Provider, EJB Server Provider, Web Container Provider, Web Server Provider, Tool Provider, and System Administrator.

role (security)

An abstract logical grouping of users that is defined by the Application Assembler. When an application is deployed, the roles are mapped to security identities, such as principals or groups, in the operational environment.

role mapping

The process of associating the groups and/or principals recognized by the container to security roles specified in the deployment descriptor. Security roles have to be mapped by the Deployer before the component is installed in the server.

rollback

The point in a transaction when all updates to any resources involved in the transaction are reversed.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

SAX

Simple API for XML. An event-driven, serial-access mechanism for accessing XML documents.

security attributes

A set of properties associated with a principal. Security attributes can be associated with a principal by an authentication protocol and/or by a J2EE Product Provider.

security constraint

A declarative way to annotate the intended protection of web content. A security constraint consists of a web resource collection, an authorization constraint, and a user data constraint.

security context

An object that encapsulates the shared state information regarding security between two entities.

security permission

A mechanism, defined by J2SE, used by the J2EE platform to express the programming restrictions imposed on Application Component Providers.

security permission set

The minimum set of security permissions that a J2EE Product Provider must provide for the execution of each component type.

security policy domain

A scope over which security policies are defined and enforced by a security administrator. A security policy domain has a collection of users (or principals), uses a well defined authentication protocol(s) for authenticating users (or principals), and may have groups to simplify setting of security policies.

security role

See <u>role (security)</u>.

security technology domain

A scope over which the same security mechanism is used to enforce a security policy. Multiple security policy domains can exist within a single technology domain.

security view

The set of security roles defined by the Application Assembler.

server principal

The OS principal that the server is executing as.

servlet

A Java program that extends the functionality of a web server, generating dynamic content and interacting with web clients using a request-response paradigm.

servlet container

A <u>container</u> that provides the network services over which requests and responses are sent, decodes requests, and formats responses. All servlet containers must support HTTP as a protocol for requests and responses, but may also support additional request-response protocols such as HTTPS.

servlet container, distributed

A servlet container that can run a web application that is tagged as distributable and that executes across multiple Java virtual machines running on the same host or on different hosts.

servlet context

An object that contains a servlet's view of the web application within which the servlet is running. Using the context, a servlet can log events, obtain URL references to resources, and set and store attributes that other servlets in the context can use.

servlet mapping

Defines an association between a URL pattern and a servlet. The mapping is used to map requests to servlets.

session

An object used by a servlet to track a user's interaction with a web application across multiple HTTP requests.

session bean

An enterprise bean that is created by a client and that usually exists only for the duration of a single client-server session. A session bean performs operations, such as calculations or accessing a database, for the client. While a session bean may be transactional, it is not recoverable should a system crash occur. Session bean objects can be either stateless or they can maintain conversational state across methods and transactions. If a session bean maintains state, then the EJB container manages this state if the object must be removed from memory. However, the session bean object itself must manage its own persistent data.

SSL

Secure Socket Layer. A security protocol that provides privacy over the Internet. The protocol allows client-server applications to communicate in a way that cannot be eavesdropped or tampered with. Servers are always authenticated and clients are optionally authenticated.

SQL

Structured Query Language. The standardized relational database language for defining database objects and manipulating data.

SQL/J

A set of standards that includes specifications for embedding SQL statements in methods in the Java programming language and specifications for calling Java static methods as SQL stored procedures and user-defined functions. An SQL checker can detects errors in static SQL statements at program development time, rather than at execution time as with a JDBC driver.

stateful session bean

A session bean with a conversational state.

stateless session bean

A session bean with no conversational state. All instances of a stateless session bean are identical.

System Administrator

The person responsible for configuring and administering the enterprise's computers, networks, and software systems.

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topic

See publish-subscribe messaging system.

transaction

An atomic unit of work that modifies data. A transaction encloses one or more program statements, all of which either complete or roll back. Transactions enable multiple users to access the same data concurrently.

transaction attribute

A value specified in an enterprise bean's deployment descriptor that is used by the EJB container to control the transaction scope when the enterprise bean's methods are invoked. A transaction attribute can have the following values: `Required`, `RequiresNew`, `Supports`, `NotSupported`, `Mandatory`, `Never`.

transaction isolation level

The degree to which the intermediate state of the data being modified by a transaction is visible to other concurrent transactions and data being modified by other transactions is visible to it.

transaction manager

Provides the services and management functions required to support transaction demarcation, transactional resource management, synchronization, and transaction context propagation.

Tool Provider

An organization or software vendor that provides tools used for the development, packaging, and deployment of J2EE applications.

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URI

Uniform Resource Identifier. A compact string of characters for identifying an abstract or physical resource. A URI is either a URL or a URN. URLs and

URNs are concrete entities that actually exist; A URI is an abstract superclass.

URL

Uniform Resource Locator. A standard for writing a textual reference to an arbitrary piece of data in the World Wide Web. A URL looks like `protocol://host/localinfo` where `protocol` specifies a protocol for fetching the object (such as HTTP or FTP), `host` specifies the Internet name of the targeted host, and `localinfo` is a string (often a file name) passed to the protocol handler on the remote host.

URL path

The URL passed by a HTTP request to invoke a servlet. The URL consists of the Context Path + Servlet Path + Path Info, where

- Context Path is the path prefix associated with a servlet context that this servlet is a part of. If this context is the default context rooted at the base of the web server's URL namespace, the path prefix will be an empty string. Otherwise, the path prefix starts with a / character but does not end with a / character.
- Servlet Path is the path section that directly corresponds to the mapping which activated this request. This path starts with a / character.
- Path Info is the part of the request path that is not part of the Context Path or the Servlet Path.

URN

Uniform Resource Name. A unique identifier that identifies an entity, but doesn't tell where it is located. A system can use a URN to look up an entity locally before trying to find it on the web. It also allows the web location to change, while still allowing the entity to be found.

user data constraint

Indicates how data between a client and a web container should be protected. The protection can be the prevention of tampering with the data or prevention of eavesdropping on the data.

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WAR file

A JAR archive that contains a web module.

web application

An application written for the Internet, including those built with Java technologies such as JavaServer Pages and servlets, as well as those built with non-Java technologies such as CGI and Perl.

web application, distributable

A web application that uses J2EE technology written so that it can be deployed in a web container distributed across multiple Java virtual machines running on the same host or different hosts. The deployment descriptor for such an application uses the distributable element.

web component

A component that provides services in response to requests; either a servlet or a JSP page.

web container

A container that implements the web component contract of the J2EE architecture. This contract specifies a runtime environment for web components that includes security, concurrency, life cycle management, transaction, deployment, and other services. A web container provides the same services as a JSP container and a federated view of the J2EE platform APIs. A web container is provided by a web or J2EE server.

web container, distributed

A web container that can run a web application that is tagged as distributable and that executes across multiple Java virtual machines running on the same host or on different hosts.

Web Container Provider

A vendor that supplies a web container.

web module

A unit that consists of one or more web components and a web deployment descriptor.

web resource collection

A list of URL patterns and HTTP methods that describe a set of resources to be protected.

web server

Software that provides services to access the Internet, an intranet, or an extranet. A web server hosts web sites, provides support for HTTP and other protocols, and executes server-side programs (such as CGI scripts or servlets) that perform certain functions. In the J2EE architecture, a web server provides services to a web container. For example, a web container typically relies on a web server to provide HTTP message handling. The J2EE architecture assumes that a web container is hosted by a web server from the same vendor, so does not specify the contract between these two entities. A web server may host one or more web containers.

Web Server Provider

A vendor that supplies a web server.

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XML

Extensible Markup Language. A markup language that allows you to define the tags (markup) needed to identify the content, data, and text, in XML documents. It differs from HTML the markup language most often used to present information on the internet. HTML has fixed tags that deal mainly with style or presentation. An XML document must undergo a transformation into a language with style tags under the control of a stylesheet before it can be presented by a browser or other presentation mechanism. Two types of style sheets used with XML are CSS and XSL. Typically, XML is transformed into HTML for presentation. Although tags may be defined as needed in the generation of an XML document, a Document Type Definition (DTD) may be used to define the elements allowed in a particular type of document. A document may be compared with the rules in the DTD to determine its validity and to locate particular elements in the document. J2EE deployment descriptors are expressed in XML with DTDs defining allowed elements. Programs for processing XML documents use SAX or DOM APIs. J2EE deployment descriptors are expressed in XML.

XSL

Extensible Stylesheet Language. An XML transformation language used for transforming XML documents into documents with flow object tags for presentation purposes. The transformation aspect of XSL has been abstracted into XSLT with the XSL name now used to designate the presentation flow language. XSL is a direct descendent of the DSSSL style language for SGML (Standard Generalized Markup Language), the language from which XML was subsetted. It was designed to have all the capabilities of CSS, the stylesheet often used with HTML. XSL flow objects can be presented by specialized browsers, and themselves transformed into PDF documents.

XSLT

XSL Transformation. An XML file that controls the transformation of an XML document into another XML document or HTML. The target document often will have presentation related tags dictating how it will be rendered by a browser or other presentation mechanism. XSLT was formerly part of XSL, which also included a tag language of style flow objects.

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Bios For Contribuing Authors

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Enterprise JavaBeans	**Dale Green** is a staff writer with Sun Microsystems, where he documents the J2EE™ platform. In previous positions he programmed business applications, designed databases, taught technical classes, and documented RDBMS products. He wrote the internationalization and reflection trails for the *Java Tutorial Continued*. In his current position he writes about Enterprise JavaBeans™ technology and the J2EE SDK.
Message-Driven Beans	**Kim Haase** is a staff writer with Sun Microsystems, where she documents the J2EE platform. In previous positions she has documented compilers, debuggers, and floating-point programming. She currently writes about the Java™ Message Service and J2EE SDK tools.

Topic	Bio
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J2EE Connector Technology	**Beth Stearns** is the president of Computer Ease Publishing, a computer consulting firm she founded in 1982. Her client list includes Sun Microsystems Inc., Silicon Graphics Inc., Oracle Corporation, and Xerox Corporation, among others. Her *Understanding EDT*, a guide to Digital Equipment Corporation's text editor, has sold throughout the world. She received her B.S. degree from Cornell University and a master's degree from Adelphi University. Beth wrote the JNI trail for the Java Tutorial. She is a co-author of *Applying Enterprise JavaBeans: Component-Based Development for the J2EE Platform.*