Lutris®

Enhydra™

Getting Started with Lutris Enhydra

Acknowledgements

Lutris Enhydra Development: Jason Abbott, Kyle Clark, Mark Diekhans, Larry Deran, Michael Gardner, Dick Gemoets, Scott Harrison, Craig Heath, Peter Hearty, Aidan Hosler, Wes Isberg, Andy John, Peter Johnson, Matthew Kalastro, Ray Kiuchi, Paul Mahar, John Marco, Shawn McMurdo, Ioan Mitrea, Paul Morgan, Christophe Ney, Robert Pirani, Scott Pirie, Joseph Shoop, Wayne Stidolph, Josh Sugnet, Simon Tuffs, Mike Ward.

Lutris Customer Services: Andy Ames, Debbie Brackeen, Peter Darrah, Jim Dumont, Jason Dunton, Anne Hopkins, Andrew Longsworth, Lindsey Lonne, Livia Peras, John Powell, Christopher Reed, Jane Richter, Katrina Seitz, Steve Slany, Daniel Thomas.

Lutris Consulting: Ashley Baumann, David Black, Dennis Chatham, Jon Coyle, Tola Dalton, Jay Gunter, John Hellier, Donna Karolchik, Bill Karwin, Alyssa Lalanne, Graham Moore, Jim Murphy, Thom Nelson, Natasha Perry, Kristen Pol, Lisa Reese, Matt Schwartz, Harvey Thompson, Robert Trama, Shiming Shi, David Simons, Jonathan Webb.

Lutris Marketing: Keith Bigelow, Scott Campbell, Lynda Hall, Holly Hamner, Klaus Krull, Helen Meservey, Lynn Renshaw, Greg Schwarzer, Gillian Webster, David Young.

Lutris Enhydra Documentation: Teresa Andrews, Ian Evans, Curtis Gavin, Laurel Kline, Michael Maceri, C. Rand McKinney.

Thanks also to the following Lutris departments: customer service, consulting, finance, legal, IS, marketing, quality assurance, research and development, sales, technical support, training, and the executive staff.

Printed in the U.S.A.
ENW-US040-35 1E3R1200
0102030405-9 8 7 6 5 4 3 2 1

1200 PACIFIC AVENUE, SUITE 300, SANTA CRUZ, CA 95060 ✦ PHONE 831.471.9753 ✦ FAX 831.471.9754 ✦ http://www.lutris.com

Contents

Chapter 1

Introduction

This book introduces the Lutris® Enhydra™ application server and the Enhydra development environment. It provides an introductory overview of Enhydra and explains how to develop an application by using an example to illustrate some of the key principles of Enhydra applications.

What you should already know

This book assumes you have the following basic skills:

- General understanding of the Internet, the World Wide Web (Web), and Hypertext Markup Language (HTML).
- Good working knowledge of the Java programming language. Some knowledge of Java servlets is also helpful.
- Knowledge of basic UNIX commands and the UNIX `make` utility. This is not necessary if you are developing your application with the Kelp toolset in an IDE such as JBuilder.
- Good understanding of relational databases; knowledge of SQL is helpful.

Conventions used in this book

The typographical conventions used in this book are listed in Table 1.1.

Table 1.1 Typographical conventions

Convention	Description
Italics	Indicates variables, new terms and concepts, and book titles. For example, • A *servlet* is a Java class that dynamically extends the functionality of a Web server.

Table 1.1 Typographical conventions (continued)

Convention	Description
`Fixed-width`	Used to indicate several types of items. These include: • Commands that you enter directly, code examples, utility programs, and options. For example, ◦ `cd mydir` ◦ `System.out.println("Hello World");` ◦ `make` utility ◦ `-keep` option • Java packages, classes, methods, objects, and other identifiers. For example, ◦ `ErrorHandler` class ◦ `run()` method ◦ `Session` object **Note:** Method names are suffixed with empty parentheses, even if the method takes parameters. **Note:** Only specific references to object names are in fixed-width; generic references to objects are shown in plain text. • File and directory names. For example: ◦ `/usr/local/bin` **Note:** UNIX path names are used throughout and are indicated with a forward slash (`/`). If you are using the Windows platform, substitute backslashes (`\`) for the forward slashes (`/`).
`Fixed-width italic` and *`<Fixed-width italic>`*	Indicates variables in commands and code. For example, • `xmlc [`*`options`*`|`*`optfile`*`.xmlc ...]` *`docfile`* **Note:** Angle brackets (`< >`) are used to indicate variables in directory paths and command options. For example, • `-class <`*`class`*`>`
Boldface	Used for the words **Note**, **Tip**, **Important**, and **Warning** when they are used as headings that draw your eye to essential or useful information.
Keycaps	Used to indicate keys on the keyboard that you press to implement an action. If you must press two or more keys simultaneously, keycaps are joined with a hyphen. For example, • *Ctrl-C*.
`|` (pipe)	Used as a separator in menu commands that you select in a graphical user interface (GUI), and to separate choices in a syntax line. For example, • File	New • `{a|b|c}` • `[a|b|c]`
{ } (braces)	Indicates a set of required choices in a syntax line. For example, • `{a|b|c}` means you must choose `a`, `b`, or `c`.
[ ] (brackets)	Indicates optional items in a syntax line. For example, • `[a|b|c]` means you can choose `a`, `b`, `c`, or nothing.

Table 1.1 Typographical conventions (continued)

Convention	Description
. . . (horizontal ellipses)	Used to indicate that portions of a code example have been omitted to simplify the discussion, and to indicate that an argument can be repeated several times in a command line. For example, • `xmlc [options|optfile.xmlc ...] docfile`
plain text	Used for URLs and generic references to objects. For example, • http://www.lutris.com/documentation/index.html • The presentation object is in the presentation layer.
ALL CAPS	Indicates SQL statements. For example: • CREATE statement

Table 1.2 lists additional conventions used in this book, including the convention used to describe the Enhydra root directory, platform-related conventions, and so on.

Table 1.2 Additional conventions

Convention	Description
Enhydra root directory	When you install Enhydra, you install the Enhydra executables and libraries in a directory of your choosing. This directory is referred to as the Enhydra root directory or <*enhydra_root*>.
Paths	UNIX path names are used throughout and are indicated with a forward slash (/). If you are using the Windows platform, substitute backslashes (\) for the forward slashes (/). For example, • `/usr/local/bin`
URLs	URLs are indicated in plain text and are generally fully qualified. For example, • http://www.lutris.com/documentation/index.html
Screen shots	Most screen shots reflect the Microsoft Windows look and feel.

Lutris Enhydra document set

The Lutris Enhydra documentation set is an excellent resource for information about Enhydra. The documentation set includes the following printed guides.

Note Online versions of these books in both PDF and HTML formats are provided with the purchase of Lutris Enhydra. These online books, along with additional Enhydra online documentation, are located in the `doc` subdirectory of the directory in which you installed Lutris Enhydra. You can also view the online books and installation instructions directly from the product CD.

Getting Started

Getting Started with Lutris Enhydra introduces the fundamentals of Enhydra. The purpose of this book is to introduce Lutris Enhydra and provide a groundwork for

understanding and working with Enhydra and its associated tools. It includes a detailed tutorial and an explanation of the Enhydra DiscRack sample application.

Note As part of our commitment to support the Enhydra and open-source communities, Lutris Technologies has made the latest online version of *Getting Started with Lutris Enhydra* available for free viewing and download from the Lutris Documentation home page at http://www.lutris.com/documentation/index.html.

Developer's Guide

The Lutris Enhydra *Developer's Guide* introduces advanced topics and explores key features of Enhydra in detail. The purpose of the *Developer's Guide* is to provide developers with the information they need to create and debug sophisticated Enhydra applications. This guide provides in-depth information on the Lutris Enhydra development tools:

- Application Wizard
- Multiserver Administration Console
- Kelp tools
- Enhydra™ XMLC
- Data Object Design Studio (DODS)
- InstantDB
- Enhydra Director

Note The *Developer's Guide* is available only with the purchase of Lutris Enhydra.

Wireless Application Developer's Guide

The Lutris Enhydra *Wireless Application Developer's Guide* presents information on wireless technologies and describes how to develop wireless applications with Enhydra. It includes a detailed tutorial and an explanation of the Enhydra AirSent wireless sample application.

Note The *Wireless Application Developer's Guide* is available only with the purchase of Lutris Enhydra.

Lutris documentation updates available online

The latest product documentation updates and release notes are available to registered users from the Lutris Documentation home page at http://www.lutris.com/documentation/index.html.

Contacting Lutris Technical Publications

We strongly encourage you to send us your feedback because it helps us understand your needs and makes our documentation even better. You can submit feedback from the Lutris website at

http://www.lutris.com/documentation/feedback/index.html. You can also submit feedback by sending email to documentation@lutris.com.

Where to find support and training for Lutris Enhydra

Lutris Enhydra includes a package of products for developing Enhydra applications, including open-source products. Lutris Technologies, Inc. provides support and services for Lutris Enhydra.

Note Open-source communities or commercial entities support the other products. For detailed information on the available support options for those products, please refer to the appropriate group or company website.

Lutris support

Lutris offers a variety of support programs designed to assist you with your technical support needs. We can help with installing and using your Lutris product, developing and debugging your code, maintaining your deployed applications, providing onsite consulting services, and delivering enterprise-level support. For more information about any of the Lutris technical support programs, see the Lutris Support home page at http://www.lutris.com/support/index.html or call Lutris Customer Service toll-free at 1-877-688-3724, Monday–Friday, 8 a.m.–6 p.m. Pacific Time (outside of North America, please call 1-831-460-7590).

Registering your product online

Lutris strongly encourages you to register your product online. Registering your product entitles you to 15 days of free installation support and provides you with the option of purchasing Lutris Support Services.

To register online, browse to the product registration form that is available at http://www.lutris.com/register.html.

Contacting Lutris Technical Support

For more information about any of Lutris' technical support programs, see the Lutris Support home page at http://www.lutris.com/support/index.html or call Lutris Customer Service toll-free at 1-877-688-3724, Monday–Friday, 8 a.m.–6 p.m. Pacific Time (outside of North America, please call 1-831-460-7590). You can also send email to support@lutris.com.

Submitting bug reports to Lutris Technical Support

To report suspected Lutris Enhydra bugs, fill out the Bug Report form available at http://lutrisbugs.custhelp.com/cgi-bin/lutrisbugs/people. We recommend that you choose the Search Bugs link before submitting a bug report so that you can see if your bug has already been reported. Be sure to include steps-to-reproduce, exact error messages, and code snippets, if applicable, to help us better evaluate your report.

Lutris training

Lutris wants to ensure your success. Our expert trainers guide participants through hands-on labs designed to provide an intensive learning environment where participants quickly learn how to maximize Lutris Enhydra in development and deployment environments.

Available training courses

The following courses are currently offered by Lutris Technologies. For more information about training offerings, see the Lutris Training home page at http://www.lutris.com/training/index.html.

Lutris Enhydra Fundamentals

Lutris Technologies currently offers a five-day, instructor-led course titled *Lutris Enhydra Fundamentals*. This course is intended primarily for developers, architects, project managers, IT staff, and consultants who will be using Lutris Enhydra or are evaluating it for future projects.

Building Wireless Applications

Lutris Technologies currently offers a two-day, instructor-led course titled *Building Wireless Applications with Lutris Enhydra*. This course is intended primarily for Enhydra developers who want to create applications that serve content to cellphones or other wireless devices.

Lutris Enhydra Database Techniques

Lutris Technologies currently offers a two-day, instructor-led course titled *Database Techniques with Lutris Enhydra*. This course is intended primarily for Enhydra developers working on applications that require existing database platform support, Java database specialists and DBAs responsible for maintaining the data layer of an Enhydra application, and evaluators interested in seeing the database capability available through Enhydra.

Contacting Lutris Education Services

For more information about training offerings, see the Lutris Training home page at http://www.lutris.com/training/index.html or call Lutris Customer Service toll-free at 1-877-688-3724, Monday–Friday, 8 a.m.–6 p.m. Pacific Time (outside of North America, please call 1-831-460-7590). You can also send email to training@lutris.com.

Additional Enhydra information available on Enhydra.org

You can find a variety of information about open-source Enhydra at the Enhydra website: http://www.enhydra.org. The Enhydra website is the home of the Enhydra open-source community, one of Enhydra's greatest assets. The Enhydra community

consists of numerous entities, including community sponsors, technology providers, users, and of course developers.

Enhydra.org mailing lists

The Enhydra.org website includes archives of the various electronic mailing lists that serve as the backbone of the Enhydra community, as well as instructions on how to subscribe to the mailing lists.

Lutris encourages you to join one or more of the following Enhydra email lists:

- **Enhydra@enhydra.org**

  The Enhydra mailing list for developer interaction. The Enhydra project team monitors this list. It is the ideal place to get answers to your questions from fellow Enhydra developers.

- **Enhydra-daily@enhydra.org**

  A daily collection of all mail sent to enhydra@enhydra.org is sent to subscribers of this list.

- **Enhydra-digest@enhydra.org**

  A weekly digest of all mail sent to enhydra@enhydra.org.

- **EnhydraEnterprise@enhydra.org**

  The Enhydra Enterprise mailing list is tailored for those who are developing and deploying Enhydra applications on a large scale. Here you can find answers to the more detailed Enhydra questions, such as those on Enterprise Java Beans (EJB) and the Common Object Request Broker Architecture (CORBA).

- **EnhydraEnterprise-digest@enhydra.org**

  A weekly digest of all mail sent to EnhydraEnterprise@enhydra.org.

- **Enhydra-announce@enhydra.org**

  The mailing list for receiving Enhydra announcements.

For information and instructions on joining one or more of these lists, go to http://www.enhydra.org/community/mailingLists/index.html.

Mailing list archives

You can search the combined Enhydra mailing list archives at http://www.enhydra.org/community/mailingLists/index.html.

Enhydra.org working groups

Enhydra *working groups* bring together developers interested in creating new Enhydra applications and contributing new technologies or bug fixes for Enhydra.

Each working group provides access to the current project source code and to the project email list. This lets you communicate with the project leaders and other developers.

For information and instructions on joining one or more of these groups, go to http://www.enhydra.org/project/workingGroups/index.html.

Documentation working group

The documentation working group is focused on facilitating developer-created documentation for open-source Enhydra and related technologies. The working group also provides a central point for documentation discussions and proposals.

Community members are encouraged to submit and collaborate on articles of any length, on topics of general interest to all Enhydra developers—from beginning to advanced.

For information and instructions on joining this groups, go to http://www.enhydra.org/project/workingGroups/index.html.

Enhydra.org community documentation

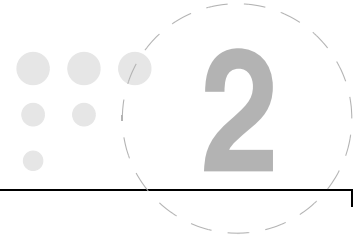
The Enhydra website also has documentation provided by members of the community. For more information on this documentation, see http://www.enhydra.org/software/documentation/enhydra/index.html.

Open-source software downloads

You can download the latest version of open-source Enhydra and other related software at: http://www.enhydra.org/software/downloads/index.html.

Acknowledgments

As an open-source product, Enhydra benefits from the contributions of many developers around the world. In particular, Lutris would like to thank the following people who have contributed information used in some form in this book: Robert Cadena, G. W. Estep, Rohan Oberoi, Dan Rosner, Peter Speck, and David Trisna.



Chapter 2

Installation

Complete step-by-step installation instructions for Lutris Enhydra and related software (including bundled third-party software) are available on the Lutris Enhydra CD. To begin, refer to the top-level `index.html` file on the Enhydra CD.

For convenience, we recommend that you print the HTML file containing the Lutris Enhydra installation instructions prior to installation. (The instructions are included in a single print-friendly HTML file.) However, you can also follow the step-by-step installation instructions online (you can toggle back and forth between the installation program and browser).

Installation instructions also freely available online

The latest Lutris Enhydra installation instructions are freely available from the Lutris Documentation home page at http://www.lutris.com/documentation/index.html.

Lutris Enhydra installation instructions freely available to Enhydra.org users

In the spirit of supporting the Enhydra and open-source communities, Lutris Technologies has made the latest Lutris Enhydra installation instructions freely available from the Lutris Documentation home page at http://www.lutris.com/documentation/index.html.

Note The Lutris Enhydra installation instructions are tailored to the installation of Lutris Enhydra. Open-source Enhydra users will need to substitute filenames and pathnames appropriately.

Why are installation instructions available in HTML format only?

Previous versions of this book included printed installation instructions. Due to book-printing schedules, this installation information was usually not as accurate as the information provided on the Lutris Enhydra CD, which is able to be updated until just prior to release. Therefore, to ensure that you always receive the latest installation information, the installation instructions are now available only on the CD or online in an easy-to-print HTML format.

It is our hope that by single-sourcing the installation instructions in print-friendly HTML and making the latest versions always available online, we are serving our Lutris Enhydra customers and the Enhydra community in the best possible way.

We hope you agree. Please feel free to send your comments to documentation@lutris.com.

Thank you,

Lutris Documentation Team

Chapter 3

Overview

This chapter provides a high-level overview of Enhydra, Enhydra applications, and the tools used to create Enhydra applications. The following topics are covered:

- What is Enhydra?
- Anatomy of an Enhydra application
- Multiserver runtime component
- Enhydra application framework
- Enhydra tools

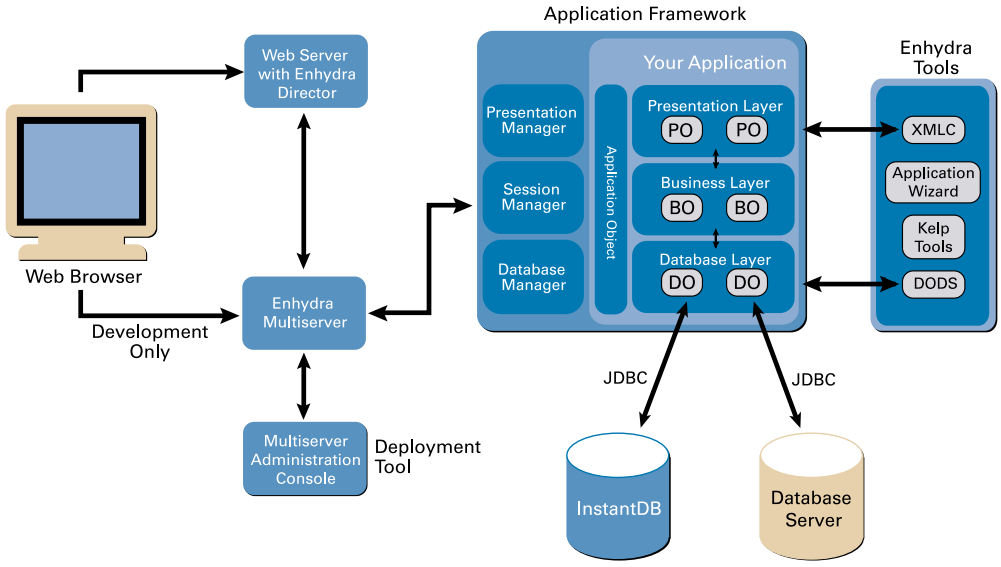
What is Enhydra?

Enhydra is an application server for running robust and scalable multi-tier Web applications, and a set of application development tools.

An *application server* usually operates between a Web server and a database server, and provides dynamically-generated content for the Web server to send to Web browser clients.

An *Enhydra application* is a Java program that runs in Multiserver and uses the Enhydra application framework at runtime. Figure 3.1, "Enhydra application model," illustrates the basic elements of an Enhydra application within the context of the Enhydra architecture.

Figure 3.1 Enhydra application model



As illustrated in Figure 3.1, Enhydra has three parts:

- **Multiserver:** Runs Enhydra applications either by itself or with a Web server.
- **Application framework:** Collection of Java classes, which provide the runtime infrastructure for Enhydra applications.
- **Enhydra tools:** Use to develop Enhydra applications.

The following sections describe Enhydra and Enhydra applications in more detail.

For more information on	See this topic
Enhydra application architecture	"Anatomy of an Enhydra application" on page 13
Multiserver	"Multiserver runtime component" on page 17
Application framework	"Enhydra application framework" on page 19
Enhydra tools	"Enhydra tools" on page 21

What's new in Lutris Enhydra

Enhydra 3.5 has a number of new features and enhancements, including:

- Improved application performance with Java 2 v1.3 support (JDK 1.3)
- Support for server-side redirects
- Wireless support enhancements, including:
  - XMLC support for VoiceXML, cHTML, and XHTML

  - AirSent sample application, a comprehensive wireless application to illustrate the capabilities and development methods associated with Enhydra wireless applications
  - *Wireless Application Developer's Guide*, detailed documentation focused on wireless application development
  - Enhydra™ Mail Demo, an extensible Enhydra application, illustrates how messaging can be used with wired and wireless Webs
- Enhydra XMLC 2.0 has significant performance improvements, updated XML and HTML parsers, and now supports compile time includes using SSI syntax
- Kelp 2.0 has support for Servlet 2.2 and Enhydra Super-servlet applications, added support for creating WML, XHTML, and cHTML clients, enhanced support for WML, JSP, and WAR files, and new import and deployment wizards
- DODS 3.0 has improved Java-database type mapping scheme, query class improvements for complex queries, and improved database code generators
- InstantDB 3.24, companion database to Lutris Enhydra, has foreign key support, XA-compliant JDBC Drivers (JDBC 2.0), and general performance improvements
- Documentation updates:
  - *Getting Started with Lutris Enhydra* has been updated to reflect changes to Enhydra and revised for accuracy.
  - *Developer's Guide* has been updated to reflect changes to Enhydra and revised for accuracy. The *Developer's Guide* also contains new material for DODS and the Application Wizard.
  - *Wireless Application Developer's Guide* has been added to provide detailed information about technologies, design considerations, development tools, and programing techniques for wireless applications

Please consult the release notes for a comprehensive list of changes and enhancements.

Anatomy of an Enhydra application

An Enhydra application can be either:

- An *Enhydra super-servlet application* that uses Enhydra's own application model
- A *servlet application* that uses the J2EE servlet application model

These two kinds of applications are similar in many ways, but have some important differences. Generally, a servlet application has a servlet for each page (HTML, WML, and so on) in the application. In contrast, a super-servlet application consists of a single servlet that contains a *presentation object* for each page.

You can use Enhydra tools such as XMLC and DODS to create both kinds of applications, and you can run both kinds of applications in any standard servlet runner, such as the Enhydra Multiserver.

For a detailed comparision of the two application models, see "Servlet versus super-servlet applications" on page 16.

Enhydra super-servlet applications

An Enhydra application has, at a minimum:

- A single application object
- One presentation object for each page to be dynamically generated

These objects run in the context of the Enhydra application framework, as described in "Enhydra application framework" on page 19.

Application objects

The *application object* is the central hub of an Enhydra application. It is a subclass of `com.lutris.appserver.server.StandardApplication` and contains application-wide data, such as:

- Name of the application
- Status of the application (for example, running/stopped/dead)
- Name and location of the configuration file that initializes the application
- Log channel to use for logging
- References to the application's session manager, database manager, and presentation manager (see"Enhydra application framework" on page 19)

Properties

You can add *properties* (instance variables) to the application object to store information that needs to be accessible throughout the application. For example, if your application has a dozen pages that need to share a collection of customer data, you can make a vector containing the data a property of the application object so all pages can easily access it.

Methods

Each application object has the following methods:

- `startup()` starts the application

  You can extend this to perform other startup functions, such as reading settings from the configuration file.

- `requestPreprocessor()` initializes the `Session` data structure

  You can extend this as needed; for example, to check for HTTP basic authorization.

In general, application objects do not deal with HTML, handle requests, or otherwise talk to the network; presentation objects perform these tasks. The next section describes presentation objects.

Presentation objects

A *presentation object* generates dynamic content for one or more pages in an Enhydra super-servlet application.

When a browser requests a URL that ends in `.po`, Enhydra passes the request on to the corresponding presentation object. Enhydra then instantiates and calls the presentation object. For example, for the URL http://www.foo.com/myapp/Xyz.po, Enhydra calls the presentation object `Xyz`.

Note Enhydra only calls a presentation object for URLs with a `.po` suffix. The Web server generally serves a static file for other requests.

Presentation objects must implement the interface `com.lutris.appserver.server.httpPresentation.HttpPresentation`. This interface has one method, `run()`, that Enhydra calls, passing it an HTTP request. Presentation objects differ from servlets in that they need handle only a single request at a time. No concurrency control is required.

Enhydra also provides a *response object* that a presentation object can use to write data in response to HTTP requests (similar to a servlet's `service()` method). Presentation objects usually handle GET requests (for example, form submissions) and respond by writing HTML, but they can perform other functions (for example, read files sent by a POST request).

Servlet applications

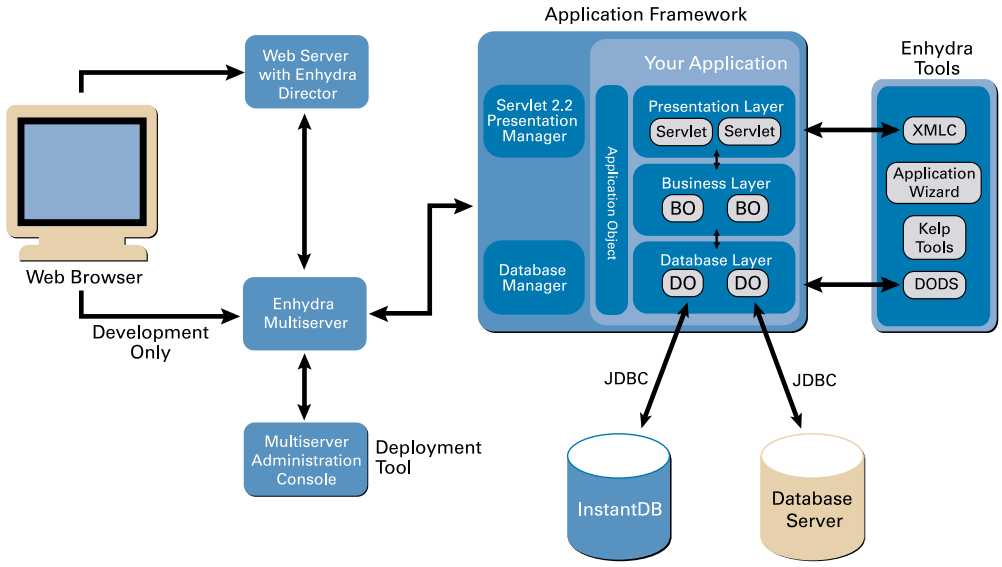
In addition to super-servlet applications, you can also create and run standard servlet applications (sometimes called Web applications) with Enhydra. Servlet applications conform to the Java servlet API specification, part of the Java 2 Enterprise Edition (J2EE) specification from Sun Microsystems. It is a popular application model for interactive Web applications.

For a detailed information on the servlet application model, see http://java.sun.com/products/servlet/index.html.

In a servlet application, each servlet is responsible for a single page of output (although this is not required, it is common practice). Each servlet must be a subclass of `javax.servlet.http.HttpServlet`, and will generally override the `doGet()` method, and possibly other methods, such as `init()`. The general architecture of a servlet application is illustrated in Figure 3.2.

Although JavaServer Pages (JSPs) are often used to create the presentation layer of servlet applications, XMLC is generally better because it provides a cleaner separation between layout code (such as HTML) and presentation logic code. Fortunately, you can use XMLC to help generate presentation code for servlet applications, too.

Figure 3.2 Servlet application model



Servlet versus super-servlet applications

While the servlet application model and the super-servlet application model are similar in many ways, they also have some key differences. You can run both kinds of applications in Enhydra Multiserver, and you can use Enhydra tools such as XMLC and DODS to help create both kinds of applications.

Since the servlet API performs its own presentation management, there is no need for the Enhydra Presentation Manager (see “Presentation Manager” on page 20). Likewise, the servlet API provides session management, so there is no need for the Enhydra Session Manager (see “Session Manager” on page 20).

One of the key differences in the two application models is how the objects in the presentation layer are instantiated. In a super-servlet application, each request creates a new instance of the requested presentation object, and the PO executes in a single-thread. In contrast, in a servlet application there is only one instance of any given servlet, and it is multithreaded (one thread for each request). So, POs can have member variables that are local to each instance, while in a servlet application, any member variable is global to all threads of the instance of the servlet.

Presentation objects have several features that you cannot take advantage of in a servlet application:

- Dynamic page recompilation (so you can change page content while an application is running)
- URL-encoding of session information for cookieless session maintenance
- Automatic setting of MIME-types, for applications that generate multiple document types (for example, HTML and WML)

Additionally, Enhydra has a sophisticated make system, especially tailored to building XMLC-based applications. You cannot use this system when building servlet applications.

The Enhydra application framework provides a number of capabilities that are very useful, including:

- Database management
- Logging

Although these are not part of the standard servlet application model, you can save a lot of development time by using them; however, your application will then be dependent on the Enhydra class libraries (contained in enhydra.jar).

Application layers

Regardless of the application model you use, you should divide your application into three distinct parts or *layers* for modularity and ease of maintenance:

- The **Presentation layer** handles how the application is presented to Web browsers through HTML. In a super-servlet application, this layer consists of presentation objects (POs); in a servlet application, it consists of servlets.
- The **Business layer** contains business objects. Business objects contain the application's business logic, including algorithms and specialized functions, but not data access or display functions.
- The **Data layer** handles the interface with the persistent data source, which is typically a relational database.

  An additional benefit of having a distinct data layer is that you can use the Data Object Design Studio (DODS) to create your data objects. DODS graphically creates data objects to populate the data layer, and creates both Java code and SQL code to create the corresponding tables in the database. For more on DODS, see "Data Object Design Studio (DODS)" on page 22.

Note The Enhydra application framework only requires that you use an application object and presentation objects. The business and data classes you create are up to you.

Dividing your application into these three layers minimizes maintenance cost because it isolates the application's data layer from the user interface. This, in turn, lets you change the data layer without affecting the presentation layer.

Multiserver runtime component

Multiserver is the runtime component of Enhydra. It provides the services that an Enhydra application uses to communicate with the Web server, and performs all other runtime functions.

To understand Enhydra Multiserver, you need to understand a little about servlets. A *servlet* is a Java class that dynamically extends the functionality of a Web server. Normally, when a browser sends a request to a Web server, the server simply finds

the files identified by the requested URL and returns them to the browser. However, if the browser requests a page constructed by a servlet, the server sends the request information to a servlet, which constructs the response dynamically and returns it to the server.

The Java Servlet API is a standard extension to Java and is part of the Java 2 Enterprise Edition (J2EE). Some Web servers support the Servlet API directly, while others require an adjunct servlet runner, such as JServ for the Apache Web server. Enhydra 3.0, and later, supports the Servlet API version 2.2.

Each Enhydra application runs as a single servlet, in contrast to a generic servlet application, which typically has one servlet for each dynamically-generated page. Enhydra Multiserver is a *servlet runner* that executes servlets, such as Enhydra applications, either with a Web server or by itself. Multiserver can run applications in a small-scale development environment on its own. For a production environment requiring greater performance, you can use Multiserver in conjunction with a Web server.

Note Because an Enhydra application is a servlet, it can run in any standards-compliant servlet runner, not just in Multiserver.

Enhydra Multiserver has a custom class loader for each application (servlet). Because of this one-to-one correspondence between servlets and class loaders, you can install and start new applications without stopping the server. To update an existing application, you simply restart its class loader.

Enhydra Director

Enhydra Director provides superior scalability for applications by distributing the user load among several Enhydra Multiservers.

The load-balancing algorithm supports session affinity and weighted round-robin distribution with server failover. *Session affinity* means that a particular session instance will always access the same Multiserver instance. The weighted round-robin, load-balancing scheme takes into account the capacity of each Multiserver instance and the number of existing connections. Server failover ensures that if a Multiserver goes down, all application connections are automatically transferred to another Multiserver instance.

The Enhydra Director uses a new connection method—the Enhydra Director connection method—and a new set of Web server extension modules. Enhydra Director works with:

- Apache servers through the Apache Module interface
- Netscape servers through Netscape Application Programming Interface (NSAPI)
- Microsoft servers through the Internet Server Application Programming Interface (ISAPI)
- Other Web servers through the Common Gateway Interface (CGI)

For more information and installation instructions for Enhydra Director, see the online documentation installed with Enhydra.

Multiserver Administration Console

Enhydra Multiserver provides an Admin Console for managing applications through a Web browser. The *Admin Console* lets you:

- Start and stop applications
- Add and remove applications from management
- Modify operational attributes for an application and check its status
- Trace the execution of an application to aid in debugging

The Admin Console is described in more detail in "Multiserver Administration Console" on page 101.

Enhydra application framework

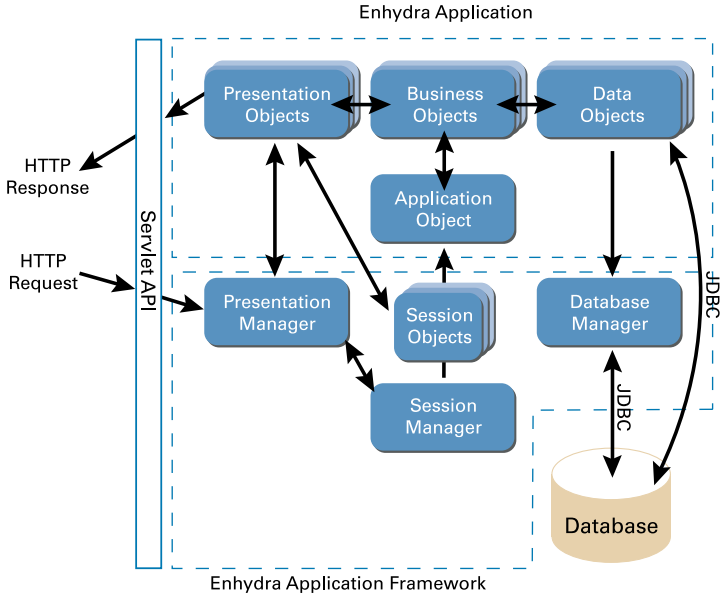
The Enhydra application framework includes:

- Presentation Manager
- Session Manager
- Database Manager

In general, the application framework includes all the classes in the `com.lutris.appserver.server.*` packages, which provide the infrastructure that Enhydra applications use at runtime.

The general architecture of an Enhydra application in the context of the application framework is illustrated in Figure 3.3, "Enhydra application and Enhydra framework."

Figure 3.3 Enhydra application and Enhydra framework



Presentation Manager

The Enhydra *Presentation Manager* handles the loading and execution of the presentation objects in an Enhydra application. The Presentation Manager maps URLs to presentation objects and calls the `run()` method of the presentation object.

Each Enhydra application has one instance of a Presentation Manager. To increase performance, the Presentation Manager caches presentation objects and associated files in memory as necessary. The Presentation Manager also provides the key that the session manager uses to locate a session. This *key* is either a cookie or a string appended to each URL in the application.

Each application has a Presentation Manager that is an instance of the class `com.lutris.appserver.server.httpPresentation.HttpPresentationManager`. The `com.lutris.appserver.server.httpPresentation` package contains classes and interfaces that the Presentation Manager and presentation objects use.

Session Manager

The Enhydra *Session Manager* enables an application to maintain state throughout a session. A *session* is defined as a series of requests from the same user (browser client) during a specified time period. Enhydra provides a general implementation of session management that you can extend to create more sophisticated state models.

Enhydra maintains user state by creating a `Session` object for each user. When a user first makes a request to an application, the Session Manager creates a new `Session` object and assigns it a unique session ID. The Session Manager uses the session ID to retrieve the `Session` object for subsequent requests. Applications can add user-specific information to the `Session` object and then access the `Session` object from the request object, as it is passed through the application.

If a user has been idle (has not issued a request to the application) for more than the period specified in the configuration file, the user's session becomes invalid, and the Session Manager releases the corresponding `Session` object. This makes it possible to implement security schemes that require users to log in before accessing the application. In such a scheme, the user enters an appropriate password and gains access to the rest of the application; however, once the user's session has been idle for more than the allowed time, the application requires the user to log in again.

Each application has a Session Manager that is an instance of the class `com.lutris.appserver.server.session.StandardSessionManager`. When it is created, the Session Manager reads the maximum time that a session can persist, the maximum session idle time, and other related information from the application configuration file, *`appName`*`.conf`.

The `com.lutris.appserver.server.session` package contains classes and interfaces that the Session Manager and the application use for session management.

Database Manager

The Enhydra *Database Manager* controls a pool of database connections for the application. The Database Manager works with logical databases. A *logical database* is an abstraction that hides the differences between different database types. A logical database uses Java Database Connectivity (JDBC) to communicate with database servers such as Oracle, Sybase, Informix, Microsoft SQL Server, PostgreSQL, InterBase, and InstantDB.

The Database Manager is responsible for the state of a database connection, the SQL statements that are being executed, and the result sets that are in progress. Specifically, the Database Manager:

- Allocates and releases connections to the logical database
- Allocates object IDs from the logical database
- Creates queries and transactions
- Maintains other database-related information

Each application has a Database Manager that is an instance of the class `com.lutris.appserver.server.sql.StandardDatabaseManager`. When it is created, the Database Manager reads a configuration file that specifies the logical database to use, the actual database types to which it maps, and other related information.

The `com.lutris.appserver.server.sql` package contains the classes and interfaces that the Database Manager and data objects use.

Enhydra tools

Enhydra includes the following tools to help you create applications:

- Enhydra Application Wizard
- Extensible Markup Language Compiler (XMLC)
- Data Object Design Studio (DODS)
- Kelp tools

Enhydra Application Wizard

The Enhydra Application Wizard (`appwizard`) is a tool with both a command-line and a graphical user interface. The wizard creates a basic framework for an Enhydra application. The wizard lets you create and run a new "stub" application in a matter of minutes, giving your development project a jump-start. For an example of using the Application Wizard GUI, see "Creating your first application" on page 27.

Note The Application Wizard has changed significantly with the release of Lutris Enhydra 3.5. Previously, the Application Wizard was a command-line tool, started by entering `newapp` with a parameter for the project name. The command for starting the Application Wizard and the parameters required to run it as a command-line tool have changed. The basic framework of files and directories generated by the Application Wizard has changed as well.

The Enhydra Application Wizard is also incorporated into the Enhydra Kelp tools, so you can create a basic framework for an Enhydra application from a graphical integrated development environment (IDE).

For additional information about the Enhydra Application Wizard, refer to Chapter 2, "Using the Application Wizard to create Enhydra applications," in the *Developer's Guide*.

Extensible Markup Language Compiler (XMLC)

The *Extensible Markup Language Compiler* (XMLC) creates a Java object that mirrors the structure of a eXtensible Markup Language (XML) document. *XML*, defined by the World Wide Web Consortium (W3C), is the universal format for structured documents and data on the Web. XMLC uses the Document Object Model (DOM), a W3C standard interface, to let programs access and update the content and structure of XML documents.

Note Although XMLC works with XML documents, this book will focus on its use with HTML pages.

XMLC lets you separate HTML templates in your application. These templates are typically created by page designers from Java code, which is usually created by programmers. This functionality provides increased modularity and eases team development and application maintenance. Page designers can change the user interface of the application without requiring any code changes, and the programmers can change the "back-end" Java code without requiring any changes to the HTML.

This command-line tool generates a Java class file from a HTML input file. An application can use the Java class at runtime to change the content or attributes of any tags with ID or CLASS attributes. For an example using the XMLC, see "Tutorial: Building Enhydra applications" on page 27.

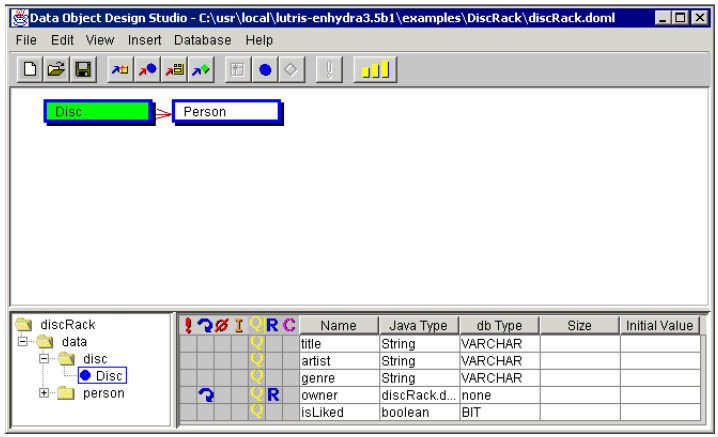
Dynamic recompilation

XMLC dynamic recompilation lets you change HTML layouts at runtime without restarting an application. With this feature, you can make any changes to the static content of HTML pages. The application automatically picks up the changes. As long as you do not add or change any ID and CLASS attributes of tags in a page, you don't have to rebuild and restart the application.

Data Object Design Studio (DODS)

The *Data Object Design Studio* (DODS), as shown in Figure 3.4, is a graphical tool you can use to define your data model.

Figure 3.4 DODS graphical user interface



Data objects in the DODS data model correspond to tables in the database. Each data object has *attributes*, which describe database columns, and *reference attributes*, which refer to other data objects. Reference attributes let you create a hierarchy of data objects (for example, many-to-one or many-to-many relationships).

Once you have defined your data model, the DODS generates all of the code to implement it. For example:

- SQL code to define the database tables
- Java code to create the corresponding application data objects

For each data object, DODS generates a set of source files. For example, if your data model includes the definition of an entity named "thing," then DODS would generate the following:

- A file named `thing.sql` containing the SQL CREATE TABLE command to construct a table in a relational database.
- Java source file defining a data object representing a row in the table.

  This class provides a "set" and "get" method for each attribute, methods to handle caching, and is a subclass of the Enhydra framework class `GenericDO`. In this example, the class would be named `ThingDO`.
- Java source file that defines a query class, which provides SQL query access to the database table.

  The query class returns a collection of `ThingDO` objects that represent the rows found in the table matching criteria passed from the application.

When DODS generates source code, it creates a directory structure that matches the package hierarchy you have designed. DODS creates the `make` files in each directory, and runs `make` on the generated source code. All that is left for you to do is to create a database using the SQL files, and write the more interesting components of your application.

For an example using DODS, see "Using DODS" on page 58.

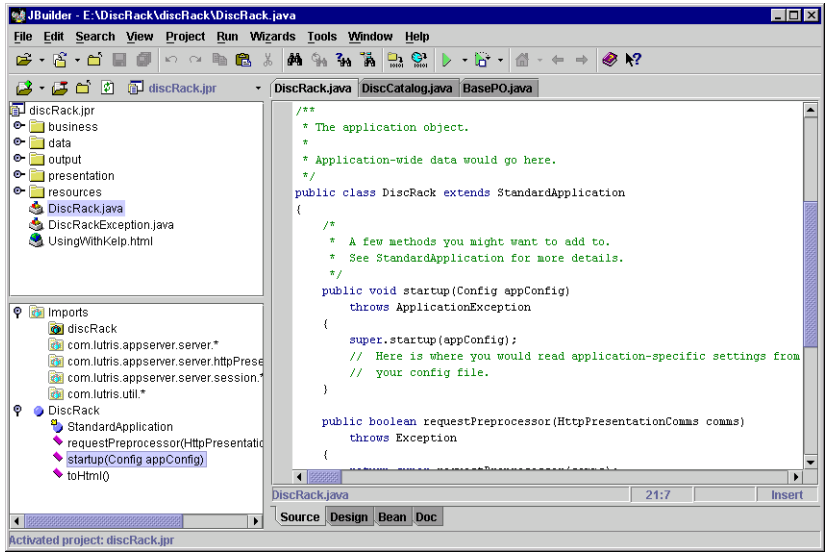
Kelp tools

The *Kelp tools* let you develop Enhydra applications in Borland JBuilder or Oracle JDeveloper integrated development environments (IDEs).

Note You can use Kelp in place of Enhydra's shell scripts and `make` files.

Figure 3.5 shows a general outline of Kelp, as features vary depending on the IDE. See Chapter 4, "Using Enhydra Kelp," of the *Developer's Guide* for the documentation included with the Kelp tools for specific features supported by your Java IDE.

Figure 3.5 JBuilder project generated with Kelp



Enhydra Application wizard

The Enhydra Application wizard incorporated into Kelp generates an Enhydra application that you can develop, run, and debug from within an IDE. The wizard lets you set the name, directory, and package for your new application. It generates the files described in "Creating your first application" on page 27. It also generates a `Readme.html` file that lists the steps to build and run the new application.

XMLC Compiler wizard

The *Compiler wizard* lets you set XMLC options, select HTML files to compile, and call the XMLC compiler from JBuilder.

The wizard also provides a mapping table that maps directories to package names. This is useful when you keep your HTML files in a directory that does not match the package name you want to use in the generated DOM classes. For example, the DiscRack sample project has HTML files in a `resources` directory that need to be compiled using the presentation package.

XMLC property pages

Property pages give you full control over how XMLC builds DOM classes from HTML files. The property pages let you customize class-name generation and set XMLC option files for the entire project, as well as for individual HTML files.

For example, the DiscRack sample includes three XMLC options files: one for the presentation package and two more for packages that reside within the presentation package. You can use the XMLC property pages to associate each HTML file in the resource directories with the appropriate XMLC options file in the presentation directories.

Enhydra sample project

The Enhydra sample project is an IDE project file that lets you build, debug, and run your application from within the IDE. The project also demonstrates how to perform several dynamic page generation tasks using XMLC. When you run the Enhydra sample project, the pages display the HTML tags and the Java methods required to perform each task.

Chapter 4

Tutorial: Building Enhydra applications

This chapter describes how to build an Enhydra application from the ground up, and provides important tips on Enhydra application development. In this tutorial, you will:

- Use the Application Wizard to create a starting framework
- Use XMLC to expand the application
- Add simple database access

If you are already familiar with the basics of Enhydra, you may want to skip to Chapter 5, "DiscRack sample application," for a look at an application with more advanced features.

Note In this tutorial, you are often instructed to enter commands. On UNIX platforms, you can enter the commands in any shell. On Windows, you must enter the commands in a Cygwin shell window.

Creating your first application

The Enhydra Application Wizard (sometimes referred to as appwizard) is a quick way to get up and running with Enhydra. The Application Wizard generates basic Java files and directory structures for new applications. For the tutorial, you will use the Application Wizard GUI.

To create a simple application with the Application Wizard:

1. Create a directory to contain your new application and name it anything you want. For example:

   ```
   mkdir myapps
   ```

2. Open a shell window and make the new directory the current directory. For example:

   ```
   cd myapps
   ```

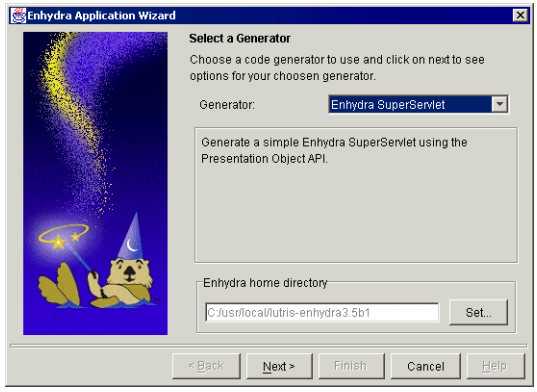
3. Start the Application Wizard GUI by entering `appwizard` at the command prompt.

   Entering `appwizard` with no arguments brings up the Application Wizard GUI. The Application Wizard can generate two distinct types of Enhydra projects: a Web

Application, and an Enhydra super-servlet application. For this tutorial, you will generate a super-servlet application.

Note If the Application Wizard does not start, the path environment variable is not set correctly. The Lutris Enhydra installation instructions provide information about setting your path environment variable. The installation instructions are available in HTML format only on the Lutris Enhydra CD (refer to the top-level `index.html`) or the Lutris Documentation home page: http://www.lutris.com/documentation/index.html.

Figure 4.1 Application Wizard GUI



Note The Application Wizard has changed significantly with the release of Lutris Enhydra 3.5. Previously, the Application Wizard was a command-line tool, started by entering `newapp` with a parameter for the project name. The command for starting the Application Wizard and the parameters required to run it as a command-line tool have changed. The basic framework of files and directories generated by the Application Wizard has changed as well.

4 Use the Application Wizard GUI to generate a simple Enhydra application.

The Application Wizard GUI steps you through the process of generating an Enhydra project.

1. Select a Generator.

   Select SuperServlet from the Generator pull-down menu and click Next.

2. Specify Client type and directory details.

   Accept the default client type of HTML. Enter `simpleApp` for the Project directory name. Enter `simpleapp` (note the difference in case) for Package. Set the Root path to `/enhydra/myapps`.

3. Specify the copyright material to use.

   Click Next to accept the default, No copyright setting.

4. Specify which Supplemental files to generate.

   Select Create Makefiles and Create Shell Scripts and click Finish.

The Application Wizard creates a new directory called `simpleApp`. This directory is sometimes referred to as the *application root directory*.

5 Make the application root directory the active directory:

```
cd simpleApp
```

6 Browse the application root directory and note the following items created by the Application Wizard:

- Two make files: `config.mk` and `Makefile`
- A `readme.html` file that contains some simple instructions to build and run the application
- A *source directory*, `src`, containing all the source code for the application
- An *input directory*, `input`, containing templates of the configuration files and start scripts for the application.

The contents of this application root directory are explained in "Directories and files in SimpleApp" on page 31. In the next section, you will finish building your simple application.

Building the application

To build the application:

1 In the shell window, enter the `make` command from the application root directory:

```
cd /enhydra/myapps/simpleApp
make
```

This creates two subdirectories in the application root directory:

- `classes` directory contains the application's class files
- `output` directory contains everything needed to run the application

The top-level make file, `Makefile`, contains directives that tell `make` to recursively descend the application directory tree, following the directives of the make file in each subdirectory. It also has an `include` directive that references `config.mk`, which in turn references `<enhydra_root>/lib/stdrules.mk`, a large make file shared by all Enhydra applications.

When you build the application, `make` compiles the files located in the simpleApp source directory (`simpleApp/src`) and creates a corresponding directory structure in the `classes` directory. It then combines those classes into a JAR (Java archive) file and places the JAR file into the `output/archive` directory, along with the configuration files needed to run the application.

2 To start the application, enter the following commands in the Enhydra shell window:

```
cd output
./start
```

Note The Multiserver Administration Console provides a GUI for managing applications. Among other functions, the Admin Console can be used to start and

stop applications. Refer to “Launching the Admin Console” on page 33 for additional information and usage instructions.

3 To access the application, enter the following URL in your browser’s location field:

```
http://localhost:9000
```

The browser will display the Welcome page for the simpleApp application.

Figure 4.2 Browser with the simpleApp welcome page loaded

You have just built and run your first Enhydra application.

4 Now press *Ctrl-C* in the shell window to stop the Enhydra process.

How it works

The application created by the Application Wizard provides a simple example of how Enhydra works.

Look at the file `myapps/simpleApp/src/simpleapp/presentation/Welcome.html`, which contains a few dozen HTML tags. Notice tags such as these:

```
<center>
   The time at the web server is:
   <span id="time">1/1/00 00:00:00 (static)</span>.
</center>
```

At runtime, Enhydra replaces the content of the `<SPAN>` tag with a date. The text in the `ID` attribute is just a placeholder; it will never appear at runtime. The period outside the `<SPAN>` tag will not be replaced. Thus, the sentence will always end with a period.

Look also at the WelcomePresentation.java file in the same directory. In particular, notice these lines of code:

```
WelcomeHTML welcome;
String now;
...
welcome = (WelcomeHTML)comms.xmlcFactory.create(WelcomeHTML.class);
now = DateFormat.getTimeInstance(DateFormat.SHORT).format(new Date());
welcome.getElementTime().getFirstChild().setNodeValue(now);
```

This code is used for replacing the text inside the <SPAN> tags.

The first couple lines of in the code snippet define welcome as an instance of the WelcomeHTML class, and now as an instance of the String class. The xmlcFactory in the next line is used to instantiate your HTML page. Next, the variable now is set to the current Date formatted as time. The last line of the snippet sets the time element in the welcome class to the value of now, and returns the value.

When you build the application, the Extensible Markup Language Compiler (XMLC) finds the <SPAN> tag in the HTML and recognizes the ID attribute with value "time". It creates a Java class called WelcomeHTML with a method getElementTime(). The application uses getElementTime() to modify the text content of the <SPAN> tag.

Note In general, XMLC will create a getElement*xxx*() method for each <SPAN> tag with ID attribute value *xxx*. The *xxx* in the method name is replaced by the capitalized spelling of the ID attribute value of the SPAN tag.

At runtime, the application replaces the original text content of the <SPAN> tag with a string representation of the current date. Then, the call to write(buffer) writes the document out to the HTTP response, looking something like this:

```
...
<CENTER>
The time at the web server is: <SPAN>10:40 AM</SPAN>.
</CENTER>
...
```

For a more detailed explanation of XMLC, see "Using XMLC" on page 37. For more information about the Enhydra Application Wizard, see "Enhydra Application Wizard" on page 21.

Directories and files in SimpleApp

Let's take a closer look at the directories and files in the simpleApp directory:

- The src directory contains the source code for the application. It contains a directory, simpleapp, corresponding to the Package name you assigned in the Applicatin Wizard. The simpleapp directory is divided into three subdirectories for the business, data, and presentation layers. The business and data directories are empty in the new application. The presentation directory contains Java, HTML, and media files.
- The classes subdirectory contains the application's compiled Java classes in their package hierarchy and any associated media files, such as .gif files.

- The `output` subdirectory contains the application's configuration files, `servlet.conf` and `simpleApp.conf`. It also has an `archive` directory with a `simpleApp.jar` file containing an archived package of everything in the `classes` directory.
- The `input` directory contains templates of the configuration files and start script. Template files have the extension `.in`. When you build your project from the application root directory, the templates will overwrite the corresponding files in the `output` directory.

The finished Enhydra application includes the JAR file, `simpleApp.jar`, and the application configuration file, `simpleApp.conf`. The `make` program also copies the Multiserver configuration file, `servlet.conf`, and the `start` script to the `output` directory to make it easier to run the application.

Configuration files

The application configuration files contain critical information that determine how an Enhydra application runs. These files include:

- Multiserver configuration file, `servlet.conf`, located in the `servlet` subdirectory
- Application configuration file, which is named `<AppName>.conf` by default (for example, `simpleApp.conf`)

Note The Admin Console is a GUI for managing applications running on the Multiserver. The Admin Console has its own configuration file, `multiserverAdmin.conf`. Additionally, files managed by the Admin Console use the default multiserver configuration file, `multiserver.conf`, located in the `<enhydra_root>` directory.

The `start` script, which is not a configuration file, specifies the `CLASSPATH` that the application will use.

Important If you do not specify a `CLASSPATH` in this file, the application will use the system `CLASSPATH`, which may not be correct.

If you edit the configuration files, you can change the various settings contained in the files, as explained in the text that follows.

Note The Application Wizard creates "input" versions of the configuration files in the `<app_root>/input` directory (for example, `simpleApp/input`). These are the files that you should edit. Running `make` creates "runtime" versions of the files in the `<app_root>/output` directory (for example, `simpleApp/output`). You should not edit the runtime versions of the files because they will be overwritten each time you build the project.

The Multiserver configuration file contains information that the Multiserver uses to run the application, including:

- Name and location of the application configuration file
- Name of the log file and other log file information
- TCP port on which the application will run
- Classname and description of the filter used to log requests made to the server

The application configuration file contains the following important application-specific information:

- `CLASSPATH` that this application will use

  The difference between this `CLASSPATH` and the one specified in the Multiserver `start` script is that this one applies to the application's own class loader, while the latter is global in scope for all applications run by that Multiserver instance.

- Class name of the application object

  For example:

  ```
  Server.AppClass = simpleapp.SimpleApp
  ```

- Prefix used to derive presentation object class names and paths from URLs

  For example:

  ```
  Server.PresentationPrefix = "simpleapp/presentation"
  ```

- Maximum length (in minutes) of a user session and the session idle time

  For example:

  ```
  SessionManager.Lifetime = 60
  SessionManager.MaxIdleTime = 2
  ```

- Default URL for the application

  For example:

  ```
  Application.DefaultUrl = "WelcomePresentation.po"
  ```

  When a browser requests the application URL, the Multiserver returns this URL (typically a presentation object) by default.

Launching the Admin Console

You can use the Admin Console to manage your Enhydra applications, as well as Java servlets, and Web archives (WAR files). In this Web-based console, you can add applications to the console, delete them from the console, start or stop applications, modify application settings, and perform some basic application debugging.

In this section of the tutorial, we will launch the Admin Console from the Enhydra shell, add the simpleApp applicatin to the console, and then use the Admin Console to start and stop simpleApp. Using the Admin Console to modify and debug Enhydra applications—as well as Java servlets and Web archives—is discussed in Chapter 3, "Using the Multiserver Administration Console," of the *Developer's Guide*.

To launch the Admin Console:

1. Enter the following command in the Enhydra shell at the prompt:

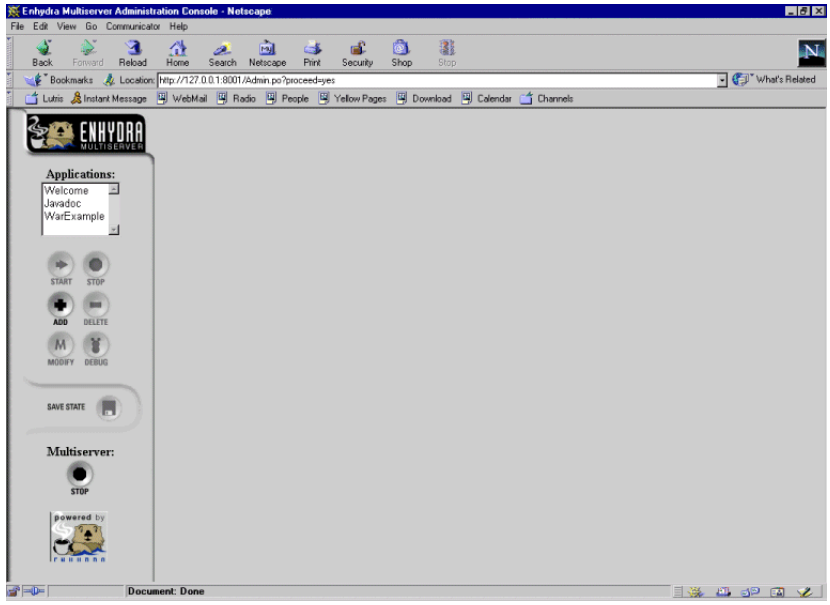
   ```
   multiserver
   ```

2. In your browser, display the Admin Console by entering this URL:

   ```
   http://localhost:8001/
   ```

The Admin Console displays a password dialog box. Enter the default user name, `admin`, and password, `enhydra`, to bring up the Admin Console in the browser as shown in Figure 4.3.

Figure 4.3 Admin Console display



Adding simpleApp to the Admin Console

Follow these steps to add simpleApp to the Multiserver, using the Admin Console:

1. First, copy the file `simpleApp.conf` from the `simpleApp/output/conf` directory to `<enhydra_root>/apps/`, the central repository for console-managed applications.

   You can either do this in the Enhydra shell with the `cp` command, or by copy-and-pasting from one folder to another in Windows. For example:

   ```
   cp simpleApp.conf /usr/local/lutris-enhydra3.5/apps/
   ```

2. Next, in the new `simpleApp.conf` file, locate the `server.Classpath` variable. Comment out the first line, and uncomment the second line. Set the variable equal to its new absolute path, `/enhydra/myapps/simpleApp/output/archive/simpleApp.jar`, like this:

   ```
   #server.Classpath[] = ../classes
   Server.Classpath[] = "/enhydra/myapps/simpleApp/output/archive/simpleApp.jar"
   ```

   Close the `simpleApp.conf` file.

3. In the Admin Console window, click the Add tool to display the Add New Application/Servlet window.

4. Since simpleApp is an application, select the Application radio button at the top of the screen.

5 Choose simpleApp from the Select Application pull-down menu.

The names in the menu represent applications with configuration files located in the /<*enhydra_root*>/app/ directory, but which have not been added to the console. This list is empty when there are no more files fitting this criteria.

Figure 4.4 Adding simpleApp using the Admin Console

6 Optionally, complete the Description field.

7 Click OK twice to return to the Admin Console.

The Applications window is updated to reflect the new application, with its status appearing in the content frame.

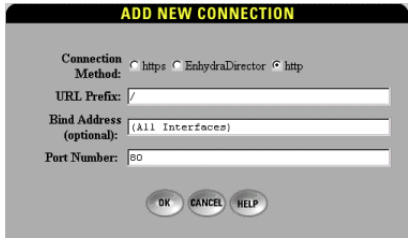
Specifying a connection method

Now it's time to specify a connection method.

1 Start by clicking the Connections tab in the content frame.

2 Click Create in the Connections screen to bring up the Add New Connection dialog box as shown in Figure 4.5.

Figure 4.5 Creating a connection for simpleApp using the Admin Console



3 Choose HTTP for the Connection Method.

You have three choices for Connection Method:

- HTTP for a standard Web connection, typically in a development environment.

- HTTPS for a secure Web connection, also in a development environment. This option is only available if you have configured your Enhydra installation with Sun's Java Secure Socket Extension Kit. For more information, see Appendix A, "Using SSL with Enhydra" of the *Developer's Guide*.
- Enhydra Director for connection via a Web server. See Chapter 9, "Using Enhydra Director," of the *Developer's Guide* for further information.

4 Leave the URL Prefix field as is for now.

5 For Port Number, enter `8080`.

In reality, you can enter any port number above 1024, as long as it doesn't conflict with a connection for another application.

6 Click OK to add the connection and return to the Connections screen.

For detailed information about the connection options, refer to Chapter 3, "Using the Multiserver Administration Console," in the *Developer's Guide*.

Starting and stopping an application

The newly added application or servlet is in the stopped state. To run your newly added application,

1 Make sure `simpleApp` is still selected in the Applications window, and click the Start button.

When you start simpleApp, the Admin Console makes the URL in the Connections screen an active link.

2 Click the URL in the Connections screen to open a new browser and display simpleApp.

The information in the Application screen of the Admin Console updates as you view and use the application in the browser. Click the Refresh button on the Application screen to update the displayed session data.

3 To make this addition permanent beyond the current Multiserver session, click the Save State button.

When you save state, the current session data, including connection data (method, URL prefix, and port number) and application state (started or stopped) for each managed application is saved in the `multiserver.conf` file. The next time you start the Admin Console, simpleApp will be started by the Admin Console and included in the list of managed applications.

4 Click the Multiserver Stop button to stop the Multiserver and all managed applications.

Using XMLC

XMLC, the Extensible Markup Language Compiler, was introduced in Chapter 3, "Overview." It is a powerful tool that you can use to create applications that have a clean separation between the user interface and the back-end programming logic.

Note In general, XMLC can work with XML pages, but for practical reasons, the remainder of this chapter focuses on how it works with HTML pages.

XMLC parses a HTML file and creates a Java object that enables an application to change the HTML file's content at runtime, without regard for its formatting. The Java objects that XMLC creates have interfaces defined by the Document Object Model (DOM) standard from the World Wide Web Consortium (W3C).

Adding a hit counter

To get a feel for how XMLC works, you are going to extend your application to display a "hit counter" that shows the number of users who have accessed it.

1. Find the files `Welcome.html` and `WelcomePresentation.java` in the `presentation` directory.
2. Add the following line of HTML to `Welcome.html` before the closing `</CENTER>` tag:

   ```
   <P>Number of hits on this page: <SPAN ID="HitCount">no count</SPAN>
   ```

   The `ID` attribute tells XMLC to generate an object corresponding to the `<SPAN>` tag, so that it can replace the text "no count" at runtime.
3. Add the lines of code shown in **bold** in the following code sample, to `WelcomePresentation.java`.

```
// Add the following line.
static int hitCount=0; // All Welcome PO's will share this.

public void run(HttpPresentationComms comms)
   throws HttpPresentationException, IOException {

   HttpPresentationOutputStream out;
   WelcomeHTML welcome;
   String now;
   byte[] buffer;

   welcome = (WelcomeHTML)comms.xmlcFactory.create(WelcomeHTML.class);
   now = DateFormat.getTimeInstance(DateFormat.SHORT).format(new Date());
   welcome.getElementTime().getFirstChild().setNodeValue(now);
   // Increment the count and write into the html.
   // Add the following line.
   welcome.setTextHitCount( String.valueOf( ++hitCount ) );
   buffer = welcome.toDocument().getBytes();
   comms.response.setContentType( "text/html" );
   comms.response.setContentLength( buffer.length );
   out = comms.response.getOutputStream();
   out.write(buffer);
   out.flush();
   }

}
```

4 Build the application by running `make` from the top-level `simpleApp` directory. Then restart Enhydra, either by starting the Admin Console (see "Launching the Admin Console" on page 33) or by entering the following commands in the shell window.

```
cd /myapps/simpleApp
make
cd output
./start
```

Building the application with `make` runs XMLC on all HTML files in the application, in this case, just `Welcome.html`.

5 Test the application by loading http://localhost:9000 in your browser.

The browser will display the Welcome page for the simpleApp application. The Welcome page should now have a hit counter beneath the redirect link, as shown in Figure 4.6.

Figure 4.6 Browser displaying the simpleApp Welcome page with a hit counter

The page now displays the number of times it has been accessed.

6 Reload the page several times to verify that it works correctly.

The count should increment each time you access the application.

The application is doing two things:

- Storing the hit count in `hitCount`, a static property of the `Welcome` presentation object
- Writing the hit count to the Web page with the `setTextHitCount()` method

Recall that the Presentation Manager instantiates a presentation object for each request. So, the `WelcomePresentation` class is instantiated once per browser request. Because `hitCount` is a static property, it is shared by all `WelcomePresentation` objects and its value gets incremented by each request.

In the same way that it added a `getElementTime()` method for the `<SPAN ID="time">` tag, XMLC creates a `setTextHitCount()` method for the `<SPAN ID="HitCount">` tag. The application then uses the `setTextHitCount()` method to write the value of `hitCount` into the page, within the corresponding `<SPAN>` tag.

Note XMLC creates the `WelcomeHTML` class, but by default it deletes the Java source file.

Understanding the Document Object Model

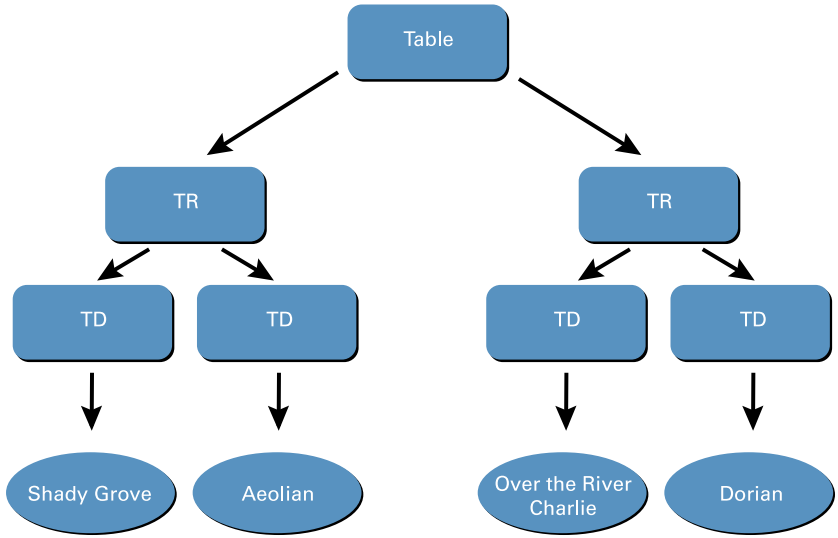
HTML documents have a hierarchical or tree-like structure that can be modeled in an object-oriented language like Java. The Worldwide Web Consortium (W3C) standard for the XML/HTML object model is called the Document Object Model (DOM).

Enhydra applications use the DOM to manipulate HTML content at runtime. For example, consider the following HTML:

```
<TABLE>
<TR>
   <TD ID="cellOne">Shady Grove</TD>
   <TD ID="cellTwo">Aeolian</TD>
</TR>
<TR>
   <TD ID="cellThree">Over the River, Charlie</TD>
   <TD ID="cellFour">Dorian</TD>
</TR>
</TABLE>
```

This HTML snippet has a `<TABLE>` tag that contains `<TR>` tags, which in turn contain `<TD>` tags containing text (or data). This defines a tree-like hierarchy, as illustrated in Figure 4.7.

Figure 4.7 DOM tree of HTML



Each box or ellipse in this figure is a *node* in the tree. The node above another node in the hierarchy is called its *parent*. The nodes below the parent are called its *children*.

Some nodes (like HTML tags) have attributes (for example, a table cell has a background color attribute). W3C defines packages and interfaces that mirror the object hierarchy of nodes in an HTML document. In addition, XMLC includes an API for changing attribute values.

For example, use code like the following to set the color of one of the table cells:

```
HTMLTableCellElement cellOne = theDocument.getElementCellOne();
cellOne.setBgColor("red");
```

In this example, the class `HTMLTableElement` and the method `setBgColor()` come from the W3C packages; `getElementCellOne()` comes from XMLC.

This code illustrates one important thing that XMLC does—create methods to access nodes in the DOM. XMLC generates the `getElement`*`xxx`*`()` methods that return objects corresponding to tags with `ID` attributes. You could change the color of a table cell with the W3C classes alone, but your code would have to traverse the DOM tree, so it would be more laborious.

SPAN and DIV tags

`<SPAN>` and `<DIV>` are HTML tags that you may not be familiar with. They are typically used to apply styles using cascading style sheets (CSS). Outside of that, they are largely ignored by browsers. However, XMLC makes extensive use of them.

- Use the `<SPAN>` tag to enclose a block of text that you want to replace at runtime.

  In general, a `<SPAN>` tag can enclose any text or inline tag. An *inline tag* is any tag that does not cause a line break in the layout; for example, `<A>` (anchor) or `<B>` (bold) tags.

Note Do not use `<SPAN>` tags to enclose other tags, such as `<TABLE>` or `<P>` (paragraph).

- Use the `<DIV>` tag to enclose block tags, such as `<TABLE>`, that cause a line break in the HTML layout.

Using XMLC from the command line

Previously, you ran XMLC implicitly when you built the project with `make`. To run XMLC from the command line, you must have the `enhydra.jar` file in your `CLASSPATH`. The make files set the `CLASSPATH` when they run. You must include `enhydra.jar` in the `CLASSPATH` yourself, before running XLMC from the command line.

Set your `CLASSPATH` with one of the following commands:

UNIX
```
export CLASSPATH=<enhydra_root>/lib/enhydra.jar:
```

Windows
```
export CLASSPATH=<enhydra_root>/lib/enhydra.jar\;
```

For more information on configuring Enhydra, see the installation and configuration instructions in the CD documentation.

The basic command-line syntax of XMLC is

```
xmlc -options file.html
```

where *`options`* is a set of command-line options, and *`file`* is the name of the input file.

There are several dozen command-line options. In this section, we introduce three immediately useful ones: `-dump`, `-class`, and `-keep`.

-dump option

The `-dump` option makes XMLC display the DOM tree for a document. This is primarily useful as a learning tool; once you are familiar with XMLC, you will rarely use it.

1. Create a new file called `Simple.html` in the `simpleApp/src/simpleapp/presentation` directory.
2. Add the following HTML to it:

```
<HTML>
<HEAD>
<TITLE>Simple Enhydra Page</TITLE>
</HEAD>
<BODY>
<H1 ID="MyHeading">Ollie Says</H1>
The current time is <SPAN ID="time">00:00:00</SPAN>.
</BODY>
</HTML>
```

3. Change to the `presentation` directory and enter this command:

```
xmlc -dump Simple.html
```

   XMLC displays the following in the shell window:

```
LazyHTMLDocument:
   HTMLHtmlElementImpl: HTML
      HTMLHeadElementImpl: HEAD
         HTMLTitleElementImpl: TITLE
            LazyText: Simple Enhydra Page
      HTMLBodyElementImpl: BODY
         HTMLHeadingElementImpl: H1: id="MyHeading"
            LazyText: Ollie Says
         LazyText: The current time is
         LazyHTMLElement: SPAN: id="time"
            LazyText: 00:00:00
         LazyText: .
```

   Each line shows the DOM object name followed by a colon and then the corresponding HTML tag. If the tag has attributes, they are listed following the tag in name/value pairs. For instance, `HTMLHeadingElement` is the DOM name for the `<H1>` tag, and it has an `ID` attribute with the value "MyHeading."

   The level of indenting shows the object relationships. So, for example, you can see that the first `HTMLHeadingElement` is the child of `HTMLBodyElement`.

-class and -keep options

By default, XMLC creates a class with the same name as the HTML file. So, for `Simple.html`, it would create `Simple.java`. To create a class with a different name, use the `-class` option to specify a name for the class that XMLC creates.

By default, XMLC deletes the Java source file that it creates, leaving only the compiled class file. The source file is useful primarily for understanding how XMLC and the DOM API works. Use the `-keep` option to keep the Java source file.

1 To create a Java object named `SimpleHTML` for the HTML file `Simple.html` and to keep the Java source file, enter this command:

```
xmlc -keep -class simpleapp.presentation.SimpleHTML Simple.html
```

XMLC generates two files: `SimpleHTML.java` and `SimpleHTML.class`.

2 Open `SimpleHTML.java` and look at the generated code.

Within the file, you will find two methods, `getElementMyHeading()` and `getElementTime()`. XMLC recognized the `ID` attributes of the heading and `<SPAN>` tags in `Simple.html` and generated these methods. Look through the file to get an idea of the object that XMLC creates for a very simple document.

3 Once you are done looking at `SimpleHTML.java` and `SimpleHTML.class`, delete them.

You are done exploring how XMLC works for now, but keep your `Simple.html` file because you are going to use it later in this tutorial.

Enhydra programming

This section covers more topics essential to Enhydra application development:

- Maintaining session state
- Adding a new page to the application
- Populating a table
- Adding a business object

Maintaining session state

Because HTTP is a stateless protocol, an application that needs to keep user-specific information across multiple requests must perform session maintenance. For an overview of how Enhydra performs session maintenance, see “Session Manager” on page 20.

Think of the user’s session as a container in which the application can store any information associated with a particular user. The class that you use as the container is `com.lutris.appserver.server.session.SessionData`. It is similar to a hash table in that it has these methods:

- A `set()` method to which you pass a string key and an object to store
- A `get()` method which returns the object, given the string key

Enhydra matches a user to a particular `SessionData` object with a *session key*, a very long randomly-generated character string. When the Enhydra Session Manager first creates a `SessionData` object for a user, it generates a session key and stores it in its internal data structure. Enhydra also gives the session key to the client, either passed as a cookie or appended to the URL. The next time the client makes a request, the Session Manager uses the key to find that user’s `SessionData` object.

Generally, you don’t need to worry about the session key—Enhydra handles all those details for you “under the hood.” You do, however, need to keep track of the

keyword strings that you use to get and set each object you want to save to the session.

To help you understand session maintenance, you are going to enhance your application so that the Welcome page displays the number of times a particular user has accessed it, in addition to the total "hits" on the page. For fun, you'll also display the session key on the page.

1 Add these four lines of HTML just before the closing `</CENTER>` tag in `Welcome.html`:

```
<P>Number of hits from you:
<SPAN ID="PersonalHitCount">no count</SPAN>
<P>Session identifier:
<SPAN ID="SessionID">no count</SPAN>
```

2 Now add this import statement to `WelcomePresentation.java`:

```
import com.lutris.util.*;
```

3 In `WelcomePresentation.java`, add this member property to the `WelcomePresentation` class (just after `hitCount`):

```
final String hits = "HITS";
```

The string "HITS" is the keyword that the application uses to save and recall the hit count information.

4 Add the following code to the `run()` method, placing the line beneath the line you added with the `setTextHitCount` method.

You can find this code in the `SessionMaint.java` file located in the `<enhydra_root>/doc/books/getting-started/samples/` directory.

```
try {
   Integer personalHits =
         (Integer)comms.session.getSessionData().get(hits);
   if(personalHits == null) {
      personalHits = new Integer(1);
   } else {
      personalHits = new Integer(personalHits.intValue() + 1);
   }
   comms.session.getSessionData().set(hits, personalHits);
   // Save personalHits to the user's session.
   welcome.setTextPersonalHitCount( personalHits.toString() );
   welcome.setTextSessionID( comms.session.getSessionKey() );
   // Shows the session key value used for session tracking.
} catch (KeywordValueException e) {
   comms.response.writeHTML("Session access error" + e.getMessage());
}
```

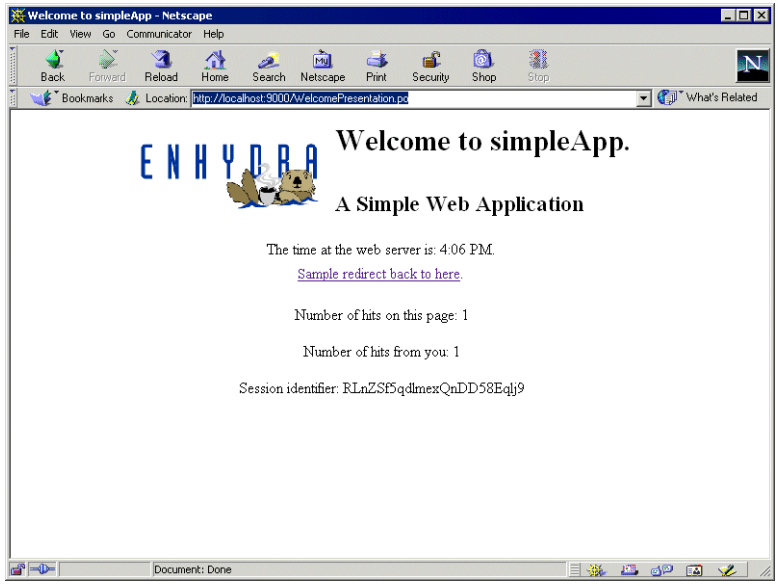
This code begins by calling `getSessionData().get(hits)` to get the value stored for the keyword string "HITS." Because `SessionData` stores only generic `java.lang.Objects`, you have to typecast it to Integer. If the object has not been previously stored in the session, the code creates a new Integer of value 1 (one). If the object exists, the value is incremented.

The code then saves the Integer object back into the session with `setSessionData().set(hits, personalHits)` and writes the value into the Web page with `getSessionKey()`. Normally, you would not need to deal with the session key, but for curiosity's sake this example shows you how to display it.

5 Rebuild and start the application, and access the page with your browser.

The Welcome page displays the total number of hits, as well as the number of hits from a particular client, as well as the client's unique Session Identifier, as shown in Figure 4.8.

Figure 4.8 Browser displaying the simpleApp Welcome page with a Session Identifier



Because you are running the application on your Localhost server, it is not accessible to any other clients, so these numbers will always be the same. However, if the application were running on a "real" server, you would see different numbers depending on how many times you had accessed the page versus the total number of hits. Notice also that the session ID string always stays the same.

Adding a new page to the application

Next, you are going to add a new page (HTML file and presentation object) to your application. You're going to use the little HTML file you created previously, `Simple.html`. In addition to learning how to add a page, you're also going to play around with the DOM a little bit to become more familiar with it.

To create a new presentation object:

1 Copy the file `WelcomePresentation.java` and call it `SimplePresentation.java`.

2 Open `SimplePresentation.java` and change the name of the class from `WelcomePresentation` to `SimplePresentation`.

3 Remove all the session-related code.

4 Change all the occurrences of `WelcomeHTML` to `SimpleHTML`.

5 Change the `welcome` identifier to `simple`.

Now you have a "stripped down" presentation object. The `run()` method should look like this:

```
public void run(HttpPresentationComms comms)
   throws HttpPresentationException, IOException {

   HttpPresentationOutputStream out;
   SimpleHTML simple;
   String now;
   byte[] buffer;

   simple = (SimpleHTML)comms.xmlcFactory.create(SimpleHTML.class);
   now = DateFormat.getTimeInstance(DateFormat.SHORT).format(new Date());
   simple.getElementTime().getFirstChild().setNodeValue(now);
   buffer = simple.toDocument().getBytes();
   comms.response.setContentType( "text/html" );
   comms.response.setContentLength( buffer.length );
   out = comms.response.getOutputStream();
   out.write(buffer);
   out.flush();
}
```

6 Add these statements at the top of the file, after the other `import` statements:

```
import org.w3c.dom.*;
import org.w3c.dom.html.*;
```

7 Add the following lines just *before* the last statement in the `run()` method:

```
HTMLHeadingElement heading = simple.getElementMyHeading();
heading.setAttribute( "align", "center" );
Text heading_text = (Text) heading.getFirstChild();
heading_text.setData( "Mr. Ollie Otter says:" );
```

This code does the following:

- Gets the `HTMLHeadingElement` object named `MyHeading` from the DOM
- Sets its `ALIGN` attribute to `CENTER` to center the heading on the page
- Gets the child object of the heading (a `Text` object)
- Sets a new value for the text string, "Mr. Ollie Otter says:"

You could have done the same thing by putting a `<SPAN>` tag around the text in the heading. XMLC would then have generated a `setTextMethod()` that you could have called in the code. This example, however, illustrates how to do it with the DOM.

Note This code performs some low-level DOM manipulation that you should normally not do in your application because it violates the separation of presentation and business logic. It is only presented here to help explain the DOM.

8 Edit `Makefile` in the `presentation` directory and add the new files to the `CLASSES` and `HTML_CLASSES` variables to make them look like this:

```
CLASSES = \
   RedirectPresentation \
   WelcomePresentation \
   SimplePresentation
HTML_CLASSES = \
   WelcomeHTML \
   SimpleHTML
```

When you run `make` in the `presentation` directory, the `HTML_CLASSES` variable is passed to the XMLC `-class` option to create the specified classes. This is what you did when you ran XMLC from the command line, using the `-class` option. The Lutris convention is to create `fooHTML` class for a file `foo.html`. This convention is defined in the following file:

`<enhydra_root>/lib/stdrules.mk`

9 Save all files and run `make` in the `presentation` directory to build the package.

By default, packages are generated in the `classes` subdirectory off of the application root directory, `simpleApp` in this example. Look in the `classes/simpleapp/presentation` directory to see the generated class files.

To create a link from the Welcome page to your new page:

1 Add the following HTML at the bottom of `Welcome.html`:

```
<A HREF="SimplePresentation.po">Go to Simple Page</A>
```

2 If you have not already done so, stop your Multiserver by pressing *Ctrl-C* in the shell window, and build the application from the top level:

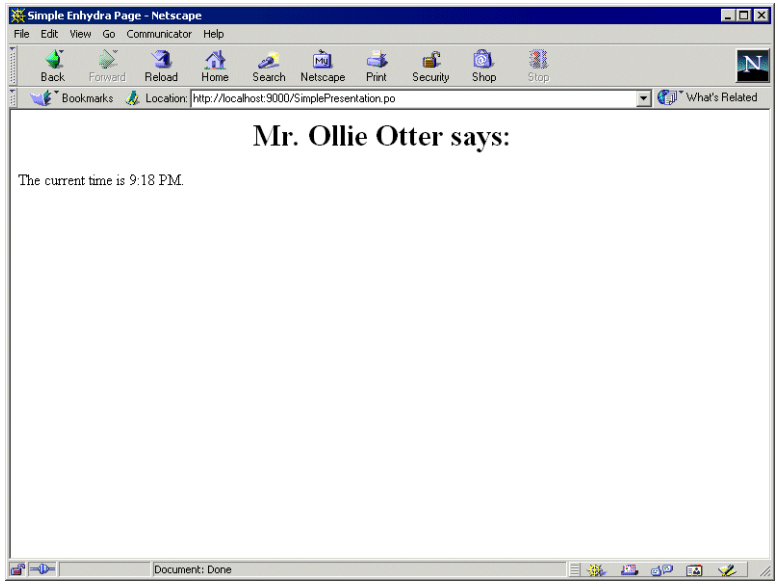
```
cd /enhydra/myapps/simpleApp
make
cd output
./start
```

3 Now access the application from your browser, as you did before.

4 Click the Go to Simple Page link to view the SimplePresentation PO.

The Simple presentation object has only a heading and the current time. You're going to make this page more interesting in the next section.

Figure 4.9 Browser displaying the simpleApp Simple presentation object



Populating a table

Another common task in Web application development is populating an HTML table with dynamic data. This section discusses populating a table using a static `String` array as the data source. In a later section, you will modify the code to get data from a database.

Follow these steps to populate a table:

- Create the table in HTML
- Programmatically populate the table
- Rebuild and run the application

Create the table in HTML

In the `Simple.html` file, create an HTML table with a template row and an `ID` attribute.

1 Edit the file `presentation/Simple.html` in your `simpleApp` project.

2 Add the HTML shown below just before the end of the `<BODY>` tag.

Note If you don't want to type in all this HTML, you can copy and paste it from `<enhydra_root>/doc/books/getting-started/samples/TableCode.html`.

```
<H2 align=center>Disc List</H2>
<TABLE border=3>
   <TR>
      <TH>Artist</TH> <TH>Title</TH> <TH>Genre</TH>
      <TH>I Like This Disc</TH>
   </TR>
   <TR id=TemplateRow>
      <TD><SPAN id=Artist>Van Halen</SPAN></TD>
      <TD><SPAN id=Title>Fair Warning</SPAN></TD>
      <TD><SPAN id=Genre>Good Stuff</SPAN></TD>
      <TD><SPAN id=LikeThisDisc>Yes</SPAN></TD>
   </TR>
</TABLE>
```

This HTML contains a table with a single "template" row (in the second `<TR>` tag). Notice that both this row and the `<SPAN>` tags enclosing the cell contents have `ID` attributes. This is called a *template row*, because it is used as a model from which you construct further rows of the table.

Programmatically populate the table

To programmatically populate the table, edit the presentation object corresponding to `Simple.html`. In the following steps, you will add code to `Simple.java` to iteratively replace the HTML table elements with text from an array of strings.

1 Copy the file `<enhydra_root>/doc/books/getting-started/samples/TableCode.java`. into your application's `presentation` directory and rename it `SimplePresentation.java`.

Note If you like, you can save your old `SimplePresentation.java` to `SimplePresentation.sav` for future reference.

2 Now, look at your new `SimplePresentation.java`.

In addition to the standard features of a presentation object, the first thing you'll notice in this code is a member property that is an array of strings representing the content the application will use to populate the table. This array takes the place of a database result set for this example:

```
String[][] discList =
   { { "Felonious Monk Fish", "Deep Sea Blues", "Jazz", "Yes" },
      { "Funky Urchin", "Lovely Spines", "Techno Pop", "Yes" },
      { "Stinky Pups", "Shark Attack", "Hardcore", "No" } };
```

The next new section of code gets the document objects for the table elements:

```
HTMLTableRowElement templateRow = simple.getElementTemplateRow();
HTMLElement artistCellTemplate = simple.getElementArtist();
HTMLElement titleCellTemplate = simple.getElementTitle();
HTMLElement genreCellTemplate = simple.getElementGenre();
HTMLElement likeThisDisc = simple.getElementLikeThisDisc();
```

The next section of code removes the `ID` attributes from these objects. The reason for this is that the DOM requires that each ID in the document to be unique. When you make a copy of the table row, you would otherwise have duplicate IDs.

The `removeAttribute()` method removes the attribute with the specified name:

```
templateRow.removeAttribute("id");
artistCellTemplate.removeAttribute("id");
titleCellTemplate.removeAttribute("id");
genreCellTemplate.removeAttribute("id");
likeThisDisc.removeAttribute("id");
```

Then, a call to `getParentNode()` gets a reference to the table document object, which you'll be using later:

```
Node discTable = templateRow.getParentNode();
```

Next comes the heart of the code, a `for` loop that iterates through each "row" in the "result set," puts text in each cell in the table row, and then appends a copy (or *clone*) of the row to the table:

```
for (int numDiscs = 0; numDiscs < discList.length; numDiscs++) {
   simple.setTextArtist(discList[numDiscs][0]);
   simple.setTextTitle(discList[numDiscs][1]);
   simple.setTextGenre(discList[numDiscs][2]);
   simple.setTextLikeThisDisc(discList[numDiscs][3]);
   discTable.appendChild(templateRow.cloneNode(true));
}
```

That last statement is crucial: The `cloneNode()` method creates a copy of the `Node` object that calls it; in this case, `templateRow`. The boolean argument `true` determines if it copies only the node itself or the node and all its children, and their children, and so on. In this example, the argument is `true` because you want to copy the row and its child nodes (the table cells and the text inside them).

Finally, `removeChild()` removes the template row from the table. This ensures that the "dummy data" in the template does not show up in the runtime page.

```
discTable.removeChild(templateRow);
```

Rebuild and run the application

Now rebuild the application and load the page in your browser.

1 If you have not already done so, stop your Multiserver by pressing *Ctrl-C* in the shell window, and build the application from the top level:

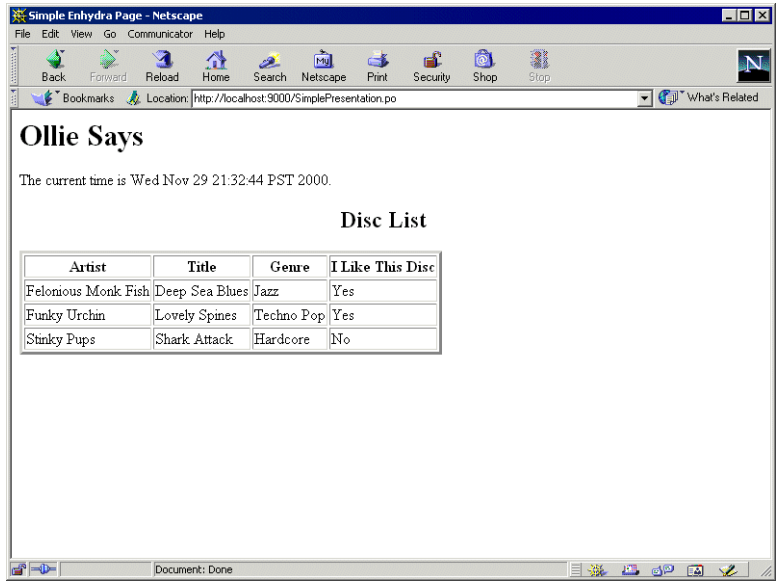
```
cd /enhydra/myapps/simpleApp
make
cd output
./start
```

2 Now access the application from your browser, as you did before.

3 Click the Go to Simple Page link to view the new SimplePresentation PO.

The Simple presentation object now includes a Disc List table, as shown in Figure 4.10.

Figure 4.10 Simple PO with a programmatically populated Disc List table



Adding a business object

So far, your application has three objects: the `SimpleApp` application object, and two presentation objects, `Welcome` and `Simple`. Now, you are going to add a business object that you will use in the following sections. This will not change what the application displays.

The business object represents a list of discs. This is not terribly useful, but it does illustrate a basic role of business objects as you proceed.

To add a business object:

1. Create a new file called `SimpleDiscList.java` in the `business` directory, `simpleApp/src/simpleapp/business`. Because `SimpleDiscList.java` is in your application's business package, the first line in the file will be:

   ```
   package simpleapp.business;
   ```

2. Add the following lines (cut and paste the array initializer from the `Simple` class, but be sure to add the underscore (_) in front of the identifier `discList`) in the body of the run method:

   ```
   public class SimpleDiscList {
      String[][] _discList =
         { { "Felonious Monk Fish", "Deep Sea Blues", "Jazz", "Yes" },
          { "Funky Urchin", "Lovely Spines", "Techno Pop", "Yes" },
          { "Stinky Pups", "Shark Attack", "Hardcore", "No" } };
         public SimpleDiscList() {
      }
      public String[][] getDiscList() {
          return _discList;
      }
   }
   ```

3. To ensure that this file gets compiled when you build the project, edit the make file, `Makefile`, in the `business` directory and add the name of the file to the `CLASSES` variable:

   ```
   CLASSES =   \
   SimpleDiscList
   ```

   This make file is automatically included by the top-level make file, so this simple coding is all you have to do to add the file to the project. Make sure the file compiles by entering `make` in the `business` directory.

4. Now, back in the `presentation` directory, edit `SimplePresentation.java` as follows:

   1. Import the new class:

      ```
      import simpleapp.business.SimpleDiscList;
      ```

   2. Add these two lines to create an instance of your new business object, and call it `getDiscList()` method. These lines take the place of the static array initializer in the previous section.

      ```
      SimpleDiscList sdl = new SimpleDiscList();
      String[][] discList = sdl.getDiscList();
      ```

5. Rebuild and test your application.

You won't see anything different, but you have extracted some functionality out of the presentation object into the new business object. This will come in handy in an upcoming section, when you replace the static array with a real database query. In that case, you won't have to change your presentation class because the business object provides a buffer between it and the data layer.

Connecting the application to a database

Enhydra uses Java Database Connectivity (JDBC), a standard Java API, to communicate with databases. Enhydra can connect to any JDBC-compliant database, such as Oracle, Sybase, Informix, Microsoft SQL Server, PostgreSQL, and InstantDB.

Before you can proceed to connect the application to a database, you are going to take a brief detour to lay some groundwork. In particular, you are going to:

- Create the database table used by the application
- Establish and test the JDBC connection to your database
- Configure Enhydra's Database Manager to connect to your database through JDBC

Important For this section of the tutorial, it is assumed that you have installed InstantDB and set the `CLASSPATH` environment variable to include the InstantDB JAR files. Refer to the Lutris Enhydra CD for installation instructions. If you choose to use a different database, you must edit the `CLASSPATH` accordingly.

Creating a database table

The remainder of this section requires the existence of a specific table in your database, so you need to create that table before proceeding. This section tells you how to create a table in your InstantDB database.

Note Most databases provide a tool for directly executing SQL statements. For example, InstantDB provides ScriptTool and Oracle supplies SQL*Plus. It is important to note, however, that the SQL format varies from database to database. The SQL sample provided for this part of the tutorial works with InstantDB, and may not work with other databases.

To create a table in InstantDB:

1. Create a new directory called `data` for your database.

   ```
   cd /enhydra/myapps
   mkdir data
   ```

2. Copy the sample properties file, `sample.prp`, from the InstantDB `Examples` directory into your `data` directory, and rename it `simpleApp.prp`. You can do this from the command line with a command like the following:

   ```
   cd /data
   cp /idb/Examples/sample.prp simpleApp.prp
   ```

3. Copy the `tutorial_create_idb.sql` SQL file located in the samples directory `<enhydra_root>/doc/books/getting-started/samples`, into your `data` directory. For example, the copy command might look like the following:

   ```
   cp /usr/local/lutris-enhydra3.5/doc/books/getting-started/samples/tutorial_create_idb.sql
   ```

   This SQL file contains a `CREATE TABLE` statement to create a simple table, LE_TUTORIAL_DISCS, and some `INSERT` statements to populate the table with data. This is the table you are going to use in the following sections of this tutorial.

4 From the command line, enter the following command to run the ScriptTool using the `tutorial_create_idb.sql` file as input to create the LE_TUTORIAL_DISCS table.

```
java org.enhydra.instantdb.ScriptTool tutorial_create_idb.sql
```

Look in the `data` directory and notice the changes. New directories have been created, including a `tables` directory.

Note The samples directory contains a SQL file for Oracle databases. Here is the command to create a table in Oracle using SQL*Plus and the supplied SQL file:

```
SQL> @<enhydra_root>/doc/books/getting-started/samples/tutorial_create.sql
```

5 Use InstantDB's DBBrowser to verify that the table was created correctly.

1 Enter the following command to start DBBrowser:

```
java -Xms16m -Xmx32m org.enhydra.instantdb.DBBrowser
```

2 In DBBrowser, click Browse to select a database. Locate and select `simpleApp.prp` and click Open.

3 Click Connect to connect to the database.

4 Select LE_TUTORIAL_DISCS from the Tables column, and click Submit to query the database.

The default query is SELECT * FROM LE_TUTORIAL_DISCS, and DBBrowser should display the following table data in response.

```
Rockin Apps,Enhydra Orchestra,Rock and Roll,1
Beethoven Symphony No.9,LA Philharmonic,Classical,1
Material Girl,Madonna,Modern Rock,0
```

5 Click Disconnect to disconnect from the simpleApp database, and then close DBBrowser.

Note The `samples` directory contains a SQL file, `tutorial_create.sql`, that works with Oracle databases. Here is the command for Oracle SQL*Plus:

```
SQL> @<enhydra_root>/doc/books/getting-started/samples/tutorial_create.sql
```

If you are using a database other than InstantDB, see your database documentation for instructions on how to execute a SQL file or create tables.

Establishing a JDBC connection

Before you can create a database application, you need to establish a JDBC connection from your system to the database server, which may be running on a different system. This section tells you how to write and execute a simple standalone program to establish a JDBC connection to the database server. Starting with a standalone program lets you isolate any problems that may occur. If you have already configured JDBC on your system, you can skip this section.

In our simple program, we will do the following:

- Load the JDBC driver
- Get a database connection using the appropriate *connection string*
- Create a statement object

- Run a query
- Print the results

For the program to run, you must have installed and configured your database, and created the LE_TUTORIAL_DISCS table.

Note This example works specifically with InstantDB. If you want to adapt the program to work with another database, you will need to change the driver information in the program, as well as the connection string. Refer to Appendix A, "Database configurations," for configuration information for other databases.

Windows The Cygnus tools require the JDBC driver to be on the C drive, so make sure the JDBC driver library is on that drive.

To use this program:

1. Create a `jdbcTest` directory for the test program and make it the current directory. For example, to create the new directory in the `tmp` directory for your database, you might use the following commands:

```
cd /enhydra/myapps/data/tmp
mkdir jdbcTest
cd jdbcTest
```

2. Copy `JDBCTest.java` from the `samples` directory into the new directory using the `cp` command. For example,

```
cp usr/local/lutris-enhydra3.5/doc/books/getting-started/samples/JDBCTest.java
```

Look at the program code to verify the JDBC driver and connection string. The JDBC driver and the connection string are shown in **bold** in the following code sample from the program.

```
import java.sql.*;

public class JDBCTest {
   public static void main( String[] args ){
      Connection con  = null;
      Statement  stmt = null;
      ResultSet  rs   = null;
// Load the driver, get a connection, create statement, run query, and print.
      try {
         // To test with a different database, replace JDBC driver information below
         Class.forName("org.enhydra.instantdb.jdbc.idbDriver");
         /* To test with a different database, provide appropriate connection data
                           (e.g., database connection string, username, and password) */
         con = DriverManager.getConnection(
      "jdbc:idb:/enhydra/myapps/data/simpleApp.prp");
         stmt = con.createStatement();
         rs = stmt.executeQuery("SELECT * FROM LE_TUTORIAL_DISCS");
         rs.next();
         System.out.println("Title = " + rs.getString("title") +
            " -- Artist = " + rs.getString("artist"));
                        con.close();
      }
      catch(ClassNotFoundException e) {
         System.err.println("Couldn't load the driver: "+ e.getMessage());
      }
      catch(SQLException e) {
         System.err.println("SQLException caught: " + e.getMessage());
      }
   }
}
```

3 Edit the JDBCTest.java, if necessary, to update the connection string.

These appear in the call to getConnection(), the second statement in the try block (see the previous code example).

4 Compile the file using the javac command:

```
javac JDBCTest.java
```

5 Run the program:

```
java JDBCTest
```

If you have populated the table as instructed previously, you will see the following in the shell window:

```
main SELECT * FROM LE_TUTORIAL_DISCS
Title = Rockin Apps -- Artist = Enhydra Orchestra
Database simpleApp is shutting down...
Database simpleApp shutdown complete.
```

If there was an error, you will see some exception messages in the shell window that should help you isolate the problem. Refer to your database JDBC documentation, and confirm your database driver and connection string information. The Enhydra mailing list is also a useful resource. See "Enhydra.org mailing lists" on page 7 for additional information about mailing lists.

Configuring the application to use JDBC

To make the JDBC classes available to your Enhydra application, you must put the JDBC driver in the CLASSPATH system variable. It is a good idea to set the CLASSPATH in your application's start script. This prevents conflicts in the event that you have multiple applications using different drivers. This also makes your application more portable.

There are two copies of the start script: the template start.in is located in the application's input directory, and start is in the output directory. As with configuration files, building the application overwrites the start script in the output directory with the template file. Therefore, set the CLASSPATH in the script located in the input directory.

Note Enhydra has its own class loader, so if you put the JDBC driver in the CLASSPATH by specifying it in the application's configuration file, the driver will not work.

To put JDBC drivers in the CLASSPATH for your application:

1 Edit the file simpleApp/input/start.in and add the following lines at the beginning of the section titled "Build up classpath:"

```
CLASSPATH="<JDBC_LIB>"
export CLASSPATH
```

where <*JDBC_LIB*> is the JDBC driver library (generally a .jar or .zip file), including the file path. For example:

```
CLASSPATH=/idb/Classes/idb.jar\;/idb/Classes/jta-spec1_0_1.jar
```

Be careful not to put any blank spaces in this line because they will prevent the script from working properly.

Note For ease of maintenance and greater portability, it is desirable to make the path to your JDBC driver library a variable. This can save time if you change drivers and need to update your `CLASSPATH`. The DiscRack and AirSent example projects both use variables for the path to a JDBC driver library. The example projects are located in the `<enhydra_root>/examples` directory.

Configuring the Database Manager

Now that you have verified your JDBC connection, you need to provide the database connection parameters to your simpleApp application. You do this in the application configuration file, `simpleApp.conf`. In this section, you will edit the template file, `simpleApp.conf.in`. The `make` utility copies this file to the `output/conf` directory after every build.

1 Open `simpleApp/input/conf/simpleApp.conf.in` in a text editor.

2 Add the following lines to the bottom of the file:

```
#-------------------------------------------------------------------------
#                   Database Manager Configuration
#-------------------------------------------------------------------------
DatabaseManager.Databases[] = "simpleApp"
DatabaseManager.DefaultDatabase = "simpleApp"
DatabaseManager.Debug = "false"
DatabaseManager.DB.simpleApp.ClassType = "Standard"
DatabaseManager.DB.simpleApp.JdbcDriver = "org.enhydra.instantdb.jdbc.idbDriver"
DatabaseManager.DB.simpleApp.Connection.Url =
"jdbc:idb:/enhydra/myapps/data/simpleApp.prp"
DatabaseManager.DB.simpleApp.Connection.User = ""
DatabaseManager.DB.simpleApp.Connection.Password = ""
DatabaseManager.DB.simpleApp.Connection.MaxPoolSize = 30
DatabaseManager.DB.simpleApp.Connection.AllocationTimeout = 10000
DatabaseManager.DB.simpleApp.Connection.Logging = false
DatabaseManager.DB.simpleApp.ObjectId.CacheSize = 20
DatabaseManager.DB.simpleApp.ObjectId.MinValue = 99
```

Note This is an example of the configuration file for InstantDB. For information on using your application with other databases, see Appendix A, “Database configurations.”

3 Verify that all the items shown in italics match your connection parameters as follows:

- Verify that the `Databases[]` and `DefaultDatabase` entries are set to `simpleApp`.
- Ensure `simpleApp` is used for the database ID attribute. For example, in the line `DatabaseManager.DB.simpleApp.ClassType = "Standard"`, `simpleApp` is the database ID attribute. Refer to Appendix A, “Database configurations,” for addtional information.
- Verify the JDBC driver entry. This example uses the driver for InstantDB:

  `org.enhydra.instantdb.jdbc.idbDriver`
- Verify the connection string. This example uses a connection string for InstantDB:

  `jdbc:idb:/enhydra/myapps/data/simpleApp.prp`

Note Make sure there is a carriage return at the end of the file; this is required for the file to work properly.

4 Save and close the configuration file.

5 Build the application and propagate your changes by running `make` from the application root directory, `simpleApp`. For example:

```
cd /enhydra/myapps/simpleApp
make
```

Adding data access functionality

Now that you have laid the groundwork, you are ready to add data access to `simpleApp`. This section describes how to add a simple data object with embedded SQL that replaces the static array used in "Populating a table" on page 47. The next section, "Using DODS," describes how to build a "real" data layer for the application using DODS.

First, you are going to create a data object that queries the database.

1 Copy the file `SimpleDiscQuery.java` from `<enhydra_root>/doc/books/getting-started/samples` to your data layer (that is, the `simpleApp/src/simpleapp/data` directory).

2 To ensure that `SimpleDiscQuery.java` gets compiled when you build the project, edit the make file in the `data` directory and add the name of the file to the `CLASSES` variable:

```
CLASSES =   \
SimpleDiscQuery
```

There should not be spaces after the slash (`\`), just a carriage return.

3 Take a look at `SimpleDiscQuery.java`. In particular, notice the import statement right at the top:

```
import java.sql.*;
```

This tells you right away that this class is going to use JDBC. In addition to the constructor, there is only one other method, `query()`, where the object performs most of its real work. The constructor has essentially one statement:

```
connection = Enhydra.getDatabaseManager().allocateConnection();
```

This statement tells the Enhydra Database Manager to allocate a database connection. Then, the `query()` method calls `executeQuery` on the connection to execute the SQL query statement:

```
resultSet = connection.executeQuery("SELECT * FROM LE_TUTORIAL_DISCS");
```

The remainder of the code in `query()` iterates through the result set returned by the `SELECT` statement, and returns it in the form of a `Vector`, `vResultSet`, consisting of a `Vector`, `vRow`, for each row in the result set. Although each row is known to contain only four elements (because there are four columns in the table), the number of rows is unknown in general, which is why the method returns a `Vector`.

However, you will recall that the presentation object `Simple` expects the data to be in the form of a two-dimensional array of Strings. So, the `SimpleDiscList` needs to perform some conversion. Edit the file for the business object you created previously, `SimpleDiscList.java`:

4 Find the file `<enhydra_root>/doc/books/getting-started/samples/SimpleDiscList.java`.

You can simply replace your old `SimpleDiscList.java` with this file, or if you prefer, you can make the changes manually:

- Add two import statements at the top:

```
import simpleapp.data.SimpleDiscQuery;
import java.util.*;
```

- Add a member variable corresponding to the data object:

```
SimpleDiscQuery _sdq;
```

- Replace the body of the `getDiscList()` method with the code in the new file. It converts the Vector of Vectors returned by `query()` to a two-dimensional `String` array that the presentation object expects.

Notice that you did not have to change the presentation object at all. The data object provides a buffer between the presentation object and the data object.

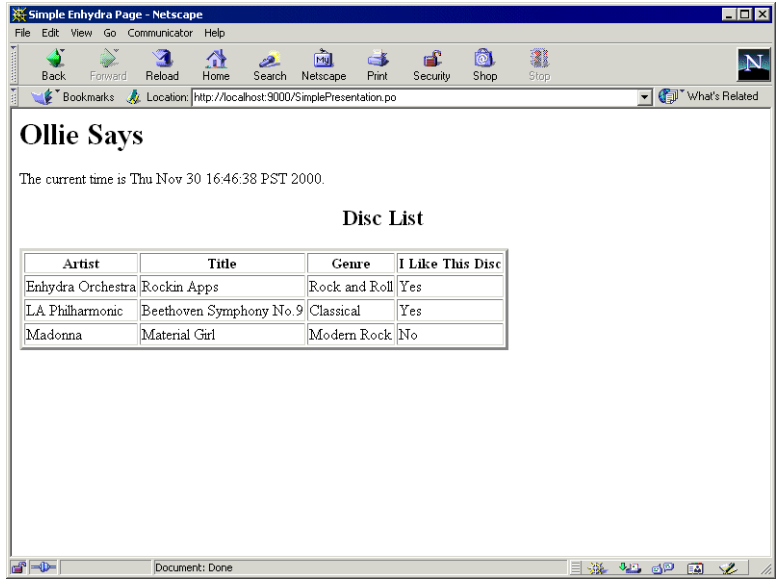
5 Now, build the application from the top level, using the make command.

```
cd /enhydra/myapps/simpleApp
make
```

6 When you get the application to compile, try running it.

The Disc List table in your Simple presentation object should now contain data from your database, as shown in Figure 4.11.

Figure 4.11 Simple PO with a Disc List table generated from the database



You've just created your first database query page. Notice that the discs displayed in the table have the values from the database, not the static array.

Using DODS

The Data Object Design Studio (DODS) is a graphical object-relational mapping tool that generates SQL code to create tables in a database and the corresponding application code to access the tables. DODS creates code that is specific to different databases, so you don't have to learn the nuances of each database. DODS also handles common issues such as transactions and data integrity. DODS is most useful when you are creating a database from scratch, or when you are free to modify the database schema, as explained in "Loading the schema" on page 65.

In the previous section, we created a table, LE_TUTORIAL_DISCS, for information about music selections (discs). In this section, we will build on this theme, using DODS to create a database schema and corresponding data objects that associate an "owner" with each "disc." This theme will be further developed in Chapter 5, "DiscRack sample application."

Note You are not required to use DODS when you develop an Enhydra database application, but it does significantly simplify the process.

Running DODS

This section introduces DODS and gives you a preview of the database schema that we will create in the following section.

1 Start DODS by entering the following command:

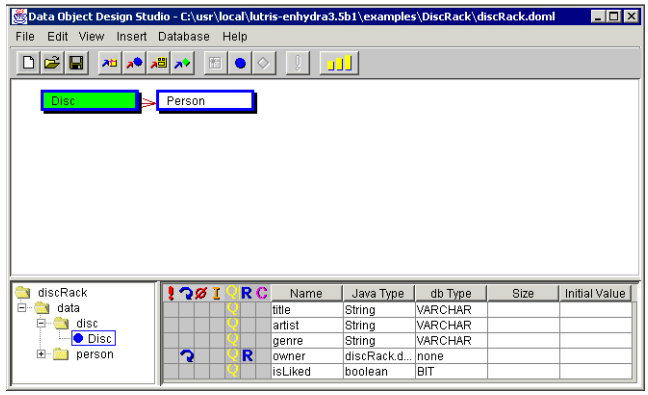
```
dods
```

You will see the DODS graphical interface.

2 Open the DODS file for the DiscRack project by choosing File | Open and selecting `<enhydra_root>/examples/DiscRack/discRack.doml`.

As shown in Figure 4.12, you can expand the directories in the lower left panel to see the package hierarchy for the data model.

Figure 4.12 DODS with the DiscRack.doml loaded



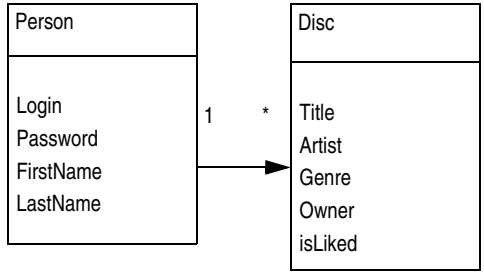
The DODS window has three subpanels:

- At the top, the *object panel* shows the entity-relationship model. Each data object (corresponding to a table in the database) is represented by a box with a name inside. Relationships between data objects are shown by red lines between the boxes.
- In the lower left, the *package panel* displays the package hierarchy in the current data model, with a directory for each object/table in the data model, and a blue dot signifying objects in each package.
- In the lower right, the *attribute panel* shows the attributes (properties or columns) of the selected data object. Each attribute is represented by a row in the grid, with various information associated with the attribute, such as the data type or whether null values are allowed, indicated in columns of the grid.

The schema of the DiscRack database is pictured in Figure 4.12. DODS shows the features common to both the database schema and the object model. For example, the `disc` data object has `title` and `artist` fields, that are the properties (members) of the Java class, as well as the columns of the corresponding database table.

DODS creates Java code for object operations and SQL code for database operations (for example, the one-to-many relationship between person and discs).

Figure 4.13 DiscRack object-model/schema



Creating the data layer

Now you are going to create the data layer for your application from scratch. DODS provides a means to design a data model and then generate the corresponding data-layer classes for an application that uses the Enhydra application framework. DODS also generates the SQL code to create the requisite tables in your database.

The data model in this section will be used for the DiscRack application data layer (see Chapter 5, "DiscRack sample application") with a slight change in the package naming.

Creating the data layer with DODS consists of the following tasks:

- Defining the package hierarchy
- Defining data objects
- Generating the data layer code

Defining the package hierarchy

Defining the package hierarchy within DODS establishes the file structure for the source files that DODS generates.

1 Create a new data model by choosing File | New.

DODS closes any open data model file and starts a new one containing a single package, named "root" by default.

2 Using the Database menu, select your database type.

For example, if you are using Oracle, choose Database | Oracle. This ensures that the SQL statements that DODS generates have the correct syntax for your database. For this example, select Standard JDBC for InstantDB.

3 Now create the package hierarchy:

- Change the name of the root package.

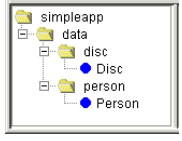
  In the lower left panel, select the `root` folder, then choose Edit | Package. Type the name of this application, `simpleApp`, in the dialog box, then press *Enter*.

- Add the data package by selecting the `simpleApp` folder and choosing Insert | Package. Type `data`, then press *Enter*.

4 Similarly, create `disc` and `person` directories as subdirectories of the `data` directory.

Recall that package names in Java begin with a lowercase letter. The package panel (in the lower left of the window) should now look like this:

Figure 4.14 Package heirarchy



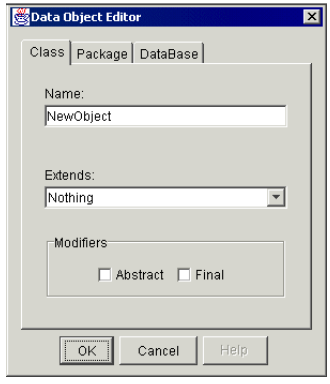
Defining data objects

Data objects in the DODS data model correspond to tables in the database. The attributes defined for data objects describe database columns.

1 Select the `person` package in the lower left pane, then choose Insert | Data Object.

You will see the Data Object Editor dialog box:

Figure 4.15 DODS Data Object Editor dialog box



2 Change the data object defaults as follows:

- In the Class tab, type `Person` in the Name field.
- In the Package tab, select the person package.
- In the DataBase tab, type `Person` in the db Table Name field.

Note that the class name starts with an uppercase letter (Person), while the package name is lowercase (person).

3 Leave the rest of the default values and click OK.

You now have a Person data object in your data model. Later, when you generate the data layer with the Build All command, DODS will generate the code to create a Person table in the database. DODS will also create a Person object that you can incorporate into your application.

4 Select the disc package in the lower left pane, then choose Insert | Data Object.

5 In the Data Object Editor dialog box, change the defaults as follows:

- In the Class tab, type `Disc` in the Name field.
- In the Package tab, select the disc package.
- In the DataBase tab, type `Disc` in the db Table Name field.

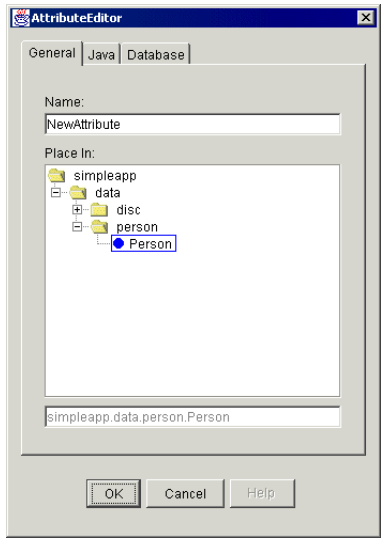
6 Leave the rest of the default values and click OK.

You now have a Disc data object in your data model.

7 Add the login attribute to the Person data object:

1 Select the Person data object (indicated by a blue dot in the simpleApp data model), and click Insert | Attribute to open the Attribute Editor dialog box, as shown in Figure 4.16.

Figure 4.16 DODS Attribute Editor dialog box



2 In the General tab, type `login` in the Name field.

3 In the Java tab, select String from the Java Type pull-down list to set the data type. String is the default Java data type.

Note When a Java data type is selected from the Java Type pull-down list in the Java tab, the corresponding database type is assigned for the db Type field in the Database tab. For example, when you selected String in the Java tab, the db Type field was set to VARCHAR.

4 In the Database tab, leave the db Type as VARCHAR and select Can Be Queried.

5 Leave the rest of the default values and click OK.

Notice that the login attribute appears in the attribute panel in the lower right of the DODS window (see Figure 4.12 on page 59). The fields show the different options you can set in the Attribute Editor. For example, the yellow Q symbol means the data object can be queried. Move the cursor over the other symbols to see what they represent.

8 Repeat the previous step to add the following three more attributes (with Java Type String and db Type VARCHAR) to the Person data object:

- password
- firstname
- lastname

Tip You can use the Add Attribute button on the toolbar to open the Attribute Editor dialog box.

9 Add the following three attributes (with Java Type String and db Type VARCHAR) to the Disc data object, as described in the previous steps:

- title
- artist
- genre

10 Define the owner attribute for the Disc data object.

Adding the owner attribute is a little more complicated than the previous attribute additions because there is a one-to-many relationship between Person and Disc based on the owner attribute.

1. Select the Disc data object and choose Insert | Attribute to open the Attribute Editor dialog box.
2. In the General tab, type `owner` in the Name field.
3. In the Java tab, select simpleapp.data.person.PersonDO from the Java Type pull-down list.
4. In the Database tab, select Can Be Queried and Referenced DO Must Exist options.
5. Click OK to close the Attribute Editor dialog box.

You will notice a red arrow in the interface between the `Disc` object and `Person` object showing that `Disc` uses `Person`. Notice that the attribute pane displays icons indicating that the `owner` attribute has an object reference and a referential constraint.

11 Define the isLiked attribute for the Disc data object.

1. Select the Disc data object and choose Insert | Attribute to open the Attribute Editor dialog box.
2. In the General tab, type `isLiked` in the Name field.
3. In the Java tab, select boolean from the Java Type pull-down list.
4. In the Database tab, select Can Be Queried.
5. Click OK to close the Attribute Editor dialog box.

You have now defined the data objects Person and Disc.

Generating the data layer code

To finish this exercise, save and build the data model.

1 Select File | Save to save the data model file.

Save the data model as `simpleApp.doml` in the top-level application directory (for example, `/enhydra/myapps/simpleApp`).

Note DODS stores the data model specification in a `.doml` file. DOML stands for Data Object Meta Langauge. The specification has an XML-like syntax.

Now that you have defined all the data objects, DODS is ready to generate and compile the code. The Build All command causes DODS to overwrite the existing

data directory with all the new information from the data model, so if you want to save your old data layer code, copy it to another directory.

2 Select File | Build All to open the Destroy and Create New DODS Directory dialog box.

1 Select the data directory of your simpleApp project (for example, /enhydra/myapps/simpleApp/simpleApp/data).

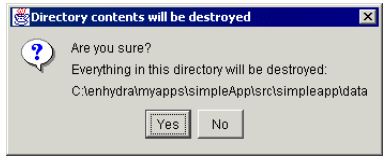
Important

Navigate to the directory that contains the business, data, and presentation directories. For example, navigate to /enhydra/myapps/simpleApp/src/simpleapp (simpleapp will be displayed in the Look In field). Single-click the data directory to select it; do not double-click the data directory.

2 Choose the Re/Create Directory button.

You will see the following warning:

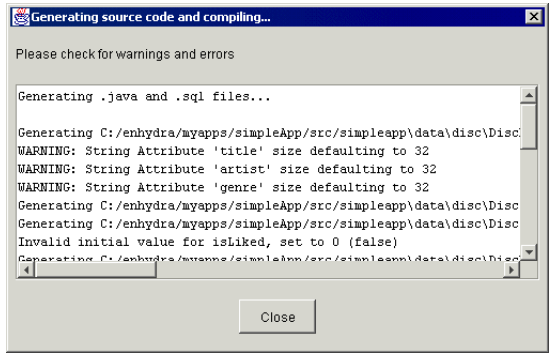
Figure 4.17 DODS Re/Create Directory warning box



3 Click Yes, and begin the build.

DODS aligns the directory structure in the GUI with the directory structure in the project, generates Java and SQL files, and then runs make to build the data layer. As it proceeds, DODS displays messages in a dialog box. For example:

Figure 4.18 DODS Build All message dialog box



If the build is successful, you will see the message DODS BUILD COMPLETE. If the build fails, look at the messages in the output screen. Verify that the paths of the files are correct. You can also search the .doml file for clues, because it is easy to read.

DODS generates the following files and subdirectories in the data directory:

- disc and person directories, which contain the Java code for the disc and person data objects, respectively, and an SQL file defining the corresponding database table

- `create_tables.sql` and `drop_tables.sql` files, which contain standard SQL statements to create and remove the disc and person tables from a database, respectively
- Two make files—`Makefile` and `config.mk`
- `classes` directory, which is initially empty

Each data object directory contains Java source files to create four classes. For example, the `person` data object directory contains `personDO`, `personDOI`, `personQuery`, and `personDataStruct`. The data object and the query classes are the most commonly used classes.

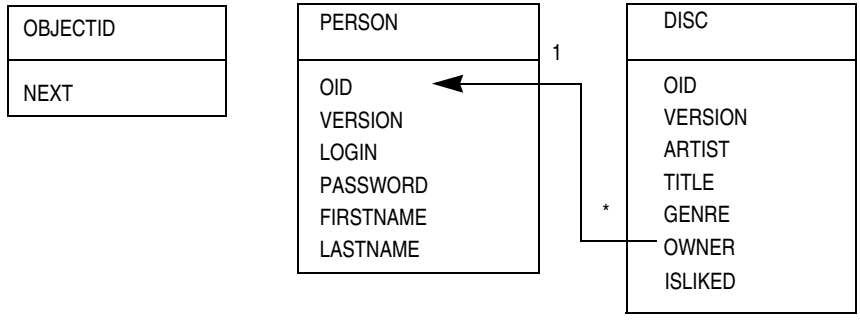
DODS also generates make files for the data layer. This lets you compile the data layer independently or along with the entire project. The empty `classes` directory is used only if you compile the data layer separately.

The next step in the process is to run the SQL script that DODS generated to create the tables in the database. You will do this in the next section.

Loading the schema

Figure 4.19 illustrates the complete schema generated by DODS:

Figure 4.19 DiscRack database schema generated by DODS



Notice there are some differences from the original database schema:

- DISC and PERSON tables have two additional fields, OID and VERSION
- There is a third table, OBJECTID, that contains one column, NEXT, with a single row

The OID column is the primary key for each table created by DODS. The application code generated by DODS ensures that every row has a value of OID that is unique within the database. Whenever a new row is added to a table, the application generates a unique object ID to put in the OID column. It uses the OBJECTID table to keep track of the next object ID to be assigned.

DODS application code uses the VERSION column in each table to ensure that the data an application is updating is accurate. Because many users can be accessing the database simultaneously, a record can change between the time an application retrieves it and when the application attempts to change the record.

Every time an application updates a row, it increments the VERSION column in the database. The application qualifies updates on both the VERSION and OID columns—if it finds that there are no rows that have the expected values, then it knows that another process has changed the row it is trying to update, and it throws an exception. You can catch the exception in your application code to handle such situations appropriately.

Running the DODS-generated scripts

To load the SQL scripts that DODS creates, follow these steps:

1 Open the `create_tables.sql` file in the `<simpleApp_root>/simpleApp/data` directory.

The file contains the SQL CREATE TABLE commands to create the PERSON, DISC, and OBJECTID tables:

```
/* This SQL was generated for a Standard database. */
create table Person
(
/* class Person */
   login VARCHAR(32) DEFAULT "" NOT NULL   ,
   password VARCHAR(32) DEFAULT "" NOT NULL   ,
   firstname VARCHAR(32) DEFAULT "" NOT NULL   ,
   lastname VARCHAR(32) DEFAULT "" NOT NULL   ,
   oid DECIMAL(19,0) NOT NULL PRIMARY KEY,
   version INTEGER NOT NULL
);

/* This SQL was generated for a Standard database. */
create table Disc
(
/* class Disc */
   title VARCHAR(32) DEFAULT "" NOT NULL   ,
   artist VARCHAR(32) DEFAULT "" NOT NULL   ,
   genre VARCHAR(32) DEFAULT "" NOT NULL   ,
   owner DECIMAL(19,0)  NOT NULL  REFERENCES Person ( oid ) ,
   isLiked INTEGER DEFAULT 0 NOT NULL   ,
   oid DECIMAL(19,0) NOT NULL PRIMARY KEY,
   version INTEGER NOT NULL
);

create table objectid(
   next DECIMAL(19,0) NOT NULL
);
```

Note DODS may generate SQL files that are not fully compatible with your database server. You may have to edit the file manually to remove extraneous text that may be causing errors when reading the file. For example, for Oracle, you may have to remove extra blank lines.

2 If necessary, edit `create_tables.sql` to work for your database.

The samples directory (`<enhydra_root>/doc/books/getting-started/samples/`) contains a `create_tables.sql` file that has been edited to work with InstantDB. The following changes were needed for the file work with InstantDB :

1 Add the following lines to the top of the file to load the JDBC driver and open the database:

```
d org.enhydra.instantdb.jdbc.idbDriver;
o jdbc:idb=<database_path>;
```

For <*database_path*> enter the location of your database properties file. For example, /enhydra/myapps/data/simpleApp.prp.

2 Put an e before each SQL statement. For example, create table Disc becomes e create table Disc.

3 Replace double quotes ("") with single quotes ('').

4 Add the following line at the end of the file to close the database:

```
c close;
```

You can configure many things about the SQL that DODS generates in the configuration file <*enhydra_root*>/dods/dods.conf. For example, by default DODS generates C-style comments, but you can change the style of comments if your database requires a different format.

3 Load the tables into the database.

For InstantDB, the command to load the SQL file using ScriptTool is:

```
java org.enhydra.instantdb.ScriptTool create_tables.sql
```

For Oracle, the command for SQL*Plus is:

```
SQL> @<simpleApp_root>/simpleApp/data/create_tables.sql
```

4 Add some dummy data to the database for testing purposes.

For InstantDB, use ScriptTool and the supplied tutorial_insert_idb.sql file (located in <*enhydra_root*>/doc/books/getting-started/samples) to add data to the database:

```
java org.enhydra.instantdb.ScriptTool tutorial_insert_idb.sql
```

For Oracle, use SQL*Plus and the supplied tutorial_insert.sql:

```
SQL> @/<enhydra_root>/doc/books/getting-started/samples/tutorial_insert.sql
```

Note The supplied files tutorial_insert_idb.sql and tutorial_insert.sql contain some sample data, including one person and three discs.

Using the DODS data objects

Now all you need to do is modify the business object, SimpleDiscList, to use the DODS data objects instead of the simplified object, SimpleDiscQuery.java, you created previously.

1 Replace SimpleDiscList.java in your application's business directory with SimpleDiscList_DODS.java from the <*enhydra_root*>/doc/books/getting-started/samples/ directory. Rename the file SimpleDiscList.java.

2 Look at the code in the new SimpleDiscList object and compare it to the code in SimpleDiscList.java in the samples directory.

The main difference between the old and new objects is in the `getDiscList()` method. Here is the heart of the method from the new object:

```
...
try {
   DiscDO[] discArray;
   DiscQuery dquery = new DiscQuery();
   discArray = dquery.getDOArray();
   String result[][] = new String[4][discArray.length];
   for(int i=0; i< discArray.length; i++) {
      result[i][0] = (String)discArray[i].getTitle();
      result[i][1] = (String)discArray[i].getArtist();
      result[i][2] = (String)discArray[i].getGenre();
      result[i][3] = discArray[i].getIsLiked() ? "Yes" : "No";
   }
}
return result;
...
```

The code in the new object uses the `DiscQuery` and `DiscDO` objects in the `data.disc` package to get data from the database.

- `DiscQuery` provides a set of methods for querying the DISC table. By default, it performs the equivalent of SELECT * FROM DISC. It has methods that you can use to qualify the query (the WHERE clause of the SELECT statement) and order the result set. The `getDOArray()` method returns an array of `DiscDO` objects returned from the query.
- The `DiscDO` object is the basic data object representing a row of data from the DISC table. It has getter and setter methods for each column in the table. The previous code only uses the getter methods `getTitle()`, `getArtist()`, `getGenre()`, and `getIsLiked()`. The `getIsLiked()` method returns a boolean value, while the other methods return a `string`. For the sake of consistency, the `getIsLiked()` method performs some simple logic to translate the boolean value to the appropriate string.

Running the application

Now we will recompile and run the simpleApp application.

1. Build the application from the top level, using the make command. For example:

   ```
   cd /enhydra/myapps/simpleApp
   make
   ```

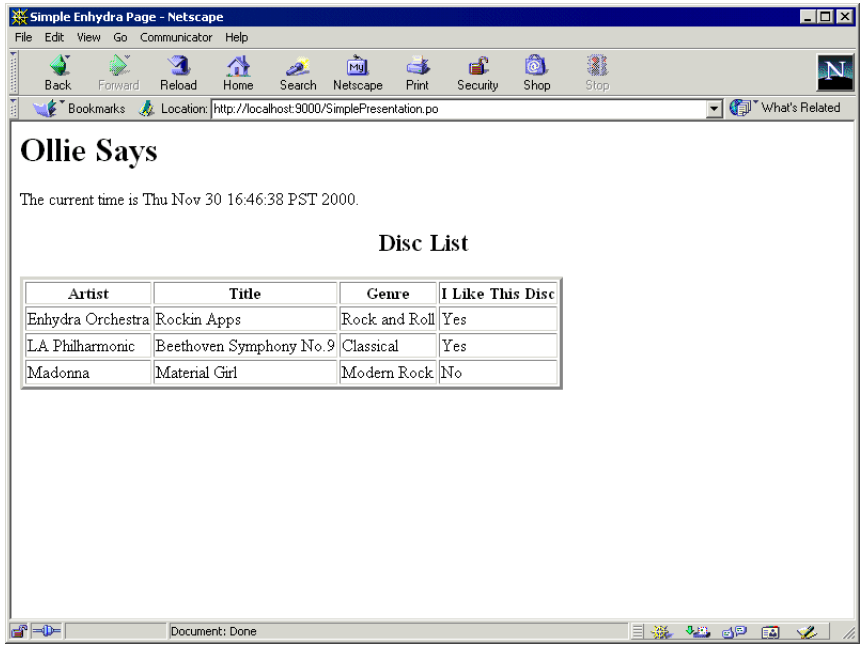
2. Start Enhydra, either by starting the Admin Console (see "Launching the Admin Console") or by entering the following commands in the shell window.

   ```
   cd output
   ./start
   ```

3. Test the application by loading http://localhost:9000 in your browser.

   The Disc List table in your Simple presentation object should now contain data from the Disc table in your database.

Figure 4.20 Simple PO with data from DODS data objects



If you don't see this page, check the following:

1. Look in the `simpleApp.conf` file in the `output` directory to make sure that the database settings are listed correctly.
2. Check the output displayed in the shell window for errors when you start the Multiserver. If the database settings are in `simpleApp.conf` and the JDBC driver is in the application's `CLASSPATH`, there should be no errors listed when Multiserver starts.
3. Re-run the JDBC connection test to verify that the database is correct and JDBC is working.
4. For Oracle databases, try putting the wrong password into the application configuration file. Multiserver should start, but the application will return an SQL exception and a stack trace.
5. Make sure you do not have any extraneous JVMs running. Sometimes, the class loader can fail to find the correct classes if it picks up an old `CLASSPATH` from a running JVM.

Chapter 5

DiscRack sample application

This chapter introduces the DiscRack application, and uses it as a comprehensive example to illustrate key concepts of Enhydra application development.

Building and running DiscRack

Enhydra includes the DiscRack application, which is installed in the `<enhydra_root>/examples/DiscRack` directory. Throughout this chapter, this top-level directory containing DiscRack is referred to as `<DiscRack_root>`.

To build and run DiscRack, you need to make the following modifications to the installed files:

1. Open `config.local.mk.in` in `<DiscRack_root>` and set the `ENHYDRA_DIR` and `JDKDIR` variables to your Enhydra root directory and JDK directory respectively.
2. Copy `config.local.mk.in` to `config.local.mk` in the `<DiscRack_root>` directory.
3. Open the application configuration template file, `discRack.conf.in`, in `<DiscRack_root>/discRack` and make sure all Database Manager configuration settings are correct. See "Configuring the Database Manager" on page 55 and Appendix A, "Database configurations."
4. Build the application by entering the `make` command from the `<DiscRack_root>` directory.

   Building the application will generate all the classes and packages for the DiscRack application.

Note The DiscRack database and corresponding application data layer are identical to the those created in Chapter 4, "Tutorial: Building Enhydra applications," with the exception of package naming. This database schema is loaded for you by default, using an InstantDB database. Alternatively, you can use the Microsoft Access database in `<DiscRack_root>/discRack/data/discRack.mdb`, with the appropriate changes to the Database Manager configuration settings in the application cofiguration file. Refer to Appendix A, "Database configurations," for additional information about using Microsoft Access with your application.

5. To use the default InstantDB database, copy the InstantDB JAR files, `idb.jar` and `jta-spec1_0_1.jar`, into the `<DiscRack_root>/lib` directory.

   The InstantDB drivers are loaded by the DiscRack `start` script.

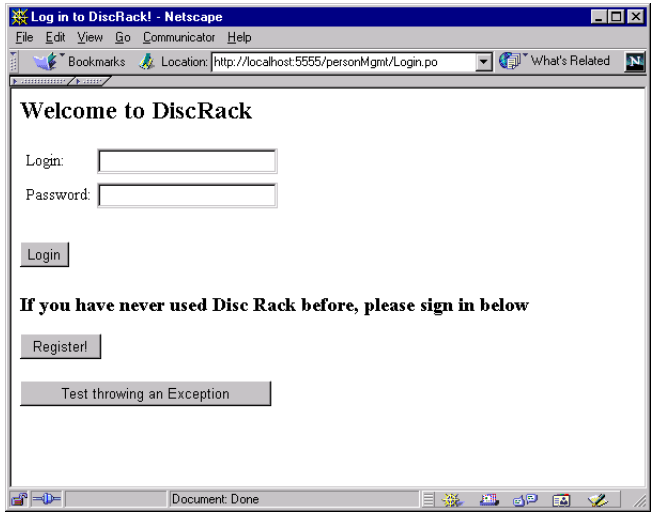
6 To run DiscRack, enter the following commands:

```
cd <DiscRack_root>/output
./start
```

7 To access the application, enter the URL `http://Localhost:5555` in your browser location field.

Your browser displays the following screen:

Figure 5.1 Browser displaying the DiscRack Login presentation object



Play around with the application to get a sense for how it works:

- Click the Register button to add yourself as a user, then add some discs to your inventory.
- Try viewing your inventory and editing one of the discs.

Process and preliminaries for developing applications

Before discussing the workings of the DiscRack application, it is useful to understand how you go about developing an Enhydra application in general. You can adapt the traditional software development process to Enhydra application development to ensure that:

- The application does what it is supposed to do.
- You complete the project in a timely and cost-effective manner.
- The application is easy to maintain and upgrade.

An in-depth discussion of software methodology is beyond the scope of this book, but it is helpful to understand the basic principles and how they apply to the simple DiscRack application, so that you can reap the benefits when developing a more complex, real-world application.

The following process is loosely based on Lutris Technologies' *Structured Delivery Process* (SDP), a rigorous methodology that Lutris developed over the course of many projects. This simplified process may be suitable for small projects. For information on methodology for large, team-development projects, see the SDP information on the Lutris Web site at http://www.lutris.com.

A simplified Enhydra application development process consists of these steps:

- Requirements definition

  As specifically as possible, create a statement of what the application is supposed to accomplish. This statement essentially defines the high-level goals of the application.

- Functional specification

  Outline how the application solves the problem(s) stated in the requirements definition.

- Design and storyboard

  Design the presentation, data, and business layers of the application, then create the storyboard.

- Development and testing

  Code and test the application.

- Deployment

  Package the application and install it in its operational environment.

This abbreviated methodology illustrates the key aspects of the development process. Complex, real-world applications generally call for a more comprehensive process that includes project milestones, cost analysis, documentation, and so on. The following sections illustrate these abbreviated steps.

DiscRack requirements definition

The Otter family needs a way to track their compact disc collections. Each family member has a CD collection, and they sometimes get mixed up: Otters forget who owns what. They decide that an Enhydra application would be the perfect way to help them manage their CDs. After some discussion, they arrive at a brief requirements definition:

> DiscRack will let each user keep track of his or her individual CD inventory by adding, modifying, and deleting CDs as needed. The application will keep track of all the pertinent information about each CD, including artist and title.

DiscRack functional specification

Briefly, DiscRack will meet its requirements as follows:

- Maintain a list of users and passwords

  To access their CD inventory, users must log in with a user name and password.
- Allow new users to sign up by entering their name, a user name, and a password.
- Once logged in, a user can see his or her CD inventory and:
  - Add new CDs to the inventory.
  - Edit existing CD entries.
  - Delete an existing entry, with a confirmation prompt.
- The information that will be displayed for each CD includes artist, title, genre, and whether or not the user likes the CD.

Design and storyboard

The bulk of this step consists of the engineering design for the application, including the design of database schema and corresponding data layer, business logic, and presentation logic. The user interface design can be largely encapsulated by a storyboard.

A *storyboard* is a visual way of describing a user's navigation paths through the application. It provides an outline of the application's user interface, and a framework from which the rest of the application design can proceed.

A conceptual storyboard, which is largely an application flowchart, is sometimes referred to as a *site map*, in contrast to a mocked-up HTML storyboard. This book refers to both as a storyboard. The storyboard for DiscRack is shown in Figure 5.2.

You can see from the storyboard that there are five HTML pages in the application. You can also see that the DiscCatalog page that shows the CD inventory is the central page in the application. The first page the user sees will always be the Login page; the last page will always be the Logout page.

DiscRack includes a working storyboard (or application "mockup") in the `resources` directory. It is a set of static HTML pages that illustrate how the application works. To see the storyboard, load this file in your browser:

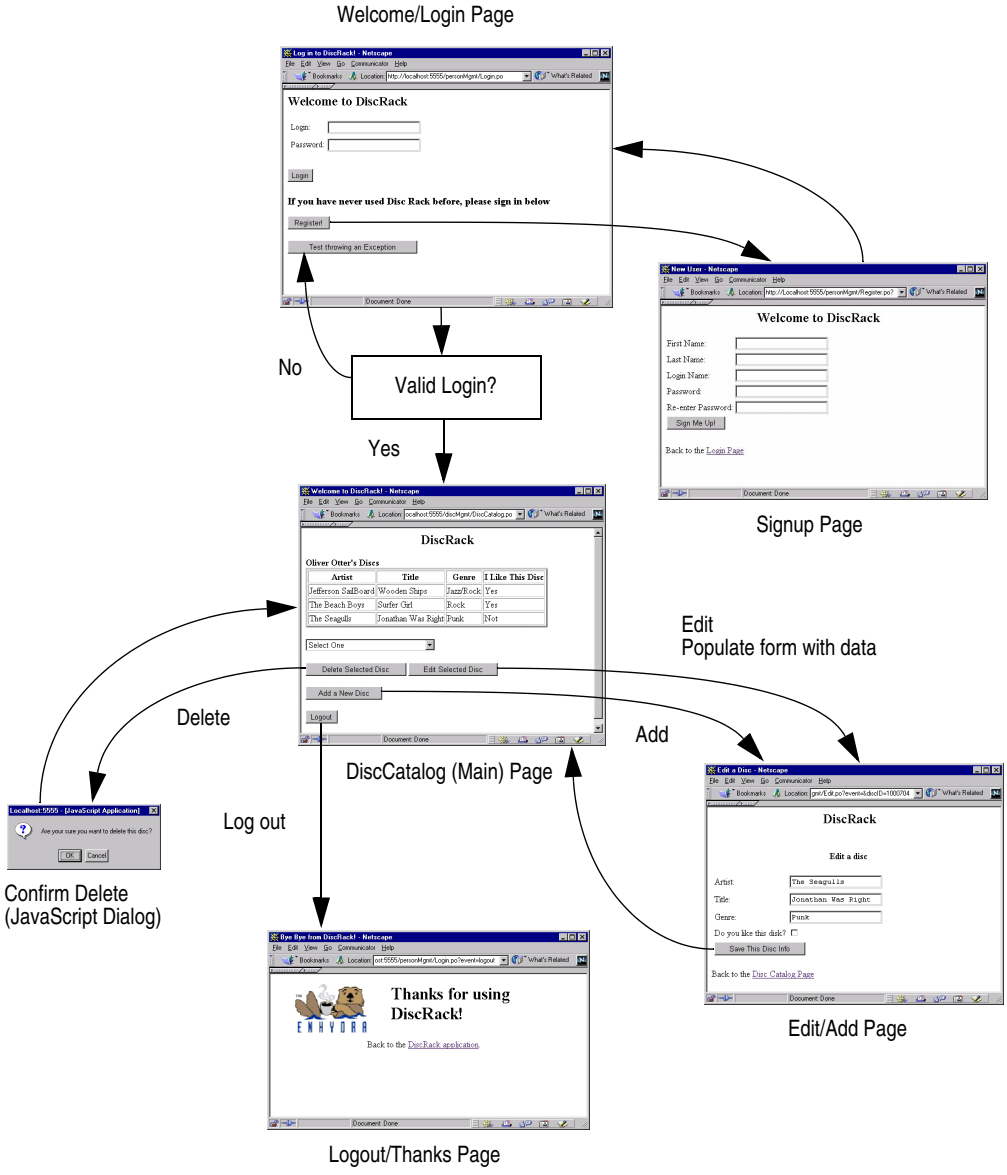
`<DiscRack_root>/discrack/resources/personMgmt/Login.html`

This displays the DiscRack login page.

- Click the Login button to log in and see the disc catalog.
- Click the Sign Up button to display the Signup page.
- Click around on the links to can see the rest of the storyboard.

The flow of the HTML pages follows Figure 5.2. Of course, none of the back-end logic is activated—all the HTML is static. But the storyboard gives you a good feel for how the application works.

Figure 5.2 DiscRack Storyboard



Developing, testing, and deploying

To finish the application process, the remaining steps include developing, testing, and finally deploying.

When you build an application from the top level, the make files create an `output` directory containing the configuration files and the `start` script. Also, there will be a `lib` directory with a `.jar` file that contains all the class files for the application, along with any other files (for example, GIFs or stylesheets).

To deploy the application, you need to copy these files to the server on which you want the application to run, and make the appropriate changes to the configuration files to reflect the new location. Of course, Enhydra must be installed on this server, and you need to have any ancillary libraries (such as your database's JDBC driver) available.

The rest of this chapter describes the DiscRack application itself.

Overview of DiscRack

The basic DiscRack application consists of 23 classes in 9 packages. The fundamental package structure and class functions for DiscRack are described in Table 5.1:

Table 5.1 DiscRack Application Overview

Class or package name	Description
discRack package	
`DiscRack`	Application object
`DiscRackException`	Simple base exception class
Presentation layer/package	
`BasePO`	Abstract base class for all presentation objects
`DiscRackSessionData`	Container for session data
`ErrorHandler`	Class to handle exceptions not caught elsewhere in the application
`DiscRackPresentationException`	Presentation layer exception class
`presentation.personMgmt` package	Package that contains the `Register` and `Login` classes for managing presentation related to the PERSON table
`presentation.discMgmt` package	Package that contains the `Edit` and `DiscCatalog` classes for managing presentation related to the DISC table
Business layer/package	
`DiscRackBusinessException`	Business layer exception class
`business.person` package	Package that contains two classes: • `Person`, which represents a person • `PersonFactory`, which has a single method that returns the `Person` object for a user name

Table 5.1 DiscRack Application Overview (continued)

Class or package name	Description
`business.disc` package	Package that contains two classes: • `Disc`, which represents a disc • `DiscFactory`, which has methods to return a `Disc` object for an ID or for the owner's name.
Data layer	
	Described in "Loading the schema" on page 65.
WAP layer/package	
	The DiscRack example application for Lutris Enhydra includes presentation templates and code for wireless access. These additional presentation templates and code comprise what is referred to as wireless profiles. Refer to Appendix C, "Using the DiscRack wireless profiles," in the *Wireless Application Developer's Guide* for additional information about DiscRack's wireless profiles.

The six HTML files are in the `resources` directory. These correspond to the five HTML pages shown in the storyboard, plus an error page that appears when an error occurs that is not handled by an exception.

Presentation layer

The presentation layer includes all of the HTML, Java, and JavaScript that defines the user interface of the application.

Presentation base class

All of the presentation objects in DiscRack are derived from a common base class, `BasePO`, which is an implementation of the Enhydra interface `HttpPresentation`. This interface has one method, `run()`, which takes the HTTP request as a parameter.

A presentation base class enables the application to group common functionality in one place. Notice that `BasePO` is an abstract class, so it cannot be instantiated itself, only subclassed. Also, some of its methods are declared abstract, so subclasses must implement them.

`BasePO` has methods to handle some of the key tasks for DiscRack:

- User log in and session maintenance
- Event handling and calling the HTML generation methods in the subclass presentation objects

Note It is important to realize that you are not required to use a base presentation class. An alternative is to use the Enhydra Application object to perform common tasks.

The central method in `BasePO` is `run()`, which makes method calls to perform session maintenance and event handling:

```
public void run(HttpPresentationComms comms) throws Exception {
   // Initialize new or get the existing session data
   initSessionData(comms);
   // Check if the user needs to be logged in for this request.
   if(this.loggedInUserRequired()) {
      checkForUserLogin();
   }
   // Handle the incoming event request
   handleEvent(comms);
}
```

Every time a client browser requests a presentation object URL, the application calls `run()`. Its logic is very simple:

- Initialize or get the existing session data by calling `initSessionData()`.
- If this presentation object requires a log in (as determined by `loggedInUserRequired()`, an abstract method implemented by each presentation object), then call `checkForUserLogin()` to determine if the user has already logged in. If not, then redirect the browser to the login page.
- Call `handleEvent()` to handle the current event and determine what HTML to generate.

Each of these methods is explained in the following sections.

The `run()` method has one parameter, `comms`, that is an object containing information about the HTTP request. Its member properties include `application`, `exception`, `request`, `response`, `session`, and `sessionData`. These six properties provide all of the information for the request.

For example, you can retrieve session data with `getComms().sessionData.get()` and query string parameters with `getComms().request.getParameter()`.

Session data and log in

The basics of Enhydra session maintenance were introduced in "Maintaining session state" on page 42. In contrast to the way session information was handled in that example, DiscRack stores all its session information in a single `DiscRackSessionData` object and saves that object in the user's session.

`DiscRackSessionData` is a simple container class containing methods to get and set these member properties:

- A `Person` object that represents the user
- A string, called `userMessage`, for error messages such as "Please choose a valid disc to edit"

There are several advantages of keeping session data in one object:

- It centralizes control of session information.

  This is especially helpful when multiple presentation objects access the same session data.

- It is type-safe.

  Because `Session.getSessionData()` returns a generic `Object`, if you store session data separately, you will have to cast each item to the appropriate type, which can lead to runtime errors that are hard to debug.

- It facilitates session data maintenance.

  If there is a large amount of session data, you can periodically clean up the unneeded data. For example, say you wanted to store an array of hundreds of discs in the user's session to speed access, but you didn't necessarily want leave it there until they log out. With a session data object, you could easily implement a method to clean up unneeded data in the session.

initSessionData() method

The first thing each presentation object does is to call `initSessionData()`. The main portion of this method is shown here:

```
Object obj = getComms().sessionData.get(DiscRackSessionData.SESSION_KEY);
if(null != obj) {
   this.mySessionData = (DiscRackSessionData)obj;
} else {
   this.mySessionData = new DiscRackSessionData();
   getComms().sessionData.set(DiscRackSessionData.SESSION_KEY, this.mySessionData);
}
```

The first statement in this code snippet gets the session data object, using the session key "DiscRackSessionData." If the session data object exists, it gets typecast to `DiscRackSessionData`; otherwise, the code creates a new `DiscRackSessionData` object and saves it to the user's session with `set()`.

loggedInUserRequired() method

`BasePO` has an abstract method called `loggedInUserRequired()` that returns a boolean value, which indicates whether a user is required to be logged in to access the associated page. Thus, every presentation object is required to implement this method.

In `BasePO.run()`, if this method returns `true`, then `checkForUserLogin()` is called.

checkForUserLogin() method

The `checkForUserLogin()` method determines if a user has a valid login. If not, then it redirects the browser to the Login page:

```
...
Person user = getUser();
if (null == user) {
...
   throw new ClientPageRedirectException(LOGIN_PAGE);
}
...
```

Several statements that write debug messages to a log channel have been removed from this code for clarity.

The call to `getUser()` is really just a call to `getSessionData().getUser()`, which retrieves the `Person` object saved in the current session. If the user has not logged in, or the session has timed out, then this method returns `null`, and the code will throw a `ClientPageRedirectException` with the URL to the Login page as the argument to the constructor.

When a client browser is redirected by a `ClientPageRedirectException`, any parameters from a query string that were available to the original presentation object are lost. So if you want to pass an error message, you must put the information in the user's session or directly into the query string of the redirected URL.

Event handling

While you could create a separate presentation object for each task in an application, in many cases it makes sense to have a single presentation object handle multiple events. For example:

- `Edit` presentation object responds to four events—showing the add page, showing the edit page, actually adding a disc to the database, and deleting a disc from the database.
- `Login` presentation object handles three events—show page, login, and logout.

Note In this context, an "event" refers to the task a user is performing.

Setting the event parameter

DiscRack keeps track of the event it is processing with the `event` parameter, which is sent in the query string of a request. For example, this URL specifies the event `showAddPage`:

```
http://Localhost:8000/discMgmt/Edit.po?event=showAddPage
```

DiscRack illustrates several techniques for setting the event:

- `showAddPage` event is defined in the `DiscCatalog.html` page by the JavaScript onClick event handler of the Add a New Disc button.

  This calls the JavaScript function `showAddPage()`, which explicitly adds the event to the URL requested:

  ```
  document.location='Edit.po?event=showAddPage'
  ```

  This function is defined in `presentation/discMgmt/DiscCatalogScript.html`, not the DiscCatalog page, as explained in "Replacing JavaScript" on page 84.

- `add` event (to add a disc to the database) is defined in the `Edit.html` page by a hidden form field:

  ```
  <input type="hidden" name="event" value="add" id="EventValue">
  ```

  When the user clicks the Add button, `event=add` is added to the form submission request along with the other form data the user entered.

- `exit` event is defined in the `DiscCatalog.html` page by the second form's ACTION attribute:

  ```
  "../personMgmt/Exit.html"
  ```

  At compile time, this URL, as explained in "URL mapping" on page 83, is replaced by:

  ```
  '../personMgmt/Login.po?event=logout'
  ```

Although DiscRack does not demonstrate it, you can also set the event when you throw a `PageRedirectException`. You use this exception to transfer control from one presentation object to another. To specify an event, add this string to the URL string passed to the constructor of `PageRedirectException`:

```
"?event=someEvent"
```

handleEvent() method

Once the event is set, the `handleEvent()` method of `BasePO` performs the actual event handling:

```
String event = getComms().request.getParameter(EVENT);
String returnHTML = null;

if (event == null || event.length() == 0) {
   returnHTML = handleDefault();
} else {
   returnHTML = getPageContentForEvent(event);
}
getComms().response.writeHTML(returnHTML);
```

This method gets the `event` parameter from the request query string and calls the appropriate event handler. If it does not find `event` in the request query string, it calls `handleDefault()`, which is an abstract method and so must be implemented by all `BasePO` subclasses. Otherwise, it calls `getPageContentForEvent()`, which returns the string content for the specific event and PO.

This method contains the following three lines:

```
Method method = this.getClass().getMethod(toMethodName(event), null);
String thePage = (String)method.invoke(this, null);
return thePage;
```

This code uses reflection (defined in the `java.lang.reflect` package) to call the method in the presentation object corresponding to the current event. *Reflection* lets you call a method whose name is defined at runtime.

The call to `toMethodName()` returns a string, `handle`*`Xxx`*, where *`Xxx`* is the current event (for example, `handleShowAddPage` for `showAddPage`). The call to `method.invoke()` then calls this method.

Reflection allows `BasePO` to call methods in its subclasses without knowing in advance the names of the methods. This scheme works as long as the presentation object code follows the appropriate naming conventions:

> For every event "foo," there must be a method `handleFoo()` in the presentation object class that needs to handle that event.

HTML pages

You will find the HTML pages for DiscRack in the `<discRack_root>/discRack/resources` directory. Keeping the HTML pages there rather than in the presentation directory cleanly separates the HTML files from the Java files. Although this is superfluous for small applications, it is a key advantage for large applications with a graphic design team and a programming team.

The make files in the presentation layer control how the application uses the HTML files. There are a total of three make files in the presentation layer—one in the top level and one in each subdirectory.

To keep the HTML files in a directory separate from the presentation classes, the make files use the `HTML_DIR` directive, which specifies the relative path to the directory containing the HTML files. For example, in `presentation/Makefile`, you'll see:

```
HTML_DIR = ../resources
```

And in `presentation/discMgmt/Makefile`:

```
HTML_DIR = ../../resources/discMgmt
```

The make rules will also find any HTML files in the presentation directories (for example, `discMgmt/DiscCatalogScript.html`).

The `HTML_CLASSES` directive indicates the names of the class files that XMLC creates, as explained in "Adding a new page to the application" on page 44.

Notice there is a `presentation/media` directory that contains only one make file. This directory mirrors the final package structure for the `.jar` file. A line in the make file copies the `.gif` into the finished `.jar` file:

```
JAR_INSTALL = \ ../../resources/media/*.gif
```

Maintaining the storyboard

The *storyboard* is initially just a mockup of the application. But with a few simple steps, you can maintain a working storyboard throughout the entire development process. This capability becomes particularly important for large applications created by a team of programmers and graphic designers. Each team can work on their part of the application separately from the other.

After the graphic designers complete their work, you can then replace the old, "mock up" user interface with the new improved interface, which may include enhanced graphics, JavaScript special effects, stylesheets, and so on. An example of doing this is illustrated in "Replacing the user interface" on page 84.

In addition to keeping the HTML files separate from the Java code, as described in the previous section, there are three steps you must follow during development to maintain the storyboard:

1. Define rules to map URLs like `Login.html` to `Login.po`
2. Remove dummy data from the HTML files
3. Replace JavaScript, if necessary

Each of these steps is described in detail in the following sections.

URL mapping

In the working storyboard, as in any static HTML pages, hyperlinks reference other HTML pages. That is, the URLs in hyperlinks end in `.html`. However, in the working application, links to dynamic pages reference presentation object URLs that end in `.po`. So, you need to do something to convert the "normal" URLs in the storyboard to `.po` URLs.

You do this by using the XMLC `-urlmapping` option to map URLs from one form to another. You use this option like this:

```
-urlmapping oldURL newURL
```

To use this option in the make process, you must create an XMLC options file, and then identify the file in the make file with the `XMLC_HTML_OPTS_FILE` directive. For example:

```
XMLC_HTML_OPTS_FILE = options.xmlc
```

The `presentation/discMgmt/options.xmlc` file contains the lines:

```
-urlmapping 'Edit.html' 'Edit.po'
-urlmapping 'DiscCatalog.html' 'DiscCatalog.po'
-urlmapping '../personMgmt/Exit.html' '../personMgmt/Login.po?event=logout'
```

When XMLC compiles the files in this directory, it replaces occurrences of the first string (for example, `Edit.html`) with the second string (for example, `Edit.po`) in hyperlink URLs and `FORM ACTION` attributes.

Removing dummy data

HTML files often contain "dummy" data to make the storyboard pages look more representative of their actual runtime appearance. You need to remove this dummy data from the production application.

Look in `presentation/discMgmt/options.xmlc` again. In particular, look at the last line:

```
-delete-class discardMe
```

The `-delete-class` option tells XMLC to remove any tags (and their contents) whose `CLASS` attribute is `discardMe`. For example, if you look in `resources/discMgmt/DiscCatalog.html`, you see this HTML:

```
<tr class="discardMe">
   <td>Sonny and Cher</td>
   <td>Greatest Hits</td>
   <td>Boring Music</td>
   <td>Not</td>
</tr>
```

It's not that we don't like Sonny and Cher, however, the `CLASS` attribute in the table row definition marks the row for deletion.

Unlike `ID`, the value of a `CLASS` attribute does not have to be unique in the page. You can remove all of the dummy in the application with the same `discardMe` value.

Replacing JavaScript

In addition to replacing URLs, you often need to replace JavaScript in the storyboard with JavaScript to be used in the "real" application. For example, `resources/DiscCatalog.html` contains the following script:

```
<SCRIPT id="DummyScript">
<!--
function doDelete()
{
   document.EditForm.action='DiscCatalog.html';
   if(confirm('Are your sure you want to delete this disc?')) {
      document.EditForm.submit();
   }
}
function showAddPage()
{
   document.location='Edit.html';
}
//-->
</SCRIPT>
```

These functions help to keep the storyboard working. At runtime, though, the application needs to use the "real" functions, which are defined in `presentation/DiscCatalogScript.html`. For example:

```
...
function showAddPage()
{
   document.location='Edit.po?event=showAddPage';
}
...
```

Because XMLC views JavaScript as a comment, the URL mapping option will not work on this URL inside the JavaScript function. So, you have to replace it at runtime with the following code in `DiscCatalog.java`:

```
DiscCatalogHTML page = new DiscCatalogHTML();
HTMLScriptElement script = new DiscCatalogScriptHTML().getElementRealScript();
XMLCUtil.replaceNode(script, page.getElementDummyScript());
```

This is an example of replacing a node with a node from another document. This implementation uses the `XMLCUtil` class.

Note Because this action happens at runtime, it may have a slight affect on performance. If performance is critical, you may want to replace the JavaScript in the final deployed version of the application.

Maintaining the storyboard seems like additional unnecessary work, but it is worth the effort when your HTML is evolving in parallel with the Java code. As an example of the power of a working storyboard, you can exchange the HTML in DiscRack from the basic HTML to designed HTML.

Replacing the user interface

Once the graphic design is completed, you can replace the user interface of the application with its final version. DiscRack includes a `resources_finished` directory containing "finished" versions of the HTML pages, along with graphics and a stylesheet.

To replace the original storyboard resources with the "finished" resources:

1 Rename the `resources` directory to `resources_old`.

2 Rename the `resources_finished` directory to `resources`.

3 Edit the `JAR_INSTALL` directive in `<DiscRack_root>/discRack/presentation/media/Makefile` by removing the two comment symbols (#) and adding a continuation character (\) after the first line so that it looks like this:

```
JAR_INSTALL = \
../../resources/media/*.gif \
../../resources/media/*.css \
../../resources/media/*.jpg
```

This ensures that the new `.jpeg` graphics files and the stylesheet file are included in the packaged application `.jar` file.

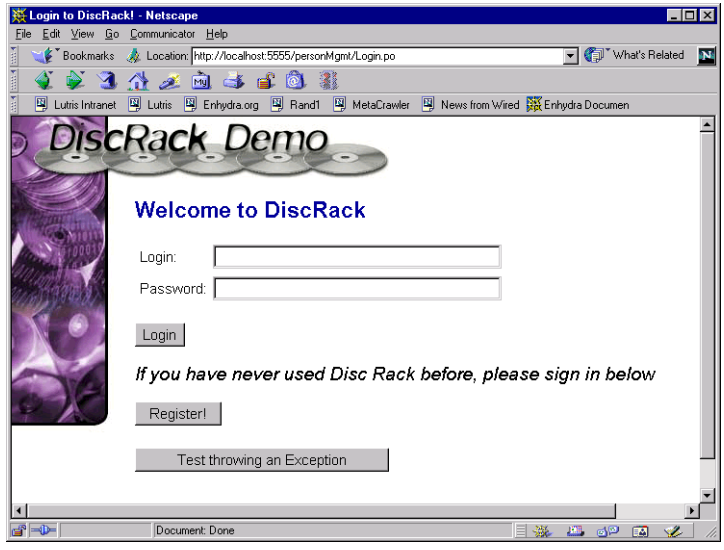
4 Rebuild the `presentation` package by entering the following commands from the directory `<DiscRack_root>/discRack/presentation`:

```
make clean
make
```

The `make clean` command removes all the old classes so that `make` will completely rebuild the application from scratch.

5 Now, restart and access the application. You see the new and improved user interface:

Figure 5.3 Browser displaying the DiscRack Login presentation object with updated graphics



Populating a list box

The DiscCatalog page illustrates how to populate a `SELECT` list box, which is a common task. First, look at the HTML for the `SELECT` tag in `DiscCatalog.html`:

```
<SELECT id="TitleList" Name="discID">
<OPTION selected VALUE="invalidID">Select One</OPTION>
<OPTION id="templateOption">Van Halen: Van Halen One</OPTION>
<OPTION class="discardMe">Sonny and Cher: Greatest Hits</OPTION>
<OPTION class="discardMe">Sublime: 40 oz. to Freedom</OPTION>
</SELECT>
```

Now look in `DiscCatalog.java` for the code that populates the list box.

```
HTMLOptionElement templateOption = page.getElementTemplateOption();
Node discSelect = templateOption.getParentNode();
```

The first line retrieves the DOM object corresponding to the template `OPTION` tag. The second line calls `getParentNode()` to get the container `SELECT` tag. Because the `SELECT` tag has an ID attribute, this line could have also been:

```
Node discSelect = page.getElementTitleList();
```

Then, following some code for populating the table, there is one line to remove the template row.

```
templateOption.removeChild(templateOption.getFirstChild());
```

The other `OPTION` tags contain `CLASS="discardMe"`, which causes XMLC to remove those items at build time, as explained in “Removing dummy data” on page 83.

Then, within the `for` loop that iterates over the discs belonging to the current user, the following lines actually populate the list box:

```
HTMLOptionElement clonedOption = (HTMLOptionElement)
   templateOption.cloneNode(true);
clonedOption.setValue( currentDisc.getHandle() );
Node optionTextNode =
   clonedOption.getOwnerDocument().createTextNode(currentDisc.getArtist()
      + ": " + currentDisc.getTitle());
clonedOption.appendChild(optionTextNode);
discSelect.appendChild(clonedOption);
```

The first line copies (clones) the template option element into a DOM object of type `HTMLOptionElement`. The second line sets the `value` attribute to the value returned by `getHandle()`, which is the disc’s `OBJECTID`, an unique identifier.

The third (very long) line creates a text node consisting of *`artistName: titleName`*. Finally, the last two lines append the text node to the option node, and then append the option node to the select node.

The resulting runtime HTML will look something like this:

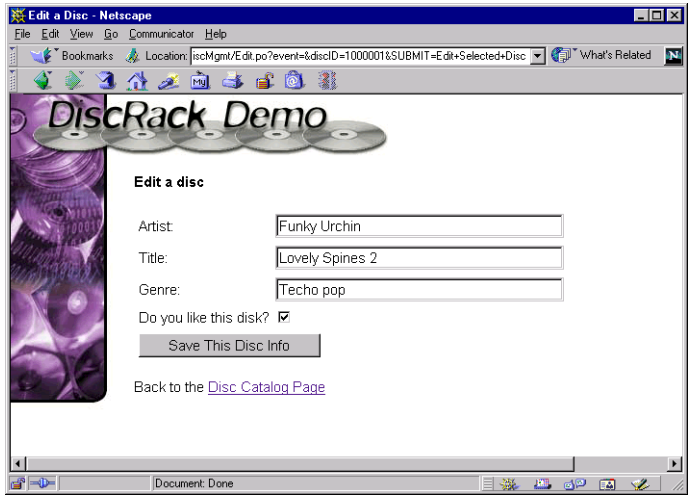
```
<SELECT name='discID' id='TitleList'>
<OPTION value='invalidID' selected>Select One</OPTION>
<OPTION value='1000001'>Funky Urchin: Lovely Spines</OPTION>
<OPTION value='1000021'>The Seagulls: Screaming Fun</OPTION>
</SELECT>
```

Although this example might seem obscure, it is fairly short, and you can extend its basic functionality to handle more complex situations. For example, you can modify it to set the default selection based on a second query.

Populating a form

When a user chooses a disc from the list box and clicks the Edit Disc button, the browser displays a form. As shown in Figure 5.3, the edit form is populated with the existing values for that disc. The user can then edit the values and submit them back to the database.

Figure 5.4 DiscRack disc edit form



Here is the HTML for the form elements in `Edit.html`. The `TABLE` tags have been omitted for clarity:

```
<INPUT TYPE="hidden" NAME="discID" VALUE="invalidID" ID="DiscID">
Artist: <input name="artist" id="Artist" >
Title: <input name="title" id="Title" >
Genre: <input name="genre" id="Genre" >
Do you like this disk?
<input TYPE="checkbox" name="like" CHECKED ID="LikeBox">
<INPUT TYPE="submit" VALUE="Save This Disc Info">
```

In `Edit.java`, the event-handling method `handleDefault()` calls `showEditPage()` with a null parameter to populate the form with the selected disc's values. Ordinarily, the only request parameter (other than the event type) is the disc ID, accessed by this statement:

```
String discID = this.getComms().request.getParameter(DISC_ID);
```

These statements also access the other request parameters, but ordinarily they are null (but see the error-handling case discussed later):

```
String title = this.getComms().request.getParameter(TITLE_NAME);
String artist = this.getComms().request.getParameter(ARTIST_NAME);
String genre = this.getComms().request.getParameter(GENRE_NAME);
```

Then, a call to `findDiscByID()` retrieves a `Disc` data object that has that ID:

```
disc = DiscFactory.findDiscByID(discID);
```

Next, there is a series of `if` statements that check the values of `title`, `artist`, `genre`, and `isLiked`, which are normally null. Therefore, the following statements are executed (the surrounding `if` statements are not shown for brevity):

```
page.getElementDiscID().setValue(disc.getHandle());
page.getElementTitle().setValue(disc.getTitle());
page.getElementArtist().setValue(disc.getArtist());
page.getElementGenre().setValue(disc.getGenre());
page.getElementLikeBox().setChecked(disc.isLiked());
```

These statements use XMLC calls to set the `value` attributes of the form elements; the values are retrieved from the `Disc` object.

When the user finishes editing and clicks Save this Disc Info, `handleEdit()` processes the changes. This method calls `saveDisc()`, which attempts to save the new values:

- If successful, it redirects the client to the DiscCatalog page.
- If any of the new values are null, though, `saveDisc()` throws an exception.

The `catch` clause then calls `showEditPage()` with an error string and request parameters.

Note `ClientPageRedirectException` is a subclass of `java.lang.Error`, so it is not caught by the `catch` clause when that statement is thrown.

```
try {
   saveDisc(disc);
   throw new ClientPageRedirectException(DISC_CATALOG_PAGE);
} catch(Exception ex) {
return showEditPage("You must fill out all fields to edit this disc");
}
```

The result is that when a user tries to edit a disc and delete some of the values, the edit page redisplays, maintaining all the non-null form element values and restoring the previous values to the null-valued form elements. The page also displays the error string.

Business layer

The DiscRack business layer is simple, consisting primarily of:

- Two packages—`Disc` and `Person`
- Two corresponding factory classes—`DiscFactory` and `PersonFactory`.

A *factory* is an object whose primary role is to create other objects.

Business objects

The business objects `Disc` and `Person` are largely wrappers for the corresponding data layer classes, `DiscDO` and `PersonDO`, with get and set methods for each property in the data objects (or column in the database tables). For example, `Disc` has `getArtist()` and `setArtist()` methods.

The objects in the business layer perform all the interfacing with the data layer. So, if the data layer needs to change, nothing in the presentation layer is affected. Conversely, if the presentation layer changes, nothing in the data layer is affected.

DiscFactory has two static methods:

- findDiscsForPerson() returns an array of Disc objects that belong to the Person object specified as the method's argument.
- findDiscByID() returns the single Disc object that has the ID specified in the method's argument.

PersonFactory has one static method, findPerson(). It returns a Person object that has the user name specified in the method's argument. If the method finds more than one person in the database, then it writes an error message to the log channel and throws an exception.

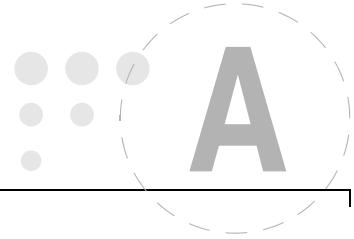
Using data objects

To help understand how DiscRack uses the DODS data layer code, look at the findPerson() method in PersonFactory. The comments have been removed from this code for brevity.

```
public static Person findPerson(String username)
throws DiscRackBusinessException
{
   try {
      PersonQuery query = new PersonQuery();
      query.setQueryLogin(username);
      query.requireUniqueInstance();
      PersonDO[] foundPerson = query.getDOArray();
      if(foundPerson.length != 0) {
         return new Person(foundPerson[0]);
      } else {
         return null;
      }
   } catch(NonUniqueQueryException ex) {
...
```

First, this method instantiates a new PersonQuery object. PersonQuery is a data layer object used to construct and execute a query on the person table. It has a number of setQuery*xxx()* methods for qualifying the query parameters (that is, setting the values to be matched in the WHERE clause of the SELECT statement). For example, the above code calls setQueryLogin() with username as a parameter to set the value to be matched in the LOGIN column.

Next, the method calls requireUniqueInstance(), which indicates that the query is to return a single row, and will throw an exception otherwise. Then, it calls getDOArray(), which executes the query, returning an array of PersonDO objects. Finally, the method returns a single Person object returned by the query; if the query did not return any rows, it returns null.



Appendix A

Database configurations

This appendix provides information on connecting Enhydra applications to specific database types. In general, you need to add the database configuration information to the application configuration file (e.g., `simpleApp.conf`). Configurable items in the code snippets that you need to specify, such as path names or database identifier, are enclosed in brackets and italicized (for example, <*path_name*> or <*database_id*>).

Note In general, Lutris supports the latest releases of the following databases. A comprehensive list of certified platforms is provided on the Lutris website at http://www.lutris.com/support/platform.html.

Driver configuration

Important Enhydra connects to databases using a JDBC driver. Enhydra has its own class loader, but the JDBC driver must be loaded by the system class loader. Therefore, it is important to specify the path to the JDBC driver in your system `CLASSPATH` and not in the Enhydra application's `CLASSPATH`.

A common way to specify the path to the JDBC driver is to save the driver in a `lib` directory in the project and define the `CLASSPATH` in the `start` script. To do this, follow these steps:

1. Create a `lib` directory in the top level of your project and copy your JDBC driver to this directory.
2. Edit your application's start file template, `start.in`, (in the <*appName*>`/input` directory) to place the driver in your `CLASSPATH`. For example:

```
...
#
# Build up classpath.
#
CLASSPATH="../lib/idb.jar\;../lib/jta-spec1_0_1.jar"
APPCP="${ENHYDRA_LIB}${PS}../classes"
...
```

3. Build the project with `make`, which will copy the `start` script to the directory <*appName*>`/output`. Use this script to start your application.

Be careful to keep the right driver with your application. For example, there are multiple versions of the Oracle JDBC driver, `classes111.zip`. When your application goes into production, make sure that the project administrator knows to reference the correct driver when the database is upgraded in the future.

Oracle

This section presents an example of an Oracle configuration, where *<database_id>* is your database identifier.

```
#---------------------------------------------------------------------
#                   Database Manager Configuration
#---------------------------------------------------------------------
DatabaseManager.Databases[] = "<database_id>"
DatabaseManager.DefaultDatabase = "<database_id>"
DatabaseManager.Debug = "false"
DatabaseManager.DB.<database_id>.ClassType = "Oracle"
DatabaseManager.DB.<database_id>.JdbcDriver = "oracle.jdbc.driver.OracleDriver"
DatabaseManager.DB.<database_id>.Connection.Url =
      "jdbc:oracle:thin:@<server_name>:<port#>:<db_instance>"
DatabaseManager.DB.<database_id>.Connection.User = "<user>"
DatabaseManager.DB.<database_id>.Connection.Password = "<password>"
DatabaseManager.DB.<database_id>.Connection.MaxPreparedStatements = 10
DatabaseManager.DB.<database_id>.Connection.MaxPoolSize = 30
DatabaseManager.DB.<database_id>.Connection.AllocationTimeout = 10000
DatabaseManager.DB.<database_id>.Connection.Logging = false
DatabaseManager.DB.<database_id>.ObjectId.CacheSize = 20
DatabaseManager.DB.<database_id>.ObjectId.MinValue = 1
```

The driver used here is the Oracle thin driver, and *<db_instance>* is the name of the Oracle database instance.

Informix

This section presents an example of an Informix configuration, where *<database_id>* is your database identifier.

```
#---------------------------------------------------------------------
#                   Database Manager Configuration
#---------------------------------------------------------------------
DatabaseManager.Databases[] = "<database_id>"
DatabaseManager.DefaultDatabase = "<database_id>"
DatabaseManager.Debug = "false"
DatabaseManager.DB.<database_id>.ClassType = "Informix"
DatabaseManager.DB.<database_id>.JdbcDriver = "com.informix.jdbc.IfxDriver"
DatabaseManager.DB.<database_id>.Connection.Url =
      jdbc:informix-sqli://<hostname>:<port#>:INFORMIXSERVER=<db_instance>;
      user=<user>;password=<password>
DatabaseManager.DB.<database_id>.Connection.User = "<user>"
DatabaseManager.DB.<database_id>.Connection.Password = "<password>"
DatabaseManager.DB.<database_id>.Connection.MaxPreparedStatements = 10
DatabaseManager.DB.<database_id>.Connection.MaxPoolSize = 30
DatabaseManager.DB.<database_id>.Connection.AllocationTimeout = 10000
DatabaseManager.DB.<database_id>.Connection.Logging = false
DatabaseManager.DB.<database_id>.ObjectId.CacheSize = 20
DatabaseManager.DB.<database_id>.ObjectId.MinValue = 1
```

Sybase

This section presents an example of a Sybase configuration, where *<database_id>* is your database identifier.

```
#---------------------------------------------------------------------
#                   Database Manager Configuration
#---------------------------------------------------------------------
DatabaseManager.Databases[] = "<database_id>"
DatabaseManager.DefaultDatabase = "<database_id>"
DatabaseManager.Debug = "true"
DatabaseManager.DB.<database_id>.ClassType = "Sybase"
DatabaseManager.DB.<database_id>.JdbcDriver = "com.sybase.jdbc2.jdbc.SybDriver"
DatabaseManager.DB.<database_id>.Connection.Url =
      "jdbc:sybase:Tds:<hostname>.sybase.com:7100"
DatabaseManager.DB.<database_id>.Connection.User = "<name>"
DatabaseManager.DB.<database_id>.Connection.Password = "<password>"
DatabaseManager.DB.<database_id>.Connection.MaxPoolSize = "2"
DatabaseManager.DB.<database_id>.Connection.AllocationTimeout = "2"
DatabaseManager.DB.<database_id>.Connection.Logging = "true"
DatabaseManager.DB.<database_id>.Connection.MaxPreparedStatements = "2"
DatabaseManager.DB.<database_id>.ObjectId.CacheSize = 2
DatabaseManager.DB.<database_id>.ObjectId.MinValue = 1
```

MySQL

MySQL is an open source database that is lightweight and fast.

Note Although some older versions of MySQL may work with Enhydra without problems, versions 3.22 and earlier do not support transactions. Because of this, you have to make a small patch to the Enhydra code to use MySQL.

Patch

Prior to version 3.23, MySQL does not support transactions, and therefore does not support autocommit. To use MySQL versions 3.22 and earlier, you have to make a small change to the code and rebuild Enhydra. You will need to change the file `com/lutris/appserver/server/sql/standard/StandardDBConnection.java` and comment out one line, as shown below:

```
public void setAutoCommit(boolean on) throws SQLException {
   validate();
   logDebug("ignores set auto commit: " + on);
   // connection.setAutoCommit(on);
}
```

You must then rebuild this Enhydra package. For details, see the Enhydra mailing list archive.

Configuration

This section presents an example of a MySQL configuration, where <*database_id*> is your database identifier.

```
#-------------------------------------------------------------------
#                  Database Manager Configuration
#-------------------------------------------------------------------
DatabaseManager.Databases[] = <database_id>
DatabaseManager.DefaultDatabase = <database_id>
DatabaseManager.Debug = true
DatabaseManager.DB.<database_id>.ClassType = Standard
DatabaseManager.DB.<database_id>.Connection.User = <username>
DatabaseManager.DB.<database_id>.Connection.Password = <password>
DatabaseManager.DB.<database_id>.Connection.MaxPoolSize = 5
DatabaseManager.DB.<database_id>.Connection.AllocationTimeout = 10000
DatabaseManager.DB.<database_id>.Connection.Logging = true
DatabaseManager.DB.<database_id>.ObjectId.CacheSize = 1024
DatabaseManager.DB.<database_id>.ObjectId.MinValue = 100
DatabaseManager.DB.<database_id>.JdbcDriver = org.gjt.mm.mysql.Driver
DatabaseManager.DB.<database_id>.Connection.Url =
      "jdbc:mysql://<hostname>:<port#>/<db_instance>"
```

PostgreSQL

Note Although other versions are available commercially, Lutris supports the open-source version of PostgreSQL for the Linux operating system for use with Enhydra.

PostgreSQL is a popular open-source database used with Enhydra. However, as explained in "Loading the schema" on page 65, DODS requires a special column named OID in each table. However, OID is a reserved word in PostgreSQL. Fortunately, the column names used for OID and VERSION are configurable.

To configure these names, add the following lines to your application configuration file:

```
DatabaseManager.ObjectIdColumnName = "<ColName_for_ObjectId>"
DatabaseManager.VersionColumnName = "<ColName_for_Version>"
```

where <*ColName_for_ObjectId*> and <*ColName_for_Version*> are the column names you want to use instead of OID and VERSION.

InstantDB

To use an InstantDB database with an Enhydra application

1. In the application configuration file <*appName*>/<*appName*>.conf (sometimes, by convention, <*appName*>/<*appName*>.conf.in) set the following line:

   ```
   DatabaseManager.DB.<database_id>.Connection.Url = "jdbc:idb:<propFile>.prp"
   ```

   where <*propFile*> is the full path to the database properties file, and <*database_id*> is the database identifier used in the configuration file.

2. In the same configuration file, identify the JDBC driver with the line:

   ```
   DatabaseManager.DB.<database_id>.JdbcDriver = "org.enhydra.instantdb.jdbc.idbDriver"
   ```

3 Add the path to `idb.jar` to the setting for `CLASSPATH` in the application's start script, in `<appName>/start`.

Note On Windows, database files must be on the C drive, due to limitations with the Cygnus tools.

Microsoft SQL Server

The exact configuration settings for connecting to MS SQL server depend on the JDBC driver you are using. We do not recommend using the JDBC-ODBC bridge with MS SQL Server.

JTurbo JDBC driver

We certified the JTurbo 2.0 JDBC driver, and the configuration settings for this are:

```
# JTurbo 2.0 JDBC Driver for MS SQL server
DatabaseManager.Databases [] = "my_db"
DatabaseManager.DefaultDatabase = "my_db"

DatabaseManager.DB.my_db.ClassType = "Standard"
DatabaseManager.DB.my_db.JdbcDriver = "com.inet.tds.TdsDriver"

# NOTE: substitute your server's IP address for 10.0.0.18 below
# Substitute the port your DB is listening on for 1433 below
DatabaseManager.DB.my_db.Connection.Url = "jdbc:inetdae:10.0.0.18:1433?database=my_db"

DatabaseManager.DB.my_db.Connection.User = "<user_name>"
DatabaseManager.DB.my_db.Connection.Password = "<password>"
```

If you are using another JDBC driver, you need to determine the driver package, for the `DatabaseManager.DB.my_db.JdbcDriver` setting, and connection string, for `DatabaseManager.DB.my_db.Connection.Url` setting.

Microsoft Access

Microsoft Access is not a true SQL database server; as such, it is suitable for development and testing, but not for a production database. Access does not have a JDBC driver. However, Access does support ODBC, and there is a JDBC-ODBC bridge in the Sun JDK, which enables Access to work with Enhydra.

Because Access cannot read-in files containing SQL commands, you must create tables in the Access GUI. See the Access documentation for more information. For the DiscRack example, you can also use the Access database provided in `<enhydra_root>/examples/DiscRack/discRack.mdb`.

You can test the ODBC access alone using the test program in "Establishing a JDBC connection" on page 52. Use the driver and connect strings from the configuration file listed here. If you encounter problems, be sure your data values are valid.

To use Enhydra with Access:

1. Register the database as an ODBC data source:
   1. Go to Start | Settings | Control Panel and click ODBC Data Sources.
   2. Click the Add button in the dialog box that comes up.
   3. Select the Microsoft Access Driver in the Create New Datasource dialog box and click Finish.

      The ODBC Microsoft Access Setup dialog box appears.
   4. Choose a name, like `discRack`, for the Data Source Name. Under Database, click the Select button, browse to the `*.mdb` file, select it, and click OK.
2. Place database information in the application's configuration file, as shown in the example below. Replace `<data_source>` with the name you chose for Data Source Name in the preceding step.

Note You don't have to place the JDBC driver in the application's `CLASSPATH` because the ODBC/JDBC bridge is in the JDK and thus is already in the system's `CLASSPATH`.

This section presents an example of an Access configuration, where `<database_id>` is your database identifier.

```
#-----------------------------------------------------------------
#                  Database Manager Configuration
#-----------------------------------------------------------------
DatabaseManager.Databases[] = "<database_id>"
DatabaseManager.DefaultDatabase = "<database_id>"
DatabaseManager.Debug = "false"
DatabaseManager.DB.<database_id>.ClassType = "Standard"
DatabaseManager.DB.<database_id>.JdbcDriver = "sun.jdbc.odbc.JdbcOdbcDriver"
DatabaseManager.DB.<database_id>.Connection.Url = "jdbc:odbc:<data_source>"
DatabaseManager.DB.<database_id>.Connection.User = "Admin"
DatabaseManager.DB.<database_id>.Connection.Password = ""
DatabaseManager.DB.<database_id>.Connection.MaxPreparedStatements = 10
DatabaseManager.DB.<database_id>.Connection.MaxPoolSize = 30
DatabaseManager.DB.<database_id>.Connection.AllocationTimeout = 10000
DatabaseManager.DB.<database_id>.Connection.Logging = false
DatabaseManager.DB.<database_id>.ObjectId.CacheSize = 20
DatabaseManager.DB.<database_id>.ObjectId.MinValue = 1
```

InterBase

InterBase® is an efficient and powerful RDBMS engine. Its vendor, Borland/Inprise, has released InterBase version 6.0 as an open-source product. See http://www.interbase.com for more information and product downloads.

InterClient

The JDBC driver for InterBase is called InterClient.™ The InterClient system includes an all-Java thin client, and a server-side daemon (also known as a service on Microsoft Windows NT) called InterServer. This daemon accepts JDBC connection requests and in turn connects to the InterBase RDBMS daemon. The three processes (JDBC client, InterServer daemon, InterBase daemon) can run all on separate hosts, all on the same host, or in any other combination.

InterClient is a class 3 JDBC driver in that it has a separate daemon on the server to serve JDBC connections; however, it also matches the definition of a class 4 driver because the client component can connect only to one DBMS back-end, InterBase.

InterClient is installed separately from InterBase. On Windows, InterClient is commonly installed in:

```
C:\Program Files\Borland\InterClient\interclient.jar
```

Depending on the version of InterClient, it might instead be installed in:

```
C:\Program Files\InterBase Corp\InterClient\interclient.jar
```

Find the JAR file and append its location to your system `CLASSPATH` environment variable on the client host where you run Java applications.

Different versions of InterClient are available.

- InterClient version 1.50x works only with JDK 1.1x.
- InterClient version 1.51x works only with JDK 1.2.x.

Whichever version of InterClient you use, you must use the matching version of InterServer.

Configuration

You need to configure both the dods.conf and your `<application>.conf` to support InterClient.

DODS configuration

You should apply the following configuration edits to `dods.conf` to make the Standard_JDBC database class match InterBase features. This is necessary because there is not yet a specific `com.lutris.appserver.server.sql.interbase` package in the Enhydra sources.

```
Database.OidDbType.Standard_JDBC=                   "DECIMAL(9,0)"
Database.BitType.Standard_JDBC=                     "SMALLINT"
Database.TimeType.Standard_JDBC=                    "DATE"
Database.TimestampType.Standard_JDBC=               "DATE"
Database.OnCascadeDelete.Standard_JDBC=             true
Database.StringQuoteCharacter.Standard_JDBC=        '
Database.StringMatch.Standard_JDBC=                 "LIKE"
Database.StringWildcard.Standard_JDBC=              "%"
```

Application configuration

This section presents an example of an Interbase configuration, where *<database_id>* is your database identifier.

```
#------------------------------------------------------------------
#                  Database Manager Configuration
#                     InterBase / InterClient
#------------------------------------------------------------------
DatabaseManager.Databases[] = "<database_id>"
DatabaseManager.DefaultDatabase = "<database_id>"
DatabaseManager.Debug = "false"
DatabaseManager.DB.<database_id>.ClassType = "Standard"
DatabaseManager.DB.<database_id>.JdbcDriver = "interbase.interclient.Driver"
DatabaseManager.DB.<database_id>.Connection.Url =
      "jdbc:interbase://loopback/<path_to_database>"
DatabaseManager.DB.<database_id>.Connection.User = "sysdba"
DatabaseManager.DB.<database_id>.Connection.Password = "masterkey"
```

Configuration notes

The JDBC driver class is `interbase.interclient.Driver`.

Server name

The general URL format for InterClient JDBC connections is as follows:

`jdbc:interbase://servername/<path_to_database>`

where *<path_to_database>* is the full path to the database file, including the name of the database (for example, `/usr/local/data/inventory.gdb`).

The *servername* is the hostname or IP address of the server running InterServer, the server-side daemon that accepts JDBC connection requests. If your Enhydra application runs on the same host where InterServer runs, you can use the special servername `loopback`.

Pathnames

The *<path_to_database>* is an absolute path to the InterBase database file on the server where the InterBase RDBMS server runs. InterBase does not have abstract handles to databases, like some database products do (for example, Oracle SIDs or BDE aliases). You must specify the real path to the database. You cannot use mapped drives or NFS filesystems in this path.

Notice the literal slash character (`/`) following the server name. If the absolute path starts with a slash character (`/`), then you should have a pair of slash characters (`//`) together. For example:

`jdbc:interbase://servername//usr/local/data/inventory.gdb`

If the server is a Windows host, the path starts with a drive letter identifier:

`jdbc:interbase://servername/C:/data/inventory.gdb`

If InterServer runs on a different host than the InterBase RDBMS server, you must specify this host in the path to database, with the following syntax:

`jdbc:interbase://<interserver_host>/<interbase_host>:<path_to_database>`

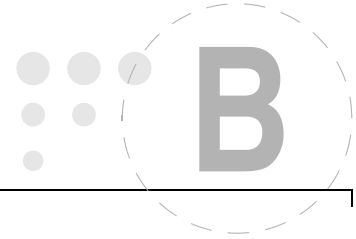
Tip Slash (/) and backslash (\) characters within path names are interchangeable to InterBase; the InterBase daemon translates these characters as needed to match the convention on the server platform. It is easier to use slashes in code, however, because escape sequences are required to represent backslashes in code.

Ports

InterBase does not take a port number argument in connection strings. InterClient and InterServer always communicate using the TCP/IP service named `interserver`, which defaults to port 3060. InterServer and InterBase always communicate using the TCP/IP service named `gds_db` , which defaults to port 3050. These services and port numbers are registered with IANA.

Username and password

The username `sysdba` and its default password `masterkey` are used in the example configuration above, but for security reasons it is recommended that you: (a) change the default `sysdba` password on your InterBase server, and (b) create a non-superuser login in the InterBase password database, and use that login for general database access.



Appendix B

Multiserver Administration Console

The Enhydra Multiserver Administration Console, also called the Admin Console, is a built-in component of the Multiserver itself. The Multiserver is a servlet runner that runs Enhydra applications, Java servlets, and JavaServer Pages (JSPs). The Multiserver can accept direct HTTP requests or requests forwarded from a Web server by Enhydra Director. It has controls that allow you to add, remove, start, stop, configure, and monitor your applications.

An Enhydra Multiserver installation typically consists of a directory containing applications, a configuration file called `multiserver.conf`, and a script to start the Multiserver. The Admin Console, which is actually just another Enhydra application running on the Multiserver, gives you access to the server and allows you to set properties defined in `multiserver.conf`.

For additional information, see Chapter 3, "Using the Multiserver Administration Console," of the *Developer's Guide*.

Launching the Admin Console

The Admin Console is an Enhydra application that allows you to add, remove, and configure applications to run with Enhydra.

Starting the Admin Console

To launch the Admin Console, follow these steps:

1 Type the following command at the command prompt to start the Multiserver:

```
<enhydra_root>/bin/multiserver
```

where *enhyra_root* is the root of your Enhydra installation. Invoking the multiserver command without giving it `a multiserver.conf` as an argument brings up the server in the default installation.

Note If the Admin Console does not start, the path environment variable is not set correctly. The Lutris Enhydra installation instructions provide information about setting your path environment variable. The installation instructions are available in HTML format only on the Lutris Enhydra CD (refer to the top-level `index.html`)

or the Lutris Documentation home page:
http://www.lutris.com/documentation/index.html.

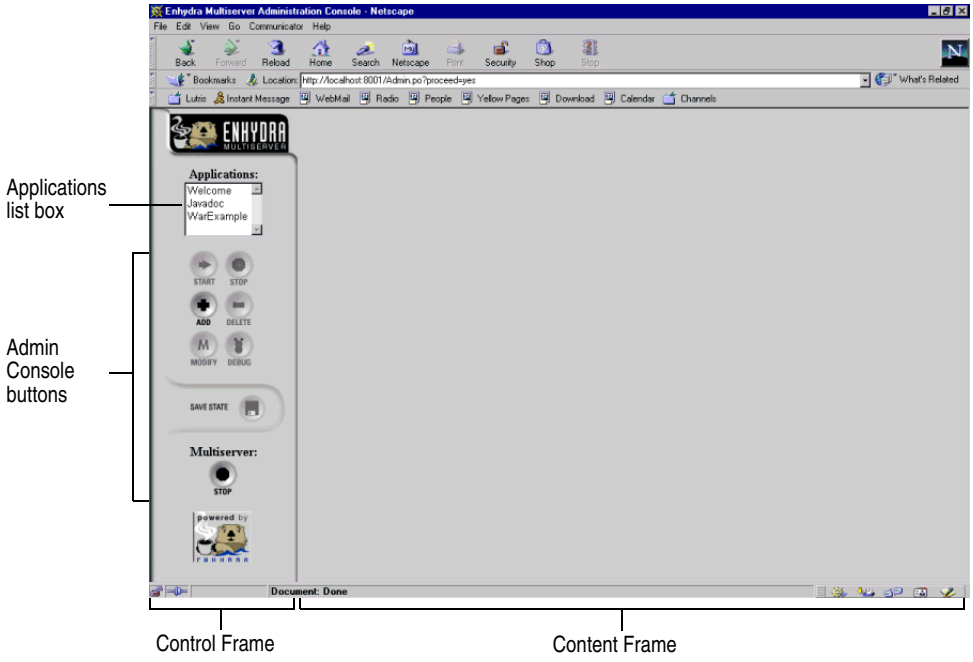
2 In your browser, display the console by entering this URL:

```
http://localhost:8001/
```

3 The console displays a password dialog box, as shown in Figure B.1. To get started, enter the default user name, `admin`, and password, `enhydra`. See Chapter 3, "Using the Multiserver Administration Console," of the *Developer's Guide* for information on changing these settings.

The Admin Console appears in your Web browser as shown in Figure B.1, "Admin Console display."

Figure B.1 Admin Console display



Admin Console display

As shown in Figure B.1, "Admin Console display," the Admin Console is divided into two frames:

- The control frame on the left contains the console buttons and the Applications list box (or window).

  The Applications window contains a list of all the applications, servlets, and Web archives (WARs) available in the Enhydra Multiserver. The console buttons below the Applications window initiate operations on the selected application.

- The content frame on the right displays information about the application that is currently selected in the Applications window. Some Admin Console functions are accessed from the content frame to display information or to request input.

Note There are two kinds of Web applications:

- Enhydra super-servlet applications, created with Enhydra development tools
- Servlet applications, otherwise known as WAR files (see "Creating a WAR file" on page 112)

Control frame

As shown in Figure B.1, "Admin Console display," the control frame has two components, an Applications window and the console buttons. Both components are described in the following sections.

Applications window

The Applications window contains a list of all applications currently available in the Enhydra Multiserver. You will see three sample applications that are initially available:

- Welcome application
- Javadoc servlet
- WarExample Web archive.

Admin Console buttons

Table B.1 describes the function of each button in the control frame (see Figure B.1 on page 102).

Table B.1 Admin Console buttons

Button	Description
Start	Starts the application currently selected in the Applications window. Unavailable when the selected application is already running.
Stop	Stops the application that is selected in the Applications window. If the application has active users, you are prompted to verify that you want the application stopped.
Add	Adds an application to the Enhydra Multiserver.
Delete	Removes the selected application from the Enhydra Multiserver.
Modify	Modifies the configurable attributes of the selected application.
Debug	Invokes the debugging utility for the selected application. When you click this button, the debugging control panel displays.
Save State	Saves the state of the Enhydra Multiserver.
Multiserver Stop	Stops the Enhydra Multiserver.

Content frame

As shown in Figure B.1, the content frame displays information relevant to the current activity of the Multiserver, typically showing Status, Modify, or Debug windows with their various tab sections. The information you see in these screens varies with the type of application (Enhydra application, servlet, or Web archive), and with the specifics of the current task.

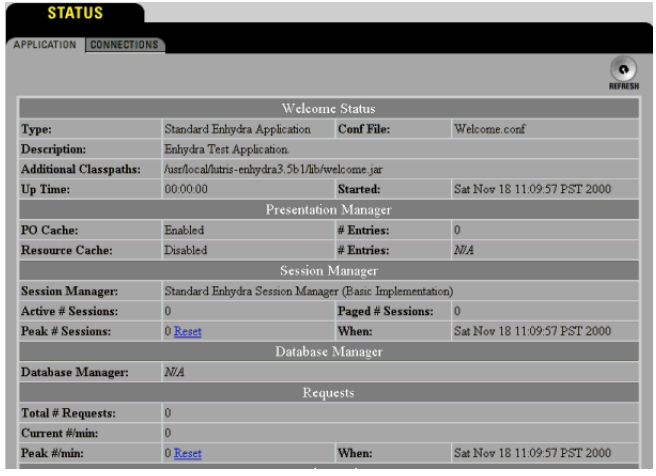
Viewing status information

To display status information about an application, select its name in the Applications list box (See Figure B.1 on page 102). The Status window appears in the content frame, containing an Applications tab and a Connections tab. Figure B.2 shows a portion of the Status window for the sample Welcome application.

Note The elements of the screen will be somewhat different for a servlet or WAR.

The Application tab contains information about the application including its CLASSPATH, session manager status, database manager status, and traffic statistics.

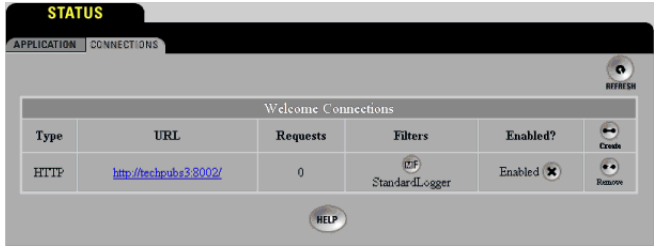
Figure B.2 Status display for an application



Viewing connections status information

Click the Connections tab to display connection status information for the application. Connections represent channels for requests coming into the application. For example, an application could be receiving direct HTTP requests on port 8000 and requests coming from a Web server via an Enhydra Director connection on port 8020. Figure B.3 shows an example of the connection status display for an application receiving direct HTTP requests.

Figure B.3 Connection status display for a running application



Using the Admin Console

This section describes how to use the Admin Console to work with your Enhydra applications and servlets. This section provides information on:

- Adding an application
- Stopping an application
- Deleting an application
- Modifying the configuration of an application
- Debugging an application
- Saving the state of the Multiserver

Adding an application

This section describes how to add an Enhydra super-servlet application, a single servlet, or a servlet application set up as a Web Archive (WAR) to the list of applications running on the server.

Note A WAR is a collection of servlets bound together for convenient administration. Using the Admin Console, you can add a WAR to the Multiserver in just a few steps. For convenience, we recommend that you bundle your servlets into a WAR and add them all in one process—see "Adding a servlet application configured as a WAR" on page 107.

Adding an Enhydra super-servlet application

Follow these steps to add an Enhydra application to the Multiserver:

1 Copy the application's configuration file from the application's root directory to `/<enhydra_root>/apps/`. For example:

```
cp simpleApp.conf /usr/local/lutris-enhydra3.5b1/apps/
```

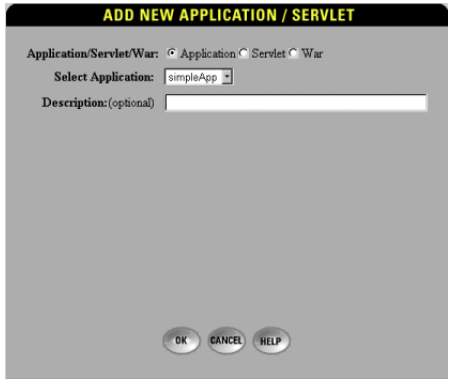
2 In the new `simpleApp.conf` file, locate the `server.Classpath` variable. Comment out the first line, and uncomment the second line. Set the `server.Classpath` variable equal to the new absolute `CLASSPATH`.

```
#server.Classpath[] = ../classes
Server.Classpath[] = "/enhydra/myapps/simpleApp/output/archive/simpleApp.jar"
```

Then save and close the configuration file.

3 Click the Add button to display the Add New Application/Servlet dialog box, and select the Application radio button if it's not already selected.

Figure B.4 Add New Application/Servlet dialog box



4 Select the name of your application from the pull-down list.

An application's name only appears in the list if its configuration file is in the `<enhydra_root>/apps` directory, and if it has not already been added to the Multiserver.

Optionally, enter a description.

5 Click OK to add your application to the Multiserver.

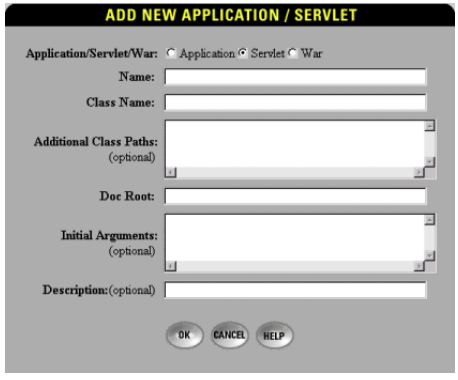
Adding a single servlet

This section describes how to use the Admin Console to add a single servlet to the Multiserver.

Note We recommend that you set up your servlet application as a WAR file. The following instructions, however, explain how to add a servlet not set up as a WAR file.

1 Click the Add button to display the Add New Application/Servlet dialog box, and select the Servlet radio button.

Figure B.5 Add New Servlet dialog box



2 In the fields provided, enter:

- Name of the servlet
- Name of the class to instantiate for the servlet
- Any additional classpaths required for the servlet
- Root of the servlet's file system on disk
- Any initial arguments for the servlet (optional)
- Description of the servlet (optional)

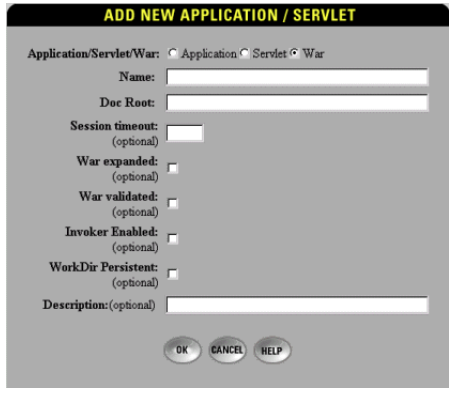
3 Click OK to add your application to the Multiserver.

Adding a servlet application configured as a WAR

This section describes how to use the Admin Console to add a WAR file to the Multiserver. For information on creating a WAR, see "Creating a WAR file" on page 112.

1 Click the Add button to display the Add New Application/Servlet dialog box, and select the WAR radio button.

Figure B.6 Add New WAR dialog box



2 In the fields provided, enter:

- Name of the archive, not necessarily the file name.
- Doc Root—path to the root directory of the Web archive after it's unzipped.
- Session Timeout—period of time, in seconds, for which the session may remain idle before timing out.
- War Expanded—leave selected; all WARs must be expanded in this release.
- War Validated—leave selected; see Tomcat documentation for details.
- Invoker Enabled—select if you want to use `/servlets/* syntax`.
- WarDir Persistent—select if you want to save the work directory after the termination of the current Multiserver session. The work directory is where the Multiserver saves compiled JSPs. If you stop the Multiserver with *Ctrl-C*, you may want to manually remove the work directory before restarting the server to avoid reuse of previously compiled JSPs.

- Description—plain English description of this archive.

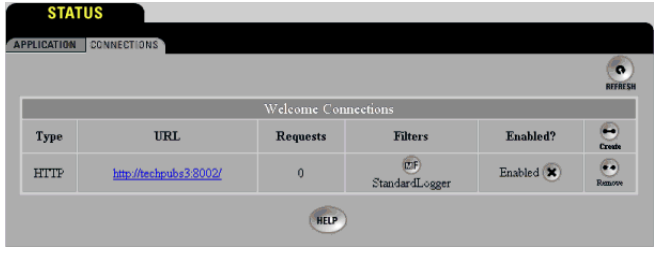
3 Click OK to finish adding the WAR to the Multiserver.

Specifying a connection method

Once you have added your application, you must establish a connection method for the item you've just added. To do that, follow these steps:

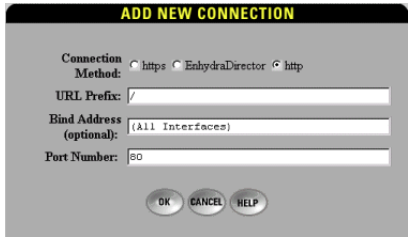
1 With the application selected in the Applications list box, click the Connections tab in the content frame.

Figure B.7 Live connection in the Connections tab



2 Click Create in the Connections tab section to display the Add New Connection dialog box.

Figure B.8 Add New Connection dialog box



3 For Connection Method, choose

- HTTP for a standard Web connection, typically in a development environment.
- HTTPS for a secure Web connection, also in a development environment. This option is only available if you have configured your Enhydra installation with Sun's Java Secure Socket Extension Kit. For more information, see Appendix A, "Using SSL with Enhydra" of the *Developer's Guide*.
- Enhydra Director for connection via a Web server. See Chapter 9, "Using Enhydra Director," of the *Developer's Guide* for further information.

4 Enter a URL Prefix to define the portion of the URL that precedes the application. For example, the demonstration uses an URL prefix of `/examples`, making the full URL to the application `http://localhost/examples`.

5 For Bind Address, enter an IP address if you want to bind to only one of the available IP addresses on a a given machine. If no IP address is specified, the server binds the given port for all IP addresses on the machine.

6 For Port Number enter an unused port number. Note that you must be root to bind to ports numbered below 1024 on UNIX systems. You may want to check that a given port is not already in use with the UNIX command `netstat`. The highest valid port number is 65535.

7 If your connection method is `EnhydraDirector`, three new configuration options are available: Session Affinity, Authentication Key, and HTTP Server URL. Session Affinity specifies whether Director will attempt to preserve session affinity in your application. Authentication Key, which specifies the password for the application if it was configured to use authentication in `enhydra_director.conf`, and HTTP Server URL, which specifies the URL of the application as set in `enhydra_director.conf`, are optional.

8 Click OK to return to the Status window.

9 To start the application, make sure it is selected in the Applications window, and click the Start button.

10 Click Save State to add the item permanently to the Multiserver. This overwrites the Multiserver's configuration file, `multiserver.conf`.

Stopping an application

To modify or delete an application, you must first stop it. To do so, select the application's name in the Applications list box, and click the Stop button.

In some situations, such as when users are still connected, you will be prompted to confirm your decision.

Deleting an application

When you remove an application from the Multiserver, you are not deleting the application or its configuration file from your computer. You are simply removing it from the Multiserver's configuration file.

Follow these steps to delete an application from the Multiserver:

1 Select the application in the Applications window.

2 Click the Stop button to stop the application.

3 Click the Delete button to delete it from the current session of the Multiserver.

4 Click the Save State button to overwrite the Multiserver configuration file and make the change permanent.

Modifying the configuration of an application

To modify an application, you must first stop it by using the Stop button. You can then edit parameters for the application. In the case of an Enhydra application, you can edit the application's configuration file using the Admin Console.

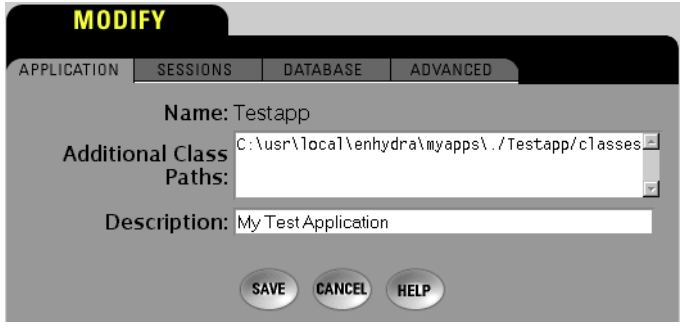
Use the following steps to modify the configuration of an application in Multiserver:

1 Select the application in the Applications window.

2 Click the Modify button.

The Content frame displays the Modify window, as shown in Figure B.9.

Figure B.9 Modify Configuration window



The Modify Configuration window features tabs that you can use to modify the application or servlet. If you are modifying an application, you can choose from among four tabs. Use the:

- Application tab to add additional `CLASSPATH`s for the application or servlet
- Sessions tab to modify Session Manager parameters
- Database tab to modify the database connection.
- Advanced tab to modify the application's default URL.

If you are modifying a servlet, there is only one tab—the Servlet tab. You can use the Servlet tab to modify the configuration options for the servlet, which are the same options that you specify when adding the servlet.

For more information about the available configuration parameters, see Chapter 3, "Using the Multiserver Administration Console," of the *Developer's Guide*.

Debugging an application

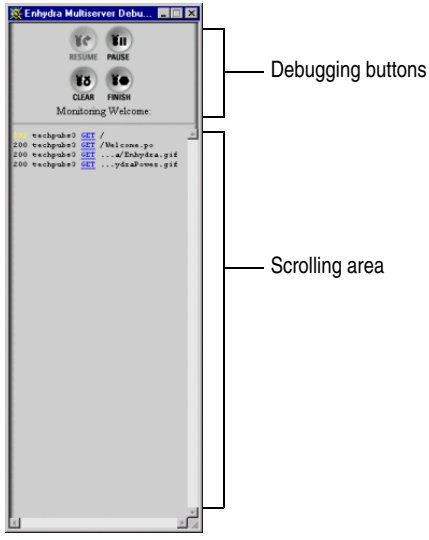
The debugging tool that comes with the Enhydra Multiserver is not a debugger in the classic sense of allowing you set breakpoints and step through your code. It is actually a traffic "snooper" that lets you see the requests going into your application and the responses being sent back. This capability can be very helpful for debugging HTTP-related issues when it is not always clear what is in the request coming from the client.

Use the following steps to debug an application running in the Multiserver:

1 Select the desired application in the Applications window.

2 Click the Debug button to display the debugging control panel, as shown in Figure B.10

Figure B.10 Debugging control panel



As shown in Figure B.10, the scrolling area in the window shows the active event list. You can use the debugging buttons as follows:

- Click the Pause button to pause the debugging function, which stops the accumulating of events in the scroll list.
- Click the Resume button to resume the debugging function.
- Click the Clear button to clear the list of events.
- Click the Finish button to halt debugging and close the popup window.

3 Make three to five requests to your application using a browser. The active event list in the scrolling lower portion of the debugger window will list the requests as they come in. The method name is captured for each request.

4 Click the name of the response type—`GET` in the above example—to display the Debug window in the content frame, with its tab sections of Request, Trace, Sessions, and Response. Use this information as needed in monitoring, debugging, or modifying your application.

Saving the state of the Multiserver

When you add or delete applications or servlets with the Console, you are changing the current configuration of the Multiserver. If you want the changes to be retained, you must save the configuration.

Use the following steps to write the current configuration to the Multiserver configuration file:

1 Click the Save State button.
2 Click OK in the Confirmation dialog box.

Stopping and restarting the Multiserver

Stopping the Multiserver terminates all running applications as well as the Admin Console itself.

- Click the Multiserver Stop button in the control frame, then click OK to confirm.
- To restart the Multiserver, return to the Enhydra shell and proceed as directed in "Launching the Admin Console" on page 101.

Creating a WAR file

This section describes how to set up the directory structure of a WAR file to deploy Java servlets, JSPs, and static content. Under the Servlet 2.2 API, JSPs and servlets are assembled into a directory structure referred to as a Web application archive, or WAR. When the WAR is finished, you can compress it into a file with a `.war` extension. Once set up, it can be moved from server to server without further configuration. A good way to understand how to construct a WAR is to look at a simple example.

A simple WAR example

Suppose you want to deploy a JSP called `Hello.jsp` and a servlet called `Hello.java`. Set up the following directory structure:

```
/tmp/webApp
   myJspDir
      Hello.jsp
   WEB-INF
      classes
         Hello.class
      web.xml
```

The directory structure begins with a document root directory that has an arbitrary name, in this case, `webApp`. The JSP page can be placed either in the document root directory or in any of its subdirectories. In this example, it is placed in an arbitrary subdirectory named `myJspDir`. `WEB-INF`, the one required subdirectory, contains the configuration file `web.xml` and a directory called `classes` which in turn contains the compiled servlet classes. If you are only using JSPs, you do not need a `classes` subdirectory. The Multiserver adds the `classes` directory to its `CLASSPATH`, so the server automatically finds servlets placed in that directory.

The last required file, `web.xml`, contains deployment information like name mappings, parameters, and default file mappings. The `web.xml` file in this simple example contains the following essentially empty file:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE web-app
   PUBLIC "-//Sun Microsystems, Inc.//DTD Web Application 2.2//EN"
   "http://java.sun.com/j2ee/dtds/web-app_2.2.dtd">

<web-app>
   <!-- configuration options would go here -->
</web-app>
```

Once you register your Web application with the Multiserver, you access the above pages with the following URLs:

- `http://<your_host>/myPrefix/myJspDir/Hello.jsp`
- `http://<your_host>/myPrefix/servlet/Hello`

The `http://<your_host>` section of the URL represents your host machine. When you configure the Multiserver to run the servlet, you tell it that the path to the document root is `/tmp/webApp`, and the URL prefix is some arbitrary string like `/myPrefix`. Therefore, every request with the prefix `myPrefix` is forwarded to the Multiserver which in turn runs your application.

The remainder of the URL for the JSP page corresponds to the directory structure. You can put HTML files in the same directory and request them in a similar manner. Calls to the servlet require the reserved word "servlet" in the URL. When the servlet server sees it, it knows to look for the corresponding class in the `classes` subdirectory of the `WEB-INF` directory.

For more information

For a somewhat more complex example, see the `WarExample` application that ships with Enhydra. Beyond that, Sun's Servlet 2.2 specification provides more information about configuring a WAR, containing both instructions and examples. You can download it from http://java.sun.com/products/servlet/download.html.

For a more in-depth discussion on using the Admin Console with WAR files, see Chapter 3, "Using the Multiserver Administration Console" in the *Developer's Guide*.

Index

Symbols

A

B

C

D

E

F

M

N

O

P

Q

R

S

T

U

V

W

X