Oracle8*i*

Oracle8*i* JDBC Developer's Guide and Reference

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Oracle8*i* JDBC Developer's Guide and Reference, Release 8.1.5

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Preface

This preface contains these sections:

Intended Audience

This manual assumes that you are an experienced programmer and that you understand Oracle databases, the SQL and Java programming languages, and the principles of JDBC.

Manual Structure

The *JDBC Developers Guide and Reference* contains eight chapters and one appendix:

Chapter 1, "Overview"	This chapter provides an overview of the Oracle implementation of JDBC and the Oracle JDBC driver architecture.
Chapter 2, "Getting Started"	This chapter introduces the Oracle JDBC drivers and some scenarios of how you can use them. This chapter also guides you through the basics of testing your installation and configuration.

Chapter 3, "Basic Features"	This chapter covers the basic steps in creating any JDBC application. It also discusses additional basic features of Java and JDBC supported by the Oracle JDBC drivers.
Chapter 4, "Oracle Extensions"	This chapter describes JDBC extensions provided by Oracle: packages, classes, and datatypes. It also describes the support for LOBs, objects, and collections provided by the extensions.
Chapter 5, "Advanced Topics"	This chapter describes advanced JDBC topics such as using NLS, working with applets, the server-side driver, and embedded SQL92 syntax.
Chapter 6, "Coding Tips and Troubleshooting"	This chapter includes coding tips and general guidelines for troubleshooting your JDBC applications.
Chapter 7, "Sample Applications"	This chapter presents sample applications that highlight advanced JDBC features and Oracle extensions.
Chapter 8, "Reference Information"	This chapter contains detailed JDBC reference information.
Appendix A, "JDBC Error Messages"	This appendix lists errors that can be thrown by the JDBC drivers.

Related Documentation

This manual contains references to the following Oracle publications:

- *Oracle8i JPublisher User's Guide*

  This book describes how to use the JPublisher utility to translate object types and other user-defined types to Java classes. If you are developing SQLJ or JDBC applications that use object types, `varray` types, nested table types, or `REF` types, then you are required to have Java classes that correspond to these types. JPublisher helps you do this by creating the mapping between object types and Java classes, and between object attribute types and their corresponding Java types.

- *Oracle8i SQLJ Developer's Guide and Reference*

  This book describes the use of SQLJ to embed static SQL operations directly into Java code. Both standard SQLJ features and Oracle-specific SQLJ features are described.

- *Oracle8i Java Stored Procedures Developer's Guide*

  This book describes Java stored procedures, which lets Java programmers access the Oracle RDBMS. With stored procedures (functions, procedures, database triggers, and SQL methods), Java developers can implement business logic at the server level, thereby improving application performance, scalability, and security.

- *Oracle8i Enterprise JavaBeans and CORBA Developer's Guide*

  This manual describes the Oracle extensions to the JavaBeans and CORBA specifications.

- *Net8 Administrator's Guide*

  Refer to this manual for more information about ANO (Advanced Network Option), the Oracle8 Connection Manager, and about Net8 network administration in general.

- *Oracle8i Error Messages*

  Refer to this document set for more information on error messages that can be passed by the Oracle Database and the Oracle JDBC drivers.

- *Oracle8i National Language Support Guide*

  Refer to this manual for more information on NLS environment variables, character sets, territories, and locale data. In addition, it contains an overview of common NLS issues, some typical scenarios, and some NLS considerations for OCI and SQL programmers.

- *Oracle8i Application Developer's Guide - Large Objects (LOBs)* and the *Oracle8i Application Developer's Reference - Packages*

  These books describe how to access and manipulate large objects (LOBs) using PL/SQL code and the `DBMS_LOB` package.

- *Oracle8i SQL Reference*

  This reference contains a complete description of the content and syntax of the Structured Query Language (SQL) used to manage information in an Oracle database.

- *PL/SQL User's Guide and Reference*

  PL/SQL is Oracle's procedural extension to SQL. An advanced fourth-generation programming language (4GL), PL/SQL offers seamless SQL access, tight integration with the Oracle server and tools, portability, security, and modern software engineering features such as data encapsulation, overloading, exception handling, and information hiding. This guide explains all the concepts behind PL/SQL and illustrates every facet of the language.

- *Oracle8i Application Server documentation*

  Refer to this documentation for more information on how the Oracle8*i* Application Server supports JDBC.

- *Oracle8 JDeveloper Suite documentation*

  Refer to this documentation for more information on how Oracle8 JDeveloper Suite supports JDBC.

Conventions Used in this Manual

Solaris syntax is used in this book, but file names and directory names for Windows NT are the same unless otherwise noted.

The term [ORACLE_HOME] is used to indicate the full path of the Oracle home directory.

In examples, an implied carriage return occurs at the end of each line, unless otherwise noted. You must press the Return key at the end of a line of input.

The following conventions are also used in this manual:

Convention	Meaning
. . .	Vertical ellipsis points in an example mean that information not directly related to the example has been omitted.
. . .	Horizontal ellipsis points in statements or commands mean that parts of the statement or command not directly related to the example have been omitted
< >	Angle brackets enclose user-supplied names.
[ ]	Brackets enclose optional clauses from which you can choose one or none.

1

Overview

This chapter provides an overview of the Oracle implementation of JDBC and contains these topics:

- What is JDBC?
- JDBC versus SQLJ
- Basic Driver Architecture
- Oracle Extensions to the JDBC Standard
- Supported JDK and JDBC Versions
- JDBC and the Oracle Application Server
- JDBC and IDEs

What is JDBC?

JDBC (Java Database Connectivity) is a standard Java interface for connecting to relational databases from Java. The JDBC standard was defined by Sun Microsystems, allowing individual providers to implement and extend the standard with their own JDBC drivers.

JDBC is based on the X/Open SQL Call Level Interface, and complies with the SQL92 Entry Level standard.

In addition to the standard JDBC API, Oracle drivers have extensions to properties, types, and performance.

JDBC versus SQLJ

This section has the following subsections:

- Advantages of SQLJ over JDBC for Static SQL
- General Guidelines for using JDBC and SQLJ

Developers who are familiar with the Oracle Call Interface (OCI) layer of client-side C code will recognize that JDBC provides the power and flexibility for the Java programmer that OCI does for the C or C++ programmer. Just as with OCI, you can use JDBC to query and update tables where, for example, the number and types of the columns are not known until runtime. This capability is called *dynamic SQL*. Therefore, JDBC is a way to use dynamic SQL statements in Java programs. Using JDBC, a calling program can construct SQL statements at runtime. Your JDBC program is compiled and run like any other Java program. No analysis or checking of the SQL statements is performed. Any errors that are made in your SQL code raise runtime errors. JDBC is designed as an API for dynamic SQL.

However, many applications do not need to construct SQL statements dynamically because the SQL statements they use are fixed or *static*. In this case, you can use SQLJ to embed *static SQL* in Java programs. In static SQL, all of the SQL statements are complete or "textually evident" in the Java program. That is, details of the database object, such as the column names, number of columns in the table, and table name, are known before runtime. SQLJ provides advantages for these applications because it permits error checking at precompile time.

The precompile step of a SQLJ program performs syntax-checking of the embedded SQL, type checking against the database to assure that the data exchanged between Java and SQL have compatible types and proper type conversions, and schema checking to assure congruence between SQL constructs and the database schema. The result of the precompilation is Java source code with SQL runtime code which,

in turn, can use JDBC calls. The generated Java code compiles and runs like any other Java program.

Although SQLJ provides direct support for static SQL operations that are known at the time the program is written, it can also inter-operate with dynamic SQL through JDBC. SQLJ allows you to create JDBC objects when they are needed for dynamic SQL operations. In this way, SQLJ and JDBC can co-exist in the same program. Convenient conversions are supported between JDBC connections and SQLJ connection contexts, as well as between JDBC result sets and SQLJ iterators. For more information on this, see the *Oracle8i SQLJ Developer's Guide and Reference*.

The syntax and semantics of SQLJ and JDBC do not depend on the configuration under which they are running, thus enabling implementation on the client or database side or in the middle tier.

Advantages of SQLJ over JDBC for Static SQL

While JDBC provides a complete dynamic SQL interface from Java to relational databases, SQLJ fills a complementary role for static SQL.

Although you can use static SQL statements in your JDBC programs, they can be represented more conveniently in SQLJ. Some advantages you gain in using SQLJ over JDBC for static SQL statements are:

- SQLJ source programs are smaller than equivalent JDBC programs because SQLJ provides a shorter syntax.
- SQLJ uses database connections to type-check static SQL code. JDBC, being a completely dynamic API, does not do any type checking until run-time.
- SQLJ programs allow direct embedding of Java bind expressions within SQL statements. JDBC requires separate get and / or set call statements for each bind variable and specifies the binding by position number.
- SQLJ provides strong typing of query outputs and return parameters and allows type-checking on calls. JDBC passes values to and from SQL without compile-time type checking.
- SQLJ provides simplified rules for calling SQL stored procedures and functions.

General Guidelines for using JDBC and SQLJ

Use SQLJ to write your program when:

- you want to be able to check your program for errors at translation-time rather than at run-time.

- you want to write an application that you can deploy to another database. Using SQLJ, you can customize the static SQL for that database at deployment-time.
- you are working with a database that contains compiled SQL. You will want to use SQLJ because you cannot compile SQL statements in a JDBC program.

Use JDBC to write your program when:

- your program uses dynamic SQL. For example, you have a program that builds queries on-the-fly or has an interactive component.
- you do not want to have a SQLJ layer during deployment or development. For example, you might want to download only the JDBC Thin driver and not the SQLJ runtime libraries to minimize download time over a slow link.

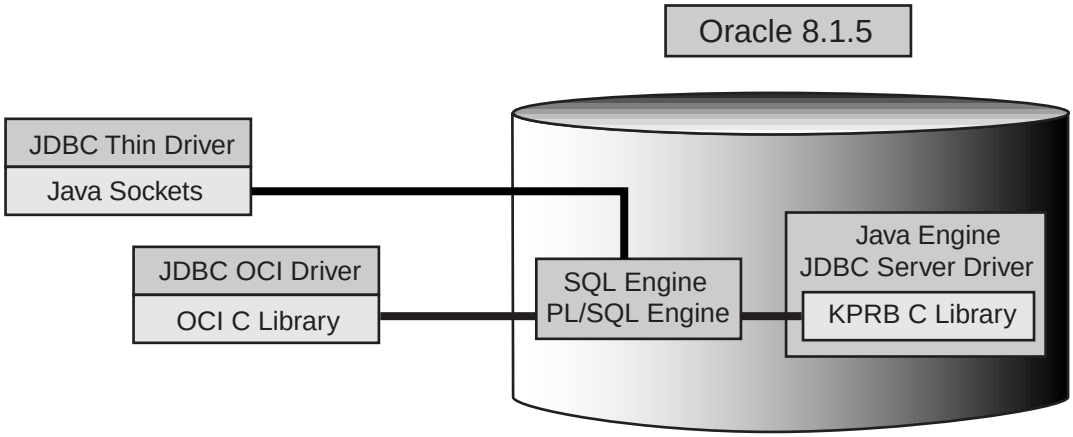
Basic Driver Architecture

This section has the following subsections:

- JDBC Thin Client-Side Driver Architecture
- JDBC OCI Client-Side Driver Architecture
- JDBC Server Driver Architecture

Figure 1–1 illustrates the driver-database architecture for the JDBC Thin, OCI, and Server drivers.

Figure 1–1 Driver-Database Architecture



JDBC Thin Client-Side Driver Architecture

The Oracle JDBC Thin driver is a Type IV driver that is targeted to applet developers. This driver is written in 100% Pure Java and complies with the JDBC 1.22 standard.

For communicating with the database, the driver includes an equivalent implementation of Oracle's TTC presentation protocol and Net8 session protocol in Java. Both of these protocols are lightweight implementation versions of their counterparts on the server. The Net8 protocol runs over TCP/IP only. To use this driver, it is not necessary to install any Oracle-specific software on the client.

The HTTP protocol is stateless but the Thin driver is not. The initial HTTP request to download the applet and the Thin driver is stateless. Once the Thin driver establishes the database connection, the communication between the browser and the database is stateful and in a two-tier configuration.

JDBC OCI Client-Side Driver Architecture

The JDBC OCI driver is a Type II driver that is targeted to client-server Java applications programmers and Java-based middle-tier developers. The JDBC OCI driver converts JDBC invocations to calls to the Oracle Call Interface (OCI). These calls are then sent over Net8 to the Oracle database server.

The JDBC OCI driver is written in a combination of Java and C because it must make calls to the OCI libraries. The driver requires the presence of the OCI libraries, Net8, CORE libraries, and other necessary files on each client machine or middle-tier application server on which it is installed.

JDBC Server Driver Architecture

The JDBC Server driver allows Java programs that use the Oracle 8.1.5 Java Virtual Machine (VM) and run inside the database to communicate with the SQL engine. The Server driver, the Java VM, the database, the KPRB (server-side) C library, and the SQL engine all run within the same address space. There are no network round-trips involved. The programs access the SQL engine by using function calls.

Oracle Extensions to the JDBC Standard

The Oracle JDBC drivers support many of the features described in the JDBC 2.0 standard. This support is provided in the form of Oracle-defined extensions for Oracle datatypes, object types, and their mappings to Java. For more information on these extensions, see Chapter 4, "Oracle Extensions".

Supported JDK and JDBC Versions

Oracle's JDBC drivers, release 8.1.5, support the JDK versions 1.0.2 and 1.1.*x*. They also comply with JDBC version 1.22 and, in addition, implement most of the features of JDBC version 2.0.

Note: There are special considerations for using the Thin driver with JDK 1.0.2 and 1.1.1 in the context of applets. See "Working with Applets" on page 5-7 for more information on this topic.

JDBC and the Oracle Application Server

Oracle Application Server is a collection of middleware services and tools that provide a scalable, robust, secure, and extensible platform for distributed, object-oriented applications. Oracle Application Server supports access to applications from both Web clients (browsers) using the Hypertext Transfer Protocol (HTTP), and CORBA clients, which use the Common Object Request Broker Architecture (CORBA) and the Internet Inter-ORB Protocol (IIOP).

You can use the JDBC OCI drivers on a middle tier in conjunction with Oracle Web Application Server versions 3.0 and higher. The Oracle Web Application Server bundles JDBC with its distribution. For more information on the use of JDBC and the Oracle Web Application Server, see your Oracle Web Application Server documentation.

JDBC and IDEs

The Oracle JDeveloper Suite provides developers with a single, integrated set of products to build, debug and deploy component-based database applications for the Oracle Internet platform. The Oracle JDeveloper environment contains integrated support for JDBC, including 100% Pure Java and native Oracle8 drivers. The database component of Oracle JDeveloper uses the JDBC drivers to manage the connection between the application running on the client and the server. See your Oracle JDeveloper documentation for more information.

2

Getting Started

This chapter guides you through the basics of testing your installation and configuration and running a simple application. The following topics are discussed:

- Oracle JDBC Drivers
- Requirements and Compatibilities for Oracle JDBC Drivers
- Verifying a JDBC Client Installation

Oracle JDBC Drivers

This section has the following subsections:

Oracle offers two different drivers for client-side use (one of which can also be used in a middle tier) and one for server-side use. Most of the information in the following chapters focuses on the client-side drivers. The server-side driver is described in detail in "JDBC on the Server: the Server Driver" on page 5-22.

Introducing the Oracle JDBC Drivers

This section describes the Oracle JDBC drivers and provides scenarios for how you would use them. Oracle produces JDBC drivers for use in clients and in the server. The client-side drivers can be used in Java applications or Java applets that run either on the client or in the middle tier of a three-tier configuration. The server-side driver provides server-side JDBC support which allows the Java VM to communicate with the SQL engine.

Common Features of Oracle JDBC Drivers

The server-side and client-side Oracle JDBC drivers provide the same functionality. They all support the following standards and features:

- JDBC 1.22
- most of the JDBC 2.0 features
- the same syntax and APIs
- the same Oracle extensions
- full support for multi-threaded applications

The only differences between the drivers are in how they connect to the database and how they transfer data.

JDBC Thin Driver

The Oracle JDBC Thin driver is a 100% Pure Java implementation that complies with the JDBC 1.22 standard. The JDBC Thin driver uses Java Sockets to connect directly to the Oracle Server and is typically used for Java applets in either a two-tier or three-tier configuration, though it can also be used for Java applications. The JDBC Thin driver provides its own implementation of a TCP/IP version of

Oracle's Net8. Because it is written entirely in Java, this driver is platform-independent. When the JDBC Thin driver is used with an applet, the client browser must have the capability to support Java sockets.

The JDBC Thin driver does not require Oracle software on the client side; it can be downloaded into a browser simultaneously with the Java applet being run. From the client (usually a browser), you select a URL from an HTML page that contains a Java applet tag. The web server downloads the Java applet and the JDBC Thin driver to the client. The JDBC Thin driver then establishes a direct connection to the database server using Java Sockets.

The JDBC Thin driver connects to any Oracle database of version 7.2.3 and higher. The JDBC Thin driver allows a direct connection to the database by emulating Net8 and TTC (the wire protocol used by OCI) on top of Java sockets. The driver supports only TCP/IP protocol and requires a TNS listener to be listening on TCP/IP sockets from the database server.

For a discussion of relevant firewall, browser, and security issues, see "Working with Applets" on page 5-7.

JDBC OCI Driver

The JDBC OCI driver provides an implementation of the JDBC interfaces using the Oracle Call Interface (OCI). The OCI driver makes use of the OCI cache, C entry points to OCI, and the OCI library. The use of native methods to call C entry points makes the driver platform-specific. The JDBC OCI driver also requires an Oracle client installation including Net8.

The JDBC OCI driver is compatible with all Oracle versions because it interfaces to Oracle databases through OCI. The driver also supports all installed Net8 adapters, including IPC, named pipes, TCP/IP, and IPX/SPX.

Because the JDBC OCI driver contains C code, it is not suitable for use in applets. However, it is an excellent choice for Java applications or Java middle tiers such as the Oracle Web Application Server. You can use the JDBC OCI driver in these configurations:

- with a Java application running on a client machine in a two-tier configuration
- with a Java application running on a middle tier in a three-tier configuration
- with a Java servlet running on a middle tier in a three-tier configuration

JDBC Server Driver

Oracle's JDBC Server driver is for server-side use only. The Server driver provides server-side JDBC support for any Java program used in the database, Java stored procedure, Enterprise Java Beans (EJB) and for communication with SQL and PL/SQL programs. The Server driver is fully consistent with, and supports the same features and extensions as the client-side drivers. For more information on the server-side driver, see "JDBC on the Server: the Server Driver" on page 5-22.

Choosing the Appropriate Driver

Four main considerations that you must bear in mind when choosing which JDBC driver to use for your application or applet are:

- If you are writing an applet, you must use the JDBC Thin driver. JDBC OCI-based driver classes cannot be downloaded to a Web browser, because they call native (C language) methods.

  Notes:

  - JDBC Thin drivers use a subset of the Net8 protocol, written entirely in Java, and connect using the TCP/IP protocol.
  - There are other restrictions on applets besides your choice of JDBC driver. For information on these restrictions, see "Browser Security and JDK Version Considerations" on page 5-20.

- If you desire maximum portability, then choose the JDBC Thin driver. You can connect to an Oracle8 data server from either an application or an applet using the JDBC Thin driver.
- If you are writing an application and need maximum performance, then choose the JDBC OCI driver.
- If you are running in the Oracle database server using the Oracle 8.1.5 Java VM, then choose the JDBC Server driver.

Requirements and Compatibilities for Oracle JDBC Drivers

Table 2–1 lists the compatibilities between versions of the Oracle database and the JDBC drivers.

Table 2–1 JDBC Driver-Database Compatibility

Database Version	Driver Version	Remarks
8.1.5	JDBC Thin Driver JDBC OCI Driver JDBC Server Driver	Both client- and server-side drivers offer full object support when run against an 8.1.5 database.
8.1.4	JDBC Thin Driver JDBC OCI Driver JDBC Server Driver	Both client- and server-side drivers offer full object support when run against an 8.1.4 database.
8.0.*x*	JDBC Thin Driver JDBC OCI Driver ***Note:*** *the JDBC Server driver is not available for version 8.0.x*	The JDBC OCI and Thin drivers do not support objects when run against an 8.0.*x* database. This is because JDBC depends on PL/SQL functions that did not exist in 8.0.*x*.
7.*x*	JDBC Thin Driver JDBC OCI Driver ***Note:*** *the JDBC Server driver is not available for version 7.x*	The JDBC OCI and Thin drivers do not support objects when run against a 7.*x* database. This is because JDBC depends on PL/SQL functions that did not exist in 7.*x* The JDBC OCI driver does not support LOBs.

Verifying a JDBC Client Installation

This section has the following subsections:

Installation of an Oracle JDBC driver is platform-specific. Follow the installation instructions for the driver you want to install in your platform-specific documentation.

This section describes the steps of verifying an Oracle client installation of the JDBC drivers. It assumes that you have already installed the driver of your choice.

If you have installed the JDBC Thin driver, no further installation on the client machine is necessary (the JDBC Thin driver requires a TCP/IP listener to be running on the database machine).

If you have installed the JDBC OCI driver, you must also install the Oracle client software. This includes Net8 and the OCI libraries.

Check Installed Directories and Files

This section assumes that you have already installed the Sun Microsystems *Java Developer's Kit (JDK)* on your system. The Oracle JDBC drivers are compatible with JDK versions 1.0.2 and 1.1.x. The Oracle JDBC drivers for version 8.1.5 do not support the JDK 1.2.

Directories for JDBC

Installing the Oracle Java server products creates, among other things, a `jdbc` directory under `[ORACLE_HOME]`, containing these subdirectories and files:

- `demo/samples`: The `samples` directory contains sample programs, including examples of how to use SQL92 and Oracle SQL syntax, PL/SQL blocks, streams, and the Oracle JDBC type and performance extensions. The `demo` directory contains only the `samples` subdirectory.
- `doc`: The `doc` directory contains documentation about the JDBC drivers.
- `lib`: The `lib` directory contains `.zip` files with required Java classes: `classes111.zip` for JDK 1.1.1 and `classes102.zip` for JDK 1.0.2.

- `readme.txt`: The `readme.txt` file contains up to the minute facts about the drivers that might not be in the manual.

Check that all these directories have been created and populated.

Check the Environment Variables

This section describes the environment variables that must be set for the JDBC OCI driver and the JDBC Thin driver.

Solaris and Windows NT Platforms

You must set the CLASSPATH for your installed JDBC OCI or Thin driver. Depending on whether you are using the JDK version 1.0.2 or version 1.1.1, you must set one of these values for the CLASSPATH:

- `[Oracle Home]/jdbc/lib/classes102.zip`

OR

- `[Oracle Home]/jdbc/lib/classes111.zip`

JDBC OCI Drivers: If you are installing the JDBC OCI driver, you must also set the following value for the library path environment variable (this will be LD_LIBRARY_PATH on Solaris or PATH on Windows NT).

- `[Oracle Home]/lib`

On Solaris, this directory contains the shared object library `libocijdbc8.so`.

JDBC Thin Drivers: If you are installing the JDBC Thin driver, you do not have to set any other environment variables.

Make Sure You Can Compile and Run Java

To further ensure that Java is set up properly on your client system, go to the `samples` directory (for example, `C:\oracle\ora81\jdbc\demo\samples` if you are using the JDBC driver on a Windows NT machine), then see if `javac` (the Java compiler) and `java` (the Java interpreter) will run without error. Enter:

```
javac
```

then enter:

```
java
```

Each should give you a list of options and parameters and then exit.

Determining the Version of the JDBC Driver

If at any time you need to determine the version of the JDBC driver that you installed, you can invoke the `getDriverVersion()` method of the `OracleDatabaseMetaData` class.

Here is sample code showing how to do it:

```
import java.sql.*;
import oracle.jdbc.driver.*;

class JDBCVersion
{
public static void main (String args [])
throws SQLException
{
// Load the Oracle JDBC driver
DriverManager.registerDriver
(new oracle.jdbc.driver.OracleDriver());
Connection conn = DriverManager.getConnection
("jdbc:oracle:thin:@host:port:sid","scott","tiger");

// Create Oracle DatabaseMetaData object
DatabaseMetaData meta = conn.getMetaData ();

// gets driver info:
System.out.println("JDBC driver version is " + meta.getDriverVersion());
}
}
```

Testing JDBC and the Database Connection: JdbcCheckup

The `samples` directory contains sample programs for a particular Oracle JDBC driver. One of the programs, `JdbcCheckup.java`, is designed to test JDBC and the database connection. The program queries you for your user name, password, and the name of a database to which you want to connect. The program connects to the database, queries for the string "`Hello World`", and prints it to the screen.

Go to the `samples` directory and compile and run `JdbcCheckup.java`. If the results of the query print without error, then your Java and JDBC installations are correct.

Although `JdbcCheckup.java` is a simple program, it illustrates several important functions:

- imports the necessary Java classes, including JDBC classes

- registers the JDBC driver
- connects to the database
- executes a simple query
- outputs the query results to your screen

"First Steps in JDBC" on page 3-2, describes these functions in greater detail. A listing of `JdbcCheckup.java` for the JDBC OCI driver appears below.

```
/*
 * This sample can be used to check the JDBC installation.
 * Just run it and provide the connect information.  It will select
 * "Hello World" from the database.
 */

// You need to import the java.sql package to use JDBC
import java.sql.*;

// We import java.io to be able to read from the command line
import java.io.*;

class JdbcCheckup
{
    public static void main (String args [])
         throws SQLException, IOException
        {
            // Load the Oracle JDBC driver
            DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

            // Prompt the user for connect information
            System.out.println ("Please enter information to test connection to
                                the database");
            String user;
            String password;
            String database;

            user = readEntry ("user: ");
            int slash_index = user.indexOf ('/');
            if (slash_index != -1)
            {
               password = user.substring (slash_index + 1);
               user = user.substring (0, slash_index);
            }
            else
              password = readEntry ("password: ");
```

```
            database = readEntry ("database (a TNSNAME entry): ");

            System.out.print ("Connecting to the database...");
            System.out.flush ();

            System.out.println ("Connecting...");
            Connection conn =
               DriverManager.getConnection ("jdbc:oracle:oci8:@" + database,
                                            user, password);

            System.out.println ("connected.");

            // Create a statement
            Statement stmt = conn.createStatement ();

            // Do the SQL "Hello World" thing
            ResultSet rset = stmt.executeQuery ("select 'Hello World'
                                                 from dual");

            while (rset.next ())
               System.out.println (rset.getString (1));
            // close the result set, the statement and connect
            rset.close();
            stmt.close();
            conn.close();
            System.out.println ("Your JDBC installation is correct.");
        }

    // Utility function to read a line from standard input
    static String readEntry (String prompt)
    {
        try
        {
            StringBuffer buffer = new StringBuffer ();
            System.out.print (prompt);
            System.out.flush ();
            int c = System.in.read ();
            while (c != '\n' && c != -1)
            {
               buffer.append ((char)c);
               c = System.in.read ();
            }
            return buffer.toString ().trim ();
        }
        catch (IOException e)
```

```
        {
            return "";
        }
    }
}
```

3

Basic Features

This chapter covers the most basic steps taken in any JDBC application. It also describes additional basic features of Java and JDBC supported by the Oracle JDBC drivers. It includes the following topics:

- First Steps in JDBC
- Sample: Connecting, Querying, and Processing the Results
- Datatype Mappings
- Using Java Streams in JDBC
- Using Stored Procedures in JDBC Programs
- Error Messages and JDBC
- Server-Side Basics
- Application Basics versus Applet Basics

First Steps in JDBC

This section describes how to get up and running with the Oracle JDBC drivers. When using the Oracle JDBC drivers, you must include certain driver-specific information in your programs. This section describes, in the form of a tutorial, where and how to add the information. The tutorial guides you through creating code to connect to and query a database from the client.

To connect to and query a database from the client, you must provide code for these tasks:

1. Importing Packages
2. Registering the JDBC Drivers
3. Opening a Connection to a Database
4. Creating a Statement Object
5. Executing a Query and Returning a Result Set Object
6. Processing the Result Set
7. Closing the Result Set and Statement Objects
8. Closing the Connection

You must supply Oracle driver-specific information for the first three tasks, which allow your program to use the JDBC API to access a database. For the other tasks, you can use standard JDBC Java code as you would for any Java application.

Importing Packages

Regardless of which Oracle JDBC driver you use, you must include the following `import` statements at the beginning of your program.

`import java.sql.*`	JDBC packages.
`import java.math.*`	Java math packages; for example, these are required for the `BigDecimal` classes.

You will need to add the following Oracle packages to your program when you want to access the extended functionality provided by the Oracle drivers. However, they are not required for the example presented in this section:

`oracle.jdbc.driver.*` and `oracle.sql.*`	Add these packages if you use any Oracle-specific extensions to JDBC in your program. For more information on Oracle extensions, see Chapter 4, "Oracle Extensions".

Registering the JDBC Drivers

You must provide the code to register your installed driver with your program. You do this with the static `registerDriver()` method of the JDBC `DriverManager` class. This class provides a basic service for managing a set of JDBC drivers.

Note: Alternatively, you can use the `forName()` method of the `java.lang.Class` class to load the JDBC drivers directly. For example:

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

However, this method is valid only for JDK-compliant Java virtual machines. It is not valid for Microsoft Java virtual machines.

Because you are using one of Oracle's JDBC drivers, you declare a specific driver name string to `registerDriver()`. You register the driver only once in your Java application.

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

Note: If you are registering a Thin driver in an applet, you must enter a driver string that is different from the one used in these examples. For more information on registering a Thin driver for an applet, see "Coding Applets" on page 5-7.

Opening a Connection to a Database

You open a connection to the database with the static `getConnection()` method of the JDBC `DriverManager` class. This method returns an object of the JDBC `Connection` class which needs as input a userid, password, connect string that identifies the JDBC driver to use, and the name of the database to which you want to connect.

Connecting to a database is a step where you must enter Oracle JDBC driver-specific information in the `getConnection()` method. If you are not

familiar with this method, continue reading the "Understanding the Forms of getConnection()" section below.

If you are already familiar with the `getConnection()` method, you can skip ahead to either of these sections, depending on the driver you installed:

- "Opening a Connection for the JDBC OCI Driver" on page 3-6
- "Opening a Connection for the JDBC Thin Driver" on page 3-7

> **Note:** The instructions in this section are specific to the client-side drivers only. To find out how to open a database connection using the server-side driver, see "Server-Side Basics" on page 3-26.

Understanding the Forms of getConnection()

The `getConnection()` method is an overloaded method that you declare by the techniques described in these sections:

- "Specifying a Database URL, Userid, and Password" on page 3-4
- "Specifying a Database URL That Includes Userid and Password" on page 3-5
- "Specifying a Database URL and Properties Object" on page 3-6

> **Note:** You do not have to specify the database name if there is a default connection. For more information about default connections, see "Connecting to the Database with the Server Driver" on page 5-22.

If you want to specify a database name in the connection, it must be in one of the following formats:

- a Net8 *keyword-value* pair
- a string of the form <*host_name*>:<*port_number*>:<*sid*> (Thin driver only)
- a `TNSNAMES` entry (OCI driver only)

For information on how to specify a *keyword-value* pair or a `TNSNAMES` entry, see your *Net8 Administrator's Guide.*

Specifying a Database URL, Userid, and Password

```
getConnection(String URL, String user, String password);
```

where the URL is of the form:

```
jdbc:oracle:<drivertype>:@<database>
```

The following example connects user `scott` with password `tiger` to a database with SID `orcl` through port 1521 of host `myhost`, using the Thin driver.

```
Connection conn =
   DriverManager.getConnection ("jdbc:oracle:thin:@myhost:1521:orcl",
       "scott", "tiger");
```

If you want to use the default connection for an OCI driver, specify either:

```
Connection conn = DriverManager.getConnection
    ("jdbc:oracle:oci8:scott/tiger@");
```

OR

```
Connection conn =
    DriverManager.getConnection ("jdbc:oracle:oci8:@", "scott", "tiger");
```

For all JDBC drivers you can also specify the database with a Net8 *keyword-value* pair. The Net8 *keyword-value* pair substitutes for the `TNSNAMES` entry. The following example uses the same parameters as the preceding example, but in the *keyword-value* format:

```
Connection conn =
    DriverManager.getConnection
    (jdbc:oracle:oci8:@MyHostString","scott","tiger");
```

OR

```
Connection conn =
DriverManager.getConnection("jdbc:oracle:oci8:@(description=(address=(host=
myhost)(protocol=tcp)(port=1521))(connect_data=(sid=orcl)))",
"scott", "tiger");
```

Specifying a Database URL That Includes Userid and Password

```
getConnection(String URL);
```

where the URL is of the form:

```
jdbc:oracle:<drivertype>:<user>/<password>@<database>
```

The following example connects user `scott` with password `tiger` to a database using the OCI driver. In this case, however, the URL includes the userid and password, and is the only input parameter.

```
Connection conn =
 DriverManager.getConnection("jdbc:oracle:oci8:scott/tiger@myhost);
```

Specifying a Database URL and Properties Object

```
getConnection(String URL, Properties info);
```

where the `URL` is of the form:

`jdbc:oracle:<drivertype>:@<database>`

In addition to the URL, use an object of the standard Java `Properties` class as input. For example:

```
java.util.Properties info = new java.util.Properties();
info.put ("user", "scott");
info.put ("password","tiger");
info.put ("defaultRowPrefetch","15");
getConnection ("jdbc:oracle:oci8:@",info);
```

Oracle Extensions to Connection Properties Object Oracle has defined several extensions to the connection properties that Oracle JDBC drivers support. For more information on this form of the `getConnection()` method and the Oracle extensions to the `Properties` object, see "Oracle Extensions for Connection Properties" on page 4-109.

Opening a Connection for the JDBC OCI Driver

For the JDBC OCI driver, you can specify the database by a `TNSNAMES` entry. You can find the available `TNSNAMES` entries listed in the file `tnsnames.ora` on the client computer from which you are connecting. On Windows NT this file is located in `[ORACLE_HOME]\NETWORK\ADMIN`. On UNIX systems, you can find it in `/var/opt/oracle`.

For example, if you want to connect to the database on host `myhost` as user `scott` with password `tiger` that has a `TNSNAMES` entry of `MyHostString`, enter:

```
Connection conn =
    DriverManager.getConnection ("jdbc:oracle:oci8:@MyHostString",
        "scott", "tiger");
```

Note that both the ":" and "@" characters are necessary.

For the JDBC OCI driver (as with the Thin driver), you can also specify the database with a Net8 *keyword-value* pair. This is less readable than a TNSNAMES entry but does not depend on the accuracy of the TNSNAMES.ORA file. The Net8 *keyword-value* pair also works with other JDBC drivers.

For example, if you want to connect to the database on host myhost that has a TCP/IP listener up on port 1521, and the SID (system identifier) is orcl, use a statement such as:

```
Connection conn =
    DriverManager.getConnection("jdbc:oracle:oci8:@(description=(address=(host=
    myhost)(protocol=tcp)(port=1521))(connect_data=(sid=orcl)))",
        "scott", "tiger");
```

Opening a Connection for the JDBC Thin Driver

Because you can use the JDBC Thin driver in applets that do not depend on an Oracle client installation, you cannot use a TNSNAMES entry to identify the database to which you want to connect. You have to either:

- explicitly list the host name, TCP/IP port and Oracle SID of the database to which you want to connect

OR

- use a *keyword-value* pair list

> **Note:** The JDBC Thin driver supports only the TCP/IP protocol.

For example, use this string if you want to connect to the database on host myhost that has a TCP/IP listener on port 1521 for the database SID (system identifier) orcl. You can logon as user scott, with password tiger:

```
Connection conn =
    DriverManager.getConnection
    ("jdbc:oracle:thin:@myhost:1521:orcl", "scott", "tiger");
```

You can also specify the database with a Net8 *keyword-value* pair. This is less readable than the first version, but also works with the other JDBC drivers.

```
Connection conn =
          DriverManager.getConnection
 ("jdbc:oracle:thin:@(description=(address=(host=myhost)(protocol=tcp)
    (port=1521))(connect_data=(sid=orcl)))", "scott", "tiger");
```

Note: If you are writing a connection statement for an applet, you must enter a connect string that is different from the one used in these examples. For more information on connecting to a database with an applet, see "Coding Applets" on page 5-7.

Creating a Statement Object

Once you connect to the database and, in the process, create your `Connection` object, the next step is to create a `Statement` object. The `createStatement()` method of your JDBC `Connection` object returns an object of the JDBC `Statement` class. To continue the example from the previous section where the `Connection` object `conn` was created, here is an example of how to create the `Statement` object:

```
Statement stmt = conn.createStatement();
```

Note that there is nothing Oracle-specific about this statement; it follows standard JDBC syntax.

Executing a Query and Returning a Result Set Object

To query the database, use the `executeQuery()` method of your `Statement` object. This method takes a SQL statement as input and returns an object of the JDBC `ResultSet` class.

To continue the example, once you create the `Statement` object `stmt`, the next step is to execute a query that populates a `ResultSet` object with the contents of the `ENAME` (employee name) column of a table of employees that is named `EMP`:

```
ResultSet rset = stmt.executeQuery ("SELECT ename FROM emp");
```

Again, there is nothing Oracle-specific about this statement; it follows standard JDBC syntax.

Note: The JDBC drivers actually return an `OracleResultSet` object, but into a standard `ResultSet` output variable. If you want to use Oracle extensions to process the result set, then you must cast the output to `OracleResultSet`. This is further discussed in "Classes of the oracle.jdbc.driver Package" on page 4-22.

Processing the Result Set

Once you execute your query, use the `next()` method of your `ResultSet` object to iterate through the results. This method loops through the result set row by row, detecting the end of the result set when it is reached.

To pull data out of the result set as you iterate through it, use the various `getXXX()` methods of the `ResultSet` object, where `XXX` corresponds to a Java datatype.

For example, the following code will iterate through the `ResultSet` object `rset` from the previous section, and will retrieve and print each employee name:

```
while (rset.next())
    System.out.println (rset.getString(1));
```

Once again, this is standard JDBC syntax. The `next()` method returns false when it reaches the end of the result set. The employee names are materialized as Java Strings.

Closing the Result Set and Statement Objects

You must explicitly close the `ResultSet` and `Statement` objects after you finish using them. This applies to all `ResultSet` and `Statement` objects you create when using the Oracle JDBC drivers. The drivers do not have finalizer methods; cleanup routines are performed by the `close()` method of the `ResultSet` and `Statement` classes. If you do not explicitly close your `ResultSet` and `Statement` objects, serious memory leaks could occur. You could also run out of cursors in the database. Closing a result set or statement releases the corresponding cursor in the database.

For example, if your `ResultSet` object is `rset` and your `Statement` object is `stmt`, close the result set and statement with these lines:

```
rset.close()
stmt.close();
```

When you close a `Statement` object that a given `Connection` object creates, the connection itself remains open.

Closing the Connection

You must close your connection to the database once you finish your work. Use the `close()` method of the `Connection` class to do this. For example, if your `Connection` object is `conn`, close the connection with this statement:

```
conn.close();
```

Sample: Connecting, Querying, and Processing the Results

The steps in the preceding sections are illustrated in the following example, which registers an Oracle JDBC Thin driver, connects to the database, creates a `Statement` object, executes a query, and processes the result set.

Note that the code for creating the `Statement` object, executing the query, returning and processing the `ResultSet` object, and closing the statement and connection all follow standard JDBC syntax.

```
import java.sql.*;
import java.math.*;
import java.io.*;
import java.awt.*;

class JdbcTest {
    public static void main (String args []) throws SQLException {
        // Load Oracle driver
        DriverManager.registerDriver (new oracle.jdbc.driver.OracleDriver());

        // Connect to the local database
        Connection conn =
            DriverManager.getConnection ("jdbc:oracle:thin:@myhost:1521:ORCL",
                "scott", "tiger");

        // Query the employee names
        Statement stmt = conn.createStatement ();
        ResultSet rset = stmt.executeQuery ("SELECT ename FROM emp");

        // Print the name out
        while (rset.next ())
            System.out.println (rset.getString (1));
```

```
        //close the result set, statement, and the connection
        rset.close();
        stmt.close();
        conn.close();
    }
}
```

If you want to adapt the code for the OCI driver, replace the `Connection` statement with the following:

```
Connection conn = DriverManager.getConnection ("jdbc:oracle:oci8:@MyHostString",
        "scott", "tiger");
```

where `MyHostString` is an entry in the `TNSNAMES.ORA` file.

> **Note:** If you are creating code for an applet, the `getConnection()` and `registerDriver()` strings will be different. For more information, see "Coding Applets" on page 5-7.

Datatype Mappings

The Oracle JDBC drivers support the SQL datatypes required by JDBC 1.22. In addition, the Oracle JDBC drivers support the Oracle-specific `ROWID` datatype and user-defined types of the `REF CURSOR` category.

For reference, the following table shows the default mappings between JDBC datatypes, native Java datatypes, SQL datatypes, and the corresponding Java datatypes defined by Oracle extensions.

The **Standard JDBC Datatypes** column lists the datatypes supported by the JDBC 1.22 standard. All of these dataypes are defined in the `java.sql.Types` class.

The **Java Native Datatypes** column lists the datatypes defined by the Java language.

The **SQL Datatypes** column lists the SQL datatypes that exist in the database.

The **Oracle Extensions—Java Classes that Represent SQL Datatypes** column lists the `oracle.sql.*` Java types that correspond to each SQL datatype in the database. These are Oracle extensions that let you retrieve all SQL data in the form of a `oracle.sql.*` Java type. Mapping SQL datatypes into the `oracle.sql` datatypes lets you store and retrieve data without losing information. Refer to "Classes of the oracle.sql Package" on page 4-7 for more information on the `oracle.sql.*` package.

For a list of all of the Java datatypes to which you can validly map a SQL datatype, see "Valid SQL-JDBC Datatype Mappings" on page 8-2.

Table 3–1 Mapping Between JDBC, Java Native, and Oracle Datatypes

Standard JDBC Datatypes	Java Native Datatypes	SQL Datatypes	Oracle Extensions—Java Classes that Represent SQL Datatypes
java.sql.Types.CHAR	java.lang.String	CHAR	oracle.sql.CHAR
java.sql.Types.VARCHAR	java.lang.String	VARCHAR2	oracle.sql.CHAR
java.sql.Types.LONGVARCHAR	java.lang.String	LONG	oracle.sql.CHAR
java.sql.Types.NUMERIC	java.math.BigDecimal	NUMBER	oracle.sql.NUMBER
java.sql.Types.DECIMAL	java.math.BigDecimal	NUMBER	oracle.sql.NUMBER
java.sql.Types.BIT	boolean	NUMBER	oracle.sql.NUMBER
java.sql.Types.TINYINT	byte	NUMBER	oracle.sql.NUMBER
java.sql.Types.SMALLINT	short	NUMBER	oracle.sql.NUMBER
java.sql.Types.INTEGER	int	NUMBER	oracle.sql.NUMBER
java.sql.Types.BIGINT	long	NUMBER	oracle.sql.NUMBER
java.sql.Types.REAL	float	NUMBER	oracle.sql.NUMBER
java.sql.Types.FLOAT	double	NUMBER	oracle.sql.NUMBER
java.sql.Types.DOUBLE	double	NUMBER	oracle.sql.NUMBER
java.sql.Types.BINARY	byte[]	NUMBER	oracle.sql.NUMBER
java.sql.Types.VARBINARY	byte[]	RAW	oracle.sql.RAW
java.sql.Types.LONGVARBINARY	byte[]	LONGRAW	oracle.sql.NUMBER
java.sql.Types.DATE	java.sql.Date	DATE	oracle.sql.DATE
java.sql.Types.TIME	java.sql.Time	DATE	oracle.sql.DATE
java.sql.Types.TIMESTAMP	javal.sql.Timestamp	DATE	oracle.sql.DATE

Oracle JDBC Extension Types

In addition, the following JDBC extensions for SQL datatypes (most of which comply with the JDBC 2.0 standard) are supported. They are not described until Chapter 4, "Oracle Extensions", but are summarized here for reference. Table 3–2 shows their mappings to Oracle datatypes.

The **SQL Datatype** column lists the SQL datatypes that exist in the database.

The **JDBC Extensions for SQL Datatypes** column lists the types into which Oracle datatypes should map according to the JDBC 2.0 standard. The class `oracle.jdbc.driver.OracleTypes.*` includes the definitions of Oracle-specific types that do not exist in the JDBC standard and is a superset of `oracle.sql.*`.

The **Oracle Extensions—Java Classes that Represent SQL Datatypes** column lists the `oracle.sql.*` Java types that correspond to each SQL datatype in the database. These are Oracle extensions that let you retrieve all SQL data in the form of a `oracle.sql.*` Java type. Refer to "Classes of the oracle.sql Package" on page 4-7 for more information on the `oracle.sql.*` package.

For a list of all of the Java datatypes to which you can validly map a SQL datatype, see "Valid SQL-JDBC Datatype Mappings" on page 8-2.

Table 3–2 Mapping Oracle Extension JDBC Types to Oracle Datatypes

SQL Datatype	JDBC Extensions for SQL Datatypes	Oracle Extensions—Java Classes that Represent SQL Datatypes
ROWID	oracle.jdbc.driver.OracleTypes.ROWID	oracle.sql.ROWID
user-defined types of the REF CURSOR category	oracle.jdbc.driver.OracleTypes.CURSOR	java.sql.ResultSet
BLOB	oracle.jdbc.driver.OracleTypes.BLOB	oracle.sql.BLOB
CLOB	oracle.jdbc.driver.OracleTypes.CLOB	oracle.sql.CLOB
BFILE	oracle.jdbc.driver.OracleTypes.BFILE	oracle.sql.BFILE
Object Value	oracle.jdbc.driver.OracleTypes.STRUCT	If there is no entry for the object value in the type map: ■ oracle.sql.STRUCT If there is an entry for the object value in the type map: ■ customized Java class
Object Reference	oracle.jdbc.driver.OracleTypes.REF	class that extends oracle.sql.REF
Collections (varrays and nested tables)	oracle.jdbc.driver.OracleTypes.ARRAY	oracle.sql.ARRAY

See Chapter 4, "Oracle Extensions", for more information on type mappings. In Chapter 4 you can also find more information on:

- packages `oracle.sql`, `oracle.jdbc.driver`, and `oracle.jdbc2`
- type extensions for the Oracle `ROWID` datatype and user-defined types of the `REF CURSOR` category
- how to use type maps with object values and collections

Using Java Streams in JDBC

This section has the following subsections:

This section describes how the Oracle JDBC drivers handle Java streams for several datatypes. Data streams allow you to read `LONG` column data of up to 2 gigabytes. Methods associated with streams let you read the data incrementally.

Oracle JDBC drivers support the manipulation of data streams in either direction between server and client. The drivers support all stream conversions: binary, ASCII, and Unicode. Following is a brief description of each type of stream:

- binary stream: returns the `RAW` bytes of the data. This corresponds to the `getBinaryStream()` method.
- ASCII stream: returns ASCII bytes in ISO-Latin-1 encoding. This corresponds to the `getAsciiStream()` method.
- Unicode stream: returns Unicode bytes with the `UCS-2` encoding. This corresponds to the `getUnicodeStream()` method.

The methods `getBinaryStream()`, `getAsciiStream()`, and `getUnicodeStream()`, return the bytes of data in an `InputStream` object. These methods are described in greater detail in Chapter 4, "Oracle Extensions".

Streaming LONG or LONG RAW Columns

When a query selects one or more `LONG` or `LONG RAW` columns, the JDBC driver transfers these columns to the client in streaming mode. After a call to `executeQuery()` or `next()`, the data of the `LONG` column is waiting to be read.

To access the data in a `LONG` column, you can get the column as a Java `InputStream` and use the `read()` method of the `InputStream` object. As an alternative, you can get the data as a string or byte array, in which case the driver will do the streaming for you.

You can get LONG and LONG RAW data with any of the three stream types. The driver performs NLS conversions for you depending on the character set of your database and the driver. For more information about NLS, see "Using NLS" on page 5-2.

LONG RAW Data Conversions

A call to `getBinaryStream()` returns RAW data "as-is". A call to `getAsciiStream()` converts the RAW data to hexadecimal and returns the ASCII representation. A call to `getUnicodeStream()` converts the RAW data to hexadecimal and returns the Unicode bytes.

For example, if your LONG RAW column contains the bytes 20 21 22, you receive the following bytes:

LONG RAW	BinaryStream	ASCIIStream	UnicodeStream
20 21 22	20 21 22	49 52 49 53 49 54 which is also '1' '4' '1' '5' '1' '6'	0049 0052 0049 0053 0049 0054 which is also: '1' '4' '1' '5' '1' '6'

For example, the LONG RAW value 20 is represented in hexadecimal as 14 or "1" "4". In ASCII, 1 is represented by "49" and "4" is represented by "52". In Unicode, a padding of zeros is used to separate individual values. So, the hexadecimal value 14 is represented as 0 "1" 0 "4". The Unicode representation is 0 "49" 0 "52".

LONG Data Conversions

When you get LONG data with `getAsciiStream()`, the drivers assume that the underlying data in the database uses an US7ASCII or WE8ISO8859P1 character set. If the assumption is true, the drivers return bytes corresponding to ASCII characters. If the database is not using an US7ASCII or WE8ISO8859P1 character set, a call to `getAsciiStream()` returns gibberish.

When you get LONG data with `getUnicodeStream()`, you get a stream of Unicode characters in the UCS-2 encoding. This applies to all underlying database character sets that Oracle supports.

When you get LONG data with `getBinaryStream()`, there are two possible cases:

- If the driver is JDBC OCI and the client character set is not US7ASCII or WE8ISO8859P1, then a call to `getBinaryStream()` returns UTF-8. If the client character set is US7ASCII or WE8ISO8859P1 then the call returns a US7ASCII stream of bytes.

- If the driver is JDBC Thin and the database character set is not US7ASCII or WE8ISO8859P1, then a call to getBinaryStream() returns UTF-8. If the server-side character set is US7ASCII or WE8ISO8859P1 then the call returns a US7ASCII stream of bytes.

For more information on how the drivers return data based on character set, see "Using NLS" on page 5-2.

> **Note:** Receiving LONG or LONG RAW columns as a stream (the default case) requires you to pay special attention to the order in which you receive data from the database. For more information, see "Data Streaming and Multiple Columns" on page 3-20.

Table 3–3 summarizes LONG and LONG RAW data conversions for each stream type.

Table 3–3 LONG and LONG RAW Data Conversions

Datatype	BinaryStream	AsciiStream	UnicodeStream
LONG	bytes representing characters in Unicode UTF-8. The bytes can represent characters in US7ASCII or WE8ISO8859P1 if: ▪ the value of NLS_LANG on the client is US7ASCII or WE8ISO8859P1. OR ▪ the database character set is US7ASCII or WE8ISO8859P1.	bytes representing characters in ISO-Latin-1 (WE8ISO8859P1) encoding	bytes representing characters in Unicode UCS-2 encoding
LONG RAW	as-is	ASCII representation of hexadecimal bytes	Unicode representation of hexadecimal bytes

Streaming Example for LONG RAW Data

One of the features of a getXXXStream() method is that it allows you to fetch data incrementally. In contrast, getBytes() fetches all of the data in one call. This section contains two examples of getting a stream of binary data. The first version uses the getBinaryStream() method to obtain LONG RAW data; the second version uses the getBytes() method.

Getting a LONG RAW Data Column with getBinaryStream() This Java example writes the contents of a LONG RAW column to a file on the local file system. In this case, the driver fetches the data incrementally.

The following code creates the table that stores a column of LONG RAW data associated with the name LESLIE:

```
-- SQL code:
create table streamexample (NAME varchar2 (256), GIFDATA long raw);
insert into streamexample values ('LESLIE', '00010203040506070809');
```

The following Java code snippet writes the data from the LESLIE LONG RAW column into a file called `leslie.gif`:

```
ResultSet rset = stmt.executeQuery ("select GIFDATA from streamexample where
NAME='LESLIE'");

// get first row
if (rset.next())
{
    // Get the GIF data as a stream from Oracle to the client
    InputStream gif_data = rset.getBinaryStream (1);
    try
    {
        FileOutputStream file = null;
        file = new FileOutputStream ("leslie.gif");
        int chunk;
        while ((chunk = gif_data.read()) != -1)
        file.write(chunk);
    }
    catch (Exception e)
    {
        String err = e.toString();
        System.out.println(err);
    }
    finally
    {
        if file != null()
            file.close();
    }
}
```

In this example the contents of the GIFDATA column are transferred incrementally in chunk-sized pieces between the database and the client. The InputStream

object returned by the call to `getBinaryStream()` reads the data directly from the database connection.

Getting a LONG RAW Data Column with getBytes() This version of the example gets the content of the `GIFDATA` column with `getBytes()` instead of `getBinaryStream()`. In this case, the driver fetches all of the data in one call and stores it in a byte array. The previous code snippet can be rewritten as:

```
ResultSet rset2 = stmt.executeQuery ("select GIFDATA from streamexample where
NAME='LESLIE'");

// get first row
if (rset2.next())
{
    // Get the GIF data as a stream from Oracle to the client
    byte[] bytes = rset2.getBytes(1);
    try
    {
        FileOutputStream file = null;
        file = new FileOutputStream ("leslie2.gif");
        file.write(bytes);
    }
    catch (Exception e)
    {
        String err = e.toString();
        System.out.println(err);
    }
    finally
    {
        if file != null()
            file.close();
    }
}
```

Because a `LONG RAW` column can contain up to 2 gigabytes of data, the `getBytes()` example will probably use much more memory than the `getBinaryStream()` example. Use streams if you do not know the maximum size of the data in your `LONG` or `LONG RAW` columns.

Avoiding Streaming for LONG or LONG RAW

The JDBC driver automatically streams any `LONG` and `LONG RAW` columns. However, there may be situations where you want to avoid data streaming. For

example, if you have a very small LONG column, you might want to avoid returning the data incrementally and instead, return the data in one call.

To avoid streaming, use the defineColumnType() method to redefine the type of the LONG column. For example, if you redefine the LONG or LONG RAW column as type VARCHAR or VARBINARY, then the driver will not automatically stream the data.

If you redefine column types with defineColumnType(), you must declare the types of *all* columns in the query. If you do not, executeQuery() will fail. In addition, you must cast the Statement object to the type oracle.jdbc.driver.OracleStatement.

As an added benefit, using defineColumnType() saves the driver two round trips to the database when executing the query. Without defineColumnType(), the JDBC driver has to request the datatypes of the column types.

Using the example from the previous section, the Statement object stmt is cast to the OracleStatement and the column containing LONG RAW data is redefined to be of the type VARBINARAY. The data is not streamed; instead, data is returned by writing it to a byte array.

```
//cast the statement stmt to an OracleStatement
oracle.jdbc.driver.OracleStatement ostmt =
   (oracle.jdbc.driver.OracleStatement)stmt;

//redefine the LONG column at index position 1 to VARBINARY
ostmt.defineColumnType(1, Types.VARBINARY);

// Do a query to get the images named 'LESLIE'
ResultSet rset = ostmt.executeQuery
         ("select GIFDATA from streamexample where NAME='LESLIE'");

// The data is not streamed here
rset.next();
byte [] bytes = rset.getBytes(1);
```

Streaming CHAR, VARCHAR, or RAW Columns

If you use the defineColumnType() Oracle extension to redefine a CHAR, VARCHAR, or RAW column as a LONGVARCHAR or LONGVARBINARY, then you can get the column as a stream. The program will behave as if the column were actually of type LONG or LONG RAW. Note that there is not much point to this, because these columns are usually short.

If you try to get a CHAR, VARCHAR, or RAW column as a data stream without redefining the column type, the JDBC driver will return a Java `InputStream`, but no real streaming occurs. In the case of these datatypes, the JDBC driver fully fetches the data into an in-memory buffer during a call to `executeQuery()` or `next()`. The `getXXXStream()` entry points return a stream that reads data from this buffer.

Note: In version 8.1.5, the `setXXXStream()` methods are not available for CHAR, VARCHAR, and RAW datatypes.

Data Streaming and Multiple Columns

If your query selects multiple columns and one of the columns contains a data stream, then the contents of the columns following the stream column are usually not available until the stream has been read. This is because the database sends each row as a set of bytes representing the columns in the SELECT order: the data after a streaming column can be read only after the stream has been read.

For example, consider the following query:

```
ResultSet rset = stmt.executeQuery
        ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");
while rset.next()
{
    //get the date data
    java.sql.Date date = rset.getDate(1);

    // get the streaming data
    InputStream is = rset.getAsciiStream(2);

    // Open a file to store the gif data
    FileOutputStream file = new FileOutputStream ("ascii.dat");

    // Loop, reading from the ascii stream and
    // write to the file
    int chunk;
    while ((chunk = is.read ()) != -1)
        file.write(chunk);
    // Close the file
    file.close();

    //get the number column data
    int n = rset.getInt(3);
}
```

The incoming data for each row has the following shape:

```
<a date><the characters of the long column><a number>
```

When you call `rset.next()`, the JDBC driver stops reading the row data just before the first character of the `LONG` column. Then the driver uses `rset.getAsciiStream()` to read the characters of the `LONG` column directly out of the database connection as a Java stream. The driver reads the `NUMBER` data from the third column only after it reads the last byte of the data from the stream.

An exception to this behavior is LOB data, which is also transferred between server and client as a Java stream. For more information on how the driver treats LOB data, see "Streaming LOBs and External Files" on page 3-23.

Bypassing Streaming Data Columns

There might be situations where you want to avoid reading a column that contains streaming data. If you do not want to read the data for the streaming column, then call the `close()` method of the stream object. This method discards the stream data and allows the driver to continue reading data for all the non-streaming columns that follow the stream. Even though you are intentionally discarding the stream, it is good programming practice to call the columns in `SELECT` list order.

In the following example, the stream data in the `LONG` column is discarded and the data from only the `DATE` and `NUMBER` column is recovered:

```
ResultSet rset = stmt.executeQuery
        ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");
while rset.next()
    {
        //get the date
        java.sql.Date date = rset.getDate(1);

        //access the stream data and discard it with close()
        InputStream is = rset.getAsciiStream(2);
            is.close();

        //get the number column data
        int n = rset.getInt(3);
    }
```

Streaming Data Precautions

This section describes some of the precautions you must take to ensure that you do not accidentally discard or lose your stream data. The drivers automatically discard stream data if you perform any JDBC operation that communicates with the database, other than reading the current stream. Two common precautions are described in the following sections:

- Use the Stream Data after You Access It
- Call the Stream Column in SELECT List Order

Use the Stream Data after You Access It To recover the data from a column containing a data stream, it is not enough to `get` the column; you must read and store its contents. Otherwise, the contents will be discarded when you get the next column.

Call the Stream Column in SELECT List Order If your query selects multiple columns, the database sends each row as a set of bytes representing the columns in the `SELECT` order. If one of the columns contains stream data, the database sends the entire data stream before proceeding to the next column.

If you do not use the `SELECT` list order to access data, then you can lose the stream data. That is, if you bypass the stream data column and access data in a column that follows it, the stream data will be lost. For example, if you try to access the data for the `NUMBER` column *before* reading the data from the stream data column, the JDBC driver first reads then discards the streaming data automatically. This can be very inefficient if the `LONG` column contains a large amount of data.

If you try to access the `LONG` column later in the program, the data will not be available and the driver will return a "`Stream Closed`" error. This is illustrated in the following example:

```
ResultSet rset = stmt.executeQuery
        ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");
while rset.next()
{
    int n = rset.getInt(3);  // This discards the streaming data
    InputStream is = rset.getAsciiStream(2);
                             // Raises an error: stream closed.
}
```

If you get the stream but do not use it *before* you get the `NUMBER` column, the stream still closes automatically:

```
ResultSet rset = stmt.executeQuery
    ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");
```

```
while rset.next()
{
    InputStream is = rset.getAsciiStream(2); // Get the stream
    int n = rset.getInt(3);
    // Discards streaming data and closes the stream
}
int c = is.read(); // c is -1: no more characters to read-stream closed
```

Streaming and Row Prefetching

If the JDBC driver encounters a column containing a data stream, row prefetching is set back to 1.

Closing a Stream

You can discard the data from a stream at any time by calling the stream's `close()` method. You can also close and discard the stream by closing its result set or connection object. You can find more information about the `close()` method for data streams in "Bypassing Streaming Data Columns" on page 3-21. For information on how to avoid closing a stream and discarding its data by accident, see "Streaming Data Precautions" on page 3-22.

Streaming LOBs and External Files

The term *large object* (LOB) refers to a data item that is too large to be stored directly in a database table. Instead, a locator is stored in the database table and points to the location of the actual data. The JDBC drivers provide support for three types of LOBs: `BLOB`s (unstructured binary data), `CLOB`s (single-byte character data) and BFILEs (external files). The Oracle JDBC drivers support the streaming of `CLOB`, `BLOB`, and `BFILE` data.

LOBs behave differently from the other types of streaming data described in this chapter. The driver transfers LOB data between server and client as a Java stream. However, unlike most Java streams, a locator representing the LOB data is stored in the table. Thus, you can access the LOB data at any time during the life of the connection.

Streaming BLOBs and CLOBs When a query selects one or more `CLOB` or `BLOB` columns, the JDBC driver transfers to the client the data pointed to by the locator. The driver performs the transfer as a Java stream. To manipulate `CLOB` or `BLOB` data from JDBC, use methods in the Oracle extension classes `oracle.sql.BLOB` and `oracle.sql.CLOB`. These classes provide functionality such as reading from the

CLOB or BLOB into an input stream, writing from an output stream into a CLOB or BLOB, determining the length of a CLOB or BLOB, and closing a CLOB or BLOB.

For a complete discussion of how to use streaming CLOB and BLOB data, see "Reading and Writing BLOB and CLOB Data" on page 4-48.

Streaming BFILEs An external file, or BFILE, is used to store a locator to a file that is outside the database, stored somewhere on the filesystem of the data server. The locator points to the actual location of the file.

When a query selects one or more BFILE columns, the JDBC driver transfers to the client the file pointed to by the locator. The transfer is performed in a Java stream. To manipulate BFILE data from JDBC, use methods in the Oracle extension classes oracle.sql.BFILE. These classes provide functionality such as reading from the BFILE into an input stream, writing from an output stream into a BFILE determining the length of a BFILE, and closing a BFILE.

For a complete discussion of how to use streaming BFILE data, see "Reading BFILE Data" on page 4-57.

Using Stored Procedures in JDBC Programs

This section describes how the Oracle JDBC drivers support stored procedures and includes these subsections:

- PL/SQL Stored Procedures
- Java Stored Procedures

PL/SQL Stored Procedures

Oracle JDBC drivers support execution of PL/SQL stored procedures and anonymous blocks. They support both SQL92 escape syntax and Oracle escape syntax. The following PL/SQL calls are all available from any Oracle JDBC driver:

```
// SQL92 Syntax
CallableStatement cs1 = conn.prepareCall
                        ( "{call proc (?,?)}" ) ;
CallableStatement cs2 = conn.prepareCall
                        ( "{? = call func (?,?)}" ) ;
// Oracle Syntax
CallableStatement cs3 = conn.prepareCall
                        ( "begin proc (:1, :2); end;" ) ;
CallableStatement cs4 = conn.prepareCall
                        ( "begin :1 := func(:2,:3); end;" ) ;
```

As an example of using Oracle syntax, here is a PL/SQL code snippet that creates a stored function. The PL/SQL function gets a character and concatenates a suffix to it:

```
create or replace function foo (val1 char)
return char as
begin
    return val1 || 'suffix';
end;
```

Your invocation call in your JDBC program should look like:

```
Connection conn = DriverManager.getConnection
       ("jdbc:oracle:oci8:@<hoststring>", "scott", "tiger");

CallableStatement cs =
    conn.prepareCall ("begin ? := foo(?); end;");
cs.registerOutParameter(1,Types.CHAR);
cs.setString(2, "aa");
cs.executeUpdate();
String result = proc.getString(1);
```

Java Stored Procedures

You can use JDBC to invoke Java stored procedures through the SQL and PL/SQL engines. The syntax for calling Java stored procedures is the same as the syntax for calling PL/SQL stored procedures. See the *Oracle8i Java Stored Procedures Developer's Guide* for more information on using Java stored procedures.

Error Messages and JDBC

To handle exceptions, the Oracle JDBC drivers throw a `java.sql.SQLException()`. Two types of errors can be returned. The first type, Oracle database errors, are returned from the Oracle database itself and consist of an error number and a text message describing the error. These errors are documented in the publication *Oracle8i Error Messages*.

The second type of error is returned by the JDBC driver itself. These messages consist of a text message, but do not have an error number. These messages describe the error and identify the method that threw the error.

You can return errors with these methods:

- `getMessage()`: returns the error message associated with the object that threw the exception
- `printStackTrace()`: prints this object name and its stacktrace to the specified print stream

This example uses both `getMessage()` and `printStackTrace()` to return errors.

```
catch(SQLException e);
{
    System.out.println("exception: " + e.getMessage());
    e.printStackTrace();
}
```

The text of all error messages has been internationalized. That is, they are available in all of the languages and character sets supported by Oracle. These error messages are listed in Appendix A, "JDBC Error Messages".

Server-Side Basics

This section has the following subsections:

- Session and Transaction Context
- Connecting to the Database

The tutorial presented in "First Steps in JDBC" on page 3-2, describes connecting to and querying a database using the client-side driver. The following sections describe some of the basic differences if you run the tutorial using the server-side driver. For a complete discussion of the server-side driver, see "JDBC on the Server: the Server Driver" on page 5-22.

Session and Transaction Context

The server-side driver operates within a default session and default transaction context. For more information on default session and transaction context for the server-side driver, see "Session and Transaction Context for the Server Driver" on page 5-23.

Connecting to the Database

The Server driver uses a default connection to the database. You can connect to the database with either the `DriverManager.getConnection()` method or the

Oracle-specific API `defaultConnection()` method. For more information on connecting to the database with the server-side driver, see "Connecting to the Database with the Server Driver" on page 5-22.

Application Basics versus Applet Basics

This section has the following subsections:

- Application Basics
- Applet Basics

Application Basics

You can use either the Oracle JDBC Thin driver or the JDBC OCI driver to create an application. Because the JDBC OCI driver uses native methods, there can be significant performance advantages in using this driver for your applications.

An application that can run on a client can run on the server by using the JDBC Server driver.

If you are using a JDBC OCI driver in an application, then the application will require an Oracle installation on its clients. For example, the application will require the installation of Net8 and client libraries.

Applications and Encryption

For applications that use the Oracle OCI driver, you can encrypt data by using Net8 ANO (Advanced Networking Option). For more information on ANO, please refer to the *Net8 Administrator's Guide*.

Applet Basics

This section describes the issues you should take into consideration if you are writing an applet that uses the JDBC Thin driver.

Applets and Security

An applet cannot open network connections except to the host machine from which it was downloaded. Therefore, an applet can connect to databases only on the originating machine. If you want to connect to a database running on a different machine, either:

- Use Oracle8 Connection Manager on the host machine. The applet can connect to Oracle8 Connection Manager, which in turn connects to a database on another machine.
- Use signed applets. If your browser supports JDK 1.1.*x*, then you can use signed applets. Signed applets can request socket connection privileges to other machines.

Both of these topics are described in greater detail in "Connecting an Applet to a Database" on page 5-9.

Applets and Firewalls

An applet that uses the JDBC Thin driver can connect to a database through a firewall. See "Using Applets with Firewalls" on page 5-14 for more information on configuring the firewall and on writing connect strings for the applet.

Applets and Encryption

Applets that use the JDBC Thin driver do not support data encryption.

Packaging and Deploying Applets

To package and deploy an applet, you must place the JDBC Thin driver classes and the applet classes in the same zip file. This is described in detail in "Packaging Applets" on page 5-17.

4

Oracle Extensions

This chapter describes Oracle extensions to standard JDBC, including the following topics:

- Introduction to Oracle Extensions
- Oracle JDBC Packages and Classes
- Data Access and Manipulation: Oracle Types vs. Java Types
- Working with LOBs
- Working with Oracle Object Types
- Working with Oracle Object References
- Working with Arrays
- Additional Oracle Extensions
- Oracle JDBC Notes and Limitations

Introduction to Oracle Extensions

Oracle's implementation of JDBC supports versions 1.0.2 and 1.1.*x* of the Sun Microsystems JDK and complies with JDBC 1.22, included with these JDK versions. This chapter describes Oracle extensions to JDBC 1.22, organized into two categories:

- type extensions to comply with a subset of JDBC 2.0, which is a part of JDK 1.2
- additional Oracle-specific type extensions and performance extensions

This section describes how Oracle JDBC supports these extensions, including the Java packages created and the datatype support issues that must be considered.

Note: The JDBC OCI, Thin, and Server drivers support the same functionality, and all of the Oracle extensions.

Packages Oracle release 8.1.5 does not support JDK 1.2. The JDBC 2.0 interfaces are part of the `java.sql` package that is included with the JDK 1.2. Therefore, to support JDBC 2.0 types, as well as additional Oracle extensions, the Oracle JDBC distribution includes the following Java packages:

- `oracle.jdbc2` (a subset of the standard JDBC 2.0 interfaces)
- `oracle.sql` (classes to support all Oracle type extensions)
- `oracle.jdbc.driver` (classes to support database access and updates in Oracle type formats)

"Oracle JDBC Packages and Classes" on page 4-6 further describes these packages and their classes.

Oracle Datatype Support A key feature of the Oracle JDBC extensions is the type support in the `oracle.sql.*` package. This package includes classes that map to all of the Oracle SQL datatypes, acting as wrappers for raw SQL data. This functionality provides two significant advantages in manipulating SQL data:

- Accessing data directly in SQL format is more efficient than first converting it to Java format.
- Performing mathematical manipulations of the data directly in SQL format avoids the loss of precision that occurs in converting between SQL and Java formats.

Once manipulations are complete and it is time to output the information, each of the `oracle.sql.*` type support classes has all of the necessary methods to convert data to appropriate Java formats.

For a more detailed description of these general issues, see "Classes of the oracle.sql Package" on page 4-7.

Specific information relating to particular `oracle.sql.*` datatype classes is discussed in the sections "Working with LOBs" on page 4-45 and "Additional Type Extensions" on page 4-111.

Oracle Object Support Perhaps the most noteworthy Oracle8 type is Oracle objects. Oracle8 supports the use of structured objects in the database, where an object datatype is a user-defined type with nested attributes. For example, a user application could define an `Employee` object type, where each `Employee` object has a `firstname` attribute (a character string), a `lastname` attribute (another character string), and an `employeenumber` attribute (integer).

Oracle's JDBC implementation supports Oracle object datatypes. When you work with Oracle object datatypes in a Java application you must consider the following:

- how to map between Oracle object datatypes and Java classes
- how to store Oracle object attributes in corresponding Java objects (they can be stored in Java format or in `oracle.sql.*` format)
- how to convert attribute data between SQL and Java formats
- how to access data

To manually create Java classes to correspond to your Oracle objects, Oracle recommends that you use the Oracle8*i* JPublisher utility to create the classes. To do this, you must define attributes according to how you want to store the data. JPublisher handles this task seamlessly with command-line options.

A *type map* defines the correspondence between Oracle object datatypes and Java classes. Type maps are objects of a special Java class that specify which Java class corresponds to each Oracle object datatype. Oracle JDBC uses these type maps to determine which Java class to instantiate and populate when it retrieves Oracle object data from a result set.

Each Java class created to correspond to an Oracle object datatype must implement one of two supported interfaces: the JDBC-standard `SQLData` interface or the Oracle `CustomDatum` interface. Each of these interfaces specifies methods to convert data between SQL and Java. Currently, JPublisher supports only the `CustomDatum` interface.

JPublisher automatically defines `get` methods of the Java classes, which retrieve data into your Java application. For more information on the JPublisher utility, see the *Oracle8i JPublisher User's Guide.*

"Working with Oracle Object Types" on page 4-62 describes Oracle JDBC support for Oracle objects.

Support for Schema Naming Oracle JDBC classes have the ability to accept and return fully qualified schema names. A fully qualified schema name has this syntax:

```
{[schema_name].}[sql_type_name]
```

where *schema_name* is the name of the schema and *sql_type_name* is the SQL type name of the object. Notice that the *schema_name* and the *sql_type_name* is separated by a dot (".").

To specify an object type in JDBC, you use its fully qualified name (that is, a schema name and SQL type name). It is not necessary to enter a schema name if the type name is in current naming space (that is, the current schema). Schema naming follows these rules:

- Both the schema name and the type name may or may not be quoted. However, if the SQL type name has a dot in it, such as `CORPORATE.EMPLOYEE`, the type name must be quoted.
- The JDBC driver looks for the first unquoted dot in the object's name and uses the string before the dot as the schema name and the string following the dot as the type name. If no dot is found, the JDBC driver takes the current schema as default. That is, you can specify only the type name (without indicating a schema) instead of specifying the fully qualified name if the object type name belongs to the current schema. This also explains why you must quote the type name if the type name has a dot in it.

  For example, assume that user Scott creates a type called `person.address` and then wants to use it in his session. Scott might want to skip the schema name and pass in `person.address` to the JDBC driver. In this case, if `person.address` is not quoted, then the dot will be detected, and the JDBC driver will mistakenly interpret `person` as the schema name and `address` as the type name.
- JDBC passes the object type name string to the database unchanged. That is, the JDBC driver will not change the character case even if it is quoted.

  For example, if `ScOtT.PersonType` is passed to the JDBC driver as an object type name, the JDBC driver will pass the string to the database unchanged. As

another example, if there is white space between characters in the type name string, then the JDBC driver will not remove the white space.

- The JDBC driver assumes that schema names do not contain dots (".").
- The JDBC driver does not allow double quotes (") as part of the schema name or the type name.

Oracle JDBC Packages and Classes

This section discusses the Java packages that support the Oracle JDBC extensions and the key classes that are included in these packages. This section has the following subsections:

- Classes of the oracle.jdbc2 Package
- Classes of the oracle.sql Package
- Classes of the oracle.jdbc.driver Package

You can refer to the Javadoc for more information about all of the classes mentioned in this section.

Classes of the oracle.jdbc2 Package

The `oracle.jdbc2` package contains the Oracle implementation of the standard JDBC 2.0 interfaces. The JDBC 2.0 interfaces are part of the `java.sql` package included in the JDK 1.2. However, since the drivers do not currently support JDK 1.2, these interfaces have been made available to the Oracle 1.0.2 and 1.1.*x* drivers as the `oracle.jdbc2` package. This package contains the JDBC 2.0 features of the JDK 1.2 `java.sql` package that the Oracle drivers support.

The following interfaces are implemented by `oracle.sql.*` type classes for JDBC 2.0-compliant Oracle type extensions. These interfaces are equivalent to the interfaces published by Sun Microsystems; the `oracle.jdbc2` versions add no new features.

- `oracle.jdbc2.Array` is implemented by `oracle.sql.ARRAY`
- `oracle.jdbc2.Struct` is implemented by `oracle.sql.STRUCT`
- `oracle.jdbc2.Ref` is implemented by `oracle.sql.REF`
- `oracle.jdbc2.Clob` is implemented by `oracle.sql.CLOB`
- `oracle.jdbc2.Blob` is implemented by `oracle.sql.BLOB`

In addition, Oracle includes the following standard JDBC 2.0 interfaces for users employing the JDBC-standard `SQLData` interface to create Java classes that map to Oracle objects:

- `oracle.jdbc2.SQLData` implemented by classes that map to Oracle objects; users must provide this implementation
- `oracle.jdbc2.SQLInput` implemented by classes that read object data; Oracle provides a `SQLInput` class that the JDBC drivers use

- `oracle.jdbc2.SQLOutput` implemented by classes that write object data; Oracle provides a `SQLOutput` class that the JDBC drivers use

The `SQLData` interface is one of the two features you can use to support Oracle objects in Java. The other feature is the Oracle `CustomDatum` interface, contained in the `oracle.sql` package. See "Understanding the SQLData Interface" on page 4-69 for more information about `SQLData`, `SQLInput`, and `SQLOutput`.

Note: Oracle recommends using the `CustomDatum` interface instead of the `SQLData` interface. `CustomDatum` works more easily in conjunction with other features of the Oracle Java product offerings, such as the JPublisher utility (which can automatically generate `CustomDatum` classes corresponding to Oracle objects) and SQLJ.

Classes of the oracle.sql Package

The `oracle.sql` package supports direct access to data in SQL format and consists primarily of classes that map to the Oracle SQL datatypes.

These classes provide Java mappings for the Oracle SQL types and are wrapper classes for the raw SQL data. Because data in an `oracle.sql.*` object remains in SQL format, no information is lost. For SQL primitive types, these classes simply wrap the SQL data. For SQL structured types (objects and arrays), they provide additional information such as conversion methods and details of structure.

Each of the Oracle datatype classes extends `oracle.sql.Datum`, a superclass that encapsulates functionality common to all of the datatypes. Some of the classes are for JDBC 2.0-compliant datatypes. These classes, as Table 4–1 indicates, implement standard JDBC 2.0 interfaces in the `oracle.jdbc2` package, as well as extending `oracle.sql.Datum`.

Table 4–1 lists the `oracle.sql` datatype classes and their corresponding Oracle SQL types.

Table 4–1 Oracle Datatype Classes

Java Class	Oracle SQL Type (and Description) and Interface Implemented if for JDBC 2.0
`oracle.sql.STRUCT`	`STRUCT` (objects) JDBC 2.0, implements `oracle.jdbc2.Struct`

Table 4–1 Oracle Datatype Classes (Cont.)

Java Class	Oracle SQL Type (and Description) and Interface Implemented if for JDBC 2.0
`oracle.sql.REF`	`REF` (object references) JDBC 2.0, implements `oracle.jdbc2.Ref`
`oracle.sql.ARRAY`	`varray` or nested table (collections) JDBC 2.0, implements `oracle.jdbc2.Array`
`oracle.sql.BLOB`	`BLOB` (large binary objects) JDBC 2.0, implements `oracle.jdbc2.Blob`
`oracle.sql.CLOB`	`CLOB` (large character objects) JDBC 2.0, implements `oracle.jdbc2.Clob`
`oracle.sql.BFILE`	`BFILE` (external files)
`oracle.sql.CHAR`	`CHAR`, `VARCHAR2`
`oracle.sql.DATE`	`DATE`
`oracle.sql.NUMBER`	`NUMBER`
`oracle.sql.RAW`	`RAW`
`oracle.sql.ROWID`	`ROWID` (row identifiers)

The following sections describe each class listed in Table 4–1. Additional details about use of the Oracle extended types (`STRUCT`, `REF`, `ARRAY`, `BLOB`, `CLOB`, `BFILE`, and `ROWID`) are described in "Working with LOBs" on page 4-45, "Working with Oracle Object References" on page 4-83, "Working with Arrays" on page 4-87, and "Additional Type Extensions" on page 4-111.

Notes:

- Beware of possible confusion between the STRUCT class, used for objects only, and the general term *structured objects*, which often indicates either objects or collections. The ARRAY class supports collections, which can be either varrays or nested tables.
- For information about retrieving data from a result set or callable statement object into oracle.sql.* types as opposed to Java types, see "Data Access and Manipulation: Oracle Types vs. Java Types" on page 4-32.
- The LONG, LONG RAW, or REF CURSOR SQL types have no oracle.sql.* classes. Use standard JDBC functionality for these types. For example, retrieve LONG or LONG RAW data as input streams using the standard JDBC methods getAsciStream(), getBinaryStream(), and getUnicodeStream(). Use getCursor() for REF CURSOR types.

In addition to the datatype classes, the oracle.sql package includes these support classes and interfaces:

- oracle.sql.ArrayDescriptor class: used in constructing oracle.sql.ARRAY objects; describes the SQL type of the array. See "Class oracle.sql.ARRAY" on page 4-14 for more information.
- oracle.sql.StructDescriptor class: used in constructing oracle.sql.STRUCT objects, which you can use as a default mapping to Oracle objects in the database. See "Class oracle.sql.STRUCT" on page 4-10 for more information.
- oracle.sql.CharacterSet and oracle.sql.CharacterSetFactory classes: used in constructing character set objects, which in turn are used in constructing oracle.sql.CHAR objects. See "Class oracle.sql.CHAR" on page 4-19 for more information.
- oracle.sql.CustomDatum and oracle.sql.CustomDatumFactory interfaces: used in Java classes implementing the Oracle CustomDatum scenario of Oracle object support. (The other possible scenario is the JDBC-standard SQLData implementation. See "Understanding the CustomDatum Interface" on page 4-75 for more information on CustomDatum.)

Refer to the Javadoc for additional information about these classes. The rest of this section further describes the `oracle.sql.*` classes.

General oracle.sql Datatype Support

Each of the Oracle datatype classes provides, among other things, the following:

- one or more constructors, typically with a constructor that uses raw bytes as input and a constructor that takes a Java type as input
- data storage as Java byte arrays for SQL data
- a `getBytes()` method, which returns the SQL data as a byte array
- a `toJdbc()` method that converts the data into an object of a corresponding Java class as defined in the JDBC specification

  The JDBC driver does not convert Oracle-specific datatypes that are not part of the JDBC specification, such as `ROWID`; the driver returns the object in the corresponding `oracle.sql.*` format. For example, it returns an Oracle `ROWID` as an `oracle.sql.ROWID`.
- a `stringValue()` or `intValue()` method, where appropriate, to convert the SQL data to a `String` or an `int`
- additional conversion, `get`, and `set` methods as appropriate for the functionality of the datatype (such as methods in the LOB classes that get the data as a stream, and methods in the `REF` class that get and set object data through the object reference)

Refer to the Javadoc for additional information about these classes.

Class oracle.sql.STRUCT

For any given Oracle object type, if you do not specify a mapping to a Java class in your connection's type map, data from the object type will be materialized in Java in an instance of the `oracle.sql.STRUCT` class.

The `STRUCT` class implements the standard JDBC 2.0 `oracle.jdbc2.Struct` class and extends `oracle.sql.Datum`.

In the database, Oracle stores the raw bytes of object data in a linearized form. A `STRUCT` object is a wrapper for the raw bytes of an Oracle object and contains a "values" array of `oracle.sql.Datum` objects holding the attribute values in SQL format. The `STRUCT` object also contains the SQL type name of the Oracle object.

In most cases you will probably want to create a custom Java type definition class to map to your Oracle object, although using the `STRUCT` class may suffice in some

cases (see "Using STRUCT Objects" on page 4-63). The attributes of a STRUCT can be materialized as `java.lang.Object[]` objects if you use the `getAttributes()` method, or as `oracle.sql.Datum[]` objects if you use the `getOracleAttributes()` method. The `oracle.sql.*` format gives you the same advantages as using `oracle.sql.*` datatype classes in general:

- The STRUCT class completely preserves data, because it maintains the data in SQL format. This is useful if you want to manipulate data but not necessarily display it.
- It allows complete flexibility in how your Java application unpacks data.

Notes:

- Elements of the values array, although of the generic `Datum` type, would actually contain data associated with the relevant `oracle.sql.*` type appropriate for the given attribute, such as `oracle.sql.CHAR` in the case of CHAR data. You can cast an element as the appropriate `oracle.sql.*` type as desired.
- The JDBC driver materializes nested objects in the values array of a STRUCT object as instances of STRUCT themselves.
- Refer to the Javadoc for more information about particular features and methods of the `oracle.sql.STRUCT` class.

In some cases you might want to manually create a STRUCT object to pass it to a prepared statement or callable statement. To do this, you must also create a `StructDescriptor` object. For more information on creating a STRUCT object, see "Creating STRUCT Objects and Descriptors" on page 4-13.

The STRUCT class includes the following methods:

- `getAttributes()`: retrieves the values from the values array, using the type map (if one has been defined) to determine which Java classes to use in materializing the data. Conceptually, `getAttributes()` returns a Java array containing the attribute values. The types of the attribute values are those that a call to `getObject()` on the same underlying types will return. That is, they are the "default" JDBC types for the corresponding underlying types.

  For example, assume that you have defined a SQL type PERSON with a name attribute of type CHAR and an age attribute of type NUMBER. If you use `getAttributes()` to get the object attributes of PERSON, then it will return the name as a Java `String` type and the age as a Java `BigDecimal` type.

If you are calling `getAttributes()` on a nested object, then you can optionally specify a type map (`java.util.Map` object) if you do not want to use your connection's default type map.

- `getOracleAttributes()`: retrieves the values of the values array as `oracle.sql.*` objects
- `getSQLTypeName()`: returns the fully qualified type name (*schema.sql_type_name*) of the Oracle object that this `STRUCT` represents
- `getDescriptor()`: returns the `StructDescriptor` object for this `STRUCT` object (see "Creating STRUCT Objects and Descriptors" on page 4-13 for information about the `StructDescriptor` class)
- `getConnection()`: returns the current connection
- `getDescriptor()`: returns the `OracleType` that identifies the Oracle object type
- `getMap()`: returns the current type map
- `isConvertibleTo(Class)`: determines if a datum object can be converted to a particular class
- `makeJdbcArray(int)`: returns a JDBC array representation of the datum
- `setDatumArray(Datum[])`: sets the `Datum` array.
- `setDescriptor(StructDescriptor)`: sets the descriptor
- `stringValue()`: converts to a String representation of the datum object
- `toBytes()`: packs the bytes representing the attributes into the format that is actually used in the database
- `toClass(Class)`: applies the normal algorithms for converting a SQL structured type to a specific Java class
- `toJdbc()`: consults the current map to determine what class to convert to, and then uses `toClass()`
- `toJdbc(Dictionary)`: consults the map to determine what class to convert to, and then uses `toClass()`
- `toSTRUCT(Object, OracleConnection)`: returns the corresponding `STRUCT` object from the input Java object

Creating STRUCT Objects and Descriptors To create an `oracle.sql.STRUCT` object, a *STRUCT descriptor* must first exist for the given Oracle object type. This descriptor is an object of the `oracle.sql.StructDescriptor` class.

A `StructDescriptor` describes a type of SQL structured object (Oracle object). Only one `StructDescriptor` is necessary for each Oracle object type.

The driver caches `STRUCT` descriptor objects to avoid recreating them if the type has already been encountered. The Oracle JDBC extensions provide a static `createDescriptor()` method that will either construct a new `StructDescriptor` object or return an existing one.

To create a `StructDescriptor` object, pass in a Java string parameter with the SQL type name of the Oracle object type and a connection object to the `StructDescriptor.createDescriptor()` method:

```
StructDescriptor structdesc = StructDescriptor.createDescriptor(sql_type_name,
connection);
```

where `sql_type_name` is a Java string containing the name of the Oracle object type (such as `EMPLOYEE`) and `connection` is your connection object.

You can also call the `StructDescriptor` object if you need to create a new `STRUCT` object. To construct a new `StructDescriptor` object, pass in a Java string parameter with the SQL type name of the Oracle object type and your connection object:

```
StructDescriptor structdesc = new StructDescriptor(sql_type_name, connection);
```

To construct a `STRUCT` object, pass in the `StructDescriptor`, your connection object, and an array of Java objects containing the attributes you want the `STRUCT` to contain.

```
STRUCT struct = new STRUCT(structdesc, connection, attributes);
```

where `structdesc` is the `StructDescriptor` created previously, `connection` is your connection object, and `attributes` is an array of type `java.lang.Object[]`.

Using StructDescriptor get Methods A `STRUCT` descriptor can be referred to as a "type object." This means that it contains information about the type code and type name of the object type and how to convert to and from the given type. Remember, there should be only one `StructDescriptor` object for any one Oracle object type. You can then use that descriptor to create as many `STRUCT` objects as you need for that type.

The `StructDescriptor` class includes the `getName()` method to return the fully qualified SQL type name of the Oracle object (that is, in *schema.sql_type_name* format. For example, `CORPORATE.EMPLOYEE`)

Embedded Objects The JDBC driver seamlessly handles embedded objects (`STRUCT` objects that are attributes of `STRUCT` objects) in the same way that it normally handles objects. When the JDBC driver retrieves an attribute that is an object, it follows the same rules of conversion, using the type map if it is available, or else using default mapping.

Class oracle.sql.REF

The `oracle.sql.REF` class is the generic class that supports Oracle object references. This class, as with all of the `oracle.sql.*` datatype classes, is a subclass of `oracle.sql.Datum`. It implements the standard JDBC 2.0 `oracle.jdbc2.Ref` interface.

Selecting a `REF` retrieves only a pointer to an object; it does not materialize the object. However, there are methods to accomplish this.

The `oracle.sql.REF` class includes the following methods:

- `getValue()`: retrieves object attributes (using your type map as necessary)
- `setValue()`: sets object attributes (using your type map as necessary)
- `getBaseTypeName()`: retrieves the fully-qualified SQL structured type name of the referenced item

The `setREF()` and `setRef()` methods of the `OraclePreparedStatement` and `OracleCallableStatement` classes support passing a `REF` object as an input parameter to a prepared statement. Similarly, the `getREF()` and `getRef()` methods of the `OracleCallableStatement` and `OracleResultSet` support passing a `REF` object as an output parameter.

You cannot create `REF` objects using JDBC.

For more information on how to use `REF` objects, see "Working with Oracle Object References" on page 4-83.

Class oracle.sql.ARRAY

The `oracle.sql.ARRAY` class supports Oracle collections, either `varray`s or nested tables. If you select either a `varray` or nested table from the database, then the JDBC driver materializes it as an object of the `ARRAY` class; the structure of the data is equivalent in either case. The `oracle.sql.ARRAY` class extends

`oracle.sql.Datum` (as do all of the `oracle.sql.*` classes) and implements `oracle.jdbc2.Array`, a standard JDBC 2.0 array interface.

You might want to manually create an ARRAY object to pass it to a prepared statement or callable statement, perhaps to insert into the database. This involves the use of `ArrayDescriptor` objects, which "Creating ARRAY Objects and Descriptors" on page 4-15 describes.

The ARRAY class includes the following methods:

- `getArray()`: retrieves the contents of the array in "default" JDBC types. If it retrieves an array of objects, then `getArray()` uses the type map to determine the types
- `getOracleArray()`: identical to `getArray()`, but retrieves the elements in `oracle.sql.*` format
- `getArrayDescriptor()`: returns the `ArrayDescriptor` object that pertains to this array (see "Creating ARRAY Objects and Descriptors" on page 4-15 for information about the `ArrayDescriptor` class)
- `getBaseType()`: returns the SQL type code for the array elements (see "Class oracle.jdbc.driver.OracleTypes" on page 4-28 for information about type codes)
- `getSQLTypeName()`: returns the SQL type name of the array elements
- `getBaseTypeName()`: for named types (such as Oracle objects), returns the particular type name (for example, EMPLOYEE)
- `getResultSet()`: materializes an array as a result set

Creating ARRAY Objects and Descriptors The `setARRAY()` method of the `OraclePreparedStatement` or `OracleCallableStatement` class supports passing an array as an input parameter to a prepared statement. You must first construct an *array descriptor*, which is an `oracle.sql.ArrayDescriptor` object, and then you must construct the `oracle.sql.ARRAY` object for the array you want to pass.

An `ArrayDescriptor` object describes the SQL type of an array; however, you need only one array descriptor for any one SQL type. You can reuse the same descriptor object to create multiple instances of an `oracle.sql.Array` object for the same array type.

Collections are strongly typed. Oracle supports only "named arrays", that is, an array given a SQL type name. For example, when you create an array with the CREATE TYPE statement:

```
CREATE TYPE num_varray AS varray(22) OF NUMBER(5,2);
```

the SQL type name for the collection type is `num_varray`.

Note: The name of the collection type has nothing to do with the type name of the elements. For example:

```
CREATE TYPE person AS object (c1 NUMBER(5), c2
VARCHAR2(30));

CREATE TYPE array_of_persons AS varray(10) OF
person;
```

in the preceding statements, the SQL type name of the collection type is `array_of_persons`. The SQL type name of the elements of the collection is `person`.

To construct an `ArrayDescriptor` object, pass the SQL type name of the collection type and your `Connection` object (which JDBC uses to go to the database to gather meta data) to the constructor.

```
ArrayDescriptor arraydesc = ArrayDescriptor.createDescriptor(sql_type_name,
connection);
```

where `sql_type_name` is the type name of the array and `connection` is your `Connection` object.

To construct an ARRAY object, pass in the array descriptor, your connection object, and a Java object containing the individual elements you want the array to contain.

```
ARRAY array = new ARRAY(arraydesc, connection, elements);
```

where `arraydesc` is the array descriptor created previously, `connection` is your connection object, and `elements` is a Java array of objects. The two possibilities for the contents of `elements` are:

- an array of Java primitives. For example, `int[]`.
- an array of Java objects. (For example, *xxx*`[]` where *xxx* represents the name of a Java object type.) For example, `Integer[]`.

Notes:

- The `setARRAY()`, `setArray()`, and `setObject()` methods of the `OraclePreparedStatement` class take an object of the type `oracle.sql.ARRAY` as an argument, not an array of objects.
- Refer to the Javadoc for more information about the features of the ARRAY and `ArrayDescriptor` classes.

Using ArrayDescriptor get Methods An array descriptor can be referred to as a *type object*, meaning it has information about the array's SQL type name, the type code of the array's elements and, if the array is a STRUCT, the type name of the elements. The array descriptor also contains the information on how to convert to and from the given type. You need only one array descriptor object for any one type, then you can use that descriptor to create as many arrays of that type as you want.

The `ArrayDescriptor` class has the following methods for retrieving an element's type code and type name:

- `getBaseType()`: returns the integer type code associated with this array descriptor (according to integer constants defined in the `OracleTypes` class, which "Classes of the oracle.jdbc.driver Package" on page 4-22 describes)
- `getBaseName()`: returns a string with the type name associated with this array element if it is a STRUCT, REF or collection

Note: The elements of an array cannot be of type ARRAY. Collections cannot have elements of type `collection`. But Oracle objects and STRUCTS can have attributes of Java type ARRAY (SQL type `collection`).

Classes oracle.sql.BLOB, oracle.sql.CLOB, oracle.sql.BFILE

BLOBs, CLOBs, and BFILEs, all referred to as *LOBs*, are for data items that are too large to store directly in the database table. Instead, the database table stores a locator that points to the location of the actual data.

The `oracle.sql` package supports LOBs in several ways:

- BLOBs point to large unstructured binary data items and are supported by the `oracle.sql.BLOB` class.

- CLOBs point to large fixed-width character data items (that is, characters that require a fixed number of bytes per character) and are supported by the `oracle.sql.CLOB` class.
- BFILEs point to the content of external files (operating system files) and are supported by the `oracle.sql.BFILE` class.

You can select a BLOB, CLOB, or BFILE locator from the database using a standard SELECT statement, but bear in mind that you are receiving only the locator, not the data itself. Additional steps are necessary to retrieve the data. This is described in "Working with LOBs" on page 4-45.

> **Note:** The `oracle.sql.CLOB` class supports all character sets that the Oracle data server supports for CLOB types.

The `oracle.sql.BLOB` class includes the following methods:

- `getBinaryOutputStream()`: returns the BLOB data
- `getBinaryStream()`: returns the BLOB designated by this `Blob` instance as a stream of bytes
- `getBytes()`: reads from the BLOB data, starting at a specified point, into a supplied buffer
- `length()`: returns the length of the BLOB in bytes
- `position()`: determines the byte position in the BLOB where a given pattern begins
- `putBytes()`: writes BLOB data, starting at a specified point, from a supplied buffer

The `oracle.sql.CLOB` class includes the following methods:

- `getAsciiOutputStream()`: writes CLOB data from an ASCII stream
- `getAsciiStream()`: returns the CLOB value designated by the `Clob` object as a stream of Ascii bytes
- `getCharacterOutputStream()`: writes CLOB data from a Unicode stream
- `getCharacterStream()`: returns the CLOB data as a stream of Unicode characters
- `getChars()`: retrieves characters from a specified point in the CLOB data into a character array

- `length()`: returns the length of the `CLOB` in characters
- `position()`: determines the character position in the `CLOB` at which a given substring begins
- `putChars()`: writes characters from a character array to a specified point in the `CLOB` data
- `getSubString()`: retrieves a substring from a specified point in the `CLOB` data
- `putString()`: writes a string to a specified point in the `CLOB` data

The `oracle.sql.BFILE` class includes the following methods:

- `openFile()`: opens the external file
- `closeFile()`: closes the external file
- `getBinaryStream()`: returns the contents of the external file as a stream of bytes
- `getBytes()`: reads from the external file, starting at a specified point, into a supplied buffer
- `getName()`: gets the name of the external file
- `getDirAlias()`: gets the directory alias of the external file
- `length()`: returns the length of the `BFILE` in bytes
- `position()`: determines the byte position at which the given byte pattern begins

---

Note: You cannot write to a `BFILE`; you can only read from it.

Class oracle.sql.CHAR

The `CHAR` class has special functionality for NLS conversion of character data. A key attribute of the `CHAR` class, and a parameter always passed in when a `CHAR` object is constructed, is the NLS character set used in presenting the character data. Without the character set being known, the bytes of data in the `CHAR` object are meaningless.

`CHAR` objects that the driver constructs and returns can be in the database character set, `UTF-8`, or ISO-Latin-1 (`WE8ISO8859P1`). `CHAR` objects which are Oracle8 objects, are returned in the database character set.

JDBC constructs and populates CHAR objects once character data has been read from the database. Additionally, you might want to construct a CHAR object yourself (to pass in to a prepared statement, for example).

When you construct a CHAR object, you must provide character set information to the CHAR object by way of an instance of the `oracle.sql.CharacterSet` class. Each instance of the `CharacterSet` class represents one of the NLS character sets that Oracle supports. A `CharacterSet` instance encapsulates methods and attributes of the character set, mainly involving functionality to convert to or from other character sets. You can find a complete list of the character sets that Oracle supports in the *Oracle8i National Language Support Guide*.

If you use a CHAR object based on a character set that Oracle does not support, then the JDBC driver will not be able to perform character set conversions with it. For example, you will not be able to use the CHAR object in an `OraclePreparedStatement.setOracleObject()` call.

Follow these general steps to construct a CHAR object:

1. Create a `CharacterSet` instance by calling the static `CharacterSet.make()` method. This method is a factory for the character set class. It takes as input an integer `OracleId`, which corresponds to a character set that Oracle supports. For example:

   ```
   int oracleId = CharacterSet.JA16SJIS_CHARSET; // this is character set 832
   ...
   CharacterSet mycharset = CharacterSet.make(OracleId);
   ```

   Each character set that Oracle supports has a unique predefined `OracleId`. If you enter an invalid `OracleId`, an exception will *not* be thrown. Instead, when you try to use the character set, you will receive unpredictable results. For more information on character sets and character set IDs, see the *Oracle8i National Language Support Guide*.

2. Construct a CHAR object. Pass to the constructor a string (or the bytes that represent the string) and the `CharacterSet` object that indicates how to interpret the bytes based on the character set. For example:

   ```
   String mystring = "teststring";
   ...
   CHAR mychar = new CHAR(teststring, mycharset);
   ```

   The CHAR class has multiple constructors: they can take a string, a byte array, or an object as input along with the `CharacterSet` object. In the case of a string,

the string is converted to the character set indicated by the `CharacterSet` object before being placed into the `CHAR` object.

Refer to the `CHAR` class Javadoc for more information.

Notes:

- The `CharacterSet` object cannot be null.
- The `CharacterSet` class is an abstract class, therefore it has no constructor. The only way to create instances is through use of the `make()` method.
- The server recognizes the special value `CharacterSet.DEFAULT_CHARSET` as the database character set. For the client, this value is not meaningful.
- Oracle does not intend or recommend that users extend the `CharacterSet` class.

The `CHAR` class provides these methods for translating character data to strings:

- `getString()`: converts the sequence of characters represented by the `CHAR` object to a string, returning a Java `String` object. If the character set is not recognized (that is, if you entered an invalid `OracleID`), then `getString()` throws a `SQLException`.
- `toString()`: identical to `getString()`, but if the character set is not recognized (that is, if you entered an invalid `OracleID`), then `toString()` returns a hexadecimal representation of the `CHAR` data and does *not* throw a `SQLException`.
- `getStringWithReplacement()`: identical to `getString()`, except a default replacement character replaces characters that have no Unicode representation in the character set of this `CHAR` object. This default character varies from character set to character set, but is often a question mark.

The server (database) and the client (or application running on the client) can use different character sets. When you use the methods of this class to transfer data between the server and the client, the JDBC drivers must convert the data from the server character set to the client character set (or vice versa). To convert the data, the drivers use Oracle's National Language Support (NLS). For more information on how the JDBC drivers convert between character sets, see "Using NLS" on page 5-2. For more information on NLS, see the *Oracle8i National Language Support Guide*.

Classes oracle.sql.DATE, oracle.sql.NUMBER, and oracle.sql.RAW

These classes map to primitive SQL datatypes, which are a part of standard JDBC. These classes provide conversions to and from their corresponding JDBC Java types. For more information, see the Javadoc.

Class oracle.sql.ROWID

This class supports Oracle `ROWID`s, which are unique identifiers for rows in database tables. You can select a `ROWID` as you would select any column of data from the table. Note, however, that you cannot manually update `ROWID`s; the Oracle database updates them automatically as appropriate.

The `oracle.sql.ROWID` class does not implement any noteworthy functionality beyond what is in the `oracle.sql.Datum` superclass. However, `ROWID` does provide a `stringValue()` method that overrides the `stringValue()` method in the `oracle.sql.Datum` class and returns the hexadecimal representation of the `ROWID` bytes.

For information about accessing `ROWID` data, see "Additional Oracle Extensions" on page 4-97.

Classes of the oracle.jdbc.driver Package

The `oracle.jdbc.driver` package includes classes that add extended features to enable data access in `oracle.sql` format. In addition, these classes provide Oracle-specific extensions to allow access to raw SQL format data by using `oracle.sql.*` objects.

Table 4–2 lists key classes for connections, statements, and result sets in this package.

Table 4–2 Connection, Statement, and Result Set Classes

Class	Key Functionality
`OracleDriver`	implements `java.sql.Driver`
`OracleConnection`	methods to return Oracle statement objects; methods to set Oracle performance extensions for any statement executed in the current connection (implements `java.sql.Connection`)

Table 4–2 Connection, Statement, and Result Set Classes (Cont.)

Class	Key Functionality
`OracleStatement`	methods to set Oracle performance extensions for individual statement; superclass of `OraclePreparedStatement` and `OracleCallableStatement` (implements `java.sql.Statement`)
`OraclePreparedStatement`	`set` methods to bind `oracle.sql.*` types into a prepared statement (implements `java.sql.PreparedStatement`; extends `OracleStatement`)
`OracleCallableStatement`	`get` methods to retrieve data in `oracle.sql` format; `set` methods to bind `oracle.sql.*` types into a callable statement (inherited from `OraclePreparedStatement`) (implements `java.sql.CallableStatement`; extends `PreparedStatement`)
`OracleResultSet`	`get` methods to retrieve data in `oracle.sql` format (implements `java.sql.ResultSet`)
`OracleResultSetMetaData`	methods to get information about Oracle result sets (implements `java.sql.ResultSetMetaData`)

The `oracle.jdbc.driver` package additionally includes:

- stream classes
- the `OracleTypes` class

The stream classes extend standard Java stream classes and read and write Oracle `LOB`, `LONG`, and `LONG RAW` data.

`OracleTypes` defines integer constants, which identify SQL types. For standard types, it uses the same values as the standard `java.sql.Types`. In addition, it adds constants for Oracle extended types.

The remainder of this section describes the classes of the `oracle.jdbc.driver` package. For more information about using these classes to access Oracle type extensions, see "Data Access and Manipulation: Oracle Types vs. Java Types" on page 4-32.

Class oracle.jdbc.driver.OracleDriver

Use this class to register the Oracle JDBC drivers for use by your application. You can input a new instance of this class to the static `registerDriver()` method of the `java.sql.DriverManager` class so that your application can access and use the Oracle drivers. The `registerDriver()` method takes as input a "driver" class; that is, a class that implements the `java.sql.Driver` interface, as is the case with `OracleDriver`.

Once you register the Oracle JDBC drivers, you can create your connection using the `DriverManager` class. For more information on registering drivers and writing a connection string, see "First Steps in JDBC" on page 3-2.

Class oracle.jdbc.driver.OracleConnection

This class extends standard JDBC connection functionality to create and return Oracle statement objects, set flags and options for Oracle performance extensions, and support type maps for Oracle objects.

"Performance Extensions" on page 4-97 describes the performance extensions, including row prefetching, update batching, and metadata `TABLE_REMARKS` reporting.

Key methods include:

- `createStatement()`: allocates a new `OracleStatement` object
- `prepareStatement()`: allocates a new `OraclePreparedStatement` object
- `prepareCall()`: allocates a new `OracleCallableStatement` object
- `getTransactionIsolation()`: gets this connection's current isolation mode
- `setTransactionIsolation()`: changes the transaction isolation level using one of the `TRANSACTION_*` values

These `oracle.jdbc.driver.OracleConnection` methods are Oracle-defined extensions:

- `getDefaultExecuteBatch()`: retrieves the default update-batching value for this connection
- `setDefaultExecuteBatch()`: sets the default update-batching value for this connection
- `getDefaultRowPrefetch()`: retrieves the default row-prefetch value for this connection

- `setDefaultRowPrefetch()`: sets the default row-prefetch value for this connection
- `getRemarksReporting()`: returns true if `TABLE_REMARKS` reporting is enabled
- `setRemarksReporting()`: enables or disables `TABLE_REMARKS` reporting
- `getTypeMap()`: retrieves the type map for this connection (for use in mapping Oracle object types to Java classes)
- `setTypeMap()`: initializes or updates the type map for this connection (for use in mapping Oracle object types to Java classes)

Class oracle.jdbc.driver.OracleStatement

This class extends standard JDBC statement functionality and is the superclass of the `OraclePreparedStatement` and `OracleCallableStatement` classes. Extended functionality includes support for setting flags and options for Oracle performance extensions on a statement-by-statement basis, as opposed to the `OracleConnection` class that sets these on a connection-wide basis.

"Performance Extensions" on page 4-97 describes the performance extensions, including row prefetching and column type definitions.

Key methods include:

- `executeQuery()`: executes a database query and returns an `OracleResultSet` object
- `getResultSet()`: retrieves an `OracleResultSet` object
- `close()`: closes the current statement

These `oracle.jdbc.driver.OracleStatement` methods are Oracle-defined extensions:

- `defineColumnType()`: defines the type you will use to retrieve data from a particular database table column
- `getRowPrefetch()`: retrieves the row-prefetch value for this statement
- `setRowPrefetch()`: sets the row-prefetch value for this statement

Class oracle.jdbc.driver.OraclePreparedStatement

This class extends standard JDBC prepared statement functionality, is a subclass of the `OracleStatement` class, and is the superclass of the

`OracleCallableStatement` class. Extended functionality consists of `set` methods for binding `oracle.sql.*` types and objects into prepared statements, and methods to support Oracle performance extensions on a statement-by-statement basis.

"Performance Extensions" on page 4-97 describes the performance extensions, including database update batching.

Key methods include:

- `getExecuteBatch()`: retrieves the update-batching value for this statement
- `setExecuteBatch()`: sets the update-batching value for this statement
- `setOracleObject()`: a generic `set` method for binding `oracle.sql.*` data into a prepared statement as an `oracle.sql.Datum` object
- `setXXX()`: `set` methods, such `setBLOB()`, for binding specific `oracle.sql.*` types into prepared statements. For more information on all of the `setXXX()` methods available for `oracle.sql.*` types, see the Javadoc.
- `setCustomDatum()`: binds a `CustomDatum` object (for use in mapping Oracle object types to Java) into a prepared statement
- `setNull()`: sets the value of the object specified by its SQL type name to `NULL`. For `setNull(param_index, type_code, sql_type_name)`, if `type_code` is `REF`, `ARRAY`, or `STRUCT`, then `sql_type_name` is the fully qualified name (*schema.sql_type_name*) of the SQL type.
- `close()`: closes the current statement

Class oracle.jdbc.driver.OracleCallableStatement

This class extends standard JDBC callable statement functionality and is a subclass of the `OracleStatement` and `OraclePreparedStatement` classes. Extended functionality includes `set` methods for binding structured objects and `oracle.sql.*` objects into prepared statements, and `get` methods for retrieving data into `oracle.sql.*` objects.

Key methods include:

- `getOracleObject()`: a generic `get` method for retrieving data into an `oracle.sql.Datum` object. It can be cast to the specific `oracle.sql.*` type as necessary.
- `getXXX()`: `get` methods, such as `getCLOB()`, for retrieving data into specific `oracle.sql.*` objects. For more information on all of the `getXXX()` methods available for `oracle.sql.*` types, see the Javadoc.

- `setOracleObject()`: a generic `set` method for binding `oracle.sql.*` data into a callable statement as an `oracle.sql.Datum` object
- `setXXX()`: `set` methods inherited from `OraclePreparedStatement`, such as `setBLOB()`, for binding specific `oracle.sql.*` objects into callable statements. For more information on all of the `setXXX()` methods available for `oracle.sql.*` types, see the Javadoc.
- `setNull()`: sets the value of the object specified by its SQL type name to `NULL`. For `setNull(param_index, type_code, sql_type_name)`, if `type_code` is `REF`, `ARRAY`, or `STRUCT`, then `sql_type_name` is the fully qualified (*schema.type*) name of the SQL type.
- `registerOutParameter()`: registers the SQL type code of the statement's output parameter. JDBC requires this for any callable statement with an `OUT` parameter. It takes an integer parameter index (the position of the output variable in the statement, relative to the other parameters) and an integer SQL type (the type constant defined in `oracle.jdbc.driver.OracleTypes`).

  This is an overloaded method. There is a version of this method that you use for named types only; that is, when the SQL type code is `OracleTypes.REF`, `STRUCT`, or `ARRAY`. In this case, in addition to a parameter index and SQL type, the method also takes a `String` SQL type name (the name of the Oracle object type in the database, such as `EMPLOYEE`).
- `close()`: closes the current result set, if any, and the current statement

Class oracle.jdbc.driver.OracleResultSet

This class extends standard JDBC result set functionality, implementing `get` methods for retrieving data into `oracle.sql.*` objects.

Key methods include:

- `getOracleObject()`: a generic `get` method for retrieving data into an `oracle.sql.Datum` object. It can be cast to the specific `oracle.sql.*` type as necessary.
- `getXXX()`: `get` methods, such as `getCLOB()`, for retrieving data into `oracle.sql.*` objects
- `next()`: advances to the next row of the result set

Class oracle.jdbc.driver.OracleResultSetMetaData

This class extends standard JDBC result set metadata functionality to retrieve information about Oracle result set objects.

Key methods include the following:

- `getColumnCount()`: returns the number of columns in an Oracle result set
- `getColumnName()`: returns the name of a specified column in an Oracle result set
- `getColumnType()`: returns the SQL type of a specified column in an Oracle result set. If the column stores an Oracle object or collection, then this method returns `OracleTypes.STRUCT` or `OracleTypes.ARRAY` respectively.
- `getColumnTypeName()`: returns the SQL type name of the data stored in the column. If the column stores an array or collection, then this method returns its SQL type name. If the column stores `REF` data, then this method returns the SQL type name of the objects to which the `REF` points.
- `getTableName()`: returns the name of the table from which an Oracle result set column was selected

Oracle Stream Classes

Oracle uses many stream classes that extend standard Java stream classes to provide special functionality, such as writing directly to an Oracle database. The JDBC drivers use these classes which are in the `oracle.jdbc.driver` package but does not intend them for use by Java applications programmers. For more information on Java streams, see "Using Java Streams in JDBC" on page 3-14.

Class oracle.jdbc.driver.OracleTypes

The `OracleTypes` class defines constants that JDBC uses to identify SQL types. Each variable in this class has a constant integer value. The `oracle.jdbc.driver.OracleTypes` class contains a copy of the standard Java `java.sql.Types` class and contains these additional Oracle type extensions:

- `OracleTypes.STRUCT`
- `OracleTypes.REF`
- `OracleTypes.ARRAY`
- `OracleTypes.BLOB`
- `OracleTypes.CLOB`

- `OracleTypes.BFILE`
- `OracleTypes.ROWID`

As in `java.sql.Types`, all of the variable names are in all-caps.

JDBC uses the SQL types identified by the elements of the `OracleTypes` class in two main areas: registering output parameters and in the `setNull()` method of the `PreparedStatement` class.

OracleTypes and Registering Output Parameters The SQL types in the `OracleTypes` class identify the SQL type of the output parameters in the `registerOutParameter()` method of the `java.sql.CallableStatement` and `oracle.jdbc.driver.OracleCallableStatement` classes.

These are the forms that `registerOutputParameter()` can take for `CallableStatement` and `OracleCallableStatement`:

```
CallableStatement.registerOutParameter(int index, int sqlType)

CallableStatement.registerOutParameter(int index, int sqlType, int scale)

OracleCallableStatement.registerOutParameter(int index, int sqlType, String
sql_name)
```

In these prototypes, `index` represents the parameter index, `sqlType` represents the SQL datatype (one of the `OracleTypes`, in this case), `sql_name` represents the name given to the datatype (that is, the "named type"), and `scale` represents the number of digits to the right of the decimal point when `sqlType` is a `NUMERIC` or `DECIMAL` datatype.

Any output parameter datatype except `STRUCT`, `ARRAY`, or `REF` can use the two forms of `CallableStatement.registerOutParameter()`.

The `OracleCallableStatement` form of `registerOutParameter()` can be used *only* when the output parameter is of type `STRUCT`, `ARRAY`, or `REF` and requires you to provide the name of the named type.

The following example uses a `CallableStatement` to call a procedure named `procout`, which returns a `CHAR` datatype. Note the use of the `OracleTypes.CHAR` SQL name in the `registerOutParameter()` method.

```
CallableStatement procout = conn.prepareCall ("BEGIN procout (?); END;");
      procout.registerOutParameter (1, OracleTypes.CHAR);
      procout.execute ();
      System.out.println ("Out argument is: " + procout.getString (1));
```

The next example uses a CallableStatement to call procout, which returns a STRUCT datatype. The form of registerOutParameter() requires you to specify the name of the SQL type, OracleTypes.STRUCT, as well as the SQL type name (that is, the name of the named type) EMPLOYEE.

The example assumes that no type mapping has been declared for the EMPLOYEE type, so it is retrieved into a STRUCT datatype. To retrieve the value of EMPLOYEE into the default STRUCT datatype, the statement object procout is cast to an OracleCallableStatement and the getSTRUCT() is applied.

```
CallableStatement procout = conn.prepareCall ("BEGIN procout (?); END;");
procout.registerOutParameter (1, OracleTypes.STRUCT, "EMPLOYEE");
procout.execute ();

// get the value into a STRUCT because it
// is assumed that no type map has been defined
STRUCT emp = ((OracleCallableStatement)procout).getSTRUCT (1);
```

OracleTypes and the setNull() Method The SQL types in the OracleTypes class identify the object, which the setNull() method sets to NULL. The setNull() method can be found in the java.sql.PreparedStatement and oracle.jdbc.driver.OraclePreparedStatement classes.

These are the forms that setNull() can take for PreparedStatement and OraclePreparedStatement classes:

```
PreparedStatement.setNull(int index, int sqlType)

OraclePreparedStatement.setNull(int index, int sqlType, String sql_name)
```

In these prototypes, index represents the parameter index, sqlType represents the SQL datatype (one of the OracleTypes, in this case), and sql_name represents the name given to the datatype (that is, the name of the "named type"). If you enter an invalid sqlType, a "Parameter Type Conflict" error is thrown.

You can use the PreparedStatement form of setNull() to set to NULL the value of an object of any datatype, except STRUCT, ARRAY, or REF.

You can use the OraclePreparedStatement form of setNull() *only* when you set to NULL the value of an object of datatype STRUCT, ARRAY, or REF.

The following example uses a PreparedStatement to insert a NULL numeric value into the database. Note the use of OracleTypes.NUMERIC to identify the numeric object that is set to NULL.

```
PreparedStatement pstmt =
```

```
    conn.prepareStatement ("INSERT INTO num_table VALUES (?)");

pstmt.setNull (1, OracleTypes.NUMERIC);
pstmt.execute ();
```

In this example, the prepared statement inserts a NULL STRUCT object of type EMPLOYEE into the database. Note that an OraclePreparedStatement is required to set a STRUCT object to NULL. Thus, the prepared statement pstmt must be cast to OraclePreparedStatement.

```
PreparedStatement pstmt =
conn.prepareStatement ("INSERT INTO employee_table VALUES (?)");

((OraclePreparedStatement)pstmt).setNull(1, OracleTypes.STRUCT, "EMPLOYEE");
pstmt.execute ();
```

Data Access and Manipulation: Oracle Types vs. Java Types

This section contains the following subsections:

This section describes data access in `oracle.sql.*` formats as opposed to Java formats. As discussed in the introduction to this chapter, the `oracle.sql.*` formats are a key factor of the Oracle JDBC extensions, offering significant advantages in efficiency and precision in manipulating SQL data.

Using `oracle.sql.*` formats involves casting your result sets and statements to `OracleResultSet`, `OracleStatement`, `OraclePreparedStatement`, and `OracleCallableStatement` objects as appropriate, and using the `getOracleObject()`, `setOracleObject()`, `getXXX()`, and `setXXX()` (where `XXX` corresponds to the types in the `oracle.sql` package) methods of these classes. Refer to the Javadoc for additional information about these classes and methods.

Data Conversion Considerations

When JDBC programs retrieve SQL data into Java variables, the SQL data is converted to the Java datatypes of those variables. The Java datatypes can be represented as members of the `oracle.sql` package instead of as members of the `java.lang` or `java.sql.Types` packages. In processing speed and effort, the `oracle.sql.*` classes provide the most efficient way of representing SQL data. These classes store the usual representations of SQL data as byte arrays. They do not reformat the data or perform any character-set conversions (aside from the usual network conversions) on it. The data remains in SQL format; therefore, no information is lost. For SQL primitive types (such as `NUMBER`, and `CHAR`), the `oracle.sql.*` classes simply wrap the SQL data. For SQL structured types (such as objects and arrays), the classes provide additional information such as conversion methods and structure details.

If you are moving data within the database, then you will probably want to keep your data in `oracle.sql.*` format. If you are displaying the data, or performing calculations on it in a Java application running outside of the database, then you will probably want to represent the data as a member of `java.sql.Types.*` or `java.lang.*`. Similarly, if you are using a parser that expects the data to be in Java

format, you must represent the data in one of the Java formats instead of as an `oracle.sql.*`.

Converting SQL NULL Data

Java represents a SQL `NULL` datum by the Java value `null`. Java datatypes fall into two categories: the fixed set of scalar types (such as `byte`, `int`, `float`) and object types (such as objects and arrays). The Java scalar types cannot represent `null`. Instead, they store the null as the value zero (as defined by the JDBC specification). This can lead to ambiguity when you try to interpret your results.

In contrast, Java object types can represent `null`. The Java language defines an object wrapper type corresponding to every scalar type (for example, `Integer` for `int`, `Float` for `float`) that can represent `null`. The object wrapper types must be used as the targets for SQL data to detect SQL `NULL` without ambiguity.

Using Result Set and Statement Extensions

The JDBC `Statement` object returns an `OracleResultSet` object, typed as a `java.sql.ResultSet`. If you want to apply only standard JDBC methods to the object, keep it as a `ResultSet` type. However, if you want to use the Oracle extensions on the object, you must cast it to an `OracleResultSet` type. The object is unchanged. The type by which the Java compiler will identify the object is changed.

When you execute a `SELECT` statement in a Java application using a standard JDBC `Statement` object, Oracle's JDBC drivers return a `java.sql.ResultSet` object. You can use this standard `ResultSet` object if all you need are standard JDBC `ResultSet` methods, but to use Oracle extensions you must cast the result set to an `OracleResultSet` object.

For example, assuming you have a standard `Statement` object `stmt`, do the following if you want to use only standard JDBC `ResultSet` methods:

```
ResultSet rs = stmt.executeQuery("SELECT * FROM emp");
```

If you need the extended functionality provided by the Oracle extensions to JDBC, you can select the results into a standard `ResultSet` object, as above, and then cast that object into an `OracleResultSet` object later.

Similarly, when you want to execute a stored procedure using a callable statement, the JDBC drivers will return an `OracleCallableStatement` object typed as a `java.sql.CallableStatement`. If you want to apply only standard JDBC methods to the object, then keep it as a `CallableStatement` type. However, if

you want to use the Oracle extensions on the object, you must cast it to an `OracleCallableStatement` type. The object is unchanged. The type by which the Java compiler identifies the object is changed.

You use the standard JDBC `java.sql.Connection.prepareStatement()` method to create a `PreparedStatement` object. If you want to apply only standard JDBC methods to the object, keep it as a `PreparedStatement` type. However, if you want to use the Oracle extensions on the object, you must cast it to an `OraclePreparedStatement` type. The object is unchanged. The type by which the Java compiler identifies the object is changed.

Key extensions to the result set and statement classes include `getOracleObject()` and `setOracleObject()` methods that you can use to access and manipulate data in `oracle.sql.*` formats instead of standard Java formats. For more information see the next section: "Comparing get and set Methods for oracle.sql.* Format with Java Format".

Comparing get and set Methods for oracle.sql.* Format with Java Format

This section describes `get` and `set` methods, particularly the JDBC standard `getObject()` and `setObject()` methods and the Oracle-specific `getOracleObject()` and `setOracleObject()` methods, and how to access data in `oracle.sql.*` format compared with Java format.

Although there are specific `getXXX()` methods for all of the Oracle SQL types (as described in "Other getXXX() Methods" on page 4-37), you can use the general `get` methods for convenience or simplicity, or if you are not certain in advance what type of data you will receive.

Standard getObject() Method

The standard JDBC `getObject()` method of a result set or callable statement returns data into a `java.lang.Object` object. The format of the data returned is based on its original type, as follows:

- For SQL datatypes that are not Oracle-specific, `getObject()` returns the default Java type corresponding to the column's SQL type, following the mapping specified in the JDBC specification.
- For Oracle-specific datatypes (such as `ROWID`, discussed in "Additional Type Extensions" on page 4-111), `getObject()` returns an object of the appropriate `oracle.sql.*` class (such as `oracle.sql.ROWID`).
- For Oracle objects, `getObject()` returns an object of the Java class specified in your type map. (Type maps specify the correlation between Java classes and

database SQL types and are discussed in "Understanding Type Maps" on page 4-66.) The `getObject(parameter_index)` method uses the connection's default type map. The `getObject(parameter_index, map)` enables you to pass in a type map. If the type map does not provide a mapping for a particular Oracle object, then `getObject()` returns an `oracle.sql.STRUCT` object.

For more information on `getObject()` return types, see Table 4–3, "Summary of getObject() and getOracleObject() Return Types" on page 4-36.

Oracle getOracleObject() Method

If you want to retrieve data from a result set or callable statement into an `oracle.sql.*` object, then cast your result set to an `OracleResultSet` type or your callable statement to an `OracleCallableStatement` type and use the `getOracleObject()` method.

When you use `getOracleObject()`, the data will be of the appropriate `oracle.sql.*` type and is returned into an `Datum` object. The prototype for the method is:

```
public oracle.sql.Datum getOracleObject(int parameter_index)
```

When you have retrieved data into a `Datum` object, you can use the standard Java `instanceOf()` operator to determine which `oracle.sql.*` type it really is.

For more information on `getOracleObject()` return types, see Table 4–3, "Summary of getObject() and getOracleObject() Return Types" on page 4-36.

Example: Using getOracleObject() with a ResultSet The following example creates a table that contains a column of character data (in this case, a row number) and a column containing a `BFILE` locator. A `SELECT` statement gets the contents of the table into a result set. The `getOracleObject()` then retrieves the `CHAR` data into the `char_datum` variable and the `BFILE` locator into the `bfile_datum` variable. Note that because `getOracleObject()` returns a `Datum` object, the results must be cast to `CHAR` and `BFILE` respectively.

```
stmt.execute ("CREATE TABLE bfile_table (x varchar2 (30), b bfile)");
stmt.execute ("INSERT INTO bfile_table VALUES ('one', bfilename ('TEST_DIR',
'file1'))");

ResultSet rset = stmt.executeQuery ("SELECT * FROM string_table");
  while (rset.next ())
   {
    CHAR char_datum = (CHAR) ((OracleResultSet)rset).getOracleObject (1);
```

```
    BFILE bfile_datum = (BFILE) ((OracleResultSet)rset).getOracleObject (2);
    ...
  }
```

Example: Using getOracleObject() in a Callable Statement The following example prepares a call to the procedure `myGetDate()`, which associates a character string (in this case a name) with a date. The program passes the string `SCOTT` to the prepared call, and registers the `DATE` type as an output parameter. After the call is executed, `getOracleObject()` retrieves the date associated with the name `SCOTT`. Note that since `getOracleObject()` returns a `Datum` object, the results are cast to a `DATE` object.

```
OracleCallableStatement cstmt =
(OracleCallableStatement)conn.prepareCall ("begin myGetDate (?, ?); end;");

cstmt.setString (1, "SCOTT");
cstmt.registerOutParameter (2, Types.DATE);
cstmt.execute ();

DATE date = (DATE) ((OracleCallableStatement)cstmt).getOracleObject (2);
...
```

Summary of getObject() and getOracleObject() Return Types

Table 4–3 summarizes the information in the preceding sections, "Standard getObject() Method" on page 4-34 and "Oracle getOracleObject() Method" on page 4-35.

This table lists the underlying return types for each method for each Oracle SQL type, but keep in mind the signatures of the methods when you write your code:

- `getObject()` always returns data into a `java.lang.Object`
- `getOracleObject()` always returns data into an `oracle.sql.Datum`

You must cast the returned object to use any special functionality (see "Casting Your get Method Return Values" on page 4-39).

Table 4–3 Summary of getObject() and getOracleObject() Return Types

Oracle SQL Type	getObject() Underlying Return Type	getOracleObject() Underlying Return Type
CHAR	String	oracle.sql.CHAR
VARCHAR2	String	oracle.sql.CHAR

Table 4–3 Summary of getObject() and getOracleObject() Return Types (Cont.)

Oracle SQL Type	getObject() Underlying Return Type	getOracleObject() Underlying Return Type
LONG	String	oracle.sql.CHAR
NUMBER	java.math.BigDecimal	oracle.sql.NUMBER
RAW	byte[]	oracle.sql.RAW
LONGRAW	byte[]	oracle.sql.RAW
DATE	java.sql.Timestamp	oracle.sql.DATE
ROWID	oracle.sql.ROWID	oracle.sql.ROWID
REF CURSOR	java.sql.ResultSet	(not supported)
BLOB	oracle.sql.BLOB	oracle.sql.BLOB
CLOB	oracle.sql.CLOB	oracle.sql.CLOB
BFILE	oracle.sql.BFILE	oracle.sql.BFILE
Oracle object	class specified in type map OR oracle.sql.STRUCT (if no type map entry)	oracle.sql.STRUCT
Oracle object reference	oracle.sql.REF	oracle.sql.REF
collection (varray or nested table)	oracle.sql.ARRAY	oracle.sql.ARRAY

For information on type compatibility between all SQL and Java types, see Table 8–1, "Valid SQL Datatype-Java Class Mappings" on page 8-2.

Other getXXX() Methods

Standard JDBC provides a `getXXX()` for each standard Java type, such as `getByte()`, `getInt()`, `getFloat()`, and so on. Each of these returns exactly what the method name implies (a `byte`, an `int`, a `float`, and so on).

In addition, the `OracleResultSet` and `OracleCallableStatement` classes provide a full complement of `getXXX()` methods corresponding to all of the `oracle.sql.*` types. Each `getXXX()` method returns an `oracle.sql.XXX`. For example, `getROWID()` returns an `oracle.sql.ROWID`.

Some of these extensions are taken from the JDBC 2.0 specification. They return objects of type `oracle.jdbc2.*` instead of `oracle.sql.*`. For example, compare the prototypes:

```
oracle.jdbc2.Blob getBlob(int parameter_index)
```

which returns an `oracle.jdbc2` type for `BLOB`s, in contrast to:

```
oracle.sql.BLOB getBLOB(int parameter_index)
```

which returns an `oracle.sql` type for `BLOB`s.

Although there is no particular performance advantage in using the specific `getXXX()` methods, they can save you the trouble of casting because they return specific object types.

Table 4–4 summarizes the underlying return types and the signature types for each `getXXX()` method. You must cast to an `OracleResultSet` or `OracleCallableStatement` to use methods that are Oracle-specific.

Table 4–4 Summary of getXXX() Return Types

Method	Underlying Return Type	Signature Type	Oracle Specific?
getArray()	oracle.sql.ARRAY	oracle.jdbc2.Array	Yes
getARRAY()	oracle.sql.ARRAY	oracle.sql.ARRAY	Yes
getBfile()	oracle.sql.BFILE	oracle.sql.BFILE	Yes
getBFILE()	oracle.sql.BFILE	oracle.sql.BFILE	Yes
getBigDecimal()	BigDecimal	BigDecimal	No
getBlob()	oracle.sql.BLOB	oracle.jdbc2.Blob	Yes
getBLOB	oracle.sql.BLOB	oracle.sql.BLOB	Yes
getBoolean()	boolean	boolean	No
getByte()	byte	byte	No
getBytes()	byte[]	byte[]	No
getCHAR()	oracle.sql.CHAR	oracle.sql.CHAR	Yes
getClob()	oracle.sql.CLOB	oracle.jdbc2.Clob	Yes
getCLOB()	oracle.sql.CLOB	oracle.sql.CLOB	Yes
getDate()	java.sql.Date	java.sql.Date	No

Table 4–4 Summary of getXXX() Return Types (Cont.)

Method	Underlying Return Type	Signature Type	Oracle Specific?
getDATE()	oracle.sql.DATE	oracle.sql.DATE	Yes
getDouble()	double	double	No
getFloat()	float	float	No
getInt()	int	int	No
getLong()	long	long	No
getNUMBER()	oracle.sql.NUMBER	oracle.sql.NUMBER	Yes
getRAW()	oracle.sql.RAW	oracle.sql.RAW	Yes
getRef()	oracle.sql.REF	oracle.jdbc2.Ref	Yes
getREF()	oracle.sql.REF	oracle.sql.REF	Yes
getROWID()	oracle.sql.ROWID	oracle.sql.ROWID	Yes
getShort()	short	short	No
getString()	String	String	No
getSTRUCT()	oracle.sql.STRUCT.	oracle.sql.STRUCT	Yes
getTime()	java.sql.Time	java.sql.Time	No
getTimestamp	java.sql.Timestamp	java.sql.Timestamp	No

Casting Your get Method Return Values

As described in "Standard getObject() Method" on page 4-34, Oracle's implementation of `getObject()` always returns a `java.lang.Object` and `getOracleObject()` always returns an `oracle.sql.Datum`. Usually, you would cast the returned object to the appropriate class so that you could use particular methods and functionality of that class.

In addition, you have the option of using a specific `getXXX()` method instead of the generic `getObject()` or `getOracleObject()` methods. The `getXXX()` methods enable you to avoid casting because the return type of `getXXX()` corresponds to the type of object returned. For example, `getCLOB()` returns an `oracle.sql.CLOB` as opposed to a `java.lang.Object`.

Example: Casting Return Values This example assumes that you have fetched data of type CHAR into a result set (where it is in column 1). Because you want to

manipulate the CHAR data without losing precision, cast your result set to an OracleResultSet ors and use getOracleObject() to return the CHAR data. (If you do not cast your result set, you have to use getObject(), which returns your character data into a Java String and loses some of the precision of your SQL data.) By casting the result set, you can use getOracleObject() and return data in oracle.sql.* format.

The getOracleObject() method returns an oracle.sql.CHAR object into an oracle.sql.Datum return variable unless you cast the output. Cast the getOracleObject() output to oracle.sql.CHAR if you want to use a CHAR return variable and later use any special functionality of that class (such as the getCharacterSet() method that returns the character set used to represent the characters).

```
CHAR char = (CHAR)ors.getOracleObject(1);
CharacterSet cs = char.getCharacterSet();
```

Alternatively, return into a generic oracle.sql.Datum return variable and cast this object later whenever you must use the CHAR getCharacterSet() method.

```
Datum rawdatum = ors.getOracleObject(1);
...
CharacterSet cs = ((CHAR)rawdatum).getCharacterSet();
```

This uses the getCharacterSet() method of oracle.sql.CHAR. The getCharacterSet() method is not defined on oracle.sql.Datum and would not be reachable without the cast.

Standard setObject() and Oracle setOracleObject() Methods

Just as there is a standard getObject() and Oracle-specific getOracleObject() in result sets and callable statements for retrieving data, there is also a standard setObject() and an Oracle-specific setOracleObject() in Oracle prepared statements and callable statements for updating data. The setOracleObject() methods take oracle.sql.* input parameters.

You can use the setObject() method to bind standard Java types to a prepared statement or callable statement; it takes a java.lang.Object as input. You can use the setOracleObject() method to bind oracle.sql.* types; it takes an oracle.sql.Datum (or any subclass) as input. The setObject() method supports some oracle.sql.* types—see note below. For other oracle.sql.* types, you must use setOracleObject().

To use `setOracleObject()`, you must cast your prepared statement or callable statement to an `OraclePreparedStatement` or `OracleCallableStatement` object.

> **Note:** The `setObject()` method has been implemented so that you can also input instances of the `oracle.sql.*` classes that correspond to JDBC 2.0-compliant Oracle extensions: `BLOB`, `CLOB`, `BFILE`, `STRUCT`, `REF`, and `ARRAY`.

Example: Using setObject() and setOracleObject() in a Prepared Statement This example assumes that you have fetched character data into a standard result set (where it is in column 1), and you want to cast the results to an `OracleResultSet` so that you can use Oracle-specific formats and methods. Since you want to use the data as `oracle.sql.CHAR` format, cast the results of the `getOracleObject()` (which returns type `oracle.sql.Datum`) to `CHAR`. Similarly, since you want to manipulate the data in column 2 as strings, cast the data to a Java `String` type (since `getObject()` returns data of type `Object`). In this example, `rs` represents the result set, `charVal` represents the data from column 1 in `oracle.sql.CHAR` format, and `strVal` represents the data from column 2 in Java `String` format.

```
CHAR charVal=(CHAR)((OracleResultSet)rs).getOracleObject(1);
String strVal=(String)rs.getObject(2);
...
```

For some prepared statement `ps`, the `setOracleObject()` method binds the `oracle.sql.CHAR` data represented by the `charVal` variable to the prepared statement. To bind the `oracle.sql.*` data, the prepared statement must be cast to an `OraclePreparedStatement`. Similarly, the `setObject()` method binds the Java `String` data represented by the variable `strVal`.

```
PreparedStatement ps= conn.prepareStatement("text_of_prepared_statement");
((OraclePreparedStatement)ps).setOracleObject(1,charVal);
ps.setObject(2,strVal);
```

Other setXXX() Methods

As with `getXXX()` methods, there are several specific `setXXX()` methods. Standard `setXXX()` methods are provided for binding standard Java types, and Oracle-specific `setXXX()` methods are provided for binding Oracle-specific types.

In addition, for compatibility with the JDBC 2.0 standard, `OraclePreparedStatement` and `OracleCallableStatement` classes provide `setXXX()` methods that take `oracle.jdbc2` input parameters for `BLOB`s, `CLOB`s,

object references, and arrays. For example, there is a `setBlob()` method that takes an `oracle.jdbc2.Blob` input parameter, and a `setBLOB()` method that takes an `oracle.sql.BLOB` input parameter.

Similarly, there are two forms of the `setNull()` method:

- `void setNull(int` *`parameterIndex`*`, int` *`sqlType`*`)`

  behaves in a similar way to the standard Java `java.sql.PreparedStatement.setNull()`. This method takes a parameter index and a SQL type code defined by `java.sql.Types`. You use this method to set an object (except for REFs, ARRAYs, or STRUCTs) to `NULL`.

- `void setNull(int` *`parameterIndex`*`, int` *`sqlType`*`, String` *`sql_type_name`*`)`

  takes a SQL type name in addition to a parameter index and a SQL type code. You use this method only when the SQL type code is REF, ARRAY, or STRUCT.

Similarly, the `OracleCallableStatement.registerOutParameter()` method also has an overloaded method that you use when working with REFs, ARRAYs, or STRUCTs.

`void registerOutParameter(int` *`parameterIndex`*`, int` *`sqlType`*`, String` *`sql_type_name`*`)`

There is no particular performance advantage in using the specific `setXXX()` methods for binding Oracle-specific types over the methods for binding standard Java types.

Table 4–5 summarizes the input types for all of the `setXXX()` methods. To use methods that are Oracle-specific, you must cast your statement to an `OraclePreparedStatement` or `OracleCallableStatement`.

Table 4–5 Summary of setXXX() Input Parameter Types

Method	Input Parameter Type	Oracle Specific?
setArray()	oracle.jdbc2.Array	Yes
setARRAY()	oracle.sql.ARRAY	Yes
setBfile()	oracle.sql.BFILE	Yes
setBFILE()	oracle.sql.BFILE	Yes
setBigDecimal()	BigDecimal	No
setBlob()	oracle.jdbc2.Blob	Yes
setBLOB()	oracle.sql.BLOB	Yes

Table 4–5 Summary of setXXX() Input Parameter Types (Cont.)

Method	Input Parameter Type	Oracle Specific?
setBoolean()	boolean	No
setByte()	byte	No
setBytes()	byte[]	No
setCHAR()	oracle.sql.CHAR	Yes
setClob()	oracle.jdbc2.Clob	Yes
setCLOB()	oracle.sql.CLOB	Yes
setDate()	java.sql.Date	No
setDATE()	oracle.sql.DATE	Yes
setDouble()	double	No
setFloat()	float	No
setInt()	int	No
setLong()	long	No
setNUMBER()	oracle.sql.NUMBER	Yes
setRAW()	oracle.sql.RAW	Yes
setRef()	oracle.jdbc2.Ref	Yes
setREF()	oracle.sql.REF	Yes
setROWID()	oracle.sql.ROWID	Yes
setShort()	short	No
setString()	String	No
setSTRUCT()	oracle.sql.STRUCT	Yes
setTime()	java.sql.Time	No
setTimestamp()	java.sql.Timestamp	No

For information on type compatibility between all SQL and Java types, see Table 8–1, "Valid SQL Datatype-Java Class Mappings" on page 8-2.

Using Result Set Meta Data Extensions

Although the `oracle.jdbc.driver.OracleResultSetMetaData` class does not implement the full JDBC 2.0 API for retrieving result set meta data, it does provide many methods to retrieve information about an Oracle result set.

The `getColumnTypeName()` method takes a column number and returns the SQL type name for columns of type REF, STRUCT, or ARRAY. In contrast, the `getColumnType()` method takes a column number and returns the SQL type. If the column stores an Oracle object or collection, then it returns an `OracleTypes.STRUCT` or an `OracleTypes.ARRAY`. For a list of the key methods provided by `OracleResultSetMetadata`, see "Class oracle.jdbc.driver.OracleResultSetMetaData" on page 4-28.

The following example uses several of the methods in the `OracleResultSetMetadata` class to retrieve the number of columns from the EMP table, and each column's numerical type and SQL type name.

```
DatabaseMetaData dbmd = conn.getMetaData();
ResultSet rset = dbmd.getTables("", "SCOTT", "EMP", null);

 while (rset.next())
 {
   OracleResultSetMetaData orsmd = ((OracleResultSet)rset).getMetaData();
   int numColumns = orsmd.getColumnCount();
   System.out.println("Num of columns = " + numColumns);

   for (int i=0; i<numColumns; i++)
   {
     System.out.print ("Column Name=" + orsmd.getColumnName (i+1));
     System.out.print (" Type=" + orsmd.getColumnType (i + 1) );
     System.out.println (" Type Name=" + orsmd.getColumnTypeName (i + 1));
  }
}
```

The program returns the following output:

```
Num of columns = 5
Column Name=TABLE_CAT Type=12 Type Name=VARCHAR2
Column Name=TABLE_SCHEM Type=12 Type Name=VARCHAR2
Column Name=TABLE_NAME Type=12 Type Name=VARCHAR2
Column Name=TABLE_TYPE Type=12 Type Name=VARCHAR2
Column Name=TABLE_REMARKS Type=12 Type Name=VARCHAR2
```

Working with LOBs

This section has these subsections:

LOBs can be either internal or external. Internal LOBs, as their name suggests, are stored inside database tablespaces in a way that optimizes space and provides efficient access. The JDBC drivers provide support for two types of internal LOBs: `BLOB`s (unstructured binary data) and `CLOB`s (single-byte character data). `BLOB` and `CLOB` data is accessed and referenced by using a locator which is stored in the database table and points to the `BLOB` or `CLOB` data.

External LOBs (`BFILES`) are large binary data objects stored in operating system files outside of database tablespaces. These files use reference semantics. They may also be located on tertiary storage devices such as hard disks, CD-ROMs, PhotoCDs and DVDs. Like `BLOB`s and `CLOB`s, a `BFILE` is accessed and referenced by a locator which is stored in the database table and points to the `BFILE` data.

This section describes how you use JDBC and the `oracle.sql.*` classes to work with LOBs. To work with LOB data, you must first obtain its locator from the table. Then, you can read data from or write data to the LOB and perform various types of data manipulation. This section also describes how to create and populate a LOB column in a table.

The JDBC drivers support these `oracle.sql.*` classes for `BLOB`s, `CLOB`s, and `BFILE`s:

- `oracle.sql.BLOB`
- `oracle.sql.CLOB`

- `oracle.sql.BFILE`

The `oracle.sql.BLOB` and `CLOB` classes implement the `oracle.jdbc2.Blob` and `Clob` interfaces, respectively. In contrast, `BFILE`s have no `oracle.jdbc2` interface.

Instances of these classes contain only the locators for these datatypes, not the data. After accessing the locators, you must perform some additional steps to access the data. These steps are described in "Reading and Writing BLOB and CLOB Data" on page 4-48 and "Reading BFILE Data" on page 4-57.

Getting BLOB and CLOB Locators

Given a standard JDBC result set or callable statement object that includes `BLOB` or `CLOB` locators, you can access the locators by using the standard `ResultSet.getObject()` method. This method returns an `oracle.sql.BLOB` object or `oracle.sql.CLOB` object, as applicable (but note that it returns the `BLOB` or `CLOB` into a variable of type `oracle.jdbc2.Blob` or `oracle.jdbc2.Clob`).

You can also access the locators by casting your result set to `OracleResultSet` or your callable statement to `OracleCallableStatement` and using the `getOracleObject()`, `getBLOB()`, or `getCLOB()` method, as appropriate.

In the `OracleResultSet` and `OracleCallableStatement` classes, `getBlob()` returns `oracle.jdbc2.Blob`, and `getBLOB()` returns `oracle.sql.BLOB`. Similarly, `getCLOB()` returns `oracle.jdbc2.CLOB` and `getClob()` returns `oracle.sql.Clob`.

Notes:

- If using `getObject()` or `getOracleObject()`, then remember to cast the output as necessary. For more information, see "Casting Your get Method Return Values" on page 4-39.
- Refer the Javadoc for more information about specific features of the `oracle.sql.BLOB` and `oracle.sql.CLOB` classes.

Example: Getting BLOB and CLOB Locators from a Result Set Assume the database has a table called `lob_table` with a column for a `BLOB` locator, `blob_col`, and a column for a `CLOB` locator, `clob_col`. This example assumes that you have already created the `Statement` object, `stmt`.

First, select the LOB locators into a standard result set, then get the LOB data into appropriate Java classes:

```
// Select LOB locator into standard result set.
ResultSet rs =
   stmt.executeQuery ("SELECT blob_col, clob_col FROM lob_table");
while (rs.next())
{
   // Get LOB locators into Java wrapper classes.
   oracle.jdbc2.Blob blob = (oracle.jdbc2.Blob)rs.getObject(1);
   oracle.jdbc2.Clob clob = (oracle.jdbc2.Clob)rs.getObject(2);
   [...process...]
}
```

The output is cast to `oracle.jdbc2.Blob` and `Clob`. As an alternative, you can cast the output to `oracle.sql.BLOB` and `CLOB` to take advantage of extended functionality offered by the `oracle.sql.*` classes. For example, you can rewrite the above code to get the LOB locators as:

```
   // Get LOB locators into Java wrapper classes.
   oracle.sql.BLOB blob = (BLOB)rs.getObject(1);
   oracle.sql.CLOB clob = (CLOB)rs.getObject(2);
   [...process...]
```

Example: Getting a CLOB Locator from a Callable Statement The callable statement methods for retrieving LOBs are identical to the result set methods. In the case of a callable statement, register the output parameter as `OracleTypes.BLOB` or `OracleTypes.CLOB`.

For example, if you have an `OracleCallableStatement ocs` that calls a function `func` that has a `CLOB` output parameter, then set up the callable statement as follows:

```
OracleCallableStatement ocs =
   (OracleCallableStatement)conn.prepareCall("{? = call func()}")
ocs.registerOutParameter(1, OracleTypes.CLOB);
ocs.executeQuery()
oracle.sql.CLOB clob = ocs.getCLOB(1);
```

Passing BLOB and CLOB Locators

To pass a LOB locator to a prepared statement or callable statement (to update a LOB locator in the database, for example), you can use the generic `setObject()` method, or you can cast the statement to `OraclePreparedStatement` or `OracleCallableStatement` and use the `setOracleObject()`, `setBLOB()`, or

setCLOB() method, as appropriate. These methods take the parameter index and a BLOB object or CLOB object as input.

Example: Passing a BLOB Locator to a Prepared Statement If you have an OraclePreparedStatement ops where its first parameter is a BLOB named my_blob, then input the BLOB to the prepared statement as follows:

```
OraclePreparedStatement ops = (OraclePreparedStatement)conn.prepareStatement
    ("INSERT INTO blob_table VALUES(?)");
ops.setBLOB(1, my_blob);
ops.execute();
```

Example: Passing a CLOB Locator to a Callable Statement If you have an OracleCallableStatement ocs where its first parameter is a CLOB, then input the CLOB to the callable statement as follows:

```
OracleCallableStatement ocs =
   (OracleCallableStatement)conn.prepareCall("{? := call func()}")
ocs.setClob(1, my_clob)
ocs.execute();
```

Reading and Writing BLOB and CLOB Data

The SQL SELECT statement queries for LOB locators. Once you have the locator, you can read and write the LOB data from JDBC. LOB data is materialized as a Java stream. However, unlike most Java streams, a locator representing the LOB data is stored in the table. Thus, you can access the LOB data at any time during the life of the connection.

To read and write the LOB data, use the methods in the oracle.sql.BLOB or oracle.sql.CLOB class, as appropriate. These classes provide functionality such as reading from the LOB into an input stream, writing from an output stream into a LOB, determining the length of a LOB, and closing a LOB.

Notes:

- The implementation of the data access API uses direct native calls in the JDBC OCI and Server drivers, thereby providing better performance. You can use the same API on the `LOB` classes in all Oracle 8.1.5 JDBC drivers.
- In the case of the JDBC Thin driver only, the implementation of the data access API uses the `DBMS_LOB` package internally. You never have to use `DBMS_LOB` directly. This is in contrast to the 8.0.*x* drivers. For more information on the `DBMS_LOB` package, see the *Oracle8i Application Developer's Guide - Large Objects (LOBs)* and the *Oracle8i Application Developer's Reference - Packages*.

To read and write LOB data, you can use these methods:

- To read from a `BLOB`, use the `getBinaryStream()` method of an `oracle.sql.BLOB` object to retrieve the entire `BLOB` as an input stream. This returns a `java.io.InputStream` object.

  As with any `InputStream` object, use one of the overloaded `read()` methods to read the LOB data and use the `close()` method when you finish.

- To write to a `BLOB`, use the `getBinaryOutputStream()` method of an `oracle.sql.BLOB` object to retrieve the `BLOB` as an output stream. This returns a `java.io.OutputStream` object to be written back to the `BLOB`.

  As with any `OutputStream` object, use one of the overloaded `write()` methods to update the `LOB` data and use the `close()` method when you finish.

- To read from a `CLOB`, use the `getAsciiStream()` or `getCharacterStream()` method of an `oracle.sql.CLOB` object to retrieve the entire `CLOB` as an input stream. The `getAsciiStream()` method returns an ASCII input stream in a `java.io.InputStream` object; the `getCharacterStream()` method returns a Unicode input stream in a `java.io.Reader` object.

  As with any `InputStream` or `Reader` object, use one of the overloaded `read()` methods to read the LOB data and use the `close()` method when you finish.

You can also use the `getSubString()` method of `oracle.sql.CLOB` object to retrieve a subset of the `CLOB` as a character string of type `java.lang.String`.

- To write to a `CLOB`, use the `getAsciiOutputStream()` or `getCharacterOutputStream()` method of an `oracle.sql.CLOB` object to retrieve the `CLOB` as an output stream to be written back to the `CLOB`. The `getAsciiOutputStream()` method returns an ASCII output stream in a `java.io.OutputStream` object; the `getCharacterOutputStream()` method returns a Unicode output stream in a `java.io.Writer` object.

  As with any `OutputStream` or `Writer` object, use one of the overloaded `write()` methods to update the `LOB` data and use the `close()` method when you finish.

Notes:

- The stream "write" methods described in this section write directly to the database when you write to the output stream. You do *not* need to execute an `UPDATE`/`COMMIT` to write the data.
- When writing to or reading from a `CLOB`, the JDBC drivers handle all character set conversions for you.

Example: Reading BLOB Data Use the `getBinaryStream()` method of the `oracle.sql.BLOB` class to read `BLOB` data. The `getBinaryStream()` method reads the `BLOB` data into a binary stream.

The following example uses the `getBinaryStream()` method to read `BLOB` data into a byte stream and then reads the byte stream into a byte array (returning the number of bytes read as well).

```
// Read BLOB data from BLOB locator.
InputStream byte_stream = my_blob.getBinaryStream();
byte [] byte_array = new byte [10];
int bytes_read = byte_stream.read(byte_array);
...
```

Example: Reading CLOB Data The following example uses the `getCharacterStream()` method to read `CLOB` data into a Unicode character stream. It then reads the character stream into a character array (returning the number of characters read as well).

```
// Read CLOB data from CLOB locator into Reader char stream.
Reader char_stream = my_clob.getCharacterStream();
char [] char_array = new char [10];
int chars_read = char_stream.read (char_array, 0, 10);
...
```

The next example uses the `getAsciiStream()` method of the `oracle.sql.CLOB` class to read `CLOB` data into an ASCII character stream. It then reads the ASCII stream into a byte array (returning the number of bytes read as well).

```
// Read CLOB data from CLOB locator into Input ASCII character stream
Inputstream asciiChar_stream = my_clob.getAsciiStream();
   byte[] asciiChar_array = new byte[10];
   int asciiChar_read = asciiChar_stream.read(asciiChar_array,0,10);
```

Example: Writing BLOB Data Use the `getBinaryOutputStream()` method of an `oracle.sql.BLOB` object to write `BLOB` data.

The following example reads a vector of data into a byte array, then uses the `getBinaryOutputStream()` method to write an array of character data to a `BLOB`.

```
java.io.OutputStream outstream;

// read data into a byte array
byte[] data = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};

// write the array of binary data to a BLOB
outstream = ((BLOB)my_blob).getBinaryOutputStream();
outstream.write(data);
...
```

Example: Writing CLOB Data Use the `getCharacterOutputStream()` method or the `getAsciiOutputStream()` method to write data to a `CLOB`. The `getCharacterOutputStream()` method returns a Unicode output stream; the `getAsciiOutputStream()` method returns an ASCII output stream.

The following example reads a vector of data into a character array, then uses the `getCharacterOutputStream()` method to write the array of character data to a `CLOB`. The `getCharacterOutputStream()` method returns a `java.io.Writer` object in an `oracle.sql.CLOB`, not an `oracle.jdbc2.Clob`.

```
java.io.Writer writer

// read data into a character array
```

```
char[] data = {'0','1','2','3','4','5','6','7','8','9'};

// write the array of character data to a CLOB
writer = ((CLOB)my_clob).getCharacterOutputStream();
writer.write(data);
writer.flush();
writer.close();
...
```

The next example reads a vector of data into a byte array, then uses the `getAsciiOutputStream()` method to write the array of ASCII data to a `CLOB`. Because `getAsciiOutputStream()` returns an ASCII output stream, you must cast the output to a `oracle.sql.CLOB` datatype.

```
java.io.OutputStream out

// read data into a byte array
byte[] data = {'0','1','2','3','4','5','6','7','8','9'};

// write the array of ascii data to a CLOB
out = ((CLOB)clob).getAsciiOutputStream();
out.write(data);
out.flush();
out.close();
```

Creating and Populating a BLOB or CLOB Column

You create and populate a `BLOB` or `CLOB` column in a table by using SQL statements.

Note: To create a `BLOB` or `CLOB` column in a table, you must use SQL statements. Using the Java `new`, such as "`new BLOB`" or "`new CLOB`" will not work.

You create a `BLOB` or `CLOB` column in a table with the SQL `CREATE TABLE` statement. Then, you populate the LOB. This includes creating the LOB entry in the table, obtaining the LOB locator, creating a file handler for the data (if you are reading the data from a file), and then copying the data into the LOB.

Creating a BLOB or CLOB Column in a New Table

To create a `BLOB` or `CLOB` column in a new table, execute the SQL `CREATE TABLE` statement. The following example code creates a `BLOB` column in a new table. This

example assumes that you have already created your Connection object conn and Statement object stmt:

```
String cmd = "CREATE TABLE my_blob_table (x varchar2 (30), c blob)";
    stmt.execute (cmd);
```

In this example, the VARCHAR2 column designates a row number, such as one or two, and the blob column stores the locator of the BLOB data.

Populating a BLOB or CLOB Column in a New Table

This example demonstrates how to populate a BLOB or CLOB column by reading data from a stream. These steps assume that you have already created your Connection object conn and Statement object stmt. The table my_blob_table is the table that was created in the previous section.

The following example writes the GIF file john.gif to a BLOB.

1. Begin by using SQL statements to create the BLOB entry in the table. Use the empty_blob syntax to create the BLOB locator.

   ```
   stmt.execute ("insert into my_blob_table values ('row1', empty_blob()");
   ```

2. Get the BLOB locator from the table.

   ```
   BLOB blob;
   cmd = "SELECT * FROM my_blob_table WHERE X='row1'";
   ResultSet rest = stmt.executeQuery(cmd);
   BLOB blob = ((OracleResultSet)rset).getBLOB(2);
   ```

3. Declare a file handler for the john.gif file, then print the length of the file. This value will be used later to ensure that the entire file is read into the BLOB. Next, create a FileInputStream object to read the contents of the GIF file, and an OutputStream object to retrieve the BLOB as a stream.

   ```
   File binaryFile = new File("john.gif");
   System.out.println("john.gif length = " + binaryFile.length());
       FileInputStream instream = new FileInputStream(binaryFile);
       OutputStream outstream = blob.getBinaryOutputStream();
   ```

4. Call getChunkSize() to determine the ideal chunk size to write to the BLOB, then create the buffer byte array.

   ```
       int chunk = blob.getChunkSize();
       byte[] buffer = new byte[chunk];
      int length = -1;
   ```

5. Use the `read()` method to read the `GIF` file to the byte array `buffer`, then use the `write()` method to write it to the `BLOB`. When you finish, close the input and output streams.

```
 while ((length = instream.read(buffer)) != -1)
   outstream.write(buffer, 0, length);
instream.close();
outstream.close();
```

Once your data is in the `BLOB` or `CLOB`, you can manipulate the data. This is described in the following section, "Accessing and Manipulating BLOB and CLOB Data".

Accessing and Manipulating BLOB and CLOB Data

Once you have your `BLOB` or `CLOB` locator in a table, you can access and manipulate the data to which it points. To access and manipulate the data, you first must select their locators from a result set or from a callable statement. "Getting BLOB and CLOB Locators" on page 4-46 describes these techniques in detail.

After you select the locators, you can get the `BLOB` or `CLOB` data. You will usually want to cast the result set to the `OracleResultSet` datatype so that you can retrieve the data in `oracle.sql.*` format. After getting the `BLOB` or `CLOB` data, you can manipulate it however you want.

This example is a continuation of the example in the previous section. It uses the SQL `SELECT` statement to select the `BLOB` locator from the table `my_blob_table` into a result set. The result of the data manipulation is to print the length of the `BLOB` in bytes.

```
// Select the blob - what we are really doing here
// is getting the blob locator into a result set
BLOB blob;
cmd = "SELECT *  FROM my_blob_table";
ResultSet rset = stmt.executeQuery (cmd)

// Get the blob data - cast to OracleResult set to
// retrieve the data in oracle.sql format
String index = ((OracleResultSet)rset).getString(1);
blob = ((OracleResultSet)rset).getBLOB(2);

// get the length of the blob
int length = blob.getlength();

// print the length of the blob
```

```
System.out.println("blob length" + length);

// read the blob into a byte array
// then print the blob from the array
byte bytes[] = blob.getBytes(0, length);
printBytes(bytes, length);
```

Getting BFILE Locators

Given a standard JDBC result set or callable statement object that includes `BFILE` locators, you can access the locators by using the standard `ResultSet.getObject()` method. This method returns an `oracle.sql.BFILE` object.

You can also access the locators by casting your result set to `OracleResultSet` or your callable statement to `OracleCallableStatement` and using the `getOracleObject()` or `getBFILE()` method.

Notes:

- In the `OracleResultSet` and `OracleCallableStatement` classes, `getBFILE()` and `getBfile()` both return `oracle.sql.BFILE`. There is no `oracle.jdbc2` class for `BFILE`.
- If using `getObject()` or `getOracleObject()`, remember to cast the output, as necessary. For more information, see "Casting Your get Method Return Values" on page 4-39.

Example: Getting a BFILE locator from a Result Set Assume that the database has a table called `bfile_table` with a single column for the `BFILE` locator `bfile_col`. This example assumes that you have already created your `Statement` object `stmt`.

Select the `BFILE` locator into a standard result set. If you cast the result set to an `OracleResultSet`, you can use `getBFILE()` to get the `BFILE` data:

```
// Select the BFILE locator into a result set
ResultSet rs = stmt.executeQuery("SELECT bfile_col FROM bfile_table");
   while (rs.next())
   {
       oracle.sql.BFILE my_bfile = ((OracleResultSet)rs).getBFILE(1);
    };
```

Note that as an alternative, you can use `getObject()` to return the `BFILE` locator. In this case, since `getObject()` returns a `java.lang.Object`, cast the results to `BFILE`. For example:

```
oracle.sql.BFILE my_bfile = (BFILE)rs.getObject(1);
```

Example: Getting a BFILE Locator from a Callable Statement Assume you have an `OracleCallableStatement ocs` that calls a function `func` that has a `BFILE` output parameter. The following code example sets up the callable statement, registers the output parameter as `OracleTypes.BFILE`, executes the statement, and retrieves the `BFILE` locator:

```
OracleCallableStatement ocs =
   (OracleCallableStatement)conn.prepareCall("{? = call func()}")
ocs.registerOutParameter(1, OracleTypes.BFILE);
ocs.execute();
oracle.sql.BFILE bfile = ocs.getBFILE(1);
```

Passing BFILE Locators

To pass a `BFILE` locator to a prepared statement or callable statement (to update a `BFILE` locator, for example), you can use the generic `setObject()` method or you can cast the statement to `OraclePreparedStatement` or `OracleCallableStatement` and use the `setOracleObject()` or `setBFILE()` method. These methods take the parameter index and an `oracle.sql.BFILE` object as input.

Example: Passing a BFILE Locator to a Prepared Statement You want to insert a `BFILE` locator into a table. Assume that you have an `OraclePreparedStatement ops` where the first parameter is a string (to designate a row number), its second parameter is a `BFILE`, and you have a valid `oracle.sql.BFILE` object (`bfile`). Input the `BFILE` to the prepared statement as follows:

```
OraclePreparedStatement ops =
(OraclePreparedStatement)conn.prepareStatement
    ("INSERT INTO my_bfile_table VALUES (?,?)");
ops.setString(1,"one");
ops.setBFILE(2, bfile);
ops.execute();
```

Example: Passing a BFILE Locator to a Callable Statement Passing a `BFILE` locator to a callable statement is similar to passing it to a prepared statement. In this case, the `BFILE` locator is passed to the `myGetFileLength()` procedure, which returns the `BFILE` length as a numeric value.

```
OracleCallableStatement cstmt =
      (OracleCallableStatement)
        conn.prepareCall ("begin ? := myGetFileLength (?); end;");
    try
    {
      cstmt.registerOutParameter (1, Types.NUMERIC);
      cstmt.setBFILE (2, bfile);
      cstmt.execute ();
      return cstmt.getLong (1);
    }
    finally
    {
      cstmt.close ();
    }
  }
```

Reading BFILE Data

To read `BFILE` data, you must first get the `BFILE` locator. You can get the locator from either a callable statement or a result set. "Getting BFILE Locators" on page 4-55 describes this.

Once you obtain the locator, there are a number of methods that you can perform on the `BFILE` without opening it. For example, you can use the `oracle.sql.BFILE` methods `fileExists()` and `isFileOpen()` to determine whether the `BFILE` exists and if it is open. However, if you want to read and manipulate the data, you must open the `BFILE`. `BFILE` data is materialized as a Java stream. Operate on `BFILE`s from JDBC as follows:

- To read from a `BFILE`, use the `getBinaryStream()` method of an `oracle.sql.BFILE` object to retrieve the entire file as an input stream. This returns a `java.io.InputStream` class.

  As with any `InputStream` object, use one of the overloaded `read()` methods to read the file data and use the `close()` method when you finish.

Notes:

- BFILEs are read-only. You cannot insert data or otherwise write to a BFILE.
- You cannot use JDBC to create a new BFILE.

Example: Reading BFILE Data The following example uses the getBinaryStream() method of an oracle.sql.BFILE object to read BFILE data into a byte stream and then read the byte stream into a byte array. The example assumes that the BFILE has already been opened.

```
// Read BFILE data from a BFILE locator
Inputstream in = bfile.getBinaryStream();
byte[] byte_array = new byte{10};
int byte_read = in.read(byte_array);
```

Creating and Populating a BFILE Column

You create a BFILE column in a table with SQL statements and specify the location where the BFILE resides. The examples below assume that you have already created your Connection object conn and Statement object stmt.

Creating a BFILE Column in a New Table

To work with BFILE data, create a BFILE column in a table and specify the location of the BFILE. To specify the location of the BFILE, use the SQL CREATE DIRECTORY...AS statement to specify an alias for the directory where the BFILE resides. Then execute the statement. In this example, the directory alias is test_dir and the location where the BFILE resides is /home/work.

```
String cmd;
cmd = "CREATE DIRECTORY test_dir AS '/home/work'";
stmt.execute (cmd);
```

Use the SQL CREATE TABLE statement to create a table containing a BFILE column, then execute the statement. In this example, the name of the table is my_bfile_table.

```
// Create a table containing a BFILE field
cmd = "CREATE TABLE my_bfile_table (x varchar2 (30), b bfile)";
stmt.execute (cmd);
```

In this example, the VARCHAR2 column designates a row number and the bfile column stores the locator of the BFILE data.

Populating a BFILE Column

Use the SQL INSERT INTO...VALUES statement to populate the VARCHAR2 and bfile fields, then execute the statement. The bfile column is populated with the locator to the BFILE data. To populate the BFILE column, use the bfilename keyword to specify the directory alias and the name of the BFILE file.

```
cmd ="INSERT INTO my_bfile_table VALUES ('one', bfilename(test_dir,
                                         'file1.data'))";
stmt.execute (cmd);
cmd ="INSERT INTO my_bfile_table VALUES ('two', bfilename(test_dir,
                                         'jdbcTest.data'))";
stmt.execute (cmd);
```

In this example, the name of the directory alias is test_dir. The locator of the BFILE file1.data is loaded into the bfile column on row one, and the locator of the BFILE jdbcTest.data is loaded into the bfile column on row two.

As an alternative, you might want to create the row for the row number and BFILE locator now, but wait until later to insert the locator. In this case, insert the row number into the table, and null as a place holder for the BFILE locator.

```
cmd ="INSERT INTO my_bfile_table VALUES ('three', null)";
stmt.execute(cmd);
```

Here, three is inserted into the row number column and null is inserted as the place holder. Later in your program, insert the BFILE locator into the table by using a prepared statement.

First get a valid BFILE locator into the bfile object:

```
rs = stmt.executeQuery("SELECT b FROM my_bfile_table WHERE x='two'");
    rs.next()
      oracle.sql.BFILE bfile = ((OracleResultSet)rs).getBFILE(2);
```

Then, create your prepared statement. Note that because this example uses the setBFILE() method to identify the BFILE, the prepared statement must be cast to an OraclePreparedStatement:

```
OraclePreparedStatement ops =
(OraclePreparedStatement)conn.prepareStatement(INSERT ? INTO my_bfile_table)
                WHERE (x = 'three');
ops.setBFILE(2, bfile);
```

```
ops.execute();
```

Now row `two` and row `three` contain the same `BFILE`.

Once you have the `BFILE` locators available in a table, you can access and manipulate the `BFILE` data. The next section, "Accessing and Manipulating BFILE Data", describes this.

Accessing and Manipulating BFILE Data

Once you have the `BFILE` locator in a table, you can access and manipulate the data to which it points. To access and manipulate the data, you must first select its locator from a result set or a callable statement.

The following example gets the locator of the `BFILE` from row `two` of a table into a result set. The result set is cast to an `OracleResultSet` so that `oracle.sql.*` methods can be used on it. Several of the methods applied to the `BFILE`, such as `getDirAlias()` and `getName()`, do not require you to open the `BFILE`. Methods that manipulate the `BFILE` data, such as reading, getting the length, and displaying, *do* require you to open the `BFILE`.

When you finish manipulating the `BFILE` data, you must close the `BFILE`. For a complete `BFILE` example, see "BFILE Sample" on page 7-10.

```
// select the bfile locator
cmd = "SELECT *  FROM my_bfile_table WHERE x = 'two'";
rset = stmt.executeQuery (cmd);

if (rset.next ())
    {
BFILE bfile = ((OracleResultSet)rset).getBFILE (2);

// for these methods, you do not have to open the bfile
println("getDirAlias() = " + bfile.getDirAlias());
println("getName() = " + bfile.getName());
println("fileExists() = " + bfile.fileExists());
println("isFileOpen() = " + bfile.isFileOpen());

// now open the bfile to get the data
bfile.openFile();

// get the BFILE data as a binary stream
InputStream in = bfile.getBinaryStream();
int length ;
```

```
// read the bfile data in 6-byte chunks
byte[] buf = new byte[6];

while ((length = in.read(buf)) != -1)
{

    // append and display the bfile data in 6-byte chunks
   StringBuffer sb = new StringBuffer(length);
   for (int i=0; i<length; i++)
      sb.append( (char)buf[i] );
      println(sb.toString());
}

// we are done working with the input stream. Close it.
in.close();

// we are done working with the BFILE. Close it.
bfile.closeFile();
```

Working with Oracle Object Types

This section contains these subsections:

- Using Default Java Classes for Oracle Objects
- Creating Custom Java Classes for Oracle Objects
- Using JPublisher with JDBC

Oracle object types provide support for composite data structures in the database. For example, you could define a type `Person` that has attributes such as name (type `CHAR`), address (type `CHAR`), phone number (type `CHAR`), and employee number (type `NUMBER`).

Oracle provides tight integration between its Oracle object features and its JDBC functionality. You can customize how SQL types map to Java classes by creating custom Java type definition classes; Oracle offers considerable flexibility in how this mapping is done. In this book, Java classes created as classes to map to Oracle objects will be referred to as *custom Java classes*.

JDBC materializes Oracle objects as instances of particular Java classes. Two main steps in using JDBC to access Oracle objects are: creating the Java classes for the Oracle objects and populating these classes. You have the option of:

- letting JDBC materialize the object as a `STRUCT`. This is described in "Using Default Java Classes for Oracle Objects" on page 4-62.

OR

- explicitly specifying the mappings between Oracle objects and Java classes. This includes customizing your Java classes for object data. The driver then must be able to populate the custom Java classes that you specify. This imposes a set of constraints on the Java classes. To satisfy these constraints, you can define your classes according to either the `SQLData` interface or the `CustomDatum` interface. "Creating Custom Java Classes for Oracle Objects" on page 4-65 describes this.

Using Default Java Classes for Oracle Objects

If you choose not to provide a type map to explicitly specify a Java class for an Oracle object, you can let Oracle JDBC materialize the object as a `Struct`.

You would typically want to use `Struct` objects instead of custom Java objects in situations where you are manipulating data. For example, your Java application might be a tool to manipulate data as opposed to being an end-user application.

You can select data from the database into `Struct` objects and create `Struct` objects for inserting data into the database. As described in "Class oracle.sql.STRUCT" on page 4-10, `STRUCT`s completely preserve data because they maintain the data in SQL format. Using `Struct` objects is more efficient and more precise in these situations where the information does not need to be in a user-friendly format.

If your code must fully comply with JDBC 2.0, use the functionality in the `oracle.jdbc2.Struct` interface:

- `getAttributes(map)`: retrieves the values from the values array as `java.lang.Object` objects; uses entries in the type map (if they have been defined) to determine the Java classes to use in materializing the data.
- `getAttributes()`: retrieves the values of the values array as `java.lang.Object` objects
- `getSQLTypeName()`: returns a Java `String` that represents the fully qualified type name (*schema.sql_type_name*) of the Oracle object that this `Struct` represents

If it is not necessary to comply with JDBC 2.0 and you want to take advantage of the extended functionality offered by Oracle-defined methods, then cast the output to `oracle.sql.STRUCT`.

The `oracle.sql.STRUCT` class implements the `oracle.jdbc2.Struct` interface and provides extended functionality beyond the JDBC 2.0 standard. Compare the list of methods above with the methods provided for `oracle.sql.STRUCT` in "Class oracle.sql.STRUCT" on page 4-10.

Using STRUCT Objects

You can use standard JDBC functionality such as `getObject()` to retrieve Oracle objects from the database as an instance of `oracle.jdbc2.Struct`. Because `getObject()` returns a `java.lang.Object`, you must cast the output of the method to a `Struct`. For example:

```
oracle.jdbc2.Struct  myStruct = (oracle.jdbc2.Struct)rs.getObject(1);
```

As described in the preceding section, the `oracle.jdbc2.Struct` class is implemented by `oracle.sql.STRUCT`. If you want to use the extended functionality offered by Oracle, you can then cast the `Struct` object to a `STRUCT`. For example, to use the `getOracleAttributes()` method to return the attributes of the `Struct`, cast `myStruct` to `oracle.sql.STRUCT`:

```
oracle.sql.STRUCT STRUCTattribute=s
```

```
((oracle.sql.STRUCT)myStruct).getOracleAttributes()
```

The `getOracleAttributes()` method returns the attributes of `myStruct` in `oracle.sql.*` format.

You can also retrieve the object directly into an `oracle.sql.STRUCT`. For example, `getObject()` is used to get a `NUMBER` object from column 1 (`col1`) of the table `struct_table`. Because `getObject()` returns an `Object` type, the result is cast to an `oracle.sql.STRUCT`. This example assumes that the `Statement` object `stmt` has already been created.

```
String cmd;
cmd = "CREATE TYPE type_struct AS object (field1 NUMBER,field2 DATE)";
stmt.execute(cmd);

cmd = "CREATE TABLE struct_table (col1 type_struct)";
stmt.execute(cmd);

cmd = "INSERT INTO struct_table VALUES (type_struct(10,'01-apr-01'))";
stmt.execute(cmd);

cmd = "INSERT INTO struct_table VALUES (type_struct(20,'02-may-02'))";
stmt.execute(cmd);

ResultSet rs= stmt.executeQuery("SELECT * FROM test_Struct");
oracle.sql.STRUCT struct_obj=(oracle.sql.STRUCT) rs.getObject(1);
```

To use an `oracle.sql.STRUCT` object to access, manipulate, or update data, you can bind the object to a prepared statement or callable statement by using the `setOracleObject()` method. This requires casting your prepared statement or callable statement to an `OraclePreparedStatement` object or `OracleCallableStatement` object.

```
PreparedStatement ps= conn.prepareStatement("text_of_prepared_statement");
STRUCT mySTRUCT = new STRUCT (...)
((OraclePreparedStatement)ps).setOracleObject(1, mySTRUCT);
```

Similarly, to get data from the database, the `OracleCallableStatement` and `OracleResultSet` classes have a `getSTRUCT()` method that returns an Oracle object as an `oracle.sql.STRUCT`. For example:

```
ResultSet rset = stmt.executeQuery (...);
oracle.sql.STRUCT mySTRUCT = ((OracleResultSet)rs).getSTRUCT();
```

Creating Custom Java Classes for Oracle Objects

If you want to define custom Java classes for your Oracle objects, then you must define a type map that specifies the custom Java classes that the drivers will generate for the corresponding Oracle objects.

You must also provide a way to create and populate the custom Java class from the Oracle object and its attribute data. The driver must be able to read from a Java custom class and populate it. In addition, the custom Java class can provide `get` and `set` methods corresponding to the Oracle object's attributes, although this is not necessary. To create and populate the custom classes, and provide these read / write capabilities, you can choose between these two interfaces:

- `SQLData` interface provided by JDBC
- `CustomDatum` interface provided by Oracle

The custom Java class you create must implement one of these interfaces.

For example, assume you have an Oracle object type, `EMPLOYEE`, in the database that consists of two attributes: `Name` (which is type `CHAR`) and `EmpNum` (employee number, which is type `NUMBER`). You use the type map to specify that the `EMPLOYEE` object should map to a custom Java class that you call `JEmployee`. You can use either the `SQLData` or `CustomDatum` interface to be implemented by the `JEmployee` class.

The most convenient way to create the custom Java class is to employ the JPublisher utility to create it for you. However, JPublisher supports only the `CustomDatum` implementation. You can also create the custom Java class yourself, and in fact must do so if you want to implement the `SQLData` interface.

The following section describes the relative advantages of using `CustomDatum` and `SQLData`.

Relative Advantages of CustomDatum vs. SQLData In deciding which of these two interface implementations to use, consider the following:

Advantages of `CustomDatum`:

- It has awareness of Oracle extensions.
- You can construct a `CustomDatum` from an `oracle.sql.STRUCT`. This is more efficient because it avoids unnecessary conversions to native Java types.
- You can obtain the corresponding `Datum` object (which is in `oracle.sql` format) from the `CustomDatum` object using the `toDatum()` method.

- It does not require a type map.
- It provides better performance: `CustomDatum` works directly with `Datum` types, which is the internal format used by the driver to hold Oracle objects.
- JPublisher supports it. Custom Java classes created by JPublisher use the `CustomDatum` implementation. As of the 8.1.5 release, `SQLData` is not supported by JPublisher.
- Oracle SQLJ supports it. As of the 8.1.5 release, `SQLData` is not supported by Oracle's implementation of SQLJ.

Advantages of `SQLData`:

- It is a JDBC standard, making your code more portable.

The `SQLData` interface only lets you populate a Java object from a SQL object—the `CustomDatum` interface is far more powerful. In addition to enabling you to populate Java objects, `CustomDatum` enables you to materialize objects from SQL types that are not necessarily objects. Therefore, you can create a `CustomDatum` object from any datatype found in an Oracle database. This is particularly useful in the case of `RAW` data that can be a serialized object.

Understanding Type Maps

If you use the `SQLData` interface to create Java custom classes, then you must create a type map that specifies the Java custom class that corresponds to the Oracle object in the database. For a description of how to create these custom Java classes with `SQLData`, see "Creating Custom Java Classes for Oracle Objects" on page 4-65.

If you do not include an object and its mapping in the type map, then the object will map to the `oracle.sql.STRUCT` class by default. See "Class oracle.sql.STRUCT" on page 4-10 for more information about this class.

The type map relates a Java class to the SQL type name of an Oracle object. This is a one-to-one mapping that is stored in a hash table as a *key-value* pair. When you read data from an Oracle object, the JDBC driver considers the type map to determine which Java class to use to materialize the data from the SQL object type. When you write data to an Oracle object, the JDBC driver gets the SQL type name from the Java class by calling the `getSQLTypeName()` method of the `SQLData` interface. The actual conversion between SQL and Java is handled by the driver.

The attributes of the Java class that corresponds to an Oracle object can use either Java native types or Oracle native types (instances of the `oracle.sql.*` classes) to store attributes.

Creating a Type Map Class

The Java application programmer is responsible for providing a type map class that implements `java.util.Dictionary`. For example, `java.util.Hashtable` implements `Dictionary`.

The type map class must implement a `put()` method used to enter each mapping entry that relates a Java class to an Oracle object type. The `put()` method must be implemented to accept a *keyword-value* pair, where the key is an Oracle SQL type name and the value is the Java class object.

Creating a Type Map Object and Defining Mappings

Each connection object has an attribute for an associated type map object. Cast your connection to an `OracleConnection` object to use type map functionality.

You can create a type map by either of the methods described in the following sections:

- Adding Entries to an Existing Type Map
- Creating a New Type Map

Adding Entries to an Existing Type Map Follow these general steps to add entries to an existing type map.

1. Use the `getTypeMap()` method of your `OracleConnection` object to return the connection's `Map` object. The `getTypeMap()` method returns a `java.util.Dictionary` object. For example:

   ```
   java.util.Dictionary myMap = oraconn.getTypeMap();
   ```

   In this example, the `getMapType()` method on the `OracleConnection` object `oraconn` returns the `myMap` `Dictionary` object.

   > **Note:** If the type map in the `OracleConnection` object has not been initialized, then the first call to `getTypeMap()` returns `null`.

2. Use the `Dictionary` object's `put()` method to add entries to the map. The `put()` method takes two arguments: a SQL type name string and the name of the Java class object to which you want to map it.

   ```
   myMap.put(sqlTypeName, classObject);
   ```

The `sqlTypeName` is a string that represents the fully qualified name of the SQL type in the database. The `classObject` is the Java class object to which you want to map the SQL type. Get the class object with the `class.forName()` method. You can rewrite the `put()` method as:

```
myMap.put(sqlTypeName, class.forName(className));
```

For example, if you have a `PERSON` SQL datatype defined in the `CORPORATE` database schema, then map it to a `Person` Java class defined as `Person` with this statement:

```
myMap.put("CORPORATE.PERSON", class.forName("Person"));
```

The map has an entry that maps the `PERSON` SQL datatype in the `CORPORATE` database to the `Person` Java class.

3. When you finish adding entries to the map, use the `OracleConnection` object's `setTypeMap()` method to overwrite the connection's existing type map. For example:

   ```
   oraconn.setTypeMap(myMap);
   ```

   In this example, `setTypeMap()` overwrites the `oraconn` connection's original map with `myMap`.

Creating a New Type Map Follow these general steps to create a new type map.

1. Create an empty map object. An empty map object can be anything that implements the `java.util.Dictionary` class. For example, the `java.util.Hashtable` class implements the `Dictionary` class.
2. Use the `Map` object's `put()` method to add entries to the map. For more information on the `put()` method, see Step 2 in the preceding section. For example, if you have an `EMPLOYEE` SQL type defined in the `CORPORATE` database, then you can map it to an `Employee` class object defined by `Employee.java` with this statement:

   ```
   newMap.put("CORPORATE.EMPLOYEE", class.forName("Employee"));
   ```

3. When you finish adding entries to the map, use the `OracleConnection` object's `setTypeMap()` method to overwrite the connection's existing type map. For example:

   ```
   oraconn.setTypeMap(newMap);
   ```

In this example, `setTypeMap()` overwrites the `oraconn` connections's original map with `newMap`.

Notes:

- You can explicitly provide type map objects in some `getXXX()` and `setXXX()` methods to override the custom or default mapping of your connection.
- If the type map does not specify a Java class mapping for an Oracle object type, then it defaults to data from the object type materialized in Java in an instance of the `oracle.sql.STRUCT` class. For more information about this class, see "Class oracle.sql.STRUCT" on page 4-10.
- Do not use the type map for inserting custom objects into the database.

STRUCTS and the Type Map If you do not specify a particular SQL object type in the type map, then the driver will materialize it as an instance of the `oracle.jdbc2.Struct` class. If the SQL object type contains embedded objects, and they are not present in the type map, the driver will materialize the embedded objects as instances of `oracle.sql.Struct`. If the embedded objects are present in the type map, a call to the `getAttributes()` method will return embedded objects as instances of the specified Java classes from the type map.

Understanding the SQLData Interface

To make an Oracle object and its attribute data available to Java applications, you can create a custom Java class for the object that implements the `SQLData` interface. Note that if you use this interface, you must supply a type map that specifies the Oracle objects in the database and the name of the corresponding custom Java classes that you will create for them.

The `SQLData` interface defines methods that translate between SQL and Java for Oracle database objects. Standard JDBC provides a `SQLData` interface and companion `SQLInput` and `SQLOutput` interfaces in the `oracle.jdbc2` package.

If you create a custom Java class that implements `SQLData`, you must provide a `readSQL()` method and a `writeSQL()` method as defined by the `SQLData` interface.

The JDBC driver calls your `readSQL()` method to read a stream of data values from the database and populate an instance of your custom Java class. Typically, the driver would use this method as part of an `OracleResultSet.getObject()` call.

Similarly, the JDBC driver calls your `writeSQL()` method to write a sequence of data values from an instance of your custom Java class to a stream that can be written to the database. Typically, the driver would use this method as part of an `OraclePreparedStatement setObject()` call.

Understanding the SQLInput and SQLOutput Interfaces The JDBC driver includes classes that implement the `SQLInput` and `SQLOutput` interfaces. It is not necessary to implement the `SQLOutput` or `SQLInput` objects. The JDBC drivers will do this for you.

The `SQLInput` implementation is an input stream class, an instance of which must be passed in to `readSQL()`. `SQLInput` includes a `readXXX()` method for every possible Java type that attributes of an Oracle object might be converted to, such as `readObject()`, `readInt()`, `readLong()`, `readFloat()`, `readBlob()`, and so on. Each `readXXX()` method converts SQL data to Java data and returns it into an output parameter of the corresponding Java type. For example, `readInt()` returns an integer.

The `SQLOutput` implementation is an output stream class, an instance of which must be passed in to `writeSQL()`. `SQLOutput` includes a `writeXXX()` method for each of these Java types. Each `writeXXX()` method converts Java data to SQL data, taking as input a parameter of the relevant Java type. For example, `writeString()` would take as input a string attribute from your Java class.

Implementing readSQL() and writeSQL() Methods When you create your custom Java class that implements `SQLData`, you must also implement the `readSQL()` and `writeSQL()` methods.

You must implement `readSQL()` as follows:

```
public void readSQL(SQLInput stream, String sql_type_name) throws SQLException
```

- `readSQL()` must take as input a `SQLInput` stream and a string that indicates the SQL type name of the data (in other words, the name of the Oracle object type, such as `EMPLOYEE`).

  When your Java application calls `getObject()`, the JDBC driver creates a `SQLInput` stream object and populates it with data from the database. The driver can also determine the SQL type name of the data when it reads it from the database. When the driver calls `readSQL()`, it passes in these parameters.

- For each Java datatype that maps to an attribute of the Oracle object, `readSQL()` must call the appropriate `readXXX()` method of the `SQLInput` stream that is passed in.

  For example, if you are reading `EMPLOYEE` objects that have an employee name as a `CHAR` variable and an employee number as a `NUMBER` variable, you must have a `readString()` call and a `readInt()` call in your `readSQL()` method. JDBC calls these methods according to the order in which the attributes appear in the SQL definition of the Oracle object type.

- `readSQL()` assigns the data that the `readXXX()` methods read and convert to the appropriate fields or elements of your custom Java class.

You must implement `writeSQL()` as follows:

```
public void writeSQL(SQLOutput stream) throws SQLException
```

- `writeSQL()` must take as input a `SQLOutput` stream.

  When your Java application calls `setObject()`, the JDBC driver creates a `SQLOutput` stream object and populates it with data from your custom Java class. When the driver calls `writeSQL()`, it passes in this stream parameter.

- For each Java datatype that maps to an attribute of the Oracle object, `writeSQL()` must call the appropriate `writeXXX()` method of the `SQLOutput` stream that is passed in.

  For example, if you are writing to `EMPLOYEE` objects that have an employee name as a `CHAR` variable and an employee number as a `NUMBER` variable, then you must have a `writeString()` call and a `writeInt()` call in your `writeSQL()` method. These methods must be called according to the order in which attributes appear in the SQL definition of the Oracle object type.

- `writeSQL()` must then write the data converted by the `writeXXX()` methods to the `SQLOutput` stream so it can be written to the database once you execute the prepared statement.

Note: Refer to the Javadoc for more information about the `SQLData`, `SQLInput`, and `SQLOutput` interfaces.

"Creating Customized Java Classes for Oracle Objects" on page 7-20 contains an example implementation of the `SQLData` interface for a given SQL definition of an Oracle object.

Reading and Writing Data with a SQLData Class

This section describes how to read data from an Oracle object or write data to an Oracle object if your corresponding Java class implements `SQLData`.

Reading Data from an Oracle Object Using a SQLData Interface This section summarizes the steps to read data from an Oracle object into your Java application when you choose the `SQLData` implementation for your custom Java class.

These steps assume you have already defined the Oracle object type, created the corresponding custom Java class, updated the type map to define the mapping between the Oracle object and the Java class, and defined a statement object `stmt`.

1. Query the database to read the Oracle object into a JDBC result set.

   ```
   ResultSet rs = stmt.executeQuery("SELECT Emp_col FROM PERSONNEL");
   rs.next();
   ```

   The `PERSONNEL` table contains one column, `Emp_col`, of SQL type `Emp_object`. This SQL type is defined in the type map to map to the Java class `Employee`.

2. Use the `getObject()` method of your result set to populate an instance of your custom Java class with data from one row of the result set. The `getObject()` method returns the user-defined `SQLData` object because the type map contains an entry for `Employee`.

   ```
   Employee emp = (Employee)rs.getObject(1);
   ```

   Note that if the type map did not have an entry for the object, `getObject()` would return an `oracle.sql.STRUCT` object. In this case you must cast the output to an `oracle.sql.STRUCT`.

   ```
   Struct empstruct = (oracle.sql.STRUCT)rs.getObject(1);
   ...
   ```

   The `getObject()` call triggers `readSQL()` and `readXXX()` calls as described above.

> **Note:** To avoid the need for the type map, use the `getSTRUCT()` method. This method always returns a `STRUCT` object even if there is a mapping entry in the type map.

3. If you have `get` methods in your custom Java class, then use them to read data from your object attributes. For example, if `EMPLOYEE` has an `EmpName` (employee name) of type `CHAR` and `EmpNum` (employee number) of type `NUMBER`, provide a `getEmpName()` method that returns a Java `String` and a `getEmpNum()` method that returns an integer (`int`). Then invoke them in your Java application as follows:

```
String empname = emp.getName();
int empnumber = emp.getEmpNum();
```

> **Note:** Alternatively, fetch data by using a callable statement object, which also has a `getObject()` method.

Passing SQLData Objects to a Callable Statement as an OUT Parameter Suppose you have an `OracleCallableStatement ocs` that calls a PL/SQL function `getEmployee(?)`. The program passes an employee number (`empnumber`) to the function; the function returns the corresponding `Employee` object.

1. Prepare an `OracleCallableStatement` to call the `getEmployee(?)` function.

```
OracleCallableStatement ocs =
  (OracleCallableStatement) conn.prepareCall("{ ? = call getEmployee(?)
}");
```

2. Declare the `empnumber` as the input parameter to `getEmployee(?)`. Register the `SQLData` object as the `OUT` parameter. The SQL type of the `Employee` object is `OracleTypes.STRUCT`. Then, execute the statement.

```
ocs.setInt(2,empnumber);
ocs.registerOutParameter(1, OracleTypes.STRUCT, "EMP_OBJECT");
ocs.execute();
```

3. Use the `getObject()` method to retrieve the employee object. Because the object is returned as a `STRUCT`, cast the output of `getObject()` to an `Employee` object.

```
Employee emp = (Employee) ocs.getObject(1);
```

Passing SQLData Objects to a Callable Statement as an IN Parameter Suppose you have a PL/SQL function `addEmployee(?)` that takes an `Employee` object as an `IN` parameter and adds it to the `PERSONNEL` table. In this example, `emp` is a valid `Employee` object.

1. Prepare an `OracleCallableStatement` to call the `addEmployee(?)` function.

   ```
   OracleCallableStatement ocs =
     (OracleCallableStatement) conn.prepareCall("{ call addEmployee(?) }");
   ```

2. Use `setObject()` to pass the `emp` object as an `IN` parameter to the callable statement. Then, execute the statement.

   ```
   ocs.setObject(1, emp);
   ocs.execute();
   ```

Writing Data to an Oracle Object Using a SQLData Interface This section describes the steps in writing data to an Oracle object from your Java application when you choose the `SQLData` implementation for your custom Java class.

This description assumes you have already defined the Oracle object type, created the corresponding Java class, and updated the type map to define the mapping between the Oracle object and the Java class.

1. If you have `set` methods in your custom Java class, then use them to write data from Java variables in your application to attributes of your Java datatype object.

   ```
   emp.setEmpName(empname);
   emp.setEmpNum(empnumber);
   ```

   This statement uses the `emp` object and the `empname` and `empnumber` variables defined in "Reading Data from an Oracle Object Using a SQLData Interface" on page 4-72.

2. Prepare a statement that updates an Oracle object in a row of a database table, as appropriate, using the data provided in your Java datatype object.

   ```
   PreparedStatement pstmt = conn.prepareStatement
      ("INSERT INTO PERSONNEL VALUES (?)");
   ```

   This assumes `conn` is your connection object.

3. Use the `setObject()` method of the prepared statement to bind your Java datatype object to the prepared statement.

   ```
   pstmt.setObject(1, emp);
   ```

4. Execute the statement, which updates the database.

   ```
   pstmt.executeUpdate();
   ```

> **Note:** You can use your Java datatype objects as either `IN` or `OUT` bind variables.

Understanding the CustomDatum Interface

To make an Oracle object and its attribute data available to Java applications, you can create a custom Java class for the object that implements the `oracle.sql.CustomDatum` and `oracle.sql.CustomDatumFactory` interfaces. The `CustomDatum` and `CustomDatumFactory` interfaces are supplied by Oracle and are not a part of the JDBC standard.

> **Note:** The JPublisher utility supports the generation of classes that implement the `CustomDatum` and `CustomDatumFactory` interfaces.

The `CustomDatum` interface has these additional advantages:

- recognizes Oracle extensions to the JDBC; `CustomDatum` uses `oracle.sql.Datum` types directly
- does not require a type map to specify the names of the Java custom classes you want to create
- provides better performance: `CustomDatum` works directly with `Datum` types, the internal format the driver uses to hold Oracle objects

The `CustomDatum` and `CustomDatumFactory` interfaces do the following:

- The `toDatum()` method of the `CustomDatum` class transforms the data into an `oracle.sql.*` representation.
- `CustomDatumFactory` specifies a `create()` method equivalent to a constructor for your custom Java class. It creates and returns a `CustomDatum` instance. The JDBC driver uses the `create()` method to return an instance of

the custom Java class to your Java application or applet. It takes as input an `oracle.sql.Datum` object and an integer indicating the corresponding SQL type code as specified in the `OracleTypes` class.

`CustomDatum` and `CustomDatumFactory` have the following definitions:

```
public interface CustomDatum
{
    Datum toDatum (OracleConnection conn) throws SQLException;
}

public interface CustomDatumFactory
{
    CustomDatum create (Datum d, int sql_Type_Code) throws SQLException;
}
```

where `conn` represents the Connection object, `d` represents an object of type `oracle.sql.Datum` and `sql_Type_Code` represents the SQL type code of the `Datum` object.

> **Note:** It is up to the developer to decide how to handle a situation where the SQL type code contradicts the type of the `Datum` object.

The JDBC drivers provide the following methods to retrieve and insert object data as instances of `CustomDatum`.

To retrieve object data:

- Use the Oracle extension `OracleResultSet.getCustomDatum ()` method:

  ```
  OracleResultSet.getCustomDatum (int col_index, CustomDatumFactory factory)
  ```

  This method takes as input the column index of the data in your result set, and a `CustomDatumFactory` instance. For example, you can implement a `getFactory()` method of your custom Java class to produce the `CustomDatumFactory` instance to input to `getCustomDatum()`. The type map is not required when using Java classes that implement `CustomDatum`.

OR

- Use the standard `ResultSet.getObject(index, map)` method to retrieve data as instances of `CustomDatum`. In this case, you must have an entry in the type map that identifies the factory class to be used for the given object type, and its corresponding SQL type name.

To insert object data:

- Use the Oracle extension `OraclePreparedStatement.setCustomDatum()` method:

  ```
  OraclePreparedStatement.setCustomDatum (int bind_index, CustomDatum
  custom_obj)
  ```

  This method takes as input the parameter index of the bind variable and the name of the object containing the variable.

OR

- Use the standard JDBC `PreparedStatement.setObject()` method. You can also use this method, in its various forms, to insert `CustomDatum` instances without requiring a type map.

The following sections describe the `getCustomDatum()` and `setCustomDatum()` methods.

To continue the example of an Oracle object `EMPLOYEE`, you might have something like the following in your Java application:

```
CustomDatum datum = ors.getCustomDatum(1, Employee.getFactory());
```

In this example, `ors` is an Oracle result set, `getCustomDatum()` is a method in the `OracleResultSet` class used to retrieve a `CustomDatum` object, and the `EMPLOYEE` is in column 1 of the result set. The `Employee.getFactory()` call will return a `CustomDatumFactory` to the JDBC driver. The JDBC driver will call `create()` from this object, returning to your Java application an instance of the `Employee` class that is populated with data from the result set.

Notes:

- `CustomDatum` and `CustomDatumFactory` are defined as separate interfaces so that different Java classes can implement them if you wish (such as an `Employee` class and an `EmployeeFactory` class).
- Your custom Java classes must import `oracle.sql.*` (or at least `CustomDatum`, `CustomDatumFactory`, and `Datum`), `oracle.jdbc.driver.*` (or at least `OracleConnection` and `OracleTypes`), and `java.sql.SQLException`.
- Refer to the Javadoc for more information about the `CustomDatum` and `CustomDatumFactory` classes.

CustomDatum versus SQLData: Comparison for Serializable Objects

The `CustomDatum` interface provides far more flexibility than the `SQLData` interface. The `SQLData` interface is designed to only let you customize the mapping of SQL object types (that is, Oracle8 object types) to Java types of your choice. Implementing the `SQLData` interface lets the JDBC driver populate the fields of the customized Java class from the original SQL object data and vice-versa, after performing the appropriate conversions between Java and SQL types.

The `CustomDatum` interface goes beyond simply supporting the customization of SQL object types to Java types. It lets you provide a mapping between Java object types and *any* SQL type supported by the `oracle.sql` package.

For example, use `CustomDatum` to store instances of Java objects that do not correspond to a particular SQL Oracle8 object type in the database in columns of SQL type `RAW`. The `create()` method in `CustomDatumFactory` would have to implement a conversion from an object of type `oracle.sql.RAW` to the desired Java object. The `toDatum()` method in `CustomDatum` would have to implement a conversion from the Java object to an `oracle.sql.RAW`. This can be done, for example, by using Java serialization.

Upon retrieval, the JDBC driver transparently retrieves the raw bytes of data in the form of an `oracle.sql.RAW` and calls the `CustomDatumFactory`'s `create()` method to convert the `oracle.sql.RAW` object to the desired Java class.

When you insert the Java object into the database, you can simply bind it to a column of type `RAW` to store it. The driver transparently calls the `CustomDatum.toDatum()` method to convert the Java object to an

`oracle.sql.RAW` object. This object is then stored in a column of type `RAW` in the database.

Support for the `CustomDatum` interfaces is also highly efficient because the conversions are designed to work using `oracle.sql.*` formats, which happen to be the internal formats used by the JDBC drivers. Moreover, the type map, which is necessary for the `SQLData` interface, is not required when using Java classes that implement `CustomDatum`. For more information on why classes that implement `CustomDatum` do not need a type map, see "Understanding the CustomDatum Interface" on page 4-75.

Reading and Writing Data with a CustomDatum Interface

This section describes how to read data from an Oracle object or write data to an Oracle object if your corresponding Java class implements `CustomDatum`.

Reading Data from an Oracle Object Using the CustomDatum Interface This section summarizes the steps in reading data from an Oracle object into your Java application. These steps apply whether you implement `CustomDatum` manually or use JPublisher to produce your custom Java classes.

These steps assume you have already defined the Oracle object type, created the corresponding custom Java class or had JPublisher create it for you, and defined a statement object `stmt`.

1. Query the database to read the Oracle object into a result set, casting to an Oracle result set.

   ```
   OracleResultSet ors = (OracleResultSet)stmt.executeQuery
      ("SELECT Emp_col FROM PERSONNEL");
   ors.next();
   ```

   where `PERSONNEL` is a one-column table. The column name is `Emp_col` of type `Employee_object`.

2. Use the `getCustomDatum()` method of your Oracle result set to populate an instance of your custom Java class with data from one row of the result set. The `getCustomDatum()` method returns an `oracle.sql.CustomDatum` object, which you can cast to your specific custom Java class.

   ```
   Employee emp = (Employee)ors.getCustomDatum(1, Employee.getFactory());
   ```

   OR

   ```
   CustomDatum datum = ors.getCustomDatum(1, Employee.getFactory());
   ```

This example assumes that Employee is the name of your custom Java class and ors is the name of your OracleResultSet object.

If you do not want to use getCustomDatum(), the JDBC drivers let you use the standard JDBC ResultSet.getObject() method to retrieve CustomDatum data. However, you must have an entry in the type map that identifies the factory class to be used for the given object type, and its corresponding SQL type name.

For example, if the SQL type name for your object is EMPLOYEE, then the corresponding Java class is Employee, which will implement CustomDatum. The corresponding Factory class is EmployeeFactory, which will implement CustomDatumFactory.

Use this statement to declare the EmployeeFactory entry for your type map:

```
map.put ("EMPLOYEE", Class.forName ("EmployeeFactory"));
```

Then use the form of getObject() where you specify the map object:

```
Employee emp = (Employee) rs.getObject (1, map);
```

If the connection's default type map already has an entry that identifies the factory class to be used for the given object type, and its corresponding SQL type name, then you can use this form of getObject():

```
Employee emp = (Employee) rs.getObject (1);
```

3. If you have get methods in your custom Java class, use them to read data from your object attributes into Java variables in your application. For example, if EMPLOYEE has Name of type CHAR and EmpNum (employee number) of type NUMBER, provide a getName() method that returns a Java string and a getEmpNum() method that returns an integer. Then invoke them in your Java application as follows:

```
String empname = emp.getName();
int empnumber = emp.getEmpNum();
```

Note: Alternatively, you can fetch data into a callable statement object. The OracleCallableStatement class also has a getCustomDatum() method.

Writing Data to an Oracle Object Using the CustomDatum Interface This section summarizes the steps in writing data to an Oracle object from your Java application

when you use JPublisher to produce your custom Java class or otherwise choose the `CustomDatum` implementation.

These steps assume you have already defined the Oracle object type, created the corresponding custom Java class or had JPublisher create it for you.

> **Note:** The type map is not used when you are performing database `INSERT`s and `UPDATE`s.

1. If you have `set` methods in your custom Java class, then use them to write data from Java variables in your application to attributes of your Java datatype object.

   ```
   emp.setName(empname);
   emp.setEmpNum(empnumber);
   ```

   This statement uses the `emp` object and the `empname` and `empnumber` variables defined in "Reading Data from an Oracle Object Using the CustomDatum Interface" on page 4-79.

2. Write an Oracle prepared statement that updates an Oracle object in a row of a database table, as appropriate, using the data provided in your Java datatype object.

   ```
   OraclePreparedStatement opstmt = conn.prepareStatement
      ("UPDATE PERSONNEL SET Employee = ? WHERE Employee.EmpNum = 28959);
   ```

   This assumes `conn` is your `Connection` object.

3. Use the `setCustomDatum()` method of the Oracle prepared statement to bind your Java datatype object to the prepared statement.

   ```
   opstmt.setCustomDatum(1, emp);
   ```

   The `setCustomDatum()` method calls the `toDatum()` method of your custom Java class to retrieve an `oracle.sql.STRUCT` object that can be written to the database.

   In this step you could also use the `setObject()` method to bind the Java datatype. For example:

   ```
   opstmt.setObject(1,emp);
   ```

Note: You can use your Java datatype objects as either `IN` or `OUT` bind variables.

Using JPublisher with JDBC

JPublisher is an Oracle utility for creating Java classes that map to Oracle objects. It generates a full class definition for a custom Java class, which you can instantiate to hold the data from an Oracle object. JPublisher-generated classes include methods to convert data from SQL to Java and from Java to SQL, as well as getter and setter methods for the attributes of the class.

If you want additional functionality you can create a subclass and add features as desired. JPublisher has features that will create references to the code you write if you need to regenerate the original class. The alternative, editing the generated class by adding methods to it, is not recommended if you anticipate running JPublisher at some future time to regenerate the class. If you run JPublisher to regenerate a class that you have modified in this way, your changes (that is, the methods you have added) will be overwritten. Even if you direct JPublisher output to a separate file, you will still need to merge your changes into the file.

You do not have to use JPublisher to create your custom Java classes, but it is usually very convenient. For more information on JPublisher, see the *Oracle8i JPublisher User's Guide.*

JPublisher Mapping Options

If you use JPublisher to implement your custom Java class, then you can choose among three mappings for attributes:

- Oracle mapping
- JDBC mapping
- Object JDBC mapping

JPublisher has a command-line option that enables you to choose among these three mapping options. For more information on the mapping options, see the *Oracle8i JPublisher User's Guide.*

Working with Oracle Object References

This section has these subsections:

You can define an Oracle object reference to an object stored in an object table. In contrast, you cannot define an object reference for an object value that is stored in a table column.

In SQL, object references (REFs) are strongly typed. For example, a reference to an EMPLOYEE object would be defined as an EMPLOYEE REF, not just a REF.

When you select an object reference in Oracle JDBC, it is materialized as an instance of the `oracle.sql.REF` class and is *not* strongly typed. So, if you select an EMPLOYEE REF, an `oracle.sql.REF` object is returned. To find out what kind of REF it really is, use the object's `getBaseTypeName()` method. This method returns the object's SQL type, which in this case would be EMPLOYEE.

An object reference is a primitive SQL type. The steps to access and manipulate object references are similar to the steps you employ for any other primitive SQL type.

Note: You cannot have a reference to an array, even though arrays, like objects, are structured types.

JDBC provides support for REFs as any of the following:

- columns in a SELECT list
- IN or OUT bind variables
- attributes in an Oracle8 object
- elements in a collection (array) type object

If you use JPublisher to generate custom Java classes, then it also generates reference classes. These reference classes are extensions of `oracle.sql.REF` and, unlike the `oracle.sql.REF` class, *are* strongly typed. For example, if you define an Oracle object EMPLOYEE, then JPublisher generates an `Employee` class and an `EmployeeRef` class.

Retrieving an Object Reference

To demonstrate how to retrieve REFs, the following example first defines an Oracle object type ADDRESS:

```
create type ADDRESS as object
   (street_name     VARCHAR2(30),
    house_no  NUMBER);

create table PEOPLE
    (col1 VARCHAR2(30),
     col2 NUMBER,
     col3 REF ADDRESS);
```

The ADDRESS object type has two attributes: a street name and a house number. The PEOPLE table has three columns: a column for character data, a column for numeric data, and a column containing a reference to an ADDRESS object.

To retrieve an object reference, follow these general steps:

1. Use a standard SQL SELECT statement to retrieve the reference from a database table REF column.
2. Use `getREF()` to get the address reference from the result set into a REF object.
3. Let `Address` be the Java custom class corresponding to the SQL object type ADDRESS.
4. Add the correspondence between the Java class `Address` and the SQL type ADDRESS to your type map.
5. Use the `getValue()` method to retrieve the contents of the `Address` reference. Cast the output to a Java `Address` object.

Here is the code for these three steps, where `stmt` is a previously defined statement object. The PEOPLE database table is defined earlier in this section:

```
ResultSet rs = stmt.executeQuery("SELECT col3 FROM PEOPLE");
rs.next();
REF ref = rs.getREF(1);
Address a = (Address)(ref.getValue());
```

As with other SQL types, you could retrieve the reference with the `getObject()` method of your result set. Note that this would require you to cast the output. For example:

```
REF ref = (REF)rs.getObject(1);
```

There is no advantage or disadvantage in using `getObject()` instead of `getREF()`.

Passing an Object Reference to a Callable Statement

To retrieve an object reference as an `OUT` parameter in PL/SQL blocks, do the following to register the bind type for your `OUT` parameter.

1. Cast your callable statement to an `OracleCallableStatement`:

   ```
   OracleCallableStatement ocs =
      (OracleCallableStatement)conn.prepareCall("{? = call func()}")
   ```

2. Register the `OUT` parameter with this form of the `registerOutParameter()` method:

   ```
   ocs.registerOutParameter(int param_index, int sql_type, string
   sql_type_name);
   ```

   where `param_index` is the parameter index and `sql_type` is the SQL type code (in this case, `OracleTypes.REF`). The `sql_type_name` is the name of the `STRUCT` to which this object reference points. For example, if the `OUT` parameter is a `REF` to an `ADDRESS` object (as in the previous section), then `ADDRESS` is the `sql_type_name` that should be passed in.

3. Execute the call:

   ```
   ocs.execute()
   ```

Accessing and Updating Object Values through an Object Reference

You could then create a Java `Address` object and update a database `ADDRESS` object through the reference as follows (omitting whatever would be required for the constructor of the `Address` class). This example assumes that you have already retrieved a valid `REF` object:

```
Address addr = new Address(...);
ref.setValue(addr);
```

Here, the `setValue()` method updates the database `ADDRESS` object.

Passing an Object Reference to a Prepared Statement

Pass an object reference to a prepared statement in the same way as you would pass any other SQL type. Use either the `setObject()` method or the `setREF()` method of a prepared statement object.

Continuing the preceding example, use a prepared statement to update an address reference based on `ROWID`, as follows:

```
PreparedStatement pstmt =
   conn.prepareStatement ("update PEOPLE set ADDR_REF = ? where ROWID = ?");
pstmt.setREF (1, addr_ref);
pstmt.setROWID (2, rowid);
```

Working with Arrays

This section has these subsections:

The `oracle.sql.ARRAY` class enables you to access and manipulate arrays and their data within a JDBC program. The `oracle.sql.ARRAY` class implements the `oracle.jdbc2.Array` interface.

JDBC provides support for arrays as any of the following:

- columns in a `SELECT` list
- `IN` or `OUT` bind variables
- attributes in an Oracle object

> **Note:** The term *arrays* in JDBC 2.0 is equivalent to *collections* in Oracle terminology.

Arrays include `varray`s (variable-length arrays) and nested tables. The methods in the `oracle.sql.ARRAY` class enable you to access and manipulate the array and its data even if it is a `varray` or nested table. That is, you do not have to add any special code when you are accessing a `varray` or nested table. The methods can determine if they are being applied to a `varray` or nested table, and respond by taking the appropriate actions.

Oracle supports only *named* arrays, where you specify a SQL type name to describe a type of array. The SQL type name is assigned to the array when you create it, as in the following SQL syntax:

```
CREATE TYPE <sql_type_name> AS <datatype>
```

The array can be either a nested table or a `varray`.

A `varray` is an array of varying size, thus the name "`varray`". A `varray` has an ordered set of data elements. All elements of a given `varray` are of the same datatype. Each element has an index, which is a number corresponding to the element's position in the `varray`. The number of elements in a `varray` is the size of

the varray. You must specify a maximum size when you declare the array type. For example:

```
CREATE TYPE myNumType AS VARRAY(10) OF NUMBER;
```

This statement defines myNumType as a SQL type name that describes a varray of NUMBERs that can contain no more than 10-elements.

A nested table is an unordered set of data elements, all of the same datatype. It has a single column, and the type of that column is a built-in type or an object type. If the table is an object type, it can also be viewed as a multi-column table, with a column for each attribute of the object type. Create a nested table with this SQL syntax:

```
CREATE TYPE myNumList AS TABLE OF integer;
```

This statement identifies myNumList as a SQL type name that defines the table type used for the nested tables of the type integer.

The remainder of this section describes how to access and update array data. For general information about the oracle.sql.ARRAY class, including how to manually create array objects, see "Class oracle.sql.ARRAY" on page 4-14. For a complete code example of creating a table with an array column, then manipulating and printing the contents, see "Array Sample" on page 7-16.

Retrieving an Array and its Elements

When you retrieve an array you get an oracle.sql.ARRAY object where each array element can be returned as a materialized Java array object or as a result set object.

You can retrieve a SQL array that has been selected into a result set by casting the result set to an OracleResultSet object and using the getARRAY() method, which returns an oracle.sql.ARRAY object. If you want to avoid casting the result set, you can get the data with the getObject() method of the oracle.sql.ResultSet class, then cast the output to oracle.sql.ARRAY.

Once you have the array in an ARRAY object, you can retrieve the data using one of these three overloaded methods of the oracle.sql.ARRAY class:

- getArray()
- getOracleArray()
- getResultSet()

Oracle provides versions of these methods that enable you to specify a type map so you can choose how you want your SQL datatypes to map to Java datatypes. Oracle also provides methods that enable you to retrieve all of an array's elements or a subset of the array (but note, there is no performance advantage in retrieving a subset of an array as opposed to retrieving the entire array).

Note: Beginning in release 8.1.5, arrays are indexed from 1. In previous releases, arrays were indexed from 0.

---

getArray() Method: The `getArray()` method retrieves the element values of the array into a `java.lang.Object[]` array. The elements are converted to the Java types corresponding to the SQL type of the data in the original array.

The `getArray()` materializes the data as an array of `oracle.sql.*` objects and does not use a type map. Oracle also provides a `getArray(map)` method to let you specify a type map and a `getArray(index,count)` method to retrieve a subset of the array.

getOracleArray() Method: The `getOracleArray()` method retrieves the element values of the array into a `Datum[]` array. The elements are converted to the `oracle.sql.*` datatype corresponding to the SQL type of the data in the original array.

Note: The `getOracleArray()` method is an Oracle-specific extension and does not belong to the `oracle.jdbc2.`ARRAY JDBC 2.0 interface.

The `getOracleArray()` method materializes the data as an array of `oracle.sql.*` objects and does not use the type map. Oracle also provides the `getOracleArray(index,count)`.

getResultSet() Method: The `getResultSet()` method returns a result set that contains elements of the array designated by the ARRAY object. The result set contains one row for each array element, with two columns in each row. The first column stores the index into the array for that element and the second column stores the element value. In the case of `varray`s, the index represents the position of the element in the array. In the case of nested tables, which are by definition unordered, the index reflects only the return order of the elements in the particular query.

Oracle recommends that you use `getResultSet()` when getting data from nested tables. Nested tables can have an unlimited number of elements. The `ResultSet` object returned by the method initially points at the first row of data. You get the contents of the nested table by using the `next()` method and the appropriate `getXXX()` method. In contrast, `getArray()` returns the entire contents of the nested table at one time.

The `getResultSet()` method uses the connection's default type map to determine the mapping between the SQL type of the Oracle object and its corresponding Java datatype. If you do not want to use the connection's default type map, another version of the method, `getResultSet(map)`, enables you to specify an alternate type map.

Oracle also provides the `getResultSet(index,count)` and `getResultSet(index,count,map)` methods to retrieve a subset of the array.

Retrieving All of an Array's Elements

If you use `getArray()` to retrieve an array of primitive datatypes, then a `java.lang.Object` that contains the element values is returned. The elements of this array are of the Java type corresponding to the SQL type of the elements. For example,

```
BigDecimal[] values=(BigDecimal[]) intArray.getArray();
```

where `intArray` is an `oracle.sql.ARRAY`, corresponding to a `varray` of type `NUMBER`. The `values` array contains an array of elements of type `java.math.BigDecimal` because the SQL `NUMBER` datatype maps to Java `BigDecimal` by default according to the Oracle JDBC drivers.

Similarly, if you use `getResultSet()` to return an array of primitive datatypes, then the JDBC drivers return a `ResultSet` object that contains, for each element, the index into the array for the element and the element value. For example:

```
ResultSet rset= intArray.getResultSet();
```

In this case, the result set contains one row for each array element, with two columns in each row. The first column stores the index into the array; the second column stores the `BigDecimal` element value.

Retrieving Array Elements According to a Type Map

By default, if you use `getArray()` or `getResultSet()`, then the Oracle objects in the array will be mapped to their corresponding Java datatypes according to the

default mapping. This is because these methods use the connection's default type map to determine the mapping.

However, if you do not want default behavior, then you can use the `getArray(map)` or `getResultSet(map)` method to specify a type map that contains alternate mappings. If there are entries in the type map corresponding to the Oracle objects in the array, then each object in the array is mapped to the corresponding Java type specified in the type map. For example:

```
Object[] object = (Object[])objArray.getArray(map);
```

where `objArray` is an `oracle.sql.ARRAY` object and `map` is a `java.util.Map` object.

If the type map does not contain an entry for a particular Oracle object, then the element is returned as an `oracle.sql.STRUCT`.

The `getResultSet(map)` method behaves in a similar manner to `getArray(map)`.

For more information on using type maps with arrays, see "Using a Type Map to Map Array Elements" on page 4-94.

Retrieving a Subset of an Array's Elements

To retrieve a subset of the array, you can pass in an index and a count to indicate where in the array you want to start and how many elements you want to retrieve. As described above, you can specify a type map or use the default type map for your connection to convert to Java types. For example:

```
Object object = arr.getArray(index, count, map);
Object object = arr.getArray(index, count);
```

Similar examples using `getResultSet()` are:

```
ResultSet rset = arr.getResultSet(index, count, map);
ResultSet rset= arr.getResultSet(index, count);
```

A similar example using `getOracleArray()` is:

```
Datum arr = arr.getOracleArray(index, count);
```

where `arr` is an `oracle.sql.ARRAY` object, `index` is type `long`, `count` is type `int`, and `map` is a `java.util.Map` object.

Retrieving an Array as an oracle.sql.Datum

Use `getOracleArray()` to return an `oracle.sql.Datum[]` array. The elements of the returned array will be of the `oracle.sql.*` type that correspond to the SQL datatype of the SQL array elements. For example,

```
Datum arraydata[] = arr.getOracleArray();
```

where `arr` is an `oracle.sql.ARRAY` object. For an example of retrieving an array and its contents, see "Array Sample" on page 7-16.

Example: Getting and Printing an Array of Primitive Datatypes from a Result Set The following example assumes that a connection object `conn` and a statement object `stmt` have already been created. In the example, an array with the SQL type name `num_array` is created to store a `varray` of `NUMBER` data. The `num_array` is in turn stored in a table `varray_table`.

A query selects the contents of the `varray_table`. The result set is cast to an `OracleResultSet` object; `getARRAY()` is applied to it to retrieve the array data into `my_array`, which is an object of type `oracle.sql.ARRAY`.

Because `my_array` is of type `oracle.sql.ARRAY`, you can apply the methods `getSQLTypeName()` and `getBaseType()` to it to return the name of the SQL type of each element in the array and its integer code.

The program then prints the contents of the array. Because the contents of `my_array` are of the SQL datatype `NUMBER`, it must first be cast to the `BigDecimal` datatype. In the `for` loop, the individual values of the array are cast to `BigDecimal` and printed to standard output.

```
stmt.execute ("CREATE TYPE num_varray AS VARRAY(10) OF NUMBER(12, 2)");
stmt.execute ("CREATE TABLE varray_table (col1 num_varray)");
stmt.execute ("INSERT INTO varray_table VALUES (num_varray(100, 200))");

ResultSet rs = stmt.executeQuery("SELECT * FROM varray_table");
ARRAY my_array = ((OracleResultSet)rs).getARRAY(1);

// return the SQL type names, integer codes,
// and lengths of the columns
System.out.println ("Array is of type " + array.getSQLTypeName());
System.out.println ("Array element is of type code " + array.getBaseType());
System.out.println ("Array is of length " + array.length());

// get Array elements
      BigDecimal[] values = (BigDecimal[]) my_array.getArray();
```

```
for (int i=0; i<values.length; i++)
{
  BigDecimal out_value = (BigDecimal) values[i];
  System.out.println(">> index " + i + " = " + out_value.intValue());
{
```

Note that if you use `getResultSet()` to obtain the array, you would first get the result set object, then use the `next()` method to iterate through it. Notice the use of the parameter indexes in the `getInt()` method to retrieve the element index and the element value.

```
ResultSet rset = my_array.getResultSet();
while (rset.next())
{
     // The first column contains the element index and the
     // second column contains the element value
     System.out.println(">> index " + rset.getInt(1)+" = " + rset.getInt(2));
};
```

Passing an Array to a Prepared Statement

Pass an array to a prepared statement as follows (use similar steps to pass an array to a callable statement):

1. Construct an `ArrayDescriptor` object for the SQL type that the array will contain (unless one has already been created for this SQL type). See "Class oracle.sql.ARRAY" on page 4-14 for information about creating `ArrayDescriptor` objects.

   ```
   ArrayDescriptor descriptor = ArrayDescriptor.createDescriptor(sql_type_name,
   connection);
   ```

   where `sql_type_name` is a Java string specifying the user-defined SQL type name of the array, and `connection` is your `Connection` object. See "Working with Arrays" on page 4-87 for information about SQL typenames.

2. Define the array that you want to pass to the prepared statement as an `oracle.sql.ARRAY` object.

   ```
   ARRAY array = new ARRAY(descriptor, elements);
   ```

   where `descriptor` is the `ArrayDescriptor` object previously constructed and `elements` is a `java.lang.Object` containing a Java array of the elements. These objects are converted to raw bytes of the appropriate SQL type.

3. Create a `java.sql.PreparedStatement` object containing the SQL statement to execute.
4. Cast your prepared statement to an `OraclePreparedStatement` and use the `setARRAY()` method of the `OraclePreparedStatement` object to pass the array to the prepared statement.

   ```
   (OraclePreparedStatement)stmt.setARRAY(parameterIndex, array);
   ```

   where `parameterIndex` is the parameter index, and `array` is the `oracle.sql.ARRAY` object you constructed previously.
5. Execute the prepared statement.

Note: You can use arrays as either `IN` or `OUT` bind variables.

Passing an Array to a Callable Statement

To retrieve a collection as an `OUT` parameter in PL/SQL blocks, do the following to register the bind type for your `OUT` parameter.

1. Cast your callable statement to an `OracleCallableStatement`:

   ```
   OracleCallableStatement ocs =
      (OracleCallableStatement)conn.prepareCall("{? = call func()}")
   ```

2. Register the `OUT` parameter with this form of the `regsiterOutParameter()` method:

   ```
   ocs.registerOutParameter(int param_index, int sql_type, string
   sql_type_name);
   ```

   where `param_index` is the parameter index, `sql_type` is the SQL type code, and `sql_type_name` is the name of the array type. In this case, the `sql_type` is `OracleTypes.ARRAY`.
3. Execute the query:

   ```
   ocs.executeQuery()
   ```

Using a Type Map to Map Array Elements

If your array contains Oracle objects, then you can use a type map to associate each object in the array with its corresponding Java class. If you do not specify a type

map or if the type map does not contain an entry for a particular Oracle object, then the element is returned as an `oracle.sql.STRUCT`.

If you want the type map to determine the mapping between the Oracle objects in the array and their associated Java classes, then you must add them to the type map if they are not already there. For instructions on how to add entries to an existing type map or how to create a new type map, see "Understanding Type Maps" on page 4-66.

The following example illustrates how you can use a type map to map the elements of an array to a custom Java object class. In this case, the array is a nested table. The example begins by defining an `EMPLOYEE` object that has a name attribute and employee number attribute. `EMPLOYEE_LIST` is a nested table type of `EMPLOYEE` objects. Then an `EMPLOYEE_TABLE` is created to store the names of departments within a corporation and the employees associated with each department. In the `EMPLOYEE_TABLE`, the employees are stored in the form of `EMPLOYEE_LIST` tables.

```
stmt.execute("CREATE TYPE EMPLOYEE AS OBJECT(EmpName VARCHAR2(50),EmpNo
INTEGER))");

stmt.execute("CREATE TYPE EMPLOYEE_LIST AS TABLE OF EMPLOYEE");

stmt.execute("CREATE TABLE EMPLOYEE_TABLE (DeptName VARCHAR2(20), Employees
EMPLOYEE_LIST) NESTED TABLE Employees STORE AS ntable1");

stmt.execute("INSERT INTO EMPLOYEE_TABLE VALUES ("SALES",
EMPLOYEE_LIST(EMPLOYEE('Susan Smith', 123), EMPLOYEE('Scott Tiger', 124)))");
```

If you want to select all of the employees belonging to the SALES department as the custom Java object `EmployeeObj`, then you must create a mapping in the type map between the `EMPLOYEE` SQL type and the `EmployeeObj` custom Java object class.

To do this, first create your statement and result set objects, then select the `EMPLOYEE_LIST` associated with the SALES department into the result set. Cast the result set to `OracleResultSet` so that the `getARRAY()` method can retrieve the `EMPLOYEE_LIST` object into the `employeeArray` object.

> **Note:** The `EmployeeObj` custom Java object type in this example implements the `SQLData` interface. "Creating the Custom Java Class" on page 7-21 contains the code that creates the `EmployeeObj` type.

```
Statement s = conn.createStatement();
OracleResultSet rs = (OracleResultSet)
     s.executeQuery("SELECT Employees FROM employee_table
          WHERE DeptName = 'SALES'");

// get the array object
ARRAY employeeArray = ((OracleResultSet)rs).getARRAY(1);
```

Now that you have the `EMPLOYEE_LIST` object, get the existing type map and add an entry that maps the `EMPLOYEE` SQL type to the `EmployeeObj` Java type.

```
// add type map entry to map SQL type
// "EMPLOYEE" to Java type "EmployeeObj"
Dictionary map = conn.getTypeMap();
map.put("EMPLOYEE", Class.forName("EmployeeObj"));
```

Retrieve the SQL `EMPLOYEE` objects from the `EMPLOYEE_LIST`. To do this, apply the `getArray()` method of the `oracle.jdbc2.Array` class to `employeeArray`. This method returns an array of objects. The `getArray()` method returns the `EMPLOYEE` objects into the `employees` object array.

```
// Retrieve array elements
Object[] employees = (Object[]) employeeArray.getArray();
```

Finally, create a loop to assign each of the `EMPLOYEE` SQL objects to the `EmployeeObj` Java object `emp`.

```
// Each array element is mapped to EmployeeObj object.
for (int i=0; i<employees.length; i++)
   {
     EmployeeObj emp = (EmployeeObj) employees[i];
     ...
   }
```

Additional Oracle Extensions

This section has the following subsections:

This section describes Oracle extensions not related to datatypes in the JDBC 2.0 specification. This consists of additional datatype extensions as well as performance extensions.

Performance Extensions

Oracle JDBC drivers support these extensions that improve performance by reducing round trips to the database:

- Prefetching rows reduces round trips to the database by fetching multiple rows of data each time data is fetched; the extra data is stored in client-side buffers for later access by the client. The number of rows to prefetch can be set as desired.
- Batching updates also reduces round trips to the database, saving on the client side a number of updates that are to be made, and then going to the database once to execute all the updates.
- Specifying column types gets around an inefficiency in the usual JDBC protocol for performing and returning the results of queries.
- Suppressing database metadata `TABLE_REMARKS` columns avoids an expensive outer join operation.

Oracle supports several extensions to connection properties objects to support these performance extensions. The properties object extensions enable you to set the `remarksReporting` flag and default values for prefetching and update-batching. For more information, see "Oracle Extensions for Connection Properties" on page 4-109.

Note: The prefetching and batch update extensions were designed prior to the announcement of the JDBC 2.0 standard. They do not match JDBC 2.0.

Row Prefetching

Oracle JDBC drivers allow you to set the number of rows to prefetch into the client while a result set is being populated during a query. This feature reduces the number of round trips to the server.

Standard JDBC receives the result set one row at a time, and each row requires a round trip to the database. The row prefetching feature associates an integer row-prefetch setting with a given statement object. JDBC fetches that number of rows at a time from the database during the query. That is, JDBC will fetch N rows that match the query criteria and bring them all back to the client at once, where N is the prefetch setting. Then, once your `next()` calls have run through those N rows, JDBC will go back to fetch the next N rows that match the criteria.

You can set the number of rows to prefetch for a particular Oracle statement (any type of statement). You can also reset the default number of rows that will be prefetched for all statements in your connection. The default number of rows to prefetch to the client is 10.

Set the number of rows to prefetch for a particular statement as follows:

1. Cast your statement object to an `OracleStatement`, `OraclePreparedStatement`, or `OracleCallableStatement` object, as applicable, if it is not already one of these.
2. Use the `setRowPrefetch()` method of the statement object to specify the number of rows to prefetch, passing in the number as an integer. If you want to check the current prefetch number, use the `getRowPrefetch()` method of the Statement object, which returns an integer.

Set the default number of rows to prefetch for all statements in a connection as follows:

1. Cast your `Connection` object to an `OracleConnection` object.
2. Use the `setDefaultRowPrefetch()` method of your `OracleConnection` object to set the default number of rows to prefetch, passing in an integer that specifies the desired default. If you want to check the current setting of the default, then use the `getDefaultRowPrefetch()` method of the `OracleConnection` object. This method returns an integer.

Row Prefetching Limitations There is no maximum prefetch setting, but empirical evidence suggests that 10 is effective. Oracle does not recommend exceeding this value in most situations. If you do not set the default row prefetch number for a connection, 10 is the default.

A statement object receives the default row prefetch setting from the associated connection at the time the statement object is created. Subsequent changes to the connection's default row prefetch setting have no effect on the statement's row prefetch setting.

If a column of a result set is of datatype `LONG` or `LONG RAW` (that is, the streaming types), JDBC changes the statement's row prefetch setting to 1, even if you never actually read a value of either of those types.

If you use the form of the `DriverManager` class `getConnection()` method that takes a `Properties` object as an argument, then you can set the connection's default row prefetch value that way. See "Specifying a Database URL and Properties Object" on page 3-6 and "Oracle Extensions for Connection Properties" on page 4-109 for more information about the Properties object and connection properties.

Example: Row Prefetching The following example illustrates the row prefetching feature. It assumes you have imported the `oracle.jdbc.driver.*` classes.

```
Connection conn =
 DriverManager.getConnection("jdbc:oracle:oci8:","scott","tiger");

//Set the default row prefetch setting for this connection
((OracleConnection)conn).setDefaultRowPrefetch(7);

/* The following statement gets the default row prefetch value for
   the connection, that is, 7.
*/
Statement stmt = conn.createStatement();

/* Subsequent statements look the same, regardless of the row
   prefetch value. Only execution time changes.
*/
ResultSet rset = stmt.executeQuery("SELECT ename FROM emp");
System.out.println( rset.next () );

while( rset.next () )
   System.out.println( rset.getString (1) );

//Override the default row prefetch setting for this statement
( (OracleStatement)stmt ).setRowPrefetch (2);

ResultSet rset = stmt.executeQuery("SELECT ename FROM emp");
System.out.println( rset.next () );
```

```
while( rset.next() )
   System.out.println( rset.getString (1) );

stmt.close();
```

Database Update Batching

Oracle JDBC drivers allow you to accumulate inserts and updates of prepared statements at the client and send them to the server in batches, reducing round trips to the server. You might want to do this when you are repeating the same statement with different bind variables.

Normally JDBC makes a round trip to the database to execute a prepared statement whenever the statement's `executeUpdate()` method is called. The Oracle update-batching feature, however, associates a batch value with each prepared statement object. Oracle JDBC accumulates execution requests for the prepared statement, then automatically passes them all to the database for execution once the batch value is reached.

Update Batching Limitations You can use update batching with `CallableStatements` except when the `CallableStatement` has `OUT` parameters. In this case, the driver automatically overrides any previous batch value and resets it to 1.

Do *not* use the `addBatch()` and `executeBatch()` methods of the JDBC 2.0 `PreparedStatement` interface. These methods are not consistent with the functionality offered by the methods associated with the `OraclePreparedStatement`.

Regardless of the batch value of an Oracle prepared statement, if any of the bind variables of the statement is (or becomes) a streaming type, then JDBC sets the batch value to 1 and sends any queued requests to the database for execution.

JDBC automatically executes the statement's `sendBatch()` method whenever the connection receives a commit request, the statement receives a close request, or the connection receives a close request.

If you use the form of the `DriverManager.getConnection()` method that takes a `Properties` object as an argument, then you can set the connection's default batch value in the object. See "Oracle Extensions for Connection Properties" on page 4-109 for more information about `Properties` objects.

The default batch update value is 1.

Setting Update Batch Value for Individual Statements You can set the batch value for any individual Oracle prepared statement by applying it to the `OraclePreparedStatement` object. The batch value that you set for an individual statement overrides the value set for the connection. You can also set a default batch value that will apply to any Oracle prepared statement in your Oracle connection by applying it to the `OracleConnection` object.

Follow these steps to apply the Oracle batch value feature for a particular prepared statement:

1. Write your prepared statement and specify input values for the first row:

```
PreparedStatement ps = conn.prepareStatement ("INSERT INTO dept VALUES
(?,?,?)");
ps.setInt (1,12);
ps.setString (2,"Oracle");
ps.setString (3,"USA");
```

2. Cast your prepared statement to an `OraclePreparedStatement` object and apply the `setDefaultExecuteBatch()` method. In this example, the default batch size of the statement is set to 2.

```
((OraclePreparedStatement)ps).setDefaultExecuteBatch(2);
```

   If you wish, insert the `getExecuteBatch()` method at any point in the program to check the default batch value for the statement:

```
System.outPrintln (" Statement Execute Batch Value " +
    ((OraclePreperedStatement)ps).getExecuteBatch());
```

3. If you send an execute update statement to the database at this point, then no data will be sent to the database. Instead, a call to `executeUpdate()` will return 0.

```
// No data is sent to the database by this call to executeUpdate
    System.out.println ("Number of rows updated so far: "
                                    + ps.executeUpdate ());
```

4. If you enter a set of input values for a second row and an execute update, then the number of batch calls to `executeUpdate()` will be equal to the batch value of 2. The data will be sent to the database and both rows will be inserted in a single round trip.

```
ps.setInt (1, 11);
ps.setString (2, "Applications");
ps.setString (3, "Indonesia");
```

```
int rows = ps.executeUpdate ();
System.out.println ("Number of rows updated now: " + rows);

ps.close ();
```

Overriding the Default Batch Update Value If you want to execute accumulated statements before the batch value is reached, then use the `sendBatch()` method of the `OraclePreparedStatement` object. For example:

1. Cast your connection to an `OracleConnection` object and apply the `setDefaultExecuteBatch()` method for the connection. This example sets the default batch for all statements in the connection to 50.

   ```
   ((OracleConnection)conn).setDefaultExecuteBatch (50);
   ```

2. Write your prepared statement and specify input values for the first row as usual, then execute the statement:

   ```
   PreparedStatement ps =
      conn.prepareStatement ("insert into dept values (?, ?, ?)");

   ps.setInt (1, 32);
   ps.setString (2, "Oracle");
   ps.setString (3, "USA");

   System.out.println (ps.executeUpdate ());
   ```

   The execute update does not happen at this point. The `ps.executeUpdate()` method returns "0".

3. If you enter a set of input values for a second row and an `executeUpdate()`, the data will still not be sent to the database since the batch default value for the statement is the same as for the connection: 50.

   ```
   ps.setInt (1, 33);
   ps.setString (2, "Applications");
   ps.setString (3, "Indonesia");

   // this execute does not actually happen at this point
   int rows = ps.executeUpdate ();

   System.out.println ("Number of rows updated before calling sendBatch: "
                           + rows);
   ```

   Note that the value of `rows` in the `println` statement is "0".

4. If you apply the `sendBatch()` method at this point, then the two previously batched executes will be sent to the database in a single round trip. The `sendBatch()` method also returns the number of updated rows. This property of `sendBatch()` is used by `println` to print the number of updated rows.

```
// Execution of both previously batched executes will happen
// at this point. The number of rows updated will be
// returned by sendBatch.
rows = ((OraclePreparedStatement)ps).sendBatch ();

System.out.println ("Number of rows updated by calling sendBatch: "
                        + rows);

 ps.close ();
```

Setting Update Batch Value for the Connection You can specify a default batch value for any Oracle prepared statement in your Oracle connection. To do this, set the `setDefaultExecute()` method on the `OracleConnection` object. For example, the following statement sets the default batch value for all prepared statements belonging to the `conn` connection object to 20:

```
((OracleConnection)conn).setDefaultExecuteBatch(20);
```

Even though this sets the default batch value for all of the prepared statements belonging to the connection, you can override it by calling `setDefaultBatch()` on individual statements.

Checking Batch Value The `getExecuteBatch()` method enables you to check the current setting of the default batch value for a specific Oracle prepared statement object or for all of the prepared statements that belong to the Oracle connection. For example:

```
Integer batch_val = ((OraclePreparedStatement)ps).getExecuteBatch();
```

OR

```
Integer batch_val = ((OracleConnection)conn).getDefaultExecuteBatch();
```

Example: Update Batching The following example illustrates how you use the Oracle update batching feature. It assumes you have imported the `oracle.jdbc.driver.*` classes.

```
Connection conn =
  DriverManager.getConnection("jdbc:oracle:oci8:","scott","tiger");
```

```
PreparedStatement ps =
  conn.prepareStatement("insert into dept values (?, ?, ?)");

//Change batch size for this statement to 3
((OraclePreparedStatement)ps).setExecuteBatch (3);

ps.setInt(1, 23);
ps.setString(2, "Sales");
ps.setString(3, "USA");
ps.executeUpdate(); //JDBC queues this for later execution

ps.setInt(1, 24);
ps.setString(2, "Blue Sky");
ps.setString(3, "Montana");
ps.executeUpdate(); //JDBC queues this for later execution

ps.setInt(1, 25);
ps.setString(2, "Applications");
ps.setString(3, "India");
ps.executeUpdate(); //The queue size equals the batch value of 3
               //JDBC sends the requests to the database

ps.setInt(1, 26);
ps.setString(2, "HR");
ps.setString(3, "Mongolia");
ps.executeUpdate(); //JDBC queues this for later execution

((OraclePreparedStatement)ps).sendBatch();
                           //JDBC sends the queued request
ps.close();
```

Notes:

- Each statement has its own batch count. Only executes on a particular statement add to the batch count.
- Updates deferred through batching can affect the results of other queries. In the following example, if the first query is deferred due to batching, then the second will return unexpected results:

```
UPDATE emp SET name = "Sue" WHERE name = "Bob";
SELECT name FROM emp WHERE name = "Sue";
```

Redefining Column Types

Oracle JDBC drivers enable you to inform the driver of the types of the columns in an upcoming query, saving a round trip to the database that would otherwise be necessary to describe the table.

When standard JDBC performs a query, it first uses a round trip to the database to determine the types that it should use for the columns of the result set. Then, when JDBC receives data from the query, it converts the data, as necessary, as it populates the result set.

When you specify column types for a query, you avoid the first round trip to the database. The server, which is optimized to do so, performs any necessary type conversions.

Redefining Column Types Limitations To use this feature, you must specify a datatype for each column of the expected result set. If the number of columns for which you specify types does not match the number of columns in the result set, the process fails with a `SQLException`.

You cannot define column types for objects or object references.

Redefining Column Types for a Query Following these general steps to redefine column types for a query:

1. Cast your statement object to an `OracleStatement`, `OraclePreparedStatement`, or `OracleCallableStatement` object, as applicable, if it is not already one of these.
2. If necessary, use the `clearDefines()` method of your `Statement` object to clear any previous column definitions for this `Statement` object.

3. Determine the following for each column of the expected result set:
   - column index (position)
   - code for the type of the expected return data (which can differ from the column type)

     This is according to `oracle.jdbc.driver.OracleTypes` for Oracle-specific types, and according to either `java.sql.Types` or `OracleTypes` for standard types (constants for standard types have the same value in `Types` and `OracleTypes`).
4. For each column of the expected result set, invoke the `defineColumnType()`, method of your `Statement` object, passing it these parameters:
   - column index (integer)
   - type code (integer)

     Use the static constants of the `java.sql.Types` class or, for Oracle-specific types, the static constants of the `oracle.jdbc.driver.OracleTypes` class (such as `Types.INTEGER`, `Types.FLOAT`, `Types.VARCHAR`, `OracleTypes.VARCHAR`, and `OracleTypes.ROWID`.).
   - (optionally) maximum field size (integer)

   For example, assuming `stmt` is an Oracle statement, use this syntax:

   ```
   stmt.defineColumnType(column_index, type);
   ```

   OR

   ```
   stmt.defineColumnType(column_index, type, max_size);
   ```

   Set maximum field size if you do not want to receive the full default length of the data. Less data than this maximum size will be returned if the maximum field size is set to a smaller value using the `setMaxFieldSize()` method of the standard JDBC `Statement` class, or if the natural maximum size of the datatype is smaller. Specifically, the size of the data returned will be the minimum of:

   – the maximum field size set in `defineColumnType()` or
   – the maximum field size set in `setMaxFieldSize()` or
   – the natural maximum size of the datatype

Once you complete these steps, use the statement's `executeQuery()` method to perform the query.

Example: Defining Column Types The following example illustrates the use of this feature. It assumes you have imported the `oracle.jdbc.driver.*` classes.

```
Connection conn =
     DriverManager.getConnection("jdbc:oracle:oci8:","scott","tiger");

Statement stmt = conn.createStatement();

/*Ask for the column as a string:
 *Avoid a round trip to get the column type.
 *Convert from number to string on the server.
 */
((OracleStatement)stmt).defineColumnType(1, Types.VARCHAR);

ResultSet rset = stmt.executeQuery("select empno from emp");

while (rset.next() )
    System.out.println(rset.getString(1));

stmt.close();
```

As this example shows, you must cast the statement (`stmt`) to type `OracleStatement` in the invocation of the `defineColumnType()` method. The connection's `createStatement()` method returns an object of type `java.sql.Statement`, which does not have the `defineColumnType()` and `clearDefines()` methods. These methods are provided only in the `OracleStatement` implementation.

The define-extensions use JDBC types to specify the desired types. The allowed define types for columns depend on the internal Oracle type of the column.

All columns can be defined to their "natural" JDBC types; in most cases, they can be defined to `Types.CHAR` or `Types.VARCHAR`.

Table 4–6 lists the valid column definition arguments you can use in the `defineColumnType()` method.

Table 4–6 Valid Column Type Specifications

If the column has Oracle SQL type:	You can use defineColumnType() to redefine it as:
NUMBER, VARNUM	BIGINT, TINYINT, SMALLINT, INTEGER, FLOAT, REAL, DOUBLE, NUMERIC, DECIMAL, CHAR, VARCHAR
CHAR, VARCHAR2	CHAR, VARCHAR
LONG	CHAR, VARCHAR, LONGVARCHAR
LONGRAW	LONGVARBINARY, VARBINARY, BINARY
RAW	VARBINARY, BINARY
DATE	DATE, TIME, TIMESTAMP, CHAR, VARCHAR
ROWID	ROWID

DatabaseMetaData TABLE_REMARKS Reporting

The `getColumns()`, `getProcedureColumns()`, `getProcedures()`, and `getTables()` methods of the database metadata classes are slow if they must report `TABLE_REMARKS` columns, because this necessitates an expensive outer join. For this reason, the JDBC driver does *not* report `TABLE_REMARKS` columns by default.

You can enable `TABLE_REMARKS` reporting by passing a `TRUE` argument to the `setRemarksReporting()` method of an `OracleConnection` object.

If you are using a standard `java.sql.Connection` object, you must cast it to `OracleConnection` to use `setRemarksReporting()`.

Example: TABLE_REMARKS Reporting Assuming `conn` is the name of your standard `Connection` object, the following statement enables `TABLE_REMARKS` reporting.

```
( (oracle.jdbc.driver.OracleConnection)conn ).setRemarksReporting(true);
```

Considerations for getProcedures() and getProcedureColumns() Methods According to JDBC versions 1.1 and 1.2, the methods `getProcedures()` and `getProcedureColumns()` treat the `catalog`, `schemaPattern`, `columnNamePattern` and `procedureNamePattern` parameters in the same way. In the Oracle definition of these methods, the parameters are treated differently:

- `catalog`: Oracle does not have multiple catalogs, but it does have packages. Consequently, the `catalog` parameter is treated as the package name. This

applies both on input (the `catalog` parameter) and output (the `catalog` column in the returned `ResultSet`). On input, the construct `" "` (the empty string) retrieves procedures and arguments without a package, that is, stand-alone objects. A `null` value means to drop from the selection criteria, that is, return information about both stand-alone and packaged objects (same as passing in "%"). Otherwise the `catalog` parameter should be a package name pattern (with SQL wild cards, if desired).

- `schemaPattern`: All objects within Oracle must have a schema, so it does not make sense to return information for those objects without one. Thus, the construct `" "` (the empty string) is interpreted on input to mean the objects in the current schema (that is, the one to which you are currently connected). To be consistent with the behavior of the `catalog` parameter, `null` is interpreted to drop the schema from the selection criteria (same as passing in "%"). It can also be used as a pattern with SQL wild cards.
- `procedureNamePattern` and `columnNamePattern`: The empty string (" ") does not make sense for either parameter, because all procedures and arguments must have names. Thus, the construct `" "` will raise an exception. To be consistent with the behavior of other parameters, `null` has the same effect as passing in "%".

Oracle Extensions for Connection Properties

One of the forms of the `DriverManager.getConnection()` method enables you to specify a URL and a properties object:

```
getConnection(String URL, Properties info);
```

where the URL is of the form:

```
jdbc:oracle:<drivertype>:@<database>
```

In addition to the URL, you use an object of the standard Java `Properties` class as input. For example:

```
java.util.Properties info = new java.util.Properties();
info.put ("user", "scott");
info.put ("password","tiger");
getConnection ("jdbc:oracle:oci8:",info);
```

Table 4–7 lists the connection properties that Oracle JDBC drivers support, including the Oracle extensions for `defaultRowPrefetch`, `remarksReporting`, and `defaultBatchValue`.

Table 4–7 Connection Properties Recognized by Oracle JDBC Drivers

Name	Short Name	Type	Description
user	N/A	String	the user name for logging into the database
password	N/A	String	the password for logging into the database
database	server	String	the connect string for the database; equivalent to using `setDefaultRowPrefetch()`
defaultRowPrefetch	prefetch	Integer	the default number of rows to prefetch from the server. The default value is 10.
remarksReporting	remarks	Boolean	true if `getTables()` and `getColumns()` should report `TABLE_REMARKS`; equivalent to using `setRemarksReporting()`. The default value is false.
defaultBatchValue	batchvalue	Integer	the default batch value that triggers an execution request. The default value is 10.

The following example shows how to use the `java.util.Properties.put()` method to set performance extension options before connection to the database.

```
//import packages and register the driver
import java.sql.*;
import java.math.*;
DriverManager.registerDriver (new oracle.jdbc.driver.OracleDriver());

//specify the properties object
java.util.Properties info = new java.util.Properties();
info.put("user", "scott");
info.put ("password", "tiger");
info.put ("defaultRowProfetch","20");
info.put ("defaultBatchValue", 5);

//specify the connection object
Connection conn = DriverManager.getConnection
("jdbc:oracle:thin:@database",info);
```

Additional Type Extensions

Oracle JDBC drivers support the Oracle-specific datatypes ROWID and REF CURSOR, which were introduced in Oracle7 and are not part of the standard JDBC specification.

ROWID is supported as a Java string and REF CURSOR as a JDBC result set.

Oracle ROWID Type

A ROWID is an identification tag that is unique for each row of an Oracle database table. ROWID can be thought of as a virtual column, containing the ID for each row.

The `oracle.sql.ROWID` class is supplied as a wrapper for ROWID SQL data.

ROWIDs provide functionality similar to the `java.sql.ResultSet.getCursorName()` and `java.sql.Statement.setCursorName()` JDBC methods, which are not supported by the Oracle implementation.

If you include the ROWID pseudo-column in a query, then you can retrieve the ROWIDs with the `ResultSet.getString()` method (passing in either the column index or the column name). You can also bind a ROWID to a `PreparedStatement` parameter with the `setString()` method. This allows in-place updates, as in the example that immediately follows.

Notes:

- The `oracle.sql.ROWID` class replaces `oracle.jdbc.driver.ROWID`, which was used in previous releases of Oracle JDBC.
- Refer to the Javadoc for information about features of the ROWID class.

Example: ROWID The following example shows how to access and manipulate ROWID data.

```
Statement stmt = conn.createStatement();

// Query the employee names with "FOR UPDATE" to lock the rows.
// Select the ROWID to identify the rows to be updated.

ResultSet rset =
   stmt.executeQuery ("SELECT ename, rowid FROM emp FOR UPDATE");
```

```
// Prepare a statement to update the ENAME column at a given ROWID

PreparedStatement pstmt =
   conn.prepareStatement ("UPDATE emp SET ename = ? WHERE rowid = ?");

// Loop through the results of the query
while (rset.next ())
{
    String ename = rset.getString (1);
    oracle.sql.ROWID rowid = rset.getROWID (2);  // Get the ROWID as a String
    pstmt.setString (1, ename.toLowerCase ());
    pstmt.setROWID (2, rowid); // Pass ROWID to the update statement
    pstmt.executeUpdate ();     // Do the update
}
```

Oracle REF CURSOR Type Category

A cursor variable holds the memory location (address) of a query work area rather than the contents of the area. So, declaring a cursor variable creates a pointer. In SQL, a pointer has the datatype REF *x* where REF is short for REFERENCE and *x* represents the entity that is being referenced. "REF CURSOR", then, identifies a reference to a cursor variable. Since many cursor variables might exist to point to many work areas, REF CURSOR can be thought of as a category or "datatype specifier" that identifies many different cursor variables.

To create a cursor variable, begin by identifying a user-defined type that belongs to the REF CURSOR category. For example:

```
DECLARE TYPE DeptCursorTyp IS REF CURSOR
```

Then create the cursor variable by declaring it to be of the user-defined type `DeptCursorTyp`:

```
dept_cv DeptCursorTyp  - - declare cursor variable
...
```

A REF CURSOR, then, is a *category* of datatype rather than a datatype.

Stored procedures can return user-defined types, or cursor variables, of the REF CURSOR category. This output is equivalent to a database cursor or a JDBC result set. A REF CURSOR essentially encapsulates the results of a query.

In JDBC, REF CURSORs are materialized as `ResultSet` objects and can be accessed like this:

1. Use a JDBC callable statement to call a stored procedure (it must be a callable statement as opposed to a prepared statement because there is an output parameter).
2. The stored procedure returns a REF CURSOR.
3. The Java application casts the callable statement to an Oracle callable statement and uses the `getCursor()` method of the `OracleCallableStatement` class to materialize the REF CURSOR as a JDBC `ResultSet` object.
4. The result set is processed as requested.

Example: Accessing REF CURSOR Data This example shows how to access REF CURSOR data.

```
import oracle.jdbc.driver.*;
...
CallableStatement cstmt;
ResultSet cursor;

// Use a PL/SQL block to open the cursor
cstmt = conn.prepareCall
         ("begin open ? for select ename from emp; end;");

cstmt.registerOutParameter(1, OracleTypes.CURSOR);
cstmt.execute();
cursor = ((OracleCallableStatement)cstmt).getCursor(1);

// Use the cursor like a normal ResultSet
while (cursor.next ())
    {System.out.println (cursor.getString(1));}
```

In the preceding example:

- A `CallableStatement` object is created by using the `prepareCall()` method of the connection class.
- The callable statement implements a PL/SQL procedure which returns a REF CURSOR.
- As always, the output parameter of the callable statement must be registered to define its type. The Oracle type code to use for a REF CURSOR is `OracleTypes.CURSOR`.
- The callable statement is executed, returning the REF CURSOR.

- The `CallableStatement` object is cast to an `OracleCallableStatement` object to use the `getCursor()` method, which is an Oracle extension to the standard JDBC API, and returns the `REF CURSOR` into a `ResultSet` object.

For a full sample application using a `REF CURSOR`, see "REF CURSOR Sample" on page 7-14.

Oracle JDBC Notes and Limitations

The following limitations exist in the Oracle JDBC implementation, but all are either insignificant or have easy work-arounds.

CursorName

Oracle JDBC drivers do not support the `getCursorName()` and `setCursorName()` methods because there is no convenient way to map them to Oracle constructs. Oracle recommends using `ROWID` instead. For more information on how to use and manipulate ROWIDs, see "Oracle ROWID Type" on page 4-111.

SQL92 Outer Join Escapes

Oracle JDBC drivers do not support SQL92 outer join escapes. Use Oracle SQL syntax with "(+)" instead. For more information on SQL92 syntax, see "Embedded SQL92 Syntax" on page 5-26.

PL/SQL TABLE, BOOLEAN and RECORD Types

Oracle JDBC drivers do not support calling arguments or return values of the PL/SQL `TABLE`, `BOOLEAN`, or `RECORD` types. This is a restriction of the OCI layer.

As a work-around for booleans, you can define an additional PL/SQL stored procedure that accepts the `BOOLEAN` argument as a `CHAR` or `NUMBER` and passes it as a `BOOLEAN` to the original stored procedure. For more information on this topic, see "Boolean Parameters in PL/SQL Stored Procedures" on page 6-7.

IEEE 754 Floating Point Compliance

The arithmetic for the Oracle `NUMBER` type does not comply with the IEEE 754 standard for floating-point arithmetic. Therefore there can be small disagreements between the results of computations performed by Oracle and the same computations performed by Java.

Oracle stores numbers in a format compatible with decimal arithmetic and guarantees 38 decimal digits of precision. It represents zero, minus infinity, and plus infinity exactly. For each positive number it represents, it represents a negative number of the same absolute value.

It represents every positive number between 10^{-30} and $(1 - 10^{-38}) * 10^{126}$ to full 38-digit precision.

Read-Only Connection

The read-only connection is not supported. There is no Oracle equivalent to the read-only connection.

Catalog Arguments to DatabaseMetaData Calls

Certain `DatabaseMetaData` methods define a `catalog` parameter. This parameter is one of the selection criteria for the method. Oracle does not have multiple catalogs, but it does have packages. For more information on how the Oracle JDBC drivers treat the `catalog` argument, see "DatabaseMetaData TABLE_REMARKS Reporting" on page 4-108.

SQLWarning Class

The `java.sql.SQLWarning` class provides information on a database access warning. Warnings typically contain a description of the warning and a code that identifies the warning. Warnings are silently chained to the object whose method caused it to be reported. The Oracle JDBC drivers do not support `SQLWarning`.

For information on how the Oracle JDBC drivers handle errors, see "Error Messages and JDBC" on page 3-25.

Bind by Name

Bind by name is not supported. Under certain circumstances previous versions of the Oracle JDBC drivers have allowed binding statement variables by name. In the following statement, the named variable `EmpId` would be bound to the integer `314159`.

```
PreparedStatement p = conn.prepareStatement("SELECT name FROM EMP
    WHERE id = :EmpId");
  p.setInt(1, 314159);
```

The capability is not part of the JDBC specification, either 1.0 or 2.0, and Oracle does not support it. The JDBC drivers can throw a `SQLException` or produce unexpected results.

Prior releases of the Oracle JDBC drivers did not retain bound values from one call of execute to the next as specified in JDBC 1.0. Bound values are now retained. For example:

```
PreparedStatement p = conn.prepareStatement("SELECT name FROM EMP
        WHERE id = :? AND dept = :?");
  p.setInt(1, 314159);
  p.setString(2, "SALES");
```

```
ResultSet r1 = p.execute();
p.setInt(1, 425260);
ResultSet r2 = p.execute();
```

Previously a `SQLException` would be thrown by the second execute since no value was bound to the second argument. In this release, the second execute will return the correct value, retaining the binding of the second argument to the string "SALES".

If the retained bound value is a stream, then the Oracle JDBC drivers will not reset the stream. Unless the application code resets, repositions, or otherwise modifies the stream, the subsequent execute calls will send `NULL` as the value of the argument.

5

Advanced Topics

This chapter describes advanced JDBC topics, including the following:

- Using NLS
- Working with Applets
- JDBC on the Server: the Server Driver
- Embedded SQL92 Syntax

Using NLS

This section contains these subsections:

Oracle's JDBC drivers support NLS (National Language Support). NLS lets you retrieve data or insert data into a database in any character set that Oracle supports. If the clients and the server use different character sets, the driver provides the support to perform the conversions between the database character set and the client character set.

For more information on NLS, NLS environment variables, and the character sets that Oracle supports, see the *Oracle8i National Language Support Guide*. See the *Oracle8i Reference* for more information on the database character set and how it is created.

Here are a few examples of commonly used Java methods for JDBC that rely heavily on NLS character set conversion:

- `java.sql.ResultSet` methods `getString()` and `getUnicodeStream()` return values from the database as Java strings and as a stream of Unicode characters, respectively.
- `oracle.sql.CLOB` method `getCharacterStream()` returns the contents of a `CLOB` as a Unicode stream.
- `oracle.sql.CHAR` methods `getString()`, `toString()`, and `getStringWithReplacement()` convert the following data to strings:
  - `getString()`: converts the sequence of characters represented by the `CHAR` object to a string and returns a Java `String` object.
  - `toString()`: identical to `getString()`, but if the character set is not recognized, `toString()` returns a hexadecimal representation of the `CHAR` data.
  - `getStringWithReplacement()`: identical to `getString()`, except characters that have no Unicode representation in the character set of this `CHAR` object are replaced by a default replacement character.

How JDBC Drivers Perform NLS Conversions

The techniques that Oracle's drivers use to perform character set conversion for Java applications depend on the character set the database uses. The simplest case is

where the database uses the US7ASCII or WE8ISO8859P1 character set. In this case, the driver converts the data directly from the database character set to UCS-2 which is used in Java applications.

If you are working with databases that employ a non-US7ASCII or non-WE8ISO8859P1 character set (for example, Japanese or Korean), then the driver converts the data, first to UTF-8, then to UCS-2. For example, the driver always converts CHAR and VARCHAR2 data in a non-US7ASCII, non-WE8ISO8859P1 character set. It does not convert RAW data.

> **Note:** The JDBC drivers perform all character set conversions transparently. No user intervention is necessary for the conversions to occur.

JDBC OCI Driver and NLS

In the case of a JDBC OCI driver installation, note that there is a client-side character set as well as a database character set. The client character set is determined at client-installation time by the value of the NLS_LANG environment variable. The database character set is determined at database creation. The character set used by the client can be different from the character set used by the database on the server. So, when performing character set conversion, the JDBC OCI driver has to take three factors into consideration:

- database character set and language
- client character set and language
- Java applications character set: UCS-2

The JDBC OCI driver transfers the data from the server to the client in the character set of the database. Depending on the value of the NLS_LANG environment variable, the driver handles character set conversions in one of two ways.

- If the value of NLS_LANG is not specified, or if it is set to the US7ASCII or WE8ISO8859P1 character set, then the JDBC OCI driver uses Java to convert the character set from US7ASCII or WE8ISO8859P1 directly to UCS-2.
- If the value of NLS_LANG is set to a non-US7ASCII or non-WE8ISO8859P1 character set, then the driver changes the value of the NLS_LANG parameter on the client to UTF-8. This happens automatically and does not require any user-intervention. OCI uses the value of NLS_LANG to convert the data from the database character set to UTF-8; the JDBC driver then converts the UTF-8 data to UCS-2.

Notes:

- The driver sets the value of NLS_LANG to UTF-8 to minimize the number of conversions it performs in Java. It performs the conversion from database character set to UTF-8 in C.
- The change to UTF-8 is for the JDBC application process only.
- For more information on the NLS_LANG parameter, see the *Oracle8i National Language Support Guide*.

JDBC Thin Driver and NLS

If your applications or applets use the JDBC Thin driver, then there will not be an Oracle client installation. Because of this, the OCI client conversion routines in C will not be available. In this case, the client conversion routines are different from the JDBC OCI driver.

If the database character set is US7ASCII or WE8ISO8859P1, then the data is transferred to the client without any conversion. The driver then converts the character set to UCS-2 in Java.

If the database character set is something other than US7ASCII or WE8ISO8859P1, then the server first translates the data to UTF-8 before transferring it to the client. On the client, the JDBC Thin driver converts the data to UCS-2 in Java.

Note: The OCI and Thin drivers both provide the same transparent support for NLS.

Server Driver and NLS

If your JDBC code running in the server accesses the database, then the JDBC Server driver performs a character set conversion based on the database character set. The target character set of all Java programs is UCS-2.

The JDBC Server driver supports the ASCII (US7ASCII) and ISO-Latin-1 (WE8ISO8859P1) character sets only.

Note: The Java VM supports only the English (US7ASCII) and ISO-Latin1 (WE8ISO8859P1) character sets.

NLS Restrictions

Data Size Restriction for NLS Conversions

There is a limit to the maximum sizes for CHAR and VARCHAR2 datatypes when used in bind calls. This limitation is necessary to avoid data corruption. This problem happens only with binds (not for defines) and it affects only CHAR and VARCHAR2 datatypes if you are connected to a multi-byte character set database.

The maximum bind lengths are limited in the following way:

CHARs and VARCHAR2s experience character set conversions that could result in an increase in the length of the data in bytes. The ratio between data sizes before and after a conversion is called the NLS Ratio. After conversion, the bind values should not be greater than 4 Kbytes (in Oracle8), or 2 Kbytes (in Oracle7).

Table 5–1 New Restricted Maximum Bind Length for Client-Side Drivers

Driver	Server Version	Datatype	Old Max Bind Length (bytes)	New Restricted Max Bind Length (bytes)
Thin and OCI	V8	CHAR	2000	min(2000,4000 / NLS_Ratio)
		VARCHAR2	4000	(4000 / NLS_Ratio)

For example, when connecting to an Oracle8 server, you cannot bind more than:

- min (2000, 4000 / NLS_RATIO) for CHAR types

OR

- 4000 / NLS_RATIO for VARCHAR2 types

Table 5–2 contains examples of the NLS Ratio and maximum bind values for some common server character sets.

Table 5–2 NLS Ratio and Size Limits for Common Server Character Sets

Server Character Set	NLS Ratio	Maximum Bind Value on Oracle8 Server (in bytes)
WE8DEC	1	4000

Table 5–2 NLS Ratio and Size Limits for Common Server Character Sets (Cont.)

Server Character Set	NLS Ratio	Maximum Bind Value on Oracle8 Server (in bytes)
US7ASCII	1	4000
ISO 8859-1 through 10	1	4000
JA16SJIS	2	2000
JA16EUC	3	1333

Working with Applets

This section describes some of the basics about working with applets that use the JDBC Thin driver. It begins with a simple example of coding a JDBC applet, it then describes what you must do to allow the applet to connect to a database. This includes how to use the Oracle8 Connection Manager or signed applets if you are connecting to a database that is not running on the same host as the web server. It also describes how your applet can connect to a database through a firewall. The section concludes with how to package and deploy the applet.

Coding Applets

Except for importing the JDBC interfaces to access JDBC entry points, you write a JDBC applet like any other Java applet. Depending on whether you are coding your applet for a JDK 1.1.1 browser or a JDK 1.0.2 browser, there are slight differences in the code that you use. In both cases, your applet must use the JDBC Thin driver, which connects to the database with TCP/IP protocol.

If you are targeting a JDK 1.1.1 browser (such as Netscape 4.*x* or Internet Explorer 4.*x*), then you must:

- import the `java.sql` package into your program. The `java.sql` package contains the standard JDBC 1.22 interfaces and is part of the standard JDK 1.1.1 class library.
- register the driver with the `oracle.jdbc.driver.OracleDriver()` class and specify the driver name in the connect string as `thin`.

If you are targeting a JDK 1.0.2 browser (such as Netscape 3.*x* or Internet Explorer 3.*x*), then you must:

- import the `jdbc.sql` package into your program.

  The `jdbc.sql` package is not a part of the standard JDK 1.0.2 class library. It is a separate library that you download as part of the JDBC distribution. The

`jdbc.sql` package was created because JDK 1.0.2 browsers do not allow packages starting with the string "`java`" to be downloaded. As a work-around, the `java.sql` package has been renamed to `jdbc.sql`. This renamed package is shipped with the Oracle JDBC product.

- register the driver with the `oracle.jdbc.dnlddriver.OracleDriver()` class and specify the driver name in the connect string as `dnldthin`.

The following sections illustrate the differences in coding an applet for a JDK 1.1.1 browser compared with a JDK 1.0.2 browser.

- Coding Applets for a JDK 1.1.1 Browser
- Coding Applets for a JDK 1.0.2 Browser

Coding Applets for a JDK 1.1.1 Browser

If you are coding an applet for a JDK 1.1.1 browser, then import the JDBC interfaces from the `java.sql` package and load the Oracle JDBC Thin driver.

```
import java.sql.*;
public class JdbcApplet extends java.applet.Applet
{
 Connection conn; // Hold the connection to the database
 public void init()
 {
 // Register the driver.
 DriverManager.registerDriver (new oracle.jdbc.driver.OracleDriver());
 // Connect to the database.
 conn = DriverManager.getConnection
 ("jdbc:oracle:thin:scott/tiger@www-aurora.us.oracle.com:1521:orcl");
 ...
 }
}
```

In this example, the connect string contains the username and password, but you can also pass them as arguments to `getConnection()` after obtaining them from the user. For more information on connecting to the database, see "Opening a Connection to a Database" on page 3-3.

Coding Applets for a JDK 1.0.2 Browser

If you are coding an applet for a JDK 1.0.2 browser, then import the JDBC interfaces from the `jdbc.sql` package, load the driver from the `oracle.jdbc.dnlddriver.OracleDriver()` class, and use the `dnldthin` sub-protocol in your connect string:

```
import jdbc.sql.*;
public class JdbcApplet extends java.applet.Applet
{
 Connection conn; // Hold the connection to the database
 public void init ()
 {
 // Register the driver
 DriverManager.registerDriver (new oracle.jdbc.dnlddriver.OracleDriver());
 // Connect to the database
 conn = DriverManager.getConnection
 ("jdbc:oracle:dnldthin:scott/tiger@www-aurora.us.oracle.com:1521:orcl");
 ...
 }
}
```

Connecting an Applet to a Database

This section includes the following subsections:

- Connecting to a Database on the Same Host as the Web Server
- Connecting to a Database on a Different Host
- Using the Oracle8 Connection Manager
- Using Signed Applets

The most common task of an applet using the JDBC driver is to connect to and query a database. Because of applet security restrictions, an applet can open TCP/IP sockets only to the host from which it was downloaded (this is the host on which the web server is running). This means that your applet can connect only to a database that is running on the same host as the web server. In this case, the applet can connect to the database directly; no additional steps are required.

However, a web server and an Oracle database server both require many resources; you seldom find both servers running on the same machine. Usually, your applet connects to a database on a host other than the one on which the web server runs. There are two possible ways in which you can work around the security restriction:

- You can connect to the database by using the Oracle8 Connection Manager.

OR

- If your web browser supports JDK 1.1.*x*, then you can use a signed applet to connect to the database directly.

This section begins with describing the most simple case, connecting to a database on the same host from which the applet was downloaded (that is, the same host as the web server). It then describes the two different ways in which you can connect to a database running on a different host.

Connecting to a Database on the Same Host as the Web Server

If your database is running on the same host from which the applet was downloaded, then you can connect to the database by specifying it in your applet. You specify the database in the connect string of the `getConnection()` method in the `DriverManager` class.

There are two ways in which you can specify the connection information to the driver. You can provide it in the form of `host:port:sid` or in the form of a TNS *keyword-value* syntax.

For example, if the database to which you want to connect resides on host `prodHost`, at port `1521`, and SID `ORCL`, and you want to connect with username `scott` with password `tiger`, then use either of the two following connect strings:

using `host:port:sid` syntax:

```
String connString="jdbc:oracle:thin:@prodHost:1521:ORCL";
conn = DriverManager.getConnection(connString, "scott", "tiger");
```

using TNS *keyword-value* syntax:

```
String connString = "jdbc:oracle:thin:@(description=(address_list=
    (address=(protocol=tcp)(port=1521)(host=prodHost)))
    (connect_data=(sid=ORCL)))"
conn = DriverManager.getConnection(connString, "scott", "tiger");
```

If you use the TNS *keyword-value* pair to specify the connection information to the JDBC Thin driver, then you must declare the protocol as TCP.

Connecting to a Database on a Different Host

If you are connecting to a database on a host other than the one on which the web server is running, then you must overcome the applet's security restrictions. You can do this by using either the Oracle8 Connection Manager or signed applets.

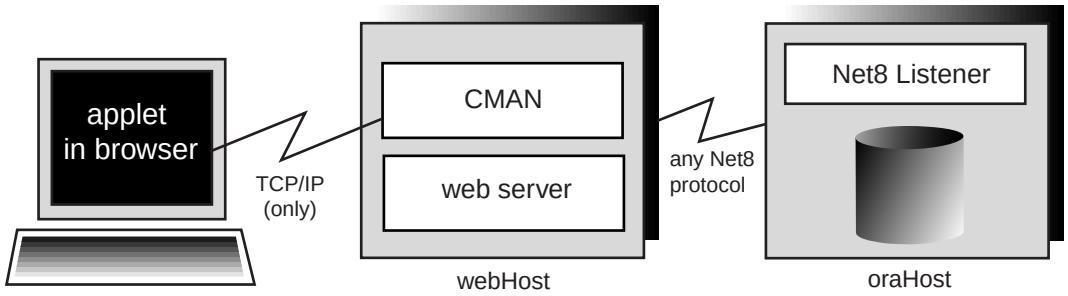
Using the Oracle8 Connection Manager

Oracle8 Connection Manager is a lightweight, highly-scalable program that can receive Net8 packets and re-transmit them to a different server. To a client running Net8, the Connection Manager looks exactly like a database server. An applet that

uses the JDBC Thin driver can connect to a Connection Manager running on the web server host and have the Connection Manager redirect the Net8 packets to an Oracle server running on a different host.

Figure 5–1 illustrates the relationship between the applet, the Oracle8 Connection Manager, and the database.

Figure 5–1 Applet, Connection Manager, and Database Relationship



Using the Oracle8 Connection Manager requires two steps that are described in these sections:

- Installing and Running the Oracle8 Connection Manager
- Writing the Connect String that Targets the Oracle8 Connection Manager

Installing and Running the Oracle8 Connection Manager You must install the Connection Manager on the web server host. You install it from the Oracle8 distribution media. Please refer to the *Net8 Administrator's Guide* if you need more help to install the Connection Manager.

On the web server host you must create a `CMAN.ORA` file in the `[ORACLE_HOME]/NET8/ADMIN` directory. The options you can declare in a `CMAN.ORA` file include firewall and connection pooling support. Please refer to the *Net8 Administrator's Guide* for more information on the options you can enter in a `CMAN.ORA` file.

Here is an example of a very simple `CMAN.ORA` file. Replace <*web-server-host*> with the name of your web server host. The fourth line in the file indicates that the connection manager is listening on port `1610`. You must use this port number in your connect string for JDBC.

```
cman = (ADDRESS_LIST =
        (ADDRESS = (PROTOCOL=TCP)
        (HOST=<web-server-host>)
        (PORT=1610)))

cman_profile = (parameter_list =
        (MAXIMUM_RELAYS=512)
        (LOG_LEVEL=1)
    (TRACING=YES)
        (RELAY_STATISTICS=YES)
        (SHOW_TNS_INFO=YES)
        (USE_ASYNC_CALL=YES)
        (AUTHENTICATION_LEVEL=0)
        )
```

Note that the Java Net8 version inside the JDBC Thin driver does not have authentication service support. This means that the `AUTHENTICATION_LEVEL` configuration parameter in the `CMAN.ORA` file must be set to `0`.

You can find a description of the options listed in the `CMAN.ORA` file in the *Net8 Administrator's Guide*.

After you create the file, start the Oracle8 Connection Manager at the operating system prompt with this command:

```
cmctl start
```

To use your applet, you must now write the connect string for it.

Writing the Connect String that Targets the Oracle8 Connection Manager This section describes how to write the connect string in your applet so that the applet connects to the Connection Manager, and the Connection Manager connects with the database. In the connect string, you specify an address list that lists the protocol, port, and name of the web server host on which the Connection Manager is running, followed by the protocol, port, and name of the host on which the database is running.

The following example describes the situation illustrated in Figure 5–1. The web sever on which the Connection Manager is running is on host `webHost` and is listening on port `1610`. The database to which you want to connect is running on host `oraHost`, listening on port `1521`, and SID `ORCL`. You write the connect string in TNS *keyword-value* format:

```
Connection conn =
    DriverManager.getConnection ("jdbc:oracle:thin:" +
```

```
    "@(description=(address_list=" +
    "(address=(protocol=tcp)(host=webHost)(port=1610))" +
    "(address=(protocol=tcp)(host=oraHost)(port=1521)))" +
    "(source_route=yes)" +
    "(connect_data=(sid=orcl)))", "scott", "tiger");
```

The first element in the `address_list` entry represents the connection to the Connection Manager. The second element represents the database to which you want to connect. The order in which you list the addresses is important.

Notice that you can also write the same connect string in this format:

```
String connString =
    "jdbc:oracle:thin:@(description=(address_list=
    (address=(protocol=tcp)(port=1610)(host=webHost))
    (address=(protocol=tcp)(port=1521)(host=oraHost)))
    (connect_data=(sid=orcl))
    (source_route=yes))";
Connection conn = DriverManager.getConnection(connString, "scott", "tiger");
```

When your applet uses a connect string such as the one above, it will behave exactly as if it were connected directly to the database on the host `oraHost`.

For more information on the parameters that you specify in the connect string, see the *Net8 Administrator's Guide*.

Connecting through Multiple Connection Managers Your applet can reach its target database even if it first has to go through multiple Connection Managers (for example, if the Connection Managers form a "proxy chain"). To do this, add the addresses of the Connection Managers to the address list, in the order that you plan to access them. The database listener should be the last address on this list. See the *Net8 Administrator's Guide* for more information about `source_route` addressing.

Using Signed Applets

If your browser supports JDK 1.1.*x*, (for example, Netscape 4.0), then you can use signed applets. Signed applets can request socket connection privileges to other machines. To set this up, you must:

1. Sign the applet. For information on the steps you must follow to sign an applet, see Sun Microsystem's *Signed Applet Example* at:

   `http://java.sun.com/security/signExample/index.html`

2. Include applet code that asks for appropriate permission before opening a socket.

   If you are using Netscape, then your code would include a statement like this:

   ```
   netscape.security.PrivilegeManager.enablePrivilege("UniversalConnect");
       Connection conn = DriverManager.getConnection(...);
   ```

   For more information on writing applet code that asks for permissions, see Netscape's *Introduction to Capabilities Classes* at:

```
http://developer.netscape.com/docs/manuals/signedobj/capabilities/contents.htm
```

3. You must obtain an object-signing certificate. See Netscape's *Object-Signing Resources* page at:

   ```
   http://developer.netscape.com/software/signedobj/index.html
   ```

   for information on obtaining and installing a certificate.

For a complete example of a signed applet that uses the Netscape Capabilities classes, see "Creating Signed Applets" on page 7-31.

Using Applets with Firewalls

Under normal circumstances, an applet that uses the JDBC Thin Driver cannot access the database through a firewall. In general, the purpose of a firewall is to prevent requests from unauthorized clients from reaching the server. In the case of applets trying to connect to the database, the firewall prevents the opening of a TCP/IP socket to the database.

You can solve this problem by using a Net8-compliant firewall and connect strings that comply with the firewall configuration. Net8-compliant firewalls are available from many leading vendors; a more detailed discussion of these firewalls is beyond the scope of this manual.

An unsigned applet can access only the same host from which it was downloaded. In this case, the Net8-compliant firewall must be installed on that host. In contrast, a signed applet can connect to any host. In this case, the firewall on the target host controls the access.

The following sections describe these topics:

- How Firewalls Work
- Configuring a Firewall for Applets that use the JDBC Thin Driver

- Writing a Connect String to Connect through a Firewall

How Firewalls Work

Firewalls are rule-based. They have a list of rules that define which clients can connect, and which cannot. Firewalls compare the client's hostname with the rules, and based on this comparison, either grant the client connect access or not. If the hostname lookup fails, the firewall tries again. This time, the firewall extracts the IP address of the client and compares it to the rules. The firewall is designed to do this so that users can specify rules that include hostnames as well as IP addresses.

Connecting through a firewall requires two steps that are described in the following sections:

- Configuring a Firewall for Applets that use the JDBC Thin Driver
- Writing a Connect String to Connect through a Firewall

Configuring a Firewall for Applets that use the JDBC Thin Driver

The instructions in this section assume that you are running a Net8-compliant firewall.

Java applets do not have access to the local system (that is, they cannot get the hostname locally or environment variables) because of security limitations. As a result, the JDBC Thin driver cannot access the hostname on which it is running. The firewall cannot be provided with the hostname. To allow requests from JDBC Thin clients to go through the firewall, you must do the following two things to the firewall's list of rules:

- Add the IP address (not the hostname) of the host on which the JDBC applet is running.
- Ensure that the hostname "`__jdbc__`" never appears in the firewall's rules. This hostname has been hard-coded as a bogus hostname inside the driver to force an IP address lookup. If you do enter this hostname in the list of rules, then every applet using Oracle's JDBC Thin driver will be able to go through your firewall.

By not including the Thin driver's hostname, the firewall is forced to do an IP address lookup and base its access decision on the IP address and not on the hostname.

Writing a Connect String to Connect through a Firewall

To write a connect string that allows you to connect through a firewall, you must specify the name of the firewall host and the name of the database host to which you want to connect.

For example, if you want to connect to a database on host `oraHost`, listening on port `1521` and SID `ORCL`, and you are going though a firewall on host `fireWallHost`, listening on port `1610`, then use the following connect string:

```
Connection conn =
       DriverManager.getConnection ("jdbc:oracle:thin:" +
       "@(description=(address_list=" +
       (address=(protocol=tcp)(host=<firewall-host>)(port=1610))" +
       "(address=(protocol=tcp)(host=oraHost)(port=1521)))" +
       "(source_route=yes)" +
       "(connect_data=(sid=orcl)))", "scott", "tiger");
```

Note: To connect through a firewall, you cannot specify the connection string in `host:port:sid` syntax. For example, a connection string specified as:

```
String connString =
"jdbc:oracle:thin:@ixta.us.oracle.com:1521:orcl";

conn =DriverManager.getConnection (connString,
"scott", "tiger");
```

will not work.

The first element in the `address_list` represents the connection to the firewall. The second element represents the database to which you want to connect. Note that the order in which you specify the addresses is important.

Notice that you can also write the preceding connect string in this format:

```
String connString =
       "jdbc:oracle:thin:@(description=(address_list=
       (address=(protocol=tcp)(port=1600)(host=fireWallHost))
       (address=(protocol=tcp)(port=1521)(host=oraHost)))
       (connect_data=(sid=orcl))
       (source_route=yes))";
Connection conn = DriverManager.getConnection(connString, "scott", "tiger");
```

When your applet uses a connect string similar to the one above, it will behave as if it were connected to the database on host `oraHost`.

> **Note:** All of the parameters shown in the preceding example are required. In the `address_list`, the firewall address must precede the database server address.

For more information on the parameters used in the above example, see the *Net8 Administrator's Guide*. For more information on how to configure a firewall, please see your firewall's documentation or contact your firewall vendor.

Packaging Applets

After you have coded your applet, you must package it and make it available to users. To package an applet you need your applet classes files and the JDBC driver classes file (this will be either `classes111.zip` if you are targeting the applet to a browser running JDK 1.1.1, or `classes102.zip` if you are targeting the applet to a browser running JDK 1.0.2).

Follow these steps:

1. Move the JDBC driver classes file `classes111.zip` (or `classes102.zip`) to an empty directory.
2. Unzip the driver classes zip file.

   If you are targeting a browser running the JDK 1.0.2, then **DELETE** the packages listed in the left-hand column of the following table. Next, ensure that the packages listed in the right-hand column are present. All of the packages listed in the table are included in the JDBC distribution.

DELETE these packages:	Ensure that these packages are present:
java.sql	jdbc.sql
java.math	jdbc.math
oracle.jdbc.driver	oracle.jdbc.dnlddriver
oracle.jdbc.dbaccess	oracle.jdbc.dnlddbaccess
oracle.jdbc.oracore	oracle.jdbc.dnldoracore
oracle.jdbc.util	oracle.jdbc.dnldutil

DELETE these packages:	Ensure that these packages are present:
oracle.jdbc.ttc7	oracle.jdbc.dnldttc7
oracle.sql	oracle.sdnldql
oracle.jdbc2	oracle.dnldjdbc2
java.io.Reader	jdbc.io.Reader
java.io.Writer	jdbc.io.Writer

3. Add your applet classes files to the directory, and any other files the applet might require.
4. Zip the applet classes and driver classes together into a single zip (or `.jar`) file.

   To target a browser running the JDK 1.1.1, the single zip file should contain:

   - the files from `classes111.zip`
   - your applet classes
   - If you are using DatabaseMetaData entry points in your applet, include the `oracle/jdbc/driver/OracleDatabaseMetaData.class` file. Note that this file is very large and might have a negative impact on performance. If you do not use DatabaseMetadata entry points, omit this file.

   To target a browser running the JDK 1.0.2, the single zip file should contain:

   - the files from `classes102.zip` (minus the files you deleted in Step 2)
   - your applet classes
   - the `jdbc` interface files from the `jdbc.sql` package in the `classes/jdbc/sql` directory of the JDBC distribution

   Note: If you are targeting your applet at a browser running the JDK 1.0.2, then you *must* package the applet in a zip file. Browsers running the JDK 1.0.2 do not support `.jar` files.

5. Ensure that the zip (or `.jar`) file is *not* compressed.

You can now make the applet available to users. One way to do this is to add the APPLET tag to the HTML page from which the applet will be run. For example:

```
<APPLET WIDTH=500 HEIGHT=200 CODE=JdbcApplet ARCHIVE=JdbcApplet.zip
        CODEBASE=Applet_Samples
</APPLET>
```

You can find a description of the APPLET, CODE, ARCHIVE, CODEBASE, WIDTH, and HEIGHT parameters in the next section.

Specifying an Applet in an HTML Page

The APPLET tag specifies an applet that runs in the context of an HTML page. The APPLET tag can have these parameters: CODE, ARCHIVE, CODEBASE, WIDTH, and HEIGHT to specify the name of the applet and its location, and the height and width of the applet display area. These parameters are described in the following sections.

CODE, HEIGHT, and WIDTH

The HTML page that runs the applet must have an APPLET tag with an initial width and height to specify the size of the applet display area. You use the HEIGHT and WIDTH parameters to specify the size, measured in pixels. This size should not count any windows or dialogs that the applet opens.

The APPLET tag must also specify the name of the file that contains the applet's compiled Applet subclass. You specify the file name with the CODE parameter. Any path must be relative to the base URL of the applet. The path cannot be absolute.

In the following example, `JdbcApplet.class` is the name of the Applet's compiled applet subclass:

```
<APPLET CODE="JdbcApplet" WIDTH=500 HEIGHT=200>
</APPLET>
```

If you use this form of the CODE tag, then the classes for the applet and the classes for the JDBC Thin driver must be in the same directory as the HTML page.

Notice that in the CODE specification, you do not include the file name extension "`.class`".

CODEBASE

The CODEBASE parameter is optional and specifies the base URL of the applet; that is, the name of the directory that contains the applet's code. If it is not specified, then the document's URL is used. This means that the classes for the applet and the JDBC Thin driver must be in the same directory as the HTML page. For example, if the current directory is `my_Dir`:

```
<APPLET WIDTH=500 HEIGHT=200 CODE=JdbcApplet CODEBASE="."
</APPLET>
```

The entry `CODEBASE="."` indicates that the applet resides in the current directory (`my_Dir`). If the value of `codebase` was set to `Applet_Samples`, for example:

```
CODEBASE="Applet_Samples"
```

then this would indicate that the applet resides in the `my_Dir/Applet_Samples` directory.

ARCHIVE

The `ARCHIVE` parameter is optional and specifies the name of the archive file (either a `.zip` or `.jar` file) that contains the applet classes and resources the applet needs. Oracle recommends the use of a `.zip` file, which saves many extra roundtrips to the server.

The `.zip` (or `.jar`) file will be preloaded. If you have more than one archive in the list, separate them with commas. In the following example, the class files are stored in the archive file `JdbcApplet.zip`:

```
<APPLET CODE="JdbcApplet" ARCHIVE="JdbcApplet.zip" WIDTH=500 HEIGHT=200>
</APPLET>
```

Note: Version 3.0 browsers do not support the `ARCHIVE` parameter.

Browser Security and JDK Version Considerations

The communication between an applet that uses the JDBC Thin driver and the Oracle database happens on top of Java TCP/IP sockets.

In a JDK 1.0.2-based web browser, such as Netscape 3.0, an applet can open sockets only to the host from which it was downloaded. For Oracle8 this means that the applet can only connect to a database running on the same host as the web server. If you want to connect to a database running on a different host, then you must connect through the Oracle8 Connection Manager. For more information, see "Using the Oracle8 Connection Manager" on page 5-10.

In a JDK 1.1.1-based web browser, such as Netscape 4.0, an applet can request socket connection privileges and connect to a database running on a different host from the web server host. In Netscape 4.0 you perform this by signing your applet (that is, writing a signed applet), then opening your connection as follows:

```
netscape.security.PrivilegeManager.enablePrivilege
        ("UniversalConnect");
connection = DriverManager.getConnection
        ("jdbc:oracle:thin:scott/tiger@dlsun511:1721:orcl");
```

Please refer to your browser documentation for more information on how to work with signed applets. You can also refer to "Using Signed Applets" on page 5-13.

JDBC on the Server: the Server Driver

This section has the following subsections:

Any Java program, Enterprise JavaBean (EJB), or Java stored procedure that runs in the database, can use the Server driver to access the SQL engine.

The Server driver is intrinsically tied to the 8.1 database and to the Java VM. The driver runs as part of the same process as the database. It also runs within the default session: this is the same session in which the Java VM was invoked.

The Server driver is optimized to run within the database server and provide direct access to SQL data and PL/SQL subprograms on the local database. The entire Java VM operates in the same address space as the database and the SQL engine. Access to the SQL engine is a function call; there is no network. This enhances the performance of your JDBC programs and is much faster than executing a remote Net8 call to access the SQL engine.

The server-side driver supports the same features, APIs, and Oracle extensions as the client-side drivers. This makes application partitioning very straight forward. For example, if you have a Java application that is data-intensive, you can easily move it into the database server for better performance, without having to modify the application-specific calls.

Connecting to the Database with the Server Driver

As described in the preceding section, the Server driver runs within a default session. You are already "connected". You can use either the Oracle-specific API `defaultConnection()` method or the standard Java `DriverManager.getConnection()` method to access the default connection.

Connecting with defaultConnection()

The `defaultConnection()` method of the `oracle.jdbc.driver.OracleServerDriver` class is an Oracle extension and always returns the same connection object. You do not need to include a connect string with the statement. For example:

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

```
import oracle.jdbc.driver.*;

class JDBCConnection {
  public static Connection connect() throws SQLException {
    Connection conn = null;
    try {
      // connect with the Server driver
         OracleDriver ora = new OracleDriver();
         conn = ora.defaultConnection();
      }

    } catch (SQLException e)
    return conn;
  }
}
```

Note that there is no `conn.close` statement. You cannot close a default connection made by the Server driver. Calling `close()` on the connection is just a no-op.

Connecting with DriverManager.getConnection()

The `DriverManager.getConnection()` method returns a new Java `Connection` object every time you call it. Note that although the method is not creating a new connection, it is returning a new object.

The fact that `DriverManager.getConnection()` returns a new connection object every time you call it is significant if you are working with object maps (or "type maps"). A type map is associated with a specific `Connection` object and with any state that is part of the object. If you want to use multiple type maps as part of your program, then you can call `getConnection()` to create a new `Connection` object for each type map.

If you connect to the database with the `DriverManager.getConnection()` method, then use the connect string `jdbc:oracle:kprb:`. For example:

```
DriverManager.getConnection("jdbc:oracle:kprb:");
```

Note that you could include a user name and password in the string, but because you are connecting from the server, they would be ignored.

Session and Transaction Context for the Server Driver

The server-side driver operates within a default session and default transaction context. The default session is the session in which the Java VM was invoked. In effect, you are already connected to the database on the server. This is different from

the client side where there is no default session: you must explicitly connect to the database.

If you run Java application code in the server, then you can manage the transaction (COMMITs and ROLLBACKs) explicitly.

Testing JDBC on the Server

Almost any JDBC program that can run on a client can also run on the server. All of the programs in the `samples` directory can be run on the server with only minor modifications. Usually, these modifications concern only the connection statement.

For example, consider the test program `JdbcCheckup.java` described in "Testing JDBC and the Database Connection: JdbcCheckup" on page 2-8. If you want to run this program on the server and connect with the `DriverManager.getConnection()` method, then open the file in your favorite text editor and change the driver name in the connection string from "`oci8`" to "`kprb`". For example:

```
Connection conn =
    DriverManager.getConnection ("jdbc:oracle:kprb:@" +
                                 database, user, password);
```

The advantage of using this method is that you need to change only a short string in your original program. The disadvantage is that you still must provide the user, password, and database information even though the driver will discard it. In addition, if you issue the `getConnection()` method again, the driver will create another new (and unnecessary) connection object.

However, if you connect with `defaultConnection()`, the preferred method of connecting to the database from the Server driver, you do not have to enter any user, password, or database information. You can delete these statements from your program.

For the connection statement, use:

```
Connection conn =  new oracle.jdbc.driver.OracleDriver ().defaultConnection ();
```

The following example is a rewrite of the `JdbcCheckup.java` program which uses the `defaultConnection()` connection statement. The connection statement is printed in bold. The unnecessary user, password, and database information statements, along with the utility function to read from standard input, have been deleted.

```
/*
 * This sample can be used to check the JDBC installation.
 * Just run it and provide the connect information.  It will select
 * "Hello World" from the database.
 */
// You need to import the java.sql package to use JDBC
import java.sql.*;
// We import java.io to be able to read from the command line
import java.io.*;

class JdbcCheckup
{
    public static void main (String args [])
         throws SQLException, IOException
        {
            Connection conn =  new oracle.jdbc.driver.OracleDriver
            ().defaultConnection ();

            // Create a statement
            Statement stmt = conn.createStatement ();

            // Do the SQL "Hello World" thing
            ResultSet rset = stmt.executeQuery ("SELECT 'Hello World'
                                                 FROM dual");

            while (rset.next ())
               System.out.println (rset.getString (1));
            System.out.println ("Your JDBC installation is correct.");
        }
}
```

Server Driver Support for NLS

For a description of how the Server driver handles database character set conversions for Java programs, see "Server Driver and NLS" on page 5-4.

Character Set Conversion of oracle.sql.CHAR Data

The Server driver performs character set conversions for `oracle.sql.CHAR` in C; this is a different implementation than for the client-side drivers. The client-side drivers perform character set conversions for `oracle.sql.CHAR` in Java. For more information on the `oracle.sql.CHAR` class, see "Class oracle.sql.CHAR" on page 4-19.

Embedded SQL92 Syntax

Oracle's JDBC drivers support some embedded SQL92 syntax. This is the syntax that you specify between curly braces. The current support is basic. This section describes the support offered by the drivers for the following SQL92 constructs:

- Time and Date Literals
- Scalar Functions
- LIKE Escape Characters
- Outer Joins
- Function Call Syntax

Where driver support is limited, these sections also describe possible work-arounds.

Disabling Escape Processing Escape processing for SQL92 syntax is enabled by default. The JDBC drivers perform escape substitution before sending the SQL code to the database. If you want the driver to use regular Oracle SQL syntax instead of SQL92 syntax, then use this statement:

```
stmt.setEscapeProcessing(false)
```

> **Note:** Since prepared statements have usually been parsed prior to making a call to `setEscapeProcessing()`, disabling escape processing for prepared statements will probably have no affect.

Time and Date Literals

Databases differ in the syntax they use for date, time, and timestamp literals. JDBC supports dates and times written only in a specific format. This section describes the formats you must use for date, time, and timestamp literals in SQL statements.

Date Literals

The JDBC drivers support date literals in SQL statements written in the format:

```
{d 'yyyy-mm-dd'}
```

where `yyyy-mm-dd` represents the year, month, and day; for example, `{d '1998-10-22'}`. The JDBC drivers will replace this escape clause with the equivalent Oracle representation: "22 OCT 1998".

This code snippet contains an example of using a date literal in a SQL statement.

```
// Connect to the database
// You can put a database name after the @ sign in the connection URL.
Connection conn =
       DriverManager.getConnection ("jdbc:oracle:oci8:@", "scott", "tiger");

// Create a Statement
Statement stmt = conn.createStatement ();

// Select the ename column from the emp table where the hiredate is Jan-23-1982
ResultSet rset = stmt.executeQuery
       ("SELECT ename FROM emp WHERE hiredate = {d '1982-01-23'}");

// Iterate through the result and print the employee names
while (rset.next ())
       System.out.println (rset.getString (1));
```

Time Literals

The JDBC drivers support time literals in SQL statements written in the format:

```
{t 'hh:mm:ss'}
```

where `hh:mm:ss` represents the hours, minutes, and seconds; for example, `{t '05:10:45'}`. The JDBC drivers will replace this escape clause with the equivalent Oracle representation: "05:10:45". If the time is specified as `{t '14:20:50'}`, then the equivalent Oracle representation would be "14:20:50", assuming the server is using a 24-hour clock.

This code snippet contains an example of using a time literal in a SQL statement.

```
ResultSet rset = stmt.executeQuery
       ("SELECT ename FROM emp WHERE hiredate = {t '12:00:00'}");
```

Timestamp Literals

The JDBC drivers support timestamp literals in SQL statements written in the format:

```
{ts 'yyyy-mm-dd hh:mm:ss.f...'}
```

where `yyyy-mm-dd hh:mm:ss.f...` represents the year, month, day, hours, minutes, and seconds. The fractional seconds portion (".f...") is optional and can be omitted. For example: `{ts '1997-11-01 13:22:45'}` represents, in Oracle format, NOV 01 1997 13:22:45.

This code snippet contains an example of using a timestamp literal in a SQL statement.

```
ResultSet rset = stmt.executeQuery
       ("SELECT ename FROM emp WHERE hiredate = {ts '1982-01-23 12:00:00'}");
```

Scalar Functions

The Oracle JDBC drivers do not support all scalar functions. To find out which functions the drivers support, use the following methods which are supported by the Oracle-specific `oracle.jdbc.driver.OracleDatabaseMetaData` and the standard Java `java.sql.DatabaseMetadata` interfaces:

- `getNumericFunctions()`: returns a comma-separated list of math functions supported by the driver. For example, ABS(*number*), COS(*float*), SQRT(*float*).
- `getStringFunctions()`: returns a comma-separated list of string functions supported by the driver. For example, ASCII(*string*), LOCATE(*string1*, *string2*, *start*).
- `getSystemFunctions()`: returns a comma-separated list of system functions supported by the driver. For example, DATABASE(), IFNULL(*expression*, *value*), USER().
- `getTimeDateFunctions()`: returns a comma-separated list of time and date functions supported by the driver. For example, CURDATE(), DAYOFYEAR(*date*), HOUR(*time*).

Oracle's JDBC drivers do not support the function keyword, '`fn`'. If you try to use this keyword, for example:

```
{fn concat ("Oracle", "8i") }
```

you will get the error "`Non supported SQL92 token at position xx: fn`" when you run your Java application. The work-around is to use Oracle SQL syntax.

For example, instead of using the `fn` keyword in embedded SQL92 syntax:

```
Statement stmt = conn.createStatement ();
stmt.executeUpdate("UPDATE emp SET ename = {fn CONCAT('My', 'Name')}");
```

use Oracle SQL syntax:

```
stmt.executeUpdate("UPDATE emp SET ename = CONCAT('My', 'Name')");
```

LIKE Escape Characters

The characters "%" and "_" have special meaning in SQL LIKE clauses (you use "%" to match zero or more characters, "_" to match exactly one character). If you want to interpret these characters literally in strings, you precede them with a special escape character. For example, if you want to use the ampersand "&" as the escape character, you identify it in the SQL statement as {escape '&'}:

```
Statement stmt = conn.createStatement ();

// Select the empno column from the emp table where the ename starts with '_'
ResultSet rset = stmt.executeQuery("SELECT empno FROM emp WHERE ename LIKE '&_%'
{ESCAPE '&'}");

// Iterate through the result and print the employee numbers
while (rset.next ())
        System.out.println (rset.getString (1));
```

Note: If you want to use the back slash character (\) as an escape character, you must enter it twice (that is, \\). For example:

```
ResultSet rset = stmt.executeQuery("SELECT empno FROM emp WHERE
ename LIKE '\\_%' {escape '\\'}");
```

Outer Joins

Oracle's JDBC drivers do not support outer join syntax: {*oj outer-join*}. The work-around is to use Oracle outer join syntax:

Instead of:

```
Statement stmt = conn.createStatement ();
ResultSet rset = stmt.executeQuery
        ("SELECT ename, dname
         FROM {OJ dept LEFT OUTER JOIN emp ON dept.deptno = emp.deptno}
         ORDER BY ename");
```

Use Oracle SQL syntax:

```
Statement stmt = conn.createStatement ();
ResultSet rset = stmt.executeQuery
        ("SELECT ename, dname
         FROM emp a, dept b WHERE a.deptno = b.deptno(+)
         ORDER BY ename");
```

Function Call Syntax

Oracle's JDBC drivers support the function call syntax shown below:

Calls without a return value:

```
{ call procedure_name (argument1, argument2,...) }
```

Calls with a return value:

```
{ ? = call procedure_name (argument1, argument2,...) }
```

SQL92 to SQL Syntax Example

You can write a simple program to translate SQL92 syntax to standard SQL syntax. The following program prints the comparable SQL syntax for SQL92 statements for function calls, date literals, time literals, and timestamp literals. In the program, the `oracle.jdbc.driver.OracleSql.parse()` method performs the conversions.

```
import oracle.jdbc.driver.OracleSql;

public class Foo
{
    public static void main (String args[]) throws Exception {
        show ("{call foo(?, ?)}");
        show ("{? = call bar (?, ?)}");
        show ("{d '1998-10-22'}");
        show ("{t '16:22:34'}");
        show ("{ts '1998-10-22 16:22:34'}");
        }

    public static void show (String s) throws Exception {
        System.out.println (s + " => " + new OracleSql().parse (s));
      }
}
```

The following code is the output which prints the comparable SQL syntax.

```
{call foo(?, ?)} => BEGIN foo(:1, :2); END;
{? = call bar (?, ?)} => BEGIN :1 := bar (:2, :3); END;
{d '1998-10-22'} => TO_DATE ('1998-10-22', 'YYYY-MM-DD')
{t '16:22:34'} => TO_DATE ('16:22:34', 'HH24:MI:SS')
{ts '1998-10-22 16:22:34'} => TO_DATE ('1998-10-22 16:22:34', 'YYYY-MM-DD
HH24:MI:SS')
```

6

Coding Tips and Troubleshooting

This chapter describes how to optimize and troubleshoot a JDBC application or applet, including the following topics:

- JDBC and Multi-Threading
- Performance Optimization
- Common Problems
- Basic Debugging Procedures
- Transaction Isolation Levels and the Oracle Server

JDBC and Multi-Threading

The Oracle JDBC drivers provide full support for programs that use multiple threads. The following example program uses the default Oracle employee database emp. The program creates a number of threads. Each thread opens a connection and sends a query to the database for the contents of the emp table. The program then displays the thread and the employee name and employee ID associated with it.

Execute the program by entering:

```
java JdbcMTSample [number_of_threads]
```

on the command line where *number_of_threads* is the number of threads that you want to create. If you do not specify the number of threads, then the program creates 10 by default.

```
import java.sql.*;
import oracle.jdbc.driver.OracleStatement;

public class JdbcMTSample extends Thread
{
    // Set default number of threads to 10
    private static int NUM_OF_THREADS = 10;

    int m_myId;

    static     int c_nextId = 1;
    static  Connection s_conn = null;

    synchronized static int getNextId()
    {
        return c_nextId++;
    }

    public static void main (String args [])
    {
        try
        {
            // Load the JDBC driver //
            DriverManager.registerDriver
                     (new oracle.jdbc.driver.OracleDriver());

            // If NoOfThreads is specified, then read it
            if (args.length > 1) {
                System.out.println("Error: Invalid Syntax. ");
                System.out.println("java JdbcMTSample [NoOfThreads]");
```

```
            System.exit(0);
        }
        else if (args.length == 1)
            NUM_OF_THREADS = Integer.parseInt (args[0]);

        // Create the threads
        Thread[] threadList = new Thread[NUM_OF_THREADS];

        // spawn threads
        for (int i = 0; i < NUM_OF_THREADS; i++)
        {
            threadList[i] = new JdbcMTSample();
            threadList[i].start();
        }

        // wait for all threads to end
        for (int i = 0; i < NUM_OF_THREADS; i++)
        {
                threadList[i].join();
        }

      }
      catch (Exception e)
      {
          e.printStackTrace();
      }
  }
}
  public JdbcMTSample()
  {
     super();
     // Assign an ID to the thread
     m_myId = getNextId();
  }

public void run()
{
    Connection conn = null;
    ResultSet     rs   = null;
    Statement  stmt = null;

    try
    {
          // Get the connection
          conn = DriverManager.getConnection("jdbc:oracle:oci8:@",
```

```
                                        "scott","tiger");

            // Create a Statement
            stmt = conn.createStatement ();

            // Execute the Query
            rs = stmt.executeQuery ("SELECT * FROM emp");

            // Loop through the results
            while (rs.next())
                System.out.println("Thread " + m_myId +
                                   " Employee Id : " + rs.getInt(1) +
                                   " Name : " + rs.getString(2));

            // Close all the resources
            rs.close();
              stmt.close();
            if (conn != null)
                conn.close();
            System.out.println("Thread " + m_myId +  " is finished. ");
        }
        catch (Exception e)
        {
            System.out.println("Thread " + m_myId + " got Exception: " + e);
            e.printStackTrace();
            return;
        }
    }

}
```

Performance Optimization

You can significantly enhance the performance of your JDBC programs by using any of these features:

- Disabling Auto-Commit Mode
- Prefetching Rows
- Batching Updates

Disabling Auto-Commit Mode

Auto-commit mode indicates to the database whether to issue an execute and commit after every SQL statement. Being in auto-commit mode can be expensive in terms of time and processing effort if, for example, you are repeating the same statement with different bind variables.

By default, new connection objects are in auto-commit mode. However, you can disable auto-commit mode with the `setAutoCommit()` method of the connection object (either `java.sql.Conection` or `oracle.jdbc.OracleConnection`).

In auto-commit mode, the commit occurs either when the statement completes or the next execute occurs, whichever comes first. In the case of statements returning a `ResultSet`, the statement completes when the last row of the `ResultSet` has been retrieved or when the `ResultSet` has been closed. In more complex cases, a single statement can return multiple results as well as output parameter values. Here, the commit occurs when all results and output parameter values have been retrieved.

If you disable auto-commit mode (`setAutoCommit(false)`), then the JDBC driver groups the connection's SQL statements into transactions that it terminates by either a `commit()` or `rollback()` statement.

Example: Disabling AutoCommit The following example illustrates loading the driver and connecting to the database. Since new connections are in auto-commit mode by default, this example shows how to disable auto-commit. In the example, `conn` represents the `Connection` object and `stmt` represents the `Statement` object.

```
// Load the Oracle JDBC driver
DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

    // Connect to the database
    // You can put a database hostname after the @ sign in the connection URL.
    Connection conn =
```

```
  DriverManager.getConnection ("jdbc:oracle:oci8:@", "scott", "tiger");

// It's faster when auto commit is off
conn.setAutoCommit (false);

// Create a Statement
Statement stmt = conn.createStatement ();
...
```

Prefetching Rows

Oracle JDBC drivers allow you to set the number of rows to prefetch into the client while the result set is being populated during a query. The default number of rows to prefetch is 10. Prefetching row data into the client reduces the number of round trips to the server. In contrast, standard JDBC fetches the result set one row at a time, where each row requires a round trip to the database.

You can set the row prefetching value for an individual statement or for all statements in your connection. For a description of row prefetching and how to enable it, see "Row Prefetching" on page 4-98.

Batching Updates

The Oracle JDBC drivers allow you to accumulate inserts and updates of prepared statements at the client and send them to the server in batches once it reaches a specified batch value. This feature reduces round trips to the server. The default batch value is one.

You can set the batch value for any individual Oracle prepared statement or for all Oracle prepared statements in your Oracle connection. For a description of update batching and how to enable it, see "Database Update Batching" on page 4-100.

Common Problems

This section describes some common problems that you might encounter while using the Oracle JDBC drivers. These problems include:

- Space Padding for CHAR Columns Defined as OUT or IN/OUT Variables
- Memory Leaks and Running Out of Cursors
- Boolean Parameters in PL/SQL Stored Procedures
- Opening More Than 16 OCI Connections for a Process

Space Padding for CHAR Columns Defined as OUT or IN/OUT Variables

In PL/SQL, CHAR columns defined as OUT or IN/OUT variables are returned to a length of 32767 bytes, padded with spaces as needed. Note that VARCHAR2 columns do not exhibit this behavior.

To avoid this problem, use the `setMaxFieldSize()` method on the `Statement` object to set a maximum limit on the length of the data that can be returned for any column. The length of the data will be the value you specify for `setMaxFieldSize()` padded with spaces as needed. You must select the value for `setMaxFieldSize()` carefully because this method is statement-specific and affects the length of all CHAR, RAW, LONG, LONG RAW, and VARCHAR2 columns.

To be effective, you must invoke the `setMaxFieldSize()` method before you register your OUT variables.

Memory Leaks and Running Out of Cursors

If you receive messages that you are running out of cursors or that you are running out of memory, make sure that all of your `Statement` and `ResultSet` objects are explicitly closed. The Oracle JDBC drivers do not have finalizer methods; they perform cleanup routines by using the `close()` method of the `ResultSet` and `Statement` classes. If you do not explicitly close your result set and statement objects, serious memory leaks could occur. You could also run out of cursors in the database. Closing a result set or statement releases the corresponding cursor in the database.

Similarly, you must explicitly close `Connection` objects to avoid leaks and running out of cursors on the server side. When you close the connection, the JDBC driver closes any open statement objects associated with it, thus releasing the cursor objects on the servers side.

Boolean Parameters in PL/SQL Stored Procedures

Due to a restriction in the OCI layer, the JDBC drivers do not support the passing of Boolean parameters to PL/SQL stored procedures. If a PL/SQL procedure contains Booleans, you can work around the restriction by wrapping the PL/SQL procedure with a second PL/SQL procedure that accepts the argument as an `int` and passes it to the first stored procedure. When the second procedure is called, the server performs the conversion from `int` to `boolean`.

The following is an example of a stored procedure, `boolProc`, that attempts to pass a Boolean parameter, and a second procedure, `boolWrap`, that performs the substitution of an integer value for the Boolean.

```
CREATE OR REPLACE PROCEDURE boolProc(x boolean)
AS
BEGIN
[...]
END;

CREATE OR REPLACE PROCEDURE boolWrap(x int)
AS
BEGIN
IF (x=1) THEN
  boolProc(TRUE);
ELSE
  boolProc(FALSE);
END IF;
END;

// Create the database connection
Connection conn = DriverManager.getConnection
("jdbc:oracle:oci8:@<hoststring>", "scott", "tiger");
CallableStatement cs =
conn.prepareCall ("begin boolWrap(?); end;");
cs.setInt(1, 1);
cs.execute ();
```

Opening More Than 16 OCI Connections for a Process

You might find that you are not able to open more than approximately 16 JDBC-OCI connections for a process at any given time. The most likely reasons for this would be either the number of processes on the server exceeded the limit specified in the initialization file or the per-process file descriptors limit was exceeded. It is important to note that one JDBC-OCI connection can use more than one file descriptor (it might use anywhere between 3 and 4 file descriptors).

If the server allows more than 16 processes, then the problem could be with the per-process file descriptor limit. The possible solution would be to increase it.

Basic Debugging Procedures

This section describes four strategies for debugging a JDBC program.

- Trapping Exceptions
- Logging JDBC Calls
- Net8 Tracing to Trap Network Events
- Using Third Party Tools

Trapping Exceptions

Most errors that occur in JDBC programs are handled as exceptions. Java provides the `try...catch` statement to catch the exception and the `printStackTrace()` method to print the stack trace.

The following code fragment illustrates how you can catch SQL exceptions and print the stack trace.

```
try { <some code> }
catch(SQLException e){ e.printStackTrace (); }
```

To illustrate how the JDBC drivers handle errors, the following incorrect code was intentionally added to the `Employee.java` sample:

```
// Iterate through the result and print the employee names
// of the code

try {
  while (rset.next ())
System.out.println (rset.getString (5)); }  // incorrect column index
  catch(SQLException e){ e.printStackTrace (); }
```

Notice an error was intentionally introduced by changing the column index to 5. When you execute the program you get the following error text:

```
java.sql.SQLException: Invalid column index
at oracle.jdbc.dbaccess.DBError.check_error(DBError.java:235)
at oracle.jdbc.driver.OracleStatement.prepare_for_new_get(OracleStatemen
t.java:1560)
at oracle.jdbc.driver.OracleStatement.getStringValue(OracleStatement.jav
a:1653)
at oracle.jdbc.driver.OracleResultSet.getString(OracleResultSet.java:175
)
at Employee.main(Employee.java:41)
```

For more information on how the JDBC drivers handle errors, and the `SQLException()` and the `printStackTrace()` methods, see "Error Messages and JDBC" on page 3-25.

Logging JDBC Calls

You can use the `java.io.PrintStream.DriverManager.setLogStream()` method to log JDBC calls. This method sets the logging / tracing PrintStream used by the DriverManager and all drivers. Insert the following line at the location in your code where you want to start logging JDBC calls:

```
DriverManager.setLogStream(System.out);
```

Net8 Tracing to Trap Network Events

You can enable client and server Net8 trace to trap the packets sent over Net8. You can use client-side tracing only for the JDBC OCI driver; it is not supported for the JDBC Thin driver. You can find more information on tracing and reading trace files in the *Net8 Administrator's Guide*.

The trace facility produces a detailed sequence of statements that describe network events as they execute. "Tracing" an operation lets you obtain more information on the internal operations of the event. This information is output to a readable file that identifies the events that led to the error. Several Net8 parameters in the `SQLNET.ORA` file control the gathering of trace information. After setting the parameters in `SQLNET.ORA`, you must make a new connection for tracing to be performed. You can find more information on these parameters in the *Net8 Administrator's Guide*.

The higher the trace level, the more detail is captured in the trace file. Because the trace file can be hard to understand, start with a trace level of 4 when enabling tracing. The first part of the trace file contains connection handshake information, so look beyond this for the SQL statements and error messages related to your JDBC program.

Note: The trace facility uses a large amount of disk space and might have significant impact upon system performance. Therefore, enable tracing only when necessary.

Client-Side Tracing

Set the following parameters in the SQLNET.ORA file on the client system.

TRACE_LEVEL_CLIENT

Purpose: Turns tracing on/off to a certain specified level

Default Value: 0 or OFF

Available Values:
- 0 or OFF - No trace output
- 4 or USER - User trace information
- 10 or ADMIN - Administration trace information
- 16 or SUPPORT - WorldWide Customer Support trace information

Example: TRACE_LEVEL_CLIENT=10

TRACE_DIRECTORY_CLIENT

Purpose: Specifies the destination directory of the trace file

Default Value: $ORACLE_HOME/network/trace

Example: on UNIX: TRACE_DIRECTORY_CLIENT=/oracle/traces
on Windows NT: TRACE_DIRECTORY_CLIENT=C:\ORACLE\TRACES

TRACE_FILE_CLIENT

Purpose: Specifies the name of the client trace file

Default Value: SQLNET.TRC

Example: TRACE_FILE_CLIENT=cli_Connection1.trc

Note: Ensure that the name you choose for the TRACE_FILE_CLIENT file is different from the name you choose for the TRACE_FILE_SERVER file.

TRACE_UNIQUE_CLIENT

Purpose: Gives each client-side trace a unique name to prevent each trace file from being overwritten with the next occurrence of a client trace. The PID is attached to the end of the file name.

Default Value: OFF

Example: TRACE_UNIQUE_CLIENT = ON

Server-Side Tracing

Set the following parameters in the SQLNET.ORA file on the server system. Each connection will generate a separate file with a unique file name.

TRACE_LEVEL_SERVER

Purpose: Turns tracing on / off to a certain specified level

Default Value: 0 or OFF

Available Values:

- 0 or OFF - No trace output
- 4 or USER - User trace information
- 10 or ADMIN - Administration trace information
- 16 or SUPPORT - WorldWide Customer Support trace information

Example: TRACE_LEVEL_SERVER=10

TRACE_DIRECTORY_SERVER

Purpose: Specifies the destination directory of the trace file

Default Value: $ORACLE_HOME / network / trace

Example: TRACE_DIRECTORY_SERVER=/oracle/traces

TRACE_FILE_SERVER

Purpose: Specifies the name of the server trace file

Default Value: SERVER.TRC

Example: TRACE_FILE_SERVER= svr_Connection1.trc

Note: Ensure that the name you choose for the `TRACE_FILE_SERVER` file is different from the name you choose for the `TRACE_FILE_CLIENT` file.

Using Third Party Tools

You can use tools such as JDBCSpy and JDBCTest from Intersolv to troubleshoot at the JDBC API level. These tools are similar to ODBCSpy and ODBCTest.

Transaction Isolation Levels and the Oracle Server

The Oracle Server supports only the `TRANSACTION_READ_COMMITTED` and `TRANSACTION_SERIALIZABLE` transaction isolation levels. The default is `TRANSACTION_READ_COMMITTED`. Use the following methods of the `oracle.jdbc.driver.OracleConnection` class to get and set the level:

- `getTransactionIsolation()`: gets this connection's current transaction isolation level.
- `setTransactionIsolation()`: changes the transaction isolation level using one of the `TRANSACTION_*` values.

7

Sample Applications

This chapter presents sample applications that highlight advanced JDBC features and Oracle extensions, including the following topics:

- Sample Applications for Basic JDBC Features
- Sample Applications for JDBC 2.0-Compliant Oracle Extensions
- Sample Applications for Other Oracle Extensions
- Creating Customized Java Classes for Oracle Objects
- Creating Signed Applets
- JDBC versus SQLJ Sample Code

Sample Applications for Basic JDBC Features

This section contains code samples that demonstrate basic JDBC features.

Streaming Data

The JDBC drivers support the manipulation of data streams in both directions between client and server. The code sample in this section demonstrates this by using the JDBC OCI driver for connecting to a database, and inserting and fetching LONG data using Java streams.

```
import java.sql.*;                                          // line 1
import java.io.*;

class StreamExample
{
  public static void main (String args [])
       throws SQLException, IOException
  {
    // Load the driver
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

    // Connect to the database
    // You can put a database name after the @ sign in the connection URL.
    Connection conn =
      DriverManager.getConnection ("jdbc:oracle:oci8:@", "scott", "tiger");

    // It's faster when you don't commit automatically
    conn.setAutoCommit (false);                             // line 18

    // Create a Statement
    Statement stmt = conn.createStatement ();

    // Create the example table
    try
    {
      stmt.execute ("drop table streamexample");
    }
    catch (SQLException e)
    {
      // An exception would be raised if the table did not exist
      // We just ignore it
    }

    // Create the table                                     // line 34
```

```
    stmt.execute ("create table streamexample (NAME varchar2 (256),
          DATA long)");

    File file = new File ("StreamExample.java");            // line 37
    InputStream is = new FileInputStream ("StreamExample.java");
    PreparedStatement pstmt =
      conn.prepareStatement ("insert into streamexample (name, data)
           values (?, ?)");
     pstmt.setString (1, "StreamExample");
     pstmt.setAsciiStream (2, is, (int)file.length ());
     pstmt.execute ();                                      // line 44

    // Do a query to get the row with NAME 'StreamExample'
    ResultSet rset =
      stmt.executeQuery ("select DATA from streamexample where
              NAME='StreamExample'");

    // Get the first row                                    // line 51
    if (rset.next ())
    {
      // Get the data as a Stream from Oracle to the client
      InputStream gif_data = rset.getAsciiStream (1);

      // Open a file to store the gif data
      FileOutputStream os = new FileOutputStream ("example.out");

      // Loop, reading from the gif stream and writing to the file
      int c;
      while ((c = gif_data.read ()) != -1)
        os.write (c);

      // Close the file
      os.close ();                                          // line 66
    }
  }
}
```

Lines 1-18: Import the necessary classes. Load the JDBC OCI driver with the `DriverManager.registerDriver()` method. Connect to the database with the `getConnection()`, as user `scott` with password `tiger`. Use the database URL `jdbc:oracle:oci8:@`. You can optionally enter a database name after the `@` symbol. Disable `AUTOCOMMIT` to enhance performance. If you do not, the driver will issue execute and commit commands after every SQL statement.

Line 34: Create a table STREAMEXAMPLE with a NAME column of type VARCHAR and a DATA column of type LONG.

Lines 37-44: Insert the contents of the `StreamExample.java` into the table. To do this, create an input stream object for the Java file. Then, prepare a statement to insert character data into the NAME column and the stream data into the DATA column. Insert the NAME data with the `setString()`; insert the stream data with `setAsciiStream()`.

Line 46: Query the table to get the contents of the DATA column into a result set.

Line 51-66: Get the data from the first row of the result set into the `InputStream` object `gif_data`. Create a `FileOutputStream` to write to the specified file object. Then, read the contents of the `gif` stream and write it to the file `example.out`.

Sample Applications for JDBC 2.0-Compliant Oracle Extensions

This section contains sample code for the following Oracle extensions:

- LOB Sample
- BFILE Sample

LOB Sample

This sample demonstrates basic support for LOBs in the OCI 8 driver. It illustrates how to create a table containing LOB columns, and includes utility programs to read from a LOB, write to a LOB, and dump the LOB contents. For more information on LOBs, see "Working with LOBs" on page 4-45.

Except for some changes to the comments, the following sample is similar to the `LobExample.java` program in the `Demo/samples/oci8/object-samples` directory.

```
import java.sql.*;                                          // line 1
import java.io.*;
import java.util.*;

// Importing the Oracle Jdbc driver package
// makes the code more readable
import oracle.jdbc.driver.*;

// Import this to get CLOB and BLOB classes
import oracle.sql.*;
```

```
public class NewLobExample1
{
  public static void main (String args [])
       throws Exception
  {
    // Load the Oracle JDBC driver
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

    // Connect to the database. You can put a database
    // name after the @ sign in the connection URL.
    Connection conn =
      DriverManager.getConnection ("jdbc:oracle:oci8:@", "scott", "tiger");

    // It's faster when auto commit is off
    conn.setAutoCommit (false);                              // line 26

    // Create a Statement
    Statement stmt = conn.createStatement ();

    try
    {
      stmt.execute ("DROP TABLE basic_lob_table");
    }
    catch (SQLException e)
    {
      // An exception could be raised here if the table did
      // not exist already but we gleefully ignore it
    }                                                        // line 38

    // Create a table containing a BLOB and a CLOB             line 40
    stmt.execute ("CREATE TABLE basic_lob_table (x varchar2 (30),
                   b blob, c clob)");

    // Populate the table
    stmt.execute ("INSERT INTO basic_lob_table VALUES ('one',
           '0101010101010101010101010101', 'onetwothreefour')");
    stmt.execute ("INSERT INTO basic_lob_table VALUES ('two',
    '02020202020202020202020202', 'twothreefourfivesix')");
                                                             // line 49
    System.out.println ("Dumping lobs");

    // Select the lobs
    ResultSet rset = stmt.executeQuery ("SELECT * FROM basic_lob_table");
    while (rset.next ())
```

```
    {
      // Get the lobs
      BLOB blob = ((OracleResultSet)rset).getBLOB (2);
      CLOB clob = ((OracleResultSet)rset).getCLOB (3);

      // Print the lob contents
      dumpBlob (conn, blob);
      dumpClob (conn, clob);

      // Change the lob contents
      fillClob (conn, clob, 2000);
      fillBlob (conn, blob, 4000);
    }
                                                          // line 68
    System.out.println ("Dumping lobs again");

    rset = stmt.executeQuery ("SELECT * FROM basic_lob_table");
    while (rset.next ())
    {
      // Get the lobs
      BLOB blob = ((OracleResultSet)rset).getBLOB (2);
      CLOB clob = ((OracleResultSet)rset).getCLOB (3);

      // Print the lobs contents
      dumpBlob (conn, blob);
      dumpClob (conn, clob);
    }
  }                                                       // line 82

  // Utility function to dump Clob contents
  static void dumpClob (Connection conn, CLOB clob)
    throws Exception
  {
    // get character stream to retrieve clob data
    Reader instream = clob.getCharacterStream();

    // create temporary buffer for read                   line 91
    char[] buffer = new char[10];

    // length of characters read
    int length = 0;

    // fetch data                                         line 98
    while ((length = instream.read(buffer)) != -1)
    {
```

```
    System.out.print("Read " + length + " chars: ");

    for (int i=0; i<length; i++)
      System.out.print(buffer[i]);
    System.out.println();
  }

  // Close input stream
  instream.close();
}                                                          // line 108

// Utility function to dump Blob contents
static void dumpBlob (Connection conn, BLOB blob)
  throws Exception
{
  // Get binary output stream to retrieve blob data
  InputStream instream = blob.getBinaryStream();

  // Create temporary buffer for read
  byte[] buffer = new byte[10];

  // length of bytes read                                  line 120
  int length = 0;

  // Fetch data
  while ((length = instream.read(buffer)) != -1)
  {
    System.out.print("Read " + length + " bytes: ");

    for (int i=0; i<length; i++)
      System.out.print(buffer[i] + " ");
    System.out.println();
  }

  // Close input stream
  instream.close();
}
                                                           // line 135
// Utility function to put data in a Clob
static void fillClob (Connection conn, CLOB clob, long length)
  throws Exception
{
  Writer outstream = clob.getCharacterOutputStream();

  int i = 0;
```

```
    int chunk = 10;

    while (i < length)
    {
      outstream.write(i + "hello world", 0, chunk);        // line 147

      i += chunk;
      if (length - i < chunk)
          chunk = (int) length - i;
    }
    outstream.close();
  }                                                                 // line 154

  // Utility function to write data to a Blob
  static void fillBlob (Connection conn, BLOB blob, long length)
    throws Exception
  {
    OutputStream outstream = blob.getBinaryOutputStream();

    int i = 0;

    byte [] data = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 };              // line 165
   int chunk = data.length;

    while (i < length)
    {
      data [0] = (byte)i;
      outstream.write(data, 0, chunk);

      i += chunk;
      if (length - i < chunk)
          chunk = (int) length - i;
    }
    outstream.close();
  }
}                                                                   // line 175
```

Lines 1-26: Import the necessary `java.*` and `oracle.*` classes. Register the driver with the `DriverManager.registerDriver()` method and connect to the database with `DriverManager.getConnection()`. Use the database URL `jdbc:oracle:oci8:@` and connect as user `scott` with password `tiger`. You can optionally enter a database name following the @ symbol.

Use `setAutoCommit(false)` to disable the `AUTOCOMMIT` feature and enhance performance. If you do not, the driver will issue execute and commit commands after every SQL statement.

Lines 27-38: Create a statement object. Drop any pre-existing table named `basic_lob_table`. Then, create a new `basic_lob_table` directory to store the LOBs in-line.

Lines 40-49: Use SQL statements to create a table with three columns: a column to store the row number as a `VARCHAR2`, a `BLOB` column, and a `CLOB` column. Then insert data into two rows of the table.

Lines 50-68: `SELECT` the contents of the table into a result set.

Retrieve the LOBs. The `getBLOB()` and `getCLOB()` methods return locators to the LOB data; to retrieve the LOB contents, you must write additional code (which is defined later in this program). To use the `getBLOB()` and `getCLOB()` methods, cast the result set to an `OracleResultSet` object. Then call the "`dump`" functions to display the contents of the LOBs, and the "`fill`" functions to change the contents of the LOBs. The `dump` and `fill` functions are defined later in this program.

Lines 69-82: Display the LOBs again, after their contents have been changed. `SELECT` the contents of the table into a result set, and then apply the dump functions. The `dump` functions are defined later in this program.

Lines 84-108: Define the utility function `dumpClob` to display the contents of a `CLOB`. Read the `CLOB` contents as a character stream. Use the `getCharacterStream()` method to get a `READER` stream object. Set up the temporary character array to read the character data in 10-character chunks.

Set up a loop to read and display the contents of the `CLOB`. The length of the `CLOB` is displayed as well. Close the input stream when you are done.

Lines 110-135: Define the utility function `dumpBlob` to display the contents of a `BLOB`. Read the `BLOB` contents as a binary stream. Use the `getBinaryStream()` method to get an `InputStream` stream object. Set up the temporary byte array to read the binary data in 10-byte chunks.

Set up a loop to read and display the contents of the `BLOB`. The length of the `BLOB` is displayed as well. Close the input stream when you are done.

Lines 136-154: Define the utility function `fillClob` to write data to a `CLOB`. The `fillClob` function needs the `CLOB` locator and the length of the `CLOB`. To write to

the CLOB, use the getCharacterOutputStream() method to get a WRITER object.

Set up a loop to write an index value and part of the string Hello World to the CLOB. Close the WRITER stream when you are done.

Lines 156-175: Define the utility function fillBlob to write data to a BLOB. The fillBlob function needs the BLOB locator and the length of the BLOB. To write to the BLOB, use the getBinaryOutputStream() method to get an OutputStream object.

Define the byte array of data that you want to write to the BLOB. The while loop causes a variation of the data to be written to the BLOB. Close the OutputStream object when you are done.

BFILE Sample

This sample demonstrates basic BFILE support in the OCI 8 driver. It illustrates filling a table with BFILEs and includes a utility for dumping the contents of a BFILE. For more information on BFILEs, see "Working with LOBs" on page 4-45.

Except for some changes to the comments, the following sample is similar to the FileExample.java program in the Demo/samples/oci8/object-samples directory.

```
import java.sql.*;                                          // line 1
import java.io.*;
import java.util.*;

//including this import makes the code easier to read
import oracle.jdbc.driver.*;

// needed for new BFILE class
import oracle.sql.*;
                                                          // line 10
public class NewFileExample1
{
  public static void main (String args [])
       throws Exception
  {
    // Load the Oracle JDBC driver                            line 16
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

    // Connect to the database
    // You can put a database name after the @ sign in the connection URL.
```

```
//
// The example creates a DIRECTORY and you have to be connected as
// "system" to be able to run the test.
// If you can't connect as "system" have your system manager
// create the directory for you, grant you the rights to it, and
//  remove the portion of this program that drops and creates the directory.
Connection conn =
  DriverManager.getConnection ("jdbc:oracle:oci8:@", "system", "manager");

// It's faster when auto commit is off
conn.setAutoCommit (false);
                                                                  // line 32
// Create a Statement
Statement stmt = conn.createStatement ();

try                                                               // line 36
{
  stmt.execute ("DROP DIRECTORY TEST_DIR");
}
catch (SQLException e)
{
  // An error is raised if the directory does not exist.  Just ignore it.
}                                                                 // line 43
stmt.execute ("CREATE DIRECTORY TEST_DIR AS '/temp/filetest'");

try                                                               // line 46
{
  stmt.execute ("drop table test_dir_table");
}
catch (SQLException e)
{
  // An error is raised if the table does not exist.  Just ignore it.
}
                                                                  // line 54
// Create and populate a table with files
// The files file1 and file2 must exist in the directory TEST_DIR created
// above as symbolic name for /private/local/filetest.
stmt.execute ("CREATE TABLE test_dir_table (x varchar2 (30), b bfile)");
stmt.execute ("INSERT INTO test_dir_table VALUES ('one', bfilename
             ('TEST_DIR', 'file1'))");
stmt.execute ("INSERT INTO test_dir_table VALUES ('two', bfilename
             ('TEST_DIR', 'file2'))");

// Select the file from the table                                 // line 64
ResultSet rset = stmt.executeQuery ("SELECT * FROM test_dir_table");
```

```
  while (rset.next ())
  {
    String x = rset.getString (1);
    BFILE bfile = ((OracleResultSet)rset).getBFILE (2);
    System.out.println (x + " " + bfile);

    // Dump the file contents
    dumpBfile (conn, bfile);
  }
}                                                          //line 75

// Utility function to dump the contents of a Bfile          line 77
static void dumpBfile (Connection conn, BFILE bfile)
  throws Exception
{                                                        // line 80
  System.out.println ("Dumping file " + bfile.getName());
  System.out.println ("File exists: " + bfile.fileExists());
  System.out.println ("File open: " + bfile.isFileOpen());

  System.out.println ("Opening File: ");                // line 84

  bfile.openFile();

  System.out.println ("File open: " + bfile.isFileOpen());

  long length = bfile.length();
  System.out.println ("File length: " + length);

  int chunk = 10;

  InputStream instream = bfile.getBinaryStream();

  // Create temporary buffer for read
  byte[] buffer = new byte[chunk];

  // Fetch data
  while ((length = instream.read(buffer)) != -1)
  {
    System.out.print("Read " + length + " bytes: ");

    for (int i=0; i<length; i++)
      System.out.print(buffer[i] + " ");
    System.out.println();
  }                                                     // line 108
```

```
    // Close input stream
    instream.close();

    // close file handler
    bfile.closeFile();
  }                                                    // line 115
}
```

Lines 1-32: Import the necessary `java.*` and `oracle.*` classes. Register the driver with the `DriverManager.registerDriver()` method and connect to the database with the `getConnection()` method. Use the database URL `jdbc:oracle:oci8:@` and connect as user `system` with password `manager`. You can optionally enter a database name following the `@` symbol.

Use `setAutoCommit(false)` to disable the `AUTOCOMMIT` feature and enhance performance. If you do not, the driver will issue execute and commit commands after every SQL statement.

Lines 33-44: Create a statement object. Drop any pre-existing directory named `TEST_DIR`. Then, create a new `TEST_DIR` directory to store the `BFILE`. You or your System Administrator can use whatever file name you wish.

Lines 46-53: Drop any pre-existing table named `test_dir_table`.

Lines 55-63: Create and populate a table with files. Use SQL statements to create a table, `test_dir_table`, with two columns: one column to indicate the row number as a `VARCHAR2` (for example, "`one`" or "`two`"), and one column to hold the `BFILE` locator.

Use SQL statements to insert some data into the table. For the first row, insert a row number in the first column, and use the `BFILENAME` keyword to insert a `BFILE`, `file1`, located in `TEST_DIR`, in the second column. Do the same thing for the second row.

Lines 64-75: `SELECT` the contents of the table into a result set. Set up a loop to retrieve the contents of the table. Use `getString()` to retrieve the row number data, and use `getBFILE()` to retrieve the `BFILE` locator. Since `BFILE` is an Oracle-specific datatype, and `getBFILE()` is an Oracle extension, cast the result set object to an `OracleResultSet` object.

Use the `dumpBfile()` method (defined later in the program) to display the `BFILE` contents and various statistics about the `BFILE`.

Line 77: Define the `dumpBfile()` method to display the `BFILE` contents and various statistics about the `BFILE`. The `dumpBfile()` method takes the `BFILE` locator as input.

Lines 80-83: Use the `getName()`, `fileExists()`, and `isFileOpen()` methods to return the name of the `BFILE`, and whether the `BFILE` exists and is open. Note that the `BFILE` does not have to be open to apply these methods to it.

Lines 84-108: Read and display the `BFILE` contents. First open the `BFILE`. You can read the `BFILE` contents as a binary stream. Use the `getBinaryStream()` method to get an input stream object. Determine the size of the "chunk" in which the stream will read the `BFILE` data, and set up the temporary byte array to store the data.

Set up a loop to read and display the contents of the `BFILE`. The length of the `BFILE` is displayed as well.

Lines 110-115: When you are finished, close the input stream and the `BFILE`.

Sample Applications for Other Oracle Extensions

This section contains sample code for these Oracle extensions:

- REF CURSOR Sample
- Array Sample

REF CURSOR Sample

Following is a complete sample program that uses JDBC to create a stored package in the data server and uses a `get` on the `REF CURSOR` type category to obtain the results of a query. For more information on `REF CURSOR`s, see "Oracle REF CURSOR Type Category" on page 4-112.

Except for some changes to the comments, the following sample is similar to the `RefCursorExample.java` program in the `Demo/samples/oci8/object-samples` directory.

```
import java.sql.*;                                          // line 1
import java.io.*;
import oracle.jdbc.driver.*;

class RefCursorExample
{
   public static void main(String args[]) throws SQLException
```

```
   {
      //Load the driver.
      DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

      // Connect to the database.
      // You can put a database name after the @ sign in the connection URL.
      Connection conn =
         DriverManager.getConnection("jdbc:oracle:oci8:@", "scott", "tiger");
                                                              // line 16
      // Create the stored procedure.
      init(conn);

      // Prepare a PL/SQL call.                                line 20
      CallableStatement call =
         conn.prepareCall("{ ? = call java_refcursor.job_listing (?) }");

      // Find out who all the sales people are.                line 24
      call.registerOutParameter(1, OracleTypes.CURSOR);
      call.setString(2, "SALESMAN");
      call.execute();
      ResultSet rset = (ResultSet)call.getObject(1);

      // Output the information in the cursor.                 line 30
      while (rset.next())
         System.out.println(rset.getString("ENAME"));
   }

// Utility function to create the stored procedure
                                                              // line 36
   static void init(Connection conn) throws SQLException
   {
      Statement stmt = conn.createStatement();
                                                              // line 40
      stmt.execute("CREATE OR REPLACE PACKAGE java_refcursor AS " +
                   " type myrctype is ref cursor return EMP%ROWTYPE; " +
                   " function job_listing(j varchar2) return myrctype; " +
                   "end java_refcursor;");
                                                              // line 45
      stmt.execute("CREATE OR REPLACE PACKAGE BODY java_refcursor AS " +
                   " function job_listing(j varchar2) return myrctype is " +
                   "    rc myrctype; " +
                   " begin " +
                   "    open rc for select * from emp where job = j; " +
                   "    return rc; " +
                   " end; " +
```

```
                    "end java_cursor;");                    // line 53
   }
}
```

Lines 1-16: Import the necessary `java.*` and `oracle.*` classes. Register the driver with the `DriverManager.registerDriver()` method and connect to the database with the `getConnection()` method. Use the database URL `jdbc:oracle:oci8:@` and connect as user `scott` with password `tiger`. You can optionally enter a database name following the `@` symbol.

Lines 18-29: Prepare a callable statement to the `job_listing` function of the `java_refcursor` PL/SQL procedure. The callable statement returns a cursor to the rows of information where `job=SALESMAN`. Register `OracleTypes.CURSOR` as the output parameter. The `setObject()` method passes the value `SALESMAN` to the callable statement. After the callable statement is executed, the result set contains a cursor to the rows of the table where `job=SALESMAN`.

Lines 30-33: Iterate through the result set and print the employee name part of the employee object.

Lines 40-45: Define the package header for the `java_refcursor` package. The package header defines the return types and function signatures.

Lines 46-53: Define the package body for the `java_refcursor` package. The package body defines the implementation which selects rows based on the value for `job`.

Array Sample

Following is a complete sample program that uses JDBC to create a table with a VARRAY. It inserts a new array object into the table, then prints the contents of the table. For more information on arrays, see "Working with Arrays" on page 4-87.

Except for some changes to the comments, the following sample is similar to the `ArrayExample.java` program in the `Demo/samples/oci8/object-samples` directory.

```
import java.sql.*;                                          // line 1
import oracle.sql.*;
import oracle.jdbc.oracore.Util;
import oracle.jdbc.driver.*;
import java.math.BigDecimal;
```

```
public class ArrayExample
{
  public static void main (String args[])
    throws Exception
  {
    // Register the Oracle JDBC driver
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

    // Connect to the database
    // You need to put your database name after the @ symbol in
    // the connection URL.
    //
    // The sample retrieves an varray of type "NUM_VARRAY" and
    // materializes the object as an object of type ARRAY.
    // A new ARRAY is then inserted into the database.

    // Please replace hostname, port_number and sid_name with
    // the appropriate values

    Connection conn =
      DriverManager.getConnection
("jdbc:oracle:oci8:@(description=(address=(host=hostname)(protocol=tcp)(port=por
t_number))(connect_data=(sid=sid_name)))", "scott", "tiger");

    // It's faster when auto commit is off
    conn.setLines (false);                                  // line 32

    // Create a Statement
    Statement stmt = conn.createStatement ();               // line 35

    try
    {
      stmt.execute ("DROP TABLE varray_table");
      stmt.execute ("DROP TYPE num_varray");
    }
    catch (SQLException e)
    {
      // the above drop statements will throw exceptions
      // if the types and tables did not exist before
    }                                                       // line 47

    stmt.execute ("CREATE TYPE num_varray AS VARRAY(10) OF NUMBER(12, 2)");
    stmt.execute ("CREATE TABLE varray_table (col1 num_varray)");
    stmt.execute ("INSERT INTO varray_table VALUES (num_varray(100, 200))");
```

```
  ResultSet rs = stmt.executeQuery("SELECT * FROM varray_table");
  showResultSet (rs);                                          // line 54

  //now insert a new row

  // create a new ARRAY object
  int elements[] = { 300, 400, 500, 600 };                     // line 59
  ArrayDescriptor desc = ArrayDescriptor.createDescriptor("NUM_VARRAY", conn);
  ARRAY newArray = new ARRAY(desc, conn, elements);
                                                               // line 62
  PreparedStatement ps =
    conn.prepareStatement ("INSERT INTO varray_table VALUES (?)");
  ((OraclePreparedStatement)ps).setARRAY (1, newArray);

  ps.execute ();

  rs = stmt.executeQuery("SELECT * FROM varray_table");
  showResultSet (rs);
}                                                              // line 70

public static void showResultSet (ResultSet rs)               // line 72
  throws SQLException
{
  int line = 0;
  while (rs.next())
  {
    line++;
    System.out.println("Row " + line + " : ");
    ARRAY array = ((OracleResultSet)rs).getARRAY (1);

    System.out.println ("Array is of type " + array.getSQLTypeName());
    System.out.println ("Array element is of type code
                         " + array.getBaseType());
    System.out.println ("Array is of length " + array.length());
                                                                        // line 86
    // get Array elements
    BigDecimal[] values = (BigDecimal[]) array.getArray();

    for (int i=0; i<values.length; i++)
    {
      BigDecimal value = values[i];
      System.out.println(">> index " + i + " = " + value.intValue());
    }
  }
}
```

```
}                                                          // line 97
```

Lines 1-32: Import the necessary `java.*` and `oracle.*` classes. Register the driver with the `DriverManager.registerDriver()` method and connect to the database with the `getConnection()` method. This example of `getConnection()` uses Net8 name-value pairs to specify the `host` as `hostname`, `protocol` as `tcp`, `port` as `1521`, `sid` as `orcl`, `user` as `scott` and `password` as `tiger`.

Use `setAutoCommit(false)` to disable the `AUTOCOMMIT` feature and enhance performance. If you do not, the driver will issue execute and commit commands after every SQL statement.

Lines 35-47: Create a Statement object and delete any previously defined tables or types named `varray_table` or `num_varray`.

Lines 49-54: Create the type `num_varray` as a `varray` containing `NUMBER` data. Create a 1-column table, `varray_table`, to contain the `num_varray` type data. Insert into the table two rows of data. The values 100 and 200 are both of type `num_varray`. Use the `showResultSet()` method (defined later in the program) to display information about the arrays contained in the table.

Lines 59-61: First, define an array of integer elements to insert into the `varray_table`. Next, create an array descriptor object that will be used to create new `ARRAY` objects. To create an array descriptor object, pass the SQL type name of the array type (`NUM_ARRAY`) and the connection object to the `createDescriptor()` method. Then create the new array object by passing to it the array descriptor, the connection object, and the array of integer elements.

Lines 63-70: Prepare a statement to insert the new array object into `varray_table`. Cast the prepared statement object to an `OraclePreparedStatement` object to take advantage of the `setARRAY()` method.

To retrieve the array contents of the table, write and execute a SQL `SELECT` statement. Again, use the `showResultSet` method (defined later in the program) to display information about the arrays contained in the table.

Lines 72-85: Define the `showResultSet()` method. This method loops through a result set and returns information about the arrays it contains. This method uses the result set `getARRAY()` method to return an array into an `oracle.sql.ARRAY` object. To do this, cast the result set to an `OracleResultSet` object. Once you have the `ARRAY` object, you can apply Oracle extensions `getSQLTypeName()`,

`getBaseType()`, as well as `length()`, to return and display the SQL type name of the array, the SQL type code of the array elements, and the array length.

Lines 87-97: You can access the `varray` elements by using the ARRAY object's `getArray()` method. Since the `varray` contains SQL numbers, cast the result of `getArray()` to a `java.math.BigDecimal` array. Then, iterate through the value array and pull out individual elements.

Creating Customized Java Classes for Oracle Objects

This section contains the following subsections:

- SQLData Sample
- CustomDatum Sample

This section contains examples of the code you must provide to create custom Java classes for Oracle objects. You create the custom classes by implementing either the `SQLData` or `CustomDatum` interface. These interfaces provide a way to create and populate the custom Java class for the Oracle object and its attributes.

Although both `SQLData` and `CustomDatum` both populate a Java object from a SQL object, the `CustomDatum` interface is far more powerful. In addition to letting you populate Java objects, `CustomDatum` lets you materialize objects from SQL types that are not necessarily objects. Thus, you can create a `CustomDatum` object from any datatype found in an Oracle database. This is particularly useful in the case of `RAW` data that can be a serialized object.

The `SQLData` interface is a JDBC standard. For more information on this interface, see "Understanding the SQLData Interface" on page 4-69.

The `CustomDatum` interface is provided by Oracle. You can write your own code to create custom Java classes that implement this interface, but you will find it easier to let the Oracle utility JPublisher create the custom classes for you. The custom classes created by JPublisher implement the `CustomDatum` interface.

For more information on the `CustomDatum` interface, see "Understanding the CustomDatum Interface" on page 4-75. See the *Oracle8i JPublisher User's Guide* for more information on the JPublisher utility.

SQLData Sample

This section contains a code sample that illustrates how you can create a custom Java type to correspond to a given SQL type. It then demonstrates how you can use

the custom Java class in the context of a sample program. The sample also contains the code to map the SQL type to the custom Java type.

Creating the SQL Object Definition

Following is the SQL definition of an EMPLOYEE object. The object has two attributes: a string EmpName (employee name) attribute and an integer EmpNo (employee number) attribute.

```
 -- SQL definition
CREATE TYPE EMPLOYEE AS OBJECT
(
     EmpName VARCHAR2(50),
     EmpNo   INTEGER,
);
```

Creating the Custom Java Class

The following program implements the custom Java class EmployeeObj to correspond to the SQL type EMPLOYEE. Notice that the implementation of EmployeeObj contains a string EmpName (employee name) attribute and an integer EmpNo (employee number) attribute. Also notice that the Java definition of the EmployeeObj custom Java class implements the SQLData interface and includes the implementations of a get method and the required readSQL() and writeSQL() methods.

```
import java.sql.*;
import oracle.jdbc2.*;

public class EmployeeObj implements SQLData
 {
  private String sql_type;

  public String empName;
  public int empNo;

  public EmployeeObj()
  {
  }
                                                          // line 14
public EmployeeObj (String sql_type, String empName, int empNo)
  {
    this.sql_type = sql_type;
    this.empName = empName;
    this.empNo = empNo;
```

```
   }                                                              // line 20

  ////// implements SQLData //////

  // define a get method to return the SQL type of the object  line 24
  public String getSQLTypeName() throws SQLException
  {
    return sql_type;
  }                                                              // line 28

  // define the required readSQL() method                        line 30
  public void readSQL(SQLInput stream, String typeName)
    throws SQLException
  {
    sql_type = typeName;

    empName = stream.readString();
    empNo = stream.readInt();
  }
  // define the required writeSQL() method                       line 39
  public void writeSQL(SQLOutput stream)
    throws SQLException
  {
    stream.writeString(empName);
    stream.writeInt(empNo);
  }
}
```

Lines 1-14: Import the needed `java.*` and `oracle.*` packages. Define the custom Java class `EmployeeObj` to implement the `SQLData` interface. `EmployeeObj` is the class to which you will later map your `EMPLOYEE` SQL object type. The `EmployeeObj` object has three attributes: a SQL type name, an employee name, and an employee number. The SQL type name is a Java string that represents the fully qualified SQL type name (*schema.sql_type_name*) of the Oracle object that the custom Java class represents.

Lines 24-28: Define a `getSqlType()` method to return the SQL type of the custom Java object.

Lines 30-38: Define a `readSQL()` method as required by the definition of the `SQLData` interface. The `readSQL()` method takes a stream `SQLInput` object and the SQL type name of the object data that it is reading.

Lines 39-45: Define a `writeSQL()` method as required by the definition of the `SQLData` interface. The `writeSQL()` method takes a stream `SQLOutput` object and the SQL type name of the object data that it is reading.

Using the Custom Java Class

After you create your `EmployeeObj` Java class, you can use it in a program. The following program creates a table that stores employee name and number data. The program uses the `EmployeeObj` object to create a new employee object and insert it in the table. It then applies a `SELECT` statement to get the contents of the table and prints its contents.

Except for some changes to the comments, the following sample is similar to the `SQLDataExample.java` program in the `Demo/samples/oci8/object-samples` directory.

```
import java.sql.*;                                          // line 1
import oracle.jdbc.driver.*;
import oracle.sql.*;
import java.math.BigDecimal;
import java.util.Dictionary;

public class SQLDataExample
{
   public static void main(String args []) throws Exception
  {

    // Connect to the database
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver ());
    OracleConnection conn = (OracleConnection)
      DriverManager.getConnection("jdbc:oracle:oci8:@",
                                  "scott", "tiger");        // line 16

    // in the type map, add the mapping of EMPLOYEE SQL     // line 18
    // type to the EmployeeObj custom Java type
    Dictionary map = conn.getTypeMap();
    map.put("EMPLOYEE", Class.forName("EmployeeObj"));      // line 21

    // Create a Statement                                      line 23
    Statement stmt = conn.createStatement ();
    try
    {
      stmt.execute ("drop table EMPLOYEE_TABLE");
      stmt.execute ("drop type EMPLOYEE");
    }
```

```
catch (SQLException e)
{
  // An error is raised if the table/type does not exist. Just ignore it.
}

// Create and populate tables                              // line 35
stmt.execute ("CREATE TYPE EMPLOYEE AS OBJECT(EmpName VARCHAR2(50),
               EmpNo INTEGER)");
stmt.execute ("CREATE TABLE EMPLOYEE_TABLE (ATTR1 EMPLOYEE)");
stmt.execute ("INSERT INTO EMPLOYEE_TABLE VALUES (EMPLOYEE('Susan Smith',
               123))");                                    // line 40

// Create a SQLData object EmployeeObj in the SCOTT schema
EmployeeObj e = new EmployeeObj("SCOTT.EMPLOYEE", "George Jones", 456);

// Insert the SQLData object into the database          // line 45
PreparedStatement pstmt
  = conn.prepareStatement ("INSERT INTO employee_table VALUES (?)");

pstmt.setObject(1, e, OracleTypes.STRUCT);
pstmt.executeQuery();
System.out.println("insert done");
pstmt.close();                                          // line 52

// Select the contents of the employee_table            // line 54
Statement s = conn.createStatement();
OracleResultSet rs = (OracleResultSet)
  s.executeQuery("SELECT * FROM employee_table");       // line 57

// print the contents of the table                                  // line 59
while(rs.next())
{
   EmployeeObj ee = (EmployeeObj) rs.getObject(1);
   System.out.println("EmpName: " + ee.empName + " EmpNo: " + ee.empNo);
}                                                       // line 64

// close the result set, statement, and connection      // line 66
rs.close();
s.close();

if (conn != null)
{
  conn.close();                                         // line 72
}
}
```

```
}
```

Lines 1-16: Import needed `java.*` and `oracle.*` packages. Register the driver with the `DriverManager.registerDriver()` method and connect to the database with the `getConnection()` method. Use the database URL `jdbc:oracle:oci8:@` and connect as user `scott` with password `tiger`. You can optionally enter a database name following the `@` symbol.

Lines 18-21: Use the `getTypeMap()` method to get the type map associated with this connection. Use the map object's `put()` method to add the mapping of the SQL `EMPLOYEE` object to the `EmployeeObj` custom Java type.

Lines 23-33: Create a statement object and drop any pre-existing tables and types named `EMPLOYEE_TABLE` and `EMPLOYEE`.

Lines 35-40: Use SQL statements to:

- create an `EMPLOYEE` object with employee name and employee number attributes
- create a table of employee objects (`EMPLOYEE_TABLE`) having a single `EMPLOYEE` column
- insert initial data values into the table

Lines 42, 43: Create a new `EmployeeObj` object (which is a `SQLData` object). Identify the schema name (`SCOTT`), SQL type name (`EMPLOYEE`), an employee name (`George Jones`) and an employee number (`456`). Note that the schema name is the same as the user name in the `getConnection()` call. If you change the user name, you must also change the schema name.

Lines 45-52: Prepare a statement to insert the new `EMPLOYEE` object into the employee table. The `setObject()` method indicates that the object will be inserted into the first index position and that the underlying type of the `EMPLOYEE` object is `oracle.sql.STRUCT`.

Lines 54-57: Select the contents of the `EMPLOYEE_TABLE`. Cast the results to an `OracleResultSet` so that you can retrieve the custom Java object data from it.

Lines 59-62: Iterate through the result set, getting the contents of the `EMPLOYEE` objects and printing the employee names and employee numbers.

Lines 66-72: Close the result set, statement, and connection objects.

CustomDatum Sample

This section describes a Java class, written by a user, that implements the `CustomDatum` and `CustomDatumFactory` interfaces. The custom Java class of type `CustomDatum` has a static `getFactory()` method that returns a `CustomDatumFactory` object. The JDBC driver uses the `CustomDatumFactory` object's `create()` method to return a `CustomDatum` instance. Note that instead of writing the custom Java class yourself, you can use the JPublisher utility to generate class definitions that implement the `CustomDatum` and `CustomDatumFactory` interfaces.

The following example illustrates a Java class definition that can be written by a user, given the SQL definition of an `EMPLOYEE` object.

SQL Definition of EMPLOYEE Object

The following SQL code defines the `EMPLOYEE` object. The `EMPLOYEE` object consists of the employee's name (`EmpName`) and the employee's associated number (`EmpNo`).

```
create type EMPLOYEE as object
     (
          EmpName VARCHAR2(50),
          EmpNo   INTEGER
     );
```

Java Class Definitions for a Custom Java Object

Below are the contents of the `Employee.java` file.

```
import java.math.BigDecimal;
import java.sql.SQLException;
import oracle.jdbc.driver.OracleConnection;
import oracle.sql.CustomDatum;
import oracle.sql.CustomDatumFactory;
import oracle.sql.Datum;
import oracle.sql.STRUCT;
import oracle.sql.StructDescriptor;

public class Employee implements CustomDatum, CustomDatumFactory // line 10
{

  static final Employee _employeeFactory = new Employee(null, null); //line 13

  public static CustomDatumFactory getFactory()
  {
```

```
    return _employeeFactory;
  }                                                          // line 18

  /* constructor */                                          // line 20
  public Employee(String empName, BigDecimal empNo)
  {
    this.empName = empName;
    this.empNo = empNo;
  }                                                          // line 25

  /* CustomDatum interface */                                // line 27
  public Datum toDatum(OracleConnection c) throws SQLException
  {
    StructDescriptor sd =
       StructDescriptor.createDescriptor("SCOTT.EMPLOYEE", c);

    Object [] attributes = { empName, empNo };

    return new STRUCT(sd, c, attributes);
  }                                                          // line 36

  /* CustomDatumFactory interface */                         // line 38
  public CustomDatum create(Datum d, int sqlType) throws SQLException
  {
    if (d == null) return null;

    System.out.println(d);

    Object [] attributes = ((STRUCT) d).getAttributes();

    return new Employee((String) attributes[0],
                        (BigDecimal) attributes[1]);
  }                                                          // line 49

  /* fields */
  public String empName;
  public BigDecimal empNo;
}
```

Line 10: As required, the `Employee` class implements the `CustomDatum` and `CustomDatumFactory` interfaces.

Lines 13-18: JPublisher defines a `_employeeFactory` object of class `Employee`, which will be returned by the `getFactory()` method and used to create new

Employee objects. The getFactory() method returns an empty Employee object that you can use to create new Employee objects.

Lines 20-25: JPublisher defines the Employee Java class to correspond to the SQL EMPLOYEE object. JPublisher creates the Employee class with two attributes: an employee name of type java.lang.String and an employee number of type java.math.BigDecimal.

Lines 27-36: The toDatum() method of the CustomDatum interface transforms the EMPLOYEE SQL data into oracle.sql.* representation. To do this, toDatum() uses:

- a STRUCT descriptor that takes the schema name, the SQL object or "type" name, and the connection object as arguments
- an object array that stores the values of the object's employee name and employee number attributes

The toDatum() returns a STRUCT containing the STRUCT descriptor, the connection object and the object attributes into an oracle.sql.Datum.

Lines 38-49: The CustomDatumFactory interface specifies a create() method that is analogous to the constructor of your Employee custom Java class. The create() method takes the Datum object and the SQL type code of the Datum object and returns a CustomDatum instance.

According to the definition, the create() method returns null if the value of the Datum object is null. Otherwise, it returns an instance of the Employee object with the employee name and employee number attributes.

Custom Java Class Usage Example

This code snippet presents a simple example of how you can use the Employee class that you created with JPublisher. The sample code creates a new Employee object, fills it with data, then inserts it into the database. The sample code then retrieves the Employee data from the database.

Except for some changes to the comments, the following sample is similar to the CustomDatumExample.java program in the Demo/samples/oci8/object-samples directory.

```
import java.sql.*;                                          // line 1
import oracle.jdbc.driver.*;
import oracle.sql.*;
import java.math.BigDecimal;
```

```
public class CustomDatumExample
{
  public static void main(String args []) throws Exception
  {

    // Connect
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver ());
    OracleConnection conn = (OracleConnection)
      DriverManager.getConnection("jdbc:oracle:oci8:@",
                                  "scott", "tiger");

    // Create a Statement                                    // line 18
    Statement stmt = conn.createStatement ();
    try
    {
      stmt.execute ("drop table EMPLOYEE_TABLE");
      stmt.execute ("drop type EMPLOYEE");
    }
    catch (SQLException e)
    {
      // An error is raised if the table/type does not exist. Just ignore it.
    }                                                       // line 28

    // Create and populate tables                           // line 30
    stmt.execute ("CREATE TYPE EMPLOYEE AS " +
          " OBJECT(EmpName VARCHAR2(50),EmpNo INTEGER)");
    stmt.execute ("CREATE TABLE EMPLOYEE_TABLE (ATTR1 EMPLOYEE)");
    stmt.execute ("INSERT INTO EMPLOYEE_TABLE " +
          " VALUES (EMPLOYEE('Susan Smith', 123))");          // line 35

    // Create a CustomDatum object                          // line 37
    Employee e = new Employee("George Jones", new BigDecimal("456"));

    // Insert the CustomDatum object                        // line 40
    PreparedStatement pstmt
      = conn.prepareStatement ("INSERT INTO employee_table VALUES (?)");

    pstmt.setObject(1, e, OracleTypes.STRUCT);
    pstmt.executeQuery();
    System.out.println("insert done");
    pstmt.close();                                          // line 47

    // Select now                                           // line 49
```

```
    Statement s = conn.createStatement();
    OracleResultSet rs = (OracleResultSet)
      s.executeQuery("SELECT * FROM employee_table");

    while(rs.next())                                          // line 54
    {
       Employee ee = (Employee) rs.getCustomDatum(1, Employee.getFactory());
       System.out.println("EmpName: " + ee.empName + " EmpNo: " + ee.empNo);
    }                                                         // line 58
    rs.close();
    s.close();

    if (conn != null)
    {
      conn.close();
    }
  }
}
```

Lines 1-16: Import needed `java.*` and `oracle.*` packages. Register the driver with the `DriverManager.registerDriver()` method and connect to the database with the `getConnection()` method. Use the database URL `jdbc:oracle:oci8:@` and connect as user `system` with password `manager`. You can optionally enter a database name following the `@` symbol.

Lines 18-28: Create a statement object and drop any pre-existing tables and types named `EMPLOYEE_TABLE` and `EMPLOYEE`.

Lines 30-35: Use SQL statements to:

- create an `Employee` object with employee name and employee number attributes
- create a table of employee objects having a single `EMPLOYEE` column
- insert initial data values into the table

Lines 37, 38: Create a new `Employee` object (which is a `CustomDatum` object) and define an employee name and employee number for it.

Lines 40-47: Prepare a statement to insert the new `Employee` object into the database. The `setObject()` method indicates that the object will be inserted into the first index position and that the underlying type of the `Employee` object is `oracle.sql.STRUCT`.

Lines 49-54: Select the contents of the `employee_table`. Cast the results to an `OracleResultSet` so that the `getCustomDatum()` method can be used on it.

Lines 54-58: Iterate through the result set, getting the contents of the `Employee` objects and printing the employee names and employee numbers.

Lines 58-62: Close the result set, statement, and connection objects.

Creating Signed Applets

This section presents an example of a signed applet which uses the JDBC Thin driver to connect to and query a database. The code used in the applet was created with Oracle JDeveloper and complies with JDK 1.1.2 and JDBC 1.22. Signed applets are also browser-specific; the applet defined in this section works with the Netscape 4.*x* browser.

The applet displays a user interface that lets you connect to a local or a remote database, depending on whether you press the "Local" or "Remote" button. The applet queries the selected database for the contents of a specified row and displays the results.

If you want to try this example on your own system, you must provide this information:

- Obtain a copy of the Capabilities classes from Netscape and an object-signing certificate. You can find instructions for this at:

```
http://developer.netscape.com/docs/manuals/signedobj/capabilities/contents.htm
```

  Follow the instructions for obtaining a certificate and downloading the classes. The example in this section requires the Capabilities classes `Principle.class`, `Privilege.class`, `PrivilegeManager.class`, and `PrivilegeTable.class`.

In the applet code, replace the following strings:

- Replace <*`local database connect string`*> with the connect string for the local database. For example:

  ```
  "jdbc:oracle:thin:@myServer.us.oracle.com:1521:orcl", "scott","tiger"
  ```

- Replace <*`select on row of local table`*> with a SQL `SELECT` statement on a row in a table in the local database. For example:

  ```
  SELECT * FROM EMP WHERE ENAME = 'Mary'
  ```

- Replace <*remote database connect string*> with the connect string for the remote database. For example:

  ```
  "jdbc:oracle:thin:@yourServer.us.oracle.com:1521:orcl", "scott","tiger"
  ```

- Replace <*select on row of remote table*> with a SQL SELECT statement on a table in the remote database. For example:

  ```
  SELECT * FROM EMP WHERE ENAME = 'Bob'
  ```

This applet uses only the Java AWT components and JDBC.

```
// Title:      JDBC Test Applet                                  // line 1
// Description:Sample JDK 1.1 Applet using the
// ORACLE JDBC Thin Driver
package JDBCApplet;

import java.awt.*;                                               // line 6
import java.awt.event.*;
import java.applet.*;
import java.sql.*;
import borland.jbcl.control.*;
import netscape.security.*;
                                                                 // line 12
public class MainApplet extends Applet {
  boolean isStandalone = false;
  BorderLayout borderLayout1 = new BorderLayout();
  Panel panel1 = new Panel();
  Label labelTitle = new Label();
  Panel panel2 = new Panel();
  BorderLayout borderLayout2 = new BorderLayout();
  TextArea txtArResults = new TextArea();
  Button button1 = new Button();
  BorderLayout borderLayout3 = new BorderLayout();
  Panel panel3 = new Panel();
  BorderLayout borderLayout4 = new BorderLayout();
  Label statusBar1 = new Label();
  Button button2 = new Button();

  // Get a parameter value                                       // line 28
  public String getParameter(String key, String def) {
    return isStandalone ? System.getProperty(key, def) :
      (getParameter(key) != null ? getParameter(key) : def);
  }                                                              // line 32

  // Construct the applet
```

```
public MainApplet() {
}

// Initialize the applet                                        line 37
public void init() {
  try { jbInit(); } catch (Exception e) { e.printStackTrace(); }
  try {
      PrivilegeManager.enablePrivilege("UniversalConnect");
      PrivilegeManager.enablePrivilege("UniversalListen");
      PrivilegeManager.enablePrivilege("UniversalAccept");
  } catch (Exception e) {
    e.printStackTrace();
  }
}

// Component initialization                                     line 49
public void jbInit() throws Exception{
  this.setBounds(new Rectangle(0, 0, 400, 400));
  panel1.setBackground(Color.lightGray);
  panel1.setLayout(borderLayout3);
  this.setSize(new Dimension(372, 373));
  labelTitle.setBackground(Color.lightGray);
  labelTitle.setFont(new Font("Dialog", 0, 12));
  labelTitle.setAlignment(1);
  labelTitle.setText("Oracle Thin JDBC Driver  Sample Applet");
  button1.setLabel("Local");
  panel3.setBackground(Color.lightGray);
  statusBar1.setBackground(Color.lightGray);
  statusBar1.setText("Ready");
  button2.setLabel("Remote");
  button2.addActionListener(new MainApplet_button2_actionAdapter(this));
  panel3.setLayout(borderLayout4);
  button1.addActionListener(new MainApplet_button1_actionAdapter(this));
  panel2.setLayout(borderLayout2);
  this.setLayout(borderLayout1);
  this.add(panel1, BorderLayout.NORTH);
  panel1.add(button1, BorderLayout.WEST);
  panel1.add(labelTitle, BorderLayout.CENTER);
  panel1.add(button2, BorderLayout.EAST);
  this.add(panel2, BorderLayout.CENTER);
  panel2.add(txtArResults, BorderLayout.CENTER);
  this.add(panel3, BorderLayout.SOUTH);
  panel3.add(statusBar1, BorderLayout.NORTH);
}
```

```
  //Start the applet                                          line 79
  public void start() {
  }

  //Stop the applet
  public void stop() {
  }

  //Destroy the applet
  public void destroy() {
  }

  //Get Applet information
  public String getAppletInfo() {
    return "Applet Information";
  }

  //Get parameter info
  public String[][] getParameterInfo() {
    return null;
  }

  //Main method
  static public void main(String[] args) {
    MainApplet applet = new MainApplet();
    applet.isStandalone = true;
    Frame frame = new Frame();
    frame.setTitle("Applet Frame");
    frame.add(applet, BorderLayout.CENTER);
    applet.init();
    applet.start();
    frame.pack();
    Dimension d = Toolkit.getDefaultToolkit().getScreenSize();
    frame.setLocation((d.width - frame.getSize().width) / 2, (d.height -
frame.getSize().height) / 2);
    frame.setVisible(true);
  }

  void button1_actionPerformed(ActionEvent e) {
    //
    // Handler for "Local" Button.
    //
    // Here is where we connect to local database            line 121

    StringBuffer b = new StringBuffer ();
```

```
  try {
      DriverManager.registerDriver ( new oracle.jdbc.driver.OracleDriver ());
      b.append ("DriverManager.registerDriver\r\n");
  } catch (SQLException oe) {
      statusBar1.setText("registerDriver: Caught SQLException");
  } catch (ClassNotFoundException oe) {
      statusBar1.setText("registerDriver: Caught ClassNotFoundException");
  }

  int numRows = 0;
  try {
      statusBar1.setText("Executing Query on Local Database ...");
      Connection conn = DriverManager.getConnection (
         "jdbc:oracle:thin:<local database connect string>");

      b.append ("[DriverManager.getConnection] \r\n");
      Statement stmt = conn.createStatement ();
      b.append ("[conn.createStatement] \r\n");
      ResultSet rset = stmt.executeQuery ("<select on row of
                                            local table>");
      b.append ("[stmt.executeQuery] \r\n");
      b.append("SQL> <select on row of local table>\r\n\n");
      b.append("DSCr\n-------------------------------------\r\n");

      while (rset.next ()) {
            String ename = rset.getString (1);
            b.append (ename);
            b.append ("\r\n");
            numRows++;
      } // [end while rset.next() loop]
      statusBar1.setText("Query Done.");
  } catch (SQLException SQLE) {
      statusBar1.setText ("Caught SQLException!");
      SQLE.printStackTrace();
  } finally {
      b.append("\r\n");
      b.append(String.valueOf(numRows) + " rows selected.\r\n");
      txtArResults.setText( b.toString ());
  }

  // End JDBC Code                                          line 165
}

void button2_actionPerformed(ActionEvent e) {
```

```
//
// Handler for the "Remote" Button                          line 170
//
StringBuffer b = new StringBuffer ();

try {
    DriverManager.registerDriver ( new oracle.jdbc.driver.OracleDriver ());
    b.append ("DriverManager.registerDriver\r\n");
} catch (SQLException oe) {
    statusBar1.setText("registerDriver: Caught SQLException");
} catch (ClassNotFoundException oe) {
    statusBar1.setText("registerDriver: Caught ClassNotFoundException");
}

int numRows = 0;                                        // line 183
try {
    statusBar1.setText("Executing Query on Remote Database ...");
    try {
            PrivilegeManager.enablePrivilege("UniversalConnect");
            b.append ("enablePrivilege(UniversalConnect)\r\n");
            PrivilegeManager.enablePrivilege("UniversalListen");
            b.append ("enablePrivilege(UniversalListen)\r\n");
            PrivilegeManager.enablePrivilege("UniversalAccept");
            b.append ("enablePrivilege(UniversalAccept)\r\n");

            Connection conn = DriverManager.getConnection (
            "jdbc:oracle:thin:<remote database connect string>"
            );
            b.append ("DriverManager.getConnection\r\n");

            Statement stmt = conn.createStatement ();
            b.append ("conn.createStatement\r\n");
            ResultSet rset = stmt.executeQuery ("<select on row
                                                 of remote table>");
            b.append ("stmt.executeQuery\r\n");
            b.append("SQL> <select on row of remote table>\r\n\n");
            b.append("ENAME\r\n----------\r\n");

            while (rset.next ()) {
                  String ename = rset.getString (1);
                  b.append (ename);
                  b.append ("\r\n");
                  numRows++;
            } // [end while rset.next() loop]
            statusBar1.setText("Query Done.");
```

```
        } catch (Exception oe) {
                oe.printStackTrace();
        }
    } catch (SQLException SQLE) {
        statusBar1.setText("Caught SQLException!");
        SQLE.printStackTrace();
    } finally {
        b.append("\r\n");
        b.append(String.valueOf(numRows) + " rows selected.\r\n");
        txtArResults.setText( b.toString ());
    }

    // End JDBC Code for Button2                              line 256

  }
}
                                                            // line 260
class MainApplet_button1_actionAdapter implements java.awt.event.ActionListener
{
  MainApplet adaptee;

  MainApplet_button1_actionAdapter(MainApplet adaptee) {
    this.adaptee = adaptee;
  }

  public void actionPerformed(ActionEvent e) {
    adaptee.button1_actionPerformed(e);
  }
}
                                                            // line 273
class MainApplet_button2_actionAdapter implements java.awt.event.ActionListener
{
  MainApplet adaptee;

  MainApplet_button2_actionAdapter(MainApplet adaptee) {
    this.adaptee = adaptee;
  }

  public void actionPerformed(ActionEvent e) {
    adaptee.button2_actionPerformed(e);
  }
}
```

Lines 6-11: Import the needed files.

Lines 13-26: Set up the graphics for the GUI which will include two buttons and a text area to display the output.

Lines 37-48: Request privileges to connect to the host other than the one from which the applet was downloaded.

Lines 49-77: Initialize the components of the applet. These components include the format and layout of the GUI and the GUI buttons and text area.

Lines 121-165: Connect to the local database. To do this, register the driver with the `DriverManager.registerDriver()` method and connect to the database with `DriverManager.getConnection()`. Connect with the server URL, port number, SID, user name, and password.

Lines 170-183: Connect to the remote database.

Lines 183-256: Test that the applet has privileges on the remote database. If it does, then connect to the database and execute SQL statements.

Lines 260-283: Code to set up events and callbacks for the buttons.

JDBC versus SQLJ Sample Code

This section contains a side-by-side comparison of two versions of the same sample code: one version is written in JDBC and the other in SQLJ. The objective of this section is to point out the differences in coding requirements between SQLJ and JDBC.

In the sample, two methods are defined: `getEmployeeAddress()` which `SELECT`s into a table and returns an employee's address based on the employee's number, and `updateAddress()` which takes the retrieved address, calls a stored procedure, and returns the updated address to the database.

In both versions of the sample code, these assumptions have been made:

- The `ObjectDemo.sql` SQL script (described below) has been run to create the schema in the database and populate the tables.
- A PL/SQL stored function `UPDATE_ADDRESS`, which updates a given address, exists.
- The Connection object (for JDBC) and Default Connection Context (for SQLJ) have previously been created by the caller.

- Exceptions are handled by the caller.
- The value of the address argument (`addr`) passed to the `updateAddress` method can be null.

Both versions of the sample code reference objects and tables created by the `ObjectDemo.sql` script.

> **Note:** The JDBC and SQLJ versions of the sample code are only code snippets. They cannot be run independently.

SQL Program to Create Tables and Objects

Following is a listing of the `ObjectDemo.sql` script that creates the tables and objects referenced by the two versions of the sample code. The `ObjectDemo.sql` script creates a `person` object, an `address` object, a typed table (`persons`) of `person` objects, and a relational table (`employees`) for employee data.

```
/*** Using objects in SQLJ ***/
SET ECHO ON;
/**

/*** Clean up ***/
DROP TABLE EMPLOYEES
/
DROP TABLE PERSONS
/
DROP TYPE PERSON FORCE
/
DROP TYPE ADDRESS FORCE
/

/*** Create an address object ***/
CREATE TYPE address AS OBJECT
(
  street        VARCHAR(60),
  city          VARCHAR(30),
  state         CHAR(2),
  zip_code      CHAR(5)
)
/

/*** Create a person object containing an embedded Address object ***/
CREATE TYPE person AS OBJECT
```

```
(
  name    VARCHAR(30),
  ssn     NUMBER,
  addr    address
)
/

/*** Create a typed table for person objects ***/
CREATE TABLE persons OF person
/

/*** Create a relational table with two columns that are REFs
     to person objects, as well as a column which is an Address object.***/

CREATE TABLE  employees
( empnumber            INTEGER PRIMARY KEY,
  person_data     REF  person,
  manager         REF  person,
  office_addr          address,
  salary               NUMBER
)

/
/*** insert code for UPDATE_ADDRESS stored procedure here
/

/*** Now let's put in some sample data
     Insert 2 objects into the persons typed table ***/

INSERT INTO persons VALUES (
            person('Wolfgang Amadeus Mozart', 123456,
    address('Am Berg 100', 'Salzburg', 'AU','10424')))
/
INSERT INTO persons VALUES (
    person('Ludwig van Beethoven', 234567,
    address('Rheinallee', 'Bonn', 'DE', '69234')))
/

/** Put a row in the employees table **/

INSERT INTO employees (empnumber, office_addr, salary) " +
            " VALUES (1001, address('500 Oracle Parkway', " +
            " 'Redwood City', 'CA', '94065'), 50000)
/
```

```
/** Set the manager and person REFs for the employee **/

UPDATE employees
  SET manager =
    (SELECT REF(p) FROM persons p WHERE p.name = 'Wolfgang Amadeus Mozart')
/

UPDATE employees
  SET person_data =
    (SELECT REF(p) FROM persons p WHERE p.name = 'Ludwig van Beethoven')
/

COMMIT
/
QUIT
```

JDBC Version of the Sample Code

Following is the JDBC version of the sample code, which defines methods to retrieve an employee's address from the database, update the address, and return it to the database. Note, the "TO DOs" in the comment lines indicate where you might want to add additional code to enhance the usefulness of the code sample.

```
import java.sql.*;
import oracle.jdbc.driver.*;

/**
  This is what we have to do in JDBC
  **/
public class SimpleDemoJDBC                                    // line 7
{

//TO DO: make a main that calls this

  public Address getEmployeeAddress(int empno, Connection conn)
    throws SQLException                                        // line 13
  {
    Address addr;
    PreparedStatement pstmt =                                  // line 16
      conn.prepareStatement("SELECT office_addr FROM employees" +
       " WHERE empnumber = ?");
    pstmt.setInt(1, empno);
    OracleResultSet rs = (OracleResultSet)pstmt.executeQuery();
    rs.next();                                                 // line 21
     //TO DO: what if false (result set contains no data)?
```

```
    addr = (Address)rs.getCustomDatum(1, Address.getFactory());
    //TO DO: what if additional rows?
    rs.close();                                              // line 25
    pstmt.close();
    return addr;                                             // line 27

  }

  public Address updateAddress(Address addr, Connection conn)
    throws SQLException                                      // line 30

  {
    OracleCallableStatement cstmt = (OracleCallableStatement)
      conn.prepareCall("{ ? = call UPDATE_ADDRESS(?) }");    //line 34
    cstmt.registerOutParameter(1, Address._SQL_TYPECODE, Address._SQL_NAME);
                                                             // line 36
    if (addr == null) {
      cstmt.setNull(2, Address._SQL_TYPECODE, Address._SQL_NAME);
    } else {
      cstmt.setCustomDatum(2, addr);
    }

    cstmt.executeUpdate();                                   // line 43
    addr = (Address)cstmt.getCustomDatum(1, Address.getFactory());
    cstmt.close();                                           // line 45
    return addr;
  }
}
```

Line 12: In the `getEmployeeAddress()` method definition, you must pass the connection object to the method definition explicitly.

Lines 16-20: Prepare a statement that selects an employee's address from the `employees` table on the basis of the employee number. The employee number is represented by a marker variable, which is set with the `setInt()` method. Note that because the prepared statement does not recognize the "`INTO`" syntax used in "SQL Program to Create Tables and Objects" on page 7-39, you must provide your own code to populate the address (`addr`) variable. Since the prepared statement is returning a custom object, cast the output to an Oracle result set.

Lines 21-23: Because the Oracle result set contains a custom object of type `Address`, use the `getCustomDatum()` method to retrieve it (the `Address` object could be created by JPublisher). The `getCustomDatum()` method requires you to use the factory method `Address.getFactory()` to materialize an instance of an

`Address` object. Since `getCustomDatum()` returns a `Datum`, cast the output to an `Address` object.

Note that the routine assumes a one-row result set. The "`TO DO`s" in the comment statements indicate that you must write additional code for the cases where the result set contains either no rows or more than one row.

Lines 25-27: Close the result set and prepared statement objects, then return the `addr` variable.

Line 29: In the `updateAddress()` definition, you must pass the connection object and the `Address` object explicitly.

The `updateAddress()` method passes an address to the database for update and fetches it back. The actual updating of the address is performed by the `UPDATE_ADDRESS` stored procedure (the code for this procedure is not illustrated in this example).

Line 33-43: Prepare an Oracle callable statement that takes an address object (`Address`) and passes it to the `UPDATE_ADDRESS` stored procedure. To register an object as an output parameter, you must know the object's SQL type code and SQL type name.

Before passing the address object (`addr`) as an input parameter, the program must determine whether `addr` has a value or is null. Depending on the value of `addr`, the program calls different `set` methods. If `addr` is null, the program calls `setNull()`, if it has a value, the program calls `setCustomDatum()`.

Line 44: Fetch the return result `addr`. Since the Oracle callable statement returns a custom object of type `Address`, use the `getCustomDatum()` method to retrieve it (the `Address` object could be created by JPublisher). The `getCustomDatum()` method requires you to use the factory method `Address.getFactory` to materialize an instance of an `Address` object. Because `getCustomDatum()` returns a `Datum`, cast the output to an `Address` object.

Lines 45, 46: Close the Oracle callable statement, then return the `addr` variable.

Coding Requirements of the JDBC Version

Note the following coding requirements for the JDBC version of the sample code:

- The `getEmployeeAddress()` and `updateAddress()` definitions must explicitly include the connection object.

- Long SQL strings must be concatenated with the SQL concatenation character ("+").
- You must explicitly manage resources (for example, close result set and statement objects).
- You must cast datatypes as needed.
- You must know the _SQL_TYPECODE and _SQL_NAME of the factory objects that you are registering as output parameters.
- Null data must be explicitly handled.
- Host variables must be represented by parameter markers in callable and prepared statements.

Maintaining JDBC Programs

JDBC programs have the potential of being expensive in terms of maintenance. For example, in the above code sample, if you add another WHERE clause, then you must change the SELECT string. If you append another host variable, then you must increment the index of the other host variables by one. A simple change to one line in a JDBC program might require changes in several other areas of the program.

SQLJ Version of the Sample Code

Following is the SQLJ version of the sample code that defines methods to retrieve an employee's address from the database, update the address, and return it to the database.

```
import java.sql.*;

/**
  This is what we have to do in SQLJ
  **/
public class SimpleDemoSQLJ                                    // line 6
{
  //TO DO: make a main that calls this?

  public Address getEmployeeAddress(int empno)                 // line 10
    throws SQLException
  {
    Address addr;                                              // line 13
    #sql { SELECT office_addr INTO :addr FROM employees
     WHERE empnumber = :empno };
    return addr;
```

```
  }
                                                          // line 18
  public Address updateAddress(Address addr)
    throws SQLException
  {
    #sql addr = { VALUES(UPDATE_ADDRESS(:addr)) };        // line 23
    return addr;
  }
}
```

Line 10: The `getEmployeeAddress()` method does not require a connection object. SQLJ uses a default connection context instance, which would have been defined previously somewhere in your application.

Lines 13-15: The `getEmployeeAddress()` method retrieves an employee address according to employee number. Use standard SQLJ `SELECT INTO` syntax to select an employee's address from the employee table if their employee number matches the one (`empno`) passed in to `getEmployeeAddress()`. This requires a declaration of the Address object (`addr`) that will receive the data. The `empno` and `addr` variables are used as input host variables. (Host variables are sometimes also referred to as bind variables.)

Line 16: The `getEmployeeAddress()` method returns the `addr` object.

Line 19: The `updateAddress()` method also uses the default connection context instance.

Lines 19-23: The address is passed to the `updateAddress()` method, which passes it to the database. The database updates it and passes it back. The actual updating of the address is performed by the `UPDATE_ADDRESS` stored function (the code for this function is not shown here). Use standard SQLJ function-call syntax to receive the address object (`addr`) output by `UPDATE_ADDRESS`.

Line 24: The `updateAddress()` method returns the `addr` object.

Coding Requirements of the SQLJ Version

Note the following coding requirements for the SQLJ version of the sample code:

- An explicit connection is not required; SQLJ assumes that a default connection context has been defined previously in your application.
- No datatype casting is required.

- SQLJ does not require knowledge of `_SQL_TYPECODE`, `_SQL_NAME`, or factories.
- Null data is handled implicitly.
- No explicit code for resource management (for closing statements or result sets, for example) is required.
- SQLJ embeds host variables in contrast to JDBC which uses parameter markers.
- String concatenation for long SQL statements is not required.
- You do not have to register out-parameters.
- SQLJ syntax is simpler; for example, `SELECT...INTO` is supported and OBDC-style escapes are not used.

8

Reference Information

This chapter contains detailed JDBC reference information, including the following topics:

- Valid SQL-JDBC Datatype Mappings
- Supported SQL and PL/SQL Datatypes
- NLS Character Set Support
- Related Information

Valid SQL-JDBC Datatype Mappings

Table 3–1 and Table 3–2 in Chapter 3 describe the default mappings between Java classes and SQL datatypes that are supported by the Oracle JDBC drivers. Compare the contents of the **Standard JDBC Datatypes, Java Native Datatypes** and **Oracle SQL Datatypes** columns in Table 3–1 and Table 3–2 with the contents of Table 8–1 below.

Table 8–1 lists all of the possible Java classes to which a given SQL datatype can be validly mapped. The Oracle JDBC drivers will support these "non-default" mappings. For example, to materialize SQL `CHAR` data as an `oracle.sql.CHAR`, use `getCHAR()`. To materialize it as a `java.math.BigDecimal`, use `getBigDecimal()`.

Table 8–1 Valid SQL Datatype-Java Class Mappings

This SQL datatype:	Can be materialized as these Java classes:
CHAR, NCHAR,VARCHAR2,	oracle.sql.CHAR
NVARCHAR2, LONG	java.lang.String
	java.sql.Date
	java.sql.Time
	java.sql.Timestamp
	java.lang.Byte
	java.lang.Short
	java.lang.Integer
	java.lang.Long
	java.lang.Float
	java.lang.Double
	java.math.BigDecimal
	byte, short, int, long, float, double
DATE	oracle.sql.DATE
	java.sql.Date
	java.sql.Time
	java.sql.Timestamp
	java.lang.String

Table 8–1 Valid SQL Datatype-Java Class Mappings (Cont.)

This SQL datatype:	Can be materialized as these Java classes:
NUMBER	oracle.sql.NUMBER
	java.lang.Byte
	java.lang.Short
	java.lang.Integer
	java.lang.Long
	java.lang.Float
	java.lang.Double
	java.math.BigDecimal
	byte, short, int, long, float, double
RAW, LONG RAW	oracle.sql.RAW
	byte[]
ROWID	oracle.sql.CHAR
	oracle.sql.ROWID
	java.lang.String
BFILE	oracle.sql.BFILE
BLOB	oracle.sql.BLOB
	oracle.jdbc2.Blob
CLOB, NCLOB	oracle.sql.CLOB
	oracle.jdbc2.Clob
OBJECT	oracle.sql.STRUCT
	oracle.SqljData
	oracle.jdbc2.Struct
REF	oracle.sql.REF
	oracle.jdbc2.Ref
TABLE (nested), VARRAY	oracle.sql.ARRAY
	oracle.jdbc2.Array
any of the above SQL types	oracle.sql.CustomDatum or oracle.sql.Datum

Notes:

- The type `UROWID` is not supported.
- `oracle.sql.Datum` is an abstract class. The value passed to a parameter of type `oracle.sql.Datum` must be of the Java type corresponding to the SQL type. Likewise, the value returned by a method with return type `oracle.sql.Datum` must be of the Java type corresponding to the SQL type.
- The mappings to `oracle.sql` classes are optimal if no conversion from SQL format to Java format is necessary.

Supported SQL and PL/SQL Datatypes

The tables in this section list SQL and PL/SQL datatypes, and whether the Oracle JDBC drivers and SQLJ support them. Table 8–2 describes Oracle JDBC driver and SQLJ support for SQL datatypes.

Table 8–2 Support for SQL Datatypes

SQL Datatype	Supported by JDBC Drivers?	Supported by SQLJ?
BFILE	yes	yes
BLOB	yes	yes
CHAR	yes	yes
CLOB	yes	yes
DATE	yes	yes
NCHAR	no	no
NCHAR VARYING	no	no
NUMBER	yes	yes
NVARCHAR2	no	no
RAW	yes	yes
REF	yes	yes
ROWID	yes	yes
UROWID	no	no
VARCHAR2	yes	yes

Table 8–3 describes Oracle JDBC driver and SQLJ support for the ANSI-supported SQL datatypes.

Table 8–3 Support for ANSI-Supported SQL Datatypes

ANSI-Supported SQL Datatypes	Supported by JDBC Drivers?	Supported by SQLJ?
CHARACTER	yes	yes
DEC	yes	yes
DECIMAL	yes	yes
DOUBLE PRECISION	yes	yes
FLOAT	yes	yes
INT	yes	yes
INTEGER	yes	yes
NATIONAL CHARACTER	no	no
NATIONAL CHARACTER VARYING	no	no
NATIONAL CHAR	no	no
NATIONAL CHAR VARYING	no	no
NCHAR	no	no
NCHAR VARYING	no	no
NUMERIC	yes	yes
REAL	yes	yes
SMALLINT	yes	yes
VARCHAR	yes	yes

Table 8–4 describes Oracle JDBC driver and SQLJ support for PL/SQL datatypes. Note that PL/SQL datatypes include these categories:

- scalar types
- scalar character types (includes boolean and date datatypes)
- composite types
- reference types
- LOB types

Table 8–4 Support for PL/SQL Datatypes

PL/SQL Datatypes	Supported by JDBC Drivers?	Supported by SQLJ?
Scalar Types:		
binary integer	yes	yes
dec	yes	yes
decimal	yes	yes
double precision	yes	yes
float	yes	yes
int	yes	yes
integer	yes	yes
natural	yes	yes
natural*n*	no	no
number	yes	yes
numeric	yes	yes
pls_integer	yes	yes
positive	yes	yes
positive*n*	no	no
real	yes	yes
signtype	yes	yes
smallint	yes	yes
Scalar Character Types:		
char	yes	yes
character	yes	yes
long	yes	yes
long raw	yes	yes
nchar	no	no
nvarchar2	no	no
raw	yes	yes
rowid	yes	yes

Table 8–4 Support for PL/SQL Datatypes (Cont.)

PL/SQL Datatypes	Supported by JDBC Drivers?	Supported by SQLJ?
string	yes	yes
urowid	no	no
varchar	yes	yes
varchar2	yes	yes
boolean	yes	yes
date	yes	yes
Composite Types:		
record	no	no
table	no	no
varray	yes	yes
Reference Types:		
REF CURSOR	yes	yes
REF object type	yes	yes
LOB Types:		
BFILE	yes	yes
BLOB	yes	yes
CLOB	yes	yes
NCLOB	no	no

Notes:

- The types natural, natural*n*, positive, positive*n*, and signtype are subtypes of binary integer.
- The types dec, decimal, double precision, float, int, integer, numeric, real, and smallint, are subtypes of number.

NLS Character Set Support

On the client, the Oracle JDBC OCI and Thin drivers support all Oracle NLS character sets. On the server, the Oracle JDBC Server driver supports only two Oracle NLS character sets: `US7ASCII` (ASCII 7-bit American) and `WE8ISO8859P1` (ISO 8859-1 West European or "ISO-Latin 1").

Related Information

This section lists web sites that contain useful information for JDBC programmers. Many of the sites are referenced in other sections of this manual. In this list you can find references to the Oracle JDBC drivers and SQLJ, Java technology, the Java Developer's Kit APIs (for versions 1.2 and 2.0), and resources to help you write applets.

Oracle JDBC Drivers and SQLJ

Oracle JDBC Driver Home Page (Oracle Corporation)

`http://www.oracle.com/st/products/jdbc/`

Oracle JDBC Driver Download Page (Oracle Corporation)

`http://www.oracle.com/products/free_software/index.html#jdbc8`

Oracle SQLJ Home Page (Oracle Corporation)

`http://www.oracle.com/st/products/jdbc/sqlj/index.html`

Java Technology

Java Technology Home Page (Sun Microsystems, Inc.):

`http://www.javasoft.com/`

Java Development Kit 1.1 (JDK1.1) (Sun Microsystems, Inc.):

`http://java.sun.com/products/jdk/1.1/`

Java Platform JDK1.1 Core API Specification (Sun Microsystems, Inc.):

`http://www.javasoft.com/products/jdk/1.1/docs/api/packages.html`

Java Development Kit 1.2 (JDK1.2) (Sun Microsystems, Inc.):

`http://java.sun.com:80/products/jdk/1.2/index.html`

Java Platform JDK1.2 Core API Specification (Sun Microsystems, Inc.):

`http://www.javasoft.com/products/jdk/1.2/docs/api/index.html`

Signed Applets

Introduction to Capabilities Classes (Netscape Communications Corp.):

`http://developer.netscape.com/docs/manuals/signedobj/capabilities/contents.htm`

Object-Signing Resources (Netscape Communications Corp.):

`http://developer.netscape.com/software/signedobj/index.html`

Signed Applet Example (Sun Microsystems, Inc.):

`http://java.sun.com/security/signExample/index.html`

A

JDBC Error Messages

This appendix lists the error messages that the Oracle JDBC drivers can return.

"Cause" and "Action" information for each message will be provided in a later release.

byte array not long enough

can only describe a query

cannot do new defines until the current result set is closed

cannot set row prefetch to zero

char array not long enough

character set not supported

closed connection

closed LOB

closed resultset

closed statement

cursor already initialized

error in defines.isNull ()

error in type descriptor parse

exception in OracleNumber

exhausted resultset

fail to construct descriptor

fail to convert between UTF8 and UCS2

fail to convert to internal representation

inconsistent Java and SQL object types

Internal error: attempt to access bind values beyond the batch value

Internal error: data array not allocated

Internal error: invalid index for data access

Internal error: invalid NLS Conversion ratio

invalid batch value

invalid character encountered in

invalid column name

invalid column type

invalid cursor

invalid dynamic column

invalid row prefetch

invalid stream maximum size

malformed SQL92 string at position

missing defines

missing defines at index

missing descriptor

missing IN or OUT parameter at index:

no data read

no such element in vector

non supported character set

non-supported SQL92 token at position

numeric overflow

only one RPA message is expected

only one RXH message is expected

parameter type conflict

protocol violation

received more RXDs than expected

REF cursor is invalid

resultSet.next was not called

setAutoClose: only support auto close mode on

setReadOnly: read-only connections not supported

setTransactionIsolation: only supports TRANSACTION_READ_ UNCOMMITTED

statement timed out

statement was cancelled

stream has already been closed

sub protocol must be specified in connection URL

the LOB locator is not valid

the size is not valid

This API cannot be be used for non-UDT types

this ref is not valid

undefined type

unsupported column type

unsupported feature

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