Table of Contents

1. INTRODUCTION

What is JDBC?

JDBC stands for **J**ava **D**ata**b**ase **C**onnectivity, which is a standard Java API for database-independent connectivity between the Java programming language, and a wide range of databases.

The JDBC library includes APIs for each of the tasks mentioned below that are commonly associated with database usage.

- Making a connection to a database.
- Creating SQL or MySQL statements.
- Executing SQL or MySQL queries in the database.
- Viewing & Modifying the resulting records.

Fundamentally, JDBC is a specification that provides a complete set of interfaces that allows for portable access to an underlying database. Java can be used to write different types of executables, such as:

- Java Applications
- Java Applets
- Java Servlets
- Java ServerPages (JSPs)
- Enterprise JavaBeans (EJBs).

All of these different executables are able to use a JDBC driver to access a database, and take advantage of the stored data.

JDBC provides the same capabilities as ODBC, allowing Java programs to contain database-independent code.

Pre-Requisite

Before moving further, you need to have a good understanding of the following two subjects:

- **Core JAVA Programming**
- **SQL or MySQL Database**

JDBC Architecture

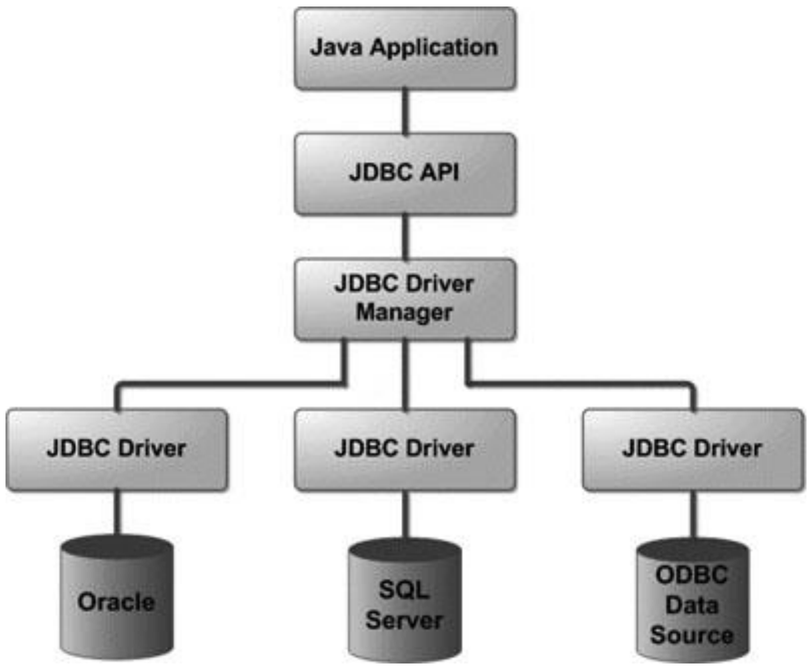
The JDBC API supports both two-tier and three-tier processing models for database access but in general, JDBC Architecture consists of two layers:

- **JDBC API:** This provides the application-to-JDBC Manager connection.
- **JDBC Driver API:** This supports the JDBC Manager-to-Driver Connection.

The JDBC API uses a driver manager and database-specific drivers to provide transparent connectivity to heterogeneous databases.

The JDBC driver manager ensures that the correct driver is used to access each data source. The driver manager is capable of supporting multiple concurrent drivers connected to multiple heterogeneous databases.

Following is the architectural diagram, which shows the location of the driver manager with respect to the JDBC drivers and the Java application:



Common JDBC Components

The JDBC API provides the following interfaces and classes:

- **DriverManager:** This class manages a list of database drivers. Matches connection requests from the java application with the proper database driver using communication subprotocol. The first driver that recognizes a certain subprotocol under JDBC will be used to establish a database Connection.
- **Driver:** This interface handles the communications with the database server. You will interact directly with Driver objects very rarely. Instead,

you use DriverManager objects, which manages objects of this type. It also abstracts the details associated with working with Driver objects.

- **Connection:** This interface with all methods for contacting a database. The connection object represents communication context, i.e., all communication with database is through connection object only.
- **Statement:** You use objects created from this interface to submit the SQL statements to the database. Some derived interfaces accept parameters in addition to executing stored procedures.
- **ResultSet:** These objects hold data retrieved from a database after you execute an SQL query using Statement objects. It acts as an iterator to allow you to move through its data.
- **SQLException:** This class handles any errors that occur in a database application.

The JDBC 4.0 Packages

The java.sql and javax.sql are the primary packages for JDBC 4.0. This is the latest JDBC version at the time of writing this tutorial. It offers the main classes for interacting with your data sources.

The new features in these packages include changes in the following areas:

- Automatic database driver loading.
- Exception handling improvements.
- Enhanced BLOB/CLOB functionality.
- Connection and statement interface enhancements.
- National character set support.
- SQL ROWID access.
- SQL 2003 XML data type support.
- Annotations.

2. SQL SYNTAX

Structured **Q**uery **L**anguage (SQL) is a standardized language that allows you to perform operations on a database, such as creating entries, reading content, updating content, and deleting entries.

SQL is supported by almost any database you will likely use, and it allows you to write database code independently of the underlying database.

This chapter gives an overview of SQL, which is a prerequisite to understand JDBC concepts. After going through this chapter, you will be able to **C**reate, **R**ead, **U**pdate, and **D**elete (often referred to as **CRUD** operations) data from a database.

For a detailed understanding on SQL, you can read our MySQL Tutorial.

Create Database

The CREATE DATABASE statement is used for creating a new database. The syntax is:

```
SQL> CREATE DATABASE DATABASE_NAME;
```

Example

The following SQL statement creates a Database named EMP:

```
SQL> CREATE DATABASE EMP;
```

Drop Database

The DROP DATABASE statement is used for deleting an existing database. The syntax is:

```
SQL> DROP DATABASE DATABASE_NAME;
```

Note: To create or drop a database you should have administrator privilege on your database server. Be careful, deleting a database would loss all the data stored in the database.

Create Table

The CREATE TABLE statement is used for creating a new table. The syntax is:

```
SQL> CREATE TABLE table_name
(
   column_name column_data_type,
   column_name column_data_type,
   column_name column_data_type
   ...
);
```

Example

The following SQL statement creates a table named Employees with four columns:

```
SQL> CREATE TABLE Employees
(
   id INT NOT NULL,
   age INT NOT NULL,
   first VARCHAR(255),
   last VARCHAR(255),
   PRIMARY KEY ( id )
);
```

Drop Table

The DROP TABLE statement is used for deleting an existing table. The syntax is:

```
SQL> DROP TABLE table_name;
```

Example

The following SQL statement deletes a table named Employees:

```
SQL> DROP TABLE Employees;
```

INSERT Data

The syntax for INSERT, looks similar to the following, where column1, column2, and so on represents the new data to appear in the respective columns:

```
SQL> INSERT INTO table_name VALUES (column1, column2, ...);
```

Example

The following SQL INSERT statement inserts a new row in the Employees database created earlier:

```
SQL> INSERT INTO Employees VALUES (100, 18, 'Zara', 'Ali');
```

SELECT Data

The SELECT statement is used to retrieve data from a database. The syntax for SELECT is:

```
SQL> SELECT column_name, column_name, ...
     FROM table_name
     WHERE conditions;
```

The WHERE clause can use the comparison operators such as =, !=, <, >, <=,and >=, as well as the BETWEEN and LIKE operators.

Example

The following SQL statement selects the age, first and last columns from the Employees table, where id column is 100:

```
SQL> SELECT first, last, age
     FROM Employees
     WHERE id = 100;
```

The following SQL statement selects the age, first and last columns from the Employees table, where *first* column contains *Zara*:

```
SQL> SELECT first, last, age
     FROM Employees
     WHERE first LIKE '%Zara%';
```

UPDATE Data

The UPDATE statement is used to update data. The syntax for UPDATE is:

```
SQL> UPDATE table_name
     SET column_name = value, column_name = value, ...
     WHERE conditions;
```

The WHERE clause can use the comparison operators such as =, !=, <, >, <=,and >=, as well as the BETWEEN and LIKE operators.

Example

The following SQL UPDATE statement changes the age column of the employee whose id is 100:

```
SQL> UPDATE Employees SET age=20 WHERE id=100;
```

DELETE Data

The DELETE statement is used to delete data from tables. The syntax for DELETE is:

```
SQL> DELETE FROM table_name WHERE conditions;
```

The WHERE clause can use the comparison operators such as =, !=, <, >, <=,and >=, as well as the BETWEEN and LIKE operators.

Example

The following SQL DELETE statement deletes the record of the employee whose id is 100:

```
SQL> DELETE FROM Employees WHERE id=100;
```

3. ENVIRONMENT

To start developing with JDBC, you should setup your JDBC environment by following the steps shown below. We assume that you are working on a Windows platform.

Install Java

Install J2SE Development Kit 5.0 (JDK 5.0) from Java Official Site.

Make sure following environment variables are set as described below:

- **JAVA_HOME:** This environment variable should point to the directory where you installed the JDK, e.g. C:\Program Files\Java\jdk1.5.0.
- **CLASSPATH:** This environment variable should have appropriate paths set, e.g. C:\Program Files\Java\jdk1.5.0_20\jre\lib.
- **PATH:** This environment variable should point to appropriate JRE bin, e.g. C:\Program Files\Java\jre1.5.0_20\bin.

It is possible you have these variable set already, but just to make sure here's how to check.

- Go to the control panel and double-click on System. If you are a Windows XP user, it is possible you have to open Performance and Maintenance, before you will see the System icon.
- Go to the Advanced tab and click on the Environment Variables.
- Now check if all the above mentioned variables are set properly.

You automatically get both JDBC packages **java.sql** and **javax.sql**, when you install J2SE Development Kit 5.0 (JDK 5.0).

Install Database

The most important thing you will need, of course is an actual running database with a table that you can query and modify.

Install a database that is most suitable for you. You can have plenty of choices and most common are:

- **MySQL DB:** MySQL is an open source database. You can download it from **MySQL Official Site**. We recommend downloading the full Windows installation.

In addition, download and install **MySQL Administrator** as well as **MySQL Query Browser.** These are GUI based tools that will make your development much easier.

Finally, download and unzip **MySQL Connector/J** (the MySQL JDBC driver) in a convenient directory. For the purpose of this tutorial, we will assume that you have installed the driver at C:\Program Files\MySQL\mysql-connector-java-5.1.8.

Accordingly, set CLASSPATH variable to C:\Program Files\MySQL\mysql-connector-java-5.1.8\mysql-connector-java-5.1.8-bin.jar. Your driver version may vary based on your installation.

- **PostgreSQL DB:** PostgreSQL is an open source database. You can download it from **PostgreSQL Official Site**.

  The Postgres installation contains a GUI based administrative tool called pgAdmin III. JDBC drivers are also included as part of the installation.

- **Oracle DB:** Oracle DB is a commercial database sold by Oracle. We assume that you have the necessary distribution media to install it.

  Oracle installation includes a GUI based administrative tool called Enterprise Manager. JDBC drivers are also included as a part of the installation.

Install Database Drivers

The latest JDK includes a JDBC-ODBC Bridge driver that makes most Open Database Connectivity (ODBC) drivers available to programmers using the JDBC API.

Now-a-days, most of the Database vendors are supplying appropriate JDBC drivers along with Database installation. So, you should not worry about this part.

Set Database Credential

For this tutorial we are going to use MySQL database. When you install any of the above database, its administrator ID is set to **root** and gives provision to set a password of your choice.

Using root ID and password you can either create another user ID and password, or you can use root ID and password for your JDBC application.

There are various database operations like database creation and deletion, which would need administrator ID and password.

For rest of the JDBC tutorial, we would use MySQL Database with **username** as ID and **password** as password.

If you do not have sufficient privilege to create new users, then you can ask your Database Administrator (DBA) to create a user ID and password for you.

Create Database

To create the **EMP** database, use the following steps:

Step 1

Open a **Command Prompt** and change to the installation directory as follows:

```
C:\>

C:\>cd Program Files\MySQL\bin

C:\Program Files\MySQL\bin>
```

Note: The path to **mysqld.exe** may vary depending on the install location of MySQL on your system. You can also check documentation on how to start and stop your database server.

Step 2

Start the database server by executing the following command, if it is already not running.

```
C:\Program Files\MySQL\bin>mysqld

C:\Program Files\MySQL\bin>
```

Step 3

Create the **EMP** database by executing the following command:

```
C:\Program Files\MySQL\bin> mysqladmin create EMP -u root -p

Enter password: ********

C:\Program Files\MySQL\bin>
```

Create Table

To create the **Employees** table in EMP database, use the following steps:

Step 1

Open a **Command Prompt** and change to the installation directory as follows:

```
C:\>
C:\>cd Program Files\MySQL\bin
C:\Program Files\MySQL\bin>
```

Step 2

Login to the database as follows:

```
C:\Program Files\MySQL\bin>mysql -u root -p
Enter password: ********
mysql>
```

Step 3

Create the table **Employee** as follows:

```
mysql> use EMP;
mysql> create table Employees
    -> (
    -> id int not null,
    -> age int not null,
    -> first varchar (255),
    -> last varchar (255)
    -> );
Query OK, 0 rows affected (0.08 sec)
mysql>
```

Create Data Records

Finally you create few records in Employee table as follows:

```
mysql> INSERT INTO Employees VALUES (100, 18, 'Zara', 'Ali');
Query OK, 1 row affected (0.05 sec)

mysql> INSERT INTO Employees VALUES (101, 25, 'Mahnaz', 'Fatma');
Query OK, 1 row affected (0.00 sec)
```

```
mysql> INSERT INTO Employees VALUES (102, 30, 'Zaid', 'Khan');
Query OK, 1 row affected (0.00 sec)


mysql> INSERT INTO Employees VALUES (103, 28, 'Sumit', 'Mittal');
Query OK, 1 row affected (0.00 sec)


mysql>
```

For a complete understanding on MySQL database, study the MySQL Tutorial.

Now you are ready to start experimenting with JDBC. Next chapter gives you a sample example on JDBC Programming.

4. SAMPLE CODE

This chapter provides an example of how to create a simple JDBC application. This will show you how to open a database connection, execute a SQL query, and display the results.

All the steps mentioned in this template example, would be explained in subsequent chapters of this tutorial.

Creating JDBC Application

There are following six steps involved in building a JDBC application:

- **Import the packages**: Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver**: Requires that you initialize a driver so you can open a communication channel with the database.
- **Open a connection**: Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with the database.
- **Execute a query**: Requires using an object of type Statement for building and submitting an SQL statement to the database.
- **Extract data from result set**: Requires that you use the appropriate*ResultSet.getXXX()* method to retrieve the data from the result set.
- **Clean up the environment**: Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

This sample example can serve as a **template** when you need to create your own JDBC application in the future.

This sample code has been written based on the environment and database setup done in the previous chapter.

Copy and past the following example in FirstExample.java, compile and run as follows:

```
//STEP 1. Import required packages
```

```
import java.sql.*;


public class FirstExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      //STEP 4: Execute a query
      System.out.println("Creating statement...");
      stmt = conn.createStatement();
      String sql;
      sql = "SELECT id, first, last, age FROM Employees";
      ResultSet rs = stmt.executeQuery(sql);

      //STEP 5: Extract data from result set
      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
```

```
          int age = rs.getInt("age");
          String first = rs.getString("first");
          String last = rs.getString("last");

          //Display values
          System.out.print("ID: " + id);
          System.out.print(", Age: " + age);
          System.out.print(", First: " + first);
          System.out.println(", Last: " + last);
       }
       //STEP 6: Clean-up environment
       rs.close();
       stmt.close();
       conn.close();
    }catch(SQLException se){
       //Handle errors for JDBC
       se.printStackTrace();
    }catch(Exception e){
       //Handle errors for Class.forName
       e.printStackTrace();
    }finally{
       //finally block used to close resources
       try{
          if(stmt!=null)
             stmt.close();
       }catch(SQLException se2){
       }// nothing we can do
       try{
          if(conn!=null)
             conn.close();
       }catch(SQLException se){
          se.printStackTrace();
       }//end finally try
```

```
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end FirstExample
```

Now let us compile the above example as follows:

```
C:\>javac FirstExample.java
C:\>
```

When you run **FirstExample**, it produces the following result:

```
C:\>java FirstExample
Connecting to database...
Creating statement...
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
C:\>
```

5. DRIVER TYPES

What is JDBC Driver?

JDBC drivers implement the defined interfaces in the JDBC API, for interacting with your database server.

For example, using JDBC drivers enable you to open database connections and to interact with it by sending SQL or database commands then receiving results with Java.

The *Java.sql* package that ships with JDK, contains various classes with their behaviours defined and their actual implementaions are done in third-party drivers. Third party vendors implements the *java.sql.Driver* interface in their database driver.

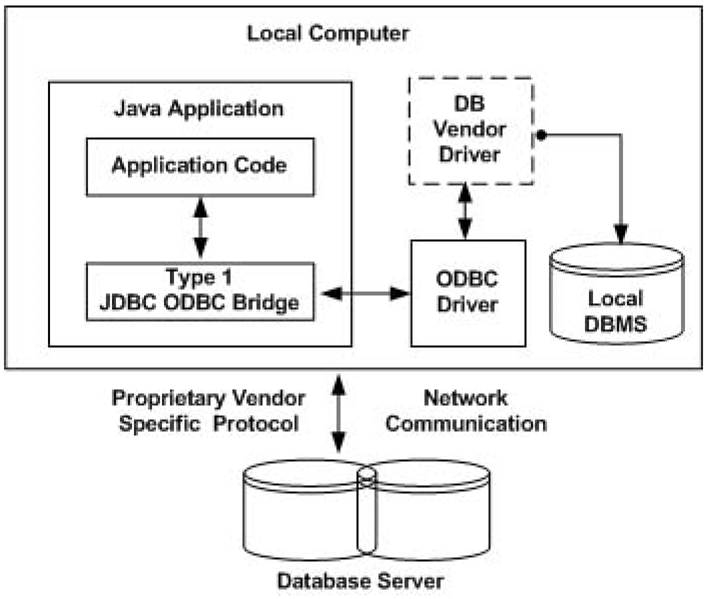
JDBC Drivers Types

JDBC driver implementations vary because of the wide variety of operating systems and hardware platforms in which Java operates. Sun has divided the implementation types into four categories, Types 1, 2, 3, and 4, which is explained below:

Type 1: JDBC-ODBC Bridge Driver

In a Type 1 driver, a JDBC bridge is used to access ODBC drivers installed on each client machine. Using ODBC, requires configuring on your system a Data Source Name (DSN) that represents the target database.

When Java first came out, this was a useful driver because most databases only supported ODBC access but now this type of driver is recommended only for experimental use or when no other alternative is available.

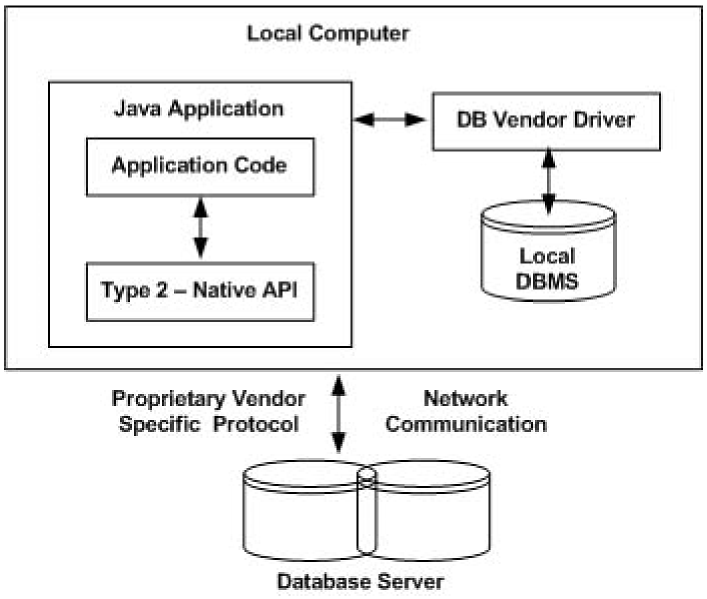


The JDBC-ODBC Bridge that comes with JDK 1.2 is a good example of this kind of driver.

Type 2: JDBC-Native API

In a Type 2 driver, JDBC API calls are converted into native C/C++ API calls, which are unique to the database. These drivers are typically provided by the database vendors and used in the same manner as the JDBC-ODBC Bridge. The vendor-specific driver must be installed on each client machine.

If we change the Database, we have to change the native API, as it is specific to a database and they are mostly obsolete now, but you may realize some speed increase with a Type 2 driver, because it eliminates ODBC's overhead.

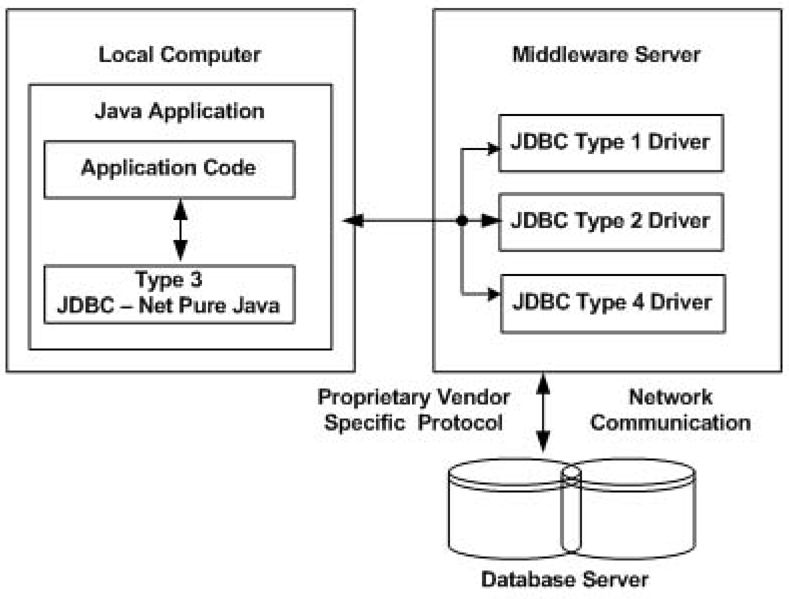


The Oracle Call Interface (OCI) driver is an example of a Type 2 driver.

Type 3: JDBC-Net Pure Java

In a Type 3 driver, a three-tier approach is used to access databases. The JDBC clients use standard network sockets to communicate with a middleware application server. The socket information is then translated by the middleware application server into the call format required by the DBMS, and forwarded to the database server.

This kind of driver is extremely flexible, since it requires no code installed on the client and a single driver can actually provide access to multiple databases.



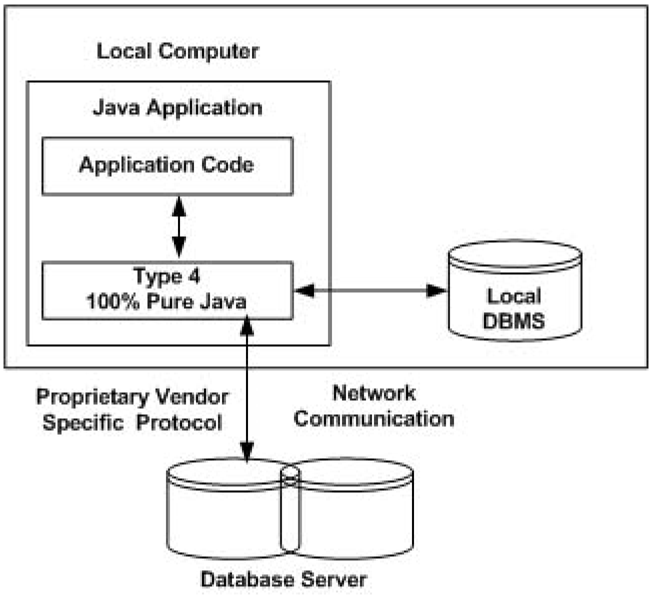
You can think of the application server as a JDBC "proxy," meaning that it makes calls for the client application. As a result, you need some knowledge of the application server's configuration in order to effectively use this driver type.

Your application server might use a Type 1, 2, or 4 driver to communicate with the database, understanding the nuances will prove helpful.

Type 4: 100% Pure Java

In a Type 4 driver, a pure Java-based driver communicates directly with the vendor's database through socket connection. This is the highest performance driver available for the database and is usually provided by the vendor itself.

This kind of driver is extremely flexible, you don't need to install special software on the client or server. Further, these drivers can be downloaded dynamically.



MySQL's Connector/J driver is a Type 4 driver. Because of the proprietary nature of their network protocols, database vendors usually supply type 4 drivers.

Which Driver should be Used?

If you are accessing one type of database, such as Oracle, Sybase, or IBM, the preferred driver type is 4.

If your Java application is accessing multiple types of databases at the same time, type 3 is the preferred driver.

Type 2 drivers are useful in situations, where a type 3 or type 4 driver is not available yet for your database.

The type 1 driver is not considered a deployment-level driver, and is typically used for development and testing purposes only.

6. CONNECTIONS

After you've installed the appropriate driver, it is time to establish a database connection using JDBC.

The programming involved to establish a JDBC connection is fairly simple. Here are these simple four steps:

- **Import JDBC Packages:** Add **import** statements to your Java program to import required classes in your Java code.
- **Register JDBC Driver:** This step causes the JVM to load the desired driver implementation into memory so it can fulfill your JDBC requests.
- **Database URL Formulation:** This is to create a properly formatted address that points to the database to which you wish to connect.
- **Create Connection Object:** Finally, code a call to the *DriverManager* object's*getConnection( )* method to establish actual database connection.

Import JDBC Packages

The **Import** statements tell the Java compiler where to find the classes you reference in your code and are placed at the very beginning of your source code.

To use the standard JDBC package, which allows you to select, insert, update, and delete data in SQL tables, add the following *imports* to your source code:

```
import java.sql.* ;  // for standard JDBC programs

import java.math.* ; // for BigDecimal and BigInteger support
```

Register JDBC Driver

You must register the driver in your program before you use it. Registering the driver is the process by which the Oracle driver's class file is loaded into the memory, so it can be utilized as an implementation of the JDBC interfaces.

You need to do this registration only once in your program. You can register a driver in one of two ways.

Approach I - Class.forName()

The most common approach to register a driver is to use Java's **Class.forName()** method, to dynamically load the driver's class file into memory, which automatically registers it. This method is preferable because it allows you to make the driver registration configurable and portable.

The following example uses Class.forName( ) to register the Oracle driver:

```
try {
   Class.forName("oracle.jdbc.driver.OracleDriver");
}
catch(ClassNotFoundException ex) {
   System.out.println("Error: unable to load driver class!");
   System.exit(1);
}
```

You can use **getInstance()** method to work around noncompliant JVMs, but then you'll have to code for two extra Exceptions as follows:

```
try {
   Class.forName("oracle.jdbc.driver.OracleDriver").newInstance();
}
catch(ClassNotFoundException ex) {
   System.out.println("Error: unable to load driver class!");
   System.exit(1);
catch(IllegalAccessException ex) {
   System.out.println("Error: access problem while loading!");
   System.exit(2);
catch(InstantiationException ex) {
   System.out.println("Error: unable to instantiate driver!");
   System.exit(3);
}
```

Approach II - DriverManager.registerDriver()

The second approach you can use to register a driver, is to use the static **DriverManager.registerDriver()** method.

You should use the *registerDriver()* method if you are using a non-JDK compliant JVM, such as the one provided by Microsoft.

The following example uses registerDriver() to register the Oracle driver:

```
try {
   Driver myDriver = new oracle.jdbc.driver.OracleDriver();
   DriverManager.registerDriver( myDriver );
}
catch(ClassNotFoundException ex) {
   System.out.println("Error: unable to load driver class!");
   System.exit(1);
}
```

Database URL Formulation

After you've loaded the driver, you can establish a connection using the **DriverManager.getConnection()** method. For easy reference, let me list the three overloaded DriverManager.getConnection() methods:

- getConnection(String url)
- getConnection(String url, Properties prop)
- getConnection(String url, String user, String password)

Here each form requires a database **URL**. A database URL is an address that points to your database.

Formulating a database URL is where most of the problems associated with establishing a connection occurs.

Following table lists down the popular JDBC driver names and database URL.

RDBMS	JDBC driver name	URL format
MySQL	com.mysql.jdbc.Driver	jdbc:mysql://hostname/ databaseName
ORACLE	oracle.jdbc.driver.OracleDriver	jdbc:oracle:thin:@hostname:port Number:databaseName
DB2	COM.ibm.db2.jdbc.net.DB2Driver	jdbc:db2:hostname:port Number/databaseName
Sybase	com.sybase.jdbc.SybDriver	jdbc:sybase:Tds:hostname: port Number/databaseName

All the highlighted part in URL format is static and you need to change only the remaining part as per your database setup.

Create Connection Object

We have listed down three forms of **DriverManager.getConnection()** method to create a connection object.

Using a Database URL with a username and password

The most commonly used form of getConnection() requires you to pass a database URL, a *username*, and a *password*:

Assuming you are using Oracle's **thin** driver, you'll specify a host:port:databaseName value for the database portion of the URL.

If you have a host at TCP/IP address 192.0.0.1 with a host name of amrood, and your Oracle listener is configured to listen on port 1521, and your database name is EMP, then complete database URL would be:

```
jdbc:oracle:thin:@amrood:1521:EMP
```

Now you have to call getConnection() method with appropriate username and password to get a **Connection** object as follows:

```
String URL = "jdbc:oracle:thin:@amrood:1521:EMP";

String USER = "username";

String PASS = "password"

Connection conn = DriverManager.getConnection(URL, USER, PASS);
```

Using Only a Database URL

A second form of the DriverManager.getConnection( ) method requires only a database URL:

```
DriverManager.getConnection(String url);
```

However, in this case, the database URL includes the username and password and has the following general form:

```
jdbc:oracle:driver:username/password@database
```

So, the above connection can be created as follows:

```
String URL = "jdbc:oracle:thin:username/password@amrood:1521:EMP";
```

```
Connection conn = DriverManager.getConnection(URL);
```

Using a Database URL and a Properties Object

A third form of the DriverManager.getConnection( ) method requires a database URL and a Properties object:

```
DriverManager.getConnection(String url, Properties info);
```

A Properties object holds a set of keyword-value pairs. It is used to pass driver properties to the driver during a call to the getConnection() method.

To make the same connection made by the previous examples, use the following code:

```
import java.util.*;


String URL = "jdbc:oracle:thin:@amrood:1521:EMP";
Properties info = new Properties( );
info.put( "user", "username" );
info.put( "password", "password" );


Connection conn = DriverManager.getConnection(URL, info);
```

Closing JDBC Connections

At the end of your JDBC program, it is required explicitly to close all the connections to the database to end each database session. However, if you forget, Java's garbage collector will close the connection when it cleans up stale objects.

Relying on the garbage collection, especially in database programming, is a very poor programming practice. You should make a habit of always closing the connection with the close() method associated with connection object.

To ensure that a connection is closed, you could provide a 'finally' block in your code. A *finally* block always executes, regardless of an exception occurs or not.

To close the above opened connection, you should call close() method as follows:

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

Explicitly closing a connection conserves DBMS resources, which will make your database administrator happy.

For a better understanding, we suggest you to study our JDBC - Sample Code tutorial.

7. STATEMENTS

Once a connection is obtained we can interact with the database. The JDBC *Statement, CallableStatement,* and *PreparedStatement* interfaces define the methods and properties that enable you to send SQL or PL/SQL commands and receive data from your database.

They also define methods that help bridge data type differences between Java and SQL data types used in a database.

The following table provides a summary of each interface's purpose to decide on the interface to use.

Interfaces	**Recommended Use**
Statement	Use this for general-purpose access to your database. Useful when you are using static SQL statements at runtime. The Statement interface cannot accept parameters.
PreparedStatement	Use this when you plan to use the SQL statements many times. The PreparedStatement interface accepts input parameters at runtime.
CallableStatement	Use this when you want to access the database stored procedures. The CallableStatement interface can also accept runtime input parameters.

The Statement Objects

Creating Statement Object

Before you can use a Statement object to execute a SQL statement, you need to create one using the Connection object's createStatement( ) method, as in the following example:

```
Statement stmt = null;
try {
   stmt = conn.createStatement( );
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   . . .
}
```

Once you've created a Statement object, you can then use it to execute an SQL statement with one of its three execute methods.

- **boolean execute (String SQL)**: Returns a boolean value of true if a ResultSet object can be retrieved; otherwise, it returns false. Use this method to execute SQL DDL statements or when you need to use truly dynamic SQL.
- **int executeUpdate (String SQL)**: Returns the number of rows affected by the execution of the SQL statement. Use this method to execute SQL statements for which you expect to get a number of rows affected - for example, an INSERT, UPDATE, or DELETE statement.
- **ResultSet executeQuery (String SQL)**: Returns a ResultSet object. Use this method when you expect to get a result set, as you would with a SELECT statement.

Closing Statement Object

Just as you close a Connection object to save database resources, for the same reason you should also close the Statement object.

A simple call to the close() method will do the job. If you close the Connection object first, it will close the Statement object as well. However, you should always explicitly close the Statement object to ensure proper cleanup.

```
Statement stmt = null;
try {
   stmt = conn.createStatement( );
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   stmt.close();
}
```

For a better understanding, we suggest you to study the Statement - Example Code tutorial.

Statement Object Example

Following is the example, which makes use of the following three queries along with the opening and closing statment:

- **boolean execute(String SQL)**: Returns a boolean value of true if a ResultSet object can be retrieved; otherwise, it returns false. Use this method to execute SQL DDL statements or when you need to use the truly dynamic SQL.
- **int executeUpdate(String SQL)**: Returns the number of rows affected by the execution of the SQL statement. Use this method to execute SQL statements, for which you expect to get a number of rows affected - for example, an INSERT, UPDATE, or DELETE statement.
- **ResultSet executeQuery(String SQL)**: Returns a ResultSet object. Use this method when you expect to get a result set, as you would with a SELECT statement.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
```

```
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      //STEP 4: Execute a query
      System.out.println("Creating statement...");
      stmt = conn.createStatement();
      String sql = "UPDATE Employees set age=30 WHERE id=103";

      // Let us check if it returns a true Result Set or not.
      Boolean ret = stmt.execute(sql);
      System.out.println("Return value is : " + ret.toString() );

      // Let us update age of the record with ID = 103;
      int rows = stmt.executeUpdate(sql);
      System.out.println("Rows impacted : " + rows );

      // Let us select all the records and display them.
      sql = "SELECT id, first, last, age FROM Employees";
      ResultSet rs = stmt.executeQuery(sql);

      //STEP 5: Extract data from result set
      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");
         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }
      //STEP 6: Clean-up environment
      rs.close();
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
```

```
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Return value is : false
Rows impacted : 1
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
Goodbye!
C:\>
```

The PreparedStatement Objects

The *PreparedStatement* interface extends the Statement interface, which gives you added functionality with a couple of advantages over a generic Statement object.

This statement gives you the flexibility of supplying arguments dynamically.

Creating PreparedStatement Object

```
PreparedStatement pstmt = null;
try {
   String SQL = "Update Employees SET age = ? WHERE id = ?";
   pstmt = conn.prepareStatement(SQL);
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   . . .
}
```

All parameters in JDBC are represented by the **?** symbol, which is known as the parameter marker. You must supply values for every parameter before executing the SQL statement.

The **setXXX()** methods bind values to the parameters, where **XXX** represents the Java data type of the value you wish to bind to the input parameter. If you forget to supply the values, you will receive an SQLException.

Each parameter marker is referred by its ordinal position. The first marker represents position 1, the next position 2, and so forth. This method differs from that of Java array indices, which starts at 0.

All of the **Statement object's** methods for interacting with the database (a) execute(), (b) executeQuery(), and (c) executeUpdate() also work with the PreparedStatement object. However, the methods are modified to use SQL statements that can input the parameters.

Closing PreparedStatement Object

Just as you close a Statement object, for the same reason you should also close the PreparedStatement object.

A simple call to the close() method will do the job. If you close the Connection object first, it will close the PreparedStatement object as well. However, you should always explicitly close the PreparedStatement object to ensure proper cleanup.

```
PreparedStatement pstmt = null;
try {
   String SQL = "Update Employees SET age = ? WHERE id = ?";
   pstmt = conn.prepareStatement(SQL);
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   pstmt.close();
}
```

For a better understanding, let us study Prepare - Example Code discussed below.

Prepare - Example Code

Following is the example, which makes use of the PreparedStatement along with opening and closing statments.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   PreparedStatement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);
      //STEP 4: Execute a query
      System.out.println("Creating statement...");
      String sql = "UPDATE Employees set age=? WHERE id=?";
      stmt = conn.prepareStatement(sql);

      //Bind values into the parameters.
      stmt.setInt(1, 35);  // This would set age
      stmt.setInt(2, 102); // This would set ID

      // Let us update age of the record with ID = 102;
      int rows = stmt.executeUpdate();
      System.out.println("Rows impacted : " + rows );

      // Let us select all the records and display them.
      sql = "SELECT id, first, last, age FROM Employees";
      ResultSet rs = stmt.executeQuery(sql);

      //STEP 5: Extract data from result set
      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }
      //STEP 6: Clean-up environment
      rs.close();
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Rows impacted : 1
```

```
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 35, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
Goodbye!
C:\>
```

The CallableStatement Objects

Just as a Connection object creates the Statement and PreparedStatement objects, it also creates the CallableStatement object, which would be used to execute a call to a database stored procedure.

Creating CallableStatement Object

Suppose, you need to execute the following Oracle stored procedure:

```
CREATE OR REPLACE PROCEDURE getEmpName
   (EMP_ID IN NUMBER, EMP_FIRST OUT VARCHAR) AS
BEGIN
   SELECT first INTO EMP_FIRST
   FROM Employees
   WHERE ID = EMP_ID;
END;
```

NOTE: Above stored procedure has been written for Oracle, but we are working with MySQL database so, let us write same stored procedure for MySQL as follows to create it in EMP database:

```
DELIMITER $$

DROP PROCEDURE IF EXISTS `EMP`.`getEmpName` $$
CREATE PROCEDURE `EMP`.`getEmpName`
   (IN EMP_ID INT, OUT EMP_FIRST VARCHAR(255))
BEGIN
   SELECT first INTO EMP_FIRST
   FROM Employees
   WHERE ID = EMP_ID;
```

```
END $$


DELIMITER ;
```

Three types of parameters exist: IN, OUT, and INOUT. The PreparedStatement object only uses the IN parameter. The CallableStatement object can use all the three.

Here are the definitions of each:

Parameter	Description
IN	A parameter whose value is unknown when the SQL statement is created. You bind values to IN parameters with the setXXX() methods.
OUT	A parameter whose value is supplied by the SQL statement it returns. You retrieve values from the OUT parameters with the getXXX() methods.
INOUT	A parameter that provides both input and output values. You bind variables with the setXXX() methods and retrieve values with the getXXX() methods.

The following code snippet shows how to employ the **Connection.prepareCall()** method to instantiate a **CallableStatement** object based on the preceding stored procedure:

```
CallableStatement cstmt = null;
try {
   String SQL = "{call getEmpName (?, ?)}";
   cstmt = conn.prepareCall (SQL);
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   . . .
}
```

The String variable SQL, represents the stored procedure, with parameter placeholders.

Using the CallableStatement objects is much like using the PreparedStatement objects. You must bind values to all the parameters before executing the statement, or you will receive an SQLException.

If you have IN parameters, just follow the same rules and techniques that apply to a PreparedStatement object; use the setXXX() method that corresponds to the Java data type you are binding.

When you use OUT and INOUT parameters you must employ an additional CallableStatement method, registerOutParameter(). The registerOutParameter() method binds the JDBC data type, to the data type that the stored procedure is expected to return.

Once you call your stored procedure, you retrieve the value from the OUT parameter with the appropriate getXXX() method. This method casts the retrieved value of SQL type to a Java data type.

Closing CallableStatement Object

Just as you close other Statement object, for the same reason you should also close the CallableStatement object.

A simple call to the close() method will do the job. If you close the Connection object first, it will close the CallableStatement object as well. However, you should always explicitly close the CallableStatement object to ensure proper cleanup.

```
CallableStatement cstmt = null;
try {
   String SQL = "{call getEmpName (?, ?)}";
   cstmt = conn.prepareCall (SQL);
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   cstmt.close();
}
```

For a better understanding, I would suggest to study Callable - Example Code.

Callable - Example Code

Following is the example, which makes use of the CallableStatement along with the following **getEmpName()** MySQL stored procedure:

Make sure you have created this stored procedure in your EMP Database. You can use MySQL Query Browser to get it done.

```
DELIMITER $$

DROP PROCEDURE IF EXISTS `EMP`.`getEmpName` $$
CREATE PROCEDURE `EMP`.`getEmpName`
   (IN EMP_ID INT, OUT EMP_FIRST VARCHAR(255))
BEGIN
   SELECT first INTO EMP_FIRST
   FROM Employees
   WHERE ID = EMP_ID;
END $$

DELIMITER ;
```

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";
```

```
public static void main(String[] args) {
Connection conn = null;
CallableStatement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to database...");
   conn = DriverManager.getConnection(DB_URL,USER,PASS);

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   String sql = "{call getEmpName (?, ?)}";
   stmt = conn.prepareCall(sql);

   //Bind IN parameter first, then bind OUT parameter
   int empID = 102;
   stmt.setInt(1, empID); // This would set ID as 102
   // Because second parameter is OUT so register it
   stmt.registerOutParameter(2, java.sql.Types.VARCHAR);

   //Use execute method to run stored procedure.
   System.out.println("Executing stored procedure..." );
   stmt.execute();

   //Retrieve employee name with getXXX method
   String empName = stmt.getString(2);
   System.out.println("Emp Name with ID:" +
            empID + " is " + empName);
   stmt.close();
   conn.close();
}catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Executing stored procedure...
Emp Name with ID:102 is Zaid
Goodbye!
```

```
C:\>
```

8. RESULT SETS

The SQL statements that read data from a database query, return the data in a result set. The SELECT statement is the standard way to select rows from a database and view them in a result set. The *java.sql.ResultSet* interface represents the result set of a database query.

A ResultSet object maintains a cursor that points to the current row in the result set. The term "result set" refers to the row and column data contained in a ResultSet object.

The methods of the ResultSet interface can be broken down into three categories:

- **Navigational methods:** Used to move the cursor around.
- **Get methods:** Used to view the data in the columns of the current row being pointed by the cursor.
- **Update methods:** Used to update the data in the columns of the current row. The updates can then be updated in the underlying database as well.

The cursor is movable based on the properties of the ResultSet. These properties are designated when the corresponding Statement that generates the ResultSet is created.

JDBC provides the following connection methods to create statements with desired ResultSet:

- **createStatement(int RSType, int RSConcurrency);**
- **prepareStatement(String SQL, int RSType, int RSConcurrency);**
- **prepareCall(String sql, int RSType, int RSConcurrency);**

The first argument indicates the type of a ResultSet object and the second argument is one of two ResultSet constants for specifying whether a result set is read-only or updatable.

Type of ResultSet

The possible RSType are given below. If you do not specify any ResultSet type, you will automatically get one that is TYPE_FORWARD_ONLY.

Type	Description
ResultSet.TYPE_FORWARD_ONLY	The cursor can only move forward in

	the result set.
ResultSet.TYPE_SCROLL_INSENSITIVE	The cursor can scroll forward and backward, and the result set is not sensitive to changes made by others to the database that occur after the result set was created.
ResultSet.TYPE_SCROLL_SENSITIVE.	The cursor can scroll forward and backward, and the result set is sensitive to changes made by others to the database that occur after the result set was created.

Concurrency of ResultSet

The possible RSConcurrency are given below. If you do not specify any Concurrency type, you will automatically get one that is CONCUR_READ_ONLY.

Concurrency	Description
ResultSet.CONCUR_READ_ONLY	Creates a read-only result set. This is the default
ResultSet.CONCUR_UPDATABLE	Creates an updateable result set.

All our examples written so far can be written as follows, which initializes a Statement object to create a forward-only, read only ResultSet object:

```
try {
   Statement stmt = conn.createStatement(
                            ResultSet.TYPE_FORWARD_ONLY,
                            ResultSet.CONCUR_READ_ONLY);
}
catch(Exception ex) {
   ....
}
finally {
   ....
}
```

Navigating a Result Set

There are several methods in the ResultSet interface that involve moving the cursor, including:

S.N.	Methods & Description
1	**public void beforeFirst() throws SQLException** Moves the cursor just before the first row.
2	**public void afterLast() throws SQLException** Moves the cursor just after the last row.
3	**public boolean first() throws SQLException** Moves the cursor to the first row.
4	**public void last() throws SQLException** Moves the cursor to the last row.
5	**public boolean absolute(int row) throws SQLException** Moves the cursor to the specified row.
6	**public boolean relative(int row) throws SQLException** Moves the cursor the given number of rows forward or backward, from where it is currently pointing.
7	**public boolean previous() throws SQLException** Moves the cursor to the previous row. This method returns false if the previous row is off the result set.
8	**public boolean next() throws SQLException** Moves the cursor to the next row. This method returns false if there are no more rows in the result set.

9	**public int getRow() throws SQLException** Returns the row number that the cursor is pointing to.
10	**public void moveToInsertRow() throws SQLException** Moves the cursor to a special row in the result set that can be used to insert a new row into the database. The current cursor location is remembered.
11	**public void moveToCurrentRow() throws SQLException** Moves the cursor back to the current row if the cursor is currently at the insert row; otherwise, this method does nothing.

For a better understanding, let us study Navigate - Example Code as discussed below.

Navigate - Example Code

Following is the example, which makes use of few navigation methods described in the Result Set tutorial.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      //STEP 4: Execute a query to create statment with
      // required arguments for RS example.
      System.out.println("Creating statement...");
      stmt = conn.createStatement(
                           ResultSet.TYPE_SCROLL_INSENSITIVE,
                           ResultSet.CONCUR_READ_ONLY);
      String sql;
      sql = "SELECT id, first, last, age FROM Employees";
      ResultSet rs = stmt.executeQuery(sql);

      // Move cursor to the last row.
      System.out.println("Moving cursor to the last...");
      rs.last();

      //STEP 5: Extract data from result set
      System.out.println("Displaying record...");
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
      String last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);

      // Move cursor to the first row.
      System.out.println("Moving cursor to the first row...");
      rs.first();

      //STEP 6: Extract data from result set
      System.out.println("Displaying record...");
      //Retrieve by column name
      id  = rs.getInt("id");
      age = rs.getInt("age");
      first = rs.getString("first");
      last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);
     // Move cursor to the first row.

      System.out.println("Moving cursor to the next row...");
      rs.next();

      //STEP 7: Extract data from result set
      System.out.println("Displaying record...");
      id  = rs.getInt("id");
      age = rs.getInt("age");
      first = rs.getString("first");
      last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);

      //STEP 8: Clean-up environment
      rs.close();
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Moving cursor to the last...
Displaying record...
ID: 103, Age: 30, First: Sumit, Last: Mittal
Moving cursor to the first row...
Displaying record...
ID: 100, Age: 18, First: Zara, Last: Ali
Moving cursor to the next row...
Displaying record...
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
Goodbye!
C:\>
```

Viewing a Result Set

The ResultSet interface contains dozens of methods for getting the data of the current row.

There is a *get* method for each of the possible data types, and each *get* method has two versions:

- One that takes in a column name.
- One that takes in a column index.

For example, if the column you are interested in viewing contains an int, you need to use one of the getInt() methods of ResultSet:

S.N.	Methods & Description
1	**public int getInt(String columnName) throws SQLException** Returns the int in the current row in the column named *columnName*.

2	**public int getInt(int columnIndex) throws SQLException** Returns the int in the current row in the specified column index. The column index starts at 1, meaning the first column of a row is 1, the second column of a row is 2, and so on.

Similarly, there are get methods in the ResultSet interface for each of the eight Java primitive types, as well as common types such as java.lang.String, java.lang.Object, and java.net.URL.

There are also methods for getting SQL data types java.sql.Date, java.sql.Time, java.sql.TimeStamp, java.sql.Clob, and java.sql.Blob. Check the documentation for more information about using these SQL data types.

For a better understanding, let us study the Viewing - Example Code as discussed below.

Viewing - Example Code

Following is the example, which makes use of few **getInt** and **getString** methods described in the Result Set chapter. This example is very similar to previous example explained in the Navigation Result Set Section.

This sample code has been written based on the environment and the database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      //STEP 4: Execute a query to create statment with
      // required arguments for RS example.
      System.out.println("Creating statement...");
      stmt = conn.createStatement(
                           ResultSet.TYPE_SCROLL_INSENSITIVE,
                           ResultSet.CONCUR_READ_ONLY);
      String sql;
      sql = "SELECT id, first, last, age FROM Employees";
      ResultSet rs = stmt.executeQuery(sql);

      // Move cursor to the last row.
      System.out.println("Moving cursor to the last...");
      rs.last();

      //STEP 5: Extract data from result set
      System.out.println("Displaying record...");
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
      String last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);

      // Move cursor to the first row.
      System.out.println("Moving cursor to the first row...");
      rs.first();

      //STEP 6: Extract data from result set
      System.out.println("Displaying record...");
      //Retrieve by column name
      id  = rs.getInt("id");
      age = rs.getInt("age");
      first = rs.getString("first");
      last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);
     // Move cursor to the first row.

      System.out.println("Moving cursor to the next row...");
      rs.next();

      //STEP 7: Extract data from result set
      System.out.println("Displaying record...");
      id  = rs.getInt("id");
      age = rs.getInt("age");
      first = rs.getString("first");
      last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);

      //STEP 8: Clean-up environment
      rs.close();
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Moving cursor to the last...
Displaying record...
ID: 103, Age: 30, First: Sumit, Last: Mittal
Moving cursor to the first row...
Displaying record...
ID: 100, Age: 18, First: Zara, Last: Ali
Moving cursor to the next row...
Displaying record...
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
Goodbye!
C:\>
```

Updating a Result Set

The ResultSet interface contains a collection of update methods for updating the data of a result set.

As with the get methods, there are two update methods for each data type:

- One that takes in a column name.
- One that takes in a column index.

For example, to update a String column of the current row of a result set, you would use one of the following updateString() methods:

S.N.	Methods & Description
1	**public void updateString(int columnIndex, String s) throws SQLException**

	Changes the String in the specified column to the value of s.
2	**public void updateString(String columnName, String s) throws SQLException** Similar to the previous method, except that the column is specified by its name instead of its index.

There are update methods for the eight primitive data types, as well as String, Object, URL, and the SQL data types in the java.sql package.

Updating a row in the result set changes the columns of the current row in the ResultSet object, but not in the underlying database. To update your changes to the row in the database, you need to invoke one of the following methods.

S.N.	Methods & Description
1	**public void updateRow()** Updates the current row by updating the corresponding row in the database.
2	**public void deleteRow()** Deletes the current row from the database.
3	**public void refreshRow()** Refreshes the data in the result set to reflect any recent changes in the database.
4	**public void cancelRowUpdates()** Cancels any updates made on the current row.
5	**public void insertRow()** Inserts a row into the database. This method can only be invoked when the cursor is pointing to the insert row.

For a better understanding, let us study the Updating - Example Code as discussed below.

Updating - Example Code

Following is the example, which makes use of the **ResultSet.CONCUR_UPDATABLE** and **ResultSet.TYPE_SCROLL_INSENSITIVE** described in the Result Set tutorial. This example would explain INSERT, UPDATE and DELETE operation on a table.

It should be noted that tables you are working on should have Primary Key set properly.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

 public static void main(String[] args) {
   Connection conn = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      //STEP 4: Execute a query to create statment with
      // required arguments for RS example.
      System.out.println("Creating statement...");
      Statement stmt = conn.createStatement(
                           ResultSet.TYPE_SCROLL_INSENSITIVE,
                           ResultSet.CONCUR_UPDATABLE);
     //STEP 5: Execute a query
      String sql = "SELECT id, first, last, age FROM Employees";
      ResultSet rs = stmt.executeQuery(sql);

      System.out.println("List result set for reference....");
      printRs(rs);

      //STEP 6: Loop through result set and add 5 in age
      //Move to BFR postion so while-loop works properly
      rs.beforeFirst();
      //STEP 7: Extract data from result set
      while(rs.next()){
         //Retrieve by column name
         int newAge = rs.getInt("age") + 5;
         rs.updateDouble( "age", newAge );
         rs.updateRow();
      }
      System.out.println("List result set showing new ages...");
      printRs(rs);
      // Insert a record into the table.
      //Move to insert row and add column data with updateXXX()
      System.out.println("Inserting a new record...");
      rs.moveToInsertRow();
      rs.updateInt("id",104);
      rs.updateString("first","John");
      rs.updateString("last","Paul");
      rs.updateInt("age",40);
      //Commit row
      rs.insertRow();
      System.out.println("List result set showing new set...");
      printRs(rs);

      // Delete second record from the table.
      // Set position to second record first
      rs.absolute( 2 );
      System.out.println("List the record before deleting...");
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
      String last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);

     //Delete row
      rs.deleteRow();
      System.out.println("List result set after \
                           deleting one records...");
      printRs(rs);

      //STEP 8: Clean-up environment
      rs.close();
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main

   public static void printRs(ResultSet rs) throws SQLException{
      //Ensure we start with first row
      rs.beforeFirst();
      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
     }
     System.out.println();
   }//end printRs()
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
List result set for reference....
ID: 100, Age: 33, First: Zara, Last: Ali
ID: 101, Age: 40, First: Mahnaz, Last: Fatma
ID: 102, Age: 50, First: Zaid, Last: Khan
ID: 103, Age: 45, First: Sumit, Last: Mittal

List result set showing new ages...
ID: 100, Age: 38, First: Zara, Last: Ali
ID: 101, Age: 45, First: Mahnaz, Last: Fatma
ID: 102, Age: 55, First: Zaid, Last: Khan
ID: 103, Age: 50, First: Sumit, Last: Mittal

Inserting a new record...
List result set showing new set...
ID: 100, Age: 38, First: Zara, Last: Ali
ID: 101, Age: 45, First: Mahnaz, Last: Fatma
ID: 102, Age: 55, First: Zaid, Last: Khan
ID: 103, Age: 50, First: Sumit, Last: Mittal
ID: 104, Age: 40, First: John, Last: Paul

List the record before deleting...
ID: 101, Age: 45, First: Mahnaz, Last: Fatma
List result set after deleting one records...
ID: 100, Age: 38, First: Zara, Last: Ali
ID: 102, Age: 55, First: Zaid, Last: Khan
ID: 103, Age: 50, First: Sumit, Last: Mittal
```

```
ID: 104, Age: 40, First: John, Last: Paul


Goodbye!
C:\>
```

9. DATA TYPES

The JDBC driver converts the Java data type to the appropriate JDBC type, before sending it to the database. It uses a default mapping for most data types. For example, a Java int is converted to an SQL INTEGER. Default mappings were created to provide consistency between drivers.

The following table summarizes the default JDBC data type that the Java data type is converted to, when you call the setXXX() method of the PreparedStatement or CallableStatement object or the ResultSet.updateXXX() method.

SQL	**JDBC/Java**	**setXXX**	**updateXXX**
VARCHAR	java.lang.String	setString	updateString
CHAR	java.lang.String	setString	updateString
LONGVARCHAR	java.lang.String	setString	updateString
BIT	boolean	setBoolean	updateBoolean
NUMERIC	java.math.BigDecimal	setBigDecimal	updateBigDecimal
TINYINT	byte	setByte	updateByte
SMALLINT	short	setShort	updateShort
INTEGER	int	setInt	updateInt
BIGINT	long	setLong	updateLong
REAL	float	setFloat	updateFloat
FLOAT	float	setFloat	updateFloat
DOUBLE	double	setDouble	updateDouble

VARBINARY	byte[ ]	setBytes	updateBytes
BINARY	byte[ ]	setBytes	updateBytes
DATE	java.sql.Date	setDate	updateDate
TIME	java.sql.Time	setTime	updateTime
TIMESTAMP	java.sql.Timestamp	setTimestamp	updateTimestamp
CLOB	java.sql.Clob	setClob	updateClob
BLOB	java.sql.Blob	setBlob	updateBlob
ARRAY	java.sql.Array	setARRAY	updateARRAY
REF	java.sql.Ref	SetRef	updateRef
STRUCT	java.sql.Struct	SetStruct	updateStruct

JDBC 3.0 has enhanced support for BLOB, CLOB, ARRAY, and REF data types. The ResultSet object now has updateBLOB(), updateCLOB(), updateArray(), and updateRef() methods that enable you to directly manipulate the respective data on the server.

The setXXX() and updateXXX() methods enable you to convert specific Java types to specific JDBC data types. The methods, setObject() and updateObject(), enable you to map almost any Java type to a JDBC data type.

ResultSet object provides corresponding getXXX() method for each data type to retrieve column value. Each method can be used with column name or by its ordinal position.

SQL	**JDBC/Java**	**setXXX**	**getXXX**
VARCHAR	java.lang.String	setString	getString
CHAR	java.lang.String	setString	getString
LONGVARCHAR	java.lang.String	setString	getString

BIT	boolean	setBoolean	getBoolean
NUMERIC	java.math.BigDecimal	setBigDecimal	getBigDecimal
TINYINT	byte	setByte	getByte
SMALLINT	short	setShort	getShort
INTEGER	int	setInt	getInt
BIGINT	long	setLong	getLong
REAL	float	setFloat	getFloat
FLOAT	float	setFloat	getFloat
DOUBLE	double	setDouble	getDouble
VARBINARY	byte[ ]	setBytes	getBytes
BINARY	byte[ ]	setBytes	getBytes
DATE	java.sql.Date	setDate	getDate
TIME	java.sql.Time	setTime	getTime
TIMESTAMP	java.sql.Timestamp	setTimestamp	getTimestamp
CLOB	java.sql.Clob	setClob	getClob
BLOB	java.sql.Blob	setBlob	getBlob
ARRAY	java.sql.Array	setARRAY	getARRAY
REF	java.sql.Ref	SetRef	getRef
STRUCT	java.sql.Struct	SetStruct	getStruct

Date & Time Data Types

The java.sql.Date class maps to the SQL DATE type, and the java.sql.Time and java.sql.Timestamp classes map to the SQL TIME and SQL TIMESTAMP data types, respectively.

Following example shows how the Date and Time classes format the standard Java date and time values to match the SQL data type requirements.

```
import java.sql.Date;
import java.sql.Time;
import java.sql.Timestamp;
import java.util.*;
public class SqlDateTime {
   public static void main(String[] args) {
      //Get standard date and time
      java.util.Date javaDate = new java.util.Date();
      long javaTime = javaDate.getTime();
      System.out.println("The Java Date is:" +
             javaDate.toString());

      //Get and display SQL DATE
      java.sql.Date sqlDate = new java.sql.Date(javaTime);
      System.out.println("The SQL DATE is: " +
             sqlDate.toString());
      //Get and display SQL TIME
      java.sql.Time sqlTime = new java.sql.Time(javaTime);
      System.out.println("The SQL TIME is: " +
             sqlTime.toString());
      //Get and display SQL TIMESTAMP
      java.sql.Timestamp sqlTimestamp =
      new java.sql.Timestamp(javaTime);
      System.out.println("The SQL TIMESTAMP is: " +
             sqlTimestamp.toString());
     }//end main
}//end SqlDateTime
```

Now let us compile the above example as follows:

```
C:\>javac SqlDateTime.java

C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java SqlDateTime

The Java Date is:Tue Aug 18 13:46:02 GMT+04:00 2009

The SQL DATE is: 2009-08-18

The SQL TIME is: 13:46:02

The SQL TIMESTAMP is: 2009-08-18 13:46:02.828

C:\>
```

Handling NULL Values

SQL's use of NULL values and Java's use of null are different concepts. So, to handle SQL NULL values in Java, there are three tactics you can use:

- Avoid using getXXX( ) methods that return primitive data types.
- Use wrapper classes for primitive data types, and use the ResultSet object's wasNull( ) method to test whether the wrapper class variable that received the value returned by the getXXX( ) method should be set to null.
- Use primitive data types and the ResultSet object's wasNull( ) method to test whether the primitive variable that received the value returned by the getXXX( ) method should be set to an acceptable value that you've chosen to represent a NULL.

Here is one example to handle a NULL value:

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

String sql = "SELECT id, first, last, age FROM Employees";

ResultSet rs = stmt.executeQuery(sql);

int id = rs.getInt(1);

if( rs.wasNull( ) ) {

   id = 0;

}
```

10. TRANSACTIONS

If your JDBC Connection is in *auto-commit* mode, which it is by default, then every SQL statement is committed to the database upon its completion.

That may be fine for simple applications, but there are three reasons why you may want to turn off the auto-commit and manage your own transactions:

- To increase performance,
- To maintain the integrity of business processes,
- To use distributed transactions.

Transactions enable you to control if, and when, changes are applied to the database. It treats a single SQL statement or a group of SQL statements as one logical unit, and if any statement fails, the whole transaction fails.

To enable manual- transaction support instead of the *auto-commit* mode that the JDBC driver uses by default, use the Connection object's **setAutoCommit()** method. If you pass a boolean false to setAutoCommit( ), you turn off auto-commit. You can pass a boolean true to turn it back on again.

For example, if you have a Connection object named conn, code the following to turn off auto-commit:

```
conn.setAutoCommit(false);
```

Commit & Rollback

Once you are done with your changes and you want to commit the changes then call **commit()** method on connection object as follows:

```
conn.commit( );
```

Otherwise, to roll back updates to the database made using the Connection named conn, use the following code:

```
conn.rollback( );
```

The following example illustrates the use of a commit and rollback object:

```
try{
   //Assume a valid connection object conn
   conn.setAutoCommit(false);
   Statement stmt = conn.createStatement();


   String SQL = "INSERT INTO Employees  " +
                "VALUES (106, 20, 'Rita', 'Tez')";
   stmt.executeUpdate(SQL);
   //Submit a malformed SQL statement that breaks
   String SQL = "INSERTED IN Employees  " +
                "VALUES (107, 22, 'Sita', 'Singh')";
   stmt.executeUpdate(SQL);
   // If there is no error.
   conn.commit();
}catch(SQLException se){
   // If there is any error.
   conn.rollback();
}
```

In this case, none of the above INSERT statement would success and everything would be rolled back.

For a better understanding, let us study the Commit - Example Code as discussed below.

Commit - Example Code

Following is the example, which makes use of **commit** and **rollback** described in the Transaction tutorial.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";
```

```
  //  Database credentials
  static final String USER = "username";
  static final String PASS = "password";

public static void main(String[] args) {
  Connection conn = null;
  Statement stmt = null;
  try{
     //STEP 2: Register JDBC driver
     Class.forName("com.mysql.jdbc.Driver");

     //STEP 3: Open a connection
     System.out.println("Connecting to database...");
     conn = DriverManager.getConnection(DB_URL,USER,PASS);

     //STEP 4: Set auto commit as false.
     conn.setAutoCommit(false);

     //STEP 5: Execute a query to create statment with
     // required arguments for RS example.
     System.out.println("Creating statement...");
     stmt = conn.createStatement(
                          ResultSet.TYPE_SCROLL_INSENSITIVE,
                          ResultSet.CONCUR_UPDATABLE);

     //STEP 6: INSERT a row into Employees table
     System.out.println("Inserting one row....");
     String SQL = "INSERT INTO Employees " +
                  "VALUES (106, 20, 'Rita', 'Tez')";
     stmt.executeUpdate(SQL);

     //STEP 7: INSERT one more row into Employees table
     SQL = "INSERT INTO Employees " +
                   "VALUES (107, 22, 'Sita', 'Singh')";
     stmt.executeUpdate(SQL);

     //STEP 8: Commit data here.
     System.out.println("Commiting data here....");
     conn.commit();

      //STEP 9: Now list all the available records.
     String sql = "SELECT id, first, last, age FROM Employees";
     ResultSet rs = stmt.executeQuery(sql);
     System.out.println("List result set for reference....");
     printRs(rs);

     //STEP 10: Clean-up environment
     rs.close();
     stmt.close();
     conn.close();
  }catch(SQLException se){
     //Handle errors for JDBC
     se.printStackTrace();
     // If there is an error then rollback the changes.
     System.out.println("Rolling back data here....");
      try{
           if(conn!=null)
           conn.rollback();
     }catch(SQLException se2){
        se2.printStackTrace();
     }//end try

  }catch(Exception e){
     //Handle errors for Class.forName
     e.printStackTrace();
  }finally{
     //finally block used to close resources
     try{
        if(stmt!=null)
           stmt.close();
     }catch(SQLException se2){
     }// nothing we can do
     try{
        if(conn!=null)
           conn.close();
     }catch(SQLException se){
        se.printStackTrace();
     }//end finally try
  }//end try
  System.out.println("Goodbye!");
}//end main

  public static void printRs(ResultSet rs) throws SQLException{
     //Ensure we start with first row
     rs.beforeFirst();
     while(rs.next()){
        //Retrieve by column name
        int id  = rs.getInt("id");
        int age = rs.getInt("age");
        String first = rs.getString("first");
        String last = rs.getString("last");

        //Display values
        System.out.print("ID: " + id);
        System.out.print(", Age: " + age);
        System.out.print(", First: " + first);
        System.out.println(", Last: " + last);
    }
    System.out.println();
  }//end printRs()
```

```
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Inserting one row....
Commiting data here....
List result set for reference....
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
ID: 106, Age: 20, First: Rita, Last: Tez
ID: 107, Age: 22, First: Sita, Last: Singh
Goodbye!
C:\>
```

Using Savepoints

The new JDBC 3.0 Savepoint interface gives you an additional transactional control. Most modern DBMS, support savepoints within their environments such as Oracle's PL/SQL.

When you set a savepoint you define a logical rollback point within a transaction. If an error occurs past a savepoint, you can use the rollback method to undo either all the changes or only the changes made after the savepoint.

The Connection object has two new methods that help you manage savepoints:

- **setSavepoint(String savepointName):** Defines a new savepoint. It also returns a Savepoint object.
- **releaseSavepoint(Savepoint savepointName):** Deletes a savepoint. Notice that it requires a Savepoint object as a parameter. This object is usually a savepoint generated by the setSavepoint() method.

There is one **rollback (String savepointName)** method, which rolls back work to the specified savepoint.

The following example illustrates the use of a Savepoint object:

```
try{
   //Assume a valid connection object conn
   conn.setAutoCommit(false);
   Statement stmt = conn.createStatement();

   //set a Savepoint
   Savepoint savepoint1 = conn.setSavepoint("Savepoint1");
   String SQL = "INSERT INTO Employees " +
                "VALUES (106, 20, 'Rita', 'Tez')";
   stmt.executeUpdate(SQL);
   //Submit a malformed SQL statement that breaks
   String SQL = "INSERTED IN Employees " +
                "VALUES (107, 22, 'Sita', 'Tez')";
   stmt.executeUpdate(SQL);
   // If there is no error, commit the changes.
   conn.commit();

}catch(SQLException se){
   // If there is any error.
   conn.rollback(savepoint1);
}
```

In this case, none of the above INSERT statement would success and everything would be rolled back.

For a better understanding, let us study the Savepoints - Example Code as discussed below.

Savepoints - Example Code

Following is the example, which makes use of **setSavepoint** and **rollback** described in the Transaction tutorial.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      //STEP 4: Set auto commit as false.
      conn.setAutoCommit(false);

      //STEP 5: Execute a query to delete statment with
      // required arguments for RS example.
      System.out.println("Creating statement...");
      stmt = conn.createStatement();

       //STEP 6: Now list all the available records.
```

```
    String sql = "SELECT id, first, last, age FROM Employees";
    ResultSet rs = stmt.executeQuery(sql);
    System.out.println("List result set for reference....");
    printRs(rs);

    // STEP 7: delete rows having ID grater than 104
    // But save point before doing so.
    Savepoint savepoint1 = conn.setSavepoint("ROWS_DELETED_1");
    System.out.println("Deleting row....");
    String SQL = "DELETE FROM Employees " +
                 "WHERE ID = 110";
    stmt.executeUpdate(SQL);
    // oops... we deleted too wrong employees!
    //STEP 8: Rollback the changes afetr save point 2.
    conn.rollback(savepoint1);

  // STEP 9: delete rows having ID grater than 104
    // But save point before doing so.
    Savepoint savepoint2 = conn.setSavepoint("ROWS_DELETED_2");
    System.out.println("Deleting row....");
    SQL = "DELETE FROM Employees " +
                 "WHERE ID = 95";
    stmt.executeUpdate(SQL);

     //STEP 10: Now list all the available records.
    sql = "SELECT id, first, last, age FROM Employees";
    rs = stmt.executeQuery(sql);
    System.out.println("List result set for reference....");
    printRs(rs);

    //STEP 10: Clean-up environment
    rs.close();
    stmt.close();
    conn.close();
```

```
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
      // If there is an error then rollback the changes.
      System.out.println("Rolling back data here....");
       try{
            if(conn!=null)
            conn.rollback();
      }catch(SQLException se2){
         se2.printStackTrace();
      }//end try

   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main

   public static void printRs(ResultSet rs) throws SQLException{
      //Ensure we start with first row
      rs.beforeFirst();
      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
     }
     System.out.println();
   }//end printRs()
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
List result set for reference....
ID: 95, Age: 20, First: Sima, Last: Chug
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
ID: 110, Age: 20, First: Sima, Last: Chug
```

```
Deleting row....
Deleting row....
List result set for reference....
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
ID: 110, Age: 20, First: Sima, Last: Chug

Goodbye!
C:\>
```

11. EXCEPTIONS

Exception handling allows you to handle exceptional conditions such as program-defined errors in a controlled fashion.

When an exception condition occurs, an exception is thrown. The term *thrown* means that current program execution stops, and the control is redirected to the nearest applicable catch clause. If no applicable catch clause exists, then the program's execution ends.

JDBC Exception handling is very similar to the Java Excpetion handling but for JDBC, the most common exception you'll deal with is **java.sql.SQLException.**

SQLException Methods

An SQLException can occur both in the driver and the database. When such an exception occurs, an object of type SQLException will be passed to the catch clause.

The passed SQLException object has the following methods available for retrieving additional information about the exception:

Method	Description
getErrorCode( )	Gets the error number associated with the exception.
getMessage( )	Gets the JDBC driver's error message for an error, handled by the driver or gets the Oracle error number and message for a database error.
getSQLState( )	Gets the XOPEN SQLstate string. For a JDBC driver error, no useful information is returned from this method. For a database error, the five-digit XOPEN SQLstate code is returned. This method can return null.
getNextException( )	Gets the next Exception object in the exception chain.

printStackTrace( )	Prints the current exception, or throwable, and its backtrace to a standard error stream.
printStackTrace(PrintStream s)	Prints this throwable and it’s backtrace to the print stream you specify.
printStackTrace(PrintWriter w)	Prints this throwable and it’s backtrace to the print writer you specify.

By utilizing the information available from the Exception object, you can catch an exception and continue your program appropriately. Here is the general form of a try block:

```
try {
   // Your risky code goes between these curly braces!!!
}
catch(Exception ex) {
   // Your exception handling code goes between these
   // curly braces, similar to the exception clause
   // in a PL/SQL block.
}
finally {
   // Your must-always-be-executed code goes between these
   // curly braces. Like closing database connection.
}
```

Example

Study the following example code to understand the usage of **try....catch...finally** blocks.

```
//STEP 1. Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";
```

```
//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to database...");
   conn = DriverManager.getConnection(DB_URL,USER,PASS);

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   Statement stmt = conn.createStatement();
   String sql;
   sql = "SELECT id, first, last, age FROM Employees";
   ResultSet rs = stmt.executeQuery(sql);

   //STEP 5: Extract data from result set
   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
      String last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);
      }
      //STEP 6: Clean-up environment
      rs.close();
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result if there is no problem, otherwise the corresponding error would be caught and error message would be displayed:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
ID: 100, Age: 18, First: Zara, Last: Ali
```

```
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
C:\>
```

Try the above example by passing wrong database name or wrong username or password and check the result.

12. BATCH PROCESSING

Batch Processing allows you to group related SQL statements into a batch and submit them with one call to the database.

When you send several SQL statements to the database at once, you reduce the amount of communication overhead, thereby improving performance.

- JDBC drivers are not required to support this feature. You should use the *DatabaseMetaData.supportsBatchUpdates()* method to determine if the target database supports batch update processing. The method returns true if your JDBC driver supports this feature.
- The **addBatch()** method of *Statement, PreparedStatement,* and *CallableStatement* is used to add individual statements to the batch. The **executeBatch()** is used to start the execution of all the statements grouped together.
- The **executeBatch()** returns an array of integers, and each element of the array represents the update count for the respective update statement.
- Just as you can add statements to a batch for processing, you can remove them with the **clearBatch()** method. This method removes all the statements you added with the addBatch() method. However, you cannot selectively choose which statement to remove.

Batching with Statement Object

Here is a typical sequence of steps to use Batch Processing with Statment Object:

- Create a Statement object using either *createStatement()* methods.
- Set auto-commit to false using *setAutoCommit()*.
- Add as many as SQL statements you like into batch using *addBatch()* method on created statement object.
- Execute all the SQL statements using *executeBatch()* method on created statement object.
- Finally, commit all the changes using *commit()* method.

Example

The following code snippet provides an example of a batch update using Statement object:

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

// Set auto-commit to false
conn.setAutoCommit(false);

// Create SQL statement
String SQL = "INSERT INTO Employees (id, first, last, age) " +
             "VALUES(200,'Zia', 'Ali', 30)";
// Add above SQL statement in the batch.
stmt.addBatch(SQL);

// Create one more SQL statement
String SQL = "INSERT INTO Employees (id, first, last, age) " +
             "VALUES(201,'Raj', 'Kumar', 35)";
// Add above SQL statement in the batch.
stmt.addBatch(SQL);

// Create one more SQL statement
String SQL = "UPDATE Employees SET age = 35 " +
             "WHERE id = 100";
// Add above SQL statement in the batch.
stmt.addBatch(SQL);

// Create an int[] to hold returned values
int[] count = stmt.executeBatch();

//Explicitly commit statements to apply changes
conn.commit();
```

For a better understanding, let us study the Batching - Example Code as discussed below.

Batching - Example Code

Here is a typical sequence of steps to use Batch Processing with Statement Object:

1. Create a Statement object using either *createStatement()* methods.
2. Set auto-commit to false using *setAutoCommit()*.
3. Add as many as SQL statements you like into batch using *addBatch()* method on created statement object.
4. Execute all the SQL statements using *executeBatch()* method on created statement object.
5. Finally, commit all the changes using *commit()* method.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
// Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      // Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      // Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      // Create statement
      System.out.println("Creating statement...");
      stmt = conn.createStatement();

      // Set auto-commit to false
      conn.setAutoCommit(false);

      // First, let us select all the records and display them.
      printRows( stmt );

      // Create SQL statement
      String SQL = "INSERT INTO Employees (id, first, last, age) " +
                   "VALUES(200,'Zia', 'Ali', 30)";
      // Add above SQL statement in the batch.
      stmt.addBatch(SQL);

      // Create one more SQL statement
      SQL = "INSERT INTO Employees (id, first, last, age) " +
            "VALUES(201,'Raj', 'Kumar', 35)";
      // Add above SQL statement in the batch.
      stmt.addBatch(SQL);

      // Create one more SQL statement
      SQL = "UPDATE Employees SET age = 35 " +
            "WHERE id = 100";
      // Add above SQL statement in the batch.
      stmt.addBatch(SQL);

      // Create an int[] to hold returned values
      int[] count = stmt.executeBatch();
      //Explicitly commit statements to apply changes
      conn.commit();

      // Again, let us select all the records and display them.
      printRows( stmt );

      // Clean-up environment
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main

public static void printRows(Statement stmt) throws SQLException{
   System.out.println("Displaying available rows...");
   // Let us select all the records and display them.
   String sql = "SELECT id, first, last, age FROM Employees";
   ResultSet rs = stmt.executeQuery(sql);

   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
      String last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);
   }
   System.out.println();
   rs.close();
}//end printRows()
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Displaying available rows...
ID: 95, Age: 20, First: Sima, Last: Chug
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
```

```
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
ID: 110, Age: 20, First: Sima, Last: Chug

Displaying available rows...
ID: 95, Age: 20, First: Sima, Last: Chug
ID: 100, Age: 35, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
ID: 110, Age: 20, First: Sima, Last: Chug
ID: 200, Age: 30, First: Zia, Last: Ali
ID: 201, Age: 35, First: Raj, Last: Kumar
Goodbye!
C:\>
```

Batching with PrepareStatement Object

Here is a typical sequence of steps to use Batch Processing with PrepareStatement Object:

1. Create SQL statements with placeholders.
2. Create PrepareStatement object using either *prepareStatement()* methods.
3. Set auto-commit to false using *setAutoCommit()*.
4. Add as many as SQL statements you like into batch using *addBatch()* method on created statement object.
5. Execute all the SQL statements using *executeBatch()* method on created statement object.
6. Finally, commit all the changes using *commit()* method.

The following code snippet provides an example of a batch update using PrepareStatement object:

```
// Create SQL statement
String SQL = "INSERT INTO Employees (id, first, last, age) " +
             "VALUES(?, ?, ?, ?)";
```

```
// Create PrepareStatement object
PreparedStatemen pstmt = conn.prepareStatement(SQL);

//Set auto-commit to false
conn.setAutoCommit(false);

// Set the variables
pstmt.setInt( 1, 400 );
pstmt.setString( 2, "Pappu" );
pstmt.setString( 3, "Singh" );
pstmt.setInt( 4, 33 );
// Add it to the batch
pstmt.addBatch();

// Set the variables
pstmt.setInt( 1, 401 );
pstmt.setString( 2, "Pawan" );
pstmt.setString( 3, "Singh" );
pstmt.setInt( 4, 31 );
// Add it to the batch
pstmt.addBatch();

//add more batches
.
.
.
.
//Create an int[] to hold returned values
int[] count = stmt.executeBatch();

//Explicitly commit statements to apply changes
conn.commit();
```

For a better understanding, let us to study the Batching - Example Code with PrepareStatement object as discussed below.

Batching - Example Code

Here is a typical sequence of steps to use Batch Processing with PrepareStatement Object:

- Create SQL statements with placeholders.
- Create PrepareStatement object using either *prepareStatement()* methods.
- Set auto-commit to false using *setAutoCommit()*.
- Add as many as SQL statements you like into batch using *addBatch()* method on created statement object.
- Execute all the SQL statements using *executeBatch()* method on created statement object.
- Finally, commit all the changes using *commit()* method.

This sample code has been written based on the environment and database setup done in the previous chapters.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
// Import required packages
import java.sql.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   PreparedStatement stmt = null;
   try{
      // Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      // Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      // Create SQL statement
      String SQL = "INSERT INTO Employees(id,first,last,age) " +
                   "VALUES(?, ?, ?, ?)";

      // Create preparedStatemen
      System.out.println("Creating statement...");
      stmt = conn.prepareStatement(SQL);

      // Set auto-commit to false
      conn.setAutoCommit(false);

      // First, let us select all the records and display them.
      printRows( stmt );

      // Set the variables
      stmt.setInt( 1, 400 );
      stmt.setString( 2, "Pappu" );
      stmt.setString( 3, "Singh" );
      stmt.setInt( 4, 33 );
      // Add it to the batch
      stmt.addBatch();

      // Set the variables
      stmt.setInt( 1, 401 );
      stmt.setString( 2, "Pawan" );
      stmt.setString( 3, "Singh" );
      stmt.setInt( 4, 31 );
      // Add it to the batch
      stmt.addBatch();

      // Create an int[] to hold returned values
      int[] count = stmt.executeBatch();

      //Explicitly commit statements to apply changes
      conn.commit();

      // Again, let us select all the records and display them.
      printRows( stmt );

      // Clean-up environment
      stmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main

public static void printRows(Statement stmt) throws SQLException{
   System.out.println("Displaying available rows...");
   // Let us select all the records and display them.
   String sql = "SELECT id, first, last, age FROM Employees";
   ResultSet rs = stmt.executeQuery(sql);

   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
      String last = rs.getString("last");

      //Display values
      System.out.print("ID: " + id);
      System.out.print(", Age: " + age);
      System.out.print(", First: " + first);
      System.out.println(", Last: " + last);
   }
   System.out.println();
   rs.close();
}//end printRows()
}//end JDBCExample
```

Now let us compile above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces following result:

```
C:\>java JDBCExample
Connecting to database...
Creating statement...
Displaying available rows...
ID: 95, Age: 20, First: Sima, Last: Chug
ID: 100, Age: 35, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
ID: 110, Age: 20, First: Sima, Last: Chug
ID: 200, Age: 30, First: Zia, Last: Ali
ID: 201, Age: 35, First: Raj, Last: Kumar

Displaying available rows...
ID: 95, Age: 20, First: Sima, Last: Chug
ID: 100, Age: 35, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 30, First: Sumit, Last: Mittal
ID: 110, Age: 20, First: Sima, Last: Chug
ID: 200, Age: 30, First: Zia, Last: Ali
ID: 201, Age: 35, First: Raj, Last: Kumar
ID: 400, Age: 33, First: Pappu, Last: Singh
ID: 401, Age: 31, First: Pawan, Last: Singh
Goodbye!
C:\>
```

13. STORED PROCEDURE

We have learnt how to use **Stored Procedures** in JDBC while discussing the JDBC – Statements chapter. This chapter is similar to that section, but it would give you additional information about JDBC SQL escape syntax.

Just as a Connection object creates the Statement and PreparedStatement objects, it also creates the CallableStatement object, which would be used to execute a call to a database stored procedure.

Creating CallableStatement Object

Suppose, you need to execute the following Oracle stored procedure:

```
CREATE OR REPLACE PROCEDURE getEmpName
   (EMP_ID IN NUMBER, EMP_FIRST OUT VARCHAR) AS
BEGIN
   SELECT first INTO EMP_FIRST
   FROM Employees
   WHERE ID = EMP_ID;
END;
```

NOTE: Above stored procedure has been written for Oracle, but we are working with MySQL database so, let us write same stored procedure for MySQL as follows to create it in EMP database:

```
DELIMITER $$

DROP PROCEDURE IF EXISTS `EMP`.`getEmpName` $$
CREATE PROCEDURE `EMP`.`getEmpName`
   (IN EMP_ID INT, OUT EMP_FIRST VARCHAR(255))
BEGIN
   SELECT first INTO EMP_FIRST
   FROM Employees
   WHERE ID = EMP_ID;
END $$
```

```
DELIMITER ;
```

Three types of parameters exist: IN, OUT, and INOUT. The PreparedStatement object only uses the IN parameter. The CallableStatement object can use all the three.

Here are the definitions of each:

Parameter	Description
IN	A parameter whose value is unknown when the SQL statement is created. You bind values to IN parameters with the setXXX() methods.
OUT	A parameter whose value is supplied by the SQL statement it returns. You retrieve values from the OUT parameters with the getXXX() methods.
INOUT	A parameter that provides both input and output values. You bind variables with the setXXX() methods and retrieve values with the getXXX() methods.

The following code snippet shows how to employ the **Connection.prepareCall()** method to instantiate a **CallableStatement** object based on the preceding stored procedure:

```
CallableStatement cstmt = null;
try {
   String SQL = "{call getEmpName (?, ?)}";
   cstmt = conn.prepareCall (SQL);
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   . . .
}
```

The String variable SQL represents the stored procedure, with parameter placeholders.

Using CallableStatement objects is much like using PreparedStatement objects. You must bind values to all the parameters before executing the statement, or you will receive an SQLException.

If you have IN parameters, just follow the same rules and techniques that apply to a PreparedStatement object; use the setXXX() method that corresponds to the Java data type you are binding.

When you use OUT and INOUT parameters, you must employ an additional CallableStatement method, registerOutParameter(). The registerOutParameter() method binds the JDBC data type to the data type the stored procedure is expected to return.

Once you call your stored procedure, you retrieve the value from the OUT parameter with the appropriate getXXX() method. This method casts the retrieved value of SQL type to a Java data type.

Closing CallableStatement Object:

Just as you close other Statement object, for the same reason you should also close the CallableStatement object.

A simple call to the close() method will do the job. If you close the Connection object first, it will close the CallableStatement object as well. However, you should always explicitly close the CallableStatement object to ensure proper cleanup.

```
CallableStatement cstmt = null;
try {
   String SQL = "{call getEmpName (?, ?)}";
   cstmt = conn.prepareCall (SQL);
   . . .
}
catch (SQLException e) {
   . . .
}
finally {
   cstmt.close();
}
```

We have studied more details in the Callable - Example Code section earlier.

JDBC SQL Escape Syntax

The escape syntax gives you the flexibility to use database specific features unavailable to you by using standard JDBC methods and properties.

The general SQL escape syntax format is as follows:

```
{keyword 'parameters'}
```

Here are the following escape sequences, which you would find very useful while performing the JDBC programming:

d, t, ts Keywords

They help identify date, time, and timestamp literals. As you know, no two DBMSs represent time and date the same way. This escape syntax tells the driver to render the date or time in the target database's format. For Example:

```
{d 'yyyy-mm-dd'}
```

Where yyyy = year, mm = month; dd = date. Using this syntax {d '2009-09-03'} is March 9, 2009.

Here is a simple example showing how to INSERT date in a table:

```
//Create a Statement object
stmt = conn.createStatement();
//Insert data ==> ID, First Name, Last Name, DOB
String sql="INSERT INTO STUDENTS VALUES" +
             "(100,'Zara','Ali', {d '2001-12-16'})";

stmt.executeUpdate(sql);
```

Similarly, you can use one of the following two syntaxes, either **t** or **ts**:

```
{t 'hh:mm:ss'}
```

Where hh = hour; mm = minute; ss = second. Using this syntax {t '13:30:29'} is 1:30:29 PM.

```
{ts 'yyyy-mm-dd hh:mm:ss'}
```

This is combined syntax of the above two syntax for 'd' and 't' to represent timestamp.

escape Keyword

This keyword identifies the escape character used in LIKE clauses. Useful when using the SQL wildcard %, which matches zero or more characters. For example:

```
String sql = "SELECT symbol FROM MathSymbols
              WHERE symbol LIKE '\%' {escape '\'}";
stmt.execute(sql);
```

If you use the backslash character (\) as the escape character, you also have to use two backslash characters in your Java String literal, because the backslash is also a Java escape character.

fn Keyword

This keyword represents scalar functions used in a DBMS. For example, you can use SQL function *length* to get the length of a string:

```
{fn length('Hello World')}
```

This returns 11, the length of the character string 'Hello World'.

call Keyword

This keywork is used to call the stored procedures. For example, for a stored procedure requiring an IN parameter, use the following syntax:

```
{call my_procedure(?)};
```

For a stored procedure requiring an IN parameter and returning an OUT parameter, use the following syntax:

```
{? = call my_procedure(?)};
```

oj Keyword

This keyword is used to signify outer joins. The syntax is as follows:

```
{oj outer-join}
```

Where outer-join = table {LEFT|RIGHT|FULL} OUTERJOIN {table | outer-join} on search-condition. For example:

```
String sql = "SELECT Employees
              FROM {oj ThisTable RIGHT
```

```
               OUTER JOIN ThatTable on id = '100'}";
stmt.execute(sql);
```

14. STREAMING DATA

A PreparedStatement object has the ability to use input and output streams to supply parameter data. This enables you to place entire files into database columns that can hold large values, such as CLOB and BLOB data types.

There are following methods, which can be used to stream data:

- **setAsciiStream():** This method is used to supply large ASCII values.
- **setCharacterStream():** This method is used to supply large UNICODE values.
- **setBinaryStream():** This method is used to supply large binary values.

The setXXXStream() method requires an extra parameter, the file size, besides the parameter placeholder. This parameter informs the driver how much data should be sent to the database using the stream.

Example

Consider we want to upload an XML file XML_Data.xml into a database table. Here is the content of this XML file:

```
<?xml version="1.0"?>
<Employee>
<id>100</id>
<first>Zara</first>
<last>Ali</last>
<Salary>10000</Salary>
<Dob>18-08-1978</Dob>
<Employee>
```

Keep this XML file in the same directory where you are going to run this example.

This example would create a database table XML_Data and then file XML_Data.xml would be uploaded into this table.

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
// Import required packages
import java.sql.*;
import java.io.*;
import java.util.*;

public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/EMP";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   PreparedStatement pstmt = null;
   Statement stmt = null;
   ResultSet rs = null;
   try{
      // Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      // Open a connection
      System.out.println("Connecting to database...");
      conn = DriverManager.getConnection(DB_URL,USER,PASS);

      //Create a Statement object and build table
      stmt = conn.createStatement();
      createXMLTable(stmt);

      //Open a FileInputStream
      File f = new File("XML_Data.xml");
      long fileLength = f.length();
      FileInputStream fis = new FileInputStream(f);

      //Create PreparedStatement and stream data
      String SQL = "INSERT INTO XML_Data VALUES (?,?)";
      pstmt = conn.prepareStatement(SQL);
      pstmt.setInt(1,100);
      pstmt.setAsciiStream(2,fis,(int)fileLength);
      pstmt.execute();

      //Close input stream
      fis.close();

      // Do a query to get the row
      SQL = "SELECT Data FROM XML_Data WHERE id=100";
      rs = stmt.executeQuery (SQL);
      // Get the first row
      if (rs.next ()){
         //Retrieve data from input stream
         InputStream xmlInputStream = rs.getAsciiStream (1);
         int c;
         ByteArrayOutputStream bos = new ByteArrayOutputStream();
         while (( c = xmlInputStream.read ()) != -1)
            bos.write(c);
         //Print results
         System.out.println(bos.toString());
      }
      // Clean-up environment
      rs.close();
      stmt.close();
      pstmt.close();
      conn.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(pstmt!=null)
            pstmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main

public static void createXMLTable(Statement stmt)
   throws SQLException{
   System.out.println("Creating XML_Data table..." );
   //Create SQL Statement
   String streamingDataSql = "CREATE TABLE XML_Data " +
                             "(id INTEGER, Data LONG)";
   //Drop table first if it exists.
   try{
      stmt.executeUpdate("DROP TABLE XML_Data");
   }catch(SQLException se){
   }// do nothing
   //Build table.
   stmt.executeUpdate(streamingDataSql);
}//end createXMLTable
}//end JDBCExample
```

Now let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating XML_Data table...
<?xml version="1.0"?>
<Employee>
<id>100</id>
<first>Zara</first>
<last>Ali</last>
<Salary>10000</Salary>
<Dob>18-08-1978</Dob>
<Employee>
Goodbye!
C:\>
```

15. CREATE DATABASE

This tutorial provides an example on how to create a Database using JDBC application. Before executing the following example, make sure you have the following in place:

- You should have admin privilege to create a database in the given schema. To execute the following example, you need to replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages**: Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver**: Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection**: Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with the database server.
- To create a new database, you need not give any database name while preparing database URL as mentioned in the below example.
- **Execute a query**: Requires using an object of type Statement for building and submitting an SQL statement to the database.
- **Clean up the environment**: Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
```

```
// JDBC driver name and database URL
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);

   //STEP 4: Execute a query
   System.out.println("Creating database...");
   stmt = conn.createStatement();

   String sql = "CREATE DATABASE STUDENTS";
   stmt.executeUpdate(sql);
   System.out.println("Database created successfully...");
}catch(SQLException se){
   //Handle errors for JDBC
   se.printStackTrace();
}catch(Exception e){
   //Handle errors for Class.forName
   e.printStackTrace();
}finally{
   //finally block used to close resources
```

```
      try{
         if(stmt!=null)
            stmt.close();
      }catch(SQLException se2){
      }// nothing we can do
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to database...
Creating database...
Database created successfully...
Goodbye!
C:\>
```

16. SELECT DATABASE

This chapter provides an example on how to select a Database using JDBC application. Before executing the following example, make sure you have the following in place:

- To execute the following example you need to replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages**: Requires that you include the packages containing the JDBC classes needed for the database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver**: Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection**: Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a **selected** database.
- Selection of database is made while you prepare database URL. Following example would make connection with **STUDENTS** database.
- **Clean up the environment**: Requires explicitly closing all the database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and past the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to a selected database...");
      conn = DriverManager.getConnection(DB_URL, USER, PASS);
      System.out.println("Connected database successfully...");
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
```

```
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java

C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample

Connecting to a selected database...

Connected database successfully...

Goodbye!

C:\>
```

17. DROP DATABASE

This chapter provides an example on how to drop an existing Database using JDBC application. Before executing the following example, make sure you have the following in place:

- To execute the following example you need to replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

NOTE: This is a serious operation and you have to make a firm decision before proceeding to delete a database because everything you have in your database would be lost.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- Deleting a database does not require database name to be in your database URL. Following example would delete **STUDENTS** database.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to delete the database.
- **Clean up the environment**: Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;
```

```
public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to a selected database...");
      conn = DriverManager.getConnection(DB_URL, USER, PASS);
      System.out.println("Connected database successfully...");

      //STEP 4: Execute a query
      System.out.println("Deleting database...");
      stmt = conn.createStatement();

      String sql = "DROP DATABASE STUDENTS";
      stmt.executeUpdate(sql);
      System.out.println("Database deleted successfully...");
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Deleting database...
Database deleted successfully...
Goodbye!
C:\>
```

18. CREATE TABLES

This chapter provides an example on how to create a table using JDBC application. Before executing the following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to create a table in a seleted database.
- **Clean up the environment**: Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to a selected database...");
      conn = DriverManager.getConnection(DB_URL, USER, PASS);
      System.out.println("Connected database successfully...");

      //STEP 4: Execute a query
      System.out.println("Creating table in given database...");
      stmt = conn.createStatement();

      String sql = "CREATE TABLE REGISTRATION " +
                   "(id INTEGER not NULL, " +
                   " first VARCHAR(255), " +
                   " last VARCHAR(255), " +
                   " age INTEGER, " +
                   " PRIMARY KEY ( id ))";

      stmt.executeUpdate(sql);
      System.out.println("Created table in given database...");
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Creating table in given database...
Created table in given database...
Goodbye!
C:\>
```

19. DROP TABLES

This chapter provides an example on how to delete a table using JDBC application. Before executing the following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

NOTE: This is a serious operation and you have to make a firm decision before proceeding to delete a table, because everything you have in your table would be lost.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so, you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to drop a table in a seleted database.
- **Clean up the environment**: Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
```

```
// JDBC driver name and database URL
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to a selected database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);
   System.out.println("Connected database successfully...");

   //STEP 4: Execute a query
   System.out.println("Deleting table in given database...");
   stmt = conn.createStatement();

   String sql = "DROP TABLE REGISTRATION ";

   stmt.executeUpdate(sql);
   System.out.println("Table  deleted in given database...");
}catch(SQLException se){
   //Handle errors for JDBC
   se.printStackTrace();
}catch(Exception e){
   //Handle errors for Class.forName
   e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Deleting table in given database...
Table  deleted in given database...
Goodbye!
C:\>
```

20. INSERT RECORDS

This chapter provides an example on how to insert records in a table using JDBC application. Before executing following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to insert records into a table.
- **Clean up the environment:** Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
   // JDBC driver name and database URL
   static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
   static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

   //  Database credentials
   static final String USER = "username";
   static final String PASS = "password";

   public static void main(String[] args) {
   Connection conn = null;
   Statement stmt = null;
   try{
      //STEP 2: Register JDBC driver
      Class.forName("com.mysql.jdbc.Driver");

      //STEP 3: Open a connection
      System.out.println("Connecting to a selected database...");
      conn = DriverManager.getConnection(DB_URL, USER, PASS);
      System.out.println("Connected database successfully...");

      //STEP 4: Execute a query
      System.out.println("Inserting records into the table...");
      stmt = conn.createStatement();

      String sql = "INSERT INTO Registration " +
                   "VALUES (100, 'Zara', 'Ali', 18)";
      stmt.executeUpdate(sql);
      sql = "INSERT INTO Registration " +
                   "VALUES (101, 'Mahnaz', 'Fatma', 25)";
      stmt.executeUpdate(sql);
      sql = "INSERT INTO Registration " +
                   "VALUES (102, 'Zaid', 'Khan', 30)";
      stmt.executeUpdate(sql);
      sql = "INSERT INTO Registration " +
                   "VALUES(103, 'Sumit', 'Mittal', 28)";
      stmt.executeUpdate(sql);
```

```
      System.out.println("Inserted records into the table...");

   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
```

```
Inserting records into the table...
Inserted records into the table...
Goodbye!
C:\>
```

21. SELECT RECORDS

This chapter provides an example on how to select/fetch records from a table using JDBC application. Before executing the following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to select (i.e. fetch) records from a table.
- **Extract Data:** Once SQL query is executed, you can fetch records from the table.
- **Clean up the environment:** Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
```

```
// JDBC driver name and database URL
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to a selected database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);
   System.out.println("Connected database successfully...");

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   stmt = conn.createStatement();

   String sql = "SELECT id, first, last, age FROM Registration";
   ResultSet rs = stmt.executeQuery(sql);
   //STEP 5: Extract data from result set
   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
      String last = rs.getString("last");
```

```
          //Display values
          System.out.print("ID: " + id);
          System.out.print(", Age: " + age);
          System.out.print(", First: " + first);
          System.out.println(", Last: " + last);
       }
       rs.close();
    }catch(SQLException se){
       //Handle errors for JDBC
       se.printStackTrace();
    }catch(Exception e){
       //Handle errors for Class.forName
       e.printStackTrace();
    }finally{
       //finally block used to close resources
       try{
          if(stmt!=null)
             conn.close();
       }catch(SQLException se){
       }// do nothing
       try{
          if(conn!=null)
             conn.close();
       }catch(SQLException se){
          se.printStackTrace();
       }//end finally try
    }//end try
    System.out.println("Goodbye!");
 }//end main
 }//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
```

```
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Creating statement...
ID: 100, Age: 18, First: Zara, Last: Ali
ID: 101, Age: 25, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
Goodbye!
C:\>
```

22. UPDATE RECORDS

This chapter provides an example on how to update records in a table using JDBC application. Before executing the following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to update records in a table. This Query makes use of **IN** and **WHERE** clause to update conditional records.
- **Clean up the environment:** Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
   // JDBC driver name and database URL
```

```
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to a selected database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);
   System.out.println("Connected database successfully...");

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   stmt = conn.createStatement();
   String sql = "UPDATE Registration " +
                "SET age = 30 WHERE id in (100, 101)";
   stmt.executeUpdate(sql);

   // Now you can extract all the records
   // to see the updated records
   sql = "SELECT id, first, last, age FROM Registration";
   ResultSet rs = stmt.executeQuery(sql);

   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
```

```
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }
      rs.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
```

```
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Creating statement...
ID: 100, Age: 30, First: Zara, Last: Ali
ID: 101, Age: 30, First: Mahnaz, Last: Fatma
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
Goodbye!
C:\>
```

23. DELETE RECORDS

This chapter provides an example on how to delete records from a table using JDBC application. Before executing following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to delete records from a table. This Query makes use of the **WHERE** clause to delete conditional records.
- **Clean up the environment:** Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
   // JDBC driver name and database URL
```

```
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to a selected database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);
   System.out.println("Connected database successfully...");

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   stmt = conn.createStatement();
   String sql = "DELETE FROM Registration " +
                "WHERE id = 101";
   stmt.executeUpdate(sql);

   // Now you can extract all the records
   // to see the remaining records
   sql = "SELECT id, first, last, age FROM Registration";
   ResultSet rs = stmt.executeQuery(sql);

   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
```

```
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }
      rs.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
```

```
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java

C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample

Connecting to a selected database...

Connected database successfully...

Creating statement...

ID: 100, Age: 30, First: Zara, Last: Ali

ID: 102, Age: 30, First: Zaid, Last: Khan

ID: 103, Age: 28, First: Sumit, Last: Mittal

Goodbye!

C:\>
```

24. WHERE CLAUSE

This chapter provides an example on how to select records from a table using JDBC application. This would add additional conditions using WHERE clause while selecting records from the table. Before executing the following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for the database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to fetch records from a table, which meet the given condition. This Query makes use of the **WHERE** clause to select records.
- **Clean up the environment:** Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages

import java.sql.*;


public class JDBCExample {
```

```
// JDBC driver name and database URL
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to a selected database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);
   System.out.println("Connected database successfully...");

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   stmt = conn.createStatement();

   // Extract records without any condition.
   System.out.println("Fetching records without condition...");
   String sql = "SELECT id, first, last, age FROM Registration";
   ResultSet rs = stmt.executeQuery(sql);

   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
```

```
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }

      // Select all records having ID equal or greater than 101
      System.out.println("Fetching records with condition...");
      sql = "SELECT id, first, last, age FROM Registration" +
                   " WHERE id >= 101 ";
      rs = stmt.executeQuery(sql);

      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }
      rs.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Creating statement...
Fetching records without condition...
ID: 100, Age: 30, First: Zara, Last: Ali
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
Fetching records with condition...
ID: 102, Age: 30, First: Zaid, Last: Khan
```

```
ID: 103, Age: 28, First: Sumit, Last: Mittal
Goodbye!
C:\>
```

25. LIKE CLAUSE

This chapter provides an example on how to select records from a table using JDBC application. This would add additional conditions using LIKE clause while selecting records from the table. Before executing the following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to fetch records from a table which meet given condition. This Query makes use of **LIKE** clause to select records to select all the students whose first name starts with "za".
- **Clean up the environment:** Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
```

```
// JDBC driver name and database URL
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to a selected database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);
   System.out.println("Connected database successfully...");

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   stmt = conn.createStatement();

   // Extract records without any condition.
   System.out.println("Fetching records without condition...");
   String sql = "SELECT id, first, last, age FROM Registration";
   ResultSet rs = stmt.executeQuery(sql);

   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
      String first = rs.getString("first");
```

```
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }

      // Select all records having ID equal or greater than 101
      System.out.println("Fetching records with condition...");
      sql = "SELECT id, first, last, age FROM Registration" +
                   " WHERE first LIKE '%za%' ";
      rs = stmt.executeQuery(sql);

      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }
      rs.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Creating statement...
Fetching records without condition...
ID: 100, Age: 30, First: Zara, Last: Ali
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
Fetching records with condition...
ID: 100, Age: 30, First: Zara, Last: Ali
```

```
ID: 102, Age: 30, First: Zaid, Last: Khan
Goodbye!
C:\>
```

26. SORTING DATA

This chapter provides an example on how to sort records from a table using JDBC application. This would use **asc** and **desc** keywords to sort records in ascending or descending order. Before executing the following example, make sure you have the following in place:

- To execute the following example you can replace the *username* and *password* with your actual user name and password.
- Your MySQL or whatever database you are using, is up and running.

Required Steps

The following steps are required to create a new Database using JDBC application:

- **Import the packages:** Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Register the JDBC driver:** Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection:** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with a database server.
- **Execute a query:** Requires using an object of type Statement for building and submitting an SQL statement to sort records from a table. These Queries make use of **asc** and **desc** clauses to sort data in ascending and descening orders.
- **Clean up the environment:** Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

Sample Code

Copy and paste the following example in JDBCExample.java, compile and run as follows:

```
//STEP 1. Import required packages
import java.sql.*;


public class JDBCExample {
```

```
// JDBC driver name and database URL
static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
static final String DB_URL = "jdbc:mysql://localhost/STUDENTS";

//  Database credentials
static final String USER = "username";
static final String PASS = "password";

public static void main(String[] args) {
Connection conn = null;
Statement stmt = null;
try{
   //STEP 2: Register JDBC driver
   Class.forName("com.mysql.jdbc.Driver");

   //STEP 3: Open a connection
   System.out.println("Connecting to a selected database...");
   conn = DriverManager.getConnection(DB_URL, USER, PASS);
   System.out.println("Connected database successfully...");

   //STEP 4: Execute a query
   System.out.println("Creating statement...");
   stmt = conn.createStatement();

   // Extract records in ascending order by first name.
   System.out.println("Fetching records in ascending order...");
   String sql = "SELECT id, first, last, age FROM Registration" +
                " ORDER BY first ASC";
   ResultSet rs = stmt.executeQuery(sql);

   while(rs.next()){
      //Retrieve by column name
      int id  = rs.getInt("id");
      int age = rs.getInt("age");
```

```
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }

      // Extract records in descending order by first name.
      System.out.println("Fetching records in descending order...");
      sql = "SELECT id, first, last, age FROM Registration" +
                   " ORDER BY first DESC";
      rs = stmt.executeQuery(sql);

      while(rs.next()){
         //Retrieve by column name
         int id  = rs.getInt("id");
         int age = rs.getInt("age");
         String first = rs.getString("first");
         String last = rs.getString("last");

         //Display values
         System.out.print("ID: " + id);
         System.out.print(", Age: " + age);
         System.out.print(", First: " + first);
         System.out.println(", Last: " + last);
      }
      rs.close();
   }catch(SQLException se){
      //Handle errors for JDBC
      se.printStackTrace();
   }catch(Exception e){
      //Handle errors for Class.forName
      e.printStackTrace();
   }finally{
      //finally block used to close resources
      try{
         if(stmt!=null)
            conn.close();
      }catch(SQLException se){
      }// do nothing
      try{
         if(conn!=null)
            conn.close();
      }catch(SQLException se){
         se.printStackTrace();
      }//end finally try
   }//end try
   System.out.println("Goodbye!");
}//end main
}//end JDBCExample
```

Now, let us compile the above example as follows:

```
C:\>javac JDBCExample.java
C:\>
```

When you run **JDBCExample**, it produces the following result:

```
C:\>java JDBCExample
Connecting to a selected database...
Connected database successfully...
Creating statement...
Fetching records in ascending order...
ID: 103, Age: 28, First: Sumit, Last: Mittal
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 100, Age: 30, First: Zara, Last: Ali
Fetching records in descending order...
```

```
ID: 100, Age: 30, First: Zara, Last: Ali
ID: 102, Age: 30, First: Zaid, Last: Khan
ID: 103, Age: 28, First: Sumit, Last: Mittal
Goodbye!
C:\>
```