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 commonly associated with database usage:

* Making a connection to a database
* Creating SQL or MySQL statements
* Executing that 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 progressing on this tutorial you need to have good understanding on the following two subjects:

1. [Core JAVA Programming](http://www.tutorialspoint.com/java/index.htm)
2. [SQL or MySQL Database](http://www.tutorialspoint.com/mysql/index.htm)

JDBC Architecture:

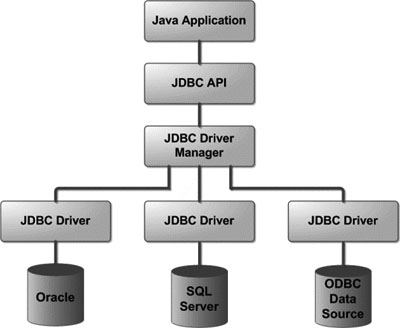
The JDBC API supports both two-tier and three-tier processing models for database access but in general JDBC Architecture consists of two layers:

1. **JDBC API:** This provides the application-to-JDBC Manager connection.
2. **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 interface 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 :** 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
* **S**tructured **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 all most any database you will likely use, and it allows you to write database code independently of the underlying database.
* This tutorial gives an overview of SQL, which is a pre-requisite to understand JDBC concepts. This tutorial gives you enough SQL to 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](http://www.tutorialspoint.com/mysql/index.htm).

# 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 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 represent 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 delete the record of the employee whose id is 100:

|  |
| --- |
| SQL> DELETE FROM Employees WHERE id=100; |

To start developing with JDBC 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](http://java.sun.com/j2se/1.5.0/download.jsp).

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 has 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's possible you have to open Performance and Maintenance before you will see the System icon.
* Go to the Advanced tab and click on Environment Variables.
* Now check 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:

1. **MySQL DB:** MySQL is an open source database. You can download it from [MySQL Official Site](http://dev.mysql.com/downloads/mysql). We recommend downloading the full Windows installation.

In addition, download and install [MySQL Administrator](http://dev.mysql.com/downloads/gui-tools/) as well as [MySQL Query Browser.](http://dev.mysql.com/downloads/gui-tools/)These are GUI based tools that will make your development much easier.

Finally, download and unzip [MySQL Connector/J](http://dev.mysql.com/downloads/connector/j/3.1.html) (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.

1. **PostgreSQL DB:** PostgreSQL is an open source database. You can download it from[PostgreSQL Official Site](http://www.postgresql.org/download/).

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

1. **Oracle DB:** Oracle DB is an 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 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 users 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 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 [MySQL Tutorial](http://www.tutorialspoint.com/mysql/index.htm).

Now you are ready to start experimenting with JDBC.

This tutorial 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:

1. **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.
2. **Register the JDBC driver .** Requires that you initialize a driver so you can open a communications channel with the database.
3. **Open a connection .** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with the database.
4. **Execute a query .** Requires using an object of type Statement for building and submitting an SQL statement to the database.
5. **Extract data from result set .** Requires that you use the appropriate*ResultSet.getXXX()* method to retrieve the data from the result set.
6. **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 previous chapter.

Copy and past 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 above example as follows:

|  |
| --- |
| C:\>javac FirstExample.java  C:\> |

When you run **FirstExample**, it produces 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:\> |

# 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.

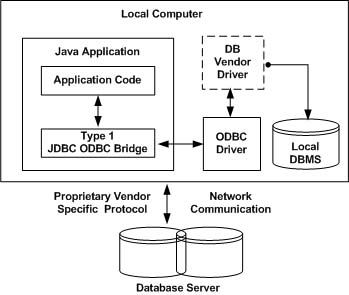
# JDBC Drivers Types:

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.

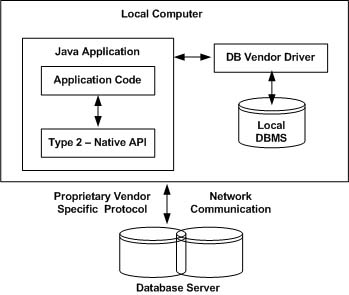


The JDBC-ODBC bridge that comes with JDK 1.2 is a good example of this kind of driver.

## 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 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.

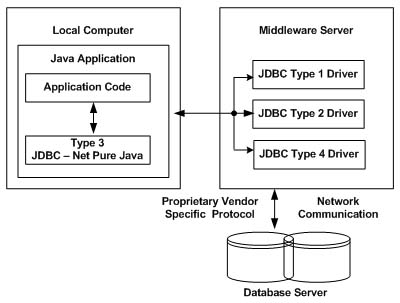


The Oracle Call Interface (OCI) driver is an example of a Type 2 driver.

## Type 3: JDBC-Net pure Java:

In a Type 3 driver, a three-tier approach is used to accessing databases. The JDBC clients use standard network sockets to communicate with an 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.



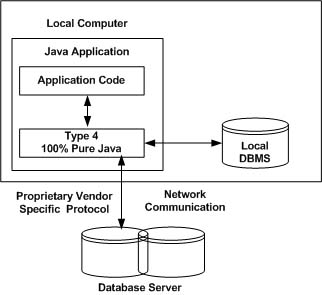
You can think of the application server as a JDBC "proxy," meaning that it makes calls for the client application. As a result, you need some knowledge of the application server's configuration in order to effectively use this driver type.

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

## Type 100: 100% pure Java:

In a Type 4 driver, a pure Java-based driver that communicates directly with 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.

After you've installed the appropriate driver, it's 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:

1. **Import JDBC Packages:** Add **import** statements to your Java program to import required classes in your Java code.
2. **Register JDBC Driver:** This step causes the JVM to load the desired driver implementation into memory so it can fulfill your JDBC requests.
3. **Database URL Formulation:** This is to create a properly formatted address that points to the database to which you wish to connect.
4. **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 your 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 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:

1. getConnection(String url)
2. getConnection(String url, Properties prop)
3. 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 occur.

Following table lists down 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 remaining part as per your database setup.

# Create Connection Object:

## Using a database URL with a username and password:

I listed down three forms of **DriverManager.getConnection()** method to create a connection object. 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 then 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's 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 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 garbage collection, especially in database programming, is 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 if an exception occurs or not.

To close 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.

This tutorial 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:

1. **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.
2. **Register the JDBC driver .** Requires that you initialize a driver so you can open a communications channel with the database.
3. **Open a connection .** Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with the database.
4. **Execute a query .** Requires using an object of type Statement for building and submitting an SQL statement to the database.
5. **Extract data from result set .** Requires that you use the appropriate*ResultSet.getXXX()* method to retrieve the data from the result set.
6. **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 previous chapter.

Copy and paste 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 above example as follows:

|  |
| --- |
| C:\>javac FirstExample.java  C:\> |

When you run **FirstExample**, it produces 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:\> |

# JDBC - 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.

Following table provides a summary of each interface's purpose to understand how do you decide which interface to use?

|  |  |
| --- | --- |
| **Interfaces** | **Recommended Use** |
| Statement | Use 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 when you plan to use the SQL statements many times. The PreparedStatement interface accepts input parameters at runtime. |
| CallableStatement | Use when you want to access 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 a SQL statement with one of its three execute methods.

1. **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.
2. **int executeUpdate(String SQL)** : Returns the numbers 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.
3. **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 Obeject:

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();  } |

# 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 to 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 start 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 take input the parameters.

## Closing PreparedStatement Obeject:

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, I would suggest to study [Prepare - Example Code](http://www.tutorialspoint.com/jdbc/preparestatement-object-example.htm).

# 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 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 theOUT 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 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 Obeject:

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](http://www.tutorialspoint.com/jdbc/callablestatement-object-example.htm).

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:

1. **Navigational methods:** used to move the cursor around.
2. **Get methods:** used to view the data in the columns of the current row being pointed to by the cursor.
3. **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 generated the ResultSet is created.

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

1. **createStatement(int RSType, int RSConcurrency);**
2. **prepareStatement(String SQL, int RSType, int RSConcurrency);**
3. **prepareCall(String sql, int RSType, int RSConcurrency);**

The first argument indicate 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 forwards and backwards, 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 forwards and backwards, 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. |

Our all the 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 to just before the first row |
| 2 | **public void afterLast() throws SQLException** Moves the cursor to 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 backwards from where it currently is 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, I would suggest to study [Navigate - Example Code](http://www.tutorialspoint.com/jdbc/navigate-result-sets.htm).

# 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:

1. One that takes in a column name.
2. 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, I would suggest to study [Viewing - Example Code](http://www.tutorialspoint.com/jdbc/viewing-result-sets.htm).

# 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:

1. One that takes in a column name.
2. 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, I would suggest to study [Updating - Example Code](http://www.tutorialspoint.com/jdbc/updating-result-sets.htm).

Following is the example which makes use of **ResultSet.CONCUR\_UPDATABLE** and**ResultSet.TYPE\_SCROLL\_INSENSITIVE** described in 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 previous chapters.

Copy and past 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 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...  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:\> |