Java Database Connectivity (JDBC)

Basic Steps in Using JDBC

1. Import required packages
2. Load driver
3. Define Connection URL
4. Establish Connection
5. Create a Statement object

Basic Steps in Using JDBC (cont.)

6. Execute query / DML
7. Process results
8. Close connection

JDBC Details of Process

JDBC: Details of Process

1. **Import package**
   - Import java.sql package
     - `import java.sql.*;`

JDBC: Details of Process

2. **Loading driver**
   - Need to load suitable driver for underlying database
   - Different drivers for different databases are available
     - For MS Access
       `Class.forName("sun.jdbc.odbc.JdbcOdbcDriver");`
     - **For Oracle**
       `Class.forName("oracle.jdbc.driver.OracleDriver ");`

JDBC: Details of Process

3. Define Connection URL

- To get a connection, we need to specify URL of database.
- If you are using a JDBC-ODBC driver you need to create a DSN. DSN is the name of your DataSource
- If the name of your DSN is "personDSN" then the url of the database will be
  - String conURL = "jdbc:odbc:personDSN"

JDBC: Details of Process, cont.

4. Establish Connection

- Connection con = null;
- Use driver manager to get the connection object

```
con = DriverManager.getConnection(conURL);
```

– If the Db requires username and password you can use overloaded version

```
String usr = "umair";
String pswd = "java";
Connection con = null;

con = DriverManager.getConnection(conURL,usr,pswd);
```


JDBC: Details of Process, cont.

5. Create Statement

- A statement is obtained from a Connection object.

```
Statement statement = con.createStatement();
```

- Once you have a statement, you can use it for various kind of SQL queries

JDBC: Details of Process, cont.

6(a) Execute Query / DML

– executeQuery(sql) method
  - Used for SQL SELECT queries
  - Returns the *ResultSet* object which is used to access the rows of the query results

```
String sql = "SELECT * FROM sometable";
ResultSet rs = statement.executeQuery(sql);
```


JDBC: Details of Process, cont.

6(b) Execute Query / DML

– executeUpdate(sql) method
  - Used for an update statement (INSERT, UPDATE or DELETE)
  - Returns an integer value representing the number of rows updated.

```
String sql = "INSERT INTO tableName " +
             "(columnNames) Values (values)";

int count = statement.executeUpdate(sql);
```


JDBC: Details of Process, cont.

7. Process Results

– `ResultSet` provides various `getXxx` methods that take a column index or name and returns the data

– First column has index 1, not 0

```
while(resultSet.next()) {
      //by using column name
      String name = rs.getString("columnName");

      //or by using index
      String name = rs.getString(1);
 }
```

JDBC: Details of Process, cont.

8. **Close Connection**

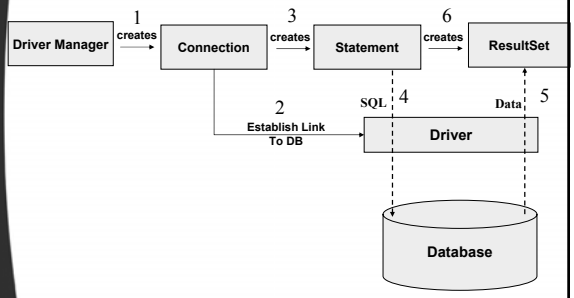
```
connection.close();
```

– As opening a connection is expensive, postpone this step if additional database operations are expected

In a nut shell

- **Class.forName("sun.jdbc.odbc.JdbcOdbcDriver");**
- **Connection con = null;**
  con = DriverManager.getConnection(url, usr, pwd);
- **Statement st = con.createStatement();**
- **ResultSet rs = st.exectuteQuery(**"Select * from Person" **);**

JDBC Architecture



Example Code

Retrieving Data from ResultSet

Example Code
Retrieving Data from ResultSet

```
//Step 1: import package
import java.sql.*;

public class JdbcEx {

  public static void main (String args [ ]){

    try {

      //Step 2: Load driver
      Class.forName("sun.jdbc.odbc.JdbcOdbcDriver");

      //Step 3: Defie the connection URL
      String url = "jdbc:odbc:personDSN";

      //Step 4: Establish the connection
      Connection con = null;
      con = DriverManager.getConnection (url , "“ ,"");
```


Example Code 14.1
Retrieving Data from ResultSet (cont.)

```
//Step 5: create the statement
Statement st = con.createStatement();

//Step 6: Execute the query
String sql = "SELECT * FROM Person";
ResultSet rs = st.executeQuery(sql);

//Step 7: Process the results
while ( rs.next() ) {

   String name = rs.getString("name");
   String add  = rs.getString("address");
   String pNum = rs.getString("phoneNum");

   System.out.println(name + " " +add +" "+pNum);
} // end while
```

Example Code 14.1
Retrieving Data from ResultSet (cont.)

```
//Step 8: close the connection
con.close();

}catch (Exception sqlEx) {

  System.out.println(sqlEx);

}

} //end main

}//end class
```


Compile & Execute

```
C:\WINDOWS\system32\cmd.exe

D:\examples\jdbc>javac JdbcEx.java

D:\examples\jdbc>java JdbcEx
ali model town 9203256
usman gulberg 8219065
raza defence 5173946
```


More on JDBC

Useful Statement Methods

- **executeQuery**
  - Executes the SQL query and returns the data in a table (ResultSet)
  - The resulting table may be empty but never null

```
ResultSet rs = stmt.executeQuery("select * from table");
```


Useful Statement Methods

- **executeUpdate**
  - Used to execute for INSERT, UPDATE, or DELETE SQL statements
  - The return is the number of rows that were affected in the database
  - Supports Data Definition Language (DDL) statements CREATE TABLE, DROP TABLE and ALTER TABLE

```
int num = stmt.executeUpdate("DELETE FROM Person " +
                             "WHERE id = 2");
```


Example Code
Executing SQL DML Statements

```
/* This progarm will take two command line argument
   that are used to update records in the database */

 import java.sql.*;   //step 1

 public class JdbcDmlEx {

   public static void main (String args [ ]){

     try {

          //steps 2 to 5
          Class.forName("driver name");

          Connection con=null;
          con = DriverManager.getConnection(url, usr, pwd);

          Statement st = con.createStatement();
```

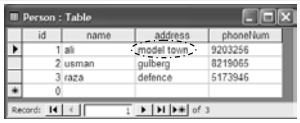
Example Code
Executing SQL DML Statements (cont.)

```
//Step 6: Execute the Query / DML

String addVar   = args[0];
String nameVar = args[1];

String sql = "UPDATE Person "  +
             " SET address =  ' " + addVar + " ' "  +
             " WHERE name = ' " + nameVar + " '  " ;

int num = st.executeUpdate(sql);

//Step 7: Process the results of the query

System.out.println(num + " records updated");
```

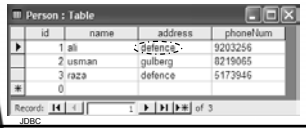

Example Code
Executing SQL DML Statements (cont.)

```
//Step 8: close the connection
 con.close();

}catch (Exception sqlEx) {

   System.out.println(sqlEx);

}

} //end main

}//end class
```


Compile & Execute



Before execution



After execution

Useful Statement Methods (Continued)

- **getMaxRows( ) / setMaxRows(int)**
  - Determines the number of rows a `ResultSet` may contain
  - Unless explicitly set, the number of rows are unlimited (return value of 0)
- **getQueryTimeout( ) / setQueryTimeout(int)**
  - Specifies the amount of a time (seconds) a driver will wait for a STATEMENT to complete before throwing a `SQLException`

Different Types of Statements

- **Overview**
  - Through the Statement object, SQL statements are sent to the database.
  - Three types of statement objects are available:
    1. **Statement**
       - for executing a simple SQL statements
    2. **PreparedStatement**
       - for executing a precompiled SQL statement passing in parameters
    3. **CallableStatement**
       - for executing a database stored procedure

Prepared Statements

Prepared Statements
(Precompiled Queries)

- **Idea**
  - If you are going to execute similar SQL statements multiple times, using "prepared" (parameterized) statements can be more efficient
  - Create a statement in standard form that is sent to the database for compilation before actually being used
  - Each time you use it, you simply replace some of the marked parameters (?) using some `set` methods

Prepared Statement, Example

```
PreparedStatement pStmt =
     con.prepareStatement("UPDATE tableName " +
                          "SET columnName = ? " +
                          "WHERE columnName = ?");
```

- `First marked parameter(?) has index 1.`

```
pStmt.setString(1, stringValue);
pStmt.setInt   (2, intValue);

pStmt.executeUpdate();
```


Example Code
Using Prepared Statements

Example Code: Modify JdbcDmlEx.java Executing Prepared Statements

```
/* Modification to the last example code
  to show the usage of prepared statements  */

  import java.sql.*;    // step1

  public class JdbcDmlEx {

    public static void main (String args [ ]){

      try {

            //steps 2 to 4
            Class.forName("driver name");

            Connection con=null;
            con = DriverManager.getConnection(url, usr, pwd);
```

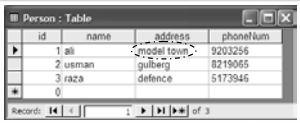

Example Code: Modify JdbcDmlEx.java Executing Prepared Statements

```
//Step 5: Create the statement
PreparedStatement pStmt = null;

String sql = "UPDATE Person SET address =  ?  WHERE name = ? " ;
pStmt = con.prepareStatement(sql);

//Step 6: Execute the Query
String addVar   = args[0];
String nameVar = args[1];

pStmt.setString(1 , addVar);
pStmt.setString(2, nameVar);
// sql = "UPDATE Person SET address = "defence" WHERE name = "ali" "
int num = pStmt.executeUpdate();
```

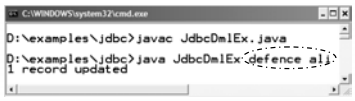

Example Code: Modify JdbcDmlEx.java 15.1 Executing Prepared Statements

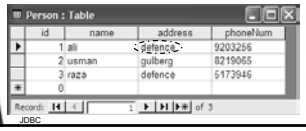
```
//Step 7: Process the results of the query
System.out.println(num + " records updated");

//Step 8: close the connection

}catch (Exception sqlEx) {
   ……….
}

 } //end main
}//end class
```

Compile & Execute

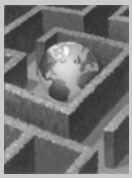


Before execution





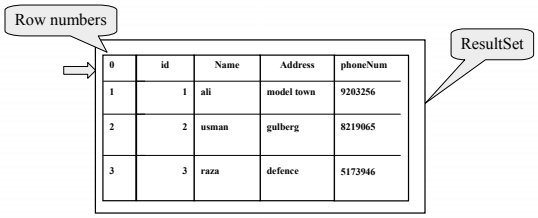
After execution



Result Set

ResultSet

- **Overview**
  - A `ResultSet` contains the results of the SQL query
    - Represented by a table with rows and columns
    - Maintains a cursor pointing to its current row of data.
    - Initially the cursor positioned before the row (0).
    - First row has index 1



ResultSet (cont.)

- **A default `ResultSet` object is not updateable and has a cursor that moves forward only**
  - You can iterate through it only once and only from the first row to last row.

```
String sql = "SELECT * FROM Person";
PreparedStatement pStmt = con.prepareStatement(sql);
ResultSet rs = pStmt.executeQuery( );
```


ResultSet (cont.)

- **Useful Methods**
  - **next( )**
    - Attempts to move to the next row in the `ResultSet`
    - If successful `true` is returned; otherwise, `false`
    - The first call to next, moves the cursor to the first row
  - **close( )**
    - Releases the JDBC and database resources
    - The result set is automatically closed when the associated Statement object executes a new query or closed by method call

ResultSet (cont.)

- **Useful Methods**
  - **getters**
    - Returns the value from the column specified by the column name or index
      - String name = rs.getString("name");
      - String add = rs.getString(3);
      - double sal = rs.getDouble("Salary")
    - Returns the value in a specified format

double	byte	int	Date	String
float	short	long	Time	Object

ResultSet (cont.)

- **It is possible to produce `ResultSet` objects that are scrollable and/or updatable (since JDK 1.2).**

```
String sql = "SELECT * FROM Person";

PreparedStatement pStmt = con.prepareStatement( sql,
                                ResultSet.TYPE_SCROLL_INSENSITIVE,
                                ResultSet.CONCUR_UPDATABLE );

    ResultSet rs = pStmt.executeQuery( );
```


ResultSet (cont.)

- **Useful Methods**
  - **previous( )**
    - Moves the cursor to the previous row in the `ResultSet` object.
    - Returns `true` if cursor is on a valid row, `false` it is off the result set.
    - Throws exception if result type is `TYPE_FORWARD_ONLY`.

Example Code: ResultSetEx previous, next & getters methods

```
import java.sql.*;

public class ResultSetEx {

 public static void main ( String args[ ]) {

   try {
        // load driver & make connection

        String sql = "SELECT * FROM Person";

        PreparedStatement pStmt = con.prepareStatement( sql,
                                ResultSet.TYPE_SCROLL_INSENSITIVE ,
                                ResultSet.CONCUR_UPDATABIE );

        ResultSet rs = pStmt.executeQuery( );
```

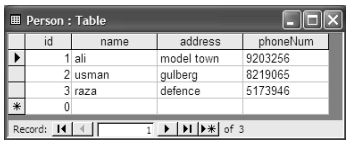

Example Code: ResultSetEx previous, next & getters methods

```
rs.next();

System.out.println("moving cursor forward");
String name = rs.getString("name");
System.out.println(name);

rs.next();

rs.previous();

System.out.println("moving cursor backward");
name = rs.getString("name");
System.out.println(name);
```


Example Code: ResultSetEx previous, next & getters methods

```
    con.close();

  } catch (Exception ex) {
        System.out.println(ex);
  }

 }// end main

}//end class
```

Compile & Execute




```
D:\examples\jdbc>javac ResultSetEx.java

D:\examples\jdbc>java ResultSetEx
moving cursor forward
ali
moving cursor backward
ali
```


ResultSet (cont.)

- **Useful Methods**
  - **absolute(int)**
    - Move the cursor to the given row number in the `ResultSet` object
    - If the row number is positive, moves the cursor forward with respect to beginning of the result set.
    - If the given row number is negative, the cursor moves to the absolute row position with respect to the end of the result set.
      - For example, calling `absolute(-1)` positions the cursor on the last row; calling `absolute(-2)` moves the cursor to next-to-last row, and so on.
    - Throws exception if result type is `TYPE_FORWARD_ONLY`.

ResultSet (cont.)

- **Useful Methods**
  - **updaters (for primitives, Object & String)**
    - Used to update column values in the current row or the *insert row*.
    - Do not update the underlying database
    - Each update method is overloaded.
    - For example of String

```
updateString(String columnName, String value)
updateString(int columnIndex, String value)
```


ResultSet (cont.)

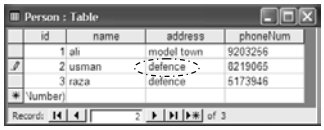
- **Useful Methods**
  - **updateRow( )**
    - Updates the underlying database with new contents of the current row of this `ResultSet` object.

Modify Example : ResultSetEx
updating existing rows

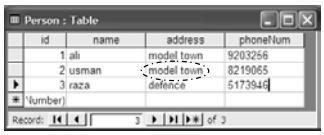
```
Import java.sql.*;
public class ResultSetEx {
   …..  // main method
    ….. Load driver, make connection
    ….. Make updatable resultset

     //move cursor to 2nd row of rs
     rs.absolute(2);

    //update address column of 2nd row in rs
    rs.updateString("address", "model town");

    //update the row in database
    rs.updateRow();

     ……. // close connection etc

  …. //end main
}// end class
```


Compile & Execute

Before execution



After execution



ResultSet (cont.)

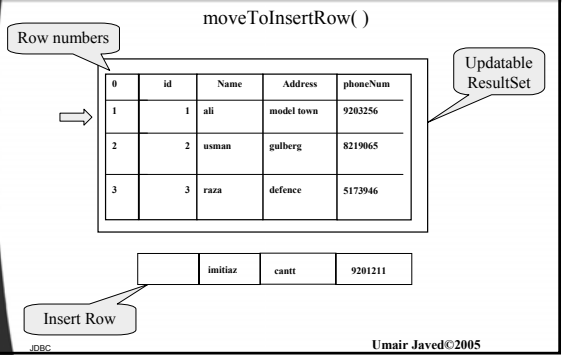
- **Useful Methods**
  - **moveToInsertRow( )**
    - An Updatable `ResultSet` object has a special row associated with it i.e. insert row.
    - Insert row – a buffer, where a new row may be construted by calling the updater methods
    - Doesn't insert row into a result set or into a database

ResultSet (cont.)

- **Useful Methods**
  - **insertRow( )**
    - Inserts the contents of the insert row into this `ResultSet` object and into the database.
    - The cursor must be on the insert row when this method is called

ResultSet (cont.)

moveToInsertRow( )

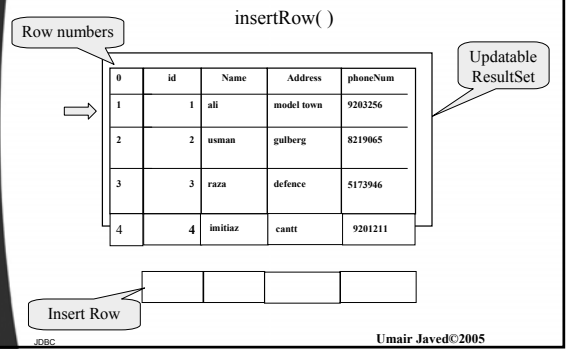


0	id	Name	Address	phoneNum
1	1	ali	model town	9203256
2	2	usman	gulberg	8219065
3	3	raza	defence	5173946

	imitiaz	cantt	9201211

ResultSet (cont.)

insertRow( )



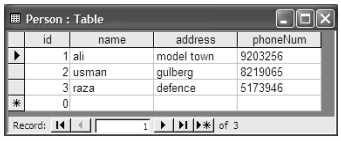
0	id	Name	Address	phoneNum
1	1	ali	model town	9203256
2	2	usman	gulberg	8219065
3	3	raza	defence	5173946
4	4	imitiaz	cantt	9201211

Modify Example : ResultSetEx
Inserting new row

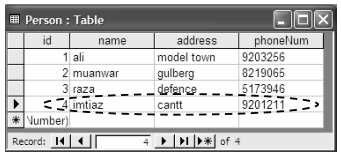
```
Import java.sql.*;
public class ResultSetEx {
   .....  // main method
     ..... Load driver, make connection
     ..... Make updatable resultset

      //move cursor to insert row
      rs.moveToInsertRow();

     // updating values into insert row
     rs.updateString("name", "imitaz');
     rs.updateString("address", "cantt');
     rs.updateString("phoneNum", "9201211');

     //insert row into rs & db
     rs.insertRow();

      .........

   .... //end main
}// end class
```


Compile & Execute

Before execution



After execution



ResultSet (cont.)

- **Useful Methods**
  - **last( ) & first( )**
    - Moves the cursor to the last & first row of the `ResultSet` object respectively.
    - Throws exception if the result set is `TYPE_FORWARD_ONLY`
  - **getRow( )**
    - Returns the current row numner
    - The first row number is 1, second row number is 2 and so on

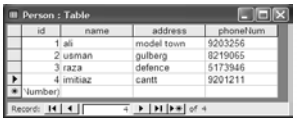
ResultSet (cont.)

- **Useful Methods**
  - **deleteRow( )**
    - Deletes the current row from this `ResultSet` object and from the underlying database.
    - Throws exception when the cursor is on the insert row

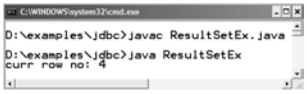
Modify Example : ResultSetEx
deleting existing row

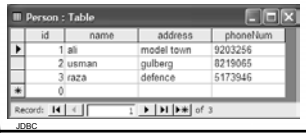
```
Import java.sql.*;
public class ResultSetEx {
   ….. // main method
    ….. Load driver, make connection
    ….. Make updatable resultset

     //moves to last row
     rs.last( );

    int rNo = rs.getRow();
    System.out.println("curr row no: "+ rNo );

    //delete current row (4) from rs & db
    rs.deleteRow();

     …….

  …. //end main
}// end class
```


Compile & Execute



Before execution

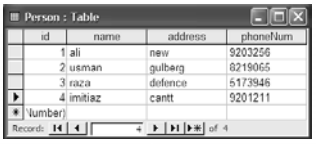




After execution

Meta Data

Meta Data



Meta Data

- **What if you want to know:**
  - How many columns are in the result set?
  - What is the name of a given column?
  - Are the column names case sensitive?
  - What is the data type of a specific column?
  - What is the maximum character size of a column?
  - Can you search on a given column?

Using ResultSetMetaData

- **Idea**
  - From a `ResultSet` (the return type of `executeQuery`), derive a `ResultSetMetaData` object
  - Use that object to look up the number, names, and types of columns

Useful ResultSetMetaData Methods

- **getColumnCount ( )**
  - Returns the number of columns in the result set
- **getColumnDisplaySize (int)**
  - Returns the maximum width of the specified column in characters
- **getColumnName(int) / getColumnLabel (int)**
  - The `getColumnName` method returns the database name of the column
  - The `getColumnLabel` method returns the suggested column label for printouts
- **getColumnType (int)**
  - Returns the SQL type for the column to compare against types in `java.sql.Types`

Example Code: MetaDataEx using ResultSetMetaData

```
import java.sql.*;

public class MetaDataEx {

  public static void main ( String args[ ]) {

    try {

        Class.forName("Driver name");

        Connection con = DriverManager.getConnection(url, usr, pwd);


        String sql = "SELECT * FROM Person";
        PreparedStatement pStmt = con.prepareStatement(sql);

        ResultSet rs = pStmt.executeQuery( );
```


Example Code: MetaDataEx (cont.) using ResultSetMetaData

```
ResultSetMetaData rsmd = rs.getMetaData();

int numColumns =  rsmd.getColumnCount();
System.out.println("Number of Columns:" + numColumns);

String cName;

for (int i=1; I <= numColumns; i++)
{
   cName = rsmd.getColumnName(i);
   System.out.print(cName);
   System.out.print("\t");
}

// changing line
System.out.println("");
```

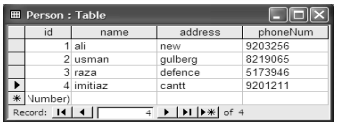

Example Code: MetaDataEx (cont.) using ResultSetMetaData

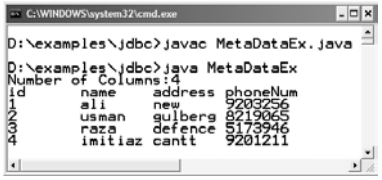
```
String id, name, add, ph;

while (rs.next())
{
   id      =  rs.getString(1);
   name =  rs.getString(2);
   add    =  rs.getString(3);
   ph     =  rs.getString(4);

   System.out.print(id);

   System.out.print("\t");
   System.out.print(name);

   System.out.print("\t");
   System.out.print(add);

   System.out.print("\t");
   System.out.print(ph);

   System.out.println("");
}
```

Example Code: MetaDataEx (cont.) using ResultSetMetaData

```
  con.close();

 } catch (Exception ex) {
     System.out.println(ex);
 }

}// end main
}//end class
```


Example Code: MetaDataEx Compile & Execute





DatabaseMetaData

- **What if we want to know**
  - What SQL types are supported by DBMS to create table?
  - What is the name of a database product?
  - What is the version number of this database product?
  - What is the name of the JDBC driver that is used?
  - Is the database in a read-only mode?

Using DatabaseMetaData

- **Idea**
  - From a `Connection`, derive a `DatabaseMetaData` object
  - Contains the comprehensive information about the database as a whole

Using DatabaseMetaData

- **Idea**
  - From a `Connection`, derive a `DatabaseMetaData` object
  - Contains the comprehensive information about the database as a whole

Useful DataBaseMetaData Methods

- **getDatabaseProductName ( )**
  - Returns the name of the database product name
- **getDatabaseProductVersion ( )**
  - Returns the version number of this database product
- **getDriverName( )**
  - Returns the name of the JDBC driver used to established the connection
- **isReadOnly ( )**
  - Retrieves whether this database is in read-only mode.
  - Returns `true` if so, `false` otherwise.

Example Code: Modify MetaDataEx
using DataBaseMetaData

```
import java.sql.*;
public class MetaDataEx {
  public static void main ( String args[ ]) {
    try {
        Class.forName("Driver name");
        Connection con = DriverManager.getConnection(url, usr, pwd);
        DatabaseMetaData dbMetadata = con.getMetaData();
        ……
```


Example Code: Modify MetaDataEx
using DataBaseMetaData

```
String pName = dbMetaData.getDatabaseProductName();
System.out.println("Database: " + pName);

String pVer = dbMetaData.getDatabaseProductVersion();
System.out.println("Version: " + pVer);

String dName = dbMetaData.getDriverName();
System.out.println("Driver: " + dName);

boolean rOnly = dbMetaData.isReadOnly();
System.out.println("Read-Only: " + rOnly);

……
```


Example Code: Modify MetaDataEx
using DataBaseMetaData

```
    // create Statement & execute query

    // process results

   con.close();

  }catch ( Exception ex) {
     System.out.printl(ex);
  }
 } // end main
} // end class
```


Example Code: Modify MetaDataEx
Compile & Execute

```
C:\WINDOWS\system32\cmd.exe
D:\examples\jdbc>javac MetaDataEx.java

D:\examples\jdbc>java MetaDataEx
Database: ACCESS
Version: 04.00.0000
Driver: JDBC-ODBC Bridge (odbcjt32.dll)
Read-Only: false
```


RowSet

RowSet

- A JDBC RowSet object holds tabular data in a way that makes it more flexible and easier to use than a result set.
- Interface RowSet configures the database connection and prepares query statements automatically.
- It is part of package javax.sql.
- It is part of J2SE, but it is normally used in the context of J2EE.

RowSet (cont.)

There are two kinds of RowSet objects:

- **Connected**
  - Makes the connection to the database and stays connected until the application ends
- **Disconnected**
  - Connects, queries the database, then closes.
  - Connection can be reestablished for updates.

RowSet (cont.)

JDBC provides the five versions of the RowSets.Two of them are:

1. **JdbcRowSet**
   - Connected RowSet that wraps a ResultSet object, allowing scrolling and updating.
   - It is most similar to a ResultSet object.

RowSet (cont.)

2. **CachedRowSet**
   - Disconnected RowSet that is scrollable and updateable.
   - It caches the data of a ResultSet in memory.
   - Manipulate data and make changes to data while it is disconnected.
   - Reconnect to the data source to write changes back to it.
   - It is also serializable, so it can be sent across a network.

JDBC Drivers Types

JDBC Driver Types

- **JDBC drivers are divided into four types or levels.**
- **Each type defines a JDBC driver implementation with increasingly higher level of platform independence, performance, deployment and administration.**
- **The four types are:**

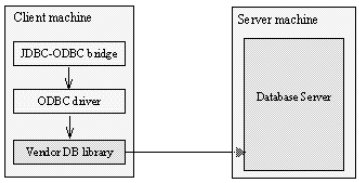
1. Type 1: JDBC – ODBC Bridge
2. Type 2: Native – API/partly Java driver
3. Type 3: Net – protocol/all–Java driver
4. Type 4: Native – protocol/all–Java driver

JDBC Driver Types (cont.)

1. **Type 1: JDBC – ODBC Bridge**
   - Translates all JDBC calls into ODBC (Open Database Connectivity) calls and send them to the ODBC driver.
   - Generally used for Microsoft databases.
   - Performance is degraded

JDBC Driver Types (cont.)

1. **Type 1: JDBC – ODBC Bridge**



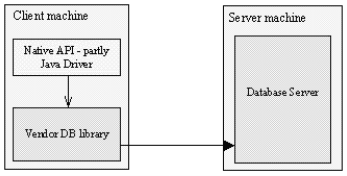
JDBC Driver Types (cont.)

2. **Type 2: Native – API/partly Java driver**

- Converts JDBC calls into database-specific calls such as SQL Server, Informix, Oracle or Sybase.
- Partly-Java drivers communicate with database-specific API (which may be in C/C++) using the Java Native Interface.
- Significantly better Performance than the JDBC-ODBC bridge.

JDBC Driver Types (cont.)

2. **Type 2: Native – API/partly Java driver**



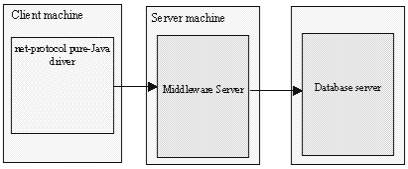
JDBC Driver Types (cont.)

3. **Type 3: Net – protocol/all–Java driver**

- Follows a three-tiered approach whereby the JDBC database requests ()are passed through the network to the middle-tier server
- Pure Java client to server drivers which send requests that are not database-specific to a server that translates them into a database-specific protocol.
- If the middle-tier server is written in java, it can use a type 1or type 2JDBC driver to do this
- No need for any vendor database library to be present on client machines because it is server-based

JDBC Driver Types (cont.)

3. **Type 3: Net – protocol/all–Java driver**



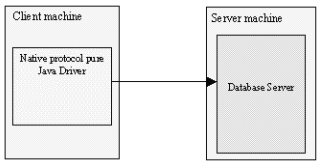
JDBC Driver Types (cont.)

4. **Type 4: Native – protocol/all–Java driver**

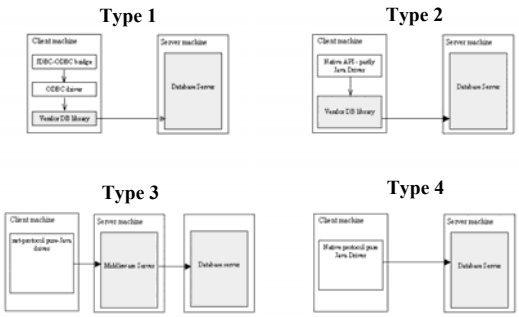
- Converts JDBC calls into the vendor-specific DBMS protocol so that client application can communicate directly with the database server.
- Completely implemented in Java to achieve platform independence and eliminate deployment issues.
- Performance is typically very good

JDBC Driver Types (cont.)

4. Type 4:Native – protocol/all–Java driver



Summary of Driver Types



Looking Insight

- JDBC is mostly collection of interfaces.
- Connection, Statement, PreparedStatement, ResultSet and RowSet are all interfaces.
- Why?
  - Any DBMS interested in providing support for java connectivity, need to provide implementation of all the above interfaces.

General Design Guideline

```
class Employee {

  String name;
  String sal;

  // constructor
  // getter / setters

  void insertEmp( ){
   // connect database
   // execute query
   // process results
  }

  void retrieveEmp ( ){ ..... }

  void calculateTax ( ) { .... }

}
```

Database connectivity & business logic all in one class

General Design Guideline

Business Logic

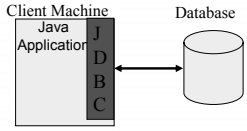
```
public class Employee {

   String name;
   String address;

    // constructor

    // getter / setters


  void insertEmp( ){
       DAO dao = new DAO();
       dao.update(name, address);
  }

  void calculateTax( ){ ..... }

}
```

Database Connectivity

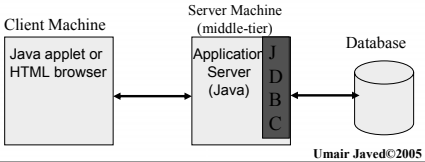
```
//step 1
public class DAO {
   public DAO ( ) {
     //step 2 - 5
       ..........
       ..........
   }

   public void insert (String n, String s)
   {
     // make statement
     // execute query + process results
   }

   public void insert(....){.....}

   protected void finalize() {
     //step 8 – close connection
   }
}
```


Architectures

- Two-tier architecture:



- Three-tier architecture:



On-line Resources

- **Sun's JDBC Site**
  - http://java.sun.com/products/jdbc/
- **JDBC Tutorial**
  - http://java.sun.com/docs/books/tutorial/jdbc/
- **List of Available JDBC Drivers**
  - http://industry.java.sun.com/products/jdbc/drivers/
- **API for java.sql**
  - http://java.sun.com/j2se/1.3/docs/api/java/sql/package-summary.html