Topic 12:
Database Programming using JDBC

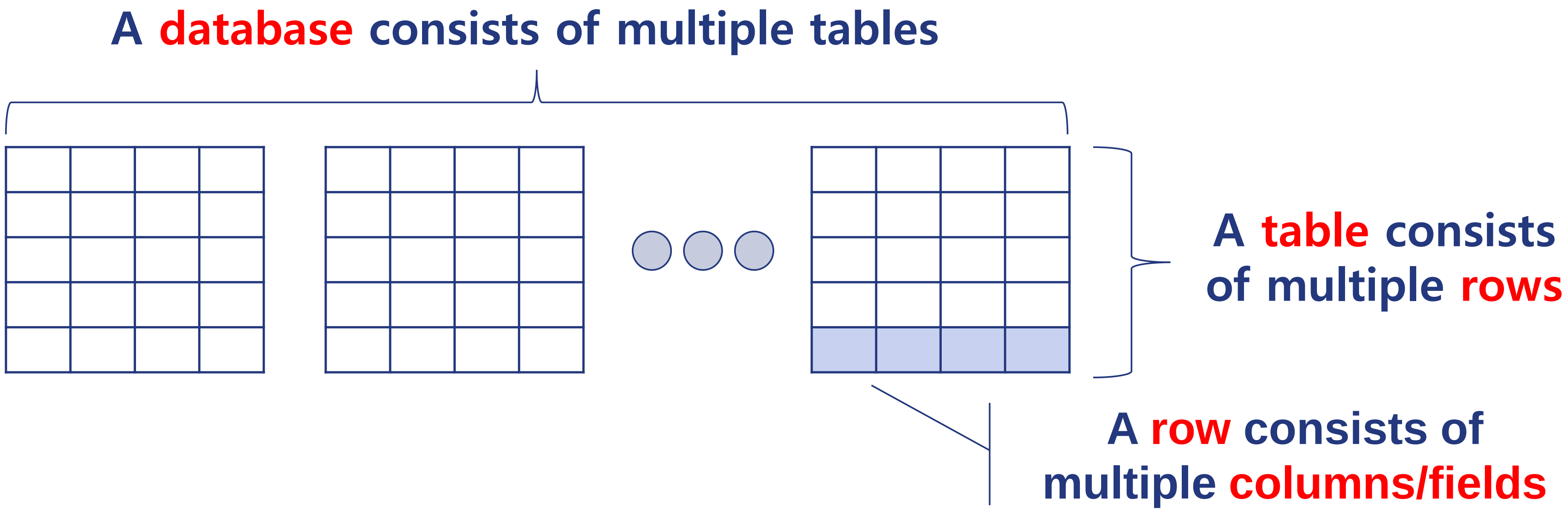
Database & DBMS

SQL

JDBC

Database

- A **database** is an integrated collection of logically related records or files consolidated into a common pool that provides data for one or more multiple uses.


A database consists of multiple tables
A table consists of multiple rows
A row consists of multiple columns/fields

Database: An Example

- Subscription database

(Patients Table)

ACCT	LastName	FirstName	DateOfBirth	HomePhone
96709	Smith	John	3/3/1955	703-456-7645
635667	Bush	George	2/4/1934	202-345-8765
78643859	Washington	Edward	5/2/1945	301-567-3412

(Medications Table)

ACCT	Med_Name	Instructions	No_Pills	Refills
96709	Atenolol 50mg	take i po qd	60	5
96709	Maxzide 25	take i po qd	90	5
78643859	Zithromycin 250mg	take i po qd	6	0
635667	Zestril 40mg	take i po qd	100	5

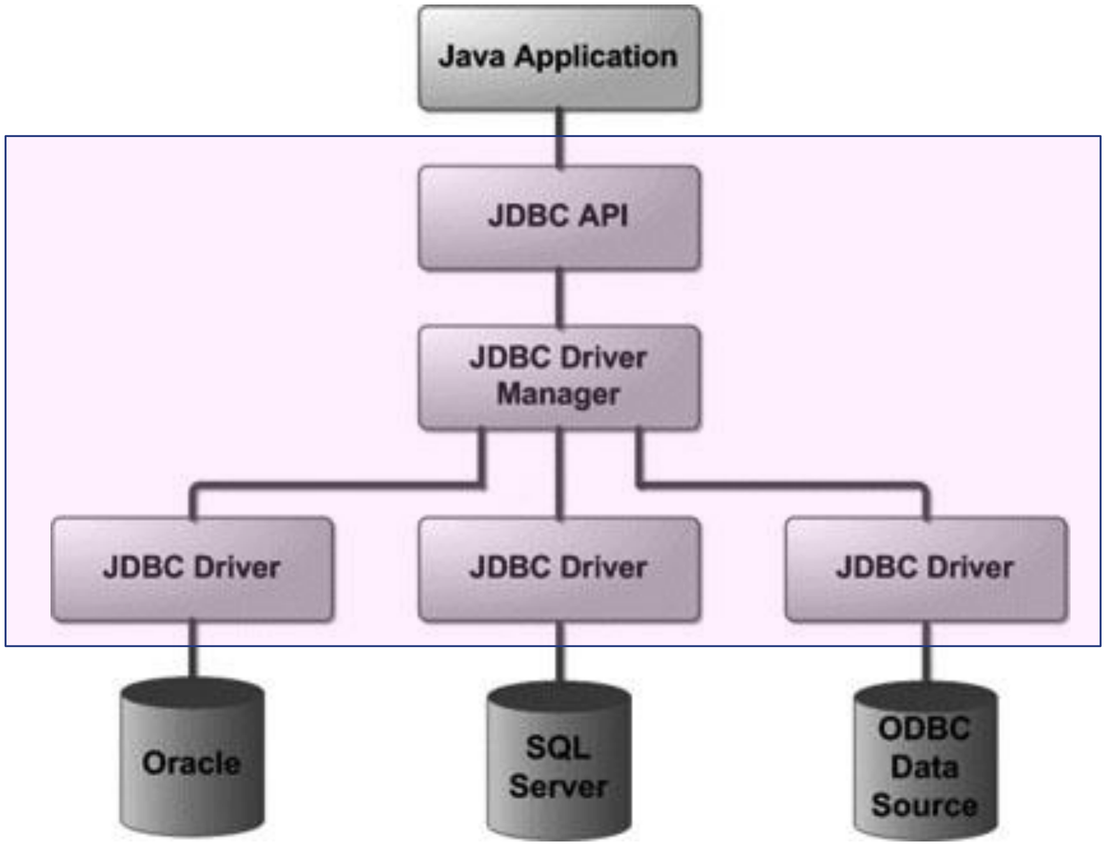
DBMS

- A **Database Management System** (**DBMS**) is a set of software that controls the creation, maintenance, and the use of the database.
- Major DBMS products include Oracle, MS SQL, and MySQL

- DBMS supports
  - Concurrent processing for a huge number of users
  - High performance with a huge number of data
  - Security
  - Load balancing
  - Availability

JDBC

- JDBC stands for **J**ava **D**ata**b**ase **C**onnectivity
- A standard Java API for communication between the Java applications and databases.
- Supports a wide range of DBMSs



A glance at JDBC API

```
Connection conn = DriverManager.getConnection(
  jdbc:mysql://localhost/Subscription", ”root”, ”admin”);

Statement stmt = conn.createStatement();
String sql = "SELECT firstName, lastName FROM Patients";
ResultSet rs = stmt.executeQuery(sql);
while ( rs.next() ) {
  //Retrieve by column name
  String first = rs.getString("firstName"); String last = rs.getString("lastName");
  //Display values
  System.out.print(", First: " + first); System.out.println(", Last: " + last);
}
//STEP 6: Clean-up environment
rs.close();
stmt.close();
conn.close();
```

SQL

JDBC

- JDBC can be used to write different types of executables, such as:
  - Java Applications
  - Java Applets
  - Java Servlets
  - Java ServerPages (JSPs)
  - Enterprise JavaBeans (EJBs)

- In other words, all of these different executables above are able to access a database with JDBC APIs

Preparation for MySQL

- MySQL: https://www.mysql.com/
  - You can download it from MySQL Official Site.
  - https://www.mysql.com/downloads/
- MySQL is an open source database, but not free for commercial application development
- Instead, consider MariaDB
  - https://mariadb.org/
  - **MariaDB** is a community-developed fork of the MySQL
  - intended to remain free under the GNU GPL

SQL (Structured Query Language)

- **A standard language for manipulating database.**

Function	SQL Syntax
Create Database	CREATE DATABASE database_name
Delete Database	DROP DATABASE database_name

Create Table	CREATE TABLE table_name (
	    column_name column_data_type,
	    column_name column_data_type,
	    …
	)

Delete Table	DROP TABLE table_name
Insert Data	INSERT INTO table_name VALUES (column1, column2, …)

Select Data	SELECT column_name, column_name, …
	FROM table_name
	WHERE conditions

Update Data	UPDATE table_name
	SET column_name = value, column_name = value, …
	WHERE conditions

Delete Data	DELETE FROM table_name WHERE conditions

MySQL Client Interface #1: Command Line

```
% C:₩Program Files₩MySQL₩MySQL Server 5.1₩bin₩mysql

mysql> create database emp;
Query OK, 1 row affected (0.00 sec)

mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| emp                |
| mysql              |
| test               |
+--------------------+
4 rows in set (0.00 sec)

mysql> use emp;
Database changed
mysql> CREATE TABLE Employees
    -> (
    ->  id INT NOT NULL,
    ->  age INT NOT NULL,
    ->  first VARCHAR(255),
    ->  last VARCHAR(255), PRIMARY KEY ( id )
    -> );
Query OK, 0 rows affected (0.01 sec)
```

Create Database

- The CREATE DATABASE statement is used for creating a new database
- The following SQL statement creates a Database named EMP:

```
mysql> create database EMP;
Query OK, 1 row affected (0.00 sec)

mysql> show databases;
+---------------------+
| Database            |
+---------------------+
| information_schema|
| emp                 |
| mysql               |
| test                |
+---------------------+
4 rows in set (0.00 sec)
```

Drop Database

- The DROP DATABASE statement is used for deleting an existing database

```
mysql> drop database EMP;
Query OK, 1 row affected (0.00 sec)
```

- 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 following SQL creates a table named Employees with four columns:

```
mysql> use Emp;
Database changed

mysql> CREATE TABLE Employees
(
   id INT NOT NULL,
   age INT NOT NULL,
   first VARCHAR(255),
   last VARCHAR(255), PRIMARY KEY ( id )
);
Query OK, 0 rows affected (0.01 sec)

mysql> show tables;
+---------------+
| Tables_in_emp |
+---------------+
| employees     |
+---------------+
1 row in set (0.00 sec)
```

Drop Table

- The DROP TABLE statement is used for deleting an existing table.
- The following SQL statement deletes a table named Employees:

```
mysql> DROP TABLE Employees;
Query OK, 0 rows affected (0.02 sec)

mysql> show tables;
Empty set (0.00 sec)
```

Insert Data

- INSERT INTO table_name VALUES (column1, column2, ...);
- The following SQL INSERT statement inserts 4 rows in the Employees.

```
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> select * from employees;
+-----+-----+--------+--------+
| id  | age | first  | last   |
+-----+-----+--------+--------+
| 100 |  18 | Zara   | Ali    |
| 101 |  25 | Mahnaz | Fatma  |
| 102 |  30 | Zaid   | Khan   |
| 103 |  28 | Sumit  | Mittal |
+-----+-----+--------+--------+
4 rows in set (0.00 sec)
```

Select Data

- The SELECT statement is used to retrieve data from a database.

```
mysql> SELECT column_name, column_name, …
       FROM table_name
       WHERE conditions;
```

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

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

+-------+------+-----+
| first | last | age |
+-------+------+-----+
| Zara  | Ali  |  18 |
+-------+------+-----+
1 row in set (0.02 sec)
```

Select Data

❖ Not all fields can be retrieved.

```
SQL> SELECT first, last
        FROM Employees
        WHERE id = 100;
+--------+-------+
| first | last |
+--------+-------+
| Zara  | Ali  |
+--------+-------+
1 row in set (0.00 sec)
```

❖ '*' is used to indicate all the fields

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

```
SQL> SELECT *
        FROM Employees
        WHERE id = 100;
```

Select Data

- The WHERE clause can use the comparison operators
  - =, !=, <, >, <=, and >=

```
SELECT first, last
FROM Employees
WHERE id >= 101
```

  - BETWEEN

```
SELECT first, last
FROM Employees
WHERE id BETWEEN 100 AND 102
```

  - LIKE operators.

```
SELECT first, last
FROM Employees
WHERE first LIKE '%a%'
```

Select Data

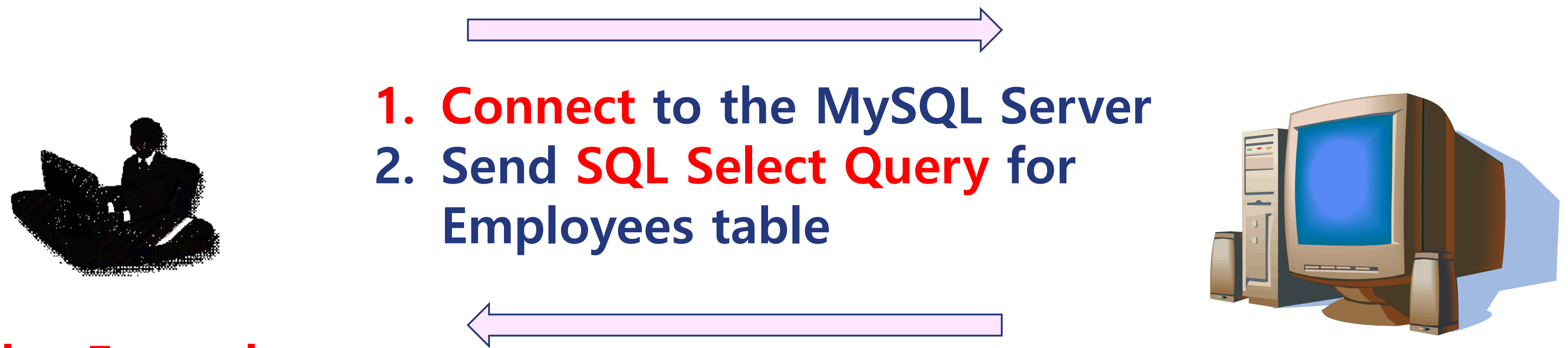
- The WHERE clause can use the logical operators: AND, OR, NOT

```
SELECT first, last
FROM Employees
WHERE id != 100 OR last LIKE '%a%'
```

- The ORDER BY clause can be used to order the result.

```
SELECT first, last
FROM Employees
WHERE first LIKE '%a%'
ORDER BY last
```

Java Code using JDBC



SelectExample

1. **Connect** to the MySQL Server
2. Send **SQL Select Query** for Employees table

3. Return the selected rows of Employees table

MySQL Server

Employees Table

id	first	last	age

```
//STEP 1. Import required packages
import java.sql.*;
public class SelectExample {
  // JDBC driver name and database URL
  static final String JDBC_DRIVER = "com.mysql.jdbc.Driver";
  static final String DB_URL = "jdbc:mysql://localhost/EMP";
  static final String USER = “guest";
  static final String PASS = “guest";

  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 = "SELECT id, first, last, age FROM Employees";
      ResultSet rs = stmt.executeQuery(sql);
```

- URL indicates the database to be accessed
- URL Format depends on DBMS

Driver name depends on DBMS

```
      //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) { se.printStackTrace(); // Handle errors for JDBC
    } catch ( Exception e ) { e.printStackTrace(); // Handle errors for Class.forName
    } 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(); }
    }
    System.out.println("Goodbye!");
  }
}
```

Running SelectExample

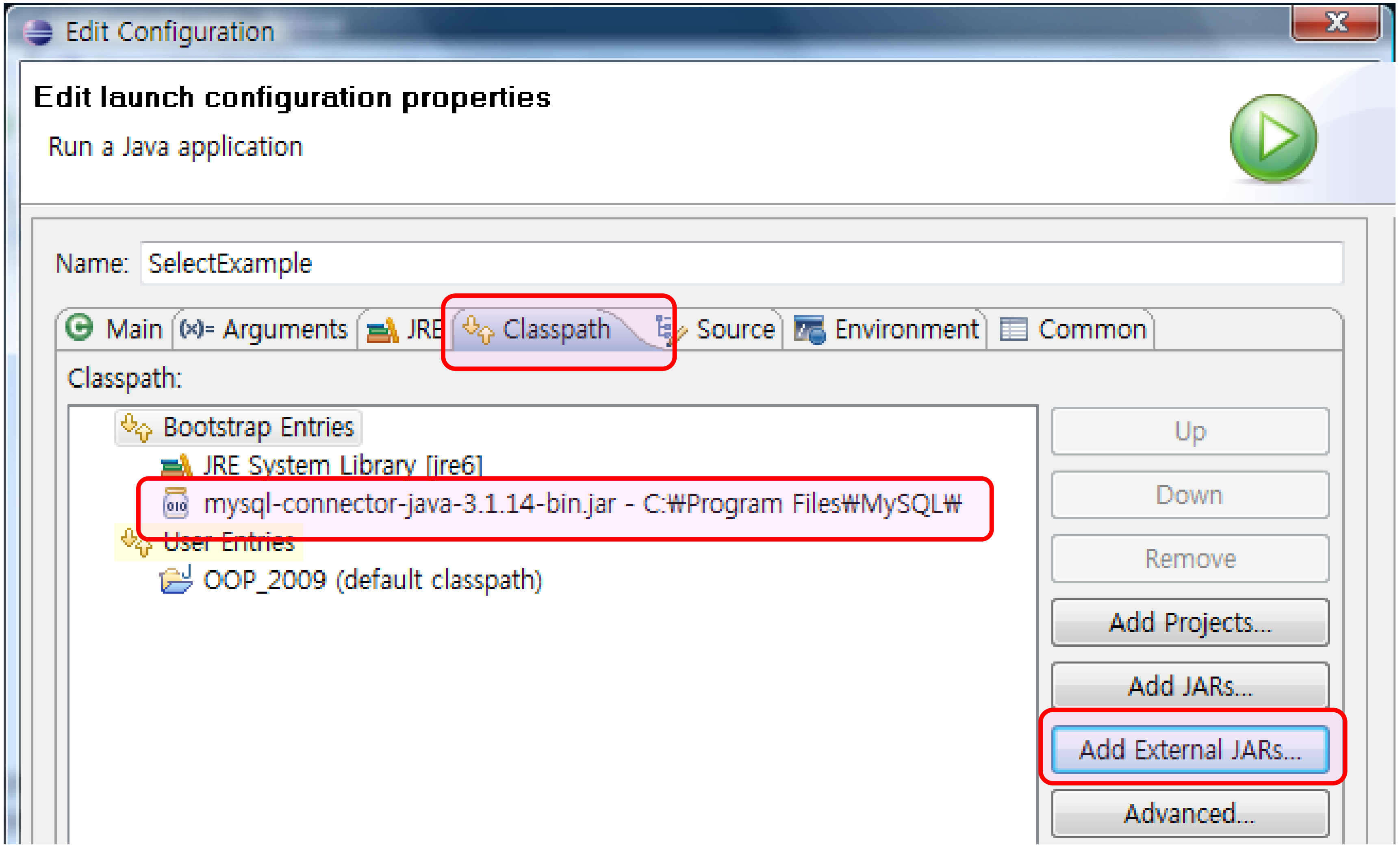
```
% java -cp .;.₩mysql-connector-java-3.1.14-bin.jar SelectExample
```

JDBC Driver Library for MySQL

```
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
Goodbye!
```

https://mariadb.com/downloads/connector

Set the JDBC library in Eclipse


Edit Configuration

Edit launch configuration properties

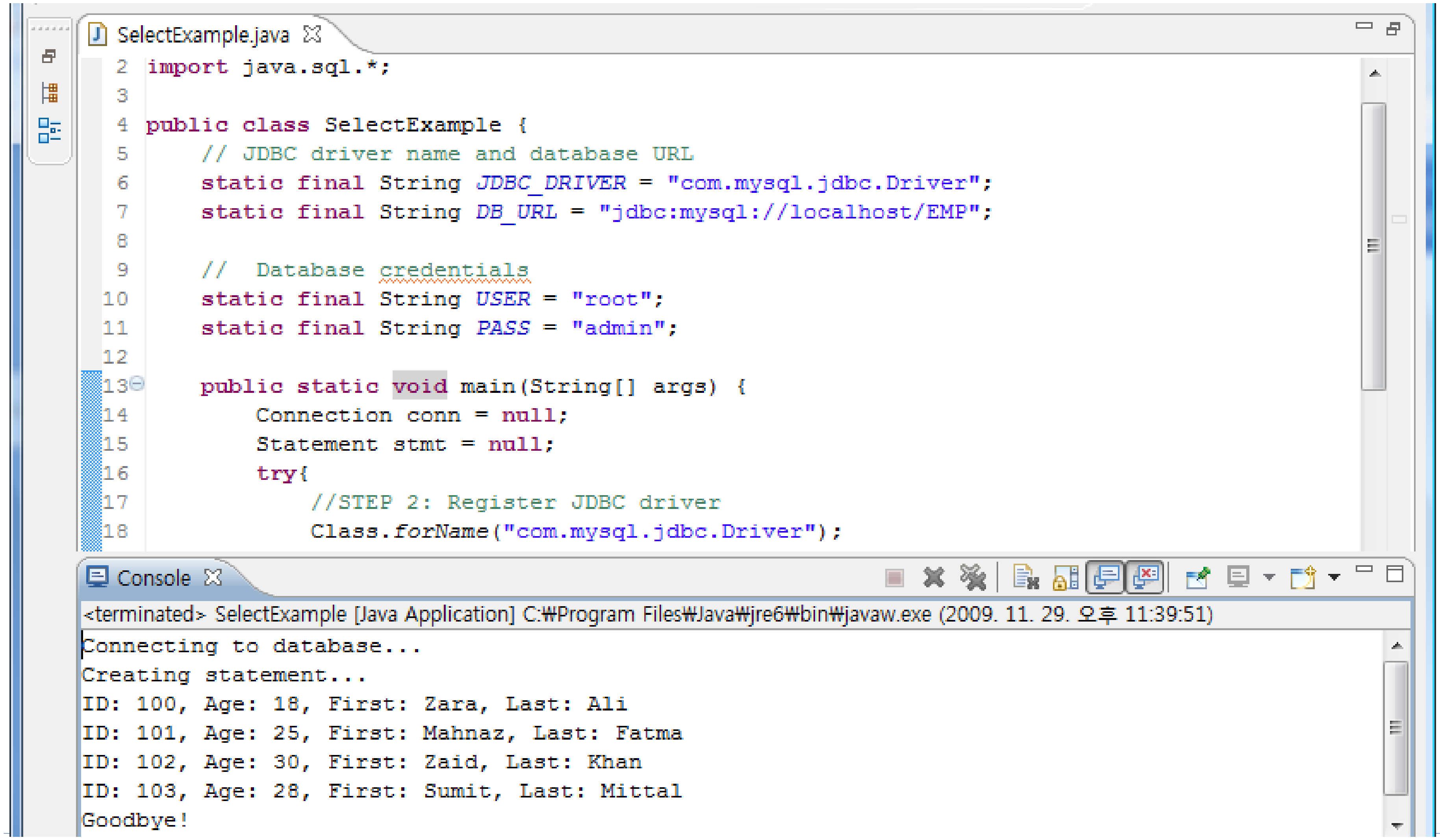
Run a Java application

Name: SelectExample

Classpath:

- Bootstrap Entries
  - JRE System Library [jre6]
  - mysql-connector-java-3.1.14-bin.jar - C:₩Program Files₩MySQL₩
- User Entries
  - OOP_2009 (default classpath)

Running SelectExample in Eclipse



```java
import java.sql.*;

public class SelectExample {
    // 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 = "root";
    static final String PASS = "admin";

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

```
<terminated> SelectExample [Java Application] C:₩Program Files₩Java₩jre6₩bin₩javaw.exe (2009. 11. 29. 오후 11:39:51)
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
Goodbye!
```

Executing SQL

```
Connection conn = null ; Statement stmt = null ;
try {
  conn = DriverManager.getConnection(DB_URL,USER,PASS);
  stmt = conn.createStatement();
  String sql = "SELECT id, first, last, age FROM Employees";
  ResultSet rs = stmt.executeQuery(sql);
}
finally {
  conn.close() ;
}
```

Type	Purpose
executeQuery	SELECT
executeUpdate	INSERT, DELETE, UPDATE, DDL
execute	All the above commands

PreparedStatement

```
Connection conn = null;
PreparedStatement stmt = null;
try{
    Class.forName("com.mysql.jdbc.Driver");

    conn = DriverManager.getConnection(DB_URL,USER,PASS);

    String sql = "Update Employees SET last = ? WHERE id = ?" ;
    stmt = conn.prepareStatement(sql);
    stmt.setString(1, "Super") ;
    stmt.setInt(2, 100) ;

    int rows = stmt.executeUpdate();
    System.out.println("Rows impacted : " + rows );

    stmt.close();
    conn.close();
} catch (...) ...
```

Commit & Rollback

```
try{
  Class.forName("com.mysql.jdbc.Driver");
  conn = DriverManager.getConnection(DB_URL,USER,PASS);

  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 = "INSERT INTO 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();
}
```

Preparing JDBC for DBMS

- Install the **driver library** by one of the following ways.
  1. % java **–cp driver.jar** MyProg
  2. Into **CLASSPATH**
  3. Into **jre/lib/ext**

- Register the **driver class** by one of the following ways.
  1. java **–Djdbc.drivers=***driver_name* MyProg
  2. System.setProperty("jdbc.drivers", "*driver_name*") ;
  3. Class.forName("*driver_name*") ;

JDBC Driver Name for DBMS

- Driver names vary with DBMSs

RDBMS	JDBC driver name	URL format
MySQL	com.mysql.jdbc.Driver	jdbc:mysql://hostname/ database Name
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 N umber/databaseName

SQL Types and Java Types

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

SQL Types and Java Types

SQL	JDBC/Java	setXXX	updateXXX
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

References

- JDBC Tutorial, Tutorials Point, http://www.tutorialspoint.com/jdbc/index.htm
- MySQL Tutorial, Tutorials Point, http://www.tutorialspoint.com/mysql/index.htm