CSC584 Enterprise Programming

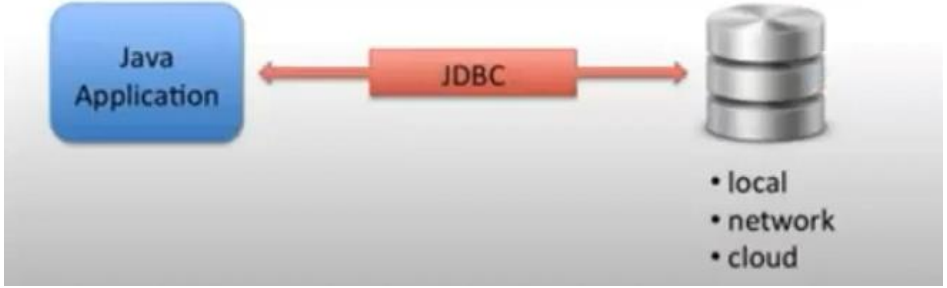
CHAPTER 5 – JAVA DATABASE CONNECTIVITY

Chapter 5 Outline

- Overview of java database programming
- Define JDBC API
- Describe various types of JDBC
- Identify JDBC product
- Describe the 2 tier server client model
- Setup JDBC connection to a database with JSP and Servlet
- Create and Execute SQL statement
- Describe ResultSet Object

What is JDBC?

- Allow Java applications to connect to relational database



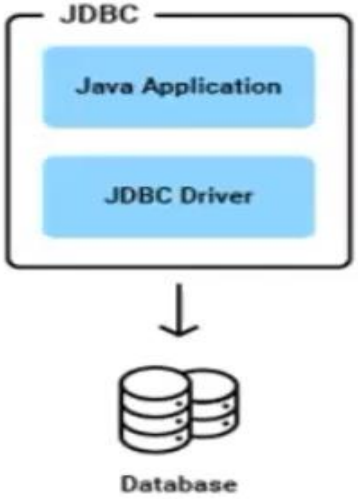
- JDBC supports a large number of databases

What is JDBC?

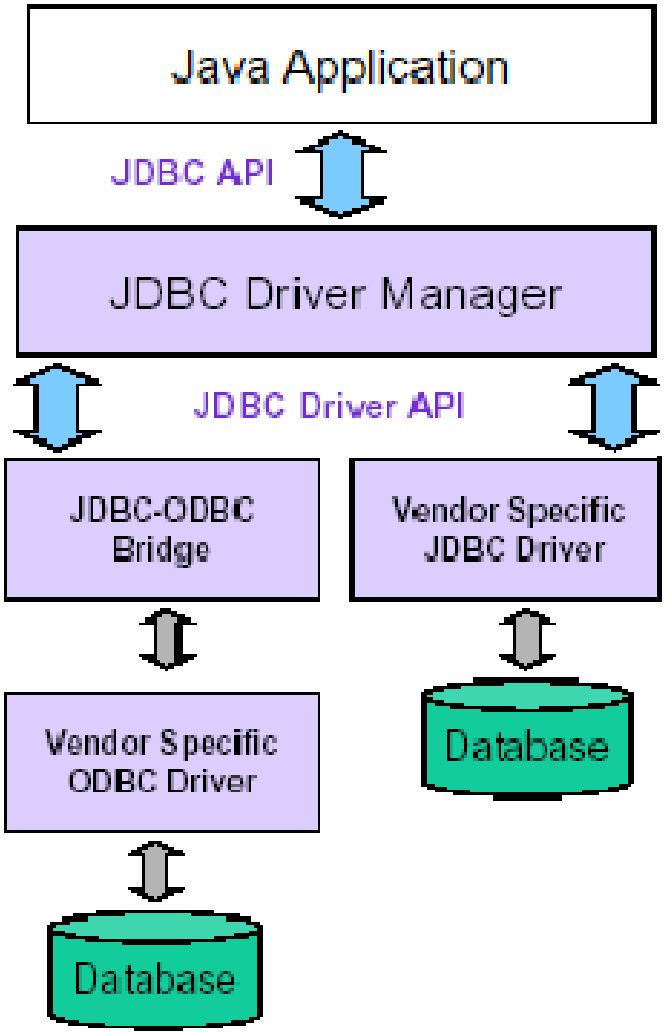
- "An API that lets you access virtually any tabular data source from the Java programming language"
- JDBC Data Access API
- What's an API?
  - See J2SE documentation
- What's a tabular data source?
  - "… access virtually any data source, from relational databases to spreadsheets and flat files."

JDBC API

- Features of JDBC API
  - Provide portable access to various databases
    - No need to develop code for different databases
- Can build your own custom SQL statements
  - Select, Insert, update, delete
  - Complex SQL queries – join, union



General Architecture



SQL

- Structured Query Language, pronounced S-Q-L, or Sequel
- To access or write applications for database systems, you need to use the Structured Query Language (SQL).
- SQL is the universal language for accessing relational database systems.
- Application programs may allow users to access database without directly using SQL, but these applications themselves must use SQL to access the database.

Examples of simple SQL statements

DDL
- Create table
- Drop table
- Describe table

DML
- Select
- Insert
- Delete
- Update

- Creating a basic table involves naming the table and defining its columns and each column's data type.

```
create table Course (
  courseId char(5),
  subjectId char(4) not null,
  courseNumber integer,
  title varchar(50) not null,
  numOfCredits integer,
  primary key (courseId)
);
```

```
create table Student (
  ssn char(9),
  firstName varchar(25),
  mi char(1),
  lastName varchar(25),
  birthDate date,
  street varchar(25),
  phone char(11),
  zipCode char(5),
  deptId char(4),
  primary key (ssn)
);
```

Examples of simple SQL statements

Create table
Drop table
Describe table
Select
Insert
Delete
Update

- remove a table definition.

```
drop table Enrollment;
drop table Course;
drop table Student;
```

Examples of simple SQL statements

Create table
Drop table
Describe table
Select
Insert
Delete
Update

- display the structure of table.

```
describe Course;
```

Examples of simple SQL statements

Create table
Drop table
Describe table
Select
Insert
Delete
Update

- fetch the data from a database table which returns this data in the form of a result table.

```
select firstName, mi, lastName
from Student
where deptId = 'CS';

select firstName, mi, lastName
from Student
where deptId = 'CS' and zipCode = '31411';

select *
from Student
where deptId = 'CS' and zipCode = '31411';
```

Examples of simple SQL statements

Create table
Drop table
Describe table
Select
Insert
Delete
Update

- add new rows of data to a table in the database.

```
insert into Course (courseId, subjectId, courseNumber, title)
values ('11113', 'CSCI', '3720', 'Database Systems', 3);
```

Examples of simple SQL statements

Create table
Drop table
Describe table
Select
Insert
Delete
Update

- delete the existing records from a table.

```
delete Course
where title = 'Database System';
```

Examples of simple SQL statements

Create table
Drop table
Describe table
Select
Insert
Delete
Update

- modify the existing records in a table.

```
update Course
set numOfCredits = 4
where title = 'Database Systems';
```

Basic steps to use a database in Java

1. Establish a **connection**
2. Create JDBC **Statements**
3. Execute **SQL** Statements
4. GET **ResultSet**
5. **Close** connections

Basic steps to use a database in Java

1. Establish a **connection**

import java.sql.*;

Load the vendor specific driver

- Dynamically loads a driver class, for Oracle database

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

Make the connection

- Establishes connection to database by obtaining a *Connection* object

```
Connection con = DriverManager.getConnection( "jdbc:oracle:thin:@oracle-prod:1521:OPROD", username, passwd);
```

Basic steps to use a database in Java

2. Create JDBC **Statements**

- Creates a Statement object for sending SQL statements to the database

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

Basic steps to use a database in Java

3. Execute **SQL** Statements

```
String createLehigh = “create table Lehigh " +
"(SSN Integer not null, Name VARCHAR(32), " + "Marks Integer)";

stmt.executeUpdate(createLehigh);
//What does this statement do?

String insertLehigh = "insert into Lehigh values" +"(123456789,'abc',100)";

stmt.executeUpdate(insertLehigh);
```

Basic steps to use a database in Java

4. GET **ResultSet**

```
String queryLehigh= "select * from Lehigh";

ResultSet rs= Stmt.executeQuery(queryLehigh);
//What does this statement do?

while (rs.next()) {
   int ssn= rs.getInt("SSN");
   String name = rs.getString("NAME");
   int marks = rs.getInt("MARKS");
}
```

Basic steps to use a database in Java

5. **Close** connections

```
stmt.close();
con.close();
```

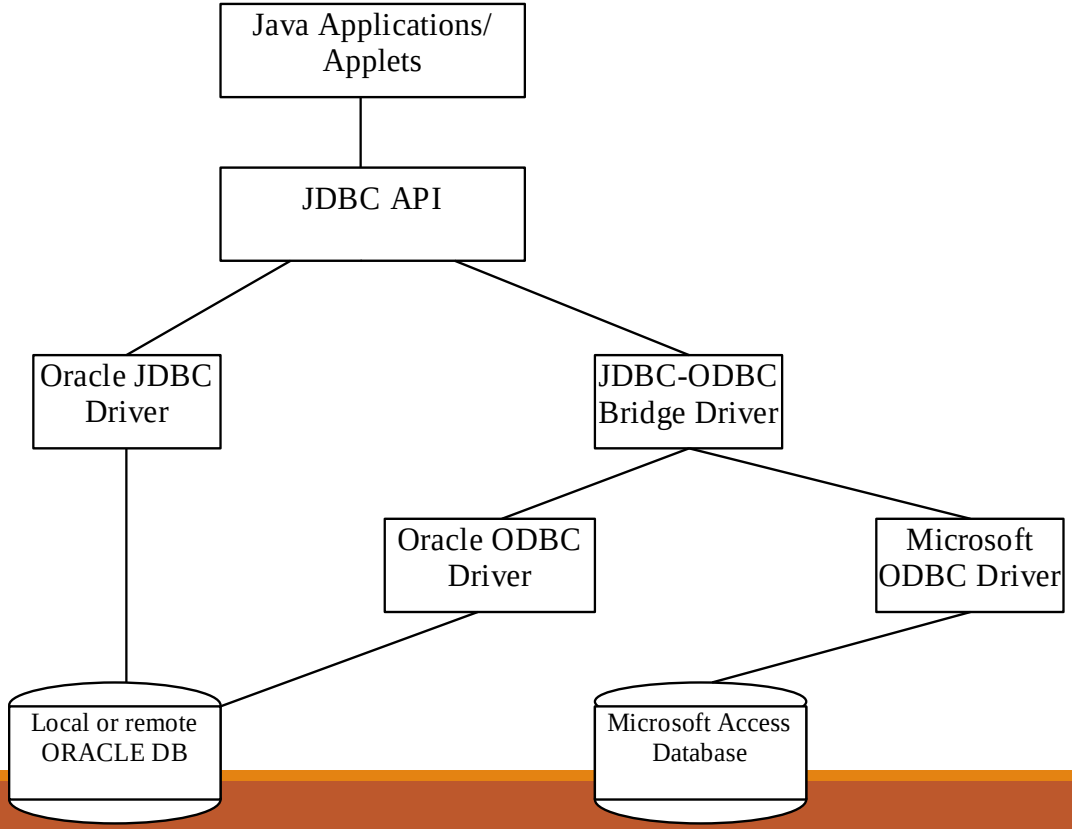
Why Java for Database Programming?

- First, Java is platform independent. You can develop platform-independent database applications using SQL and Java for any relational database systems.
- Second, the support for accessing database systems from Java is built into Java API, so you can create database applications using all Java code with a common interface.
- Third, Java is taught in almost every university either as the first programming language or as the second programming language.

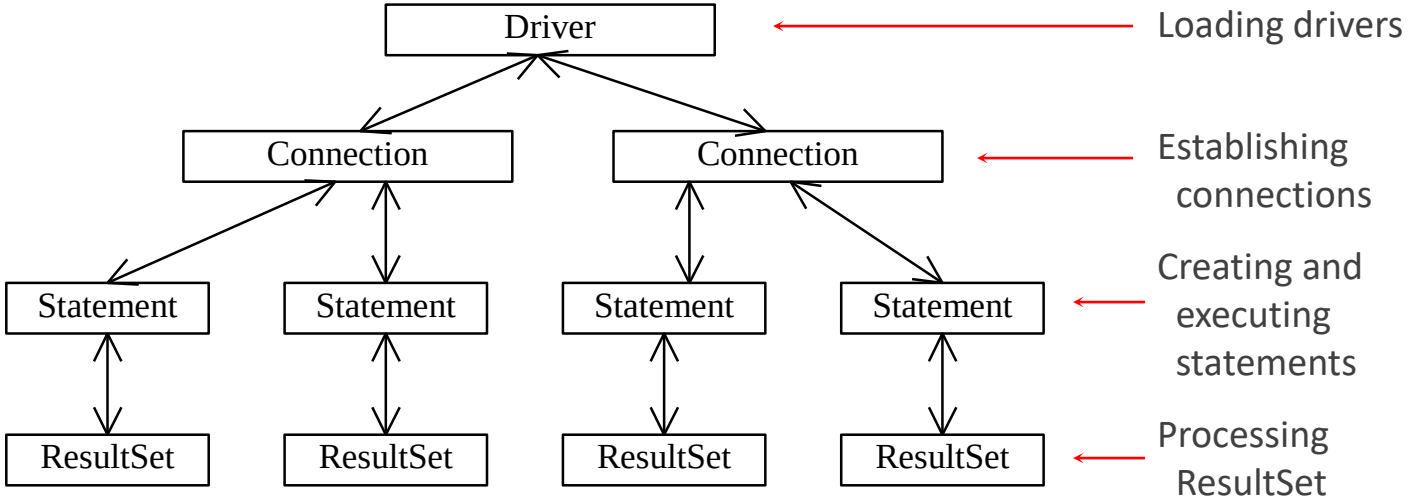
Database Applications Using Java

- GUI
- Client/Server
- Server-Side programming

The Architecture of JDBC



The JDBC Interfaces



Developing JDBC Programs

Loading driver

Establishing connections

Creating and executing statements

Processing ResultSet

Close connection

Statement to load a driver:

```
Class.forName("JDBC Driver Class");
```

A driver is a class. For example:

Database	Driver Class	Source
Access	sun.jdbc.odbc.jdbcOdbcDriver	Already in JDK
MySQL	com.mysql.jdbc.Driver	Website
Oracle	oracle.jdbc.driver.OracleDriver	Website
Java DB	org.apache.derby.jdbc.ClientDriver	Already in JDK

The JDBC-ODBC driver for Access is bundled in JDK.

MySQL driver class is in mysqljdbc.jar

Oracle driver class is in classes12.jar

Example:

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

To use the MySQL and Oracle drivers, you have to add mysqlconnector.jar and ojdbc6.jar in the classpath

Developing JDBC Programs

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Connection conn = DriverManager.getConnection(database URL);

Database	URL Pattern
Access	jdbc:odbc:dataSource
MySQL	jdbc:mysql://hostname/dbname
Oracle	jdbc:oracle:thin:@hostname:port#:oracleDBSID
Java DB	jdbc:derby://hostname:port#/dbname

Examples:

For Access:

```
Connection conn = DriverManager.getConnection("jdbc:odbc:ExampleMDBDataSource");
```

For MySQL:

```
Connection conn = DriverManager.getConnection ("jdbc:mysql://localhost/test");
```

For Oracle:

```
Connection conn =
    DriverManager.getConnection("jdbc:oracle:thin:@localhost:1521:xe",  "hr", "hr");
```

For Java DB:

```
Connection conn = DriverManager.getConnection ("jdbc:derby://localhost:1527/test");
```

Developing JDBC Programs

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Creating statement:

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

Executing statement (for update, delete, insert, DDL):

```
stmt.executeUpdate
   ("create table Temp (col1 char(5), col2 char(5))");
```

Executing statement (for select):

```
// Select the columns from the Student table
ResultSet rs = stmt.executeQuery
  ("select firstName, mi, lastName from Student where lastName "
   + " = 'Smith'");
```

Developing JDBC Programs

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Close connection

Executing statement (for select):

```
// Select the columns from the Student table
ResultSet rs = stmt.executeQuery
  ("select firstName, mi, lastName from Student where lastName "
    + " = 'Smith'");
```

Processing ResultSet (for select):

```
// Iterate through the result and print the student names
while (rs.next())
  System.out.println(rs.getString(1) + " " + rs.getString(2)
    + ". " + rs.getString(3));
```

Developing JDBC Programs

Loading drivers

Establishing connections

Creating and executing statements

Processing ResultSet

Close connection

```
// Close the connection
stmt.close();
conn.close()
```

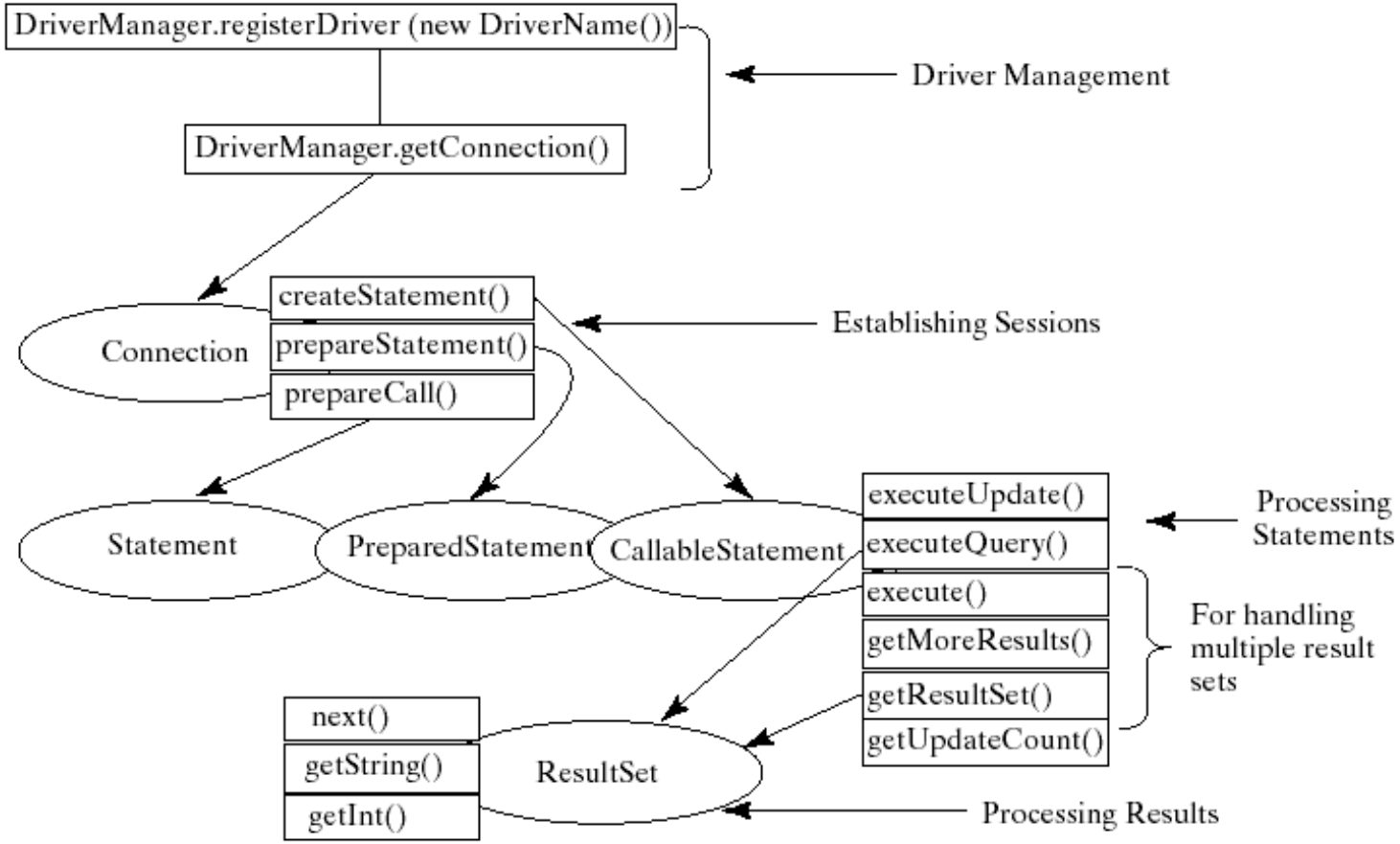
Simple JDBC Example

```
import java.sql.*;
public class SimpleJdbc {
    public static void main(String[] args)
      throws SQLException, ClassNotFoundException {
    // Load the JDBC driver
    Class.forName("com.mysql.jdbc.Driver");
    System.out.println("Driver loaded");

    // Establish a connection
    Connection conn = DriverManager.getConnection
        ("jdbc:mysql://localhost/cs","root","");
    System.out.println("Database connected");

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

    // Execute a statement"select std_id, std_name from Student"
    ResultSet rs = stmt.executeQuery
      ("select std_id, std_name from Student");

    // Iterate through the result and print the student id, names
    while (rs.next()){
        System.out.println(rs.getString(1) + "\t " +
          rs.getString(2));
    }
    // Close the connection
    conn.close();
  }
}
```

Processing Statements

- Once a connection to a particular database is established, it can be used to send SQL statements from your program to the database.
- JDBC provides the Statement, PreparedStatement, and CallableStatement interfaces to facilitate sending statements to a database for execution and receiving execution results from the database.

Processing Statements Diagram



The execute, executeQuery, and executeUpdate Methods

- The methods for executing SQL statements are execute, executeQuery, and executeUpdate, each of which accepts a string containing a SQL statement as an argument.
- This string is passed to the database for execution.
- The execute method should be used if the execution produces multiple result sets, multiple update counts, or a combination of result sets and update counts.
- The executeQuery method should be used if the execution produces a single result set, such as the SQL select statement.
- The executeUpdate method should be used if the statement results in a single update count or no update count, such as a SQL INSERT, DELETE, UPDATE, or DDL statement.

PreparedStatement

- The PreparedStatement interface is designed to execute dynamic SQL statements and SQL-stored procedures with IN parameters. These SQL statements and stored procedures are precompiled for efficient use when repeatedly executed.

```
Statement pstmt = connection.prepareStatement
  ("insert into Student (firstName, mi, lastName) +
    values (?, ?, ?)");
```

Handling Errors with Exceptions

- Programs should recover and leave the database in a consistent state.
- If a statement in the try block throws an exception or warning, it can be caught in one of the corresponding catch statements
- How might a finally {…} block be helpful here?
- E.g. you could rollback your transaction in a catch {…} block or close database connection and free database related resources in finally {…} block

Sample Program

```
import java.sql.*;
class TestJDBC {
   public static void main(String[] args) {
      try {
         // Load the JDBC driver
         Class.forName("com.mysql.jdbc.Driver");//dynamic loading of driver
         System.out.println("Driver loaded");

         // Establish a connection
         Connection conn = DriverManager.getConnection("jdbc:mysql://localhost/cs","root","");
         Statement s = conn.createStatement();
         s.execute("create table TEST12345 ( firstcolumn integer )");
         s.execute("insert into TEST12345 values(1)");
         s.execute("select firstcolumn from TEST12345");

         ResultSet rs = s.getResultSet();
         if (rs != null) // if rs == null, then there is no ResultSet to view
         while ( rs.next() ) // this will step through our data row by row
         {   /* the next line will get the first column in our current row's ResultSet
                as a String (getString(columnNumber)) and output it to the screen */
            System.out.println("Data from column_name: " + rs.getString(1));
         }
         s.close(); // close Statement to let the database know we're done with it
         conn.close(); //close connection
      }
      catch (Exception err) {
         System.out.println("ERROR: " + err);
      }
   }
}
```

Mapping types JDBC -Java

JDBC Type	Java Type
BIT	boolean
TINYINT	byte
SMALLINT	short
INTEGER	int
BIGINT	long
REAL	float
FLOAT DOUBLE	double
BINARY VARBINARY LONGVARBINARY	byte[]
CHAR VARCHAR LONGVARCHAR	String

JDBC Type	Java Type
NUMERIC DECIMAL	BigDecimal
DATE	java.sql.Date
TIME TIMESTAMP	java.sql.Timestamp
CLOB	Clob*
BLOB	Blob*
ARRAY	Array*
DISTINCT	mapping of underlying type
STRUCT	Struct*
REF	Ref*
JAVA_OBJECT	underlying Java class

*SQL3 data type supported in JDBC 2.0

Retrieving Database Metadata

- Database metadata is the information that describes database itself.
- JDBC provides the DatabaseMetaData interface for obtaining database wide information and the ResultSetMetaData interface for obtaining the information on the specific ResultSet.

DatabaseMetadata, cont.

- The DatabaseMetaData interface provides more than 100 methods for getting database metadata concerning the database as a whole.

- These methods can be divided into three groups: for retrieving general information, for finding database capabilities, and for getting object descriptions.

General Information

- The general information includes the URL, username, product name, product version, driver name, driver version, available functions, available data types and so on.

Obtaining Object Descriptions

- The examples of the database objects are tables, views, and procedures.

Examples

```
DatabaseMetaData dbMetaData = conn.getMetaData();

System.out.println("database URL: " +
   dbMetaData.getURL());
System.out.println("database username: " +
  dbMetaData.getUserName());
System.out.println("database product name: " +
  dbMetaData.getDatabaseProductName());
System.out.println("database product version: " +
  dbMetaData.getDatabaseProductVersion());
System.out.println("JDBC driver name: " +
  dbMetaData.getDriverName());
System.out.println("JDBC driver version: " +
  dbMetaData.getDriverVersion());
System.out.println("JDBC driver major version: " +
  new Integer(dbMetaData.getDriverMajorVersion()));
System.out.println("JDBC driver minor version: " +
  new Integer(dbMetaData.getDriverMinorVersion()));
System.out.println("Max number of connections: " +
  new Integer(dbMetaData.getMaxConnections()));
System.out.println("MaxTableNameLentgh: " +
  new Integer(dbMetaData.getMaxTableNameLength()));
System.out.println("MaxColumnsInTable: " +
  new Integer(dbMetaData.getMaxColumnsInTable()));
conn.close();
```

Sample Run

```
database URL: jdbc:mysql://localhost/cs
database username: root@localhost
database product name: MySQL
database product version: 5.7.33
JDBC driver name: MySQL-AB JDBC Driver
JDBC driver version: mysql-connector-java-5.1.23 ( Revision: ${bzr.revision-id} )
JDBC driver major version: 5
JDBC driver minor version: 1
Max number of connections: 0
MaxTableNameLentgh: 64
MaxColumnsInTable: 512
```

JDBC references

JDBC Data Access API –JDBC Technology Homepage

- http://java.sun.com/products/jdbc/index.html

JDBC Database Access –The Java Tutorial

- http://java.sun.com/docs/books/tutorial/jdbc/index.html

JDBC Documentation

- http://java.sun.com/j2se/1.4.2/docs/guide/jdbc/index.html

java.sql package

- http://java.sun.com/j2se/1.4.2/docs/api/java/sql/package-summary.html

JDBC Technology Guide: Getting Started

- http://java.sun.com/j2se/1.4.2/docs/guide/jdbc/getstart/GettingStarted TOC.fm.html

JDBC Tutorial

https://www.javatpoint.com/java-jdbc