Chapter 32 Java Database Programming
Objectives

- To understand the concept of database and database management systems (§32.2).
- To understand the relational data model: relational data structures, constraints, and languages (§32.2).
- To use SQL to create and drop tables, and to retrieve and modify data (§32.3).
- To learn how to load a driver, connect to a database, execute statements, and process result sets using JDBC (§32.4).
- To use prepared statements to execute precompiled SQL statements (§32.5).
- To use callable statements to execute stored SQL procedures and functions (§32.6).
- To explore database metadata using the DatabaseMetaData and ResultSetMetaData interfaces (§32.7).
What is a Database System?

- Application Users
- Application Programs
- Database Management System (DBMS)
- Database
- System Users
Database Application Systems

Application Users

Application Programs

Database Management System

Database Management System

...
Rational Database and Relational Data Model

Most of today’s database systems are relational database systems, based on the relational data model. A relational data model has three key components: structure, integrity and languages.

- *Structure* defines the representation of the data.
- *Integrity* imposes constraints on the data.
- *Language* provides the means for accessing and manipulating data.
Relational Structure

A relational database consists of a set of relations. A relation has two things in one: a schema and an instance of the schema. The schema defines the relation and an instance is the content of the relation at a given time. An instance of a relation is nothing more than a table with rows and named columns. For convenience with no confusion, we refer instances of relations as just relations or tables.
# Course Table

<table>
<thead>
<tr>
<th>courseId</th>
<th>subjectId</th>
<th>courseNumber</th>
<th>title</th>
<th>numOfCredits</th>
</tr>
</thead>
<tbody>
<tr>
<td>11111</td>
<td>CSCI</td>
<td>1301</td>
<td>Introduction to Java I</td>
<td>4</td>
</tr>
<tr>
<td>11112</td>
<td>CSCI</td>
<td>1302</td>
<td>Introduction to Java II</td>
<td>3</td>
</tr>
<tr>
<td>11113</td>
<td>CSCI</td>
<td>3720</td>
<td>Database Systems</td>
<td>3</td>
</tr>
<tr>
<td>11114</td>
<td>CSCI</td>
<td>4750</td>
<td>Rapid Java Application</td>
<td>3</td>
</tr>
<tr>
<td>11115</td>
<td>MATH</td>
<td>2750</td>
<td>Calculus I</td>
<td>5</td>
</tr>
<tr>
<td>11116</td>
<td>MATH</td>
<td>3750</td>
<td>Calculus II</td>
<td>5</td>
</tr>
<tr>
<td>11117</td>
<td>EDUC</td>
<td>1111</td>
<td>Reading</td>
<td>3</td>
</tr>
<tr>
<td>11118</td>
<td>ITEC</td>
<td>1344</td>
<td>Database Administration</td>
<td>3</td>
</tr>
</tbody>
</table>
### Student Table

<table>
<thead>
<tr>
<th>ssn</th>
<th>firstName</th>
<th>mi</th>
<th>lastName</th>
<th>phone</th>
<th>birthDate</th>
<th>street</th>
<th>deptID</th>
</tr>
</thead>
<tbody>
<tr>
<td>444111110</td>
<td>Jacob</td>
<td>R</td>
<td>Smith</td>
<td>9129219434</td>
<td>1985-04-09</td>
<td>Kingston Street</td>
<td>BIOL</td>
</tr>
<tr>
<td>444111111</td>
<td>John</td>
<td>K</td>
<td>Stevenson</td>
<td>9129219434</td>
<td>null</td>
<td>100 Main Street</td>
<td>BIOL</td>
</tr>
<tr>
<td>444111112</td>
<td>George</td>
<td>K</td>
<td>Smith</td>
<td>9129213454</td>
<td>1974-10-10</td>
<td>1200 Abercorn St.</td>
<td>CS</td>
</tr>
<tr>
<td>444111113</td>
<td>Frank</td>
<td>E</td>
<td>Jones</td>
<td>9125919434</td>
<td>1970-09-09</td>
<td>100 Main Street</td>
<td>BIOL</td>
</tr>
<tr>
<td>444111114</td>
<td>Jean</td>
<td>K</td>
<td>Smith</td>
<td>9129219434</td>
<td>1970-02-09</td>
<td>100 Main Street</td>
<td>CHEM</td>
</tr>
<tr>
<td>444111115</td>
<td>Josh</td>
<td>R</td>
<td>Woo</td>
<td>7075989434</td>
<td>1970-02-09</td>
<td>555 Franklin St.</td>
<td>CHEM</td>
</tr>
<tr>
<td>444111116</td>
<td>Josh</td>
<td>R</td>
<td>Smith</td>
<td>9129219434</td>
<td>1973-02-09</td>
<td>100 Main Street</td>
<td>BIOL</td>
</tr>
<tr>
<td>444111117</td>
<td>Joy</td>
<td>P</td>
<td>Kennedy</td>
<td>9129229434</td>
<td>1974-03-19</td>
<td>103 Bay Street</td>
<td>CS</td>
</tr>
<tr>
<td>444111118</td>
<td>Toni</td>
<td>R</td>
<td>Peterson</td>
<td>9129229434</td>
<td>1964-04-29</td>
<td>103 Bay Street</td>
<td>MATH</td>
</tr>
<tr>
<td>444111119</td>
<td>Patrick</td>
<td>R</td>
<td>Stoneman</td>
<td>9129229434</td>
<td>1969-04-29</td>
<td>101 Washington St.</td>
<td>MATH</td>
</tr>
<tr>
<td>444111120</td>
<td>Rick</td>
<td>R</td>
<td>Carter</td>
<td>9125919434</td>
<td>1986-04-09</td>
<td>19 West Ford St.</td>
<td>BIOL</td>
</tr>
<tr>
<td>ssn</td>
<td>courseId</td>
<td>dateRegistered</td>
<td>grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
<td>---------------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111110</td>
<td>11111</td>
<td>2004-03-19</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111110</td>
<td>11112</td>
<td>2004-03-19</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111110</td>
<td>11113</td>
<td>2004-03-19</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111111</td>
<td>11111</td>
<td>2004-03-19</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111111</td>
<td>11112</td>
<td>2004-03-19</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111111</td>
<td>11113</td>
<td>2004-03-19</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111112</td>
<td>11114</td>
<td>2004-03-19</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111112</td>
<td>11115</td>
<td>2004-03-19</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111112</td>
<td>11116</td>
<td>2004-03-19</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111113</td>
<td>11111</td>
<td>2004-03-19</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111113</td>
<td>11113</td>
<td>2004-03-19</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111114</td>
<td>11115</td>
<td>2004-03-19</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111115</td>
<td>11115</td>
<td>2004-03-19</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111115</td>
<td>11116</td>
<td>2004-03-19</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111116</td>
<td>11111</td>
<td>2004-03-19</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111117</td>
<td>11111</td>
<td>2004-03-19</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111118</td>
<td>11111</td>
<td>2004-03-19</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111118</td>
<td>11112</td>
<td>2004-03-19</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>444111118</td>
<td>11113</td>
<td>2004-03-19</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table vs. File

NOTE:

A table or a relation is not same as a file. Most of the relational database systems store multiple tables in a file.
Integrity Constraints

An integrity constraint imposes a condition that all legal instances of the relations must satisfy. In general, there are three types of constraints: domain constraint, primary key constraint, and foreign key constraint. Domain constraints and primary key constraints are known as intra-relational constraints, meaning that a constraint involves only one relation. The foreign key constraint is known as inter-relational, meaning that a constraint involves more than one relation.
Domain Constraints

Enrollment Table

<table>
<thead>
<tr>
<th>ssn</th>
<th>courseId</th>
<th>dateRegistered</th>
<th>grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>444111110</td>
<td>11111</td>
<td>2004-03-19</td>
<td>A</td>
</tr>
<tr>
<td>444111110</td>
<td>11112</td>
<td>2004-03-19</td>
<td>B</td>
</tr>
<tr>
<td>444111110</td>
<td>11113</td>
<td>2004-03-19</td>
<td>C</td>
</tr>
</tbody>
</table>

Each value in courseId in the Enrollment table must match a value in courseId in the Course table.

Course Table

<table>
<thead>
<tr>
<th>courseId</th>
<th>subjectId</th>
<th>courseNumber</th>
<th>title</th>
<th>numOfCredits</th>
</tr>
</thead>
<tbody>
<tr>
<td>11111</td>
<td>CSCI</td>
<td>1301</td>
<td>Introduction to Java I</td>
<td>4</td>
</tr>
<tr>
<td>11112</td>
<td>CSCI</td>
<td>1302</td>
<td>Introduction to Java II</td>
<td>3</td>
</tr>
<tr>
<td>11113</td>
<td>CSCI</td>
<td>3720</td>
<td>Database Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

Each row must have a value for courseId, and the value must be unique.

Each value in the numOfCredits column must be greater than 0 and less than 5.
### Primary Key Constraints

<table>
<thead>
<tr>
<th>Enrollment Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>ssn</td>
</tr>
<tr>
<td>444111110</td>
</tr>
<tr>
<td>444111110</td>
</tr>
<tr>
<td>444111110</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

Each value in courseId in the Enrollment table must match a value in courseId in the Course table.

### Course Table

<table>
<thead>
<tr>
<th>courseId</th>
<th>subjectId</th>
<th>courseNumber</th>
<th>title</th>
<th>numOfCredits</th>
</tr>
</thead>
<tbody>
<tr>
<td>11111</td>
<td>CSCI</td>
<td>1301</td>
<td>Introduction to Java I</td>
<td>4</td>
</tr>
<tr>
<td>11112</td>
<td>CSCI</td>
<td>1302</td>
<td>Introduction to Java II</td>
<td>3</td>
</tr>
<tr>
<td>11113</td>
<td>CSCI</td>
<td>3720</td>
<td>Database Systems</td>
<td>3</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each row must have a value for courseId, and the value must be unique.

Each value in the numOfCredits column must be greater than 0 and less than 5.

*Primary key constraint*
Foreign Key Constraints

Each value in courseId in the Enrollment table must match a value in courseId in the Course table.

Each value in the numOfCredits column must be greater than 0 and less than 5.

Each row must have a value for courseId, and the value must be unique.

**Foreign key constraint**
Domain Constraints

Domain constraints specify the permissible values for an attribute. Domains can be specified using standard data types such as integers, floating-point numbers, fixed-length strings, and variant-length strings. The standard data type specifies a broad range of values. Additional constraints can be specified to narrow the ranges. You can also specify whether an attribute can be null.
Domain Constraints Example

```sql
create table Course (  
courseId char(5),  
subjectId char(4) not null,  
courseNumber integer,  
title varchar(50) not null,  
numOfCredits integer,  
constraint greaterThanOne  
check (numOfCredits >= 1));
```
## Superkey

<table>
<thead>
<tr>
<th>Superkey</th>
<th><strong>A superkey is an attribute or a set of attributes that uniquely identify the relation. That is, no two tuples have the same values on the superkey.</strong> By definition, a relation consists of a set of distinct tuples. The set of all attributes in the relation forms a superkey.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key</td>
<td><strong>Key</strong></td>
</tr>
<tr>
<td>Candidate key</td>
<td><strong>Candidate key</strong></td>
</tr>
<tr>
<td>Primary key</td>
<td><strong>Primary key</strong></td>
</tr>
</tbody>
</table>
Key and Candidate Key

A key $K$ is a minimal superkey, meaning that any proper subset of $K$ is not a superkey. It is possible that a relation has several keys. In this case, each of the keys is called a candidate key.
Primary Key

The primary key is one of the candidate keys designated by the database designer. The primary key is often used to identify tuples in a relation.

```sql
create table Course(
    subjectCode char(4),
    courseNumber int,
    title varchar(50),
    numOfCredits int
    constraint greaterThanOne check (numOfCredits >= 1),
    primary key (subjectCode, courseNumber));
```
Primary Key

The primary key is one of the candidate keys designated by the database designer. The primary key is often used to identify tuples in a relation.

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

Primary Key Constraints

The *primary key constraint* specifies that the primary key value of a tuple cannot be null and no two tuples in the relation can have the same value on the primary key. The DBMS enforces the primary key constraint. For example, if you attempt to insert a record with the same primary key as an existing record in the table, the DBMS would report an error and reject the operation.
Foreign Key Constraints

In a relational database, data are related. Tuples in a relation are related and tuples in different relations are related through their common attributes. Informally speaking, the common attributes are foreign keys. The foreign key constraints define the relationships among relations.
Foreign Key Constraints Formal Definition

Formally, a set of attributes $FK$ is a foreign key in a relation $R$ that references relation $T$ if it satisfies the following two rules:

- The attributes in $FK$ have the same domain as the primary key in $T$.
- A non-null value on $FK$ in $R$ must match a primary key value in $T$. 

$R \rightarrow FK \rightarrow T$
Foreign Key Example

create table Enrollment (  
  ssn char(9),  
  courseId char(5),  
  dateRegistered date,  
  grade char(1),  
  primary key (ssn, courseId),  
  foreign key (ssn) references Student,  
  foreign key (courseId) references Course  
);
Foreign Key Discussion

A foreign key is not necessarily the primary key or part of the primary in the relation. For example, subjectCode is a foreign key in the Course table that references the Subject table, but it is not the primary key in Course. departmentCode is a foreign key in the Subject table that references Department, but it is not the primary key in Subject.
Foreign Key Discussion, cont.

The referencing relation and the referenced relation may be the same table. For example, `supervisorId` is a foreign key in `Faculty` that references `facultyId` in `Faculty`.
Foreign Key Discussion, cont.

The foreign key is not necessary to have the same name as its referenced primary key as long as they have the same domain. For example, headId is a foreign key in Department that references facultyId in Faculty.
Foreign Key Discussion, cont.

A relation may have more than one foreign key. For example, `headId` and `collegeCode` are both foreign keys in `Department`. 
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

<table>
<thead>
<tr>
<th>Command</th>
<th>SQL Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create table</td>
<td><code>create table Course (courseId char(5), subjectId char(4) not null, courseNumber integer, title varchar(50) not null, numOfCredits integer, primary key (courseId));</code></td>
</tr>
<tr>
<td>Drop table</td>
<td></td>
</tr>
<tr>
<td>Describe table</td>
<td></td>
</tr>
<tr>
<td>Select</td>
<td></td>
</tr>
<tr>
<td>Insert</td>
<td></td>
</tr>
<tr>
<td>Delete</td>
<td></td>
</tr>
<tr>
<td>Update</td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>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));</code></td>
</tr>
</tbody>
</table>
Examples of simple SQL statements

Create table
Drop table
Describe table
Select
Insert
Delete
Update
drop table Enrollment;
drop table Course;
drop table Student;
Examples of simple SQL statements

- Create table
- Drop table
- Describe table
- Select
- Insert
- Delete
- Update

```sql
describe Course;  -- Oracle
```
Examples of simple SQL statements

Create table

Drop table

Describe table

Select

Insert

Delete

Update

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

```sql
insert into Course (courseId, subjectId, courseNumber, title)
values ('11113', 'CSCI', '3720', 'Database Systems', 3);
```
**Examples of simple SQL statements**

<table>
<thead>
<tr>
<th>SQL Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>update Course</td>
</tr>
<tr>
<td>set numOfCredits = 4</td>
</tr>
<tr>
<td>where title = 'Database Systems';</td>
</tr>
</tbody>
</table>

Create table
Drop table
Describe table
Select
Insert
Update
Delete
Examples of simple SQL statements

- `Create table`
- `Drop table`
- `Describe table`
- `Select`
- `Insert`
- `Update`
- `Delete`

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

- Java Programs
- JDBC API
  - MySQL JDBC Driver
    - Local or remote MySQL DB
  - Oracle JDBC Driver
    - Local or remote ORACLE DB
  - JDBC-ODBC Bridge Driver
    - Microsoft ODBC Driver
      - Microsoft Access Database
The JDBC Interfaces

- Loading drivers
- Establishing connections
- Creating and executing statements
- Processing ResultSet
Developing JDBC Programs

Statement to load a driver:
Class.forName("JDBCDriverClass");

A driver is a class. For example:

<table>
<thead>
<tr>
<th>Database</th>
<th>Driver Class</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>sun.jdbc.odbc.JdbcOdbcDriver</td>
<td>Already in JDK</td>
</tr>
<tr>
<td>MySQL</td>
<td>com.mysql.jdbc.Driver</td>
<td>Website</td>
</tr>
<tr>
<td>Oracle</td>
<td>oracle.jdbc.driver.OracleDriver</td>
<td>Website</td>
</tr>
</tbody>
</table>

The JDBC-ODBC driver for Access is bundled in JDK.
MySQL driver class is in mysqljdbc.jar
Oracle driver class is in classes12.jar

To use the MySQL and Oracle drivers, you have to add mysqljdbc.jar and classes12.jar in the classpath using the following DOS command on Windows:
classpath=%classpath%;c:\book\mysqljdbc.jar;c:\book\classes12.jar
Developing JDBC Programs

**Loading drivers**

**Establishing connections**

**Creating and executing statements**

**Processing ResultSet**

Connection connection = DriverManager.getConnection(databaseURL);

<table>
<thead>
<tr>
<th>Database</th>
<th>URL Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>jdbc:odbc:dataSource</td>
</tr>
<tr>
<td>MySQL</td>
<td>jdbc:mysql://hostname/dbname</td>
</tr>
<tr>
<td>Oracle</td>
<td>jdbc:oracle:thin:@hostname:port#:oracleDBSID</td>
</tr>
</tbody>
</table>

Examples:

For Access:

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

For MySQL:

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

For Oracle:

Connection connection = DriverManager.getConnection("jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl", "scott", "tiger");

See Supplement IV.D for creating an ODBC data source
Developing JDBC Programs

Creating statement:

Statement statement = connection.createStatement();

Executing statement (for update, delete, insert):

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

Executing statement (for select):

// Select the columns from the Student table
ResultSet resultSet = statement.executeQuery("select firstName, mi, lastName from Student where lastName "
+ " = 'Smith'");
Developing JDBC Programs

Executing statement (for select):
   // Select the columns from the Student table
   ResultSet resultSet = 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 (resultSet.next())
      System.out.println(resultSet.getString(1) + " " + resultSet.getString(2) + ". " + resultSet.getString(3));
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 connection = DriverManager.getConnection
            ("jdbc:mysql://localhost/test");
        System.out.println("Database connected");

        // Create a statement
        Statement statement = connection.createStatement();

        // Execute a statement
        ResultSet resultSet = statement.executeQuery
            ("select firstName, mi, lastName from Student where lastName "
            + " = 'Smith'");

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

        // Close the connection
        connection.close();
    }
}
Creating ODBC Data Source

Please follow the steps in Supplement on the Companion Website to create an ODBC data source on Windows.
Example:
Accessing Database from JavaFX

This example demonstrates connecting to a database from a Java applet. The applet lets the user enter the SSN and the course ID to find a student’s grade.

NOTE: To run this program from here, you need:
1. To have a MySQL database setup just like the one in the text.
2. Set MySQL JDBC driver in the classpath.
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 execute, executeQuery, and executeUpdate Methods, cont.

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 (?, ?, ?)");
Example:
Using PreparedStatement to Execute Dynamic SQL Statements

This example rewrites the preceding example using PreparedStatement.
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.
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 Database Capabilities

The examples of the database capabilities are whether the database supports the GROUP BY operator, the ALTER TABLE command with add column option, supports entry-level or full ANSI92 SQL grammar.
Obtaining Object Descriptions

the examples of the database objects are tables, views, and procedures.
DatabaseMetaData dbMetaData = connection.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("MaxTableNameLength: " +
    new Integer(dbMetaData.getMaxTableNameLength()));
System.out.println("MaxColumnsInTable: " +
    new Integer(dbMetaData.getMaxColumnsInTable()));
Sample Run

database URL: jdbc:mysql://localhost/test
database username: nobody@localhost
database product name: MySQL
database product version: 4.0.14-max-debug
JDBC driver name: MySQL-AB JDBC Driver
JDBC driver version: mysql-connector-java-3.0.9-stable
Major: 12 $, $Revision: 1.27.2.25 $ )
JDBC driver major version: 3
JDBC driver minor version: 0
Max number of connections: 0
MaxTableNameLength: 64
MaxColumnsInTable: 512