Accessing a Database in Java

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Data Storage

- Memory (Small (1 - 16 GB), Non-persistent)
- Text Files (inefficient, difficult to organize)
- Databases
  - Manages possibly huge quantities of data
  - Facilitates fast and easy access
  - Makes data integrity guarantees
  - Implementations (MySQL, Microsoft SQL Server, , Oracle,)

Database Organization

- A single database has multiple tables
- A table has multiple rows
- Each row has multiple columns
- Each column represents a different data category

Table of actors:

id	name	date of birth	gender
0	Tom Cruise	07/03/1962	M
1	Katie Holmes	12/18/1978	F
2	Chris Farley	02/15/1964	M
3	Tina Fey	05/18/1970	F

Database Operations (CRUD)

- **C**reate data in a table
- **R**ead data from a table
- **U**pdate data in a table
- **D**elete data in a table
- **Structured Query Language** (SQL) : language used to interface with a database, allows a user to perform CRUD operations on a particular database

Tables

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

```
create table Enrollment (
 ssn char(9),
 courseId char(5),
 dateRegistered date,
 grade char(1),
 primary key (ssn, courseId),
 foreign key (ssn) references Students (ssn),
 foreign key (courseId) references Courses
(courseId)
 );
```

```
create table Students (
  ssn char(9),
  firstName varchar(25),
  lastName varchar(25),
  birthDate date,
  phone char(11),
  primary key (ssn)
);
```

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

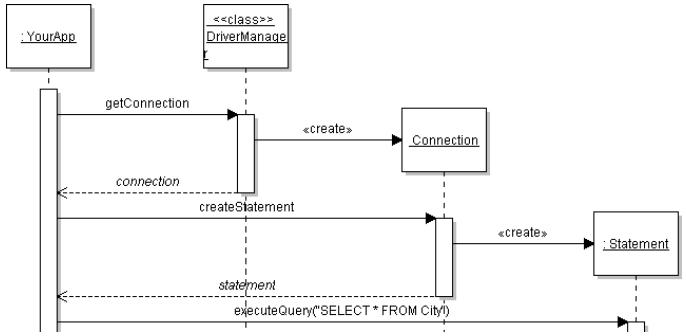
```
select * from Enrollment;
```

```
UPDATE Courses   SET  title = 'DB'
     WHERE title = "Database
     Systems';
```

- DELETE FROM Courses WHERE title = 'DB' ;

JDBC Overview

1. JDBC – Java Database Connectivity
2. Get a Connection to the database.
3. Create a *Statement* using the Connection.
4. Execute the *Statement* with SQL string.
5. Use the results.



JDBC Code

```
static final String URL = "jdbc:mysql://dbserver/world";
static final String USER = "student";
static final String PASSWORD = "secret";
// 1. Get a Connection to the database.
Connection connection =
    DriverManager.getConnection( URL, USER, PASSWORD );
// 2. Create a Statement
Statement statement = connection.createStatement();
// 3. Execute the Statement with SQL command.
ResultSet rs = statement.executeQuery("SELECT * FROM ...");
// 4. Use the Result.
while ( rs.next( )  )  {
   String name = rs.getString("name");
```

Database URL

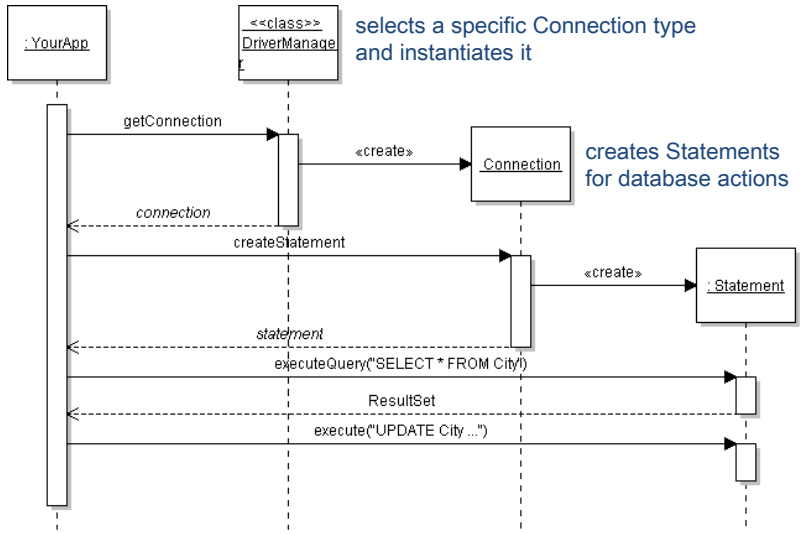
The format of a database URL is:

```
String DB_URL = "jdbc:mysql://dbserver:3306/world";
```

Protocol | Sub-protocol | Hostname | Port | DatabaseName

- Port is the TCP port number where the database server is listening.
  - 3306 is the **default port** for MySQL
- Use hostname `"localhost"` for the local machine.

JDBC Overview



Where is the Database Driver?

Driver is in a JAR file.

JAR file must be on the CLASSPATH.

Use one of these:

1. add as an *external jar file* to your IDE project
2. add the JAR to your CLASSPATH
   `CLASSPATH = /my/path/mysql-connector.jar;.`
3. add JAR using the Java command line:
   `java -cp /my/path/mysql-connector.jar ...`
4. Put JAR file in the **`JRE/lib/ext`** directory:
   `C:/java/jre1.6.0/lib/ext/mysql-connector.jar`

How to Execute SQL Commands

The Statement interface defines many execute :

```
Resultset rs =
      statement.executeQuery("SELECT ...");
```

- use for statements that return data values (SELECT)

```
int count =
      statement.executeUpdate("UPDATE ...");
```

- use for INSERT, UPDATE, and DELETE

```
boolean b =
      statement.execute("DROP TABLE test");
```

- use to execute any SQL statement(s)

Object-Relational Mapping

Purpose

- save object as a row in a database table
- create object using data from table
- save and create *associations* between objects

Design Goals

- separate O-R mapping service from our application
- localize the impact of change in database

Goal

- Applications need to save data to *persistent storage*.
- Persistent storage can be database, directory service, XML files, spreadsheet, ...
- For O-O programming, we'd like to save and retrieve *objects* to/from storage.

How to do Object Persistence

Choices for How to do Object Persistence?

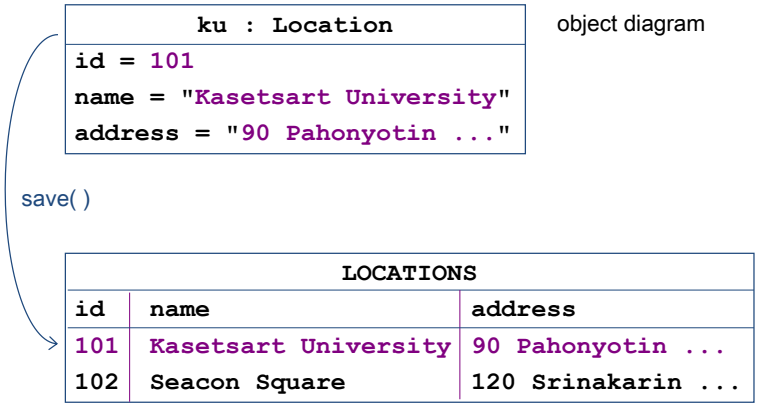
1. write your own DAO using JDBC
2. Use an Object-Relational Mapping (ORM) Framework
   - Hibernate, TopLink, MyBatis, Apache Cayenne
3. Use a Standard Persistence API.
   - Java Persistence Architecture (JPA)
     - standard used in JavaEE
     - implemented by EclipseLink, Hibernate, OpenJPA

The Problem with Databases

Object-Relational Paradigm Mismatch

- Database stores data as rows in *tables*, which are not like objects.
- Objects have associations and collections databases have relations between tables.
- Objects are unique,
  database row data is *copied* each time you query it.

Mapping an Object



4 Approaches to ORM

1. No ORM -- JDBC in my code.

   No Layers! Put the JDBC right in your app code.

2. Do It Myself.

   Write your own DAO using JDBC.

3. Use a Framework.

   Hibernate, MyBatis, TopLink, or other.

4. Use a Standard.

   Java Persistence Architecture (JPA) or Java Data Objects (JDO) provide a *standard API* that have *many implementations*.

Bean and DAO

```
public class StudentBean {
  private Integer age;
  private String name;
  private Integer id;

  public void setAge(Integer age) {
    this.age = age;}

  public Integer getAge() {
    return age;}

  public void setName(String name) {
    this.name = name;}

public String getName() {
    return name;}

  public void setId(Integer id) {
    this.id = id;}

     public Integer getId() {
    return id;
  }
}
```

```
public class StudentDAO {

  public void create(String name, Integer age) {
    String SQL = "insert into Student (name, age) values (?, ?)“;
// send the command to the database
System.out.println("Created Record Name = " + name + " Age = " +
age);
  }

  public Student getStudent(Integer id) {
    String SQL = "select * from Student where id = ?";
    //get the data and fill it in new object
    return student;
  }

  public List<Student> listStudents() {
    String SQL = "select * from Student";
return students;
  }

  public void delete(Integer id) {
    String SQL = "delete from Student where id = ?";
}

  public void update(Integer id, Integer age){
    String SQL = "update Student set age = ? where id = ?";
System.out.println("Updated Record with ID = " + id );
}
}
```

Persistence Frameworks

Hibernate - most popular open-source persistence framework for Java. NHibernate for .Net.

Uses POJOs and object-query language. Completely decouple Java from database. Can reverse engineer.

MyBatis - simple, uses SQL maps. Database schema not transparent to Java code.

Cayenne - Apache project, has GUI modeler that eliminates need to write xml. Can reverse engineer database or generate database schema & Java code.

TopLink (Oracle)

Torque (Apache DB)