Web-based information systems 1

Database interaction and Java software design

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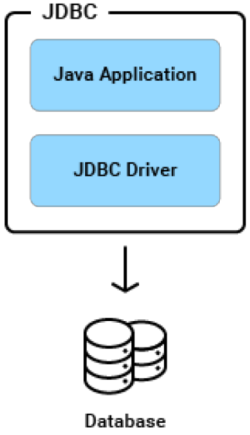
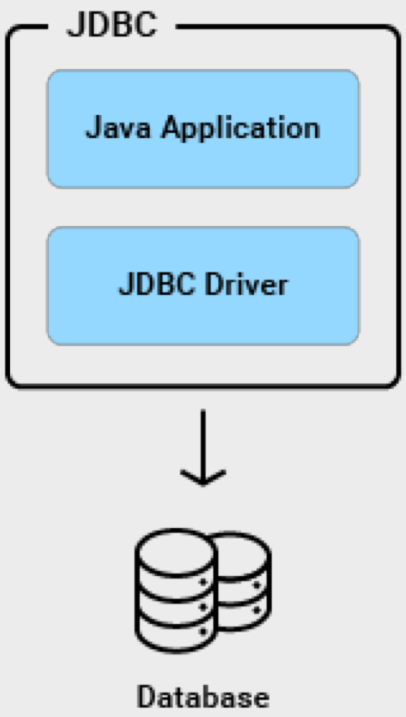


introduction



- Database interaction with Java applications: JDBC
- Java design issues that ensure flexible, reusable code that will easily deal with changing specs:
  - a different database provider
  - a different view
  - different analysis components
  - etc etc
- Just remember: the only constant in programming is change

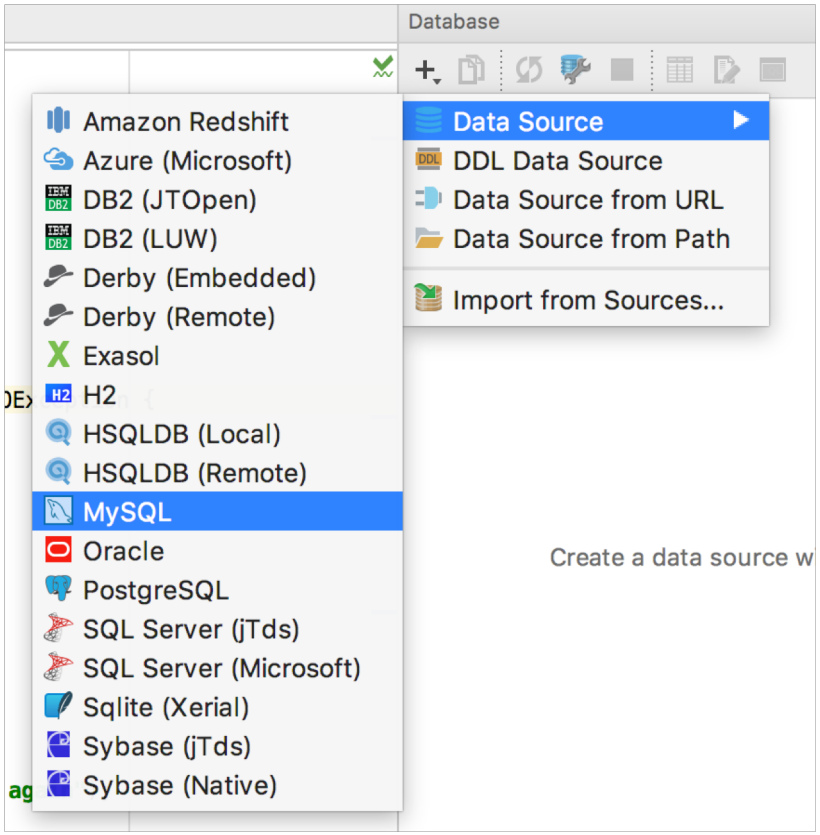
JDBC

- Let's start with the simple thing: how to communicate with a database using Java.
- Suppose we have a database called MyDB with this single, simple table Users

Field	Type
user_id	int (auto_inc)
user_name	varchar(30)
user_password	varchar(30)
user_email	varchar(30)
role	enum('GUEST', 'USER', 'ADMIN')

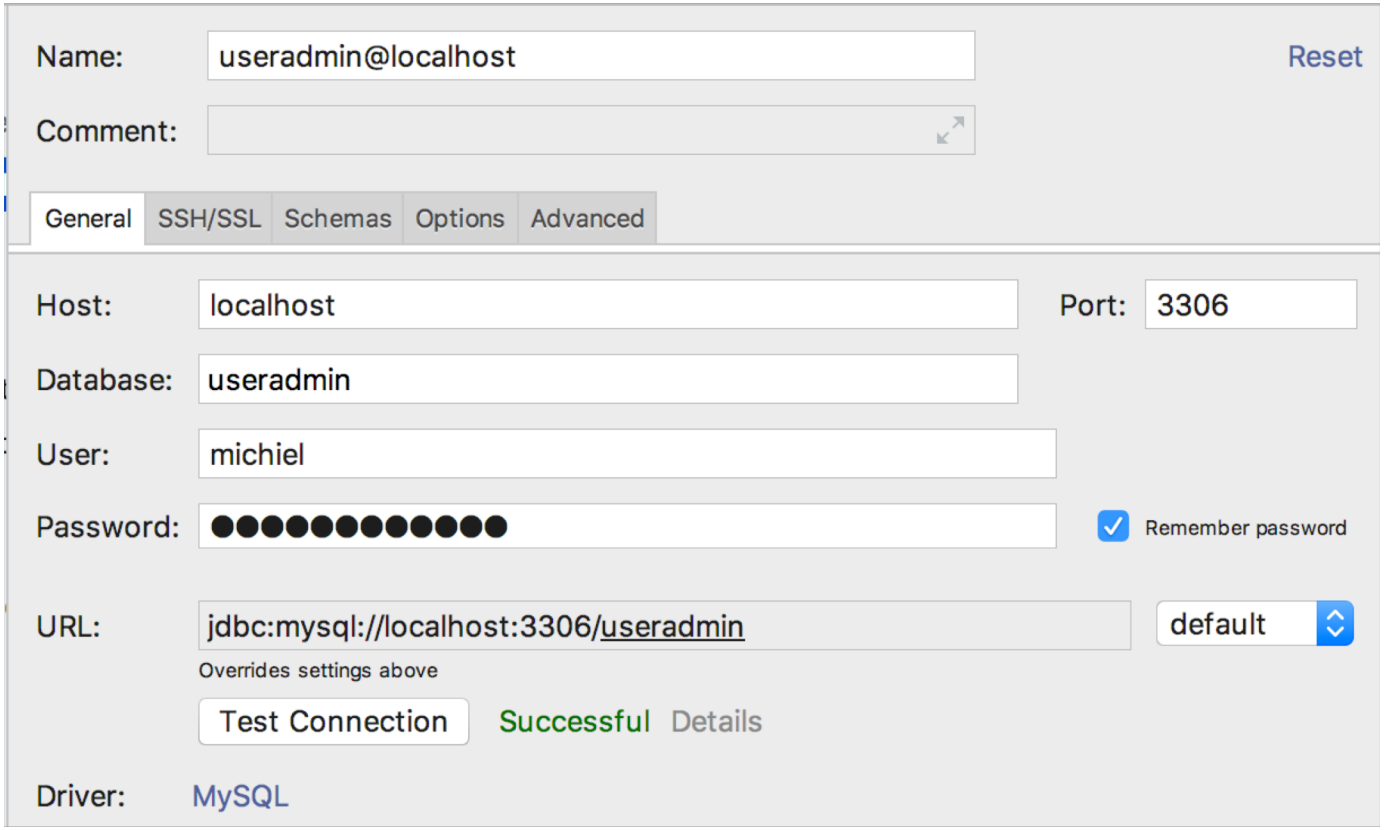
Database actions within IntelliJ

- To get the Database toolbox:
  - View -> Tool Windows -> Database
- Click “+” -> Data Source -> MySQL



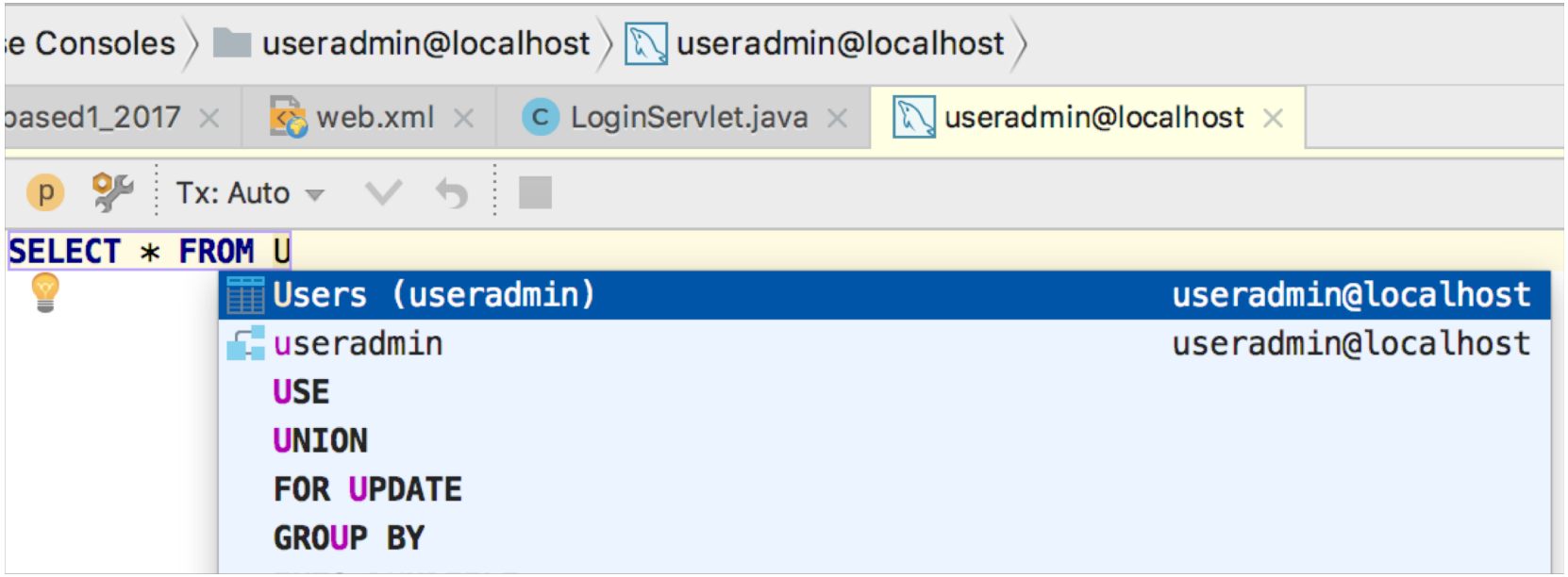
Fill in the blanks

- Click “download missing driver files
- Click “test connection”



MySQL within IntelliJ

- Open the console,
- Enter a command
- Press Ctrl + enter



Add some data

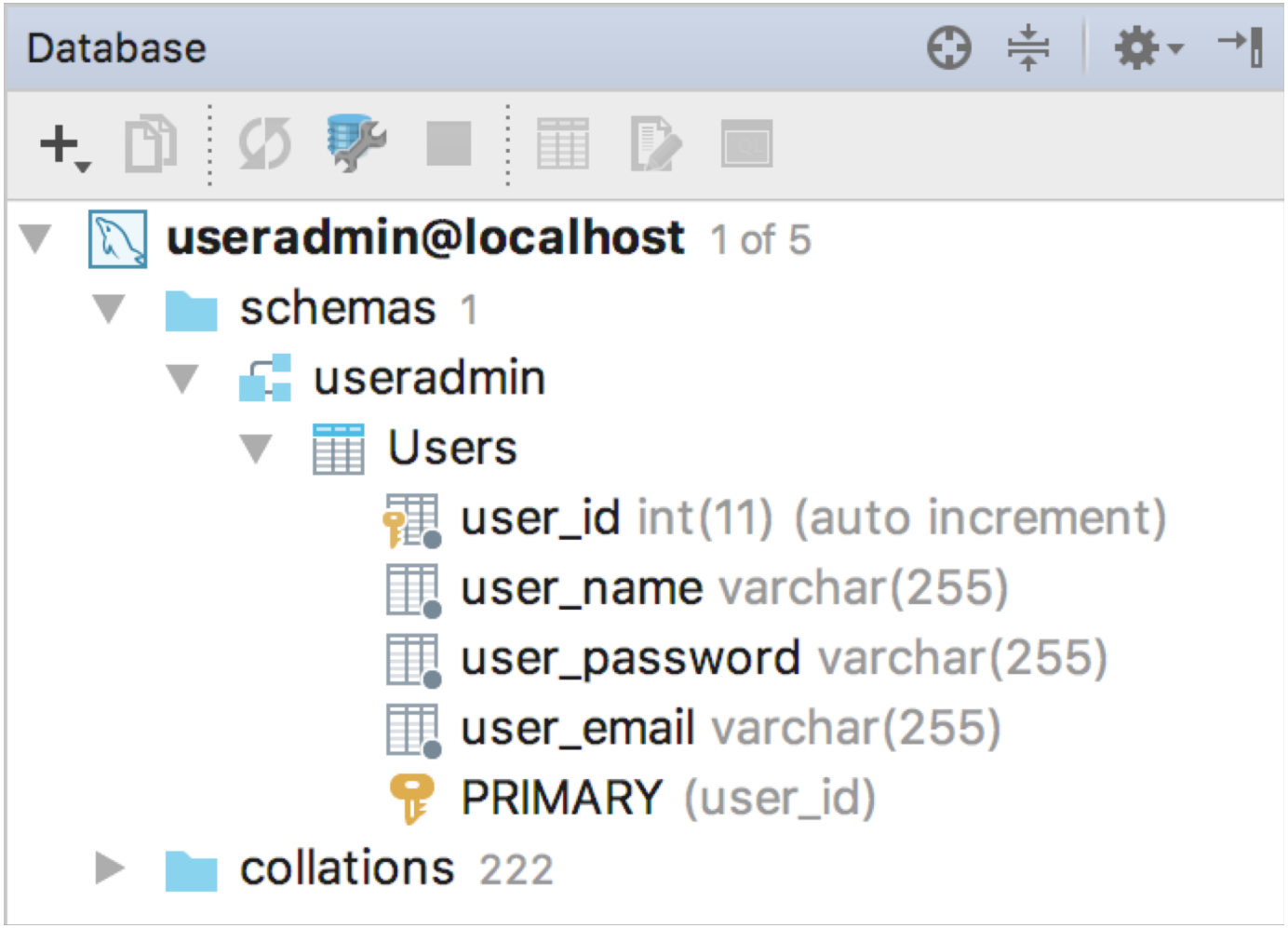
```sql
DROP TABLE IF EXISTS Users;

CREATE TABLE Users (
  user_id INT NOT NULL auto_increment,
  user_name VARCHAR(100) NOT NULL,
  user_password VARCHAR(100) NOT NULL,
  user_email VARCHAR(255) NOT NULL,
  user_role VARCHAR(100) NOT NULL,
  primary key(user_id)
);

INSERT INTO Users (user_name, user_password, user_email)
  VALUES ('Henk', 'Henkie', 'Henk@example.com', 'ADMIN');

#SELECT * FROM Users;
```

IntelliJ Database tool window

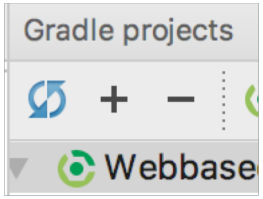


Add project dependency

- In build.gradle, add

```
// https://mvnrepository.com/artifact/mysql/mysql-connector-java
compile group: 'mysql', name: 'mysql-connector-java', version: '5.1.6'
```

- You may need to refresh your Gradle project in the Gradle Tool window



Code against interfaces, not implementations

- This is especially relevant for database access!
- Change of database implementation…

```
public interface MyAppDao{
  public void connect();
  public User getUser(String uName, String uPass);
  public void insertUser(String uName, String uPass, String eMail);
  public void disconnect();
}
```

(1) define the interface methods

(2) implement the interface

```
class MyDbConnector implements MyAppDao{ ... }
```

(3) write code agianst the interface type

```
public class MyApp {
  private connectDB(){
    MyAppDao dao = MyDbConnector.getInstance();
    dao.connect();
  }}
```

JDBC class loading

- Like all programming languages, you need drivers. You can load them like this in Java:

```
import java.sql.*;
class MyDbConnector implements MyAppDao {

  public void connect(){
    Class.forName("com.mysql.jdbc.Driver");
  }
}
```

Of course you will need to import the correct classes/packages

This is how you load the JDBC driver

This mechanism is called **dynamic class loading**

JDBC creating a Connection

- After loading the driver class(es), you will need to establish a connection:

```
class MyDbConnector{
  Connection connection;
  String dbUrl = "jdbc:mysql://bioinf.nl/MyDB";
  String dbUser = "Fred";
  String dbPass = "Pass";

  public MyDbConnector(){
    connectDb();
  }

  public void connectDB(){
    Class.forName("com.mysql.jdbc.Driver");
    try{
      connection = DriverManager.getConnection(dbUrl,dbUser,dbPass);
    }catch(Exception e){e.printStackTrace();}
  }
}
```

These are the required objects. The actual connection is of course a Connection object

Here you establish the connection. Talking to a DB is risky business, so yo'have to put it in a try/catch block

JDBC filling the database

- Now you are ready to put some data in the database:

```
public void insertUser(String name, String pass, String eMail) {
    try {
        String insertQuery =
             "INSERT INTO Users (user_name, user_password, user_email) "
             + " VALUES (?, ?, ?)";
        PreparedStatement ps = connection.prepareStatement(insertQuery);
        ps.setString(1, name);
        ps.setString(2, pass);
        ps.setString(3, eMail);
        ps.executeUpdate();
        ps.close();
    } catch (SQLException e) {
        e.printStackTrace();
    }
}
```

JDBC getting data out of the database

- Now the other way around: get data out of the database:

```
public void getUser(String name, String pass ){
    try {
        String fetchQuery =
          "SELECT * FROM Users WHERE user_name = ? AND user_password = ?";
        PreparedStatement ps = connection.prepareStatement(fetchQuery);
        ps.setString(1, name);
        ps.setString(2, pass);
        ResultSet rs = ps.executeQuery();
        while (rs.next()) {
            String userMail = rs.getString("user_email");
            String userIdStr = rs.getString("user_id");
            System.out.println("userMail = " + userMail);
            System.out.println("userIdStr = " + userIdStr);

        }
        ps.close();
    } catch (SQLException e) … }
```

JDBC resource efficiency

- PreparedStatements, Connections and ResultSets are expensive objects in terms of computer resources; you should instantiate them sparingly.
- Here follow some code constructs to do this:
- First: the **Singleton Pattern**. This is an object-oriented design pattern that is used to ensure there is always only one object of a particular class alive in an application.

Singleton Pattern

```
class MyDbConnector{
  private static MyDbConnector uniqueInstance;

  private MyDbConnector(){}

  public static getInstance(){
    if (uniqueInstance == null ){
      uniqueInstance = new MyDbConnector();
    }
    return uniqueInstance;
  }
}
```

These are the key ingredients to implementing the singleton pattern:

(1) have a static variable of the one instance
(2) make the constructor private
(3) provide a single access point to the instance and create it on first request

Cashing PreparedStatements

- PreparedStatements should be reused as much as possible:

```
@Override
public void connect() throws DatabaseException {
    //connection code omitted
    prepareStatements();
}
/**Prepares statements and stores them for reuse*/
private void prepareStatements() throws SQLException {
    String fetchQuery = "SELECT * FROM Users WHERE user_name = ?
                        AND user_password = ?";
    PreparedStatement ps = connection.prepareStatement(fetchQuery);
    this.preparedStatements.put("GET_USER", ps);

    String insertQuery = "INSERT INTO Users (user_name, user_password,
                 user_email, user_role) VALUES (?, ?, ?, ?)";
    ps = connection.prepareStatement(insertQuery);
    this.preparedStatements.put("INSERT_USER", ps);
}
```

Using PreparedStatements

```
private HashMap<String, PreparedStatements> pStmts;
void getUser(String name, String pass ){
  try{
    PreparedStatement ps = pStmts.get("fetch_user");
    preparedStatement.setString(1, "JohnDoe");
    preparedStatement.setString(2, "mypass");
    ResultSet rs = preparedStatement.executeQuery();
    while (resultSet.next()) {
      String userMail = resultSet.getString("user_email");
      String userIdStr = resultSet.getString("user_id");
    }
  }catch( Exception e ){ ... }
}
```

Cleaning up PreparedStatements

- After you are finished, you should clean up your resources
- In a web app, this happens at shutdown time (there are hooks for this!)

```
  private HashMap<String, PreparedStatements> pStmts;
  void disconnect() {
    try {
      for (String key : pStmts.keySet()) {
        pStmts.get(key).close();
      }
    } catch(Exception e) {
      e.printStackTrace();
    } finally {
      connection.close();
    }
  }
}
```

Data access summary

- ALWAYS code data access logic against an interface
- Restrict use of database-specific code to dedicated classes
- Implement the singleton pattern for data access objects
- Keep use of data access resources to a minimum
- Do not forget to close prepared statements and connections

The final picture