Database Access with JDBC

Connecting Via JDBC, Executing Statements, SQL Injection,

Advanced Concepts

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Questions

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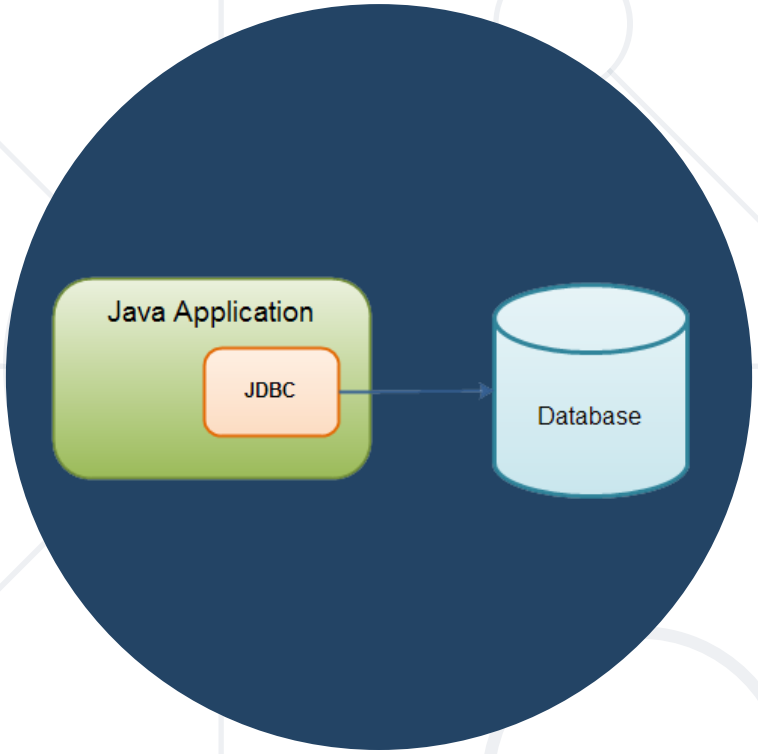
#Java-DB



Accessing Data Via Client Application

Application to Database Connection

ORM Frameworks Overview (1)

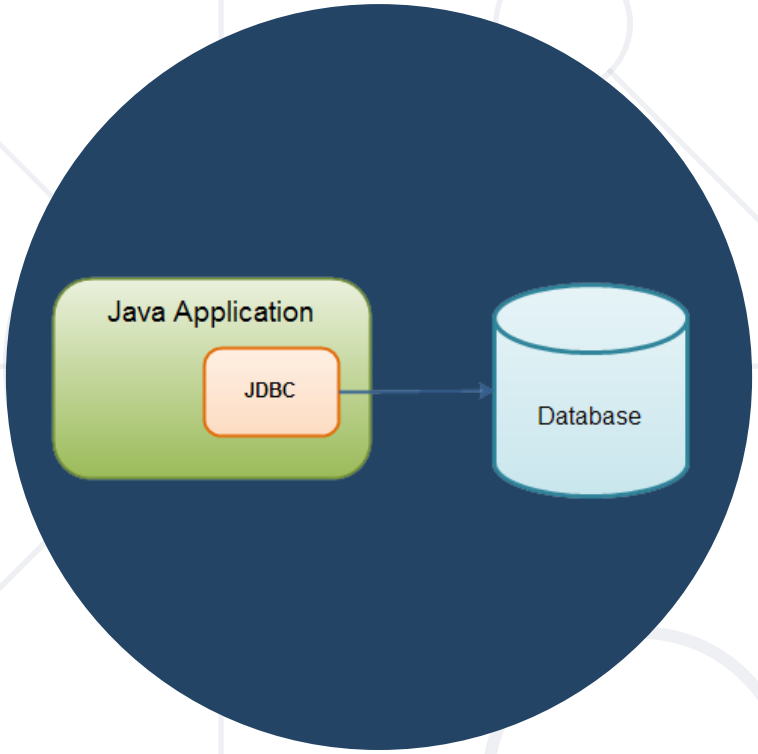
- In development programmers use **object relational mapping** frameworks.
  - Mapping Java classes and data types to **DB tables** and **SQL data types**
  - Generate SQL calls and **relieves** the developer from the **manual handling**
    - E.g. (pseudo-code)

```
User user = new User("Peter", 25);
dbManager.saveToDB(user);
```

SQL Encapsulated in method

ORM Frameworks Overview (2)

- ORM frameworks **do not** drop the need to write SQL!
  - At some point you might need some **manual query optimization**
- ORM Frameworks **examples**:
  - Java – **Hibernate**, EclipseLink, TopLink…
  - .NET – Entity Framework, NHibernate…
  - PHP – Doctrine, Laravel(Eloquent)...



Demo

Application to Database Connection

Connection to DB Via Java App Demo (1)

- Download the demo from the **course instance**.
- You are given a simple application that:
  - Establishes connection with the "**soft_uni**" DB
  - Executes simple MySQL statement to retrieve the employees names by **given salary criteria**

Connection to DB Via Java App Demo (2)

- Let's analyze the program:
  - Connection to DB is established by asking the user to give credentials:

```
System.out.print("Enter username default (root): ");
String user = sc.nextLine();
user = user.equals("") ? "root" : user;
…
System.out.print("Enter password default (empty):");
String password = sc.nextLine().trim();
…
```

Connection to DB Via Java App Demo (3)

- Using an external library (**MySQL Connector/J**) we make a connection via a **DriverManager** and a **Connection** class.

```
Properties props = new Properties();
        props.setProperty("user", user);
        props.setProperty("password", password);


Connection connection =
DriverManager.getConnection("jdbc:mysql://localhost:3306/s
oft_uni", props);
```

Connection to DB Via Java App Demo (4)

- We retrieve the result with the **ResultSet** and the **PreparedStatement** classes.

```
PreparedStatement stmt = connection.prepareStatement
("SELECT * FROM employees WHERE salary > ?");

String salary = sc.nextLine();
stmt.setDouble(1, Double.parseDouble(salary));
ResultSet rs = stmt.executeQuery();
```

SQL Query

Salary criteria by user input

Runs the SQL statement and returns retrieved result

Connection to DB Via Java App Demo (5)

- Iterating over the result:

Retrieved data

```
while(rs.next()) {
        System.out.printf("%s  %s",
        rs.getString("first_name")
        rs.getString("last_name"));
}
```

The ResultSet is a set of table rows

Demo Conclusion

- We can access databases on a programmer level.
  - No manual actions needed
- In a bigger applications we can:
  - Encapsulate custom SQL logic in methods
  - Achieve database abstraction

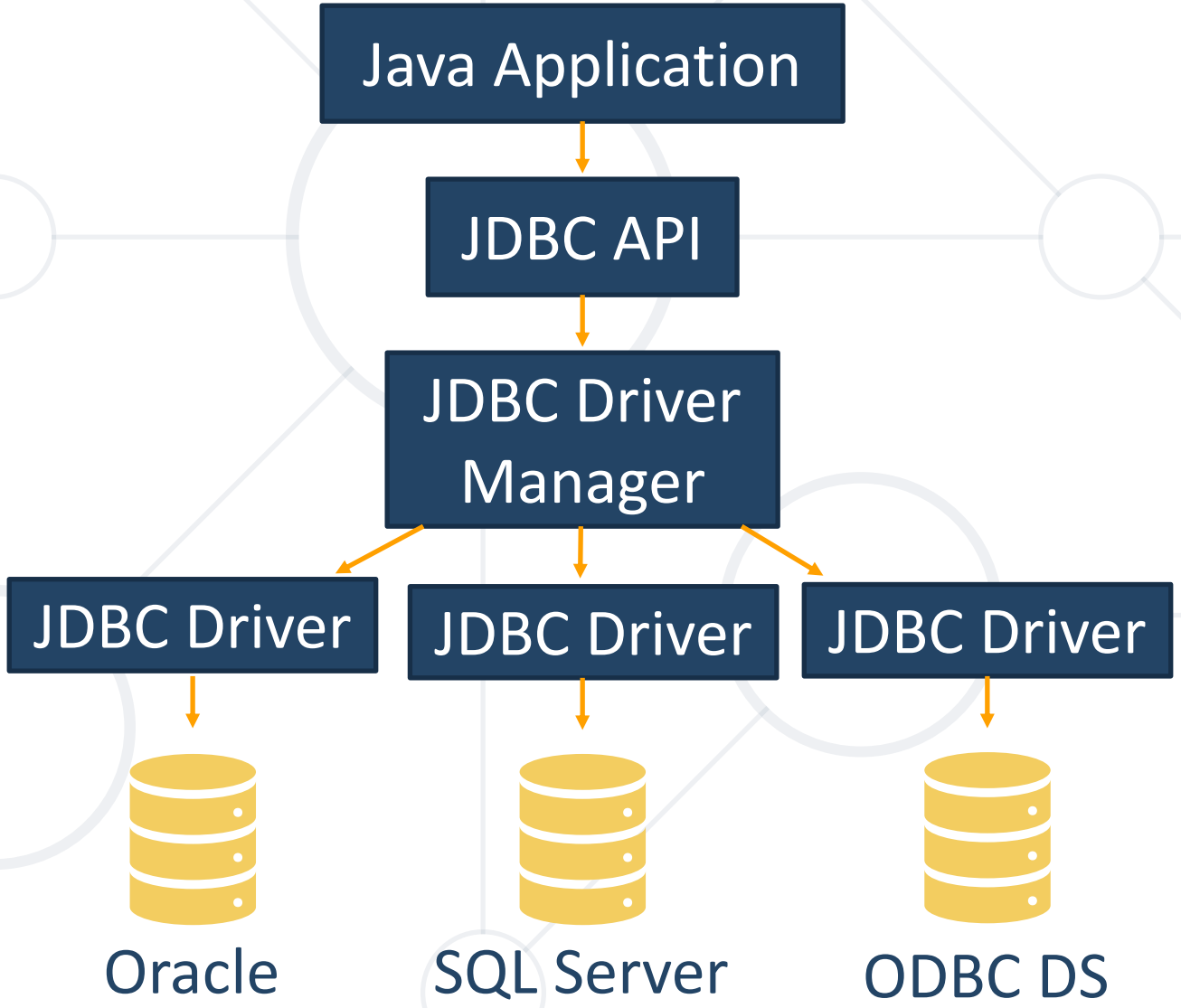
Client Access to a Database

Java Database Connection

Java Database Connectivity (JDBC)

- JDBC is a standard Java API for database-independent connectivity
- Includes APIs for:
  - Making a connection to a database
  - Creating and executing **SQL** queries in the database
  - Viewing & Modifying the resulting records

JDBC Architecture (1)



JDBC Architecture (2)

- JDBC **API** – provides the connection between the application and the driver manager
- JDBC **Driver Manager** – establishes the connection with the correct driver
  - Supports multiple drivers connected to different types of databases
- JDBC **Driver** - handles the communications with the database

JDBC API

- JDBC API provides several interfaces and classes:
  - **DriverManager** – matches requests from the application with the proper DB driver
  - **Driver** – handles the communication with the DB server
  - **Connection** – all methods for contacting a database
  - **Statement** – methods and properties that enable you to send SQL
  - **ResultSet** – retrieved data (set of table rows)
  - **SQLException**

JDBC API – ResultSet Class (1)

- ResultSet maintains a **cursor** pointing to its **current row of data**
  - Not updatable
  - Iterable only once and only from the first row to the last row
- Provides getter methods for retrieving column values from the current row
  - E.g. from previous demo:

```
while(rs.next()) {
        System.out.printf("%s %s", rs.getString("first_name"),
rs.getString("last_name"));}
```

Getter method

Column name

JDBC API – ResultSet Class (2)

- Retrieved information is reached by getter methods:
  - E.g.:
    - getString("column_name")
    - getDouble("column_name")
    - getBoolean("column_name") etc.
- The driver converts the underlying data to the Java type

Java.sql* and MySQL Driver

- The java.sql package provides all previously mentioned JDBC classes
- In order to work with JDBC we need to download a MySQL Driver – Connector/J
  - It can be found on the following webpage:

    https://dev.mysql.com/downloads/connector/j/

MySQL Driver Connection

- Connection with the database is established via **connection string**
  - jdbc:<driver protocol>:<connection details>
  - E.g. connection from previous demo:

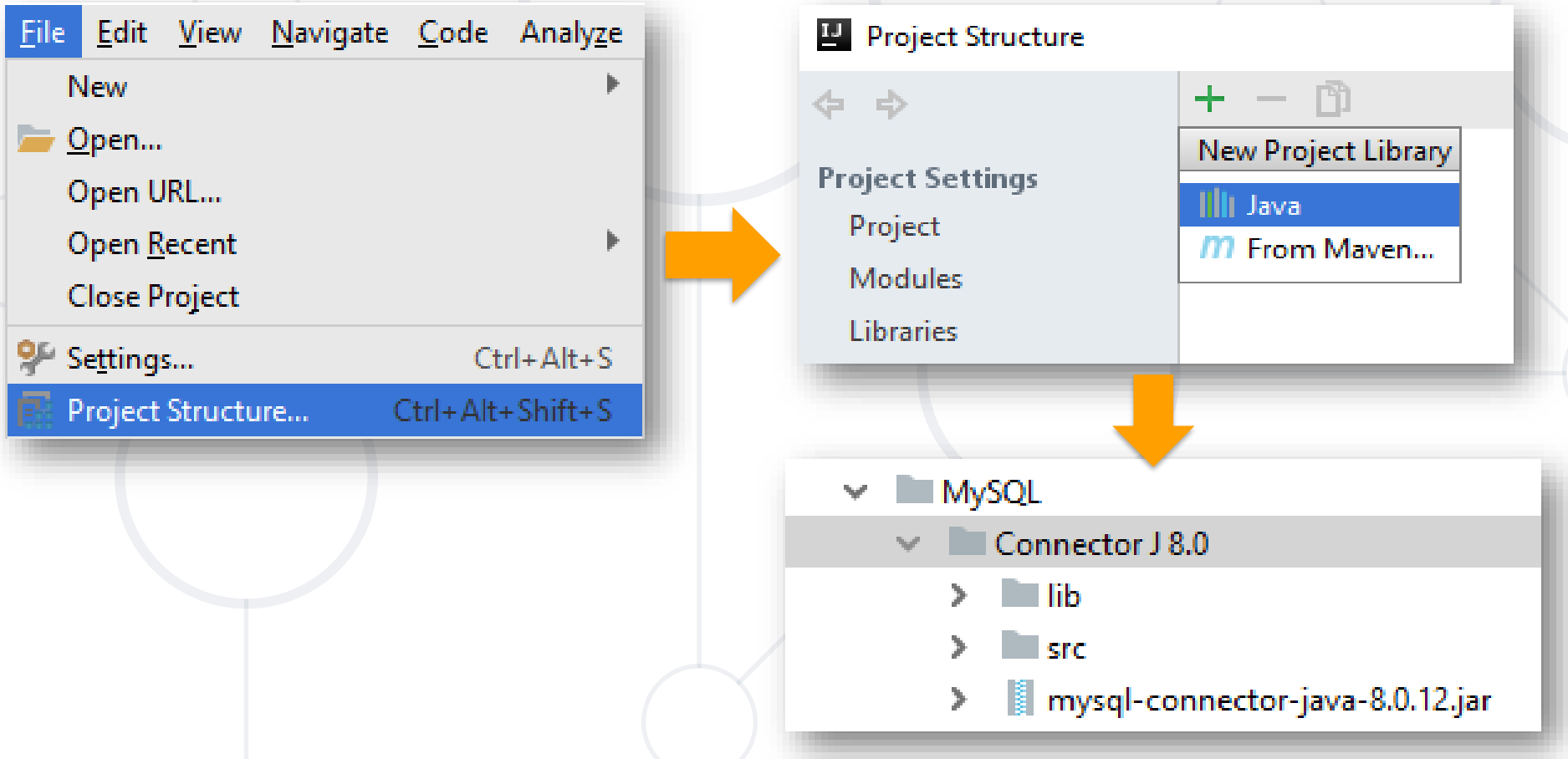
```
Connection c = DriverManager.getConnection(
"jdbc:mysql://localhost:3306/soft_uni", props);
```

Database name

Credentials

Setting Up the Driver in IntelliJ IDEA

- Add the driver as an external library:
  - "File" -> "Project Structure" -> "Libraries"



Statement, PreparedStatement, CallableStatement

Statements

- The JDBC **Statement interface** defines the methods and properties that enable you to send SQL commands to the database.

Interfaces	Recommended use
`Statement`	For general-purpose access to your database and static SQL statements at runtime. Cannot accept parameters.
`PreparedStatement`	For SQL statements used many times. Accepts parameters.
`CallableStatement`	Used for stored procedures. Accepts parameters.

Statements Example

- Example(PreparedStatement) from previous demo:

```
PreparedStatement stmt =
connection.prepareStatement("SELECT * FROM employees WHERE
salary > ?");

String salary = sc.nextLine();
stmt.setDouble(1, Double.parseDouble(salary));
```

SQL Query

Statements are created via the connection

Query parameter

Parameter Index

Parameter value

How to Prevent It?

SQL Injection

What is SQL Injection?

- Placement of **malicious** code in SQL Statements
  - Usually done via user input
- To protect our data, we can place parameters in our statements
  - We can do it by using **PreparedStatement**

SQL Injection Example: Login Form Input by User (1)

- Ask the user to input username and password in fields
  - If we don't secure our statements, we risk SQL Queries to be written as an input
  - E.g. :
    - username: "example_user "
    - password: "12345"
    - The following query will be built and executed to the data source:

```
SELECT id FROM users
WHERE username = 'example_user' AND password = '12345';
```

SQL Injection Example: Login Form Input by User (2)

- In result the **id of the user** will be returned.
  - User will be authenticated to do actions in the application
- Without validating and securing our statements information might get exposed:
  - Value for password: ''1' OR username = 'admin';'
  - The following query will be executed:

```
SELECT id FROM users
WHERE username = 'pesho'
AND password = '1' OR username = 'admin';
```

SQL Injection Example: Login Form Input by User (3)

- In result the id **an admin** will be returned
  - Will permit actions to the user that can harm our application and database
- We can validate the input by setting rules
  - Length, special characters, digits etc.
  - Set up validation in our code in different layers (front-end, back-end etc.)

Transactions and DAO Pattern

Advanced Concepts

JDBC Transaction Pattern (1)

- Every JDBC Connection is set to **auto-commit** by default
  - SQL statements are committed on completion
- In bigger applications we want greater control
  - If and when changes are applied to the database
- Turn off auto-commit:

```
connection.setAutoCommit(false);
```

JDBC Transaction Pattern (2)

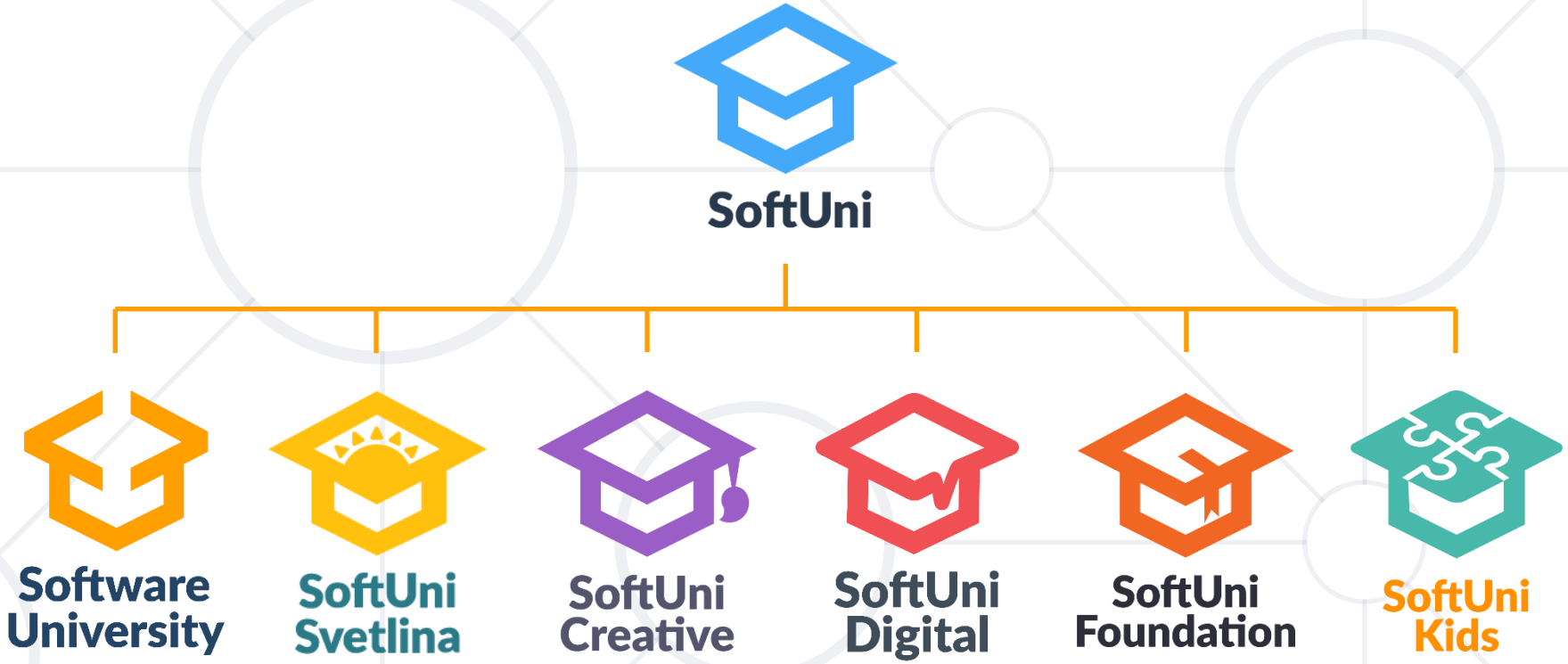
- Example (**pseudo code**):

```
try {
   connection.setAutoCommit(false);
   Statement stmt = conn.createStatement();
   String sql = "…";
   stmt.executeUpdate(sql);
   // If there is no error
   connection.commit();
} catch(SQLException se){
   // If there is any error
   conn.rollback();
}
```

Summary

- ORM Frameworks map **Java objects** to **SQL entities**
- JDBC provides us **classes** for operating with a database
- SQL Injection can seriously harm our data source or expose it
  - Our application should secure the statements being sent

Questions?



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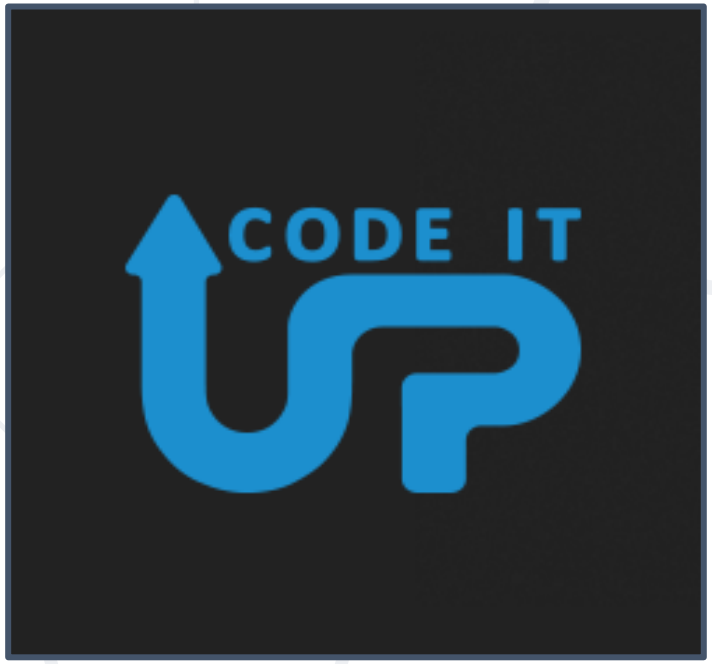

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