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Object Oriented Architectures and Secure Development

JDBC: Java Database Connectivity

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What is JDBC?

- JDBC = Java Database Connectivity
- An API in the Java Standard Edition
- The JDBC API allows you to talk to (relational) databases from within your Java Program
- Native JDBC drivers exist, e.g. for MySQL
- Interested in more background info?
  https://docs.oracle.com/javase/tutorial/jdbc/index.html

In this course: MySQL

- We will be using MySQL
- Can be installed/obtained in multiple ways:
  - WampServer
  - Standalone installer
  - …
- To download standalone MySQL, go to https://dev.mysql.com/downloads/
- We will be using a GUI administration client (such as SQLYog, MySQL Workbench or DataGrip)
  - SQLYog
    https://github.com/webyog/sqlyog-community/wiki/Downloads
  - Workbench
    https://dev.mysql.com/downloads/workbench/
  - JetBrains DataGrip
    https://www.jetbrains.com/datagrip/

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Adding MySQL support to your project

- Go to www.mvnrepository.com.
- Look for MySQL Connector/J in the list of available artifacts.
- Make sure to copy-paste the correct version reference (depending on your MySQL version) into your **build.gradle** file:

```
dependencies {
    testImplementation("org.junit.jupiter:junit-jupiter-api:5.7.0")
    testRuntimeOnly("org.junit.jupiter:junit-jupiter-engine:5.7.0")

    // https://mvnrepository.com/artifact/mysql/mysql-connector-java
    implementation group: 'mysql', name: 'mysql-connector-java', version: '8.0.21'
}
```


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Opening the database connection

- We obtain a Connection instance in a **try-with-resources-block**.

```
private static final String URL = "jdbc:mysql://localhost/mydatabase";
private static final String USERNAME = "myuser";
private static final String PASSWORD = "mypassword";

private static final Logger LOGGER = Logger.getLogger(ProductsDemo.class.getName());

public static void main(String[] args) {

    try (Connection con = DriverManager.getConnection(URL, USERNAME, PASSWORD)) {
        // use connection
    } catch (SQLException ex) {
        LOGGER.log(Level.SEVERE, String.format("Error connecting to DB: %s", ex.getMessage());
        throw new ShopException("Unable to connect to DB.");
    }

}
```

- Reason: when block closes, the resources (here: Connection) are automatically released (closed).
- In case of problem, SQLException is thrown, so we need to catch and process it appropriately.

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The connection string

- In its most basic form, this is the format of a MySQL connection string:

  ```
  jdbc:mysql://servername/dbname
  ```

- Some MySQL server instances/driver combinations require additional parameter(s).
- For example:

  ```
  jdbc:mysql://localhost/mydatabase?serverTimezone=UTC
  jdbc:mysql://localhost/mydatabase?useSSL=false&serverTimeZone=UTC
  ```

- When in doubt, consult the exception message.

Executing a query

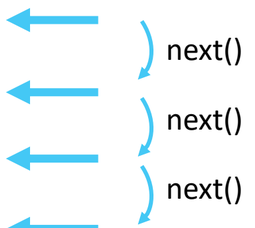
- We distinguish two kinds of queries:
  - SELECT
  - INSERT, UPDATE, DELETE
- When executing a SELECT statement, we get a ResultSet as return value (=the resulting row(s)).
- When executing an INSERT, UPDATE or DELETE statement, we get an int as return value (=the number of affected rows).

Executing a SELECT (1)

- We ask the connection to **prepare** a statement, based on our SQL
  = **PreparedStatement**
- Next, the prepared statement is **executed**, and we obtain a pointer to the resulting rows.
  = **ResultSet**
- The pointer to the resulting rows starts **before the first row** and can be queried using **next()**, returning a boolean (true → points to a row).
- Therefore, you need to execute next() once before getting access to the first row.

SELECT * FROM product

id	name	price
1	laptop	750
2	Smartphone	255
3	Oled tv	1400



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Executing a SELECT (2)

```
private static final String SQL_SELECT_ALL_PRODUCTS = "select * from product";

private List<Product> getProducts() {
    try (Connection connection = DriverManager.getConnection(URL, USERNAME, PASSWORD);
         PreparedStatement prep = connection.prepareStatement(SQL_SELECT_ALL_PRODUCTS);
         ResultSet rs = prep.executeQuery()) {

        List<Product> products = new ArrayList<>();

        while (rs.next()) {
            products.add(resultSetToProduct(rs));
        }

        return products;
    } catch (SQLException ex) {
        LOGGER.log(Level.SEVERE, "A database error occured.", ex);
        throw new RuntimeException("A database error occured.");
    }
}
```

Executing a SELECT (3)

```
private Product resultSetToProduct(ResultSet rs) throws SQLException {
    return new Product(rs.getInt("id"), rs.getString("name"),
            rs.getDouble("price"));
}
```

- Keyword **throws** will allow the SQLException that can be thrown by **rs.getXXX** methods to be caught by the calling method (i.e. getProducts).

Executing a SELECT – with parameters

```
private static final String SQL_SELECT_PRODUCTS = "select * from product where price > ?";

private List<Product> getProducts() {
    try (Connection connection = DriverManager.getConnection(URL, USERNAME, PASSWORD);
         PreparedStatement prep = connection.prepareStatement(SQL_SELECT_PRODUCTS)) {

        prep.setDouble(1, 300);

        try (ResultSet rs = prep.executeQuery()) {
            ...

            return products;
        }
    } catch (SQLException ex) {
        // ...
    }
}
```

Specify parameters in SQL query using question marks ?

Set values using the PreparedStatement's **setXXX** methods

Index-based, starting at 1

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Executing an INSERT/UPDATE/DELETE

```
private static final String SQL_ADD_PRODUCT =
                                "insert into product(name, price) values(?, ?)";

private void addProduct() {
    try (Connection connection = DriverManager.getConnection(URL, USERNAME, PASSWORD);
         PreparedStatement prep = connection.prepareStatement(SQL_ADD_PRODUCT)) {
        prep.setString(1, "tablet");
        prep.setDouble(2, 499);

        prep.executeUpdate();
    } catch (SQLException ex) {
        LOGGER.log(Level.SEVERE, "A database error occured.", ex);
        throw new RuntimeException("A database error occured.");
    }
}
```


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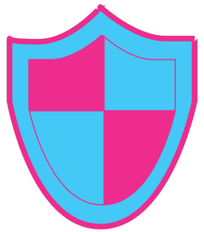
Security attention points

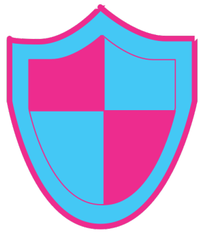


- Always use prepared statements **with parameters**.
- They help you avoid SQL injection (and in certain situations can also enhance the application’s performance).
- **Never ever** concatenate Strings to build your SQL!

- Do not connect to the database using root credentials.
- Give your database user the lowest privileges necessary for the application to function.

Throwing custom exceptions and logging details

```
} catch (SQLException ex) {
    logger.log(Level.SEVERE, "DB error", ex);
    throw new ShopException("A database error occured.");
}
```



- We **do not** pass confidential information in our own exceptions.
  - Oracle secure coding guideline 2.1.
  - https://www.oracle.com/technetwork/java/seccodeguide-139067.html#2-1
- Using loggers
  - We can log more details about what goes wrong.
  - Take into account Oracle secure coding guideline 2.2.
  - https://www.oracle.com/technetwork/java/seccodeguide-139067.html#2-2

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More advanced JDBC topics (1)

- Requesting the AUTOINCREMENT value immediately after an INSERT operation:

```
private void addProduct(Product product) {
    try (Connection connection = DriverManager.getConnection(URL, USERNAME, PASSWORD);
         PreparedStatement prep = connection.prepareStatement(SQL_ADD_PRODUCT,
                 Statement.RETURN_GENERATED_KEYS)) {
        prep.setString(1, product.getName());
        prep.setDouble(2, product.getPrice());

        prep.executeUpdate();

        try (ResultSet autoId = prep.getGeneratedKeys()) {
            autoId.next();
            product.setId(autoId.getInt(1));
        }
    } catch (SQLException ex) {
        LOGGER.log(Level.SEVERE, "A database error occured.", ex);
        throw new ShopException("A database error occured.");
    }
}
```


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More advanced JDBC topics (2)

- Working with transactions:

```
connection.setAutoCommit(false);

Savepoint trx = connection.setSavepoint();

try {
    // execute SQL1
    // execute SQL2
    connection.commit();
} catch (SQLException ex) {
    connection.rollback(trx);
} finally {
    connection.setAutoCommit(true);
}
```

- https://docs.oracle.com/javase/tutorial/jdbc/basics/transactions.html

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