Java Database Connectivity

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What's this about?

Previously when using SQL we've used it as its own thing...

- Running queries in SQL directly
- Presenting responses as tables

In the *real world* we rarely want to access a database in its own right

- Rather it is used within a programming language as part of a program

Different languages have different APIs for different databases...

- ...but Java has the *JDBC* for almost all of them

JDBC

- Library is in `java.sql` and `javax.sql` packages
- Wraps all of a databases functionality into something that looks a lot like *Oracle* SQL.
- Supports *prepared statements* (you want to use these)

What does it look like?

```
import java.sql.*;

try (final Connection conn = DriverManager.getConnection("jdbc:sqlite:database.db")) {
    conn.createStatement()
            .executeQuery("CREATE TABLE users(username TEXT PRIMARY KEY, password TEXT)");
} catch (final SQLException err) {
    System.out.println(err);
}
```

```
java.sql.SQLException: No suitable driver found for jdbc:sqlite:database.db
```

And when you've found a suitable driver and added it to your CLASSPATH...

```
import java.sql.*;

try (final Connection conn = DriverManager.getConnection("jdbc:sqlite:database.db")) {
    conn.createStatement()
        .executeQuery("CREATE TABLE users(username TEXT PRIMARY KEY, password TEXT)");
} catch (final SQLException err) {
    System.out.println(err);
}
```

```
org.sqlite.SQLiteException: [SQLITE_ERROR] SQL error or missing database (table users already exists)
```

Lets add some suitable users...

```
import java.sql.*;
import java.util.*;

final var users = new HashMap<String, String>();
users.put("Joseph", "password");
users.put("Matt", "password1");
users.put("Partha", "12345");

try (final Connection conn = DriverManager.getConnection("jdbc:sqlite:database.db")) {
    conn.createStatement().executeUpdate("DELETE FROM users");
    final var statement = conn.prepareStatement("INSERT INTO users VALUES(?, ?)");
    for (final var user : users.keySet()) {
        statement.setString(1, user);
        statement.setString(2, users.get(user));
        statement.executeUpdate();
    }
} catch (final SQLException err) {
    System.out.println(err);
}
```

And list them back out...

```
import java.sql.*;
import java.util.*;

System.out.println("|User | Password");
try (final Connection conn = DriverManager.getConnection("jdbc:sqlite:database.db")) {
    final var results = conn.createStatement()
        .executeQuery("SELECT * FROM users");
    while (results.next())
        System.out.println("| "+results.getString(1)
                           +" | "+results.getString(2));
} catch (final SQLException err) {
    System.out.println(err);
}
```

User	Password
Matt	password1
Joseph	password
Partha	12345

Why not this...

When adding all the users we used a `PreparedStatement` to add all the users.

```
final var statement = conn.prepareStatement("INSERT INTO users VALUES(?, ?)");
for (final var user : users.keySet()) {
    statement.setString(1, user);
    statement.setString(2, users.get(user));
    statement.executeUpdate();
}
```

Wouldn't this be easier?

```
for (final var user : users.keySet())
    conn.createStatement()
        .executeUpdate("INSERT INTO users "+"VALUES ('"+user+"', '"+users.get(user)+"')");
```

SQL Injection

This leads to a *horrible* vulnerability called an *injection attack*

- You can do something similar with shellscript too `;-)`
- Search for *Shellshock vulnerability* if you're interested...

What a prepared statement does is ensure that the things you add are what you say they are
Suppose you do the something similar for the login code:

```
SELECT username FROM users
WHERE username = "Joseph"
AND password = "password";
```

username
Joseph

Suppose the username and password are taken from a website login form...

- What happens if I try and login with a password of:

```
" OR 1 OR password = "heheh
```

Bad things

With a prepared statement:

```
SELECT username FROM users
WHERE username = "Joseph"
AND password = """ OR 1 OR password = ""heheh";
```

Without a prepared statement:

```
SELECT username FROM users
WHERE username = "Joseph"
AND password = "" OR 1 OR password = "heheh";
```

username
Matt
Joseph
Partha

ALWAYS USE PREPARED STATEMENTS

The compiler will even spew warnings and errors about this nowadays...

- Or *findbugs* will...

Transactions

Another *cool* thing that JDBC makes easy are *transactions*...
Suppose you want to do a bunch of additions and updates to a database...

- What happens if something goes wrong *in the middle*?

You *could* go and manually *roll back* all the new data you added and changes you made...

- Sounds tedious
- Lets automate it!

Transaction workflow

1. Start a new transaction
2. Do your work
3. Commit to it when done
4. Rollback if an error occurs

And in Java please?

```
import java.sql.*;
import java.util.*;

try (final Connection conn = DriverManager.getConnection("jdbc:sqlite:database.db")) {
    conn.setAutoCommit(false);
    final var save = conn.setSavepoint();
    try {
        conn.createStatement() .executeQuery("INSERT INTO users VALUES ('Alice', 'pa55w0rd')");
        conn.createStatement() .executeQuery("INSERT INTO users VALUES ('Bob', 'Pa55w0Rd7')");
        if (true) throw new Exception("Whoops!");
        conn.createStatement() .executeQuery("INSERT INTO users VALUES ('Eve', 'backd00r')");
        conn.commit();
    } catch (final Exception err) {
        conn.rollback(save);
    } finally {
        conn.setAutoCommit(true);
    }
} catch (final SQLException err) {
    System.out.println(err);
}
```

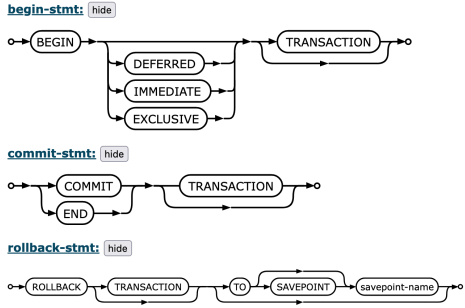
Now if we query users...

```
SELECT * FROM users;
```

username	password
Matt	password1
Joseph	password
Partha	12345

Our table *remains* unaltered... the whole transaction was *rolled back*.

(Oh, and BTW SQLite also can do transactions in SQL)



Back to Entity Relationship Diagrams...

Right back at the start of the database run of videos we were doodling diagrams instead of building databases

- A Java class looks *an awful lot* like an entity

Wouldn't it be neat if we could take a class and get the database importing and saving all handled for us?

Hibernate!

`https://hibernate.org`
Builds *on top* of JDBC to do just that!

- Annotate your classes
- Write a bunch of XML to tell it about your database format
- Magic and a *slightly* higher-level query language

We'll play with it in the lab...

Conclusions

JDBC lets you access SQL from Java

- Make sure you load the right driver
- Catch SQLExceptions
- Use prepared statements and transactions to prevent errors
- And an ORM like *Hibernate* if you like.

IMPORTANT NOTE

Please don't actually implement password storage like we did in the lecture...

- Go speak to someone in the cyber or crypto groups *first*...
- Or read NIST 800-63 first

I will write papers about you if you do `;-)`

> *Joseph Hallett, Nikhil Patnaik, Benjamin Shreeve and Awais Rashid. "Do this! Do that!, And nothing will happen" Do specifications lead to securely stored passwords? 2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE). 2021.*