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04 - Persistence tier (1)

The DAO / Repository pattern & JDBC

AMT 2020

Olivier Liechti

Webcasts (**legacy**). Use this if you want to configure Wildfly, Payara, etc.

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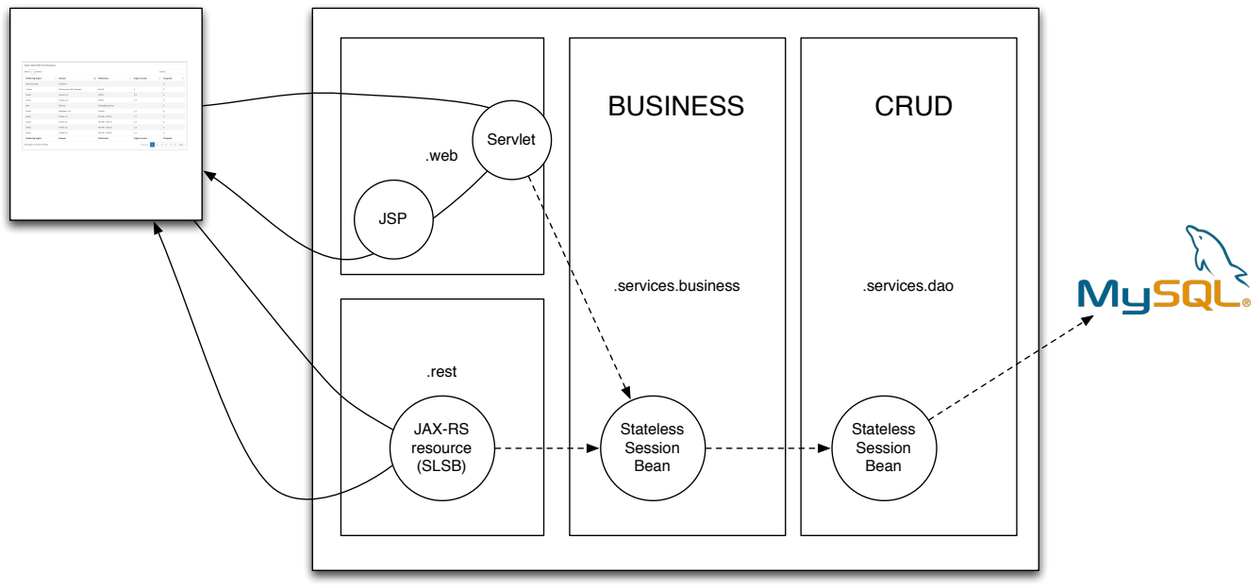

Why are data source useful in Java EE?
What is JDBC and what is its relationship with Java EE?
What is a DAO?

Tasks

1. Prepare the environment
1.1. add a MySQL image to our Docker topology
1.2. add a PhpMyAdmin image to our Docker topology
1.3. insert sample data into our database

2. Configure Glassfish (manually)
2.1. Install MySQL driver
2.2. Configure connection pool and data source

3. Configure Glassfish (Docker)
3.1. Install MySQL driver
3.2. Configure connection pool and data source

4. Configure Wildfly (manually)
4.1. Install MySQL driver
4.2. Configure data source

5. Configure Wildfly (Docker)
5.1. Install MySQL driver
5.2. Configure data source

6. Implement a Data Access Object (DAO)
6.1. Create a new Stateless Session Bean (SLSB)
6.2. Inject the data source into the SLSB
6.3. Use JDBC to send SQL queries to the DB

Webcasts (**legacy**). Use this if you want to configure Wildfly, Payara, etc.

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17		**Bootcamp 4.1: Intro aux webcasts "tiers d'accès aux données avec JDBC"** by oliechti	4:07
18		**Bootcamp 4.2: ajout de mysql et phpmyadmin dans notre topologie docker-compose** by oliechti	10:53
19		**Bootcamp 4.3: configuration de Glassfish** by oliechti	17:20
20		**Bootcamp 4.4: configuration de la data source dans Docker** by oliechti	8:00
21		**Bootcamp 4.5: configuration de Wildfly via l'interface web** by oliechti	7:16
22		**Bootcamp 4.6: configuration de Wildfly via Docker** by oliechti	24:30
23		**Bootcamp 4.7: écriture du code et test dans Glassfish** by oliechti	8:17

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≃ Repository

The DAO Design Pattern

What is the **DAO design pattern** and what are its benefits?

Éviter dépendance forte

On veut pouvoir accéder aux données facilement (BDD)

- Most applications manipulate data that is stored in one or more **data stores**.
- There are **different ways** to implement a data store. Think about specific RDMS, NoSQL DBs, LDAP servers, file systems, etc.
- When you implement business logic, you would like to create code that is **independent** from a particular data store implementation (*).
- In other words, you want to **reduce coupling** between your business service and your data store implementation.
- When you apply the **Data Access Object** design pattern, you create an abstraction layer to achieve this goal.

↳ DAO

(*) This is true only to some extent… you cannot completely forget about it, for instance for performance reasons

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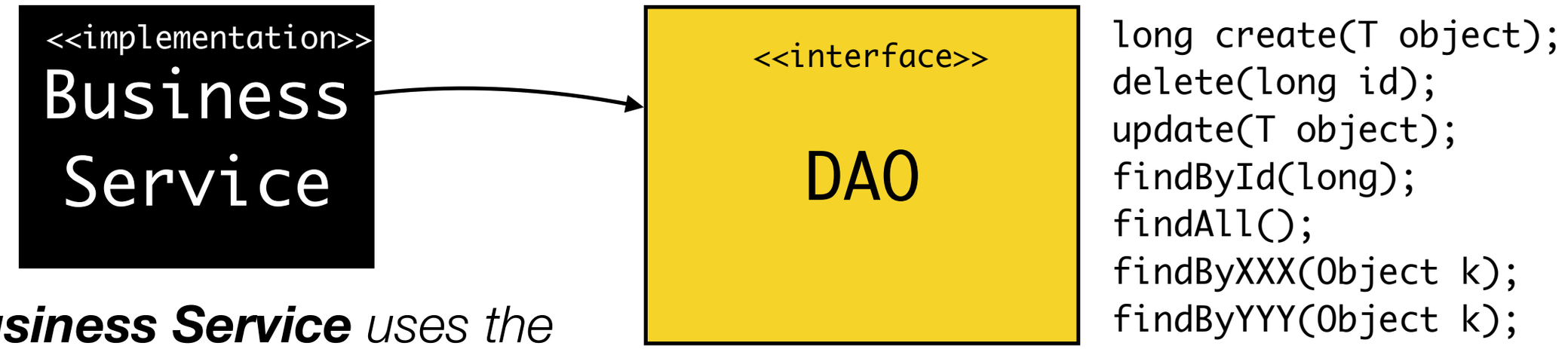
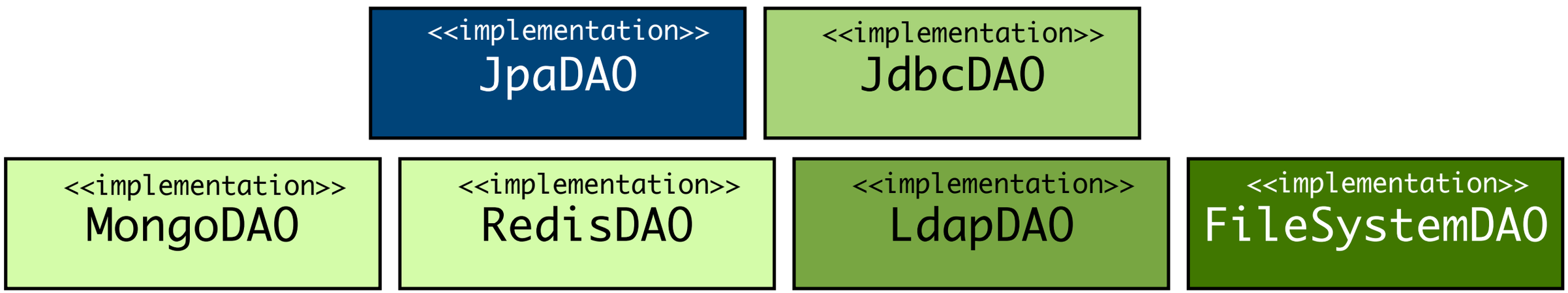
passe toujours par l'interface DAO

*The **DAO interface** defines generic **CRUD** operations and **finder** methods*

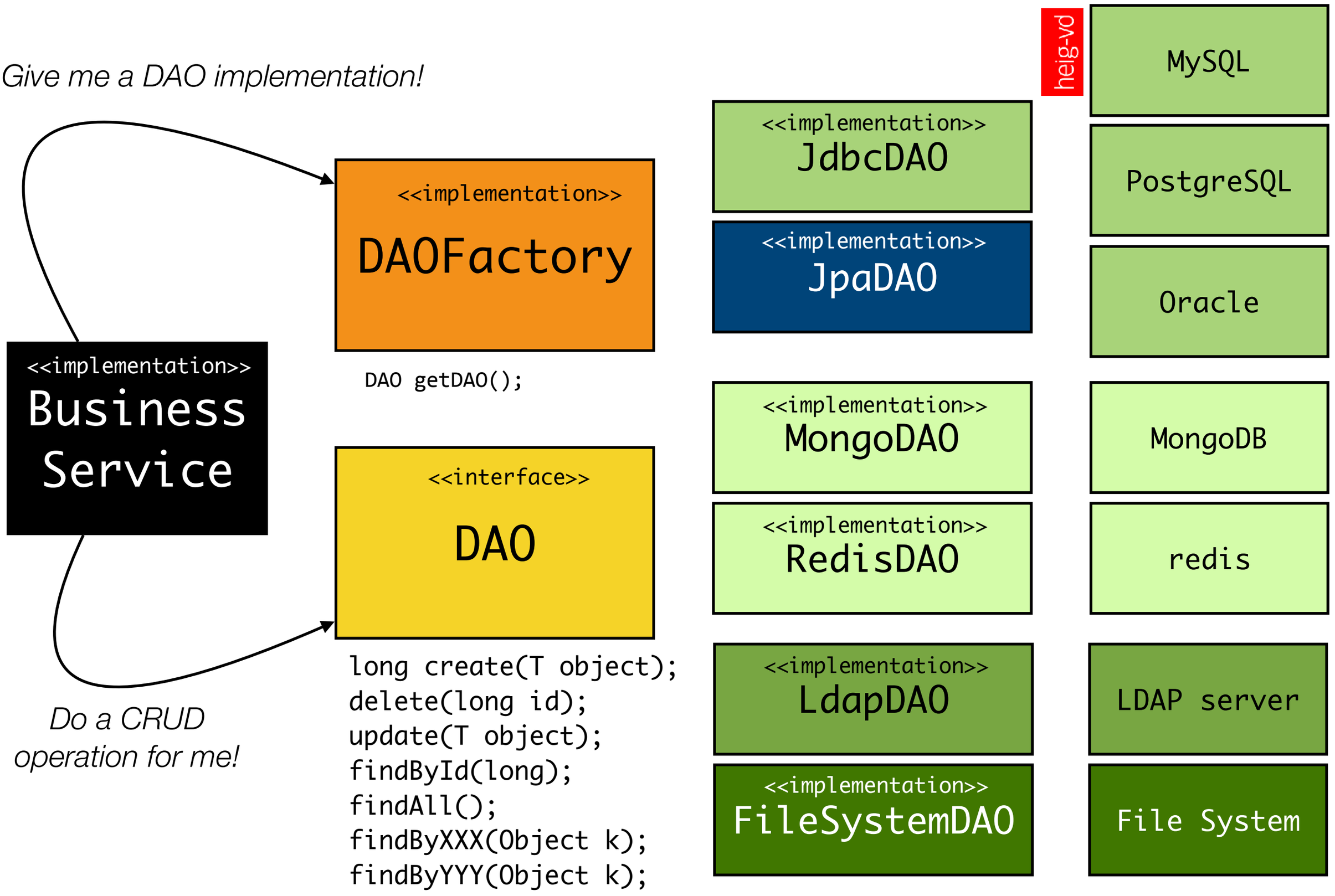


*The **Business Service** uses the DAO interface to interact with a particular DAO implementation*

***DAO implementations** handle interactions with specific data stores*



Give me a DAO implementation!



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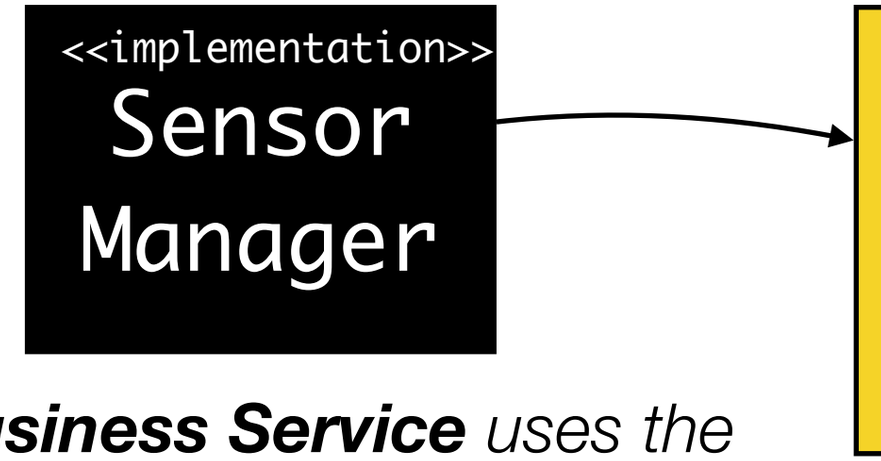
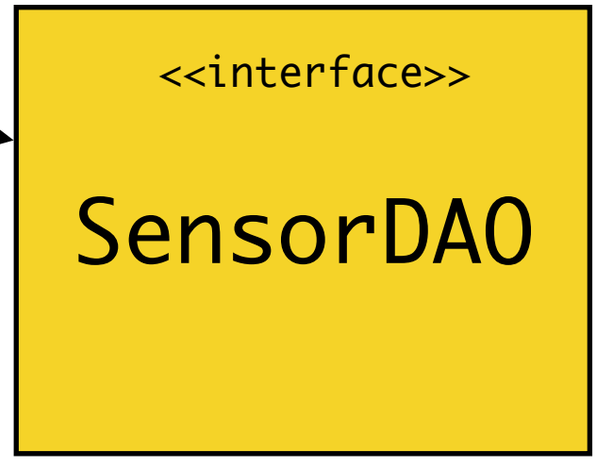
*The **DAO interface** defines generic **CRUD** operations and **finder** methods*

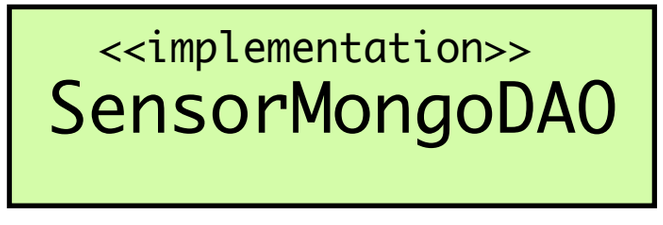


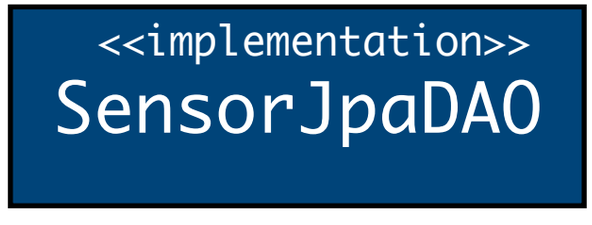


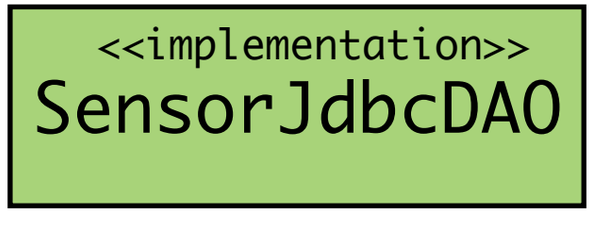

```
long create(Sensor s);
delete(long id);
update(T object);
findById(long);
findAll();
findByLocation(Location l);
findByType(SensorType t);
```

*The **Business Service** uses the DAO interface to interact with a particular DAO implementation*

***DAO implementations** handle interactions with specific data stores*



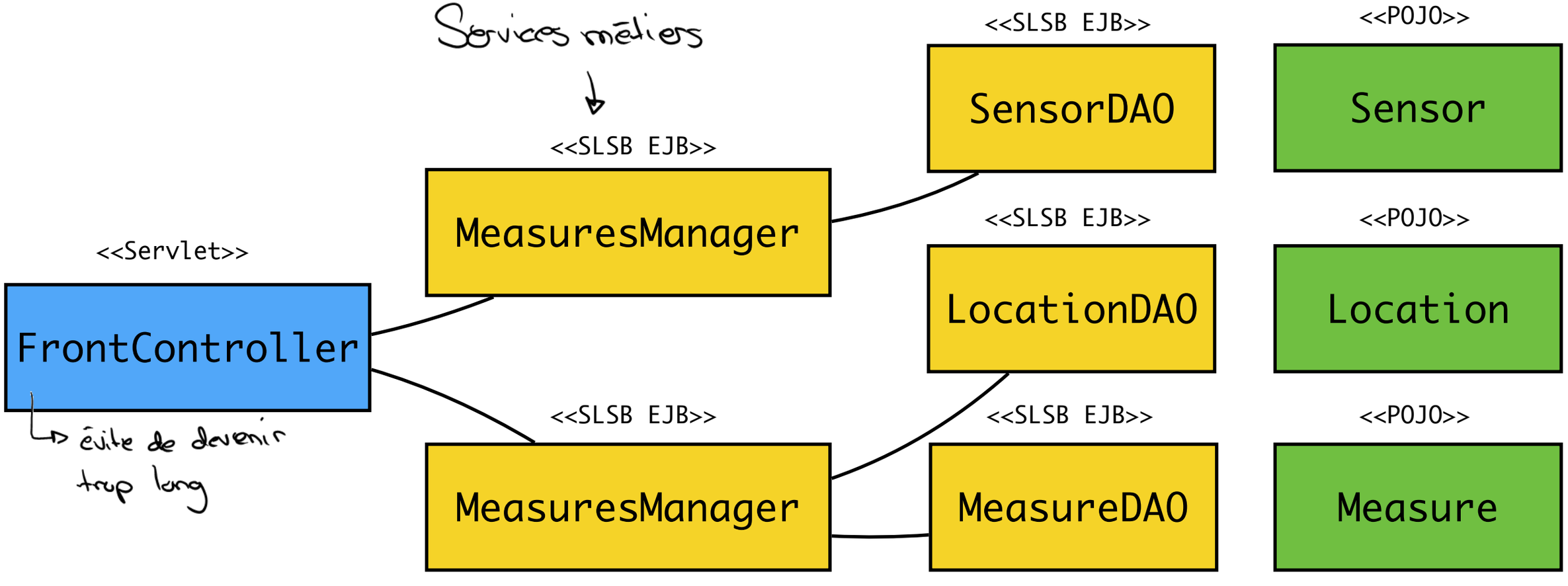




How do I implement the DAO pattern with Java EE technologies?

Permet d'éviter d'avoir un Controller trop long => compliqué à maintenir

- There are **different ways to do it**. Some frameworks (e.g. Spring) do that in the web tier (with POJOs).
- If you use **EJBs**, then your architecture is going to look like this:



Is it possible to have **two EJB classes** that implement the **same interface**?

- In the examples so far (and in most cases in practice), we have always created **one local interface** and **one stateless session bean class**.
- If we define the **DAO interface as a local interface** and implement two stateless session beans (JdbcDAO and JpaDAO), then we have an issue:

The **container is unable to resolve this dependency**, because there is more than one implementation. Which one should it choose?

```
public class MyServlet extends HttpServlet
{
  @EJB
  SensorDAOLocal sensorDAO;
}
```

```
@Local
public interface SensorDAOLocal {
  public long insert(Sensor sensor);
}
```

```
@Stateless
public class SensorJdbcDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

```
@Stateless
public class SensorJpaDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

Is it possible to have **two EJB classes** that implement the **same interface**?

- We can help the container by giving additional information in the annotation.
- If we define the **DAO interface as a local interface** and implement two stateless session beans (JdbcDAO and JpaDAO), then we have an issue:

The **name**, **beanName** and **mappedName** annotation attributes have different purposes.

```
public class MyServlet extends HttpServlet {
  @EJB(beanName="SensorJdbcDAO")
  SensorDAOLocal sensorDAO;
}
```

```
@Local
public interface SensorDAOLocal {
  public long insert(Sensor sensor);
}
```

```
@Stateless
public class SensorJdbcDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

```
@Stateless
public class SensorJpaDAO {
          implements SensorDAOLocal
  public long insert(Sensor sensor){}
}
```

DAO in the (**legacy**) MVCDemo Project

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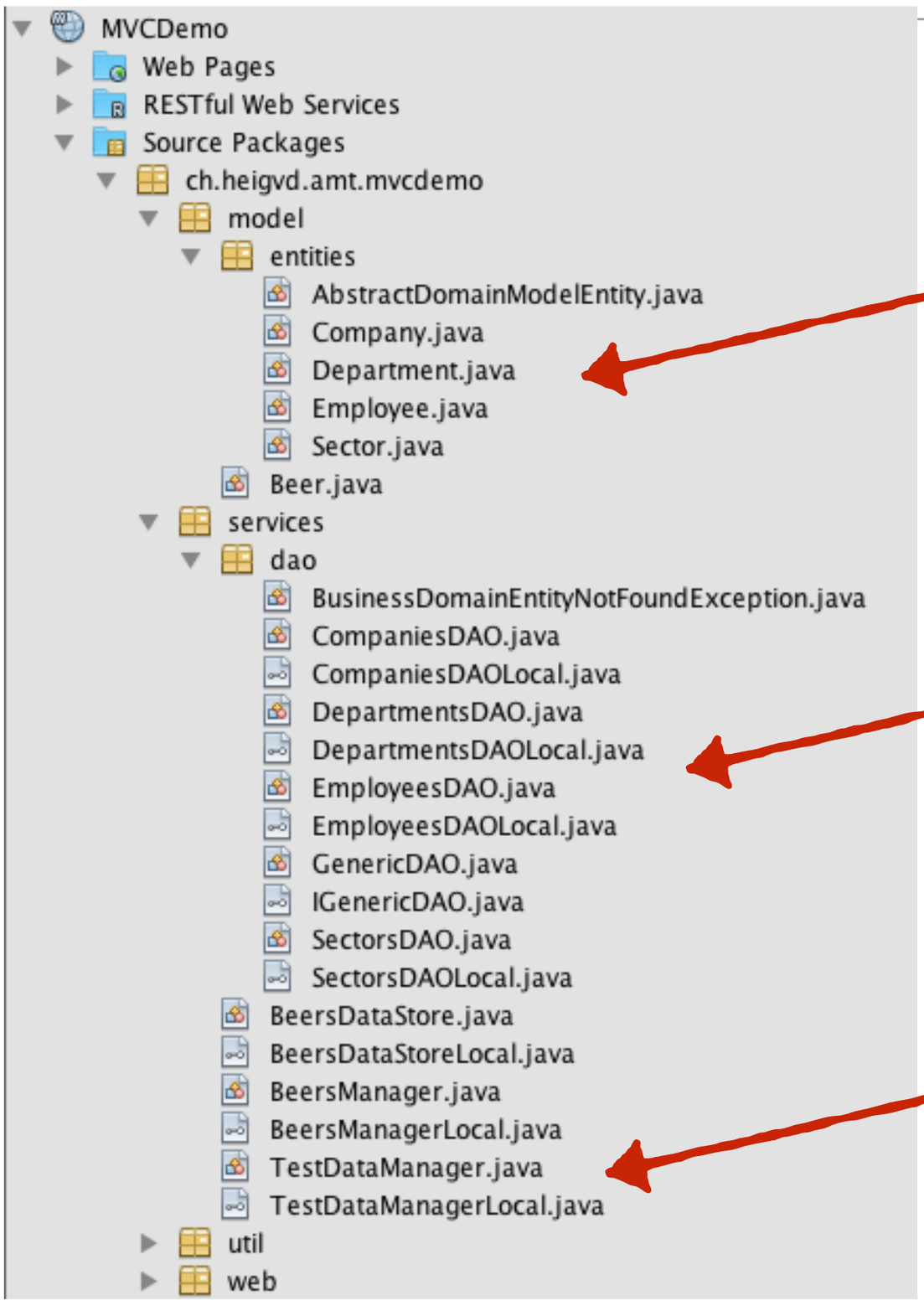
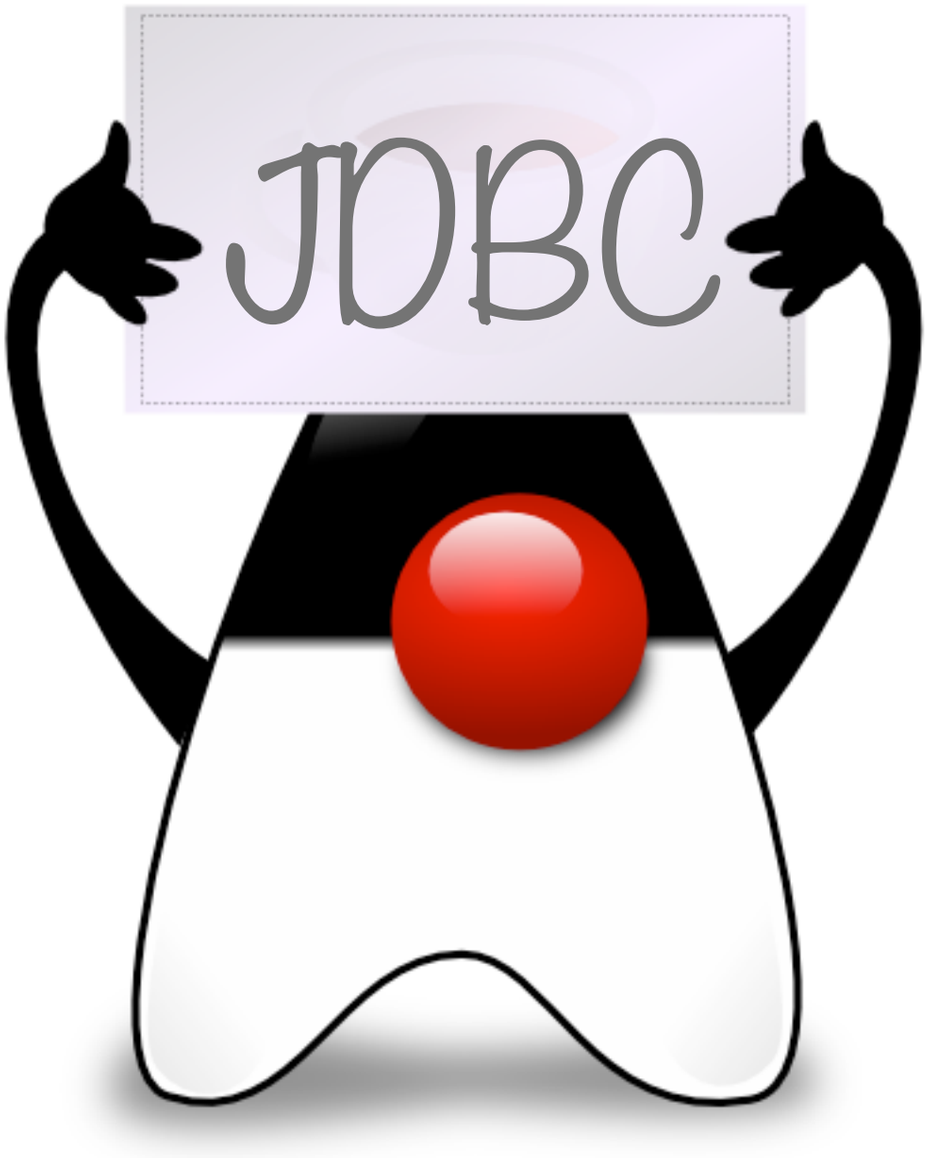


These are the model classes, which can be used with different DAO implementations

These are the DAOs. We only have one implementation, based on JPA.

We use the DAOs to generate test data



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DAO restent utiles avec JDBC

Java DataBase Connectivity

What is **JDBC**?

=> Une API Java

- The **Java DataBase Connectivity** is a specification that defines how applications can interact with **relational database** management systems in a **standard way**.
- Its goal is to **create an abstraction layer** between applications and specific RDBMS (MySQL, Oracle, PostgresSQL, DB2, etc.).
- Through this abstraction layer, applications can **submit SQL queries to read**, **insert**, **update** and **delete** records in tables.
- Applications can also get **metadata** about the relational schema (table names, column names, etc.).

What does it look like?

```
@Stateless
public class SensorJdbcDAO implements SensorDAOLocal {

  @Resource(lookup = "jdbc/AMTDatabase")
  private DataSource dataSource;

 public List<Sensor> findAll() {
    List<Sensor> result = new LinkedList<>();
    try {
      Connection con = dataSource.getConnection();

    PreparedStatement ps = con.prepareStatement("SELECT * FROM Sensors");
    ResultSet rs = ps.executeQuery();

    while (rs.next()) {
      Sensor sensor = new Sensor();
      sensor.setId(rs.getLong("ID"));
      sensor.setDescription(rs.getString("DESCRIPTION"));
      sensor.setType(rs.getString("TYPE"));
      result.add(sensor);
    }

    ps.close();
    con.close();

  } catch (SQLException ex) {
    Logger.getLogger(SensorJdbcDAO.class.getName()).log(Level.SEVERE, null, ex);
  }
  return result;
}
```

dependency injection

↳ On en aura besoin !

get a connection from the pool

create and submit a SQL query

scroll through the tabular result set

get data from the result set

le socket n'est pas fermé

return the connection to the pool

What is **JDBC**?

JDBC API

`java[x].sql.*` interfaces

JDBC Service (provided by JRE)

`java[x].sql.*` classes

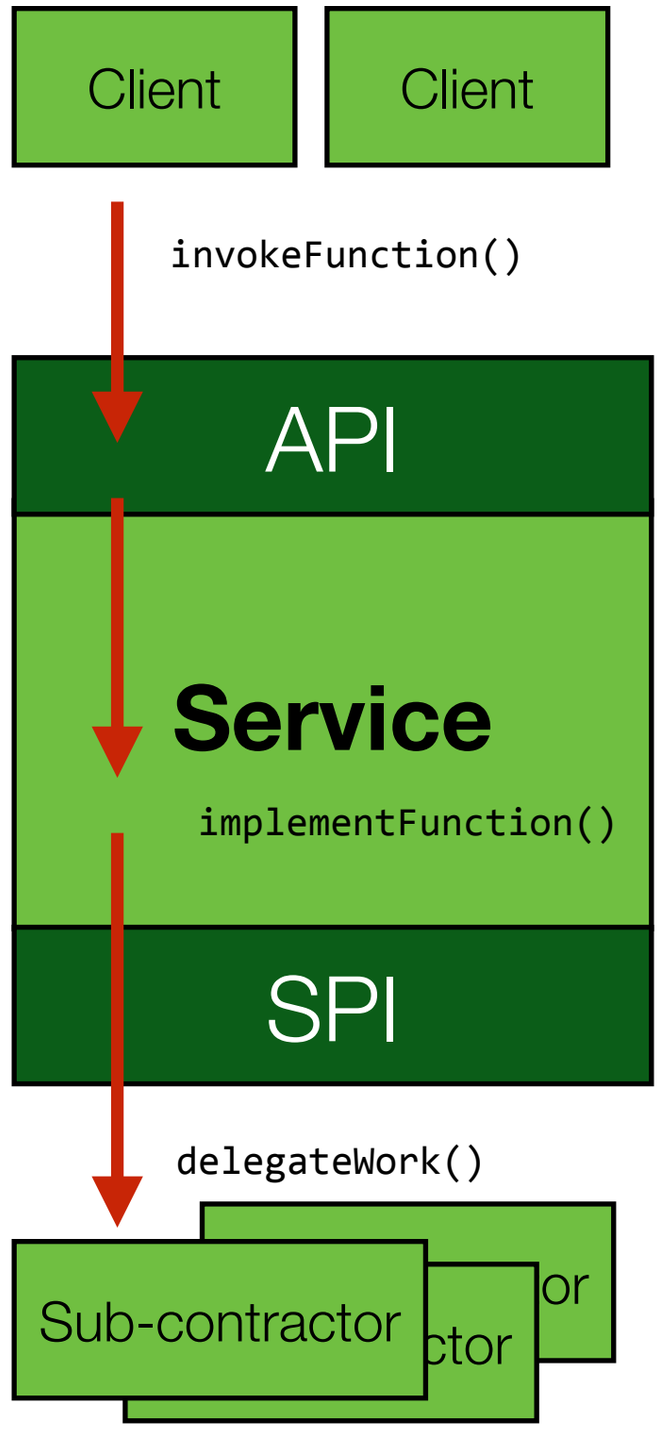
JDBC SPI (extends JDBC API)

JDBC MySQL driver

implements `java[x].sql.*` interfaces

What is the difference between an **API** and a **SPI**?

- An **Application Programming Interface** (API) is a **contract** between a client and a service.
- It **defines what the client can request** from the service.
- A **Service Provider API** (SPI) is a contract between a service and its **subcontractors** (components to which it delegates some of the work).
- It **defines what the subcontractors need to do** in order to receive work from the service.



What is the difference between an **API** and a **SPI**?

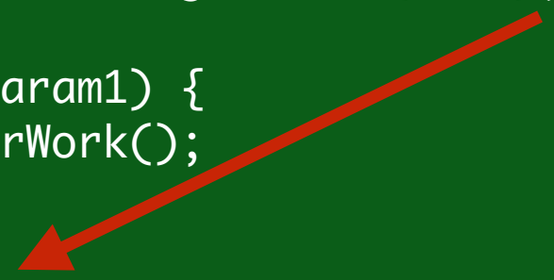
```
public interface ServiceAPI {
  public void invokeFunction1();
  public String invokeFunction2(Object param1);
}
```

```
public class Service implements ServiceAPI {
  private ServiceSPI provider;

  public void invokeFunction1() { provider.delegateWork(null); };

  public String invokeFunction2(Object param1) {
    doSomething(); provider.delegateOtherWork();
  }

  public void registerServiceProvider(ServiceSPI provider) {
    this.provider = provider
  }
}
```



```
public interface ServiceSPI {
  public void delegateWork(String[] params);
  public void delegateOtherWork();
  public void doSomething();
}
```

In some cases, the SPI is an **extension** of the API.

```
public interface ServiceAPI {
  public void invokeFunction1();
  public String invokeFunction2(Object param1);
}
```

```
public class Service implements ServiceAPI {
  private ServiceSPI provider;

  public void invokeFunction1() { provider.invokeFunction1(); };

  public String invokeFunction2(Object param1) {
    provider.invokeFunction2(param1); provider.doSomethingNotExposedInAPI();
  }

  public void registerServiceProvider(ServiceSPI provider) {
    this.provider = provider
  }
}
```

```
public interface ServiceSPI extends ServiceAPI {
  public void doSomethingNotExposedInAPI();
}
```

How is it possible to **obtain a reference** to a JDBC service provider (driver)?

- At some point, the application wants to **obtain a reference to a specific provider**, so that that it can invoke JDBC functions.
- The method depends on the Java environment. You do not the same thing if you are in a **Java SE** or **Java EE** environment.

Java SE

`java.sql.DriverManager`

*Think "**explicit** class loading and connection URLs"*

Java EE

`java.sql.DataSource`

*Think "**managed** resources and "dependency injection"*

How do I **obtain a reference** to a JDBC service provider in **Java SE**?

- In Java SE, the **DriverManager** class addresses this need:
  - It is used by clients who use the API.
  - It is also used by drivers who implement the SPI.
- Think of it as a **broker**, or a **registry**, who puts clients and service providers in relation.
- As a client, I am **explicitly** loading JDBC drivers (1 or more).
- As a client, I am **explicitly** telling with which database I want to interact (via a URL). The URL is used both to find a proper driver and to establish a connection (e.g. hostname, port, etc.).

How do I **obtain a reference** to a JDBC service provider in **Java SE**?

- From the specifications: “Key `DriverManager` methods include:

1. A service provider registers itself in the directory.

  - `registerDriver` — this method **adds a driver to the set of available drivers** and is invoked implicitly when the driver is loaded. The registerDriver method is typically called by the static initializer provided **by each driver**.

Used by **SPI** implementations

  - `getConnection` — the method the **JDBC client** invokes to establish a connection. The invocation includes a JDBC URL, which the `DriverManager` passes to each driver in its list until it finds one whose `Driver.connect` method recognizes the URL. That driver returns a `Connection` object to the `DriverManager`, which in turn passes it to the application.”

Used by **API** clients

2. A client looks for a service provider in the directory.

How do I **obtain a reference** to a JDBC service provider in **Java SE**?

Client

```
Class.forName("ch.heigdb.HeigDbDriver");
DriverManager.getConnection("jdbc:heigdb://localhost:2205");
```

JDBC Service (provided by JRE)

```
java.sql.DriverManager
registerDriver(Driver driver)
Connection getConnection(String url)
```

JDBC HeigDB driver

```
public class HeigDbDriver implements java.sql.Driver {

    static {
        DriverManager.registerDriver(new HeigDBDriver());
    }
    public boolean acceptsURL(String url) {};
    public Connection connect(String url, Properties p) {};
}
```

1. Load a class
2. "I am an SPI provider"
3. "Find a SPI provider that will connect me to this DB"
4. "Can you connect me with this DB?"
5. "Connect me with this DB"

How do I **obtain a reference** to a JDBC service provider in **Java EE**?

- In Java EE, the **DataSource** interface is used for managing DB connections.
  - It is used by **application components** (servlets, EJBs, etc.) to obtain a connection to a database.
  - It is also used by **system administrators**, who define the **mapping** between a logical data source name and a concrete database system (by configuration).
- As a developer, I am only using a logical name and I know that it will be bound to a specific system at runtime (but I don't care which…).
- As a developer, I obtain a DataSource either by doing a **JNDI lookup** or via **dependency injection** (with annotations).

How do I **obtain a reference** to a JDBC service provider in **Java EE**?

Client

```
Context ctx = new InitialContext();
DataSource ds = (DataSource)ctx.lookup("jdbc/theAppDatabase");
```

OR

3
```
@Resource(lookup="jdbc/theAppDatabase")
DataSource ds;
```

4
```
ds.getConnection();
```

JDBC Service (provided by Java EE)

`java.sql.DataSource`

mysql-connector-java-5.1.33.jar

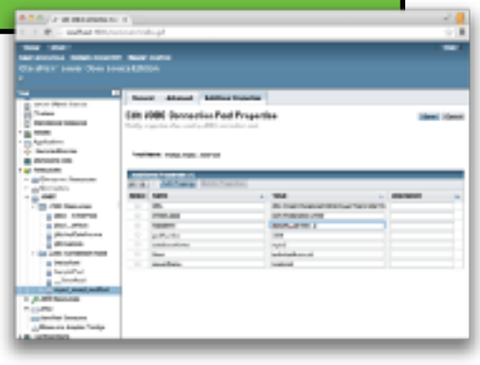
1

Install a **driver** (.jar file) in the app server (/lib/)

2

Create a (logical) data source…

3



… and map it to a (physical) connection pool

Edit JDBC Resource

localhost:4848/common/index.jsf

Home | About... | Help

User: anonymous | **Domain:** domainAMT | **Server:** localhost

GlassFish™ Server Open Source Edition

Tree

- server (Admin Server)
- Clusters
- Standalone Instances
- Nodes
- Applications
- Lifecycle Modules
- Monitoring Data
- Resources
  - Concurrent Resources
  - Connectors
  - JDBC
    - JDBC Resources
      - jdbc/__TimerPool
      - jdbc/__default
      - jdbc/myDataSource
      - jdbc/sample
    - JDBC Connection Pools
      - DerbyPool
      - SamplePool
      - __TimerPool
      - mysql_mysql_rootPool
  - JMS Resources
  - JNDI
  - JavaMail Sessions
  - Resource Adapter Configs
- Configurations

Edit JDBC Resource

Save | Cancel

Edit an existing JDBC data source.

Load Defaults

JNDI Name: jdbc/myDataSource

Pool Name: mysql_mysql_rootPool

Use the JDBC Connection Pools page to create new pools

Deployment Order: 100

Specifies the loading order of the resource at server startup. Lower numbers are loaded first.

Description:

Status: Enabled

Additional Properties (0)

Add Property | Delete Properties

Select	Name	Value	Description
No items found.			

A **JDBC Resource** simply defines a **mapping** between a **logical name** (used in the code) and a **concrete DB connection pool** (hooked to a “physical” DB).

Edit JDBC Connection Pool

localhost:4848/common/index.jsf

Home | About... | Help

User: anonymous | **Domain:** domainAMT | **Server:** localhost

GlassFish™ Server Open Source Edition

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      - __TimerPool
      - mysql_mysql_rootPool
  - JMS Resources
  - JNDI
  - JavaMail Sessions
  - Resource Adapter Configs
- Configurations

General | **Advanced** | **Additional Properties**

Edit JDBC Connection Pool Properties

Save | Cancel

Modify properties of an existing JDBC connection pool.

Pool Name: mysql_mysql_rootPool

Additional Properties (7)

Add Property | Delete Properties

Select	Name	Value	Description
	URL	jdbc:mysql://localhost:3306/mysql?zeroDateTin	
	driverClass	com.mysql.jdbc.Driver	
	Password	akAUKLJdf!!882_2	
	portNumber	3306	
	databaseName	mysql	
	User	technicalAccount	
	serverName	localhost	

The **connection pool** is configured with “physical” database attributes (host, port, credentials, etc.).

What are some of the key JDBC interfaces and classes?

DriverManager

DataSource

XADataSource

Connection

PreparedStatement

ResultSet

ResultSetMetaData

- **`DriverManager`** and **`DataSource`** variations provide a means to obtain a **`Connection`**.
- **`XADataSource`** is used for distributed transactions.
- Once you have a **`Connection`**, you can submit SQL queries to the database.
- The most common way to do that is to create a **`PreparedStatement`** (rather than a **`Statement`**, which is useful for DDL commands).
- The response is either a number (number of rows modified by an UPDATE or DELETE query), or a **`ResultSet`** (which is a tabular data set).
- **`ResultSetMetadata`** is a way to obtain information about the returned data set (column names, etc.).

How do I use these classes in my code?

```
@Stateless
public class SensorJdbcDAO implements SensorDAOLocal {

  @Resource(lookup = "jdbc/AMTDatabase")
  private DataSource dataSource;

 public List<Sensor> findAll() {
    List<Sensor> result = new LinkedList<>();
    try {
      Connection con = dataSource.getConnection();

    PreparedStatement ps = con.prepareStatement("SELECT * FROM Sensors");
    ResultSet rs = ps.executeQuery();

    while (rs.next()) {
      Sensor sensor = new Sensor();
      sensor.setId(rs.getLong("ID"));
      sensor.setDescription(rs.getString("DESCRIPTION"));
      sensor.setType(rs.getString("TYPE"));
      result.add(sensor);
    }

    ps.close();
    con.close();

  } catch (SQLException ex) {
    Logger.getLogger(SensorJdbcDAO.class.getName()).log(Level.SEVERE, null, ex);
  }
  return result;
}
```

dependency injection

get a connection from the pool

create and submit a SQL query

scroll through the tabular result set

get data from the result set

return the connection to the pool

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JDBC with Open Liberty

TL;DR: "repository" is another name for "DAO"

Long story: start with https://martinfowler.com/eaaCatalog/repository.html
https://www.baeldung.com/java-dao-vs-repository, and dig into DDD

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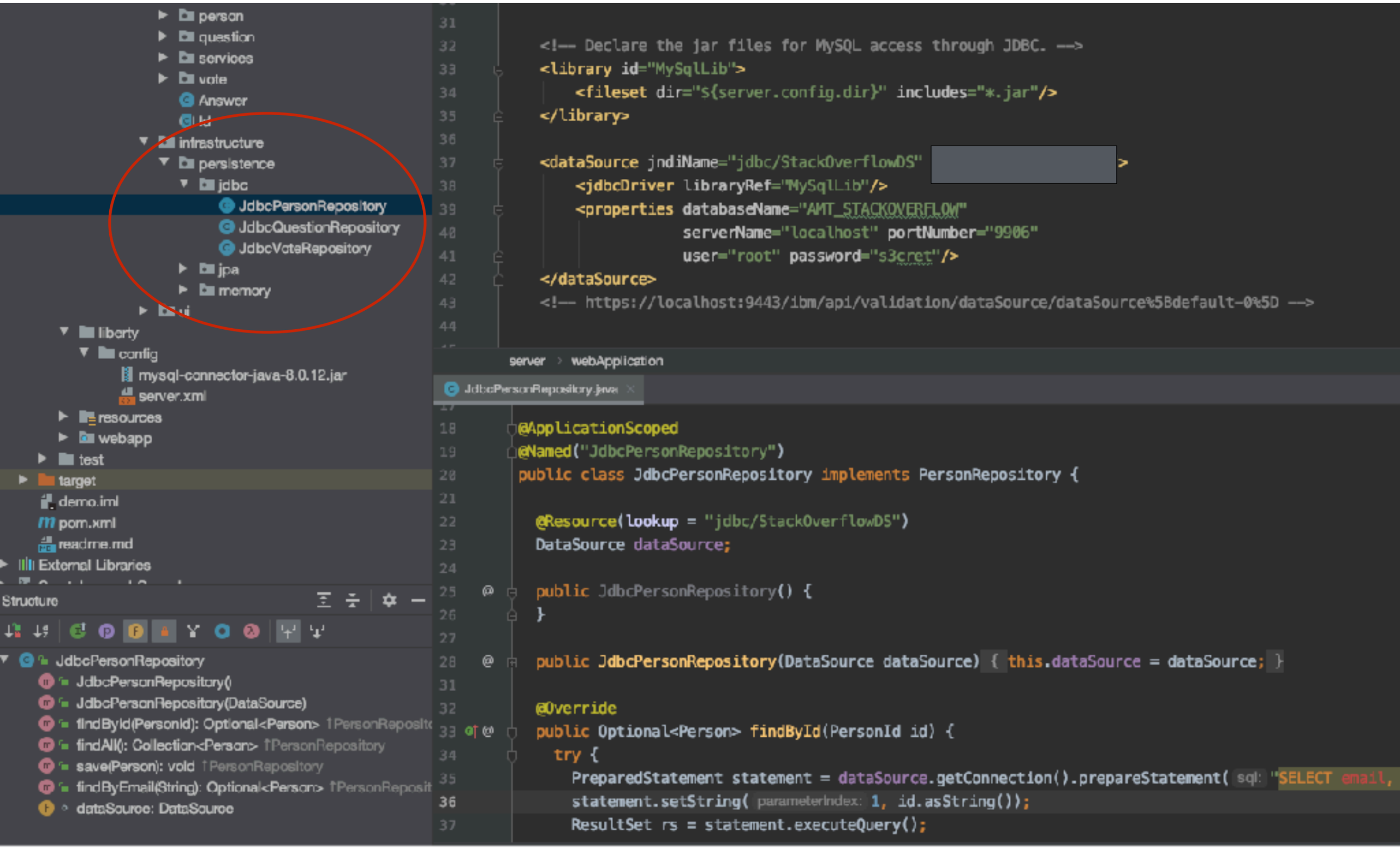

Install a driver and define a data source

When you download the MySQL driver, pay attention to the version that you get. Remember that version when you dig into detailed documentation.

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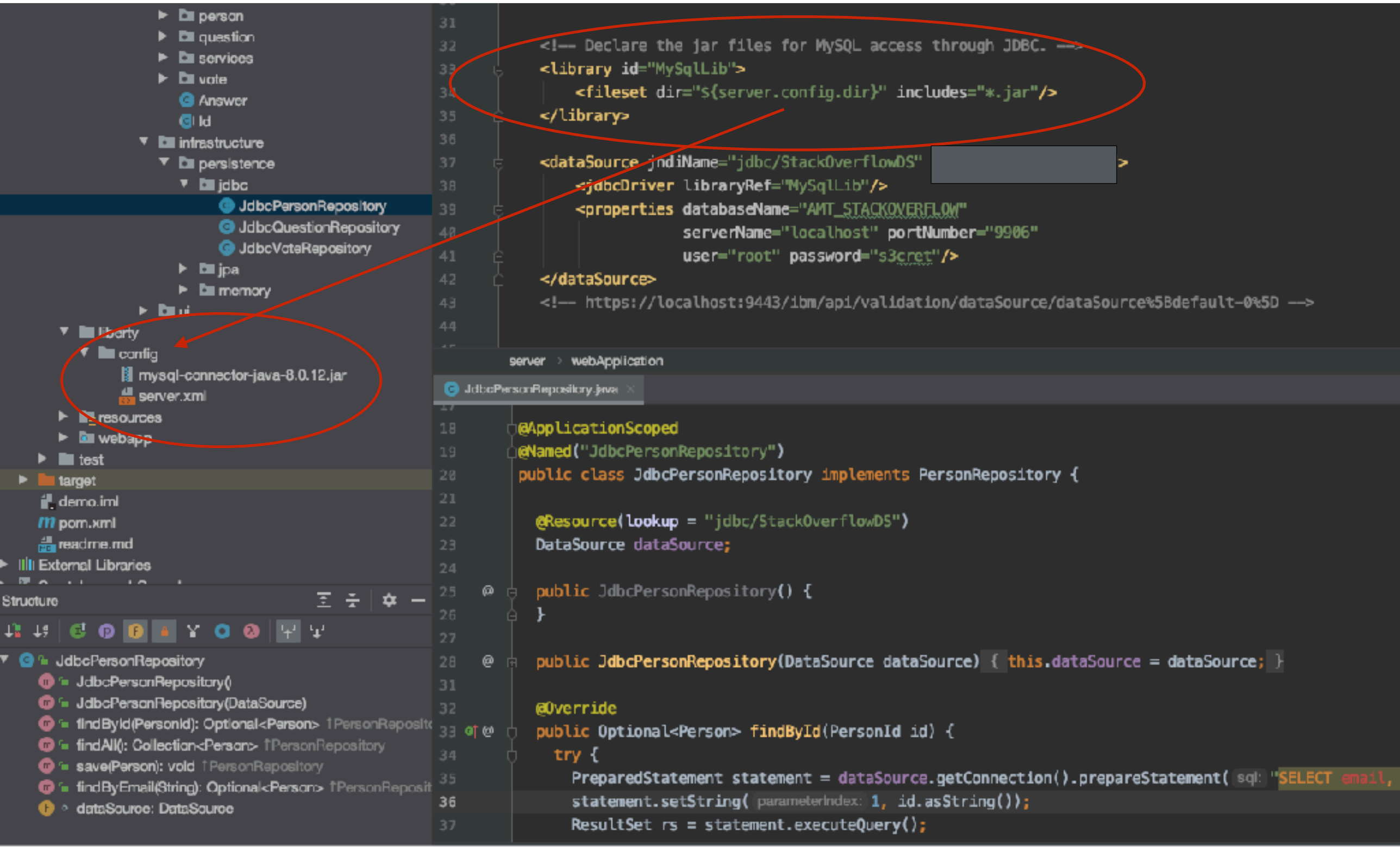

Define a data source

Ouch… credentials hard-coded in a the code base. See https://openliberty.io/docs/20.0.0.10/reference/config/server-configuration-overview.html and look for environment variables

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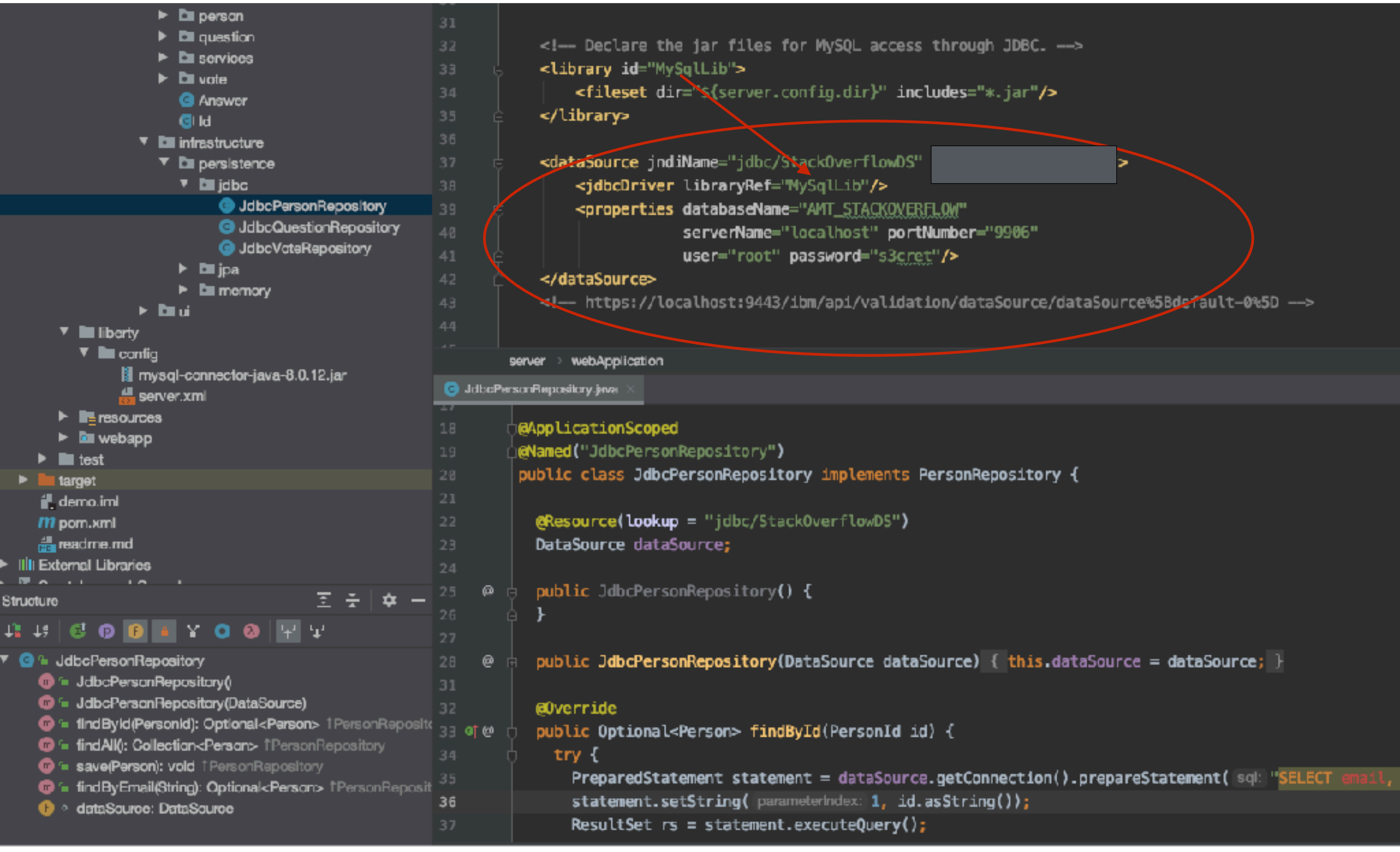

Define a data source

This assumes that you have a MySQL accessible via the loopback interface and port 9906 (instead of 3306). In this setup, it runs in a Docker topology.

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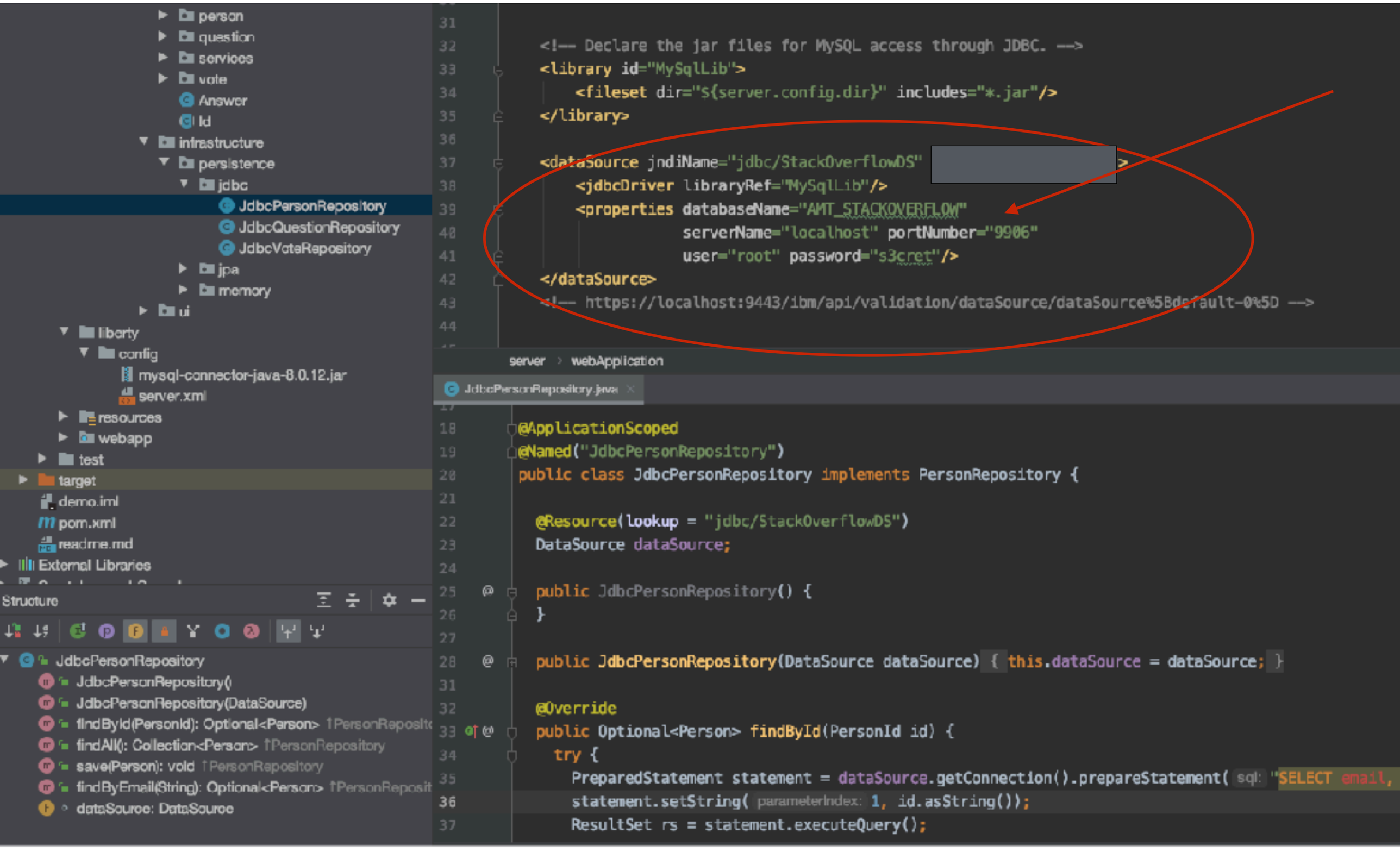

Inject the data source in your code

@Resource works in a similar way as @EJB last week: the container injects a reference to the connection pool into the dataSource variable

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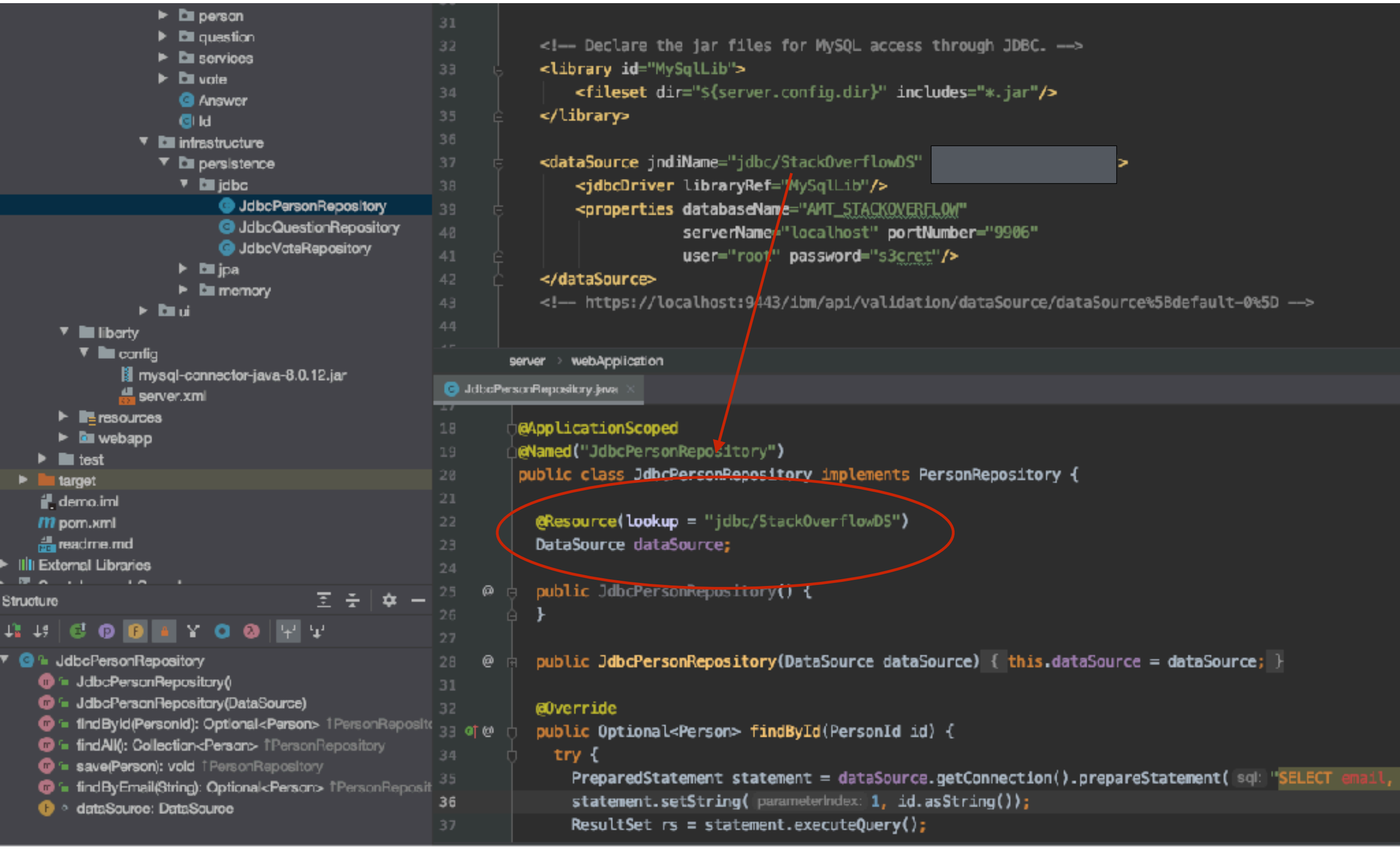

Use the data source

Warning: you need to call **close** on the dataSource (it will actually not be closed, but rather returned into the pool). So use a variable instead of this half-baked code.

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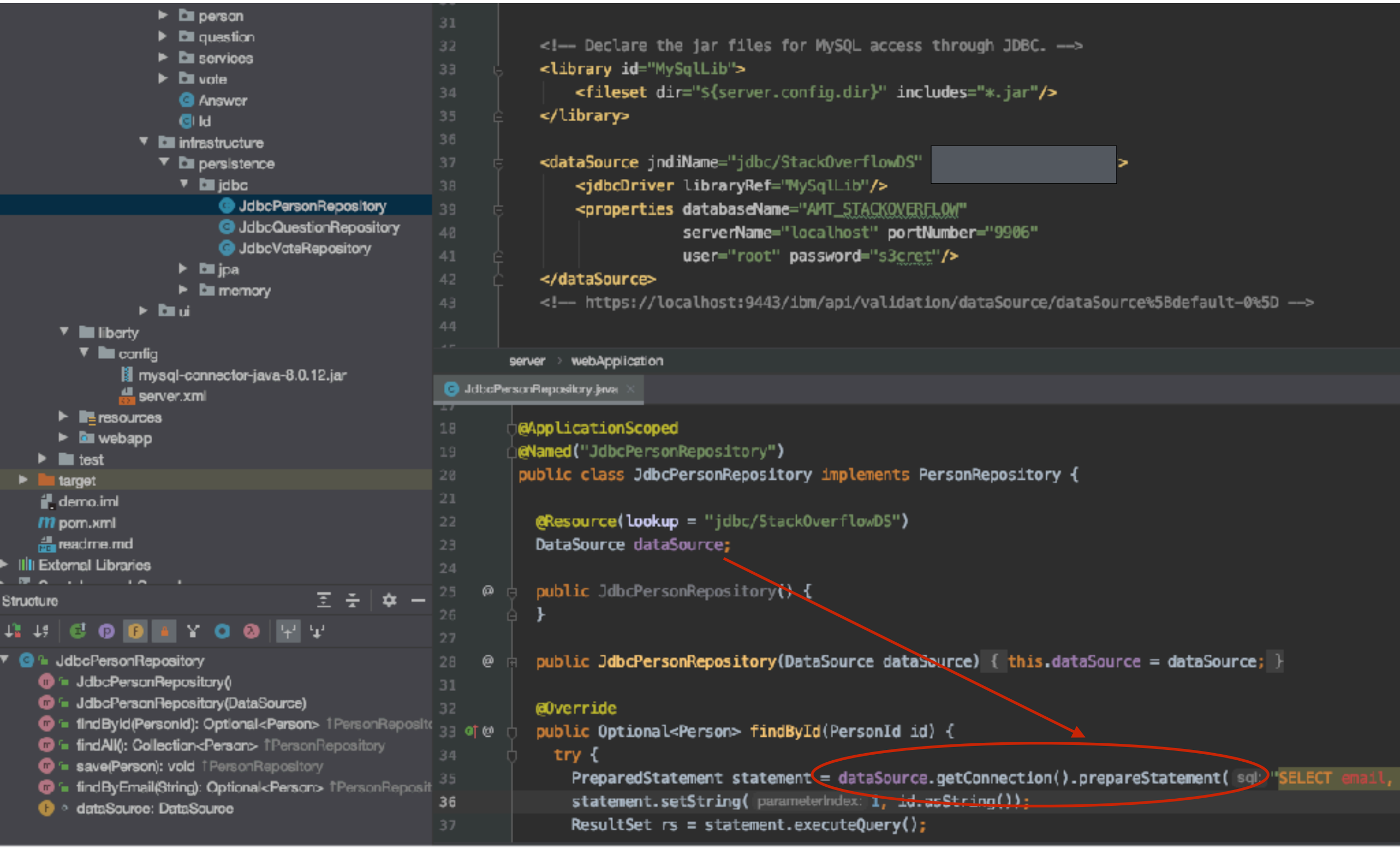

Side note: dependency injection with CDI 2.0

We have seen @Singleton and @Stateless to define managed components (EJB). @ApplicationScoped does the same thing, with a more general API provided by Java EE: CDI. @Inject is used instead of @EJB.

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