jOOQ Workshop

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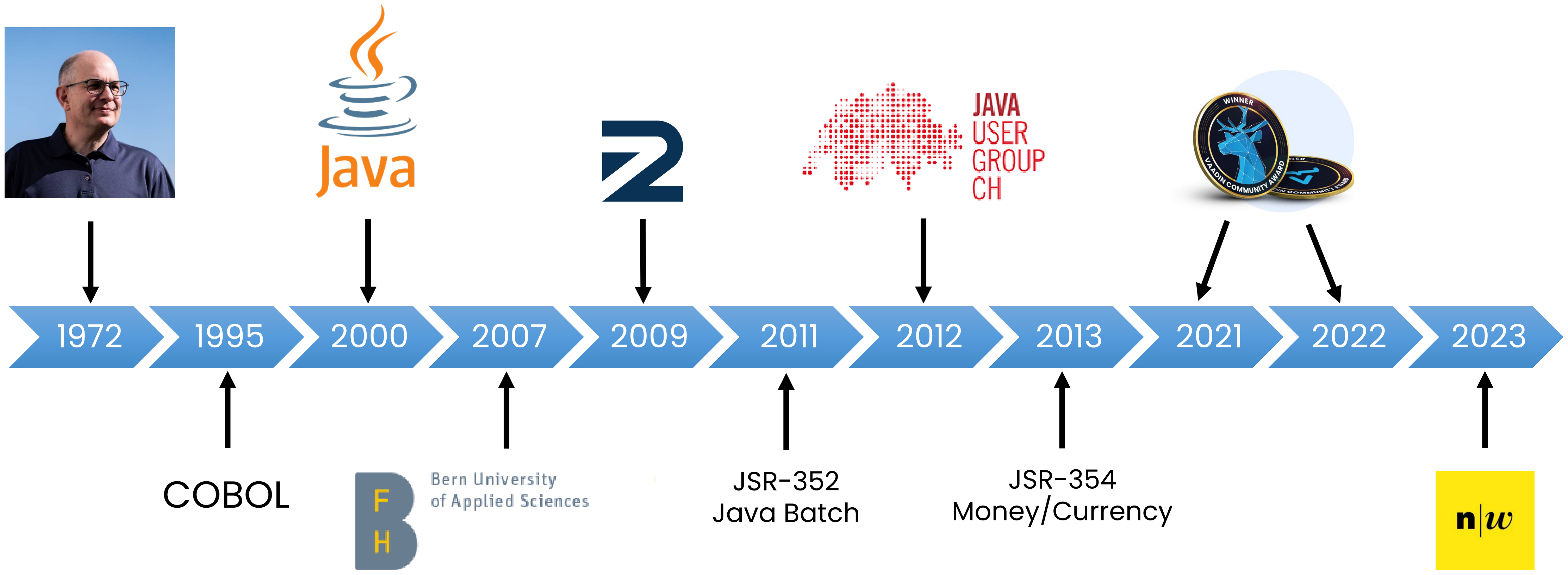
About me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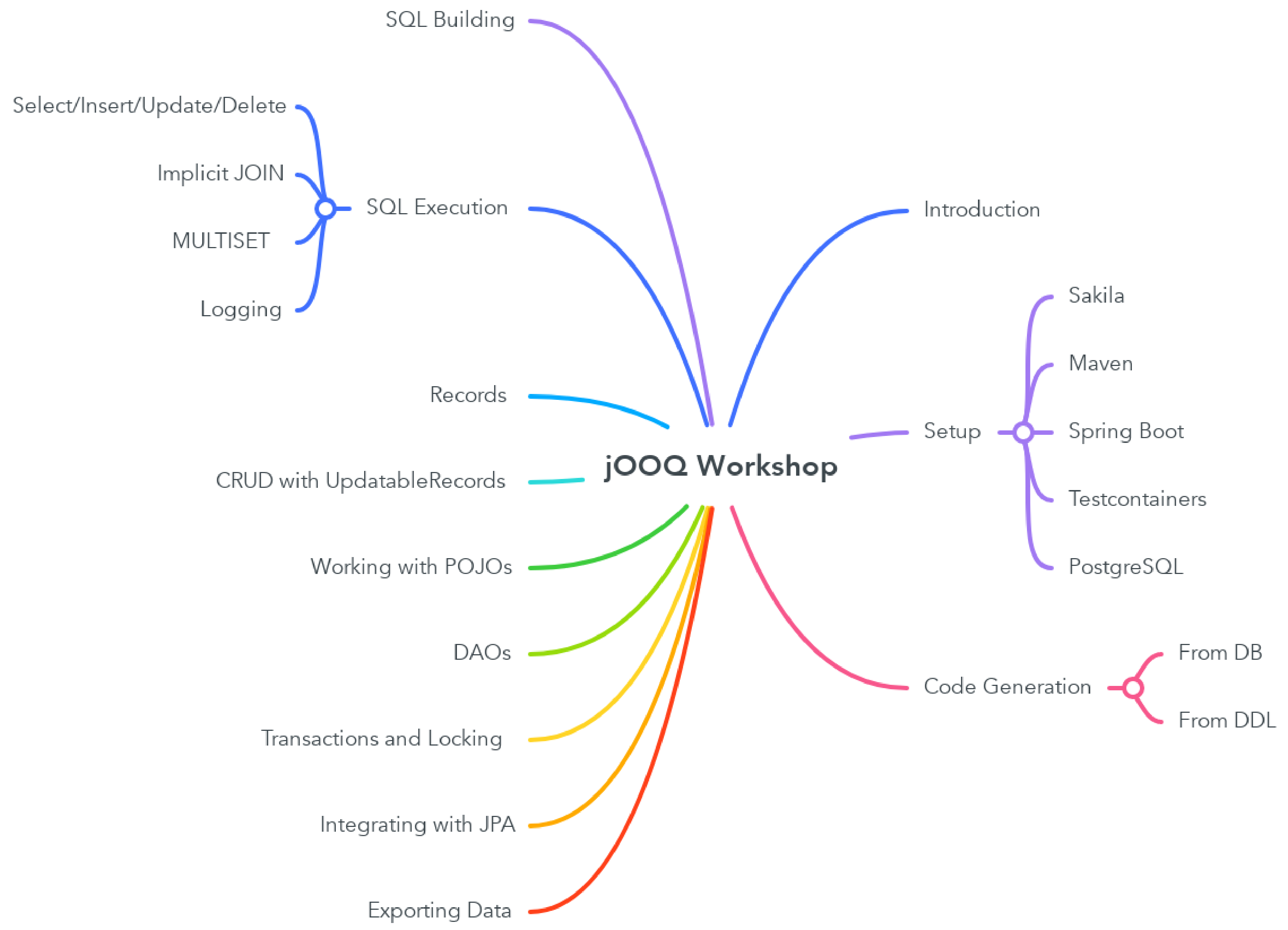
About you

- What’s your name?
- What’s your day job?
- Did you ever use jOOQ?
- Are you using JPA/Hibernate, QueryDSL or MyBatis?
- What are your expectations?


jOOQ Workshop
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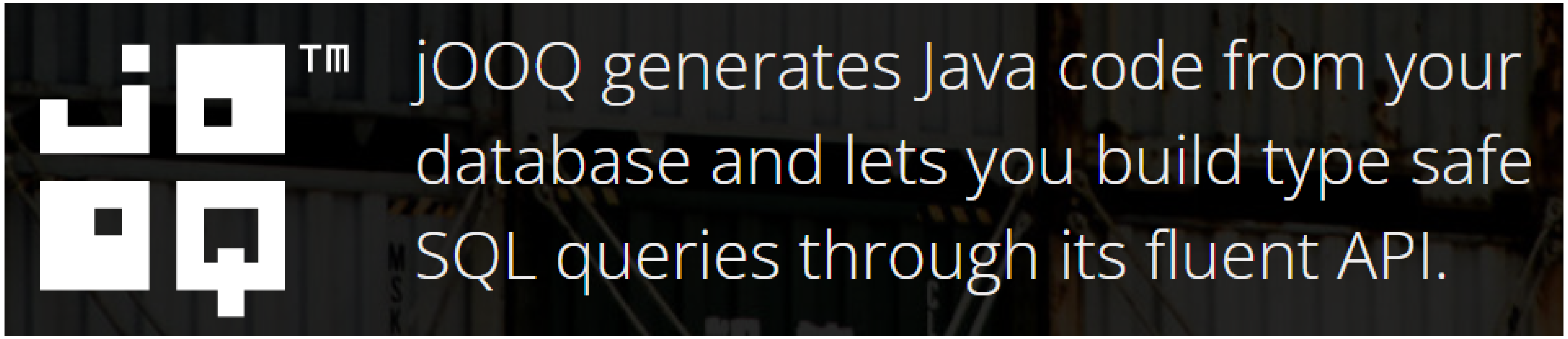


jOOQ generates Java code from your database and lets you build type safe SQL queries through its fluent API.

Introduction

Why jOOQ?

SQL was never meant to be abstracted. To be confined in the narrow boundaries of heavy mappers, hiding the beauty and simplicity of relational data.
SQL was never meant to be object-oriented.
SQL was never meant to be anything other than... SQL!

- Lukas Eder

Use Cases

- Type-safe database object referencing through generated artifacts
- Type-safe SQL construction / SQL building through a complete querying DSL API modeling SQL as a domain-specific language in Java
- Convenient query execution through an improved API for result fetching
- SQL dialect abstraction and SQL clause emulation to improve cross-database compatibility and to enable missing features in simpler databases

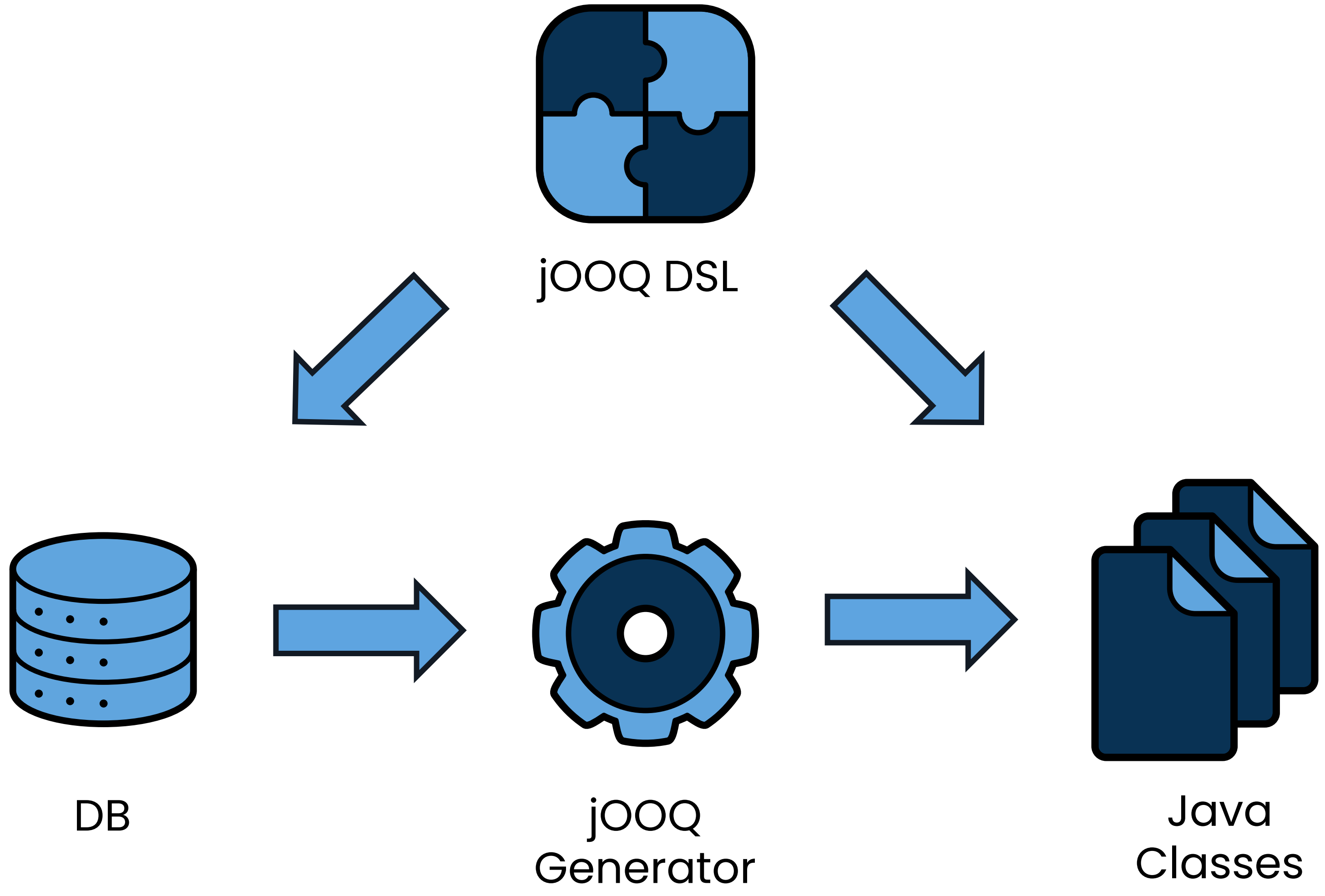
Scenarios

- Using Hibernate for 70% of the queries (i.e. CRUD) and jOOQ for the remaining 30% where SQL is really needed
- Using jOOQ for SQL building and JDBC for SQL execution
- Using jOOQ for SQL building and Spring Data for SQL execution
- Using jOOQ without the source code generator to build the basis of a framework for dynamic SQL execution

Set-Based Thinking

- Most conceptual differences between JPA and jOOQ are not technology-specific, but a matter of how you think about your database interactions
- There are two approaches
  1. Working with entity state transitions
  2. Working with data set transformations
- Neither approach is "the best" one; both approaches are better suited to certain use cases
- https://www.jooq.org/doc/latest/manual/coming-from-jpa/

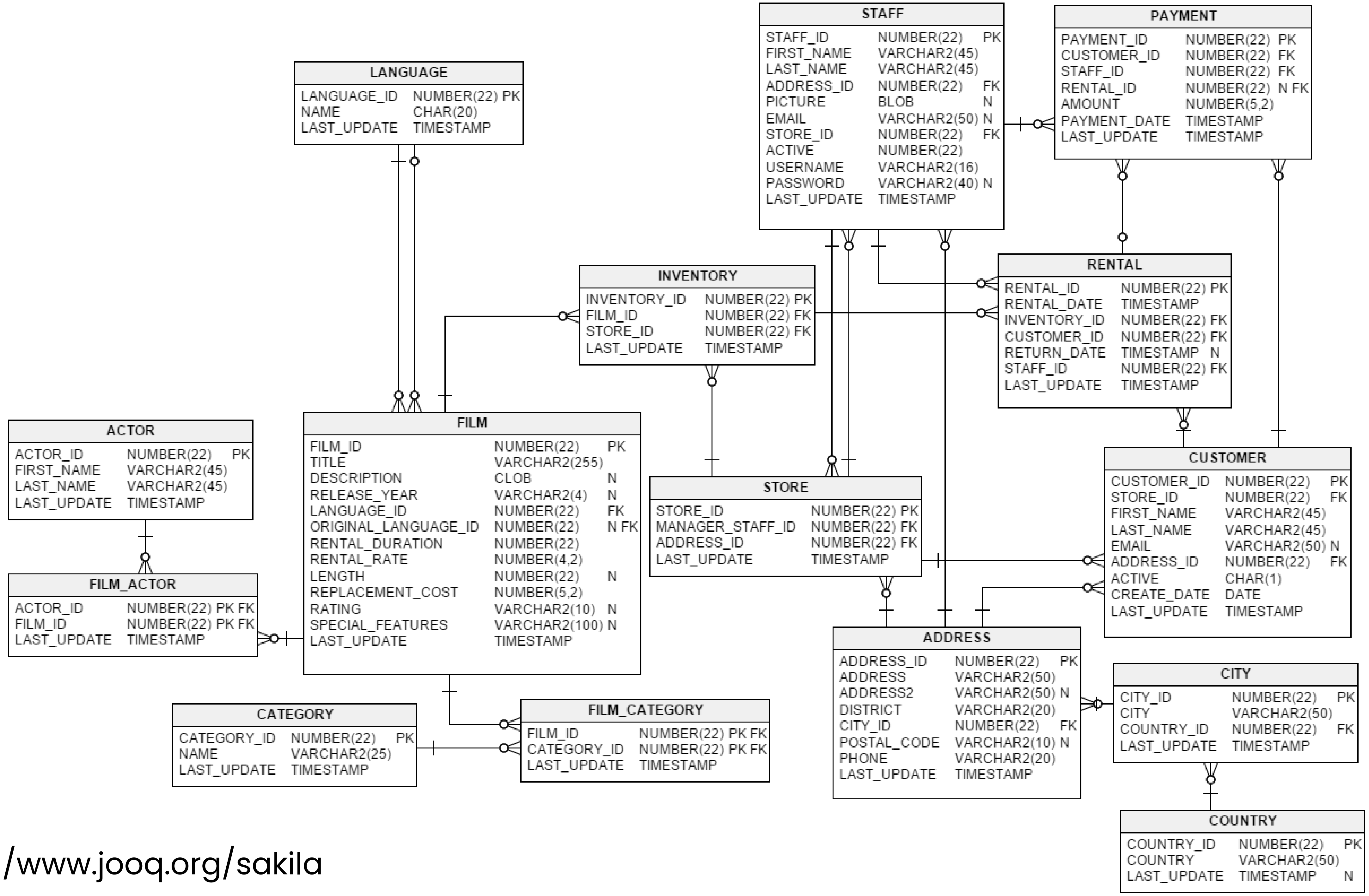
Architecture



Where to Start?

- https://jooq.org
- https://github.com/jOOQ/demo

Setup



LANGUAGE		
LANGUAGE_ID	NUMBER(22)	PK
NAME	CHAR(20)	
LAST_UPDATE	TIMESTAMP	

STAFF		
STAFF_ID	NUMBER(22)	PK
FIRST_NAME	VARCHAR2(45)	
LAST_NAME	VARCHAR2(45)	
ADDRESS_ID	NUMBER(22)	FK
PICTURE	BLOB	N
EMAIL	VARCHAR2(50)	N
STORE_ID	NUMBER(22)	FK
ACTIVE	NUMBER(22)	
USERNAME	VARCHAR2(16)	
PASSWORD	VARCHAR2(40)	N
LAST_UPDATE	TIMESTAMP	

PAYMENT		
PAYMENT_ID	NUMBER(22)	PK
CUSTOMER_ID	NUMBER(22)	FK
STAFF_ID	NUMBER(22)	FK
RENTAL_ID	NUMBER(22)	N FK
AMOUNT	NUMBER(5,2)	
PAYMENT_DATE	TIMESTAMP	
LAST_UPDATE	TIMESTAMP	

INVENTORY		
INVENTORY_ID	NUMBER(22)	PK
FILM_ID	NUMBER(22)	FK
STORE_ID	NUMBER(22)	FK
LAST_UPDATE	TIMESTAMP	

RENTAL		
RENTAL_ID	NUMBER(22)	PK
RENTAL_DATE	TIMESTAMP	
INVENTORY_ID	NUMBER(22)	FK
CUSTOMER_ID	NUMBER(22)	FK
RETURN_DATE	TIMESTAMP	N
STAFF_ID	NUMBER(22)	FK
LAST_UPDATE	TIMESTAMP	

ACTOR		
ACTOR_ID	NUMBER(22)	PK
FIRST_NAME	VARCHAR2(45)	
LAST_NAME	VARCHAR2(45)	
LAST_UPDATE	TIMESTAMP	

FILM		
FILM_ID	NUMBER(22)	PK
TITLE	VARCHAR2(255)	
DESCRIPTION	CLOB	N
RELEASE_YEAR	VARCHAR2(4)	N
LANGUAGE_ID	NUMBER(22)	FK
ORIGINAL_LANGUAGE_ID	NUMBER(22)	N FK
RENTAL_DURATION	NUMBER(22)	
RENTAL_RATE	NUMBER(4,2)	
LENGTH	NUMBER(22)	N
REPLACEMENT_COST	NUMBER(5,2)	
RATING	VARCHAR2(10)	N
SPECIAL_FEATURES	VARCHAR2(100)	N
LAST_UPDATE	TIMESTAMP	

STORE		
STORE_ID	NUMBER(22)	PK
MANAGER_STAFF_ID	NUMBER(22)	FK
ADDRESS_ID	NUMBER(22)	FK
LAST_UPDATE	TIMESTAMP	

CUSTOMER		
CUSTOMER_ID	NUMBER(22)	PK
STORE_ID	NUMBER(22)	FK
FIRST_NAME	VARCHAR2(45)	
LAST_NAME	VARCHAR2(45)	
EMAIL	VARCHAR2(50)	N
ADDRESS_ID	NUMBER(22)	FK
ACTIVE	CHAR(1)	
CREATE_DATE	DATE	
LAST_UPDATE	TIMESTAMP	

FILM_ACTOR		
ACTOR_ID	NUMBER(22)	PK FK
FILM_ID	NUMBER(22)	PK FK
LAST_UPDATE	TIMESTAMP	

ADDRESS		
ADDRESS_ID	NUMBER(22)	PK
ADDRESS	VARCHAR2(50)	
ADDRESS2	VARCHAR2(50)	N
DISTRICT	VARCHAR2(20)	
CITY_ID	NUMBER(22)	FK
POSTAL_CODE	VARCHAR2(10)	N
PHONE	VARCHAR2(20)	
LAST_UPDATE	TIMESTAMP	

CITY		
CITY_ID	NUMBER(22)	PK
CITY	VARCHAR2(50)	
COUNTRY_ID	NUMBER(22)	FK
LAST_UPDATE	TIMESTAMP	

CATEGORY		
CATEGORY_ID	NUMBER(22)	PK
NAME	VARCHAR2(25)	
LAST_UPDATE	TIMESTAMP	

FILM_CATEGORY		
FILM_ID	NUMBER(22)	PK FK
CATEGORY_ID	NUMBER(22)	PK FK
LAST_UPDATE	TIMESTAMP	

COUNTRY		
COUNTRY_ID	NUMBER(22)	PK
COUNTRY	VARCHAR2(50)	
LAST_UPDATE	TIMESTAMP	N

https://www.jooq.org/sakila

Tools

- Maven
- Spring Boot
- Testcontainers
- PostgreSQL

Testcontainers

- https://testcontainers.com/
- Lifecycle management https://testcontainers.com/guides/testcontainers-container-lifecycle/

Code Generation

https://www.jooq.org/doc/latest/manual/code-generation/

Why?

- **Increased IDE support**
  Type your Java code directly against your database schema, with all type information available

- **Type-safety**
  When your database schema changes, your generated code will also change, removing columns will lead to compilation errors, which you can detect early

From Where?

- jOOQ assumes your database already exists

- There are two option
  1. Real Database
     - Use all DB features
     - Use reference database or Testcontainers
  2. DDL scripts
     - Limited to “standard” SQL
     - Convenient because no running DB is needed

How?

- https://www.jooq.org/doc/latest/manual/code-generation/codegen-configuration/

Ex00: Get Familiar With the Project

- Inspect the project
  https://github.com/simasch/jooq-workshop

  1. pom.xml
  2. DDL Scripts

- Run

```
mvnw test
```

SQL Building

https://www.jooq.org/doc/latest/manual/sql-building/

The Query DSL Type

- Problem
  - SQL is a declarative language that is hard to integrate into procedural, object-oriented, functional, or any other programming language
- Solution
  - jOOQ integrates SQL as an "internal domain-specific language" directly into Java
  - SQL building is the main feature of jOOQ
  - All other features (such as SQL execution and code generation) are mere conveniences built on top of jOOQ’s SQL-building capabilities

The Static Query DSL API

- jOOQ exposes many interfaces and hides most implementation facts from client code. The reasons for this are:
  - Interface-driven design. This allows for modelling queries in a fluent API most efficiently
  - Reduction of complexity for client code.
  - API guarantee. You only depend on the exposed interfaces, not concrete (potentially dialect-specific) implementations.
- The `org.jooq.impl.DSL` class is the main class from where you will create all jOOQ objects. It is a static factory for table expressions, column expressions (or “fields”), conditional expressions, and many other QueryParts.

The DSLContext API

- https://www.jooq.org/doc/latest/manual/sql-building/dsl-context/

Settings

- https://www.jooq.org/doc/current/manual/sql-building/dsl-context/custom-settings/

```
@Configuration
public class JtafJooqConfiguration {

    @Bean
    Settings jooqSettings() {
        return new Settings()
                .withRenderNameCase(RenderNameCase.LOWER)
                .withRenderQuotedNames(RenderQuotedNames.NEVER);
    }
}
```

DSLContext Example

```
DSLContext dsl = DSL.using(connection, dialect);


Result<?> result = dsl
                  .select()
                  .from(BOOK)
                  .where(BOOK.TITLE.like("Animal%"))
                  .fetch();
```

JOIN

- “Regular” JOINS

```
join(FILM_ACTOR)
.on(FILM_ACTOR.ACTOR_ID.eq(ACTOR.ACTOR_ID))
```

- Implicit JOINS

```
select(FILM_ACTOR.actor().LAST_NAME)
```

Superpower MULTISET

- https://www.jooq.org/doc/current/manual/sql-building/column-expressions/multiset-value-constructor/

Ex01: Write Your First jOOQ Queries

- Create your very first jOOQ query that selects all Actors
  - Inspect the generated SQL statement
- Get all names of the Films, incl. the Language
  - Try the various JOINs incl. IMPLICIT JOIN
- List all Actors first and last name with their number of Films
- Evaluate MULTISET
  - Load the name of the Category and the name of the Film as nested element

SQL Execution

https://www.jooq.org/doc/latest/manual/sql-execution/

SQL Execution with JDBC

- JDBC calls executable objects "java.sql.Statement".
  It distinguishes between three types of statements:
  - `java.sql.Statement`, or "static statement"
  - `java.sql.PreparedStatement`
  - `java.sql.CallableStatement`

- These things are abstracted away by jOOQ, which exposes such concepts in a more object-oriented way

Comparing jOOQ and JDBC

- https://www.jooq.org/doc/latest/manual/sql-execution/comparison-with-jdbc/

Fetching

- The standard fetch

```
Result<R> fetch();
```

- When you know your query returns at most one record. This may return null.

```
R fetchOne();
```

- When you know your query returns exactly one record. This never returns null.

```
R fetchSingle();
```

- When you know your query returns at most one record.

```
Optional<R> fetchOptional();
```

Ex02: Use Different Return Types

- Select the first and last name of a the first Actor
- Select a list of Films ordered by release year, ascending
- Create a query that returns a Customer as Optional

jOOQ Records

https://www.jooq.org/doc/latest/manual/sql-execution/fetching/record-vs-tablerecord/

Fetching Records

```
BookRecord book = dsl
                   .selectFrom(BOOK)
                   .where(BOOK.ID.eq(1))
                   .fetchOne();


// Typesafe field access
System.out.println("Title: " + book.getTitle());
```

Record1 to Record22

- Type-safety is also applied to records for degrees up to 22
- To express this fact, `org.jooq.Record` is extended by `org.jooq.Record1` to `org.jooq.Record22`

Example Record2

```
public interface Record2<T1, T2> extends Record {
    // Access fields and values as row value expressions
    Row2<T1, T2> fieldsRow();
    Row2<T1, T2> valuesRow();
    // Access fields by index
    Field<T1> field1();
    Field<T2> field2();
    // Access values by index
    T1 value1();
    T2 value2();
}
```

Arrays, Maps and Lists

- https://www.jooq.org/doc/latest/manual/sql-execution/fetching/arrays-maps-and-lists/

Handling Records

- Record Handler
  https://www.jooq.org/doc/latest/manual/sql-execution/fetching/recordhandler/

- RecordMapper
  https://www.jooq.org/doc/latest/manual/sql-execution/fetching/recordmapper/

Ex03: Records are your Friends

- Return the Film title and length ordered by length descending
- Use a `RecordHandler` to log the result
- Select the Film but return only a List of IDs

CRUD with UpdatableRecords

https://www.jooq.org/doc/latest/manual/sql-execution/crud-with-updatablerecords/

CRUD

- Your database application probably consists of 50% - 80% CRUD, but only 20% - 50% of querying
  - Create (INSERT)
  - Read (SELECT)
  - Update (UPDATE)
  - Delete (DELETE)
- CRUD always uses the same patterns and leads to a lot of boilerplate code
- Like Hibernate/JPA and other ORMs, jOOQ facilitates CRUD using a specific API involving `org.jooq.UpdatableRecord` types

Primary Keys and Updatability

```
-- Inserting uses a previously generated key value or generates it afresh
INSERT INTO BOOK (ID, TITLE) VALUES (5, 'Animal Farm');

-- Other operations can use the generated key value
SELECT * FROM BOOK WHERE ID = 5;
UPDATE BOOK SET TITLE = '1984' WHERE ID = 5;
DELETE FROM BOOK WHERE ID = 5;
```

Simple CRUD with UpdatableRecord

```
// Store (insert or update) a record to the database.
int store() throws DataAccessException;

// Delete a record from the database
int delete() throws DataAccessException;

// Refresh a record from the database.
void refresh() throws DataAccessException;
```

Ex04: Fun with Updatable Records

- A Customer wants to rent a film

1. Find the Staff by e-mail
2. Find the Customer by first and last name
3. Find an Inventory by the Film name
4. Create and save the Rental

Working with POJOs

https://www.jooq.org/doc/latest/manual/sql-execution/fetching/pojos/

Usage

```
// A "mutable" POJO class
public class MyBook1 {
  public int id;
  public String title;
}

// Fetching records into your custom POJOs:
MyBook1 myBook = dsl.select().from(BOOK).fetchAny().into(MyBook1.class);
List<MyBook1> myBooks = dsl.select().from(BOOK).fetch().into(MyBook1.class);
List<MyBook1> myBooks = dsl.select().from(BOOK).fetchInto(MyBook1.class);
```

Storing POJOs

```java
// A "mutable" POJO class
public class MyBook {
  public int id;
  public String title;
}
```

```java
// Create a new POJO instance
MyBook myBook = new MyBook();
myBook.id = 10;
myBook.title = "Animal Farm";

// Populate a jOOQ-generated
// BookRecord from your POJO
BookRecord book = dsl.newRecord(BOOK,
myBook);

// Insert it (implicitly)
book.store();
```

Ex05: The Joy of POJOs

- Like in Ex03, return the Film title and length ordered by length descending like
  - But this time, create a Java Record FilmAndLength and use it as the result

- Use a nested Java Record to hold the result of the MULTISET exercise from Ex03

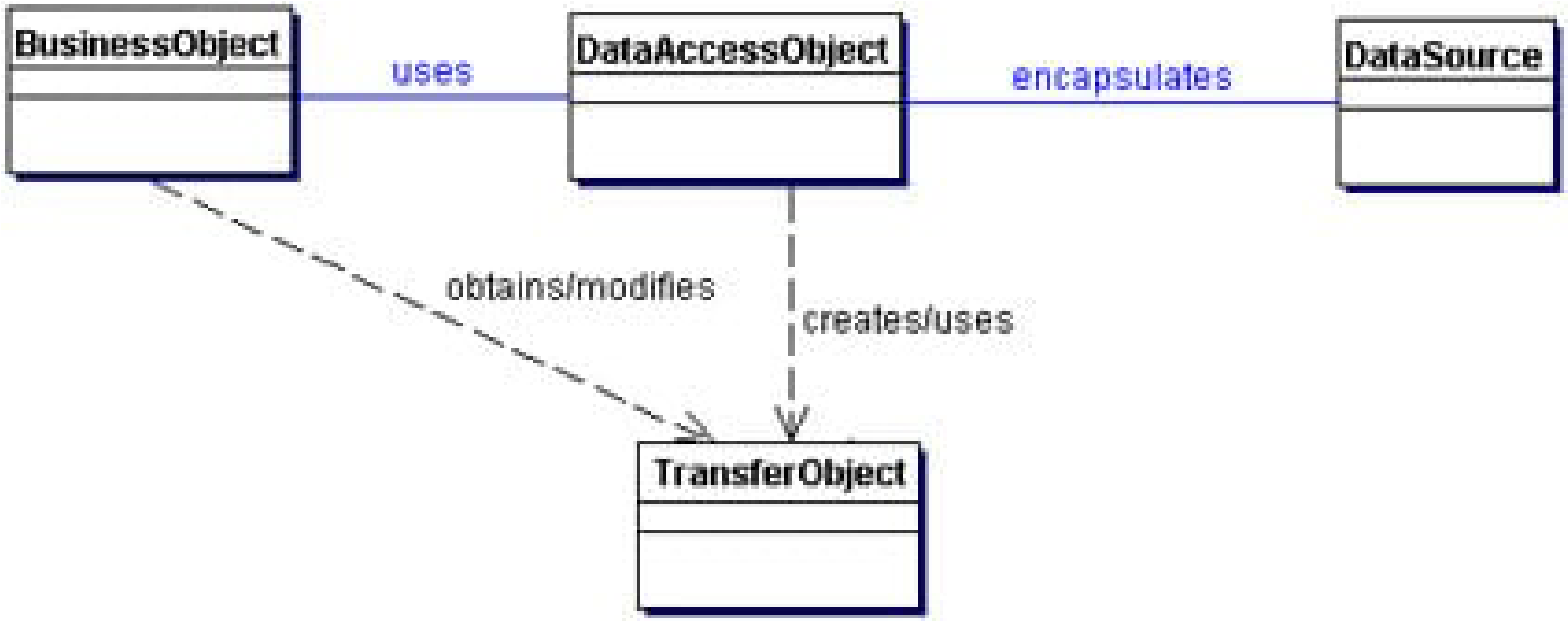
DAOs

https://www.jooq.org/doc/current/manual/sql-execution/daos/

Data Access Object (DAO)

- Access to data varies depending on the source of the data.
- Access to persistent storage, such as to a database, varies greatly depending on the type of storage (relational databases, object-oriented databases, flat files, and so forth) and the vendor implementation

https://www.oracle.com/java/technologies/dataaccessobject.html


BusinessObject
uses
DataAccessObject
encapsulates
DataSource
obtains/modifies
creates/uses
TransferObject

DAO per UpdatableRecord

- If you're using jOOQ's code generator, you can configure it to generate POJOs and DAOs for you
- jOOQ then generates one DAO per `UpdatableRecord`, i.e. per table with a single-column primary key
- Generated DAOs implement a common jOOQ type called `org.jooq.DAO`

Example

```java
public class BookDao extends DAOImpl<BookRecord, Book, Integer> {

    // Columns with primary/unique keys produce fetchOne() methods
    public Book fetchOneById(Integer value) { ... }

    // Other columns produce fetch() methods, returning a list
    public List<Book> fetchByAuthorId(Integer... values) { ... }
    public List<Book> fetchByTitle(String... values) { ... }
}
```

Ex06: DAOs are Convenient

- Inspect the generated DAOs. Which methods are generated and which are inherited?

- Use the RentalDao to
  - Read by rental date
  - Update the rental date
  - Delete by id

Transactions and Locking

https://www.jooq.org/doc/current/manual/sql-execution/transaction-management/

https://www.jooq.org/doc/current/manual/sql-execution/crud-with-updatablerecords/optimistic-locking/

jOOQ and Transactions

- Use third-party libraries like Spring Transactions
- Use a JTA-compliant Java EE transaction manager from your container
- Call JDBC's `Connection.commit()`, `Connection.rollback()` and other methods on your JDBC driver
- You can issue vendor-specific COMMIT, ROLLBACK and other statements directly in your database
- You use jOOQ's transaction API

jOOQ Transactions

```
dsl.transaction((Configuration trx) -> {
    // Important: Use the DSLContext of the transation
    AuthorRecord author = trx.dsl()
        .insertInto(AUTHOR, AUTHOR.FIRST_NAME, AUTHOR.LAST_NAME)
        .values("George", "Orwell")
        .returning()
        .fetchOne();

    // Implicit commit executed here
});
```

Optimistic Locking

- jOOQ allows you to perform CRUD operations using optimistic locking
- You can immediately take advantage of this feature by activating the relevant `executeWithOptimisticLocking` Setting

Optimistic Locking: Processing

1. Before UPDATE or DELETE statements, jOOQ will run a SELECT .. FOR UPDATE statement, pessimistically locking the record for the subsequent UPDATE/DELETE
2. The data fetched with the previous SELECT will be compared against the data in the record being stored or deleted
   - An `org.jooq.exception.DataChangedException` is thrown if the record has been modified in the meantime
   - The record is successfully stored/deleted, if the record had not been modified in the meantime

Optimistic Locking: Comparison

- By default, jOOQ compares all fields
- But you can also use a TIMESTAMP or VERSION field

- Reference: https://www.jooq.org/doc/current/manual/code-generation/codegen-advanced/codegen-config-database/codegen-database-record-version-timestamp-fields/

DataAccessException

- `DataAccessException`
  General exception usually originating from a `java.sql.SQLException`
- `DataChangedException`
  An exception indicating that the database's underlying record has been changed in the meantime
- `DataTypeException`
  Something went wrong during the type conversion
- `DetachedException`
  A SQL statement was executed on a "detached" UpdatableRecord or a "detached" SQL statement.
- `InvalidResultException`
  An operation was performed expecting only one result, but several results were returned.
- `MappingException`
  Something went wrong when loading a record from a POJO or when mapping a record into a POJO

Ex07: Locking and transactions understood

- Write a test that updates a record in parallel and try to produce a `DataChangedException`
  - Hint: You will need to start two threads and add a wait time in one of the threads

- Read about nested transactions
  - https://blog.jooq.org/nested-transactions-in-jooq/

Integrating with JPA

https://www.jooq.org/doc/current/manual/getting-started/jooq-and-jpa/

Using jOOQ with JPA Native Query

```
// Extract the SQL statement from the jOOQ query:
Query result = em.createNativeQuery(query.getSQL());

// Extract the bind values from the jOOQ query:
List<Object> values = query.getBindValues();
for (int i = 0; i < values.size(); i++) {
      result.setParameter(i + 1, values.get(i));
}

return result.getResultList();
```

Ex08: Hello JPA

- Create JPA entities for Category and Film and map the OneToMany relationship from Category to Film

- Construct a query with jOOQ and use it in a JPA native Query
    - Check if the result are Entities

Exporting Data

https://www.jooq.org/doc/current/manual/sql-execution/exporting/

Exporting

- jOOQ can export `Result<Record>` to
  - XML
  - CSV
  - JSON
  - HTML
  - Text
  - Charts

Ex08: Export it!

- Try the various export formats

Thank you!

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