Final project
Databases for Developers

The final project assignment is to develop the backend part of a web application and deploy the whole solution to the cloud. You need to implement 3 solutions with following databases:

- relational database,
- document database,
- graph database.

Recommended database cloud services: Azure MySQL server, MongoDB Atlas, Neo4j AuraDB.

Examples of the possible projects – you can come up with your own idea

- car rental system
- art collection system
- system for reviews of concerts and music releases
- banking system
- web shop
- movie rental / streaming system
- system for user reviews and recommendations of best restaurants etc – like yelp.com
- stock brokerage web app
- airline reservation system
- library management system
- job portal
- RPG – role-playing game
- …

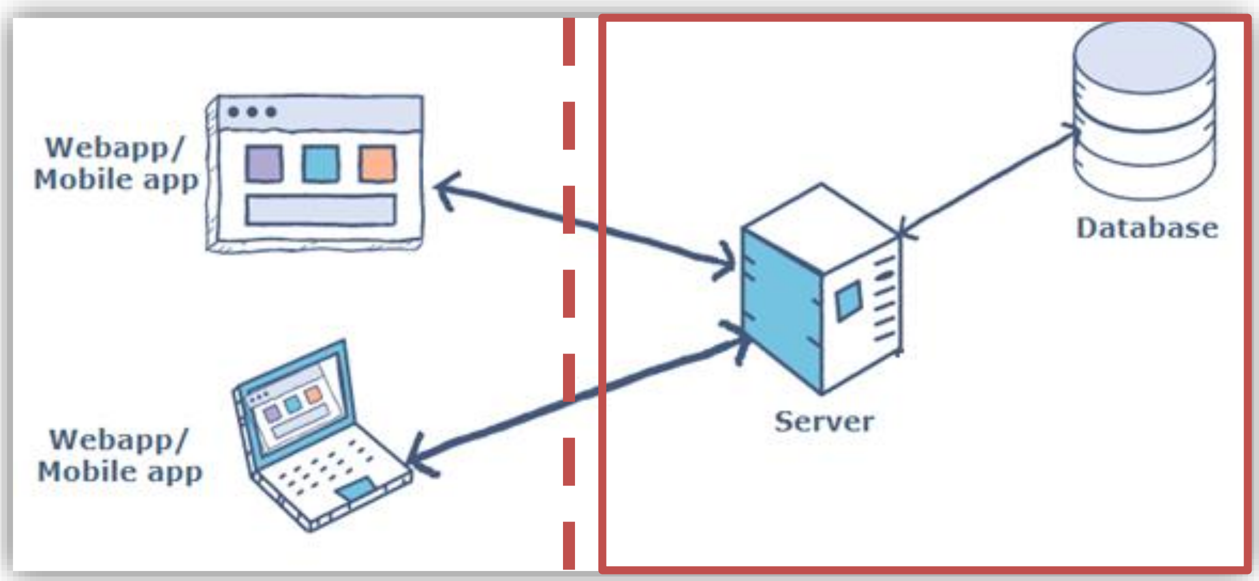
Databases should be complex enough to cover the curriculum of the whole course.

Domain model complexity

The relational database should have at least 10 entities (join tables do not count).

The other 2 solutions must be able to store the same data and query the same information – of course, the design and structure will be different.

We are aiming for the following architecture where we focus on the backend part:

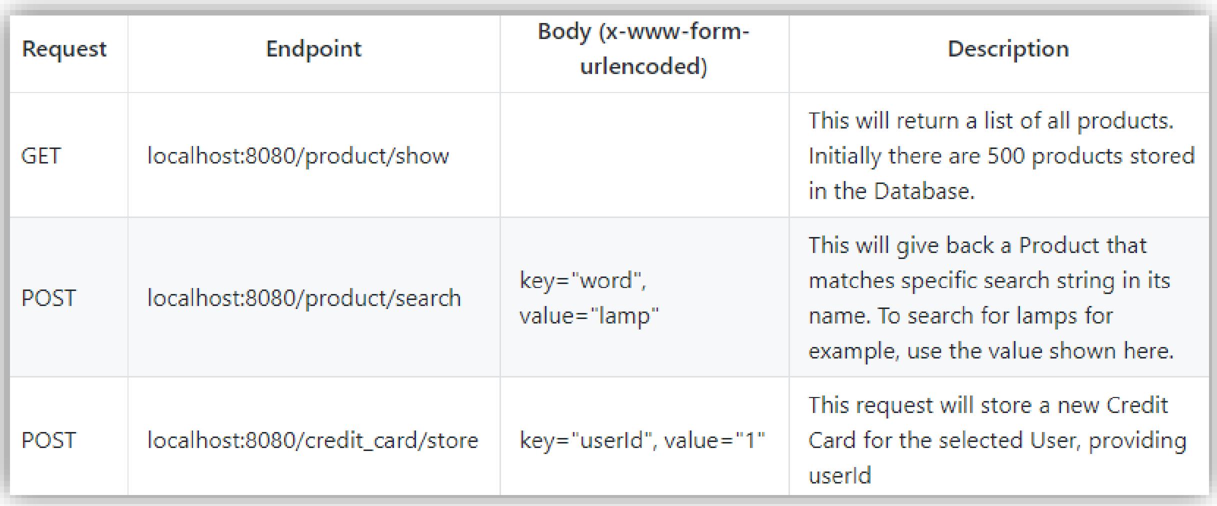


As you can see, we are working with a “monolithic” design. We don’t want to complicate things with more complex architecture like using microservices etc. Instead, we want to focus on dealing with databases from the software developer perspective.

Substituting the frontend with Postman or Swagger UI:

The focus will be on the database and the backend server. Use Postman, Swagger UI, etc. to simulate the interaction with a web client. If you happen to have a frontend, it is fine, but it will not be the topic for the report and the exam because it is not relevant, so you don’t get any credit for the frontend.

API documentation example:



Request	Endpoint	Body (x-www-form-urlencoded)	Description
GET	localhost:8080/product/show		This will return a list of all products. Initially there are 500 products stored in the Database.
POST	localhost:8080/product/search	key="word", value="lamp"	This will give back a Product that matches specific search string in its name. To search for lamps for example, use the value shown here.
POST	localhost:8080/credit_card/store	key="userId", value="1"	This request will store a new Credit Card for the selected User, providing userId

Most frameworks allow you to use Swagger to create a documentation for your APIs, so you can have a swagger with 3 sets of endpoints – one set for each database:

Example:

- …/mysql/products
- …/mongodb/products
- …/neo4j/products

Project will consist of the following:

1.Part: Relational Database

- Database design.
- A CRUD application
- Documentation for the database and the app

2.Part: Document Database

- Database design.
- A CRUD application
- Documentation for the database and the app

3.Part: Graph Database

- Database design.
- A CRUD application
- Documentation for the database and the app

You are free to choose whichever tools you consider appropriate. The recommendations are MySQL as a relational database, MongoDB as a document database, and Neo4j as a graph database, because we will use them during the lectures. However, you may choose any other databases of the same type if all the requirements are fulfilled.

For the CRUD application, you are free to choose any development stack – for example JavaScript or TypeScript for Node.js / Express,

- Java / Spring Boot,
- C# / ASP .NET,
- Python / Django / Fast API
- PHP / Laravel,
- …

The final project should contain following elements:

- An Entity/Relationship Diagram.
- A relational database, including its tables, primary and foreign keys, indexes, constraints, and referential integrity checks.
- Test data.
- Transactions.
- Stored objects: Views, Stored procedures, Stored functions, Triggers, Events.
- An audit solution involving the use of triggers.
- Definition of users and privileges.
- A CRUD application covering the desired functionality.
- A solution using MongoDB or another document database:
    - Database design
    - CRUD application
- A solution using Neo4j or another graph database:
    - Database design
    - CRUD application
- Migration application that will migrate the existing data from SQL database into MongoDB and Neo4j.
- Cloud deployment
- Integration tests (cooperation between the application and the database)

Test data

At the delivery time, the databases should contain some meaningful amount of realistic data. Aim for having at least 10 records for each entity – like 10 rows in each table, 10 documents in each collection, etc. But, if possible, try to generate a larger dataset.

Database user privileges

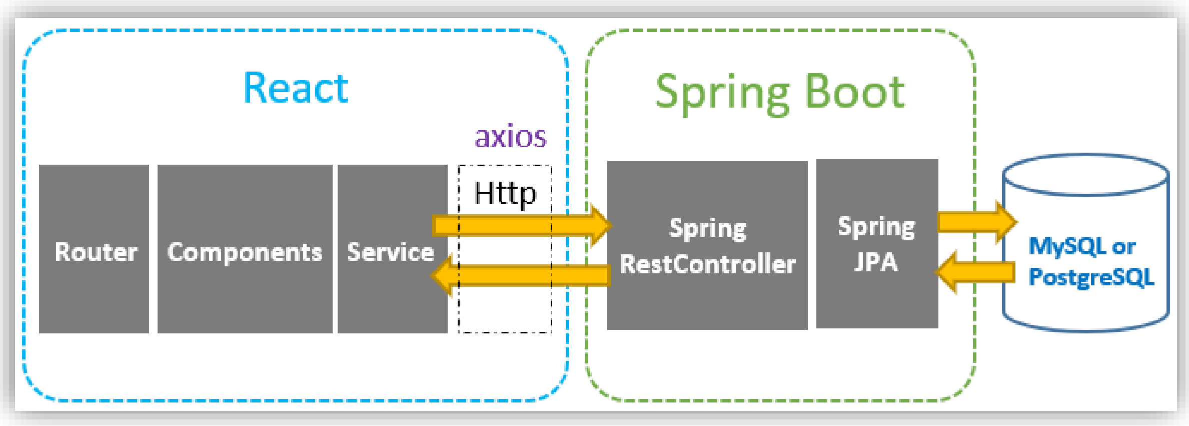
Users will be defined at database level. There will be, at least:

- A user for the application (with the minimum privileges it needs)
- A user with full database admin privileges
- A user with read-only privileges
- A user with restricted reading privileges, which will be unable to see some data

We need to define a user for the CRUD application itself for connecting to the database server. The application should not have admin rights, but it should only have the minimum rights it needs to perform its functionality.

Examples with Spring Boot (remember - frontend is not part of this project)

MySQL solution (or another relational database)



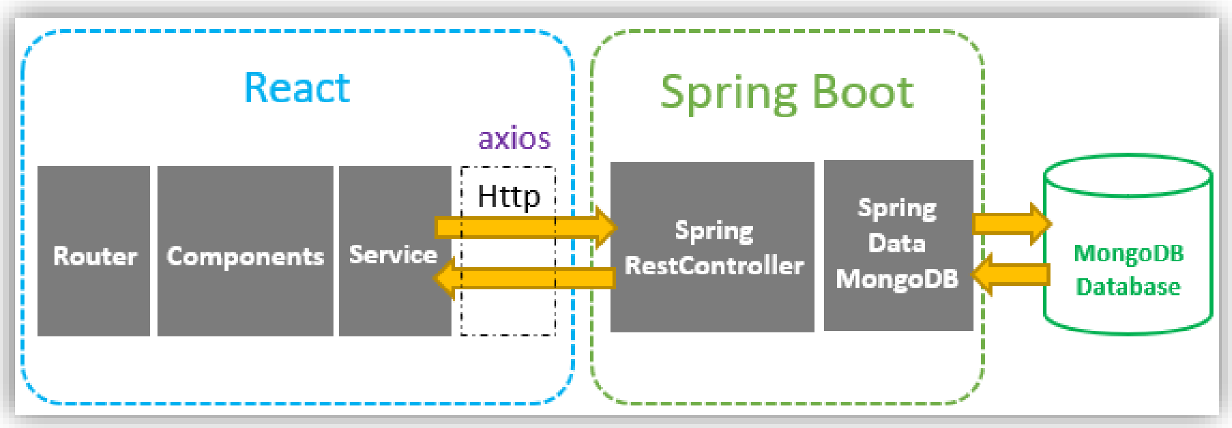
A CRUD application (create/read/update/delete) functionality to implement can be:

- Login/logout.
- Query data from the tables.
- Functionality depending on the business logic

The application will comply with the following:

- All database queries will be prepared to avoid SQL injection.
- There will be a multiple search option which will search products by several fields, also implementing full text search.

MongoDB solution (or another document database)

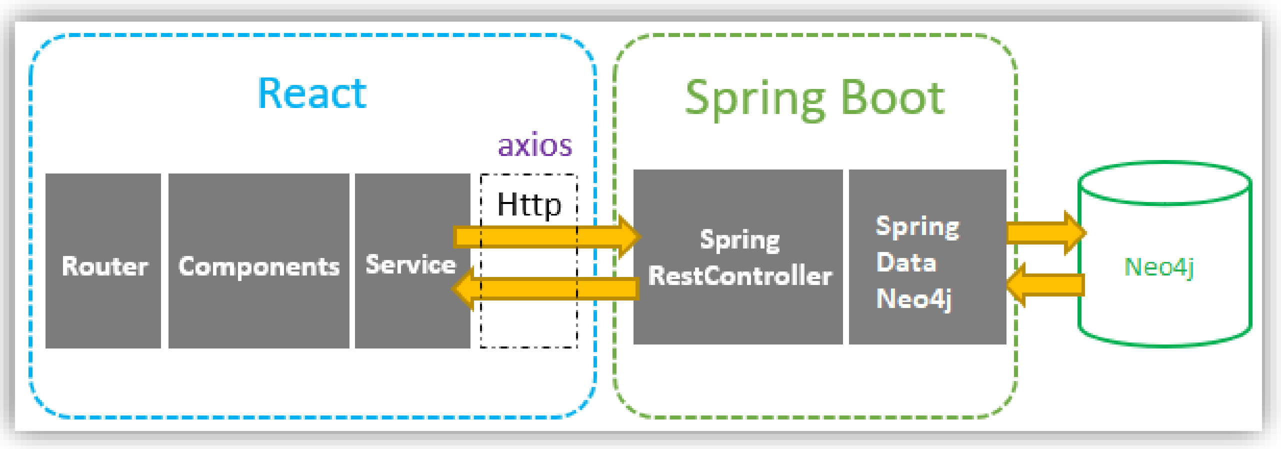


The goal is to implement the same functionality (or at least most of it) as with the relational database.

You can either add the document database as a parallel data source to existing web server (and create parallel REST APIs or GraphQL API) or you can create a new web server application just for this database.

To move from the relational model to document design, we usually need to de-normalize our relational model. For example, if we have tables like customers, orders, order_items, products we can have all this information in a customer document which will contain multiple levels of embedded documents – a customer document will contain an array of order documents. Each order can contain multiple order_item documents…

Neo4j solution (or another graph database)



The goal is to implement the same functionality (or at least most of it) as with the relational and document database.
You can either add the graph database as another data source to the existing web server (and create parallel REST APIs or GraphQL API) or you can create a new server application just for this database.

A graph database consists of nodes and relationships which makes it easy to traverse between nodes – for example if we want to know who a friend of a friend of a friend is… (social media app) or if we want to know what other products were purchased by customers who ordered or looked at a particular product (product recommendation).

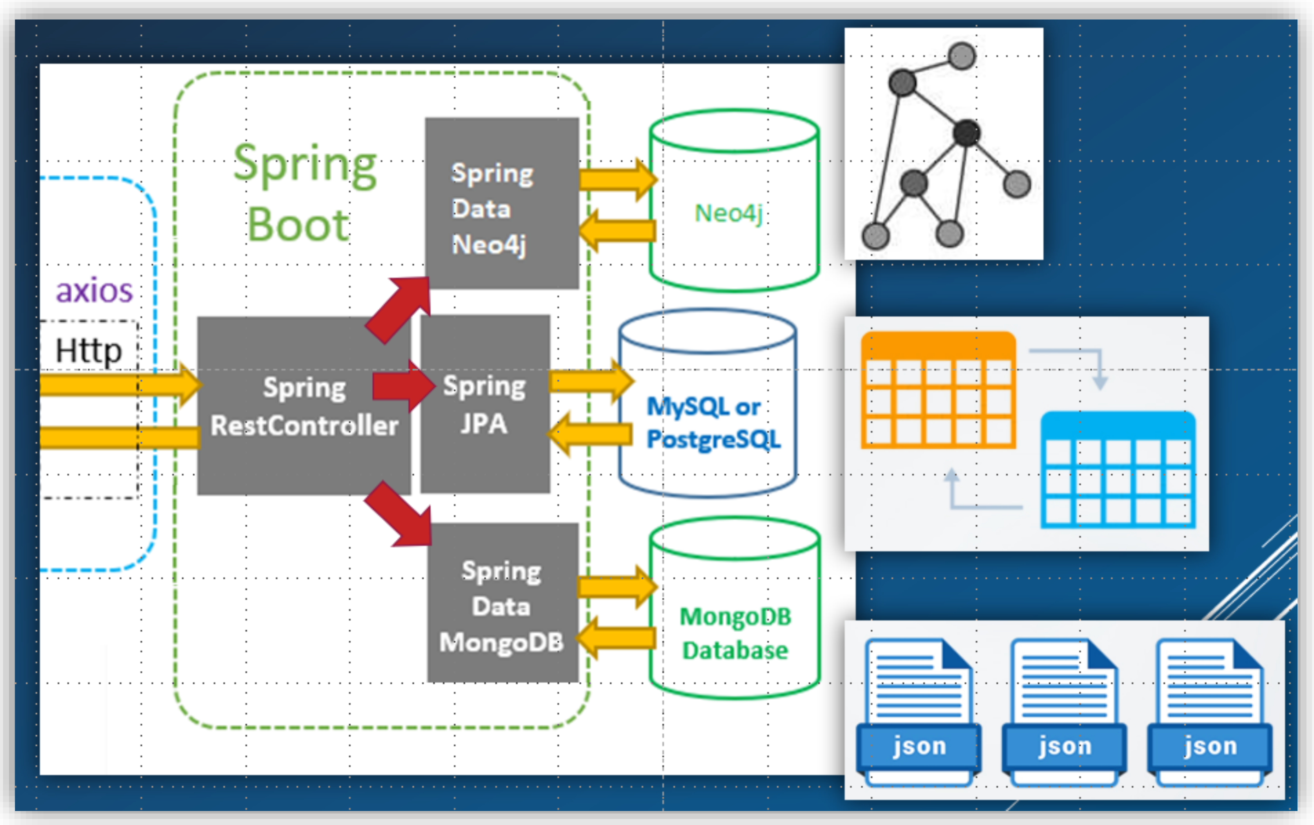
Summary

- ➢ We start with creating a system which uses an RDBMS like MySQL.
- ➢ Then we implement the same functionality with MongoDB (or similar DB).
- ➢ Then we implement the same functionality with Neo4j (or similar DB).

Implementing the same functionality with different database technologies simulates a scenario when a company decides to switch from one database technology to another.

It will also help to compare the strengths and weaknesses of used database technologies.

Example of all 3 solutions in one Spring Boot project



Final Project Delivery

The final group project will be uploaded individually to WISEflow. It will consist of a report and a series of artifacts.

Final Project Artifacts – public code repository

- Relational database scripts (one or several), including:
    - Database creation, including tables, keys, indexes, constraints, and referential integrity checks.
    - Load of test data
    - Stored procedures
    - Triggers
    - Views
    - Events
    - Creation of users and privileges
- The source code of the CRUD application - included as a link to an external public code repository (like GitHub).

- For MongoDB system:
    - dump file of the document database
    - Script for loading the test data
    - The source code of the CRUD application.
- For Neo4j system:
    - dump file of the graph database
    - Script for loading the test data
    - The source code of the CRUD application.
- The source code of the migration application (link to GitHub or another public repo).
- A brief installation procedure that specifies how to organize the code and import the databases in a test environment with full operational capabilities. For this, it is recommended to use a containerized solution with docker-compose.

Final Project Report

The final report will have a big influence on the exam grade. It is the only information that is accessible to the external censor prior to the oral exam.

The report should have this structure:

Cover page, including:

- Title
- Full names of all students in the group
- Group number
- Date of delivery

List of figures
List of appendices
Table of contents (paginated index)
1. Introduction
1.1. Problem description (+ architecture schema of the whole system)
1.2. Explanation of choices for databases and programming languages, and other tools.
2. **Relational database**
2.1. Intro to relational databases
2.2. Database design
2.2.1. Entity/Relationship Model (Conceptual -> Logical -> Physical model)
2.2.3. Normalization process
2.3. Physical data model
2.3.1. Data types
2.3.2. Primary and foreign keys
2.3.3. Indexes
2.3.4. Constraints and referential integrity
2.4. Stored objects – stored procedures / functions, views, triggers, events
2.5. Transactions. Explanation of the structure and implementation of transactions
2.6. Auditing. Explanation of the audit structure implemented with triggers

2.7. Security.
2.7.1. Explanation of users and privileges
2.7.2. SQL Injection – what is it and how it is dealt with in the project?
2.8. Description of the CRUD application for RDBMS

- Mainly the data layer – models, repositories, etc. but also mention the other layers like services and controllers.
- Graphical schema of the backend modules (model, repository, service, controller, etc).
- Other relevant topics like transactions, calling the stored procedures, security…

3. **Document database**
3.1. Intro to document databases
3.2. Database design + features like indexes, PKs, constraints, etc.
3.3. Description of the CRUD application for the document database

- same as for the RDBMS – if you have identical solution where the only difference is the data layer, you can just focus on the parts that are different.

4. Graph database
4.1. Intro to graph databases
4.2. Database design + features
4.3. Description of the CRUD application for the document database

- same as for the RDBMS – if you have identical solution where the only difference is the data layer, you can just focus on the parts that are different.

5. Conclusions (discussing the similarities and differences between used database types)
6. References / Literature

Report formal requirements

You should work in groups of 2 – 4 students (it is possible to work alone as well).
The formal requirements for the report can be found in the course catalog, in the exam section:
https://katalog.kea.dk/course/9942152/2024-2025