

# Spring Data Workshop

## Lab 3

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### 1 Lab setup

Make sure you have the following items installed

- MySQL 8.x
- Latest LTS JDK version (at this point: JDK 21)
- Spring Tool Suite (STS) or IntelliJ IDEA
- Latest version of Maven (at this point: Maven 3.9.9)
- A free account at Postman and installed the Postman app
- A suitable text editor (Notepad ++)
- A utility to extract zip files (7-zip)

In each of the main lab folders, there are two subfolders: `changes` and `final`. The `changes` subfolder just holds the source code files for the lab, while the `final` subfolder holds the complete Eclipse project starting from its project root folder. We will use the code from the `changes` subfolder to build up our applications from scratch and you can always fall back on the complete Eclipse project if you encounter any errors while building up the application.

## 2 Designing REST API

In this lab, we will repeat the implementation of a REST API that we had designed in an earlier lab from scratch. This time around we will use a MySQL database table as the underlying persistence storage, rather than just a basic in-memory list.

The first thing we will do again is to create the underlying classes that model the business domain and then determine the REST API endpoints that access and manipulate a collection of objects from these classes.

The REST service that we had previously created was intended to maintain a list of developers with the following schema:

Developer
id: Integer
name: String
age: Integer
languages: Array[String]
married: Boolean

It will expose the following API endpoints for consumption by a service:

Method	Endpoint	Description
GET	/api/developers	Get the list of developers
GET	/api/developers/{id}	Retrieve the developer with the specified id
GET	/api/developers?language=XXX	Retrieve the developers with capability in the specified language
GET	/api/developers?married=XXX	Retrieve the developers with the specified marital status
GET	/api/developers?married=XXX &language=YYY	Combination of the two previous conditions
GET	/api/developers?age>XX age<XX	Retrieve the developers whose age is more or less than XX
GET	/api/developers?limit=X&page=Y	Pagination functionality to retrieve page no Y containing a total of X developers
POST	/api/developers	Add a new developer to the list of developers
PUT	/api/developers/{id}	Make a modification to a developer with the specified id
DELETE	/api/developers/{id}	Delete a developer with the specified id

We have left out the PATCH operation at the moment as this requires JSON PATCH or specialized logic to perform correctly.

### 3 Creating the application package structure

The main folder for this lab is JPA-REST-App

Start up STS. Switch to the Java EE perspective.

Go to File -> New -> Other -> Spring Boot -> Spring Starter Project. Complete it with the following details:

Name: JPAREstApp

Group: com.workshop.jpa

Artifact: JPAREstApp

Version: 0.0.1-SNAPSHOT

Description: REST API with Spring Data JPA using MySQL app for developers

Package: com.workshop.jpa

Add the following dependencies:

Web -> Spring Web

SQL -> Spring Data JPA

SQL -> MySQL Driver

Developer Tools -> Project Lombok

Developer Tools -> Spring Boot DevTools

The Spring Boot DevTool dependency will automatically restart the Spring Boot application whenever it detects changes in your compiled application code – this will facilitate the development of REST API service as you will not need to start / restart the service every time you change your source code and save. If you wish to leave out this dependency, then make sure you manually start / restart your app after source code changes in all the subsequent lab sessions.

In src/main/java, create the following packages which are going to have the following purposes:

Package name	Purpose
com.workshop.jpa.model	Holds all the classes for the business domain model. This will be stored in the database table via Spring Data JPA, and will thus be @Entity classes.
com.workshop.jpa.dto	Holds all the DTO classes that encapsulate the data to be exchanged between the client and service. This includes custom error messages.
com.workshop.jpa.repository	Holds the user-defined interfaces that extend on the standard Spring Data JPA Repositories (CrudRepository, PagingAndSortingRepository, etc)
com.workshop.jpa.service	Holds the classes that extract data from the repository interfaces and perform any required business logic on them
com.workshop.jpa.controller	Holds all the @RestController classes that implement the various @XXMapping methods for the REST API utilizing the various Service classes.
com.workshop.jpa.exception	Holds all the user defined exceptions and the primary @ControllerAdvice exception handling class containing the individual @ExceptionHandler methods

The main `@SpringBootApplication` class (`JpaRestAppApplication`) will reside in the top level package: `com.workshop.jpa` so that Spring will scan all its subpackages to locate `@Component` / `@Service` / `@Repository` classes for DI.

## 4 Creating initial classes and interfaces

In `com.workshop.jpa.model`, place:

```
Developer
```

In `com.workshop.jpa.dto`, place:

```
DeveloperDTO
```

In `com.workshop.jpa.repository`, place:

```
DeveloperRepository
```

In `com.workshop.jpa.service`, place:

```
DeveloperService
```

In `com.workshop.jpa.controller`, place:

```
DeveloperController
```

We will use a Data Transfer Object (DTO) to encapsulate the data to be transferred between the client and the REST service we are implementing. The DTO is necessary since the structure of the domain class (marked with `@Entity`) is slightly different from the structure of the class that we are intend to serialize into JSON to be returned to the client.

In the domain class `Developer`, the `languages` field (which represents the languages that the developer is capable of coding in) is stored as a single `String` where the different languages are separated by commas. This is because MySQL does not easily incorporate the storage of an array as a basic data type. On the other hand, the JSON that is exchanged between the client and service will list these languages as an array as this is a more natural way to represent them.

We will thus use the DTO to represent the structure of the data to be exchanged between the client and service, and then perform conversion between DTO / domain object when storing to or retrieving from the underlying database table.

We have the skeleton now for the main controller class that will provide the logic for mapping all the API endpoints. This will be fleshed out step by step.

## 5 Initializing the app with SQL tables

In `src/main/resources`, place the files

```
application.properties
data.sql
schema.sql
```

Ensure that you have completed the previous lab 2 on creating a MySQL user account with a password that you will now be using in `application.properties`. The remaining properties set in this file have been already discussed at length in the previous lab.

Start the MySQL server, connect to it with the MySQL command line client and remove the table `developers` from `workshopdb` if it already exists:

```
USE workshopdb;

DROP TABLE IF EXISTS developers;
```

Next, start the app from the Boot dashboard in the usual way.

Open the MySQL command line client and check that the `Developers` table has been created and populated with sample data through the initialization code:

```
USE workshopdb;

SHOW TABLES;

SELECT * FROM developers;
```

**NOTE:** If for some reason this `developers` table accidentally is deleted while working in future lab sessions, you do not have to rerun this lab session again to create it. Instead, this table is already in the `sqltables` folder of your `labcode` folder.

Open a command prompt in this folder (or navigate to it), then type:

```
mysql -u root -p workshopdb < devtable.sql
```

You will again be prompted for the admin (root) password.

Back in the MySQL command line client, verify that the table has been created with:

```
SHOW TABLES;
```

Check the contents of the table with:

```
SELECT * FROM developers;
```

## 6 Implement GET `/api/developers`

In `src/main/resources`, make the change:

```
application.properties-v2
```

In `com.workshop.jpa.controller`, make the change:

`DeveloperController-v2`

In `com.workshop.jpa.service`, make the change:

`DeveloperService-v2`

In `com.workshop.jpa.dto`, make the change:

`DeveloperDTO-v2`

Notice that the `@GetMapping` returns a `DeveloperDTO` object to the client (in order to produce serialized JSON where the `languages` key has a value of an array of strings). However, the objects retrieved from the database are in the `Developer` class format: so there needs to be a conversion between these two classes. This is accomplished by having a new constructor in the `DeveloperDTO` class that initializes a new object from a `Developer` parameter.

`DeveloperService` in turn uses the existing `findAll` functionality of the repository to retrieve the existing list of developers (of type `Developer`) from the table, which we have already seen in action in a previous lab. It then creates a list of `DeveloperDTOs` from this list and returns that to the calling method in `DeveloperController`.

Start up Postman and create a collection to group requests for this app: `Developer REST requests`

Make a GET request to:

`localhost:8080/api/developers`

and verify that the initial list of developers in `Developers` table is returned correctly in JSON.

## 7 Implement POST `/api/developers`

In `com.workshop.jpa.controller`, make the change:

`DeveloperController-v3`

In `com.workshop.jpa.service`, make the change:

`DeveloperService-v3`

In `com.workshop.jpa.model`, make the change:

`Developer-v3`

In `com.workshop.jpa.repository`, make the change:

`DeveloperRepository-v3`

In `com.workshop.jpa.dto`, place the following file:

```
CustomErrorMessage
```

In `com.workshop.jpa.exception`, place the following file:

```
IncorrectJSONFormatException
```

In `com.workshop.jpa.exception`, place the following file:

```
DeveloperControllerExceptionHandler
```

The primary issue in performing a POST correctly is to return the URL to retrieve the newly created resource (which will be a new row in the Developers table). This URL will include the id of the new created row. To obtain the id of this new row (which will automatically be the last row in the table if we use an autoincrement attribute for the primary key id), we create a special native SQL query in `DeveloperRepository`.

We also create a user defined `IncorrectJSONFormatException`, a custom class `CustomErrorMessage` to return to the client and a `DeveloperControllerExceptionHandler` to house all the future exception handling methods.

Make a POST request to:

```
localhost:8080/api/developers
```

with the following raw JSON content in the body:

☐ none ☐ form-data ☐ x-www-form-urlencoded ☒ raw ☐ binary ☐ GraphQL **JSON** ▾

```
{
  "name": "Ryan",
  "age": 42,
  "languages": [
    "php",
    "python",
    "java"
  ],
  "married": true
}
```

Check that a status 201 Created is returned with the following URL in the Location header:

<http://localhost:8080/api/developers/xxx>

where xxx is the id of the newly created record in the Developers table.

Body Cookies Headers (5) Test Results ↻ 201 Created

Key	Value
Location	http://localhost:8080/api/developers/31

You can also verify this in the MySQL command line client.

You can also verify it by making another GET request to retrieve all the developers:

```
localhost:8080/api/developers
```

Introduce an error into the POST submission by leaving out an important field (either name, age or languages). For e.g. sent a POST to the same URL with this content:

```
{
  "name": "Aaron",
  "age": 42,
  "married": true
}
```

Verify that the correct exception handling method is invoked server side and an appropriate error message is returned.

Make another GET request to the same URL (or check through the MySQL command line client) to verify that this information was not added as a new developer.

```
localhost:8080/api/developers
```

Introduce an error by submitting invalid JSON using a POST for e.g.

```
{
  "name": "Debbie"
  "age": 29
  "languages": [
    "JavaScript",
    "Python",
    "Java"
  ]
  "married": false
}
```

Verify that the correct exception handling method is invoked server side and an appropriate error message is returned.

Make another GET request to the same URL (or check through the MySQL command line client) to verify that this information was not added as a new developer.

```
localhost:8080/api/developers
```



## 8 Implement PUT /api/developers/{id}

In `com.workshop.jpa.repository`, make the change:

```
DeveloperRepository-v4
```

In `com.workshop.jpa.controller`, make the change:

```
DeveloperController-v4
```

In `com.workshop.jpa.exception`, make the change:

```
DeveloperControllerExceptionHandler-v4
```

In `com.workshop.jpa.service`, make the change:

```
DeveloperService-v4
```

In `com.workshop.jpa.exception`, create the files:

```
IncorrectURLFormatException
```

In `DeveloperRepository`, we create a new native SQL update statement and this will need to be annotated with `@Modifying` and `@Transactional` for it to work properly.

`DeveloperController` and `DeveloperService` include additional logic to check for errors in the request and will throw appropriate exceptions if this occurs. We have created a new Exception class: `IncorrectURLFormatException` to cater for URL-related errors such as invalid id type or id out of range. This is catered for appropriately in `DeveloperControllerExceptionHandler`

Note: Technically speaking, specifying a developer id that does not exist in the table should be a case of `DeveloperNotFoundException`, rather than a `IncorrectURLFormatException`. However, we use `IncorrectURLFormatException` since the semantics of this exception covers a wide range of other URL-related error issues as well which minimizes the number of user-defined exceptions we might need to create.

Restart the app.

Make a PUT request to:

```
localhost:8080/api/developers/3
```

with the following raw JSON content in the body:

☐ none ☐ form-data ☐ x-www-form-urlencoded ☒ raw ☐ binary ☐ GraphQL **JSON** ▼

```
{
  "name": "Edwin",
  "age": 21,
```

```
"languages": [
  "python",
  "c++"
],
"married": false
}
```

Verify that this returns with status 200 OK.

To verify that the developer with id 3 has had the details changed accordingly, make a GET request to:

localhost:8080/api/developers

Alternatively, verify from the MySQL command line client.

You can repeat the operation several times to change the details of a few other random developers.

Let's introduce some potential errors in the request.

Make a PUT request to:

localhost:8080/api/developers/888

using some valid JSON content. Verify that the error message returned points out that no developer with such id exists.

Make a PUT request to:


localhost:8080/api/developers/3sw

Verify that the error message returned points out that the developer id needs to be specified correctly as a number.

Make a PUT request to:

localhost:8080/api/developers/3

with the following raw JSON content in the body:

☐ none ☐ form-data ☐ x-www-form-urlencoded ☒ raw ☐ binary ☐ GraphQL **JSON** 

```
{
  "age": 21,
  "languages": [
    "Python",
    "C++"
  ],
  "married": false
}
```

Verify that the correct error message is returned regarding incorrect format for developer

## 9 Implement DELETE /api/developers/{id}

In `com.workshop.jpa.controller`, make the change:

```
DeveloperController-v5
```

In `com.workshop.jpa.service`, make the change:

```
DeveloperService-v5
```

The implementation here is reasonably straight forward since there is already an existing `deleteById` method from `CrudRepository` that we can call directly from `DeveloperService`.

Restart the app.

Make a DELETE request to:

```
localhost:8080/api/developers/3
```

Verify that this returns with status 200 OK.

To verify that the developer with id 3 has been deleted, make a GET request to:

```
localhost:8080/api/developers
```

Alternatively, verify from the MySQL command line client.

You can repeat this operation to delete a few other random records and verify accordingly.

We can check for similar errors as in the case of the PUT operation.

Make a DELETE request to:

```
localhost:8080/api/developers/888
```

Verify that the error message returned points out that no developer with such id exists.

Make a DELETE request to:

```
localhost:8080/api/developers/3sw
```

Verify that the error message returned points out that the developer id needs to be specified correctly as a number.

**NOTE:** If you have deleted too many rows from the table, you can always restore the original table which is already in the `sqltables` folder of your `labcode` folder.  
Open a command prompt in this folder (or navigate to it), then type:

```
mysql -u root -p workshopdb < devtable.sql
```

You will again be prompted for the admin (root) password.

Back in the MySQL command line client, verify that the table has been created with:

```
SHOW TABLES;
```

Check the contents of the table with:

```
SELECT * FROM developers;
```

## 10 Implementing GET /api/developers/{id}

In `com.workshop.jpa.controller`, make the change:

```
DeveloperController-v6
```

In `com.workshop.jpa.service`, make the change:

```
DeveloperService-v6
```

The implementation here is reasonably straight forward since there is already an existing `findById` method from `CrudRepository` that we can call directly from `DeveloperService`.

Restart the app.

Make a GET request to:

```
localhost:8080/api/developers/x
```

where `x` is valid developer ID. Verify that the correct developer is returned by inspecting from MySQL command line client if necessary.

We can check for similar errors as in the case of the PUT operation.

Make a GET request to:

```
localhost:8080/api/developers/888
```

Verify that the error message returned points out that no developer with such id exists.

Make a GET request to:

```
localhost:8080/api/developers/3sw
```

Verify that the error message returned points out that the developer id needs to be specified correctly as a number.

## 11 Implementing GET /api/developers with query parameters

In `com.workshop.jpa.controller`, make the change:

DeveloperController-v7

In `com.workshop.jpa.service`, make the change:

DeveloperService-v7

Since there are many query parameters that can be passed via a GET to `/api/developers`, we will refactor the existing code base to streamline our implementation by having the `DeveloperService` determine the underlying operation to perform on the `DeveloperRepository` based on the query parameters being passed.

We initially make distinction between a GET request without any query parameters (which should return the list of all developers) and a request with some query parameters (which we initially list and will subsequently process one at a time).

Restart the app.

Make a GET request to:

`localhost:8080/api/developers`

and verify that the entire contents of the Developers table is returned.

Make a GET request to the same URL but with some random query parameters, for e.g:

`localhost:8080/api/developers?hero=ironman&age=33`

and verify that nothing is returned now (even though status remains as 200 OK) and the key value pairs are logged on the server side

### 11.1 Query parameter: language=XXX

In `com.workshop.jpa.service`, make the change:

DeveloperService-v8

In `com.workshop.jpa.repository`, make the change:

DeveloperRepository-v8

We declare the derived query method `findByLanguagesContaining` in `DeveloperRepository` to perform a filtering on the language `column`, and provide appropriate logic in `DeveloperService` to call this method when the appropriate query parameter is present.

Restart the app.

Make multiple GET requests to:

```
localhost:8080/api/developers?language=XXXX
```

where XXX can be any of the valid languages associated with the existing developers: e.g. python, java, c++, c # etc.

An important issue that we need to watch out for is for the language values: C++ and C#. The symbols + and # are reserved characters, so trying to incorporate them directly into a URL, for e.g:

```
localhost:8080/api/developers?language=c++
```

will result in an error in retrieving them on the server side. In order to retrieve them correctly, they would need to be encoded first using the [standard URL encoding scheme](#):

Thus, for the parameter

```
language=c++
```

we would need to specify it as:

```
language=c%2B%2B
```

and for the parameter

```
language=c#
```

we would need to specify it as:

```
language=c%23
```

The other alternative is to require the client to just use alphanumeric characters for specifying parameter values e.g.

```
language=cplusplus
```

or

```
language=sharp
```

and then on the server side (in `DeveloperService`) match this values to the actual corresponding language values of C++ or C#.

To keep things simple here, we will just use the first approach of requiring the client to specify the values using the correct URL encoding although the second approach is probably preferable in a production grade application.

Also try entering a random string for XXX to verify that an empty list is returned, e.g

```
localhost:8080/api/developers?language=donkey
```

Verify that the correct subset of developers is returned with a status 200 OK and double check at the MySQL command line if necessary.

Also verify that making a GET request to:

```
localhost:8080/api/developers
```

without any query parameters should still return the entire contents of the Developers table.

### 11.2 Query parameter: `married=XXX`

In `com.workshop.jpa.service`, make the change:

```
DeveloperService-v9
```

In `com.workshop.jpa.repository`, make the change:

```
DeveloperRepository-v9
```

Again, we declare the derived query method `findByMarried` in `DeveloperRepository` to perform a filtering on the column `married`, and provide appropriate logic in `DeveloperService` to call this method when the appropriate query parameter is present. We also return an error message to the client if a value other than `true` or `false` is supplied for this parameter.

Restart the app.

Make GET requests to:

```
localhost:8080/api/developers?married=false
```

and

```
localhost:8080/api/developers?married=true
```

Verify that the correct subset of developers is returned with a status 200 OK.

Make a GET request with an invalid value for the `married` parameter, for e.g.

```
localhost:8080/api/developers?married=sdf
```

Verify that an appropriate error message is returned with a status 400 BAD REQUEST.

Also verify that making a GET request to:

```
localhost:8080/api/developers
```

without any query parameters should still return the entire contents of the Developers table.

### 11.3 Combine query parameters: `language=XXX&marriage=YYY`

In `com.workshop.jpa.service`, make the change:

```
DeveloperService-v10
```

In `com.workshop.jpa.repository`, make the change:

```
DeveloperRepository-v10
```

Again, we declare the derived query method `findByMarriedAndLanguagesContaining` in `DeveloperRepository` to perform a filtering on the columns `languages` and `married`, and provide appropriate logic in `DeveloperService` to call this method when both query parameters are present.

Restart the app.

Make a GET request to:

```
localhost:8080/api/developers?married=true&language=java
```

Verify that the correct subset of developers is returned with a status 200 OK.

Notice that changing the order of appearance of the parameters does not affect the result:

```
localhost:8080/api/developers?language=java&married=true
```

Experiment around with a few other combinations for the `married` and `language` parameters and verify that the correct subset of developers is returned with a status 200 OK.

You can stop the app from the Boot dashboard in the usual way.

#### 11.4 Query parameter: `age>XX` or `age<XX`

In `com.workshop.jpa.service`, make the change:

```
DeveloperService-v11
```

In `com.workshop.jpa.repository`, make the change:

```
DeveloperRepository-v11
```

Note that the format: `age>XX` or `age<XX` is counted as a key without a value as the `=` sign is used to separate keys and values.

Again, we declare the derived query method `findByAgeLessThan` and `findByAgeGreaterThan` in `DeveloperRepository` to perform a filtering on the `age` column, and provide appropriate logic in `DeveloperService` to call either of these methods depending on whether the symbol `>` or `<` is used. We also incorporate logic to check the expression for non-integer or negative values and return a suitable error message to the client if this occurs.

Restart the app.

Make a GET request to:

```
localhost:8080/api/developers?age<30
```

Verify that the correct subset of developers is returned with a status 200 OK.



Make a GET request to:

```
localhost:8080/api/developers?age>50
```

Verify that the correct subset of developers is returned with a status 200 OK.

Make a GET request to the following incorrect URLs:

```
localhost:8080/api/developers?age>-200
localhost:8080/api/developers?age<-1
localhost:8080/api/developers?age>asdf
localhost:8080/api/developers?age=kewlstuff
```

and verify that an error message is returned.

## 11.5 Query parameters: limit=X&page=Y

In `com.workshop.jpa.service`, make the change:

```
DeveloperService-v12
```

For pagination, we can simply use the existing `findAll(pageable)` method available from `PagingAndSortingRepository` demonstrated in a previous lab. We just need to incorporate logic to extract the values for the `limit` and `page` parameters correctly, as well as logic to ensure that both of them are supplied at the same time and have positive integer values. If this is not the case, we return a suitable error message to the client.

Make a GET request to:

```
localhost:8080/api/developers?page=0&limit=5
```

```
localhost:8080/api/developers?page=1&limit=5
```

```
localhost:8080/api/developers?page=2&limit=5
```

Verify that the correct subset of developers is returned with a status 200 OK.

Make a GET request to:

```
localhost:8080/api/developers?page=3&limit=3
```

Verify that the correct subset of developers is returned with a status 200 OK.

Make a GET request to:

```
localhost:8080/api/developers?page=5&limit=10
```

Notice that even though the `page` and `limit` specified exceeds the total remaining number of developers in the list, no error is flagged and an empty list is returned instead.

Errors will be flagged if:

- Non-numeric or negative values are specified for either the `page` or `limit` parameters
- The `page` or `limit` parameter is supplied individually without the other (both are required for the pagination functionality to work)

Make GET requests to these URLs to verify that all of these errors are flagged with appropriate error message responses:

```
localhost:8080/api/developers?page=xxx&limit=10
```

```
localhost:8080/api/developers?page=2&limit=yyy
```

```
localhost:8080/api/developers?page=-1&limit=5
```

```
localhost:8080/api/developers?page=2
```

```
localhost:8080/api/developers?limit=6
```

At this point, it is also good to verify that making a GET request to:

```
localhost:8080/api/developers
```

without any query parameters should still return the entire contents of the Developers table.

## 11.6 Further filtering / sorting functionality to implement

Query parameters used with GET requests are ideal for performing a variety of filtering and sorting functionality. For e.g. we could sort the list of developers returned on ascending or descending value of a particular field (such as age or name). The query parameter might look like this:

```
GET /api/developers?sort=-age
```

which might mean to sort on descending order of the age field of the developers.

```
GET /api/developers?sort=+name
```

which might mean to sort on ascending order of the name field of the developers.

```
GET /api/developers?sort=-age,+name
```

which might mean to sort on descending order of the age field of the developers first (primary sort), and then sort on ascending order of the name field for the case of developers who have the same age (secondary sort).

See whether you can implement this sorting functionality using either native SQL queries or the sorting functionality provided by `PagingAndSortingRepository`: both of which have already been demonstrated in a previous lab.