

# Internet Technologies

RESTful API Server



University of Cyprus  
Department of Computer  
Science

# How to build RESTful APIs?



- Develop **JAVA** RESTful API server:
  - **Spring Boot** (<https://spring.io/guides/gs/rest-service/>)
  - **Jersey** (<https://eclipse-ee4j.github.io/jersey/>)
- Develop JavaScript RESTful API server:
  - **Node.js** (<https://nodejs.org/>) and **Express** (<https://expressjs.com/>)
- Develop **Python** RESTful API server:
  - **Django** Framework (<https://www.djangoproject.com/>)
  - **FastAPI** (<https://fastapi.tiangolo.com/>)
  - **Flask** (<https://flask.palletsprojects.com/>)
    - **Flask RESTful** (<https://flask-restful.readthedocs.io/en/latest/>)
      - Flask extension for quickly building REST APIs
    - **Flask RESTPlus** (<https://flask-restplus.readthedocs.io/en/stable/index.html>)
      - Flask extension for quickly building REST APIs



# Java or Python for RESTful APIs?

- Java is recommended for enterprise-level, high-load APIs
  - Slower development time
  - Heavier resource (RAM) usage
  - Easier application packaging (.jar)
  - Significant version dependence => expensive system support
- JavaScript is recommended for fast-prototyping, medium-load APIs
  - Use the same familiar syntax for both client and server-side tasks (faster development time)
  - Lightweight resource usage, ideal for real-time data processing
  - Slower than Java
- Python is recommended for fast-prototyping, low-load, personal-use APIs
  - Faster development time
  - No compilation, faster testing
  - Minimal version dependence (given that Python 2.x is deprecated and rarely used)

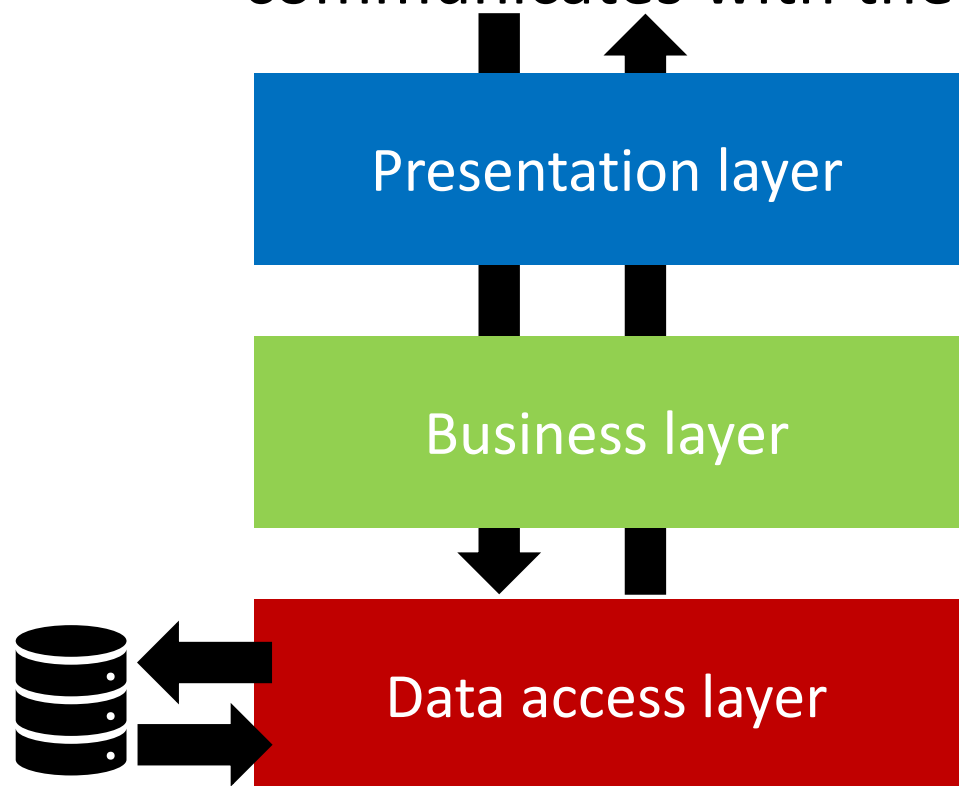
# Case study - RESTful API using Spring Boot

- Create a system to store/deliver information about the books of a library along with their reviews
- **Entities** served by the RESTful API: **books, reviews**
  - API will be used to **Create, Retrieve, Update and Delete** (CRUD) book and review data
- **Steps:**
  1. Create a **DB table for each entity**
  2. Create a **RESTful API in Spring Boot** to enable CRUD operations on each entity
  3. Test RESTful API using Postman



# Spring Boot Application Architecture

- Spring Boot framework follows a layered architecture in which each layer communicates with the layer directly below or above



**Handles incoming HTTP requests** and transfers them to the business layer. It is responsible for converting (mapping) JSON messages to Java objects and vice-versa. This layer can perform authentication (verify user before allowing access to API resources). Java classes in this layer are called **controllers**.

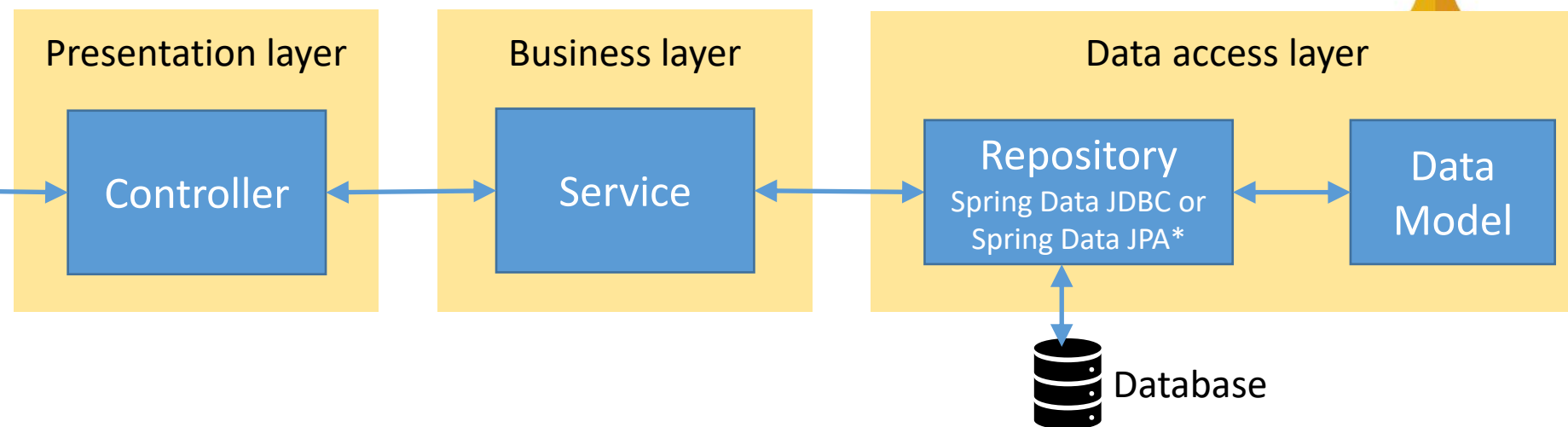
**Handles all the business logic** which encodes real-world business rules (e.g. a user can borrow up to 3 books) that determine how entities can be created, retrieved, updated and deleted. Business layer uses functions provided by the data access layer to exchange entity-related information from/to DB. Java classes in this layer are called **services**.

**Handles all the storage logic.** It is responsible for performing CRUD (create, retrieve, update, delete) operations on the entities. **Database entities are mapped as Java classes.** Java classes in this layer are called **models**. Data access layer involves **repository** Java classes which provide functions to interact with the database.

# Spring Boot Application Flow Architecture



POSTMAN



1. RESTful API client (e.g POSTMAN) issues HTTP requests (e.g. GET, POST, PUT, DELETE)
  - Example: GET the book with id=3
2. The request handled by the controller object which transfers it to the service object
3. Service class calls one or more repository functions to retrieve the requested data
  - Repository is a mechanism for enabling CRUD operations on entities (tables of DB)
  - Example: call the specific repository function which returns the book based on its id
4. The retrieved entity (book) is mapped to a Java object (model)
5. Controller converts book object to JSON message and returns it to API client

(\*) Spring Data JDBC is faster, gives control over SQL queries (allows for creating complex SQL queries) compared to Spring Data JPA. Spring Data JPA allows for faster development, hides complexity (no need to write SQL queries), offers lazy loading, data caching.



# Create project using Spring initializr

- **Start from scratch:** [Spring Initializr](#)
  - Add dependencies:
    - **Spring Web:** Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.
    - **Spring Data JDBC:** Persists data in SQL stores (e.g. MariaDB) with plain JDBC using Spring Data.
    - **Spring Boot DevTools:** Provides fast application restarts, LiveReload, and configurations for enhanced development experience.
  - After we set the parameters (see next slide) we press Generate at the bottom of the page to download the zip folder of the project



Project

☐ Gradle - Groovy ☐ Gradle - Kotlin

☒ Maven

Language

☒ Java ☐ Kotlin ☐ Groovy

Spring Boot

☐ 3.3.0 (SNAPSHOT) ☐ 3.3.0 (M3) ☐ 3.2.5 (SNAPSHOT) ☒ 3.2.4

☐ 3.1.11 (SNAPSHOT) ☐ 3.1.10

Project Metadata

Group

Artifact

Name

Description

Package name

Packaging ☒ Jar ☐ War

Java ☐ 22 ☐ 21 ☒ 17

Dependencies

ADD DEPENDENCIES... CTRL + B

Spring Web WEB

Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.

Spring Data JDBC SQL

Persist data in SQL stores with plain JDBC using Spring Data.

Spring Boot DevTools DEVELOPER TOOLS

Provides fast application restarts, LiveReload, and configurations for enhanced development experience.

GENERATE CTRL + G

EXPLORE CTRL + SPACE

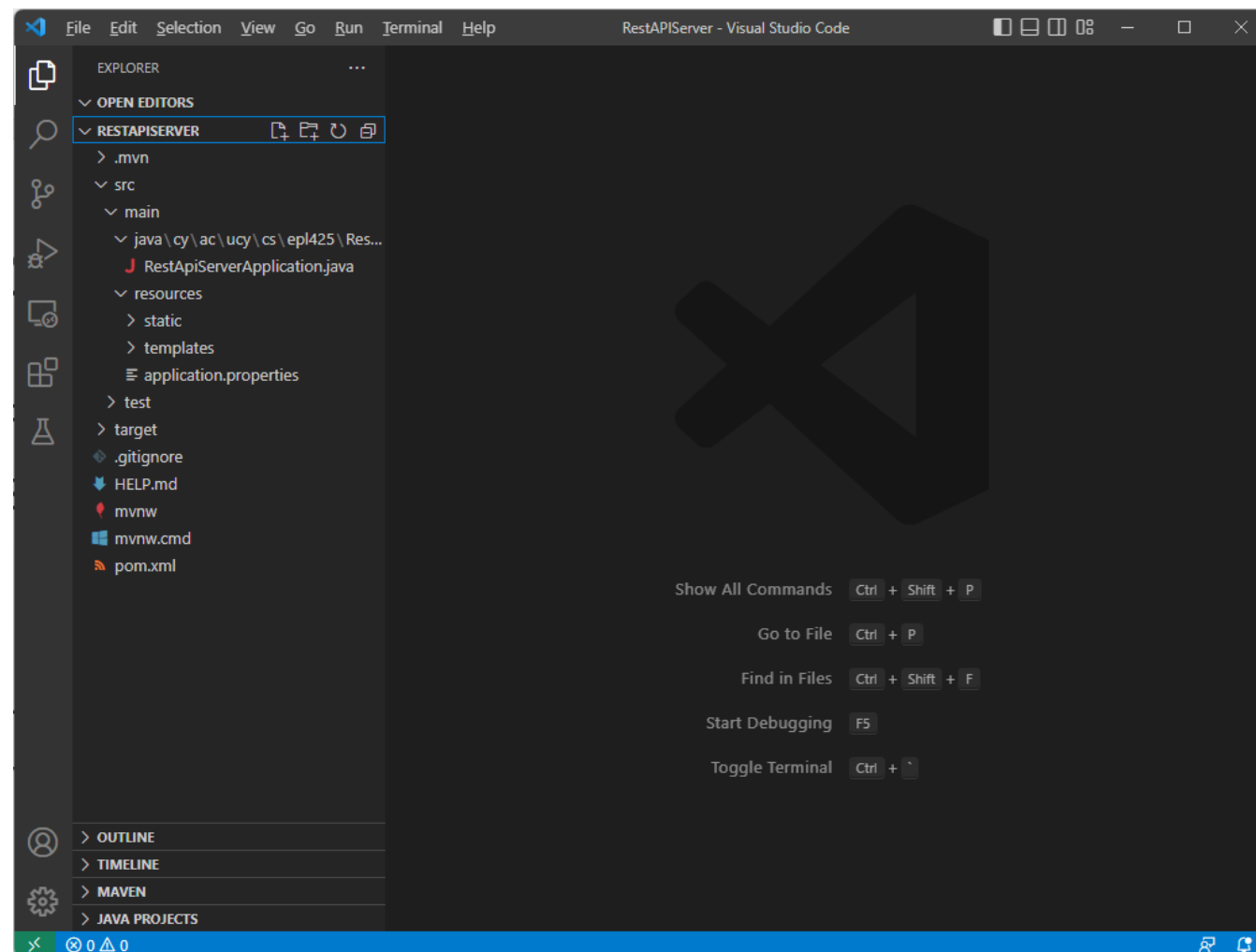
SHARE...



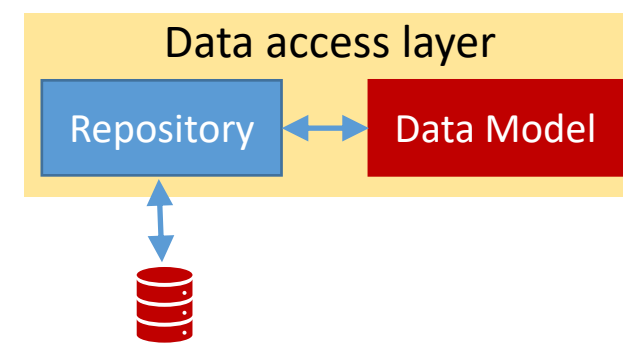


# Open Spring Boot Project in VS Code

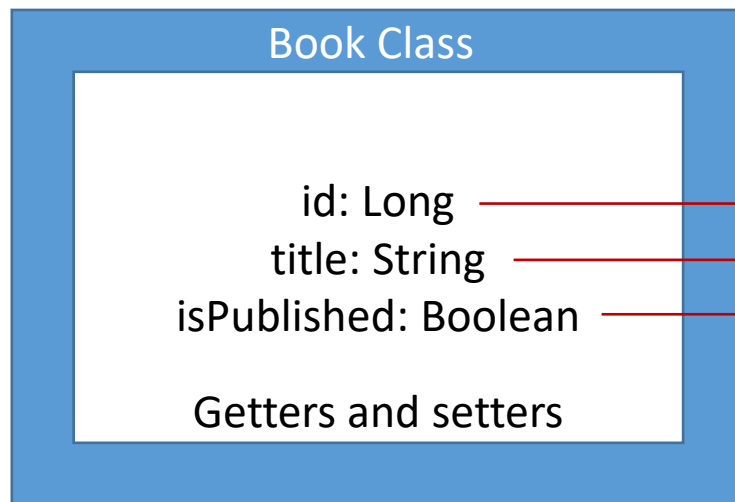
- Extract RestAPIServer.zip
  - Ensure that the RestAPIServer folder exists containing the src and target folders as well as pom.xml
- Open VS code
- Click on Explorer tab
- Click on Open RestAPIServer Folder
- Select the RestAPIServer directory



# Book entity: Java class (data model) to DB table mapping



- In Spring Boot, book entity is modelled as a Java class with attributes: id, title, publishedDate. Also the class has getters and setters.
- In Database, book entity is modelled as a table



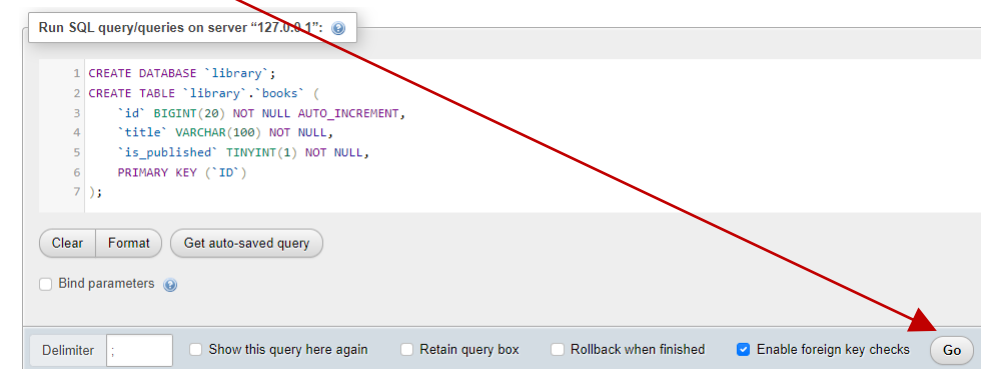
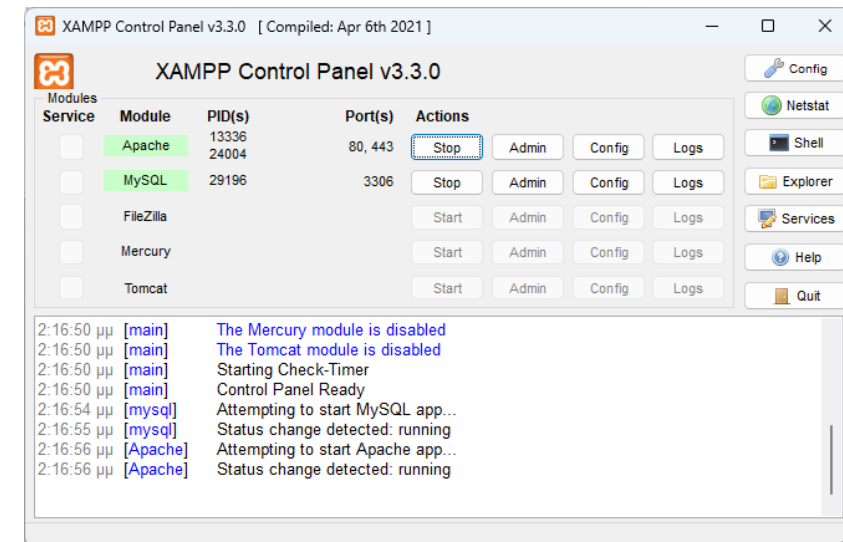
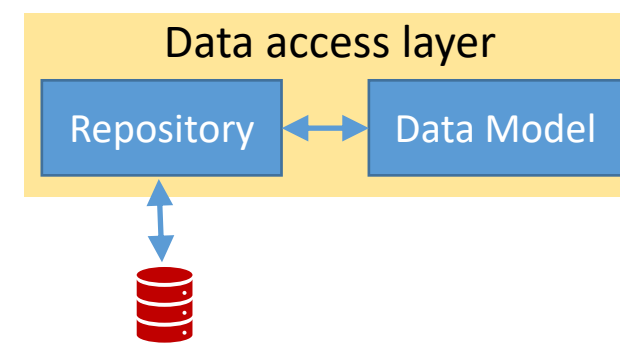
```
CREATE DATABASE `library`;  
CREATE TABLE `library`.`books` (  
  `id` BIGINT(20) NOT NULL AUTO_INCREMENT,  
  `title` VARCHAR(100) NOT NULL,  
  `is_published` TINYINT(1) NOT NULL,  
  PRIMARY KEY (`id`)  
);
```

Spring Data JDBC uses, by default, a naming strategy that maps Java classes to relational database tables, and attributes to column names. By default, the **Camel Case names of classes and attributes are mapped to snake case names of DB tables and columns**, respectively. For example, **attribute named *isPublished* is mapped to a table's column named *is\_published***

# Book entity: **Create DB table**

- Create database and table using phpMyAdmin:
  - Launch XAMPP and start Apache and MySQL
  - Navigate to <https://localhost/phpmyadmin>
  - Open SQL tab
  - Copy the following script and click on Go:

```
CREATE DATABASE `library`;
CREATE TABLE `library`.`books` (
  `id` BIGINT(20) NOT NULL AUTO_INCREMENT,
  `title` VARCHAR(100) NOT NULL,
  `is_published` TINYINT(1) NOT NULL,
  PRIMARY KEY (`id`)
);
```





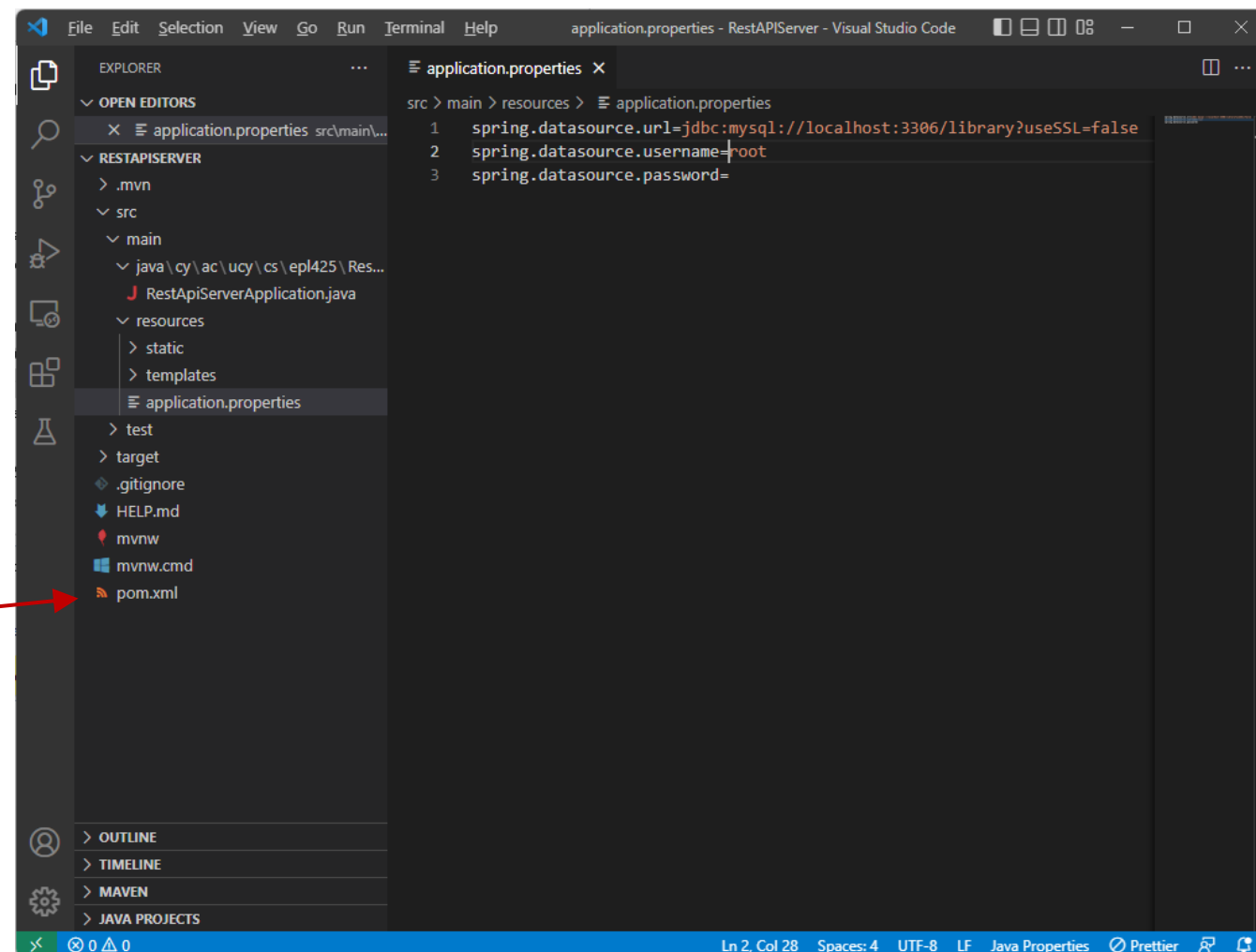
# Set configuration properties

- Open resources folder
- Open application.properties file and insert the following

```
spring.datasource.url=jdbc:mariadb://localhost:3306/library?useSSL=false
spring.datasource.username=root
spring.datasource.password=
spring.datasource.driver-class-name=org.mariadb.jdbc.Driver
```

- Add one dependency to pom.xml for MariaDB (enable maven project to download related Java classes):

```
<dependency>
  <groupId>org.mariadb.jdbc</groupId>
  <artifactId>mariadb-java-client</artifactId>
</dependency>
```



# Book entity: Create Java class (data model)

```
// map Java class with books table with @Table annotation
@Table("books")
public class Book {

    // In Spring Data JDBC, the Java class is required to
    // have an @Id annotation to identify entities.
    @Id
    private Long id;

    // map attribute with column with @Column annotation
    @Column("title")
    private String title;

    @Column("is_published")
    private Boolean isPublished;

    public Book() {

    }

    public Book(String title, Boolean isPublished) {
        this.title = title;
        this.isPublished = isPublished;
    }
}
```

```
// getters
public Long getId() {
    return id;
}

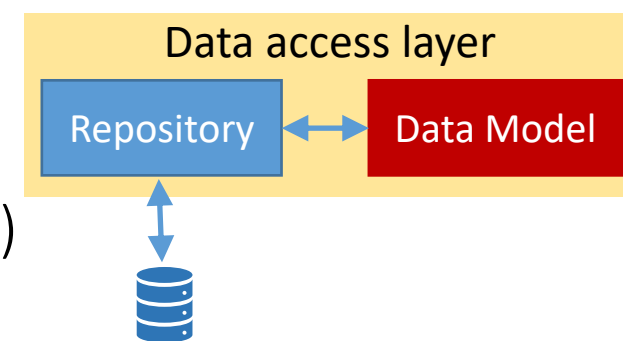
public String getTitle() {
    return title;
}

public Boolean getIsPublished() {
    return isPublished;
}

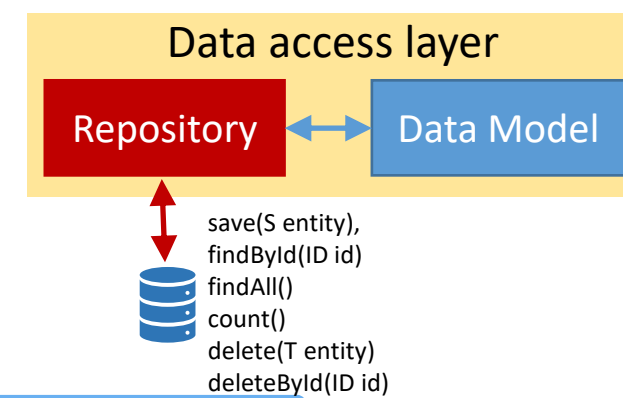
// setters
public void setTitle(String title) {
    this.title = title;
}

public void setIsPublished(Boolean isPublished) {
    this.isPublished = isPublished;
}

@Override
public String toString() {
    return "Book [id=" + id + ", title=" + title + ",
published date=" + isPublished + "]";
}
}
```



# Book Repository



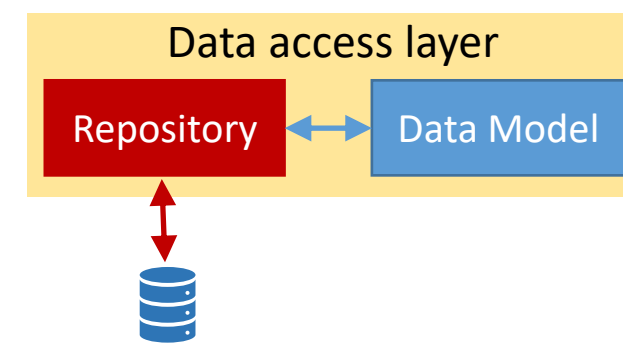
- Repository is used to interact with books table from the database
- BookRepository extends the [CrudRepository](#) class

```
@Repository
```

```
public interface BookRepository extends CrudRepository<Book, Long> {  
  
}
```

- We can use [CrudRepository](#)'s methods without implementing them:
  - `save(S entity)` : saves given entity in database
  - `findById(ID id)` : retrieves an entity identified by the given id
  - `findAll()` : returns all entities
  - `count()` : returns the number of entities available
  - `delete(T entity)` : deletes the given entity
  - `deleteById(ID id)` : deletes the entity with the given id

# Book Repository



- Repository is used to interact with books table from the database
- BookRepository extends the [CrudRepository](#) class

**@Repository**

```
public interface BookRepository extends CrudRepository<Book, Long> {
    List<Book> findByTitleContaining(String val);
    List<Book> findByIsPublished(Boolean val);
}
```

- We can also define **additional custom** finder method **header**:
  - **findByTitleContaining**(String val): selects the **title** column
    - returns all Book entities from database where the title column **contains** the val value
      - Function calls this query: `SELECT * FROM books WHERE title LIKE '%val%'`
  - **findByIsPublished**(Boolean val): searches on the **is\_published** column
    - returns all Book entities from database where the is\_published column has the val value



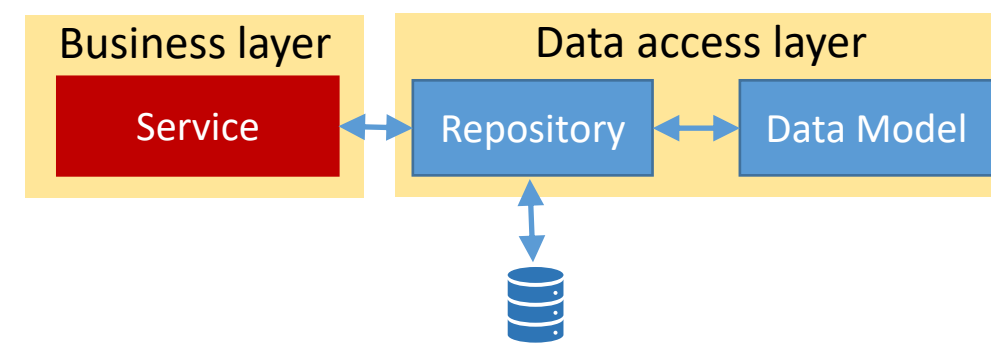
# Custom querying functions

- The query builder mechanism built into Spring Data repository infrastructure is useful for building constraining queries over entities of the repository – see more [here](#)

- `Optional<User> findByUsername(String val);`
  - `SELECT * FROM users WHERE username=val`
- `List<User> findAllByOrderByUsernameAsc();`
  - `SELECT * FROM users ORDER BY username ASC`
- `List<User> findByRegistrationDateBetween(LocalDate start, LocalDate end);`
  - `SELECT * FROM users WHERE registration_date BETWEEN start AND end`
- `List<User> findByUsernameContaining(String text);`
- `List<User> findByUsernameAndEmail(String username, String email);`
- `List<User> findByUsernameContainingAndEmailContaining(String username, String email);`
- `List<User> findByUsernameOrEmail(String username, String email);`
- `List<User> findByUsernameIgnoreCase(String username);`
- `List<User> findByLevelOrderByUsernameDesc(int level);`
- `List<User> findByLevelGreaterThanOrEqualTo(int level);`
- `List<User> findByUsernameLike(String text);`
- `List<User> findByUsernameStartingWith(String start);`
- `List<User> findByUsernameEndingWith(String end);`
- `List<User> findByActive(boolean active);`
- `List<User> findByRegistrationDateIn(Collection<LocalDate> dates);`
- `List<User> findByRegistrationDateNotIn(Collection<LocalDate> dates);`



# Book Service



- **BookService.java** class implements the business logic of the system
- Calls repository's functions to perform business logic operations

## @Service

```

public class BookService {
    // Spring injects bookRepository object when BookService
    // object is created
    @Autowired BookRepository bookRepository;

    public List<Book> getAllBooks() {
        List<Book> books = new ArrayList<Book>();
        this.bookRepository.findAll().forEach(books::add);
        return books;
    }

    public Book getBookById(Long id) {
        Optional<Book> book = this.bookRepository.findById(id);
        if(book.isPresent())
            return book.get();
        else return null;
    }

    public List<Book> getBooksByTitle(String title) {
        return this.bookRepository.findByTitleContaining(title);
    }
}

```

Repository's function `findAll()` returns a list of book entities from database as an `Iterable` object. Using `forEach`, we add all books to a List of books which is returned.

Repository's function `findById()` returns the book entity with the given id from database. `findById` returns `Optional`, so you can get the book by `get()` method. Check if book is present.

```

public List<Book> getPublishedBooks() {
    return this.bookRepository.findByIsPublished(true);
}

```

Repository's custom function `findByIsPublished()` returns a list of book entities having true in their `is_published` column from database.

```

public Book saveBook(Book book) {
    return this.bookRepository.save(book);
}

```

Repository's function `save()` stores the given book in database.

```

public void deleteAllBooks() {
    this.bookRepository.deleteAll();
}

```

Repository's function `deleteAll()` deletes all books from database.

```

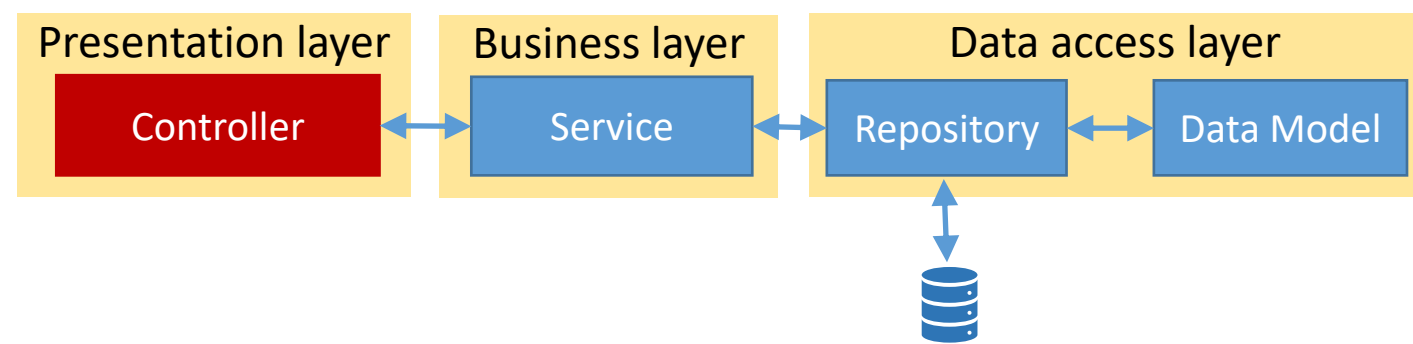
public void deleteBookById(Long id) {
    this.bookRepository.deleteById(id);
}

```

Repository's function `deleteById()` deletes the book with the given id from database.

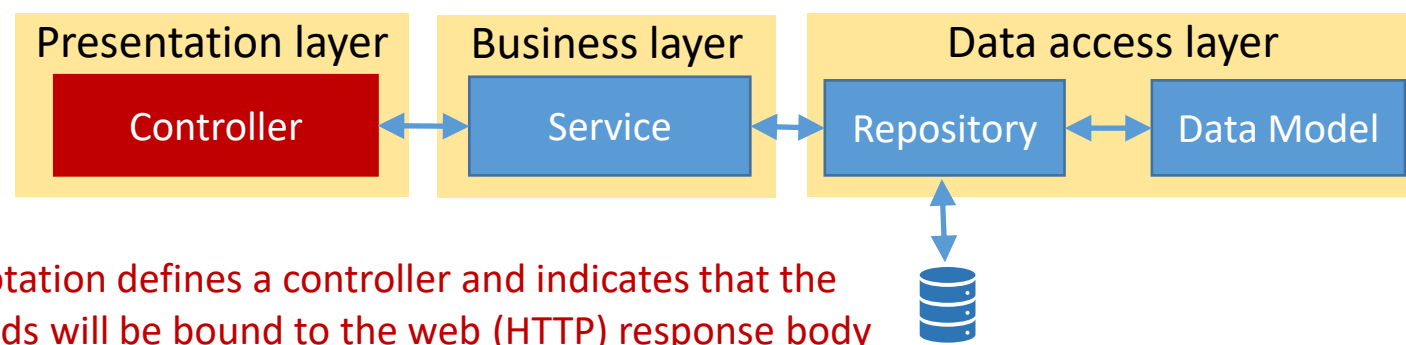
Repository's custom function `findByTitleContaining()` returns a list of book entities containing the given string in their title column from database.

# Book Controller



Method	API Endpoint (URL)	Description
GET	/api/books	retrieve all Books
GET	/api/books?title=[keyword]	retrieve all Books whose title contains keyword
GET	/api/books/published	retrieve all published Books
GET	/api/books/:id	retrieve a Book by :id
POST	/api/books	create new Book
PUT	/api/books/:id	update a Book by :id
DELETE	/api/books	delete all books
DELETE	/api/books/:id	delete a Book by :id

For each API endpoint, a separate method needs to be implemented in the Controller class



# Book Controller

**@RestController** ← **@RestController** annotation defines a controller and indicates that the return value of methods will be bound to the web (HTTP) response body

**@RequestMapping("/api")** ← **@RequestMapping** annotation declares that all API endpoints' urls in BookController will start with /api

**@GetMapping("/books")** ← **@GetMapping** annotation declares that getAllBooks() handles a GET request matched with the /books

**ResponseEntity** ← **ResponseEntity** represents the whole HTTP response: status code, headers, and body. This function returns a list of book objects within the body of the HTTP response message.

```

public class BookController {

    @Autowired
    BookService bookService;

    @GetMapping("/books")
    public ResponseEntity<List<Book>> getAllBooks(@RequestParam(required = false) String title) {
        try {
            List<Book> books;

            if (title == null)
                books = bookService.getAllBooks();
            else
                books = bookService.getBooksByTitle(title);

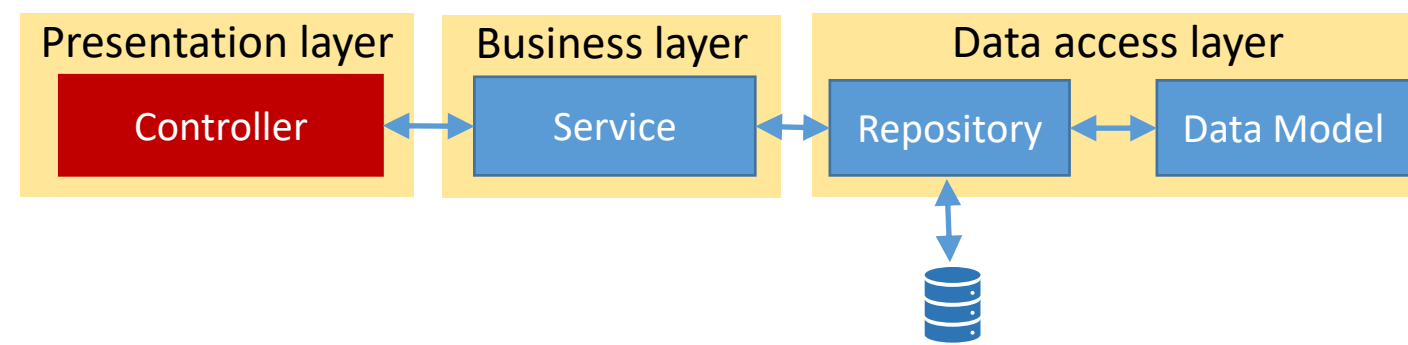
            if (books.isEmpty()) {
                return new ResponseEntity<>(HttpStatus.NO_CONTENT);
            }

            return new ResponseEntity<>(books, HttpStatus.OK);
        } catch (Exception e) {
            return new ResponseEntity<>(null, HttpStatus.INTERNAL_SERVER_ERROR);
        }
    }
}
    
```

**@RequestParam** is used to extract query parameters (declared after ?) from the GET request. If, for example the request is /api/books?title=test the query parameter is title and its value is test. In order to extract the value of the title query param we need to define a **function input parameter** with the same name. The title query parameter is not required so the GET request /api/books can be also handled by the same function

- If no book entity is found, the HTTP response message “204 No Content” will be returned to API client
- Otherwise, the list of books is returned in the body of an HTTP response message “200 OK”
- In the unexpected event of an internal problem (e.g. in the communication with the database), an HTTP response message “500 Internal Server Error” is to be returned

# Book Controller



```

@GetMapping("/books/{id}")
public ResponseEntity<Book> getBookById(@PathVariable("id") long id) {
    Book book = bookService.getBookById(id);

    if (book != null) {
        return new ResponseEntity<>(book, HttpStatus.OK);
    } else {
        return new ResponseEntity<>(HttpStatus.NOT_FOUND);
    }
}

```

Handles a **GET** request matched with the `api/books/id` endpoint where `id` is within the path (`@PathVariable`) of the API endpoint url and needs to be an integer number.

```

@PostMapping("/books")
public ResponseEntity<Book> createBook(@RequestBody Book book) {
    try {
        Book _book = bookService
            .saveBook(new Book(book.getTitle(), book.getIsPublished()));
        return new ResponseEntity<>(_book, HttpStatus.CREATED);
    } catch (Exception e) {
        return new ResponseEntity<>(null, HttpStatus.INTERNAL_SERVER_ERROR);
    }
}

```

Handles a **POST** request matched with the `api/books` endpoint which contains a book entity as a JSON string in the body of the message (`@RequestBody`) as shown below:

```

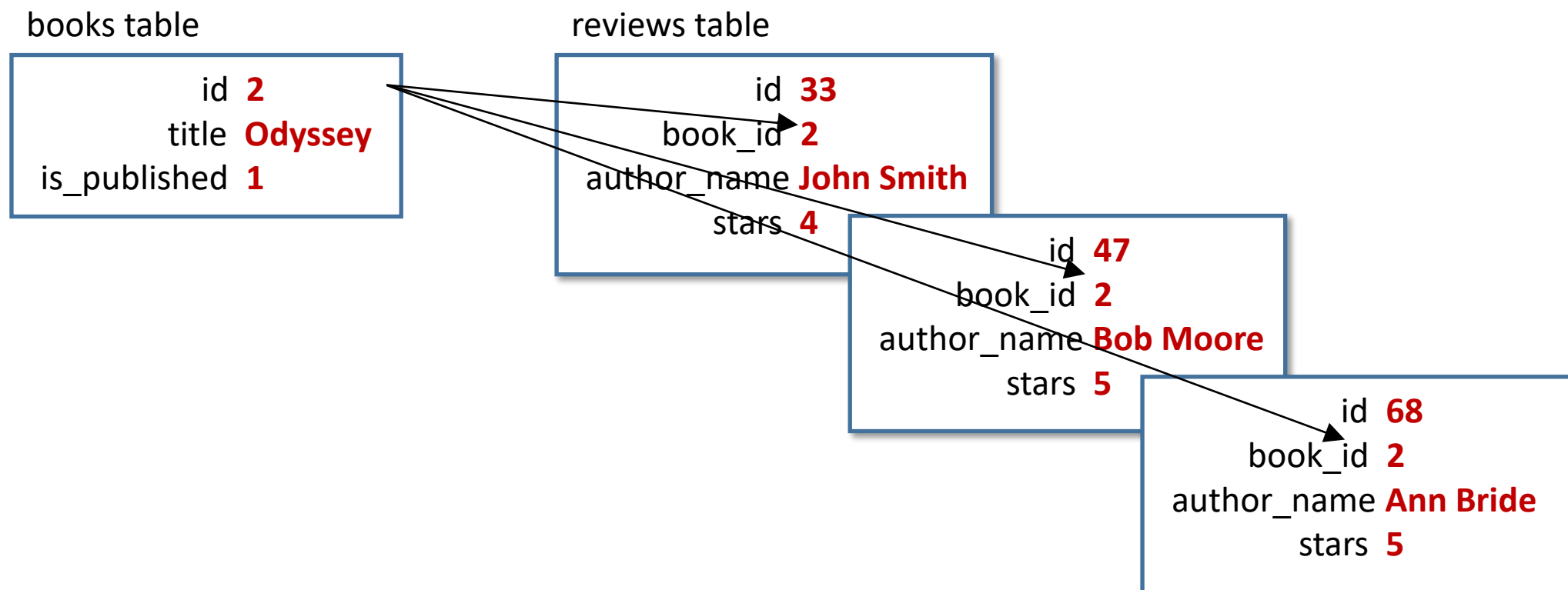
{
  "title": "Orient Express",
  "isPublished": true
}

```



# Add Book Reviews

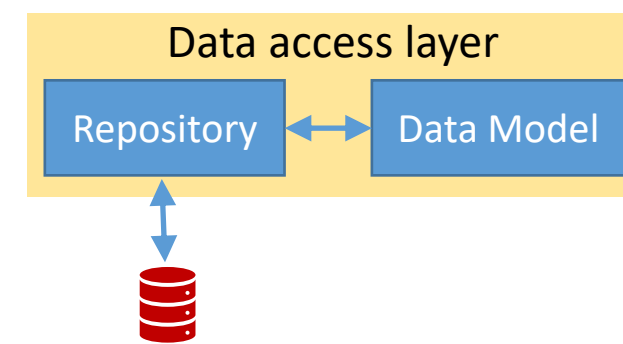
- New entity needed: Review
- Each book can have one or more reviews: one-to-many relationship



# Review entity: Create DB table

- Create table using phpMyAdmin:
  - Copy the following script and click on Go:

```
CREATE TABLE `library`.`reviews` (  
  `id` BIGINT(20) NOT NULL AUTO_INCREMENT,  
  `book_id` BIGINT(20) NOT NULL,  
  `author_name` VARCHAR(30) NOT NULL,  
  `title` VARCHAR(30) NOT NULL,  
  `stars` INT NOT NULL,  
  PRIMARY KEY (`id`),  
  CONSTRAINT `review_id_fk`  
    FOREIGN KEY (`book_id`)  
    REFERENCES `books` (`id`)  
    ON DELETE CASCADE  
);
```



# Review entity: Create Java class (data model)

```
@Table("reviews")
public class Review {
```

```
    @Id
    private Long id;

    // Ignore the bookId when serializing object to JSON
    @JsonIgnore
    @Column("book_id")
    private Long bookId;

    @Column("author_name")
    private String authorName;

    @Column("title")
    private String title;

    @Column("stars")
    private Integer stars;
```

```
    public Review(Long bookId, ...) {
        ...
    }
    // getters
    ...

    // setters
    ...
```

Set supports  
One-to-Many  
relationship.  
Creates a collection  
of the referenced  
entities.

```
@Table("books")
public class Book {
```

```
    ...

    // reference to book_id
    @MappedCollection(idColumn = "book_id")
    private Set<Review> reviews;
```

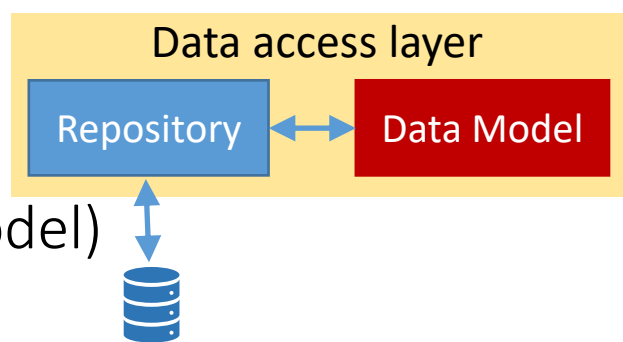
```
    ...

    // getters
    public Set<Review> getReviews() {
        return reviews;
    }
```

```
    ...

    // setters
    public void setReviews(Set<Review> reviews) {
        this.reviews = reviews;
    }

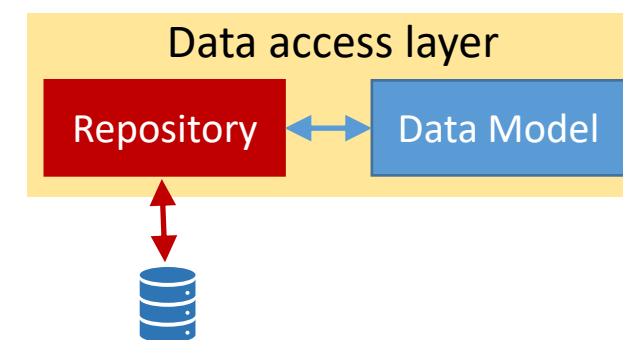
    public void setReview(Review review) {
        this.reviews.add(review);
    }
```



## Modify book data model

idColumn indicates the foreign key  
of the entity (review) referencing  
the id column of book entity

# Review **Repository**



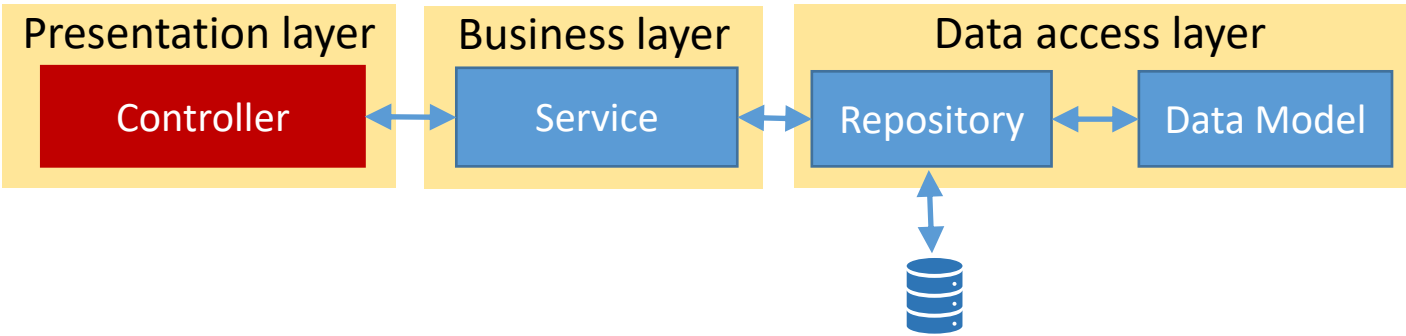
- ReviewRepository extends the [CrudRepository](#)

**@Repository**

```
public interface BookRepository extends CrudRepository<Book, Long> {
    List<Review> findByBookId(Long bookId);
    List<Review> findByBookIdAndAuthorNameContaining(Long bookId, String authorName);
    List<Review> findByBookIdAndTitleContaining(Long bookId, String val);
    List<Review> findByBookIdAndAuthorNameContainingAndTitleContaining(Long bookId,
String authorName, String title);
    List<Review> findByStarsEquals(Integer num);
    Long deleteByBookId(Long bookid);
}
```



# Review Controller

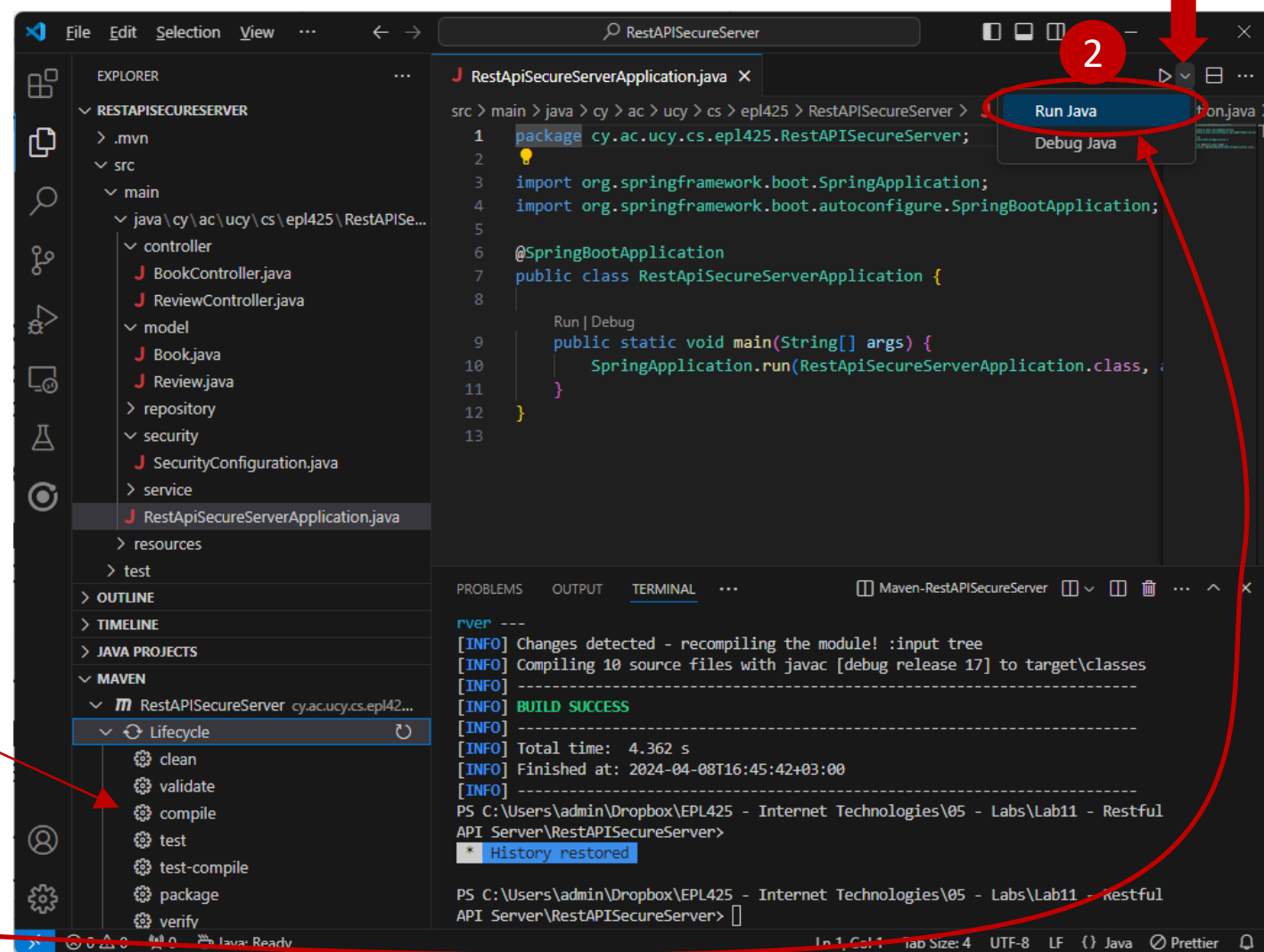


Method	API Endpoint (URL)	Description
GET	/api/books/:bid/reviews	retrieve all Reviews of Book by :bid
	/api/books/:bid/reviews?authorName=[keyword1]	retrieve all Reviews by :bid whose authorName contains keyword1
	/api/books/:bid/reviews?title=[keyword2]	retrieve all Reviews by :bid whose title contains keyword2
GET	/api/books/:bid/reviews/:id	retrieve the Review by :id of the Book by :bid
POST	/api/books/:bid/reviews	create new Review of the Book by :bid
PUT	/api/books/:bid/reviews/:id	update the Review by :id of the Book by :bid
DELETE	/api/books/:bid/reviews	delete all Reviews of the Book by :bid
DELETE	/api/books/:bid/reviews/:id	delete the Review by :id of the Book by :bid

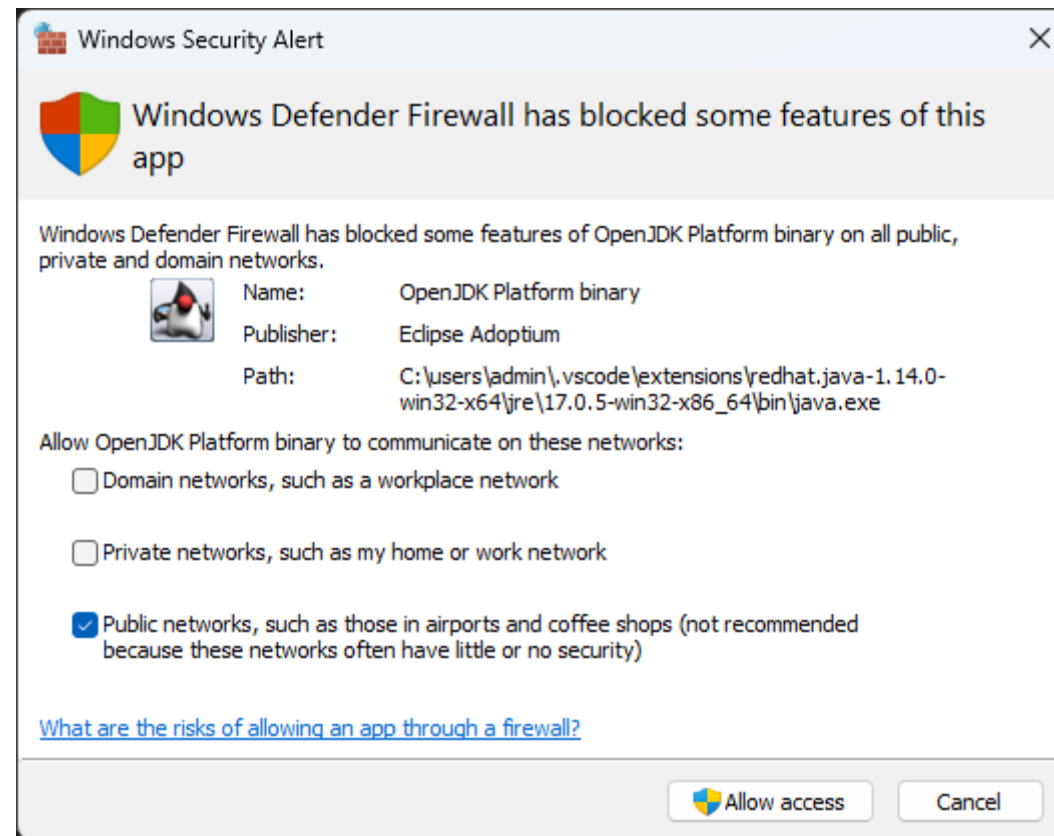
# Download, extract, compile, run application



- Download RestAPIServer.zip which contains the implementation of all API endpoints
- Extract it
- Open RestAPIServer folder via VS Code
- In Maven tab, click on compile to build the project
- Open the file RestApiServerApplication.java
- Run the project (click on Run Java, not Run Code if it exists)



# Allow RESTful API Server to be accessible





# Embedded Application Server

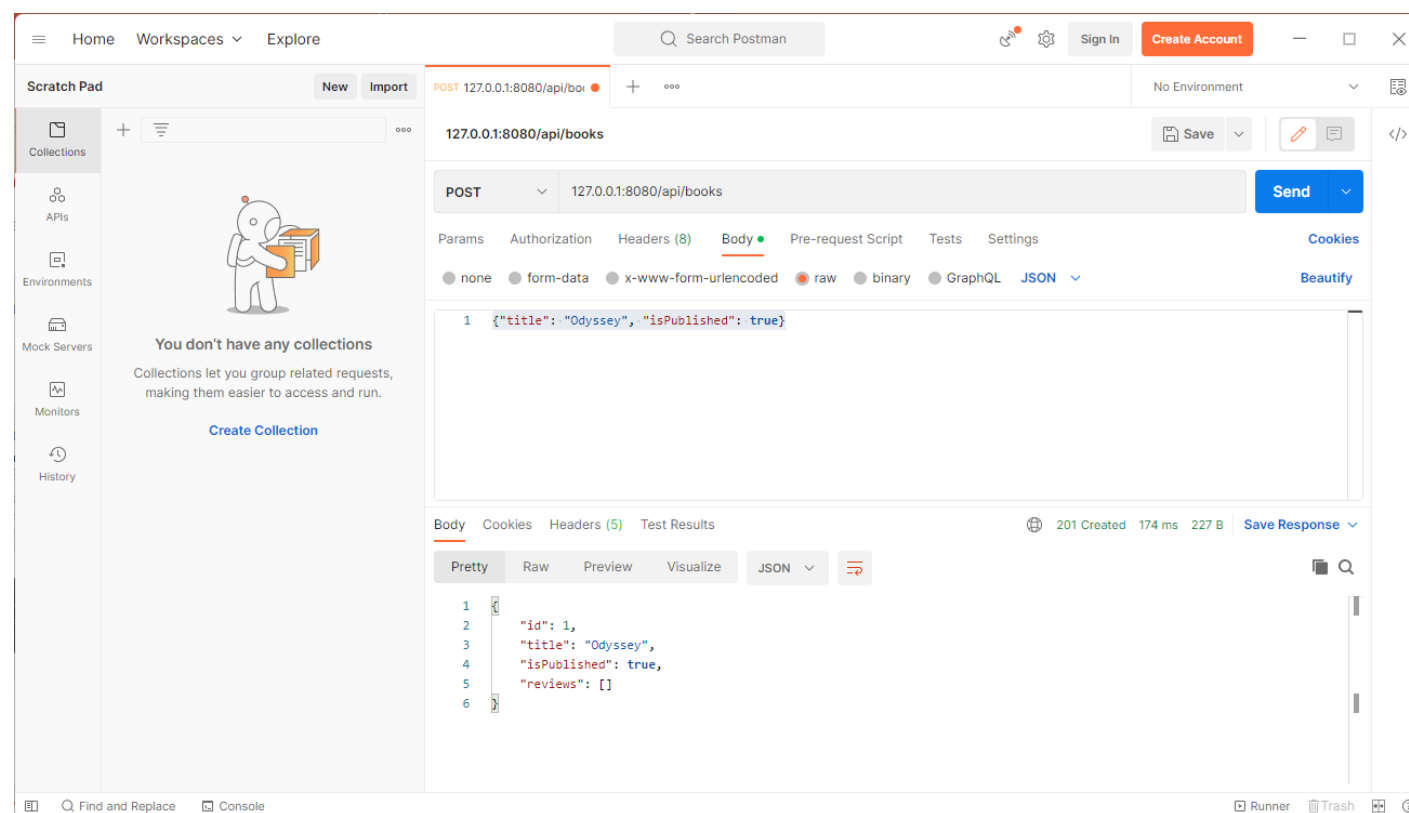
- When running the application, Spring Boot starts up an embedded application server (servlet container), an Apache Tomcat instance by default, to host the RESTful API
  - We can use another servlet container such as Jetty [by modifying pom.xml](#)
- Test RESTful API endpoints by opening up a browser or a RESTful API client such as Postman and access the endpoint urls such as:  
<http://localhost:8080/api/books>



# Use Postman to test RESTful API

- Create a book:
  - Send a POST message to `localhost:8080/api/books`
  - In message body provide a raw string in JSON format describing the entity to be created:

```
{"title": "Odyssey", "isPublished": true}
```

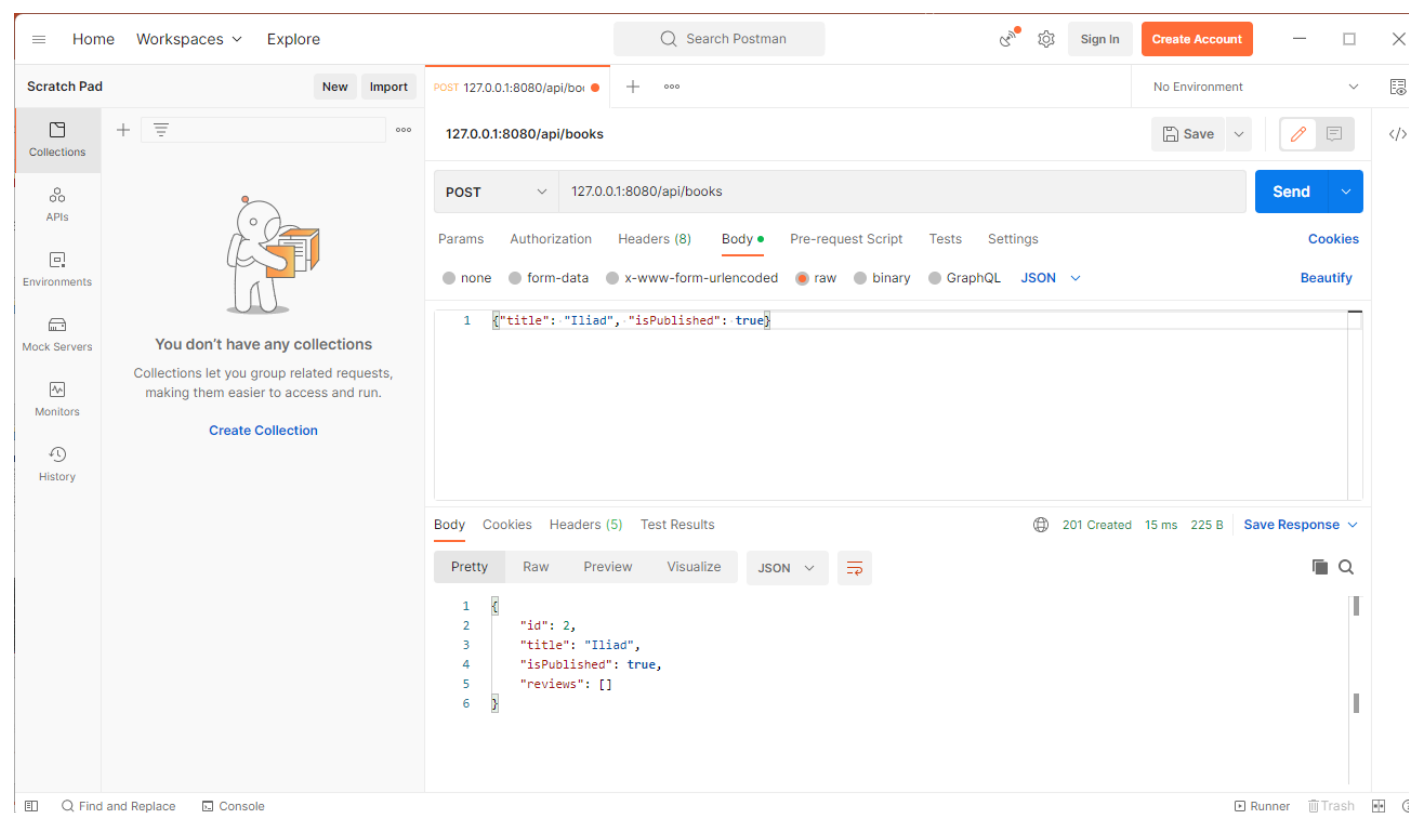




# Use Postman to test RESTful API

- Create another book:
  - Send a POST message to `localhost:8080/api/books`
  - In message body provide a raw string in JSON format describing the entity to be created:

```
{"title": "Iliad", "isPublished": true}
```



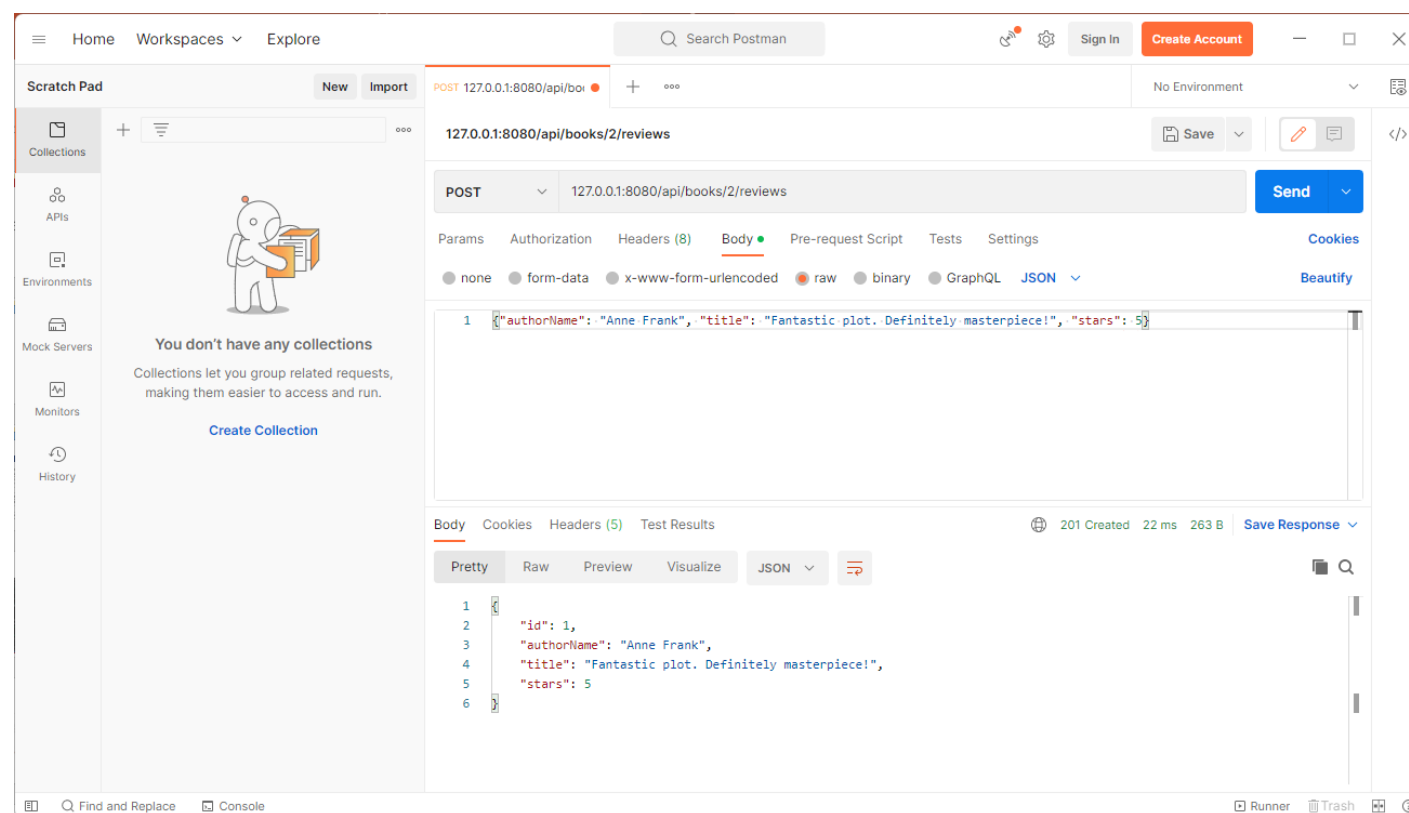


# Use Postman to test RESTful API

- Create a review for the book with id = 2:

- Send a POST message to `localhost:8080/api/books/2/reviews`
- In message body provide a raw string in JSON format describing the entity to be created:

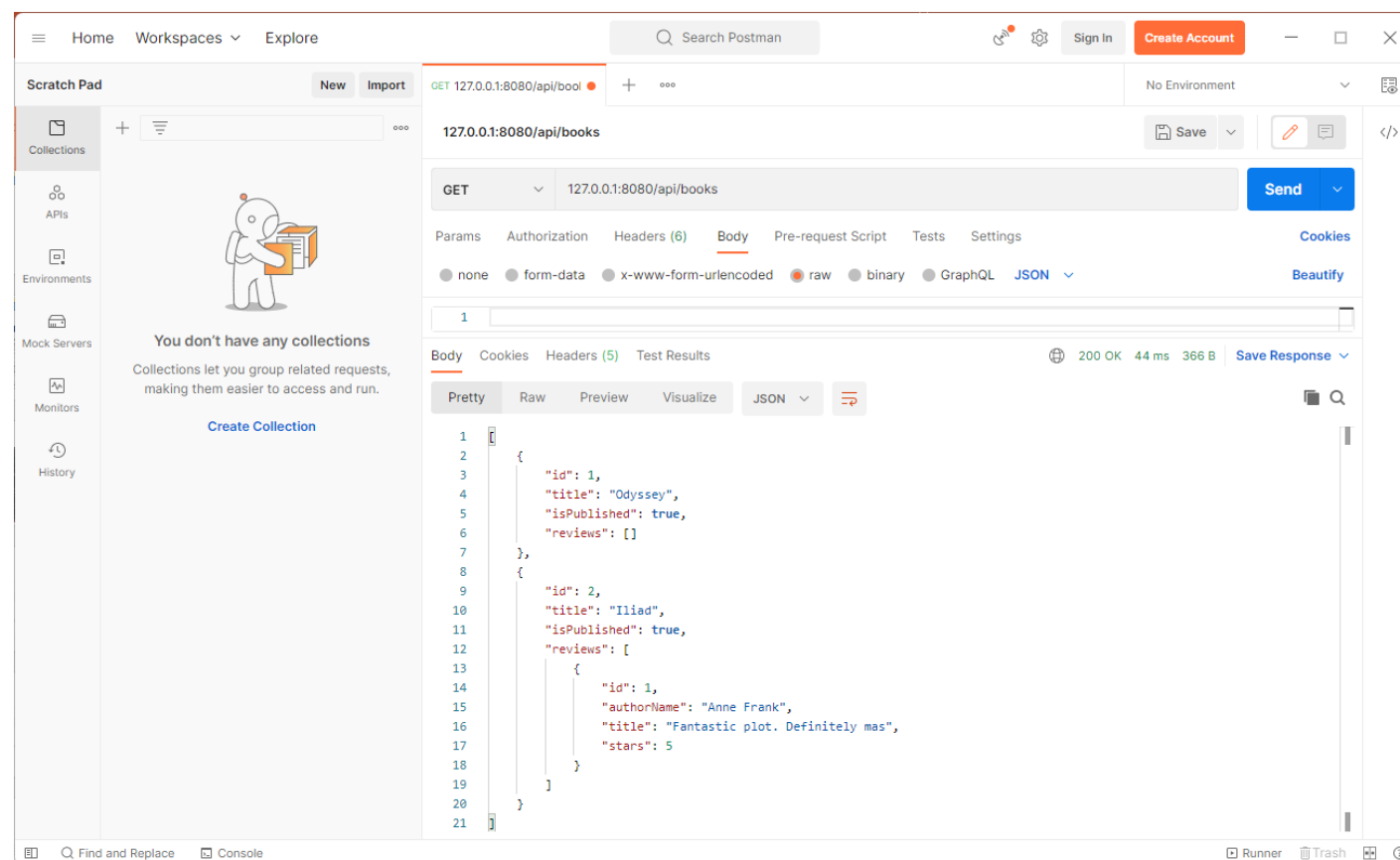
```
{"authorName": "Anne Frank", "title": "Fantastic plot. Definitely masterpiece!", "stars": 5}
```





# Use Postman to test RESTful API

- **Retrieve all books**
  - Send a GET message to `localhost:8080/api/books`
- Retrieve all books whose titles contain the phrase sey
  - Send a GET message to `localhost:8080/api/books?title=sey`
- Retrieve all reviews for the book with id = 2:
  - Send a GET message to `localhost:8080/api/books/2/reviews`

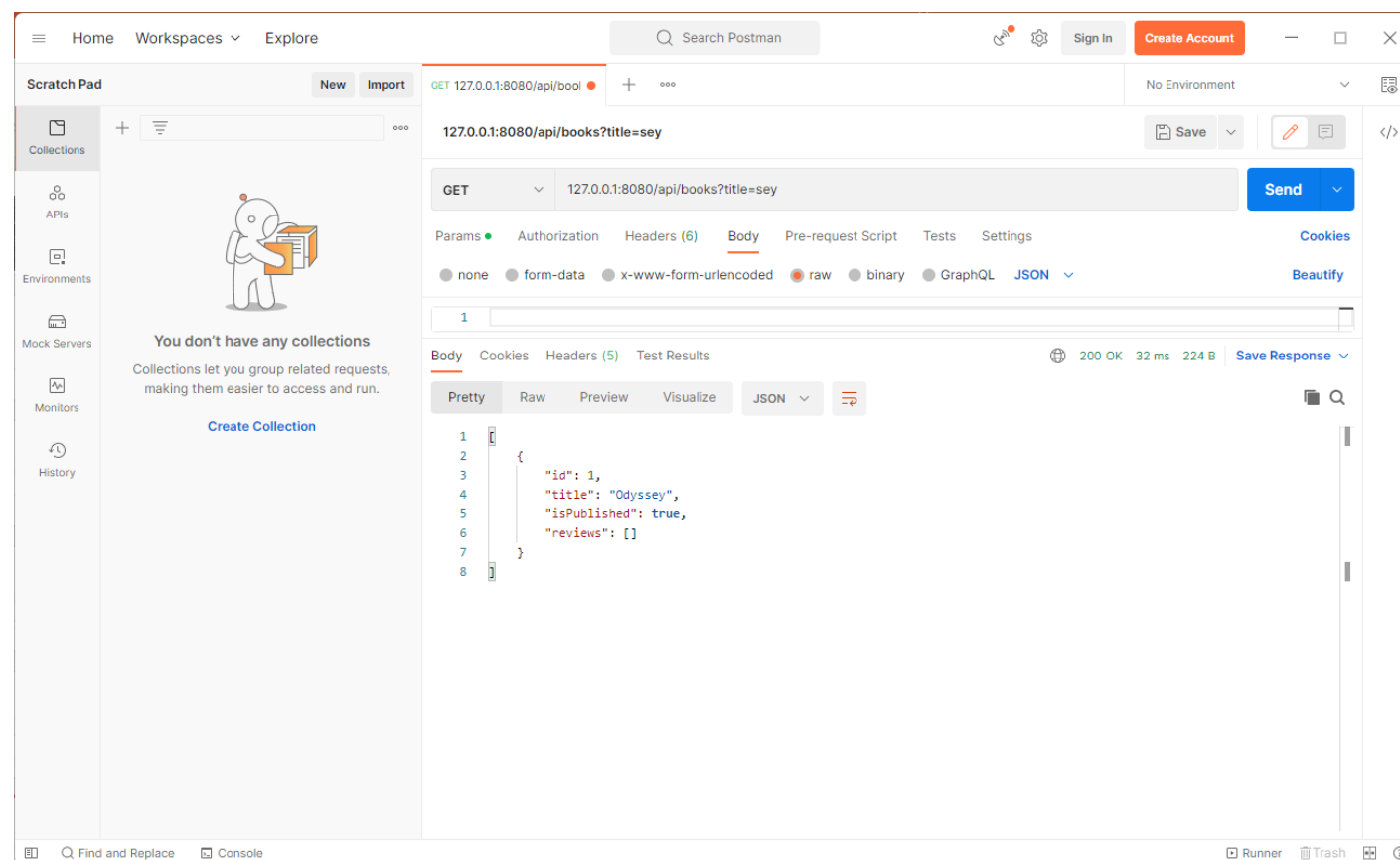






# Use Postman to test RESTful API

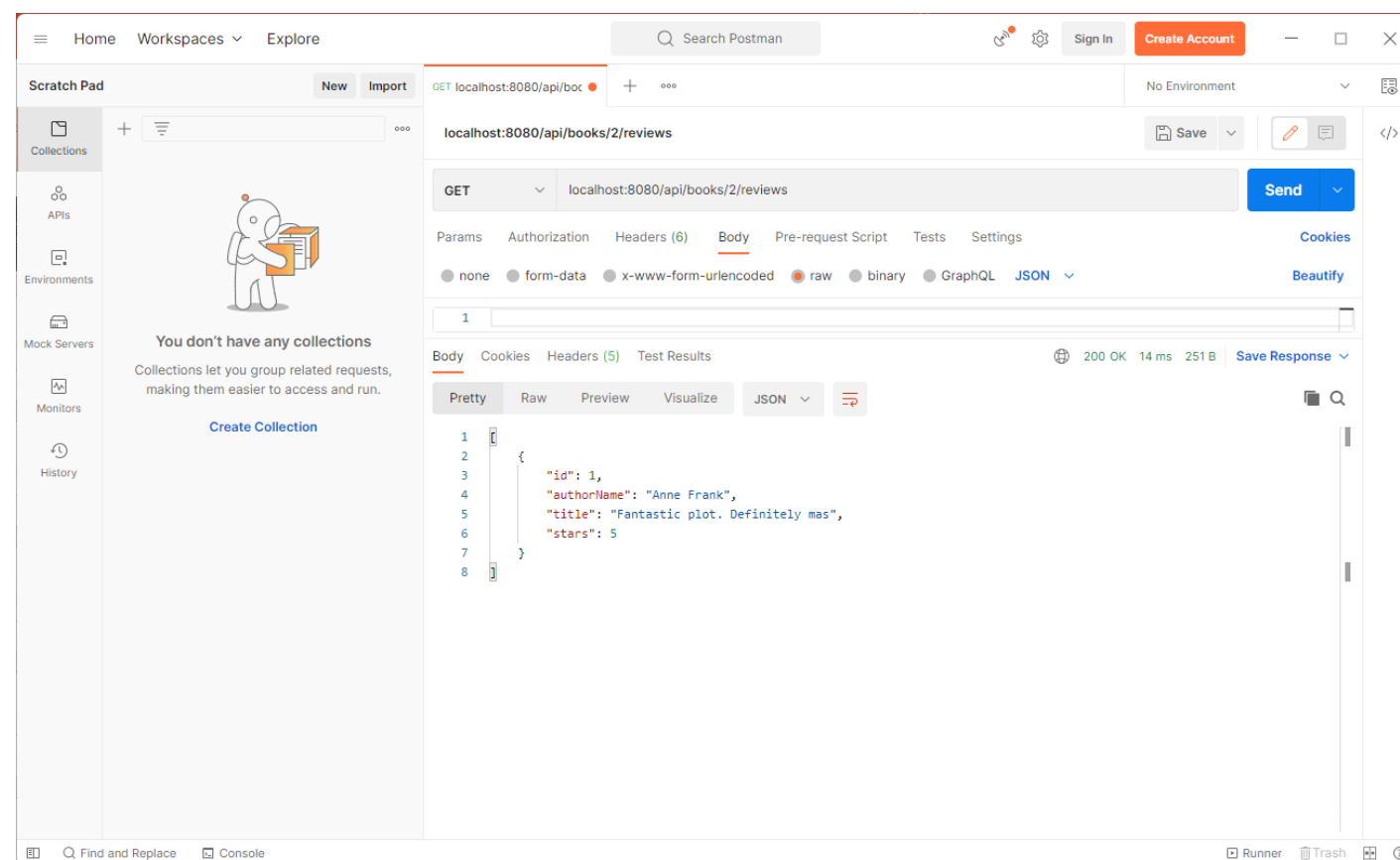
- Retrieve all books
  - Send a GET message to `localhost:8080/api/books`
- Retrieve all books whose titles contain the phrase **sey**
  - Send a GET message to `localhost:8080/api/books?title=sey`
- Retrieve all reviews for the book with `id = 2`:
  - Send a GET message to `localhost:8080/api/books/2/reviews`





# Use Postman to test RESTful API

- Retrieve all books
  - Send a GET message to `localhost:8080/api/books`
- Retrieve all books whose titles contain the phrase sey
  - Send a GET message to `localhost:8080/api/books?title=sey`
- Retrieve all reviews for the book with id = 2:
  - Send a GET message to `localhost:8080/api/books/2/reviews`





# Package and deploy

- In Maven tab, execute package command to create a .jar file
  - .jar includes all dependencies and application server
- Open RestAPIServer/target folder to locate the .jar file
- You can launch the RESTful API from command line (cmd) using the following command:  
`java -jar myfile.jar`

The screenshot shows the Visual Studio Code interface. On the left, the 'EXPLORER' sidebar displays the project structure, including the 'MAVEN' tab where the 'package' command is selected. A red arrow points from the 'package' command in the Maven sidebar to the 'package' command in the list. The main editor shows the 'RestApiServerApplication.java' file with the following code:

```
1 package cy.ac.ucy.cs.ep1425.RestAPIServer;
2
3 import org.springframework.boot.SpringApplication;
4 import org.springframework.boot.autoconfigure.SpringBootApplication;
5
6 @SpringBootApplication
7 public class RestApiServerApplication {
8
9     public static void main(String[] args) {
10         SpringApplication.run(RestApiServerApplication.class, args);
11     }
12 }
13
```

The bottom panel shows the 'TERMINAL' tab with the following output:

```
s/plexus/plexus-utils/3.4.2/plexus-utils-3.4.2.jar (267 kB at 713 kB/s)
[INFO] Building jar: c:\Users\admin\Downloads\RestAPIServer\target\RestAPIServer-0.0.1-SNAPSHOT.jar
[INFO]
[INFO] --- spring-boot-maven-plugin:3.0.0:repackage (repackage) @ RestAPIServer ---
[INFO] Replacing main artifact with repackaged archive
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 14.910 s
[INFO] Finished at: 2022-12-22T11:46:57+02:00
[INFO] -----
PS C:\Users\admin\Downloads\RestAPIServer>
```

# Securing your RESTful API



- Sooner or later everyone needs to add security to a RESTful API
- In Spring ecosystem this is performed with the help of the Spring Security library
- Spring Security is a set of **servlet filters** that help you add **authentication** and **authorization** to your web application

# Authentication & Authorization



- Authentication

- Verifies the identity of a user. Typically done with a username & password check
  - Other available authentication mechanisms provided by Spring Security are shown [here](#).
- If user not authenticated, **HTTP 401 Unauthorized** response message is issued

- Authorization

- Determines user rights: verifies what each user has access to
  - In simpler applications, authentication might be enough: As soon as a user authenticates, can access every part of an application
  - Most applications have the concept of permissions (or roles) e.g.: simple users who have access to read resources and administrators who have access to create/update/remove resources
- If user doesn't have access permission, **HTTP 403 Forbidden** response message is issued



# Servlet filters

- Filters are placed *in front* of @RestController servlets and are configured to authenticate and authorize every incoming HTTP request before it hits the servlet
- A chain of filters can be used to handle every incoming request to:
  1. Extract a username/password from the request. It could be via a **Basic Auth HTTP Header** (default security mechanism, see next slide), or **login form fields**, or a **cookie**, etc.
  2. Validate that username/password combination against *something*, like a database, an in-memory (RAM) storage, etc. [Authentication filter]
  3. Allow access to resources based on user role [Authorization filter]



# Default filter: Basic Authentication

- Simplest method of securing HTTP requests through a special req. header:  
`Authorization: Basic <credentials>`
- API client can generate the `credentials` token, using username and password (given by API server), joined by the semicolon character and encode the resulting string with [Base64](#)
  - Example: If username is `pavlos` and password is `ep1425$` the credentials string is `pavlos:ep1425$`. When we encode it with Base64 we get `cGF2bG9zOmVwbDQyNSQ=` The header's value is:  
`Authorization: Basic cGF2bG9zOmVwbDQyNSQ=`
- API clients need to provide this header field in every request

# Basic Authentication when sending a request using Postman



- Add the header manually
  - Go to headers tab, set “*Authorization*” as the key and the credentials token as value

Params • Authorization Headers (10) Body • Pre-request Script Tests Settings Cookies

Headers 9 hidden

	KEY	VALUE	DESCRIPTION	...	Bulk Edit	Presets ▾
<input checked="" type="checkbox"/>	Authorization	Basic cGF2bG9zOmVwbDQyNSQ=				
	Key	Value	Description			

- Or use the Authorization tab (recommended)
  - select “*Basic Auth*” as the authorization type and insert username password

Params • Authorization Headers (11) Body • Pre-request Script Tests Settings Cookies

Type Basic Au... ▾

The authorization header will be automatically generated when you send the request.  
[Learn more about authorization ↗](#)

Username

Password

☒ Show Password

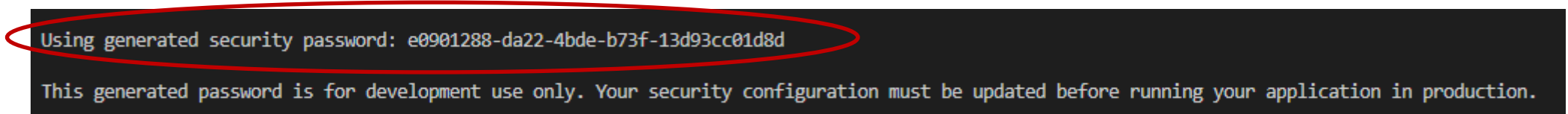


# Add Spring Security to secure your Restful API

- Spring Security can be added to Spring Boot project via pom.xml

```
<dependency>  
  <groupId>org.springframework.boot</groupId>  
  <artifactId>spring-boot-starter-security</artifactId>  
</dependency>
```

- ... then all API endpoints will not be accessible anymore
- When you re-run the web application, on VSCode terminal you can see (among other) the following message:



```
Using generated security password: e0901288-da22-4bde-b73f-13d93cc01d8d
```

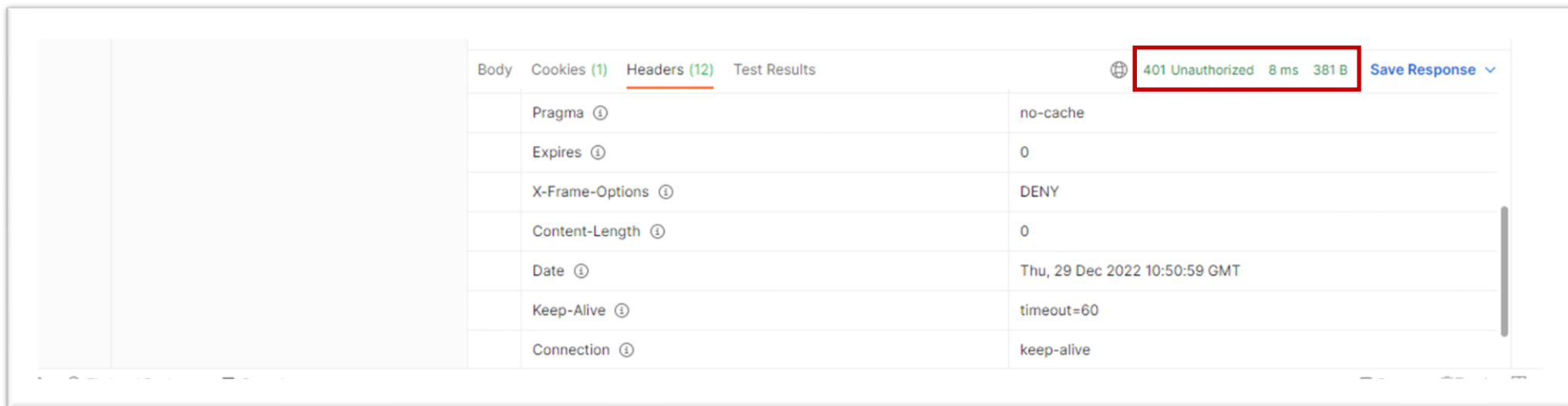
```
This generated password is for development use only. Your security configuration must be updated before running your application in production.
```

- This is the auto-generated password for the Basic Authentication scheme
- Is there any username? Yes, the default username is **user**



# Securing your RESTful API

- When you try to access: `localhost:8080/api/books`
- HTTP 401 Unauthorized response code returned
  - Indicates that the client request has not been completed because it lacks valid authentication credentials (username and password) for the requested resource.





# Securing your RESTful API

- Access API endpoint `localhost:8080/api/books` by taking into account the username (user) and the generated password

GET

localhost:8080/api/books

Send

Params

Authorization

Headers (11)

Body

Pre-request Script

Tests

Settings

Cookies

Type

Basic Au...

Username

user

Password

5b28f07b-45a3-4970-8a0a-cd6b8048635d

☒ Show Password

The authorization header will be automatically generated when you send the request.

[Learn more about authorization](#)

Body

Cookies (1)

Headers (11)

Test Results

200 OK

326 ms

536 B

Save Response

Pretty

Raw

Preview

Visualize

JSON

1

[

2

{

3

"id": 1,

4

"title": "Odyssey",

5

"isPublished": true,

6

"reviews": []

7

},





# Overriding default credentials

- We can override the default username and auto-generated password provided by the Spring Security mechanism
- Custom user credentials can be set in any of the following ways:
  1. manually via the `application.properties` file
    - `spring.security.user.name=pavlos`
    - `spring.security.user.password=ep1425$`
  2. using a dedicated Java class that retrieves credentials from:
    - a) memory (Java variables) or
    - b) database

# Credentials in Memory

In Spring, the objects that form the backbone of your application and that are managed by Spring are called beans. A bean is an object that is instantiated, assembled, and otherwise managed by Spring and it is globally available to the entire application.



- **userDetailsManager()** method creates in-memory users
  - To start with we have added two users: **employee** and **manager**
- **passwordEncoder()** returns an instance of BCryptPasswordEncoder which is used to encode the password

```
@Bean
public InMemoryUserDetailsManager userDetailsManager() {
    List<UserDetails> userDetailsList = new ArrayList<>();
    userDetailsList.add(User
        .withUsername("employee")
        .password(passwordEncoder().encode("ep1425$"))
        .roles("EMPLOYEE")
        .build());

    userDetailsList.add(User
        .withUsername("manager")
        .password(passwordEncoder().encode("password"))
        .roles("EMPLOYEE", "MANAGER")
        .build());

    return new InMemoryUserDetailsManager(userDetailsList);
}

@Bean
public PasswordEncoder passwordEncoder() {
    return new BCryptPasswordEncoder();
}
```



# Adding roles

- **userDetailsManager()** method creates in-memory users **with specific roles** in order to enable authorization
  - employee is assigned the **EMPLOYEE** role and manager both **EMPLOYEE** and **MANAGER** roles

```
@Bean
public InMemoryUserDetailsManager userDetailsManager() {
    List<UserDetails> userDetailsList = new ArrayList<>();
    userDetailsList.add(User
        .withUsername("employee")
        .password(passwordEncoder().encode("ep1425$"))
        .roles("EMPLOYEE")
        .build());

    userDetailsList.add(User
        .withUsername("manager")
        .password(passwordEncoder().encode("password"))
        .roles("EMPLOYEE", "MANAGER")
        .build());

    return new InMemoryUserDetailsManager(userDetailsList);
}

@Bean
public PasswordEncoder passwordEncoder() {
    return new BCryptPasswordEncoder();
}
```



# Security Filter Chain

- How does Spring Security know that we want to **require all users to be authenticated**?
- How does Spring Security know we want to **support Basic authentication**?
- How does Spring Security know where to **find user credentials for user authentication**?
- How does Spring Security know how to **authorize access to content based on the different roles**?
- Actually, there is a configuration class (called `SecurityFilterChain`) that is being invoked behind the scenes.

# Security Filter Chain **default** configuration



- Ensures that any request to our application requires the user to be authenticated
- Lets users authenticate with form based login
- Lets users authenticate with HTTP Basic authentication

```
@Bean
public SecurityFilterChain
filterChain(HttpSecurity http) throws Exception {
    http
        .authorizeRequests(authorize -> authorize
            .anyRequest().authenticated()
        )
        .formLogin(Customizer.withDefaults())
        .httpBasic(Customizer.withDefaults())
    };
    return http.build();
}
```





# Security Filter Chain

- We can create an instance of the `SecurityFilterChain` to define a custom filter chain in and define what to apply on each request
  - In this example, any request is required to be authenticated and access to content is authorized on the basis of HTTP method and roles
  - In this example, authentication manager relies on In-Memory credentials
  - In this example, users authenticate with Basic Authentication

```
@Bean
public SecurityFilterChain securityFilterChain(HttpSecurity http)
throws Exception {

    AuthenticationManagerBuilder authenticationManagerBuilder =
http.getSharedObject(AuthenticationManagerBuilder.class);
    authenticationManagerBuilder.userDetailsService(userDetailsManag
er());
    authenticationManager = authenticationManagerBuilder.build();

    http
        .csrf(csrf->csrf.disable())
        .httpBasic(Customizer.withDefaults())
        .authorizeHttpRequests(authorize -> authorize
            .requestMatchers(HttpMethod.POST,
"/api/books/**") .hasAnyRole("MANAGER")
            .requestMatchers(HttpMethod.PUT,
"/api/books/**") .hasAnyRole("MANAGER")
            .requestMatchers(HttpMethod.DELETE,
"/api/books/**") .hasAnyRole("MANAGER")
            .requestMatchers(HttpMethod.GET, "/api/books/**") .permitAll()
            .anyRequest().authenticated()
        )
        .authenticationManager(authenticationManager);

    return http.build();
}
```

If you want to disable CORS when testing API from localhost see [here](#)

# Download, extract, compile, run application



- Download RestAPISecureServer.zip which contains the implementation of all secure API endpoints for Books and Reviews
- Extract it
- Open RestAPISecureServer folder via VS Code
- In Maven tab, click on compile to build the project
- Open the file RestApiServerApplication.java
- Run the project

```

src > main > java > cy > ac > ucy > cs > epl425 > RestAPISecureServer > RestApiSecureServerApplication.java >
1 package cy.ac.ucepl425.RestAPISecureServer;
2
3 import org.springframework.boot.SpringApplication;
4 import org.springframework.boot.autoconfigure.SpringBootApplication;
5
6 @SpringBootApplication
7 public class RestApiSecureServerApplication {
8
9     Run | Debug
10    public static void main(String[] args) {
11        SpringApplication.run(primarySource: RestApiSecureServerApplication.class, args);
12    }
13

```

2023-03-06T18:41:37.890+02:00 INFO 29076 --- [ restartedMain] o.s.b.d.a.OptionalLiveReloadServer : LiveReload server is running on port 35729

2023-03-06T18:41:38.922+02:00 INFO 29076 --- [ restartedMain] o.s.s.web.DefaultSecurityFilterChain : Will secure any request with [org.springframework.security.web.session.DisableEncodeUrlFilter@2f802fe1, org.springframework.security.web.context.request.async.WebAsyncManagerIntegrationFilter@7acbb1d, org.springframework.security.web.context.SecurityContextHolderFilter@66f85bed, org.springframework.security.web.header.HeaderWriterFilter@46d8633e, org.springframework.security.web.authentication.logout.LogoutFilter@4d098157, org.springframework.security.web.authentication.www.BasicAuthenticationFilter@2302671d, org.springframework.security.web.savedrequest.RequestCacheAwareFilter@68bc4839, org.springframework.security.web.servletapi.SecurityContextHolderAwareRequestFilter@5e8ca23, org.springframework.security.web.authentication.AnonymousAuthenticationFilter@7d2d0ede, org.springframework.security.web.access.ExceptionTranslationFilter@3c8ea8e6, org.springframework.security.web.access.intercept.AuthorizationFilter@4e6cdd19]

2023-03-06T18:41:39.232+02:00 INFO 29076 --- [ restartedMain] o.s.b.w.embedded.tomcat.TomcatWebServer : Tomcat started on port(s): 8080 (http) with context path ''

2023-03-06T18:41:39.259+02:00 INFO 29076 --- [ restartedMain] a.u.c.e.R.RestApiSecureServerApplication : Started RestApiSecureServerApplication in 5.122 seconds (process running for 5.649)

# Appendix

# Replace Tomcat with Jetty



- Modify pom.xml as shown below:

```
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
    <exclusions>
      <exclusion>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-tomcat</artifactId>
      </exclusion>
    </exclusions>
  </dependency>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-jetty</artifactId>
  </dependency>
</dependencies>
```

exclude the default added  
spring-boot-starter-tomcat  
dependency

add the dependency for  
spring-boot-starter-jetty

# Disable CORS on API for localhost



```
@Bean
public SecurityFilterChain securityFilterChain(HttpSecurity http) throws Exception {

    AuthenticationManagerBuilder authenticationManagerBuilder = http.getSharedObject(AuthenticationManagerBuilder.class);
    authenticationManagerBuilder.userDetailsService(userDetailsService());
    authenticationManager = authenticationManagerBuilder.build();

    http
        .csrf(csrf->csrf.disable())
        .httpBasic(Customizer.withDefaults())
        .cors(cors -> cors.configurationSource(corsConfigurationSource()))
        ...
}

CorsConfigurationSource corsConfigurationSource() {
    CorsConfiguration configuration = new CorsConfiguration();
    configuration.setAllowCredentials(true);
    configuration.setAllowedOrigins(Arrays.asList("http://localhost"));
    configuration.setAllowedMethods(Arrays.asList(CorsConfiguration.ALL)); // e.g. GET, POST, PATCH, PUT, DELETE, OPTIONS, HEAD
    configuration.setAllowedHeaders(Arrays.asList(CorsConfiguration.ALL));
    //configuration.setMaxAge(3600L);
    UrlBasedCorsConfigurationSource source = new UrlBasedCorsConfigurationSource();
    source.registerCorsConfiguration("/**", configuration);
    return source;
}
```