5COSC022W.2 Client-Server Architectures

Tutorial Week 07: RESTful web services with JAX-RS

INTRODUCTION

Java API for RESTful Web Services (JAX-RS) is a set of APIs and specifications that simplify the development of RESTful web services in Java. REST (Representational State Transfer) is an architectural style for designing networked applications, and JAX-RS provides a Java-based approach for implementing RESTful services.

1. **Purpose of JAX-RS:**
    - JAX-RS simplifies the creation of web services that follow REST principles.
    - It provides a set of annotations and APIs for building scalable and flexible web services in Java.
2. **RESTful Web Services:**
    - RESTful services are designed around the concept of resources, which can be identified and manipulated using standard HTTP methods (GET, POST, PUT, DELETE).
    - These services emphasize statelessness, scalability, and a uniform interface.
3. **Java EE and Jakarta EE:**
    - JAX-RS is part of the Java EE (Enterprise Edition) and Jakarta EE (successor to Java EE) specifications.
    - Java EE and Jakarta EE are comprehensive enterprise platforms that provide a range of technologies for building scalable and distributed applications.
4. **Modularity and Extensibility:**
    - JAX-RS allows developers to create modular and extensible applications by leveraging features like resource classes, annotations, and providers.
    - It supports the creation of both client and server components for interacting with RESTful services.
5. **Annotation-Based Programming:**
    - One of the strengths of JAX-RS is its use of annotations for defining various aspects of a web service, such as resource paths, HTTP methods, and parameter extraction.

REQUIREMENTS

- NetBeans IDE
- Apache Tomcat 9.x.x
- Postman Desktop API

SETTING UP THE DEVELOPMENT ENVIRONMENT

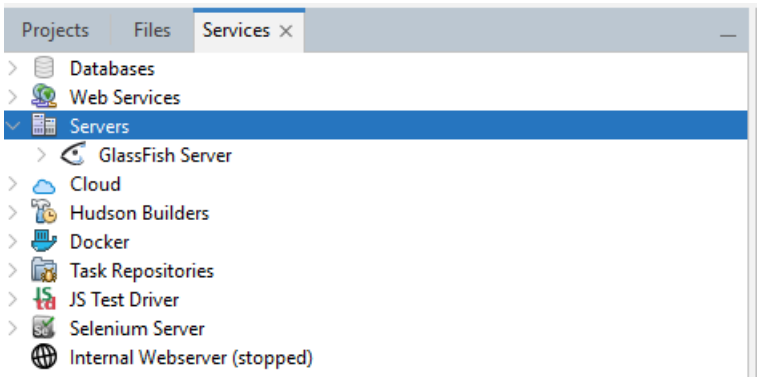
To start implementing any JAX-RS application, we need to add a web application server. For all tutorials, we will use **Apache Tomcat**.

Apache Tomcat is an open-source web server and servlet container developed by the Apache Software Foundation. It is designed to execute Java Servlets and render Java Server Pages (JSP), providing a robust environment for deploying and running Java web applications. Here are key points to understand about Apache Tomcat:

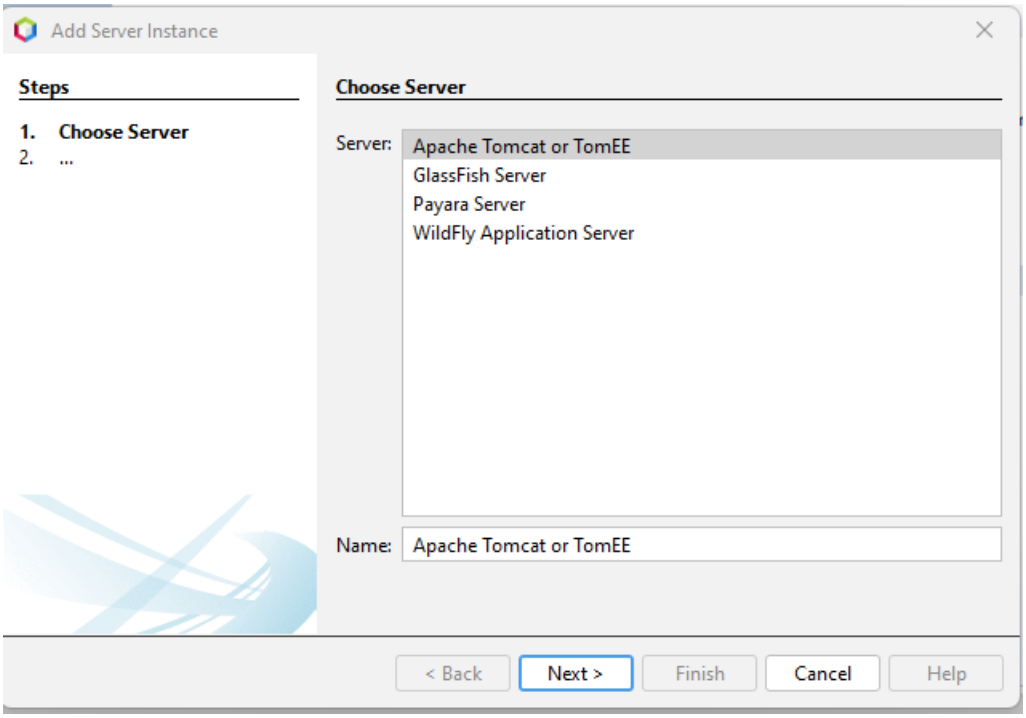
- **Servlet Container:**
    - Apache Tomcat serves as a servlet container, implementing the Java Servlet.
    - A servlet container is a part of web servers responsible for managing the execution of servlets, which are Java classes that handle HTTP requests and responses.
- **Open Source:**
    - Apache Tomcat is open-source software, released under the Apache License.
    - Being open-source allows developers to access and modify the source code, contributing to its improvement and customization.
- **Java EE Compatibility:**
    - While Apache Tomcat is not a full-fledged Java EE (Enterprise Edition) application server, it is often used for deploying Java web applications that adhere to the Servlet.
    - It is lightweight compared to some other Java EE application servers, making it suitable for simpler applications and development environments.
- **HTTP Server Capabilities:**
    - In addition to its role as a servlet container, Tomcat can also function as a standalone web server capable of handling HTTP requests and responses.
    - It supports the basic HTTP features and can be used as a lightweight alternatives like GlassFish and WildFly.

Set up Apache Tomcat server

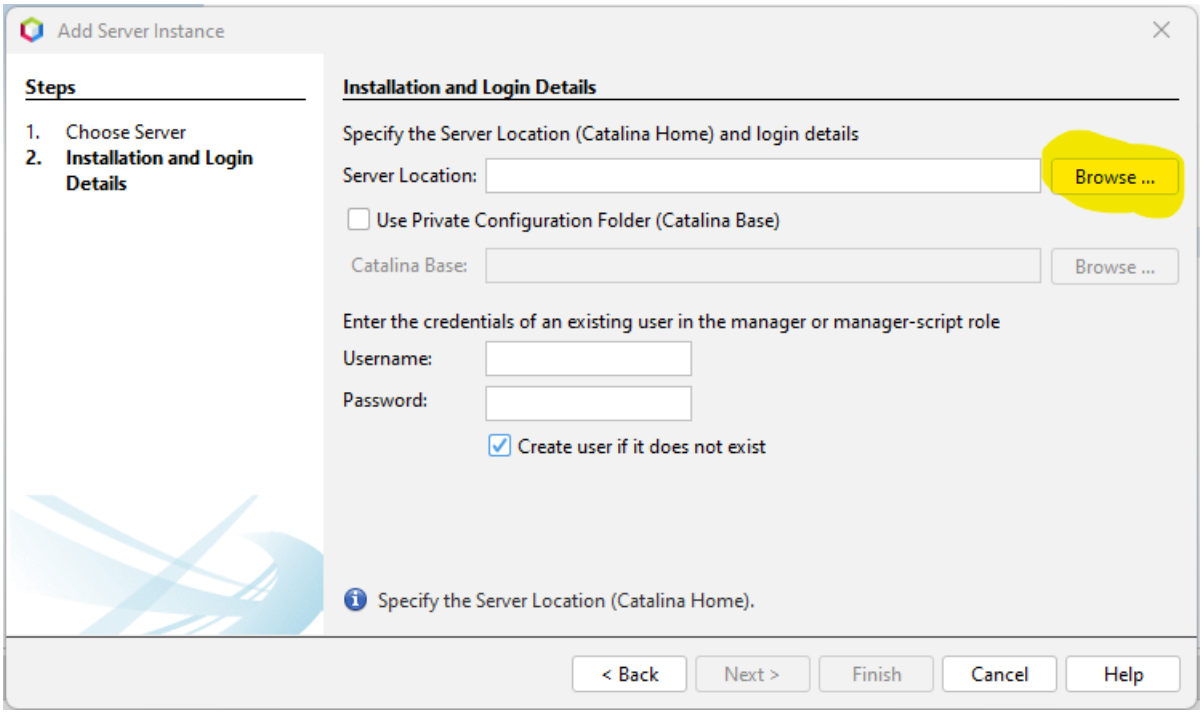
1. Download the Apache Tomcat server provided as a ZIP file under Week07 in the Blackboard.
2. Then extract it in a specific location
3. In the Services tab, right-click on the Server and then click on Add Server



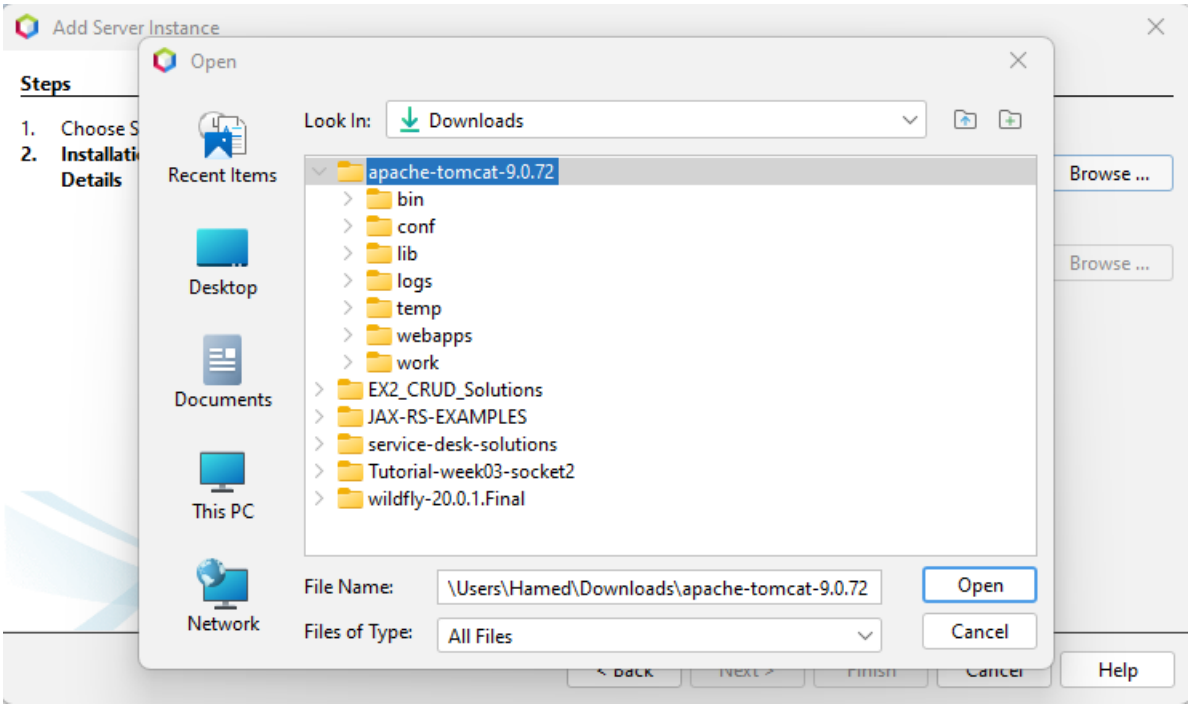
4. In the **Add Server Instance** window, select **Apache Tomcat or TomEE** and then click on **next.**



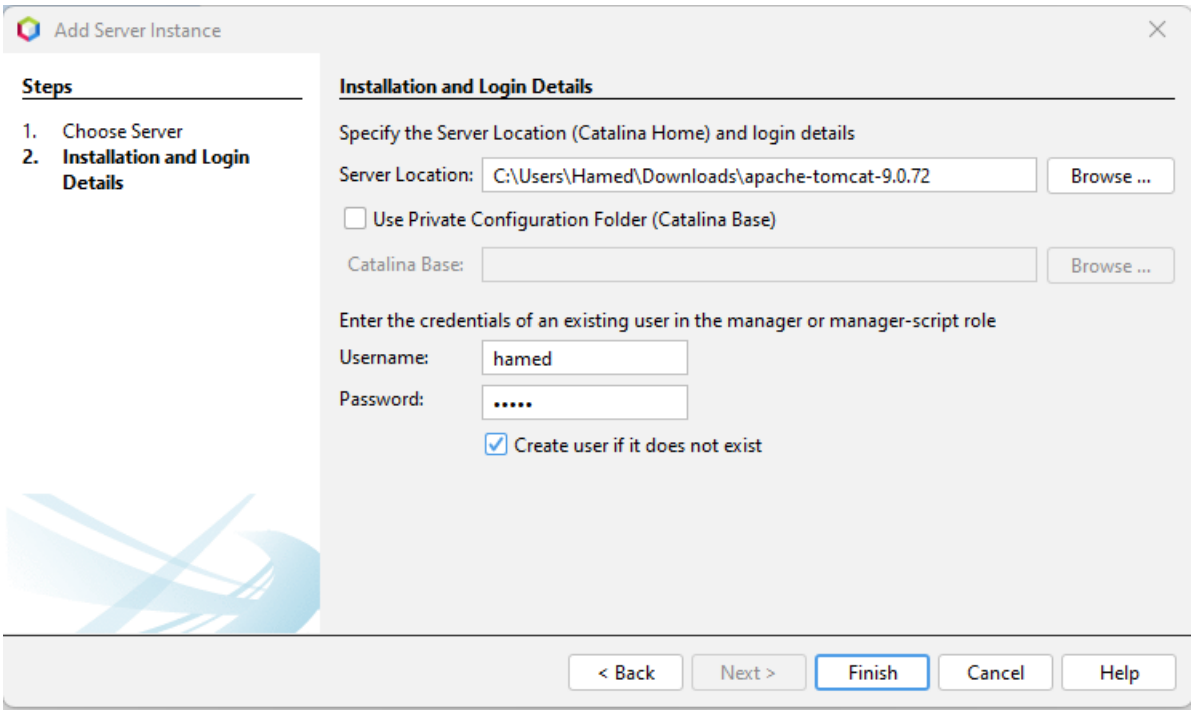
5. Then, click on **Browse** and locate the Tomcat Server folder that you already extracted it.



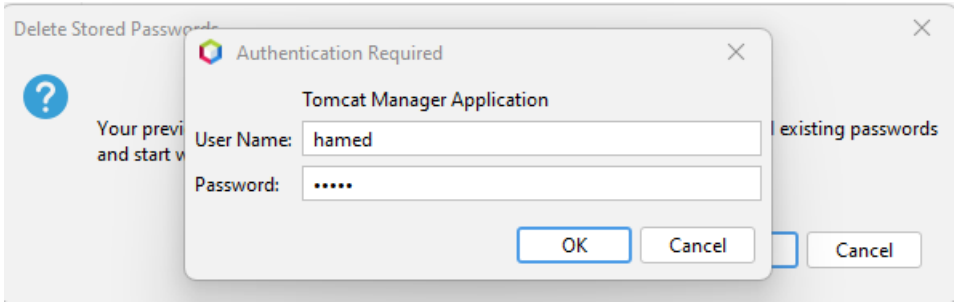
6. After locating the extracted file, click on **apache-tomcat-9.0.72** and then click on **Open.**

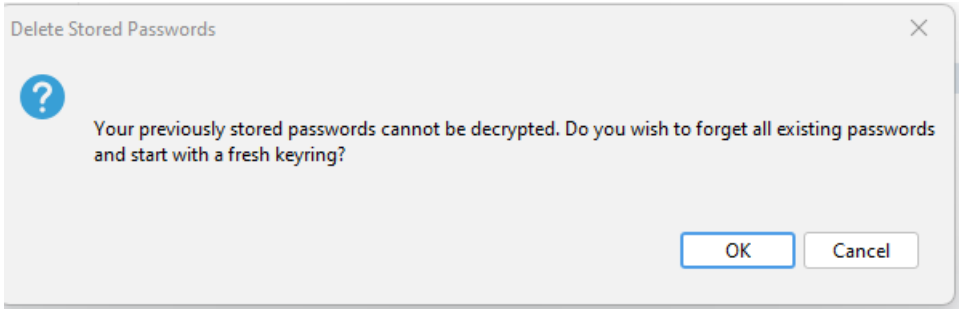


7. After locating the file, provide username and password. You can use anything as you wish. Here I'm using my name for both fields. Finally, click on finish.

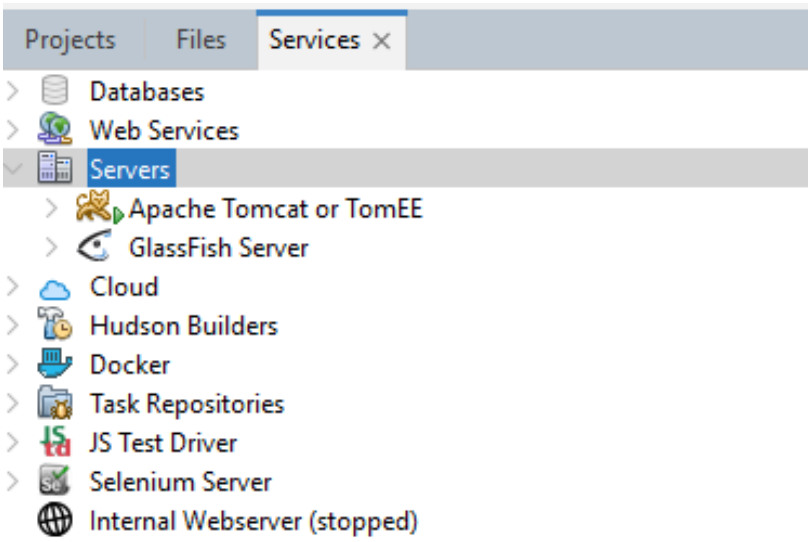


8. After clicking on Finish, the Apache Tomcat asks you to enter the credentials that you provided in the previous step. Then, click on ok. Please note, sometimes if you have existing passwords for the Apache Tomcat, it will ask to remove them. If you are asked to do so, please click on ok.



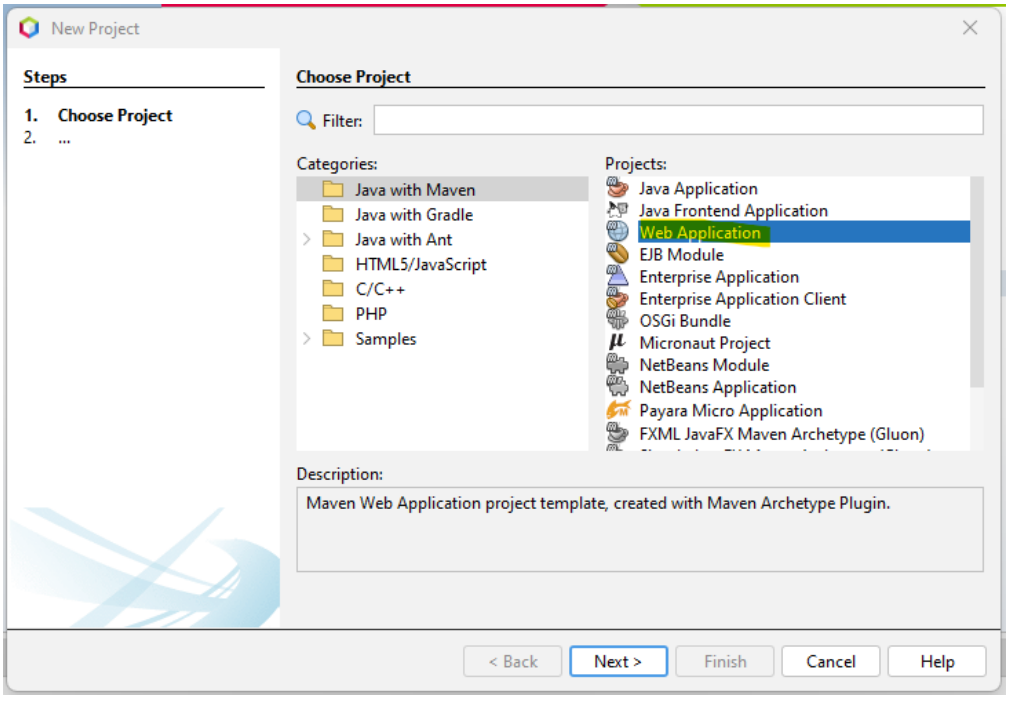


9. If you check the **Services** tab, you should see a small green triangle which means that the Server is up and running. There you go!. You are ready to start with implementation.



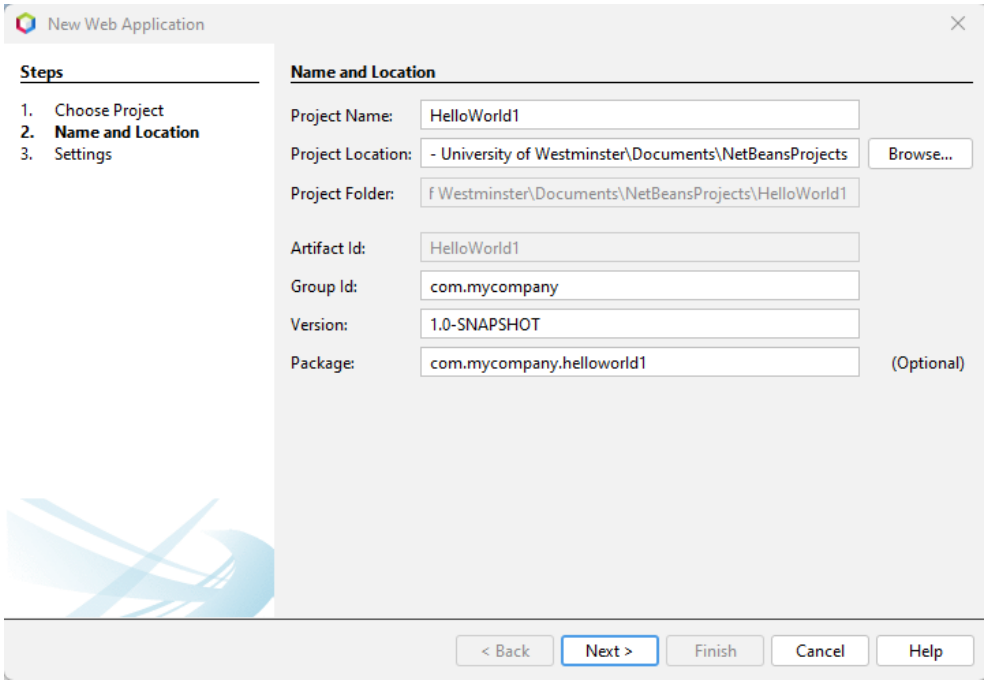
CREATE A NEW PROJECT

Open NetBeans and create a new project. Select Java with Maven -> Web Application.



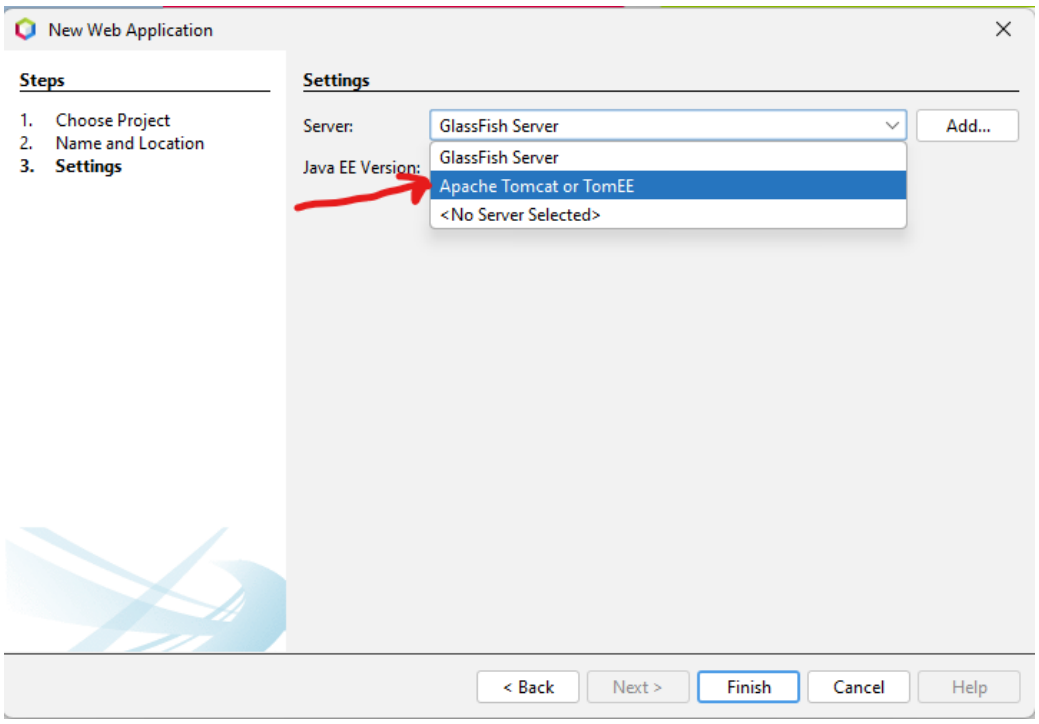
SET UP THE PROJECT

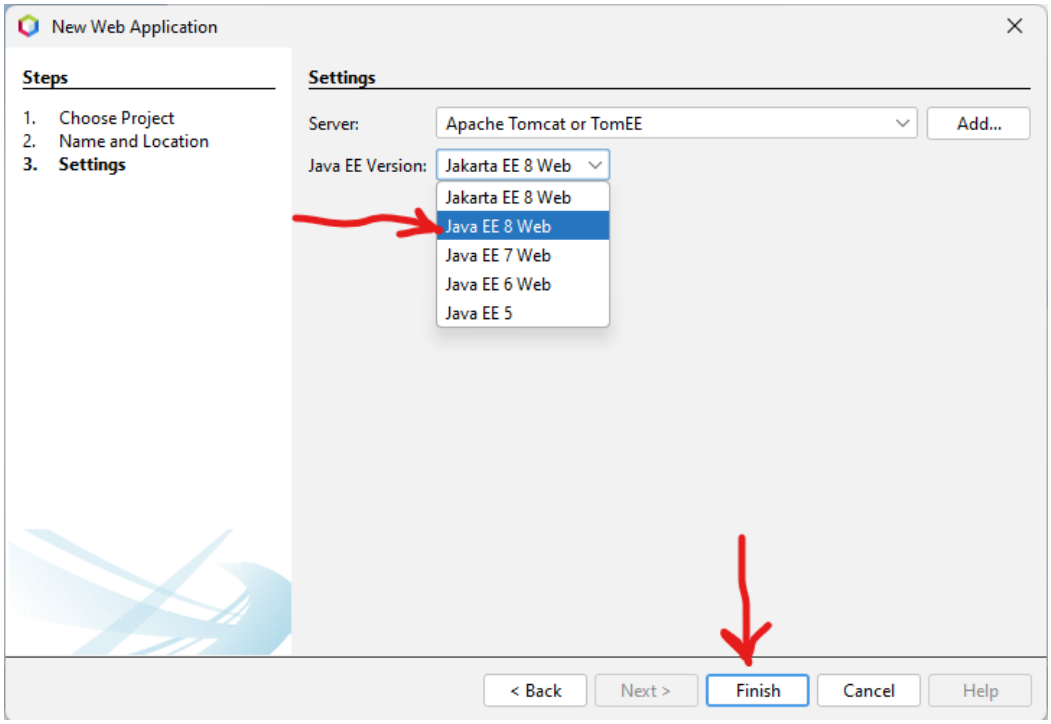
Name your project as “HelloWorld1”



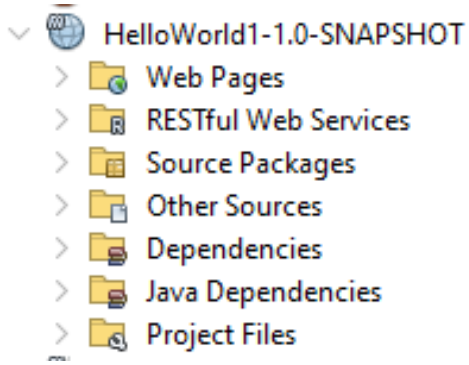
SELECT A SERVER

After clicking on the Next, you will be asked to select a Server to deploy your application. To do so, please select Apache Tomcat or TomEE and then select the Java EE 8 Web. Please note, if you have not installed Apache Tomcat, it will not be available in the menu.





2. **Project architecture:** After clicking on Finish, if you check the Projects tab, the structure of the application must look like as follows:



ADDING DEPENDENCIES

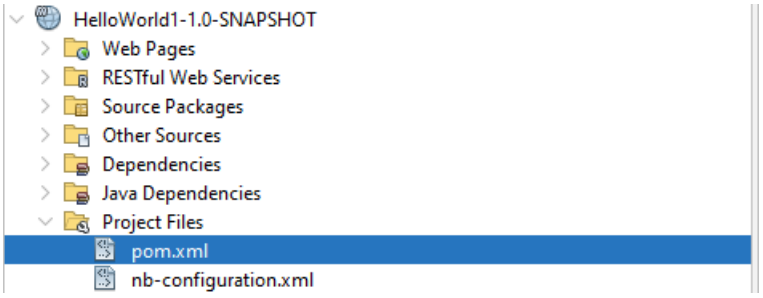
Dependencies in a JAX-RS (Java API for RESTful Web Services) application must include external libraries or modules that provide the required functionality for building, deploying, and running the application. These dependencies are typically packaged as JAR (Java Archive) files and are added to the project to bring in additional features, libraries, or frameworks. Here are several reasons why adding dependencies to a JAX-RS application is essential:

1. **Modularization and Code Reusability:**
    - Dependencies allow developers to modularize their applications. Instead of reinventing the wheel for common functionalities, developers can include existing libraries developed, tested, and proven to work well.
    - Reusing well-established libraries promotes code reusability and saves development time.
2. **Framework Support:**
    - JAX-RS itself is a set of APIs, but it requires an implementation to be used in an actual application. Popular implementations include Jersey, RESTEasy, and Apache CXF. Adding the appropriate implementation as a dependency provides the runtime environment for your JAX-RS application.
3. **Simplify Development:**
    - Dependencies often simplify the development process by providing high-level abstractions and utilities. For example, adding a JSON processing library as a dependency simplifies the task of marshalling and unmarshalling JSON data in your JAX-RS application.

4. **Connectivity and Integration:**
    - JAX-RS applications often need to interact with databases, messaging systems, or other external services. Dependencies for JDBC drivers, JMS libraries, or other connectors enable seamless integration with these systems.
5. **Security Features:**
    - Security is a critical aspect of web applications. Dependencies related to security, such as authentication and authorization libraries, help in implementing secure access control mechanisms in your JAX-RS application.
6. **Testing Frameworks:**
    - Dependencies on testing frameworks like JUnit or TestNG are crucial for writing and executing unit tests for your JAX-RS resources and components. Testing ensures the reliability and correctness of your application.

STEP-BY-STEP GUIDE ON HOW TO ADD DEPENDENCIES TO A JAX-RS APPLICATION IN NETBEANS 18

1. **Open the Project's POM.xml file**: In the Projects window, expand your project and locate the **pom.xml** file. This is the Project Object Model (POM) file for Maven projects, which is used to manage project dependencies.



2. **Edit the POM.xml file**: Double-click the pom.xml file to open it. You'll see an XML structure. You need to add your dependencies inside the <dependencies> tag.
3. **Add the JAX-RS dependencies**: For your JAX-RS application, please edit the file using the following dependencies:

```xml
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>com.mycompany</groupId>
    <artifactId>HelloWorld1</artifactId>
    <version>1.0-SNAPSHOT</version>
    <packaging>war</packaging>
        <dependencies>
        <!-- JAX-RS Jersey implementation -->
        <dependency>
            <groupId>org.glassfish.jersey.containers</groupId>
            <artifactId>jersey-container-servlet</artifactId>
            <version>2.32</version>
        </dependency>
        <dependency>
            <groupId>org.glassfish.jersey.inject</groupId>
            <artifactId>jersey-hk2</artifactId>
            <version>2.32</version>
        </dependency>
    </dependencies>

    <build>
        <plugins>
            <plugin>
                <groupId>org.apache.maven.plugins</groupId>
                <artifactId>maven-compiler-plugin</artifactId>
                <version>3.8.1</version>
                <configuration>
                    <target>8</target>
                    <source>8</source>
                </configuration>
            </plugin>
            <plugin>
                <groupId>org.apache.maven.plugins</groupId>
                <artifactId>maven-war-plugin</artifactId>
                <version>3.2.2</version>
                <configuration>
                    <failOnMissingWebXml>false</failOnMissingWebXml>
                </configuration>
            </plugin>
        </plugins>
    </build>
    <name>HelloWorld1-1.0-SNAPSHOT</name>
</project>
```

MAVEN DEPENDENCIES

JERSEY CONTAINER SERVLET:

- **Group ID:** org.glassfish.jersey.containers
- **Artifact ID**: jersey-container-servlet
- **Version**: 2.32

- **Purpose:** This dependency includes the Jersey implementation of the servlet container. It provides classes and components necessary for integrating Jersey with a servlet-based web application.

JERSEY HK2 (HUNDRED KILOBYTES KERNEL):

- **Group ID: org.glassfish.jersey.inject**
- **Artifact ID: jersey-hk2**
- **Version: 2.32**
- **Purpose:** HK2 is the dependency injection framework used by Jersey. This dependency includes the necessary components for integrating HK2 with Jersey, enabling dependency injection within your JAX-RS resources and components.

MAVEN BUILD PLUGINS

MAVEN COMPILER PLUGIN:

- **Group ID:** org.apache.maven.plugins
- **Artifact ID:** maven-compiler-plugin
- **Version:** 3.8.1
- **Purpose:** The Maven Compiler Plugin is used to configure and customize the behavior of the Java compiler during the build process. In this case, it sets the Java version to be used by the compiler to version 8, both for source code and target bytecode.

MAVEN WAR PLUGIN:

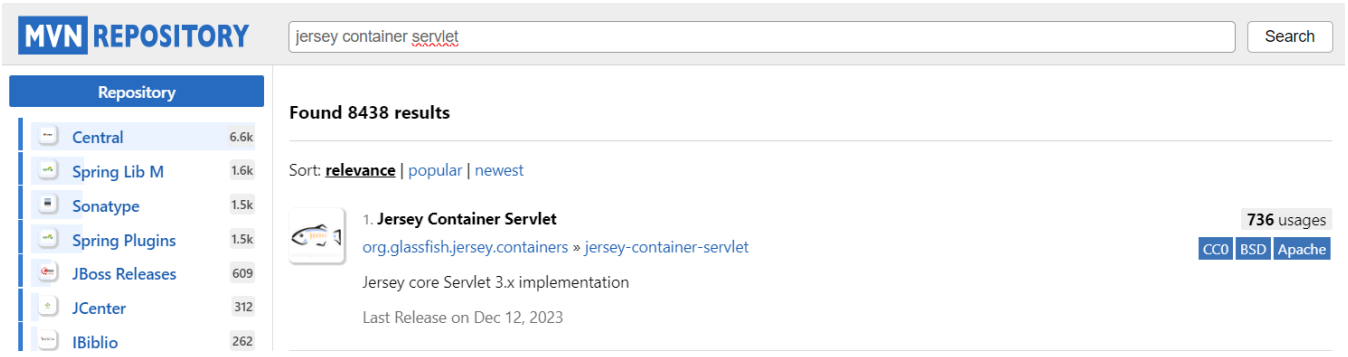
- **Group ID:** org.apache.maven.plugins
- **Artifact ID:** maven-war-plugin
- **Version:** 3.2.2
- **Purpose:** The Maven WAR Plugin is used to build and package the project as a Web Application Archive (WAR) file. In this configuration, it disables the requirement for a **web.xml** file:

(**<failOnMissingWebXml>false</failOnMissingWebXml>**), which is common in modern servlet containers and JAX-RS applications that use annotated classes for configuration.

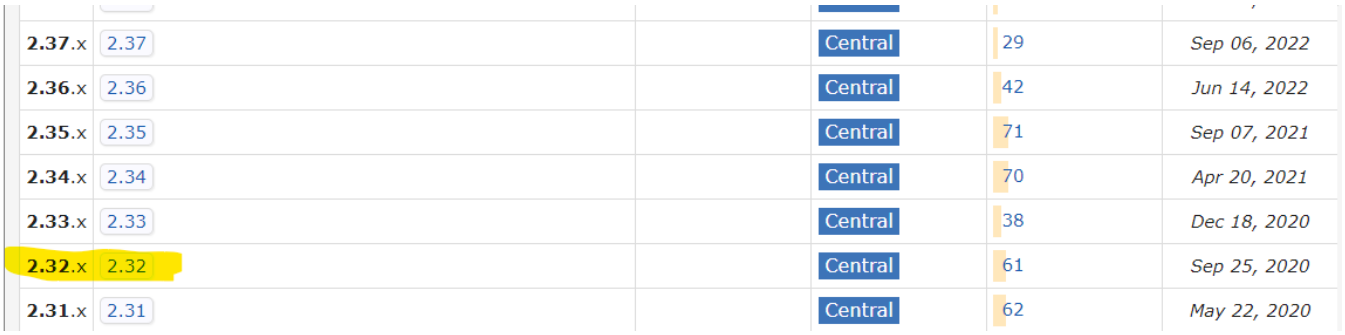
FINDING MAVEN DEPENDENCIES

In order to find maven dependencies you need to visit [maven repository web site](). Once you locate the website, you need to enter any dependencies that you need to include inside pom.xml file.

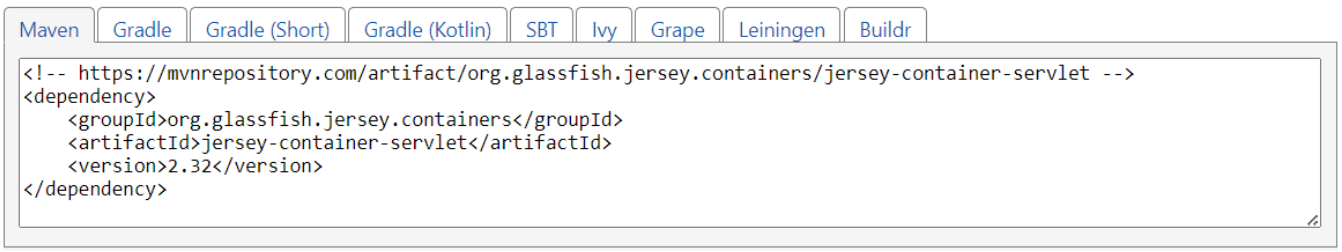
For example, to find jersey servlet, we need to search for this in the repository as follows:



Once you locate it, click on and then select version 2.32 which is compatible with the Apache Tomcat version 9.



After choosing the specific version for servlet container, then you can copy the maven content shown as follows and paste it inside the pom.xml file.



SAVE POM.XML FILE

After editing and adding the dependencies, please save the **pom.xml** file.

SETTING UP RESOURCE CLASS

1. Open Source Packages and under **helloworld1** package, create a class called **HelloWorldResource**
2. Remove **JAXRSConfiguration.java**

STEP 1: IMPORT NECESSARY LIBRARIES

```
import javax.ws.rs.GET;

import javax.ws.rs.Path;

import javax.ws.rs.Produces;

import javax.ws.rs.core.MediaType;
```

Get: It is used to annotate a Java method to indicate that it will handle HTTP GET requests.

Path: It is Used to annotate a Java class or method to indicate the base URI path for which the resource or resource method will handle requests.

Produces: It is Used to specify the media types (MIME types) that the resource method can produce as output.

MediaType: It is class that defines standard media types (MIME types). It is often used in conjunction with @Produces to specify the expected response format.

STEP 2: SPECIFYING RESOURCE AND HTTP METHOD

```
@Path("/hello")
public class HelloWorldResource {
    @GET
    @Produces(MediaType.TEXT_PLAIN)
    public String getHello() {
        return "Hello, World!";
    }
}
```

CODES BREAKDOWN:

1. **@Path("/hello"):**
    - This annotation is applied to the class and specifies the base URI path for which this resource class will handle requests. In this case, it indicates that this resource class will handle requests for the path "/hello."
2. **Resource Class (HelloWorldResource):**
    - This is a simple Java class that acts as a JAX-RS resource. It is annotated with **@Path("/hello")**, and all methods within this class will handle requests under the base path "/hello."
3. **@GET:**
    - This annotation is applied to the **getHello** method, indicating that this method will handle HTTP GET requests.
4. **@Produces(MediaType.TEXT_PLAIN):**
    - This annotation is used to specify the media type (MIME type) that the method can produce as output. In this case, it indicates that the **getHello** method produces plain text (**text/plain**) as its response.
5. **public String getHello() { ... }:**
    - This is the method that will be invoked when an HTTP GET request is made to the "/hello" path. It returns a simple string, "Hello, World!", as the response.

SETTING UP APPLICATION PATH CLASS

Create a new class called **MyApplication** under the same package and add the following packages

```
import javax.ws.rs.ApplicationPath;

import javax.ws.rs.core.Application;

import java.util.HashSet;

import java.util.Set;
```

CODES BREAKDOWN:

JAVAX.WS.RS.APPLICATIONPATH

- This package contains the ApplicationPath annotation. This is crucial for defining the base URI path for all your REST resources within the application.
- **Example:** If you annotate a class with @ApplicationPath("/api"), all your REST resources' URIs will begin with /api.

JAVAX.WS.RS.CORE.APPLICATION

- This package contains the core Application class. This class acts as the central configuration point or "blueprint" for your JAX-RS application. By extending it, you can:
    - Register your REST resources.
    - Define providers for custom data type handling, exception mapping, etc.

JAVA.UTIL.HASHSET AND JAVA.UTIL.SET

- These come from the Java Collections Framework.
    - Set is an interface that represents a collection of unique elements.
    - HashSet provides a concrete implementation of Set using a hash table for efficient storage and retrieval.

Then, please complete the rest by adding the following codes:

```
@ApplicationPath("rest")
public class MyApplication extends Application {
    @Override
    public Set<Class<?>> getClasses() {
        Set<Class<?>> classes = new HashSet<>();
        classes.add(HelloWorldResource.class);
        return classes;
    }
}
```

CODES BREAKDOWN:

1. @ApplicationPath("rest")

- This annotation on the MyApplication class defines the root path for all your RESTful resources within the application. With this, all your resource URIs would be prefixed with /rest.

2. public class MyApplication extends Application { ... }

- MyApplication is the core configuration class of your REST application. It extends the javax.ws.rs.core.Application class, providing a place to manage the registration of resources and other configuration aspects.

3. @Override public Set<Class<?>> getClasses() { ... }

- The getClasses() method is a crucial part of configuring a JAX-RS application. By overriding it, you specify the REST resource classes the JAX-RS runtime should manage.
- **Inside the method:**
    - Set<Class<?>> classes = new HashSet<>(); : Creates a HashSet to store references to your resource classes. Using a HashSet ensures uniqueness and efficient lookups.
    - classes.add(HelloWorldResource.class); : Adds the HelloWorldResource class to the set. This implies that HelloWorldResource contains your REST endpoint definitions.
    - return classes;: Returns the set of registered resource classes.

APPLICATION CONFIGURATION CLASS

We need configuration because of the following reasons:

- **DEFINING THE STRUCTURE OF YOUR REST API:**

JAX-RS, at its core, provides the building blocks for creating RESTful services. The configuration acts as the architectural blueprint for your API. It's where you tell the JAX-RS runtime:

- **Base path:** The root URL segment that your REST endpoints will share (e.g., /api, /rest).
- **REST resources:** Which classes contain your actual RESTful endpoint logic. These classes handle incoming requests and produce responses.
- **Providers:** Components that can handle custom data conversions, exception mapping, security, and more.

- **DISCOVERY AND MANAGEMENT**

JAX-RS implementations need a way to understand how to turn your Java classes into a functional REST API. The configuration provides a structured way for the runtime to:

- Scan for classes marked with relevant JAX-RS annotations (@Path, @GET, etc.).
- Understand which URL patterns map to which methods.
- Manage the lifecycle of your resources and providers.

- **CUSTOMIZATION**

The configuration layer lets you tailor the behavior of your REST API. You can:

- Register filters or interceptors to manipulate requests or responses.
- Provide custom message converters for handling non-standard data formats.
- Configure security mechanisms.

Now, let's implement the class by taking the following steps:

STEP 1: FIRST OF ALL ADD THE FOLLOWING LIBRARY:

```
import org.glassfish.jersey.server.ResourceConfig;
```

- **org.glassfish.jersey.server.ResourceConfig:** This class is a core part of the Jersey framework, which is a popular implementation of the JAX-RS (Java API for RESTful Web Services) specification. Here's what it does:
    - **Central Configuration Point:** The ResourceConfig class acts as the primary configuration mechanism for your Jersey-based REST applications. You extend this class (or use it directly) to define the essential components of your API.
    - **Key Functionality:** Within a ResourceConfig class, you can:
        - Register your REST resource classes (the classes containing @Path annotations and HTTP method annotations).
        - Register providers (for custom message body handling, exception mapping, etc.).
        - Configure features (security, filters, etc.)
        - Set properties to tune the behavior of the Jersey runtime.

STEP 2: IMPLEMENT CONFIGURATION LOGIC:

```
public class MyApplicationConfig extends ResourceConfig {
    public MyApplicationConfig() {
        register(HelloWorldResource.class);
    }
}
```

CODES BREAKDOWN:

1. **public class MyApplicationConfig extends ResourceConfig:**

   This defines a class named MyApplicationConfig. The key point is that it extends the ResourceConfig class provided by the Jersey framework. ResourceConfig acts as a streamlined configuration mechanism specifically designed for resource registration.

2. **public MyApplicationConfig() { ... }**

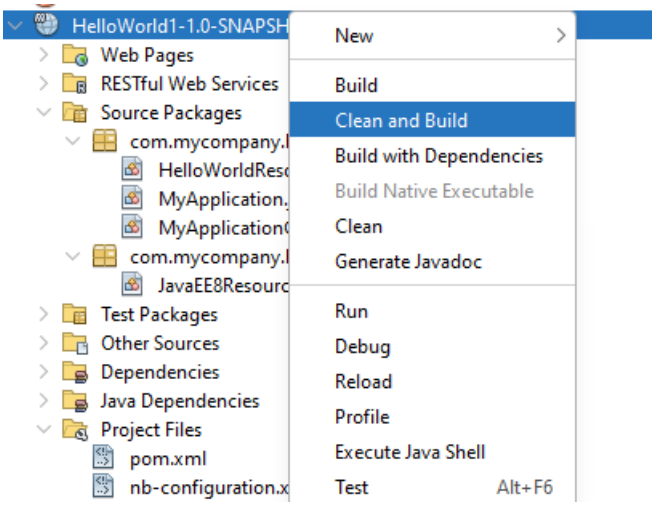
This is the constructor of your MyApplicationConfig class. It's where core initialization logic happens.

3. **register(HelloWorldResource.class);**

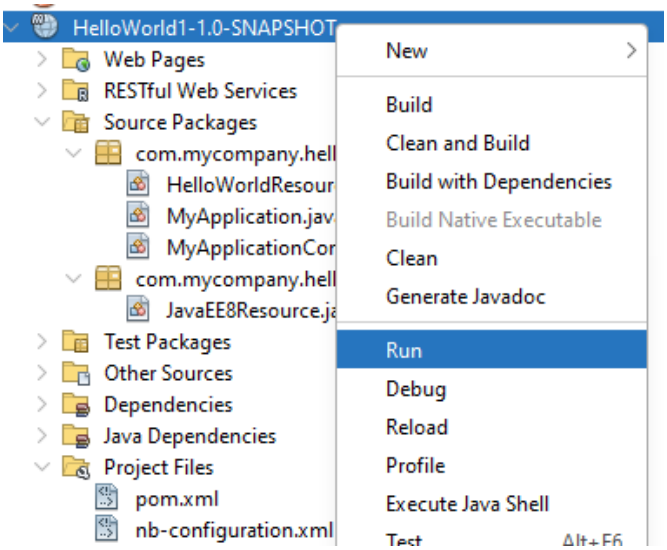
This is the critical line inside the constructor. The register() method instructs the Jersey framework to directly manage the HelloWorldResource class as a RESTful resource. This means that the JAX-RS runtime will recognize this class and its methods that likely have JAX-RS annotations (@Path, @GET, etc.).

RUN THE APPLICATION

We are now ready to test the first RESTful service developed by JAX-RS. To do this, first of all please do right-click on the project and click on **Clean and Build.** This allows us to make sure that all dependencies are installed properly.



Once we ensure that the build process is successful, then you can do right-click on the project and this time click on **Run.**

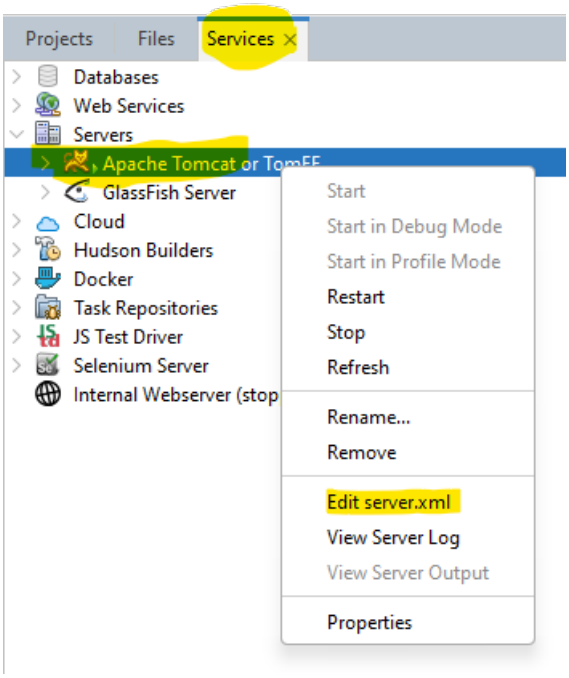


TEST THE APPLICATION

Now, you can test you application using the following URI:

`localhost:8080/HelloWorld1/rest/hello`

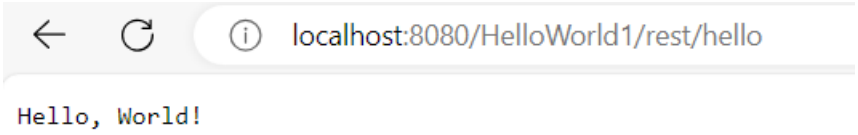
Please note that, in this URI the port number is 8080 that must be the same as one specified in the Apache Tomcat configuration. To check the connector port number in the Apache Tomcat, please do right-click on the Apache Tomcat in the Services tab and then select **Edit server.xml**



Once you locate the following lines inside the **server.xml**, you can check if the port number in the URI is the same as the number in the tomcat Connector port.

```
<Connector port="8080" protocol="HTTP/1.1"
           connectionTimeout="20000"
           redirectPort="8443" />
<!-- A "Connector" using the shared thread pool-->
```

Finally, if everything is OK, you expect to see the following result shown in the web browser. Please not that once you run the application a default browser will be automatically launched after a couple of seconds.




```
Hello, World!
```

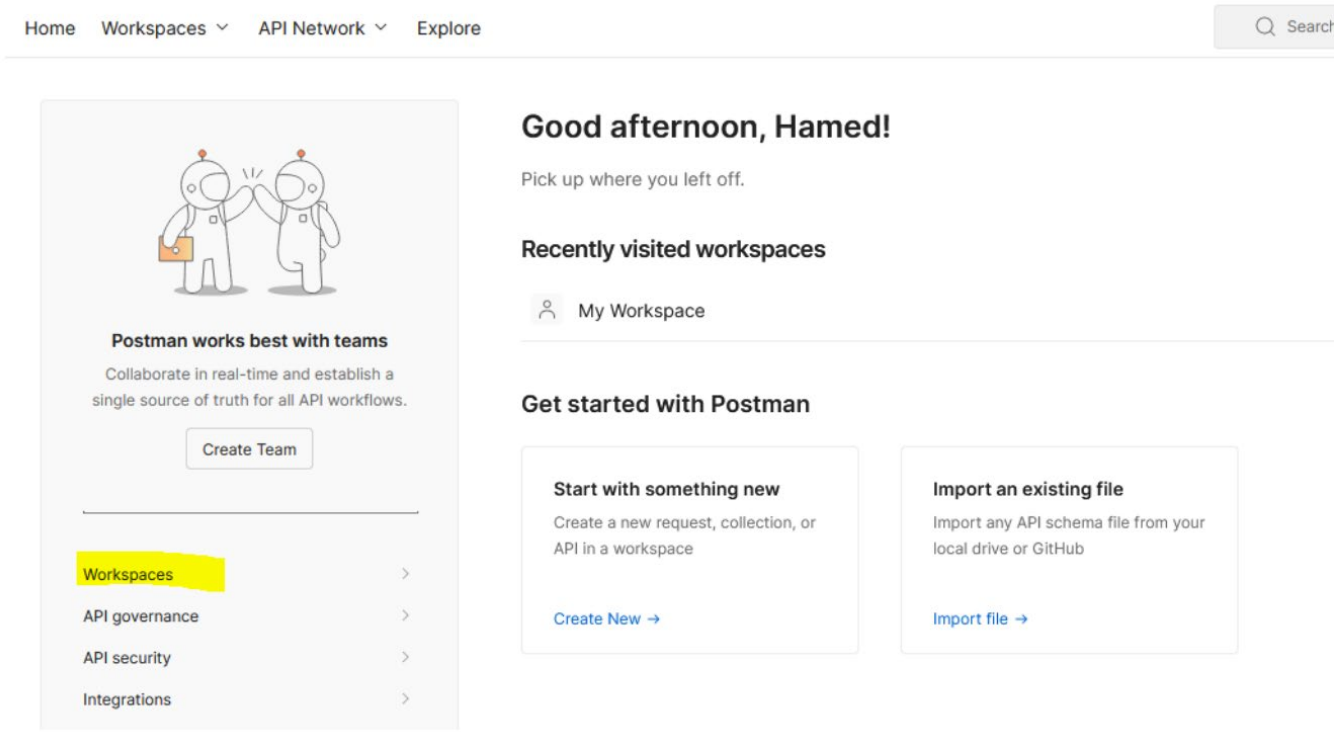
TESTING THE SERVICE USING POSTMAN

Postman is an API platform for building and using APIs. Postman simplifies each step of the API lifecycle and streamlines collaboration so you can create better APIs—faster. Using the Postman you can call HTTP methods in your RESTful service in an interactive interface. You can also download the Postman as use it as a desktop app.

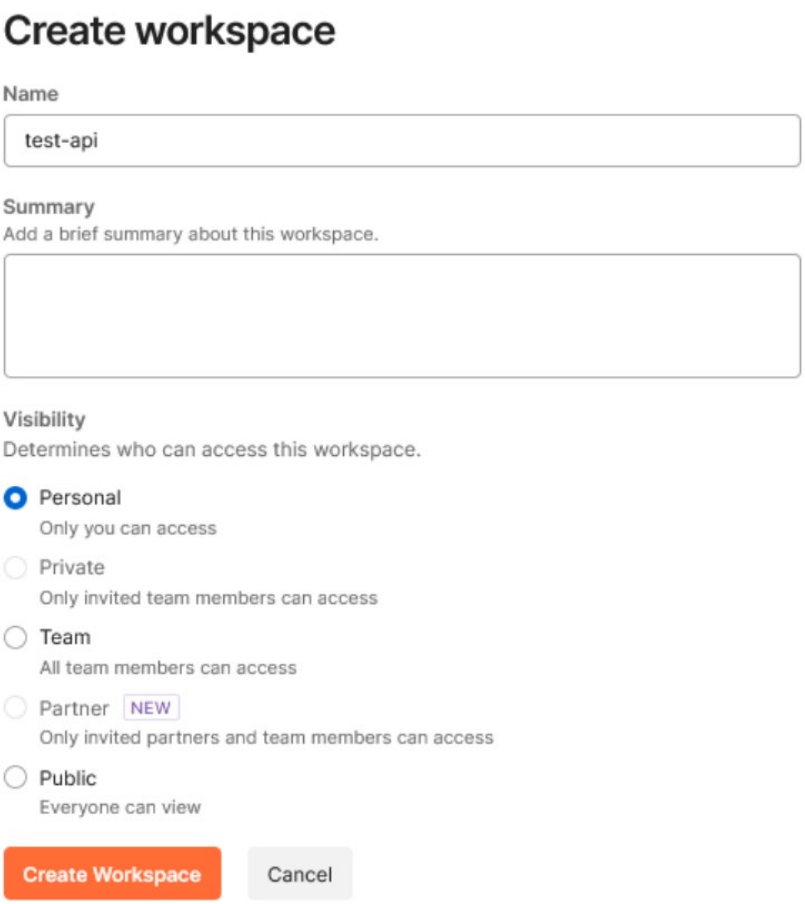
- To use Postman, you need to signup to it using the following link:

  https://identity.getpostman.com/signup 2.

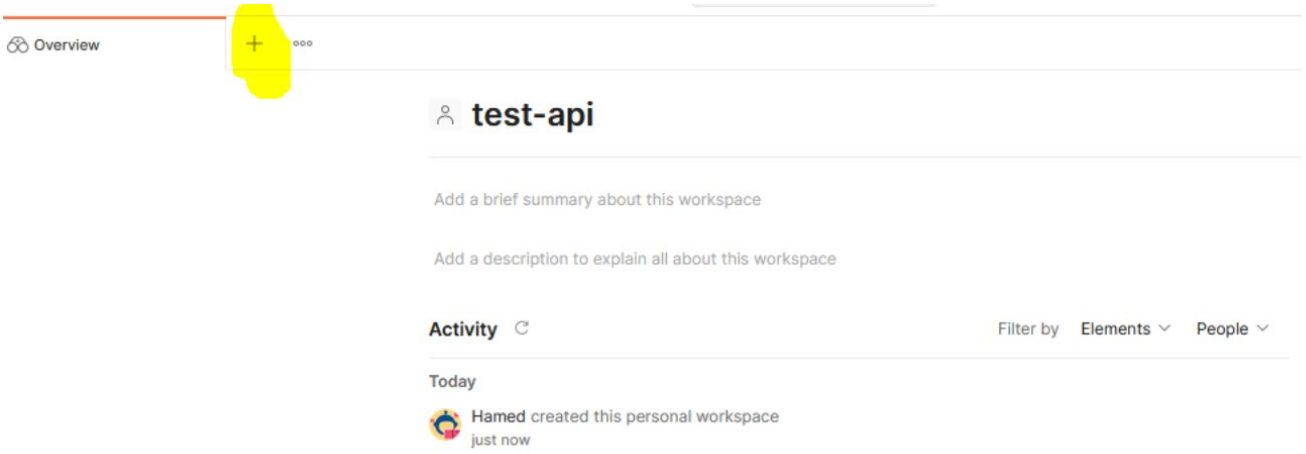
- After signing up. Use your credentials to login to the service. 3. Then you need to create a workspace by clicking on the workspaces



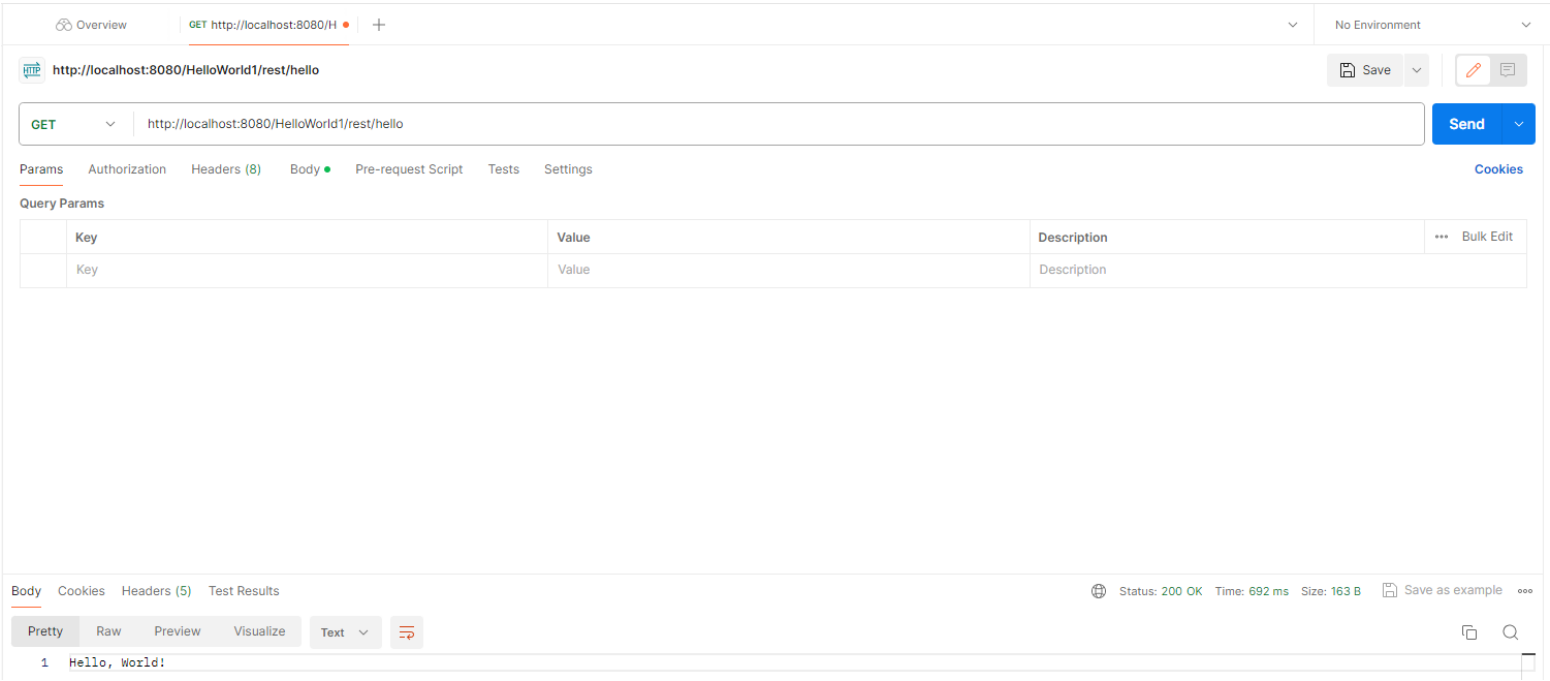
- Then you can create a workspace by clicking on Create Workspace. Then specify a name for that like test-api and set it up to Personal



- Click on “+” specify by yellow colour.



- Then, you are ready to go. The only thing you need to do is to include the full URI in the box and click on **Send** to see the effects. As we have only implemented GET method, you can only send GET request.



EXERCISE 1

In this exercise you will improve the previous JAX-RS example by taking the following steps:

1. CREATE A CLASS CALLED USER

Create a class named **User** with three attributes: **id**, **name** and **email**. Please also add a default constructor and also one with all three attributes. Finally, add getters and setters.

2. DECLARE A LIST FOR USERS:

Introduce a static List<String> to store user names. Place this declaration at the class level, outside any method

3. MODIFY THE RESPONSE LOGIC

Update the **getHello()** method to include logic for adding a new user to the list and constructing a response string with all users. Use a StringBuilder to efficiently build the response. The code snippet utilizes a for loop to iterate over each element in the **users** list.

4. RUN THE APPLICATION AND TEST IT USING POSTMAN

EXERCISE 2

In this exercise, you will improve the first exercise by doing the following steps:

1. IMPORT NECESSARY PACKAGES: Determine which additional packages or classes need to be imported for the new functionality. In this case, you'll need **import javax.ws.rs.PathParam;**, **import java.util.Map;**, **import java.util.HashMap;**, and **import java.util.Set;**.

2. INITIALIZE DATA (IF NECESSARY): If the new functionality requires some initial data, initialize it. In this case, the **users** map is initialized with some sample data in a static block.

3. IMPLEMENT NEW METHODS: Add methods to handle the new functionality. In this case, **getUserById** and **getAllUsers** methods are added. Annotate these methods with appropriate JAX-RS annotations such as **@GET**, **@Produces**, and **@Path**.

4. IMPLEMENT THE LOGIC: Write the logic inside the newly added methods to fulfill the requirements. For example, in **getUserById**, check if the requested user exists in the map and return the corresponding response. In **getAllUsers**, iterate over the map and build the response string.

5. TEST THE CODE: After implementing the changes, test the code thoroughly to ensure it works as expected. Test each endpoint with different inputs to verify the behavior.

EXERCISE 3

In the previous exercise, we realised that the output is not a real JSON format. In this exercise you will learn a new concept of serializing Java objects to JSON format and deserializing JSON to Java objects. This concept is implemented using the **Jackson** library, specifically the ObjectMapper class, which is part of the com.fasterxml.jackson.databind package.

JSON (JavaScript Object Notation) is a lightweight data-interchange format commonly used for exchanging data between a server and a web client in web development. It is human-readable and easy for both humans and machines to understand.

The **ObjectMapper** class provided by the Jackson library allows Java objects to be converted into JSON format (serialization) and vice versa (deserialization). This enables seamless communication between Java-based web services and clients that consume JSON data.

HERE ARE THE KEY POINTS REGARDING THE NEW CONCEPT THAT WILL BE INCLUDED IN THE CODE:

1. **Jackson Library Usage**:

The code includes the Jackson library (**com.fasterxml.jackson.core.JsonProcessingException** and **com.fasterxml.jackson.databind.ObjectMapper**). This library is utilized for transforming Java objects into JSON strings (**serialization**) and JSON strings back into Java objects (**deserialization**).

2. **Serialization in getUserById Method**:

In the **getUserById** method, the **ObjectMapper** is used to serialize the **User** object into a JSON string. This JSON representation of the user is then returned as the response. The **@Produces(MediaType.APPLICATION_JSON)** annotation indicates that the method produces JSON as its output.

3. **Serialization in getAllUsers Method**:

Similarly, in the **getAllUsers** method, a list of **User** objects is converted into a JSON array using the **ObjectMapper**, and the resulting JSON string is returned as the response.

4. **Handling JSON Processing Exceptions**:

The code includes error handling for potential exceptions during the JSON processing using Jackson. If an exception occurs (e.g., during serialization), an error message is returned instead of the JSON representation.

TAKE THE FOLLOWING STEPS TO UPDATE THE CODES

STEP 1:

In a static block, please add some initial user data to the users map. Three users with IDs 1, 2, and 3 are created using the User class and added to the map.

STEP 2:

Inside getUserById method, check if the users map contains the specified user ID. If it does, it retrieves the corresponding User object from the map. Then, Inside the try block, use the **ObjectMapper** to convert the User object to a **JSON** string using the **writeValueAsString** method. If successful, the JSON string is returned as the response. Finally, If an exception of type **JsonProcessingException** occurs during JSON processing, it is caught, the stack trace is printed, and an error message is returned.

STEP 3

Inside getAllUsers() method and Inside the try block, use the **ObjectMapper** to convert the list of User objects to a JSON array string using the **writeValueAsString** method. If successful, the JSON array string is returned as the response. If an exception of type **JsonProcessingException** occurs during JSON processing, it is caught, the stack trace is printed, and an error message is returned.

STEP 4

Test the application in Postman and share the results with your tutorial instructor.