**RESTful Web Services**

## What is REST?

REST stands for **RE**presentational **S**tate **T**ransfer. REST is web standards based architecture and uses HTTP Protocol for data communication. It revolves around resource where every component is a resource and a resource is accessed by a common interface using HTTP standard methods. REST was first introduced by Roy Fielding in 2000.

In REST architecture, a REST Server simply provides access to resources and REST client accesses and presents the resources. Here each resource is identified by URIs/ global IDs. REST uses various representations to represent a resource like text, JSON and XML. Now a days JSON is the most popular format being used in web services.

## HTTP Methods

Following well known HTTP methods are commonly used in REST based architecture.

* **GET** - Provides a read only access to a resource.
* **PUT** - Used to create a new resource.
* **DELETE** - Used to remove a resource.
* **POST** - Used to update a existing resource or create a new resource.
* **OPTIONS** - Used to get the supported operations on a resource.

## RESTFul Web Services

A web service is a collection of open protocols and standards used for exchanging data between applications or systems. Software applications written in various programming languages and running on various platforms can use web services to exchange data over computer networks like the Internet in a manner similar to inter-process communication on a single computer. This interoperability (e.g., between Java and Python, or Windows and Linux applications) is due to the use of open standards.

Web services based on REST Architecture are known as RESTful web services. These web services use HTTP methods to implement the concept of REST architecture. A RESTful web service usually defines a URI, Uniform Resource Identifier a service, provides resource representation such as JSON and set of HTTP Methods.

# First Application

Let us start writing actual RESTful web services with Jersey Framework. Before you start writing your first example using Jersey framework, you have to make sure that you have setup your Jersey environment properly. So let us proceed to write a simple Jersey Application which will expose a web service method to display list of users.

## Step 1 - Create Java Project:

The first step is to create a Dynamic Web Project using Eclipse IDE. Follow the option **File -> New -> Project** and finally select **Dynamic Web Project** wizard from the wizard list. Now name your project

## Step 2 - Add Required Libraries:

As a second step let us add Jersey Framework and its dependencies (libraries) in our project. Copy all jars from following directories of download jersey zip folder in WEB-INF/lib directory of the project.

* \jaxrs-ri-2.17\jaxrs-ri\api
* \jaxrs-ri-2.17\jaxrs-ri\ext
* \jaxrs-ri-2.17\jaxrs-ri\lib

Now, right click on your project name and then follow the following option available in context menu: **Build Path -> Configure Build Path** to display the Java Build Path window.

Now use **Add JARs** button available under **Libraries** tab to add the JARs present in WEB-INF/lib directory.

## Step 3 - Create Source Files:

Now let us create actual source files under the project. First we need to create a package. To do this, right click on **src** in package explorer section and follow the option: **New -> Package**.

*User.java*

package com.tutorialspoint;

import java.io.Serializable;

import javax.xml.bind.annotation.XmlElement;

import javax.xml.bind.annotation.XmlRootElement;

@XmlRootElement(name = "user")

public class User implements Serializable {

private static final long serialVersionUID = 1L;

private int id;

private String name;

private String profession;

public User(){}

public User(int id, String name, String profession){

this.id = id;

this.name = name;

this.profession = profession;

}

public int getId() {

return id;

}

@XmlElement

public void setId(int id) {

this.id = id;

}

public String getName() {

return name;

}

@XmlElement

public void setName(String name) {

this.name = name;

}

public String getProfession() {

return profession;

}

@XmlElement

public void setProfession(String profession) {

this.profession = profession;

}

}

*UserDao.java*

package com.tutorialspoint;

import java.io.File;

import java.io.FileInputStream;

import java.io.FileNotFoundException;

import java.io.FileOutputStream;

import java.io.IOException;

import java.io.ObjectInputStream;

import java.io.ObjectOutputStream;

import java.util.ArrayList;

import java.util.List;

public class UserDao {

public List<User> getAllUsers(){

List<User> userList = null;

try {

File file = new File("Users.dat");

if (!file.exists()) {

User user = new User(1, "Mahesh", "Teacher");

userList = new ArrayList<User>();

userList.add(user);

saveUserList(userList);

}else{

FileInputStream fis = new FileInputStream(file);

ObjectInputStream ois = new ObjectInputStream(fis);

userList = (List<User>) ois.readObject();

ois.close();

}

} catch (IOException e) {

e.printStackTrace();

} catch (ClassNotFoundException e) {

e.printStackTrace();

}

return userList;

}

private void saveUserList(List<User> userList){

try {

File file = new File("Users.dat");

FileOutputStream fos;

fos = new FileOutputStream(file);

ObjectOutputStream oos = new ObjectOutputStream(fos);

oos.writeObject(userList);

oos.close();

} catch (FileNotFoundException e) {

e.printStackTrace();

} catch (IOException e) {

e.printStackTrace();

}

}

}

*UserService.java*

package com.tutorialspoint;

import java.util.List;

import javax.ws.rs.GET;

import javax.ws.rs.Path;

import javax.ws.rs.Produces;

import javax.ws.rs.core.MediaType;

@Path("/UserService")

public class UserService {

UserDao userDao = new UserDao();

@GET

@Path("/users")

@Produces(MediaType.APPLICATION\_XML)

public List<User> getUsers(){

return userDao.getAllUsers();

}

}

There are following two important points to note about the main program, UserService.java:

1. First step is to specify a path for the web service using @Path annotation.
2. Second step is to specify a path for the particular web service method using @Path annotation to method.

## Step 4 - Create Web.xml configuration File:

You need to create a Web xml Configuration file which is an XML file and is used to specify Jersey framework servlet for our application.

*web.xml*

<?xml version="1.0" encoding="UTF-8"?>

<web-app xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

xmlns="http://java.sun.com/xml/ns/javaee"

xsi:schemaLocation="http://java.sun.com/xml/ns/javaee

http://java.sun.com/xml/ns/javaee/web-app\_3\_0.xsd"

id="WebApp\_ID" version="3.0">

<display-name>User Management</display-name>

<servlet>

<servlet-name>Jersey RESTful Application</servlet-name>

<servlet-class>org.glassfish.jersey.servlet.ServletContainer</servlet-class>

<init-param>

<param-name>jersey.config.server.provider.packages</param-name>

<param-value>com.tutorialspoint</param-value>

</init-param>

</servlet>

<servlet-mapping>

<servlet-name>Jersey RESTful Application</servlet-name>

<url-pattern>/rest/\*</url-pattern>

</servlet-mapping>

</web-app>

## Step 5 - Deploying the Program

Once you are done with creating source and web configuration files, you are ready for this step which is compiling and running your program. To do this, using Eclipse, export your application as a war file and deploy the same in tomcat. To create WAR file using eclipse, follow the option **File -> export -> Web > War File** and finally select project UserManagement and destination folder. To deploy war file in Tomcat, place the UserManagement.war in **Tomcat Installation Directory** > webapps directory and start the Tomcat.

## Step 6 - Running the Program

We are using [Postman](http://www.getpostman.com/)/restclient, a Chrome extension, to test our webservices.

Make a request to project to get list of all the users. Put <http://localhost:8080/xyz/abc> in POSTMAN with GET request and see the below result.

Congratulations, you have created your first RESTful Application successfully.

# Resources

## What is a Resource?

REST architecture treats every content as a resource. These resources can be text files, html pages, images, videos or dynamic business data. REST Server simply provides access to resources and REST client accesses and modifies the resources. Here each resource is identified by URIs/ global IDs. REST uses various representations to represent a resource where text, JSON, XML. XML and JSON are the most popular representations of resources.

## Representation of Resources

A resource in REST is similar Object in Object Oriented Programming or similar to Entity in a Database. Once a resource is identified then its representation is to be decided using a standard format so that server can send the resource in above said format and client can understand the same format.

For example, in [RESTful Web Services - First Application](http://www.tutorialspoint.com/restful/restful_first_application.htm) tutorial, User is a resource which is represented using following XML format:

<user>

<id>1</id>

<name>Mahesh</name>

<profession>Teacher</profession>

</user>

Same resource can be represented in JSON format as follows:

{

"id":1,

"name":"Mahesh",

"profession":"Teacher"

}

## Good Resources Representation

REST does not impose any restriction on the format of a resource representation. A client can ask for JSON representation where as another client may ask for XML representation of same resource to the server and so on. It is responsibility of the REST server to pass the client the resource in the format that client understands.

Following are important points to be considered while designing a representation format of a resource in a RESTful web services.

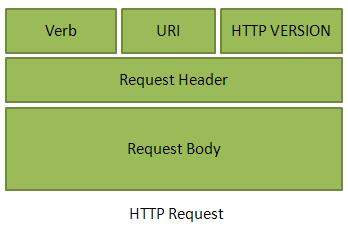
* **Understandability:** Both Server and Client should be able to understand and utilize the representation format of the resource.
* **Completeness:** Format should be able to represent a resource completely. For example, a resource can contain another resource. Format should be able to represent simple as well as complex structures of resources.
* **Linkablity:** A resource can have a linkage to another resource, a format should be able to handles such situations.

However, at present most of the web services are representing resources using either XML or JSON format. There are plenty of libraries and tools available to understand, parse, and modfiy XML and JSON data.

# Messages

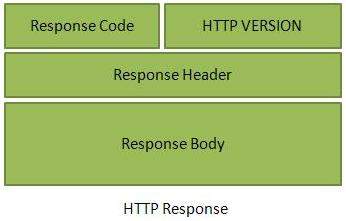
RESTful web services make use of HTTP protocol as a medium of communication between client and server. A client sends a message in form of a HTTP Request and server responds in form of a HTTP Response. This technique is termed as Messaging. These messages contain message data and metadata i.e. information about message itself. Let's have a look on HTTP Request and HTTP Response messages for HTTP 1.1.

## HTTP Request

A HTTP Request has five major parts:

* **Verb**- Indicate HTTP methods such as GET, POST, DELETE, PUT etc.
* **URI**- Uniform Resource Identifier (URI) to identify the resource on server
* **HTTP Version**- Indicate HTTP version, for example HTTP v1.1 .
* **Request Header**- Contains metadata for the HTTP Request message as key-value pairs. For example, client ( or browser) type, format supported by client, format of message body, cache settings etc.
* **Request Body**- Message content or Resource representation.

## HTTP Response

A HTTP Response has four major parts:

* **Status/Response Code**- Indicate Server status for the requested resource. For example 404 means resource not found and 200 means response is ok.
* **HTTP Version**- Indicate HTTP version, for example HTTP v1.1 .
* **Response Header**- Contains metadata for the HTTP Response message as key-value pairs. For example, content length, content type, response date, server type etc.
* **Response Body**- Response message content or Resource representation.

# Addressing

Addressing refers to locating a resource or multiple resources lying on the server. It is analogous to locate a postal address of a person.

Each resource in REST architecture is identified by its URI, Uniform Resource Identifier. A URI is of following format:

<protocol>://<service-name>/<ResourceType>/<ResourceID>

Purpose of an URI is to locate a resource(s) on the server hosting the web service. Another important attribute of a request is VERB which identifies the operation to be performed on the resource. For example, in [RESTful Web Services - First Application](http://www.tutorialspoint.com/restful/restful_first_application.htm) tutorial, URI is**http://localhost:8080/UserManagement/rest/UserService/users** and VERB is GET.

## Constructing a standard URI

Following are important points to be considered while designing a URI:

* **Use Plural Noun** - Use plural noun to define resources. For example, we've used **users** to identify users as a resource.
* **Avoid using spaces** - Use underscore(\_) or hyphen(-) when using a long resource name, for example, use authorized\_users instead of authorized%20users.
* **Use lowercase letters** - Although URI is case-insensitive, it is good practice to keep url in lower case letters only.
* **Maintain Backward Compatibility**- As Web Service is a public service, a URI once made public should always be available. In case, URI gets updated, redirect the older URI to new URI using HTTP Status code, 300.
* **Use HTTP Verb** - Always use HTTP Verb like GET, PUT, and DELETE to do the operations on the resource. It is not good to use operations names in URI.

## Example

Following is an example of a poor URI to fetch a user.

http://localhost:8080/UserManagement/rest/UserService/getUser/1

Following is an example of a good URI to fetch a user.

http://localhost:8080/UserManagement/rest/UserService/users/1

# Methods

As we have discussed so far that RESTful web service makes heavy uses of HTTP verbs to determine the operation to be carried out on the specified resource(s). Following table states the examples of common use of HTTP Verbs.

|  |  |
| --- | --- |
| **S.N.** | **HTTP Method, URI and Operation** |
| 1 | **GET** |
| http://localhost:8080/UserManagement/rest/UserService/users |
| Get list of users |
| (Read Only) |
| 2 | **GET** |
| http://localhost:8080/UserManagement/rest/UserService/users/1 |
| Get User of Id 1 |
| (Read Only) |
| 3 | **PUT** |
| http://localhost:8080/UserManagement/rest/UserService/users/2 |
| Insert User with Id 2 |
| (Idempotent) |
| 4 | **POST** |
| http://localhost:8080/UserManagement/rest/UserService/users/2 |
| Update User with Id 2 |
| (N/A) |
| 5 | **DELETE** |
| http://localhost:8080/UserManagement/rest/UserService/users/1 |
| Delete User with Id 1 |
| (Idempotent) |
| 6 | **OPTIONS** |
| http://localhost:8080/UserManagement/rest/UserService/users |
| List the supported operations in web service |
| (Read Only) |
| 7 | **HEAD** |
| http://localhost:8080/UserManagement/rest/UserService/users |
| Returns only HTTP Header, no Body. |
| (Read Only) |

Here are important points to be considered:

* GET operations are read only and are safe.
* PUT and DELETE operations are idempotent means their result will always same no matter how many times these operations are invoked.
* PUT and POST operation are nearly same with the difference lying only in the result where PUT operation is idempotent and POST operation can cause different result.

## Testing the Web Service

Jersey provides APIs to create a Web Service Client to test web services. We've created a sample test class **WebServiceTester.java** under the com.tutorialspoint package in the same project.

# Statelessness

As per REST architecture, a RESTful web service should not keep a client state on server. This restriction is called statelessness. It is responsibility of the client to pass its context to server and then server can store this context to process client's further request. For example, session maintained by server is identified by session identifier passed by the client.

RESTful Web services should adhere to this restriction. We've seen in [RESTful Web Services - Methods](http://www.tutorialspoint.com/restful/restful_methods.htm) tutorial, that Web service methods are not storing any information from the client they are invoked from.

Consider the following URL:

http://localhost:8080/UserManagement/rest/UserService/users/1

If you hit the above url using browser, using java based client or using postman, result will always be the User XML whose Id is 1 because server does not store any information about the client.

<user>

<id>1</id>

<name>mahesh</name>

<profession>1</profession>

</user>

## Advantages of Statelessness

Following are the benefits of statelessness in RESTful web services

* Web services can treat each method request independently.
* Web services need not to maintain client's previous interactions. It simplifies application design.
* As HTTP is itself a statelessness protocol, RESTful Web services work seamlessly with HTTP protocol.

## Disadvantages of Statelessness

Following are the disadvantages of statelessness in RESTful web services

* Web services need to get extra information in each request and then interpret to get the client's state in case client interactions are to be taken care of.

# Caching

Caching refers to storing server response in client itself so that a client needs not to make server request for same resource again and again. A server response should have information about how a caching is to be done so that a client caches response for a period of time or never caches the server response.

Following are the headers which a server response can have in order to configure a client's caching:

|  |  |
| --- | --- |
| **S.N.** | **Header & Description** |
| 1 | **Date** |
| Date and Time of the resource when it was created. |
| 2 | **Last Modified** |
| Date and Time of the resource when it was last modified. |
| 3 | **Cache-Control** |
| Primary header to control caching. |
| 4 | **Expires** |
| Expiration date and time of caching |
| 5 | **Age** |
| Duration in seconds from when resource was fetched from the server. |

## Cache-Control Header

Following are the details of Cache-Control header

|  |  |
| --- | --- |
| **S. N.** | **Directive & Description** |
| 1 | **Public** |
| Indicates that resource is cachable by any component. |
| 2 | **Private** |
| Indicates that resource is cachable by only client and server, no intermediary can cache the resource. |
| 3 | **no-cache/no-store** |
| Indicates that resource is not cachable |
| 4 | **max-age** |
| Indicates the caching is valid up to max-age in seconds. After this, client has to make another request. |
| 5 | **must-revalidate** |
| Indication to server to revalidate resource if max-age has passed. |

## Best practices for Cache-ControlBest Practices

* Always keep static contents like images, css, JavaScript cacheable, with expiration date of 2 to 3 days.
* Never keep expiry date too high.
* Dynamic contents should be cached for few hours only.

# Security

As RESTful web services work with HTTP URLs Paths so it is very important to safeguard a RESTful web service in the same manner as a website is be secured. Following are the best practices to be followed while designing a RESTful web service.

* **Validation** - Validate all inputs on the server. Protect your server against SQL or NoSQL injection attacks.
* **Session based authentication** - Use session based authentication to authenticate a user whenever a request is made to a Web Service method.
* **No sensitive data in URL** - Never use username, password or session token in URL , these values should be passed to Web Service via POST method.
* **Restriction on Method execution** - Allow restricted use of methods like GET, POST, DELETE. GET method should not be able to delete data.
* **Validate Malformed XML/JSON** - Check for well-formed input passed to a web service method.
* **Throw generic Error Messages** - A web service method should use HTTP error messages like 403 to show access forbidden etc.

## HTTP Code:

|  |  |
| --- | --- |
| **S.N.** | **HTTP Code & Description** |
| 1 | **200** |
| **OK**, shows success. |
| 2 | **201** |
| **CREATED**, when a resource is successful created using POST or PUT request. Return link to newly created resource using location header. |
| 3 | **204** |
| **NO CONTENT**, when response body is empty for example, a DELETE request. |
| 4 | **304** |
| **NOT MODIFIED**, used to reduce network bandwidth usage in case of conditional GET requests. Response body should be empty. Headers should have date, location etc. |
| 5 | **400** |
| **BAD REQUEST**, states that invalid input is provided e.g. validation error, missing data. |
| 6 | **401** |
| **UNAUTHORIZED**, states that user is using invalid or wrong authentication token. |
| 7 | **403** |
| **FORBIDDEN**, states that user is not having access to method being used for example, delete access without admin rights. |
| 8 | **404** |
| **NOT FOUND**, states that method is not available. |
| 9 | **409** |
| **CONFLICT**, states conflict situation while executing the method for example, adding duplicate entry. |
| 10 | **500** |
| **INTERNAL SERVER ERROR**, states that server has thrown some exception while executing the method. |

# Java (JAX-RS)

**JAX-RS** stands for JAVA API for RESTful Web Services. JAX-RS is a JAVA based programming language API and specification to provide support for created RESTful Webservices. Its 2.0 version was released in 24 May 2013. JAX-RS makes heavy use of annotations available from Java SE 5 to simplify development of JAVA based web services creation and deployment. It also provides supports for creating clients for RESTful web services.

## Specification

Following are the commonly used annotations to map a resource as a web service resource.

|  |  |
| --- | --- |
| **S.N.** | **Annotation & Description** |
| 1 | **@Path** |
| Relative path of the resource class/method. |
| 2 | **@GET** |
| HTTP Get request, used to fetch resource. |
| 3 | **@PUT** |
| HTTP PUT request, used to create resource. |
| 4 | **@POST** |
| HTTP POST request, used to create/update resource. |
| 5 | **@DELETE** |
| HTTP DELETE request, used to delete resource. |
| 6 | **@HEAD** |
| HTTP HEAD request, used to get status of method availability. |
| 7 | **@Produces** |
| States the HTTP Response generated by web service, for example APPLICATION/XML, TEXT/HTML, APPLICATION/JSON etc. |
| 8 | **@Consumes** |
| States the HTTP Request type, for example application/x-www-form-urlencoded to accept form data in HTTP body during POST request. |
| 9 | **@PathParam** |
| Binds the parameter passed to method to a value in path. |
| 10 | **@QueryParam** |
| Binds the parameter passed to method to a query parameter in path. |
| 11 | **@MatrixParam** |
| Binds the parameter passed to method to a HTTP matrix parameter in path. |
| 12 | **@HeaderParam** |
| Binds the parameter passed to method to a HTTP header. |
| 13 | **@CookieParam** |
| Binds the parameter passed to method to a Cookie. |
| 14 | **@FormParam** |
| Binds the parameter passed to method to a form value. |
| 15 | **@DefaultValue** |
| Assigns a default value to a parameter passed to method. |
| 16 | **@Context** |
| Context of the resource for example HTTPRequest as a context. |