IBM z/OS Connect (OpenAPI 3.0)

Developing and Administering RESTful APIs for Db2 Native REST Services

IBM Z
Wildfire Team –
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Important: On the desktop there is a file named *OpenAPI 3 development APIs CopyPaste.txt*. This file contains commands and other text used in this workshop. Locate that file and open it. Use the copy-and-paste function (**Ctrl-C** and **Ctrl-V**) to enter commands or text. It will save time and help avoid typo errors. As a reminder text that appears in this file will be highlighted in yellow.

Overview

The objective of these exercises is to gain experience with working with *z/OS Connect* and the *z/OS Connect Designer*. This exercise is offered in conjunction with a Washington Systems Center Wildfire workshop for z/OS Connect. For information about scheduling this workshop in your area contact your IBM representative.

Important – You do not need any skills with Db2 to perform this exercise. Even if Db2 is not relevant to your current plans, performing the steps in this exercise will give additional experience using the *z/OS Connect Designer* to developing and administer APIs.

General Exercise Information and Guidelines

- ✓ This exercise requires using z/OS user identities *Fred, USER1* and *USER2*. The *Designer* passwords for these identities are *fredpwd, user1* and *user2* respectively and are case sensitive. The RACF password for these users are *FRED, USER1* and *USER2* respectively and are case insensitive.

- ✓ The IP address of the image where the *z/OS Connect Designer* containers are running has been configured in the *../etc/hosts* file as *designer.washington.ibm.com.* This was done so the host name that appears in this exercise would be consistent regardless of whether the containers were running in a local Windows Subsystem for Linux image using a loop back adapter or a remote server image.

- ✓ Any time you have any questions about the use of screens, features or tools do not hesitate to reach out for assistance.

- ✓ Text in **bold** and highlighted in **yellow** in this document should be available for copying and pasting in a file named *OpenAPI 3 development APIs CopyPaste* file on the desktop

- ✓ Please note that there may be minor differences between the screen shots in this exercise versus what you see when performing this exercise. These differences should not impact the completion of this exercise. For example, the text might reference host name *designer.washington.ibm.com* when a screen shot shows the host as *designer.ibm.com* or even *localhost*. All of these names resolve to the same IP address. Another example is that a section of a page has been expanded for display purposes. If a section or screen shot does not look exactly as what you are observing, consider maximizing or minimizing that section

Db2 REST services and z/OS Connect

Accessing a Db2 REST service from z/OS Connect differs from the ways in which z/OS Connect accesses the resources of other z/OS subsystems. Other subsystem's resources are accessed by using their normal subsystem interfaces (e.g., OTMA, IPIC, JMS, etc.).
A z/OS Connect server accesses Db2 not as a Db2 client using JDBC, but rather as a RESTful client accessing an existing Db2 REST service. This may raise the question as to what value-add does z/OS Connect provide if z/OS Connect can only access an existing Db2 REST service? The answer is that (1) the REST services support provided by Db2 only supports the POST method with only a few administrative services that support the GET method. There is no support for PUT or DELETE methods normally expected for a robust RESTful API service. Another reason (2) is that the API function of transforming JSON request or response messages, e.g., assigning values or removing fields from the interface is not available when using the Db2 native REST Services directly.. And finally (3) z/OS Connect provides security mechanism (e.g., OAUTH and JWT tokens) not available with Db2. If a full function RESTful API with support for the major HTTP methods (POST, PUT, GET and DELETE), or transforming JSON payloads and/or additional authentication methods are required, then z/OS Connect is the solution

Creating and testing Db2 REST Services

Db2 REST services are defined either using a Db2 provided RESTful administrative service (DB2ServiceManager) or by using the Db2 BIND command using an update provided in Db2 PTF UI51748 and APAR PI98649 (PTF UI584231 or UI58425). Only the latter technique that will be shown in this exercise.

___1. Log onto TSO and access data set USER1.ZCEE.CNTL

___2. Select member *DB2REST1* in *USER1.ZCEE.CNTL* and right- mouse button clicking and submit this job for execution. It should complete with a completion code of 0.

```
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
//STEPLIB  DD DSN=DSN1210.DB2.SDSNEXIT,DISP=SHR
//         DD DSN=DSN1210.DB2.SDSNLOAD,DISP=SHR
//SYSTSPRT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//DSNSTMT  DD *
  SELECT EMPNO AS "employeeNumber", FIRSTNME AS "firstName",
        MIDINIT AS "middleInitial", LASTNAME as "lastName",
        WORKDEPT AS "department", PHONENO AS "phoneNumber",
        JOB AS "job"
  FROM USER1.EMPLOYEE WHERE EMPNO = :employeeNumber
//SYSTSIN  DD *
 DSN SYSTEM(DSN2)
 BIND SERVICE("zCEEService") -
  NAME("selectEmployee") -
  SQLENCODING(1047) -
  DESCRIPTION('Select an employee from table USER1.EMPLOYEE')
/*
```


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This defines a Db2 native REST Services that select a single row from table USER1.EMPLOYEE based on the employee number (column EMPNO).

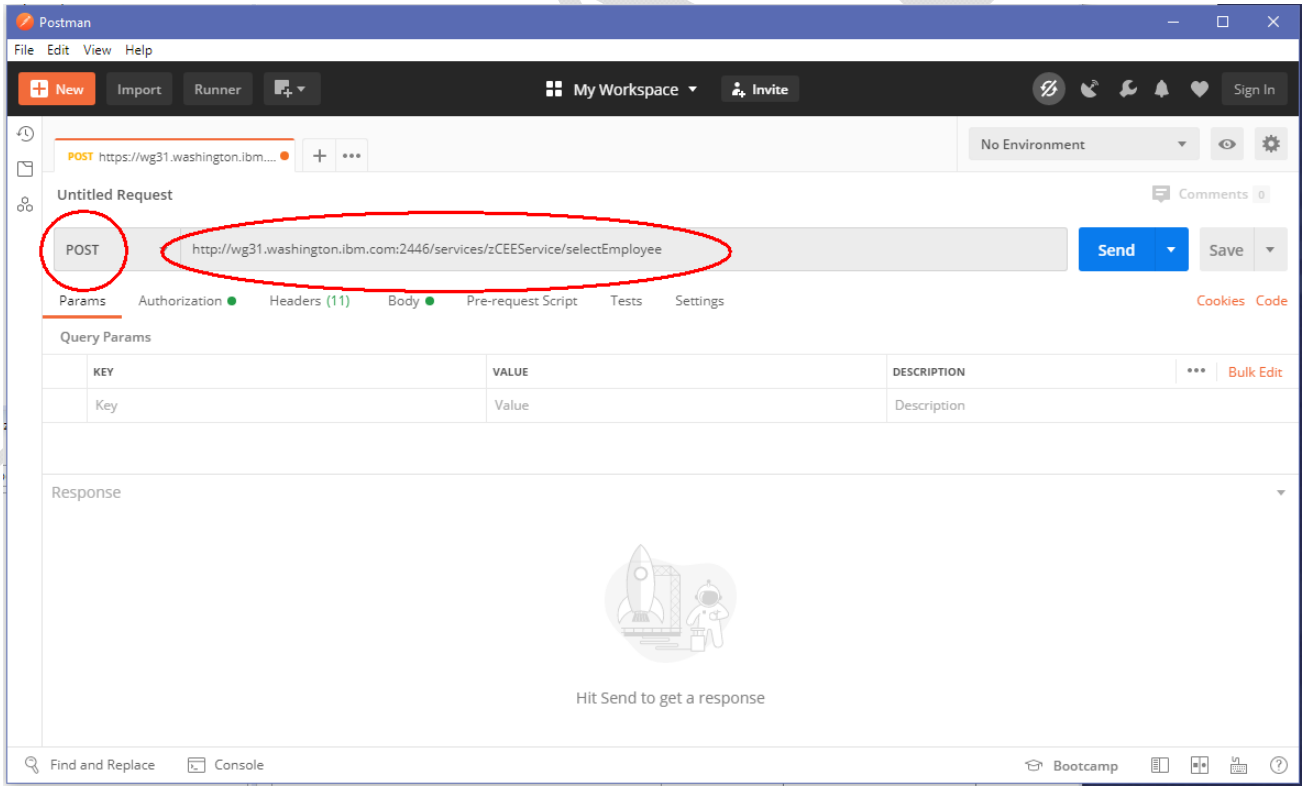
Important: The DBA creating this native Db2 REST service is excluding other table columns, e.g., SEX, SALARY, BONUS, COMMISION, etc. from the selection by omitting these columns from the SELECT statement. The DBA's use of the *AS* cause will also ensure the assigning of meaningful JSON property names rather than the original Db2 column names to the JSON request and response messages.

Tech-Tip: The input to DD DSNSTMT can be a CALL, DELETE, INSERT, SELECT, TRUNCATE, UPDATE, or WITH SQL statement.

To delete a service created by using the Db2 BIND command use the Db2 FREE command, e.g., FREE SERVICE("zCEEService"."selectEmployee")

Tech-Tip: A minimum of EXECUTE authority on package zCEEService.selectEmployee would be required to have the ability to execute this service.

___3. Open the *Postman* tool icon on the desktop and if necessary reply to any prompts and close any welcome messages, use the down arrow to select **POST** and enter ***http://wg31.washington.ibm.com:2446/services/zCEEService/selectEmployee*** in the URL area (see below).



Tech-Tip: If the above Postman view is not displayed select *File* on the toolbar and then choose *New Tab* on the pull down. Alternatively, if the *Launchpad* view is displayed, click on the *Create a request* option.

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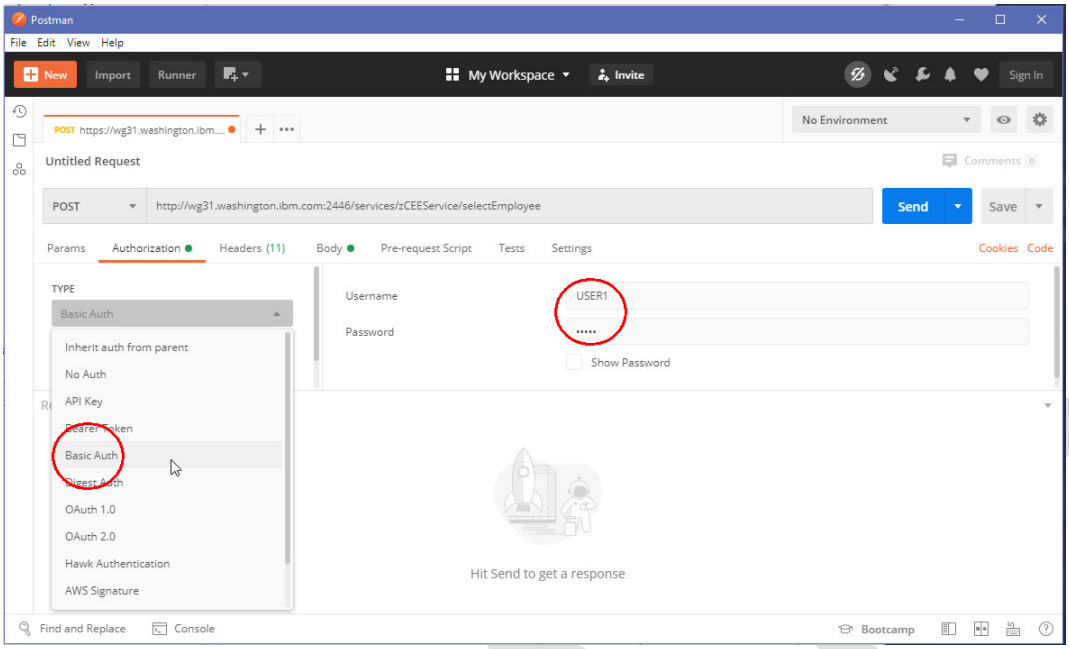
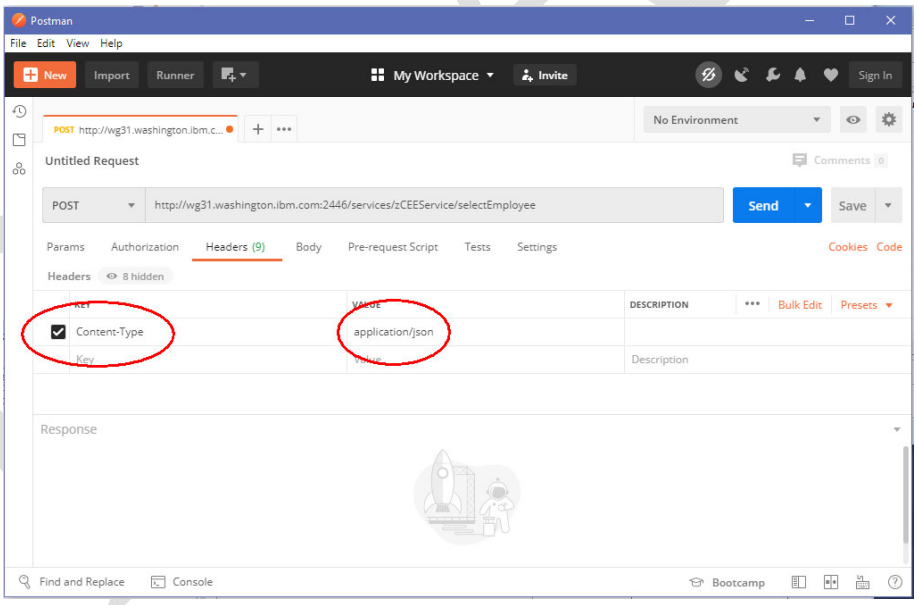
___4. No *query* or *path* parameters are required so next select the *Authorization* tab to enter an authorization identity and password. Use the pull down arrow to select *Basic Auth* and enter ***USER1*** as the *Username* and USER1's password as the *Password*.



___5. Next select the *Headers* tab and under *KEY* use the code assist feature to enter ***Content-Type*** and under *VALUE* use the code assist feature to enter ***application/json***.



Tech-Tip: Code assist simply means that when text is entered in field, all the valid values for that field that match the typed text will be displayed. You can select the desired value for the field from the list displayed and that value will populate that field.

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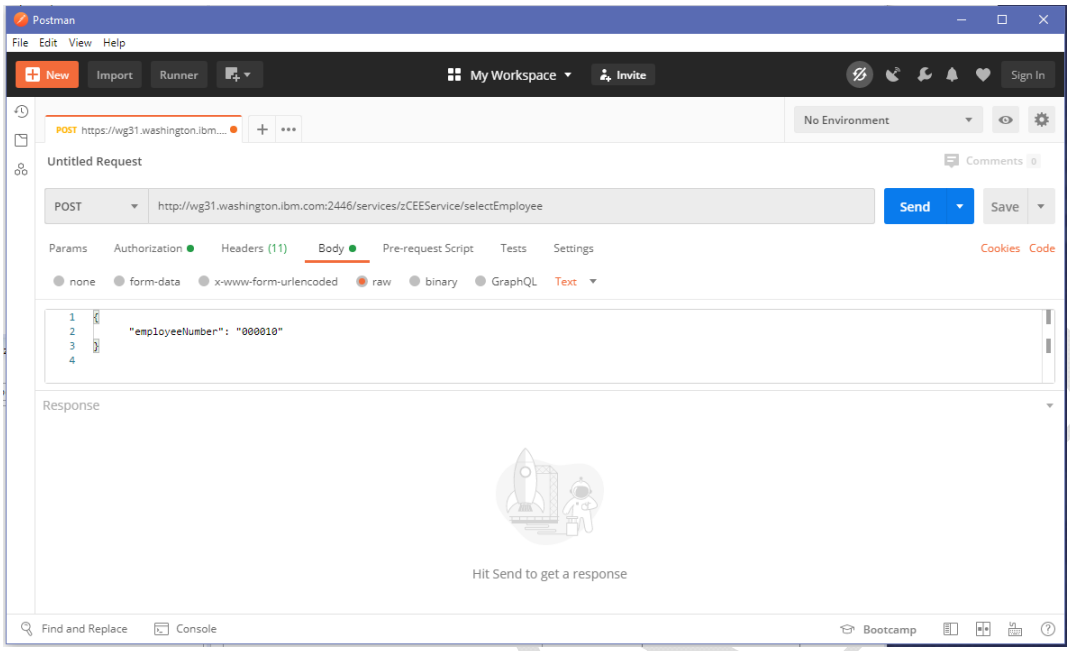
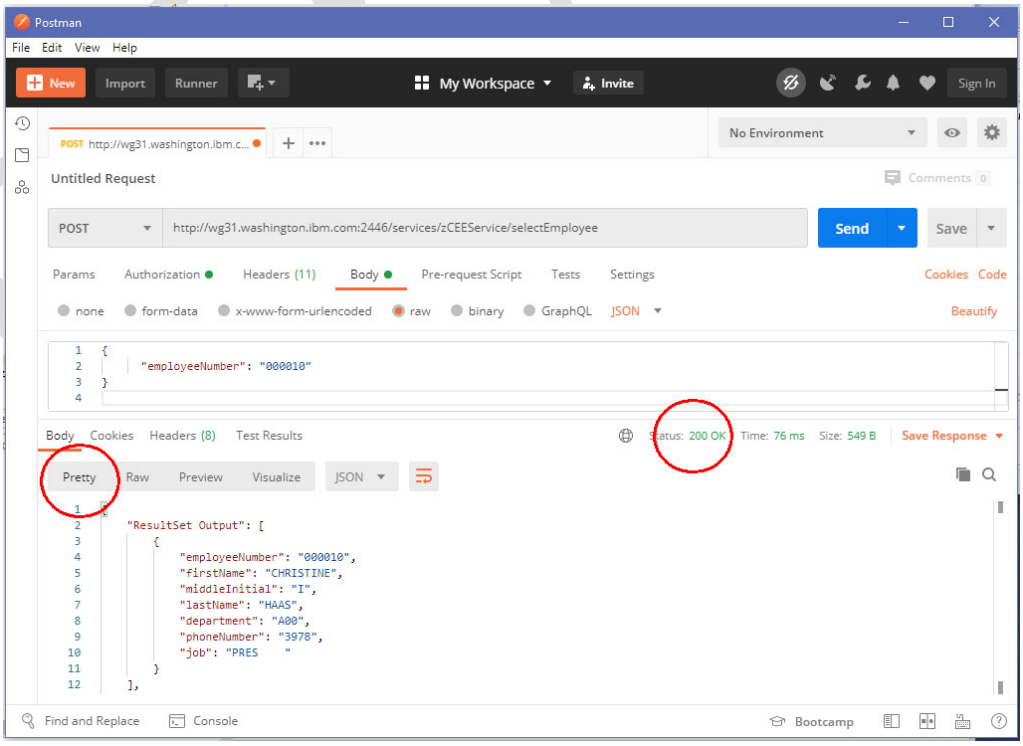
___6. Next select the *Body* tab and select the *raw* radio button and enter the JSON message below in the *Body* area and press the **Send** button.

```
{
      "employeeNumber": "000010"
}
```



___7. Pressing the **Send** button invokes the API. The Status of request should be *200 OK* and pressing the *Pretty* tab will display the response



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___8. Submit member DB2REST2 in *USER1.ZCEE. CNTL* for execution. It should complete with a completion code of 0.

```
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
//STEPLIB  DD DSN=DSN1210.DB2.SDSNEXIT,DISP=SHR
//         DD DSN=DSN1210.DB2.SDSNLOAD,DISP=SHR
//SYSTSPRT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//DSNSTMT  DD *
DELETE FROM USER1.EMPLOYEE WHERE EMPNO = :employeeNumber
//SYSTSIN  DD *
 DSN SYSTEM(DSN2)

 BIND SERVICE("zCEEService") -
  NAME("deleteEmployee") -
  SQLENCODING(1047) -
  DESCRIPTION('Delete an employee from table USER1.EMPLOYEE')
/*
```

This creates a user Db2 native REST Service named *deleteEmployee* that deletes a row from table USER1.EMPLOYEE using the same JSON request message used in Step 6. Optionally test this service by using same Postman session with URL ***http://wg31.washington.ibm.com:2446/services/zCEEService/deleteEmployee*** and the JSON request message below.

```
{
      "employeeNumber": "000340"
}
```

You should see this result in the response area.

```
{
    "Update Count": 1,
    "StatusCode": 200,
    "StatusDescription": "Execution Successful"
}
```

___9. Submit member DB2REST3 in *USER1.ZCEE. CNTL* for execution. It should complete with a completion code of 0.

```
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
//STEPLIB  DD  DSN=DSN1210.DB2.SDSNEXIT,DISP=SHR
//         DD  DSN=DSN1210.DB2.SDSNLOAD,DISP=SHR
//SYSTSPRT DD  SYSOUT=*
//SYSPRINT DD  SYSOUT=*
//SYSUDUMP DD  SYSOUT=*
//DSNSTMT  DD  *
   SELECT EMPNO AS "employeeNumber", FIRSTNME AS "firstName",
         MIDINIT AS "middleInitial", LASTNAME as "lastName",
         WORKDEPT AS "department", PHONENO AS "phoneNumber",
         JOB AS "job"
   FROM USER1.EMPLOYEE WHERE JOB = :job AND WORKDEPT = :department
//SYSTSIN  DD  *
 DSN SYSTEM(DSN2)

 BIND SERVICE("zCEEService") -
  NAME("selectByRole") -
  SQLENCODING(1047) -
  DESCRIPTION('Select an employee based on job and department')
/*
```

This creates a user Db2 native REST Service named *selectByRole* that selects rows from table USER1.EMPLOYEE based on the contents of the WORKDEPT and JOB columns.

Important: The DBA creating this native Db2 REST service is excluding other table columns, e.g. SEX, SALARY, BONUS, COMMISION, etc. from the selection by omitting these columns from the SELECT statement. The DBA's use of the *AS* cause will also ensure the assigning of meaningful JSON property names rather than the original Db2 column names to the JSON request and response messages.

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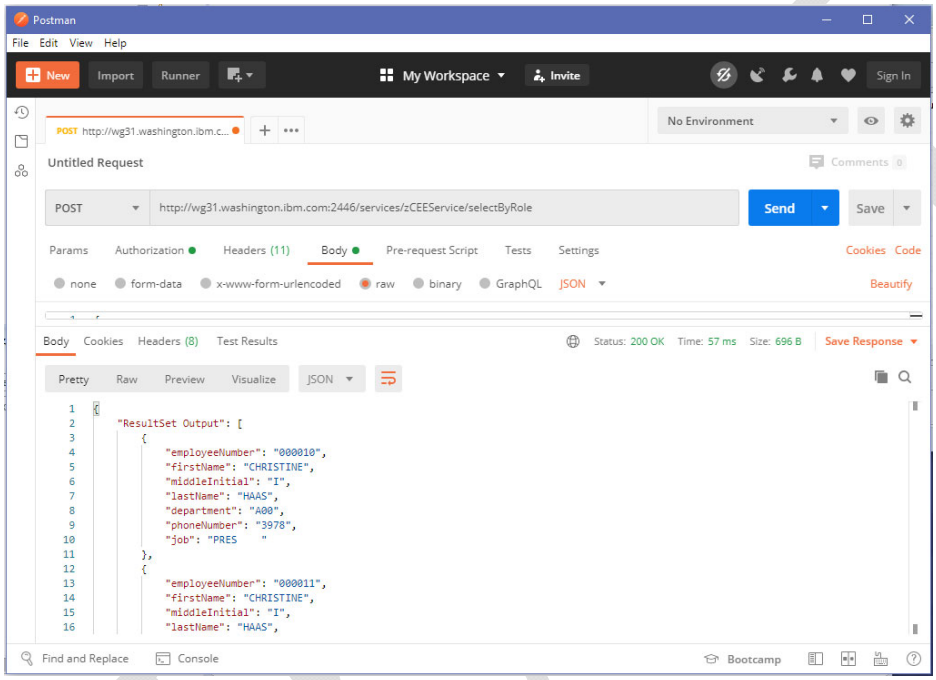
10. Test this service by using a URL of ***http://wg31.washington.ibm.com:2446/services/zCEEService/selectByRole*** and a JSON request message of:

```
{
       "job": "PRES",
       "department": "A00"
}
```



11. Submit member DB2REST5 in *USER1.ZCEE.CNTL* for execution. It should complete with a completion code of 0.

```
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
//STEPLIB  DD DSN=DSN1210.DB2.SDSNEXIT,DISP=SHR
//         DD DSN=DSN1210.DB2.SDSNLOAD,DISP=SHR
//SYSTSPRT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//DSNSTMT  DD *
  INSERT INTO USER1.EMPLOYEE
         (EMPNO,FIRSTNME,MIDINIT,LASTNAME,WORKDEPT,PHONENO,
          HIREDATE,JOB,EDLEVEL,SEX,BIRTHDATE,SALARY,BONUS,COMM)
     VALUES (:employeeNumber, :firstName, :middleINit, :lastname,
             :department, :phoneNumber, :hireDate, :job,
             :educationLevel, :sex, :birthDate,
             :salary, :bonus, :commission)
//SYSTSIN  DD *
DSN SYSTEM(DSN2)
BIND SERVICE("zCEEService") -
NAME("insertEmployee") -
SQLENCODING(1047) -
DESCRIPTION('Insert an employee into table USER1.EMPLOYEE')
/*
```

This creates a user Db2 native REST Service named *insertEmployee* that inserts a new row into table USER1.EMPLOYEE).

> **Tech-Tip:** The host variables specified in the VALUES clause will determine the JSON request and response message property names.

12. Test this service by using a URL of ***http://wg31.washington.ibm.com:2446/services/zCEEService/insertEmployee***

```
{
      "employeeNumber": "999999",
      "firstName": "Matt",
      "middleInitial": "T",
      "lastName": "Johnson",
      "department": "A00",
      "phoneNumber": "9999",
      "hireDate": "2013-01-01",
      "job": "Staff",
      "educationLevel": "27",
      "sex": "M",
      "birthDate": "1985-06-18",
      "salary": "100000",
      "bonus": "15000",
      "commission": "10000"
}
```

You should see this result in the response area.

```
{
    "Update Count": 1,
    "StatusCode": 200,
    "StatusDescription": "Execution Successful"
}
```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13. Next submit job *DB2REST6* to create two new Db2 native services. Db2 native REST service *updateEmployee* updates the SALARY, BONUS and COMM columns in the Db2 table. Db2 native REST service *displayEmployee* will display all the columns of the table (remember Db2 native REST service *selectEmployee* only returns a subset of the columns).

```
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
//SYSTSPRT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//DSNSTMT  DD *
  UPDATE USER1.EMPLOYEE
         SET SALARY = :salary, BONUS  = :bonus, COMM   = :commission
    WHERE EMPNO = :employeeNumber
//SYSTSIN  DD *
DSN SYSTEM(DSN2)
BIND SERVICE("zCEEService") -
NAME("updateEmployee") SQLENCODING(1047) -
DESCRIPTION('Insert an employee row into table USER1.EMPLOYEE')
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
//SYSTSPRT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//DSNSTMT  DD *
  SELECT * FROM USER1.EMPLOYEE WHERE EMPNO = :employeeNumber
//SYSTSIN  DD *
DSN SYSTEM(DSN2)
BIND SERVICE("zCEEService") -
NAME("displayEmployee") SQLENCODING(1047) -
DESCRIPTION('Display an employee row in table USER1.EMPLOYEE')
('Select an employee from table USER1.EMPLOYEE')
```

This completes the creation of the Db2 native REST Services that will be used in an API. In the next section, the OpenAPI 3 specification document will be imported into the *z/OS Connect Designer* and used to develop an API.

But before we continue; go back and review the Db2 response messages. Notice that there is a pattern in the response messages from the Db2 REST services. When a Db2 resources is added, updated, or deleted, the response message included an *Update Count* field. The field contains the number of Db2 resources affected by this invoking this service. In the same token, when Db2 resources were retrieved, the Db2 resources were returned in a list or array (e.g., *Resultset Output*) containing one or more list elements. These fields will be used in the *z/OS Connect Designer* to know if a specific REST method was successful or not.

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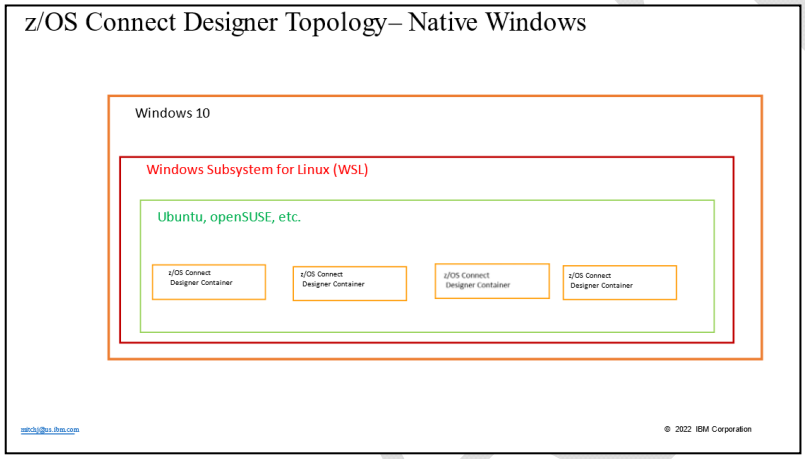
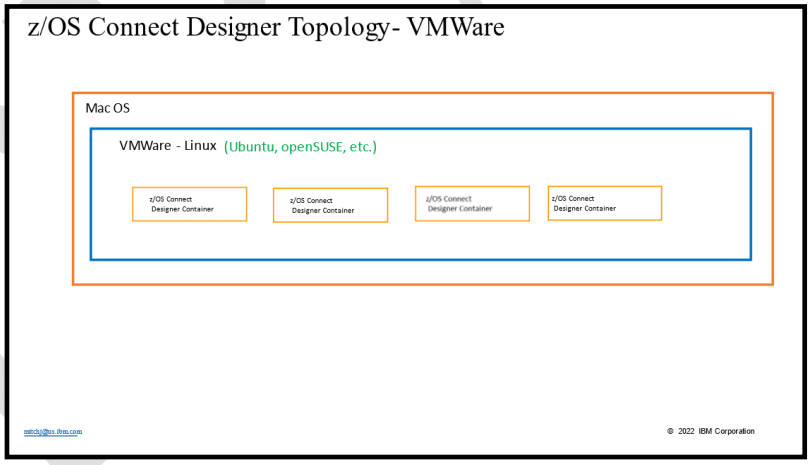
The z/OS Connect Designer Container environment

APIs for accessing Db2 resources are developed using the *z/OS Connect Designer* which is an application that runs in a Liberty server environment. Each Liberty server with a *z/OS Connect Designer* (*Designer*) installed can only support the development of a single API. This should not be an issue since these Liberty servers are running in containers and multiple containers can run concurrently on a single image. Currently these containers must be running in a host Linux environment. And again, limiting containers to a Linux host is not a major issue because even if a native Linux environment is not available, current versions of Windows and Mac OS can host Linux host images using either *Windows Subsystems for Linux (WSL)* or virtual images.

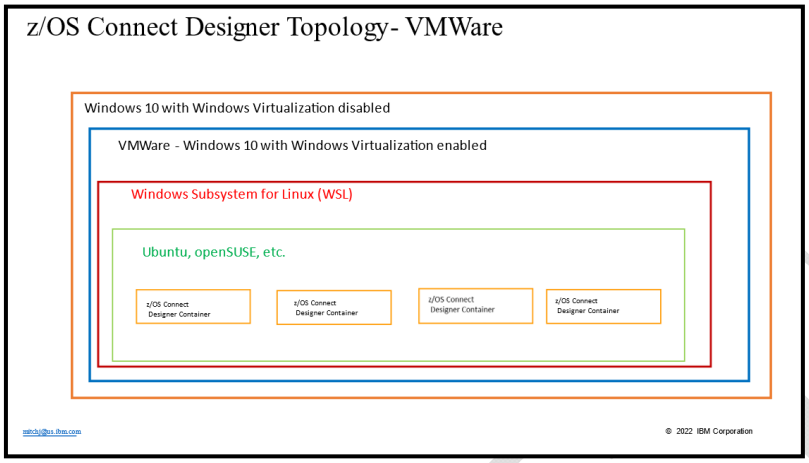
For example, consider the diagram below. This diagram is showing a Windows image with *WSL* enabled. The *WSL* environment allows the installation of a Linux distribution (*Ubuntu* in our case), and this *Ubuntu* host image can support multiple container each running the *z/OS Connect Designer* application in a Liberty server.



This diagram shows another scenario for a Mac OS image where VMWare Fusion© or Parallels© can be used to run a virtual Linux image in which where the Liberty *Designer* containers can run.

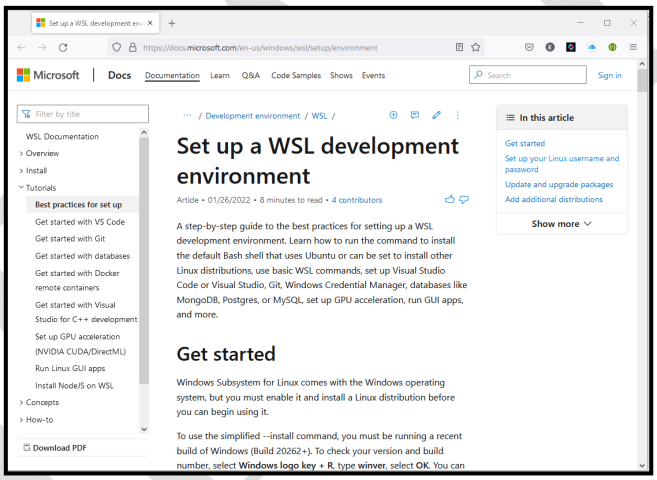


Another example is shown here where a Windows VMWare© can be used to host a Windows image which has WSL configure in which a host Linux image is running with multiple Liberty *Designer* containers running.

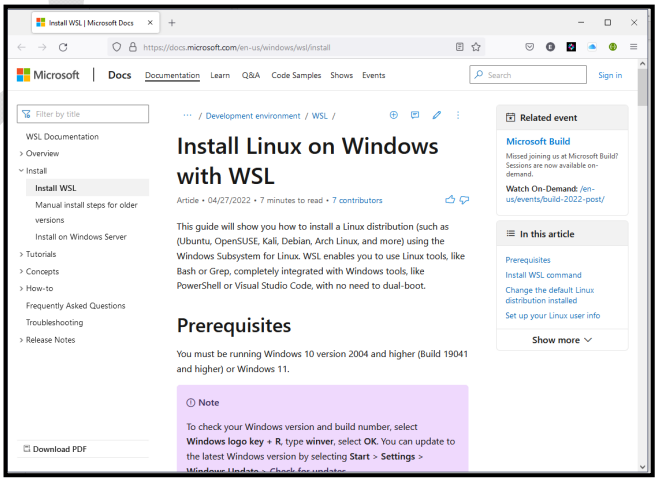


Setup required Windows Subsystems for Linux support

When running on Windows, the environment for the *Designer* containers required the enablement of *Windows Subsystem for Linux (WSL)*. WSL was configured using the instructions at URL https://docs.microsoft.com/en-us/windows/wsl/setup/enviroment.



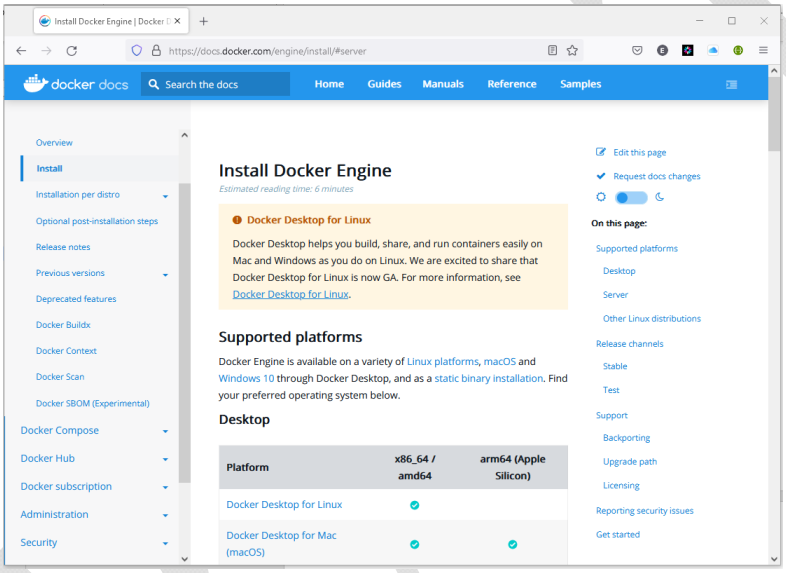
A Linux distribution can be installed following the instructions at URL https://docs.microsoft.com/en-us/windows/wsl/install



Once the host Linux distribution is installed, a container runtime product is required. The z/OS Connect product documentation refers to using *Docker Desktop* and other products. Know that the *Docker Desktop* is a licensed product with yearly cost per license. If the license cost are not issue then by all means, follow the product documentation, and use *Docker Desktop*. But for our purposes, *Docker Desktop* was not an option and z/OS *Connect Designer* containers for this exercise run in containers support by products that do not require licenses, *Docker Engine* and *Podman.*

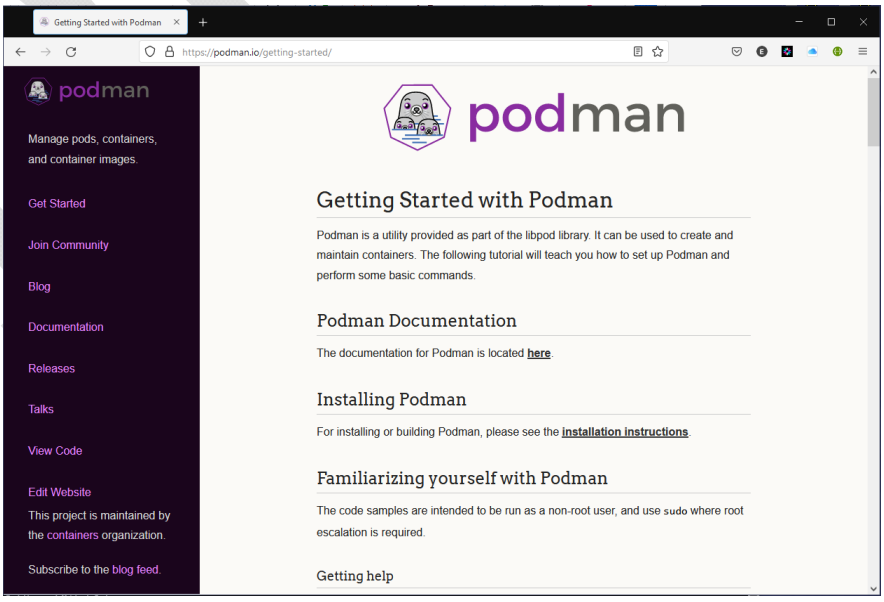
Docker Engine

As stated earlier, Docker Engine was used for this exercise since it does not require a license. Docker Engine was installed the host Linux image using the information at URL https://docs.docker.com/engine/install/#server



Podman

An alternative to using *Docker Engine* is to use *Podman* which also not require a license. *Podman* was installed in the host Linux image using the information at URL https://docs.docker.com/engine/install/#server



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The container configuration file

Regardless of whether *Docker Engine, Docker Desktop*, *Podman* or some other container runtime product is being used, the container's environment required configuration.

First, the container requires that Db2 related environment variable be provided. These variables are used to customize the Db2 related server XML configuration elements. For this exercise, the container was configured with these environment variables set in the *docker-compose.yaml* file (in ***bold***).

```
version: "3.2"
services:
    zosConnect:
        image: icr.io/zosconnect/ibm-zcon-designer:3.0.57
        user: root
        environment:
            - CICS_USER=USER1
            - CICS_PASSWORD=USER1
            - CICS_HOST=wg31.washington.ibm.com
            - CICS_PORT=1491
            - DB2_USERNAME=USER1
            - DB2_PASSWORD=USER1
            - DB2_HOST=wg31.washington.ibm.com
            - DB2_PORT=2446
            - HTTP_PORT=9080
        ports:
            - "9449:9443"
            - "9086:9080"
        volumes:
            - ./project:/workspace/project
            - ./logs/:/logs/
            - ./certs:/output/resources/security/
```

Connecting to a Db2 subsystem requires the addition of a *zosconnect_db2Connection* configuration element to the container's Liberty configuration. And since this API has role-based security elements configured, additional configuration elements for a basic registry and authorization roles are also required. These Liberty configuration elements are described next.

Connecting to Db2 and the required server XML configuration

The *zosconnect_db2Connection* element used to connect to a Db2 subsystem in this exercise looks like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="Db2 zosconnect_db2Connection ">
    <featureManager>
        <feature>zosconnect:db2-1.0</feature>
    </featureManager>

<zosconnect_db2Connection id="db2Conn"
   host="${DB2_HOST}"
   port="${DB2_PORT}"
   credentialRef="commonCredentials" />

<zosconnect_credential id="commonCredentials"
   user="${DB2_USERNAME}"
   password="${DB2_PASSWORD}" />

</server>
```

Notice the environment variables *${DB2_HOST}, ${DB2_PORT},${DB2_USERNAME}* and *${DB2_PASSWORD}* are set to the values provided in the *docker-compose.yaml* file.

Basic security and the required server XML configuration

The *basicRegistry* and *authorization-roles* elements used in this exercise looks like this:

```
<server description="basic security">

    <!-- Enable features -->
    <featureManager>
     <feature>appSecurity-2.0</feature>
     <feature>restConnector-2.0</feature>
    </featureManager>

    <webAppSecurity allowFailOverToBasicAuth="true" />

    <basicRegistry id="basic" realm="zosConnect">
        <user name="Fred" password="fredpwd" />
        <user name="user1" password="user1" />
        <user name="user2" password="user2" />
     <group name="Manager">
        <member name="Fred"/>
     </group>
     <group name="Staff">
        <member name="Fred"/>
        <member name="user1"/>
     </group>
    </basicRegistry>

   <administrator-role>
    <group>Manager</group>
   </administrator-role>

   <authorization-roles id="zCEERoles">
    <security-role name="Manager"> <group name="Manager"/> </security-role>
    <security-role name="Staff"> <group name="Staff"/> </security-role>
   </authorization-roles>
</server>
```

In the above configuration, identity *Fred* is a member of the *Manager* and *Staff* group. Identities *USER1* and is a member of the *Staff* group. Identity *USER2* is not a member of any role-based groups.

The role names *Manager* and *Staff* correspond to the values that appear in the API's specification document . In this example, a default role of *Manager* is defined in the root of the OpenAPI definition. Each of the GET operations defines a role of *Staff*. So only users in or with access to the *Staff* role all allowed to perform the GET methods. And only users in or with access to the *Manager* role all allowed to perform the POST, PUT and DELETE methods. A user with only *Staff* access with receive an HTTP 403 (Forbidden) response if they try to invoke one of these privileged methods.

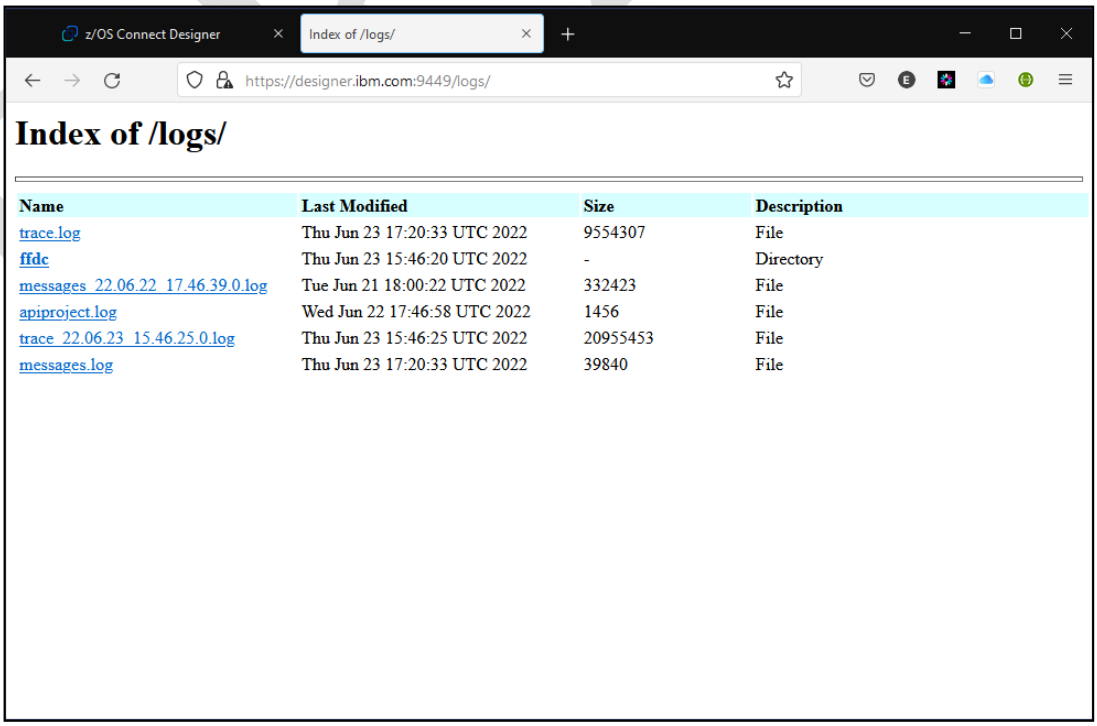
```
openapi: 3.0.0
x-ibm-zcon-roles-allowed:
- Manager
security:
- BasicAuth: []
- BearerAuth: []
paths:
  "/roles/{job}":
    get:
----------------------------
      x-ibm-zcon-roles-allowed:
        - Staff
----------------------------
  /employees:
    post:
----------------------------
  /employees/details/{employee}:
    get:
----------------------------
      x-ibm-zcon-roles-allowed:
        - Staff
----------------------------
  "/employees/{employee}":
    get:
----------------------------
      x-ibm-zcon-roles-allowed:
        - Staff
----------------------------
    delete:
----------------------------
    put:
----------------------------
```

Accessing the z/OS Connect Designer log and trace files

The Liberty server in which the z/OS Connect Designer has been further customized with the addition of the server XML configuration elements below. These XML configuration elements enables the Liberty server to become a file server.

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="Default server">
<webApplication id="resources-dropins" name="dropins"
   location="/opt/ibm/wlp/usr/servers/defaultServer/dropins">
    <web-ext context-root="dropins"
      enable-file-serving="true" enable-directory-browsing="true">
      <file-servering-attribute name="extendDocumentRoot"
       value="/opt/ibm/wlp/usr/servers/defaultServer/dropins" />
    </web-ext>
</webApplication> >
<webApplication id="resources-logs" name="logs"
   location="/logs">
    <web-ext context-root="logs"
      enable-file-serving="true" enable-directory-browsing="true">
      <file-servering-attribute name="extendDocumentRoot"
       value="/logs" />
    </web-ext>
</webApplication> >
</server>
```

This is very useful because this allows the viewing of the server's log and trace file from a browser. This means an API developer using *z/OS Connect Designer* in one tab of browser will be able to monitor the messages and/or traces in other browser tabs as they are developing or testing their API. To access the server's logs directory, start with the same host and port as the *Designer* but with the URI path to */logs*. Double clicking on a file such as *trace.log* or *messages.log* allows the real time monitoring of trace messages or server messages by clicking the browser's refresh button.



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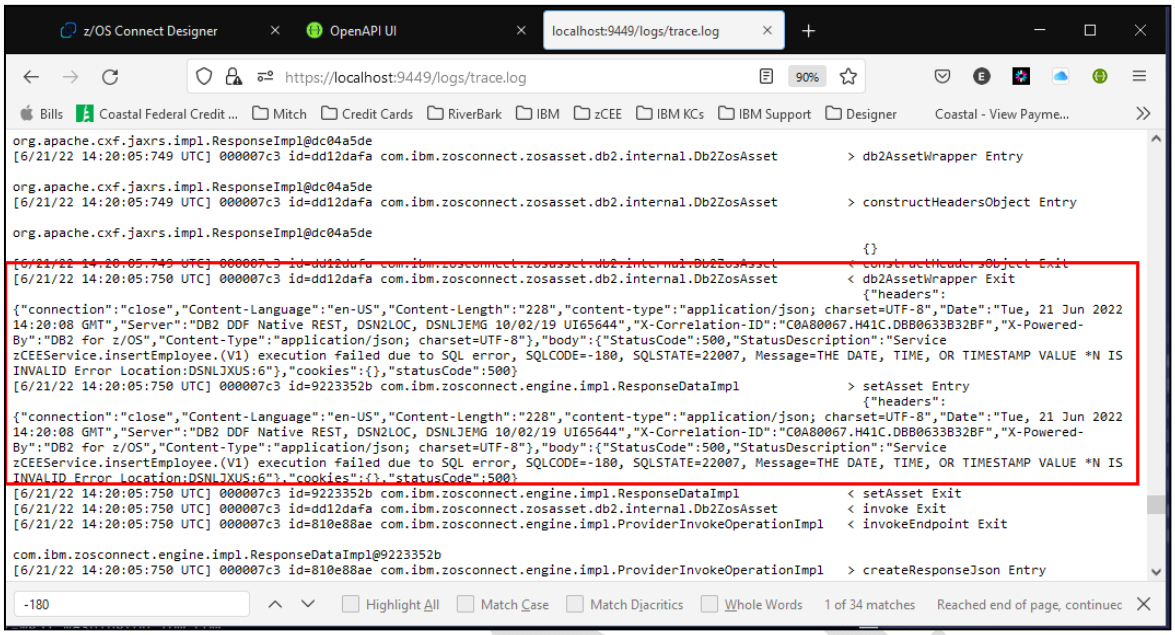
For example, using this technique the details of a SQL request and any SQL errors will appear in a *trace.log*. In this case this is information not returned in the response message but written to the trace by the service provider. This is very useful when the expected results are not returned.



Managing the z/OS Connect Designer container

Using Docker commands

The section explores the use of Docker and other commands when creating and administering *Designer* containers. They are provided more reference purposes since their execution is not required to complete the remainder of the exercise. That said, there is one set commands described here that can be used to 'refresh' a container or start over if you want to restart the API development process. These commands have been combined in a script file named *refreshDockerContainer*. If anytime you wish to restart, open an Ubuntu terminal shell, and enter command ***refreshDockerContainer employees*.** To open an Ubuntu terminal shell, click on the Ubuntu icon (see below) in the Windows task bar.

Creating a new container

___1. Access an *Ubuntu* terminal shell.

___2. Make new Linux directory for the container

mkdir /home/workstation/docker/sandbox

___3. Change location to the new directory

cd /home/workstation/docker/sandbox

___4. Make a configuration path

mkdir -p project/src/main/liberty/config

___5. Copy server XML configuration file from the Linux to the container's config directory

cp /mnt/c/z/openApi3/xml/* project/src/main/liberty/config

___6. Make the certs and logs subdirectories

mkdir certs

mkdir logs

___7. Copy the base docker-compose.yaml file into current directory

cp /mnt/c/z/openApi3/yaml/docker-compose.yaml .

___8. Edit docker-compose.yaml file and make the ports unique

sed -i "s/9080:9080/9086:9080/" docker-compose.yaml

sed -i "s/9443:9443/9449:9443/" docker-compose.yaml

___9. Start the container

docker-compose up -d

___10. Copy server XML override files from Linux into a container's configuration directory

docker cp /mnt/c/z/openApi3/xml/. sandbox_zosConnect_1:/config/configDropins/overrides

Tech-Tip: The above commands can be placed in a script, e.g., *createDockerContainer,* see below. Since this script has been placed in directory /home/workstation/bin and this directory has been added to the PATH environment variable, the script can be invoked in any directory by simply entering ***createDockerContainer containerName httpPort httpsPort*** (where *containerName* is the name of the container without the *zosConnect 1 suffix* and *httpPort* and *httpsPort* are the ports to be configured for HTTP and HTTPS connections to the container).

```
echo on
[ -z "$2" ] && HTTP_port=9080 || HTTP_port=$2
[ -z "$3" ] && HTTPS_port=9443 || HTTPS_port=$3
echo creating container "$1"_zosConnect_1 with HTTP_port="$HTTP_port" and
HTTPS_port="$HTTPS_port"
mkdir $containerHome/docker/"$1"
cd $containerHome/docker/"$1"
mkdir certs
mkdir logs
mkdir -p project/src/main/liberty/config
cp /mnt/c/z/openApi3/xml/* project/src/main/liberty/config
cp /mnt/c/z/openApi3/yaml/docker-compose.yaml .
sed -i "s/9080:9080/$HTTP_port:9080/" docker-compose.yaml
sed -i "s/9443:9443/$HTTPS_port:9443/" docker-compose.yaml
docker-compose up -d
docker cp /mnt/c/z/openApi3/xml/. "$1"_zosConnect_1:/config/configDropins/overrides
```

___11. Display the status of the active containers

docker ps

```
root:/home/workstation:> docker ps
CONTAINER ID   IMAGE                                        COMMAND                  CREATED             STATUS             PORTS
NAMES
0a53e5d3a7af   icr.io/zosconnect/ibm-zcon-designer:3.0.57   "/opt/ibm/helpers/ru…"   About an hour ago   Up About an hour   0.0.0.0:9086->9080/tcp,
:::9086->9080/tcp, 0.0.0.0:9449->9443/tcp, :::9449->9443/tcp
 employees_zosConnect_1
```

Refresh an existing container

These set of commands can be used to restart the development of API.

____1. Stop the container

docker stop sandbox_zosConnect_1

____2. Remove the container

docker container rm sandbox_zosConnect_1

____3. Change to the host Linux directory of the container

cd /home/workstation/docker/sandbox

____4. Remove the existing *project* directory and all subdirectories (this is required to delete the previous API artifacts.

rm -r project/*

____5. Make a new *project* directory and *config* subdirectory

mkdir -p project/src/main/liberty/config

____6. Copy XML configuration files into the *config* subdirectory.

cp /mnt/c/z/openApi3/xml/* project/src/main/liberty/config

____7. Start the container

docker-compose up -d

____8. Copy the XML configuration files into the container's configuration *override*s directory

docker cp /mnt/c/z/openApi3/xml/. sandbox_zosConnect_1:/config/configDropins/overrides

Tech-Tip: The above commands can be placed in a script, e.g., *refreshDockerContainer,* see below. Since this script has been placed in directory /home/workstation/bin and this directory has been added to the PATH environment variable, the script can be invoked in any directory by simply entering ***refreshDockerContainer containerName***
(Where *containerName* is the name of the container without the *zosConnect 1 suffix*).

```
echo refreshing container "$1"_zosConnect_1
docker stop "$1"_zosConnect_1
docker container rm "$1"_zosConnect_1
cd $containerHome/docker/"$1"
rm -r project/*
mkdir -p project/src/main/liberty/config
cp /mnt/c/z/openApi3/xml/* project/src/main/liberty/config
docker-compose up -d
docker cp /mnt/c/z/openApi3/xml/.
"$1"_zosConnect_1:/config/configDropins/overrides
```

Using Podman commands

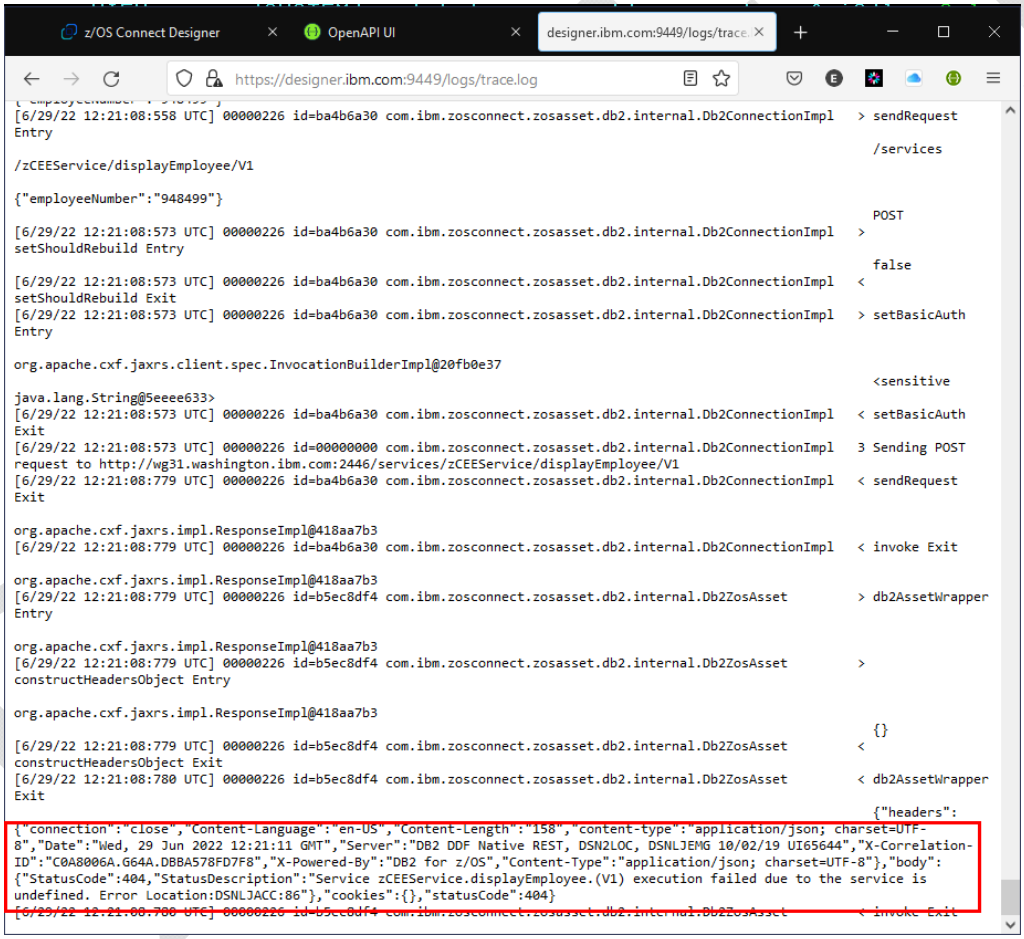
Note, *Podman* commands are the same as *Docker* commands. Just replace the *docker* command with *podman*.

Designer problem determination

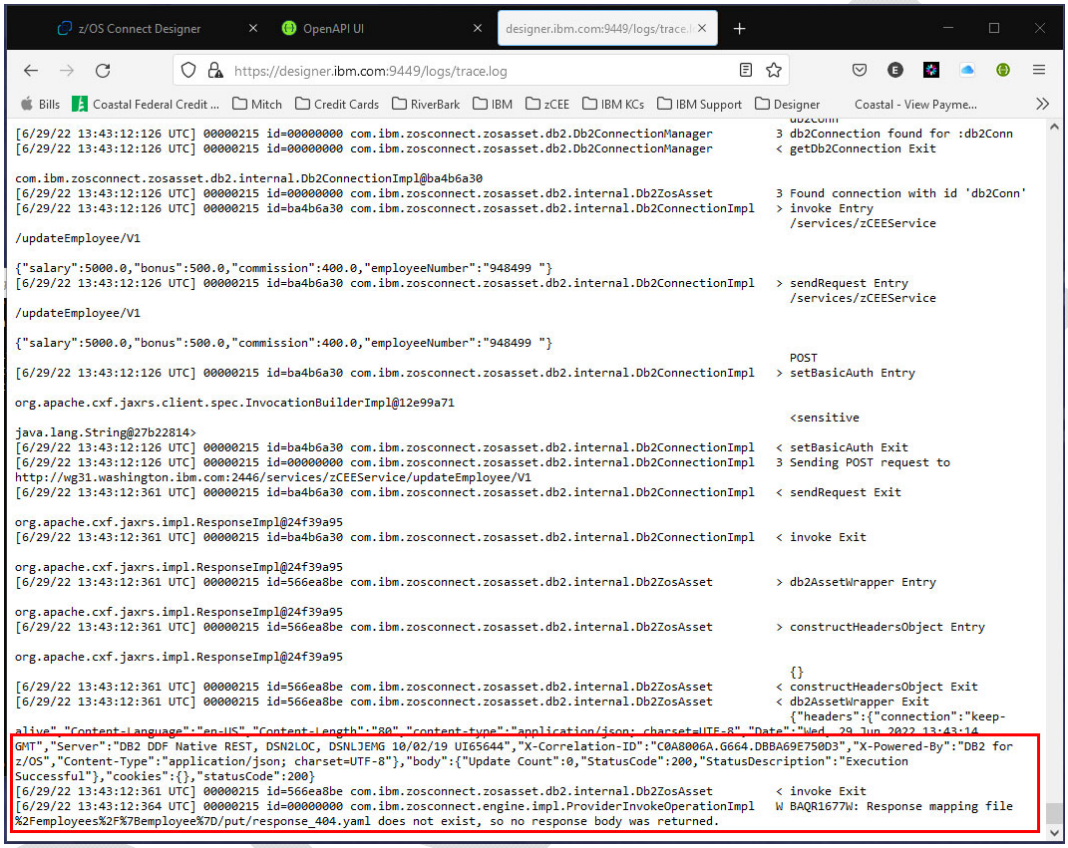
In this section, we will explore various scenarios using tracing to resolve API development issues, the trace output was created using this trace specification.

```
<logging traceSpecification="
        zosConnectCics=all:
        zosConnectDb2=all"
        />
```

____1. Invoking a method returned an HTTP 404 response and no other response. There should have been a message displayed to state that a record for this employee did not exist. A review of the trace showed the Db2 REST service did return an HTTP 404 status code and a status message. The status message indicated that the request Db2 REST service did not exist. The resource not found (HTTP 404) was the REST service, not the employee record.



____2. Here is another situation. Invoking a method returned an HTTP 404 response and no other details. There should have been a message displayed to state that a record for this employee did not exist. A review of the trace showed the Db2 REST service did return an HTTP 200 code but not the results array. In this case a review of trace showed the issue was that the response mapping for this situation, *response_404.yaml,* did not exist in the API. It was this resource not being found which generated the HTTP 404 (not found) condition, not the employee record and not the Db2 REST service.



Developing a z/OS Connect APIs that accesses Db2

This section of the exercise provides an opportunity to compose and test an API that accesses Db2.

But before actually staring the exercise, let's do some container housekeeping.

a) Open an Ubuntu terminal shell by clicking on the Ubuntu icon (see below) in the Windows task bar.

*b) Switch to root authority by entering command **sudo su** and replying to the password prompt with root's password of **passw0rd**.*

*c) On Windows the Docker daemon needs to be running. Enter command **dockerd &** and wait until you see a message Daemon has completed initialization*

*d) This exercise uses the employees_zosConnect_1 container. Enter command **docker ps** to see a list of the active containers.*

*e) If this container does not appear in list, enter command **docker start employees_zosConnect_1** to start this container.*

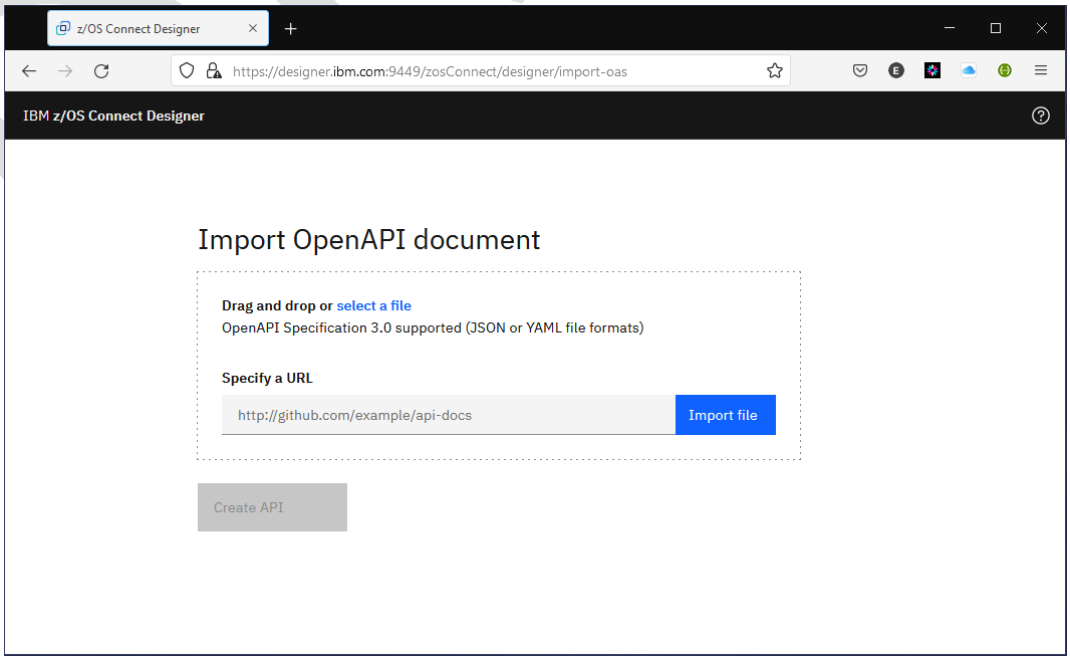
*f) Repeat the **docker ps** command and verify this command now appears in the list of active containers.*

```
CONTAINER ID   IMAGE                                          COMMAND                  CREATED       STATUS         PORTS
NAMES
27dcfdbc8760   icr.io/zosconnect/ibm-zcon-designer:3.0.58   "/opt/ibm/helpers/ru…"   11 days ago   Up 2 seconds   0.0.0.0:9086-
>9080/tcp, :::9086->9080/tcp, 0.0.0.0:9449->9443/tcp, :::9449->9443/tcp   employees_zosConnect_1
```

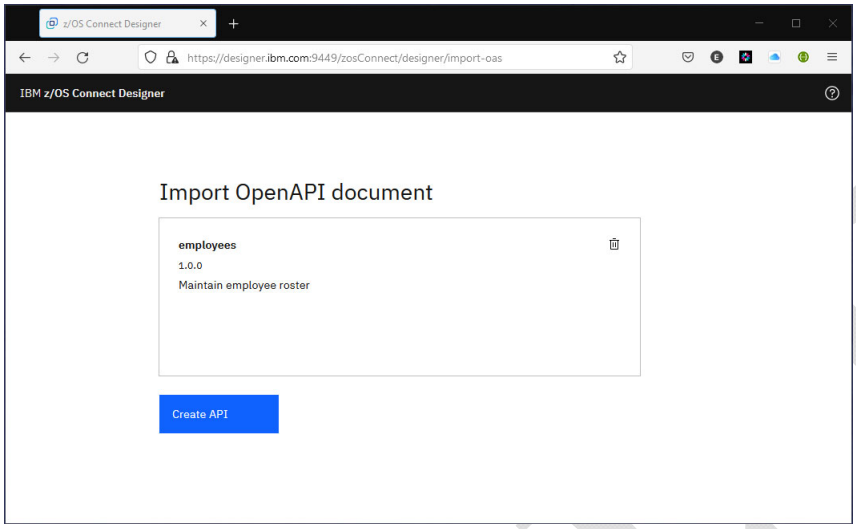
Container housekeeping is now complete.

___1. Start by opening the Firefox browser and going to URL ***https://designer.washington.ibm.com:9449/zosConnect/designer/***

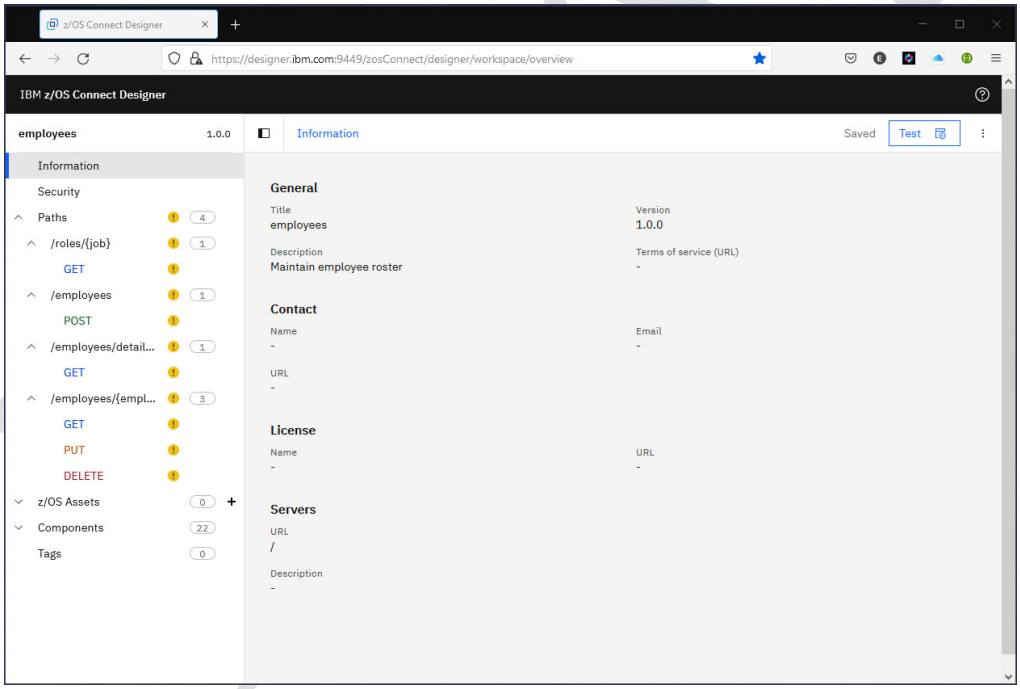
___2. The first window you will see in a 'fresh' *Designer* environment gives you the opportunity to import an OpenAPI document. On the *Import OpenAPI document* window, click on ***select a file*** and traverse in the *File Upload* window to the directory where the specification document files are stored, e.g., *C:/z/openApi3/yaml*. Select file *employee.yaml* and click the **Open** button to continue.



___3. On the next *Import OpenAPI document* window, click the **Create API** button to complete the importation of the specification document file into the *Designer.*



___4. The next *Designer* page to be displayed will be the details of the API provided by the specification document. Expand the **Paths** on the left-hand side and you will see the URI paths of the API. Expand the URI paths will display the individual methods of each path. For example, expanding URI paths */employees* and */employees/{employee}* will display the *POST, GET, PUT* and *DELETE* methods associated with these URI paths (see below).

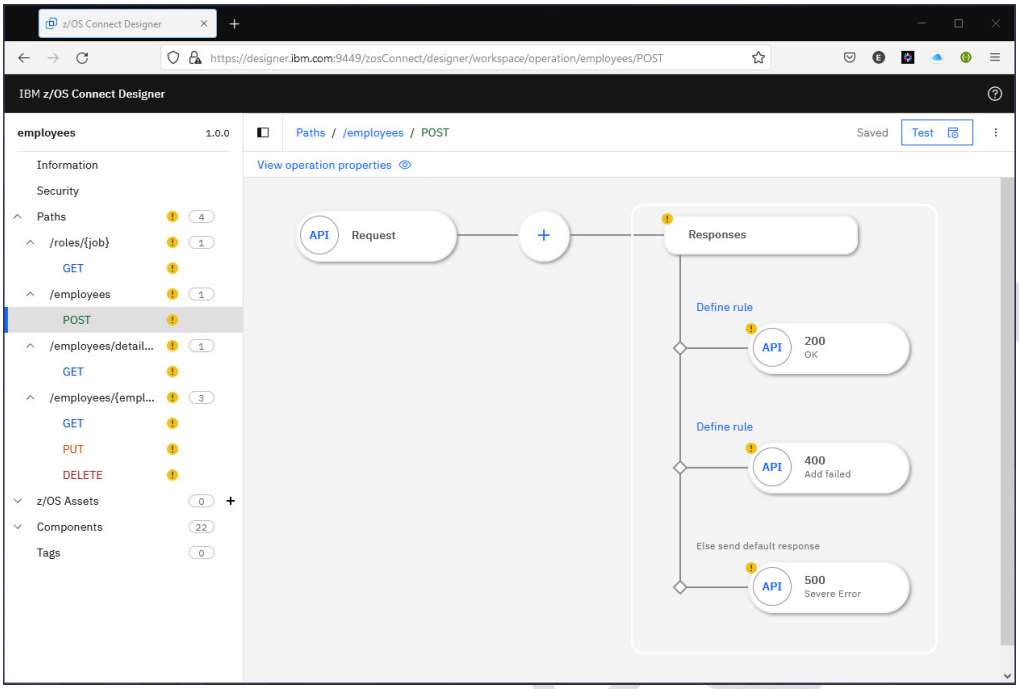


*Important: When using this tool, monitor the upper right-hand corner of the page. You will see either status of either **Saved** or **Saving**. It is suggested that you wait until changes are saved before continuing using the Designer.*

> **Tech-Tip:** The yellow exclamation marks simply indicate the underling configuration for this element is incomplete. As the exercise progresses, the exclamation marks will disappear.

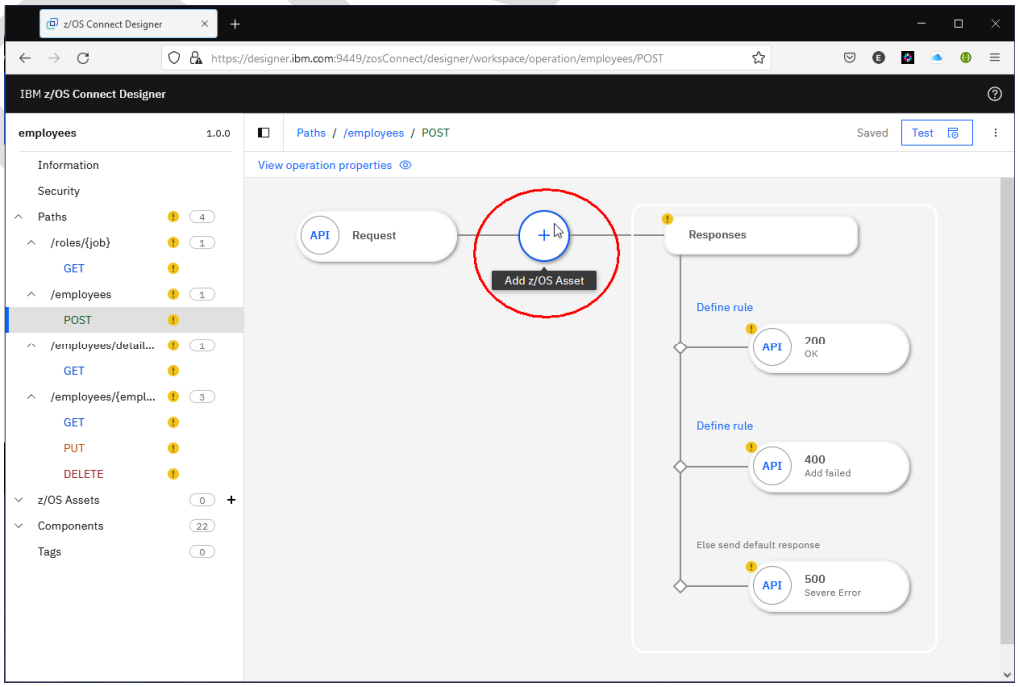
Configure the POST method for URI path /employees

___1. Selecting a method will display the operation properties of the method. Start with the *POST* method under */employees* and by selecting it, the view like the one below will appear.



In the example above, we see that the specification document defined 3 responses for this method. One is a 200-status code which indicate the invocation of the method (an insert) was successful. A 400-status code which indicates, in this case, that the request to insert an employee record failed. And finally, a 500-status code which indicates a severe error has occurred while processing the request.

___2. The first step in configuring this method for this URI path is to associate it with a z/OS asset or resource. Click the plus sign on the page to start the association of a z/OS asset with this URI path.



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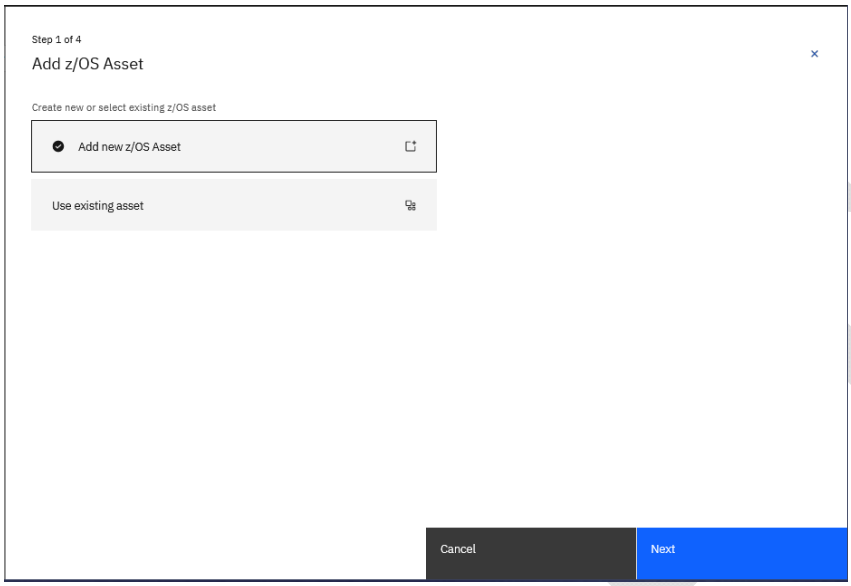
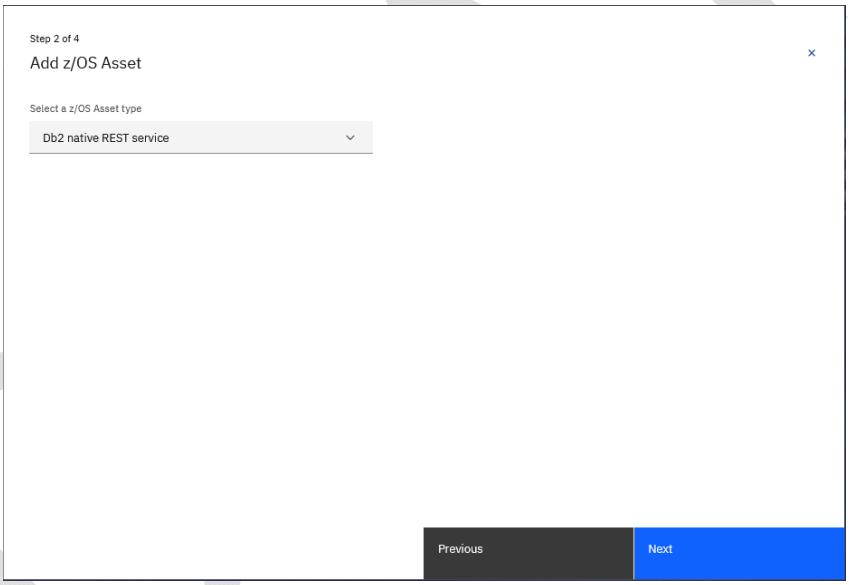
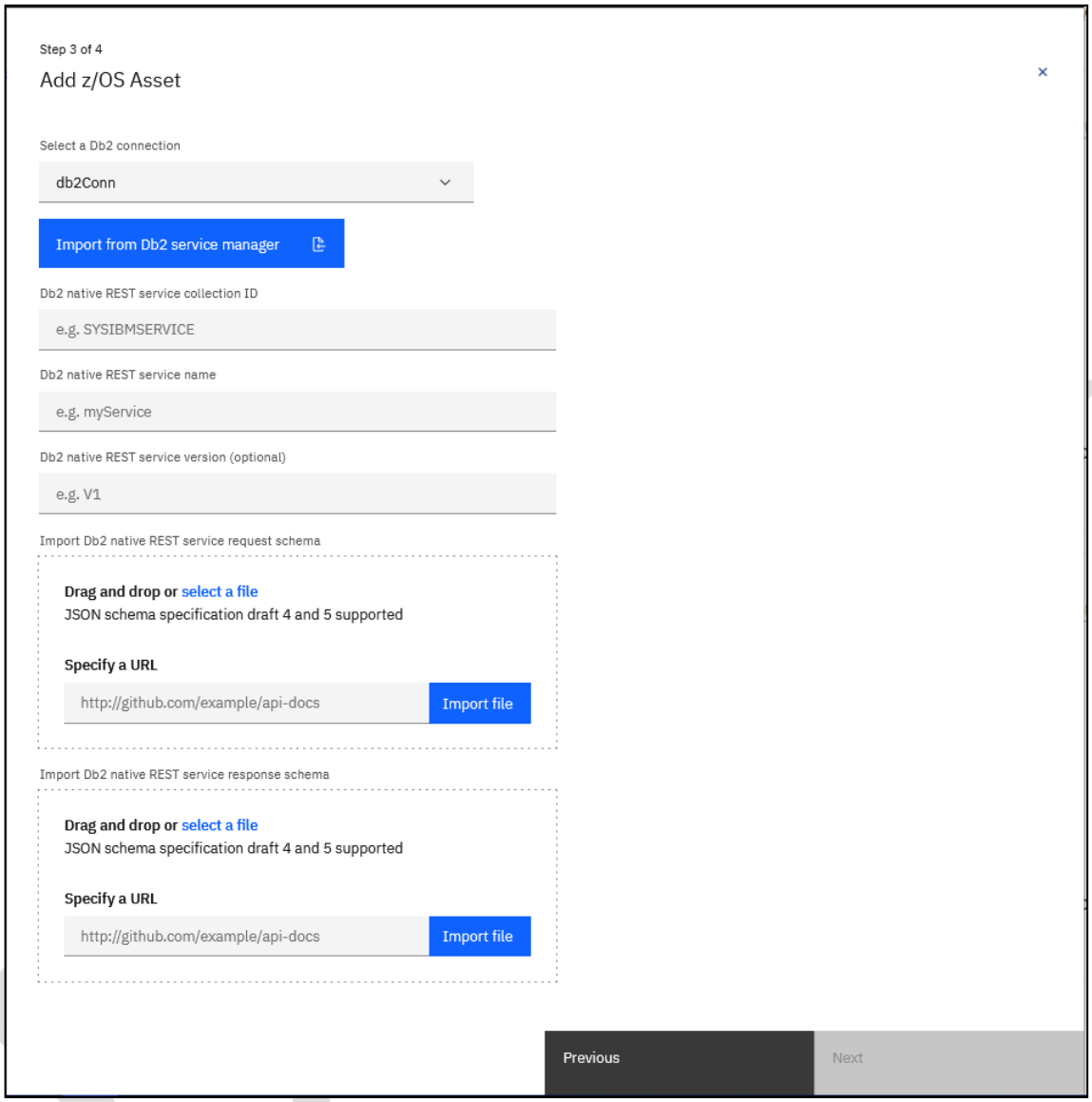
___3. On the *Add z/OS Asset (Step 1 of 4)* page, select the *Add new z/OS Asset* and press **Next** to continue.



___4. On the *Add z/OS Asset (Step 2 of 4)* page, use the pull-down arrow and select *Db2 native REST service* and press **Next** to continue.

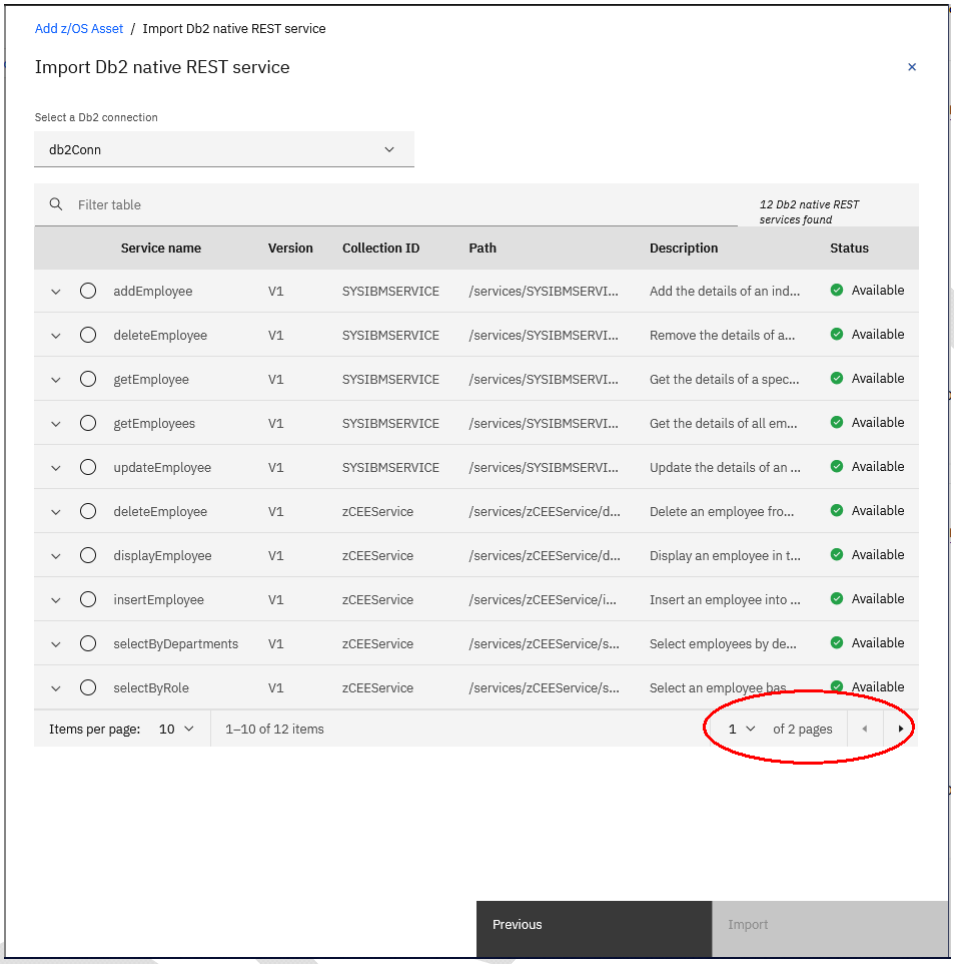


___5. On the *Add z/OS Asset (Step 3 of 4)* page, use the pull-down arrow and select the *db2conn* Db2 connection. This action will cause the full page to be displayed. Press **Import from Db2 service manager** to access Db2 and to list the available Db2 REST services. Note that the *collection ID*, *service name* and *version* can be used to filter the list.



Tech-Tip: The name ***db2conn*** is the name of the *zosconnect_db2Connection* configuration element described earlier in this exercise.

___6. A list of the available Db2 REST services will be displayed. In this case we want to associate the method with the Db2 REST service *insertEmployee* in the *zCEEService* collection. In this screen shot below, this service is on the first page. If it had not been, there would have been a need to use the page forward arrow at the bottom to go to page 2 of the list to display other pages of the list.



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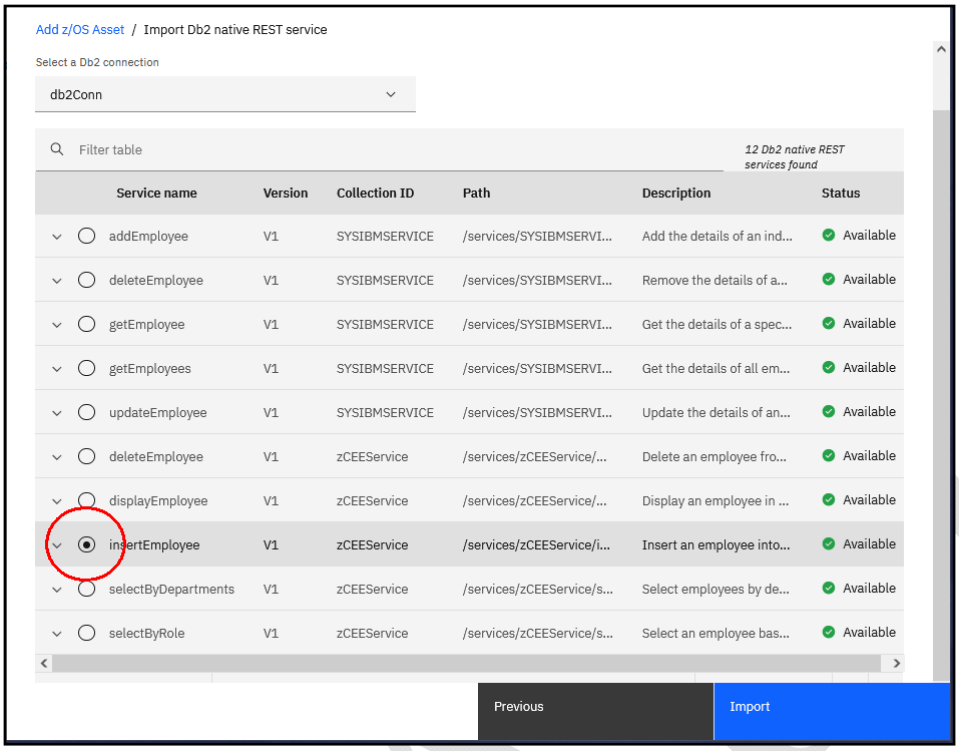
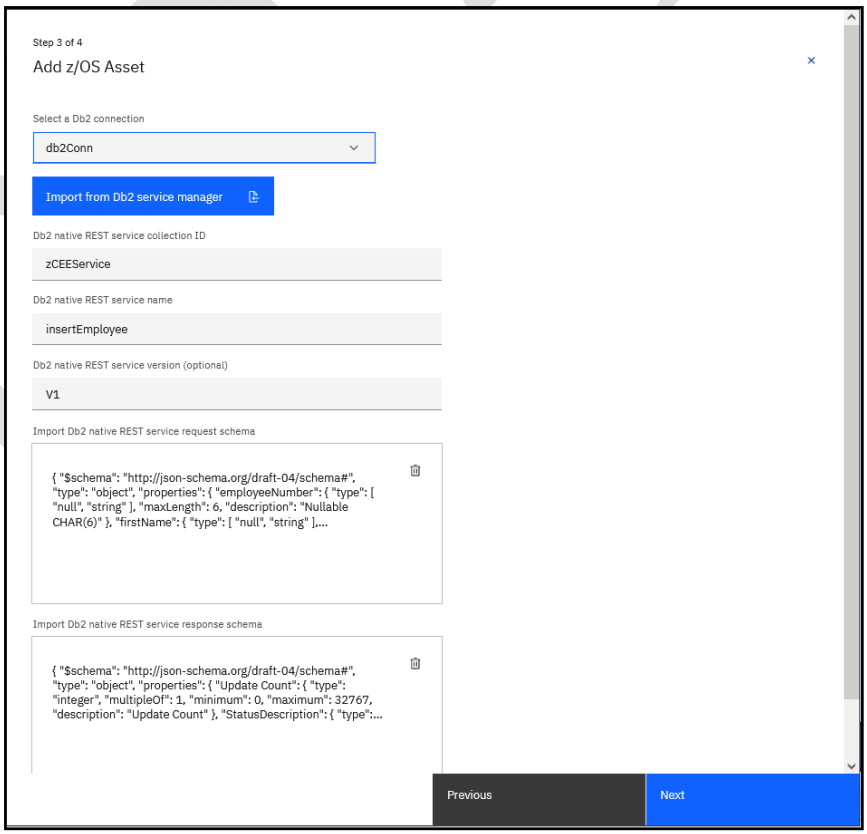
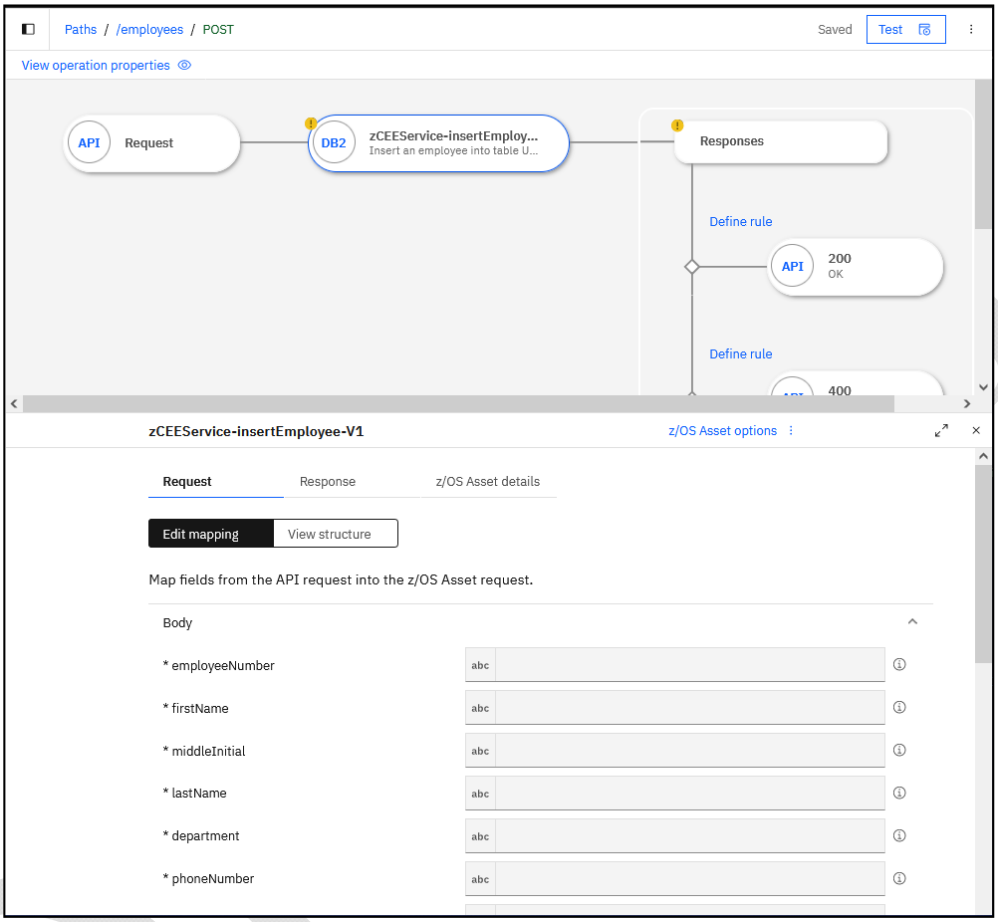
___7. Select the radio button beside the *insertEmployee* service under *Service Name* and in collection *zCEEService* see below. Press the **Import** button to have the Db2 native REST service information retrieved from Db2.



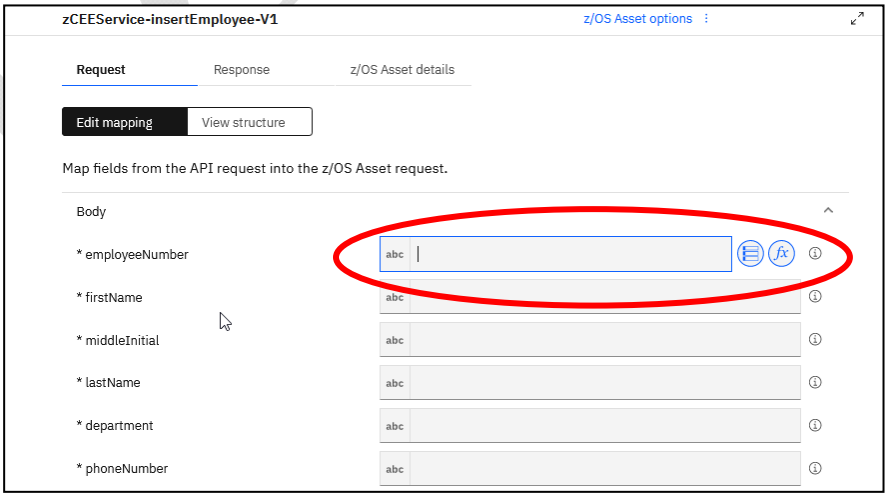
___8. This will return you back to the *Add z/OS Asset (Step 3 of 4)* page with the details (request and response schema, etc.) populated from the Db2 service repository. Click **Next** to continue.



___9. On the *Add z/OS Asset (Step 4 of 4)* page, we are given an opportunity to rename or update the description of the z/OS asset. In this exercise, simply press **Add z/OS Asset** to continue. Eventually you see a brief message that the asset has been added successfully and the operation properties page will reflect the z/OS asset request mapping details (see below). On this page we are seeing the request properties from the Db2 request schema. What needs to be done is to map these fields to the request schema properties of the API as defined in the specification document that described the entire API.



Note: It is very important that when working with mapping fields that the field has been properly selected. A properly selection field will be displayed in a blue box as shown below.



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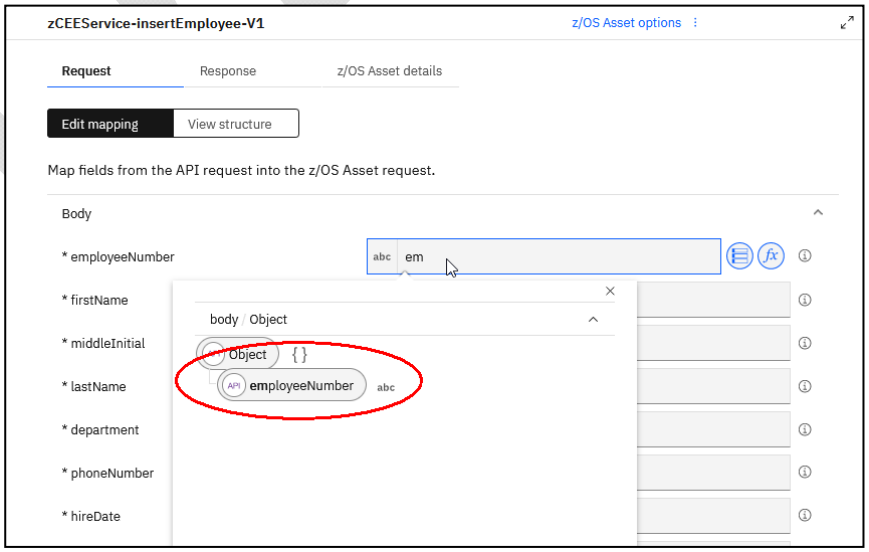
___10. Now map the Db2 request message fields with the corresponding API request message fields. But first become familiar with the fields in the API request message for this method. To display the API's request message fields, select any container field, and then select the *Insert a mapping* tool (see below).

___11. This will display the header and body mappings available for this method of the API. Become familiar with the mappings available in the body of the request message (you will have to use the scroll bar to see all the available mappings). Knowledge of the mappings in the body will help greatly in the next few steps.

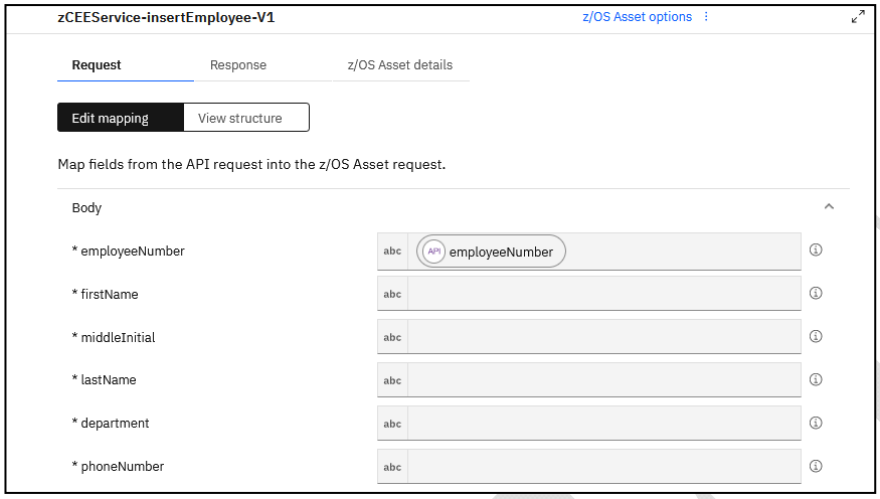
There are two ways to map the Db2 request schema with the corresponding specification document API request fields. Both will be demonstrated in this section of the exercise. Use which ever method you prefer when mapping fields later in this exercise.

___12. Start by selecting an empty Db2 request message field and start typing the corresponding API request message field name. For example, entering the string ***em*** in the area beside *employeeNumber* will eventually match a field in the API request message whose name includes the same characters, and that schema field will be displayed in the drop-down list (see below).



Mitch Johnson (mitchj@us.ibm.com)

___13. Select the field and the area beside the Db2 request schema property name this will cause the API's request message field name to populate the area and complete the mapping.



Tech-Tip: The icon ⤢ can be used to maximize or reset this area of the page.

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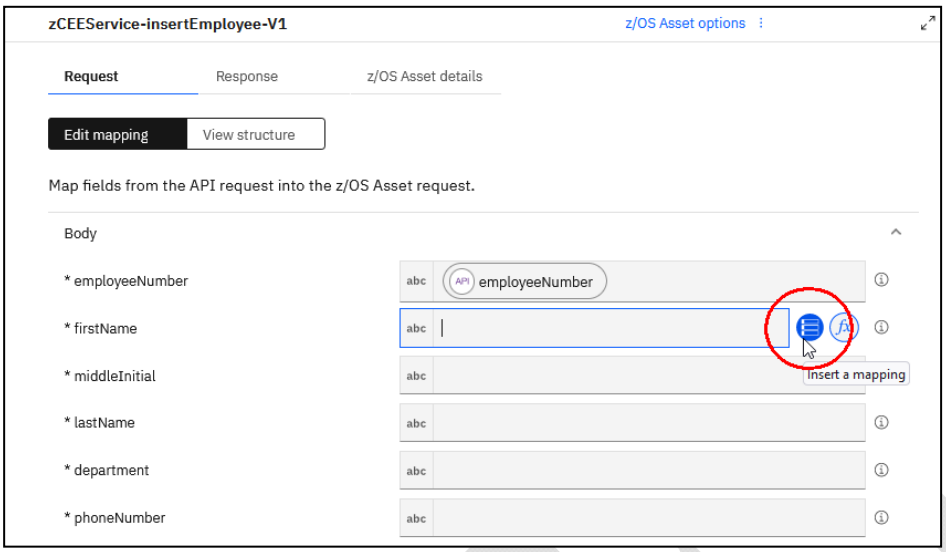
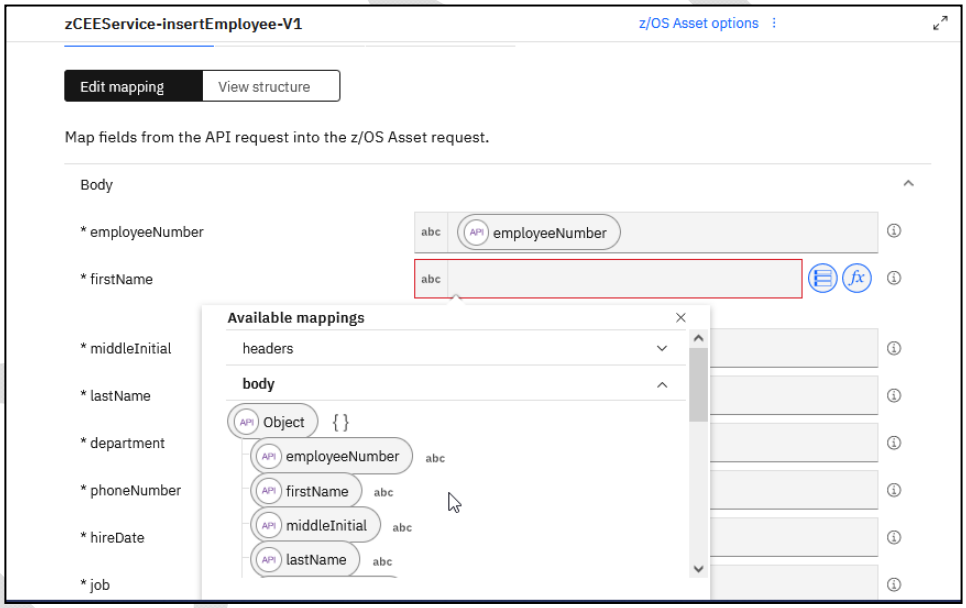
___14. The alternate mapping method is to select the *Insert a mapping* tool (see below).



___15. This will display a list of available mapping fields. Since this is a request message and the fields are in the request *body*. Scroll up or down and choose appropriate field from the fields from the *body*, not a query parameter, nor a path parameter. In this case, the field to select is the *firstName* field.



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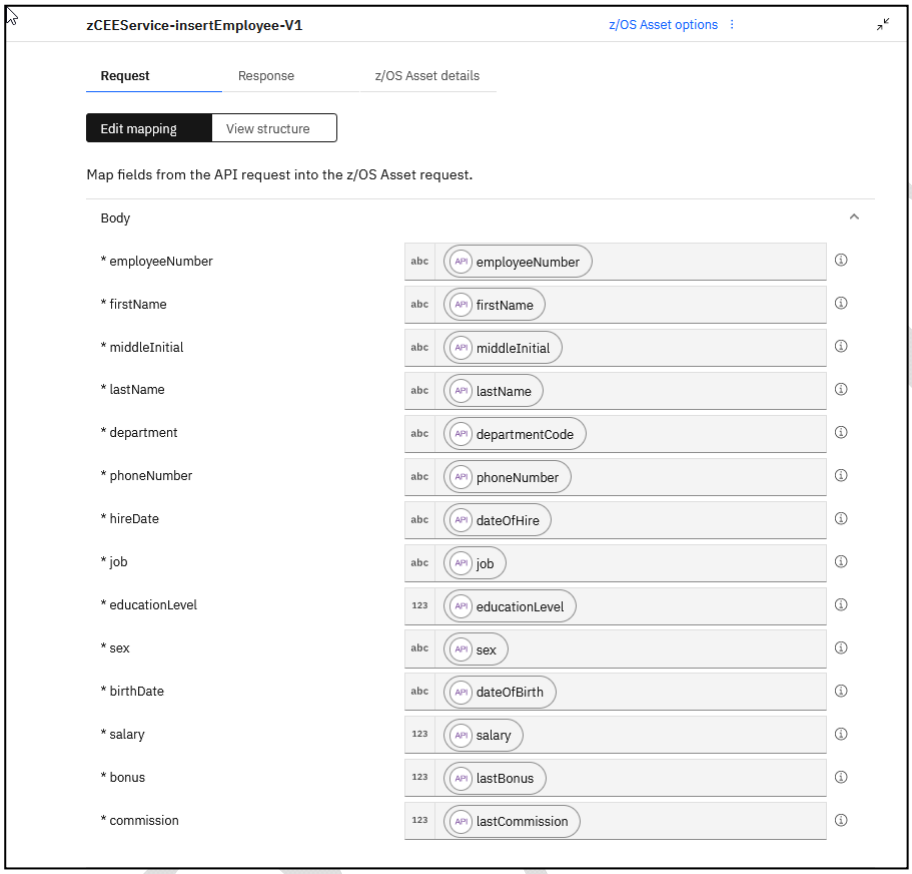
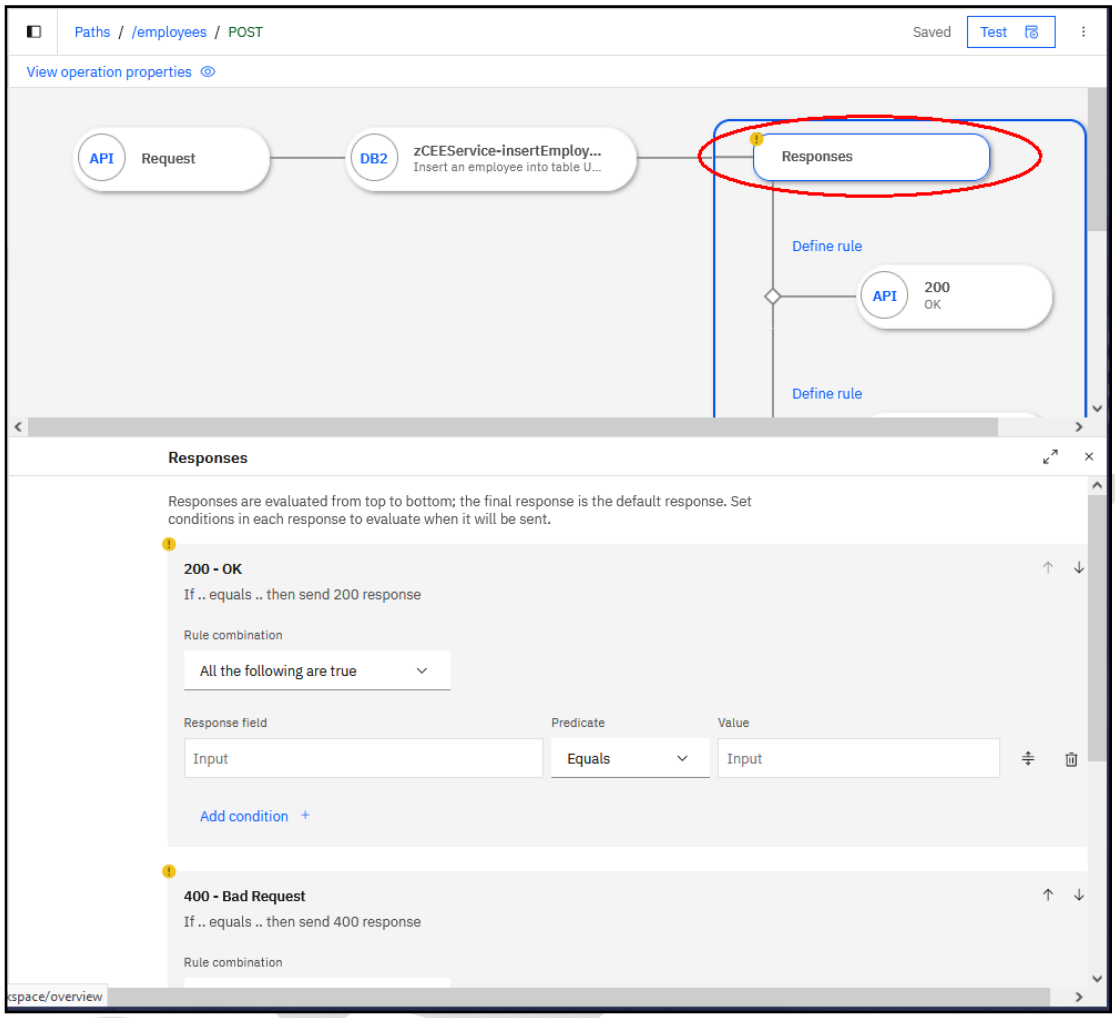
___16. Use either technique to complete the mappings. When completed, the results should look something like this the page below.



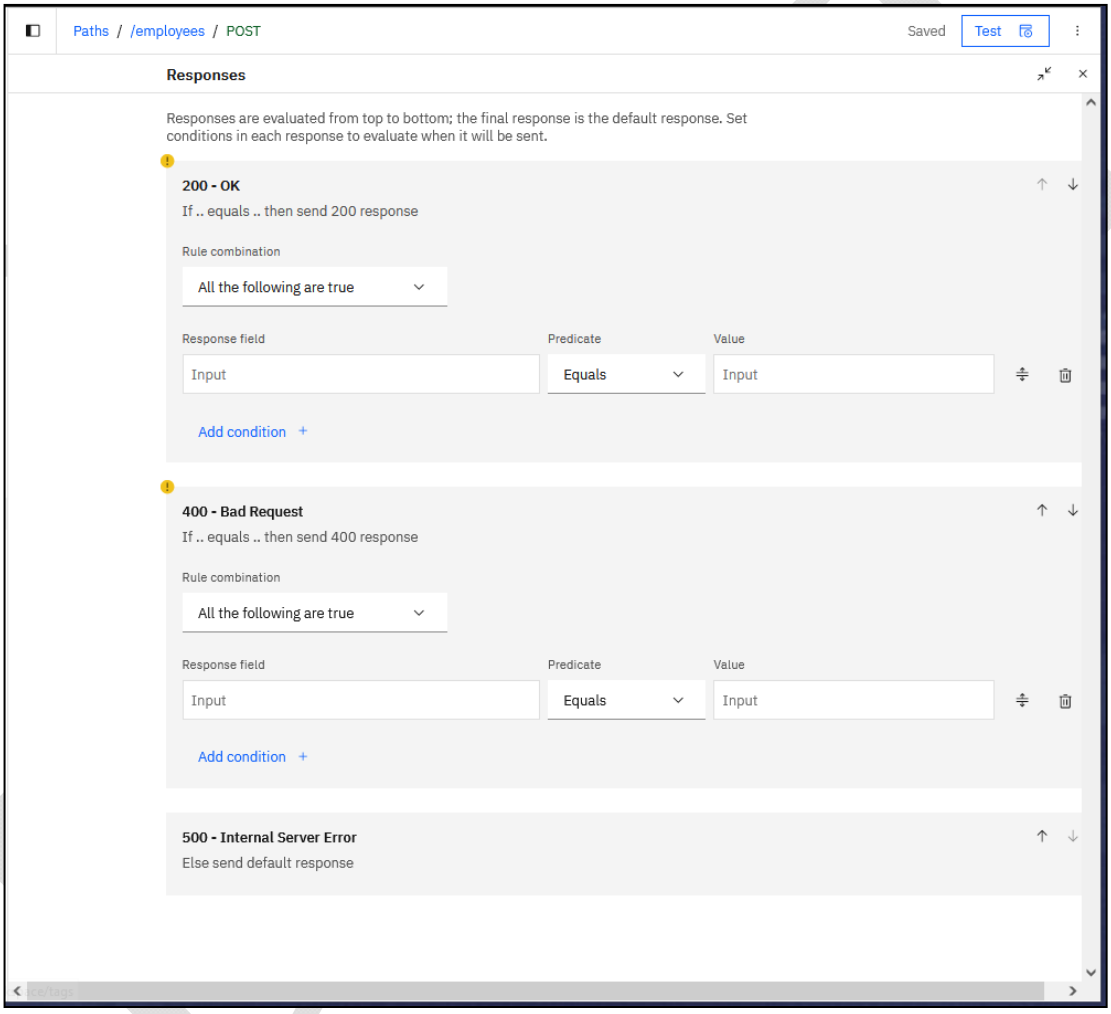
___17. The next step is to provide the configuration to evaluate the responses that come back in the Db2 REST service response message. Select the *Responses* box in the *view operation properties* page.



___18. Maximize the *Responses* area of the browser's page (see below).

Responses from the Db2 REST service are evaluated in the order shown in the sequence shown. The first check is to see if the record was inserted successfully. Db2 REST services will return an HTTP status code of 200 if the Db2 REST service was able to complete regardless of whether a row was inserted or not. So, we need another way to determine whether a row was really inserted. Fortunately, a Db2 REST service returns another response field, *Update Count,* which we can check the value to see how many rows were affected by this request.

So, we are going to check the response fields to (1) confirm the HTTP status code from Db2 is 200 and (2) the value of *Update Count* is set to either 1 or zero.



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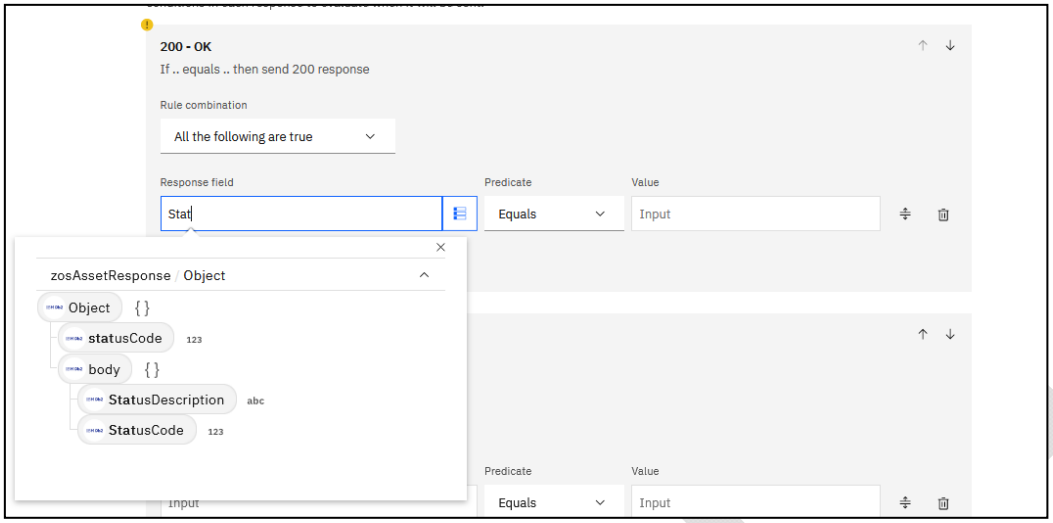
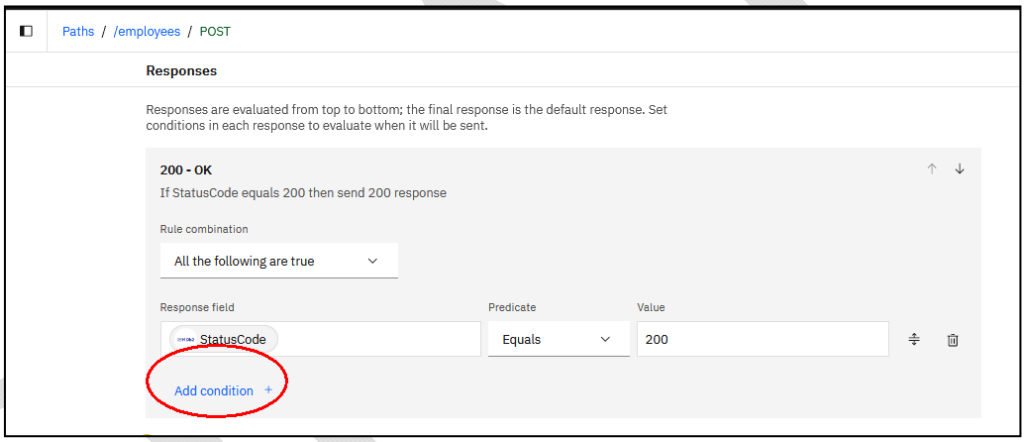
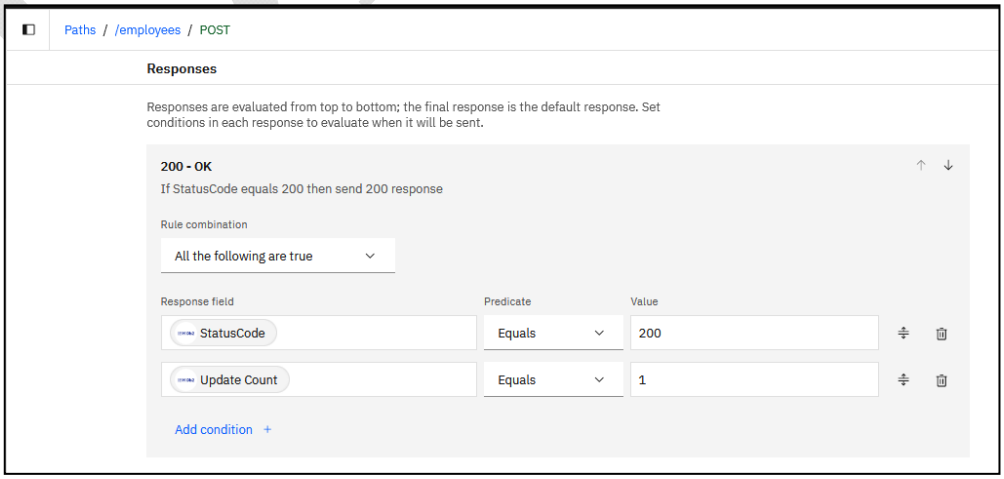
19. Under the *200 – OK* response, Enter the string ***Stat*** in the *Input* area under *Response field*. This will display all the fields in the Db2 REST response which match this string (position of the string in the field name does not matter, if the entered string matches any portion of the field name, that field will be displayed). In this case, select the *StatusCode* field. Leave the *Predicate* as *Equals* and enter ***200*** in the *Input* field for *Value*.



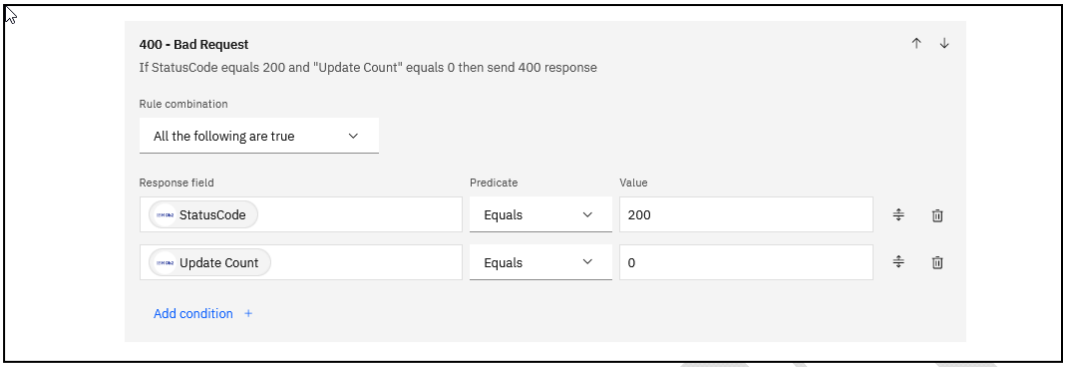
20. Next add a condition check for the value of *Update Count* by clicking on *Add condition* in the *200 – OK* evaluation.



21. Use the same technique described above to add a check for response field Update Count. Leave the *Predicate* as *Equals* and set the value to ***1*** as shown below:

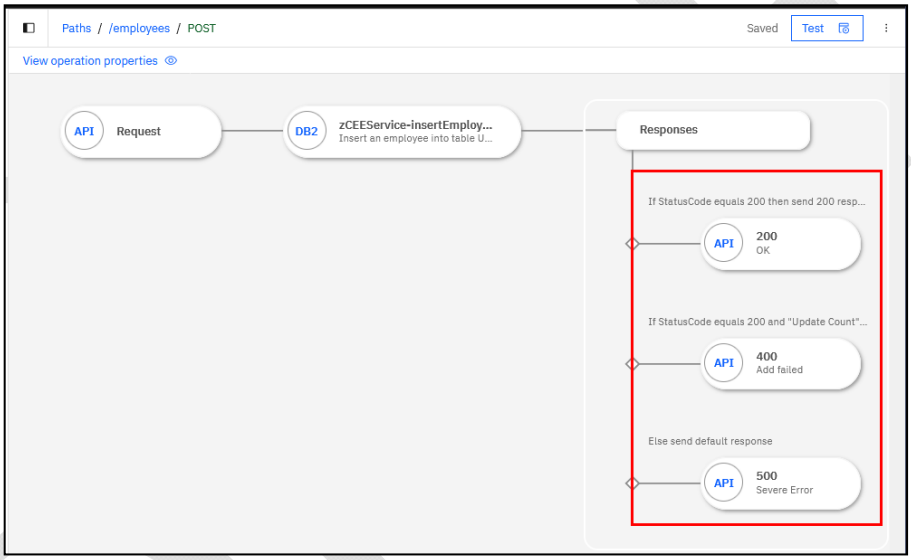


___22. For the *400 – Bad Request* check, add a check for ***StatusCod***e equaling ***200*** and a check for Update Count equaling ***0***



___23. If neither of these connections are met, simply return with a HTTP 500 status code.

___24. Next the API response messages need to be configured for each of these potential status codes.



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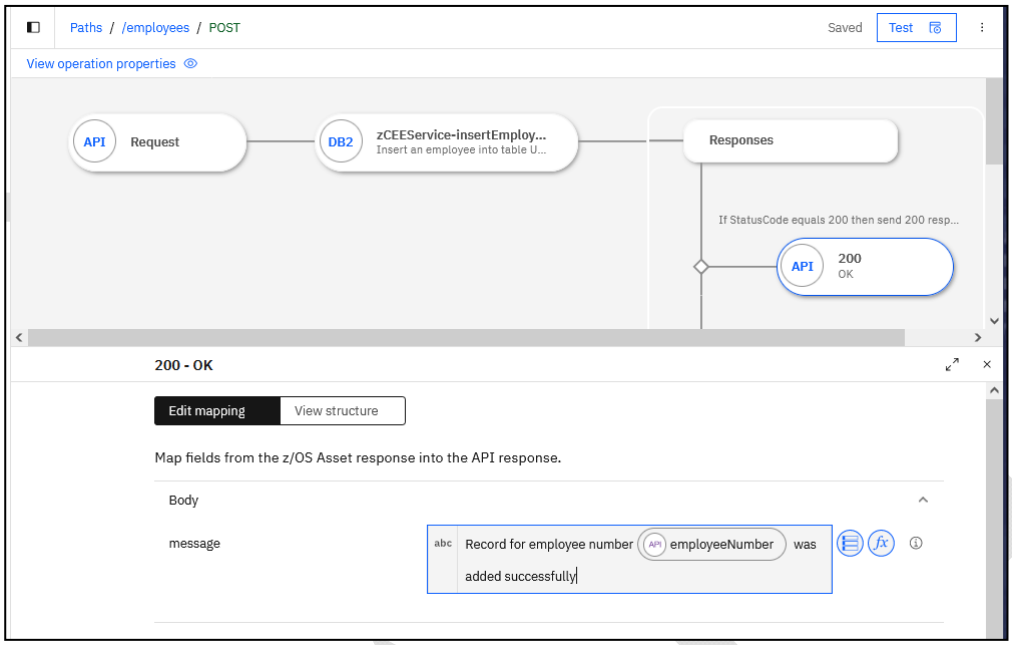
___25. Select the response for *200 OK* paste the text below in the *message* area.

Record for employee number {{$apiRequest.body.employeeNumber}} was added successfully



The same techniques used to map API response with the Db2 REST request message can be used to insert Db2 REST response files into text like this message which is then subsequently mapped to a field in the API response message. There is flexibility is building complex text strings based on the fields in the Db2 REST response message.

___26. Select the response for *400 Add failed* response mapping and paste the text below in the *message* area.

Record for employee number {{$apiRequest.body.employeeNumber}} was not added - {{$zosAssetResponse.body.StatusDescription}}

Tech-Tip: Db2 REST response property field *StatusDescription* provides more information regarding the issue that caused the insert to fail.

___27. Finally in the 500 – Severe Error response mapping paste the following in the area for the message property

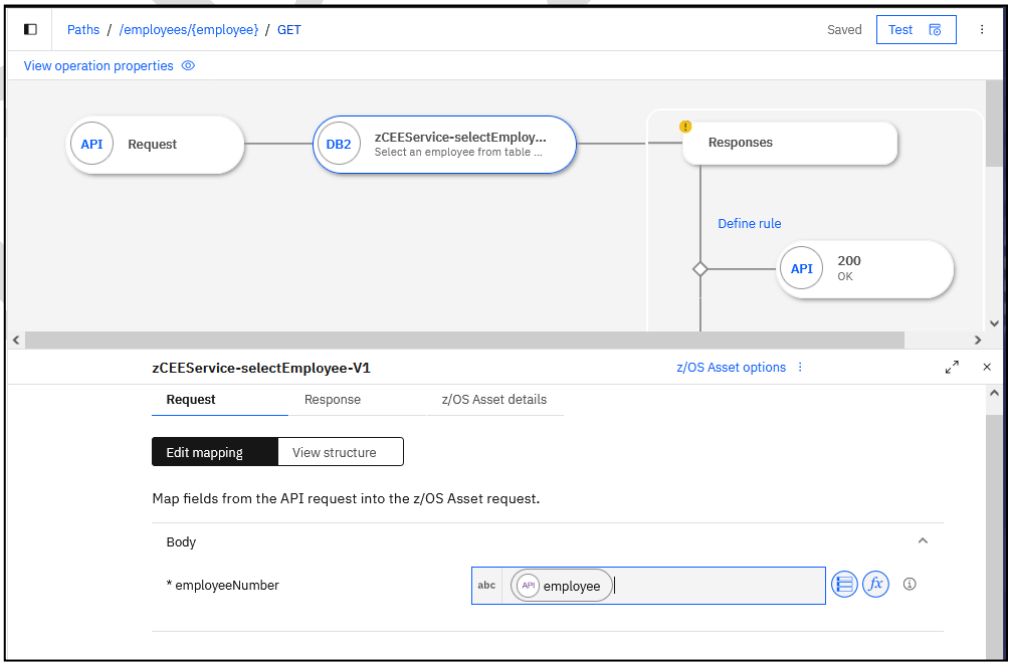
A severe error has occurred - {{$zosAssetResponse.body.StatusDescription}}

The completes the configuration of this method of this URI path of the API. All the exclamation marks for this method should now have disappeared. If not investigate which subcomponent still has an exclamation mark and resolve the issue.

Configure the GET method for URI path /employees/{employee}

Now let's repeat the process and complete the configuration for the *GET* method of URI Path */employees/{employee}*

___1. Start by adding a new z/OS Asset for Db2 REST service *zCEEService-selectEmployee* to this method by using the same steps as performed before. Map the path parameter *employee* to the Db2 REST service request message field *employeeNumber* as shown below.



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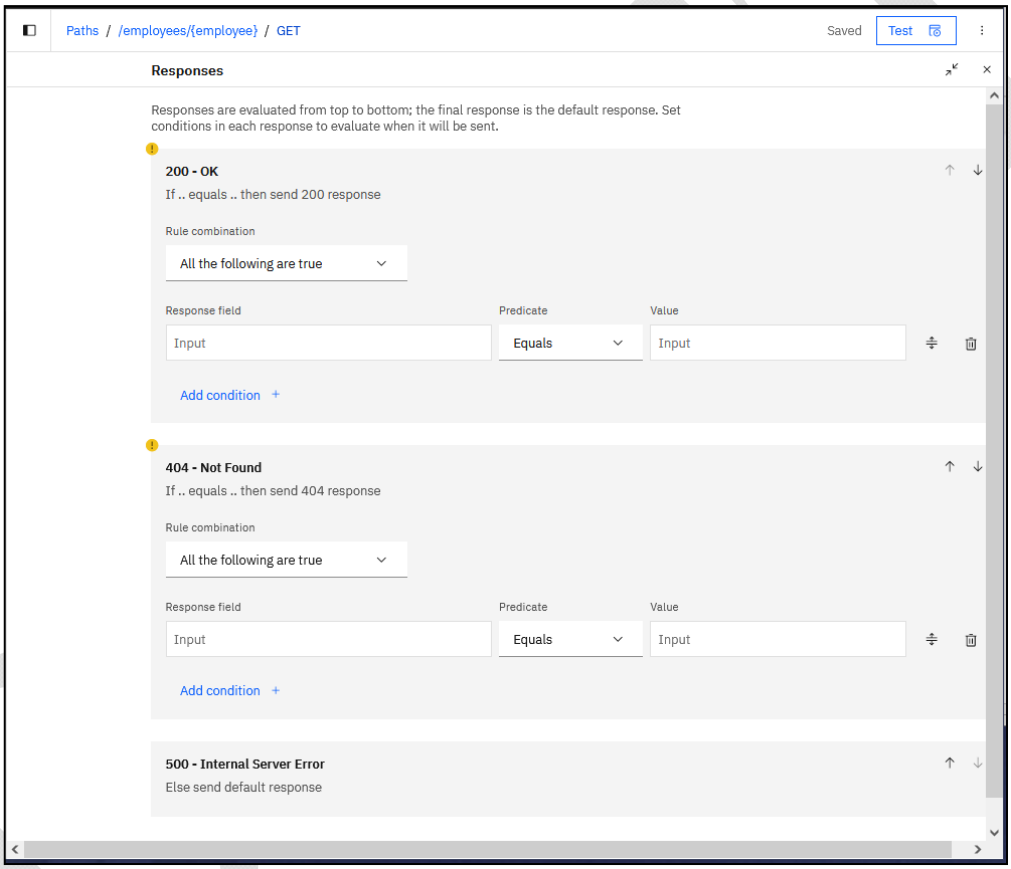
___2. Maximize the *Responses* area of the browser's page (see below).

Again, responses from the Db2 REST service are evaluated in the order shown in the sequence shown. The first check is to see if the record a row or rows were returned as intended. Db2 REST services will return an HTTP status code of 200 if the Db2 REST service was able to complete regardless of whether a row was selected or not. So, we need another way to determine whether a row was really selected. In this case a Db2 REST service will return the rows selected in a list or array. We are going to take advantage of function that will return the number of elements in the list or array, e.g., $count. If the result of invoking the function against a list returns a non-zero values, the list or array contains elements. If the result is zero, no elements are in the list and therefore no rows were selected.

So, we are going to check the response fields to (1) confirm the HTTP status code from Db2 is 200 and (2) and the value of invoking the $count function against the list of returned rows.



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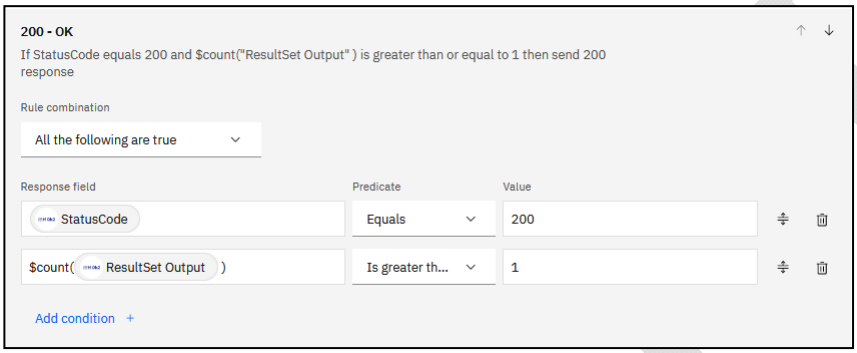
Under the *200 – OK* response, Enter the string ***Stat*** in the *Input* area under *Response field*. This will display all the fields in the Db2 REST response which match this string (position of the string in the field name does not matter, if the entered string matches any portion of the field name, that field will be displayed). In this case, select the *StatusCode* field. Leave the *Predicate* as *Equals* and enter ***200*** in the *Input* field for *Value*.

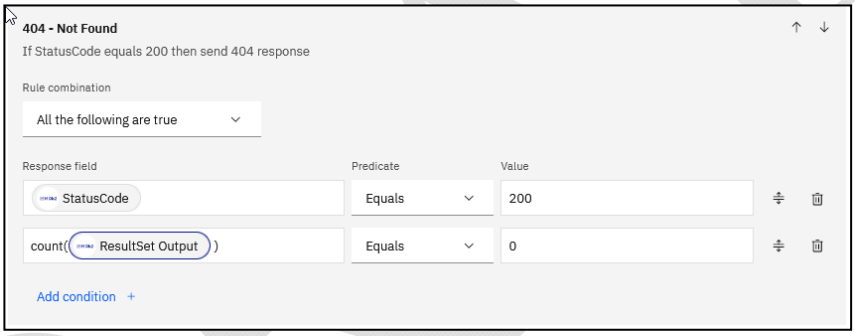
Next add a condition check for the value of invoking the function $count against the array of rows returned by the Db2 REST service *Count* by clicking on Add condition in the *200 – OK* evaluation and entering the string below in the area for the new check of a Response field.

$count($zosAssetResponse.body."ResultSet Output")

And set the *Predicate* to *Is greater than or equal to* a *Value* of ***1***.

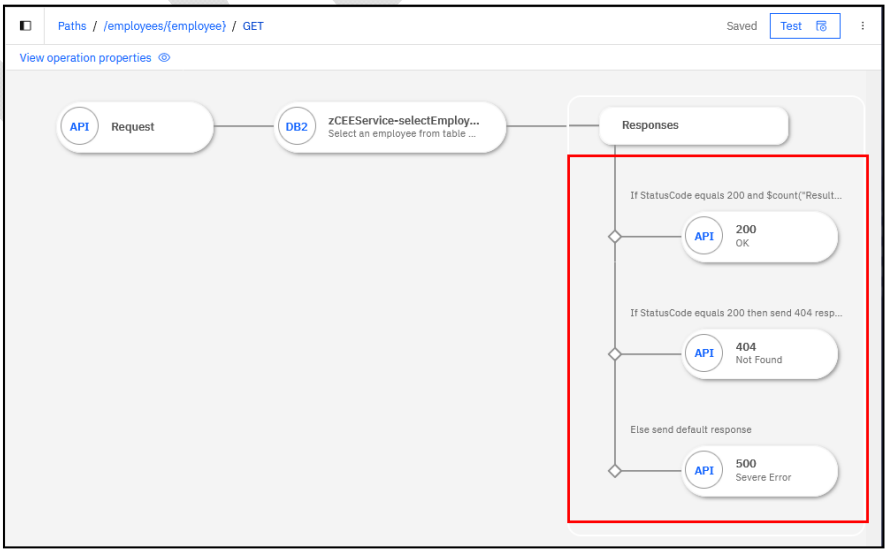


___3. For the *404 – Not Found* check, add a check for ***StatusCod***e equaling ***200*** and a check for the count equaling zero.



___4. If neither of these connections are met, simply return with a HTTP 500 status code.

___5. Next the API response messages need to be configured for each of these potential status codes.



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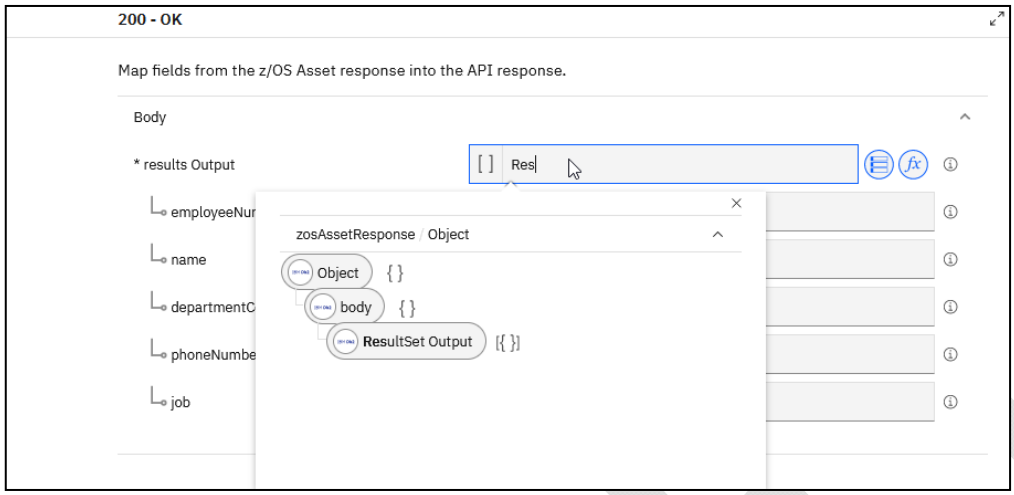
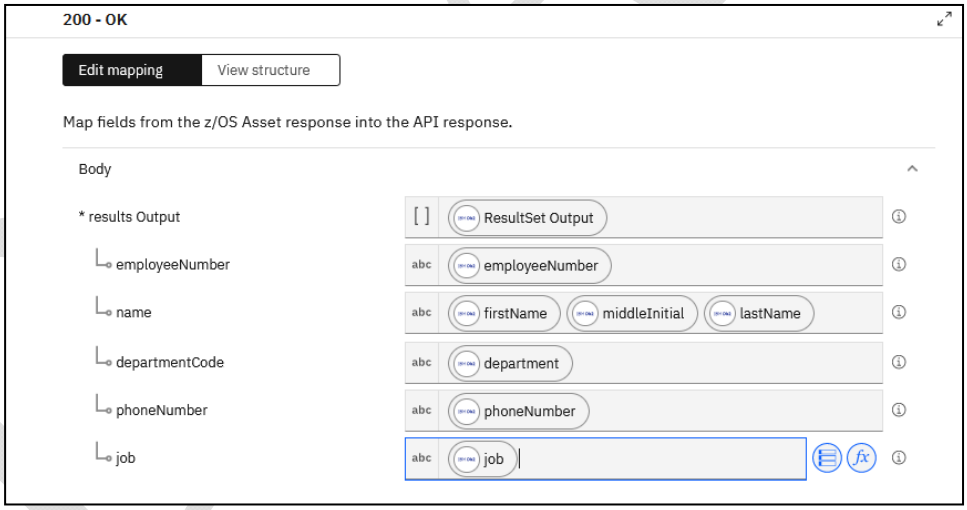
___6. Select the response for *200 OK* and map the fields from the Db2 REST response message. Start by mapping the *ResultSet Output* field from the Db2 REST response message to the API response field *results Output*. This must be done first to be able to access the elements in the array.



___7. Be careful at this point to ensure you are selecting fields in the *ResultSet output* array in the *body* of the *zosAssetResponse*. The same property name may appear in another one of the available mappings, e.g., *apiRequest, ResultSet Row item,* etc. and if a property is selected from one these mappings, the results will be unpredictable.

___8. Complete the mapping for the other properties. Notice the mapping of the Db2 REST response properties *firstName, middleInitial* and *lastName* into the single API response property *name*.



___9. Select the response for *404 Not found* response mapping and paste the text below in the *message* area.

Record for employee number {{$apiRequest.pathParameters.employee}} was not found

Notice that the mapping for the property in the message was from the API request message and not the Db2 REST response message.

___10. Finally in the 500 – Severe Error response mapping paste the following in the area for the message property

A severe error has occurred - {{$zosAssetResponse.body.StatusDescription}}

The completes the configuration of this method of this URI path of the API. All the exclamation marks for this method should now have disappeared. If not investigate which subcomponent still has an exclamation mark and resolve the issue.

Tech-Tip: Note that the exclamation mark has disappeared from *zCEEService-insertEmployee* on the operation page.

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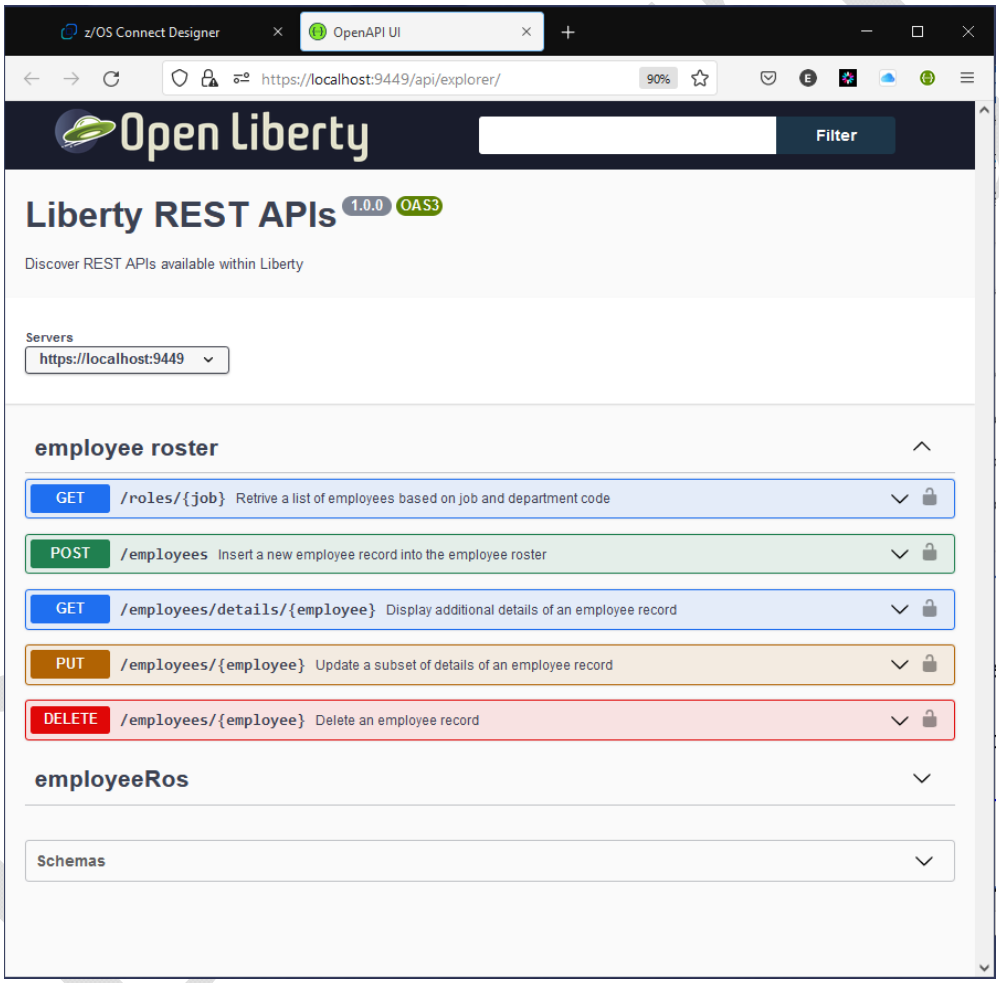
Testing the API's POST and GET methods

As the API was being developed, the changes have been saved and a Web Archive (WAR) file was generated with each change. If the upper right-hand corner of the browser page there will be a **Test** button. Clicking this button will open an API Explorer page. All the URI paths and methods in the original OpenAPI 3 specification document will be displayed, but only the *POST* for */employees* and the *GET* for */employees/{employee}* have been created. Executing one of the other methods will return an HTTP 404 because the components required to execute these methods cannot be found in the WAR.

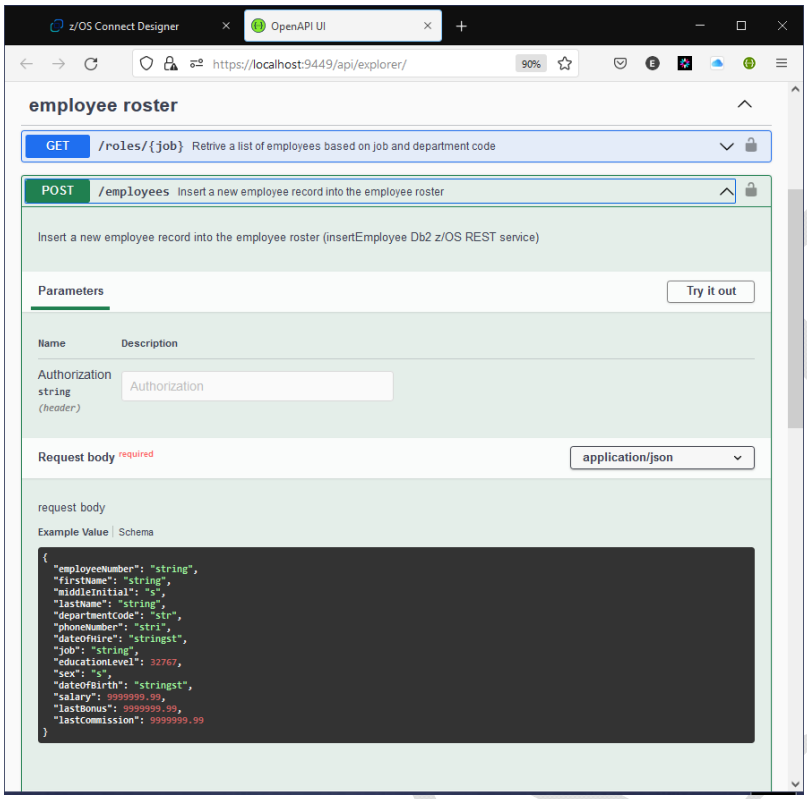
Let's test what has been developed so far.

___1. Click the Test button to open the API Explorer.

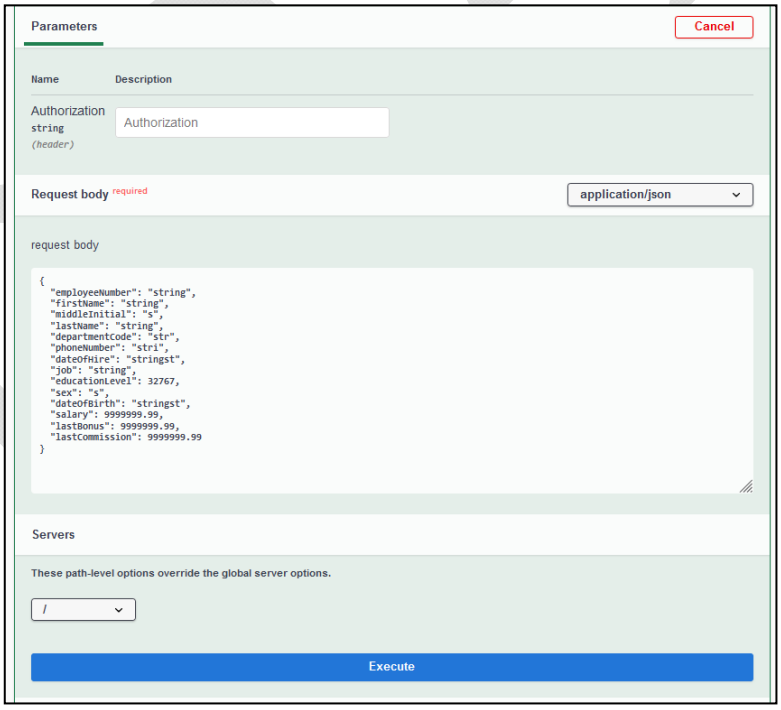


Tech Tip: You may be challenged by browser because the digital certificate used by the *Designer* is self-signed Click the **Advanced** button to continue. Scroll down and then click on the **Accept the Risk and Continue** button. Next you may see a prompt you for a userid and password. If you do see the prompt, enter the username ***Fred*** and password **fredpwd** (case matters) and click **OK**. Remember we are using basic security, and this is the user identity and password defined in the server.xml file.

___2. Click on *Post /employees* URI path to display the request body view of the URI path.



___3. Next press the ***Try it out*** button to enable the entry of an authorization string and a request message body

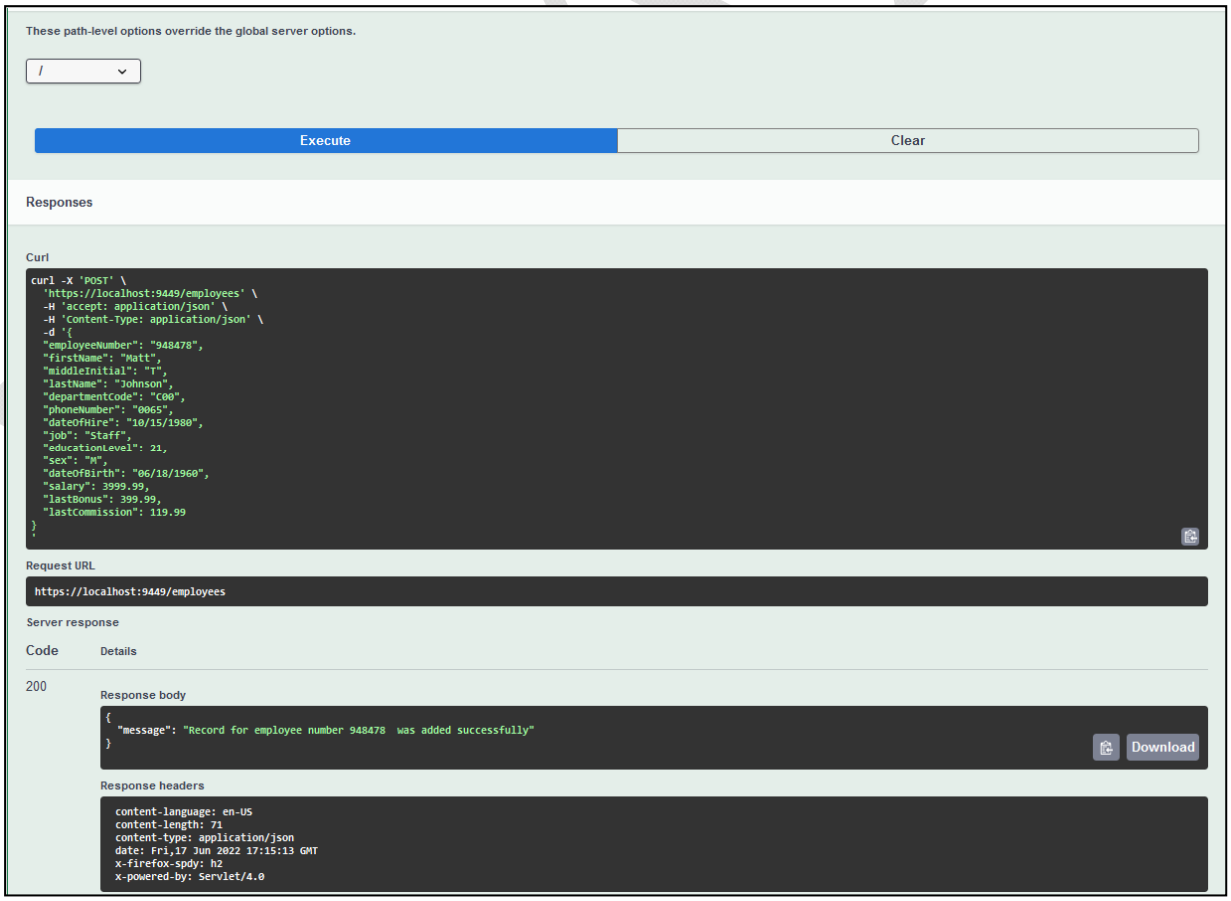


___4. Enter the JSON request message below in the *Request body* section and press the **Execute** button.

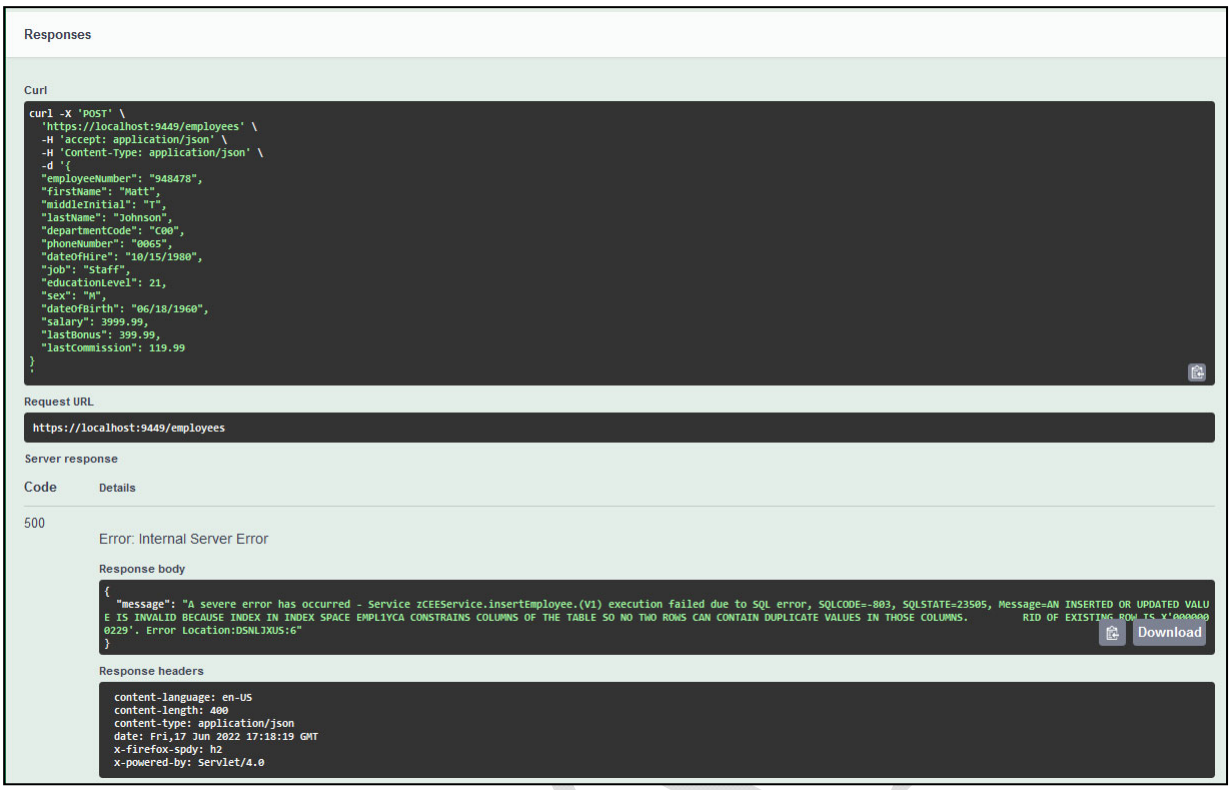
```
{
  "employeeNumber": "948478",
  "firstName": "Matt",
  "middleInitial": "T",
  "lastName": "Johnson",
  "departmentCode": "C00",
  "phoneNumber": "0065",
  "dateOfHire": "10/15/1980",
  "job": "Staff",
  "educationLevel": 21,
  "sex": "M",
  "dateOfBirth": "06/18/1960",
  "salary": 3999.99,
  "lastBonus": 399.99,
  "lastCommission": 119.99
}
```

___5. Security was enabled in the original specification document, so you will be required to sign in with one of the identities defined in the basicSecurity.xml file explored earlier. Use ***Fred*** for the *Username* and ***fredpwd*** for the *Password*. Please note that this identity can be changed unless all browser sessions are stopped.

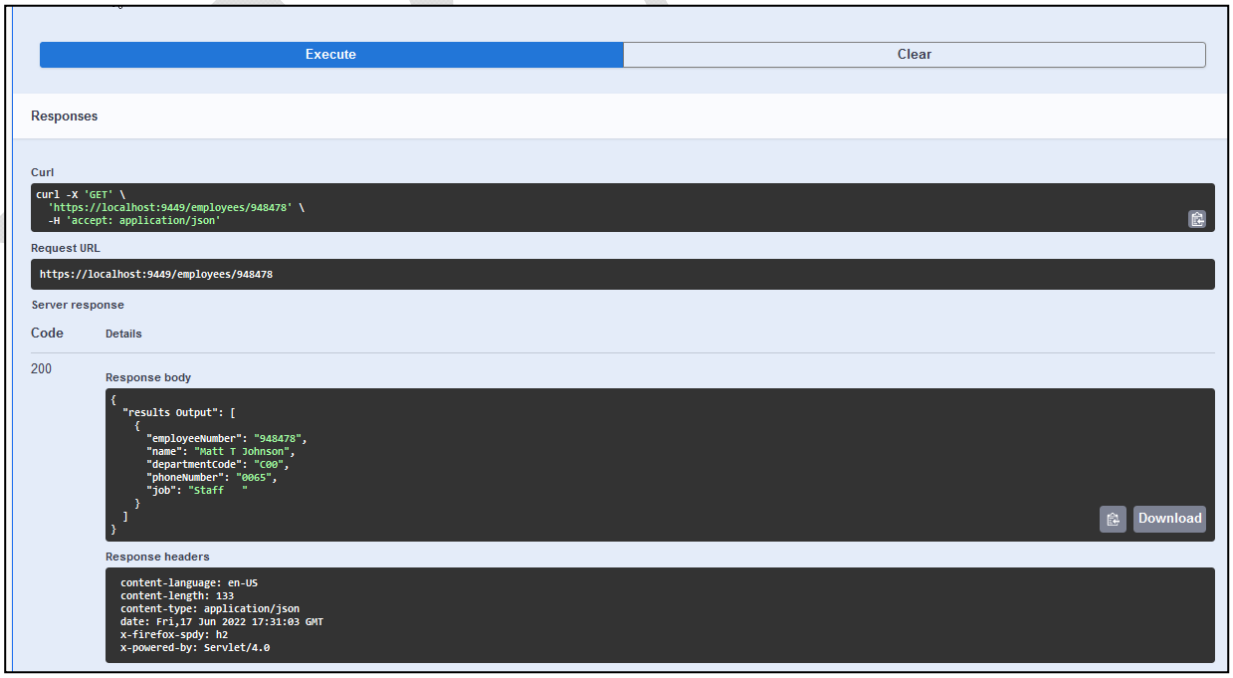
___6. Scroll down the view and you should see the *Response body* with the expected successful message.



___7. Press the **Execute** button again and observe the results. A row for this employee number already existed in the employee roster (a Db2 tables) so the request failed with an HTTP 500.



___8. Scroll down and click on *GET /employees/{employees}* URI path to display the request body view of the URI path for this method. Next click on the ***Try it out*** button to enable the entry of data for this method. Enter ***948478*** as the employee identity and press the **Execute** button to retrieve a subset of data for this employee.



___9. Try this again using number ***121212*** and observe the results. You see the message that the employee was not found.

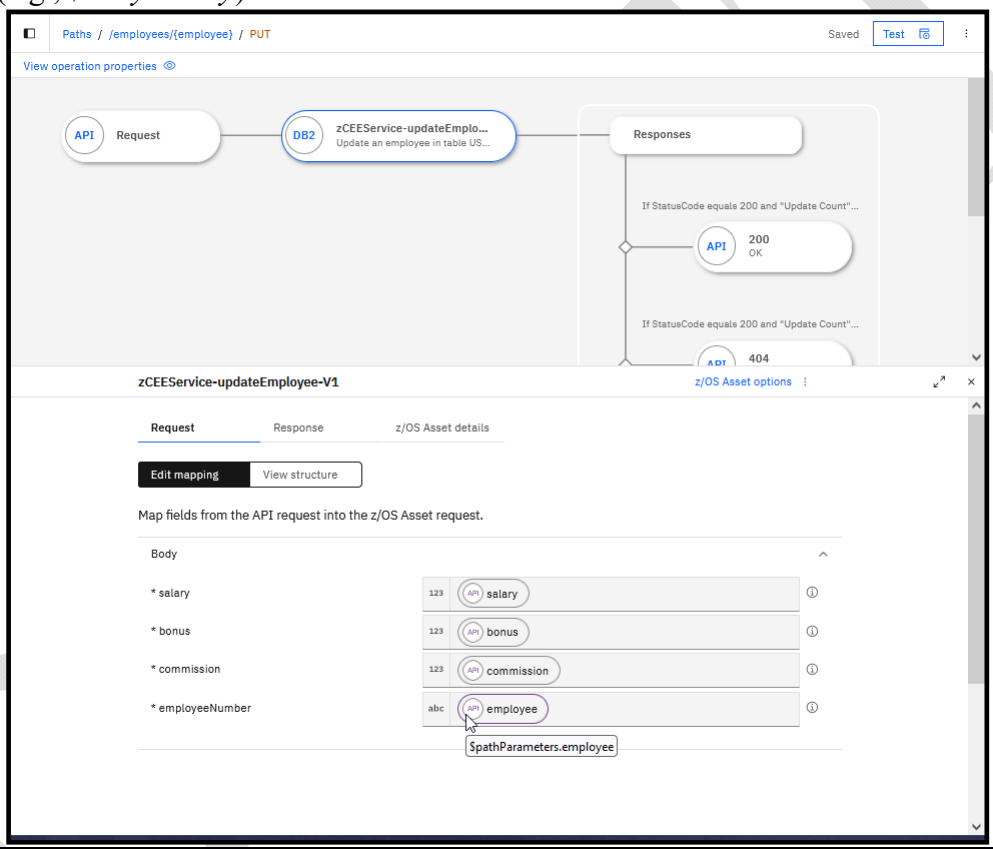
Compete the configuration of the API (Optional)

To be able to fully test all the URI paths and methods the other methods need to be configured. Otherwise, you may advance to the section *Deploying and Installing APIs in a z/OS Connect Native Server*.

Configure the PUT method for URI path /employees/{employee}

Now add support for updated a subset of the details of an employee record by completing the configuration for the *PUT* method of URI Path */employees/{employee}*

___1. Start by adding a new z/OS Asset for Db2 REST service *zCEEService-updatetEmployee* to this method. Map the API request path parameter field *employee (*$*pathParameters.employee*) to the DB2 REST request message field *employeeNumber* as shown below. Map *salary, bonus,* and *commission* fields from the body of the API request message (e.g., *$body.salary*)

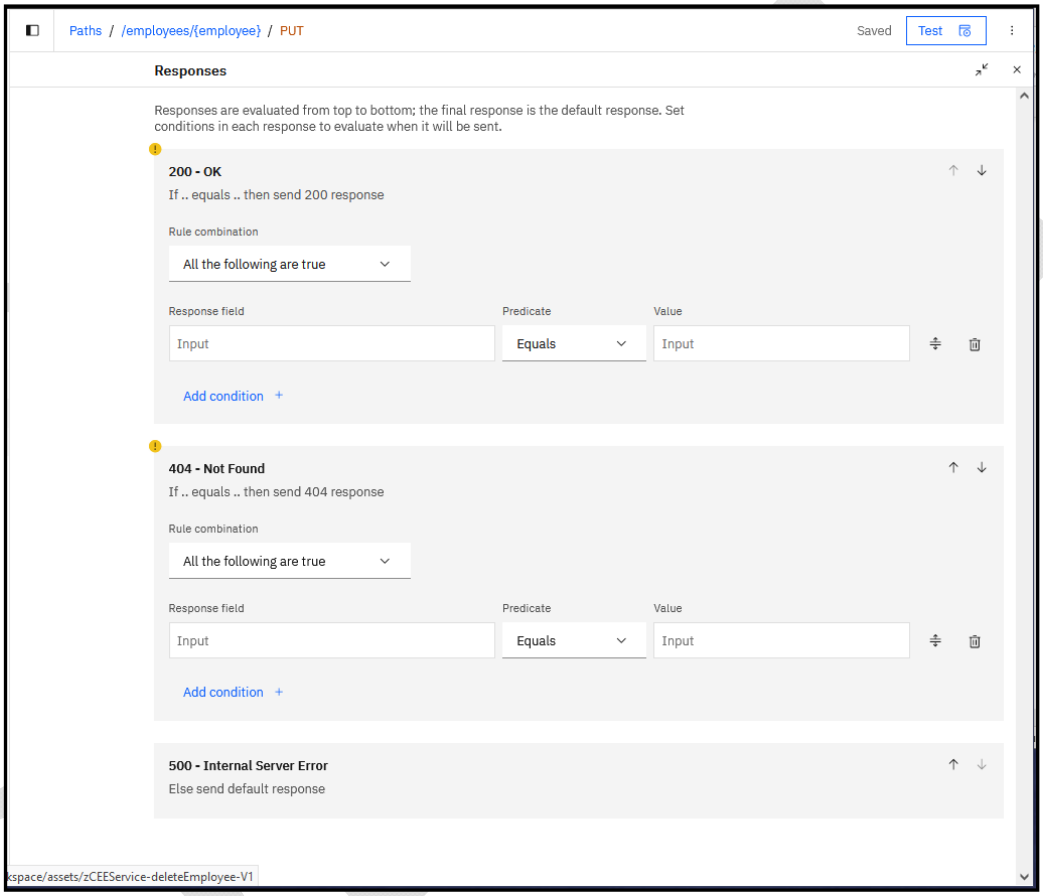


Tech Tip: Hover each of the properties and you see that all the properties except *employee* are mapped to the Db2 REST service from the *body* of the API request message. Property *employee* is mapped to the Db2 REST service from the path parameter.

___2. Maximize the *Responses* area of the browser's page (see below).

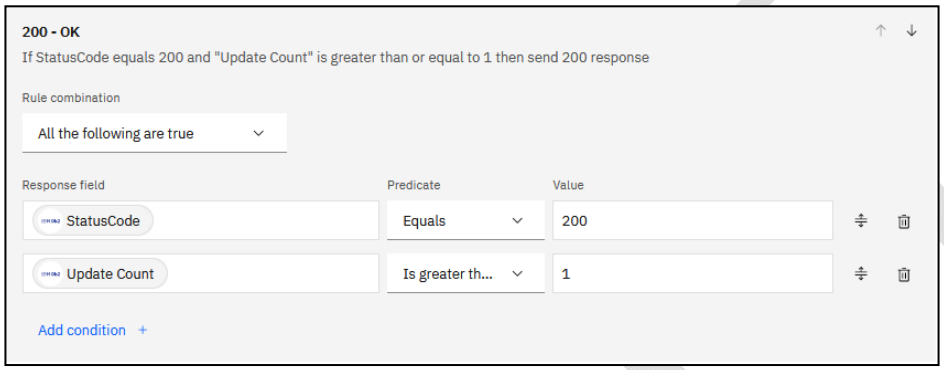
Responses from the Db2 REST service are evaluated in the order shown in the sequence shown. The first check is to see if the record was updated as intended. Db2 REST services will return an HTTP status code of 200 if the Db2 REST service was able to complete regardless of whether a row was updated or not. So, we need another way to determine whether a row was really updated. Again, we will use the *Update Count* response field to check the value to see how many rows were affected by this request.

So, we are going to check the response fields to (1) confirm the HTTP status code from Db2 is 200 and (2) and for the value of *Update Count*.

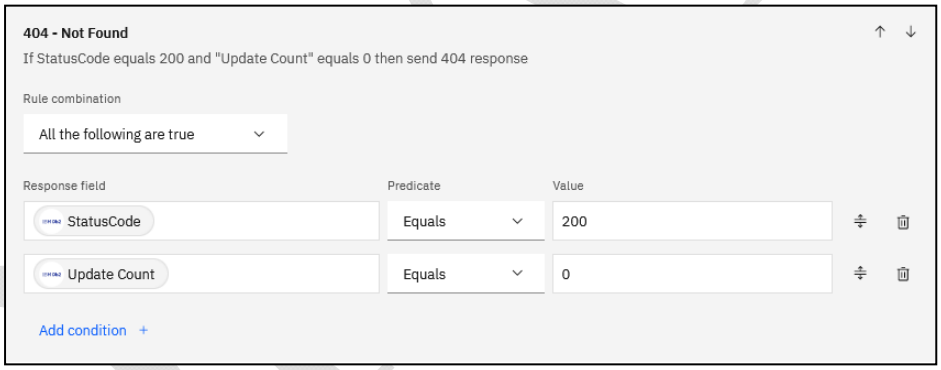


___3. Under the *200 – OK* response, Enter the string ***Stat*** in the *Input* area under *Response field*. This will display all the fields in the Db2 REST response which match this string (position of the string in the field name does not matter, as long as the string entered matches any portion of the field name, that field will be displayed). In this case, select the *StatusCode* field. Leave the *Predicate* as *Equals* and enter ***200*** in the *Input* field for *Value*.

Next add a condition check for the value of the *Update Count* Db2 REST response property by clicking on the *Add condition* in the *200 – OK* evaluation and entering the string below in the area for the new check of a Response field. Enter property ***Update Count*** for the Response field name. Set the *Predicate* to *Is greater than or equal to* and a value of ***1***.

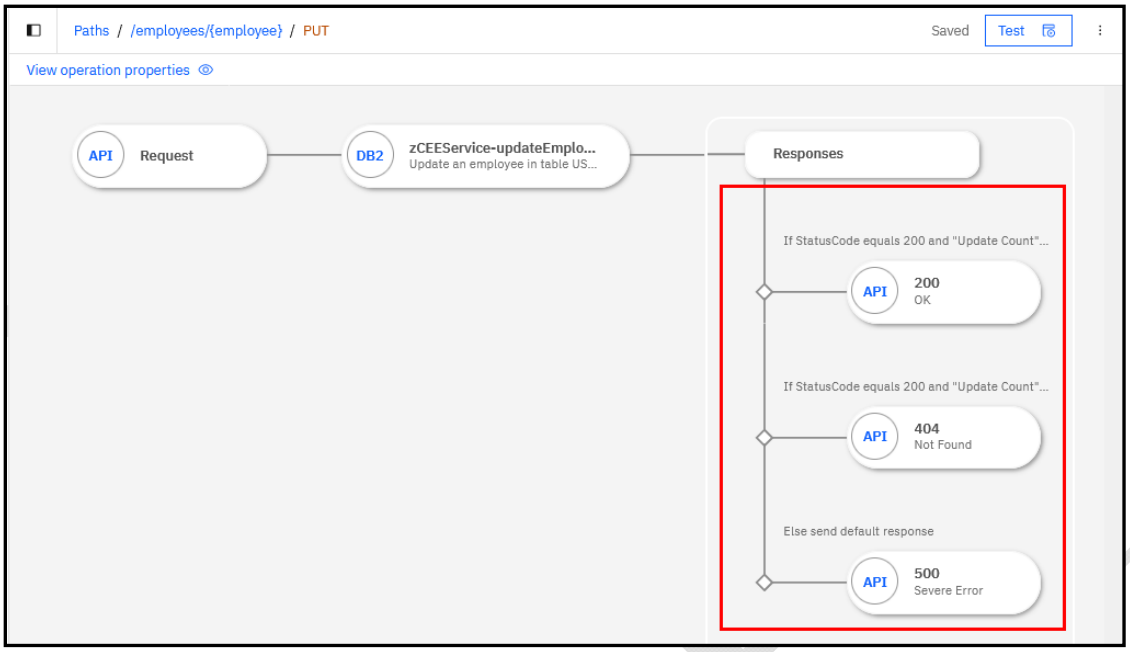


___4. For the *404 – Not Found* check, add a check for ***StatusCod***e equaling ***200*** and a check for *Update Count* equaling zero.



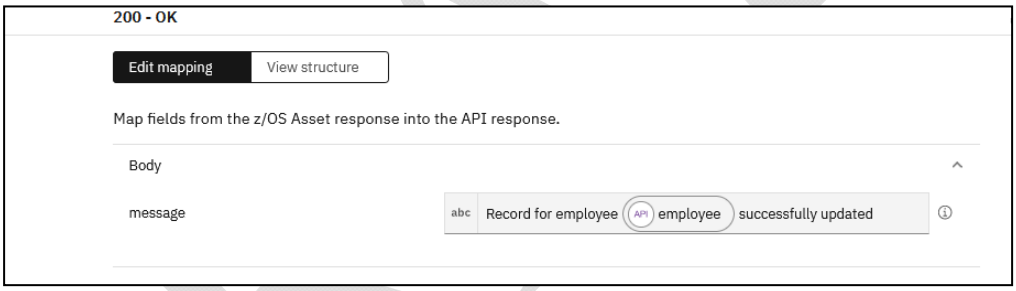
___5. If neither of these connections are met, simply return with a HTTP 500 status code.

___6. Next the API response messages need to be configured for each of these potential status codes.



___7. Select the response for *200 OK* paste the text below in the *message* area.

Record for employee {{$apiRequest.pathParameters.employee}} successfully updated



___8. Select the response for *404 Not found* response mapping and paste the text below in the *message* area.

Record for employee number {{$apiRequest.pathParameters.employee}} was not found

Notice that the mapping for the property in the message was from the API request message and not the Db2 REST response message.

___9. Finally in the 500 – Severe Error response mapping paste the following in the area for the message property

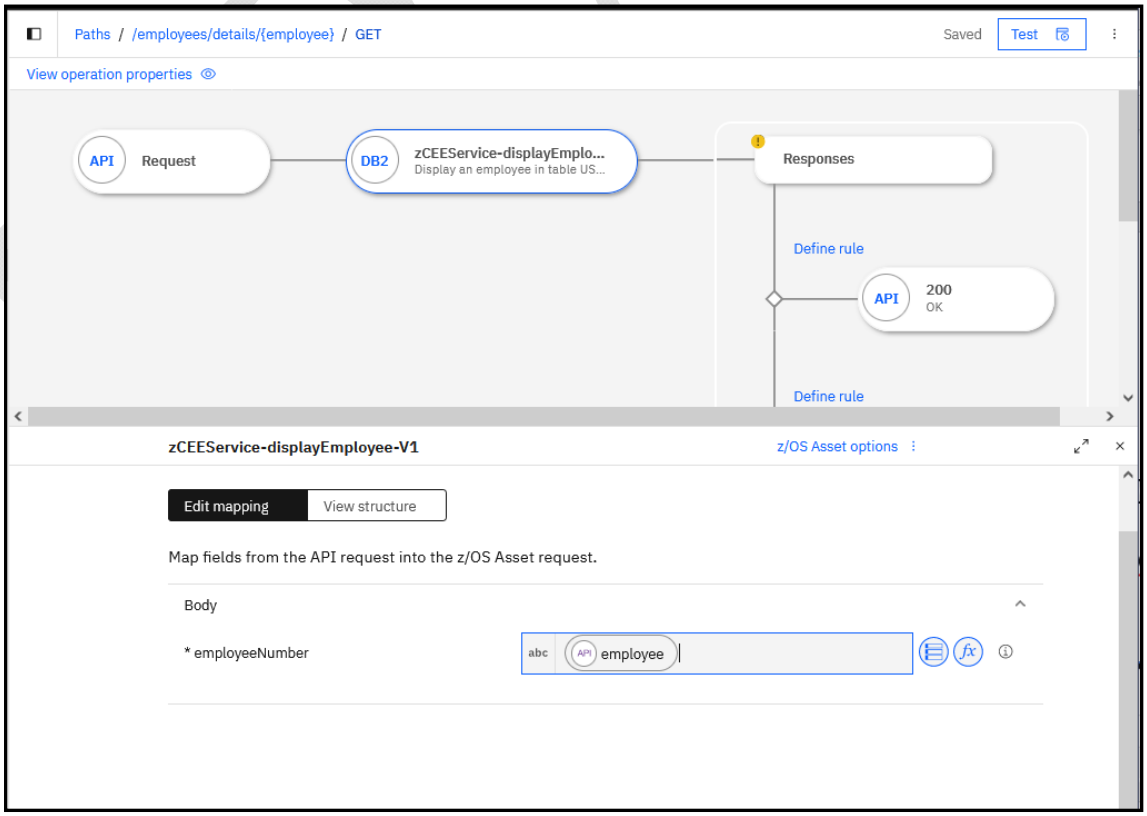
A severe error has occurred - {{$zosAssetResponse.body.StatusDescription}}

The completes the configuration of this method of this URI path of the API. All the exclamation marks for this method should now have disappeared. If not investigate which subcomponent still has an exclamation mark and resolve the issue.

Configure the GET method for URI path /employees/details/{employee}

Now let's repeat the process and complete the configuration for the *GET* method of URI Path */employees/details/{employee}*

___1. Start by adding a new z/OS Asset for Db2 REST service *zCEEService-displayEmployee* to this method. Map the API request field *employee* to the DB2 REST request message field *employeeNumber* as shown below.



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___2. Maximize the *Responses* area of the browser's page (see below).

Again, responses from the Db2 REST service are evaluated in the order shown in the sequence shown. The first check is to see if the record a row or rows were returned as intended. Db2 REST services will return an HTTP status code of 200 if the Db2 REST service was able to complete regardless of whether a row was selected or not. So, we need another way to determine whether a row was really selected. A Db2 REST service will return the rows selected in a list or array. We are going to take advantage of function that will return the number of elements in the list or array, e.g., $count. If the result of invoking the function returns a non-zero values, the list or array contains elements. If the result is zero, no rows were selected.

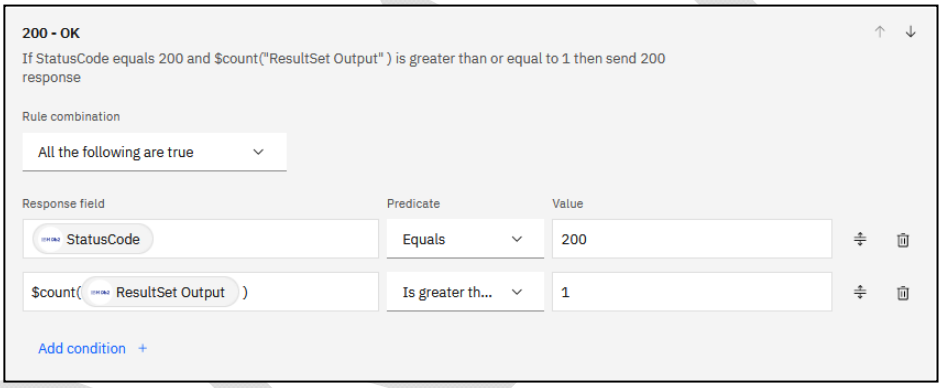
So, we are going to check the response fields to (1) confirm the HTTP status code from Db2 is 200 and (2) and for the value of invoking the $count function against the array of returned rows.

___3. Under the *200 – OK* response, Enter the string ***Stat*** in the *Input* area under *Response field*. This will display all the fields in the Db2 REST response which match this string (position of the string in the field name does not matter, if the entered string matches any portion of the field name, that field will be displayed). In this case, select the *StatusCode* field. Leave the *Predicate* as *Equals* and enter ***200*** in the *Input* field for *Value*.

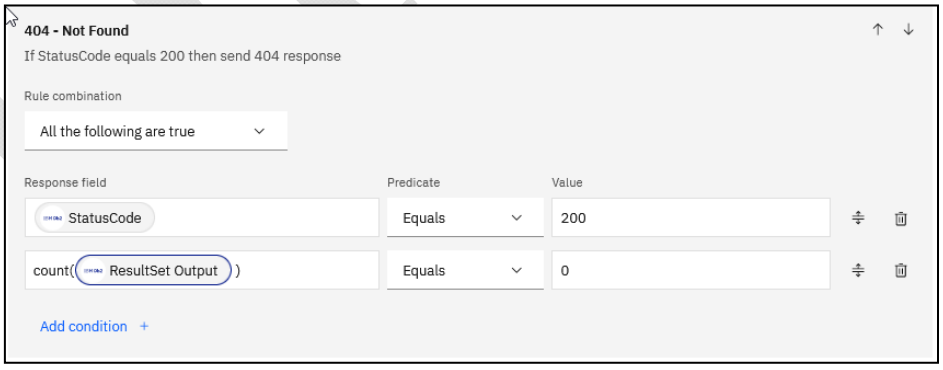
Next add a condition check for the value of invoking the function $count against the array of rows returned by the Db2 REST service *Count* by clicking on Add condition in the *200 – OK* evaluation and entering the string below in the area for the new check of a Response field.

$count($zosAssetResponse.body."ResultSet Output")

And set the *Predicate* to *Is greater than or equal to* a *Value* of ***1***.

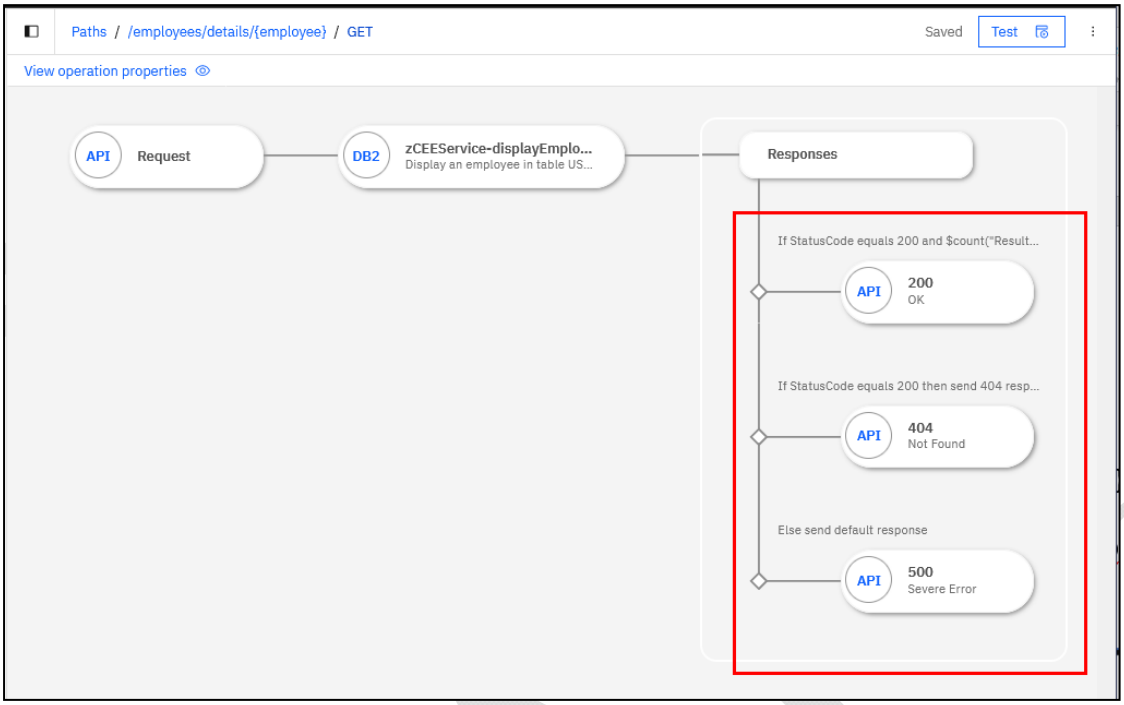


___4. For the *404 – Not Found* check, add a check for ***StatusCod***e equaling ***200*** and a check for the count equaling zero.

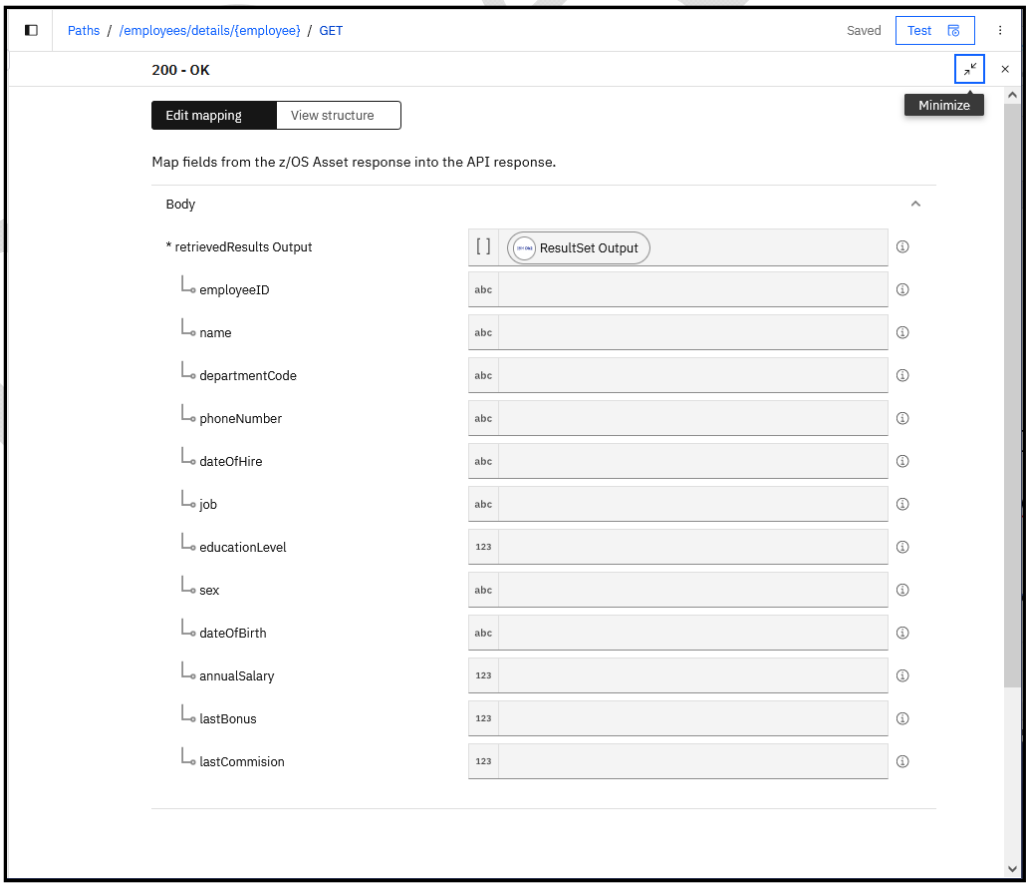


___5. If neither of these connections are met, simply return with a HTTP 500 status code.

___6. Next the API response messages need to be configured for each of these potential status codes.



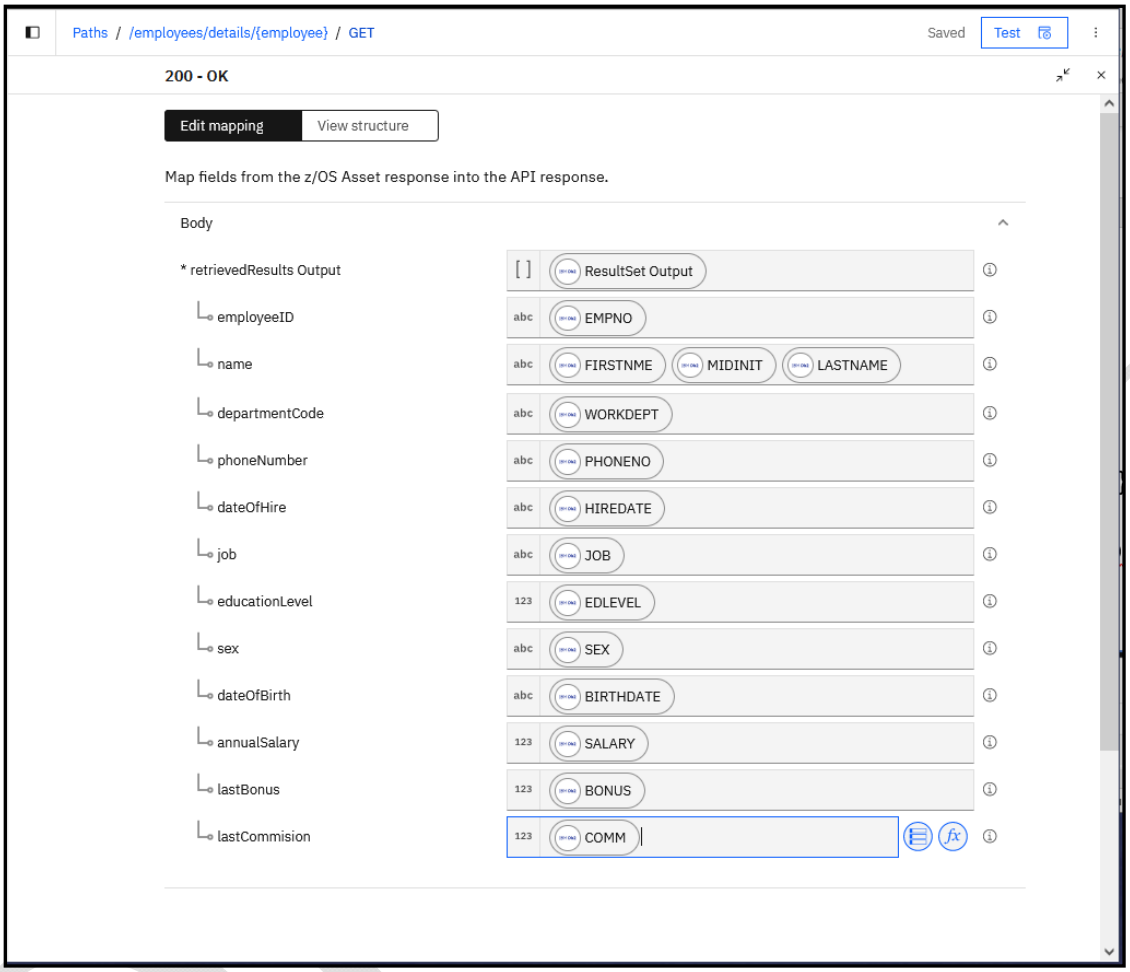
___7. Select the response for *200 OK* and map the fields from the Db2 REST response message. Start by mapping the *ResultSet Output* field from the Db2 REST response message to the API response field *results Output*. This must be done first to access the elements in the array.



Mitch Johnson (mitchj@us.ibm.com)

___8. Be careful at this point to ensure you are selecting fields in the *ResultSet output* array in the *body* of the *zosAssetResponse*. The same property name may appear in another one of the available mappings, e.g., *apiRequest, ResultSet Row item,* etc. and if a property is selected from one these mappings, the results will be invalid.

___9. Complete the mapping for the other properties. Notice the mapping of the Db2 REST response properties *firstName, middleInitial* and *lastName* into the API response property *name*.



Mitch Johnson (mitchj@us.ibm.com)

___10. Select the response for *404 Not found* response mapping and paste the text below in the *message* area.

Record for employee number {{$apiRequest.pathParameters.employee}} was not found

Notice that the mapping for the property in the message was from the API request message and not the Db2 REST service response message.

___11. Finally in the 500 – Severe Error response mapping paste the following in the area for the message property

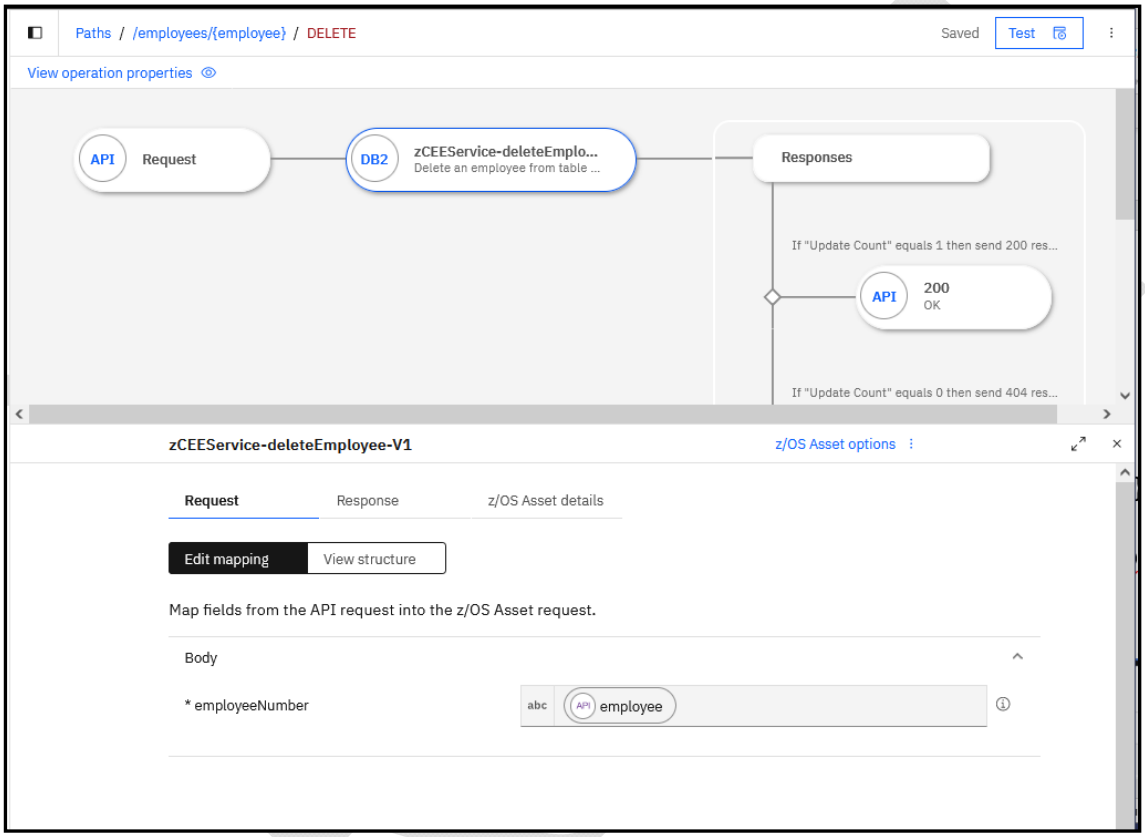
A severe error has occurred - {{$zosAssetResponse.body.StatusDescription}}

The completes the configuration of this method of this URI path of the API. All the exclamation marks for this method should now have disappeared. If not investigate which subcomponent still has an exclamation mark and resolve the issue.

Configure the DELETE method for URI path /employees/{employee}

Now let's repeat the process and complete the configuration for the *DELETE* method of URI Path */employees/{employee}*

___1. Start by adding a new z/OS Asset for Db2 REST service *zCEEService-deleteEmployee* to this method. Map the API request field *employee* to the DB2 REST request message field *employeeNumber* as shown below.



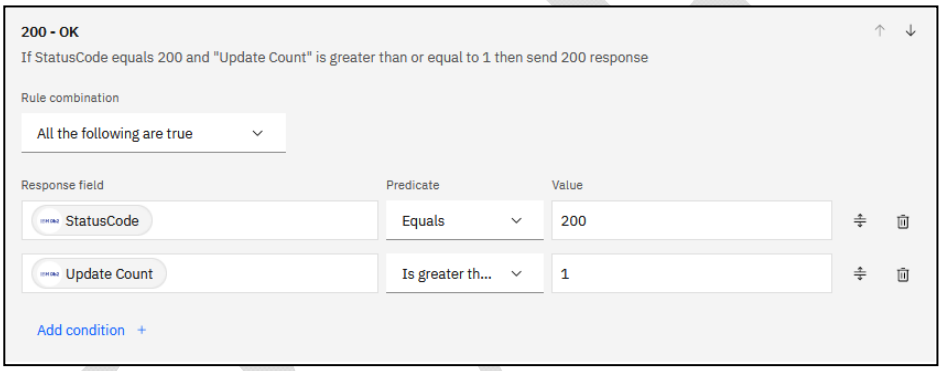
___2. Maximize the *Responses* area of the browser's page (see below).

Responses from the Db2 REST service are evaluated in the order shown in the sequence shown. The first check is to see if the record was updated as intended. Db2 REST services will return an HTTP status code of 200 if the Db2 REST service was able to complete regardless of whether a row was updated or not. So, we need another indication whether a row was really updated. Again, we will use the *Update Count* response field to check the value to see how many rows were affected by this request.

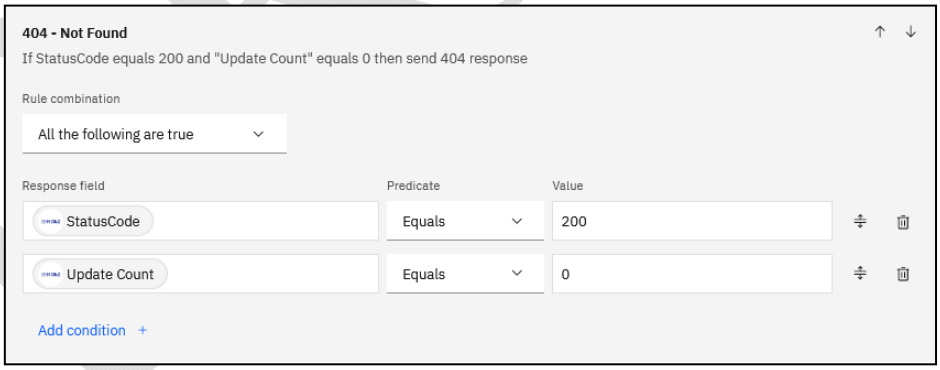
So, we are going to check the response fields to (1) confirm the HTTP status code from Db2 is 200 and (2) and for the value of *Update Count*.

___3. Under the *200 – OK* response, Enter the string ***Stat*** in the *Input* area under *Response field*. This will display all the fields in the Db2 REST response which match this string (position of the string in the field name does not matter, if the entered string matches any portion of the field name, that field will be displayed). In this case, select the *StatusCode* field. Leave the *Predicate* as *Equals* and enter ***200*** in the *Input* field for *Value*.

Next add a condition check for the value of the *Update Count* Db2 REST response property by clicking on the *Add condition* in the *200 – OK* evaluation and entering the string below in the area for the new check of a Response field. Enter property ***Update Count*** for the Response field name. Set the *Predicate* to *Is greater than or equal to* and a value of ***1***.

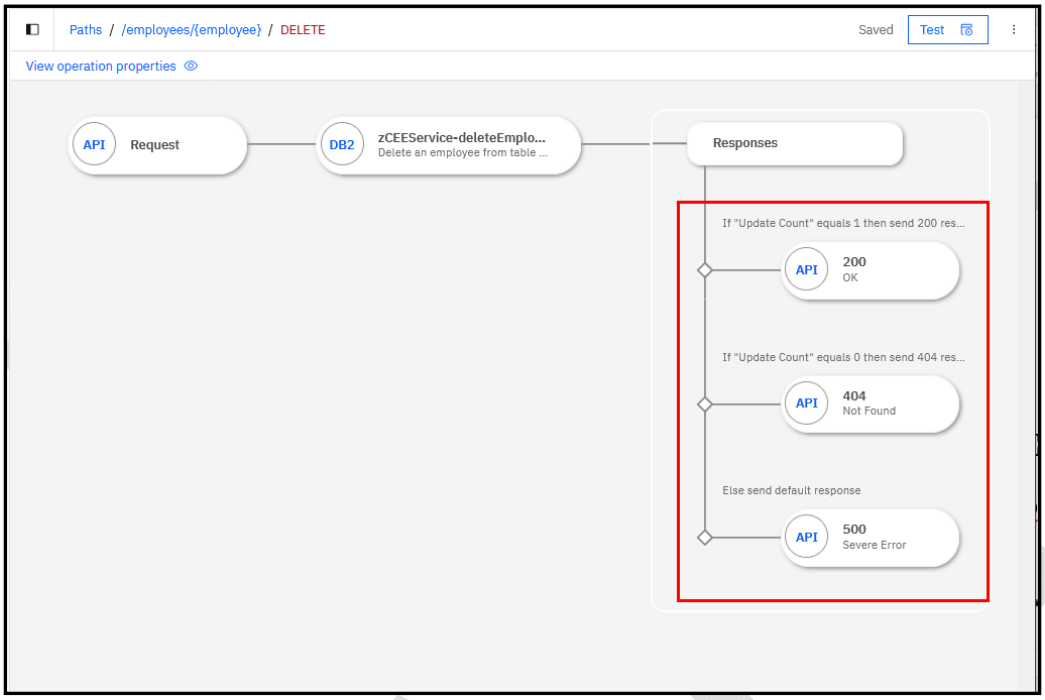


___4. For the *404 – Not Found* check, add a check for ***StatusCod***e equaling ***200*** and a check for an update count equaling zero.



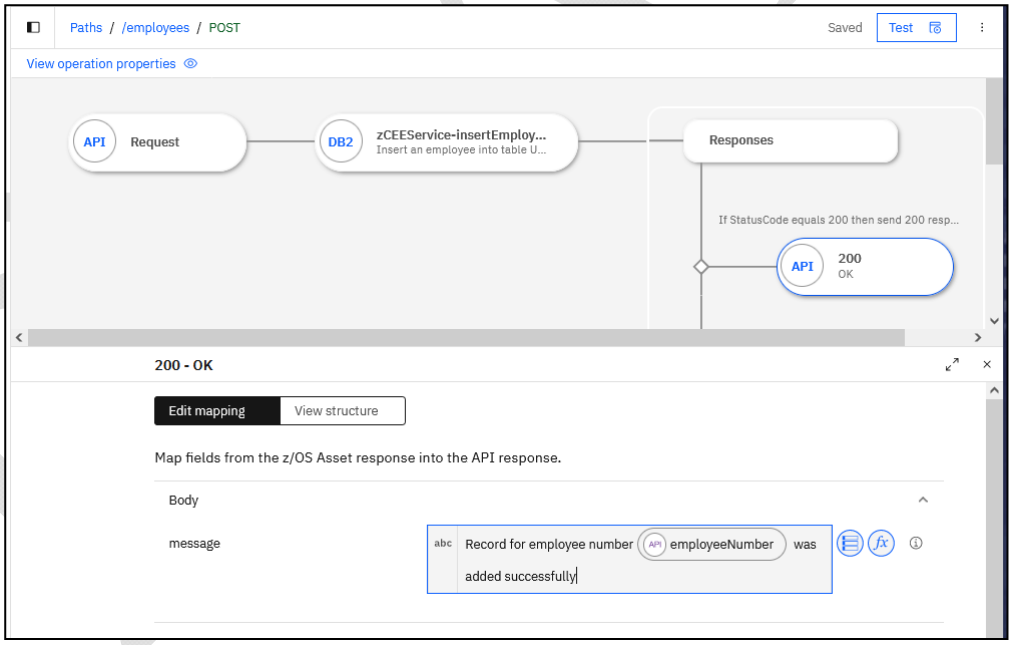
___5. If neither of these connections are met, simply return with a HTTP 500 status code.

___6. Next the API response messages need to be configured for each of these potential status codes.



___28. Select the response for *200 OK* paste the text below in the *message* area.

Record for employee number {{$apiRequest.body.employeeNumber}} was deleted successfully



___12. Select the response for *404 Not found* response mapping and paste the text below in the *message* area.

Record for employee number {{$apiRequest.pathParameters.employee}} was not found

Notice that the mapping for the property in the message was from the API request message and not the Db2 REST response message.

___13. Finally in the 500 – Severe Error response mapping paste the following in the area for the message property

A severe error has occurred - {{$zosAssetResponse.body.StatusDescription}}

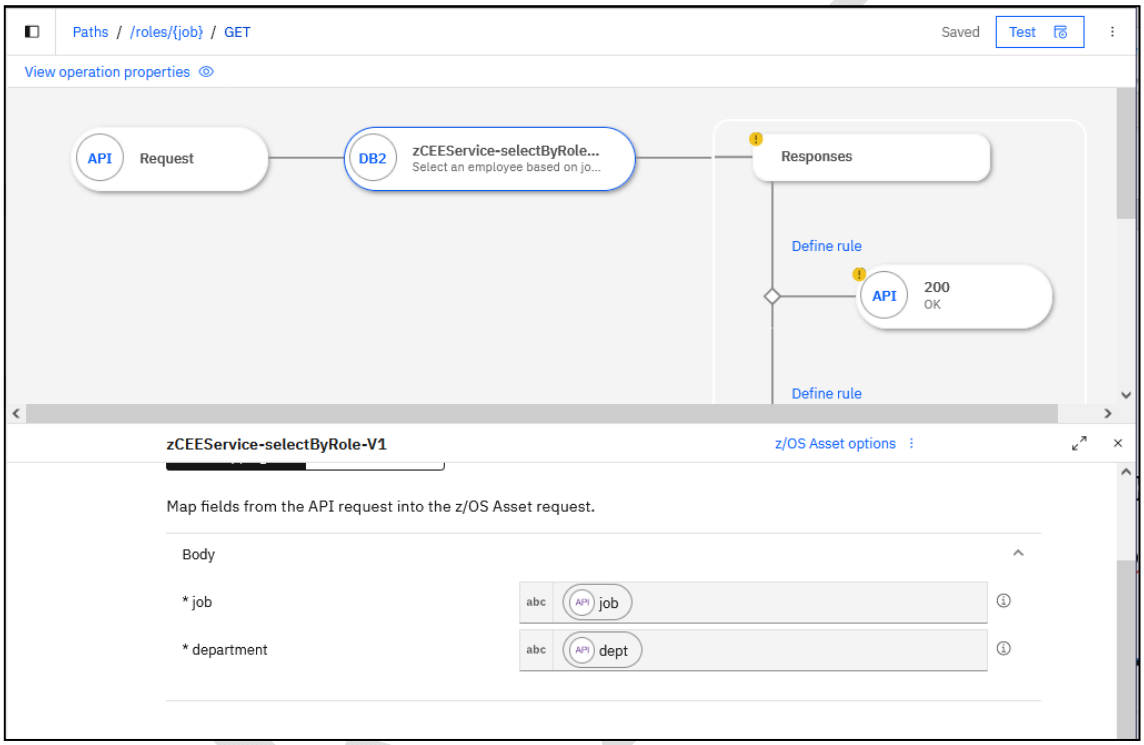
Tech-Tip: Db2 REST response property field *StatusDescription* provides more information regarding the issue that caused the insert to fail.

The completes the configuration of this method of this URI path of the API. All the exclamation marks for this method should now have disappeared. If not investigate which subcomponent still has an exclamation mark and resolve the issue.

Configure the GET method for URI path /roles/{job}

Now complete the configuration for the *GET* method of URI Path */roles/{job}*. This method includes both a path parameter and a query parameter.

___1. Start by adding a new z/OS Asset for Db2 REST service *zCEEService-selectByRole* to this method. Map the API request path parameter *job* to the DB2 REST server request message field *job* and the API query parameter *department* to the Db2 REST service request message field *dept*.



___2. Maximize the *Responses* area of the browser's page (see below).

Again, responses from the Db2 REST service are evaluated in the order shown in the sequence shown. The first check is to see if the record a row or rows were returned as intended. Db2 REST services will return an HTTP status code of 200 if the Db2 REST service was able to complete regardless of whether a row was selected or not. So, we need another indication whether a row was really selected. A Db2 REST service will return the rows selected in a list or array. We are going to take advantage of function that will return the number of elements in the list or array, e.g., $count. If the result of invoking the function returns a non-zero values, the list or array contains elements. If the result is zero, no rows were selected.

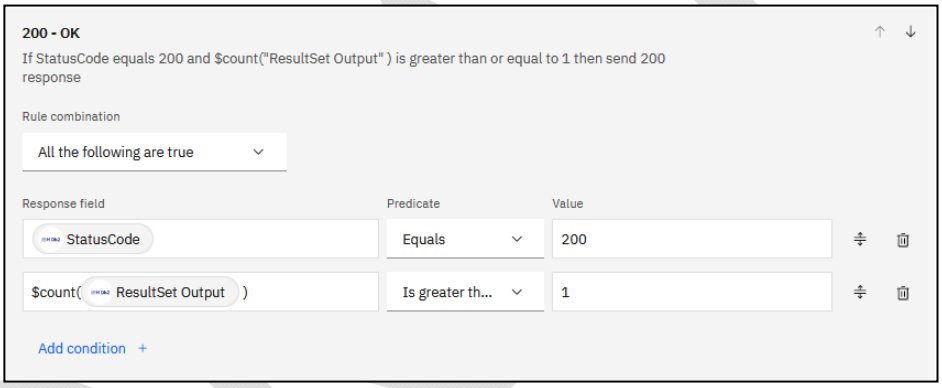
So, we are going to check the response fields to (1) confirm the HTTP status code from Db2 is 200 and (2) and for the value of invoking the $count function against the array of returned rows.

___3. Under the *200 – OK* response, Enter the string ***Stat*** in the *Input* area under *Response field*. This will display all the fields in the Db2 REST response which match this string (position of the string in the field name does not matter, if the entered string matches any portion of the field name, that field will be displayed). In this case, select the *StatusCode* field. Leave the *Predicate* as *Equals* and enter ***200*** in the *Input* field for *Value*.

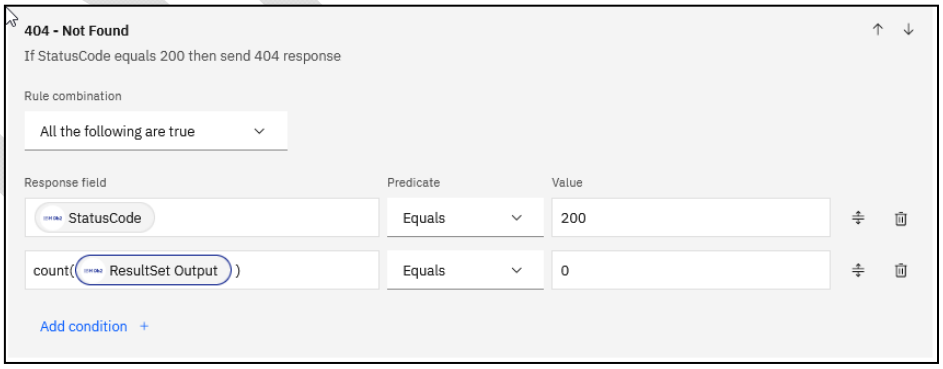
Next add a condition check for the value of invoking the function $count against the array of rows returned by the Db2 REST service *Count* by clicking on Add condition in the *200 – OK* evaluation and entering the string below in the area for the new check of a Response field.

$count($zosAssetResponse.body."ResultSet Output")

And set the *Predicate* to *Is greater than or equal to* a *Value* of ***1***.

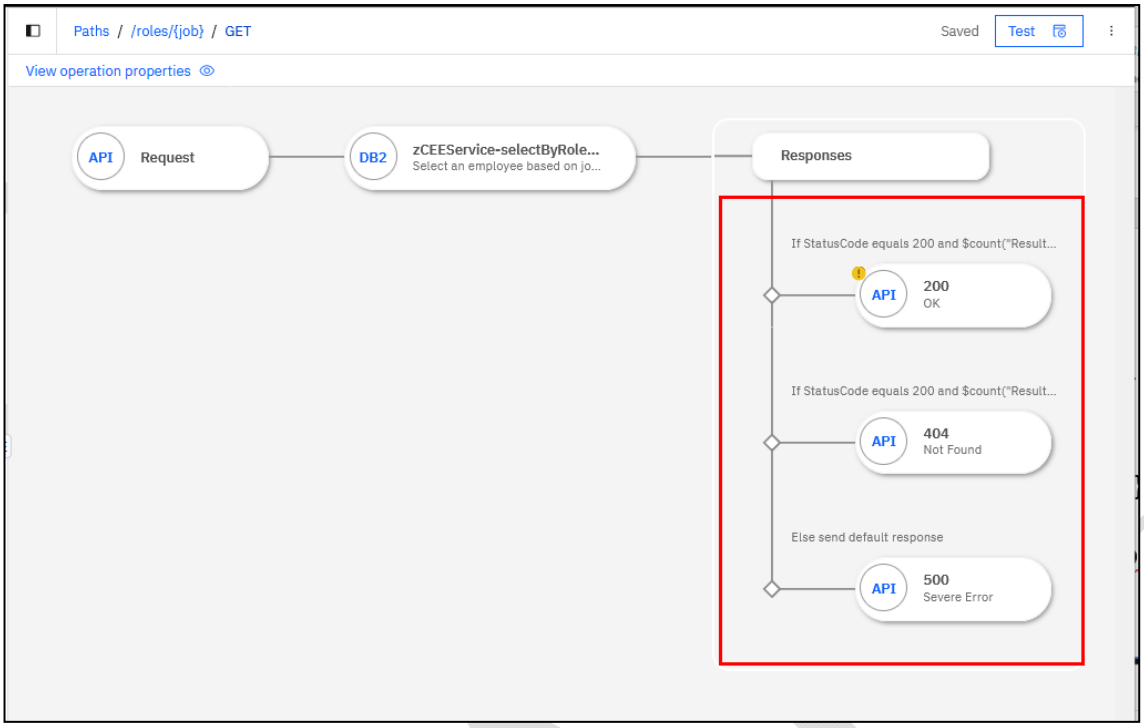


___4. For the *404 – Not Found* check, add a check for ***StatusCod***e equaling ***200*** and a check for count equaling zero.



___5. If neither of these connections are met, simply return with a HTTP 500 status code.

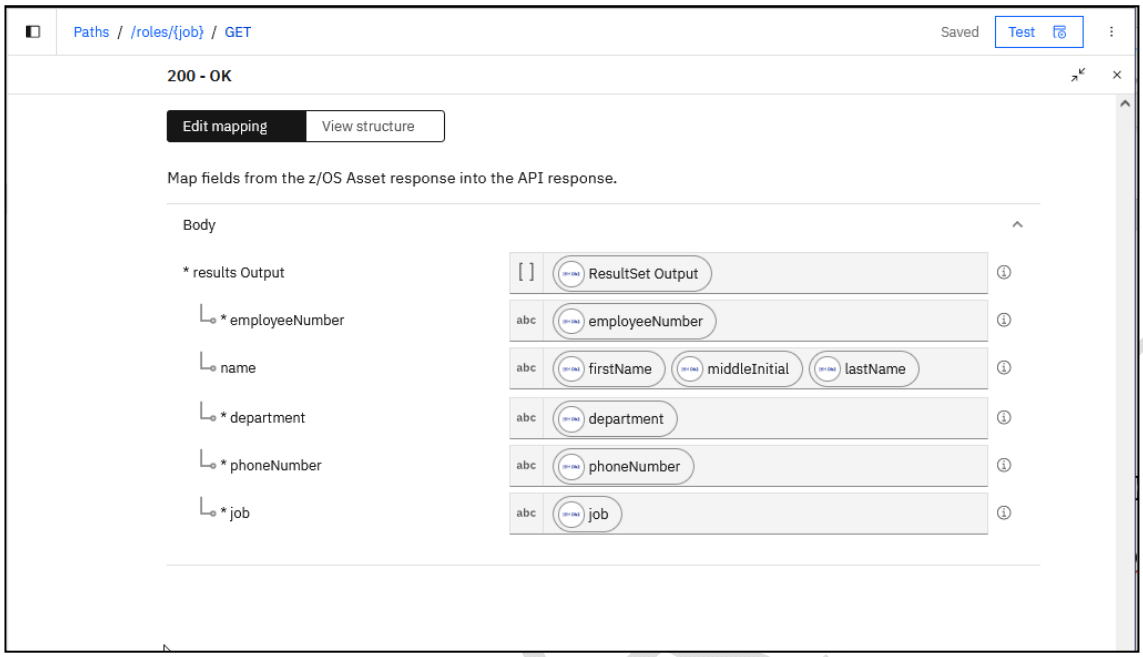
___6. Next the API response messages need to be configured for each of these potential status codes.



___7. Select the response for *200 OK* and map the fields from the Db2 REST response message. Start by mapping the *ResultSet Output* field from the Db2 REST response message to the API response field *results Output*. This must be done first to be able to access the elements in the array.

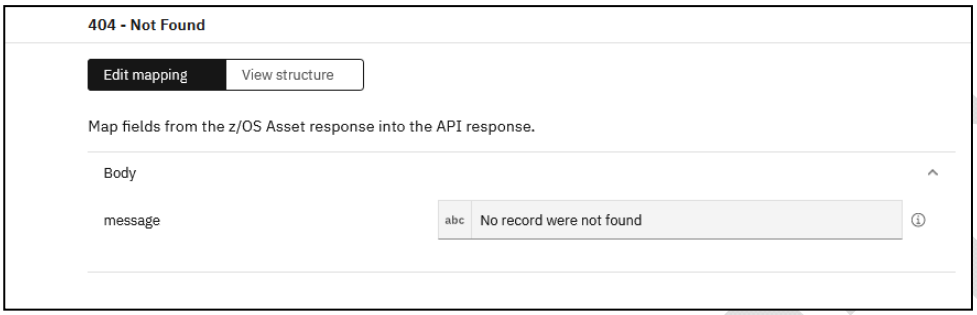
___8. Be careful at this point to ensure you are selecting fields in the *ResultSet output* array in the *body* of the *zosAssetResponse*. The same property name may appear in another one of the available mappings, e.g., *apiRequest, ResultSet Row item,* etc. and if a property is selected from one these mappings, the results will be invalid.

___9. Complete the mapping for the other properties. Notice the mapping of the Db2 REST response properties *firstName, middleInitial* and *lastName* into the API response property *name*.



___10. Select the response for *404 Not found* response mapping and paste the text below in the *message* area.

No records were found



___11. Finally in the 500 – Severe Error response mapping paste the following in the area for the message property

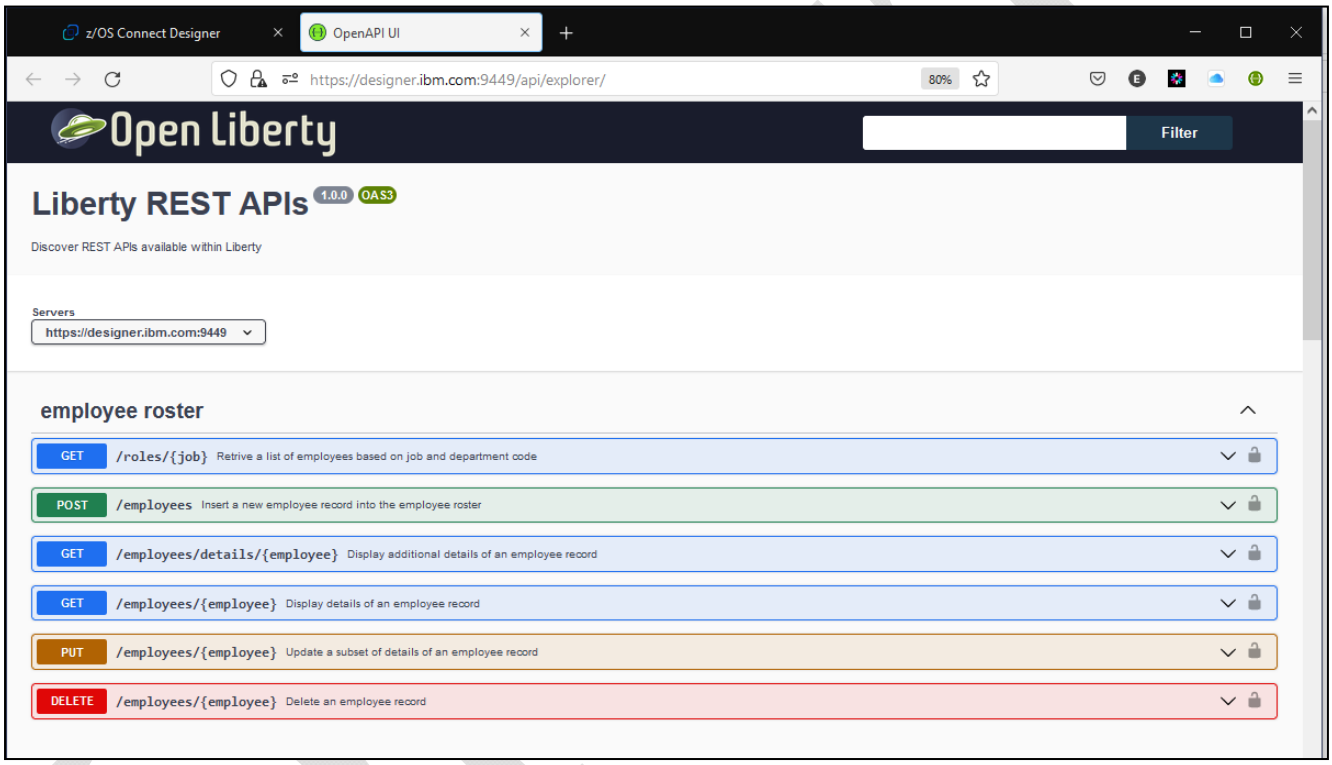
A severe error has occurred - {{$zosAssetResponse.body.StatusDescription}}

The completes the configuration of this method of this URI path of the API. All the exclamation marks for this method should now have disappeared. If not investigate which subcomponent still has an exclamation mark and resolve the issue.

Testing APIs deployed in a z/OS Connect Designer container

The deployed APIs are accessible as long as the *Designer* container is active, even when the *Designer* is not opened in a browser. In fact, there are advantages in this behavior when testing security roles. This section will demonstrate using common HTTP clients to test APIs specifically with security enabled.

We know the URI paths of the API from the initial page of the *API Explorer* displayed when testing in the *Designer*. From this page the first part of the URL can be determined, e.g., *https://designer.washington.ibm.com:9449/*. This along with the URI path of each methods provides the URL we need to use to invoke a method. For example, to invoke the GET to display the additional details of an employee record in any client, the URL will be *https://designer.washington.ibm.com:9449/employee/{employee}*



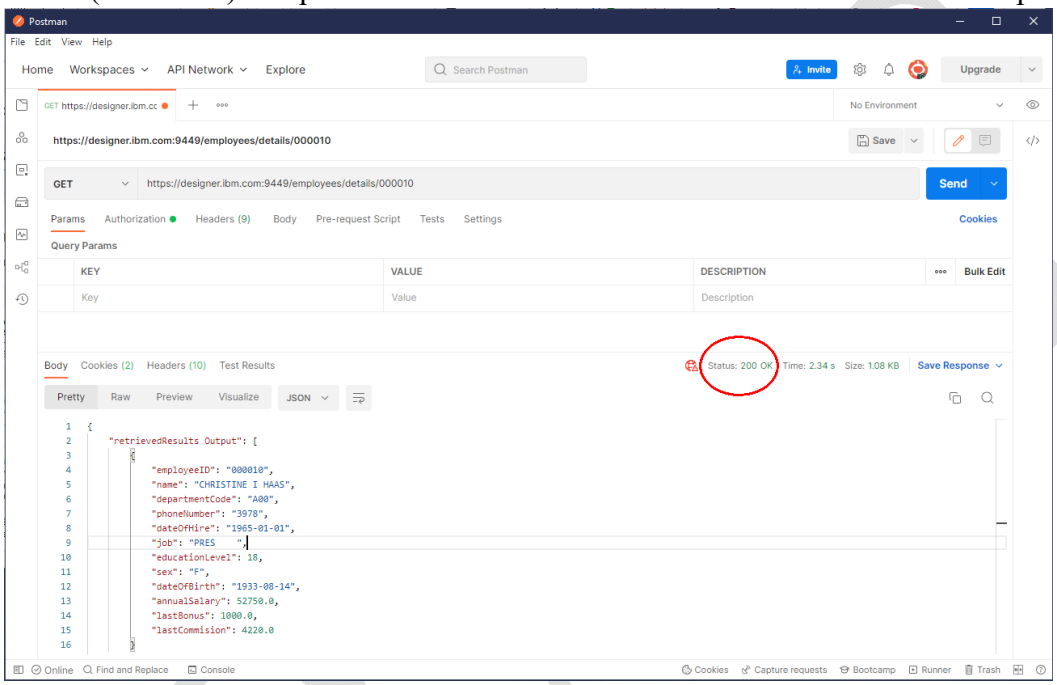
From this display, the methods and URLs required to access the API deployed in this container are:

- GET https://designer.washington.ibm.com:9449/employeee/{job}
- POST https://designer.washington.ibm.com:9449/employees
- GET https://designer.washington.ibm.com:9449/employees/details/{employee}
- GET https://designer.washington.ibm.com:9449/employee/{employee}
- PUT https://designer.washington.ibm.com:9449/employee/{employee}
- DELETE https://designer.washington.ibm.com:9449/employee/{employee}

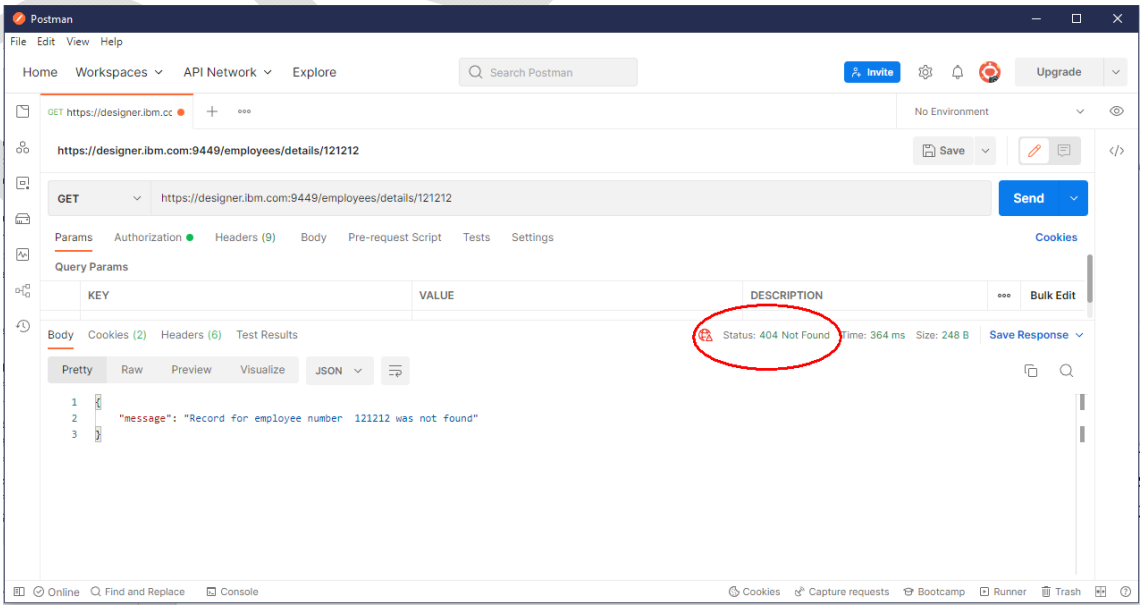
Using Postman

Start a Postman session using the Postman icon on the desktop.

____1. Open the *Postman* tool icon on the desktop and if necessary reply to any prompts and close any welcome messages. Set *Authorization* type to to basic and use ***Fred*** as the *Username* and ***fredpwd*** as the *Password* as and add a header preoprty of ***Content-Type*** with a value of ***application/json***. Then use the down arrow in the *Body* tab to select **GET** and enter ***https://designer.washington.ibm.com:9449/employees/details/000010*** in the URL area (see below) and press **Send**. You should see results like below in the response *Body* area.



____2. Next enter an invalid employee number such as 121212, ***https://designer.washington.ibm.com:9449/employees/details/121212*** in the URL area (see below) and press **Send**. You should see results like below in the response Body area.



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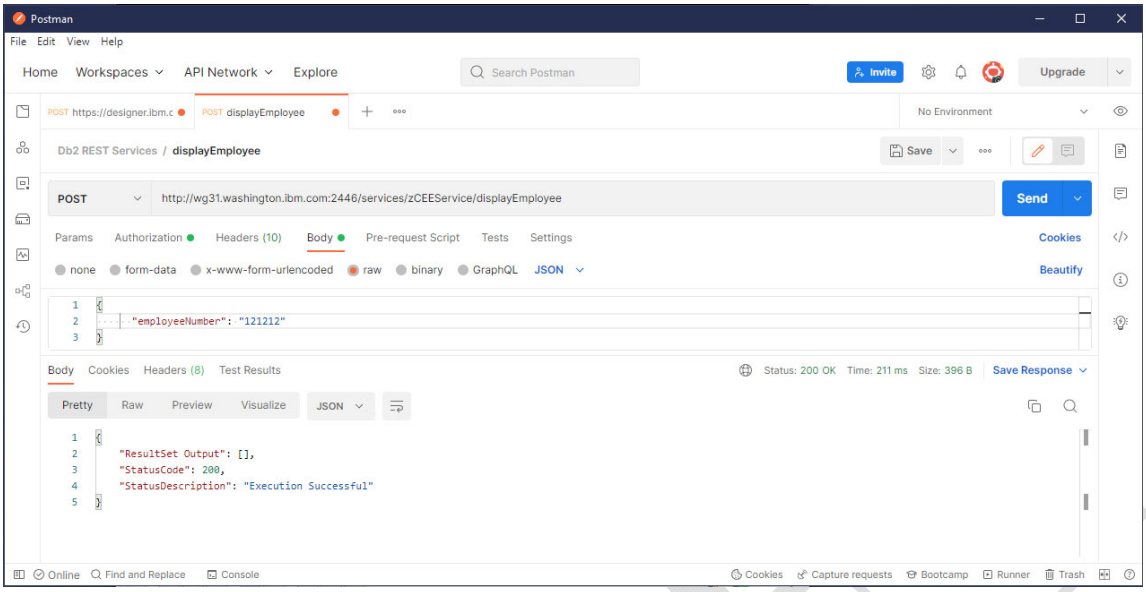
If you invoked the underlying Db2 REST service *(/services/zCEEService/displayEmployee*), you would receive an HTTP 200 with an empty *ResultSet Output* array.

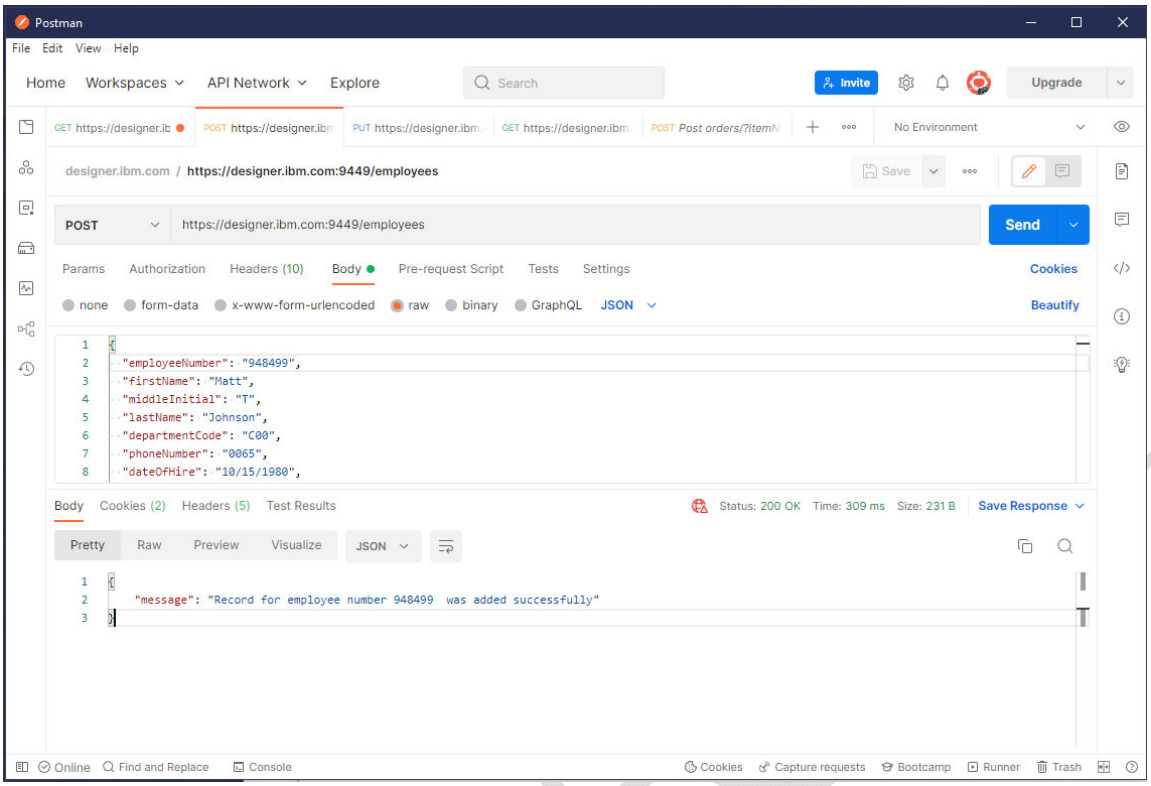


This demonstrates one of the advantages of using z/OS Connect APIs as a gateway to Db2 REST services.

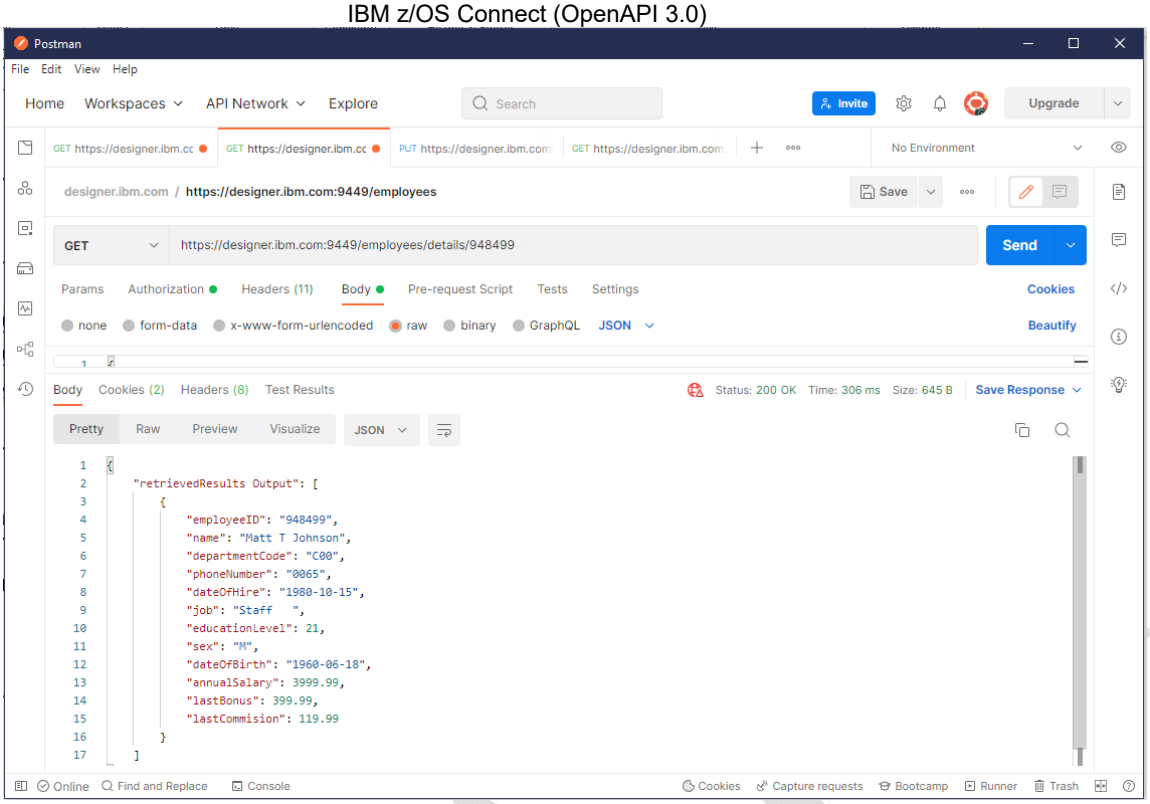
___3. Next use *Postman* to invoke a *POST* method with URL ***https://designer.washington.ibm.com:9449/employees*** and the JSON below for the request message.

```
{
  "employeeNumber": "948499",
  "firstName": "Matt",
  "middleInitial": "T",
  "lastName": "Johnson",
  "departmentCode": "C00",
  "phoneNumber": "0065",
  "dateOfHire": "10/15/1980",
  "job": "Staff",
  "educationLevel": 21,
  "sex": "M",
  "dateOfBirth": "06/18/1960",
  "salary": 3999.99,
  "lastBonus": 399.99,
  "lastCommission": 119.99
}
```

Pressing the **Send** button invokes the POST method of URI path */employees* which in turns invokes the Db2 REST service *zCEEService.insertEmployee*.



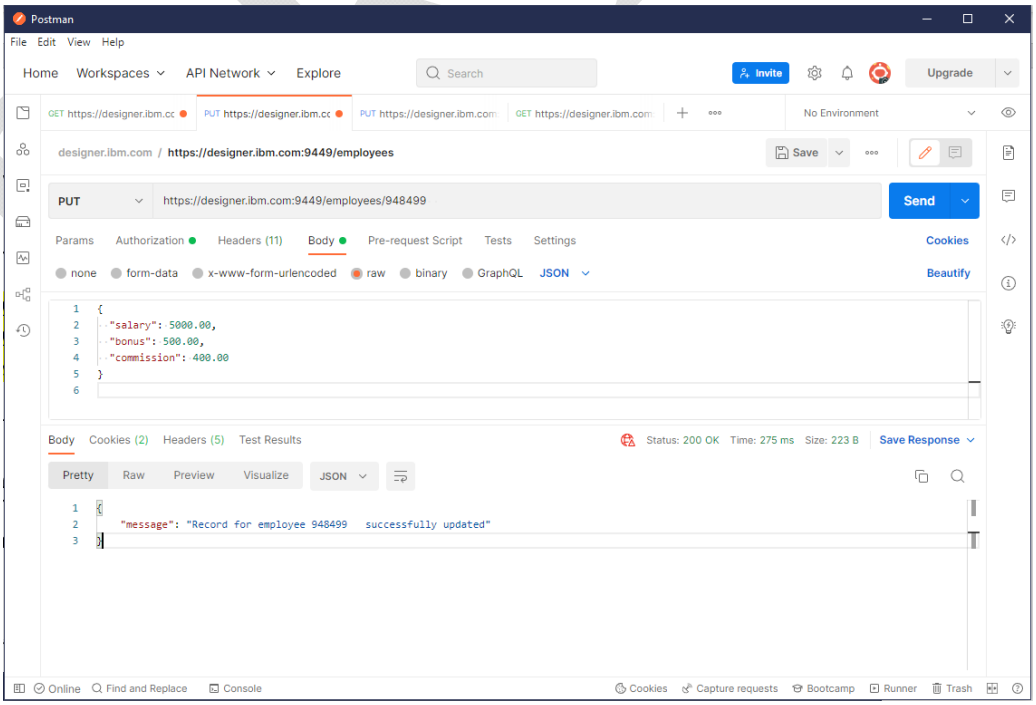
____4. Invoke the GET method with URL ***https://designer.washington.ibm.com:9449/employees/details/948499*** to display the record just inserted.



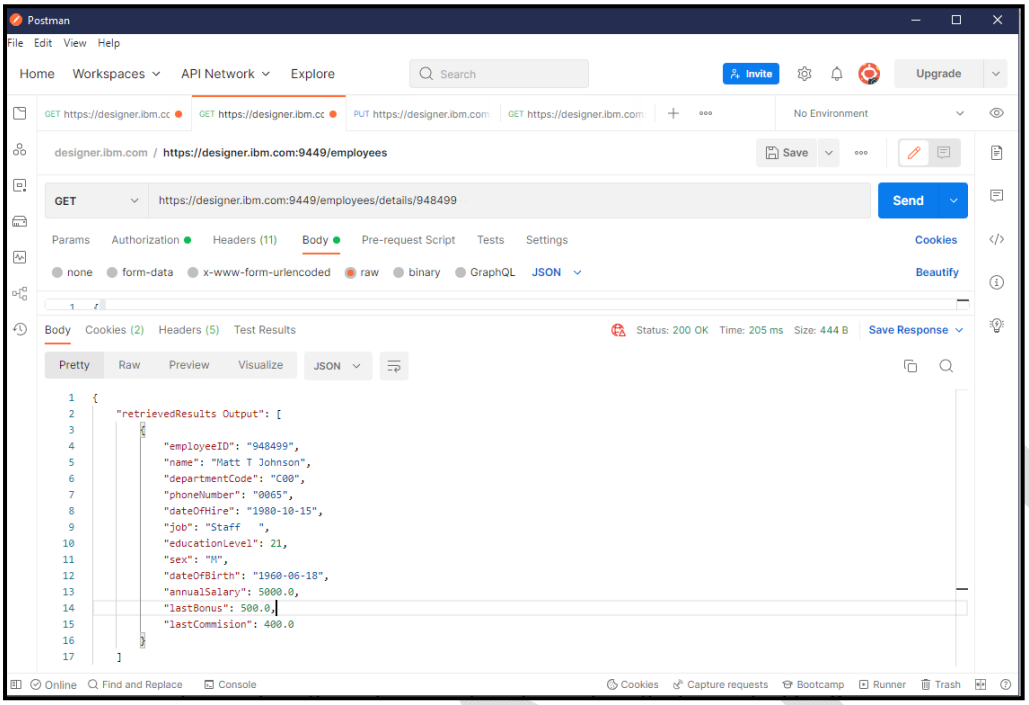
____5. Invoke a *PUT* method with URL ***https://designer.washington.ibm.com:9449/employees/948499*** and the JSON below for the request message to update the *salary, bonus, and commission* columns of this row.

```
{
  "salary": 5000.00,
  "bonus": 500.00,
  "commission": 400.00
}
```

____6.

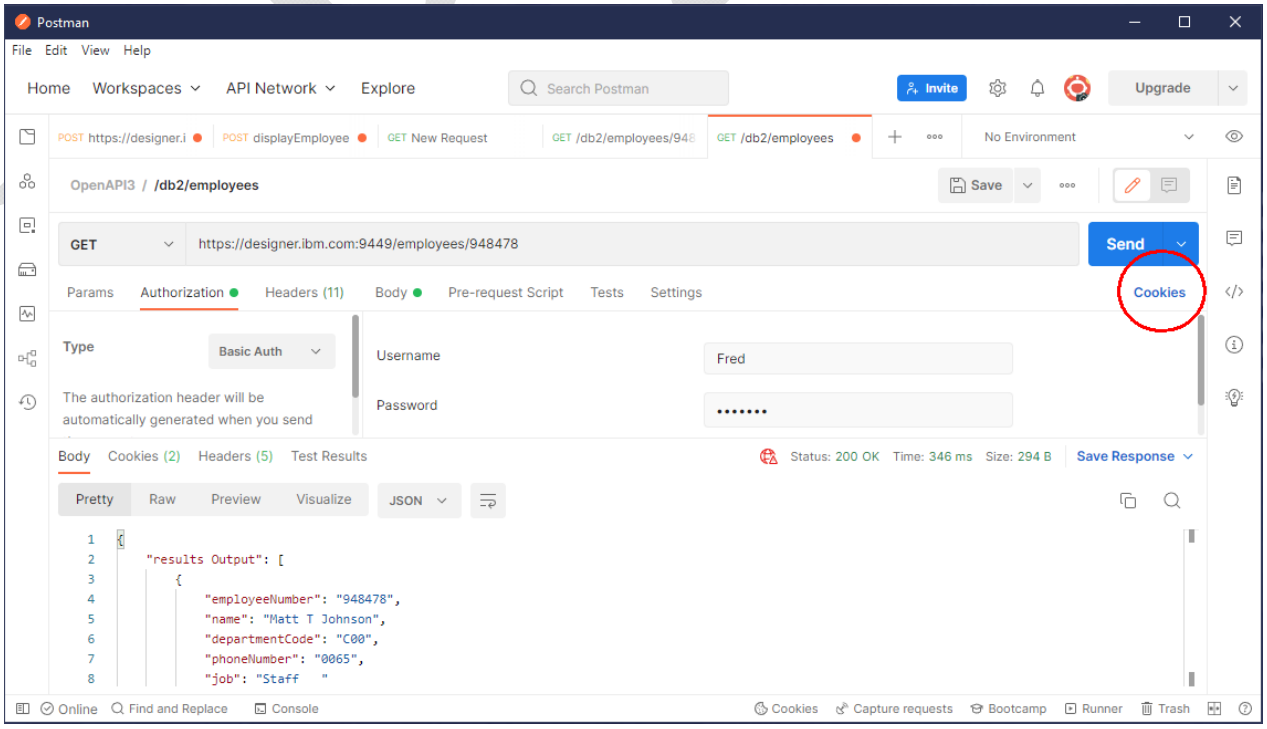


____7. Display the updated record by using a *GET* method with URL ***https://designer.washington.ibm.com:9449/employees/details/948499***

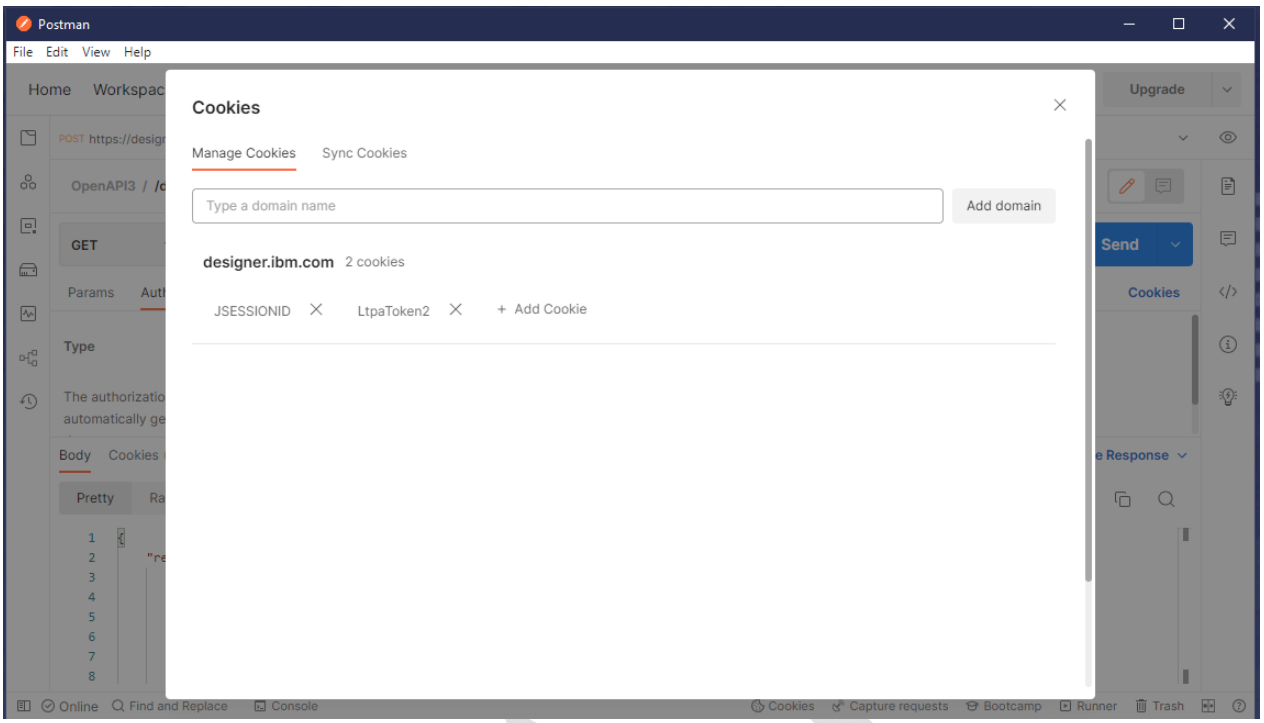


____8. Up until this point you have been using the role assigned to user *Fred*. Now experiment using user *user1* and/or *user2*. Before we can use other credentails we have to clear the credentails that cached by *Postman*. Unless this is done, *Postman* will continue to use the credentails for *Fred* regardless of what is provided in the authorization header.

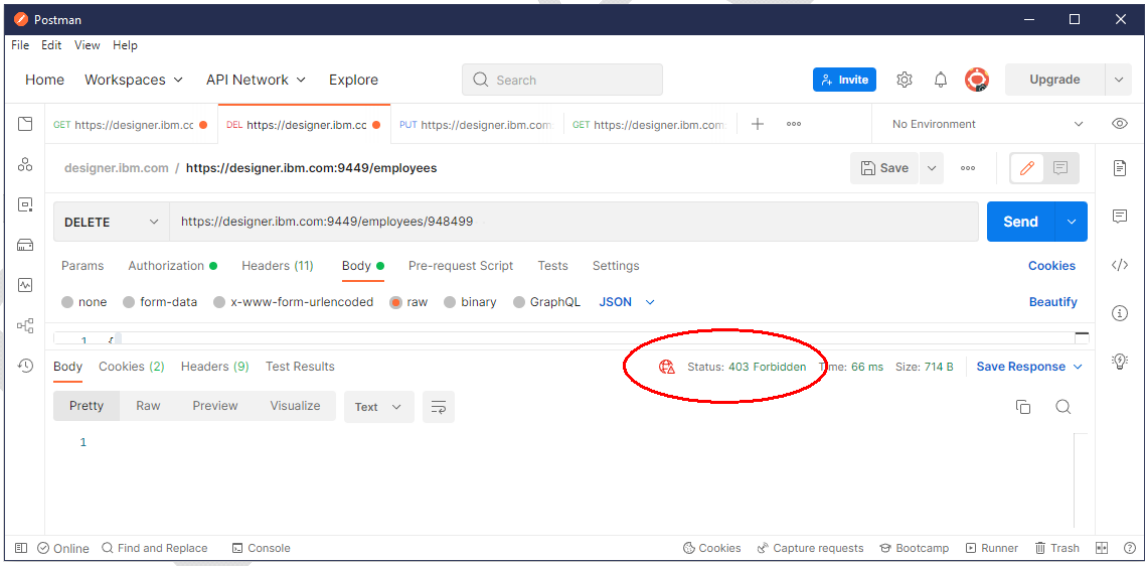
____9. To clear the *Postman* cachced security tokens, click on the *Cookies* section of the *Postman* window and



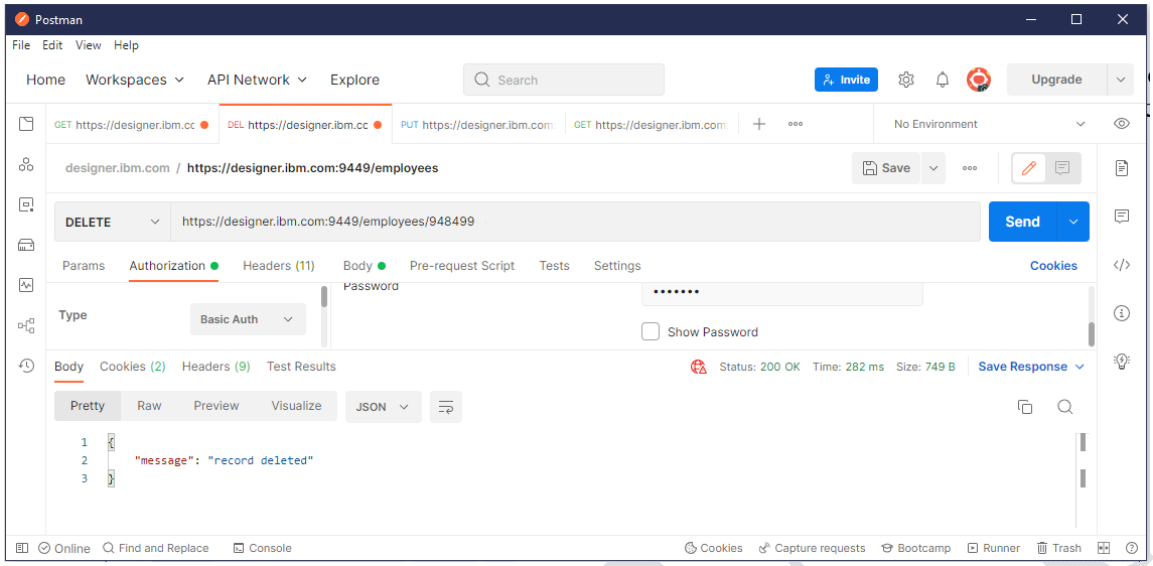
And delete any *JSESSIONID* and *LtpaToken2* cookies displayed.



Test various methods using Username *user1* and *user2* and observe the results. Remember, *user1* can only invoke *GET* methods and *user2* can not invoke any method. For example, if you try to delete a record as *user1*, you should see an HTTP Status code of 403 (Forbidden).



While an delete request by Fred is successful.



Using cURL

Client for URL (*cURL*) is a common tool for driving REST client request to APIs. In this section, the *curl* command will be used to test the API's methods deployed into the *z/OS Connect Designer's* container and more importantly, demonstrate role-based security. *Postman* caches security credentials between tests and the cached credentials must be cleared if the identity being used is changed. *cURL* does not this caching of credentials and therefore it is easier to change security credentials between request with *cURL* than with *Postman*.

____1. Start a DOS command prompt session and go to directory *c:\z\openapi3, e.g.,* ***cd \z\openap3***.

____2. Enter the *curl* command below and observe the response.

```
curl -X GET  -w " - HTTP CODE %{http_code}" --user Fred:fredpwd --header "Content-Type:
application/json" --insecure
https://designer.washington.ibm.com:9449/employees/details/000010
```

```
c:\z\openapi3>curl -X GET  -w " - HTTP CODE %{http_code}" --user Fred:fredpwd --
header "Content-Type: application/json" --insecure
https://localhost:9449/employees/details/000010
{"retrievedResults Output":[{"employeeID":"000010","name":"CHRISTINE I HAAS",
"departmentCode":"A00","phoneNumber":"3978","dateOfHire":"1965-01-01","job":"PRES
",
"educationLevel":18,"sex":"F","dateOfBirth":"1933-08-14","annualSalary":52750.0,
"lastBonus":1000.0,"lastCommision":4220.0}]} - HTTP CODE 200
```

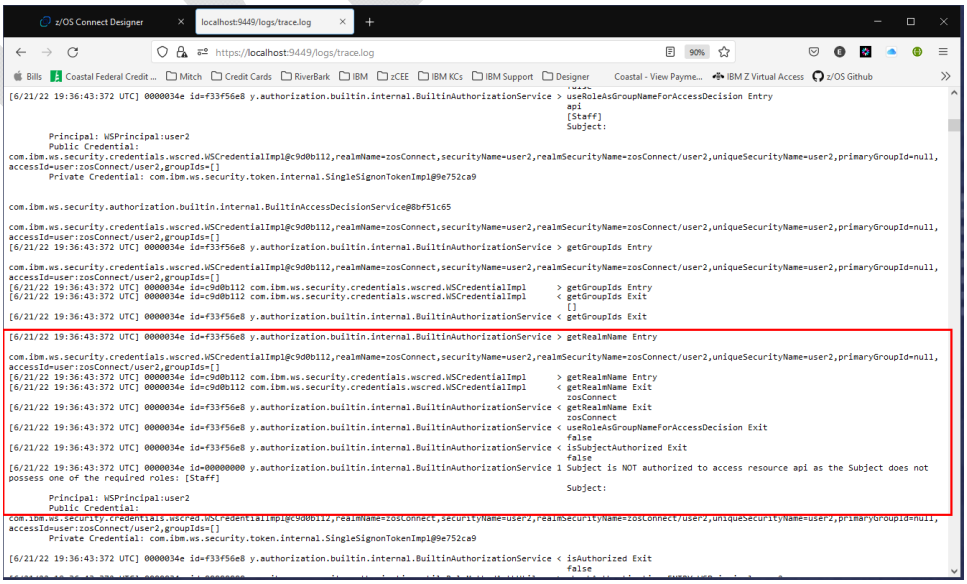
Fred is a member of the *Staff* group and has *Staff* access to the **Staff** role. Any identity with **Staff** access can invoke one of the GET methods.

____3. Enter the *curl* command below and observe the response.

```
curl -X GET  -w " - HTTP CODE %{http_code}" --user user2:user2 --header "Content-Type:
application/json" --insecure
https://designer.washington.ibm.com:9449/employees/details/000010
```

```
curl -X GET  -w " - HTTP CODE %{http_code}" --user user2:user2 --header "Content-
Type: application/json" --insecure
https://localhost:9449/employees/details/000010
```

A review of the trace.log file will show the HTTP 403 (Forbidden) occurred because the identity *user2* is not a member of the *Staff* group.



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Tech-Tip: If you had provided an invalid password, e.g., *–user user2:userx, the request would have failed with an HTTP status of 401, Unauthorized.*

____4. Enter the *curl* command below and observe the response.

```
curl -X POST -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fredpwd --data @insertEmployee.json https://designer.washington.ibm.com:9449/employees/
```

```
c:\z\openapi3>curl -X POST -w " - HTTP CODE %{http_code}"  --header "Content-Type: application/json" --insecure --user Fred:fredpwd --data @insertEmployee.json https://designer.washington.ibm.com:9449/employees/
{"message":"Record for employee number 948489  was added successfully"} - HTTP CODE 200
```

In the above command, the file insertEmployee.json has the contents below:

```
{
  "employeeNumber": "948489",
  "firstName": "Matt",
  "middleInitial": "T",
  "lastName": "Johnson",
  "departmentCode": "C00",
  "phoneNumber": "0065",
  "dateOfHire": "10/15/1980",
  "job": "Staff",
  "educationLevel": 21,
  "sex": "M",
  "dateOfBirth": "06/18/1960",
  "salary": 3999.99,
  "lastBonus": 399.99,
  "lastCommission": 119.99
}
```

____5. Enter the *curl* command below to invoke the *GET* method with URI path */roles/{job}.*

```
curl -X GET -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fredpwd https://designer.washington.ibm.com:9449/roles/PRES?dept=A00
```

```
curl -X GET -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fredpwd https://designer.washington.ibm.com:9449/roles/PRES?dept=A00
{"results Output":[{"employeeNumber":"[\"000010\",\"000011\"]","name":"[\"CHRISTINE\",\"CHRISTINE\"]
[\"I\",\"I\"] [\"HAAS\",\"HAAS\"]","department":"[\"A00\",\"A00\"]","phoneNumber":"[\"3978\",\"A1A1\"]",
"job":"[\"PRES    \",\"PRES    \"]"},{"employeeNumber":"[\"000010\",\"000011\"]","name":"[\"CHRISTINE\",
\"CHRISTINE\"][\"I\",\"I\"] [\"HAAS\",\"HAAS\"]","department":"[\"A00\",\"A00\"]","phoneNumber":"
[\"3978\",\"A1A1\"]","job":"[\"PRES    \",\"PRES    \"]"}]} - HTTP CODE 200
```

Now try using user2's credentials.

____6. Enter the *curl* command below to invoke the *DELETE* method with URI path */employees/{employee}*.

curl -X DELETE -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fredpwd https://designer.washington.ibm.com:9449/employees/948489

curl -X DELETE -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fredpwd https://designer.washington.ibm.com:9449/employees/948489
{"message":"record deleted"} - HTTP CODE 200

____7. Enter the *curl* command below to invoke the *DELETE* method again with URI path */employees/{employee}*.

curl -X DELETE -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user user1:user1 https://designer.washington.ibm.com:9449/employees/948489

curl -X DELETE -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user user1:user1 https://designer.washington.ibm.com:9449/employees/948489
- HTTP CODE 403

____8. Enter the *curl* command below to invoke the *PUT* with URI path */employees/{employee}*.

curl -X PUT -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fredpwd --data @updateEmployee.json https://designer.washington.ibm.com:9449/employees/948489

curl -X PUT -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fredpwd --data @updateEmployee.json https://designer.washington.ibm.com:9449/employees/948489
- HTTP CODE 200

In the above command, the file *updateEmployee.json* has the contents below:

```
{
  "salary": 5000.00,
  "bonus": 500.00,
  "commission": 400.00
}
```

Invoke other curl commands varying the credentials , methods, etc. until you feel comfortable the API is working as intended.

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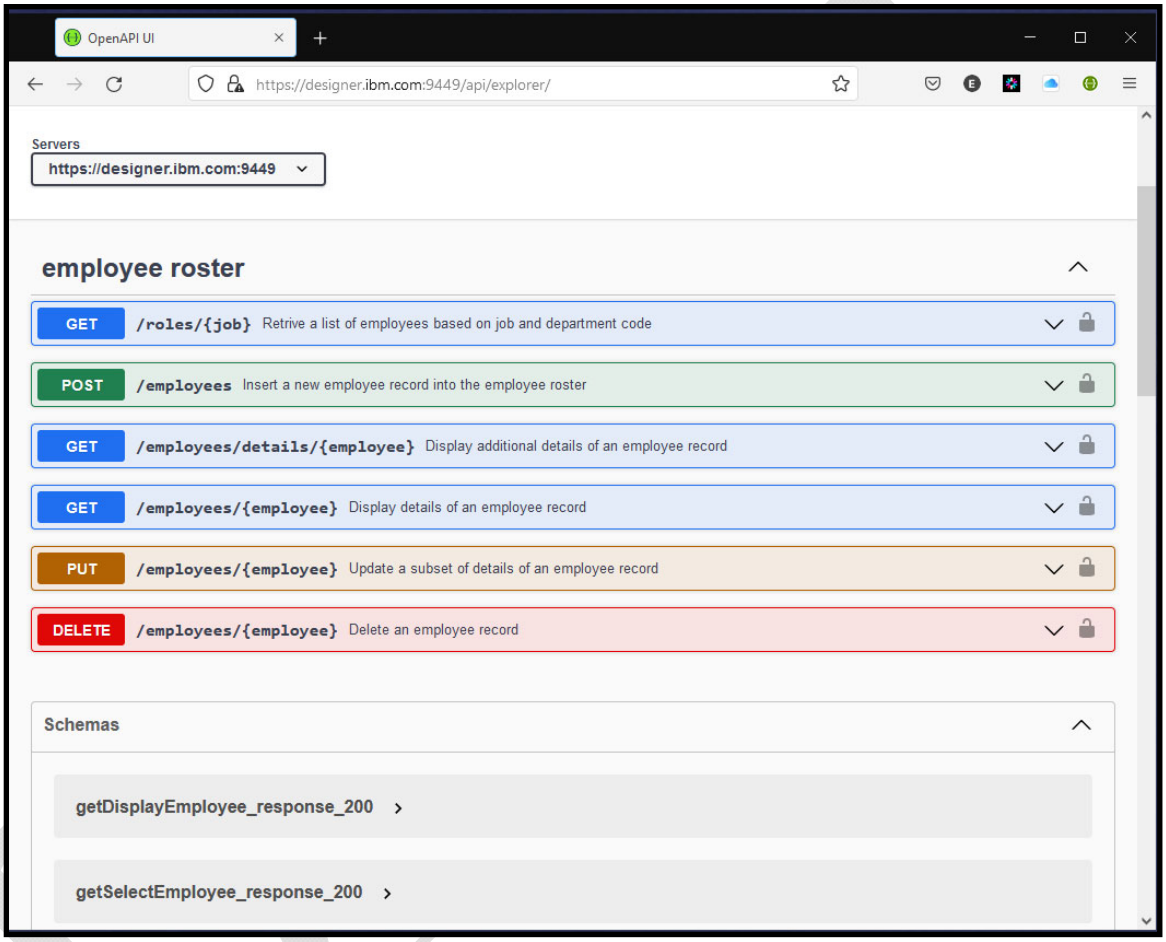
Using the API Explorer

The API Explorer was used in the Designer to test the APIs as they were being developed. The API Explorer All the URI paths and methods in the original OpenAPI 3 specification document will be displayed, but only the *POST* for */employees* and the *GET* for */employees/{employee}* have been created. Executing one of the other methods will return an HTTP 404 because the components required to execute these methods cannot be found in the WAR.

___1. Using the Firefox browser, go to URL ***https://designer.washington.ibm.com:9449/api/explorer*** to start the API Explorer.



Tech Tip: You may be challenged by browser because the digital certificate used by the *Designer* is self-signed Click the **Advanced** button to continue. Scroll down and then click on the **Accept the Risk and Continue** button. Next you may see a prompt you for a userid and password. If you do see the prompt, enter the username ***Fred*** and password **fredpwd** (case matters) and click **OK**. Remember we are using basic security, and this is the user identity and password defined in the server.xml file.

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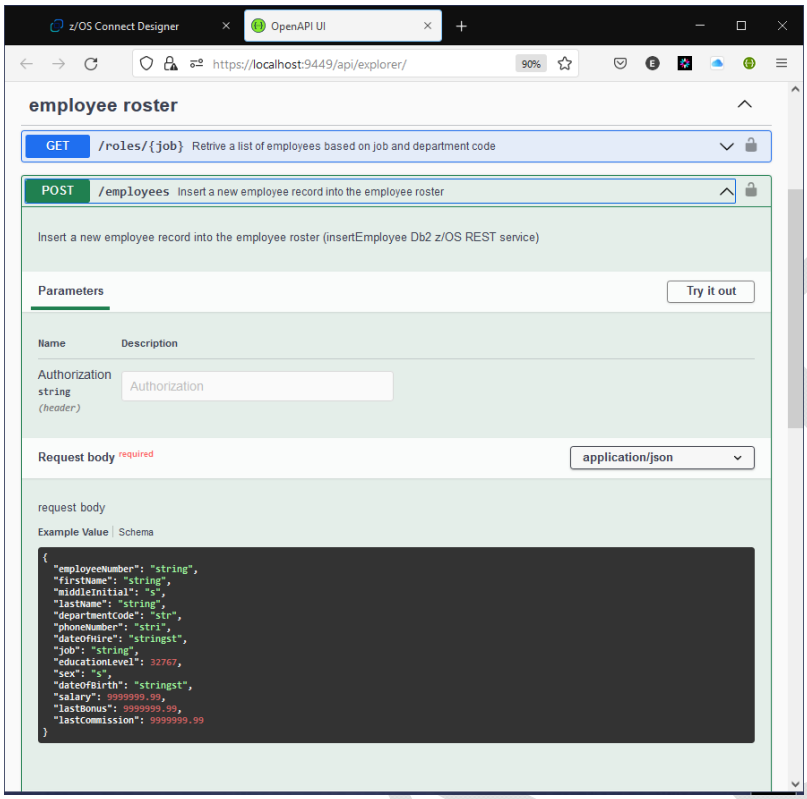
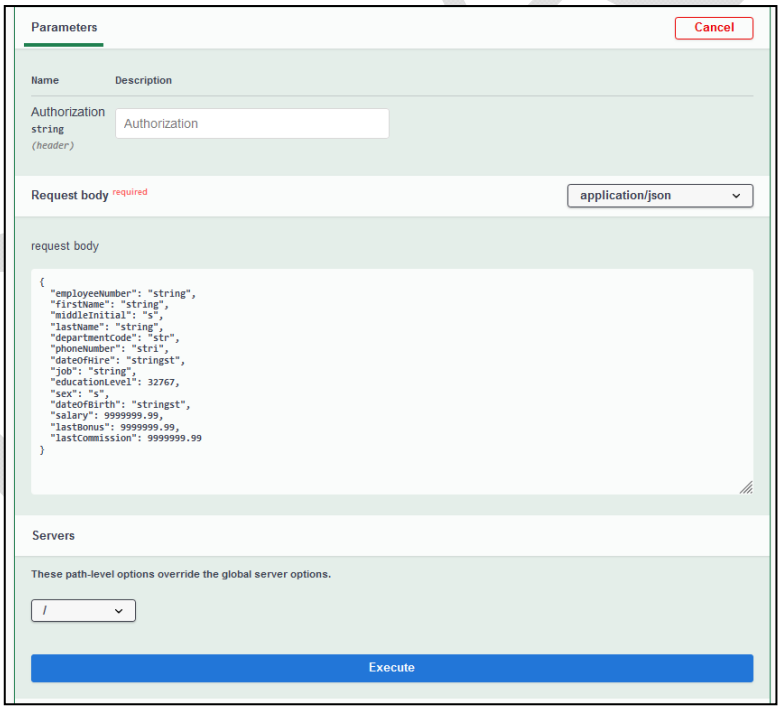
Click on *Post /employees* URI path to display the request body view of the URI path.



___2. Next press the ***Try it out*** button to enable the entry of an authorization string and a request message body



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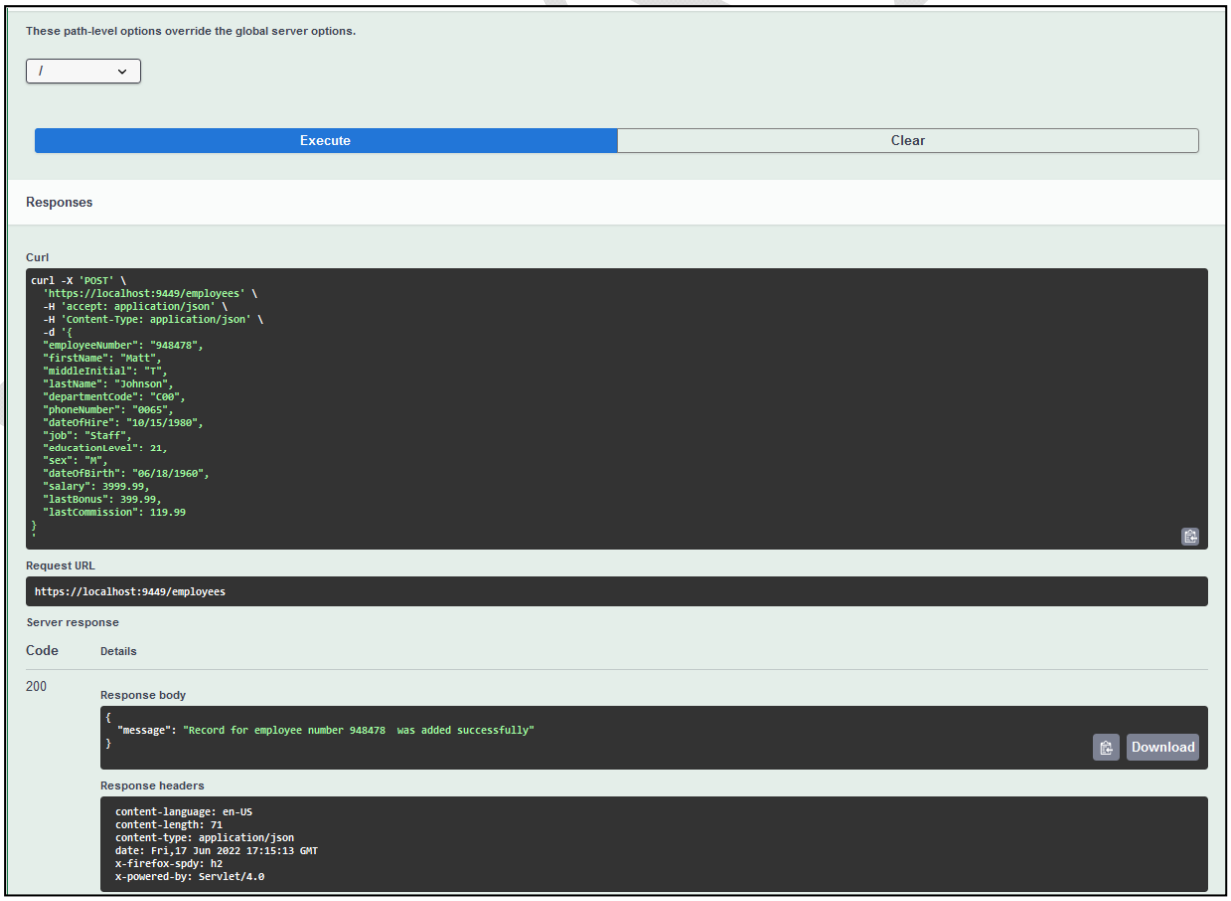
___3. Enter the JSON request message below in the *Request body* section and press the **Execute** button.

```
{
  "employeeNumber": "948478",
  "firstName": "Matt",
  "middleInitial": "T",
  "lastName": "Johnson",
  "departmentCode": "C00",
  "phoneNumber": "0065",
  "dateOfHire": "10/15/1980",
  "job": "Staff",
  "educationLevel": 21,
  "sex": "M",
  "dateOfBirth": "06/18/1960",
  "salary": 3999.99,
  "lastBonus": 399.99,
  "lastCommission": 119.99
}
```

___4. Security was enabled in the original specification document, so you will be required to sign in with one of the identities defined in the basicSecurity.xml file explored earlier. Use ***Fred*** for the *Username* and ***fredpwd*** for the *Password*. Please note that this identity can be changed unless all browser sessions are stopped.

___5. Scroll down the view and you should see the *Response body* with the expected successful message.



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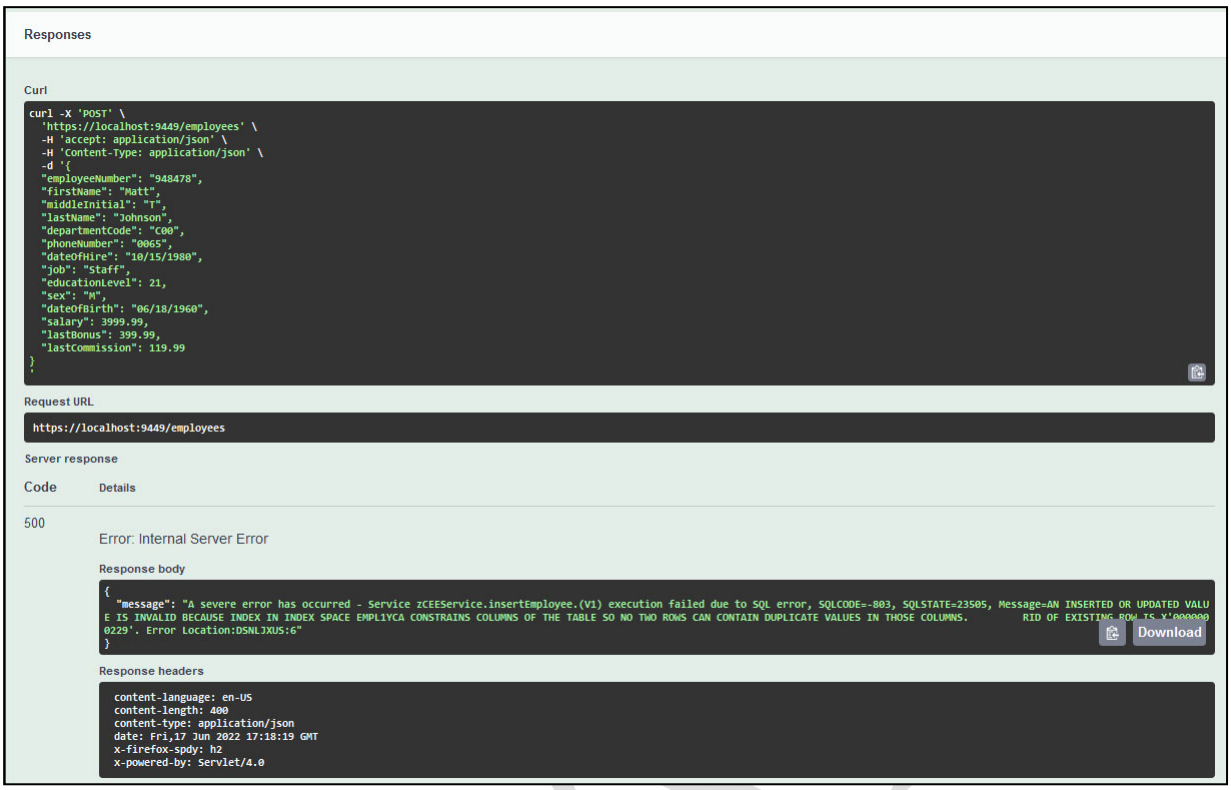
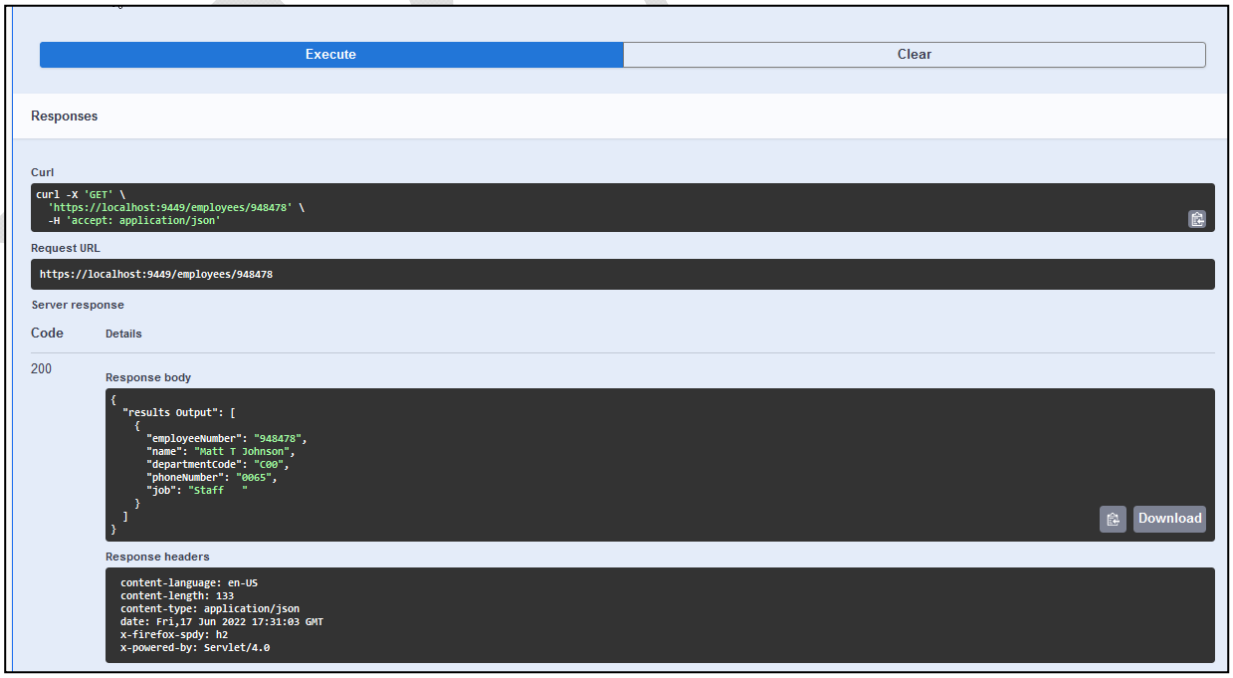
___6. Press the **Execute** button again and observe the results. A row for this employee number already existed in the employee roster (a Db2 tables) so the request failed with an HTTP 500.



___7. Scroll down and click on *GET /employees/{employees}* URI path to display the request body view of the URI path for this method. Next click on the ***Try it out*** button to enable the entry of data for this method. Enter ***948478*** as the employee identity and press the **Execute** button to retrieve a subset of data for this employee.



___8. Try this again using number ***121212*** and observe the results. You see the message that the employee was not found.

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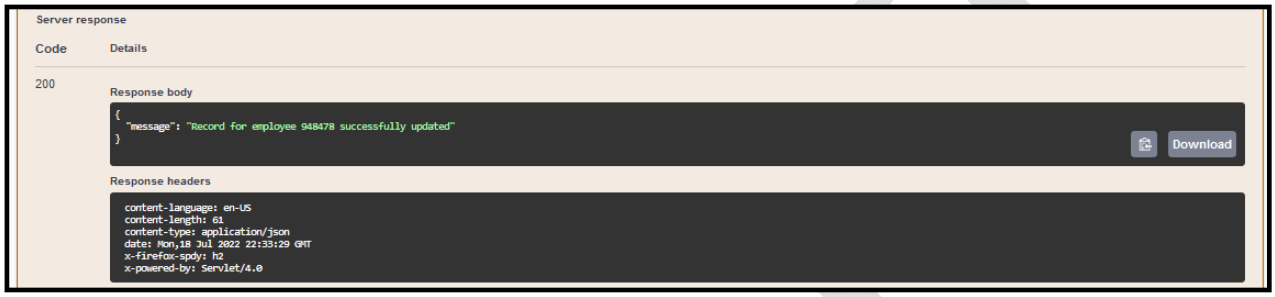
___9. Expand the *PUT* method and enter press the **Try it out** button.

___10. Enter ***948478*** in the *employee* field and paste the JSON below in the request body area.

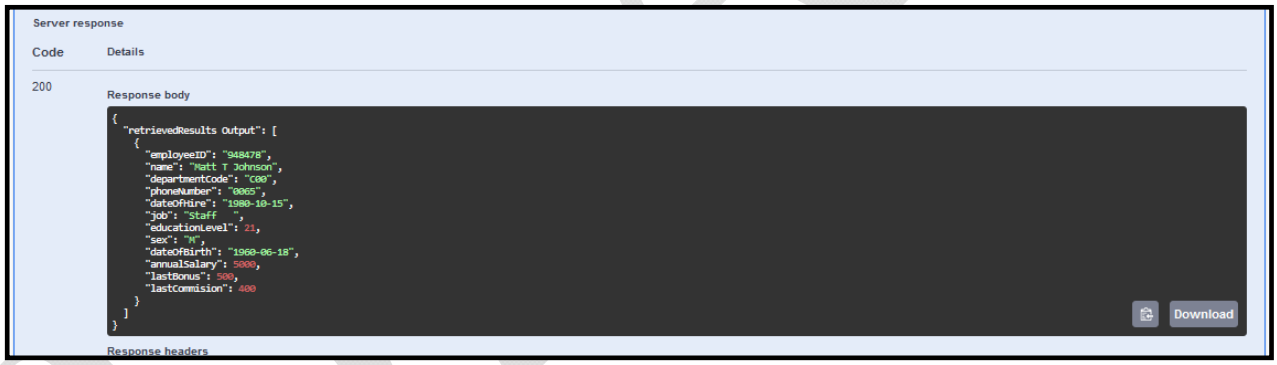
```
{
  "salary": 5000.00,
  "bonus": 500.00,
  "commission": 400.00
}
```

___11. Press the **Execute** button.



___12. Expand the *GET* method for URI path */employees/details/{employee}* and enter press the **Try it out** button.

___13. Enter ***948478*** in the *employee* field and press the **Execute** button. Observe that the updates values have been applied.



___14. Expand the *DELETE* method for URI path */employees/{employee}* and enter press the **Try it out** button. Observe the record has been deleted.

___15. Repeat either of the two *GET* method request for employee ***948478*** and you see a message that the record could not be found.

Try other methods using other rows in the table. The initial contents of the Db2 table are shown below.

EMPNO	FIRSTNME	MIDINIT	LASTNAME	WORKDEPT	PHONENO	HIREDATE	JOB	EDLEVEL	SEX	Birthdate	Salary	Bonus	COMM
000011	CHRISTINE	I	HAAS	A00	A1A1	1965-01-01	PRES	18	F	1933-08-14	52750.00	1000.00	4220.00
000020	MICHAEL	L	THOMPSON	B01	3476	1973-10-10	MANAGER	18	M	1948-02-02	41250.00	800.00	3300.00
000030	SALLY	A	KWAN	C01	4738	1975-04-05	MANAGER	20	F	1941-05-11	38250.00	800.00	3060.00
000050	JOHN	B	GEYER	E01	6789	1949-08-17	MANAGER	16	M	1925-09-15	40175.00	800.00	3214.00
000060	IRVING	F	STERN	D11	6423	1973-09-14	MANAGER	16	M	1945-07-07	32250.00	600.00	2580.00
000070	EVA	D	PULASKI	D21	7831	1980-09-30	MANAGER	16	F	1953-05-26	36170.00	700.00	2893.00
000090	EILEEN	W	HENDERSON	E11	5498	1970-08-15	MANAGER	16	F	1941-05-15	29750.00	600.00	2380.00
000100	THEODORE	Q	SPENSER	E21	0972	1980-06-19	MANAGER	14	M	1956-12-18	26150.00	500.00	2092.00
000110	VINCENZO	G	LUCCHESI	A00	3490	1958-05-16	SALESREP	19	M	1929-11-05	46500.00	900.00	3720.00
000120	SEAN		O'CONNELL	A00	2167	1963-12-05	CLERK	14	M	1942-10-18	29250.00	600.00	2340.00
000130	DOLORES	M	QUINTANA	C01	4578	1971-07-28	ANALYST	16	F	1925-09-15	23800.00	500.00	1904.00
000140	HEATHER	A	NICHOLLS	C01	1793	1976-12-15	ANALYST	18	F	1946-01-19	28420.00	600.00	2274.00
000150	BRUCE		ADAMSON	D11	4510	1972-02-12	DESIGNER	16	M	1947-05-17	25280.00	500.00	2022.00
000160	ELIZABETH	R	PIANKA	D11	3782	1977-10-11	DESIGNER	17	F	1955-04-12	22250.00	400.00	1780.00
000170	MASATOSHI	J	YOSHIMURA	D11	2890	1978-09-15	DESIGNER	16	M	1951-01-05	24680.00	500.00	1974.00
000180	MARILYN	S	SCOUTTEN	D11	1682	1973-07-07	DESIGNER	17	F	1949-02-21	21340.00	500.00	1707.00
000190	JAMES	H	WALKER	D11	2986	1974-07-26	DESIGNER	16	M	1952-06-25	20450.00	400.00	1636.00
000200	DAVID		BROWN	D11	4501	1966-03-03	DESIGNER	16	M	1941-05-29	27740.00	600.00	2217.00
000210	WILLIAM	T	JONES	D11	0942	1979-04-11	DESIGNER	17	M	1953-02-23	18270.00	400.00	1462.00
000220	JENNIFER	K	LUTZ	D11	0672	1968-08-29	DESIGNER	18	F	1948-03-19	29840.00	600.00	2387.00
000230	JAMES	J	JEFFERSON	D21	2094	1966-11-21	CLERK	14	M	1935-05-30	22180.00	400.00	1774.00
000240	SALVATORE	M	MARINO	D21	3780	1979-12-05	CLERK	17	M	1954-03-31	28760.00	600.00	2301.00
000250	DANIEL	S	SMITH	D21	0961	1969-10-30	CLERK	15	M	1939-11-12	19180.00	400.00	1534.00
000260	SYBIL	V	JOHNSON	D21	8953	1975-09-11	CLERK	16	F	1936-10-05	17250.00	300.00	1380.00
000270	MARIA	L	PEREZ	D21	9001	1980-09-30	CLERK	15	F	1953-05-26	27380.00	500.00	2190.00
000280	ETHEL	R	SCHNEIDER	E11	8997	1967-03-24	OPERATOR	17	F	1936-03-28	26250.00	500.00	2100.00
000290	JOHN	R	PARKER	E11	4502	1980-05-30	OPERATOR	12	M	1946-07-09	15340.00	300.00	1227.00
000300	PHILIP	X	SMITH	E11	2095	1972-06-19	OPERATOR	14	M	1936-10-27	17750.00	400.00	1420.00
000310	MAUDE	F	SETRIGHT	E11	3332	1964-09-12	OPERATOR	12	F	1931-04-21	15900.00	300.00	1272.00
000320	RAMLAL	V	MEHTA	E21	9990	1965-07-07	FIELDREP	16	M	1932-08-11	19950.00	400.00	1596.00
000330	WING		LEE	E21	2103	1976-02-23	FIELDREP	14	M	1941-07-18	25370.00	500.00	2030.00
000340	JASON	R	GOUNOT	E21	5698	1947-05-05	FIELDREP	16	M	1926-05-17	23840.00	500.00	1907.00

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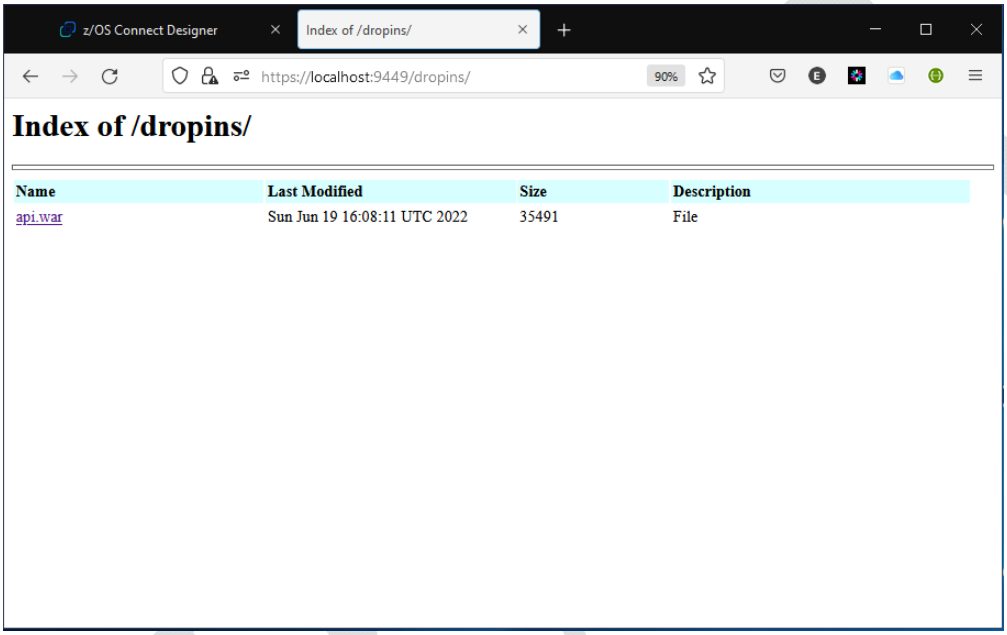
Deploying and installing APIs in a z/OS Connect Native Server

As the *z/OS Connect Designer* is being used to develop the API from specification file, a Web Archive (WAR) file is being constantly regenerated and being automatically deployed to the z/OS Connect server embedded in the *Designer.* This section of the exercises provides details on how this WAR file can be extracted from the *Designer* container, moved to a zOS OMVS directory, and then added to a native z/OS Connect server.

Moving the API Web Archive file from the container to a z/OS OMVS directory

___1. The first step is to use the file serving capability added the Liberty server's configuration. Use a web browser to access URL https://designer.washington.ibm.com:9449/dropins.



Double click the *api.war* file and save the file in local directory, e.g., *c:\z\openApi3\wars*. Specify a *File* name of ***employees.war***.

___2. Open a DOS command prompt and use the change directory command to go to directory C:\z\openApi3\wars, e.g., ***cd C:\z\openApi3\wars***

___3. Start a file transfer session with the WG31 host using the *ftp* command, e.g., **ftp wg31**

___4. Logon as USER1 and then use the *cd* command to change to directory to data set */var/zcee/openApi3/apps, e.g.* ***cd /var/zcee/openApi3/apps***

___5. Toggle prompting off by entering command **prompt**

___6. Enter binary mode transmission but entering command **bin**

___7. Perform multiple put requests by using the multiple put command, **mput employees.war**

___8. When the last transfer has completed enter the **quit** command.

```
c:\z\openApi3> cd wars
c:\z\openApi3\wars>ftp wg31.washington.ibm.com
Connected to wg31.washington.ibm.com.
220-FTP 16:26:23 on 2018-02-15.
220 Connection will close if idle for more than 200 minutes.
User (wg31.washington.ibm.com:(none)): user1
331 Send password please. user1
Password:
230 USER1 is logged on.  Working directory is "USER1.".
ftp> cd /var/zcee/openApi3
250 HFS directory /var/zcee/openApi3/apps is the current working directory
ftp> prompt
Interactive mode Off .
ftp> bin
200 Representation type is Image
ftp> mput employees.war
200 Port request OK.
125 Storing data set /var/zcee/openApi3/apps/employees.war
250 Transfer completed successfully.
ftp: 35491 bytes sent in 0.39Seconds 90.77Kbytes/sec.
ftp> quit
```

These steps have moved the WAR file from the Designer container to the OMVS directory accessible by the z/OS Connect native server.

Updating the server xml

The next step is to add a *webApplication* server XML configuraton element for the API to the OpenAPI 3 server's configuration.

___1. Edit OMVS file **server.xml** in directory */var/zcee/openApi3* and add this configuration element.

```
<webApplication id="db2" contextRoot="/db2"  name="db2API"
location="${server.config.dir}apps/employees.war"/>
```

The addition of this configuration adds the web application found in the *employees.war* file to the server's configuration. The context root of */db2* is prepended is to the URI paths of each URI path found in the web application to ensure the uniqueness of this API's URI paths versus the URI paths of other APIs installed in the server.

___2. Use MVS modify command ***F ZCEEAPI3,REFRESH,CONFIG*** to have the server XML changes installed.

Tech-Tip: To refresh an application using the MVS modify command ***F ZCEEAPI3,REFRESH,APPS***

This completes the installation of the API's web application.

Defining the required RACF EJBRole resources

The API has been installed but the required RACF EJBRoles have not been defined and access permitted. This section describes the steps required to complete the RACF configuration required to execute the API.

Remember the specification file defined two roles for invoking the methods of this API, *Manager* and *Staff*. In the basicSecurity.xml configuration file we saw how we configured these roles and granted access to the roles in a Liberty internal registry. On z/OS we want to use RACF. The names of the required RACF EJBRoles are derived by combining information from 3 sources. The first is the *profilePrefix* attribute of the server XML *safCredentials* configuration element. In our case, the value of *profilePrefix* is **ATSZDFLT**. The next source is the name of the web application. The name of the web application is either derived from information in the specification or the *name* attribute provided on the webApplication configuration element. In our case, this value should be **db2API**. The final source is the role name provided in the specification document, **Manager** or **Staff**. So, two EJBRoles need to be defined, **ATSZDFLT.db2API.Manager** and **ATSZDFLT.db2API.Staff**.

___1. Use the RACF RDEFINE command to define EJBROLE **ATSZDFLT.db2API.Manager.**

```
rdefine ejbrole ATSZDFLT.db2API.Manager   uacc(none)
```

___2. Use the RACF RDEFINE command to define EJBROLE **ATSZDFLT.db2API.Staff.**

```
rdefine ejbrole ATSZDFLT.db2API.Staff  uacc(none)
```

___3. Use the RACF PERMIT command to permit identity FRED READ access to EJBROLE **ATSZDFLT.db2API.Manager.**

```
permit ATSZDFLT.db2API.Manager  class(ejbrole) id(fred) acc(read)
```

___4. Use the RACF PERMIT command to permit identity FRED READ access to EJBROLE **ATSZDFLT.Db2API.STAFF.**

```
permit ATSZDFLT.db2API.Staff  class(ejbrole) id(fred) acc(read)
```

___5. Use the RACF PERMIT command to permit identity USER1 READ access to EJBROLE **ATSZDFLT.Db2API.STAFF.**

```
permit ATSZDFLT.db2API.Staff  class(ejbrole) id(user1) acc(read)
```

___6. Use the RACF SETROPTS command to refresh the EJBRole instorage profiles.

```
setropts raclist(ejbrole) refresh
```

Now we are ready to test the invoking of the methods of this API.

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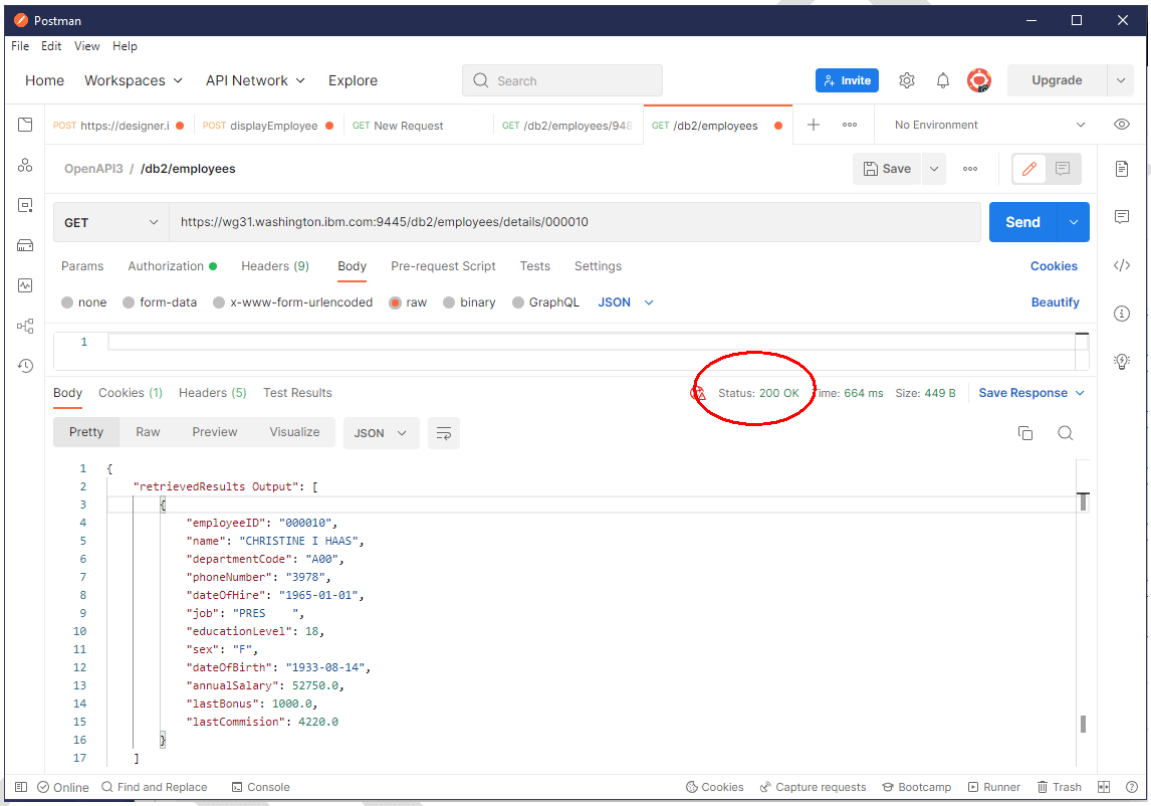
Testing APIs deployed in a native z/OS server

Using Postman

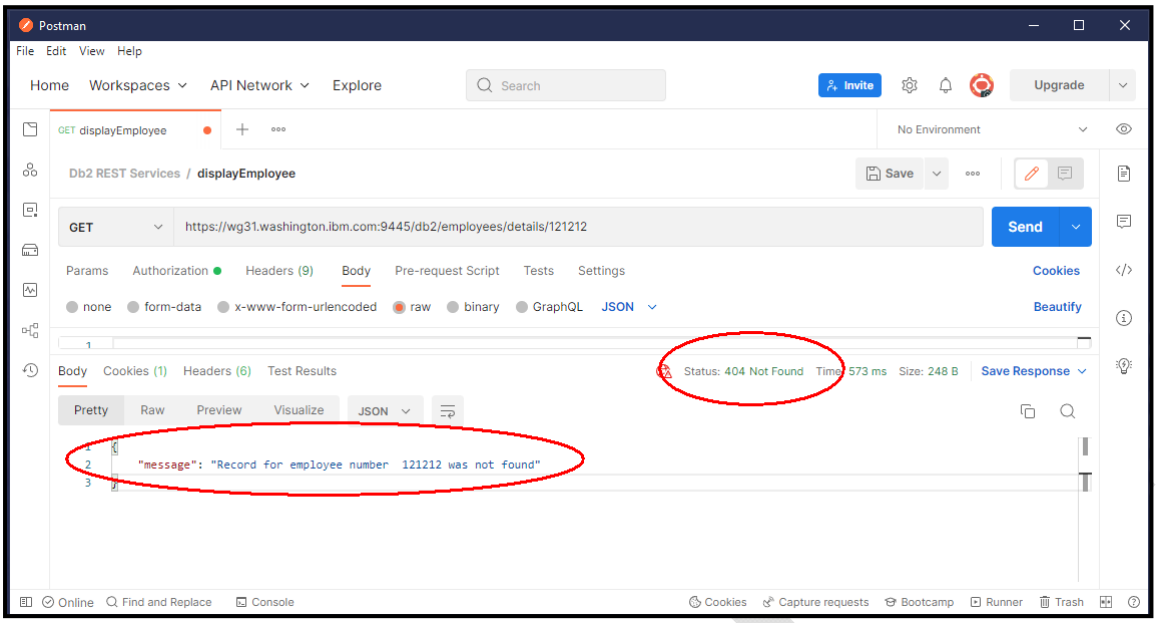
Start a Postman session using the Postman icon on the desktop.

____1. Open the *Postman* tool icon on the desktop and if necessary reply to any prompts and close any welcome messages. Set *Authorization* type to to basic and use ***fred*** as the *Username* and ***fred*** as the *Password* as we did when directly testing the Db2 REST services and add a header preoprty of ***Content-Type*** with a value of ***application/json***. Then use the down arrow in the *Body* tab to select **GET** and enter ***https://wg31.washington.ibm.com:9445/db2/employees/details/000010*** in the URL area (see below) and press **Send**. You should see results like below in the response *Body* area.

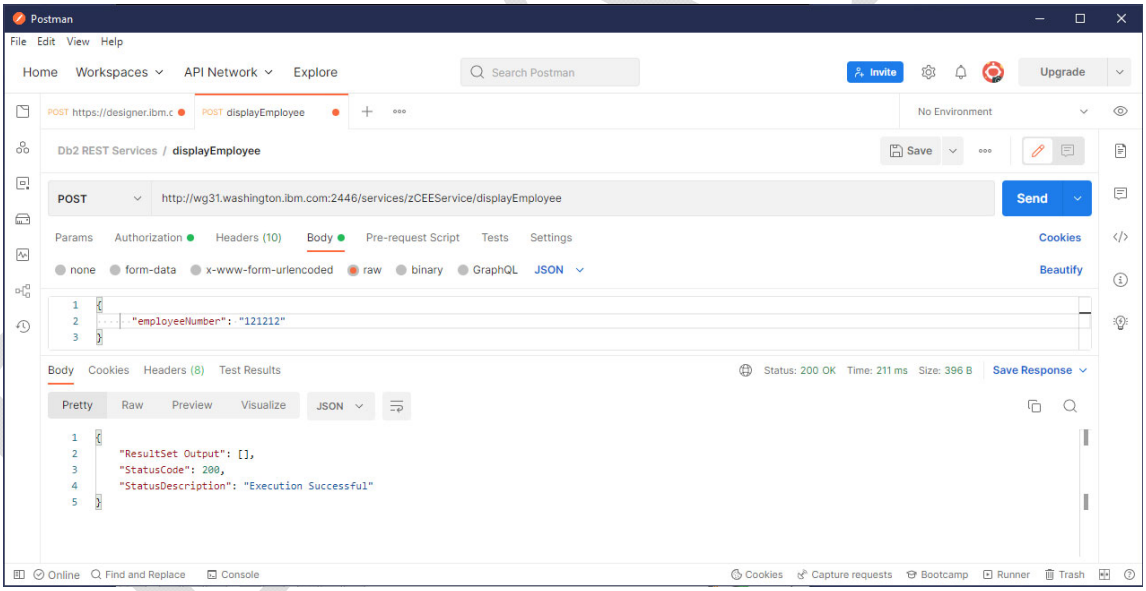


Notice what is different from the earlier testing when the API was deployed in the *Designer* container. First the credentials were for the RACF credentials (*fred*) with access to the RACF EJBRole. The other major differences was of the context root of */db2* in the URI path. This was the value of the *contextRoot* attribute in the *webApplication* configuration element that defined this application in the z/OS Connect server.

____2. Next enter an invalid employee number such as 121212, ***https://wg31.washington.ibm.com:9445/db2/employees/details/121212*** in the URL area (see below) and press **Send**. You should see results like below in the response *Body* area.



If you invoked the underlying Db2 REST service *(/services/zCEEService/displayEmployee*) you would receive an HTTP 200 with an empty *ResultSet Output* array.



The API created in the *Designer* essentially intercepted the response from the Db2 service and was to determine no results were found and returned an HTTP 404 (not found) to the client rather than an HTTP 200 (OK).

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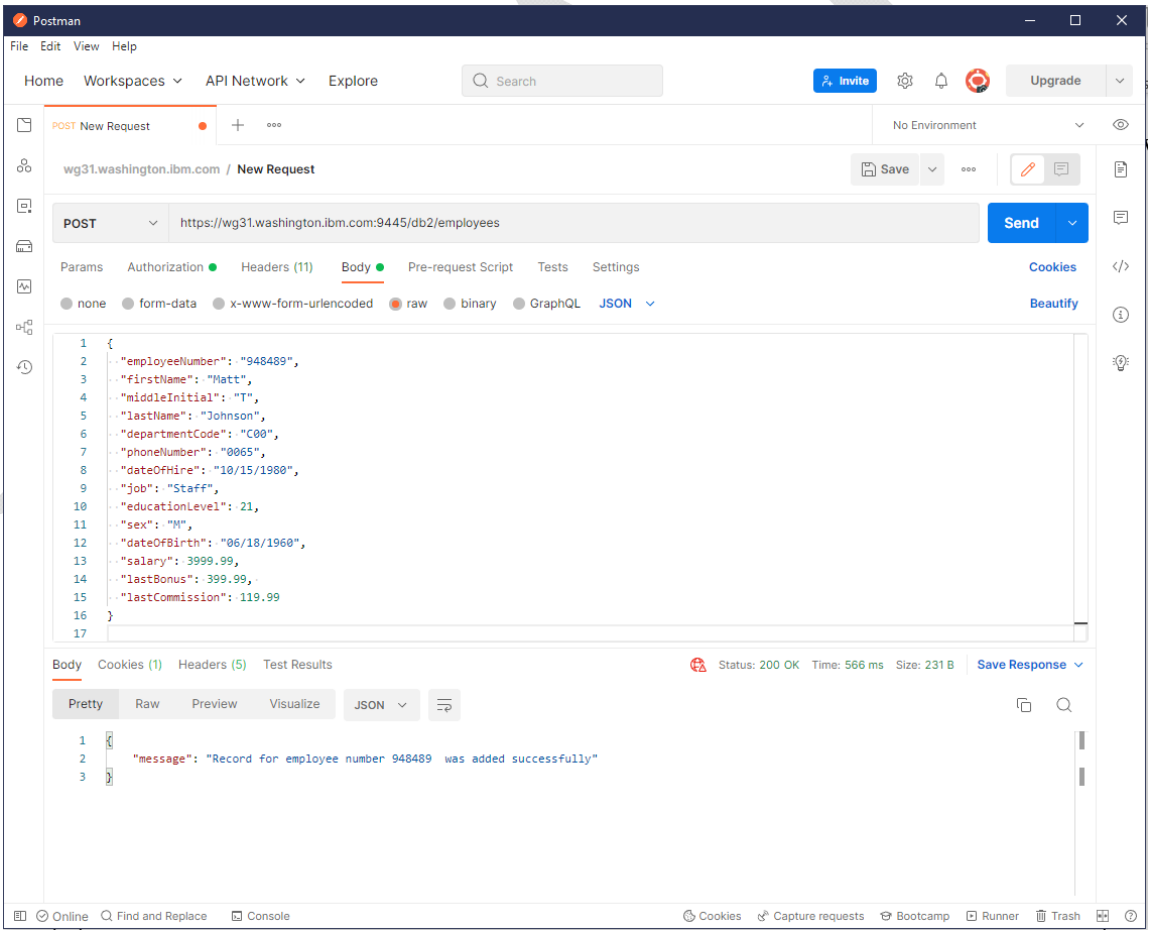
Optional, experiment using *Postman* to invoke other methods of the API. For example, if you want to invoke a *POST* with URI path */employees,* use the JSON below for the request message.

```
{
  "employeeNumber": "948489",
  "firstName": "Matt",
  "middleInitial": "T",
  "lastName": "Johnson",
  "departmentCode": "C00",
  "phoneNumber": "0065",
  "dateOfHire": "10/15/1980",
  "job": "Staff",
  "educationLevel": 21,
  "sex": "M",
  "dateOfBirth": "06/18/1960",
  "salary": 3999.99,
  "lastBonus": 399.99,
  "lastCommission": 119.99
}
```



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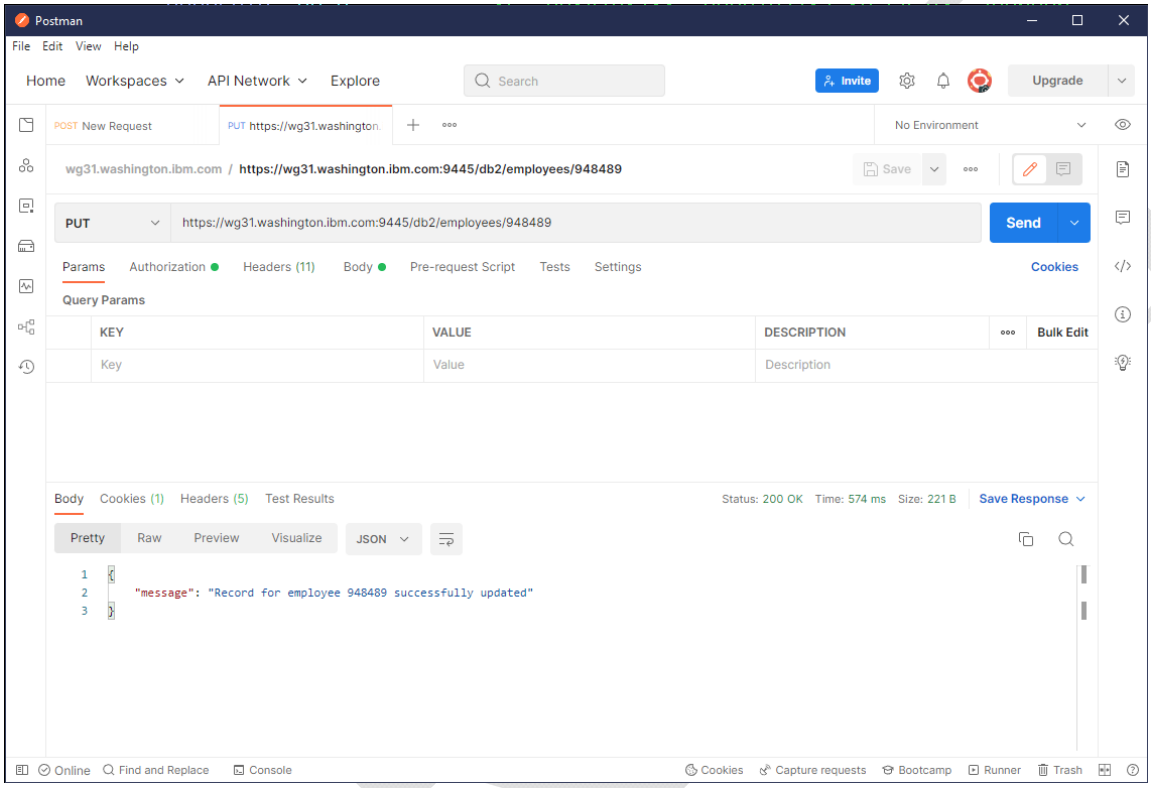
Or if you want to do a *PUT* with URI path /db2/employees/{employee} use this JSON request message.

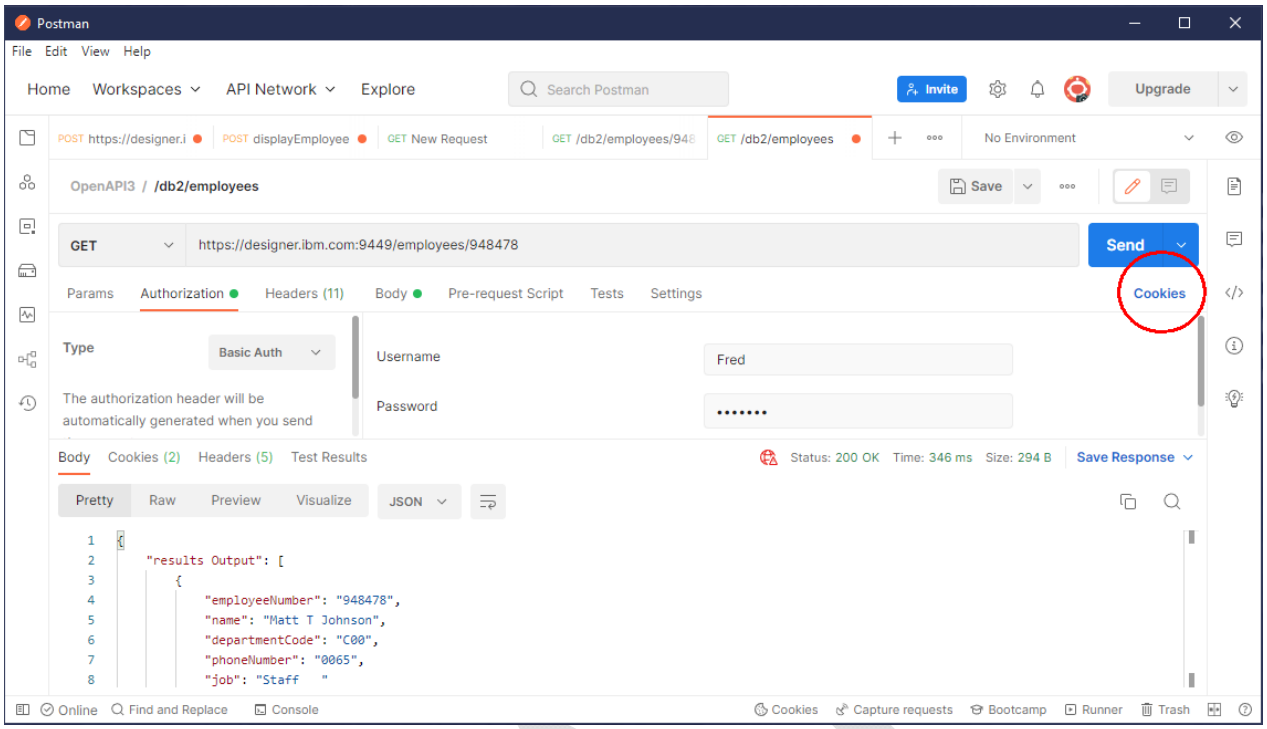
https://wg31.washington.ibm.com:9445/db2/employees/948489

```
{
  "salary": 5000.00,
  "bonus": 500.00,
  "commission": 400.00
}
```

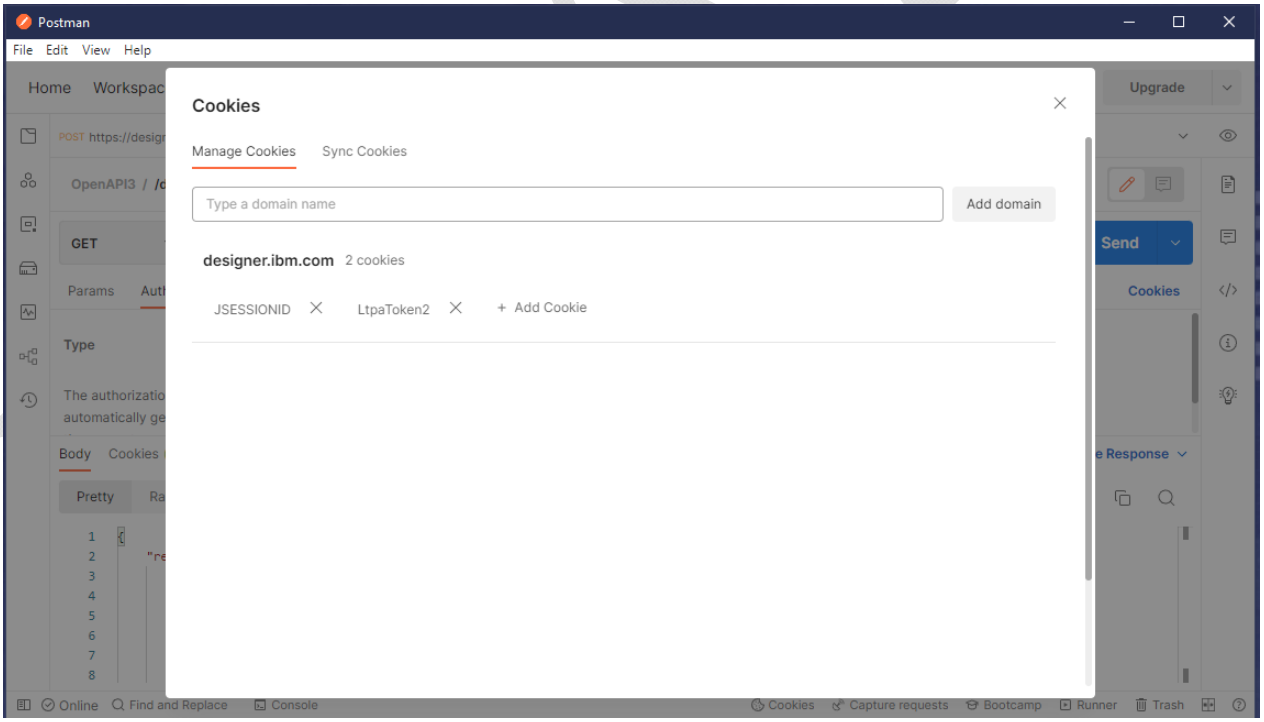


____3. Up until this point you have been using the role assigned to user *Fred*. Now experiment using user *user1* and/or *user2*. Before we can use other credentails we have to clear the credentails that cached by *Postman*. Unless this is done, *Postman* will continue to use the credentails for *Fred* regardless of what is provided in the authorization header

____4. To clear the *Postman* cachced tokens, click on the *Cookies* section of the *Postman* window and



And delete any *JSESSIONID* and *LtpaToken2* cookies displayed.



Test various methods using Username *user1* and *user2* and observe the results. Remember, *user1* can only invoke GET methods and *user2* can not invoke any method.

Using cURL

Client for URL (*cURL*) is a common tool for driving REST client request to APIs. In this section, the *curl* command will be used to test the API's methods deployed into the *z/OS Connect Designer's* container and more importantly, demonstrate role-based security. *Postman* caches security credentials between tests and the cached credentials must be cleared if the identity being used is changed. *cURL* does not this caching of credentials and therefore it is easier to change security credentials between request with *cURL* than with *Postman*.

____1. Start a DOS command prompt session and go to directory *c:\z\openapi3, e.g.,* ***cd \z\openap3***.

____2. Enter the *curl* command below and observe the response.

curl -X GET -w " - HTTP CODE %{http_code}" --user Fred:fred --header "Content-Type: application/json" --insecure https://wg31.washington.ibm.com:9445/db2/employees/details/000010

c:\z\openapi3>***curl -X GET -w " - HTTP CODE %{http_code}" --user Fred:fredpwd --header "Content-Type: application/json" --insecure https://localhost:9449/employees/details/000010***
{"retrievedResults Output":[{"employeeID":"000010","name":"CHRISTINE I HAAS",
"departmentCode":"A00","phoneNumber":"3978","dateOfHire":"1965-01-01","job":"PRES ",
"educationLevel":18,"sex":"F","dateOfBirth":"1933-08-14","annualSalary":52750.0,
"lastBonus":1000.0,"lastCommision":4220.0}]} - **HTTP CODE 200**

Fred is a member of the *Staff* group and has *Staff* access to the **Staff** role. Any identity with **Staff** access can invoke one of the GET methods.

____3. Enter the curl command below and observe the response.

curl -X GET -w " - HTTP CODE %{http_code}" --user user2:user2 --header "Content-Type: application/json" --insecure https://wg31.washington.ibm.com:9445/db2/employees/details/000010

c:\z\openapi3>***curl -X GET -w " - HTTP CODE %{http_code}" --user user2:user2 --header "Content-Type: application/json" --insecure https://localhost:9449/employees/details/000010***
- **HTTP CODE 403**

Tech-Tip: If you had provided an invalid password, e.g., *–user user2:userx, the request would have failed with an HTTP status of 401, Unauthorized.*

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____4. Enter the curl command below and observe the response.

curl -X POST -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fred --data @insertEmployee.json https://wg31.washington.ibm.com:9445/db2/employees/

In the above command, the file insertEmployee.json has the contents below:

```
{
 "employeeNumber": "948489",
 "firstName": "Matt",
 "middleInitial": "T",
 "lastName": "Johnson",
 "departmentCode": "C00",
 "phoneNumber": "0065",
 "dateOfHire": "10/15/1980",
 "job": "Staff",
 "educationLevel": 21,
 "sex": "M",
 "dateOfBirth": "06/18/1960",
 "salary": 3999.99,
 "lastBonus": 399.99,
 "lastCommission": 119.99
}
```

```
c:\z\openapi3>curl -X POST -w " - HTTP CODE %{http_code}"  --header "Content-Type: application/json" --insecure --user Fred:fred --data @insertEmployee.json https://wg31.washington.ibm.com:9445/employees/
```

____5. Enter the curl command below to invoke the *GET* method with URI path */roles/{job}*.

curl -X GET -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fred https://wg31.washington.ibm.com:9445/db2/roles/PRES?dept=A00

____6. Enter the curl command below to invoke the *DELETE* method with URI path */employees/{employee}*.

curl -X DELETE -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user Fred:fred https://wg31.washington.ibm.com:9445/db2/employees/000012

____7. Enter the curl command below to invoke the *DELETE* method with URI path */employees/{employee}*.

curl -X DELETE -w " - HTTP CODE %{http_code}" --header "Content-Type: application/json" --insecure --user user1:user1 https://wg31.washington.ibm.com:9445/db2/employees/000012

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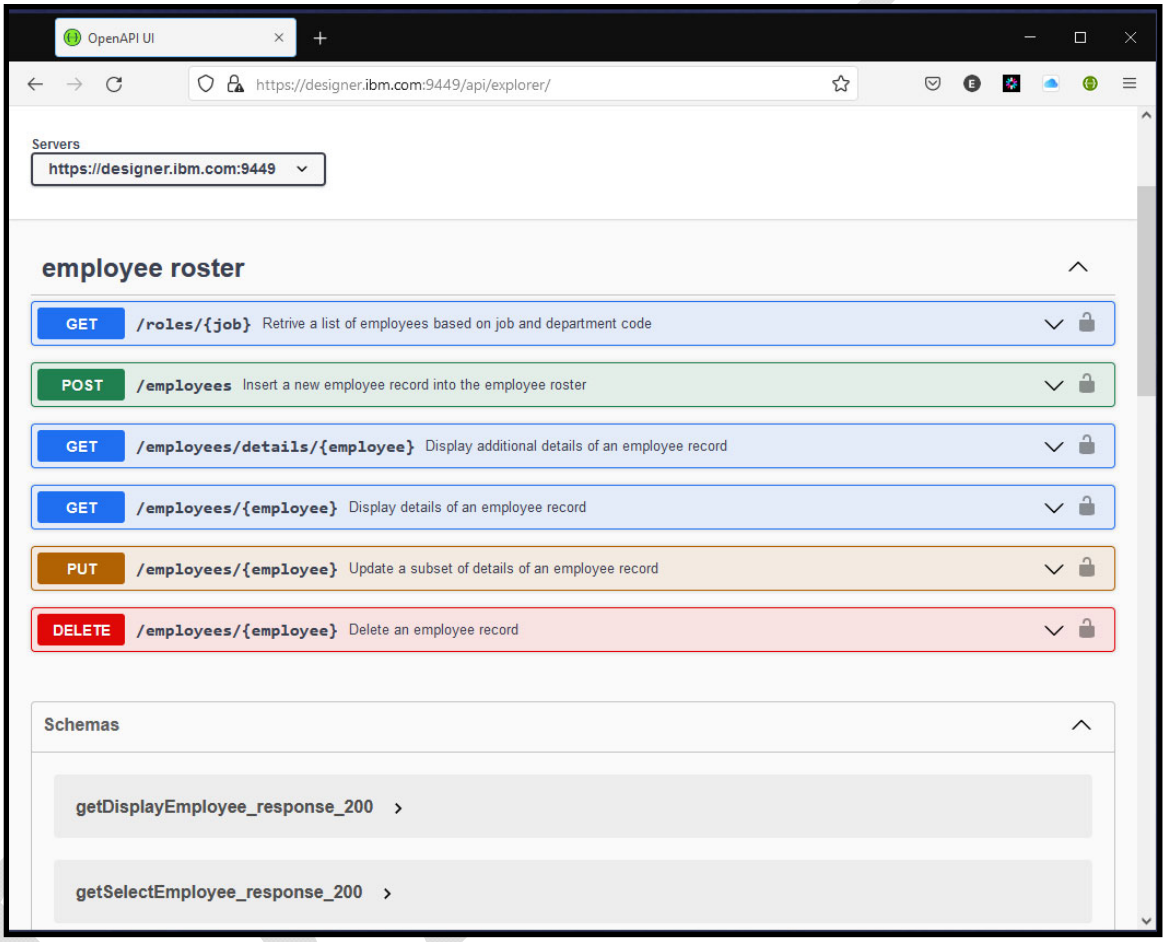
Using the API Explorer

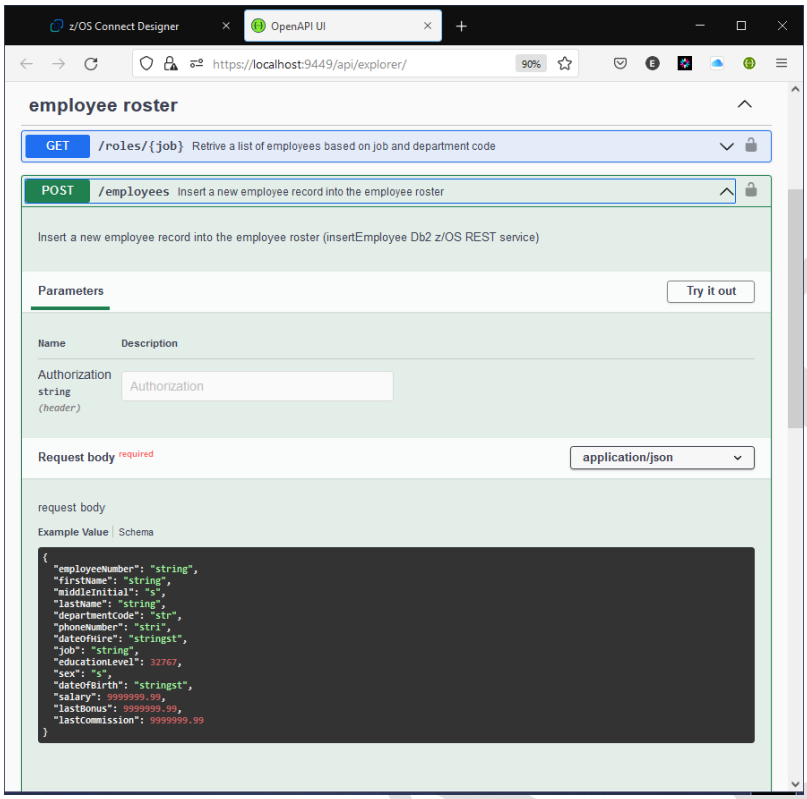
The API Explorer was used in the Designer to test the APIs as they were being developed. The API Explorer All the URI paths and methods in the original OpenAPI 3 specification document will be displayed, but only the *POST* for */employees* and the *GET* for */employees/{employee}* have been created. Executing one of the other methods will return an HTTP 404 because the components required to execute these methods cannot be found in the WAR.

___16. Using the Firefox browser, go to URL ***https://wg31.washington.ibm.com:9445/api/explorer*** to start the API Explorer.

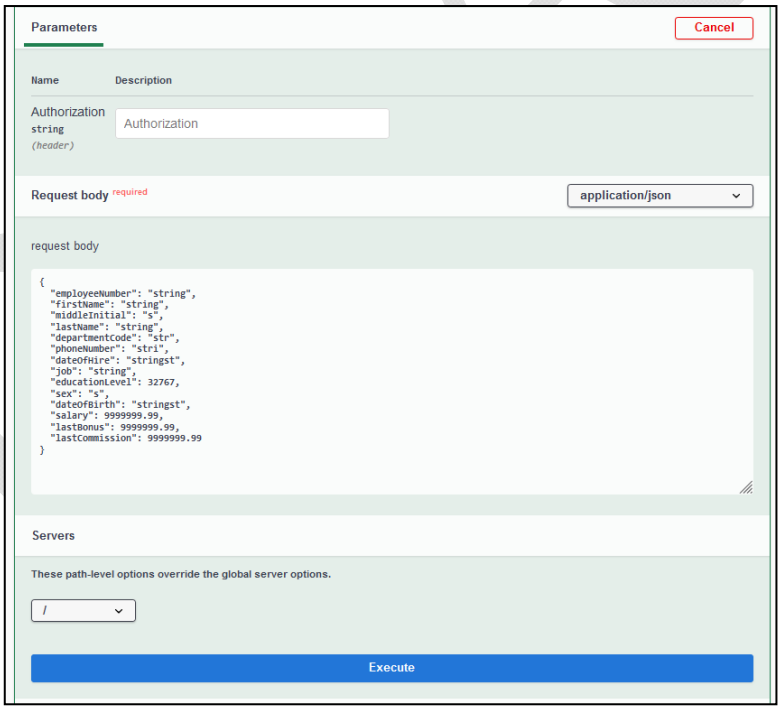


Tech Tip: You may be challenged by browser because the digital certificate used by the *Designer* is self-signed Click the **Advanced** button to continue. Scroll down and then click on the **Accept the Risk and Continue** button. Next you may see a prompt you for a userid and password. If you do see the prompt, enter the username ***Fred*** and password **fredpwd** (case matters) and click **OK**. Remember we are using basic security, and this is the user identity and password defined in the server.xml file.

Click on *Post /employees* URI path to display the request body view of the URI path.



___17. Next press the ***Try it out*** button to enable the entry of an authorization string and a request message body



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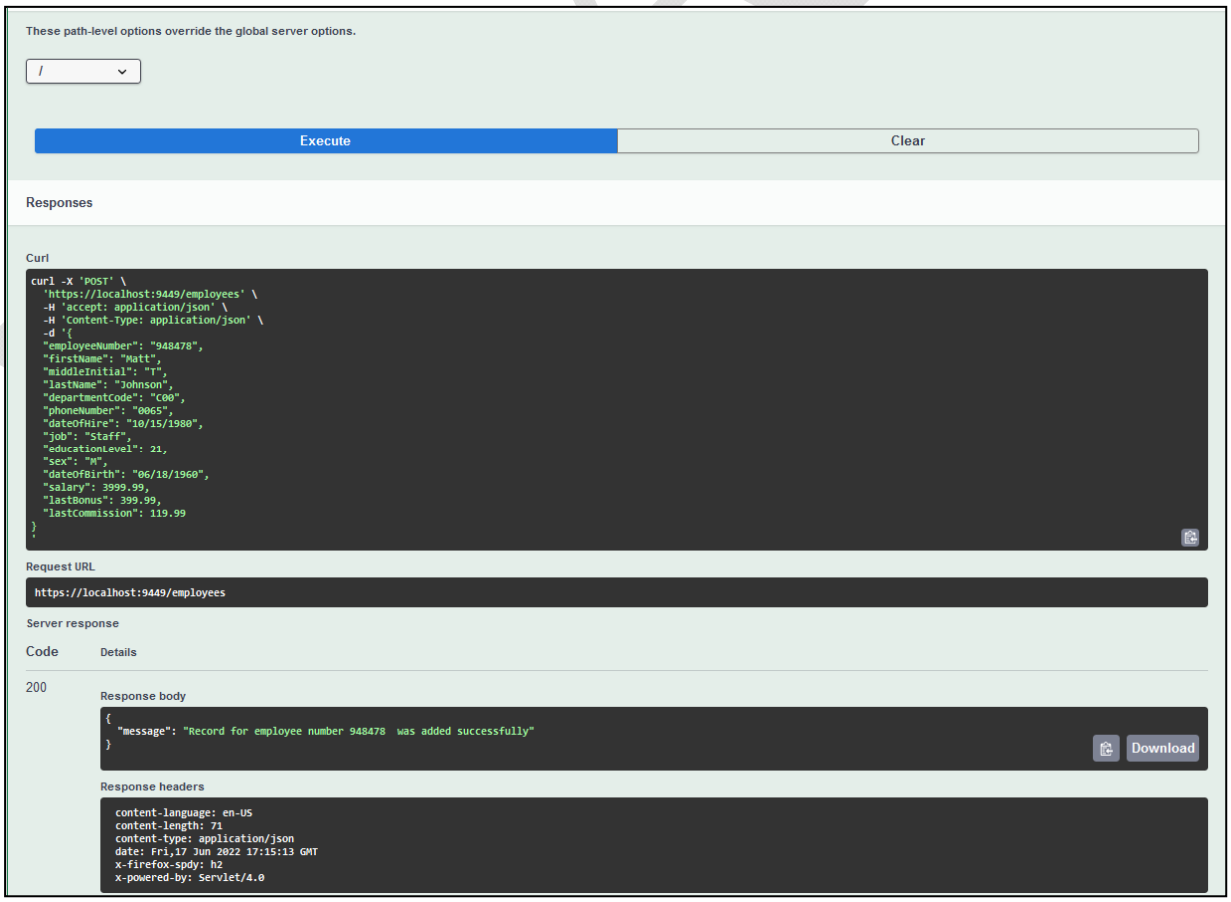
___18. Enter the JSON request message below in the *Request body* section and press the **Execute** button.

```
{
  "employeeNumber": "948478",
  "firstName": "Matt",
  "middleInitial": "T",
  "lastName": "Johnson",
  "departmentCode": "C00",
  "phoneNumber": "0065",
  "dateOfHire": "10/15/1980",
  "job": "Staff",
  "educationLevel": 21,
  "sex": "M",
  "dateOfBirth": "06/18/1960",
  "salary": 3999.99,
  "lastBonus": 399.99,
  "lastCommission": 119.99
}
```

___19. Security was enabled in the original specification document, so you will be required to sign in with one of the identities defined in the basicSecurity.xml file explored earlier. Use ***Fred*** for the *Username* and ***fredpwd*** for the *Password*. Please note that this identity can be changed unless all browser sessions are stopped.

___20. Scroll down the view and you should see the *Response body* with the expected successful message.



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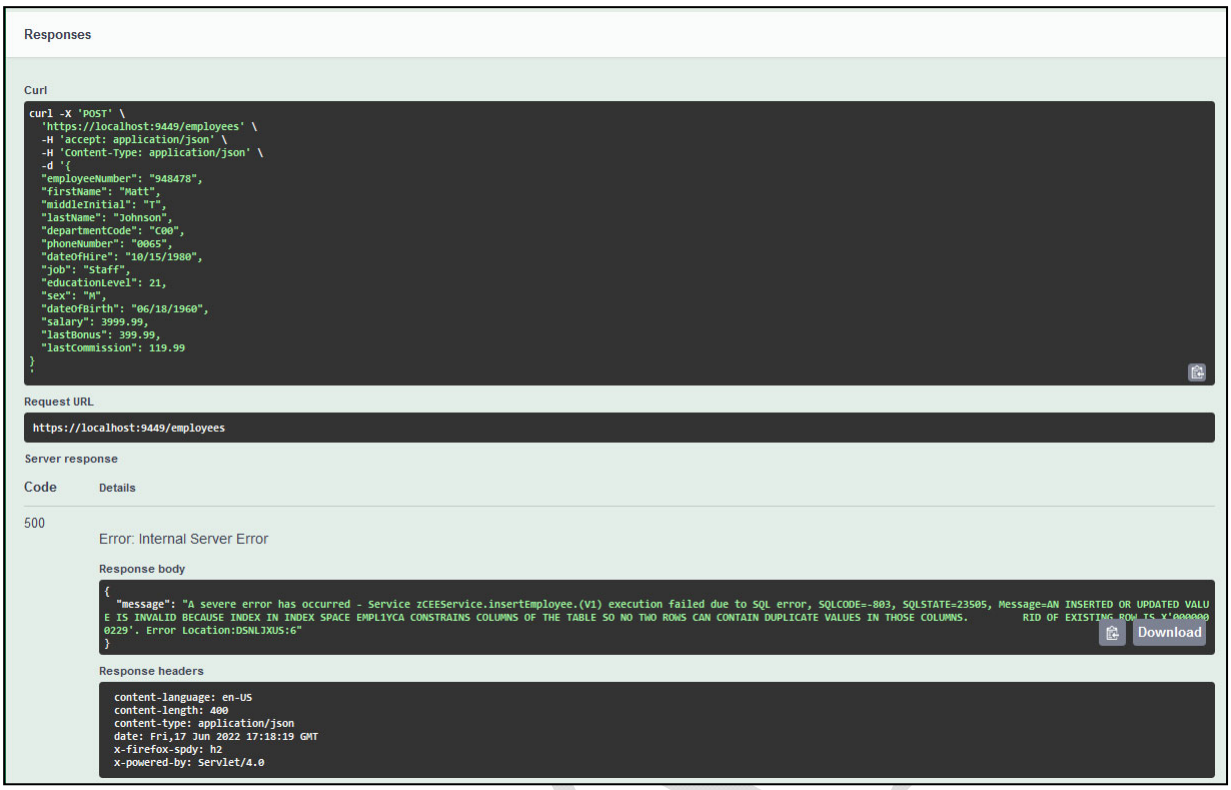
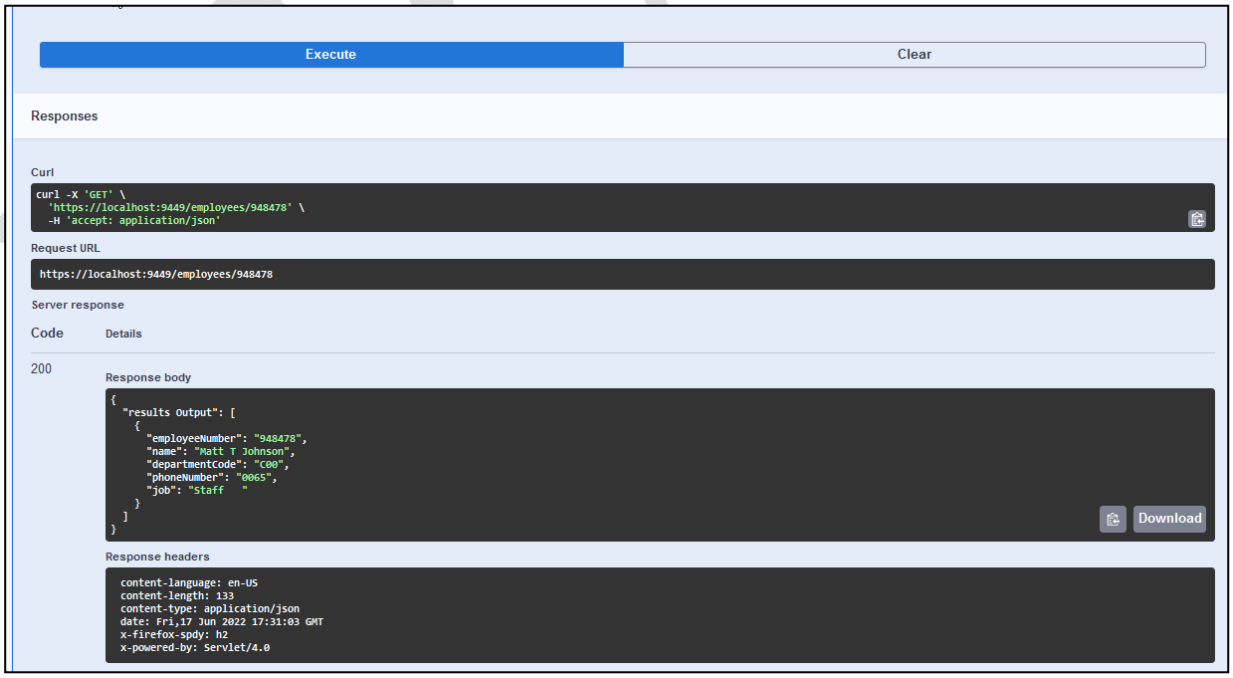
21. Press the **Execute** button again and observe the results. A row for this employee number already existed in the employee roster (a Db2 tables) so the request failed with an HTTP 500.



22. Scroll down and click on *GET /employees/{employees}* URI path to display the request body view of the URI path for this method. Next click on the ***Try it out*** button to enable the entry of data for this method. Enter ***948478*** as the employee identity and press the **Execute** button to retrieve a subset of data for this employee.



23. Try this again using number ***121212*** and observe the results. You see the message that the employee was not found.

The initial contents of the Db2 table are shown below.

EMPNO	FIRSTNME	MIDINIT	LASTNAME	WORKDEPT	PHONENO	HIREDATE	JOB	EDLEVEL	SEX	Birthdate	Salary	Bonus	COMM
000011	CHRISTINE	I	HAAS	A00	A1A1	1965-01-01	PRES	18	F	1933-08-14	52750.00	1000.00	4220.00
000020	MICHAEL	L	THOMPSON	B01	3476	1973-10-10	MANAGER	18	M	1948-02-02	41250.00	800.00	3300.00
000030	SALLY	A	KWAN	C01	4738	1975-04-05	MANAGER	20	F	1941-05-11	38250.00	800.00	3060.00
000050	JOHN	B	GEYER	E01	6789	1949-08-17	MANAGER	16	M	1925-09-15	40175.00	800.00	3214.00
000060	IRVING	F	STERN	D11	6423	1973-09-14	MANAGER	16	M	1945-07-07	32250.00	600.00	2580.00
000070	EVA	D	PULASKI	D21	7831	1980-09-30	MANAGER	16	F	1953-05-26	36170.00	700.00	2893.00
000090	EILEEN	W	HENDERSON	E11	5498	1970-08-15	MANAGER	16	F	1941-05-15	29750.00	600.00	2380.00
000100	THEODORE	Q	SPENSER	E21	0972	1980-06-19	MANAGER	14	M	1956-12-18	26150.00	500.00	2092.00
000110	VINCENZO	G	LUCCHESI	A00	3490	1958-05-16	SALESREP	19	M	1929-11-05	46500.00	900.00	3720.00
000120	SEAN		O'CONNELL	A00	2167	1963-12-05	CLERK	14	M	1942-10-18	29250.00	600.00	2340.00
000130	DOLORES	M	QUINTANA	C01	4578	1971-07-28	ANALYST	16	F	1925-09-15	23800.00	500.00	1904.00
000140	HEATHER	A	NICHOLLS	C01	1793	1976-12-15	ANALYST	18	F	1946-01-19	28420.00	600.00	2274.00
000150	BRUCE		ADAMSON	D11	4510	1972-02-12	DESIGNER	16	M	1947-05-17	25280.00	500.00	2022.00
000160	ELIZABETH	R	PIANKA	D11	3782	1977-10-11	DESIGNER	17	F	1955-04-12	22250.00	400.00	1780.00
000170	MASATOSHI	J	YOSHIMURA	D11	2890	1978-09-15	DESIGNER	16	M	1951-01-05	24680.00	500.00	1974.00
000180	MARILYN	S	SCOUTTEN	D11	1682	1973-07-07	DESIGNER	17	F	1949-02-21	21340.00	500.00	1707.00
000190	JAMES	H	WALKER	D11	2986	1974-07-26	DESIGNER	16	M	1952-06-25	20450.00	400.00	1636.00
000200	DAVID		BROWN	D11	4501	1966-03-03	DESIGNER	16	M	1941-05-29	27740.00	600.00	2217.00
000210	WILLIAM	T	JONES	D11	0942	1979-04-11	DESIGNER	17	M	1953-02-23	18270.00	400.00	1462.00
000220	JENNIFER	K	LUTZ	D11	0672	1968-08-29	DESIGNER	18	F	1948-03-19	29840.00	600.00	2387.00
000230	JAMES	J	JEFFERSON	D21	2094	1966-11-21	CLERK	14	M	1935-05-30	22180.00	400.00	1774.00
000240	SALVATORE	M	MARINO	D21	3780	1979-12-05	CLERK	17	M	1954-03-31	28760.00	600.00	2301.00
000250	DANIEL	S	SMITH	D21	0961	1969-10-30	CLERK	15	M	1939-11-12	19180.00	400.00	1534.00
000260	SYBIL	V	JOHNSON	D21	8953	1975-09-11	CLERK	16	F	1936-10-05	17250.00	300.00	1380.00
000270	MARIA	L	PEREZ	D21	9001	1980-09-30	CLERK	15	F	1953-05-26	27380.00	500.00	2190.00
000280	ETHEL	R	SCHNEIDER	E11	8997	1967-03-24	OPERATOR	17	F	1936-03-28	26250.00	500.00	2100.00
000290	JOHN	R	PARKER	E11	4502	1980-05-30	OPERATOR	12	M	1946-07-09	15340.00	300.00	1227.00
000300	PHILIP	X	SMITH	E11	2095	1972-06-19	OPERATOR	14	M	1936-10-27	17750.00	400.00	1420.00
000310	MAUDE	F	SETRIGHT	E11	3332	1964-09-12	OPERATOR	12	F	1931-04-21	15900.00	300.00	1272.00
000320	RAMLAL	V	MEHTA	E21	9990	1965-07-07	FIELDREP	16	M	1932-08-11	19950.00	400.00	1596.00
000330	WING		LEE	E21	2103	1976-02-23	FIELDREP	14	M	1941-07-18	25370.00	500.00	2030.00
000340	JASON	R	GOUNOT	E21	5698	1947-05-05	FIELDREP	16	M	1926-05-17	23840.00	500.00	1907.00

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Using TLS to access Db2

Creating the RACF resources

In this section, the certificates and key ring required for TLS connections to Db2 will be imported into and/or defined to RACF.

The certificate authority public certificate, labeled as *Db2 CA*, be imported into RACF as a CERTAUTH certificate. There are also personal certificates signed by the same certificate authority that will be used as Db2's server certificate (labeled *DB2USER*) and sent to the client to be used as a client certificate (labeled *designer*) for use when mutual authentication is enabled. The personal certificates are provided by the certificate authority in encrypted files since they contain private keys. This means that the certificate authority has also provide a password or pass phrase that can be used to decrypt the contents of these files.

The certificate authority (CERTAUTH) certificate and the personal certificate labeled DB2USER will be connected to the RACF key ring used by Db2 as the server endpoint. *Note that Db2 actually depends on AT-TLS to act as the server endpoint on behalf of Db2.*

The CERTAUTH certificate will also be provided to Db2 clients in order for them to verify the server certificate provided by Db2 during the handshake. Only clients with the public key of the certificate authority that signed the Db2'a server certificate in their trust stores will be able perform TLS handshakes with Db2.

Private keys in a personal certificate are by both server and client endpoints to encrypt a message during the TLS handshake. The other endpoint uses the public key of the sending endpoint to decrypt the message encrypted with the private key. Being able to successfully decrypt a message encrypted with a private key, verifies the identity of the sending endpoint (asymmetric encryption) since only the holder of a private key should the owner of the certificate.

> **Tech-Tip:** In this exercise we are using RACF as our certificate authority. This is unusual and you probably will be using a non-RACF certificate authority, either internal your organization or one of the well-known certificate authorities like Verisign or Entrust. So, you probably not be using RACF to create certificate authority certificates or using certificate authority certificates to sign certificate request. More than likely you will only be using the RACDCERT command to create keyrings and connecting certificates to these key rings.

___1. Browse data set *USER1.ZCEE30.CNTL*. You should see the members in that data set.

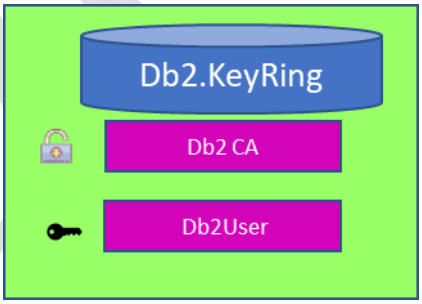
___2. Browse member **DB2TLS3**. The job contains the RACF RACDCERT commands below. Submit the job for execution.

```
 /* Add CERTAUTH and personal certificates to RACF */
racdcert CERTAUTH withlabel('DB2 CA') -
  add('USER1.DB2CA.PEM')

racdcert id(db2user) withlabel('DB2USER') -
  add('USER1.DB2USER.P12') password('secret')

racdcert id(USER1) withlabel('Designer') -
  add('USER1.DESIGNER.P12') password('secret')

racdcert id(USER2) withlabel('USER2') -
  add('USER1.USER2.P12') password('secret')

racdcert id(ATSSERV) Withlabel('ATSSERV Db2 Cert') -
  add('USER1.ATSSERV.P12') password('secret')

setr raclist(digtcert,digtnmap) refresh

 /* Create DB2 key ring and connect CA and personal certificates */
racdcert id(db2user) addring(Db2.KeyRing)

racdcert id(db2user) connect(ring(Db2.KeyRing) +
          label('DB2 CA') certauth usage(certauth))

 /* Connect default personal certificiate */
racdcert id(db2user) connect(ring(Db2.KeyRing) +
          label('DB2USER') default

setropts raclist(digtring,digtnmap) refresh
```

The commands in this job:

- Imports (adds) the certificate authority and personal certificates to RACF. The personal certificates are added because if they are to be used in TLS handshakes, they have to associated with valid RACF identities
- Define a key ring to be used for TLS handshakes.
- Connect the Db2 server personal certificate to this key ring.
- Connect the CA public certificate used to sign the Db2 server's certificate to this key ring.
- The in-storage profile for digital certificates resources are refreshed.

When finished, the Db2 key ring looks something like this:



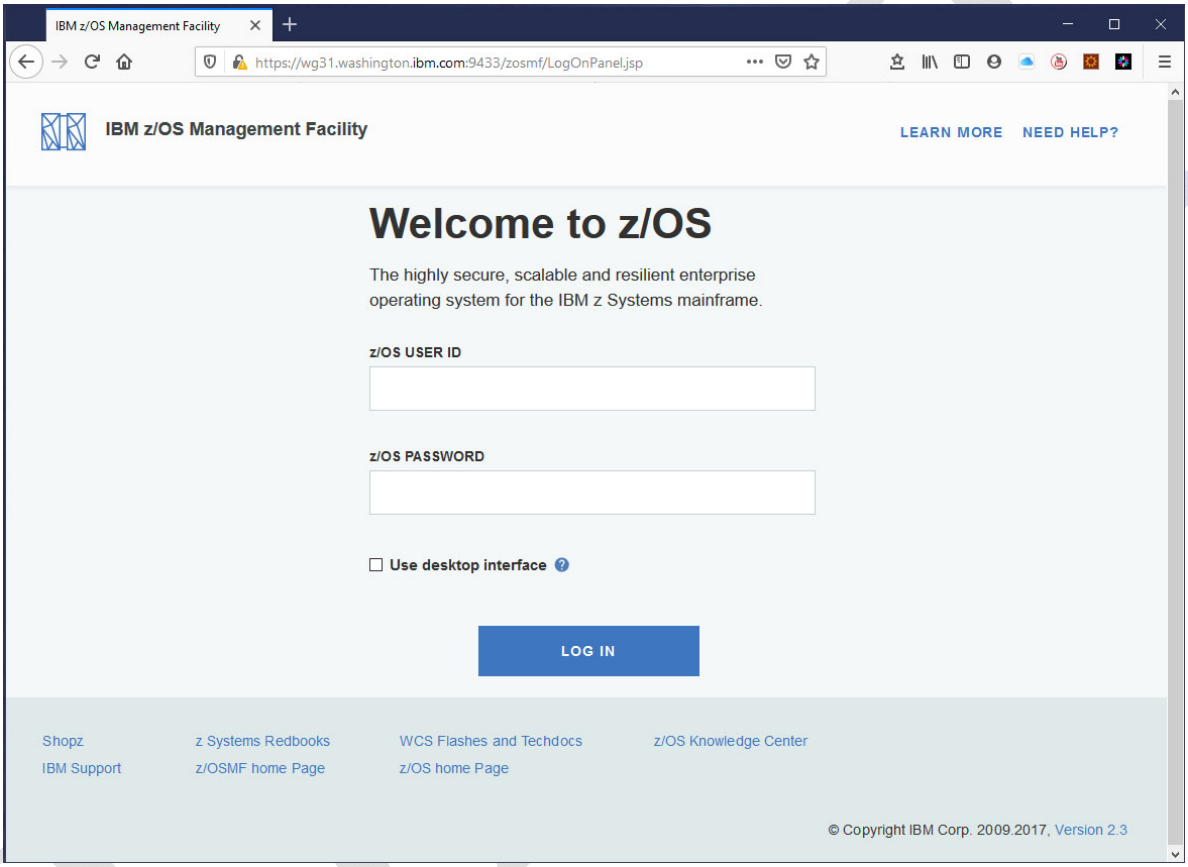
Tech-Tip: Both server certificates and client certificates are personal certificates. The differences is the role of the certificate during the handshake. The endpoint that initiates the connection is the client and its personal certificate is referred to as a client certificate. The endpoint that receives the connection request is the server and its personal certificate is referred to as a server certificate. A personal certificate can be used as either a client or a server certificate at any time as long as the certificate contains a private key that can be used to encrypt handshake messages.

Configuring the Db2 AT-TLS inbound policy

Db2 depends on AT-TLS to perform the handshakes and the encrypting and decrypting of messages. So, the RACF resources created in the previous section are not configured in Db2 but rather AT-TLS. The required AT-TLS configuraton steps are done in this section

z/OSMF will be used in this section to configure the AT-TLS configuration for the desired outbound policy.

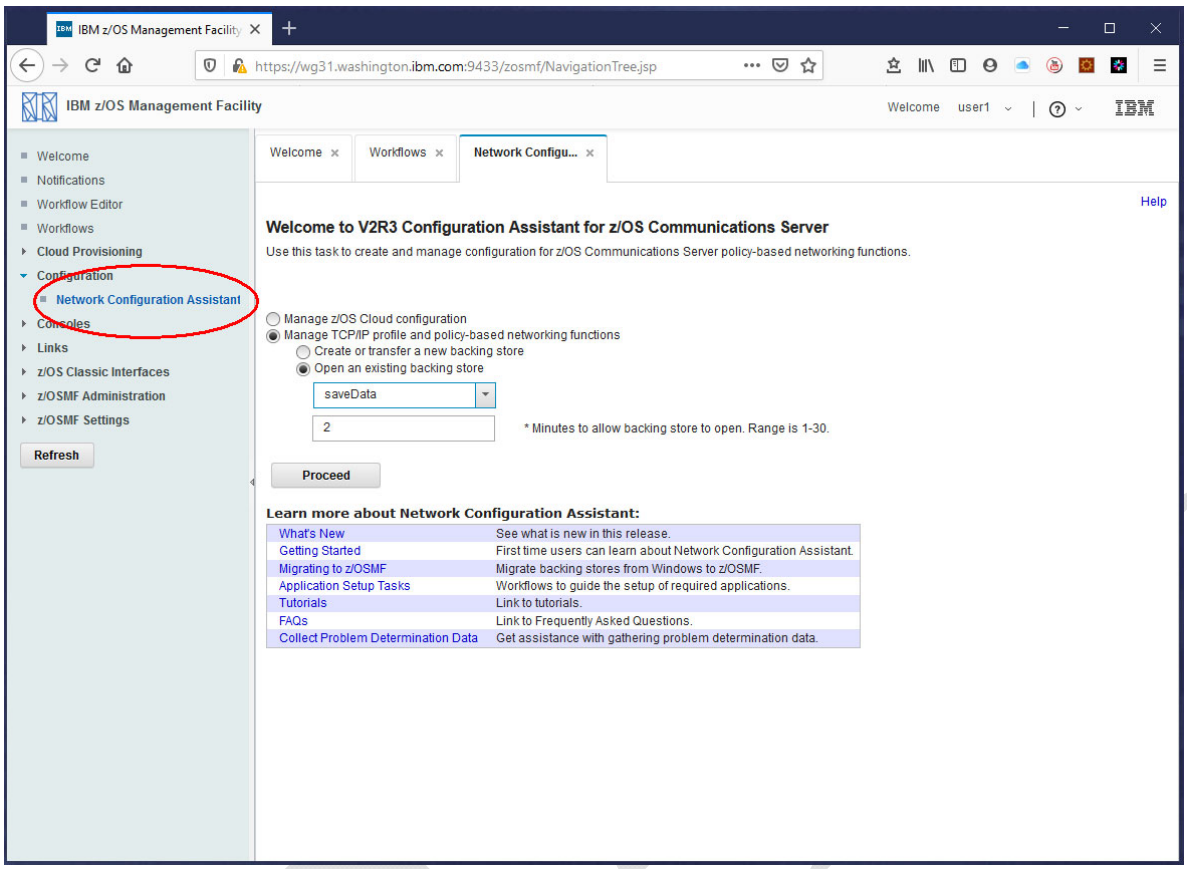
___1. In a Firefox browser, enter URL ***https://wg31.washington.ibm.com:9433/zosmf*** and you should see the *IBM z/OS Management Facility* window.



Note that some of the AT-TLS configurations steps described here may have been performed in another exercise.

___2. Enter *USER1* as the *z/OS USER ID* and USER1's password and click the **LOG IN** button.

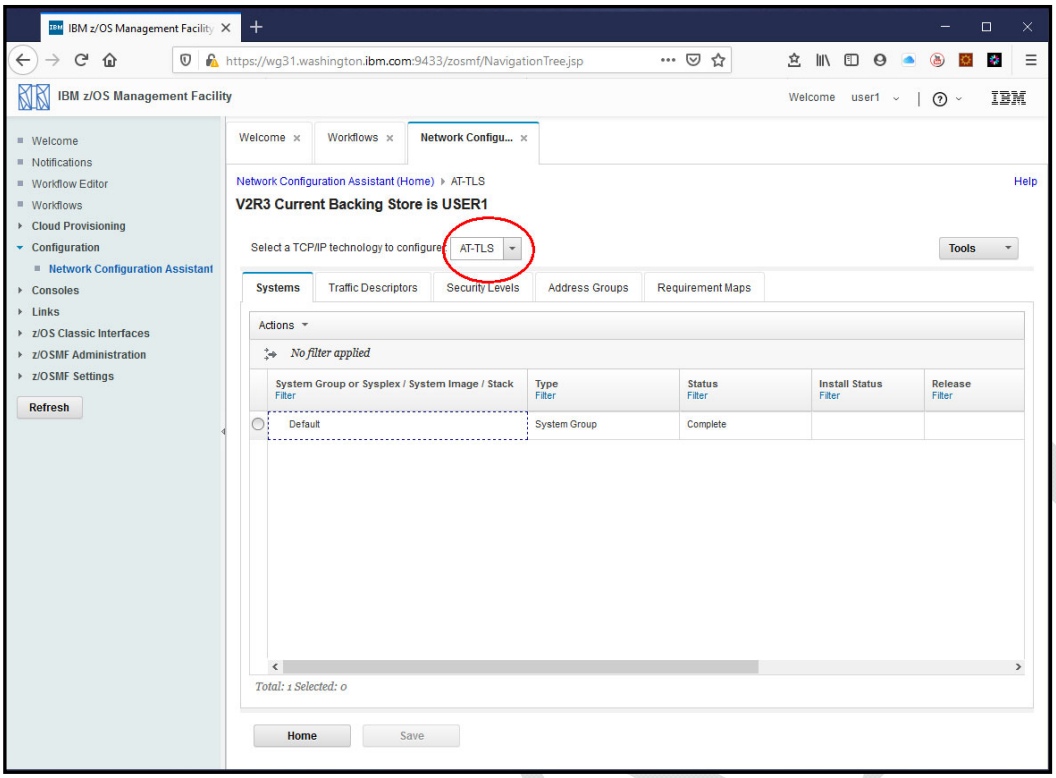
___3. The *Welcome* screen should be displayed. On the left-hand side expand the *Configuration* tab to expose the *Network Configuration Assistance* option. Select this option to expose the *Network Configuration* tab.



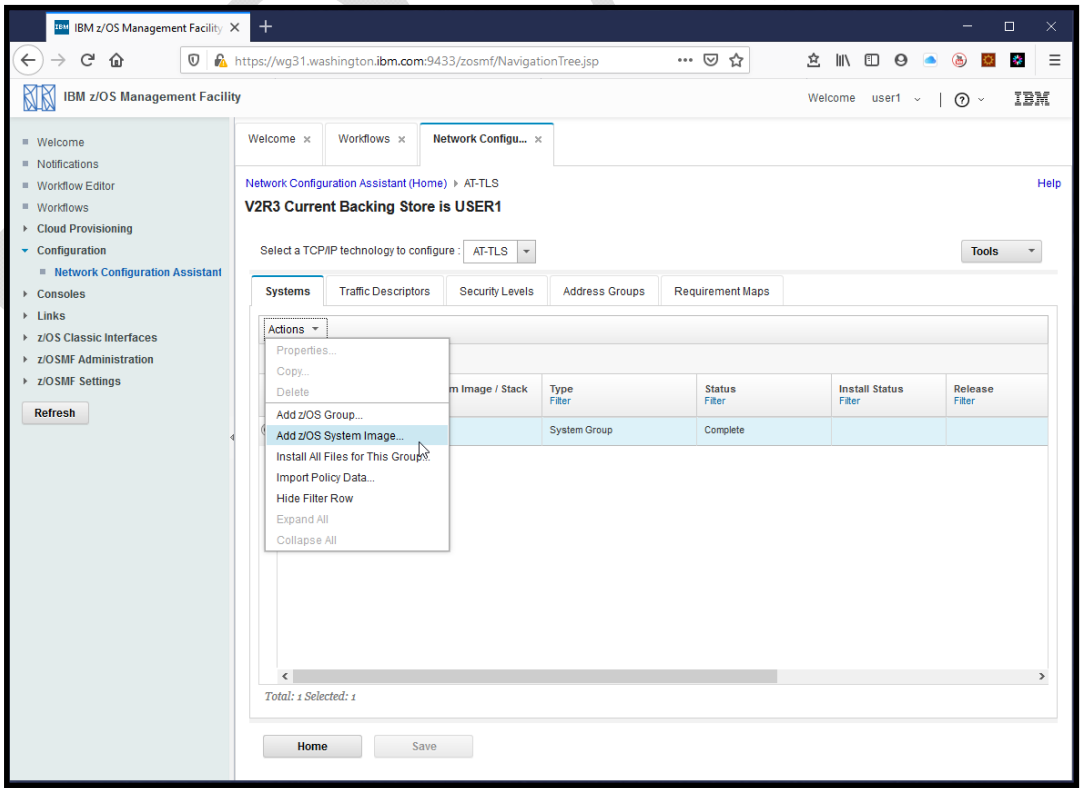
___4. Select the radio button beside *Create or transfer a new backing store* option and click the **Proceed** button.

___5. On the next screen select the radio button beside *Create a New Backing Store File* and enter ***USER1*** in the area beside *File Name*. Press the **OK** button and press the **OK** button on the Information pop-up.

___6. On the *Network Configuration* tab use the pull-down arrow to select *AT-TLS* as the *TCP/IP technology to configure.*



___7. Select the radio button beside the *Default - System Group* and use the *Action* pull-down button to select *Add z/OS System Image* option.



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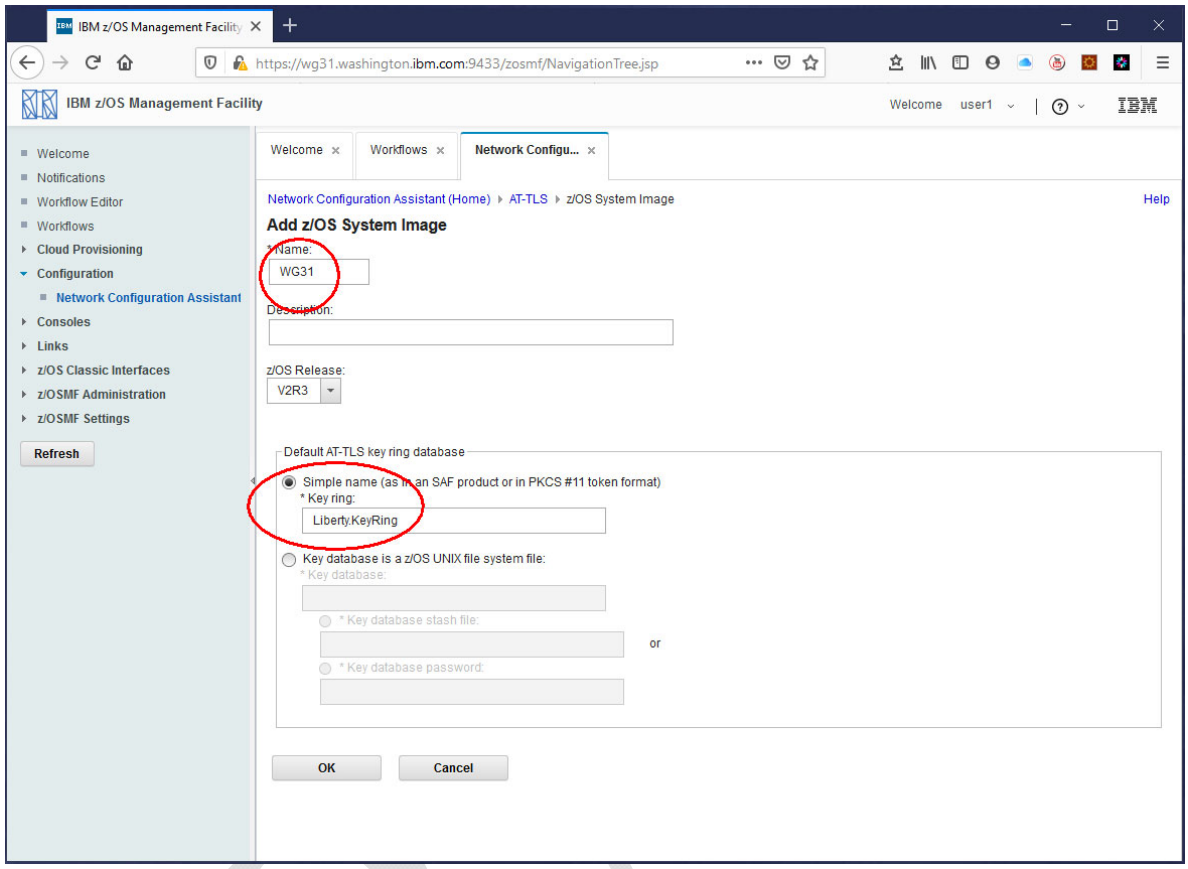
___8. On the *Add z/OS System Image* window enter ***WG31*** for the image *Name* and check the radio button beside *Simple name (as in an SAF product…)*. Enter ***Liberty.KeyRing*** as the default AT-TLS key ring name. Click **OK** to continue.



Tech Tip: The value for the key ring will be used if an explicit key ring is not provided for a policy.

We recommend establishing a naming convention for key rings with each SAF identity by using the same key ring name. Using this name as an example, you could create a unique key ring named *Liberty.KeyRing* for SAF identities USER1, USER2, FRED, etc. Each user's key ring would have the same name but a different set of connected certificates. One default key ring specified at the image level covers all users.

___9. On the *Proceed to the Next Step?* pop-up click the **Proceed** button.

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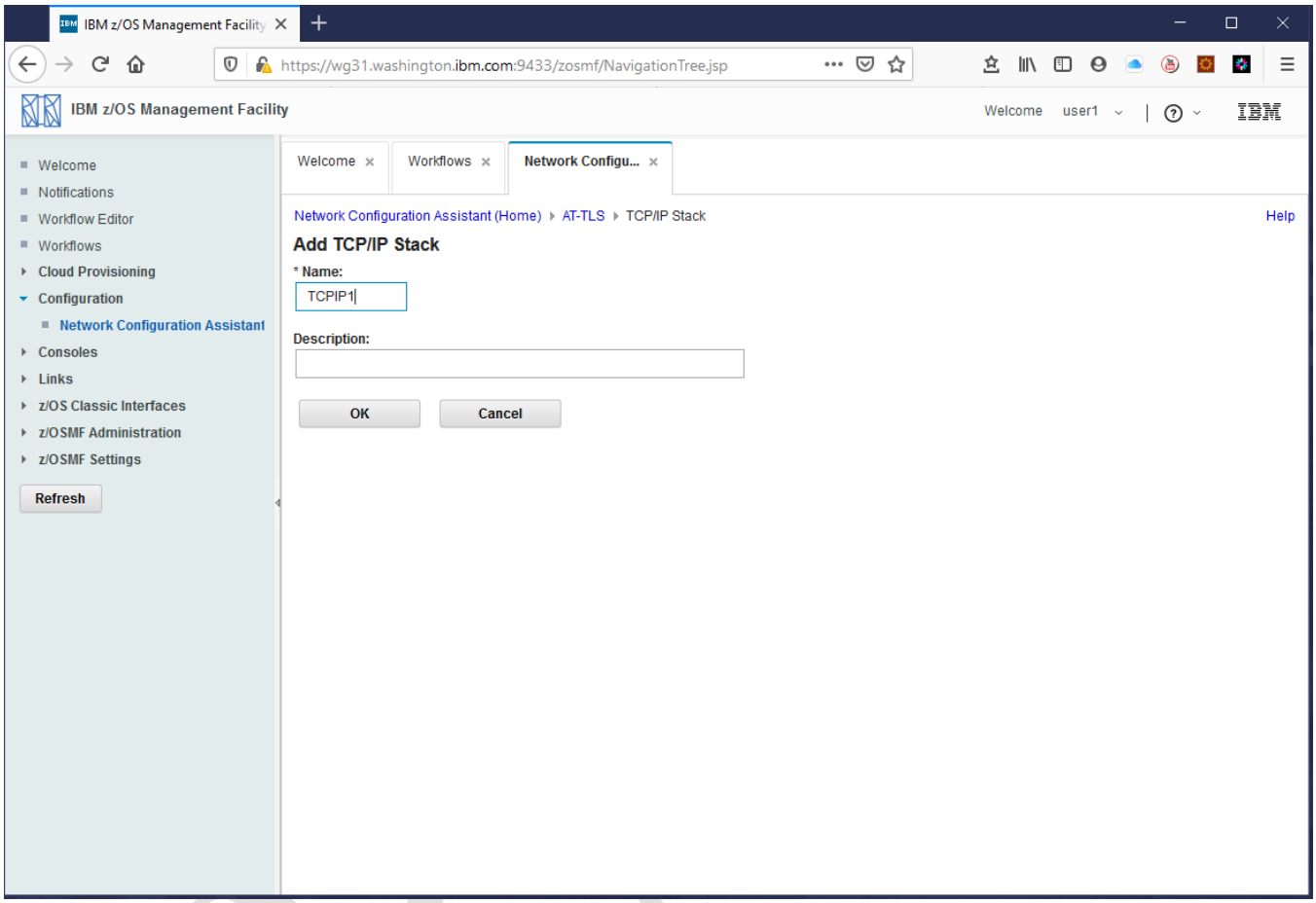
10. The *Add TCP/IP Stack* screen should be displayed. Select this option to expose the *Network Configuration* tab. Enter ***TCPIP1*** as the name of the stack. Click **OK** to continue.



Tech-Tip: The value for the stack name was determined by the TCPIP Name display by entering the MVS command D TCPIP.

```
EZAOP50I TCPIP STATUS REPORT 007
COUNT    TCPIP NAME    VERSION     STATUS
-----    ----------    --------    ------------------------
    1    TCPIP1        CS V2R3     ACTIVE
*** END TCPIP STATUS REPORT ***
 EZAOP41I 'DISPLAY TCPIP' COMMAND COMPLETED SUCCESSFULLY
```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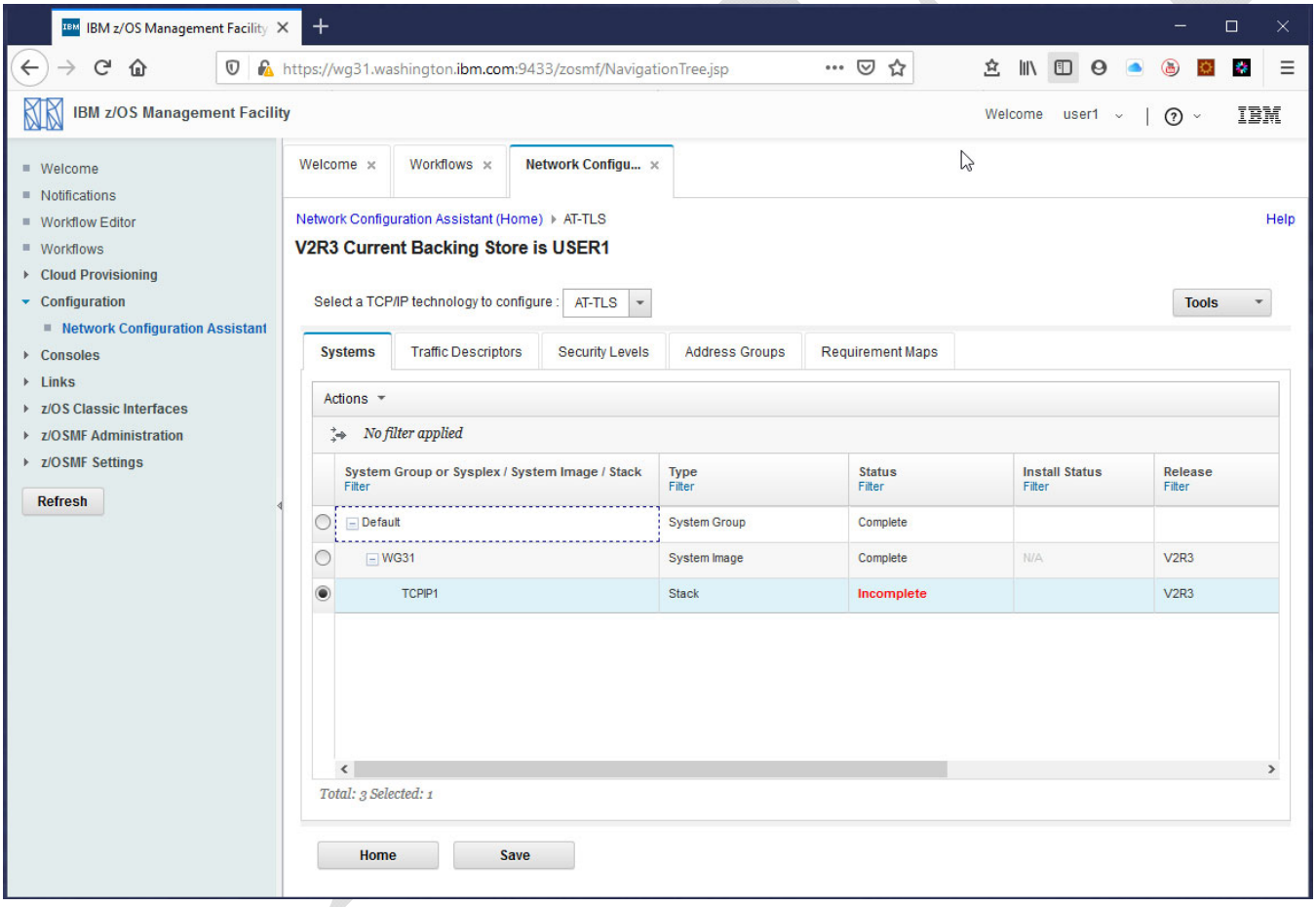
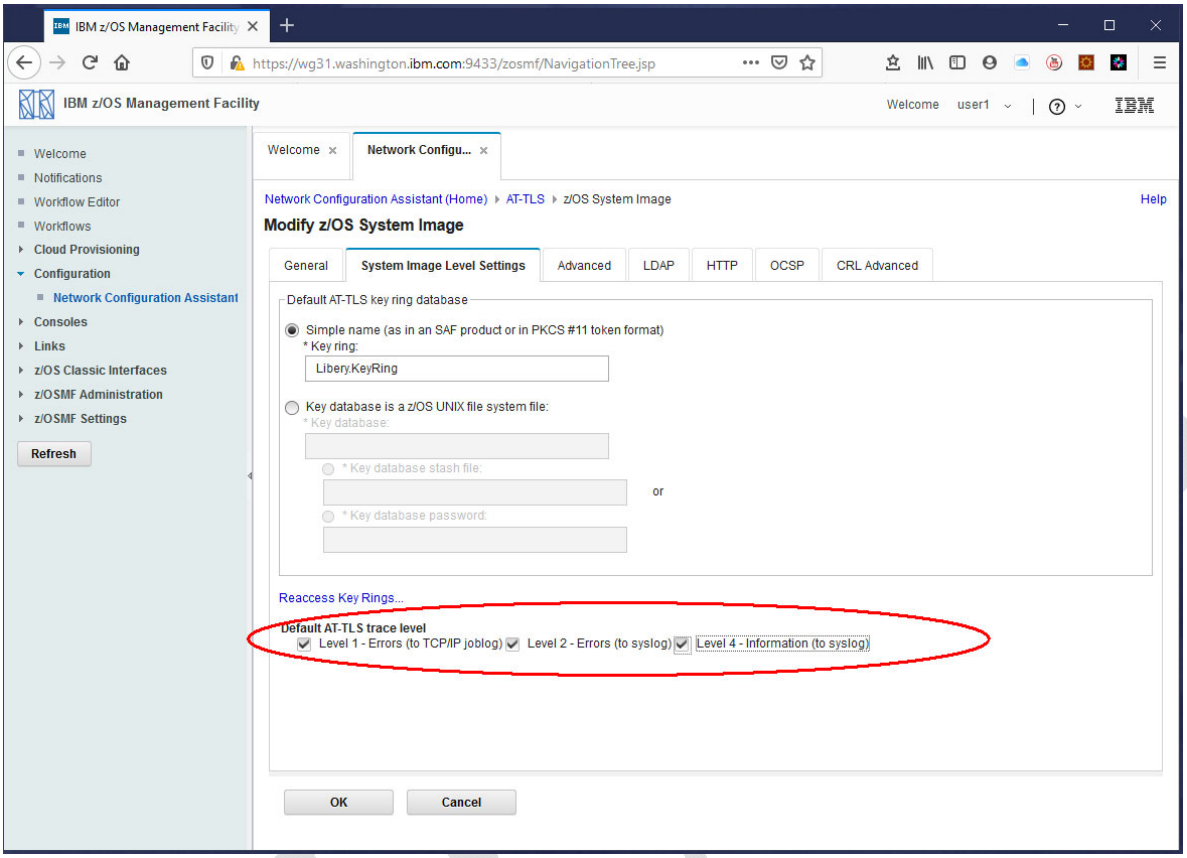
___11. Before any TCP/IP stack rules can be added, *Traffic Descriptors*, *Address Groups* and *Requirement Maps* need to be defined. Click **Cancel** on the *Proceed to the Next Step*? displayed at this time.

___12. This will display the window below:

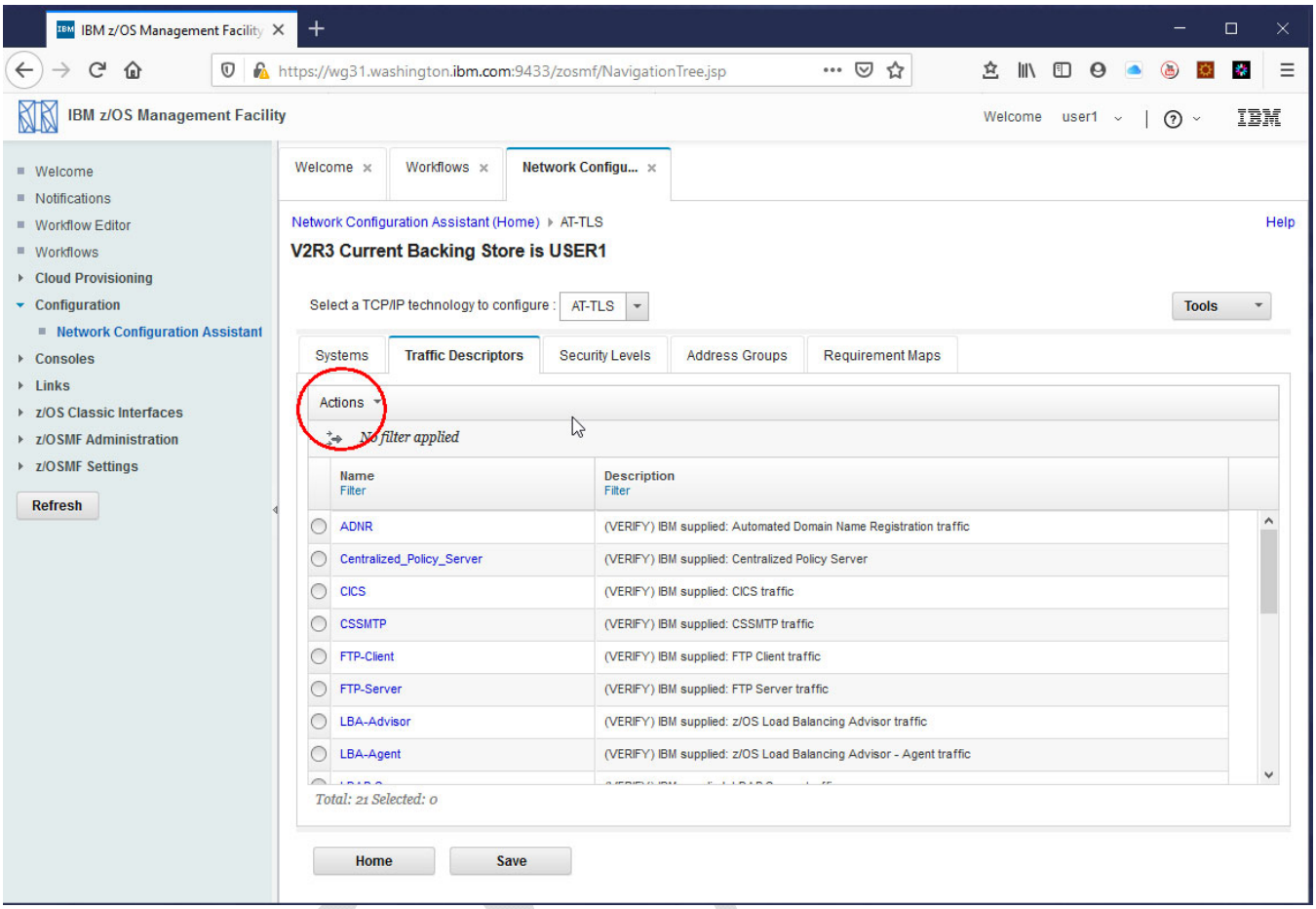


Tech Tip: The Incomplete warning will be addressed shortly.

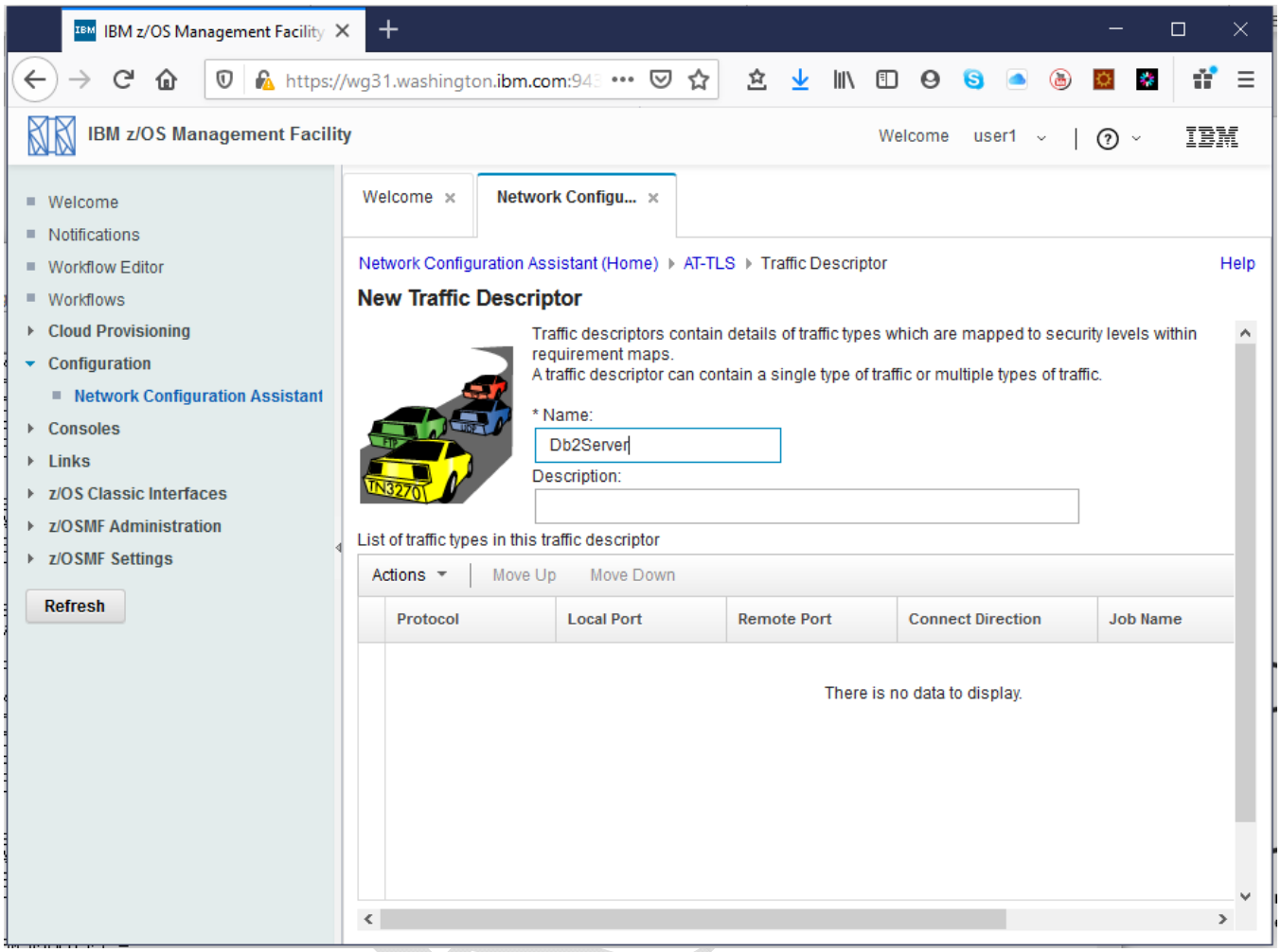
13. Select the radio button beside *WG31* and use the *Actions* pull-down to select *Properties*. On the *Modify z/OS System Image* window, select the *System Image Level Settings* tab. Check all the trace level boxes as shown below. This is being done so we can confirm AT-TLS is being invoked and identify issues. Press **OK** to continue.



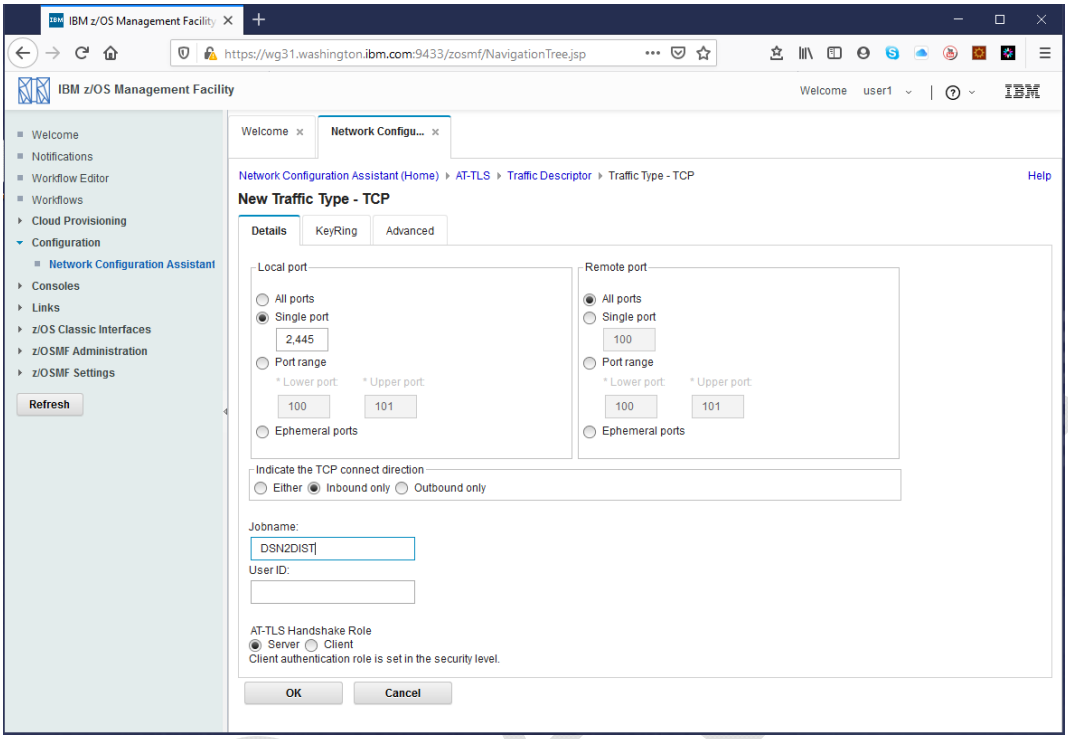
___14. Select the *Traffic Descriptors* tab and use the *Actions* pull-down to select *New*.



15. On the *New Traffic Descriptor* window, enter ***Db2Server*** as the *Name.* Use the *Actions* pull-down and select *New* to start the definition of a new traffic descriptor type.



16. On the *New Traffic Type – TCP* window, select the radio button beside *Single ports* under *Local port* and enter ***2445*** as the port number. Select the radio button *All ports* under *Remote port*. Select the radio button beside *Inbound only* under *Indicate the TCP connection direction*. Enter ***DSN2DIST*** in the area under *Jobname* and finally select the radio button beside *Server* under *AT-TLS Handshake Role*. Next click on the *KeyRing* tab to continue.



Tech-Tip: This traffic definition is triggered when a client attempts to connect to port *2445*. Port 2445 was identified as the Db2 SECPORT in startup message.

```
DSNL004I  -DSN2 DDF START COMPLETE
          LOCATION  DSN2LOC
          LU        USIBMWZ.DSN2APPL
          GENERICLU -NONE
          DOMAIN    WG31.WASHINGTON.IBM.COM
          TCPPORT   2446
          SECPORT   2445
          RESPORT   2447
          IPNAME    -NONE
          OPTIONS:
          PKGREL = COMMIT
```

If all the defined conditions are met, AT-TLS will act as a surrogate for the server during a TLS handshake. Note the *KeyRing* tab can be used to specify the name of the key ring to be used for this handshake, e.g., Db2.KeyRing. Otherwise, the default is to use the same key ring name defined for the z/OS System image, e.g., Liberty.KeyRing.

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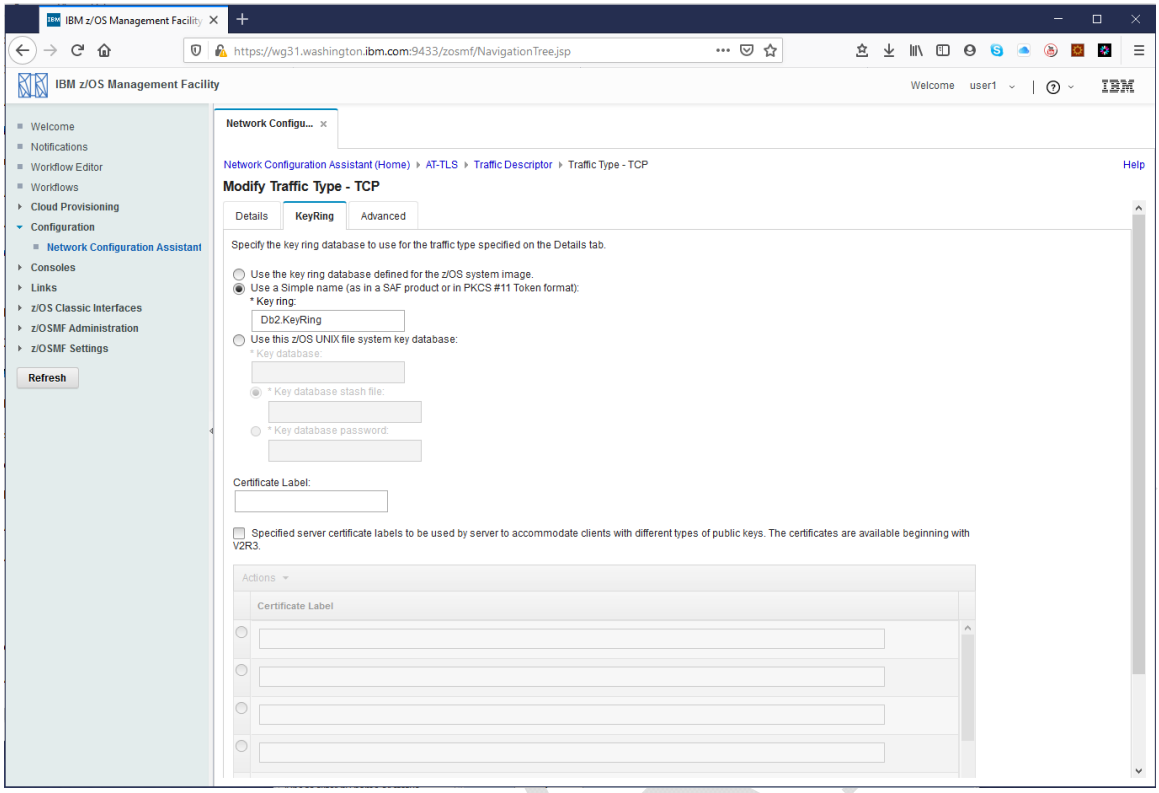
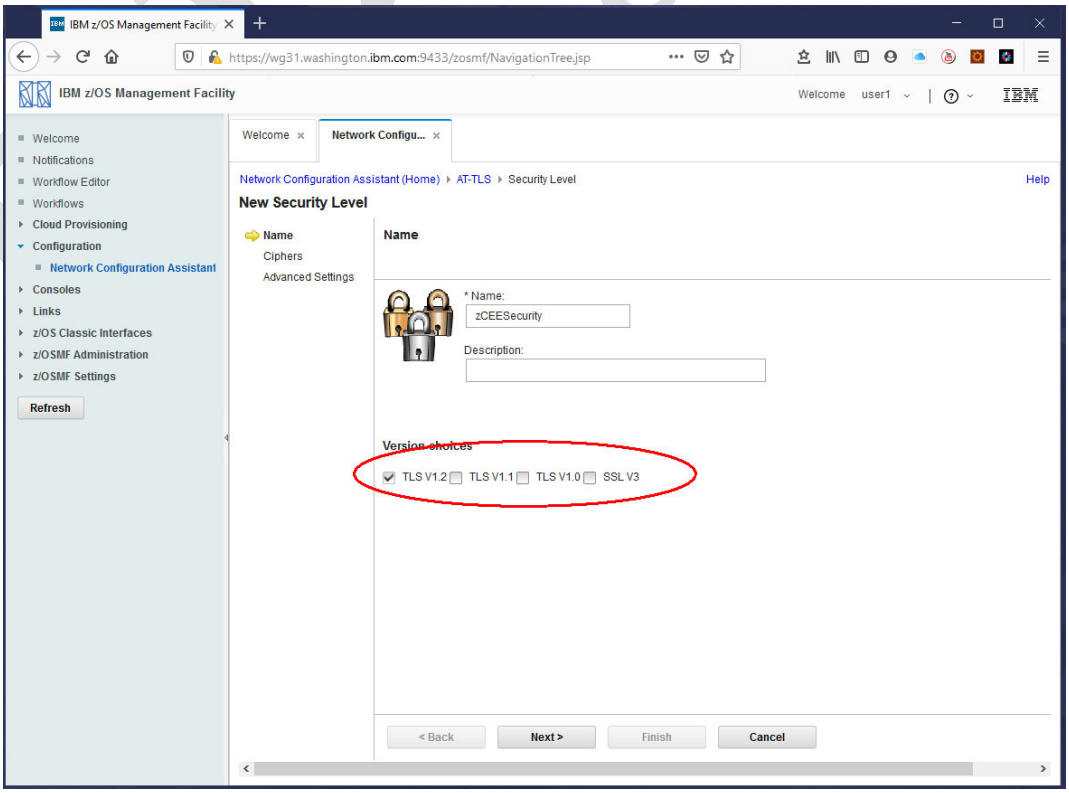
___17. On the *KeyRing* tab, select the radio button beside *Use a Simple name* and enter ***Db2.KeyRing*** as the key ring name. Click **OK** twice to continue.



___18. Next, click the Security Levels tab and use the *Actions* pull-down button and select the *New* option. On the *New Security Level* windows, enter ***zCEESecurity*** for the *Name* and check the box beside *TLS V1.2* and uncheck the other boxes. Click **Next** to display the *Cipher selection* options. Click **Next** to display the *Advanced Settings* options exploring as you like but there is no need to make any changes. Click **Finish** to continue.



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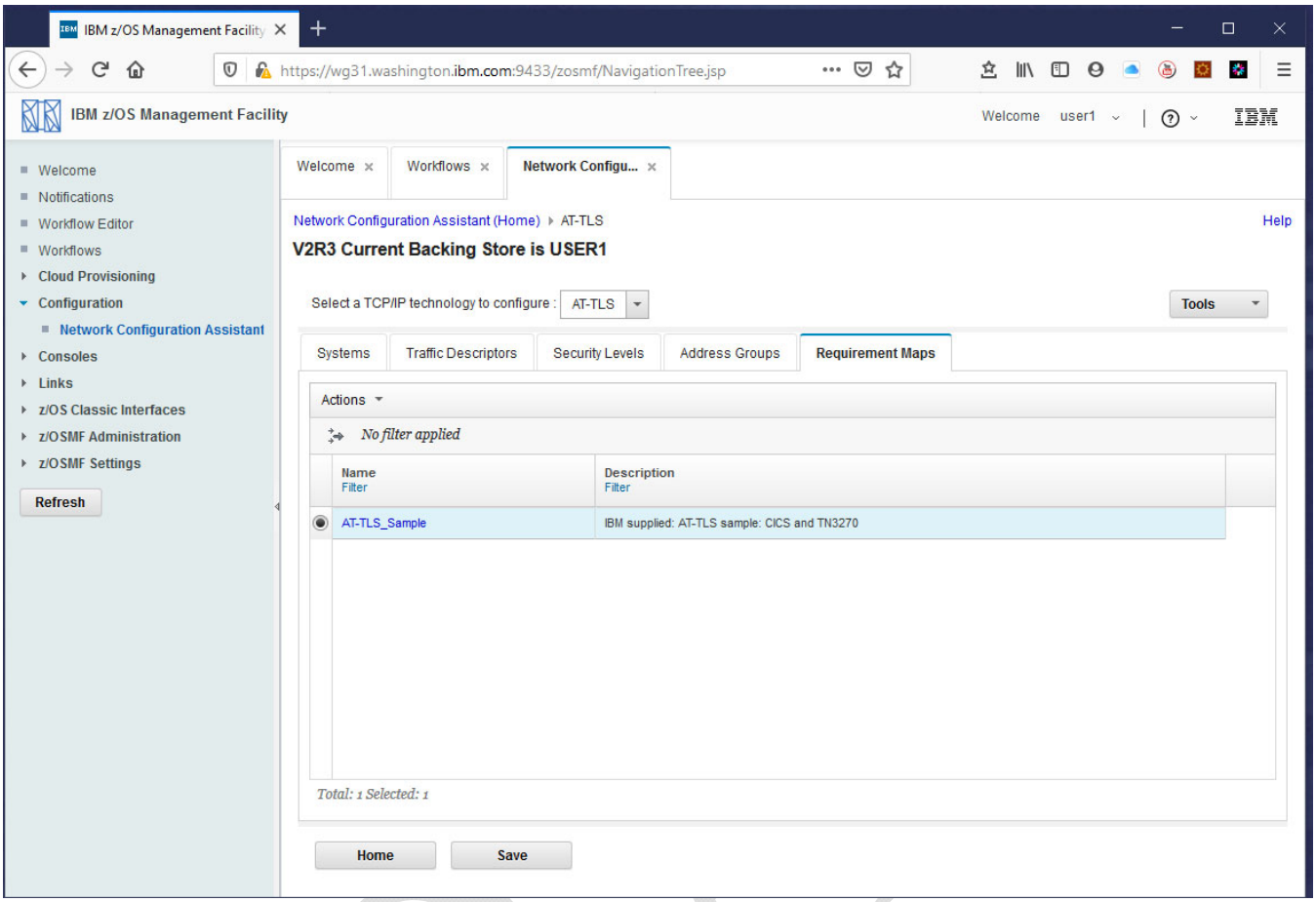
___19. Next, click the *Requirement Maps* tab. Use the *Actions* pull-down button to select the *New* option.



Tech Tip: The key ring specified here belongs to identity DB2USER This is the identity under which the z/OS Connect server is running. This ring has these certificates connected.

```
     >Db2.KeyRing<
Certificate Label Name              Cert Owner     USAGE      DEFAULT
--------------------------------    ------------   --------   -------
DB2 CA                              CERTAUTH       CERTAUTH     NO
zCEE CA                             CERTAUTH       CERTAUTH     NO
DB2USER                             ID(DB2USER)    PERSONAL     YES
```

The z/OS Connect out bound JSSE key ring has these certificates connected.

```
Ring:
     >zCEE.KeyRing<
Certificate Label Name              Cert Owner     USAGE      DEFAULT
--------------------------------    ------------   --------   -------
zCEE CA                             CERTAUTH       CERTAUTH     NO
Liberty CA                          CERTAUTH       CERTAUTH     NO
zCEE Client Cert                    ID(LIBSERV)    PERSONAL     YES
zCEE-CertAuth                       CERTAUTH       CERTAUTH     NO
DB2 CA                              CERTAUTH       CERTAUTH     NO
```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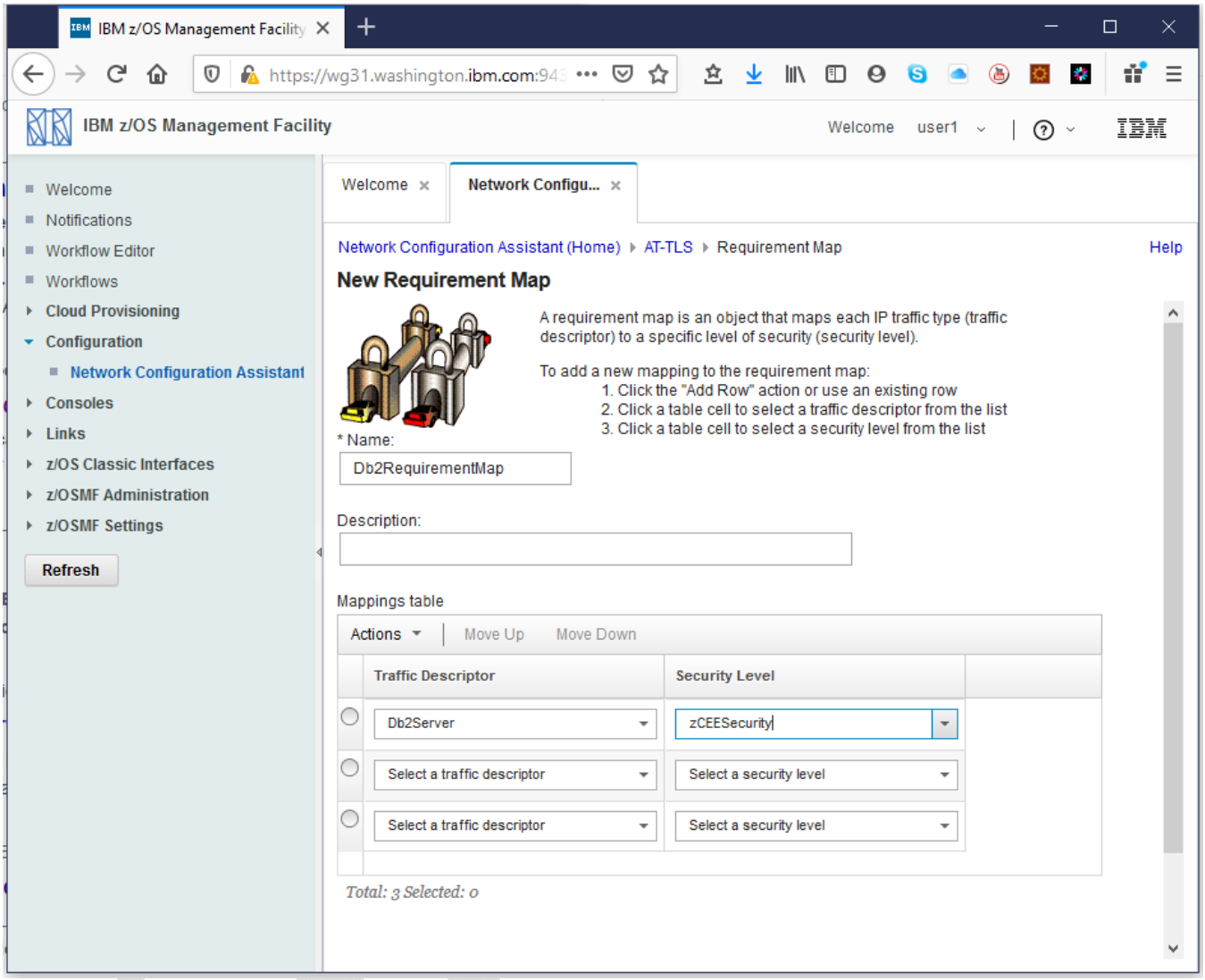
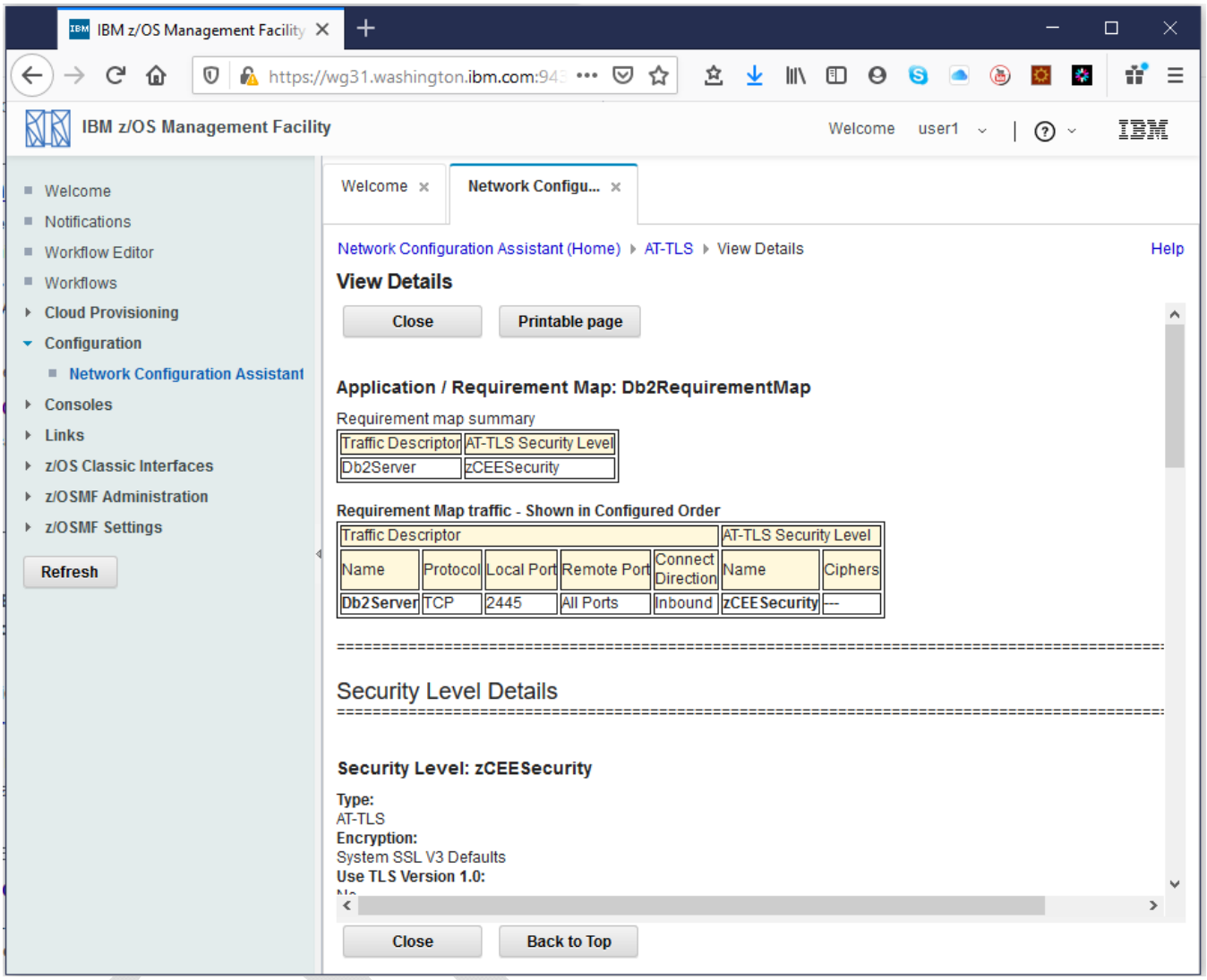
___20. On the *New Requirement Map* window, enter ***Db2RequirementMap*** as the *Name*. Use the pull-down arrows to select *Db2Server* as the *Traffic Descriptor* and *zCEESecurity* as the *Security Level* for this map. Click **OK** to continue.

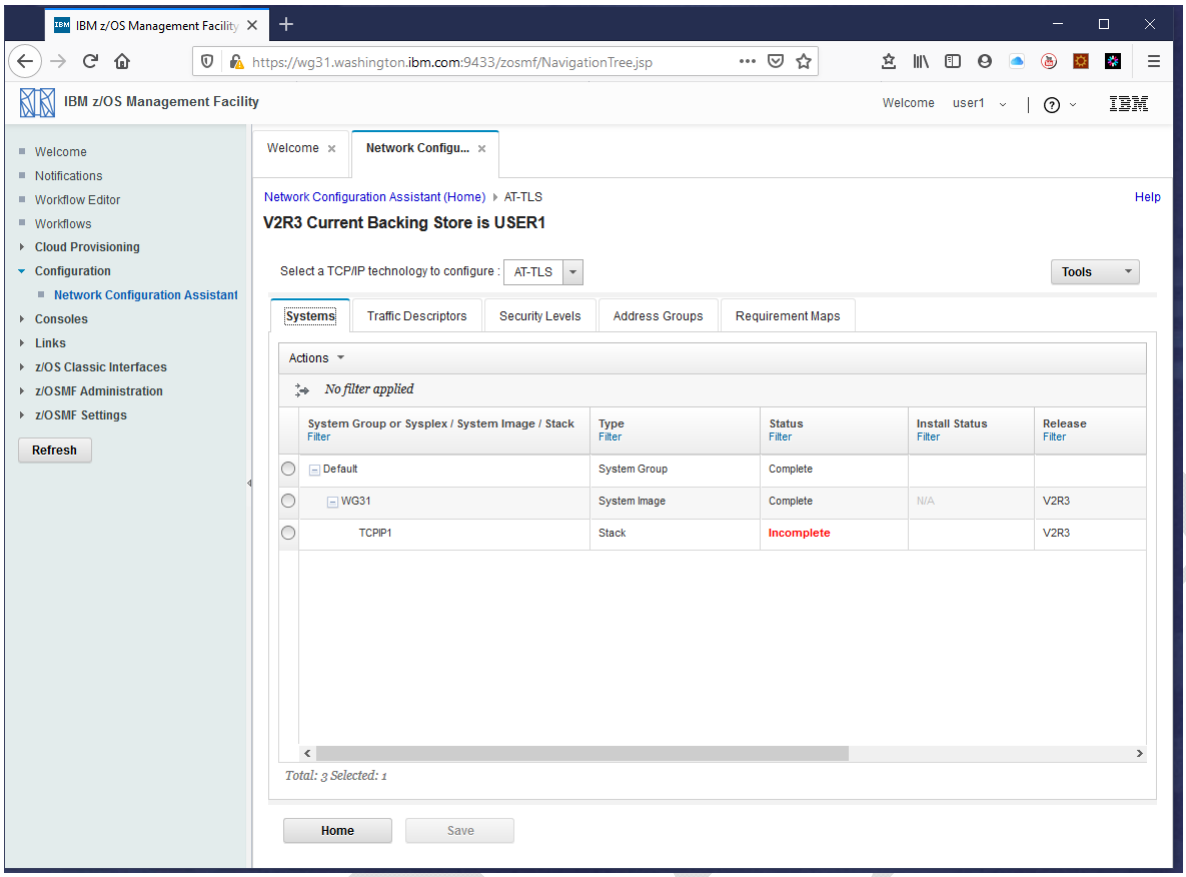


21. Select the radio button beside *Db2RequirementMap* and use the *Actions* pull-down to select the *View Details* options to display the window below. Review the details and click the **Close** button to continue.

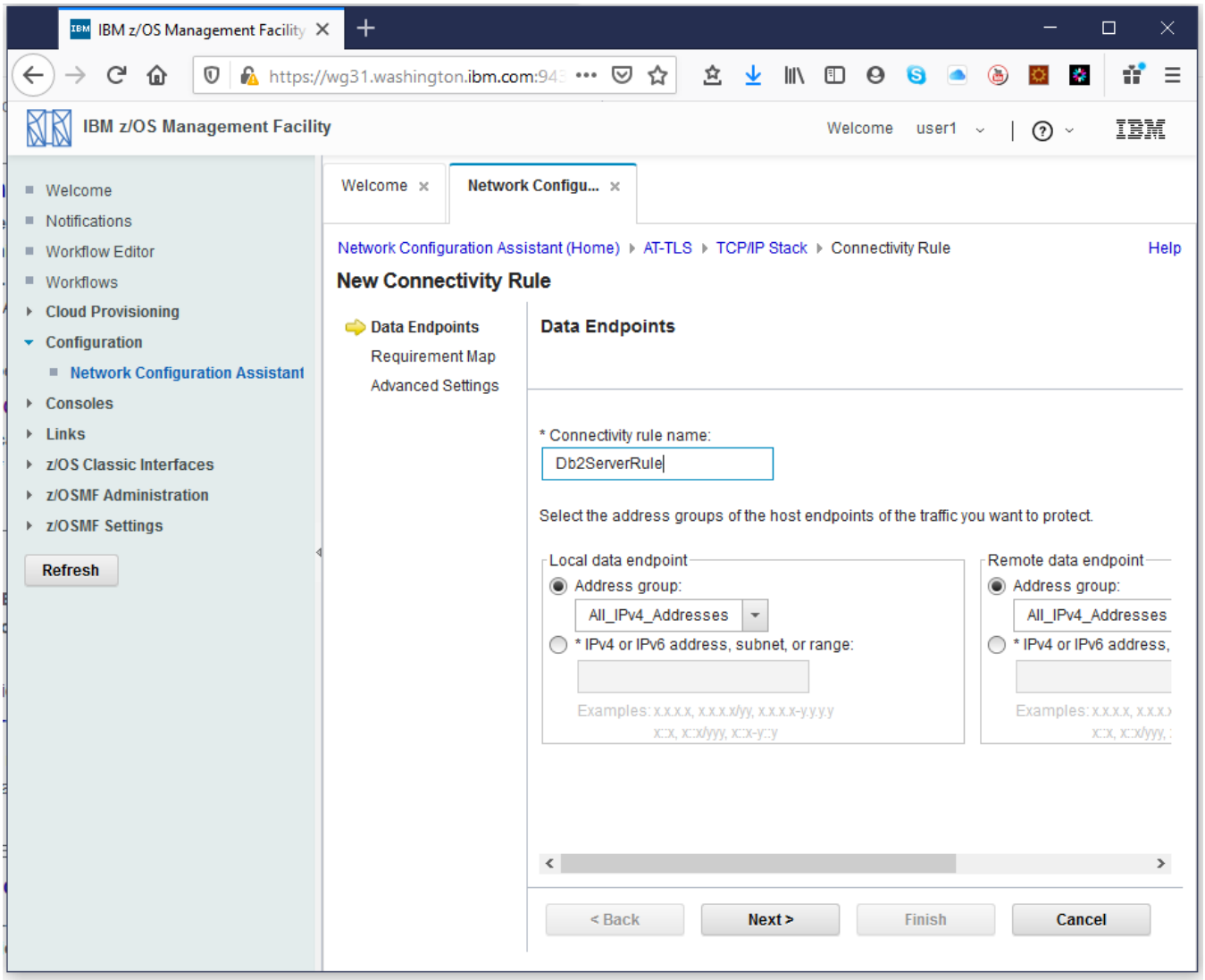


22. Click the **Save** button to save the configuration.

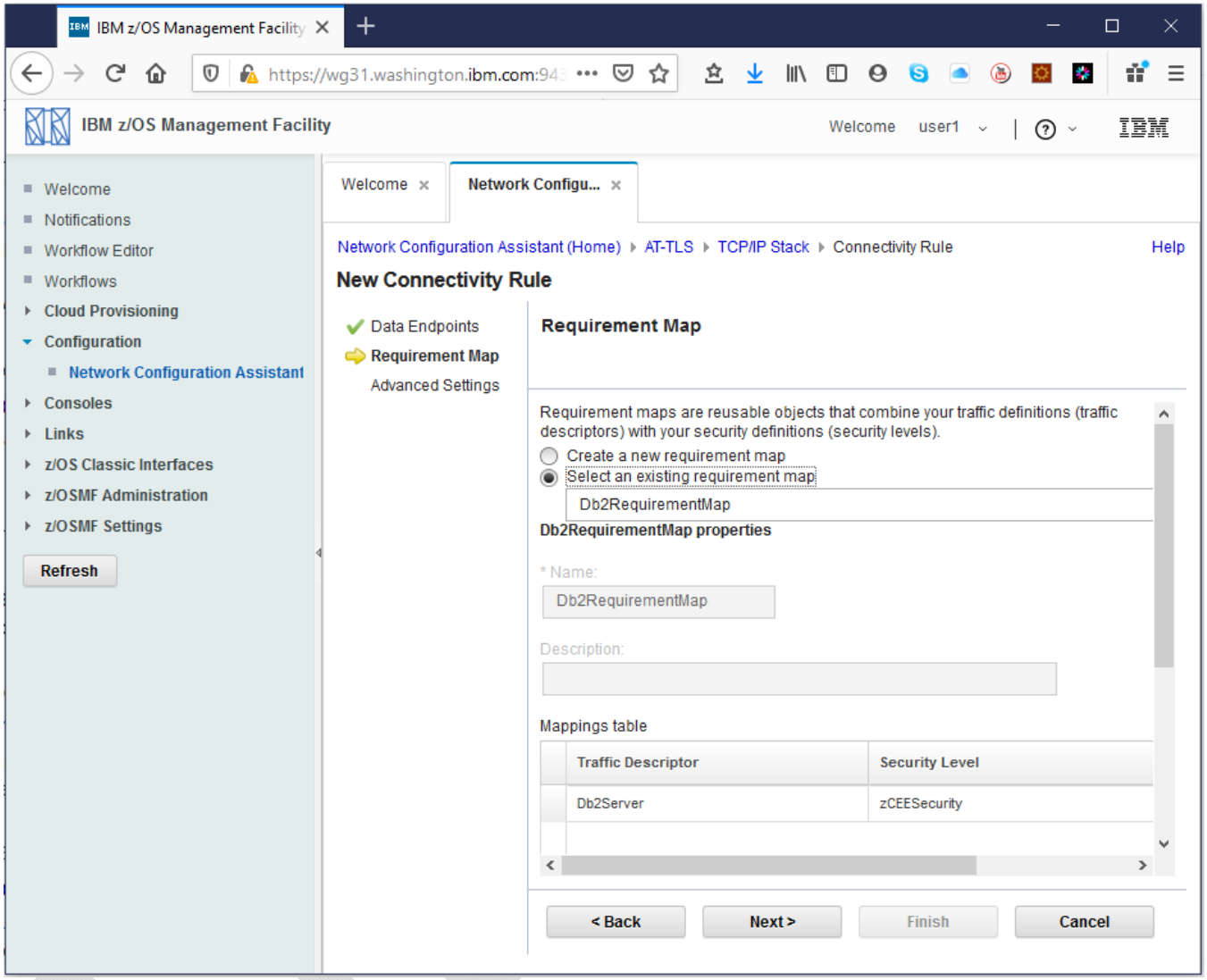
___23. When the save has completed, click on the *Systems* tab to return to this window.



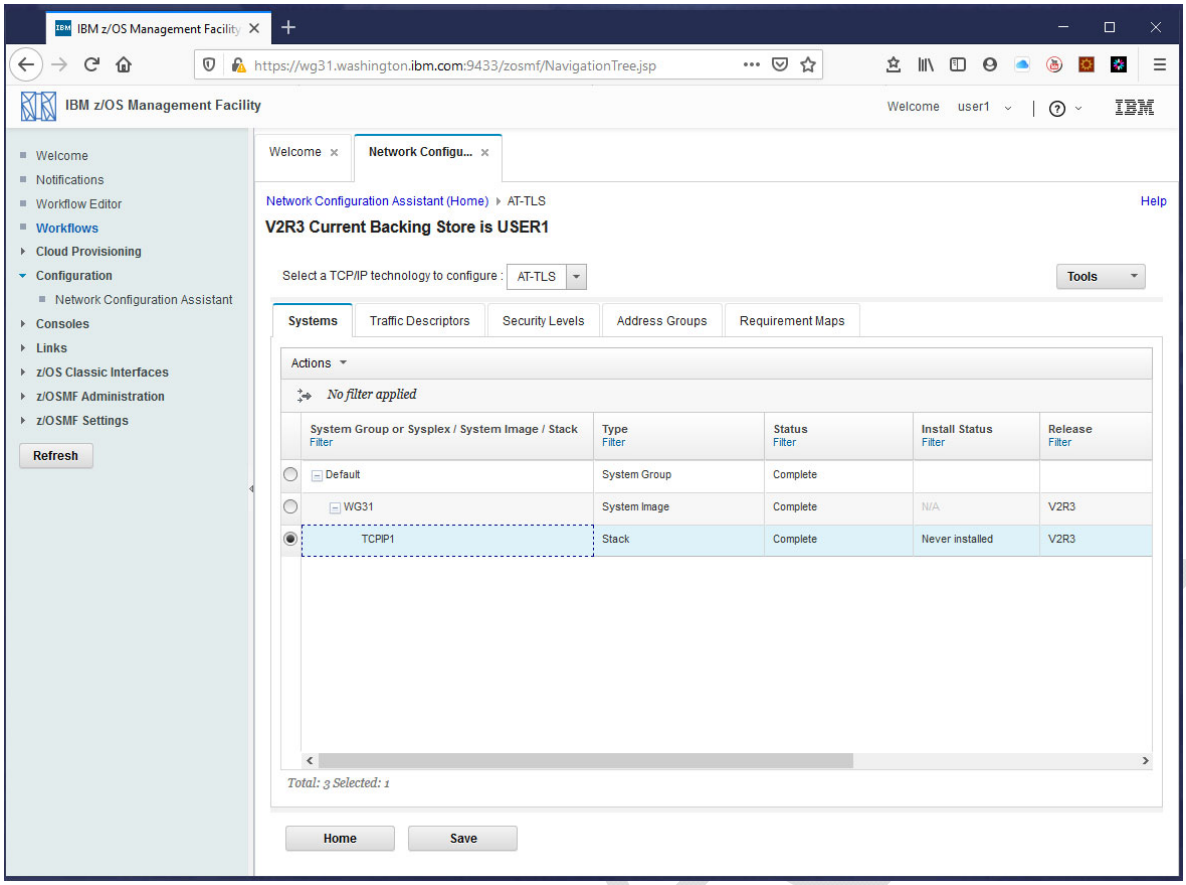
24. Select the radio button beside *TCPIP1* and use the *Actions* pull-down to select *Rules*. This is where these definitions will be tied together. Use the *Actions* pull-down again and select *New* to create a new connectivity rule. Enter ***Db2ServerRule*** for the *Connectivity rule name* and press **Next** to continue.



25. On the *New Connectivity Rule – Requirement Map* window, select the radio button beside *Select an existing requirement map* and use the pull-down to select *Db2RequirementMap*. This should automatically populate the mapping table with *Db2Server* as the traffic descriptor and *zCEESecurity* as the security level. Press **Next** and then **Finish** to continue.

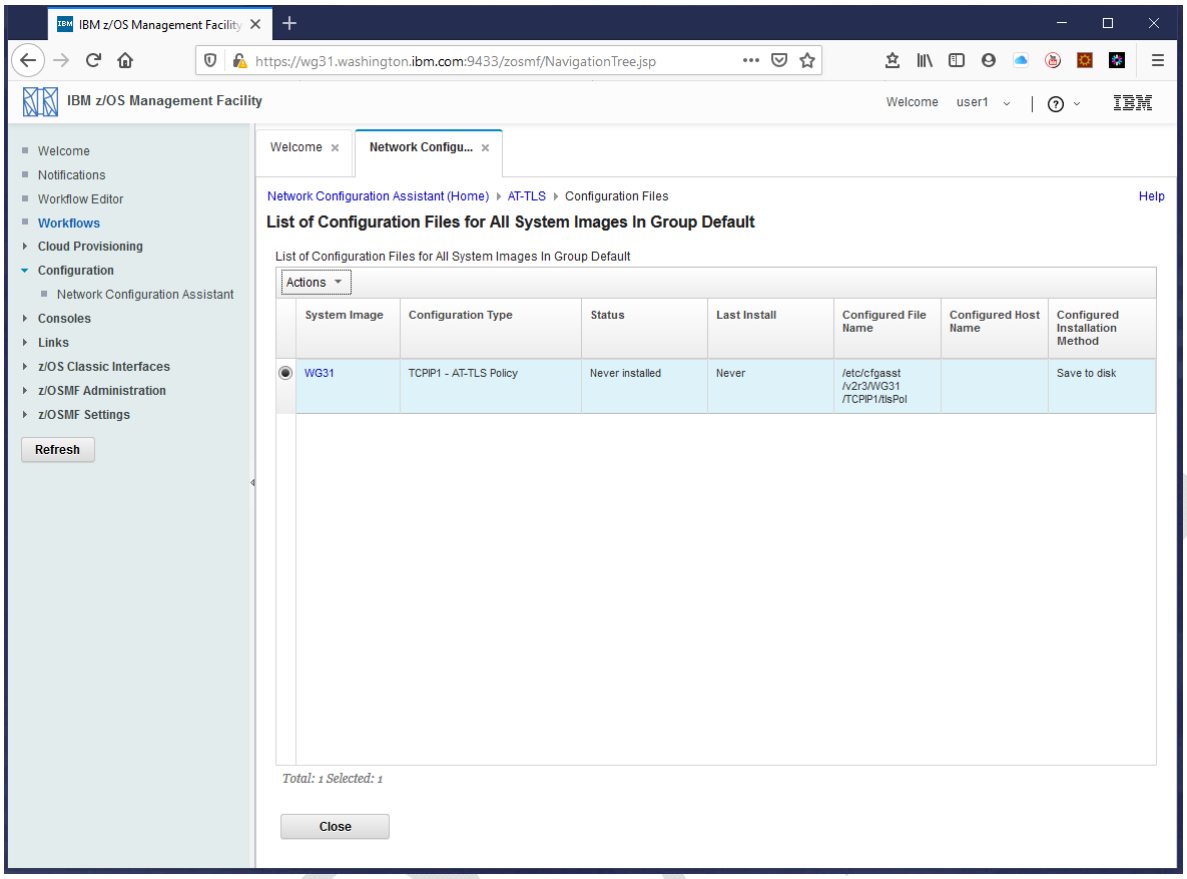


___26. Press **Close** to return to this window. Note that the status of the configuration is now complete.

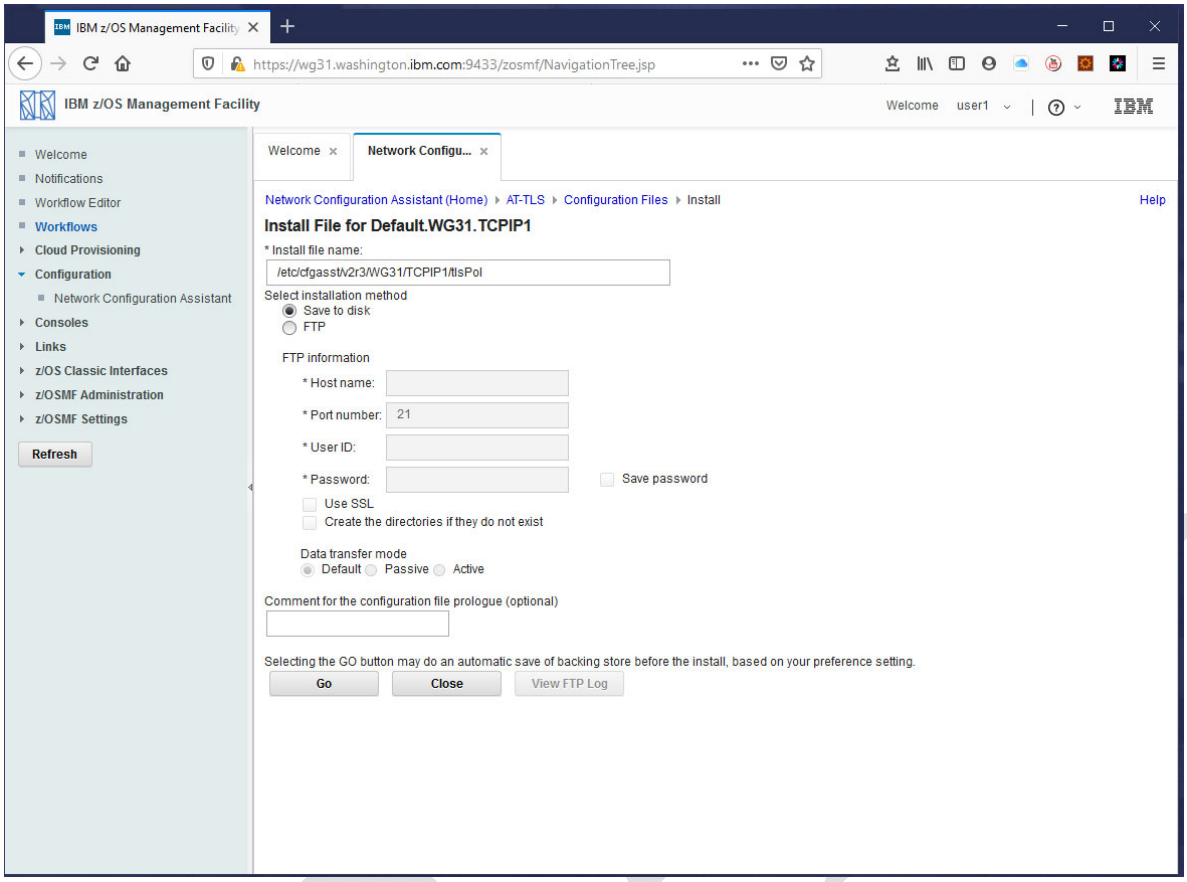


___27. Select the radio button beside *TCPIP1* and use the *Actions* pull-down to select *Install All Files for This Group.*

28. On the *List of Configuration Files for All Systems Images in Group Default* window, select *WG31* and use the *Actions* pull-down to select *Install*.

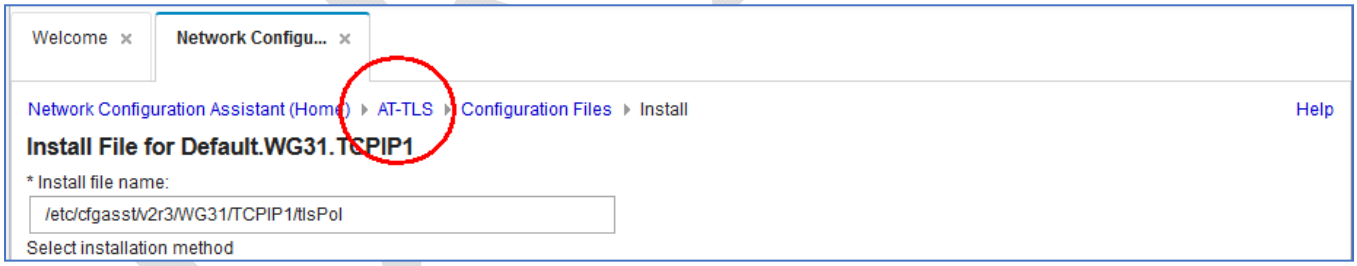


___29. On the *Install File for Default.WG31.TCPIP1* window, click the **GO** button to continue.



___30. Click **OK** twice to continue.

___31. Next, click on *AT-TLS* as shown below to return to the primary window.



___32. The AT-TLS configuration has been completed and is installed, but it is not active yet.

Activating the AT-TLS configuration

The AT-TLS configuration has been saved in an OMVS file but has not been installed in the active policy agent task (e.g., PAGENT).

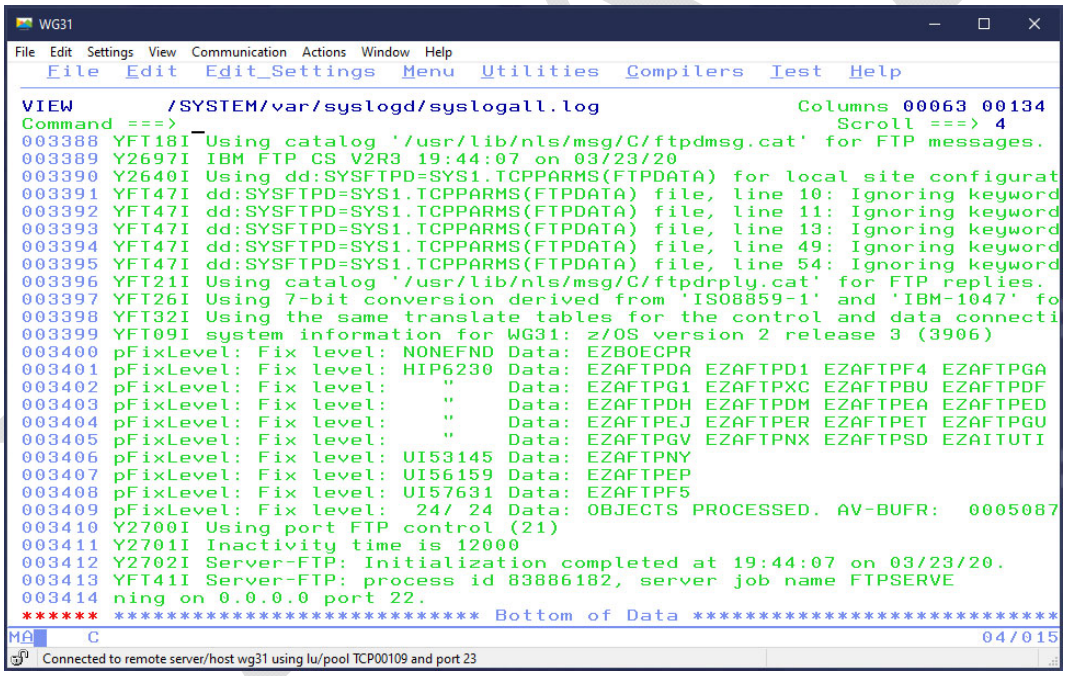
___1. This instance of the policy agent has been configured to use the *SYSLOGD* daemon task to log messages.

```
//PAGENT   EXEC PGM=PAGENT,REGION=0K,TIME=NOLIMIT,
//      PARM='ENVAR("_CEE_ENVFILE_S=DD:STDENV")/ -l SYSLOGD'
```

___2. The *SYSLOGD* daemon has been configured to write all log messages to file */var/syslogd/syslogall.log* (see the *syslog.conf* file in the **/etc** subdirectory) as shown below:

```
######################################################################
#
# Write all messages with priority err and higher to log file errors.
#
#*.err             /var/log/%Y/%m/%d/errors
*.*               /var/syslogd/syslogall.log
#
```

___3. Use ISPF option 3.4 to access directory */var/syslogd* and the *v* line command to view *syslogall.log* Go the bottom of the file and you will something like what is shown below:



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___4. Start the policy agent task using MVS command ***S PAGENT***

___5. Exit the *syslogall.log* view session and reopen the file do a find for sting ***EZZ8431I PAGENT STARTING***. You should see these messages.

```
003414 0.0.0 port 22.
003415 main: EZZ8431I PAGENT STARTING
003416 main: Compiled on Sep 26 2016 at 18:37:59
003417 main: Use environment PAGENT_CONFIG_FILE = '/etc/pagent.conf'
003418 main: List all environment variables:
003419 main:   EXPORT '_CEE_ENVFILE_S=DD:STDENV'
003420 main:   EXPORT 'LIBPATH=/usr/lib:.'
003421 main:   EXPORT 'PAGENT_CONFIG_FILE=/etc/pagent.conf'
003422 main:   EXPORT 'PAGENT_LOG_FILE=SYSLOGD'
003423 main:   EXPORT 'TZ=EST5EDT'
003424 main:   EXPORT 'GSK_TRACE=0xFFFF'
003425 main: using code page 'IBM-1047'
003426 main: Using log level 511
```

___6. Do a find for the character string TTLSRule, e.g. ***f TTLSRule*** and you see multiple occurrences where the AT-TLS configuration elements added earlier are being processed.

```
003515 _profile: Processing Image TTLS config file: '/etc/cfgasst/v2r3/WG31/
003516  Processing:  'TTLSRule                          Db2ServerRule~1'
003517  Processing:  'TTLSGroupAction                   gAct1~Db2Server'
003518  Processing:  'TTLSEnvironmentAction             eAct1~Db2Server'
003519  Processing:  'TTLSConnectionAction              cAct1~Db2Server'
003520  Processing:  'TTLSConnectionAdvancedParms       cAdv1~Db2Server'
003521  Processing:  'TTLSKeyringParms                  keyR~WG31'
003522  Processing:  'IpAddrSet                         addr1'
003523  Processing:  'PortRange                         portR1'
003524  Processing:  'PortRange                         portR2'
003525 _profile: Finished processing Image TTLS config file
003526 Processing TTLS Group action 'gAct1~ Db2Server'
003527 Processing TTLS Connection action 'cAct1~Db2Server'
003528 Processing TTLS Environment action 'eAct1~Db2Server'
003529 ocessing TTLS rule 'Db2Server~1'
```

___7. Go the bottom of this file and you see these messages

```
EZD1579I PAGENT POLICIES ARE NOT ENABLED FOR TCPIP1 : TTLS
EZZ8771I PAGENT CONFIG POLICY PROCESSING COMPLETE FOR TCPIP1 : QOS
EZZ8771I PAGENT CONFIG POLICY PROCESSING COMPLETE FOR TCPIP1 : TTLS
EZD1586I PAGENT HAS INSTALLED ALL LOCAL POLICIES FOR TCPIP1
Finished main config file update
```

Tech-Tip: If a policy or otherwise changed the new or updated policy can be installed with an MVS modify command, ***F PAGENT,REFRESH***

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___8. The policy agent is active. The policies have been loaded, but there is one remaining step. The TCPIP stack has not been modified to enable TTLS. On this image this has been configured this way so the AT-TLS is disabled by default and must be explicitly enabled. This is done by an MVS VARY command.

V TCPIP,,OBEY,SYS1.TCPPARMS(TTLS)

Where the contents of SYS1.TCPPARMS(TTLS) is simply TCPCONFIG TTLS

Issue this command and you should see these messages in the console, see below:

```
V TCPIP,,OBEY,SYS1.TCPPARMS(TTLS)
EZZ0060I PROCESSING COMMAND: VARY TCPIP,,OBEY,SYS1.TCPPARMS(TTLS)
EZZ0300I OPENED OBEYFILE FILE 'SYS1.TCPPARMS(TTLS)'
EZZ0309I PROFILE PROCESSING BEGINNING FOR 'SYS1.TCPPARMS(TTLS)'
EZZ0316I PROFILE PROCESSING COMPLETE FOR FILE 'SYS1.TCPPARMS(TTLS)'
EZZ0053I COMMAND VARY OBEY COMPLETED SUCCESSFULLY
```

Tech-Tip: AT-TLS can also be disabled with a VARY command, *V TCPIP,,OBEY,SYS1.TCPPARMS(NOTTLS)* where the contents of SYS1.TCPPARMS(NOTTLS) is

TCPCONFIG NOTTLS

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Test the TLS connection from the z/OS Connect Designer to a Db2 subsystem

In the following steps you will download the Db2 CERTAUTH public key certificate exported from RACF in a previous section and add it to a *Designer* trust key store that will be used to perform a TLS handshake with Db2 (via AT-TLS) and used to access Db2 from the *Designer* using TLS.

___1. On the Windows desktop, open DOS command prompt by clicking on the DOS icon.

___2. Enter the command: ***cd c:\z\openApi3\certs***

___3. Enter the command: ***ftp wg31.washington.ibm.com***

___4. Logon with *USER1* and the password for that ID

___5. Enter the command: ***prompt off***

___6. Enter the command: ***mget db2ca.pem***

___7. Enter the command: ***bin***

___8. Enter the command: ***mget designer.p12***

___9. Enter the command***: quit***

```
Microsoft Windows [Version 10.0.19044.1766]
(c) Microsoft Corporation. All rights reserved.

c:\z>cd c:\z\openApi3

c:\z\openapi3>ftp wg31.washington.ibm.com
Connected to wg31.washington.ibm.com.
220-FTP 13:34:13 on 2022-07-05.
220 Connection will close if idle for more than 200 minutes.
501 command OPTS aborted -- no options supported for UTF8
User (wg31.washington.ibm.com:(none)): user1
331 Send password please.
Password:
230 USER1 is logged on.  Working directory is "USER1.".
ftp> prompt
Interactive mode Off .
ftp> mget db2ca.pem
200 Representation type is Ascii NonPrint
200 Port request OK.
125 Sending data set USER1.DB2CA.PEM
250 Transfer completed successfully.
ftp: 1244 bytes received in 0.00Seconds 414.67Kbytes/sec.
ftp> bin
200 Representation type is Image
ftp> mget designer.p12
200 Representation type is Image
200 Port request OK.
125 Sending data set USER1.DESIGNER.P12
250 Transfer completed successfully.
ftp: 3416 bytes received in 0.11Seconds 31.05Kbytes/sec.
ftp> quit
221 Quit command received. Goodbye.
```

> **Tech-Tip:** The significance of the P12 file extensions of the certificate is that this extension usually indicates the file contains a private key and will require a password or pass phrase to be able to access this certificate.

___10. On the Windows desktop, open an Ubuntu terminal shell by clicking on the *Ubuntu* icon in the task bar.

___11. In the Ubuntu session, switch to *root* access by entering the command: ***sudo su***

___12. Enter root's password of ***passw0rd***.

Using a JSSE key store from the Designer

In this section a JSSE trust store will be create for use in TLS handshakes with Db2. Note that JSSE supports the use of the same or different key store files for both the personal and CERTAUTH repositories.

First, create a Db2 trust store and import the Db2 CA PEM into the JSSE trust store.

___1. In an Ubuntu session, copy the CERTAUTH public key certificate file (*DB2CA.PEM*) from Windows into the Linux directory mapped to a container's directory (see the docker-compose.yaml) file.

cp /mnt/c/z/openApi3/certs/DB2CA.PEM /home/workstation/docker/employees/certs

___2. In an Ubuntu session, import the CERTAUTH public key into the container's Db2 trust key store (this will create the JSSE keystore file).

docker exec -it employees_zosConnect_1 keytool -keystore /output/resources/security/db2TrustStore.jks -storetype PKCS12 -storepass changeit -importcert -file /output/resources/security/DB2CA.PEM -alias Db2CA

> **Tech-Tip:** The command, *docker exec -it cscvinc_zosConnect_1* provides a command interface for invoking command in the container. In this case, the *docker exec* command is being used to invoke the *keytool* command in the container.

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Note that there will be a prompt as to whether the certificate is to be trusted or not, reply ***yes***.

```
root:/home/workstation/docker/employees:> docker exec -it employees_zosConnect_1 keytool -keystore
/output/resources/security/db2TrustStore.jks -storetype PKCS12 -storepass changeit -importcert -file
/output/resources/security/DB2CA.PEM  -alias Db2CA
Owner: CN=Db2 CA, OU=ATS, O=IBM
Issuer: CN=Db2 CA, OU=ATS, O=IBM
Serial number: 0
Valid from: 7/1/22 5:00 AM until: 1/1/23 4:59 AM
Certificate fingerprints:
         MD5:  3A:40:CE:00:0C:84:36:D4:77:4F:7A:61:92:73:6C:F8
         SHA1: 6A:92:D9:C4:9C:A8:D5:5E:AB:5D:1D:82:1D:AF:5D:7D:63:8F:47:1E
         SHA256: CF:6F:A2:B7:CA:FA:56:44:ED:A8:6A:07:FD:E2:05:3D:FF:78:D2:88:C0:87:C0:D3:9E:0A:79:71:7A:18:AF:A2
         Signature algorithm name: SHA256withRSA
         Version: 3

Extensions:

#1: ObjectId: 2.16.840.1.113730.1.13 Criticality=false
0000: 16 30 47 65 6e 65 72 61  74 65 64 20 62 79 20 74  .0Generated.by.t
0010: 68 65 20 53 65 63 75 72  69 74 79 20 53 65 72 76  he.Security.Serv
0020: 65 72 20 66 6f 72 20 7a  2f 4f 53 20 28 52 41 43  er.for.z.OS..RAC
0030: 46 29                                              F.


#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: be f3 b3 48 61 b0 07 fd  d0 d4 e0 da 0d b5 4f 4b  ...Ha.........OK
0010: a9 6c 61 27                                        .la.
]
]

#4: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
CA:true
PathLen:2147483647
]

Trust this certificate? [no]:  yes
Certificate was added to keystore
```

___3. To view the contents of this key store using this command

docker exec -it employees_zosConnect_1 keytool -keystore /output/resources/security/db2TrustStore.jks -storetype PKCS12 --storepass changeit -list

```
root:/home/workstion/docker/employees:> docker exec -it employees_zosConnect_1 keytool -list -keystore
/output/resources/security/db2TrustStore.jks -storetype PKCS12 --storepass changeit

Keystore type: PKCS12
Keystore provider: IBMJCE

Your keystore contains 1 entries

db2ca, Jul 1, 2022, trustedCertEntry,
Certificate fingerprint (SHA1): 6A:92:D9:C4:9C:A8:D5:5E:AB:5D:1D:82:1D:AF:5D:7D:63:8F:47:1E
```

This JSSE keystore contains one trustedCertEntry(CERTAUTH) certificate (labeled *db2ca*)

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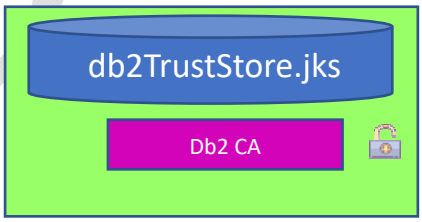
___4. Now list the contents of the details of the *db2ca* certificate using this command

docker exec -it employees_zosConnect_1 keytool -keystore /output/resources/security/db2TrustStore.jks -storetype PKCS12 --storepass changeit -list -alias db2ca -v

```
root:/home/workstation/docker/employees:> docker exec -it employees_zosConnect_1 keytool -keystore
/output/resources/security/db2KeyStore.jks -storetype PKCS12 --storepass changeit -list  -alias db2ca -v
Alias name: db2ca
Creation date: Jul 1, 2022
Entry type: trustedCertEntry

Owner: CN=Db2 CA, OU=ATS, O=IBM
Issuer: CN=Db2 CA, OU=ATS, O=IBM
Serial number: 0
Valid from: 7/1/22 5:00 AM until: 1/1/23 4:59 AM
Certificate fingerprints:
         MD5:  3A:40:CE:00:0C:84:36:D4:77:4F:7A:61:92:73:6C:F8
         SHA1: 6A:92:D9:C4:9C:A8:D5:5E:AB:5D:1D:82:1D:AF:5D:7D:63:8F:47:1E
         SHA256: CF:6F:A2:B7:CA:FA:56:44:ED:A8:6A:07:FD:E2:05:3D:FF:78:D2:88:C0:87:C0:D3:9E:0A:79:71:7A:18:AF:A2
         Signature algorithm name: SHA256withRSA
         Version: 3

Extensions:

#1: ObjectId: 2.16.840.1.113730.1.13 Criticality=false
0000: 16 30 47 65 6e 65 72 61  74 65 64 20 62 79 20 74  .0Generated.by.t
0010: 68 65 20 53 65 63 75 72  69 74 79 20 53 65 72 76  he.Security.Serv
0020: 65 72 20 66 6f 72 20 7a  2f 4f 53 20 28 52 41 43  er.for.z.OS..RAC
0030: 46 29                                             F.


#2: ObjectId: 2.5.29.15 Criticality=true
KeyUsage [
  Key_CertSign
  Crl_Sign
]

#3: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: be f3 b3 48 61 b0 07 fd  d0 d4 e0 da 0d b5 4f 4b  ...Ha.........OK
0010: a9 6c 61 27                                       .la.
]
]

#4: ObjectId: 2.5.29.19 Criticality=true
BasicConstraints:[
CA:true
PathLen:2147483647
]
```

In this output we are seeing that even though it is a self-signed certificate also (refer to the distinguished names) we imported this certificate as a trustedCertEntry (e.g., CERTAUTH) certificate. Also note that this certificate has *Key_CertSign* as a *KeyUsage* attribute. This means that it can be used to validate personal certificates signed by the *Issuer*, *CN=Db2 CA, OU=ATS, O=IBM*

This is a diagram of what we just created.



This is the minimum required to enable sever authentication TLS support between a *Designer* container and Db2.

Server certificate authentication

The container in which the *Designer* is running needs to be updated with new environment variables. Adding environment variables to a container requires updating the *docker-compose.yaml* file with the new variables and the stopping and then restarting the container with a *docker-compose* or *podman-compose* commands technique.

Update the *docker-compose.yaml* file to add three new environment variables, *DB2SSL_PORT* and *DB2TRUSTSTORE_PASSWORD, DB2KEYSTORE_PASSWORD* with values as shown below:

```
version: "3.2"
services:
    zosConnect:
        image: icr.io/zosconnect/ibm-zcon-designer:3.0.57
        user: root
        environment:
            - CICS_USER=USER1
            - CICS_PASSWORD=USER1
            - CICS_HOST=wg31.washington.ibm.com
            - CICS_PORT=1491
            - DB2_USERNAME=USER1
            - DB2_PASSWORD=USER1
            - DB2_HOST=wg31.washington.ibm.com
            - DB2_PORT=2446
            - DB2TRUSTSTORE_PASSWORD=changeit
            - DB2KEYSTORE_PASSWORD=secret
            - DB2SSL_PORT=2445
            - HTTP_PORT=9080
        ports:
            - "9449:9443"
            - "9086:9080"
        volumes:
            - ./project:/workspace/project
            - ./logs/:/logs/
            - ./certs:/output//resources/security/
```

Tech Tip: The value for the trust store password (*changeit*) is the value of -*STORPASS* used in the keytool command when the trust store was initially created. The value for the key store password is *secret* (the encryption password provided by the certificate authority and used in the earlier *RACDDERT ADD* commands). The *Db2KEYSTORE* environment variable will be used in a later section of the exercise.

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____1. If you are comfortable with the vi editor, the *docker-compose.yaml* file in the container's base Linux directory can be updated directly and then proceed to Step 4. Otherwise, using an Ubuntu session, copy the container's *docker-compose.yaml* file to a Windows directory using command:

cp /home/workstation/docker/employees/docker-compose.yaml /mnt/c/openapi3/

____2. Update the *docker-compose.yaml* file as described above using your favorite Windows editor.

____3. In an Ubuntu session, copy the update YAML file back to the Linux directory for this container.

cp /mnt/c/openapi3/docker-compose.yaml /home/workstation/docker/employees

____4. The container needs to be stopped and restarted in order for the new environment variables to be recognized. Stop the container with command:

docker stop employees_zosConnect_1

____5. Restart the container with this command (*invoke this command while in directory /home/workstation/docker/employees*).

docker-compose up -d

Now the *zosconnect.db2Connection* entry for the Db2 connection needs to have additional attributes added for TLS.

____6. Copy the Windows file *db2tlsServer.xml* to the container configuration directory as file *db2.xml.*

cp /mnt/c/z/openapi3/tls/db2TlsServer.xml /home/workstation/docker/employees/project/src/main/liberty/config/db2.xml

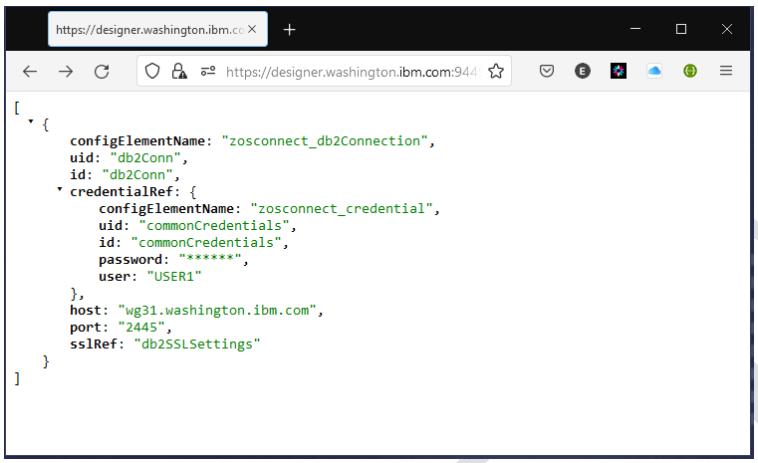
Below are the contents of *db2TlsServer.xml*. The boldfaced lines are the additions made to the original contents of db2.xml for adding TLS support between the *Designer* and Db2.

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="DB2 SSL">
    <featureManager>
        <feature>zosconnect:db2-1.0</feature>
    </featureManager>
    <zosconnect_credential id="commonCredentials" />
      user="${DB2_USERNAME}" password="${DB2_PASSWORD}" />
    <zosconnect_db2Connection id="db2Conn"
      host="${DB2_HOST}" port="${DB2_PORT}"
      credentialRef="commonCredentials"
      sslRef="db2SSLSettings" />
     <ssl id="db2SSLSettings"
      keyStoreRef="db2TrustStore"
      trustStoreRef="db2TrustStore" />
    <keyStore id="db2TrustStore"
     location="/output/resources/security/db2TrustStore.jks"
     password="${DB2TRUSTSTORE_PASSWORD}" type="PKCS12" />
</server>
```

The above configuration defines a TLS repertoire (*db2SSLSettings*) for use when connection to a Db2. Note the *sslRef* in the *zosconnect_db2Connection* configuration elements references *db2SSLSettings.* The TLS repertoire has attributes *keyStoreRef* and *trustStoreRef* referencing the same *keystore* element. This is where we could have made a distinction between personal certificates and CERTAUTH key store files. The *keystore* element, db2KeyStore, identifies the key store we created in the previous section. This key store contains our self-signed personal certificate and the Db2 *CERTAUTH* certificate.

____7. Enter the URL below in a browser to verify the updated *zosconnect_db2Connection* configuraton

https://designer.washington.ibm.com:9449/ibm/api/config/zosconnect_db2Connection

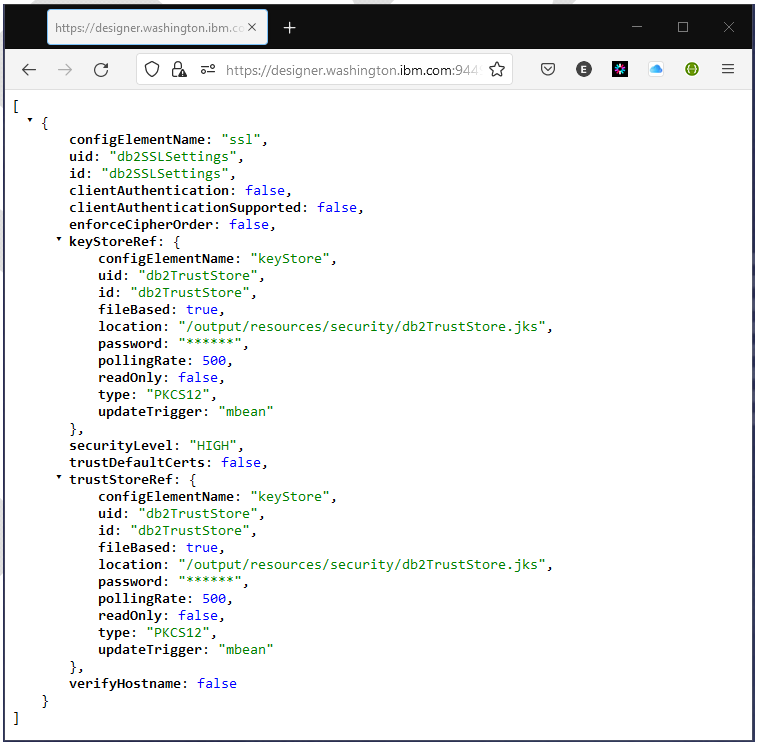


If a logon is required, use ***Fred*** as the *Username* and ***fredpwd*** as the *Password.*

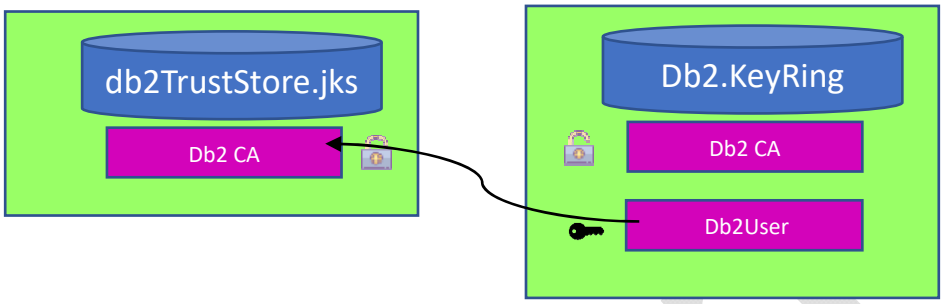
Tech-Tip: Installing the *restConnector-2.0* feature and providing an *administrator-role* configuration element, (see the *basicSecurity.xml file*), enabled the displaying of configuration elements in a web browser. This is good method for reviewing for syntax or other configuration errors in the installed server XML configuration element names particularly when other configuration elements are referenced.

Enter the URL below in a browser to verify the updated zosconnect_db2Connection configuraton

https://designer.washington.ibm.com:9449/ibm/api/config/ssl?id=db2SSLSettings



This diagram shows the TLS handshake flow as it currently configured. When a client requests a connection, Db2 (via AT-TLS) will send its server certificate to the client where it will be validated with a local CERTAUTH certificate. The client will validate the server certificate and an encrypted connection will be established (this is not mutual authentication).



To directly invoke a Db2 REST service, entering this curl command in a Windows DOS command session in directory c:\z\openapi3 with the ***-v*** trace will display the handshake flow in the **bold red** below:

curl -X POST -w " - HTTP CODE %{http_code}" --user user1:user1 --header "Content-Type: application/json" --data @selectEmployee.json --cacert certs\DB2CA.PEM https://wg31.washington.ibm.com:2445/services/zCEEService/selectEmployee -v

```
c:\z\openapi3>curl -X POST  -w " - HTTP CODE %{http_code}" --user user1:user1 --header "Content-Type: application/json" --data
@selectEmployee.json --cacert certs\DB2CA.PEM https://wg31.washington.ibm.com:2445/services/zCEEService/selectEmployee  -v
Note: Unnecessary use of -X or --request, POST is already inferred.
*   Trying 9.82.31.201:2445...
* Connected to wg31.washington.ibm.com (9.82.31.201) port 2445 (#0)
* ALPN, offering h2
* ALPN, offering http/1.1
*  CAfile: DB2CA.pem
*  CApath: none
* TLSv1.0 (OUT), TLS header, Certificate Status (22):
* TLSv1.3 (OUT), TLS handshake, Client hello (1):
* TLSv1.2 (IN), TLS header, Certificate Status (22):
* TLSv1.3 (IN), TLS handshake, Server hello (2):
* TLSv1.2 (IN), TLS handshake, Certificate (11):
* TLSv1.2 (IN), TLS handshake, Server finished (14):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Client key exchange (16):
* TLSv1.2 (OUT), TLS header, Finished (20):
* TLSv1.2 (OUT), TLS change cipher, Change cipher spec (1):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Finished (20):
* TLSv1.2 (IN), TLS header, Finished (20):
* TLSv1.2 (IN), TLS header, Certificate Status (22):
* TLSv1.2 (IN), TLS handshake, Finished (20):
* SSL connection using TLSv1.2 / AES256-SHA
* ALPN, server did not agree to a protocol
* Server certificate:
*  subject: O=IBM; OU=ATS; CN=wg31.washington.ibm.com
*  start date: Jul  1 05:00:00 2022 GMT
*  expire date: Jan  1 04:59:59 2023 GMT
*  common name: wg31.washington.ibm.com (matched)
*  issuer: O=IBM; OU=ATS; CN=Db2 CA
*  SSL certificate verify ok.
* Server auth using Basic with user 'user1'
* TLSv1.2 (OUT), TLS header, Supplemental data (23):
> POST /services/zCEEService/selectEmployee HTTP/1.1
> Host: wg31.washington.ibm.com:2445
> Authorization: Basic dXNlcjE6dXNlcjE=
> User-Agent: curl/7.82.0
> Accept: */*
> Content-Type: application/json
> Content-Length: 34
>
* TLSv1.2 (IN), TLS header, Supplemental data (23):
* Mark bundle as not supporting multiuse
< HTTP/1.1 200 OK
< Connection: keep-alive
< Content-Length:                227
< Content-Type: application/json; charset=UTF-8
< Date: Sat,  2 Jul 2022 20:25:13 GMT
< X-Powered-By: DB2 for z/OS
< Server: DB2 DDF Native REST, DSN2LOC, DSNLJEMG 10/02/19 UI65644
< Content-Language: en-US
< X-Correlation-ID: C0A8006A.G887.DBBE89586028
<
{"ResultSet
Output":[{"employeeNumber":"000050","firstName":"JOHN","middleInitial":"B","lastName":"GEYER","department":"E01","phoneNumber":"6789","job"
:"MANAGER "}],"StatusCode": 200,"StatusDescription": "Execution Successful"}* Connection #0 to host wg31.washington.ibm.com left intact
 - HTTP CODE 200
```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Note the server certificate subject distinguished name in the trace matches the distinguished name of the personal certificate connect to the Db2 key ring. Also note that the issuer or signer of the personal certificate is the Db2 CERTAUTH.

Test the TLS connection between the *Designer* and Db2 using a curl command.

```
curl -X GET  -w " - HTTP CODE %{http_code}" --user Fred:fredpwd --header "Content-Type: application/json" --insecure
https://designer.washington.ibm.com:9449/employees/details/000010
```

```
c:\z\openapi3>curl -X GET  -w " - HTTP CODE %{http_code}" --user Fred:fredpwd --header "Content-Type:
application/json" --insecure  https://designer.washington.ibm.com:9449/employees/details/000010
{"retrievedResults Output":[{"employeeID":"000010","name":"CHRISTINE I
HAAS","departmentCode":"A00","phoneNumber":"3978","dateOfHire":"1965-01-01","job":"PRES
","educationLevel":18,"sex":"F","dateOfBirth":"1933-08-
14","annualSalary":52750.0,"lastBonus":1000.0,"lastCommision":4220.0}]} - HTTP CODE 200
```

A review of the AT-TLS trace shows a successful handshake.

```
Jul  1 19:57:17 wg31/TCPIP    TCPIP1   TTLS[345]: 14:57:17 TCPIP1   EZD1281I TTLS Map   CONNID:
00002F0F LOCAL: 192.168.17.201..2445 REMOTE: 192.168.0.106..1570 JOBNAME: DSN2DIST USERID: DB2USER
TYPE: InBound STATUS: Enabled RULE: Db2ServerRule~1 ACTIONS: gAct1~Db2Server eAct1~Db2Server
cAct1~Db2Server
Jul  1 19:57:17 wg31/TCPIP    TCPIP1   TTLS[345]: 14:57:17 TCPIP1   EZD1283I TTLS Event GRPID:
00000001 ENVID: 00000003 CONNID: 00002F0F  RC:    0 Initial Handshake 0000005011527E10
0000005011522750 TLSV1.2  F0F0F3F5
```

And a review of the Liberty traces shows the handshake flow.

```
                                                                                                RSA

Socket[addr=wg31.washington.ibm.com/9.82.31.201,port=2445,localport=41164]
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Target host: wg31.washington.ibm.com
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Certificate information:
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Subject DN: CN=wg31.washington.ibm.com, OU=ATS, O=IBM
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Issuer DN: CN=Db2 CA, OU=ATS, O=IBM
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Serial number: 1
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Certificate information:
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Subject DN: CN=Db2 CA, OU=ATS, O=IBM
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Issuer DN: CN=Db2 CA, OU=ATS, O=IBM
[7/3/22 14:25:27:564 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Serial number: 0
[7/3/22 14:25:27:565 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Delegating to X509TrustManager implementation: com.ibm.jsse2.br
[7/3/22 14:25:27:566 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     3
Server is trusted by all X509ExtendedTrustManager.
[7/3/22 14:25:27:566 UTC] 00000808 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                     <
checkServerTrusted Exit
[7/3/22 14:25:27:811 UTC] 00000808 id=ca4fabf7 com.ibm.zosconnect.zosasset.db2.internal.Db2ConnectionImpl   <
sendRequest Exit

org.apache.cxf.jaxrs.impl.ResponseImpl@f64b8103
```

In the trace below, the *--cacert* attribute was omitted, and the handshake failed as expected.

```
c:\z\openapi3>curl -X POST  -w " - HTTP CODE %{http_code}" --user user1:user1 --header "Content-Type: application/json" --data
@selectEmployee.json  https://wg31.washington.ibm.com:2445/services/zCEEService/selectEmployee  -v
Note: Unnecessary use of -X or --request, POST is already inferred.
*   Trying 9.82.31.201:2445...
* Connected to wg31.washington.ibm.com (9.82.31.201) port 2445 (#0)
* ALPN, offering h2
* ALPN, offering http/1.1
*  CAfile: C:\z\software\nonIBM\cURL\curl-7.82.0-win64-mingw\bin\curl-ca-bundle.crt
*  CApath: none
* TLSv1.0 (OUT), TLS header, Certificate Status (22):
* TLSv1.3 (OUT), TLS handshake, Client hello (1):
* TLSv1.2 (IN), TLS header, Certificate Status (22):
* TLSv1.3 (IN), TLS handshake, Server hello (2):
* TLSv1.2 (IN), TLS handshake, Certificate (11):
* TLSv1.2 (OUT), TLS header, Unknown (21):
* TLSv1.2 (OUT), TLS alert, unknown CA (560):
* SSL certificate problem: self-signed certificate in certificate chain
* Closing connection 0
curl: (60) SSL certificate problem: self-signed certificate in certificate chain
More details here: https://curl.se/docs/sslcerts.html

curl failed to verify the legitimacy of the server and therefore could not
establish a secure connection to it. To learn more about this situation and
how to fix it, please visit the web page mentioned above.
 - HTTP CODE 000
```

In the SYSLOG on the z/OS side these messages appear in the console log

```
EZD1287I TTLS Error RC:  435 Initial Handshake 514
  LOCAL: 192.168.17.201..2445
  REMOTE: 192.168.0.106..16795
  JOBNAME: DSN2DIST RULE: Db2ServerRule 1
  USERID: DB2USER GRPID: 00000004 ENVID: 00000017 CONNID: 000098F5
DSNL511I  -DSN2 DSNLIENO TCP/IP CONVERSATION FAILED 515
           TO LOCATION ::192.168.0.106
           IPADDR=::192.168.0.106 PORT=16795
           SOCKET=RECV RETURN CODE=1121 REASON CODE=77A9733D
```

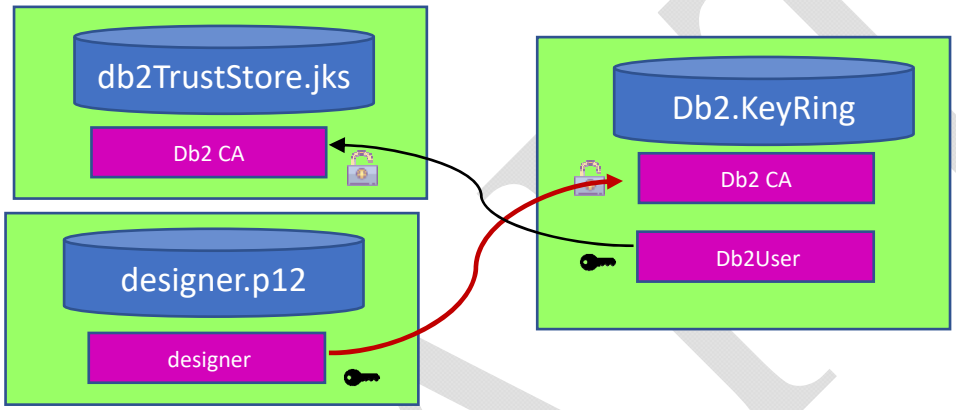
An explanation for a return of **435** (Certification authority is unknown) can be found at URL https://www.ibm.com/docs/en/zos/2.3.0?topic=codes-ssl-function-return

This completes the basic configuraton of just a server handshake,

Client certificate (mutual) authentication

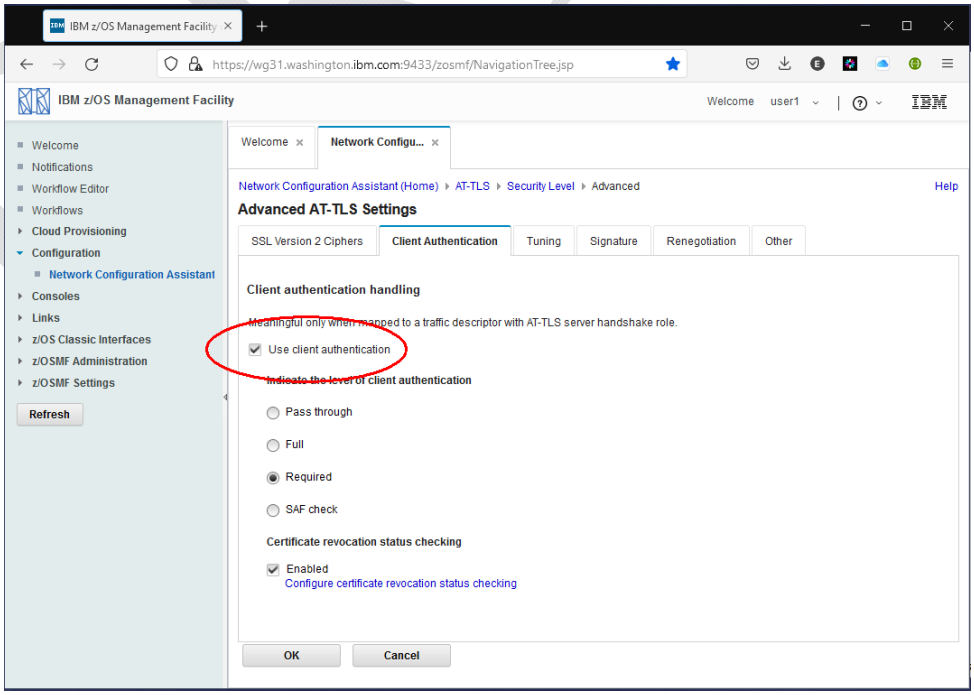
Now let's look at implementing mutual authentication. Mutual authentication occurs when the server endpoint requires the client to provide a proof of its identity by using a digital certificate. When mutual authentication is enabled, the client's personal certificate must have a private key.

Initially the client will send the public portion of its personal certificate (including a public key) to the server where the public contents of certificate will be validated with a local CERTAUTH certificate. Verification of the client is ensured because the client will then create a message digest (hash) of all the messages exchanged with the server. This digest is then encrypted with the client private key and sent to the server. The server uses the client public key to decrypt the digest. If the decrypted digest matches the server's digest derived from its record of the messages exchanged, then the client has proven its identity.



To configure mutual authentication in AT-TLS go to the *Security Level* tab and modify security level *zCEESecurity.* Select the *Advanced Settings* tab and then the ***Advanced Settings*** button to open the *Client Authentication* tab. Then check the box beside Use client authentication and the save and install the updated policy.

The updates can be activated by refreshing the policy agent task with MVS modify command ***F PAGENT,REFRESH***



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A *curl* test that directly invokes a Db2 REST service at this time would fail as shown here:

```
c:\z\openapi3>curl -X POST  -w " - HTTP CODE %{http_code}" --user user1:user1 --header
"Content-Type: application/json" --data @selectEmployee.json --cacert DB2CA.pem
https://wg31.washington.ibm.com:2445/services/zCEEService/selectEmployee  -v
Note: Unnecessary use of -X or --request, POST is already inferred.
*   Trying 9.82.31.201:2445...
* Connected to wg31.washington.ibm.com (9.82.31.201) port 2445 (#0)
* ALPN, offering h2
* ALPN, offering http/1.1
*  CAfile: DB2CA.pem
*  CApath: none
* TLSv1.0 (OUT), TLS header, Certificate Status (22):
* TLSv1.3 (OUT), TLS handshake, Client hello (1):
* TLSv1.2 (IN), TLS header, Certificate Status (22):
* TLSv1.3 (IN), TLS handshake, Server hello (2):
* TLSv1.2 (IN), TLS handshake, Certificate (11):
* TLSv1.2 (IN), TLS handshake, Request CERT (13):
* TLSv1.2 (IN), TLS handshake, Server finished (14):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Certificate (11):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Client key exchange (16):
* TLSv1.2 (OUT), TLS header, Finished (20):
* TLSv1.2 (OUT), TLS change cipher, Change cipher spec (1):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Finished (20):
* TLSv1.2 (IN), TLS header, Unknown (21):
* OpenSSL SSL_connect: Connection was reset in connection to wg31.washington.ibm.com:2445
* Closing connection 0
curl: (35) OpenSSL SSL_connect: Connection was reset in connection to
wg31.washington.ibm.com:2445
 - HTTP CODE 000
```

In the SYSLOG on the z/OS side these messages appear in the console log

```
EZD1287I TTLS Error RC:  403 Initial Handshake 447
  LOCAL: 192.168.17.201..2445
  REMOTE: 192.168.0.106..1127
  JOBNAME: DSN2DIST RULE: Db2ServerRule 1
  USERID: DB2USER GRPID: 00000003 ENVID: 00000011 CONNID: 000075B3
DSNL511I  -DSN2 DSNLIENO TCP/IP CONVERSATION FAILED 448
           TO LOCATION ::192.168.0.106
           IPADDR=::192.168.0.106 PORT=1127
           SOCKET=RECV RETURN CODE=1121 REASON CODE=77A9733D
```

An explanation for a return of **403** (No certificate received from partner) can be found at URL https://www.ibm.com/docs/en/zos/2.3.0?topic=codes-ssl-function-return

____1. In an Ubuntu session, copy the user's private keycertificate file (*DB2CA.PEM*) from Windows into the Linux directory mapped to a container's directory (see the docker-compose.yaml) file.

cp /mnt/c/z/openApi3/certs/DESIGNER.P12 /home/workstation/docker/employees/certs

____2. In an Ubuntu session, copy the Windows file *db2TlsMutual.xml* to the container configuration directory as file *db2.xml.*

cp /mnt/c/z/openapi3/tls/db2TlsMutual.xml /home/workstation/docker/employees/project/src/main/liberty/config/db2.xml

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Below are the contents of *db2TlsServer.xml*. The boldfaced lines are the additions made to the original contents of db2.xml for adding TLS support between the *Designer* and Db2.

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="Db2 zosconnect_db2Connection ">
    <featureManager>
        <feature>zosconnect:db2-1.0</feature>
    </featureManager>

<zosconnect_db2Connection id="db2Conn"
   host="${DB2_HOST}"
   port="${DB2SSL_PORT}"
   credentialRef="commonCredentials"
   sslRef="db2SSLSettings" />

<zosconnect_credential id="commonCredentials"
   user="${DB2_USERNAME}"
   password="${DB2_PASSWORD}"/>

 <ssl id="db2SSLSettings"
      keyStoreRef="db2KeyStore"
      trustStoreRef="db2TrustStore" />
 <keyStore id="db2TrustStore"
     location="/output/resources/security/db2TrustStore.jks"
     password="${DB2TRUSTSTORE_PASSWORD}" type="PKCS12" />
 <keyStore id="db2KeyStore"
     location="/output/resources/security/DESIGNER.P12"
     password="${DB2KEYSTORE_PASSWORD}" type="PKCS12" />
</server>
```

The above configuration defines a TLS repertoire (*db2SSLSettings*) for use when connection to a Db2. Note the *sslRef* in the *zosconnect_db2Connection* configuration elements references *db2SSLSettings.* The TLS repertoire has attributes *keyStoreRef* and *trustStoreRef* referencing different *keystore* elements. The *keystore* element, **db2TrustStore**, identifies the key store we used for server authentication in the previous section. This key store contains Db2 *CERTAUTH* certificate. The keystore element, **db2KeyStore**, identifies the key store that contains this client's personal certificate.

____3. In an Ubuntu session, stop the container using this command:

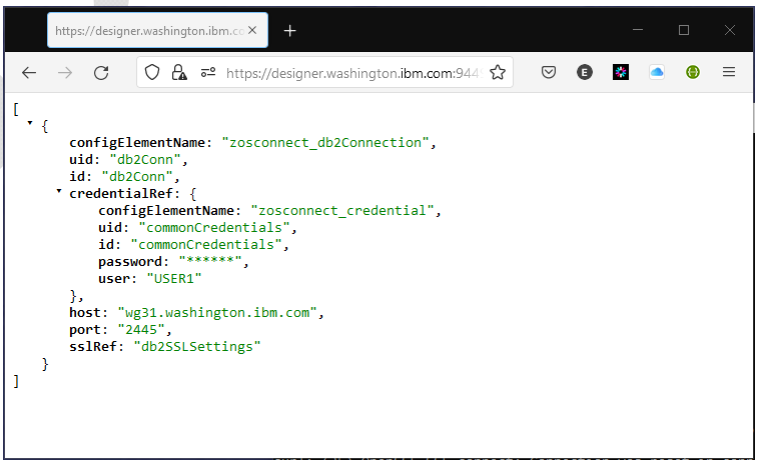
docker stop employees_zosConnect_1

____4. In an Ubuntu session, restart the container using this command:

docker start employees_zosConnect_1

____5. Enter the URL below in a browser to verify the updated *zosconnect_db2Connection* configuraton

https://designer.washington.ibm.com:9449/ibm/api/config/zosconnect_db2Connection

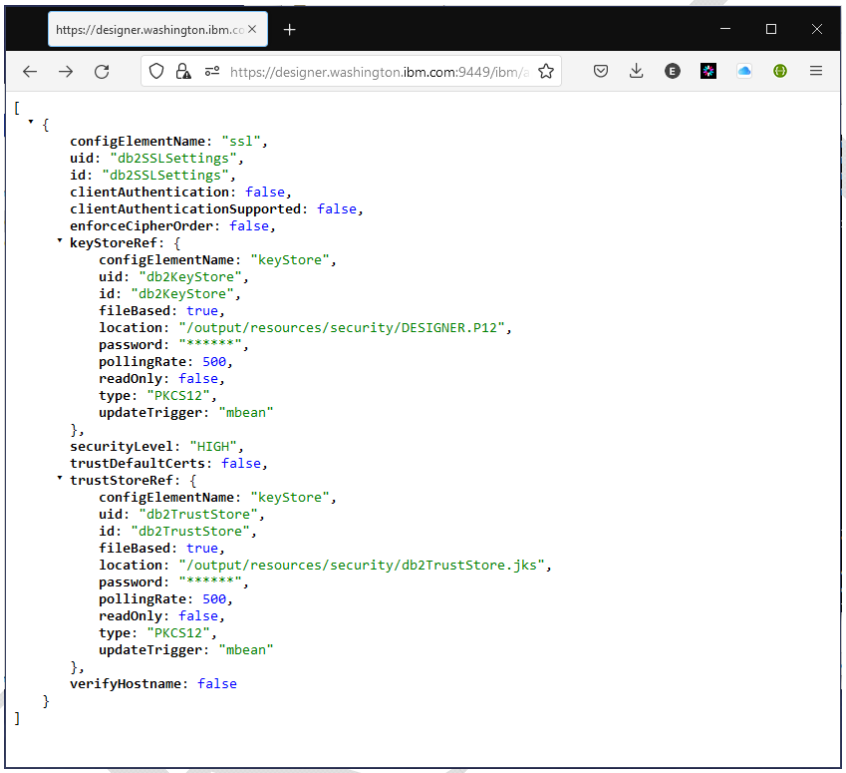


If a logon is required, use ***Fred*** as the *Username* and ***fredpwd*** as the *Password*

Tech-Tip: Installing the *restConnector-2.0* feature and providing an *administrator-role* configuration element, (see the *basicSecurity.xml file*), enabled the displaying of configuration elements in a web browser. This is good method for reviewing for syntax or other configuration errors in the installed server XML configuration element names particularly when other configuration elements are referenced.

____6. Enter the URL below in a browser to verify the updated zosconnect_db2Connection configuraton

https://designer.washington.ibm.com:9449/ibm/api/config/ssl?id=db2SSLSettings



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To demonstrate the new TLS handshake flow, invoke a Db2 REST service by entering this *curl* command in a Windows DOS command session in directory c:\z\openapi3 with the ***-v*** trace will display the additions related to mutual authentication in the handshake flow in the **bold red** below:

curl -X POST -w " - HTTP CODE %{http_code}" --user user1:user1 --header "Content-Type: application/json" --data @selectEmployee.json --cacert certs\DB2CA.PEM --cert DESIGNER.P12:secret --cert-type P12 https://wg31.washington.ibm.com:2445/services/zCEEService/selectEmployee -v

```
c:\z\openapi3>curl -X POST  -w " - HTTP CODE %{http_code}" --user user1:user1 --header "Content-Type: application/json" --data
@selectEmployee.json --cacert DB2CA.PEM https://wg31.washington.ibm.com:2445/services/zCEEService/selectEmployee  -v --cert
DESIGNER.P12:secret --cert-type P12
Note: Unnecessary use of -X or --request, POST is already inferred.
*   Trying 9.82.31.201:2445...
* Connected to wg31.washington.ibm.com (9.82.31.201) port 2445 (#0)
* ALPN, offering h2
* ALPN, offering http/1.1
*  CAfile: DB2CA.PEM
*  CApath: none
* TLSv1.0 (OUT), TLS header, Certificate Status (22):
* TLSv1.3 (OUT), TLS handshake, Client hello (1):
* TLSv1.2 (IN), TLS header, Certificate Status (22):
* TLSv1.3 (IN), TLS handshake, Server hello (2):
* TLSv1.2 (IN), TLS handshake, Certificate (11):
* TLSv1.2 (IN), TLS handshake, Request CERT (13):
* TLSv1.2 (IN), TLS handshake, Server finished (14):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Certificate (11):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Client key exchange (16):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, CERT verify (15):
* TLSv1.2 (OUT), TLS header, Finished (20):
* TLSv1.2 (OUT), TLS change cipher, Change cipher spec (1):
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Finished (20):
* TLSv1.2 (IN), TLS header, Finished (20):
* TLSv1.2 (IN), TLS header, Certificate Status (22):
* TLSv1.2 (IN), TLS handshake, Finished (20):
* SSL connection using TLSv1.2 / AES256-SHA
* ALPN, server did not agree to a protocol
* Server certificate:
*  subject: O=IBM; OU=ATS; CN=WG31.WASHINGTON.IBM.COM
*  start date: Jul  4 05:00:00 2022 GMT
*  expire date: Jan  1 04:59:59 2024 GMT
*  common name: WG31.WASHINGTON.IBM.COM (matched)
*  issuer: O=IBM; OU=ATS; CN=DB2 CA
*  SSL certificate verify ok.
* Server auth using Basic with user 'user1'
* TLSv1.2 (OUT), TLS header, Supplemental data (23):
> POST /services/zCEEService/selectEmployee HTTP/1.1
> Host: wg31.washington.ibm.com:2445
> Authorization: Basic dXNlcjE6dXNlcjE=
> User-Agent: curl/7.82.0
> Accept: */*
> Content-Type: application/json
> Content-Length: 34
>
* TLSv1.2 (IN), TLS header, Supplemental data (23):
* Mark bundle as not supporting multiuse
< HTTP/1.1 200 OK
< Connection: keep-alive
< Content-Length:                227
< Content-Type: application/json; charset=UTF-8
< Date: Tue,  5 Jul 2022 20:00:23 GMT
< X-Powered-By: DB2 for z/OS
< Server: DB2 DDF Native REST, DSN2LOC, DSNLJEMG 10/02/19 UI65644
< Content-Language: en-US
< X-Correlation-ID: C0A8006A.H0F5.DBC249645DE9
<
{"ResultSet
Output":[{"employeeNumber":"000050","firstName":"JOHN","middleInitial":"B","lastName":"GEYER","department":"E01","phoneNumber":"6789","job"
:"MANAGER "}],"StatusCode": 200,"StatusDescription": "Execution Successful"}* Connection #0 to host wg31.washington.ibm.com left intact
 - HTTP CODE 200
```


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Test the TLS connection between the *Designer* and Db2 using a curl command.

curl -X GET -w " - HTTP CODE %{http_code}" --user Fred:fredpwd --header "Content-Type: application/json" --insecure https://designer.washington.ibm.com:9449/employees/details/000010

```
c:\z\openapi3>curl -X GET  -w " - HTTP CODE %{http_code}" --user Fred:fredpwd --header "Content-Type:
application/json" --insecure  https://designer.washington.ibm.com:9449/employees/details/000010
{"retrievedResults Output":[{"employeeID":"000010","name":"CHRISTINE I
HAAS","departmentCode":"A00","phoneNumber":"3978","dateOfHire":"1965-01-01","job":"PRES
","educationLevel":18,"sex":"F","dateOfBirth":"1933-08-
14","annualSalary":52750.0,"lastBonus":1000.0,"lastCommision":4220.0}]} - HTTP CODE 200
```

A review of the AT-TLS trace shows a successful handshake.

```
Jul  1 19:57:17 wg31/TCPIP    TCPIP1   TTLS[345]: 14:57:17 TCPIP1   EZD1281I TTLS Map   CONNID:
00002F0F LOCAL: 192.168.17.201..2445 REMOTE: 192.168.0.106..1570 JOBNAME: DSN2DIST USERID: DB2USER
TYPE: InBound STATUS: Enabled RULE: Db2ServerRule~1 ACTIONS: gAct1~Db2Server eAct1~Db2Server
cAct1~Db2Server
Jul  1 19:57:17 wg31/TCPIP    TCPIP1   TTLS[345]: 14:57:17 TCPIP1   EZD1283I TTLS Event GRPID:
00000001 ENVID: 00000003 CONNID: 00002F0F  RC:    0 Initial Handshake 0000005011527E10
0000005011522750 TLSV1.2  F0F0F3F5
```


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And a review of the Liberty traces show the completion of the mutual authentication handshake flow.

```
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Target host: wg31.washington.ibm.com
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Certificate information:
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Subject DN: CN=WG31.WASHINGTON.IBM.COM, OU=ATS, O=IBM
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Issuer DN: CN=DB2 CA, OU=ATS, O=IBM
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Serial number: 1
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Certificate information:
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Subject DN: CN=DB2 CA, OU=ATS, O=IBM
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Issuer DN: CN=DB2 CA, OU=ATS, O=IBM
[7/6/22 13:35:51:321 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Serial number: 0
[7/6/22 13:35:51:322 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Delegating to X509TrustManager implementation: com.ibm.jsse2.br
[7/6/22 13:35:51:350 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    3
Server is trusted by all X509ExtendedTrustManager.
[7/6/22 13:35:51:350 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509TrustManager                    <
checkServerTrusted Exit
[7/6/22 13:35:51:353 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      >
chooseClientAlias Entry
                                                                                                            RSA

CN=DB2 CA, OU=ATS, O=IBM

CN=zCEE CA, OU=ATS, O=IBM

CN=WG31.WASHINGTON.IBM.COM, OU=ATS, O=IBM

Socket[addr=wg31.washington.ibm.com/9.82.31.201,port=2445,localport=42506]
[7/6/22 13:35:51:353 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      <
chooseClientAlias Exit
[7/6/22 13:35:51:353 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      >
chooseClientAlias Entry
                                                                                                            RSA

CN=DB2 CA, OU=ATS, O=IBM

CN=zCEE CA, OU=ATS, O=IBM

CN=WG31.WASHINGTON.IBM.COM, OU=ATS, O=IBM
[7/6/22 13:35:51:353 UTC] 00000040 id=00000000 com.ibm.websphere.ssl.JSSEHelper                         >
getOutboundConnectionInfo Entry
[7/6/22 13:35:51:353 UTC] 00000040 id=00000000 com.ibm.ws.ssl.config.ThreadContext                      3
getOutboundConnectionInfo
[7/6/22 13:35:51:353 UTC] 00000040 id=00000000 com.ibm.websphere.ssl.JSSEHelper                         <
getOutboundConnectionInfo Exit

null
[7/6/22 13:35:51:354 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      <
chooseClientAlias (from JSSE) Exit

designer
[7/6/22 13:35:51:354 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      >
getPrivateKey Entry

designer
[7/6/22 13:35:51:354 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      3
getX509KeyManager -> com.ibm.jsse2.bn
[7/6/22 13:35:51:354 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      <
getPrivateKey -> true Exit
[7/6/22 13:35:51:354 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      >
getCertificateChain: designer Entry
[7/6/22 13:35:51:354 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      3
getX509KeyManager -> com.ibm.jsse2.bn
[7/6/22 13:35:51:354 UTC] 00000040 id=00000000 com.ibm.ws.ssl.core.WSX509KeyManager                      <
getCertificateChain Exit
                                                                                                            [

[
  Version: V3
  Subject: CN=Designer, OU=ATS, O=IBM
  Signature Algorithm: SHA256withRSA, OID = 1.2.840.113549.1.1.11

  Key:  IBMJCE RSA Public Key:
```

This completes the basic configuraton of just a mutual authentication handshake.

Using RACF key rings from the native z/OS server

To enable TLS connections between a z/OS Connect native server a RACF key ring will have to be created and the CERTAUTH certificate and a personal for the native server's RACF identity (if mutual authentication is required) connected to this key ring.

____1. Invoke these are the commands to add the certificates provide by the certificate authority to a new key ring. These commands do not include the command to connect a personal certificate to the key ring.

racdcert id(atsserv) addring(Db2Client.KeyRing)

racdcert id(atsserv) connect(ring(Db2Client.KeyRing) label('DB2 CA') certauth usage(certauth))

setropts raclist(digtring,digtnmap) refresh

____2. Update the current contents */var/zcee/openapi3/includes/db2Api3.xml* with the contents in bold below:

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="DB2 SSL">
    <featureManager>
        <feature>zosconnect:db2-1.0</feature>
    </featureManager>
    <zosconnect_credential id="commonCredentials" />
      user="${DB2_USERNAME}" password="${DB2_PASSWORD}" />
    <zosconnect_db2Connection id="db2Conn"
      host="${DB2_HOST}" port="${DB2_PORT}"
      credentialRef="commonCredentials"
      sslRef="db2SSLSettings" />
     <ssl id="db2SSLSettings"
      keyStoreRef="db2KeyRing"
      trustStoreRef="db2KeyRing" />
    <keyStore id="db2KeyRing"
     location="safkeyring:///Db2Client.KeyRing"
     password="password" type="JCERACFKS"
    fileBased="false" readOnly="true" />
 </server>
```

____3. Change the value of the *DB2_PORT* variable */var/zcee/openapi3/includes/openApi3.xml* from 2446 to ***2445***.

```
<variable name="DB2_HOST" value="wg31.washington.ibm.com"/>
<variable name="DB2_PORT" value="2445"/>
<variable name="DB2_USERNAME" value="USER1"/>
<variable name="DB2_PASSWORD" value="USER1"/>
```

____4. Update the server's configuration using a MVS modify command:

F ZCEEAPI3,REFRESH,CONFIG

____5. Repeat some of the tests perform in section *Testing APIs deployed in a native z/OS server*, see page 90

Congratulations, you have completed this exercise.

Additional information and samples

This section contains samples of using command to generate self-signed certificates and having them signed and then imported into a JSSE keystore. The details of the AT-TLS policy that was generated using zOSMF. And the contents of the original YAML file used to develop the Open API 3 API.

JCL to define and load the Db2 table USER1.EMPLOYEE

Below is the JCL used to load the Db2 table accessed by this API. This table was based on the standard Db2 sample employee with some constraints removed.

```
//EMPLOYEE EXEC PGM=IKJEFT01,DYNAMNBR=20
//SYSTSPRT DD  SYSOUT=*
//SYSTSIN  DD  *
 DSN SYSTEM(DSN2)
 RUN  PROGRAM(DSNTIAD) PLAN(DSNTIA12) -
      LIB('DSN2.RUNLIB.LOAD')
//SYSPRINT DD  SYSOUT=*
//SYSUDUMP DD  SYSOUT=*
//SYSIN    DD  *
  DROP TABLE USER1.EMPLOYEE;
  COMMIT;

 CREATE TABLE USER1.EMPLOYEE
               (EMPNO     CHAR(6)        NOT NULL,
                FIRSTNME  VARCHAR(12)    NOT NULL,
                MIDINIT   CHAR(1)        NOT NULL,
                LASTNAME  VARCHAR(15)    NOT NULL,
                WORKDEPT  CHAR(3)                ,
                PHONENO   CHAR(4)                ,
                HIREDATE  DATE                   ,
                JOB       CHAR(8)                ,
                EDLEVEL   SMALLINT               ,
                SEX       CHAR(1)                ,
                BIRTHDATE DATE                   ,
                SALARY    DECIMAL(9, 2)          ,
                BONUS     DECIMAL(9, 2)          ,
                COMM      DECIMAL(9, 2)          ,
                PRIMARY KEY(EMPNO));

GRANT ALL PRIVILEGES ON TABLE USER1.EMPLOYEE TO USER1;

//LOAD    EXEC DSNUPROC,PARM='DSN2,DSNTEX',COND=(4,LT)
//SORTLIB  DD  DSN=SYS1.SORTLIB,DISP=SHR
//SORTOUT  DD  UNIT=SYSDA,SPACE=(4000,(20,20),,,ROUND)
//SORTWK01 DD  UNIT=SYSDA,SPACE=(4000,(20,20),,,ROUND)
//SORTWK02 DD  UNIT=SYSDA,SPACE=(4000,(20,20),,,ROUND)
//SORTWK03 DD  UNIT=SYSDA,SPACE=(4000,(20,20),,,ROUND)
//SORTWK04 DD  UNIT=SYSDA,SPACE=(4000,(20,20),,,ROUND)
//DSNTRACE DD  SYSOUT=*
//SYSRECEM DD  DSN=DSN1210.DB2.SDSNSAMP(DSN8LEM),
//             DISP=SHR
//SYSUT1   DD  UNIT=SYSDA,SPACE=(4000,(50,50),,,ROUND)
//SYSIN    DD  *

 LOAD DATA INDDN(SYSRECEM) CONTINUEIF(72:72)='X'
      INTO TABLE USER1.EMPLOYEE
           (EMPNO     POSITION( 1)  CHAR(6),
            FIRSTNME  POSITION( 8)  VARCHAR,
            MIDINIT   POSITION(21)  CHAR(1),
            LASTNAME  POSITION(23)  VARCHAR,
            WORKDEPT  POSITION(36)  CHAR(3),
            PHONENO   POSITION(40)  CHAR(4),
            HIREDATE  POSITION(45)  DATE EXTERNAL,
            JOB       POSITION(56)  CHAR(8),
            EDLEVEL   POSITION(65)  INTEGER EXTERNAL(2),
            SEX       POSITION(68)  CHAR(1),
            BIRTHDATE POSITION(80)  DATE EXTERNAL,
            SALARY    POSITION(91)  INTEGER EXTERNAL(5),
            BONUS     POSITION(97)  INTEGER EXTERNAL(5),
            COMM      POSITION(103) INTEGER EXTERNAL(5))
      ENFORCE NO
```


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Client Certificate Requests

___1. Create a self-signed certificate (and indirectly create a local keystore)

docker exec -it employees_zosConnect_1 keytool -keystore /output/resources/security/zceeusr.p12 -storetype PKCS12 -storepass changeit -genkey -keysize 2048 -alias zceeusr -dname "CN=zceeusr.washington.ibm.com, O=IBM, C=US" -keyalg RSA -validity 365

___2. Now list the contents of the details of the *designer* certificate store using this command

docker exec -it employees_zosConnect_1 keytool -keystore /output/resources/security/zceeusr.p12 -storetype PKCS12 --storepass changeit -list -alias zceeusr -v

```
root:/home/mitchj/docker/employees/certs:> docker exec -it employees_zosConnect_1 keytool -keystore
/output/resources/security/zceeusr.p12 -storetype PKCS12 --storepass changeit -list  -alias zceeusr -v
Alias name: zceeusr
Creation date: Jul 8, 2022
Entry type: keyEntry
Certificate chain length: 1
Certificate[1]:
Owner: CN=zceeusr, O=IBM, C=US
Issuer: CN=zceeusr, O=IBM, C=US
Serial number: 2b86ea89
Valid from: 7/8/22 7:20 PM until: 7/8/23 7:20 PM
Certificate fingerprints:
         MD5:  69:44:17:E0:BE:B9:0A:AE:2F:25:6C:41:1E:79:B2:5D
         SHA1: AB:7B:77:C6:80:2F:B9:AA:AB:48:DD:20:30:6F:7D:8B:C9:D1:8F:85
         SHA256: EB:85:F7:F4:33:78:CF:3A:B6:1B:82:91:88:DD:0A:1E:3B:83:E9:6F:9F:33:A5:91:A2:DD:0B:B0:A1:AA:84:E3
         Signature algorithm name: SHA256withRSA
         Version: 3

Extensions:

#1: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: 4b 34 2b f8 ed 42 27 63  22 4e 06 9c 31 d5 a7 7f  K4...B.c.N..1...
0010: d7 81 5b 0e                                        ....
]
]]
```

Note in the above output that the *Issuer* and *Owner* have the same distinguished name, the very definition of a self-signed certificate.

___3. Create a certificate request from the self-signed certificate

docker exec -it employees_zosConnect_1 keytool -certreq -alias zceeusr -keystore /output/resources/security/zceeusr.p12 -storetype PKCS12 -storepass changeit -file /output/resources/security/zceeusr.csr

Send the certificate request file *zceeusr.csr* to the certificate authority for signing.

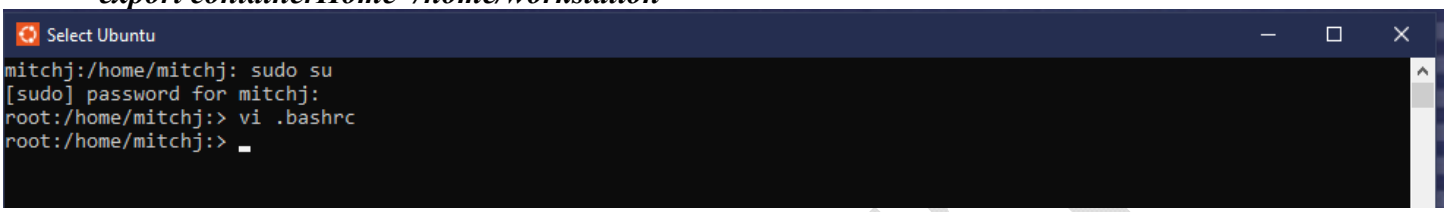
___4. Import the signed personal certificate into the local keystore

docker exec -it employees_zosConnect_1 keytool -importcert -file /output/resources/security/ZCEEUSR.ARM -alias zceeusr -storetype PKCS12 --noprompt -keystore /output/resources/security/db2TrustStore.jks --storepass changeit

Suggestions for customizing the Linux shell environment

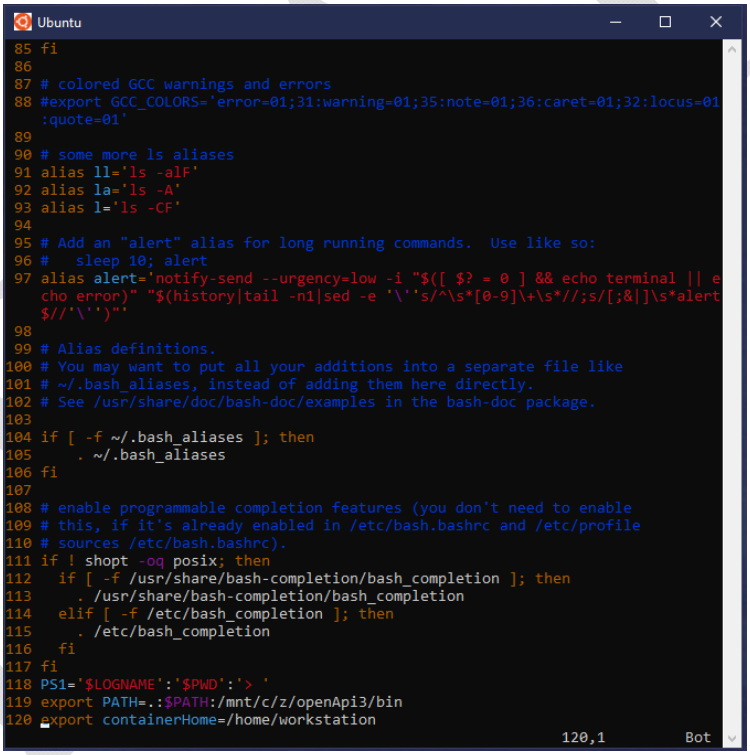
- Adding these lines to file ***.bashrc*** in your Linux home directory add path details to the Linux command prompt

  PS1='$LOGNAME':'$PWD':> '
  export PATH=.:$PATH:/mnt/c/z/openApi3/bin
  export containerHome=/home/workstation



- Creating a file named ***.exrc*** in your Linux home directory improves the *vi* editor experience

  set showmode
  set redraw
  set wrapmargin=3
  set nu



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Useful commands for managing containers

- Start a new container or update an existing container using a *docker-compose-yaml* file

  docker-compose -f /home/mitchj/docker/sandbox/docker-compose.yaml up -d

- Start a new container using *docker-compose-yaml* while in directory /home/mitchj/docker/sandbox

  docker-compose up –d

- Stop the container using docker-compose command while in directory /home/mitchj/docker/sandbox

  docker-compose down

- Start the sandbox container regardless of current directory

  docker start sandbox-zosConnect-1

- Stop the sandbox container regardless of current directory

  docker stop sandbox-zosConnect-1

- Copy server XML override files from Linux into a container directory*

  docker cp /home/mitchj/xml/. sandbox_zosConnect_1:/config/configDropins/overrides

- List the active containers

  docker ps

```
CONTAINER ID   IMAGE                                          COMMAND                  CREATED          STATUS
PORTS                                                                                   NAMES
97756ede6692   icr.io/zosconnect/ibm-zcon-designer:3.0.55   "/opt/ibm/helpers/ru…"   26 hours ago     Up 26 hours
0.0.0.0:9088->9080/tcp, :::9088->9080/tcp, 0.0.0.0:9429->9443/tcp, :::9429->9443/tcp   employees_zosConnect_1
642f17a4063a   icr.io/zosconnect/ibm-zcon-designer:3.0.55   "/opt/ibm/helpers/ru…"   47 hours ago     Up 20 hours
0.0.0.0:9082->9080/tcp, :::9082->9080/tcp, 0.0.0.0:9445->9443/tcp, :::9445->9443/tcp   sandbox_zosConnect_1
```

- List all active and stopped containers

  docker ps -a

- Remove a container by name or container ID

  docker rm sandbox_zosconnect_1

  or

  docker rm 642f17a4063a

- Start a bash shell in the container

  docker exec -it sandbox_zosConnect_1 bash

- List the installed images

  docker images

```
REPOSITORY                                TAG       IMAGE ID       CREATED          SIZE
icr.io/zosconnect/ibm-zcon-designer   3.0.57    386f4ac8cbd0   25 hours ago     1.16GB
icr.io/zosconnect/ibm-zcon-designer   3.0.56    cf167f4230b5   6 weeks ago      1.57GB
icr.io/zosconnect/ibm-zcon-designer   3.0.55    be9c9101f533   2 months ago     1.52GB
hello-world                           latest    feb5d9fea6a5   8 months ago     13.3kB
```

- Remove an installed image

  docker rmi icr.io/zosconnect/ibm-zcon-designer:3.0.56

- Install the Podman *podman-compose* command

  pip install podman-compose

- Display the details of a container

  docker container inspect sandbox-zosConnect-1

- Create a copy of a container

  docker commit sandbox_zosConnect_1 sandbox_zosconnect_1_Next

- Copy the configuration XML override file from Linux into the container

  docker cp /home/mitchj/xml/. sandbox_zosConnect_1:/config/configDropins/overrides/

- Copy the war files and from the container

  docker cp sandbox_zosConnect_1:/workspace/project/build/libs/api.war /home/mitchj/wars/cscvinc.war

- Copy the configuration XML files from the container into Linux

  docker cp /home/mitchj/xml/. sandbox_zosConnect_1:/config/configDropins/overrides

- Pull in a new (download) a z/OS Connect Designer image

  docker pull icr.io/zosconnect/ibm-zcon-designer:3.0.57

- Save the z/OS Connect Docker image to a file

  docker save icr.io/zosconnect/ibm-zcon-designer:3.0.57 | gzip > 3.0.57.tar.gz

- Copy the z/OS Connect Docker image file to a Windows directory location

  cp *.tar.gz /mnt/c/z/ftp

- Use FTP to move the image file from the original image to the target Linux image
- Load the z/OS Connect Docker image on the Linux image

  docker load < 3.0.57.tar.gz

AT-TLS policy file

```
##
## AT-TLS Policy Agent Configuration file for:
##    Image: WG31
##    Stack: TCPIP1
##
## Created by the IBM Configuration Assistant for z/OS Communications
Server
## Version 2 Release 3
## Backing Store = USER1
## Install History:
## 2022-07-06 13:53:25 : Save To Disk
##
## End of Network Configuration Assistant information
TTLSRule                          Db2ServerRule~1
{
  LocalAddrSetRef                 addr1
  RemoteAddrSetRef                addr1
  LocalPortRangeRef               portR1
  Jobname                         DSN2DIST
  Direction                       Inbound
  Priority                        255
  TTLSGroupActionRef              gAct1~Db2Server
  TTLSEnvironmentActionRef        eAct1~Db2Server
  TTLSConnectionActionRef         cAct1~Db2Server
}
TTLSGroupAction                   gAct1~Db2Server
{
  TTLSEnabled                     On
  Trace                           7
}
TTLSEnvironmentAction             eAct1~Db2Server
{
  HandshakeRole                   Server
  EnvironmentUserInstance         0
  TTLSKeyringParmsRef             keyR1
}
TTLSConnectionAction              cAct1~Db2Server
{
  HandshakeRole                   Server
  TTLSConnectionAdvancedParmsRef  cAdv1~Db2Server
  CtraceClearText                 Off
  Trace                           7
}
TTLSConnectionAdvancedParms       cAdv1~Db2Server
{
  SSLv3                           Off
  TLSv1                           Off
  TLSv1.1                         Off
  SecondaryMap                    Off
  TLSv1.2                         On
}
TTLSKeyringParms                  keyR1
{
  Keyring                         Db2.KeyRing
}
IpAddrSet                         addr1
{
  Prefix                          0.0.0.0/0
}
PortRange                         portR1
{
  Port                            2445
}
```

The contents of the employees.yaml file

```
openapi: 3.0.0
info:
  description: "Db2 Employees sample table"
  version: 1.0.0
  title: employees
servers:
- url: /
x-ibm-zcon-roles-allowed:
- Manager
security:
- BasicAuth: []
- BearerAuth: []
paths:
  /employees:
    post:
      tags:
        - db2employee
      operationId: postInsertEmployee
      parameters:
        - name: Authorization
          in: header
          required: false
          schema:
            type: string
      requestBody:
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/postInsertEmployee_request"
        description: request body
        required: true
      responses:
        "200":
          description: OK
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/postInsertEmployee_response_200"
        "400":
          description: OK
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/postInsertEmployee_response_400"
        "500":
          description: OK
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/postInsertEmployee_response_500"
  /employees/department:
    get:
      tags:
        - db2employee
      operationId: getSelectByDepartments
      parameters:
        - name: Authorization
          in: header
          required: false
          schema:
            type: string
        - name: dept1
          in: query
          required: false
          schema:
            type: string
            maxLength: 3
        - name: dept2
          in: query
          required: false
          schema:
            type: string
            maxLength: 3
```

```
    responses:
      "200":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getSelectByDepartments_response_200"
      "404":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getSelectByDepartments_response_404"
      "500":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getSelectByDepartments_response_500"
"/employees/details/{employee}":
  get:
    tags:
      - db2employee
    operationId: getDisplayEmployee
    parameters:
      - name: Authorization
        in: header
        required: false
        schema:
          type: string
      - name: employee
        in: path
        required: true
        schema:
          type: string
          maxLength: 6
    responses:
      "200":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getDisplayEmployee_response_200"
      "404":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getDisplayEmployee_response_404"
      "500":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getDisplayEmployee_response_500"
"/employees/{employee}":
  get:
    tags:
      - db2employee
    operationId: getSelectEmployee
    parameters:
      - name: Authorization
        in: header
        required: false
        schema:
          type: string
      - name: employee
        in: path
        required: true
        schema:
          type: string
          maxLength: 6
    responses:
      "200":
        description: OK
        content:
          application/json:
```

```
          schema:
            $ref: "#/components/schemas/getSelectEmployee_response_200"
      "404":
        description: Not Found
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getSelectEmployee_response_404"
      "500":
        description: Not Found
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getSelectEmployee_response_500"
  put:
    tags:
      - db2employee
    operationId: putInsertEmployee
    parameters:
      - name: Authorization
        in: header
        required: false
        schema:
          type: string
      - name: employee
        in: path
        required: true
        schema:
          type: string
          maxLength: 6
    requestBody:
      content:
        application/json:
          schema:
            $ref: "#/components/schemas/putInsertEmployee_request"
      description: request body
      required: true
    responses:
      "200":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/putInsertEmployee_response_200"
      "404":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/putInsertEmployee_response_404"
      "500":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/putInsertEmployee_response_500"
  delete:
    tags:
      - db2employee
    operationId: deleteDeleteEmployee
    parameters:
      - name: Authorization
        in: header
        required: false
        schema:
          type: string
      - name: employee
        in: path
        required: true
        schema:
          type: string
          maxLength: 6
    responses:
      "200":
        description: OK
        content:
          application/json:
```

```
              schema:
                $ref: "#/components/schemas/deleteDeleteEmployee_response_200"
          "404":
            description: Not Found
            content:
              application/json:
                schema:
                  $ref: "#/components/schemas/deleteDeleteEmployee_response_404"
          "500":
            description: Not Found
            content:
              application/json:
                schema:
                  $ref: "#/components/schemas/deleteDeleteEmployee_response_500"
  "/employees/roles/{job}":
    get:
      tags:
        - db2employee
      operationId: getSelectByRole
      parameters:
        - name: Authorization
          in: header
          required: false
          schema:
            type: string
        - name: job
          in: path
          required: true
          schema:
            type: string
            maxLength: 8
        - name: dept
          in: query
          required: true
          schema:
            type: string
            maxLength: 3
      responses:
        "200":
          description: OK
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/getSelectByRole_response_200"
        "404":
          description: OK
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/getSelectByRole_response_404"
        "500":
          description: OK
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/getSelectByRole_response_500"
components:
  schemas:
    getSelectEmployee_response_200:
      type: object
      required:
        - ResultSet Output
        - StatusCode
        - StatusDescription
      properties:
        ResultSet Output:
          type: array
          items:
            type: object
            description: ResultSet Row
            properties:
              employeeNumber:
                type: string
                description: CHAR(6)
                maxLength: 6
              firstName:
                type: string
```

```
            description: VARCHAR(12)
            maxLength: 12
          middleInitial:
            type: string
            description: CHAR(1)
            maxLength: 1
          lastName:
            type: string
            description: VARCHAR(15)
            maxLength: 15
          department:
            type: string
            description: Nullable CHAR(3)
            maxLength: 3
          phoneNumber:
            type: string
            description: Nullable CHAR(4)
            maxLength: 4
          job:
            type: string
            description: Nullable CHAR(8)
            maxLength: 8
        required:
          - department
          - employeeNumber
          - firstName
          - job
          - lastName
          - middleInitial
          - phoneNumber
    StatusDescription:
      type: string
      description: Service invocation status description
    StatusCode:
      type: integer
      description: Service invocation HTTP status code
      minimum: 100
      maximum: 600
  description: Service selectEmployee invocation HTTP response body
getSelectEmployee_response_404:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record could not be found
getSelectEmployee_response_500:
  type: object
  properties:
    message:
      type: string
  example:
    message: A severe error has occurred
deleteDeleteEmployee_response_200:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record deleted
putInsertEmployee_request:
  type: object
  required:
    - bonus
    - commission
    - salary
  properties:
    salary:
      type: number
      description: Nullable DECIMAL(9,2)
      minimum: -9999999.99
      maximum: 9999999.99
    bonus:
      type: number
      description: Nullable DECIMAL(9,2)
      minimum: -9999999.99
      maximum: 9999999.99
```

```
    commission:
      type: number
      description: Nullable DECIMAL(9,2)
      minimum: -9999999.99
      maximum: 9999999.99
  description: Service updateEmployee invocation HTTP request body
deleteDeleteEmployee_response_404:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record could not be found to be deleted
deleteDeleteEmployee_response_500:
  type: object
  properties:
    message:
      type: string
  example:
    message: A severe error has occurred
putInsertEmployee_response_200:
  type: object
  required:
    - StatusCode
    - StatusDescription
    - Update Count
  properties:
    Update Count:
      type: integer
      description: Update Count
      minimum: 0
      maximum: 32767
    StatusDescription:
      type: string
      description: Service invocation status description
    StatusCode:
      type: integer
      description: Service invocation HTTP status code
      minimum: 100
      maximum: 600
  description: Service updateEmployee invocation HTTP response body
putInsertEmployee_response_404:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record could not be inserted
putInsertEmployee_response_500:
  type: object
  properties:
    message:
      type: string
  example:
    message: A severe error has occurred
getDisplayEmployee_response_200:
  type: object
  required:
    - ResultSet Output
    - StatusCode
    - StatusDescription
  properties:
    ResultSet Output:
      type: array
      items:
        type: object
        description: ResultSet Row
        properties:
          EMPNO:
            type: string
            description: CHAR(6)
            maxLength: 6
          FIRSTNME:
            type: string
            description: VARCHAR(12)
            maxLength: 12
          MIDINIT:
```

```
        type: string
        description: CHAR(1)
        maxLength: 1
      LASTNAME:
        type: string
        description: VARCHAR(15)
        maxLength: 15
      WORKDEPT:
        type: string
        description: Nullable CHAR(3)
        maxLength: 3
      PHONENO:
        type: string
        description: Nullable CHAR(4)
        maxLength: 4
      HIREDATE:
        type: string
        description: Nullable DATE yyyy-[m]m-[d]d
        minLength: 8
        maxLength: 10
        pattern: ^(?![0]{4})([0-9]{4})-(0?[1-9]|1[0-2])-(0?[1-9]|[1-2][0-9]|3[0-1])$
      JOB:
        type: string
        description: Nullable CHAR(8)
        maxLength: 8
      EDLEVEL:
        type: integer
        description: Nullable SMALLINT
        minimum: -32768
        maximum: 32767
      SEX:
        type: string
        description: Nullable CHAR(1)
        maxLength: 1
      BIRTHDATE:
        type: string
        description: Nullable DATE yyyy-[m]m-[d]d
        minLength: 8
        maxLength: 10
        pattern: ^(?![0]{4})([0-9]{4})-(0?[1-9]|1[0-2])-(0?[1-9]|[1-2][0-9]|3[0-1])$
      SALARY:
        type: number
        description: Nullable DECIMAL(9,2)
        minimum: -9999999.99
        maximum: 9999999.99
      BONUS:
        type: number
        description: Nullable DECIMAL(9,2)
        minimum: -9999999.99
        maximum: 9999999.99
      COMM:
        type: number
        description: Nullable DECIMAL(9,2)
        minimum: -9999999.99
        maximum: 9999999.99
    required:
      - BIRTHDATE
      - BONUS
      - COMM
      - EDLEVEL
      - EMPNO
      - FIRSTNME
      - HIREDATE
      - JOB
      - LASTNAME
      - MIDINIT
      - PHONENO
      - SALARY
      - SEX
      - WORKDEPT
StatusDescription:
  type: string
  description: Service invocation status description
StatusCode:
  type: integer
  description: Service invocation HTTP status code
  minimum: 100
```

```
      maximum: 600
  description: Service displayEmployee invocation HTTP response body
getDisplayEmployee_response_404:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record could not be inserted
getDisplayEmployee_response_500:
  type: object
  properties:
    message:
      type: string
  example:
    message: A severe error has occurred
postInsertEmployee_request:
  type: object
  required:
    - birthDate
    - bonus
    - commission
    - department
    - educationLevel
    - employeeNumber
    - firstName
    - hireDate
    - job
    - lastName
    - middleInitial
    - phoneNumber
    - salary
    - sex
  properties:
    employeeNumber:
      type: string
      description: Nullable CHAR(6)
      maxLength: 6
    firstName:
      type: string
      description: Nullable VARCHAR(12)
      maxLength: 12
    middleInitial:
      type: string
      description: Nullable CHAR(1)
      maxLength: 1
    lastName:
      type: string
      description: Nullable VARCHAR(15)
      maxLength: 15
    department:
      type: string
      description: Nullable CHAR(3)
      maxLength: 3
    phoneNumber:
      type: string
      description: Nullable CHAR(4)
      maxLength: 4
    hireDate:
      type: string
      description: Nullable DATE yyyy-[m]m-[d]d
      minLength: 8
      maxLength: 10
      pattern: ^(?![0]{4})([0-9]{4})-(0?[1-9]|1[0-2])-(0?[1-9]|[1-2][0-9]|3[0-1])$
    job:
      type: string
      description: Nullable CHAR(8)
      maxLength: 8
    educationLevel:
      type: integer
      description: Nullable SMALLINT
      minimum: -32768
      maximum: 32767
    sex:
      type: string
      description: Nullable CHAR(1)
      maxLength: 1
```

```
    birthDate:
      type: string
      description: Nullable DATE yyyy-[m]m-[d]d
      minLength: 8
      maxLength: 10
      pattern: ^(?![0]{4})([0-9]{4})-(0?[1-9]|1[0-2])-(0?[1-9]|[1-2][0-9]|3[0-1])$
    salary:
      type: number
      description: Nullable DECIMAL(9,2)
      minimum: -9999999.99
      maximum: 9999999.99
    bonus:
      type: number
      description: Nullable DECIMAL(9,2)
      minimum: -9999999.99
      maximum: 9999999.99
    commission:
      type: number
      description: Nullable DECIMAL(9,2)
      minimum: -9999999.99
      maximum: 9999999.99
  description: Service insertEmployee invocation HTTP request body
postInsertEmployee_response_200:
  type: object
  required:
    - StatusCode
    - StatusDescription
    - Update Count
  properties:
    Update Count:
      type: integer
      description: Update Count
      minimum: 0
      maximum: 32767
    StatusDescription:
      type: string
      description: Service invocation status description
    StatusCode:
      type: integer
      description: Service invocation HTTP status code
      minimum: 100
      maximum: 600
  description: Service insertEmployee invocation HTTP response body
postInsertEmployee_response_400:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record could not be inserted
postInsertEmployee_response_500:
  type: object
  properties:
    message:
      type: string
  example:
    message: A severe error has occurred
getSelectByRole_response_200:
  type: object
  required:
    - ResultSet Output
    - StatusCode
    - StatusDescription
  properties:
    ResultSet Output:
      type: array
      items:
        type: object
        description: ResultSet Row
        properties:
          employeeNumber:
            type: string
            description: CHAR(6)
            maxLength: 6
          firstName:
            type: string
            description: VARCHAR(12)
```

```
            maxLength: 12
          middleInitial:
            type: string
            description: CHAR(1)
            maxLength: 1
          lastName:
            type: string
            description: VARCHAR(15)
            maxLength: 15
          department:
            type: string
            description: Nullable CHAR(3)
            maxLength: 3
          phoneNumber:
            type: string
            description: Nullable CHAR(4)
            maxLength: 4
          job:
            type: string
            description: Nullable CHAR(8)
            maxLength: 8
        required:
          - department
          - employeeNumber
          - firstName
          - job
          - lastName
          - middleInitial
          - phoneNumber
    StatusDescription:
      type: string
      description: Service invocation status description
    StatusCode:
      type: integer
      description: Service invocation HTTP status code
      minimum: 100
      maximum: 600
  description: Service selectByRole invocation HTTP response body
getSelectByRole_response_404:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record could not be inserted
getSelectByRole_response_500:
  type: object
  properties:
    message:
      type: string
  example:
    message: A severe error has occurred
getSelectByDepartments_response_200:
  type: object
  required:
    - StatusCode
    - StatusDescription
  properties:
    ResultSet 1 Output:
      type: array
      description: Stored Procedure ResultSet 1 Data
      items:
        type: object
        description: ResultSet Row
        properties: {}
    Anonymous ResultSets:
      type: integer
      description: Number of Anonymous ResultSets
      minimum: 0
      maximum: 1
    StatusDescription:
      type: string
      description: Service invocation status description
    StatusCode:
      type: integer
      description: Service invocation HTTP status code
      minimum: 100
```


Mitch Johnson (mitchj@us.ibm.com)

```
      maximum: 600
  description: Service selectByDepartments invocation HTTP response body
getSelectByDepartments_response_404:
  type: object
  properties:
    message:
      type: string
  example:
    message: Record could not be inserted
getSelectByDepartments_response_500:
  type: object
  properties:
    message:
      type: string
  example:
    message: A severe error has occurred
```