z/OS Connect Enterprise Edition V3.0

Topics Guide

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(If you have comments or feedback on the contents of this document, please send an e-mail to **John Brefach** (john.j.brefach@ibm.com).

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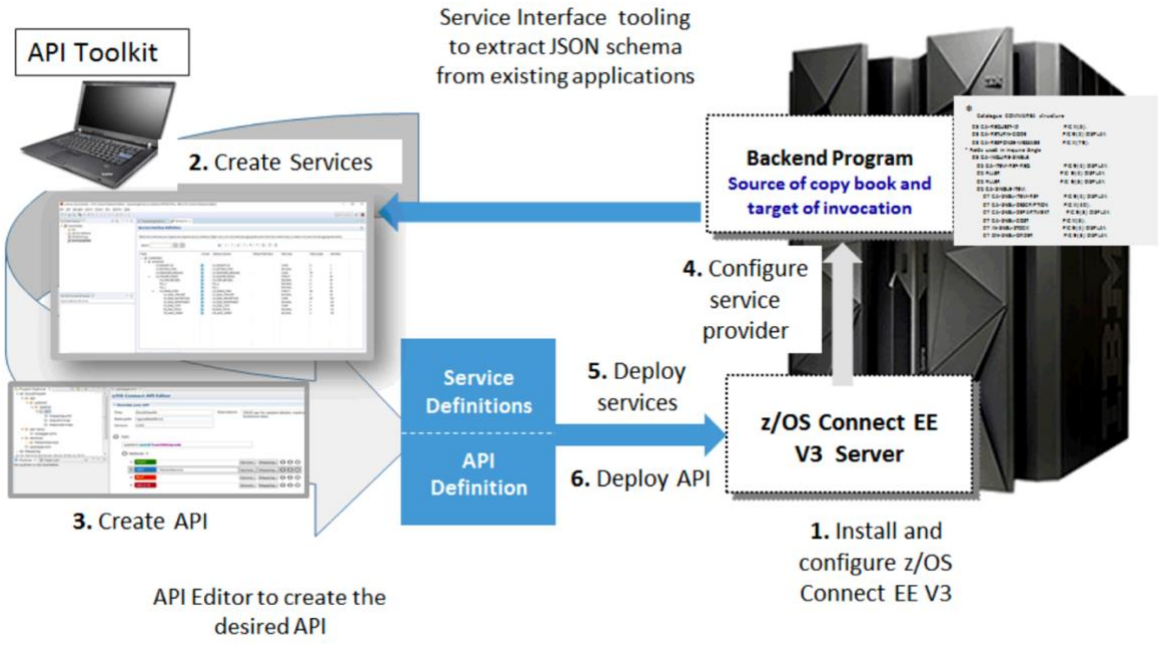
Introduction

IBM® z/OS® Connect Enterprise Edition V3.0 provides a framework that enables z/OS based programs and data to participate fully in the new API economy for mobile and cloud applications facilitating the inclusion of z/OS assets into the cloud environment. IBM® z/OS® Connect Enterprise Edition V3.0 can be incorporated into a native cloud style of development and deployment further enhancing z/OS inclusion into the cloud.



IBM z/OS Connect Enterprise Edition V3.0 (zCEE) provides RESTful API access to z/OS subsystems, such as CICS®, IMS™, IBM® MQ, Db2®, as well as potentially other z/OS applications. The framework provides concurrent access, through a common interface, to multiple z/OS subsystems. In addition, z/OS Connect EE provides support for outbound RESTful API from CICS, IMS and other MVS applications. This rich framework also provides a common security model, as well as logging, tracking and API development and deployment services.

The goal of this document is to provide a step-by-step guide to setting up z/OS Connect EE servers for usage with either CICS, IMS, MQ or Db2. Emphasis will be placed on CICS, IMS, Db2 and MQ since they are most common use cases.

Program numbers and FMIDs

Program number: **5655-CE3** **z/OS Connect EE V3.0 continuous delivery**
Base FMID: **HZC3000** **z/OS Connect EE V3.0 core product**
FMID: **JZC3002** **z/OS Connect EE optional CICS dependencies**

Program number: **5655-CE5**
Base FMID: **HZC3000** **z/OS Connect EE V3.0 core product**
FMID: **JZC3002** **z/OS Connect EE optional CICS dependencies**
FMID: **JZC3003** **z/OS Connect EE unlimited activation**

Service and Maintenance URLs

• z/OS Connect Enterprise Edition change history:
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=whats-new-in-zos-connect
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=connect-removal-notices

What's new in z/OS Connect EE

• Blog: https://community.ibm.com/community/user/blogs/shruthi-krishnan/2025/07/17/zos-connect-3095-now-available or https://tinyurl.com/sefkh7n6
• OpenAPI 3:
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=connect-whats-new-in-zos-zosconnect-30
• OpenAPI 2:
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=connect-whats-new-in-zos-zosconnect-20

The z/OS Connect EE Knowledge Center URL

• z/OS Connect EE Knowledge Center (OAS 2 & 3):
https://www.ibm.com/docs/en/zos-connect/3.0.0

The WebSphere Application Server for z/OS Liberty Knowledge Center URL

• WebSphere Application Server Liberty Knowledge Center:
https://www.ibm.com/docs/en/was-liberty/base?topic=liberty-overview

Additional IBM Support web pages

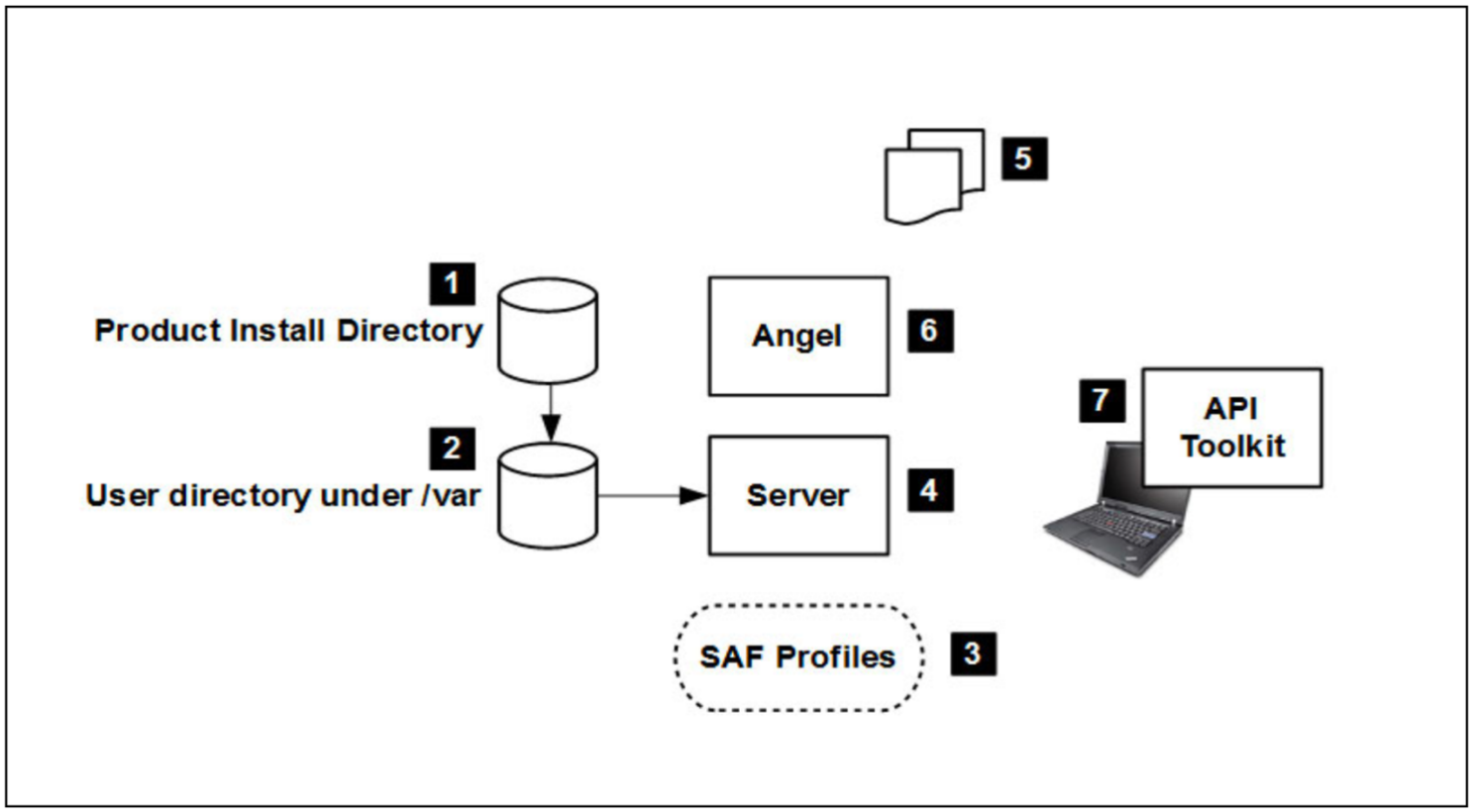
• Details of the WebSphere Liberty Profile(WLP) upgrades shipped with z/OS Connect EE:
https://www.ibm.com/support/pages/upgrading-liberty-profile-cics-ts-and-zos-connect-ee-latest-fix-pack

• WLP Server configuration elements:
https://www.ibm.com/docs/en/was-liberty/zos?topic=overview-server-configuration

Broadcom Support web pages

• Site of What ACF2 security setup is needed for IBM's z/OS Connect Enterprise Edition V3.0?
https://knowledge.broadcom.com/external/article/128597/what-acf2-security-setup-is-needed-for-i.html\
• Site of ACF2 setup for z/OS Connect Enterprise Edition V3.0
https://knowledge.broadcom.com/external/article/142172/acf2-setup-for-zos-connect-enterprise-ed.html
• Site of Setting up Liberty Server for z/OS with Top Secret
https://knowledge.broadcom.com/external/article/37272/setting-up-liberty-server-for-zos-with-t.html

Installation and Initial Setup



Notes:

1. SMP/E is used to install z/OS Connect EE using standard SMP/E installation processes. The result is a file system mounted at the location you specify and other SMP/E target data sets.
2. The *zconsetup* shell script must be executed to create a set of subdirectories under directory */var/zosconnect*. This script must be run at least once per LPAR because one of these subdirectories is the z/OS Connect EE *extensions* directory. The *extensions* directory contains properties files that will be accessed by any z/OS Connect EE server started on this LPAR.
3. SAF profiles are required to allow z/OS Connect EE to operate as a started task and performed authorized functions.
4. Create a basic WebSphere Liberty Profile (Liberty) server with the z/OS Connect EE feature.
5. Copy the sample JCL procedures to your procedure library from the SBAQSAMP TLIB.
6. The angel process will be required in most circumstances. There may already be an angel active on your system. We will guide you through the process of configuring an angel specificity for z/OS Connect EE servers.
7. Install the z/OS Connect EE API Tool Kit on your workstation.

SMP/E install of z/OS Connect EE

IBM z/OS Connect EE (zCEE) is installed using standard SMP/E RECEIVE, APPLY and ACCEPT processes. This will require someone with SMP/E skills to accomplish this.

The Knowledge Center article for installing IBM z/OS Connect EE is here:

https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=installing-zos-connect-smpe

Follow the instructions in the program directory to install the product into its target OMVS filesystem and data sets.

The remainder of the section covers the details required to activate z/OS Connect on an LPAR and configure and start a z/OS Connect Liberty server.

Essential prerequisites

You will need the following:

- z/OS 2.4 or higher
- IBM 64-bit SDK for z/OS, Java Technology Edition V8.0.0 or higher

Do the following:

- Verify your level of z/OS is 2.4 or higher
- Check to see if you have a valid 64-bit IBM Java SDK for z/OS, V8.0.0 instance. If not available have your system administrator installed V8.0.0

Important: *Before you continue with z/OS Connect configuration, a decision needs to be made regarding how OMVS ownership and permission bits will be set for the directories and files created in the next steps. Review the section titled OMVS Ownership and Permission Bits Considerations to understand the significance of ownership and permission bits and decide which configuration solution is best for your environment.*

OMVS Ownership/Permission Bits Considerations

A common issue during the configuration of a z/OS Connect EE server is caused by the setting of ownership and permission bits of directories and files created during the customization process. Specifically, when configuration directories and files are created and configured by one identity and a different identity will be used to start the z/OS Server. This situation can easily result in the z/OS Connect server not having the required read/write access to the configuration directories and files and therefore not being able to properly initialize at all or have some key feature (e.g. SSL) disabled.

There are options for avoiding issues with ownership and permission bits. Two suggestions will be described in this section. Subsequent examples in this document will try to provide examples of using the options described in this section.

You do not have to use the techniques described here but not using them or their equivalents will mean that configuring and managing servers may be more problematic.

Use of Surrogate Access

Learn more about allowing surrogate job submission on z/OS at the link provided:
https://www.ibm.com/docs/en/zos/3.1.0?topic=submitted-allowing-surrogate-job-submission

Since the identities associated with started task are normally restricted and cannot be used for accessing TSO or OMVS shells, one option to create the server's configuration is to use RACF surrogate access. Surrogate access allows a designated administrative identity the ability to invoke commands and perform functions as if they were running under the identity that will be used for the z/OS Connect EE server started task.

Use the following examples as guides and create the surrogate resources and permit access. In these examples, ***LIBSERV*** represents the identity under which the z/OS Connect server will be running and ***adminUser*** represent the administrative identity:

Define a SURROGAT profile for the server's SAF identity

RDEFINE SURROGAT BPX.SRV.*LIBSERV*

Define a SURROGAT profile to allow job submission as the server's SAF identity

RDEFINE SURROGAT *LIBSERV*.SUBMIT

Permit an administrative identity to act as a surrogate of the Liberty task identity

PERMIT BPX.SRV.*LIBSERV* CLASS(SURROGAT) ID(*adminUser*) ACC(READ)
PERMIT *LIBSERV*.SUBMIT CLASS(SURROGAT) ID(*adminUser*) ACC(READ)

Refresh the SURROGAT in storage profiles

SETROPTS RACLIST(SURROGAT) REFRESH

These commands allow the administrator identity (*adminUser)* to use the OMVS switch user command (*su*) with the *-s* flag (e.g. ***su -s LIBSERV***) to switch identities to the Liberty's started task identity (*LIBSERV)* and invoke OMVS commands (e.g. creating configuration directories and files) as the Liberty's started task identity. This ensures all permission bits are set to the started task's identity. Access to the SUBMIT resource allows an administrator identity (*adminUser)* to submit jobs as the Liberty's servers task identity without the need to provide the password of started task user's identity. This is done by simply adding *USER=**LIBSERV*** to the JOB card.

Permit access to Unix Privileges

An alternative to using a surrogate access is to permit the identity under which the customization will be done to enhanced Unix privileges. Specially, permitting the identity to Unix privileges SUPERUSER.FILESYS and SUPERUSER.FILESYS.CHOWN.

See the z/OS Knowledge Center *Using UNIXPRIV class profiles* at URL

https://www.ibm.com/docs/en/zos/3.1.0?topic=security-using-unixpriv-class-profiles

Permit an administrative identity to write to any local directory or file

PERMIT SUPERUSER.FILESYS CLASS(UNIXPRIV) ID(*adminUser*) ACC(CONTROL)

Permit an administrative identity to change the ownership of any directory or file

PERMIT SUPERUSER.FILESYS.CHOWN CLASS(UNIXPRIV) ID(*adminUser*) ACC(READ)

Refresh the UNIXPRIV in storage profiles

SETROPTS RACLIST(UNIXPRIV) REFRESH

Confirm that a Java runtime can be created

The SAF identity used to perform z/OS Connect customization will need to be able run Java in OMVS. Confirm the SAF identity can execute Java by doing the following:

Adding these export commands to the administrator *.profile* file in their home directory, e.g. */u/adminUser* will provide access to the Java executables.

```
export JAVA_HOME=path_to_your_64-bit_Java_SDK
export $PATH=.:$JAVA HOME/bin:$PATH
```

Tech Tip: The *.profile* file can be found in the user's home directory. Use ISHELL prior to entering OMVS or use the OMVS *oedit* command to add these exports to the *.profile* file and restart the OMVS command shell. Otherwise, these environment variables will have to be exported each time an OMVS session is started.

You can use either an OMVS command (1) to confirm the Java environment can be created or you can submit a job (2) for execution. Both methods are shown here.

Note: This section shows two ways to confirm Java has been properly configured. The first uses the OMVS command line prompt to invoke Java and the second uses JCL to invoke the Java OMVS command. Subsequent OMVS commands used in this document can obviously be invoked at a command line prompt, but we recommend using JCL. Invoking the commands in JCL has various advantages over entering commands at a prompt. Such as documenting the commands that have been entered and JCL can easily be resubmit as needed and ported to other systems.

1) Start an OMVS shell session using Telnet, SSH or the OMVS TSO command. Enter the commands below:

export JAVA_HOME=path_to_your_64-bit_Java_SDK
export $PATH=.:$JAVA_HOME/bin:$PATH
java –version

Tech Tip: The OMVS in green above would not be required if the exports have been added to the user's *.profile* file.

Your output should look something like this:

```
java -version
java version "1.8.0"
Java(TM) SE Runtime Environment (build pmz6480sr3fp20-20161019_02(SR3 FP20))
IBM J9 VM (build 2.8, JRE 1.8.0 z/OS s390x-64 Compressed References 20161013_322
271 (JIT enabled, AOT enabled)
J9VM - R28_Java8_SR3_20161013_1635_B322271
JIT  - tr.r14.java.green_20161011_125790
GC   - R28_Java8_SR3_20161013_1635_B322271_CMPRSS
J9CL - 20161013_322271)
JCL - 20161018_01 based on Oracle jdk8u111-b14
```

In the above output, the build string of ***build pmz6480sr3fp20-20161019_02(SR3 FP20))*** indicates that the installed Java was built in October of 2016 as Service Release 3, fix pack 20. You should try to keep more current with Java service than a 4-year-old release of Java. The current level of Java for z/OS can be download from URL
https://developer.ibm.com/javasdk/support/zos/
The string ***s390x-64*** confirms this is a 64-bit Java SDK.

2) Alternatively, the job below can also be used to check out the Java environment, see example job ***CHKJAVA.jcl***, which accompanies this document.

```
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET JAVAHOME='/usr/lpp/java/J8.0_64'
//*************************************************************
//*  STEP JAVA - INVOKE THE java -version COMMAND
//*************************************************************
//JAVA  EXEC PGM=IKJEFT01,REGION=0M
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//STDENV   DD DUMMY
//SYSTSPRT DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
 BPXBATCH SH +
 export JAVA_HOME=&JAVAHOME; +
 $JAVA_HOME/bin/java -version
```

If the java command fails (with an error JVMJ9VM011W EDC5204E) then it is likely because your identity does not can get the memory needed to create the JVM. Adjust[1] the size parameters of the user's TSO segment using the TSO *ALTUSER* command:

ALU user-name TSO(SIZE(1048576)) OMVS(ASSIZEMAX(1073741824) MEMLIMIT(1G))

1 You may need to work with your system administrator to accomplish this. The key point the ID must be able to instantiate a JVM or you cannot proceed. This test checks to see if the ID has the ability. If not, correct the issue.

Liberty angel Considerations

Access to privileged z/OS functions, e.g., SAF checks, writing SMF records, workload management (WLM), resource recovery services (RRS), etc. from or by a Liberty server are managed by the presence of an angel task and related security resource definitions. Some features of z/OS Connect EE will require that a Liberty angel be active [2].

If you have z/OSMF or other Liberty instances already running, you may already have an angel active [3]. Regardless, you should still use an angel configured to use the code provided with z/OS Connect.

Note: If you do choose to use an existing angel process, it is probably not compatible with z/OS Connect EE. If you see message: *CWWKB0307E: The angel process on this system is not compatible with the local communication service,* this means the existing angel is back leveled with the requirements of z/OS Connect and needs to be upgraded. Rather than upgrading the existing angel process, configuring another angel JCL started task procedure that references the WebSphere Liberty Profile (WLP) directories shipped with z/OS Connect and provide a unique name for that angel (e.g., *NAME=**angelName***), for the z/OS Connect Liberty servers, see the next section.

Named angels

Each angel can be uniquely identified by a name at startup. An angel started with no name specified is known as the default angel.

Learn more about configuring named angels from the IBM Tech Doc links below:

OpenAPI 2: https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=20-configuring-named-angels

OpenAPI 3: https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=30-configuring-named-angels

Learn more about configuring the Liberty angel process & z/OS authorized services:

OpenAPI 2: https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=20-configuring-liberty-angel-process-zos-authorized-services

OpenAPI 3: https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=30-configuring-liberty-angel-process-zos-authorized-services

All Liberty servers (including a z/OS Connect server) can be configured to select which angel it will use for authentication by specifying a system property. If no angel name is specified by a Liberty server (property *com.ibm.ws.zos.core.angelName*) then the default angel (i.e. the one with no name) will be selected. Another system property (*com.ibm.ws.zos.core.angelRequired*) can be set to require the successful connection to angel to continue the startup of the server. That is, if the required angel is not available, the Liberty server will shut itself down.

2 For more on Liberty z/OS and the Angel process: https://www.ibm.com/docs/en/was-liberty/zos?topic=zos-named-angel
3 z/OSMF 2.1 is based on Liberty z/OS, and it requires the Angel for access to z/OS authorized services.

To provide these properties for a z/OS Connect EE server:

1. Create an options file for angel properties, e.g. *zcee.options* in an OMVS directory, e.g. */var/zosconnect* and enter the system properties as below:

```
-Dcom.ibm.ws.zos.core.angelName=angelName
-Dcom.ibm.ws.zos.core.angelRequired=true
```

Where *angelName* is the name of the angel to be used for security

2. Use the *JAVA_OPTIONS* environment variable in the z/OS Connect servers JCL and provide these properties in this file using the STDENV input. The STDENV DD statement can reference a file in an OMVS directory. We strongly recommend implement the latter where an OMVS file is used. Otherwise, the limitation of a maximum 80 characters and no continuation support in STDENV JCL input will quickly become a problem as you progress with this product.

```
_BPX_SHAREAS=YES
_CEE_RUNOPTS=HEAPPOOLS(ON),HEAPPOOLS64(ON)
JAVA_HOME=<Java home directory>
#JVM_OPTIONS=<Optional JVM parameters>
WLP_USER_DIR=/var/zosconnect
JVM_OPTIONS=-Xoptionsfile=/var/zosconnect/zcee.options                -
```

Tech Tip: The runtime uses environment variable **WLP_USER_DIR** to determine the location of server configuration files and application artifacts. If no value is provided for **WLP_USER_DIR**, the default value is */var/zosconnect*. If a value other than the default will be used for **WLP_USER_DIR**, then mount a ZFS file system at this directory. For example, if **WLP_USER_DIR** is set to */var/ats/zosconnect,* create a ZFS filesystem and mount the ZFS filesystem at */var/ats/zosconnect/servers*.

```
MOUNT FILESYSTEM('OMVS.ATS.ZCEE.ZFS') TYPE(ZFS)
MODE(RDWR)MOUNTPOINT('/var/ats/zosconnect/servers')
```

Please note that if named angels are used, then additional SERVER SAF profiles will need to be defined and permission granted to the SAF identities of the z/OS Connect EE servers, see sections *SAF Groups & Server IDs* and *SAF Server & Facility profiles* on pages **18** & **19**

For example, if angel is started with a name of *PRODUCTION*, then a SAF SERVER profile for this name, i.e., *BBG.ANGEL.PRODUCTION* must be defined and the z/OS Connect EE server running under identity *LIBSERV* must be given READ access to this profile.

Post SMP/E configuration steps

___1. Create directory */var/zosconnect* and mount a small ZFS filesystem at this mount point. This directory structure will be shared among all the z/OS Connect servers running on the same LPAR. The primary purpose of this directory structure is to provide a common location where properties (e.g. location of product executables, etc.) for some of the service providers not shipped with z/OS Connect can be located. This directory path is embedded in scripts, so it should not be changed. The contents of this directory are static and rarely will change. Mount

points can be created in this directory structure and other filesystems mounted at these mount points.

Tech Tip: The directory will be the default location for server configuration files and application artifacts. A ZFS filesystem mounted with AGGRGROW should be used to allow for growth.

Tech Tip: The runtime uses environment variable **WLP_USER_DIR** to determine the location of server configuration files and application artifacts. If no value is provided for **WLP_USER_DIR**, the default value is */var/zosconnect*. If a value other than the default will be used for **WLP_USER_DIR**, then mount a ZFS file system at this directory. For example, if **WLP_USER_DIR** is set to */var/ats/zosconnect,* create a ZFS filesystem and mount the ZFS filesystem at */var/ats/zosconnect/servers*.

```
MOUNT FILESYSTEM('OMVS.ATS.ZCEE.ZFS') TYPE(ZFS)
  MODE(RDWR)MOUNTPOINT('/var/ats/zosconnect/servers')
```

Tech Tip: We are recommending that a dedicated filesystem for */var/zosconnect* be created and mounted for each LPAR. This is done so the configuration information is not lost when the root filesystem on a LPAR is updated with a refresh of z/OS.

Tech Tip: The *zconsetup* script creates a symbolic link from the */wlp/etc/extensions* sub directory embedded with z/OS Connect product directory structure to external directory */var/zosconnect/v3r0/extensions*. The former directory is usually mounted read/only while the latter is mounted read/write. This allows the customization for additional product service providers on an LPAR by LPAR basis. We also recommend that the *zconsetup* script be run in the SMP/E maintained filesystem, so the symbolic link is not lost when service is applied, and the z/OS Connect filesystem is refreshed.

___2. Create a mount point named *servers* in */var/zosconnect* and mount a ZFS filesystem at this mount point. Ensure the identities that the identities under which the zCEE servers will run have write access to this directory.

___3. Verify the product installation file system is mounted R/W. The *zconsetup* script provided with the product will need to create a symbolic link from this file system to directory */var/zosconnect/v3R0/extensions* and the installation filesystem needs to be R/W for this to succeed.

___4. Run the *zconsetup install* script. The identity under which the script executed must have the authority required to create a symbolic link in directory /usr/lpp/IBM/zosconnect/v3r0/wlp/etc[4]. Running this script will create a symbolic link between the product directory and the *extensions* directory.

[4] This document assumes z/OS Connect EE V3 was installed into the default directory.

a) Use the TSO *OMVS* command or use Telnet or SSH to open an OMVS shell and go to directory */usr/lpp/IBM/zosconnect/v3r0/bin.* Run the script with this command: ***zconsetup install*** to create a symbolic link between the product directory and the *extensions* directory.

cd /usr/lpp/IBM/zosconnect/v3r0/bin
zconsetup install

The output should look like this:

```
zconsetup will use product feature directory /var/zosconnect/v3r0
zconsetup created the link to the product feature directory
zconsetup created /var/zosconnect/v3r0/extensions/zosconnect.properties
zconsetup created /var/zosconnect/v3r0/extensions/imsmobile.properties
zconsetup install completed successfully
```

b) As an alternative, submit the JCL below to execute this command in a batch job.

```
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET JAVAHOME='/usr/lpp/java/J8.0_64'
// SET ZCEEPATH='/usr/lpp/IBM/zosconnect/v3r0'
//*************************************************************
//*  STEP ZCSETUP - INVOKE THE ZCONSETUP SCRIPT
//*************************************************************
//ZCSETUP  EXEC PGM=IKJEFT01,REGION=0M
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//STDENV   DD DUMMY
//SYSTSPRT DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
 BPXBATCH SH +
 export JAVA_HOME=&JAVAHOME; +
 &ZCEEPATH/bin/zconsetup install
```

Tech Tip: Including a period in the PATH environment variable back on page 12 implicitly adds the current directory to the PATH search order. Otherwise the *zconsetup* command would have had to be entered as ***./zconsetup*** or as ***. zconsetup***.

___5. Remount the product installation file system as R/O.

Review the file system. You should see a directory structure like this:

Directory	*Purpose*
/usr/lpp/IBM/zosconnect/v3r0/bin	Product Code
/usr/lpp/IBM/zosconnect/v3r0/dev/	Java classes for user service providers
/usr/lpp/IBM/zosconnect/v3r0/doc	Java Doc zip file
/usr/lpp/IBM/zosconnect/v3r0/imsmobile	IMS Service Provider
/usr/lpp/IBM/zosconnect/v3r0/runtime/lib/	Feature Files
/usr/lpp/IBM/zosconnect/v3r0/wlp	WebSphere Liberty product code
/usr/lpp/IBM/zosconnect/v3r0/wlp/etc/extensions	Contains symbolic link to directory /var/zosconnect/extensions
/usr/lpp/IBM/zosconnect/v3r0/zconnbt.zip	z/OS Connect EE build tool
/var/zosconnect/v3r0/extensions	Properties files for product features[5]
/var/zosconnect/servers	Server configuration files and applications[6]

SAF Resources

The SAF resources for z/OS Connect EE are best planned and created ahead of time.

OpenAPI 2: https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=authentication-configuring-basic-saf-registry
OpenAPI 3: https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=apba-configuring-basic-authentication-saf-registry

> **Note:** For the *initial* setup we will keep things simple and use basic authentication and basic security. Basic authentication means a client with authentication using an identity and password combination. Basic security means the identity and passwords are maintain in the server's configuration file, e.g. *server.xml,* To understand how to move beyond these simple security definitions, see ***Beyond the simple server.xml security elements*** on page 35. What follows are z/OS security elements that must be in place before operating the z/OS Connect EE server.

SAF Groups and Server IDs

It is not required that the Liberty IDs be connected to a common group. Illustrated here is one approach. Identities ***LIBSERV, LIBANGL*** and group ***LIBGRP*** are just examples. Use the values appropriate for your system.

Work with your security administrator and do the following:

- Plan the values you will use for your angel ID and server ID, and the group ID.

Use the following examples as guides and create the group and IDs:

Creates a Liberty Profile group ID

ADDGROUP *LIBGRP* OMVS(AUTOGID) OWNER(SYS1)

Creates the angel ID and connects it to the Liberty Profile group

5 This subdirectory contains "property" files which identify which products have been added to z/OS Connect to extend its functionality. This directory name should not be changed.
6 The value for this directory is based on environment variable WLP_USER_DIR. The default value is shown.

ADDUSER *LIBANGL* DFLTGRP(*LIBGRP*) OMVS(AUTOUID
HOME(*/u/libangl*) PROGRAM(/bin/sh)) NAME('Liberty angel')
OWNER(*LIBGRP*) NOPASSWORD NOOIDCARD

Creates the Liberty Profile server ID and connects it to the Liberty Profile group

ADDUSER *LIBSERV* DFLTGRP(*LIBGRP*) OMVS(AUTOUID
HOME(*/u/libserv*) PROGRAM(/bin/sh)) NAME('Liberty Server')
OWNER(*LIBGRP*) NOPASSWORD NOOIDCARD

See example job ***ZCEESTC.jcl,*** which accompanies this document.

SAF STARTED profiles

SAF STARTED profiles are used to assign the identity when the server is started as a z/OS started task. They are based on the JCL start procedure name. z/OS Connect EE comes with sample JCL, and you may keep the default JCL procedure names or create your own.

Work with your security administrator and do the following:

Plan your JCL start procedure names (either default or your own values)

Use the following examples as guides and create the STARTED profiles:

Creates the STARTED profile for the angel Process

RDEF STARTED *angelProc. UACC(NONE) STDATA(USER(*LIBANGL*)**
GROUP(*LIBGRP*) PRIVILEGED(NO) TRUSTED(NO) TRACE(YES))

Creates the STARTED profile for the Liberty Profile server

RDEF STARTED *serverProc. UACC(NONE) STDATA(USER(*LIBSERV*)**
GROUP(*LIBGRP*) PRIVILEGED(NO) TRUSTED(NO) TRACE(YES))

Tech Tip: The combination of NOPASSWORD and NOIDCARD makes this a PROTECTED identity. This means that this identity cannot be used to access this system by any means that requires a password to be specified, such as a TSO logon, CICS sign on, or via a batch job that specifies a password on the JOB statement. These attributes also mean that this identity will not be revoked if an attempt is made to access the system with an invalid password. This identity should be used for any z/OS Connect authentication/authorization purposes.

Refreshes the STARTED class profiles

SETROPTS RACLIST(STARTED) REFRESH

SAF SERVER and FACILITY profiles

The SERVER and FACILITY profiles grant access to authorized services or features that the z/OS Connect EE may need to function. Some of these profiles are not strictly required for z/OS Connect EE, but you may decide to create all the profiles indicated just to have them on hand in case you need them later. See the notes that follow for a brief explanation of which are optional and why.

Work with your security administrator and do the following[7]:

Tech Tip: Generic SERVER profiles for controlling access to angels should be avoided. The presence of a generic angel resource may have unintended consequences regarding access to privileged functions.

Use the following examples as guides and create the SERVER profiles, see example job ***ZCEESAF.jcl*** which accompanies this document.

Grants an ID general access to the angel process for authorized services:
RDEF SERVER BBG.ANGEL UACC(NONE) OWNER(SYS1)
PERMIT BBG.ANGEL CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Grants an ID general access to a named angel process for authorized services:
RDEF SERVER BBG.ANGEL.*angelName*[8] UACC(NONE) OWNER(SYS1)
PERMIT BBG.ANGEL.*angelName* CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Controls which server processes can use the BBGZSAFM authorized module in the angel process:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM CLASS(SERVER) ACCESS(READ)
ID(*LIBSERV*)

Controls which server processes can use BBGZSAFM for SAF authorization services:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.SAFCRED UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM.SAFCRED CLASS(SERVER) ACCESS(READ)
ID(*LIBSERV*)

Controls which server processes can use BBGZSAFM for WLM services:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.ZOSWLM UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM.ZOSWLM CLASS(SERVER) ACCESS(READ)
ID(*LIBSERV*)

Controls which server processes can use BBGZSAFM for RRS services:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.TXRRS UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM.TXRRS CLASS(SERVER) ACCESS(READ)
ID(*LIBSERV*)

Controls which server processes can use BBGZSAFM for z/OS Dump services:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.ZOSDUMP UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM.ZOSDUMP CLASS(SERVER) ACCESS(READ)
ID(*LIBSERV*)

Controls which server processes can use BBGZSAFM for WOLA services:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.WOLA UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM.WOLA CLASS(SERVER) ACCESS(READ)
ID(*LIBSERV*)

Controls which server processes can use BBGZSAFM for LOCALCOM services:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.LOCALCOM UACC(NONE) OWNER(SYS1)

7 These `SERVER` profiles can be used by *any* Liberty z/OS, whether z/OS Connect EE or not. You may already have these profiles created. If so, then you do *not* need to create the profile, you need only grant your server ID READ to the profile.
8 The angelName must match the NAME parameter used to start the targeted angel process.

PERMIT BBG.AUTHMOD.BBGZSAFM.LOCALCOM CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Controls which server processes can use the authorized client module BBGZSCFM:
RDEF SERVER BBG.AUTHMOD.BBGZSCFM UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSCFM CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Controls which server processes can use optimized local adapter client services:
RDEF SERVER BBG.AUTHMOD.BBGZSCFM.WOLA UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSCFM.WOLA CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Controls access to EJBROLE definitions based on the SAF profile prefix in use for a server:
RDEF SERVER BBG.SECPFX.*BBGZDFLT*[9] UACC(NONE) OWNER(SYS1)
PERMIT BBG.SECPFX.*BBGZDFLT* CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Controls access to IFAUSAGE services (SMF):
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.PRODMGR UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM.PRODMGR CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Writing SMF records also requires access to this FACILITY resource:
RDEF FACILITY BPX.SMF UACC(NONE) OWNER(SYS1)
PERMIT BPX.SMF CLASS(FACILITY) ACCESS(READ) ID(*LIBSERV*)

Controls access to AsyncIO services based on the prefix in use for a server:
RDEF SERVER BBG.AUTHMOD.BBGZSAFM.ZOSAIO UACC(NONE) OWNER(SYS1)
PERMIT BBG.AUTHMOD.BBGZSAFM.ZOSAIO CLASS(SERVER) ACCESS(READ) ID(*LIBSERV*)

Refreshes the SERVER and FACILITY class profiles:
SETROPTS RACLIST(SERVER,FACILITY) REFRESH

Notes:

- **SAFCRED** – needed if you intend to use SAF for security elements such as registry, certificates and EJBROLEs. For initial validation you do not need this, but for any real-world usage of z/OS Connect EE you will need this service available.
- **ZOSWLM** – needed if you wish to classify work using WLM. Initially you won't do this, but later you might. Better to create now and have available when you need it.
- **TXRRS** – needed for access to RRS for transaction coordination. You should not need this for z/OS Connect EE as it does not create global transactions and therefore does not need the services of RRS for that purpose. You may want to create and have on hand for *other* Liberty servers not running z/OS Connect EE.
- **ZOSDUMP** – needed if you wish to use the MODIFY interface to the Liberty z/OS server to process a dump operation. This is good to have available if IBM support requests a dump for your z/OS Connect EE server.
- **PRODMGR** – needed if you wish to enable IFAUSAGE (SMF) for Liberty on z/OS.

9 BBG.SECPFX.BBGZDFLT is the default value for this resource. The security prefix is based on the profilePrefix value in the safCredentials configuration element in the server.xml.

- **ZOSAIO** – needed if you wish to permit the enablement of the use of Asynchronous TCP/IP sockets I/O for Liberty on z/OS.
- **LOCALCOM** – needed for optimized local adapter services.
- **WOLA** – needed if you wish to use WebSphere Optimized Local Adapter support for cross memory communications between tasks.

With z/OS Connect EE installed and the required SAF profiles in place, you are ready to create your server and perform initial validation of the environment.

z/OS Connect Server creation

The Knowledge Center URL for this task is:

OpenAPI 2:

https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=20-creating-zos-connect-server

OpenAPI 3:

https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=30-creating-zos-connect-server

You can use either an OMVS command to create the server configuration or you can submit a job for execution. Using a job is shown here:

1) Start an OMVS shell session using Telnet, SSH or the OMVS TSO command.

- Optionally, first switch to the ID you planned to use for the server's started task using the OMVS ***su*** command, e.g. **su -s *LIBSERV***

> **Tech Tip:** To display the current user and group setting use the OMVS *id* command
> $ ***id***
> uid=20019(LIBSERV) gid=200017(LIBGRP)

- Go to the *bin* directory where z/OS Connect EE is installed, e.g.

  cd /usr/lpp/IBM/zosconnect/v3r0/bin

- Export environment variable *WLP_USER_DIR* to identify the directory location of where the server configuration will be created.

> **Tech Tip:** The same value used for WLP_USER_DIR when creating the server needs to be exported in the JCL used to start the server.

export WLP_USER_DIR=/var/zosconnect

- To create a server, use the *zosconnect* command:

  zosconnect create serverName --template=templateName

  Where ***templateName*** can be:
  - *zosconnect:apiRequester* for an API requester enabled z/OS Connect server
  - *zosconnect:default* template for base/OS Connect servers
  - *zosconnect:sampleCicsIpicCatalogManager* for a sample CICS enabled z/OS Connect server
  - *zosconnect:sampleDb2Project* for a sample Db2 enabled z/OS Connect server
  - *zosconnect:sampleDatabase* for a sample IMS database enabled z/OS Connect server
  - *zosconnect:samplePhonebook* for a sample IMS transaction enabled z/OS Connect server
  - *zosconnect:sampleMQStockManager* for a sample MQ enabled z/OS Connect server
  - *zosconnect:sampleWolaCatalogManager* for a sample WOLA enabled z/OS Connect server

Where ***serverName*** is any value you wish, such as ***zceesrvr***. If you are unsure which template to use, you can start with the *default* template. Once your z/OS Connect Server is built, you can add

the required features to the server.xml. For example, you can add this feature for CICS: *<feature>zosconnect:cicsService-1.0</feature>* within the server.xml.

Tech Tip: The differences between these templates are the features added to the *featureManager* configuration element in the initial server.xml, e.g. the IMS template adds the *imsmobile* feature the CICS template add the *cicsService* feature and the API requester template adds the *apiRequester* feature, etc. The additional directories created in the .../*resources/zosconnect* subdirectory in the server's configuration path are specified by these templates. All the templates create the *apis, services* and *rules* subdirectories but only the *apiRequesters* templates creates the *apiRequesters* subdirectory. If the apiRequesters feature is added to an existing server be sure to manually create this subdirectory with the correct permission bits and ownership.

It is our recommendation to use the *apiRequester* template to initially create a server and then enhance this basic configuration by referring to the sample temples for the features each installs and connection examples, see the *server.xml* files in subdirectories in */usr/lpp/IBM/zosconnect/v3r0/runtimes/templates* directory for these examples.

- Optionally, if you did not use the switch user command then the ownership of the configuration directory structure needs to be changed with a *chown* command.

  chown -R LIBSERV:LIBGRP $WLP_USER_DIR/servers/*serverName*

2) Submit JCL like the JCL shown below, see example job ***MYSERVER.jcl*** which accompanies this document.

```
//MYSERVER JOB 'ZCEE',CLASS=A,REGION=0M,NOTIFY=&SYSUID,USER=LIBSERV
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET JAVAHOME='/usr/lpp/java/J8.0_64'
// SET ZCEEPATH='/usr/lpp/IBM/zosconnect/v3r0'
// SET SERVER='myServer'
// SET TEMPLATE='zosconnect:apiRequester'
// SET WLPUSER='/var/zosconnect'
// SET USER='LIBSERV'
// SET GROUP='LIBGRP'
//*************************************************************
//*  Step ZCEESRVR - Use the zosconnect command to create a server
//*************************************************************
//ZCEESRVR EXEC PGM=IKJEFT01,REGION=0M
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSPRT DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
 BPXBATCH SH +
 export JAVA_HOME=&JAVAHOME; +
 export WLP_USER_DIR=&WLPUSER; +
 &ZCEEPATH/bin/zosconnect create &SERVER +
 --template=&TEMPLATE
//*************************************************************
//*  Step CHOWN - Change directory and file ownership
//*************************************************************
//CHOWN  EXEC PGM=IKJEFT01,REGION=0M
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSPRT DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
 BPXBATCH SH +
 export WLP_USER_DIR=&WLPUSER; +
 chown -R &USER:&GROUP $WLP_USER_DIR/servers/&SERVER
```

Tech Tip: If surrogate access has been enabled, the ***USER=LIBSERV*** JCL parameter can be added to the JOB as shown above. In this example, the job will execute under the ***LIBSERV*** identity, and all directories and files will be owned by ***LIBSERV*** with the appropriate permissions bits set. If surrogate access has not been enabled, then the directory and file ownership can be changed to LIBSERV by executing the change owner command in step CHOWN. Either the USER parameter or the CHOWN step should be used.

After the server is created go to *the /var/zosconnect/servers* (i.e. the directory specified by environment variable *WLP_USER_DIR)* directory and verify that a sub-directory with the name ***serverName*** was created, and under the ***serverName*** directory there exists a *server.xml* file.

TCP ports and host element

A few minor updates to */var/zosconnect/servers/**serverName**/server.xml* may be required at this point.

Do the following:

- Consult with your TCP networking administrator and see if the default ports of 9080 and 9443 are acceptable. If not, plan the two TCP ports you will use:
- Edit the server.xml file and update the ports specified in the httpEndPoint element.

```
<httpEndpoint id="defaultHttpEndpoint"
                  host="*"
              httpPort="9080"
              httpsPort="9443" />
```

The two ports should reflect either the default values (shown) or your planned values.

Tech Tip: A Liberty server's configuration file, e.g. *server.xml* file and any included files must be in ASCII. Use the ASCII editor available when using ISPF option 3.4 or 3.17 when accessing these files.

Tech Tip: Setting a port to minus 1 (-1) disables that protocol.

- Save the file.

Starting a z/OS Connect EE Server

Earlier you created the STARTED profiles to assign an identity to the started task. z/OS Connect EE comes with sample JCL start procedures you can copy to your PROCLIB and customize for your environment.

Do the following:

- Copy the sample server JCL from member BAQSTRT in your SMP/E SBAQSAMP target library to your PROCLIB, renaming it as you desire as you copy. Make sure the resulting procedure's JCL does not have sequence numbers columns 73-80. If you find them, issue command *unnum* to remove the numbers. That will also set the ISPF profile to NUMBER OFF.

Tech Tip: Characters in columns 73-80 will cause havoc if they appear in the input to the STDENV DD statement.

- Rename the procedure so it matches the STARTED profile you created for the server.
- Customize the server JCL:

```
//BAQSTRT  PROC PARMS='serverName' 1
//*
   (comment lines removed to save space in this document)
//*-------------------------------------------------------------------
//* Start the Liberty server
//*
//* STDOUT  - Destination for stdout (System.out)
//* STDERR  - Destination for stderr (System.err)
//* STDENV  - Initial z/OS UNIX environment for the specific
//*           server being started
//*
// SET ZCONHOME='<Install path>'  2
//*
//ZCON     EXEC PGM=BPXBATSL,REGION=0M,MEMLIMIT=8G,
//         PARM='PGM &ZCONHOME./bin/zosconnect run &PARMS.'
//STDOUT   DD   SYSOUT=*
//STDERR   DD   SYSOUT=*
//STDIN    DD   DUMMY
//STDENV   DD   *
_BPX_SHAREAS=YES
_CEE_RUNOPTS=HEAPPOOLS(ON),HEAPPOOLS64(ON)
JAVA_HOME=<Java home directory>   3
WLP_USER_DIR=<User directory>     4
#JVM_OPTIONS=<Optional JVM parameters> 5
//*
// PEND
//
```

Notes:

1. Change **serverName** to match the name of the server created earlier (case matters).

2. Set the *<Install path>* value to the path of the z/OS Connect EE install location, e.g. */usr/lpp/IBM/zosconnect/v3r0* or whatever your value is. Make sure to enclose the value in single quotes as shown in the JCL.

3. Set *JAVA_HOME* to the path to your 64-bit IBM Java SDK, e.g. */usr/lpp/java/J8.0_64*

4. Set *WLP_USER_DIR* to the location where the shared resources and server definitions will be created. The default value is */var/zosconnect*.

5. If you will be using a named angel this property is where you can specify the angel's name, see the information on page 13 regarding named angels.

Tech Tip: The same value used for WLP_USER_DIR that was used when creating the server needs to be exported in the JCL used to start the server. *WLP_USER_DIR* is a Liberty environment variable. See ***Liberty Environment Variables*** on page 95 for information on other Liberty environment variables.

If you intend to use an already-existing angel process, then skip over the following steps[10]. Otherwise, follow these steps to create and start an angel process.

- Copy the sample angel JCL from member BAQZANGL in SBAQSAMP to your PROCLIB.
- Rename the procedure so it matches the STARTED profile you created for the angel.
- Customize the angel JCL:

```
//BAQANGL PROC PARMS='',COLD=N,NAME='',SAFLOG=N 1  2
//*
//* z/OS Connect Enterprise Edition
//*
//*-------------------------------------------------------------------
//  SET ROOT='/usr/lpp/IBM/zosconnect/v3r0/wlp'3
//*-------------------------------------------------------------------
//* Start the Liberty angel process
//*-------------------------------------------------------------------
//* This proc may be overwritten by fixpacks or iFixes.
//* You must copy to another location before customizing.
//*-------------------------------------------------------------------
//STEP1   EXEC PGM=BPXBATA2,REGION=0M,TIME=NOLIMITE,
//  PARM='PGM &ROOT./lib/native/zos/s390x/bbgzangl COLD=&COLD NAME=X
//             &NAME &PARMS SAFLOG=&SAFLOG'
//STDOUT    DD SYSOUT=*
//STDERR    DD SYSOUT=*
```

Notes:

1. A name can be given to an angel either by providing a value in the NAME parameter in the JCL by overriding the *NAME* parameter when the angel is started, e.g.

Start the angel with MVS command ***S angelProc***

S BAQZANGL,NAME=PRODUCTION

2. We recommend the *SAFLOG* parameter be set to ***Y***.

3. Change the *SET ROOT=* value so it reflects the install location for z/OS Connect EE, ***including*** the */wlp* sub-directory.

10 If you see "CWWKB0307E: The angel process on this system is not compatible with the local communication service. The current angel version is 2, but the required angel version is 3," then update the existing Angel JCL start proc to point to z/OS Connect EE and restart the Angel.

Tech Tip: The SAFLOG parameters was added in a recent Liberty drop. If this parameter is set to **Y** additional security related messages will be written to the JES messages and console if a Liberty does not have authorization to use an angel control privilege function. For example, if a server is requesting access to SAF authentication and the necessary permits have not been done, this message will appear.

```
ICH408I USER(LIBSERV ) GROUP(LIBGRP  ) NAME(LIBERTY SERVER
  BBG.AUTHMOD.BBGZSAFM.SAFCRED CL(SERVER  )
  INSUFFICIENT ACCESS AUTHORITY
  ACCESS INTENT(READ   )  ACCESS ALLOWED(NONE   )
```

- Start the angel and verify the angel received the authorization ID you intended, see message IEF695I. This validates the STARTED profile you created for the angel process.

Tech Tip: The name of the angel can be provided using the NAME parameter on the start command, e.g. ***S BAQZANGL,NAME=PRODUCTION***. Any Liberty server that will use this angel for security must be configured as described above using the *com.ibm.ws.zos.core.angelName* and *com.ibm.ws.zos.angelRequired* system properties, see *Named Angels on page 13*. Using a named angel will also require additional RACF resources, see section *SAF SERVER and FACILITY profiles on page 18.*

Setup of basic security

Here you will set up security definitions in the server.xml to provide the minimum required (by default).

Overview of Security (OpenAPI 2): https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=20-overview-zos-connect-security

Overview of Security (OpenAPI 3): https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=30-overview-zos-connect-zosconnect-security

Do the following:

- *Go* to the */var/zosconnect/servers/**serverName*** directory
- Edit the *server.xml* file.

- Create a file named *basicSecurity.xml* in a director, e.g. */var/zosconnect* and add the configuration statements shown here.

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

<!-- Enable features -->
<featureManager>
      <feature>appSecurity-2.0</feature>    1
</featureManager>

<keyStore id="defaultKeyStore" password="Liberty"/>  2

<webAppSecurity allowFailOverToBasicAuth="true" />     3

<basicRegistry id="basic1" realm="zosConnect">        4
      <user name="Fred" password="fredpwd" />
</basicRegistry>

<authorization-roles id="zos.connect.access.roles">    5
      <security-role name="zosConnectAccess">
            <user name="Fred"/>
      </security-role>
</authorization-roles>

</server>
```

Notes:

1. Enables application security, which z/OS Connect EE will use[11].
2. Enables use of a default key/trust store generated by Liberty. This allows SSL from the REST client to z/OS Connect EE without having to introduce the complexity of creating and managing certificates at this point.
3. This will result in a userid and password prompt at the REST client, rather than using the default client certificate mechanism.
4. This defines a user registry with a single entry of Fred and a password.
5. This provides access to the z/OS Connect EJBRole to the authenticated user.

Tech Tip: Any Liberty server's included configuration file must be in ASCII. Use the ASCII editor available when using ISPF option 3.4 or 3.17 when accessing these files.

- Add an include element the basicSecurity.xml file created above as shown below:

```
<server description="new*server">
<include location="/var/zosconnect/basicSecurity.xml"
optional="true"/>
```

Tech Tip: For more information about including configuration elements from other files and sources see URL https://www.ibm.com/docs/en/was-liberty/zos?topic=files-using-include-elements-in-configuration

11 This is redundant. If you look at the `messages.log` output from earlier, you will see that `appSecurity-2.0` is loaded automatically. That's because z/OS Connect EE was loaded, and application indicated it needed `appSecurity-2.0`. So, Liberty auto-loaded it. Including it as a `<feature>` does not hurt. It is a good visual reminder of key features required by z/OS Connect EE 2.

- Save the files.

For a more detailed descriptions of the steps required to configure a basic z/OS Connect server see the security exercise *IBM z/OS Connect EE V3.0 Basic Configuration* at URL

https://tinyurl.com/37nvdhn5

Next start the server and verify basic operations:

- Start the z/OS Connect server with the following command:

  S serverProc,PARMS='serverName'

  Where *serverProc* is the name you gave your z/OS Connect EE server JCL start procedure, and *serverName* is the name you gave your created server.

- Verify the server received the authorization ID you intended, see message IEF695I. This validates the STARTED profile you created for the server.
- Go to the */var/zosconnect/servers/serverName/logs* directory

Notes: The PARMS= value is case sensitive. Issue this command in the z/OS "command extensions" (a single slash in SDSF) to preserve the case. Otherwise entering ***/S proc,PARMS='servername'*** in SDSF will fold the entire command to uppercase including the *servername*. If you want to simplify the start command ***/S proc***, then update the first line of the JCL procedure and include the server name in the PARM= parameter on the first line. Then when you issue /S proc the *PARMS='servername'* will be derived from the first line of the JCL.

- Look in the messages.log file. You should see the following messages[12]. See notes that follow:

12 The messages may occur in a slightly different order. That's okay; the important thing is the various success indicators are present.

```
CWWKE0001I: The server serverName has been launched.
CWWKB0125I: This server requested a REGION size of 0KB. The below-the-line storage limit is 8MB and the above-
the-line storage limit is 1542MB.
CWWKB0126I: MEMLIMIT=1000. MEMLIMIT CONFIGURATION SOURCE=JCL.
CWWKB0124I: Angel ZCEE is required, server was configured to wait up to 0 seconds to connect to the targeted
Angel.
CWWKB0122I: This server is connected to the ZCEE angel process.
CWWKB0103I: Authorized service group KERNEL is available.
CWWKB0103I: Authorized service group LOCALCOM is available.
CWWKB0103I: Authorized service group SAFCRED is available.    1
CWWKB0103I: Authorized service group TXRRS is available.
CWWKB0103I: Authorized service group WOLA is available.
CWWKB0103I: Authorized service group ZOSDUMP is available.
CWWKB0103I: Authorized service group ZOSWLM is available.
CWWKB0104I: Authorized service group PRODMGR is available.
CWWKB0104I: Authorized service group ZOSAIO is available.                2
CWWKB0103I: Authorized service group CLIENT.WOLA is available.
CWWKB0108I: IBM Corp product z/OS Connect version 03.00 successfully registered with z/OS.
CWWKB0113I: The number of successfully registered products with z/OS is 1. These products will deregister from
z/OS when the address space terminates.
CWWKB0121I: The server process UMASK value is set to 0000.
CWWKE0002I: The kernel started after 1.688 seconds
CWWKF0007I: Feature update started.
CWWKS0007I: The security service is starting...
CWWKO0229I: Native Asynchronous I/O support for z/OS has been activated.
DYNA1001I: WebSphere Dynamic Cache instance named baseCache initialized successfully.
DYNA1071I: The cache provider default is being used.
DYNA1056I: Dynamic Cache (object cache) initialized successfully.
CWPKI0802I: Creating the SSL certificate. This may take a few seconds.
CWWKS4103I: Creating the LTPA keys. This may take a few seconds.
CWWKS1123I: The collective authentication plugin with class name NullCollectiveAuthenticationPlugin has been
activated.
BAQR0000I: z/OS Connect Enterprise Edition version 3.0.34.0 (20200615-1601)
DYNA1056I: Dynamic Cache (object cache) initialized successfully.
DYNA1001I: WebSphere Dynamic Cache instance named zosconnect_safcache initialized successfully.
DYNA1071I: The cache provider default is being used.
CWWKO0219I: TCP Channel defaultHttpEndpoint has been started and is now listening for requests on host *
(IPv4) port 9080. 3
CWWKS4104A: LTPA keys created in 1.629 seconds. LTPA key file:
/var/zosconnect/servers/serverName/resources/security/ltpa.keys
CWWKF0012I: The server installed the following features: [appSecurity-2.0, distributedMap-1.0, jaxrsClient-
2.0, jndi-1.0, json-1.0, servlet-3.1, ssl-1.0, zosconnect:zosConnect-2.0, zosconnect:zosConnectCommands-1.0].
CWWKF0008I: Feature update completed in 4.548 seconds.          4
CWWKF0011I: The serverName server is ready to run a smarter planet. The serverName server started in 5.038
seconds.
CWWKS4105I: LTPA configuration is ready after 1.642 seconds.
SRVE0169I: Loading Web Module: z/OS Connect. 5
SRVE0250I: Web Module z/OS Connect has been bound to default_host.
CWWKT0016I: Web application available (default_host): http://wg31.washington.ibm.com:9080/
SESN8501I: The session manager did not find a persistent storage location; HttpSession objects will be stored
in the local application server's memory.
SESN0176I: A new session context will be created for application key default_host/
SESN0172I: The session manager is using the Java default SecureRandom implementation for session ID
generation.
SRVE9103I: A configuration file for a web server plugin was automatically generated for this server at
/var/zosconnect/ser vers/serverName/logs/state/plugin-cfg.xml.
DYNA1056I: Dynamic Cache (object cache) initialized successfully.
SRVE0242I: [com.ibm.zosconnect] [/] [com.ibm.zosconnect.internal.web.ServiceProxyServlet]: Initialization
successful.
CWWKS9122I:  For URL /* in application com.ibm.zosconnect, the following HTTP methods are uncovered, and
accessible: OPTIONS
CWPKI0803A: SSL certificate created in 4.248 seconds. SSL key file:
/var/zosconnect/servers/serverName/logs/state/plugin-cfg.xml.
Successfully loaded default keystore: /var/zosconnect/servers/serverName/resources/security/key.p12 of type:
PKCS12
CWWKO0219I: TCP Channel defaultHttpEndpoint-ssl has been started and is now listening for requests on host *
(IPv4) port 9443.
```

Notes:

1. The "Authorized service group" messages indicate the success of the server to access the angel process with the SERVER profiles you created.
2. Some *Authorized service group* messages may not be available depending on what SERVER profiles you created and whether the server ID was granted READ to the profile.
3. You should see your HTTP port show up in this message.
4. You should see *zosconnect:zosConnect-2.0* show up in the features that were installed.
5. The z/OS Connect web module should show loaded.

Key Point: This kept as simple as possible at this phase of setup and validation. We do that because we want to get you to the definition of services and APIs as quickly and easily as possible. The security setup we illustrate here works but is not suitable for anything but testing purposes. If you are interested in seeing how to enable SAF to perform these security functions, see section ***Using SAF for controlling z/OS connect EE access*** on *page 40*

Use a browser and enter the following URL:

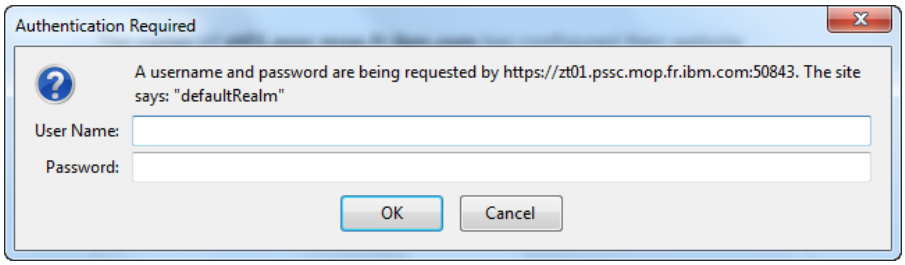
https://<host>:<port>/zosConnect/apis

where:

- The protocol is http**s** (note the "s")
- *<host>* is the TCP host for your server
- *<port>* is the secure port (httpsPort=) for your server
- The "C" in "zosConnect" is in uppercase (otherwise you'll get a 404 not found error)

Tech Tip: Accessing the server using a browser can be done at this stage. But be aware the server is using a self-signed certificate at this time and some browsers will not always accept self-signed certificates. If this is an issue download and install the cURL tool ,see section ***Testing z/OS Connect Services Using cURL*** on *page 90* and follow the instructions later in this section for using cURL to verify the server.

- Your browser will challenge the security of the connection because the certificate authority that signed the server certificate is the default Liberty CA, and your browser does not recognize that. Accept the challenge[13].
- You should then get a basic authentication prompt:

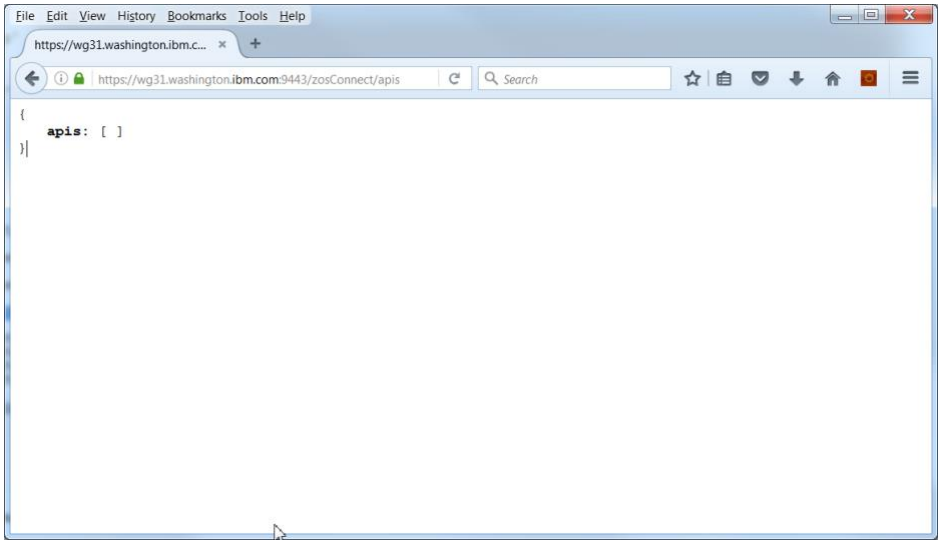


This is because of the *allowFailOverToBasicAuth="true"* in the server.xml.

Provide the userid and password you supplied for the basicRegistry entry in the server.xml file: **Fred** and **fredpwd** (*this is case sensitive*).

13 This will create an error in `messages.log` and an FFDC directory with entries there to capture the error. This is expected.

- You should then see a screen like the following:



Tech Tip: The browser add-on or plug-in *JSONView* has been installed in this browser. This add-on formats JSON messages so they are easier to read and enables hyperlinks, etc. The browser screen shots in this document show the effects of this browser add-on.

That is telling you z/OS Connect sees no APIs are currently configured. That is a good sign at this point – it is telling you the Liberty z/OS server recognizes that z/OS Connect EE V3.0 is in fact active, but no APIs are currently present.

- Stop the server with **/P *<server_proc>*** [14]. This will give you a clean messages.log on the next start, which makes it easier to look for and find the key success messages.

The essentials are in place for you to begin coding up services and using the API editor to create the API artifacts.

- Optionally, verify the server using cURL. For details regarding this test tool see ***Testing z/OS Connect Services Using cURL*** on *page 90*.

curl -X GET --user Fred:fredpwd --header "Content-Type: application/json" --insecure https://<host>:<port>/zosConnect/apis

14 It's really `/P <jobname>`, but earlier you started the server with just the proc name, so that becomes the jobname as well.

- You should then see something like the following:

> ***curl -X GET --user Fred:fredpwd --header "Content-Type: application/json" --insecure https://wg31.washington.ibm.com:9443/zosConnect/apis***
> {"apis":[]}

Again, this is telling you z/OS Connect sees no APIs are currently configured. That is a good sign at this point – it is telling you the Liberty z/OS server recognizes that z/OS Connect EE is in fact active, but no APIs are currently present.

- Stop the server with MVS command **P *serverProc*** [15]. This will give you a clean messages.log on the next start, which makes it easier to look for and find the key success messages.

The essentials are in place for you to begin coding up services and using the API editor to create the API artifacts.

Tech Tip: If the above test fails adding a -v flag to the curl command will provide a trace that may be useful in resolving the cause of the failure.

15 It's really `/P <jobname>`, but earlier you started the server with just the proc name, so that becomes the jobname as well.

Security Topics

Beyond the simple server.xml security elements

Turning off TLS and/or authentication

By default, z/OS Connect EE will require both transport security (commonly referred to as "SSL," but more precisely called "TLS," or Transport Layer Security) and user authentication. Earlier in this document you saw that requirement surface: the instructions had you accept the security challenge caused by the self-signed server certificate, and then supply the userid and password. But you may have certain services or APIs on which you do not wish to enforce transport security (HTTPS) or authentication. z/OS Connect EE provides a way to turn off either or both.

Requiring HTTPS and authentication are controlled by two configuration attributes for controlling security, but of which default to *"true".* Attribute *requireSecure* controls whether a connection to a z/OS Connect server must be on a HTTPS connection (*requireSecure="true")* or whether HTTP is supported (*requireSecure="false").* Attribute *requireAuth* controls where an authenticated identity is required and whether this authenticated identity is used for subsequent authorization checks (*requireAuth="true*").

Turning off security at the Global Level

Both *requireSecure and requireAuth* default to *true*. Either one or both can be disabled for the entire server in the *zosconnect_zosConnectManager* configuration for the entire sever (globally) as shown below.

```
<zosconnect_zosConnectManager
   requireAuth="false"  requireSecure="false"/>
```

Turning off security at the API level

Security for a specific API can be controlled by adding a *zosconnect_zosConnectAPIs* configuration element and then adding explicit zosConnectAPI sub element for that API in a as shown below.

```
<zosconnect_zosConnectAPIs location="">
    <zosConnectAPI name="catalog"
     requireAuth="false" requireSecure="false"/>
</zosconnect_zosConnectAPIs>
```

Where *requireAuth* controls authentication, and *requireSecure* controls transport layer encryption. Coding ***"false"*** turns off either requirement for the API.

Clients may then access this API without authenticating and without going through the handshake protocol to establish encryption. This is true even if the underlying service definition still requires both authentication and encryption.

Turning off security at the service level

Security for a specific service can be controlled by adding an explicit *service* element for that Service in a *zosconnect_services configuration* element.

```
<zosconnect_services>
   <service name="inquireSingleService"
        requireAuth="false" requireSecure="false"/>
</zosconnect_service>
```

The following is from the Knowledge Center.

> **Note**
>
> If your service is called as part of an API call, the interceptors and security configuration included with the API will override the configuration included in the service.

This means that any security settings at the service level are only applicable when the service is invoked directory outside of an API.

Turning off security at the API requester level

Security for a specific API requester can be controlled by adding an explicit *apiRequester* for that API requester in a *zosconnect_apiRequesters* configuration element.

```
<zosconnect_apiRequesters requireAuth="false">
    <apiRequester name="ccscvincapi_1.0.0"
         requireAuth="false" requireSecure="false" />
</zosconnect_apiRequesters>
```

Requiring the authentication and authorization for use of an API requester can be controlled for all API requester artifacts by using the *requireAuth* attribute on a *zosconnect_apiRequesters* configuration element or for a specific API requester using an individual *apiRequester* element. The use of HTTP or HTTPS can be controlled for a specific API requester in a an *apiRequester* element using the *requireSecure* attribute.

Turning off security at the service endpoint level

Security for a specific service, e.g. WOLA, DVM or services that use the service provider supplied by IBM MQ can be controlled by adding an explicit *zosconnect_zosConnectService* element.

```
<zosconnect_zosConnectService id="zosConnectDvsService"
        invokeURI="/dvs" serviceDescription=""
        serviceRef="dvsService" serviceName="dvsService"
        requireAuth="false" requireSecure="false"/>
```

These services are generally services created using the BAQLS2JS utility or third-party providers.

Using SAF for registry and access role checking

Up to this point Liberty has been configured to use "basic" security – that is, all security information for identities, passwords, and role access are defined in *server.xml* and managed by the Liberty server. In this section the steps required to enable authentication to a system authorization facility (SAF), e.g. RACF will be shown. For more details on this topic, see the exercise ***zCEE Customization Basic Security*** which can be found at URL https://tinyurl.com/37nvdhn5.

• First, defined some basic SAF resources, e.g. RACF APPL resources, see sample job ***ZCEERACF.jcl*** which accompanies this document. You can find the full sample job here: https://tinyurl.com/3x6c9fe8.

```
ADDGROUP WSGUESTG OMVS(AUTOGID) OWNER(SYS1) 1
ADDGROUP ZCEEUSRS OMVS(AUTOGID) OWNER(SYS1) 2
ADDUSER WSGUEST RESTRICTED DFLTGRP(WSGUESTG) OMVS(AUTOUID -
HOME(/u/wsguest) PROGRAM(/bin/sh)) NAME('UNAUTHENTICATED USER') -
NOPASSWORD NOOIDCARD

ADDUSER FRED DFLTGRP(ZCEEUSRS) OMVS(AUTOUID HOME(/u/fred/) -    3
 PROGRAM(/bin/sh)) NAME('USER FRED')
ALTUSER FRED PASSWORD(FRED) NOEXPIRE

RDEFINE APPL BBGZDFLT UACC(NONE) OWNER(SYS1)4
PERMIT BBGZDFLT CLASS(APPL) RESET
PERMIT BBGZDFLT CLASS(APPL) ACCESS(READ) ID(WSGUEST,ZCEEUSRS)5

SETROPTS RACLIST(APPL) REFRESH  6
```

Notes:

1. Add an identity that will be used for SAF checks during the unauthenticated state prior to the actual authentication of SAF identity and password.
2. Add a group containing the authorized users of this server.
3. An example of the commands for adding a RACF identity, note that the OMVS segment with a UID is required for the identity (as well as an GID for the groups to which the user is connected).
4. Define the security prefix to be used for this Liberty server.
5. Permit the unauthenticated identity and other groups to have access to this APPL resource.
6. Permit the members of group LIBGRP access to this APPL resource.
7. Refresh the in storage for the APPL resources.

Tech Tip: The value *BBGZDFLT* in the above commands must match the value of attribute *profileprefix* in the *safSecurity.xml* file described on the next page.

• Next, defined the required EJBROLE resource and grant access, see below.

```
RDEFINE EJBROLE BBGZDFLT.zos.connect.access.roles.zosConnectAccess -  1
OWNER(SYS1) UACC(NONE)
PE BBGZDFLT.zos.connect.access.roles.zosConnectAccess CLASS(EJBROLE) RESET
PE BBGZDFLT.zos.connect.access.roles.zosConnectAccess -    2
  CLASS(EJBROLE) ID(ZCEEUSRS) ACCESS(READ)
SETR RACLIST(EJBROLE) REFRESH                      3
```

Notes:

1. Defines the EJBRole required by z/OS Connect, e.g. *zos.connect.access.roles.zosConnectAccess*. using the value defined in the APPL resources, e.g. *BBGZDFLT,* as the resource's prefix.
2. Permit authorized users to this EJBRole resource.
3. Refresh the in storage EJBrole profiles.

• The *server.xml* needs to be changed to remove the current 'basic' configuration elements and replace them with the elements for enabling SAF security. Basic security was enabled by including *basicSecurity.xml* file in the main *server.xml* file. SAF security can be enabled by creating an *safSecurity.xml* file and replacing the include *basicSecurity.xml* to an include of *safSecurity.xml*.

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="saf security">

    <!-- Enable features -->
    <featureManager>
        <feature>appSecurity-2.0</feature>
        <feature>zosSecurity-1.0</feature>     1
    </featureManager>

    <keyStore id="defaultKeyStore" password="Liberty"/>  2

    <webAppSecurity allowFailOverToBasicAuth="true" />

    <safRegistry id="saf" />                        3
    <safAuthorization racRouteLog="ASIS" />
    <safCredentials unauthenticatedUser="WSGUEST"
       profilePrefix="BBGZDFLT" />        4
```

Notes

1. The *zosSecurity-1.0* feature adds the z/OS security feature
2. This not-SAF trust store will still be required until a SAF key ring is configured.
3. The *safRegistry, safAuthorization* and *safCredentials* elements enable authentication and authorization using SAF.
4. The profilePrefix attribute must match value of the APPL resource

• Refresh the z/OS Connect server configuration with MVS command

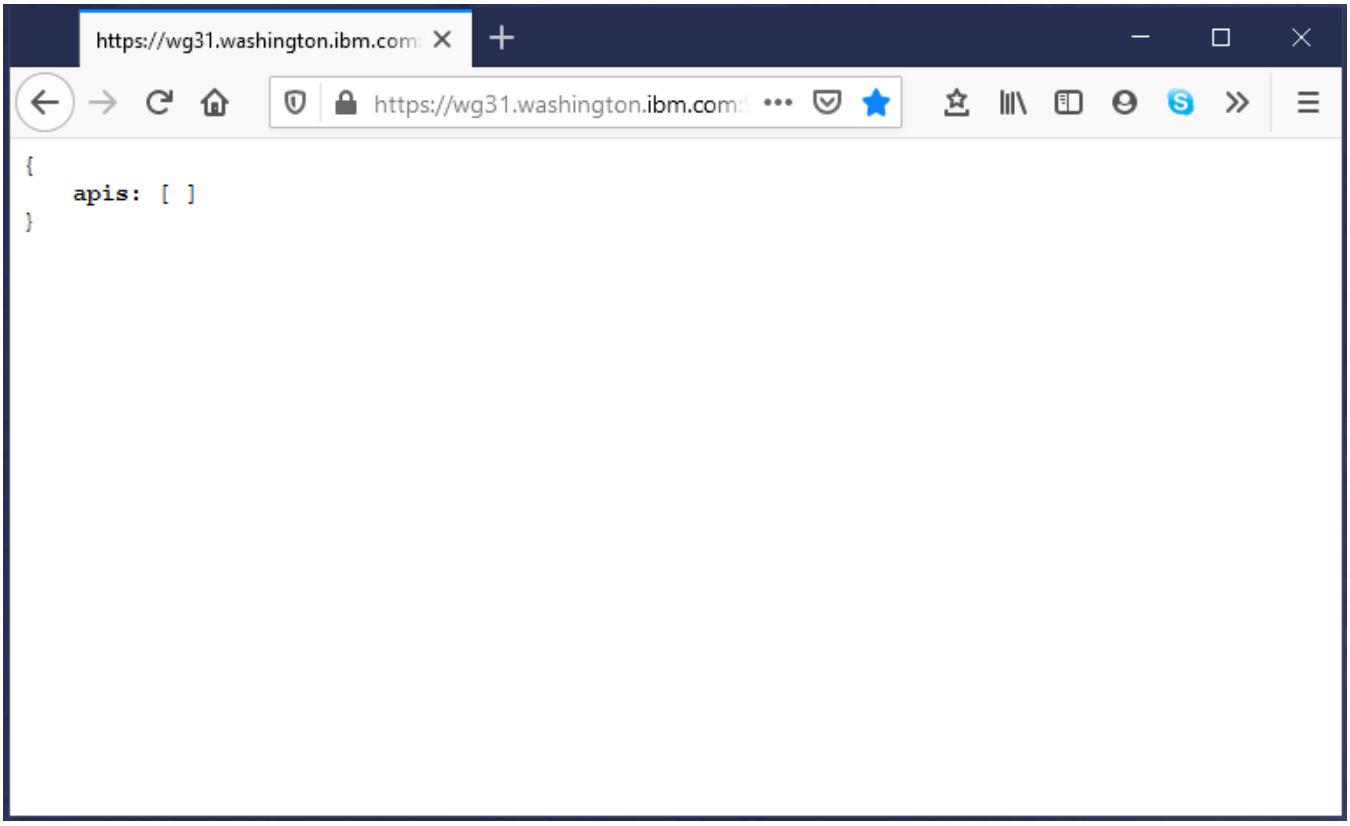
F BAQSTRT,REFRESH,CONFIG

• Close all instances of the Firefox browser (we want to force another prompt for ID, and closing the browser clears any authorization tokens from the browser's cache).

• Start Firefox and enter the following URL:
https://wg31.washington.ibm.com:9443/zosConnect/apis

• In the userid/password prompt, enter ***Fred*** and ***FRED*** (the SAF identity and password from above).

• You should see a list of the APIs (below is just an example):



• Close the browser again and restart it and access the same URL. This time enter another identity, USER2, not permitted to the EJBRole.

• The request should fail with message *Error 403: AuthorizationFailed*. Check the system log using SDSF if using RACF you should an ICH408I message (see below). USER2 does not have access to the EJBROLE resource protecting the z/OS Connect server.

```
ICH408I USER(USER2    ) GROUP(SYS1     ) NAME(WORKSHOP USER2
   BBGZDFLT.zos.connect.access.roles.zosConnectAccess
   CL(EJBROLE )
   INSUFFICIENT ACCESS AUTHORITY
   ACCESS INTENT(READ    )  ACCESS ALLOWED(NONE    )
```

Summary

The registry and authorization information were removed from the *server.xml*, and other XML elements were to configure using SAF as security registry (for userid and password) and role checking (EJBROLE).

Using SAF for controlling z/OS connect EE access

The steps required to enable group checking for authorization will be shown in this section.

In this example, identity FRED will have administrative authority and USER1 will only have API execution authority. For more details on this topic, see the exercise zCEE ***Customization Basic Security*** which can be found at URL https://tinyurl.com/37nvdhn5.

- Add two new groups will using the ***ADDGROUP*** command, e.g.

  ADDGROUP GMADMIN OMVS(AUTOGID)

  ADDGROUP GMINVOKE OMVS(AUTOGID)

- Connect user FRED to group *GMADMIN* using the ***CONNECT*** command, e.g.

  CONNECT FRED GROUP(GMADMIN)

- Connect user USER1 to group *GMINVOKE* using the ***CONNECT*** command, e.g.

  CONNECT USER1 GROUP(GMINVOKE)

See example job ***ZCEEGRPS.jcl*** which accompanies this document.

Tech Tip: The z/OS Connect server is executing as an OMVS process. These means that all user identities and groups that used for security must have an OMVS segment. OMVS segments can be display by either an ***LU identity OMVS*** or ***LG group OMVS*** TSO command. Also note that each identity's OMVS segment requires a valid HOME directory that actually does exist and one that the identity has R/W access.

• Below is an example server.xml showing the configuration attributes that can be used to control access to z/OS Connect resources using group access checking. In this example the groups created above are shown along with other groups (lower case names) just to show the variety of combinations can be configured.

```
<zosconnect_zosConnectManager
         globalInterceptorsRef="interceptorList_g"
         globalAdminGroup="GMADMIN,admgrp1,admgrp2"
         globalOperationsGroup="GMOPERS,oprgrp1,oprgrp2"
         globalInvokeGroup="GMINVOKE,invgrp1,invgrp2"
         globalReaderGroup="GMREADR,readgrp1,readgrp2"/>

<zosconnect_authorizationInterceptor id="auth"/>
<zosconnect_authorizationInterceptor id="audit"/>
<zosconnect_zosConnectInterceptors id="interceptorList_g"
       interceptorRef="auth"/>
<zosconnect_zosConnectInterceptors id="interceptorList_a"
       interceptorRef="auth,audit"/>

<zosconnect_zosConnectAPIs>
   <zosConnectAPI name="catalog"
        runGlobalInterceptorsRef="true"
        adminGroup="GMADMIN,aapigrp1,aapigrp2"
        operationsGroup="GMOPERS,oapigrp1,oapigrp2"
        invokeGroup="GMINVOKE,iapigrp1,oapigrp2"
        readerGroup="GMREADR,rapigrp1,rapigrp2"/>
</zosconnect_zosConnectAPIs>

<zosconnect_apiRequesters>
   <apiRequester name="cscvincapi_1.0.0"
        runGlobalInterceptorsRef="false"
        interceptorsRef="interceptorList_a"
        adminGroup="GMADMIN,aaprgrp1,aaprgrp2"
        operationsGroup="GMOPERS,oaprgrp1,oaprgrp2"
        invokeGroup="GMINVOKE,iaprgrp1,oaprgrp2"
        readerGroup="GMREADR,raprgrp1,raprgrp2"/>
</zosconnect_apiRequesters>

<zosconnect_services>
  <service id="selectByEmployee" name="selectEmployee"
        runGlobalInterceptorsRef="false"
        interceptorsRef="interceptorList_a"
        adminGroup="GMADMIN,asrvgrp1,asrvgrp2"
        operationsGroup="GMOPERS,osrvgrp1,osrvgrp2"
        invokeGroup="GMINVOKE,isrvgrp1,isrvgrp2"
        readerGroup="GMREADR,rsrvrgrp1,rsrvgrp2"/>
</zosconnect_services>
```

Note:

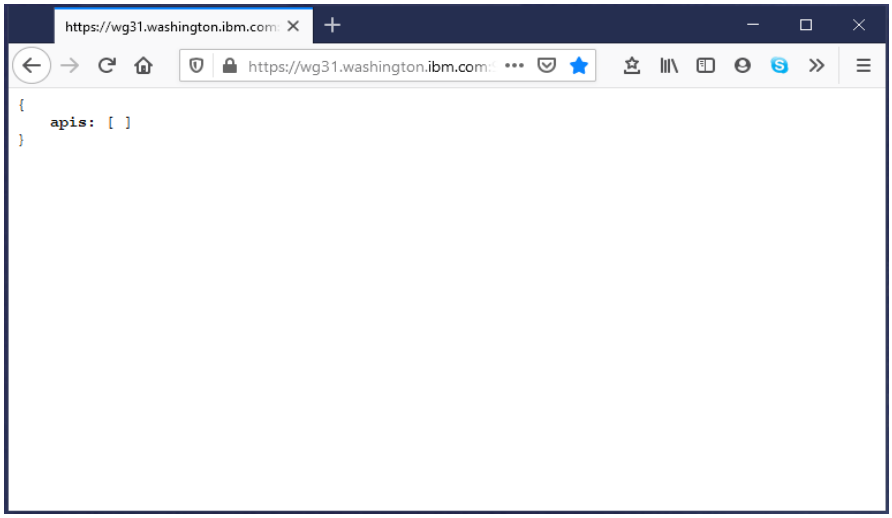
- If the *runGlobalInterceptorsRef* is set to “false” then the *interceptorRef* attribute must be supplied for group membership to be use for authorization.
- The use of a specific group control is optional as well as listing multiple groups.

• Stop and restart the z/OS Connect server.

• Close all instances of the Firefox browser (we want to force another prompt for ID, and closing the browser clears the security token).

• Start Firefox and enter the following URL https://wg31.washington.ibm.com:9443/zosConnect/apis.

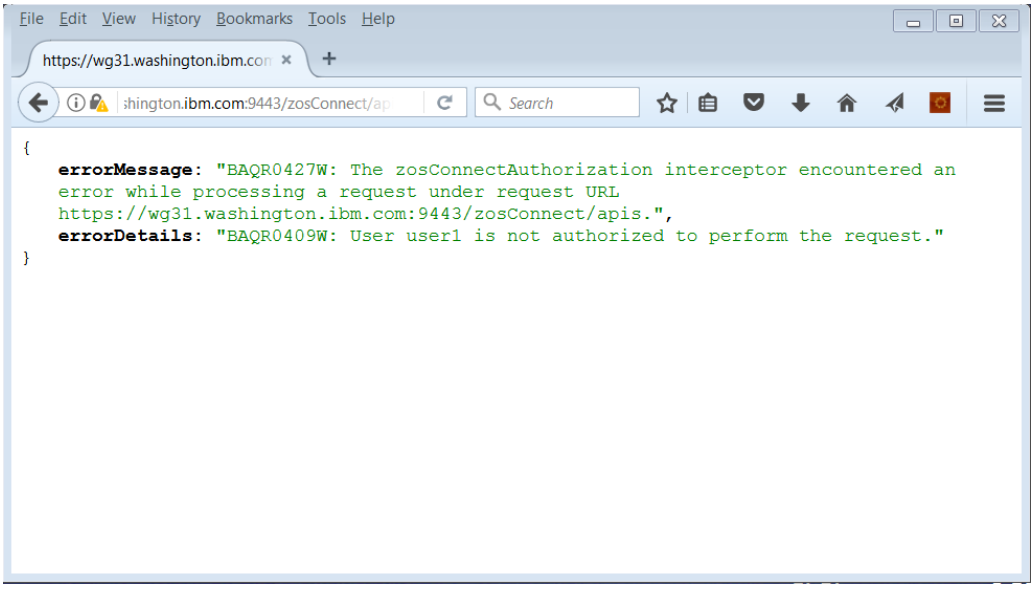
• On the *Authentication Required* popup window enter, enter ***Fred*** and ***FRED***. You should see:



FRED in in the administrator's group and has the authority perform this function.

• Close Firefox session to clear the security token and restart and access the same URL.

• On the *Authentication Required* popup enter ***USER1*** and USER1's password of USER1. You should see:



Next try to invoke an API.
Enter the command below at a command prompt and press **Enter**.

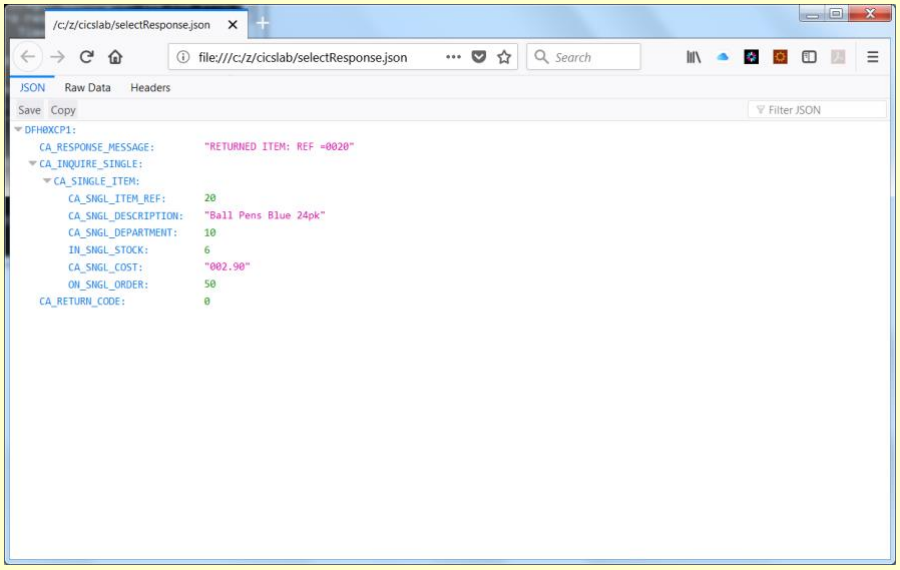
curl -X POST --user USER1:USER1 --header "Content-Type: application/json"
-d @inquireSingle.json --insecure
https://wg31.washington.ibm.com:9443/zosConnect/services/inquireSingle?action=invoke

- You should see the response below:


```
{"DFH0XCP1":{"CA_RESPONSE_MESSAGE":"RETURNED ITEM: REF =0020","CA_INQUIRE_SINGLE
":{"CA_SINGLE_ITEM":{"CA_SNGL_ITEM_REF":20,"CA_SNGL_DESCRIPTION":"Ball Pens Blue
 24pk","CA_SNGL_DEPARTMENT":10,"IN_SNGL_STOCK":6,"CA_SNGL_COST":"002.90","ON_SNG
L_ORDER":50}},"CA_RETURN_CODE":0}}
```


USER1 can invoke the service but has no administrative authority.

Tech Tip: Adding the *-o* flag to the cURL command will write the JSON response message to a file rather than back to the terminal session. So if you add ***-o selectResponse.json*** to the cURL command and use the command ***firefox file:///c:\z\cicslab\selectResponse.json*** you will see a browser session open with the JSON response formatted as below:



- To demonstrate an operational function, paste the command below at the command prompt and press **Enter**.

curl -X PUT --user USER1:USER1 --insecure
https://wg31.washington.ibm.com:9443/zosConnect/services/inquireSingle?status=stopped

• You should see the response below:

```
{"errorMessage":"BAQR0406W: The zosConnectAuthorization interceptor encountered
an error while processing a request for service under request URL https://wg31.
washington.ibm.com:9443/zosConnect/services/inquireSingle.","errorDetails":"BAQR
0409W: User USER1 is not authorized to perform the request."}
```

USER1 can invoke the service but has no administrative authority.

Using RACF for TLS and trust/key store management

Authentication as configured now requires a user identity and password. Providing an identity and password is not always feasible and that case digital certificates can be used for authentication. This section shows the steps required to add support for digital certificates to the z/OS Connect server (Liberty). In this section the steps required to enable authentication to a system authorization facility (SAF), e.g. RACF will be shown. For more details on this topic, see the exercise ***zCEE Customization Basic Security*** which can be found at URL https://tinyurl.com/37nvdhn5.

• First, defined some basic SAF resources, e.g. RACF digital certificates, see example job ***ZCEETLSS.jcl*** which accompanies this document.

```
RACDCERT CERTAUTH GENCERT SUBJECTSDN(CN('CA for Liberty') -                    1
  OU('LIBERTY')) WITHLABEL('Liberty CA') TRUST -
  SIZE(2048) NOTAFTER(DATE(2022/12/31))
RACDCERT CERTAUTH EXPORT(LABEL('Liberty CA')) -                               2
  DSN('USER1.CERTAUTH.CRT') FORMAT(CERTDER)
RACDCERT ID(LIBSERV) GENCERT SUBJECTSDN(CN('wg31.washington.ibm.com') -       3
  O('IBM') OU('LIBERTY')) WITHLABEL('Liberty Client Cert') -
  SIGNWITH(CERTAUTH LABEL('Liberty CA')) SIZE(2048) -
  NOTAFTER(DATE(2022/12/31))
RACDCERT ID(LIBSERV) ADDRING(Liberty.KeyRing)                                 4
RACDCERT ID(LIBSERV) CONNECT(ID(LIBSERV) -
  LABEL('Liberty Client Cert') RING(Liberty.KeyRing)DEFAULT)                  5
RACDCERT ID(LIBSERV) CONNECT(CERTAUTH LABEL('Liberty CA') -                   6
  RING(Liberty.KeyRing))
PERMIT IRR.DIGTCERT.LISTRING -                                                7
  CLASS(FACILITY) ID(LIBSERV) ACCESS(READ)
PERMIT IRR.DIGTCERT.LIST -
  CLASS(FACILITY) ID(LIBSERV) ACCESS(READ)                                    8
SETR RACLIST(FACILITY) REFRESH                                                9
```

Notes:

1. Generate a Liberty certificate authority (CA) certificate. This certificate will be used to sign and authenticate personal certificates.
2. The just create CA certificate will be exported from RACF and imported into trust stores for use by clients on other platforms. This will allow the authentication of any personal certificate signed by the CA certificate when presented to the client on the other platforms.
3. Generate a personal certificate signed by the Liberty CA certificate. This will be the personal certificate provided by the Liberty server when it needs to provide a digital certificate during a TLS handshake.

4. Create a RACF key ring for managing certificates. This key ring will below to the RACF identity under which the z/OS Connect is running.
5. Connect or attach the z/OS Connect personal certificate to the z/OS Connect server's key ring.
6. Connect or attach the Liberty CA certificate to the z/OS Connect server's key ring.
7. Permit the z/OS Connect server access to its own key ring.
8. Permit the z/OS Connect server access to its own certificate.
9. Refresh the FACILITY class in storage profiles.

- Stop your server again with MVS command ***/P BAQSTRT***.

- Next, create and export additional personal certificates for use in authenticating other users.

```
RACDCERT ID(FRED) GENCERT SUBJECTSDN(CN('Fred D. Client') -   1
  O('IBM') OU('LIBERTY')) WITHLABEL('FRED') -
  SIGNWITH(CERTAUTH LABEL('Liberty CA')) SIZE(2048) -
  NOTAFTER(DATE(2022/12/31))
RACDCERT ID(FRED) EXPORT(LABEL('FRED')) -             2
  DSN('USER1.FRED.P12') FORMAT(PKCS12DER) -
  PASSWORD('secret')
RACDCERT ID(FRED) EXPORT(LABEL('FRED')) -          3
  DSN('USER1.FRED.PEM') -
  PASSWORD('secret')
RACDCERT ID(USER1) GENCERT SUBJECTSDN(CN('USER1 D. Client') -   4
  O('IBM') OU('LIBERTY')) WITHLABEL('USER1') -
  SIGNWITH(CERTAUTH LABEL('Liberty CA')) SIZE(2048) -
  NOTAFTER(DATE(2022/12/31))
RACDCERT ID(USER1) EXPORT(LABEL('USER1')) -     5
  DSN('USER1.USER1.P12') FORMAT(PKCS12DER) -
  PASSWORD('secret')
RACDCERT ID(USER1) EXPORT(LABEL('USER1')) -    6
  DSN('USER1.USER1.PEM') -
  PASSWORD('secret')
SETR RACLIST(DIGTCERT DIGTRING) REFRESH     7
```

1. Generate a personal certificate for identity FRED signed with the Liberty CA certificate.
2. Export FRED's personal certificate encrypted and protected with a password.
3. Export FRED's personal certificate in PEM format (universal format).
4. Generate a personal certificate for identity USER1 signed with the Liberty CA certificate.
5. Export USER1's personal certificate encrypted and protected with a password.
6. Export USER2's personal certificate in PEM format (universal format).
7. Refresh the digital certificate and key ring in in storage profiles.

Tech-Tip: The personal certificates are being exported so they can be moved to other platforms. On the other platforms they will be used by various clients as means to identify themselves to the z/OS Connect server.

• Update the z/OS Connect server's *server.xml* by adding a new feature (*transportSecurity*) to the existing *featureManager* list and SSL related configuration elements, see below:

```
 <featureManager>
    <feature>transportSecurity-1.0</feature>      1
</featureManager>

 <sslDefault sslRef="DefaultSSLSettings" />    2
 <ssl id="DefaultSSLSettings"
    keyStoreRef="CellDefaultKeyStore"
    trustStoreRef="CellDefaultKeyStore" />
 <keyStore id="CellDefaultKeyStore"            3
    location="safkeyring:///Liberty.KeyRing"
    password="password" type="JCERACFKS"
    fileBased="false" readOnly="true" />
```

Notes

- *transportSecurity-1.0* feature enables TLS support
- The use of DefaultSSLSettings specifies the default *ssl* configuration element.
- The *keystore* element identity the RACF keyring containing the CA and personal certificates and replaces the previous non-SAF trust store.

Tech-Tip: The *password* attribute is required but is not used on z/OS. It still should be set to *password*. On z/OS the keyring is identified by the SAF user under which the task is executeing.

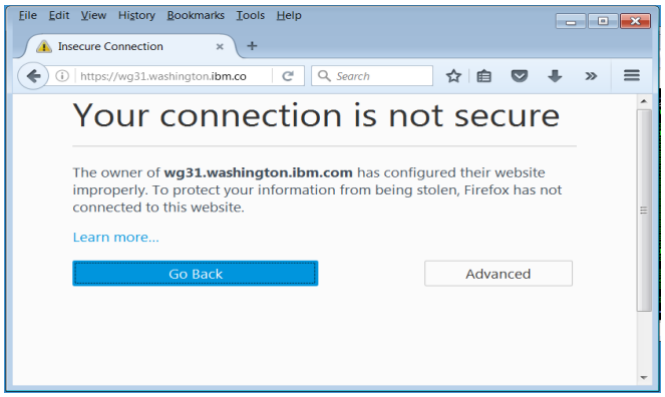
• Stop and restart the server.

• Close all instances of your Firefox browser[16].

• Start Firefox and issue the following URL:

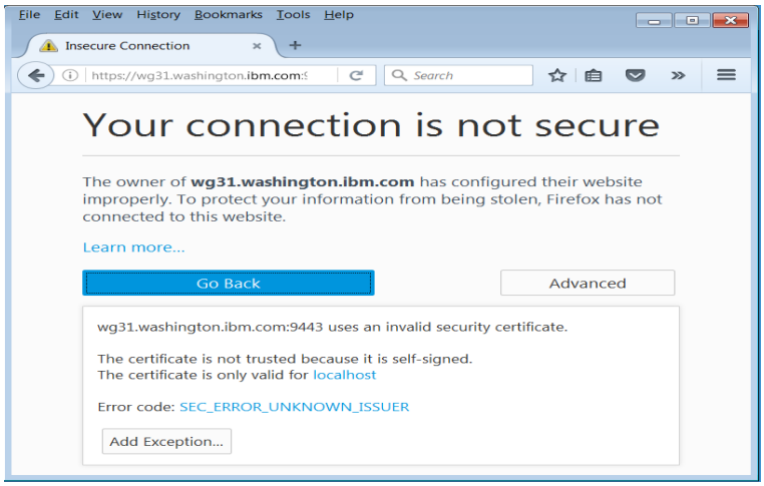
https://wg31.washington.ibm.com:9443/zosConnect/apis

A challenged by Firefox will be display because the digital certificate used by the Liberty z/OS server does not recognize RACF signed certificates. Click on the **Advanced** button to continue.

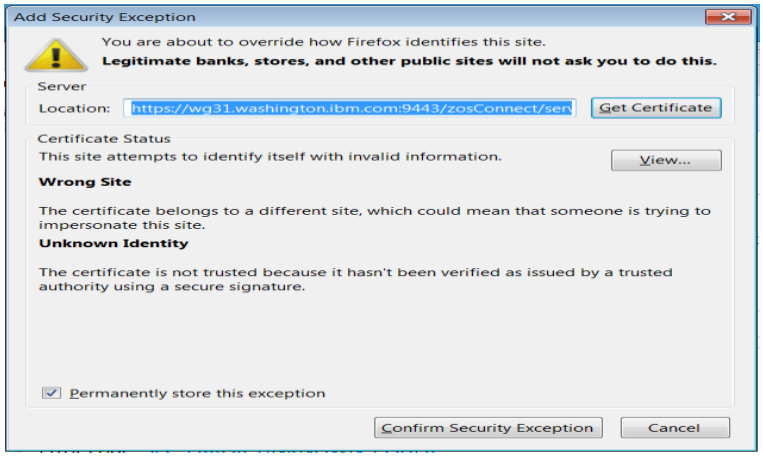


16 So, the certificate accepted earlier is cleared and you're forced to see the new SAF-created certificate.

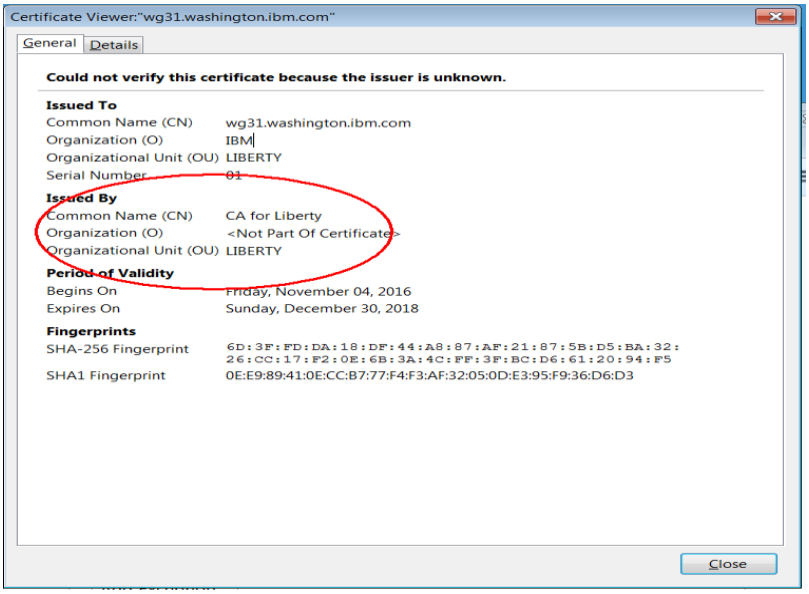
- Click the **Add Exception** button to continue.



- Click on the **View** button to display details about the certificate.



- This Certificate Authority (CA) that issued this certificate does not exist in the trust store used by Firefox. Click the **Close** button to continue.

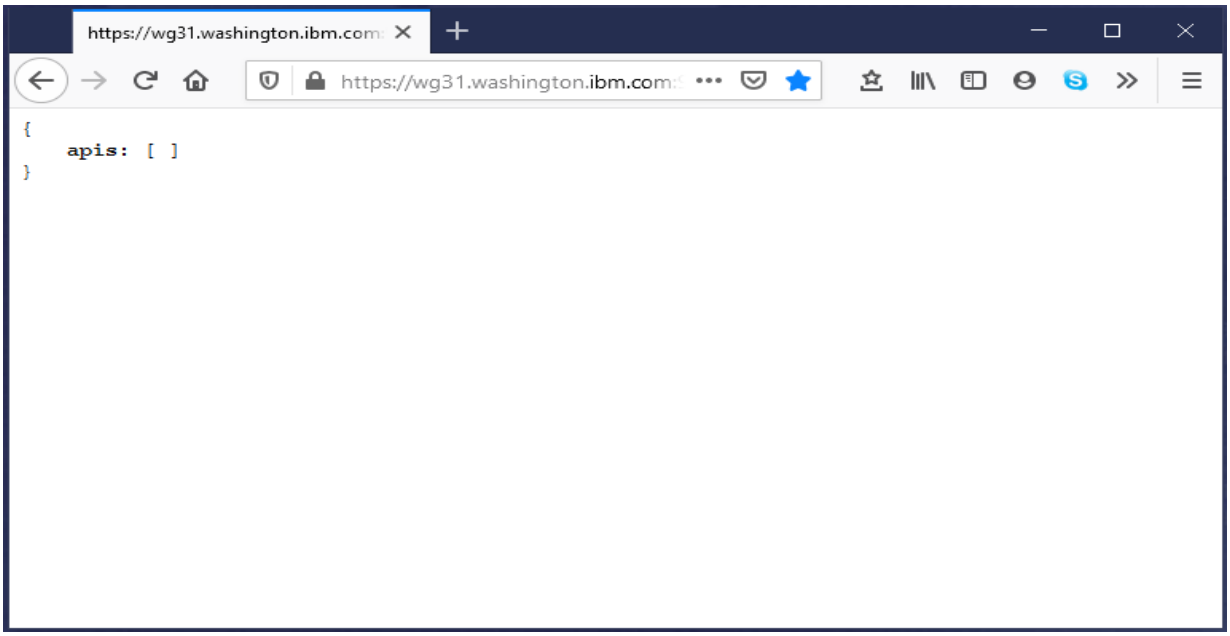


• Click on the **Confirm Security Exception** button.

• In the userid/password prompt window enter ***Fred*** and ***Fred***'s password.

RACF on the system used in this example does not support mixed case identities or passwords. So, all userid and password values are stored in upper-case. Anything entered in lowercase or mixed is folded to uppercase and compared against the RACF registry.

• You should see a familiar list of APIs:



For more examples of using mutual authentication see the exercise ***zCEE Customization Basic Security*** at URL https://tinyurl.com/37nvdhn5.

Summary

One more element of the security infrastructure was moved from the "basic" Liberty implementation down into SAF. In this case it was the certificates for the establishment of the encrypted link.
In the "real world" a known Certificate Authority (such as VeriSign) would be used to sign the server certificate. In that case the browser would trust the certificate based on the well-known CA and you would not get a challenge.

Using client certificates for authentication

Up until now the server has been sending its server certificate for the client to validate with its local copy of the CA certificate in its trust store. It is also possible to have the client send its personal certificate to the z/OS Connect for validation with the CA certificate connected to the server key ring. Once this client certificate has been validated the SAF identity associated with that certificate can be used for subsequent authorization checks. This section describes the steps to implement this exchange of certificates between the client and server which is also known as mutual authentication. The steps required to enable authentication to a system authorization facility (SAF), e.g. RACF will be shown. For more details on this topic, see the exercise ***zCEE Customization Basic Security*** which can be found at URL https://tinyurl.com/37nvdhn5.

- Stop the the z/OS Connect server.

- Update the default configuration element by adding the lines in bold below:

```
     <sslDefault sslRef="DefaultSSLSettings" />
    <ssl id="DefaultSSLSettings"
        keyStoreRef="CellDefaultKeyStore"
        trustStoreRef="CellDefaultTrustStore"
        clientAuthenticationSupport="true"       1
        clientAuthentication="true" />           2
```

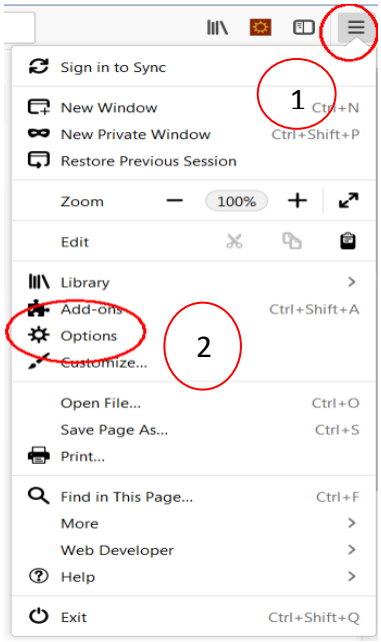
Notes

1. If set to *true* and the client presents a personal certificate it will be validated during the handshake process, e.g. mutual authentication is enabled.
2. Client authentication is required when set to *true.*

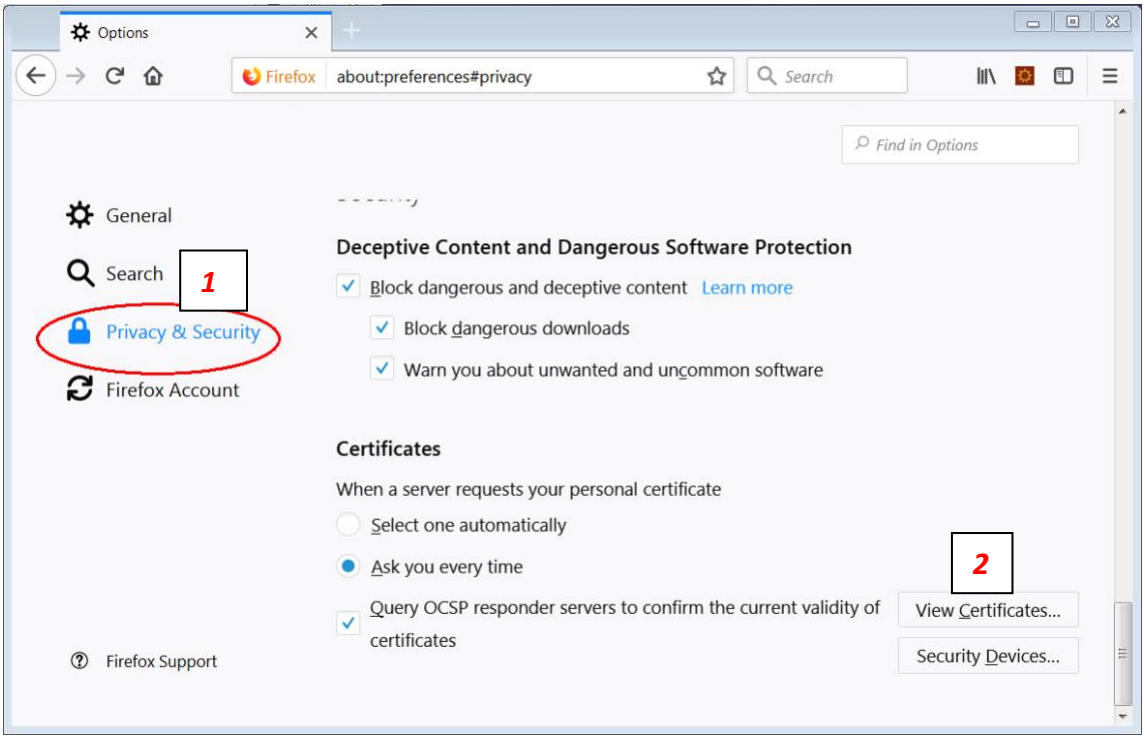
- Download the exported certificate authority and personal certificates to:
  - Certificates exported in PEM format should be downloaded in ASCII mode, e.g., *USER1. FRED.PEM.*
  - Certificates exported in PKCS12DER format should be download in Binary mode, e.g. *USER1.FRED.P12*.
  - Certificates exported in CERDER format should be downloaded, e.g., *USER1.CERTAUTH.CRT*.

With the certificates downloaded, the next step is to import them into a Firefox web browser. That's next. For other browsers, e.g., Chrome or Edge, use the *certmgr* command to import the certificates into the Windows trust store.

- In Firefox, click on the to the *Open Menu* (1) icon and select the *Options* (2) tool.



- Click on *Privacy & Security* (1) then scroll down to the *Certificates* (2) tab:

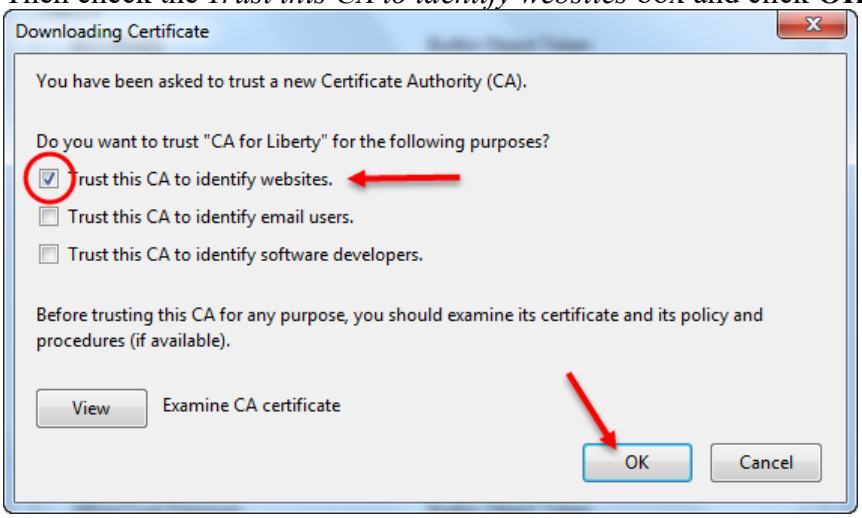


Then click the **View Certificates** button.

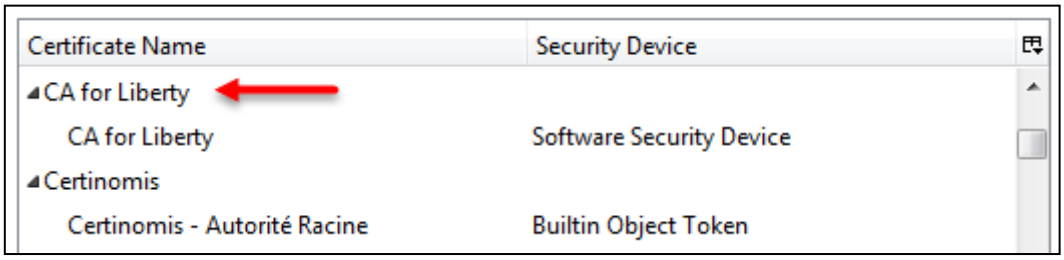
• Then click on the *Authorities* tab, and the **Import** button.

• Navigate to the directory to where the **certauth.crt** file was downloaded and double-click on the **certauth.crt** file.

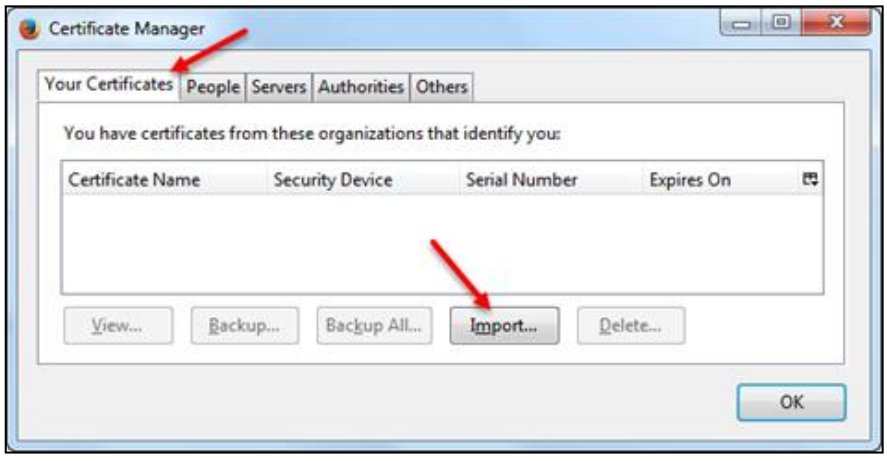
Then check the *Trust this CA to identify websites* box and click **OK:**



Verify the certificate has been imported by scrolling down and looking for the "CA for Liberty" certificate in the list:

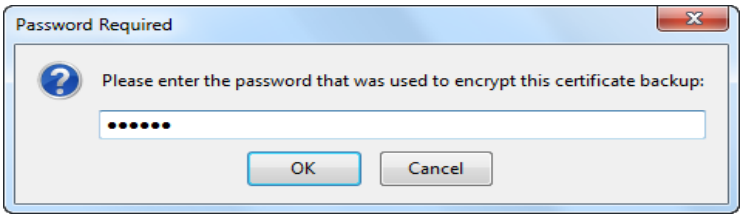


Next, click the *Your certificates tab* and then the **Import** button:



• It should open up at the same directory from before, but if not then navigate to that location. Locate the **fred.p12** certificate and double-click on it.

A window will appear asking you to enter the password for the certificate:



Enter the value[17] ***secret*** and click **OK**. You should see confirmation:

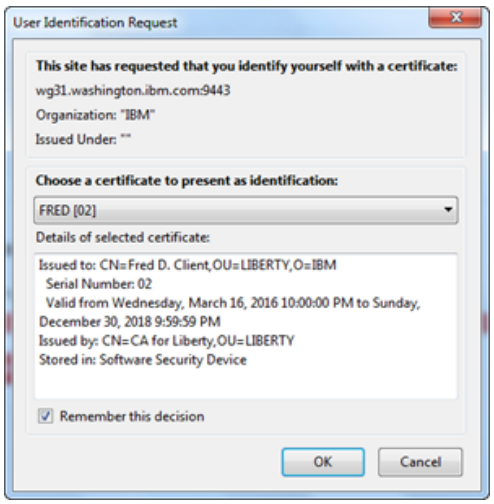
• Click **OK** to clear the confirmation, then

• **OK** to close the certificate manager panel, **OK** to close the options panel, and then close *all instances* of your Firefox browser.

• Restart your server.

• Start Firefox and go to URL ***https://wg31.washington.ibm.com:9443/zosConnect/apis***

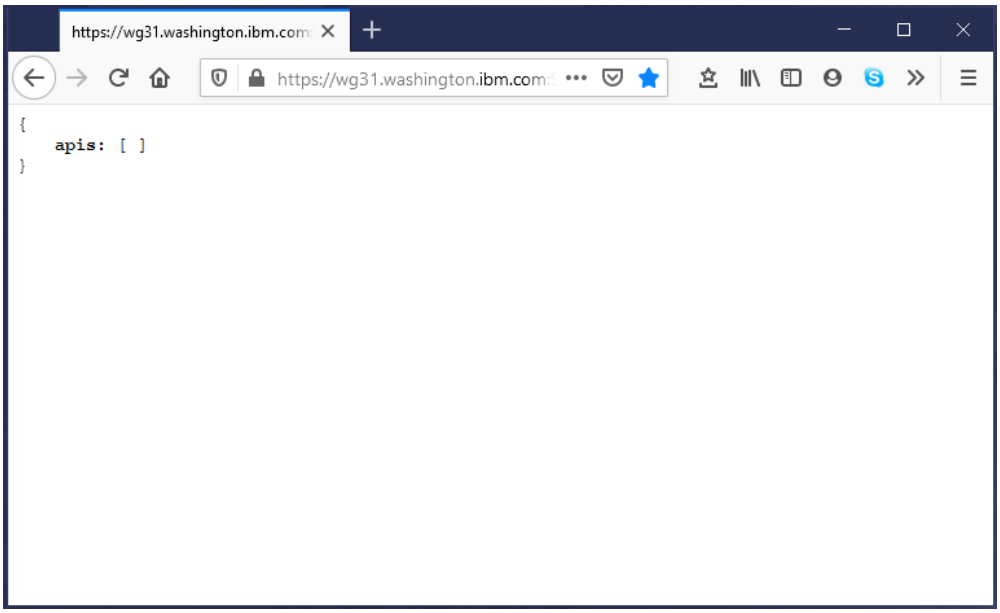
You will be prompted for which client certificate you wish to use:



• You only have one, and it's selected ... so click **OK**.

[17] The password specified when the certificate was exported.

• You should see the list of installed APIs:



• Assuming service *inquireSingle* was installed. Entering the command below at a command prompt and pressing **Enter**.

curl -X put --cacert certauth.pem --cert user1.p12:secret --cert-type P12 https://wg31.washington.ibm.com:9443/zosConnect/services/inquireSingle?action=start

• You should see the response below:

```
{"errorMessage":"BAQR0406W: The zosConnectAuthorization interceptor encountered
an error while processing a request for service inquireSingle under request URL
https://wg31.washington.ibm.com:9443/zosConnect/services/inquireSingle.","errorD
etails":"BAQR0409W: User USER1 is not authorized to perform the request."}
```

The USER1 identity is determined by the client certificate specified in user1.p12.

• Enter the command below at a command prompt and press **Enter**.

curl -X put --cacert certauth.pem --cert fred.p12:secret --cert-type P12 https://wg31.washington.ibm.com:9443/zosConnect/services/inquireSingle?action=start

- You should see the response below:


```
{"zosConnect":{"serviceName":"inquireSingle","serviceDescription":"","servicePro
vider":"CICS-1.0","serviceURL":"https://wg31.washington.ibm.com:9443/zosConnect/
services/inquireSingle","serviceInvokeURL":"https://wg31.washington.ibm.com:9443
/zosConnect/services/inquireSingle?action=invoke","dataXformProvider":"zosConnec
tWVXform-1.0","serviceStatus":"Started"}}
```


The FRED identity is determined by the client certificate specified in fred.p12 and FRED has administrator authority.

For more examples of using mutual authentication see the exercise ***zCEE Customization Basic Security*** at URL https://tinyurl.com/37nvdhn5.

RACF Certificate Mapping and Filtering

Rather than creating or maintaining digital certificates for every user we can create a mapping that can be used to associate a RACF identity with any valid digital certificates where the subject's distinguished name and/or the issuer's distinguished name matches a pattern or filter.

- Filters can be created with a RACDCERT command. Enter command RACDCERT ID MAP to create a filter that assigns RACF identity ATSUSER to any digital certificate signed with the ATS client signer certificate and where the subject is organizational unit ATS in organization IBM.

```
racdcert id(atsuser) map sdnfilter('OU=ATS.O=IBM') idnfilter('CN=ATS Client
CA.OU=ATS.O=IBM')withlabel('ATS USERS')
```

- Enter command RACDCERT ID MAP to create a filter that assigns RACF identity OTHUSER to any digital certificate signed by the ATS client signer certificate and where the subject is in organization IBM.

```
racdcert id(othuser) map sdnfilter('O=IBM') idnfilter('CN=ATS Client
CA.OU=ATS.O=IBM') withlabel('IBM USERS')
```

Tech-Tip: The commands in these examples were entered in mixed case in order to emphasize the case sensitivity of the filter values and labels in these commands. The values for the common name (CN), organizational unit (OU) and organization(O) in the subject's and issuer's distinguished name filters (sdnfilter and idnfilter) must match the value and case specified in the original certificate request. Using "o=ibm" in the generate key request will not match a filter or map created with 'O=IBM' in sdnfilter.

- Enter command SETROPTS to refresh the storage profiles for the digital certificate's maps.

```
      setropts raclist(digtnmap) refresh
```

Now any valid client certificate presented to the z/OS Connect server issued by a CA named CN=ATS Client CA.OU=ATS.O=IBM with a subject of OU=ATS.O=IBM will use identity ATSUSER for any authorization checks. Other valid client certificated presented to the z/OS Connect server issued by the same CA but with a subject of O=IBM (OU is value other than ATS) will use OTHUSER for any subsequent authorization checks

Summary

In the web browser you were prompted for a client certificate (because of an option that defaulted when you imported the client certificate). z/OS Connect used that client certificate and mapped it to the SAF ID of FRED. That's what allowed you to invoke the *zosConnect/services* API and get the list of services. In the cURL example the client certificate specified by the *–cert* flag determined which identity was used for authorization checking in z/OS Connect EE because *clientAuthenication* was enabled.

CICS Identity propagation

To enable the propagation of the authenticated identity onto CICS for CICS authorization checks, perform the following steps. Use your own values for NetworkID, APPLID. In this section the steps required to enable authentication to a System Authorization Facility (SAF), e.g., RACF will be shown. For more details on this topic, see the zCEE ***Customization CICS Security*** which can be found at URL https://tinyurl.com/4bytp74z.

- Activate the SAF IDIDMAP class, e.g., ***SETROPTS CLASSACT(IDIDMAP)***

- Define a mapping from the distributed identity to a local SAF identity, e.g.

racmap id(fred) map userdidfilter(name('Fred')) registry(name('zosConnect')) withlabel('fred')

- Refresh the IDIDMAP in store profiles, e.g., ***setropts raclist(ididmap) refresh.***

- Add *zosConnectNetworkid* and *zosConnectApplid* elements to a *zosconnect_cicsIpicConnection* configuration element.

```
<zosconnect_cicsIpicConnection id="cscvinc"
   host="wg31.washington.ibm.com"
   zosConnectNetworkid="ZOSCONN"  1
   zosConnectApplid="ZOSCONN"     2
   port="1491"/>
```

Notes:
1. The value of zosConnectNetworkid must match the value of the *NETWORKID* of the IPCONN CICS resource
2. The value of zosConnectApplid must match the value of the *APPLID* of the IPCONN CICS resource

- Define a CICS IPCONN resources using these attributes:

```
DEFINE IPCONN(ZOSCONN) GROUP(SYSPGRP)
    APPLID(ZOSCONN)  1
    NETWORKID(ZOSCONN)           2
    TCPIPSERVICE(ZOSCONN)  3
    LINKAUTH(SECUSER)
    USERAUTH(IDENTIFY)
    IDPROP(REQUIRED)
```

Notes:
1. The value of *NETWORKID* must match the value of the *zosConnectNetworkid* of the *zosconnect_cicsIpicConnection* element.
2. The value of *APPLID* must match the value of the zosConnectApplid of the *zosconnect_cicsIpicConnection* element.
3. The value of TCPIPSERVICE must match the name of the CICS TCPIPService that defines the port that corresponds to the port configured in the *zosconnect_cicsIpicConnection* element.

- Define CICS TCPIPService specifying a URM value of NO.

- The CICS region must have security enabled *(SEC=YES),* TCP/IP enabled *(TCPIP=YES)* and intersystem communication enabled (*ISC=YES*).

Tech Tip: There will be at least one security check performed when CICS starts the mirror transaction. The security check will be for *READ* access to either transaction code *CSMI* (the CICS default mirror transaction) or the value of the transaction code specified in service's configuration for the *Transaction ID* attribute when the *Transaction ID Usage* attribute is set to *EIB_AND MIRROR*

A SAF check will be performed with the identity propagated from z/OS Connect. But before this check, another SAF check may be performed using a *link identity*. The *link identity* is determined as follows. For an SSL connection, e.g., *LINKAUTH(CERTUSER),* the *link identity* will be the local SAF identity mapped to the client certificate. For a non-SSL connection, e.g., *LINKAUTH(SECUSER),* the *link identity* will be the value provided in the *SECURITYNAME* IPCONN attribute. If no value is provided in this attribute, the CICS default user identity will be used for the *link identity*.

If the *link identity* matches the SAF identity under which the CICS region is running, only the propagated identity is used for a SAF check for access to the mirror transaction. If the *link identity* does not match the SAF identity of the CICS region then a SAF check is also performed for the *link identity's* access to the mirror transaction.

Review the CICS documentation regarding the *IDprop* attribute. Behavior of this attribute depends on whether the zCEE server and the CICS region are in the same Sysplex or not

RACF PassTickets

An alternative to providing a RACF password when using basic authentication is to use an authentication token called a PassTicket. When enabled for an application or subsystem, a client using basic authentication can send a PassTicket token to that application or subsystems instead of a password. See *How RACF processes the PassTicket* at URL https://www.ibm.com/docs/en/zos/3.1.0?topic=guide-using-passtickets for a detailed description of how security credentials are created and protected by a secret sign-on key and time stamps when using PassTickets.

In short, a PassTicket is generated by or for a client by using a secure sign-on key to encrypt a valid RACF identity combined with the *application name* of the targeted resource. Also embedded in the PassTicket is a time stamp (based on the current Universal Coordinated Time (UCT)) which sets the time when the PassTicket will expire (usually 10 minutes).

On z/OS, PassTickets are created and managed using the RACF PTKTDATA class. If not already active, this class can be activated with SETROPTS commands

SETROPTS CLASSACT(PTKTDATA) RACLIST(PTKTDATA)
SETROPTS GENERIC(PTKTDATA)

For z/OS Connect, a RACF PassTicket can be used for basic authentication when connecting from a client to a z/OS Connect Liberty server and also for a subset of requests from a z/OS Connect server to z/OS resources.

REST client PassTickets

REST clients generally do not have access to z/OS RACF facilities for generating a RACF PassTicket. A REST client on a non z/OS platform can still use PassTickets, but there must be some other mechanism used to generate the PassTicket.
The algorithm for the generation of PassTickets has been published in IBM manual *z/OS Security Server RACF Macros and Interfaces, SA23-2288-40.* There are several repositories on GitHub with examples of generating PassTickets using this algorithm. The key is the non-z/OS generation of a PassTicket must use the same secure sign-on key as configured in the RACF PTKTDATA resource for the application name of the targeted resource. For examples of these non-z/OS solutions, see https://github.com/chrrel/racf-passticket-generator and/or https://github.com/topics/passticket.

Using the example at https://github.com/chrrel/racf-passticket-generator as a test, we generated a PassTicket in an Eclipse environment for identity *FRED* using *BBGZDFLT* for the application name and *1234567890ABCDEF0* for the sign-on key. These values were derived from the following sources.

- The application name, *BBGZDFLT*, was the value of the *profilePrefix* attribute in the *safCredentials* configuration element.

```
<safCredentials unauthenticatedUser="WSGUEST"
   profilePrefix="BBGZDFLT" />
```

- The secure sign on key, *1234567890ABCDEF0,* matched the value specified for the SSIGNON attribute when the BBGZDFLT PTKTDATA resource was defined.

```
RDEFINE PTKTDATA BBGZDFLT SSIGNON(KEYMASK(123456789ABCDEF0))
```

In the test, the generated PassTicket, ***RQELV4J5***, was provided in a *cURL* command as the password attribute in the *--user* parameter, e.g.

```
curl -X get --user FRED:RQELV4J5 -insecure
https://wg31.washington.ibm.com:9443/cscvinc/employee/000100
{"cscvincSelectServiceOperationResponse":{"Container1":{"RESPONSE_
CONTAINER":{"CEIBRESP2":0,"fileArea":{"date":"26 11 81",
"employeeName":"S. D. BORMAN", "amount":"$0100.11",
"address":"SURREY,ENGLAND","phone":"32156778",
"employeeNumber":"000100"},"userIdentity":"FRED","CEIBRESP":0}}}}
```

As shown above, the PassTicket was accepted and enabled the execution of the API. Repeating this request a few minutes later failed with a HTTP 401. The PassTicket had expired. This same technique can be used any time basic authentication is used to authenticate to a z/OS Connect server.

API Requester client PassTickets

API requester applications running in MVS or IMS batch do have access to RACF facilities for the generation of a PassTicket. These COBOL applications can directly invoke RACF pass ticket service IRRSPK00 to have a pass ticket generated.

Click the link below to discover more around *API requester PassTicket Authentication to IBM z/OS Connect(OpenAPI 3)*: https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=options-passticket-authentication-zos-connect

For example, a COBOL program was developed by the Washington System Center to wrap the call to IRRSPK00. This wrapper program could then be used by an API requester program. When the COBOL wrapper program is called it obtains the RACF identity to be used in the PassTicket from environment variable *BAQUSERNAME*. The value for the APPL attribute was derived from a new environment variable named *ATSAPPL*. The identity and APPL values are parameters in call to RACF service routine IRRSPK00. IRRSPK00 generates a pass ticket and returns it to the wrapper program which passes it on to the communication stub using environment variable *BAQPASSWORD.*

If interested in seeing the actual wrapper COBOL code and compile and link edit JCL, send an email to mitchj@us.ibm.com or emitchj@gmail.com.

The following considerations were required for the new *ATSAPPL* environment variable.

• The application value for environment variable *ATSAPPL*, e.g., *BBGZDFLT*, must match the value of the *profilePrefix* attribute in the *safCredentials* configuration element.

```
<safCredentials unauthenticatedUser="WSGUEST"
   profilePrefix="BBGZDFLT" />
```

• There must also be a PTKTDATA resource defined for this same APPL

```
RDEFINE PTKTDATA BBGZDFLT SSIGNON(KEYMASK(123456789ABCDEF0))
```

• Finally, there must be PTKTDATA resource with name IRRPTAUTH.***applid.identity*** where ***applid*** which should match the *profilePrefix in* the server server.xml file and the value of ***identity*** corresponds to the SAF identity under which the job is executing. The RACF identity under which the job executes requires *UPDATE* access to this PTKTDATA resource. For examples, the commands below were used.

```
/* To define a discrete PTKTDATA resource
RDEFINE PTKTDATA IRRPTAUTH.BBGZDFLT.USER1 UACC(NONE)
PERMIT IRRPTAUTH.BBGZDFLT.USER1 ID(USER1) ACCESS(UPDATE)
SETROPTS RACLIST(PTKTDATA) REFRESH
/* To define a generic PTKTDATA resource
RDEFINE PTKTDATA IRRPTAUTH.BBGZDFLT.* UACC(NONE)
PERMIT IRRPTAUTH.BBGZDFLT.* ID(LIBSERV,USER1) +
        CLASS(PTKTDATA) ACCESS(UPDATE)
SETROPTS RACLIST(PTKTDATA) REFRESH
```

The COBOL API requester was modifed as follows to call the wrapper program.

```
         WORKING-STORAGE SECTION.
          77 PTKT-STUB-PGM-NAME PIC X(8) VALUE 'ATSPTKTC'.

         MAINLINE SECTION.
          CALL PTKT-STUB-PGM-NAME.
```

The JCL to invoke the API requester was the modified as shown below to add the ATSAPPL environment variable.

```
//GETAPI  EXEC PGM=GETAPIPT,PARM='111111'
//STEPLIB  DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB  1
//         DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//SYSOUT   DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//CEEOPTS  DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9080",
 "BAQUSERNAME=USER1",
 "ATSAPPL=BBGZDFLT")  2
```

Notes:

1. The COBOL Java wrapper is loaded from USER1.ZCEE.LOADLIB at execution time.

2. Environment variable *ATSAPPL* provides the application value used to generate the PassTicket
During testing it was observed that if the exception below was generated, it meant that either the above required PTKTDATA resources were not defined or the user did have sufficient access to the resource.

```
SAF_return_code:      00000008
RACF_return_code:     00000008
RACF_reason_code:     00000016
```

For an explanation of these return and reason codes, see URL
https://www.ibm.com/docs/en/zos/3.1.0?topic=extract-return-reason-codes

IMS TM PassTickets

z/OS Connect service level V3.0.33 added support for the use of PassTickets between a z/OS Connect server and IMS Connect. This required some additional RACF resources which will be documented in this section.

There is additional information around *Configuring PassTicket support for IMS Services (OpenAPI 2)* at the link provided: https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=server-configuring-passticket-support-ims-services

Configuring PassTicket support for an IMS z/OS Asset (OpenAPI 3):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=connections-configuring-passticket-support-ims-zos-asset

- PTKTDATA resources were defined for the target IMS Connect:

RDEFINE PTKTDATA IMSAPPL SSIGNON(KEYMASK(123456789ABCDEF0)) +
APPLDATA('NO REPLAY PROTECTION'*)*

Tech-Tip: The value IMSAPPL was derived from the APPL name in the IMS Connect DRDAPORT definition, e.g.

DATASTORE=(GROUP=OTMAGRP,ID=IVP1,MEMBER=HWSMEM,DRU=HWSYDRU0,
TMEMBER=OTMAMEM,**APPL=IMSAPPL**)

The value for the key mask was an arbitrary 16 hexadecimal string. If multiple RACF databases are involved this value must be the same for all.

- The identity under which the z/OS Connect server is running was given authorization to generate pass tickets for this specific PTKTDATA resource:

RDEFINE PTKTDATA IRRPTAUTH.IMSAPPL.* UACC(NONE)
PERMIT IRRPTAUTH.IMSAPPL.* ID(LIBSERV) CLASS(PTKTDATA)
ACC(UPDATE)

- The RACF in storage profile need were updated:

SETROPTS RACLIST(PTKTDATA) REFRESH)

- The *ims-connections* configuration file needs to be updated by adding an *applicationName* attribute to properties.gmoa with a value that matches the APPL name configured in IMS Connect.

```
<server>
<imsmobile_imsConnection comment="" connectionFactoryRef="IVP1"
id="IMSCONN"/>
<connectionFactory id="IVP1">
<properties.gmoa hostName="wg31.washington.ibm.com" portNumber="4000"
  applicationName="IMSAPPL" />
</connectionFactory>
</server>
```

IMS DB PassTickets

z/OS Connect service level V3.0.33 added support for the use of PassTickets between a z/OS Connect server and IMS Connect. This required some additional RACF resources which will be documented in this section.

Configuring PassTicket support for IMS database services (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=provider-configuring-passticket-support-ims-database-services

Configuring PassTicket support for an IMS z/OS Asset (OpenAPI3):
https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=connections-configuring-passticket-support-ims-zos-asset

- PTKTDATA resources were defined for the target IMS Connect:

RDEFINE PTKTDATA IMSAPPL SSIGNON(KEYMASK(123456789ABCDEF0)) +
APPLDATA('NO REPLAY PROTECTION'*)*

Tech-Tip: The value IMSAPPL was derived from the APPL name in the IMS Connect DRDAPORT definition, e.g.

ODACCESS=(ODBMAUTOCONN=Y,IMSPLEX=(MEMBER=IMS15HWS,TMEMBER=PLEX1),
DRDAPORT=(ID=5555,PORTTMOT=6000),ODBMTMOT=6000,**APPL=IMSAPPL**)

The value for the key mask was an arbitrary 16 hexadecimal string. If multiple RACF databases are involved this value must be the same for all.

- The identity under which the z/OS Connect server is running was given authorization to generate pass tickets for this specific PTKTDATA resource:

RDEFINE PTKTDATA IRRPTAUTH.IMSAPPL.* UACC(NONE)
PERMIT IRRPTAUTH.IMSAPPL.* ID(LIBSERV) CLASS(PTKTDATA)
ACC(UPDATE)

- The RACF in storage profile need were updated:

SETROPTS RACLIST(PTKTDATA) REFRESH)

- The server's xml *properties.imsudbJLocal* element in the *connectionFactory* element was updated to add attribute *applicationName* with a value that match the APPL name defined in IMS Connect.

```
<connectionFactory id="DFSIVPAConn">
<properties.imsudbJLocal
   databaseName="DFSIVPA"
   datastoreName="IVP1"
   datastoreServer="wg31.washington.ibm.com"
   driverType="4"
   portNumber="5555"
   applicationName="IMSAPPL"
   flattenTables="True"/>
</connectionFactory>
```

Db2 PassTickets

z/OS Connect service level V3.0.15 added support for the use of PassTickets between a z/OS Connect server and Db2. This required some additional RACF resources which will be documented in this section which require knowledge of the application name (*applName*). The value of the *applName* can be the VTAM LU name of a single Db2 instance. Or in the case a Db2 data sharing group, the *applName* is the generic LU name shared by members of the data sharing group. If LU names are not being used, the *applName* is the value of the IPNAME of Db2 instances as defined by the Db2 administrator.

Refer to the IBM Documentation for additional information around *Configuring Db2 connection with PassTicket authentication (OpenAPI 3)*: https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=db2-configuring-connection-passticket-authentication

Configuring PassTicket support for Db2 services (OpenAPI 2): https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=db2-configuring-passticket-support-services

The value of *applName* can be determined by using the Db2 ***DISPLAY DDF*** commands. Below is an example of the output from a DISPLAY DDF command which shows LU names.

```
DSNL080I  -DSN2 DSNLTDDF DISPLAY DDF REPORT FOLLOWS:
DSNL081I STATUS=STARTD
DSNL082I LOCATION           LUNAME            GENERICLU
DSNL083I DSN2LOC            USIBMWZ.DSN2APPL  USIBMWZ.DSN0APPL
DSNL084I TCPPORT=2446  SECPORT=2445  RESPORT=2447  IPNAME=-NONE
DSNL085I IPADDR=::192.168.17.201
DSNL086I SQL    DOMAIN=WG31.WASHINGTON.IBM.COM
DSNL105I CURRENT DDF OPTIONS ARE:
DSNL106I PKGREL = COMMIT
DSNL106I SESSIDLE = 001440
DSNL099I DSNLTDDF DISPLAY DDF REPORT COMPLETE
```

And an example of the output when an IPNAME has been assigned.

```
DSNL080I  -DSNC DSNLTDDF DISPLAY DDF REPORT FOLLOWS:
DSNL081I STATUS=STARTD
DSNL082I LOCATION           LUNAME            GENERICLU
DSNL083I DSN2LOC            -NONE             -NONE
DSNL084I TCPPORT=2446  SECPORT=2445  RESPORT=2447  IPNAME=DB2IPNM
DSNL085I IPADDR=::192.168.17.252
DSNL086I SQL    DOMAIN=WG31.WASHINGTON.IBM.COM
DSNL086I RESYNC DOMAIN=WG31.WASHINGTON.IBM.COM
DSNL089I MEMBER IPADDR=::192.168.17.252
DSNL105I CURRENT DDF OPTIONS ARE:
DSNL106I PKGREL = COMMIT
DSNL106I SESSIDLE = 001440
DSNL099I DSNLTDDF DISPLAY DDF REPORT COMPLETE
```

Which value should be used for applName is determine for use in RACF resources is determine as shown below.

- If GENERICLU is defined, use the second part of GENERICLU for *applName*, e.g., ***DSN0APPL***
- If GENERICLU is not defined, use the second part of LUNAME for *applName*, e.g., ***DSN2APPL***
- If neither GENERICLU nor LUNAME is defined, use the value of the IPNAME for *applName,* e.g. ***DB2IPNM***

Using ***DSN2APPL*** as an example, these are the required RACF commands.

- Define PTKTDATA resource using the applName for the target Db2 subsystem:

  RDEFINE PTKTDATA DSN2APPL SSIGNON(KEYMASK(123456789ABCDEF0))
  APPLDATA('NO REPLAY PROTECTION')

- The identity under which the z/OS Connect server is running was given authorization to generate pass tickets for this specific PTKTDATA resource:

  RDEFINE PTKTDATA IRRPTAUTH.DSN2APPL.* UACC(NONE)

  PERMIT IRRPTAUTH.DSN2APPL.* ID(LIBSERV) CLASS(PTKTDATA)
  ACCESS(UPDATE)

- The RACF in storage profile need were updated:

  SETROPTS RACLIST(PTKTDATA) REFRESH)

The server's xml *zosconnect_zosConnectServiceRestClientBasicAuth* for the connection to the Db2 subsystem to use *applName* attribute rather than the *userName* and *password* attributes.

```
<zosconnect_zosConnectServiceRestClientConnection id="db2Conn"
       host="wg31.washington.ibm.com"
       port="2446"
       basicAuthRef="dsn2Auth" />

 <zosconnect_zosConnectServiceRestClientBasicAuth id="dsn2Auth"
       applName="DSN2APPL"/>
```

Db2 REST services security

This section covers a few topics related to Db2 REST services security.

- SAF class DSNR

  Access to Db2 REST services requires READ access to the Db2 subsystem DSNR resource. If a request for Db2 REST services fails to Db2 subsystem DSN2 with this message:

```
ICH408I USER(USER2   ) GROUP(SYS1    ) NAME(WORKSHOP USER2
  DSN2.REST CL(DSNR    )
  INSUFFICIENT ACCESS AUTHORITY
  ACCESS INTENT(READ   )  ACCESS ALLOWED(NONE   )
DSNL030I  -DSN2 DSNLJTIN.S30 DDF PROCESSING FAILURE
```

  Simply permit READ access to this resource to the identity in question, e.g.

  PERMIT DSN2.REST CLASS(DSNR) ID(USER2) ACC(READ)

  SETROPTS RACLIST(DSNR) REFRESH

- Db2 package access

  If a user is not able to display a valid Db2 REST services in the z/OS Connect Db2 services development tooling or by using a **POST** to the Db2 provided REST interface URL of http://wg31.washington.ibm.com:2446/services/DB2ServiceDiscover, then they may not have sufficient access to the package containing the service.

  For example, if service *zCEEService.selectEmployee* is defined to Db2 but not visible in the z/OS Connect tooling or if a **GET** request to URL

  http://wg31.washington.ibm.com:2446/services/zCEEService/selectEmployee fails with message:

```
{
    "StatusCode": 500,
    "StatusDescription": "Service zCEEService.selectEmployee discovery failed due to
SQLCODE=-551 SQLSTATE=42501, USER2 DOES NOT HAVE THE PRIVILEGE TO PERFORM OPERATION
EXECUTE PACKAGE ON OBJECT zCEEService.selectEmployee. Error Location:DSNLJACC:35"
}
```

The user needs to be granted execute authority on package *zCEEService.selectEmployee* with command:

GRANT EXECUTE ON PACKAGE "zCEEService"."selectEmployee" TO USER2 or

GRANT EXECUTE ON PACKAGE "zCEEService"."*" TO USER2

MQ services security

To assert an identity from z/OS Connect to MQ for subsequent MQ authorization is done using JMS property *useCallerPrincipal.* This property much be specified on a service level in a zosconnect_services configuration element (see below). When properly useCallerPrincipal is set to true the JMS provider in z/OS Connect with send the z/OS Connect authorization identity to MQ.

```
<zosconnect_services>
       <service name="mqPutService">
            <property name="useCallerPrincipal" value="true"/>
       </service>
 </zosconnect_services>
```

MQ TLS security

To enable TLS encryption and between a z/OS Connect server and a MQ queue manager the jmsConnectionFactory configuration element must specify a *transportType* of ***Client*** and a channel which has an SSL cipher enabled.

For example, the jmsConnectionFactory connects to queue manager ZMQ1 over the network using channel LIBERT.SSL.SVRCONN.

```
<jmsConnectionFactory id="qmgrCf" jndiName="jms/qmgrCf"
      connectionManagerRef="ConMgr1">
      <properties.wmqJMS transportType="CLIENT"
               queueManager="ZMQ1"
               channel="LIBERTY.SSL.SVRCONN"
               hostName="wg31.washington.ibm.com"
               sslcipherSuite="SSL_RSA_WITH_AES_256_CBC_SHA256"
               port="1422" />
</jmsConnectionFactory>
```

The *LIBERTY.SSL.SVRCONN* channel has been defined to the queue manger using these commands:

```
DEFINE CHANNEL ('LIBERTY.SSL.SVRCONN') REPLACE +
       CHLTYPE(SVRCONN) TRPTYPE(TCP)              +
       SSLCIPH('TLS_RSA_WITH_AES_256_CBC_SHA256')
SET CHLAUTH('LIBERTY.SSL.SVRCONN') ACTION(REPLACE) +
    TYPE(SSLPEERMAP) ADDRESS('*')  CHCKCLNT(ASQMGR) +
    SSLCERTI('CN=MQ CA,OU=ATS,O=IBM') SSLPEER('OU=ATS') USERSRC(CHANNEL)
```

The channel authentication record simply validates the certificate was issued by the specific certificate authority.

To relate the JSSE ciphers specified in the JMS connection factory to the corresponding IBM or Oracle JRE MQ Cipher Suite names use this URL

https://www.ibm.com/docs/en/ibm-mq/9.4?topic=java-tls-cipherspecs-ciphersuites-in-mq-classes

Table 1. CipherSpecs supported by IBM MQ and their equivalent CipherSuites

CipherSpec	Equivalent CipherSuite (IBM JRE)	Equivalent CipherSuite (Oracle JRE)	Protocol
ECDHE_ECDSA_3DES_EDE_CBC_SHA256	SSL_ECDHE_ECDSA_WITH_3DES_EDE_CBC_SHA	TLS_ECDHE_ECDSA_WITH_3DES_EDE_CBC_SHA	TLS 1.2
ECDHE_ECDSA_AES_128_CBC_SHA256	SSL_ECDHE_ECDSA_WITH_AES_128_CBC_SHA256	TLS_ECDHE_ECDSA_WITH_AES_128_CBC_SHA256	TLS 1.2
ECDHE_ECDSA_AES_128_GCM_SHA256	SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256	TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256	TLS 1.2
ECDHE_ECDSA_AES_256_CBC_SHA384	SSL_ECDHE_ECDSA_WITH_AES_256_CBC_SHA384	TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA384	TLS 1.2
ECDHE_ECDSA_AES_256_GCM_SHA384	SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384	TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384	TLS 1.2
ECDHE_ECDSA_NULL_SHA256	SSL_ECDHE_ECDSA_WITH_NULL_SHA	TLS_ECDHE_ECDSA_WITH_NULL_SHA	TLS 1.2
ECDHE_ECDSA_RC4_128_SHA256	SSL_ECDHE_ECDSA_WITH_RC4_128_SHA	TLS_ECDHE_ECDSA_WITH_RC4_128_SHA	TLS 1.2
ECDHE_RSA_3DES_EDE_CBC_SHA256	SSL_ECDHE_RSA_WITH_3DES_EDE_CBC_SHA	TLS_ECDHE_RSA_WITH_3DES_EDE_CBC_SHA	TLS 1.2
ECDHE_RSA_AES_128_CBC_SHA256	SSL_ECDHE_RSA_WITH_AES_128_CBC_SHA256	TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256	TLS 1.2
ECDHE_RSA_AES_128_GCM_SHA256	SSL_ECDHE_RSA_WITH_AES_128_GCM_SHA256	TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256	TLS 1.2
ECDHE_RSA_AES_256_CBC_SHA384	SSL_ECDHE_RSA_WITH_AES_256_CBC_SHA384	TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384	TLS 1.2
ECDHE_RSA_AES_256_GCM_SHA384	SSL_ECDHE_RSA_WITH_AES_256_GCM_SHA384	TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384	TLS 1.2
ECDHE_RSA_NULL_SHA256	SSL_ECDHE_RSA_WITH_NULL_SHA	TLS_ECDHE_RSA_WITH_NULL_SHA	TLS 1.2
ECDHE_RSA_RC4_128_SHA256	SSL_ECDHE_RSA_WITH_RC4_128_SHA	TLS_ECDHE_RSA_WITH_RC4_128_SHA	TLS 1.2
TLS_RSA_WITH_3DES_EDE_CBC_SHA [1]	SSL_RSA_WITH_3DES_EDE_CBC_SHA	TLS_RSA_WITH_3DES_EDE_CBC_SHA	TLS 1.0
TLS_RSA_WITH_AES_128_CBC_SHA	SSL_RSA_WITH_AES_128_CBC_SHA	TLS_RSA_WITH_AES_128_CBC_SHA	TLS 1.0
TLS_RSA_WITH_AES_128_CBC_SHA256	SSL_RSA_WITH_AES_128_CBC_SHA256	TLS_RSA_WITH_AES_128_CBC_SHA256	TLS 1.2
TLS_RSA_WITH_AES_128_GCM_SHA256	SSL_RSA_WITH_AES_128_GCM_SHA256	TLS_RSA_WITH_AES_128_GCM_SHA256	TLS 1.2
TLS_RSA_WITH_AES_256_CBC_SHA	SSL_RSA_WITH_AES_256_CBC_SHA	TLS_RSA_WITH_AES_256_CBC_SHA	TLS 1.0
TLS_RSA_WITH_AES_256_CBC_SHA256	SSL_RSA_WITH_AES_256_CBC_SHA256	TLS_RSA_WITH_AES_256_CBC_SHA256	TLS 1.2
TLS_RSA_WITH_AES_256_GCM_SHA384	SSL_RSA_WITH_AES_256_GCM_SHA384	TLS_RSA_WITH_AES_256_GCM_SHA384	TLS 1.2

z/OS Connect and AT-TLS

In some situations, z/OS Connect requires Application Transparent – TLS (AT-TLS) to enable encryption and security between a z/OS Connect server from an inbound REST client or between a z/OS Connecter server to an outbound endpoint. AT-TLS is a component of the IBM z/OS Communication Server product (specifically the TCP IP stack) that can provide TLS support between endpoints(applications). The Transparent part of the name means that endpoints (client or server) need not be aware that network traffic is being encrypted and/or digital certificates are being used for security.

There is an Educational Package around Digital Certificates & TLS Handshake within the GitHub Site. This package contains a high-level overview of the Anatomy of a Digital Certificate, Components of a Public Key Infrastructure, the TLS Handshake Flow, and Problem Tracing Options for debugging purposes. See the Educational Package here https://tinyurl.com/4nnthuwv.

AT-TLS is needed when TLS is required for communications with Db2 and IMS Connect and/or when TLS is required by an API client requester application running in MVS batch job or an IMS region. This section will describe configuring AT-TLS for an API requester application running in other non-CICS environments. For details and examples of configuring AT-TLS in other scenarios, see the security exercises at URL https://tinyurl.com/56vzzxz2

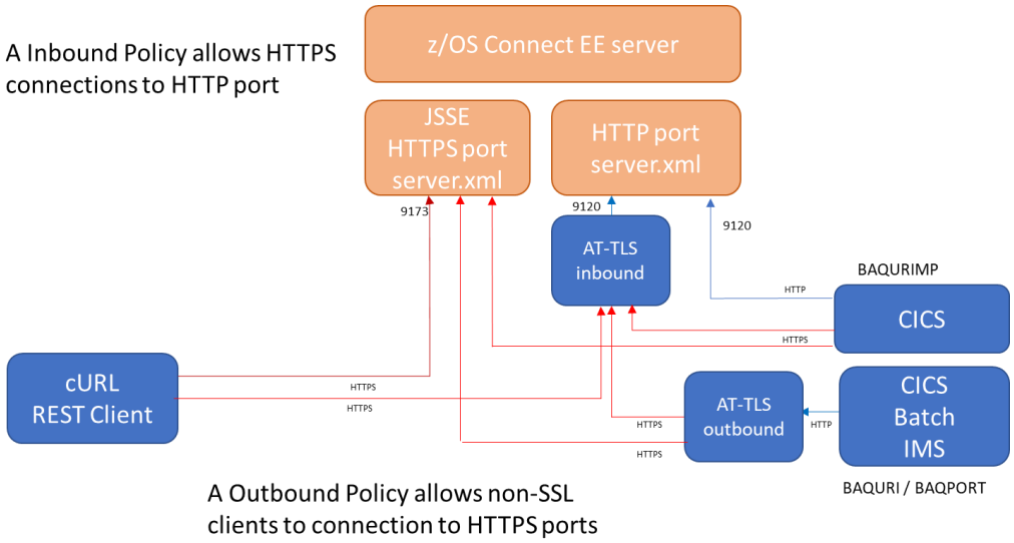
In addition to our educational package and security exercises you can find more information around AT-TLS and z/OS Connect at the IBM Doc links below:

OAS2 & 3: https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=connect-application-transparent-transport-layer-security-tls

HTTPS Communication Options

The diagram below shows the flows for inbound communication to a z/OS Connect server. REST Clients such as browsers, Postman and cURL provide TLS support and can interact directly with the JSSE support provided by the Liberty runtime in which z/OS Connect server is running. Also, CICS SSL support provides the same functionality.

AT-TLS is required for TLS support between MVS batch and/or IMS applications to a z/OS Connect server. Two types of AT-TLS configurations or policies would be required. An inbound policy provides the TLS server functions for inbound HTTPS request connecting when connecting to an HTTP port and an outbound policy provides the TLS client functions for outbound request originating from a non-TLS enabled client.



AT-TLS policies are stored in a file in an OMVS directory which contains configuration information for ports, traffic directions, IP addresses, key rings and ciphers, etc. All this information is not easily manageable using an editor, so the use of the *Configuration Assistant* tool provided by IBM z/OS Manager Facility (z/OSMF) is a highly recommended way to configure AT-TLS policies. See Redbook *IBM z/OS V2R2 Communications Server TCP/IP Implementation: Volume 4 Security and Policy-Based Networking*, *SG24-8363-00* for details regarding the configuring and usage of the Policy Agent and *Configuration Assistant*.

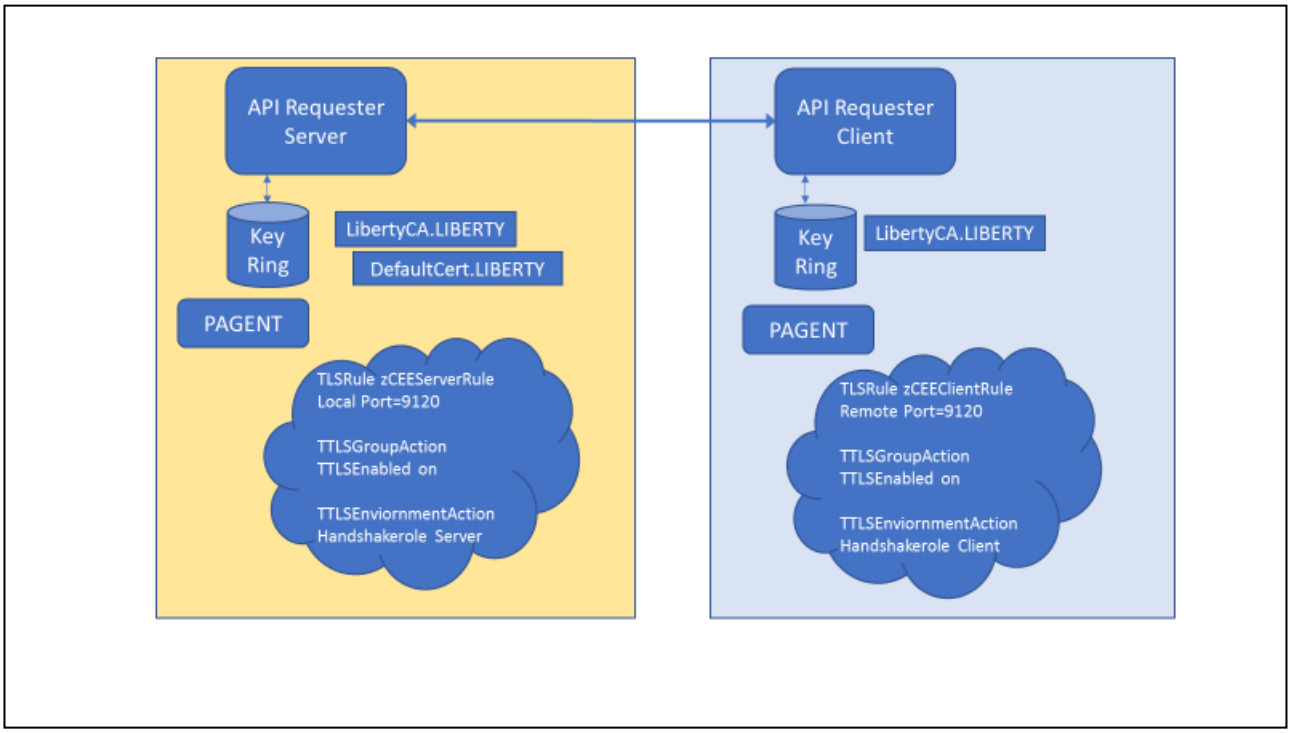
Section *HTTPS Client Traffic Descriptor* shows screen shots from the *Configuration Assistant* that were used to configure a simple configuration. Not all the steps for using the *Configuration Assistant* are shown, just the key screens. For details see the site referenced earlier.

AT-TLS Configuration

Let's explore these inbound and outbound policies in a little more detail. The diagram below demonstrates both inbound and outbound policies.

The TCP/IP stack's *Policy Agent* (PAGENT) performs various functions, one of which monitors TCP/IP traffic at the transport layer and triggers AT-TLS when the properties of a network traffic request match a set of criteria defined in an AT-TLS policy.

For the API requester server, the policy identifies the target port for an inbound request, the key ring to be used for TLS handshakes, encryptions cyphers, etc. and what role should be played by AT-TLS during a handshake, e.g., server. For the API requester client, the policy identifies the target port for an outbound request, the key ring to be used for TLS handshakes, encryptions cyphers, etc. and what role should be played by the AT-TLS during a handshake, e.g., client.



In the example above, the keyring configured in the AT-TLS policy for the API requester server is the same key ring (*Libery.KeyRing*) created ***Using RACF for TLS and trust/key store management*** *on page 44*.

Tech-Tip: The same key ring can be referenced in a AT-TLS policy, or in Liberty server's configuration file and a CICS region's resource definitions.

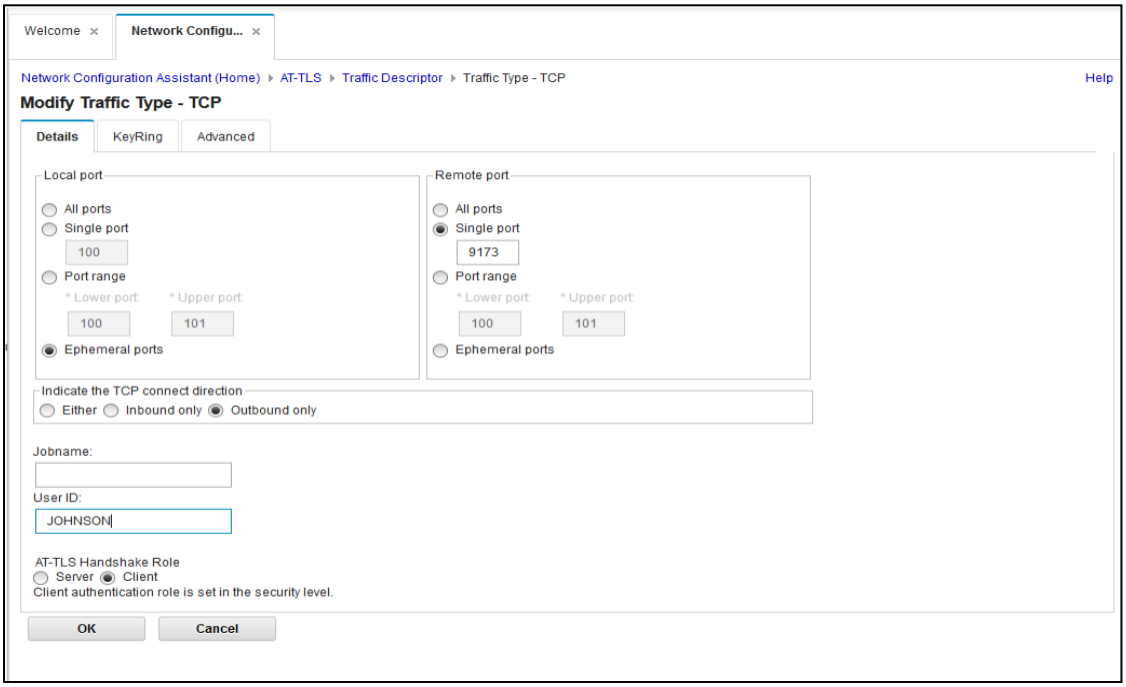
The server's end points are configured as shown below:

```
<httpEndpoint id="defaultHttpEndpoint"
              host="*" httpPort="9120" httpsPort="9173" />
```

Since in this example mutual authentication will not be configured, only the signer certificate of the server's certificate sent by the z/OS Connect server needs to be connected to the client's key ring.

HTTPS Client Traffic Descriptor

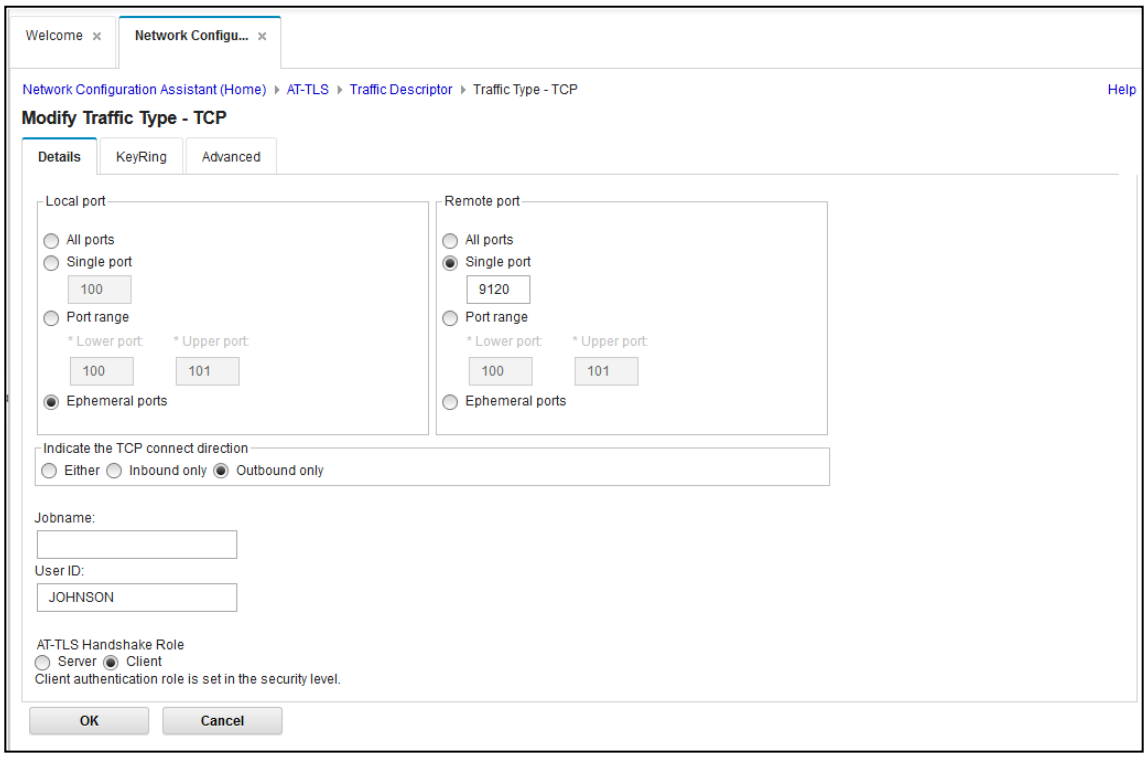
As shown below, the HTTPS client traffic descriptor defines the remote port for the server as being HTTPS port 9173 and the client coming from any local port. This descriptor applies to all inbound IP address but only if the client is running under a SAF identity of JOHNSON. When these criteria are met, AT-TLS will act as a client during a TLS handshake with server. The specific *User ID* was provided so other clients running under other identities could connect to the server's HTTPS port as normal. This policy will act as a client during a TLS handshake.



The remote port is 9173 which is configured in the server as an JSSE HTTPS port. This is a AT-TLS client interacting with a JSSE port.

HTTP Client Traffic Descriptor

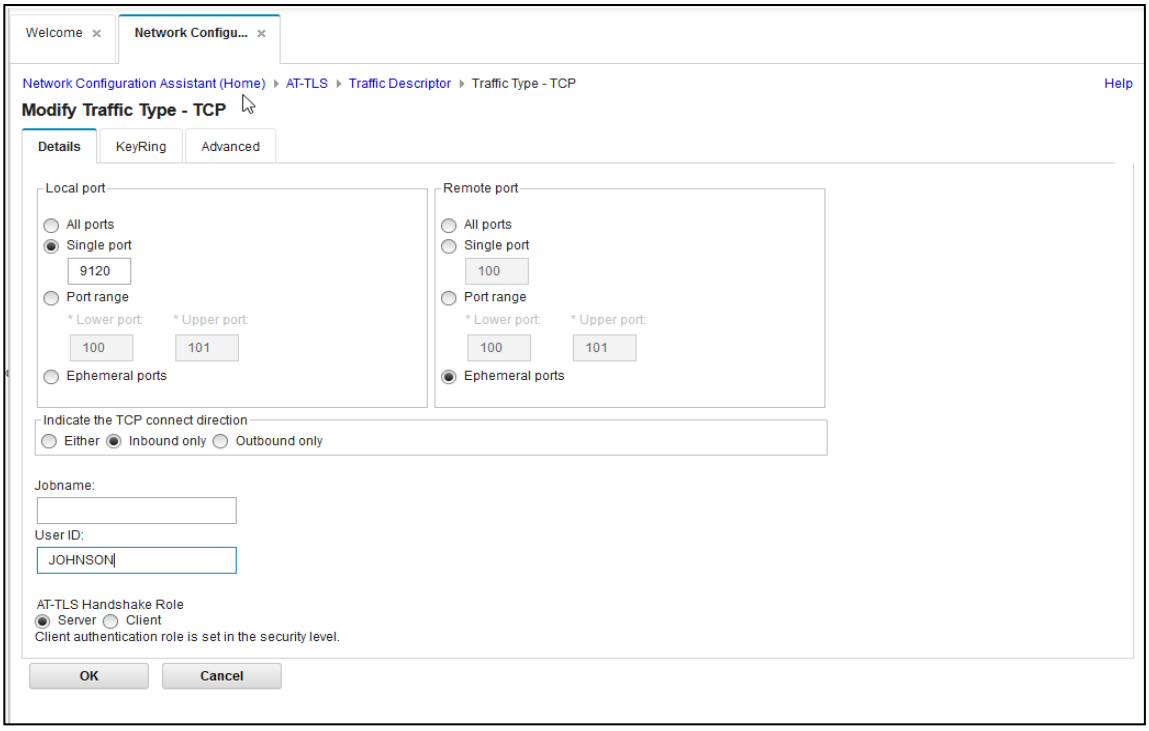
The *Configuration Assistant* screen below identifies the target port and handshake role in a *Traffic Descriptor* outbound policy for the HTTP port 9120. As shown below this descriptor identifies the remote port for the server as being 9120 "outbound" from any local HTTP client request. This descriptor applies to all inbound IP address. but only if the requester is running under a SAF identity of JOHNSON. When these criteria` are met, AT-TLS will act as a client during a TLS handshake with the server. The *User ID* was provided so other clients running under other identities could connect to the server's HTTP port as normal. This policy will act as a client during a TLS handshake.



When this traffic descriptor is combined with other definitions in a policy there will be a need to be a corresponding inbound policy to act as server during a TLS handshake (the z/OS Connect server is not involved in the TLS process at all) for connection request to port 9120. That is the next example.

Server Traffic Descriptor (AT-TLS server and TLS client)

This outbound AT-TLS policy identifies the local port and handshake role in a Traffic Descriptor inbound policy to HTTP port 9120. As shown below this descriptor identifies the local port for the server as being 9120 from any local port. This descriptor applies to all inbound IP addresses but only if the client is running under a SAF identity of JOHNSON. The *User ID* was provided so other clients running under other identities could connect to the server's HTTP port as normal. This policy will act as a server during a TLS handshake. Also defined in the descriptor is the key ring, e.g., *Liberty.KeyRing. (This is the same key ring used by the Liberty server for JSSE handshakes shown earlier).*



When the configuration is complete in the *Configuration Assistant* it is exported to an OMVS file and the Policy Agent is told to update its configuraton with an MVS modify command,

F PAGENT,UPDATE

Note that the names of traffic discritors, rules, etc configured in the Configuration Assistance are mangled during the export process.

When an API requester uses the options below while running under identity JOHNSON, an AT-TLS rule will be trigged by the policy. AT-TLS will initiate a TLS handshake with the server listening on port 9120. This handshake request will trigger another AT-TLS rule. This AT-TLS rule will act as the TLS server in lieu of the application server during the handshake.

```
//CEEOPTS  DD *
  POSIX(ON),
  ENVAR("BAQURI=wg31.washington.ibm.com",
  "BAQPORT=9120")
```

When an API requester is uses the options below while running under identity JOHNSON, an AT-TLS rule will be trigged by the policy. AT-TLS will initiate a TLS handshake with the server listening on port 9473. The handshake will proceed using the JSSE support configured in the Liberty server where z/OS Connect is running. No inbound AT-TLS policy is triggered.

```
//CEEOPTS  DD *
  POSIX(ON),
  ENVAR("BAQURI=wg31.washington.ibm.com",
  "BAQPORT=9173")
```

Again, for examples of the steps required to enable security between a z/OS Connect server and subsystems, like Db2 and IMS Connect or from a MVS batch job to a z/OS Connect server, see the security exercises at URL https://tinyurl.com/56vzzxz2

Troubleshooting RACF issues with Liberty and z/OS connect Servers

This section documents some of the more common RACF related resource and/or configuration issues. This is not an all-encompassing list of issues or their causes but perhaps the information contained here will help a reader identity and address their specific issue or situation.

Liberty server startup errors

This first set of messages appear in the *messages.log* file at server startup and indicate insufficient access to the angel and/or other required RACF SERVER resources.
The RACF command that permits the required access is provided for each message. In these examples ATSGRP is a RACF group for the RACF identities under which the z/OS Connect Liberty servers ae running. Group ATSUSERS is a RACF group of identities authorized to use an instance of z/OS Connect.

- ***CWWKB0117W: The ZCEE angel process is not available. No authorized services will be loaded. The reason code is 5.***

Cause/Solution: The server is trying to access a named angel but no angel with the specified name (e.g., *zCEE*) is active. Start an angel with this name (*S BBGZANGL,**NAME=ZCEE***) or change the *com.ibm.ws.zos.core.angelName* Java option to provide the name of an active angel.

```
CWWKB0079I THE ANGEL BUILD LEVEL IS 19.0.0.9 20190905-0519 / 2019.9.0.0 20190905-0519
CWWKB0069I INITIALIZATION IS COMPLETE FOR THE ZCEE ANGEL PROCESS.
```

- ***CWWKB0117W: The angel process is not available. No authorized services will be loaded. The reason code is 4.***

Cause/Solution: The server is trying to access the default angel, but the default angel is not active. Start a default angel (e.g., one with no name).

- ***CWWKB0118W: This server is not authorized to connect to the ZCEE angel process. No authorized services will be loaded.***

Cause/Solution: The RACF identity under which the server is executing does not have sufficient (READ) access to the RACF SERVER resource protecting the angel, be sure the appropriate profile is define and permit the Liberty server's RACF identity (group or user) to have READ access to this profile.

```
PERMIT  BBG.ANGEL.ZCEE CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0117W: The ZCEE angel process is not available. No authorized services will be loaded. The reason code is 4,104.***
  CWWKB0115I: This server is not authorized to load module bbgzsafm. No authorized services will be loaded.

Cause/Solution: The server registration with the angel failed because the server was not authorized to the BBGZSAFM resource. Permit READ access to SERVER resource BBG.AUTHMOD.BBGZSAFM to the RACF identity under which the server is executing.

```
PERMIT  BBG.AUTHMOD.BBGZSAFM CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

The next set of messages are related to required features. Access to these features require READ access to various SERVER resources.

- ***CWWKB0104I: Authorized service group LOCALCOM is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.LOCALCOM CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group PRODMGR is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.PRODMGR CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group SAFCRED is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.SAFCRED CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group TXRRS is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.TXRRS CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group ZOSAIO is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.ZOSAIO CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group ZOSDUMP is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.ZOSDUMP CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group ZOSWLM is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.ZOSWLM CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group WOLA is not available.***

```
PERMIT BBG.AUTHMOD.BBGZSAFM.WOLA CLASS(SERVER)ACCESS(READ) ID(ATSGRP)
```

- ***CWWKB0104I: Authorized service group CLIENT.WOLA is not available***

```
PERMIT BBG.AUTHMOD.BBGZSCFM CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
PERMIT BBG.AUTHMOD.BBGZSCFM.WOLA CLASS(SERVER) ACCESS(READ) ID(ATSGRP)
```

Messages related to enabling RACF security

RACF enablement messages will sometimes appear in the SYSLOG and/or console messages, but the real issue is usually identified in the *messages.log* file.

- ***BPXP015I HFS PROGRAM programName IS NOT MARKED PROGRAM CONTROLLED***

The BPXP015I message will appear in the SYSLOG output along with other BPX messages. The *programName* value in the message will vary.

```
BPXP015I HFS PROGRAM /usr/lib/java_runtime/libifaedjreg64.so IS NOT  MARKED
PROGRAM CONTROLLED.
BPXP014I ENVIRONMENT MUST BE CONTROLLED FOR DAEMON (BPX.DAEMON)
PROCESSING.
BPXP015I HFS PROGRAM /usr/lib/java_runtime/libifaedjreg64.so IS NOT MARKED
PROGRAM CONTROLLED.
BPXP014I ENVIRONMENT MUST BE CONTROLLED FOR DAEMON (BPX.DAEMON)
PROCESSING
```

Generally, the BPX messages in the SYSLOG are misleading. The useful information will appear concurrently in the *messages.log* file as shown below:

CWWKS2930W: A SAF authentication attempt using authorized SAF services was rejected because the server is not authorized to access the APPL-ID ATSZDFLT. Authentication will proceed using unauthorized SAF services.

CWWKS2933E: The username and password could not be checked because the BPX.DAEMON profile is active, and the address space is not under program control.

CWWKS1100A: Authentication did not succeed for user ID Fred. An invalid user ID or password was specified.

CWWKS2933E: The username and password could not be checked because the address space is not under program control.

The issue is caused a missing RACF resource or lack of access to a RACF APPL resource identified in message *CWWKS2930W*. In this example the server.xml file contained the *safCredential* configuration element shown below:

```
<safCredentials unauthenticatedUser="ZCGUEST" Prefix="ATSZDFLT" />
```

The value used for *profilePrefix* (the default value is *BBGZDFLT*) must be defined as a RACF APPL resource. Note that all RACF identities that will be access this server must have READ access to this APPL resource. A server resource BBG.SECPFX.***ATSZDFLT*** must also all be defined with the Liberty server's RACF identity having READ access to this resource.

```
RDEFINE APPL ATSZDFLT UACC(NONE) OWNER(SYS1)
PERMIT ATSZDFLT CLASS(APPL) ACCESS(READ) ID(ZCGUEST,ATSGRP)
RDEFINE SERVER BBG.SECPFX.ATSZDFLT UACC(NONE)
PERMIT  BBG.SECPFX.ATSZDFLT CLASS(SERVER) ACCESS(READ)
ID(ATSGRP)
```

The following messages will primarily appear in the messages.log file.

- ***CWWKS2909E: A SAF authentication or authorization attempt was rejected because the server is not authorized to access the following SAF resource: APPL-ID ATSZDFLT. Internal error code 0x03008108.***

  This identity under which the server is running does not have READ access to the APPL resource ATSZDFLT. Connect the user to a group which has READ access or provide explicit access using the command shown below:

```
PERMIT ATSZDFLT CLASS(APPL) ACCESS(READ) ID(ATSSERV) ACC(READ)
```

▪ ***CWWKS2911E: SAF Service RACROUTE_AUTH did not succeed because the resource profile ATSZDFLT.zos.connect.access.roles.zosConnectAccess in class EJBROLE does not exist. SAF return code 0x00000004. RACF return code 0x00000004. RACF reason code 0x00000000.***

The RACF return and reason code indicate that this RACF EJBROLE resource has not been defined. The value of the *profilePrefix* specified in the *safCredential* configuration element is prepended to the role *zos.connect.access.roles.zosConnectAccess* to form the name of the RACF EJBROLE resource which controls access to this server. The EJBRole is defined to RACF as shown below. Note that all authorized z/OS Connect users will need READ access to this EJBROLE.

RDEFINE EJBROLE ATSZDFLT.zos.connect.access.roles.zosConnectAccess OWNER(SYS1) UACC(NONE)

Then permit access to this resource to all authorized users

PERMIT ATSZDFLT.zos.connect.access.roles.zosConnectAccess CLASS(EJBROLE) ID(ATSUSERS,ATSSERV) ACCESS(READ)

▪ ***CWWKS2907E: SAF Service IRRSIA00_CREATE did not succeed because user user1 has insufficient authority to access APPL-ID ATSZDFLT. SAF return code 0x00000008. RACF return code 0x00000008. RACF reason code 0x00000020.***

CWWKS1100A: Authentication did not succeed for user ID user1. An invalid user ID or password was specified.

This user does not have READ access to the APPL resource ATSZDFLT. Connect the user to the *ATSUSERS* group or provide explicit access using the command shown below:

PERMIT ATSZDFLT CLASS(APPL) ACCESS(READ) ID(USER1) ACC(READ)

▪ *MVS console message:*

ICH408I USER(USER1) GROUP(SYS1) NAME(WORKSHOP USER1

ATSZDFLT.zos.connect.access.roles.zosConnectAccess

CL(EJBROLE)

INSUFFICIENT ACCESS AUTHORITY

ACCESS INTENT(READ) ACCESS ALLOWED(NONE)

This user does not have READ access to the EJBROLE resource. Connect the user to the *ATSUSERS* group or provide explicit access using the command shown below:

```
PERMIT ATSZDFLT.zos.connect.access.roles.zosConnectAccess  CLASS(EJBROLE) ID(USER1)
ACCESS(READ)
```

▪ ***FFDC1015I: An FFDC Incident has been created: "java.io.IOException : R_datalib (IRRSDL00) error: profile for ring not found (8, 8, 84) com.ibm.ws.ssl.config.WSKeyStore$1 do_getKeyStore" at ffdc_19.11.20_13.28.35.0.log***

Cause/Solution: The key ring identified in the keystore configuration element has not been defined in RACF. Define and configure the key ring, e.g. *Liberty.KeyRing*.

```
<ssl id="DefaultSSLSettings"
  clientAuthentication="false"
  clientAuthenticationSupported="true"
  keyStoreRef="CellDefaultKeyStore"
  trustStoreRef="CellDefaultKeyStore" />
<keyStore id="CellDefaultKeyStore"
  location="safkeyring:///Liberty.KeyRing"
  password="password" type="JCERACFKS"
  fileBased="false" readOnly="false" />
```

▪ ***CWWKO0801E: Unable to initialize SSL connection. Unauthorized access was denied or security settings have expired. Exception is javax.net.ssl.SSLHandshakeException: no cipher suites in common***

Cause/Solution: There may be many causes for this issue but first confirm the RACF identity under which the server is running has READ access to FACILITY resources *IRR.DIGTCERT.LISTRING* and *IRR.DIGTCERT.LIST*. The first resource gives the identity access to their own key ring and the second allows access to the certificates.

```
PERMIT IRR.DIGTCERT.LISTRING CLASS(FACILITY) ID(ATSSERV) ACCESS(READ)
PERMIT IRR.DIGTCERT.LIST CLASS(FACILITY) ID(ATSGRP)  ACCESS(READ)
```

An alternative cause/Solution: For a TLS handshake to occur, the server must first have access to a private or site certificate that has a private key and the server must have access to that certificate's private key. The latter can happen only if the following conditions are true.

• If the certificate is connected to the key ring with the PERSONAL usage option, when one of the following two conditions are true:

  ○ The caller's user ID is the user ID associated with the certificate the access to the key ring is through the checking on IRR.DIGTCERT.LISTRING in the FACILITY CLASS, or

- The caller's user ID has READ or UPDATE authority to the <ringOwner>.<ringName>.LST resource in the RDATALIB class. READ access enables retrieving one's own private key, UPDATE access enables retrieving another's private key.

• If the certificate is connected to the key ring with the CERTAUTH or SITE usage option, when the following conditions are true:

- The certificate is connected to its key ring with the PERSONAL usage option.
- And one of the following three conditions is true:

  - The caller's user ID is RACF special regardless of access checking method, or
  - The caller's user ID has CONTROL authority to the IRR.DIGTCERT.GENCERT resource in the FACILITY class if the access to the key ring is through the checking on IRR.DIGTCERT.LISTRING in the FACILITY CLASS, or
  - The caller's user ID has CONTROL authority to the <ringOwner>.<ringName>.LST resource in the RDATALIB class.

Messages related to exchanging digital certificates (TLS)

This set of messages may appear when connecting to a server in a browser or when invoking an outbound API request. With a few exceptions most of TLS errors will require a review of a trace. Enable the *traceSpecification* shown below and review the generated trace for these.

```
<logging traceSpecification="com.ibm.ws.security.*=all:
       SSLChannel=all:SSL=all:zosConnectSaf=all"/>
```

This will generate a *trace.out* file in the *logs* subdirectory. This trace will provide details about the key ring and certificates involved in the handshake. There is a wealth of information about the flow between the client and server endpoints Review this trace for exceptions. The following exceptions are the ones most commonly experienced.

• ***Error occurred during a read, exception:javax.net.ssl.SSLHandshakeException: null cert chain***

This exception occurs when the server configuration set to require client certificates (*clientAuthenication="true")* and the client had no certificate to provide and no alternative authentication method was available.

This can occur when a browser tries to connection to the administrative interface and the local key store does not have a valid personal certificate. The browser will display a message that a ***Secure Connection Failed*** and a message like the one below:
An error occurred during a connection to wg31.washington.ibm.com:9443.
PR_END_OF_FILE_ERROR

• ***Error occurred during a read, exception:javax.net.ssl.SSLHandshakeException: null cert chain***

This exception occurs when the server configuration set to require client certificates (*clientAuthenication="true")* and the client had no certificate to provide and no alternative authentication method was available.

This can occur when a browser tries to connection to the administrative interface and the local key store does not have a valid personal certificate. The browser will display a message that a ***Secure Connection Failed*** and a message like the one below:
An error occurred during a connection to wg31.washington.ibm.com:9443.
PR_END_OF_FILE_ERROR

- ***Error occurred during a read, exception:javax.net.ssl.SSLException: Received fatal alert: bad_certificate error (handshake), vc=1083934466***
Caught exception during unwrap, javax.net.ssl.SSLException: Received fatal alert: bad_certificate

This is usually caused when the client certificate presented to the server did not have a valid CA certificate for the client's personal certificate in the server's trust store key ring.

- ***FFDC1015I: An FFDC Incident has been created: "java.io.IOException: Failed validating certificate paths com.ibm.ws.ssl.config.WSKeyStore$1 do_getKeyStore" at ffdc_19.12.04_20.51.47.0.log***

This can occur when the CA certificate used to sign the server's personal certificate was not connected to the server's local trust store (key ring on z/OS).

- ***java.io.IOException: IOException invoking https://132.25.33.351:9443/employees/John?validated=true: HTTPS hostname wrong: should be <132.25.33.351>***

Cause/resolution: In this situation the endpoint for the outbound API request was configured to use an IP address rather than a hostname. This should not be an issue unless an exchange of digital certificates is required.

The trace showed that during the handshake process the outbound API provider server's certificate had a common name (CN) which specified the hostname of the TCPIP stack where the API resided. This hostname was not known (e.g. DNS-resolvable) on the TCPIP stack where the z/OS Connect server was executing. This meant that communications back to the API requester's TCPIP stack based on the hostname was not possible which caused the IO exception. The best solution would be to use the host name in the server.xml configuration rather than the IP address and either add an entry to the local TCPIP stack's hostname (e.g. hosts) file for the IP address and hostname or add an entry to the DNS servers used by this TCPIP stack.

WebSphere Optimized Local Adapter

WOLA Security

WOLA connections between z/OS Connect EE servers and CICS, MVS batch or other subsystems use CBIND RACF resources to provide security. For example, if the following zosLocalAdapters element was define in the server.xml

```
    <zosLocalAdapters
        wolaGroup="MYSERVER"
        wolaName2="MYSERVER"
        wolaName3="MYSERVER" />
```

Then the following RACF would be required

Grants an ID general access to WOLA interface to the RACF identities of a CICS region and MVS batch job or task

```
RDEF CBIND BBG.WOLA.MYSERVER.MYSERVER.MYSERVER UACC(NONE)OWNER(SYS1)
PERMIT BBG.WOLA.MYSERVER.MYSERVER.MYSERVER CLASS(CBIND) ACCESS(READ) ID(cics_id,mvs_id)
```

WOLA Error Messages

In this section the following configuration for the *zosLocalAdapters* configuration element are in the server.xml file of the Liberty server.

```
<zosLocalAdapters wolaGroup="ZCEESRVR"
    wolaName2="ZCEESRVR"
    wolaName3="ZCEESRVR"/>

<connectionFactory id="wolaCF"
    jndiName="eis/ola">
    <properties.ola/>
</connectionFactory>
```

- *Call to BBOA1REG failed with Return Code = 00000012 Reason Code = 00000016*

There are several causes for this message but the most common is that the RACF CBIND that is used to managed connection to the WOLA interface is not defined. Problem isolation begins by reviewing the Liberty server's messages.log file to determine if the message below appears:

- *CWWKB0501I: The WebSphere Optimized Local Adapter channel registered with the Liberty profile server using the following name: ZCEESRVR ZCEESRVR ZCEESRVR*

If this message does not appear and there are no other WOLA related error messages, try confirming the CBIND resource for this name has been defined and the identity associated with

```
RDEFINE CBIND BBG.WOLA.ZCEESRVR.ZCEESRVR.ZCEESRVR UACC(NONE)
OWNER(SYS1)
PERMIT BBG.WOLA.ZCEESRVR.ZCEESRVR.ZCEESRVR  CLASS(CBIND) ACCESS(READ)
ID(USER1,CICSX)
```

the client request has READ access. If not defined the resource as shown below:

- ***Call to BBOA1SRV failed - Return Code = 00000012 Reason Code = 00000014***

This message indicates that the RACF identity of the client does not have access to the CBIND resource protecting the WOLA interface. Ensure that the user ID is authorized to the CBIND SAF class for the requested WOLA server as shown above.

- ***Call to BBOA1REG failed - Return Code = 00000012 Reason Code = 00000088***

The most common cause is that no Liberty server has successfully registered a WOLA channel with the names specified by the client. Problem isolation begins by reviewing the Liberty server's messages.log file to determine if the message below appears:

- ***CWWKB0501I: The WebSphere Optimized Local Adapter channel registered with the Liberty profile server using the following name: ZCEESRVR ZCEESRVR ZCEESRVR***

If this message has not appeared, then review the messages.log file and resolve any WOLA related issues identified in the Liberty server's configuration and/or RACF profile access and then try to restart the client.

Miscellaneous Topics

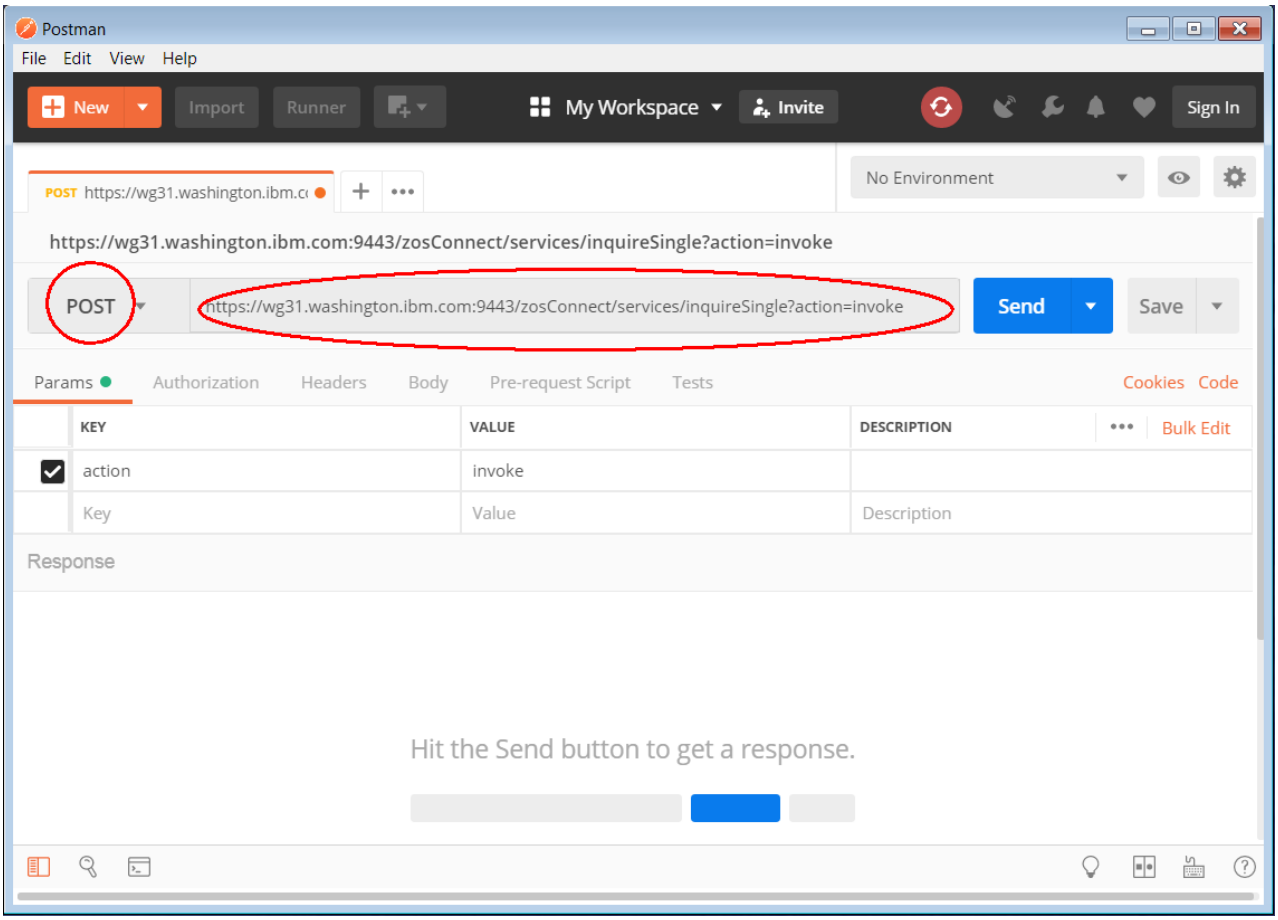
Testing z/OS Connect Services Using Postman

Two products which seem to be most popular tools for testing RESTful APIs can be used to test the services gererated by z/OS Connect tooling. The two products are *Postman* which is available for downloading from https://www.getpostman.com/apps and *cURL (client URL)* which is available for downloading from https://curl.haxx.se/download.html. The use of Postman will be shown in this section.
The basic steps shown here apply for any z/OS Connect services, not just for CICS service shown here.

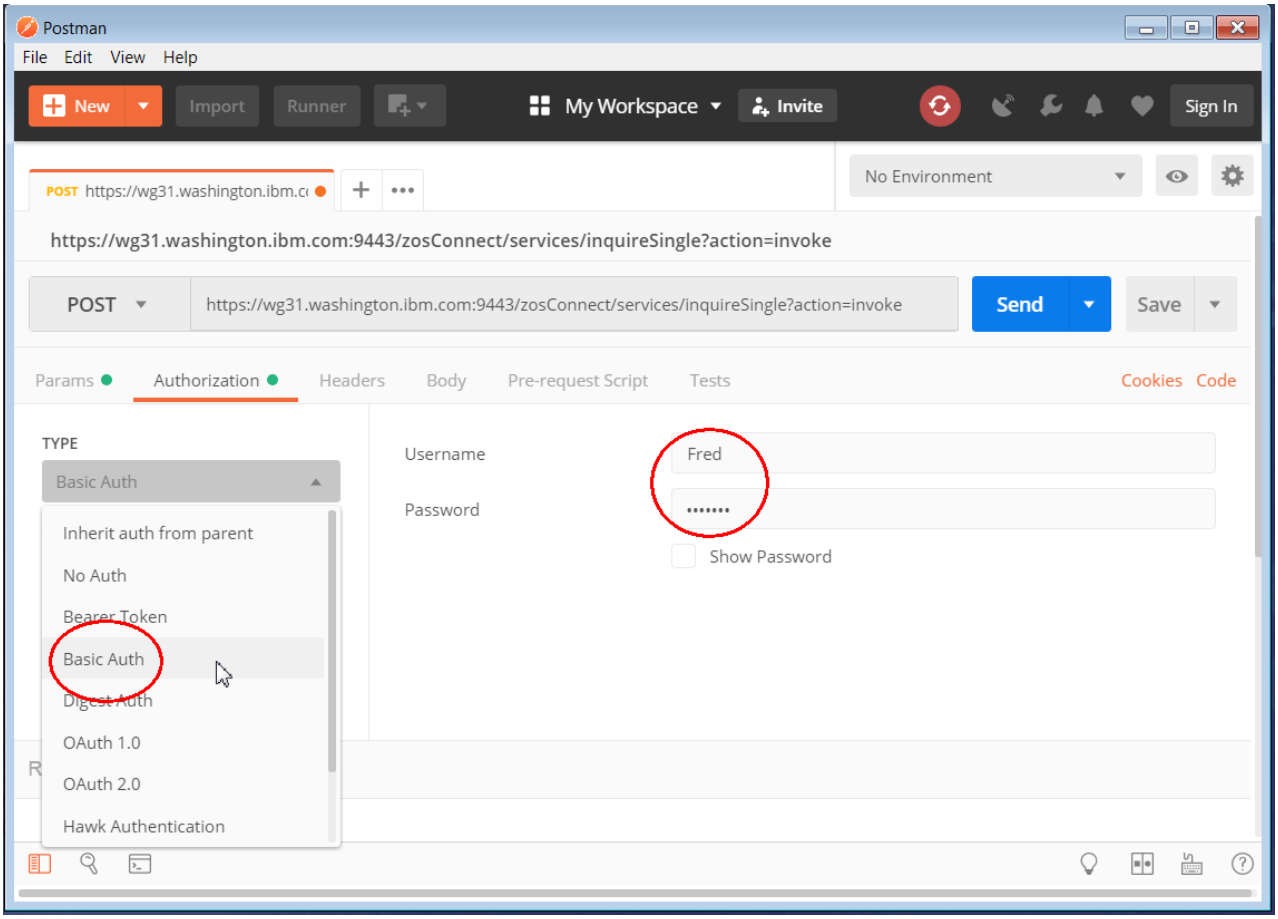
- Every REST request will be a *POST* method
- Every service will include *?action=invoke* attribute as part of the service name
- Every request will require a basic authorization token
- Every request will specify *Content-Type* of *application/json*
- The only items that vary are the service name and the request and response JSON messages

Using Postman

1. To test the *inqurieSingle* service 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 in the URL area containing an invoke request the service name (see below).
https://wg31.washington.ibm.com:9443/zosConnect/services/inquireSingle?action=invoke

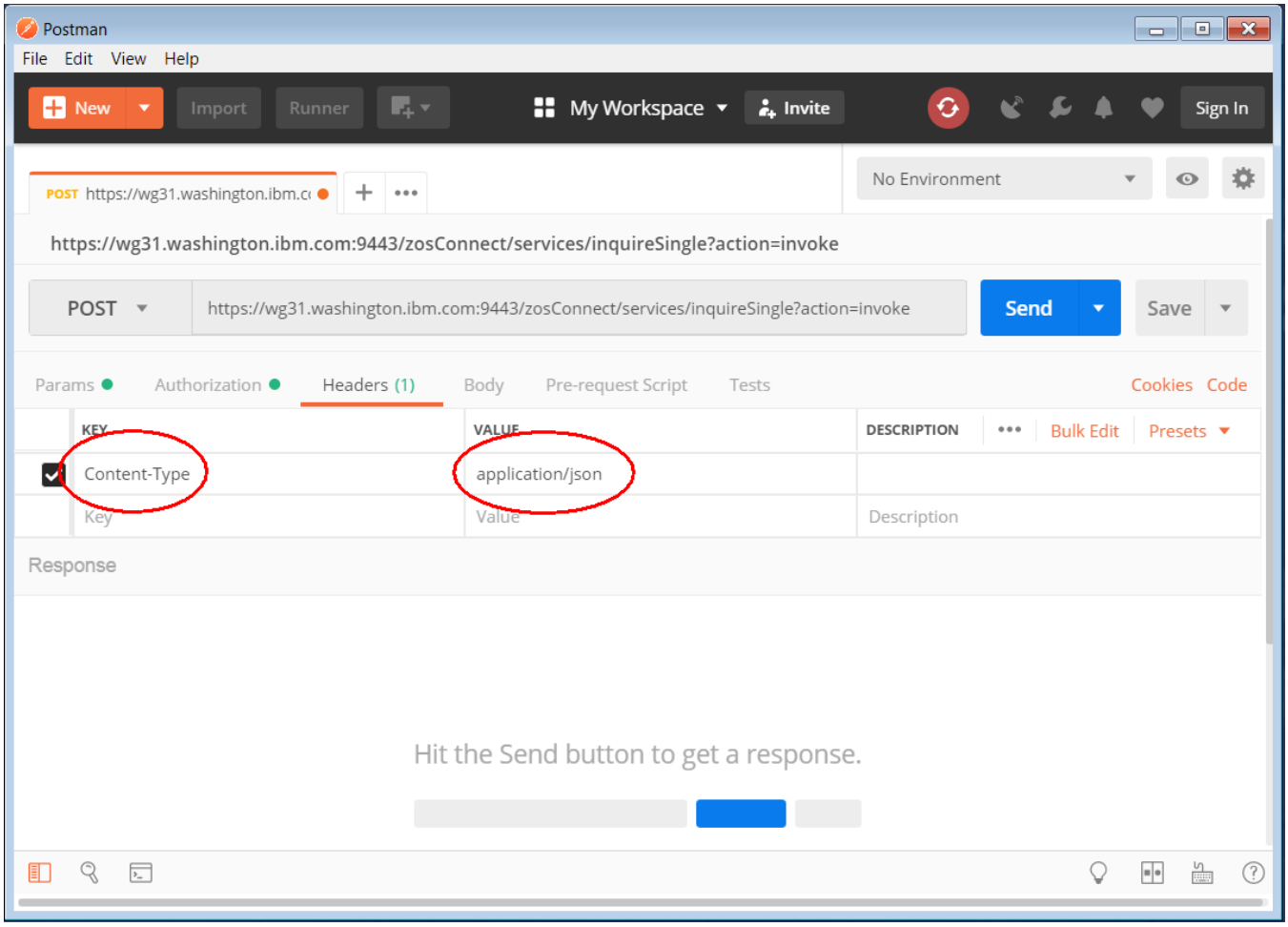


2. No *query* or *path* parameters are required so next select the *Authorization* tab to enter an authorization identity and password. Use the pull down arrow to select *Basic Auth* and enter ***Fred*** as the username and ***fredpwd*** as the Password (these are the identity and password defined in the server.xml).



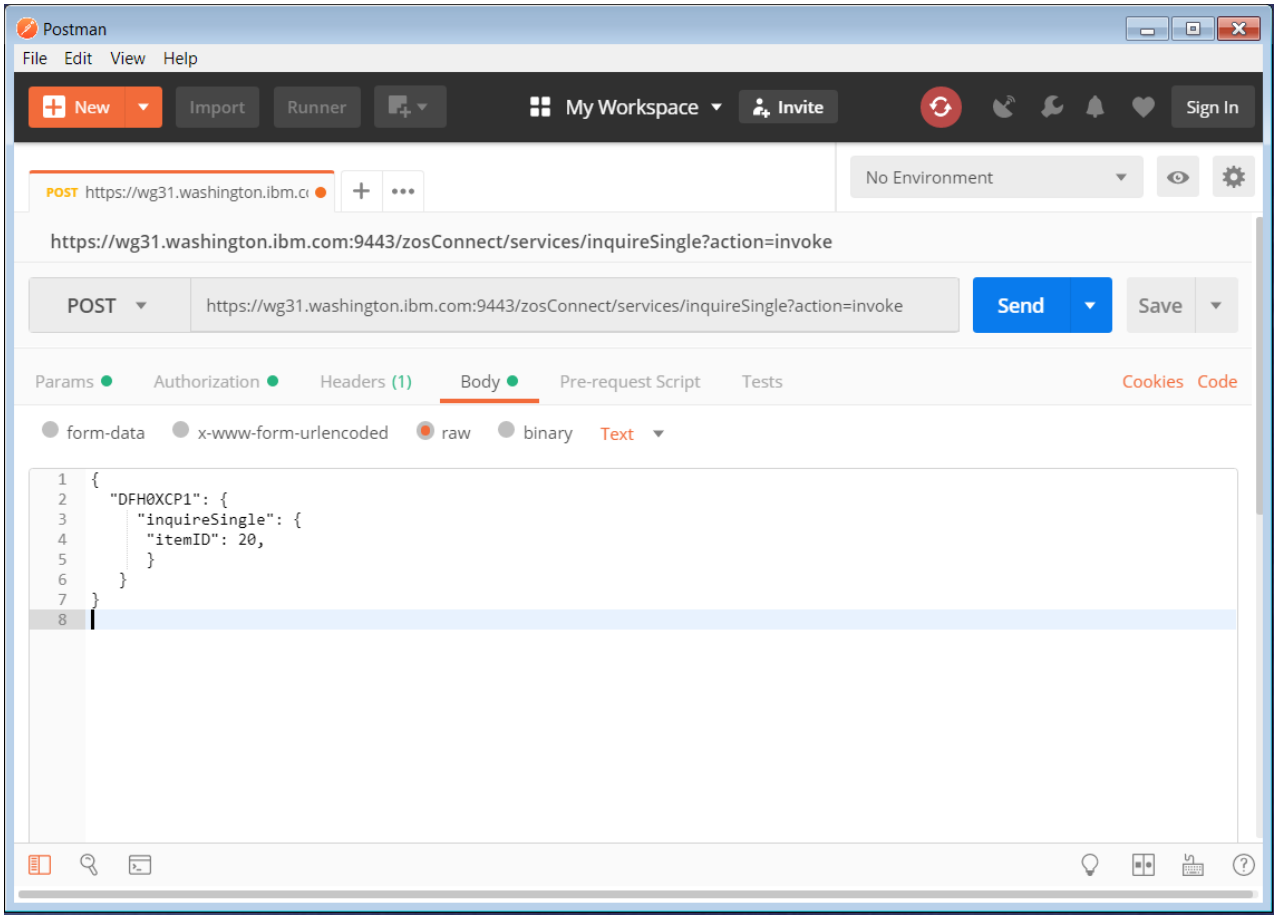
3. Next select the *Headers* tab and under *KEY* use the code assist feature to enter ***Content-Type*** and under *VALUE* use the code assist feature to enter ***application/json***.

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.

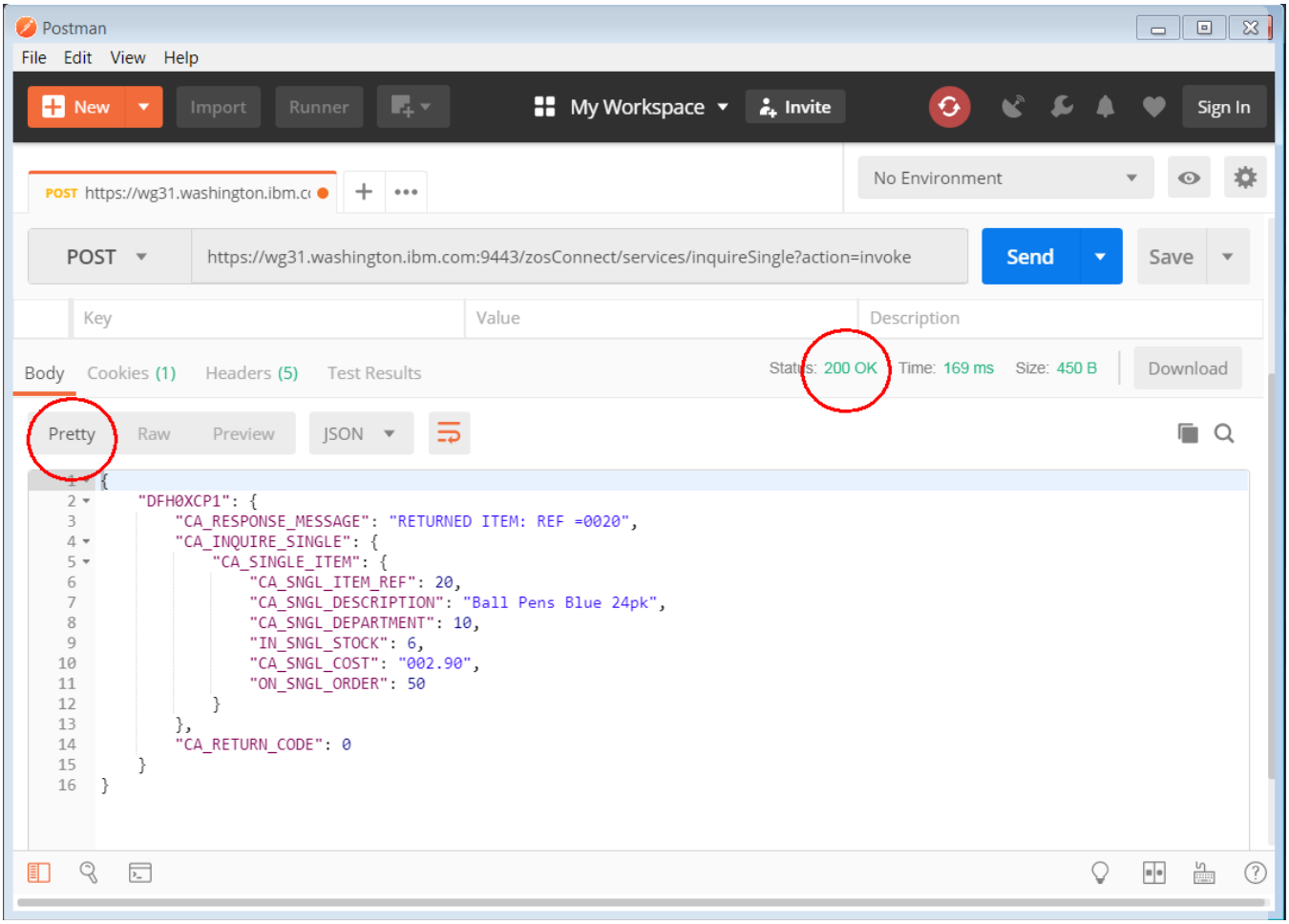


4. Next select the *Body* tab and select the *raw* radio button and enter the JSON message below in the *Body* area and press the **Send** button.

```
{
  "DFH0XCP1": {
     "inquireSingle": {
      "itemID": 20,
      }
   }
}
```



5. Pressing the **Send** button invokes the API. The Status of request should be *200 OK* and pressing the *Pretty* tab will display the response message is an easy-to-read format, see below.



Testing z/OS Connect Services Using cURL

Two products which seem to be most popular tools for testing RESTful APIs can be used to test the services gererated by z/OS Connect tooling. The two products are *Postman* which is available for downloading from https://www.getpostman.com/apps and *cURL (client URL)* which is available for downloading from https://curl.haxx.se/download.html. The use of cURL will be shown in this section.
The basic steps shown here apply for any z/OS Connect services, not just for CICS service shown here.

- Every REST request will be a *POST* method
- Every service will include *?action=invoke* attribute as part of the service name
- Every request will require a basic authorization token
- Every request will specify *Content-Type* of *application/json*
- Every request will contain an -d attribute which specifies a file contain the JSON request message
- The only items that vary are the service name and the request and response JSON messages

Using cURL

The *cURL* tool provides a command line interface to REST APIs. The same service just tested with *Postman* can be tested with *cURL* as shown here.

6. Enter the command below at the command prompt

```
curl -X POST --user Fred:fredpwd --header "Content-Type: application/json"
-d @inquireSingle.json --insecure
https://wg31.washington.ibm.com:9443/zosConnect/services/inquireSingle?action=invoke
{"DFH0XCP1":{"CA_RESPONSE_MESSAGE":"RETURNED ITEM: REF
=0020","CA_INQUIRE_SINGLE":{"CA_SINGLE_ITEM":{"CA_SNGL_ITEM_REF":20,"CA_SNGL_DESCRIPT
ION":"Ball Pens Blue 24pk", "CA_SNGL_DEPARTMENT":10, "IN_SNGL_STOCK":6,
"CA_SNGL_COST":"002.90", "ON_SNGL_ORDER":50}}, "CA_RETURN_CODE":0}}
```

Tech-Tip: In the above example:

--user Fred:fredpwd could have been specified as ***--header "Authorization: Basic RnJlZDpmcmVkcHdk"***

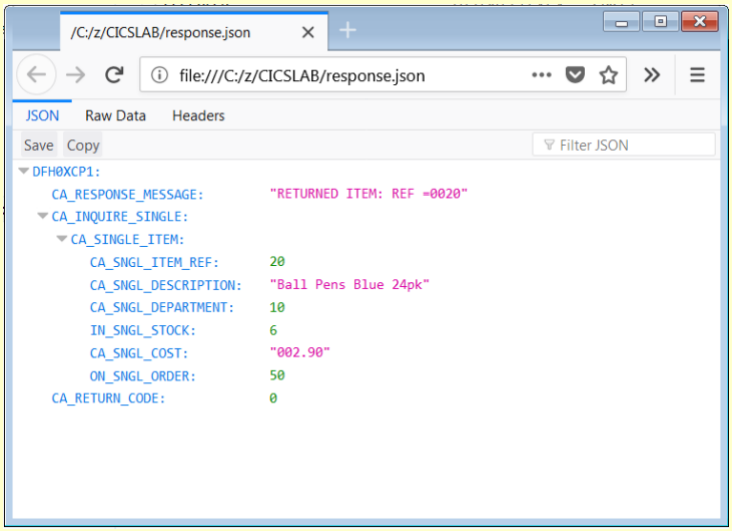
@inquireSingle.json is a file in the same directory that contains the request JSON message

--insecure is a *cURL* directive that tells *cURL* to ignore the self-signed certificate sent by the z/OS Connect EE server

The text in green is the JSON response message.

Tech-Tip: Another useful cURL directive is *-o response.json*

When this directive is used the JSON response message is written to a file named *response.json* which then can be opened with Firefox and viewed in a more readable format, e.g. command *firefox response.json*



Entering Firefox as a command assumes the directory containing the Firefox executable has been added to the PATH environment variable.

Tech-Tip: A recent update of Windows included an update to curl.exe file in the *c:\Windows\System32* directory. This update broke my use of cURL when trying to do SSL handshakes. I was receiving messages.

curl: (77) schannel: next InitializeSecurityContext failed: SEC_E_UNTRUSTED_ROOT (0x80090325) - The certificate chain was issued by an authority that is not trusted.

The resolution to this problem was to place the directory which contained the curl.exe I wanted to use earlier in the PATH environment variable than the Window's version of the curl.exe.

Implementing z/OS Connect EE Policies

This section provides an example of implement a z/OS Connect EE policy which determines the transaction identity under which the CICS mirror program will run.

- The first step is to create a rule set. If an HTTP header is provided in the request which matches a condition in the ruleset, the value associated with the header will be checked with the rule conditions. If the header value matches one of the values in a condition, the action specified in the rule will be invoked.

  In the example below (*cicsRules.xml*) if the header named *cicsMirror* is included in the request, the header value will be checked to see if it matches CSMI, MIJO, ATS0 or ATS1. If there is a match, then the CICS transaction identity will be set to the header value and the CICS mirror program DFHMIRS will be started with this value. The same applies to *cicsConnection,* if there is a match then the CICS connection reference will be set to the header value of HTTP property cicsConnection.

```
<ruleset name="CICS rules">
     <rule name="csmi-rule">
         <conditions>
             <header name="cicsMirror" value="CSMI,MIJO,ATS0,ATS1"/>
         </conditions>
         <actions>
             <set property="cicsTransId" value="${cicsMirror}"/>
         </actions>
     </rule>
     <rule name="connection-rule">
        <conditions>
            <header name="cicsConnection"   value="cscvinc,cics92,cics93"/>
        </conditions>
        <actions>
            <set property="cicsConnectionRef" value="${cicsConnection}"
        </actions>
    </rule>
 </ruleset>
```

- Next add a *zosconnect_policy* element in the *server.xml* to identify the rule set file name location and name.

```
<zosconnect_policy id="cicsPolicy"
   location="${server.config.dir}resources/zosconnect/rules">
   <ruleset file="cicsRules.xml"/>
 </zosconnect_policy>
```

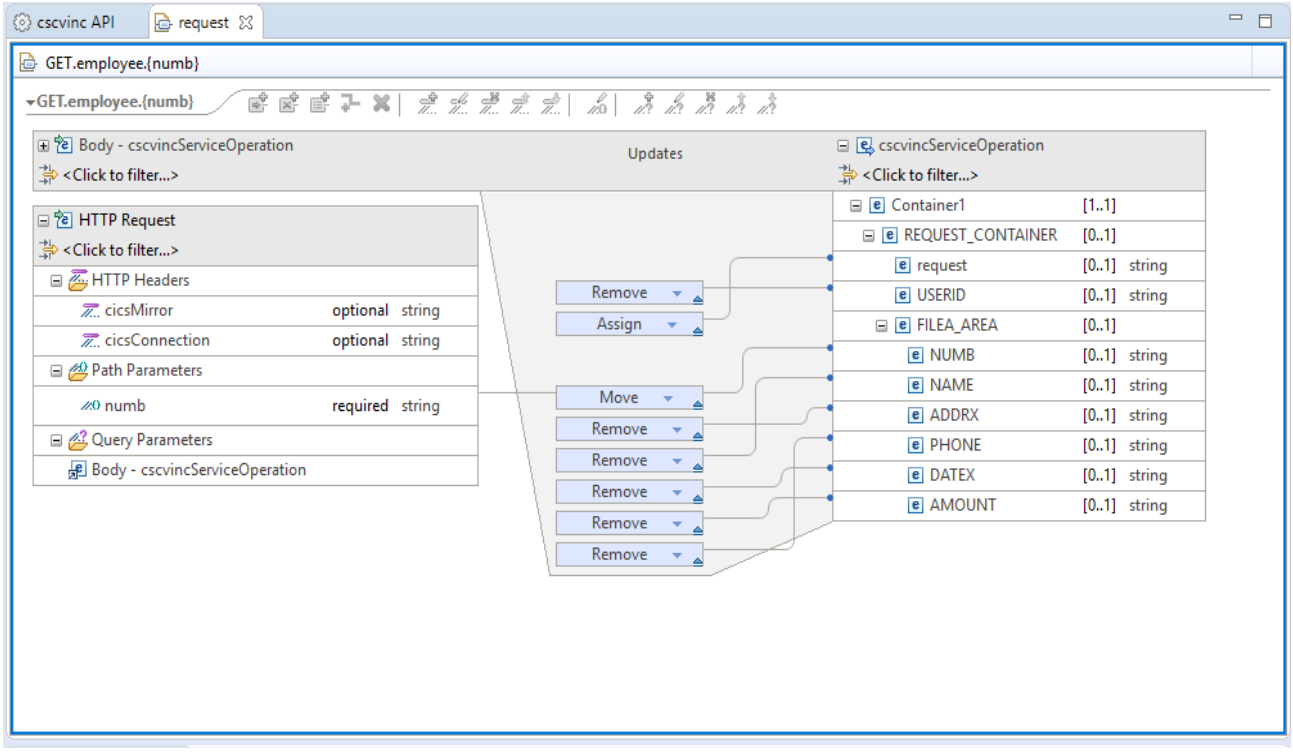
- Finally enable the policy identified in the *zosconnect_policy* element either globally in the *zosConnectApi* element or for a specific API.

```
  <!-- zosConnect APIs -->
   <zosconnect_zosConnectAPIs pollingRate="5s" updateTrigger="polled"
       policyRef="cicsPolicy"/>
```

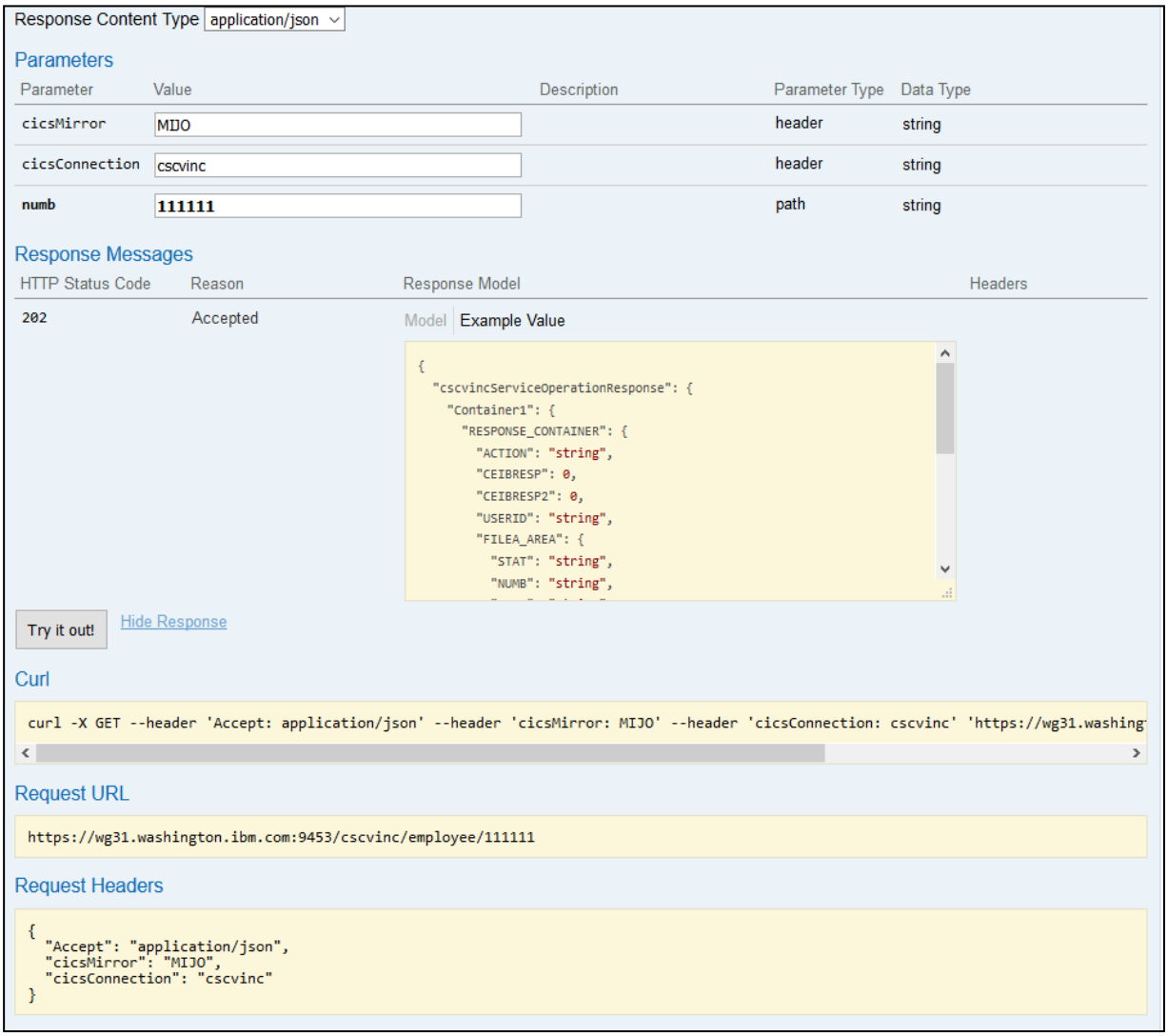
The name/value pairs added as header *cicsMirror* and *cicsConnecton* to a request as shown below:

```
curl -X GET --header 'Accept: application/json' --header 'Authorization:
Basic 'Fred:fredpwd' --header 'cicsMirror: MIJO' --header 'cicsConnection:
cics92' 'https://wg31.washington.ibm.com:9443/cscvinc/employee/333333'
```

Note also these header properties can be added during the mapping phases:



They will now be accessible when using the Swagger-UI test interface.



Managing CORS updates

Occasionally applying service will require changing the CORS configuration in a server's *server.xml* file, e.g. the PTF for z/OS Connect V3.00.35 Rather than updating the *server.xml* of each server, we suggest creating a *cors.xml* file in a shared location. The contents of the new or updated *cors.xml* file can be obtained from file *server.xml* in directory */usr/lpp/IBM/zosconnect/v3r0/runtime/templates/servers/default* after the service has been applied. Then add an <*include*> statement the *server.xml* of each server for the common *cors.xml* file at the same time removing any existing CORS configuration elements. The CORS update will be available the next time the server is restarted. This technique avoids needing to change or modify the CORS elements in every server.xml file for every server.

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="CORS include">

    <!-- add cors to allow cross origin access, e.g. when using
swagger doc from zOS Connect Enterprise Edition  -->
    <cors id="defaultCORSConfig"
          domain="/"
          allowedOrigins="*"
          allowedMethods="GET, POST, PUT, DELETE, OPTIONS"
          allowedHeaders="Origin, Content-Type, Authorization,
Cache-Control, Expires, Pragma"
          allowCredentials="true"
          maxAge="3600"/>

</server>
```

Liberty Environment Variables

- **WLP_LOGGING_CONSOLE_LOGLEVEL** - The logging level used to filter messages written to system streams (STDOUT). The valid values are INFO, AUDIT, WARNING, ERROR, and OFF. By default, the WLP_LOGGING_CONSOLE_LOGLEVEL environment variable is set to AUDIT. Valid options are:
  - **AUDIT -** Audit and warning messages will be written to the system output stream (STDOUT). Error messages will be written to the system error stream (STDERR).
  - **ERROR -** Error messages will be written to the system error stream (STDERR).
  - **INFO -** Info, audit, and warning messages will be written to the system output stream. Error messages will be written to the system error stream (STDERR)
  - **OFF -** No server output is written to system streams (STDOUT). Only JVM output is written to system streams(STDOUT).
  - **WARNING -** Warning messages will be written to the system output stream (STDOUT). Error messages will be written to the system error stream (STDERR).

STDOUT and STDERR refer to the DD statements in the server JCL, e.g. spool output.

• **WLP_LOGGING_CONSOLE_FORMAT** - The required format for the console. Valid values are DEV, SIMPLE, or JSON format. By default, WLP_LOGGING_CONSOLE_FORMAT is set to DEV. Valid options are:

- **DEV -** Use the dev logging format.
- **JSON -** Use the JSON logging format.
- **SIMPLE -** Use the simple logging format. As of Liberty release 20.0.0.6 (z/OS Connect V3.034), this format writes the messages to STDOUT and STDERR with time stamps included.

• **WLP_OUTPUT_DIR** - This environment variable can be used to specify an alternative location for server generated output such as logs, the workarea directory, and generated files.

• **WLP_USER_DIR** – This environment variables specifies where the runtime environment looks for shared resources and server definitions.

Environment variables can also be used in the server configuration files. For example the following environment variables are automatically set in a Liberty server.

• **server.config.dir** – whose value will automatically be set to the value of variable WLP_USER_DIR concatenated with the name of the server, e.g. */var/ats/zosconnect/serverName*

• **server.output.dir -** whose value will automatically be set to the value of variable WLP_OUTPUT_DIR concatenated with the name of the server, e.g. */var/ats/zosconnect/serverName*

See URL *https://tinyurl.com/yyy4tjga* for more information.

Managing a z/OS Connect EE server with the Admin Center

WebSphere Liberty Profile provides an *Admin Center* feature which provide a web browser interface for viewing and/or managing a z/OS Connect EE server's configuration. Detailed information for this feature can be found at URL https://tinyurl.com/y2ec5m4l

This section provides details on how to add this feature to the Liberty server in which z/OS Connect EE is running and how to enable security and how to enable access to the *server.xml* and any include files referenced by the *server.xml*.

Security

• If SAF security register has not been enabled, add a <*user*> configuration <user> element for each administrator identity as shown below for identity Fred.

```
<administrator-role>
    <user>Fred</user>
 </administrator-role>
```

• If a SAF security register is being used, define an EJBRole resource and permit read access to each administrator's identity to this EJBRole resource (see below).

```
RDEFINE EJBROLE
BBGZDFLT.com.ibm.ws.management.security.resource.Administrator
OWNER(SYS1) UACC(NONE)

PERMIT BBGZDFLT.com.ibm.ws.management.security.resource.Administrator
                          CLASS(EJBROLE)  RESET

PERMIT BBGZDFLT.com.ibm.ws.management.security.resource.Administrator
CLASS(EJBROLE) ID(FRED) ACCESS(READ)

SETR RACLIST(EJBROLE) REFRESH
```

Tech Tip: The value ***BBGZDFLT*** in the above commands must match the value of attribute *profileprefix* in the existing *safCredentials* element in the server.xml.

Updates to the server.xml

The following Liberty *server.xml* updates are required.

- Add the *adminCenter-1.0* feature to the feature manager list.

```
  <featureManager>
            <feature>adminCenter-1.0</feature>
  </featureManager>
```

- To enable the updating of the *server.xml* from the web browser add these configuration elements to the server.xml.

```
<remoteFileAccess>
    <writeDir>${server.config.dir}</writeDir>
 </remoteFileAccess>
```

Tech Tip: The Admin Center can be used to view (and edit) the *server.xml*. But any files included in the *server.xml* must be accessible via the ${server.config.dir} directory structure. To address this requirement, I created a symbolic link from ${server.config.dir} to the directory containing the included files by entering OMVS command ***ln -s /wasetc/zc3lab zc3lab*** while positioned in ${server.config.dir} directory.

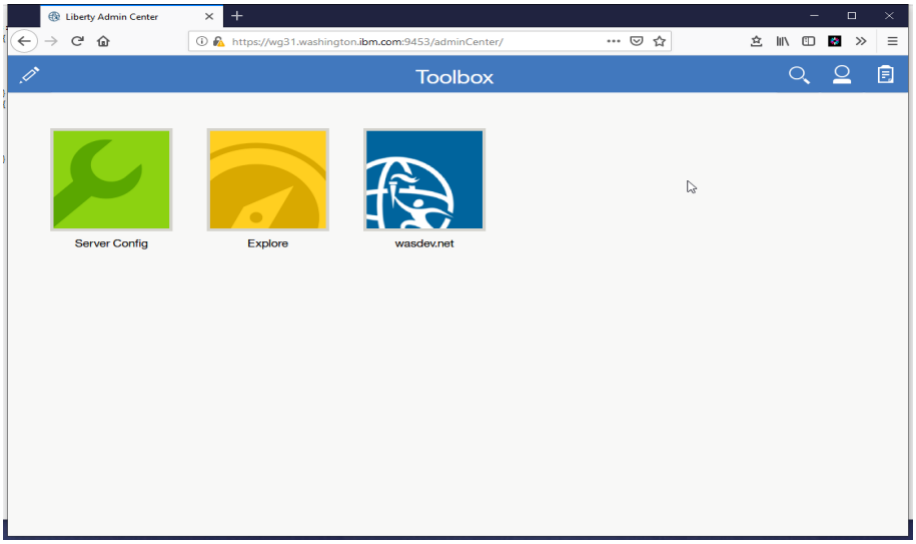
This makes files included from directory */wasetc/zc3lab* editable when included in the *server.xml* using statement *${server.config.dir}/zc3lab/* as in

<include location="${server.config.dir}/zc3lab/safSecurity.xml" optional="true"/>

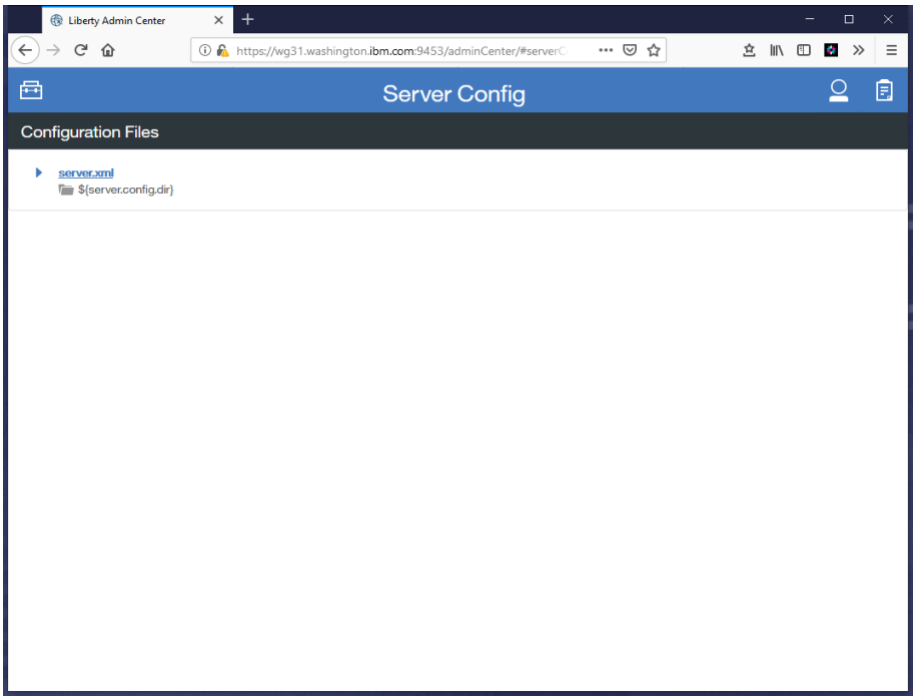
Accessing the Admin Center console

- To access the Admin Center console, enter in a web console the URI path /*adminCenter*, e.g. https://wg31.washington.ibmcom:9443/adminCenter and enter a valid user identity and password. Then press the **Submit** button.

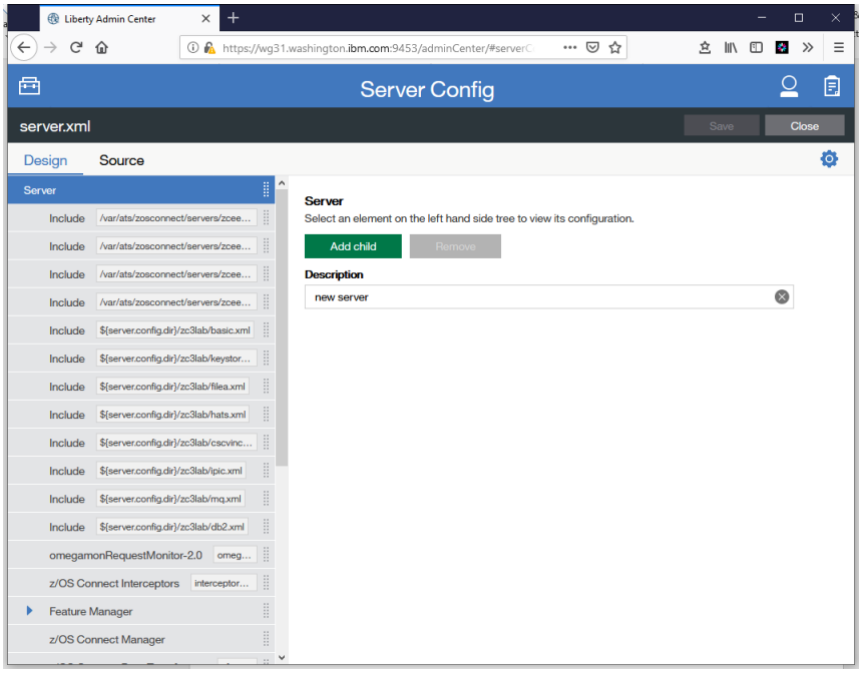
- You should see a screen like the one below. Click on the *Server Config* icon to continue.



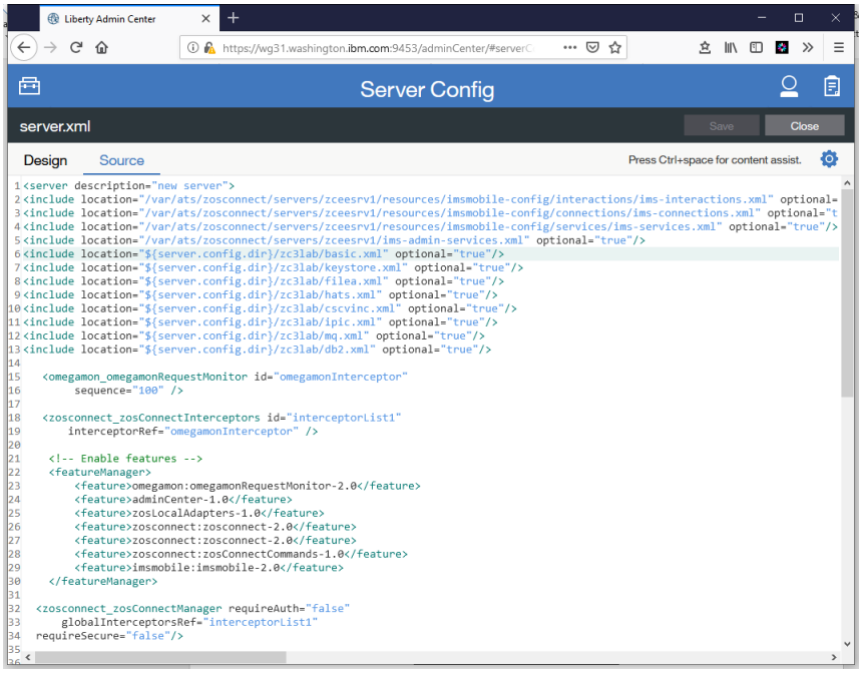
- This should display the screen below. Click on *server.xml* to continue.



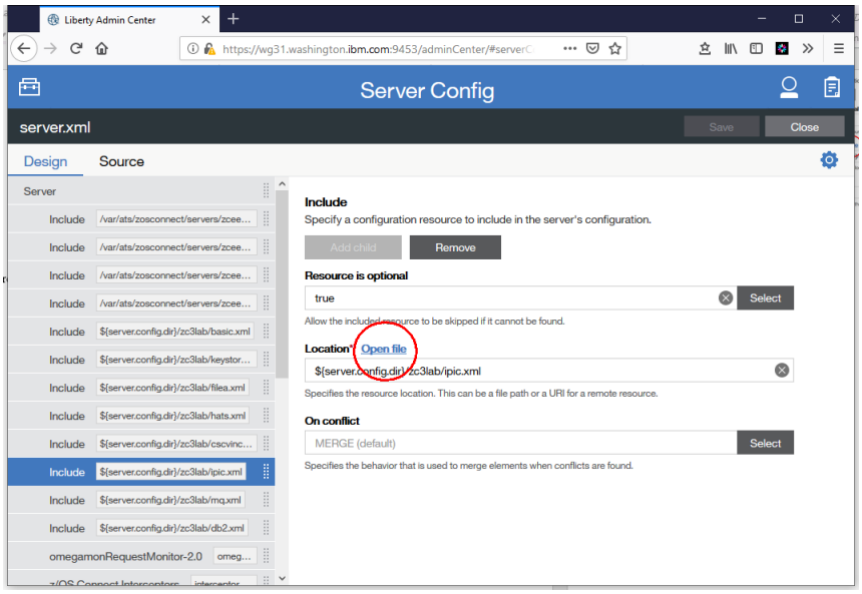
- Toggle between *Design* and *Source* to switch between views of the contents of the *server.xml*.
  - Design View:



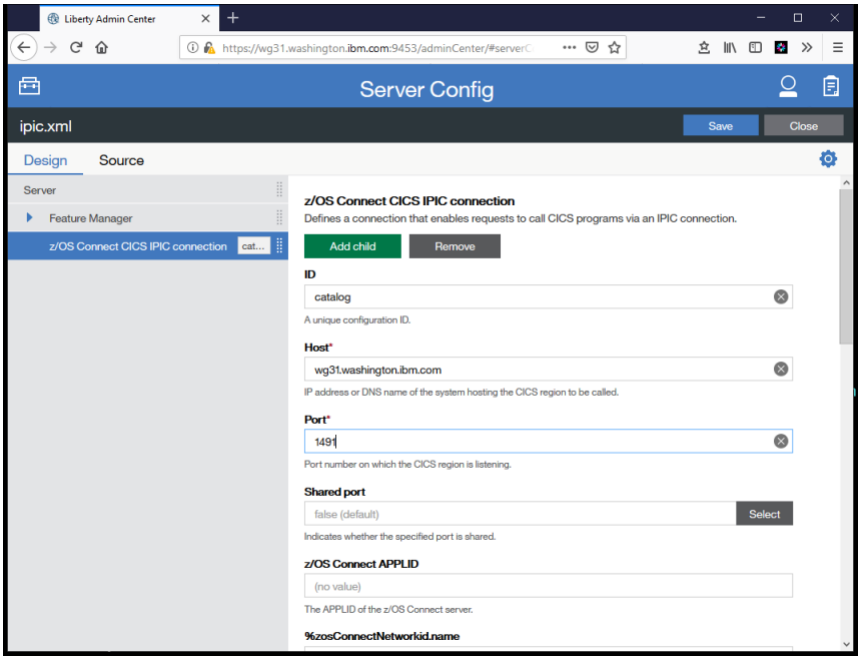
  - Source View:



• Using the *Design* view, you can select an include file and use the Open file option (see below) to display the contents of the file.



• On this screen an administrator can make changes to the configuration.



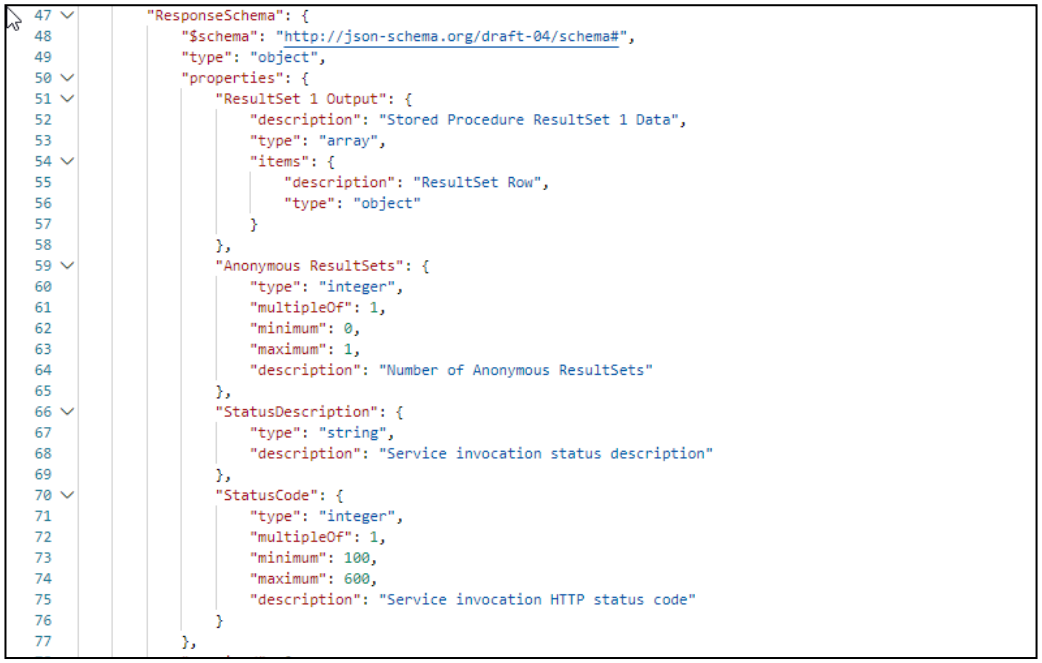
This provided a basic introduction to using the Admin Center console.

Db2 Stored Procedure Considerations

Accessing a Db2 stored procedure from a Db2 REST service has special considerations regarding the response message. When a Db2 REST services is created, the JSON request and response schemas are derived from "describe" information which is created and stored within the actual Db2 REST service package during the service creation process.

When a Db2 REST service is created that calls a stored procedure, the only “describe” information available is the name and signature of the stored procedure the maximum number of returned dynamic results sets (see DYNAMIC RESULTS SETS at URL https://tinyurl.com/sd7p544d).

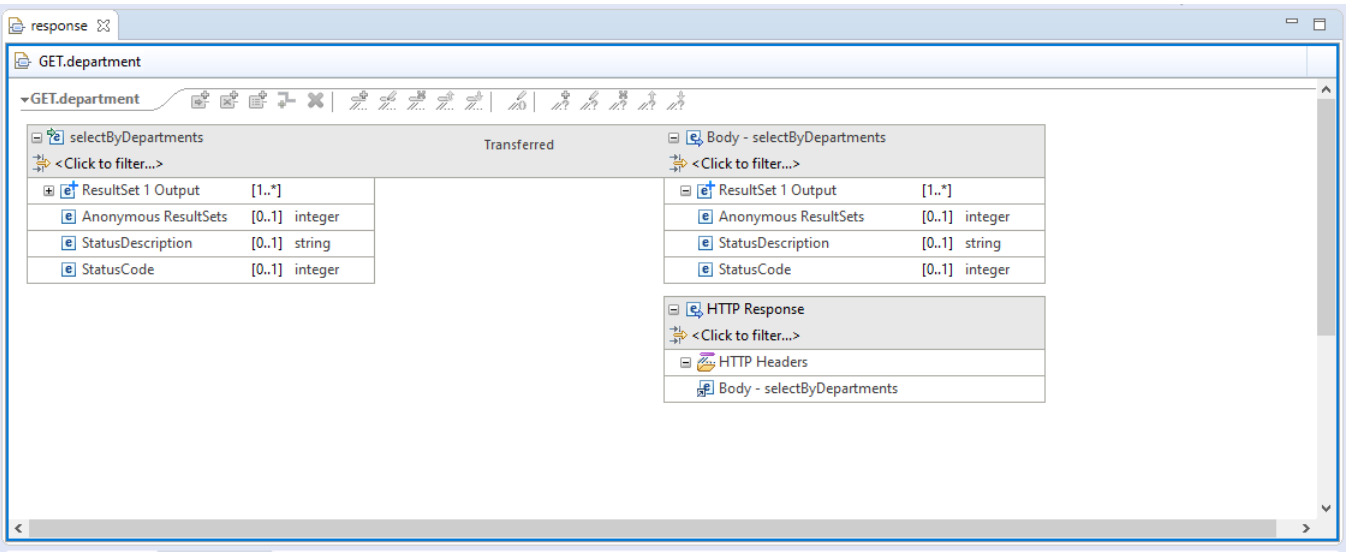
This means that for a Db2 REST service that calls a stored procedure, the JSON response schema for the results set does not have details on the contents of the results set entries, see below.



```
"ResponseSchema": {
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "object",
    "properties": {
        "ResultSet 1 Output": {
            "description": "Stored Procedure ResultSet 1 Data",
            "type": "array",
            "items": {
                "description": "ResultSet Row",
                "type": "object"
            }
        },
        "Anonymous ResultSets": {
            "type": "integer",
            "multipleOf": 1,
            "minimum": 0,
            "maximum": 1,
            "description": "Number of Anonymous ResultSets"
        },
        "StatusDescription": {
            "type": "string",
            "description": "Service invocation status description"
        },
        "StatusCode": {
            "type": "integer",
            "multipleOf": 1,
            "minimum": 100,
            "maximum": 600,
            "description": "Service invocation HTTP status code"
        }
    },
```

The results set entries are JSON arrays, where an individual array entry is the information returned by the stored procedure in JSON format.

The z/OS Connect API Editor given this response will only show the results as an array with no details of the array entries.



Let's see how these details can be obtained by a client.
Below is an actual response message from invoking a Db2 REST services. Note that JSON properties in the results set array, e.g. *firstName, lastName, middleInitial, phoneNumber*, *department and employeeNumber,* do not appear in the JSON response schema for the reason noted above.


```
{
    "Output Parameters": {},
    "StatusDescription": "Execution Successful",
    "ResultSet 1 Output": [
        {
            "firstName": "SALLY",
            "lastName": "KWAN",
            "middleInitial": "A",
            "phoneNumber": "4738",
            "department": "C01",
            "employeeNumber": "000030"
        },
        {
            "firstName": "DOLORES",
            "lastName": "QUINTANA",
            "middleInitial": "M",
            "phoneNumber": "4578",
            "department": "C01",
            "employeeNumber": "000130"
        },
        {
            "firstName": "HEATHER",
            "lastName": "NICHOLLS",
            "middleInitial": "A",
            "phoneNumber": "1793",
            "department": "C01",
            "employeeNumber": "000140"
        },
        {
            "firstName": "KIM",
            "lastName": "NATZ",
            "middleInitial": "N",
            "phoneNumber": "1793",
            "department": "C01",
            "employeeNumber": "200140"
        }
    ],
```

These fields will have to be manually extracted from the *result set* property in the response message by the client. The sample code below shows how do this in Java.

ZceeGet.java

```
48          URL url = new URL("https://wg31.washington.ibm.com:9443/db2/department?dept1=C01&dept2=C01");
49          System.out.println("URL: " + url);
50          HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();
51          conn.setRequestMethod("GET");
52          conn.setRequestProperty("Content-Type", "application/json");
53          conn.addRequestProperty("Authorization", "Basic VVNFUjE6VVNFUjE=");
54
55          try {
56
57              if (conn.getResponseCode() != 200) {
58                  throw new RuntimeException("Failed : HTTP error code : " + conn.getResponseCode());
59              }
60              BufferedReader bufferReader = new BufferedReader(new InputStreamReader((conn.getInputStream())));
61              String output;
62              StringBuilder stringBuffer = new StringBuilder();
63              while ((output = bufferReader.readLine()) != null) {
64                  ;
65                  stringBuffer.append(output);
66              }
67              JSONObject json = new JSONObject(stringBuffer.toString());
68              JSONArray jsonArray = json.getJSONArray("ResultSet 1 Output");
69              JSONObject jsonEntry = new JSONObject();
70              for (int index = 0; index < jsonArray.length(); index++) {
71                  jsonEntry = jsonArray.getJSONObject(index);
72                  if (jsonEntry.has("employeeNumber")){
73                      System.out.println("\nEmployee Number:  " + jsonEntry.get("employeeNumber"));
74                  }
75                  if (jsonEntry.has("firstName")){
76                     System.out.println("First Name  :     " + jsonEntry.get("firstName"));
77                  }
78                  if (jsonEntry.has("lastName")){
79                     System.out.println("Last Name:        " + jsonEntry.get("lastName"));
80                  }
81                  if (jsonEntry.has("middleInitial")){
82                      System.out.println("Middle Initial:   " + jsonEntry.get("middleInitial"));
83                  }
84                  if (jsonEntry.has("phoneNumber")){
85                     System.out.println("Phone Number:     " + jsonEntry.get("phoneNumber"));
86                  }
87                  if (jsonEntry.has("department")){
88                      System.out.println("Department:       " + jsonEntry.get("department"));
89                  }
90                  if (jsonEntry.has("missingField")){  // This checks to see if the field is present
91                      System.out.println("Missing Field:    " + jsonEntry.get("missingField"));
92                  } else System.out.println("field not present in JSON response");
93              }
94
95              System.out.println("\nStatusCode: " + json.get("StatusCode").toString());
96              System.out.println("StatusDescription: " + json.get("StatusDescription").toString());
97              conn.disconnect();
```

The results are shown below:

Problems | Javadoc | Declaration | Console | Coverage

```
<terminated> ZCEEGet [Java Application] C:\Program Files\IBM\Java80\jre\bin\javaw.exe (Aug 13, 2020, 12:37:28 PM)
URL: https://wg31.washington.ibm.com:9443/db2/department?dept1=C01&dept2=C01

Employee Number:  000030
First Name  :     SALLY
Last Name:        KWAN
Middle Initial:   A
Phone Number:     4738
Department:       C01
field not present in JSON response

Employee Number:  000130
First Name  :     DOLORES
Last Name:        QUINTANA
Middle Initial:   M
Phone Number:     4578
Department:       C01
field not present in JSON response

Employee Number:  000140
First Name  :     HEATHER
Last Name:        NICHOLLS
Middle Initial:   A
Phone Number:     1793
Department:       C01
field not present in JSON response

Employee Number:  200140
First Name  :     KIM
Last Name:        NATZ
Middle Initial:   N
Phone Number:     1793
Department:       C01
field not present in JSON response

StatusCode: 200
StatusDescription: Execution Successful
```

Alternatives to using CEEOPTS DD input for API Requesters

LE runtime options are used to pass parameters to the z/OS Connect EE (zCEE) API requester communication stub when an MVS batch or IMS API requester application invokes an external API using the zCEE API requester feature.

These LE runtime options enable a POSIX compatible runtime LE enclave (required for the stub) and environment variables which provide the host name on which a zCEE server resides and the port on which the server is listening for inbound request. Also present are environment variables that provide security credentials used for authenticating to the zCEE server.

These security credentials (and perhaps the host and port information also) are sensitive and probably not desirable to have these credentials exposed in clear text in the JCL of the job used to execute an API requester application, see the CEEOPTS DD statement input as shown below.

```
//GET  EXEC PGM=GETAPI,PARM='111111'
//STEPLIB  DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB
//         DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//SYSOUT   DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//CEEOPTS  DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9120",
"BAQUSERNAME=USER1",
"BAQPASSWORD=USER1")
//
```

A possible way to avoid specifying these LE runtime options in the JCL is to take advantage of an LE customization option where LE runtime options can be stored in a load module and obtained at execution time either by dynamically loading this module or having the module statically linked into the application load module.

Dynamically loading LE runtime options overrides is done be creating a load module named CEEROPT. This load module is then place in either the JOBLIB or STEPLIB concatenation sequences. This technique provides a solution where multiple sets of API requester applications can access the same load library containing the CEEROPT module and share the same set of LE override options concurrently. Statically linking a LE runtime options override module is done by creating a load module names CEEUOPT and then directly linking CEEUOPT into the API requester application load module during its linkage editing process.

There are advantages to both methods. For example, when using the dynamic loaded CEEROPT module a change to a username or password simply means recreating the load module once and all application have immediate access to the change information the next time they are executed Changing the statically linked module CEEUOPT means a change to its runtime options requires relinking all applications once the CEEUOPT module is updated. Statically linking the runtime options into the application load modules does provide runtime options isolation.

These load modules are described in the LE Customization Guide.

Creating a CEEROPT module

When dynamic loading is enabled (e.g. *SETCEE CEEROPT,ALL*), the LE runtime will check to see if a CEEROPT load module is accessible in either the JOBLIB or STEPLIB concatenation sequences. If a module with this name found, then this module will be used to provide overrides for system-wide default LE runtime options. This allows the same CEEROPT module to be shared across multiple instances of API requester client application. The CEEROPT load module is created by assembling a CEEXOPT macro and linking it into a load library.

```
//ASSEM EXEC PGM=ASMA90,PARM='DECK,NOOBJECT'
//SYSPRINT DD SYSOUT=*
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSPUNCH DD DSN=&&TEMPOBJ(CEEROPT),DISP=(,PASS),UNIT=SYSDA,
// SPACE=(TRK,(1,1,1)),DCB=(BLKSIZE=3120,LRECL=80,DSORG=PO)
//SYSLIB DD DSN=CEE.SCEEMAC,DISP=SHR
//       DD DSN=SYS1.MACLIB,DISP=SHR
//SYSIN DD *
CEEROPT  CSECT
CEEROPT  AMODE ANY
CEEROPT  RMODE ANY
         CEEXOPT POSIX=((ON),OVR),                                    +
               ENVAR=(('BAQURI=wg31.washington.ibm.com',              +
               'BAQPORT=9120',                                        +
               'BAQUSERNAME=USER1',                                   +
               'BAQPASSWORD=USER1'),OVR),                             +
               RPTOPTS=((ON),OVR)
         END
//LKED  EXEC  PGM=IEWL,
//          PARM='NCAL,RENT,LIST,XREF,LET,MAP,SIZE=(9999K,96K)'
//SYSPRINT DD  SYSOUT=*
//SYSUT1   DD  UNIT=SYSDA,SPACE=(TRK,(5,5))
//SYSLMOD  DD  DSNAME=USER1.ZCEE.LOADLIB,DISP=SHR
//SYSLIB   DD  DSN=&&TEMPOBJ,DISP=(OLD,PASS)
//SYSLIN   DD  *
 INCLUDE SYSLIB(CEEROPT)
  ENTRY  CEEROPT
   ORDER CEEROPT
 NAME CEEROPT(R)
/*
```

Tech-Tip: In the above example the plus signs (+) are in column 72 of the macro's source. The CEEXOPT macro starts in column 10 and the continuation lines start in column 16. The RUNOPTS options displays the LE runtime options as they are set at execution time in the job's output.

This load library (USER1.ZCEE.LOADLIB) can then be placed in the JOBLIB or STEPLIB concatenation list of the JCL used to execute the API requester client applications (see below).

Compiling and linking an API requester application

The JCL used to compile and link-edit an API requester client application does not change

```
//COMPILE EXEC IGYWCL,LNGPRFX=IGY620,PARM.COBOL='NODYNAM'
//COBOL.SYSIN  DD DISP=SHR,DSN=USER1.ZCEE.SOURCE(GETAPI)
//COBOL.SYSLIB DD DISP=SHR,DSN=USER1.ZCEE.SOURCE
//             DD DISP=SHR,DSN=ZCEE30.SBAQCOB
//LKED.SYSLMOD DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB(GETAPI)
//LKED.SYSLIB  DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB
//LKED.BAQLIB  DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//LKED.SYSIN   DD *
  INCLUDE BAQLIB(BAQCSTUB)
//
```

Only the BAQCSTUB needs to be include in the linkage process.

Tech-Tip: Unless the CEEPRMxx member in SYS1.PARMLIB used at IPL enables the loading and use of CEEROPT for run time option (CEEROPT(ALL)), these runtime options modules will be ignored. This can be overridden with MVS command ***SETCEE CEEROPT,ALL***

Creating a CEEUOPT module

Statically linking the runtime options module for each individual API requester application means that the CEEUOPT module is linked directly into the API requester load module. The CEEUOPT load module is created by assembling a CEEXOPT macro and then linking it into a load library.

```
//ASSEM EXEC PGM=ASMA90,PARM='DECK,NOOBJECT'
//SYSPRINT DD SYSOUT=*
//SYSUT1 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT2 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSUT3 DD UNIT=SYSDA,SPACE=(CYL,(1,1))
//SYSPUNCH DD DSN=&&TEMPOBJ(CEEUOPT),DISP=(,PASS),UNIT=SYSDA,
// SPACE=(TRK,(1,1,1)),DCB=(BLKSIZE=3120,LRECL=80,DSORG=PO)
//SYSLIB DD DSN=CEE.SCEEMAC,DISP=SHR
//       DD DSN=SYS1.MACLIB,DISP=SHR
//SYSIN DD *
CEEUOPT  CSECT
CEEUOPT  AMODE ANY
CEEUOPT  RMODE ANY
         CEEXOPT POSIX=(ON),                                          +
               ENVAR=('BAQURI=wg31.washington.ibm.com',               +
               'BAQPORT=9120',                                        +
               'BAQUSERNAME=Fred',                                    +
               'BAQPASSWORD=fredpwd')
         END
//LKED    EXEC  PGM=IEWL,
//         PARM='NCAL,RENT,LIST,XREF,LET,MAP,SIZE=(9999K,96K)'
//SYSPRINT DD  SYSOUT=*
//SYSUT1   DD  UNIT=SYSDA,SPACE=(TRK,(5,5))
//SYSLMOD  DD  DSN=USER1.ZCEE.LOADLIB,DISP=SHR
//SYSLIB   DD  DSN=&&TEMPOBJ,DISP=(OLD,PASS)
//SYSLIN   DD  *
 INCLUDE SYSLIB(CEEUOPT)
  ENTRY  CEEUOPT
   ORDER CEEUOPT
 NAME CEEUOPT(R)
/*
```

Tech-Tip: In the above example the plus signs (+) are in column 72 of the macro's source. The CEEXOPT macro starts in column 10 and the continuation lines start in column 16.

Compiling and linking an API requester application with static override

The JCL to compile and link API request module in this case does change to add ORDER and INCLUDE statements for the CEEUOPT module.

```
//COMPILE EXEC IGYWCL,LNGPRFX=IGY620,PARM.COBOL='NODYNAM'
//COBOL.SYSIN  DD DISP=SHR,DSN=USER1.ZCEE.SOURCE(GETAPI)
//COBOL.SYSLIB DD DISP=SHR,DSN=USER1.ZCEE.SOURCE
//             DD DISP=SHR,DSN=ZCEE30.SBAQCOB
//LKED.SYSLMOD DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB(GETAPI)
//LKED.SYSLIB  DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB
//LKED.BAQLIB  DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//LKED.SYSIN   DD *
 ORDER CEESTART
 INCLUDE SYSLIB(CEEUOPT)
 INCLUDE BAQLIB(BAQCSTUB)
//
```

Updated JCL for executing the API request application

When using either dynamic or static LE option overrides, the JCL to execute the API requester application is changed to remove the CEEOPTS DD statement. Otherwise, the JCL is the same.

```
//COMPILE EXEC PGM=GETAPI,PARM='111111'
//STEPLIB  DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB
//         DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//SYSOUT   DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//
```

Eliminating the CEEOPTS in an API Requester's JCL

Providing LE runtime options (e.g. POSIX(ON)) and z/OS Connect environment variables for BAQURI and PORT and be avoided by using a combination of options. As described in the previous section, LE runtime options and requirement environment variables can be provided using LE runtime option modules CEEROPT or CEEUOPT. This solution works but does not provide a means to dynamically or programmatically specify z/OS Connect environment variables at execution time. This section will describe how z/OS Connect environment variables can be specified by the COBOL application.

If you want to eliminate entirely the need for a *CEEOPTS* DD statement, you will still need to specify the LE POSIX option (see below) in a CEEROPT or CEEUOPT options module.

```
          PRINT NOGEN
CEEROPT   CSECT
CEEROPT   AMODE ANY
CEEROPT   RMODE ANY
          CEEXOPT POSIX=((ON),OVR)
          END
```

Follow the instructions in the previous section but this time the only CEEXOPT attribute that is needed is the POSIX attribute.

LE provides a function (CEEENV) that provides to direct access to the current set of environment variables from a COBOL application. This allows the COBOL application to either add a new environment variable or replacing the value of a current environment variable at execution. This applies to the z/OS Connect environment variables:

- BAQURI
- BAQPORT
- BAQUSERNAME
- BAQTIMEOUT
- BAQVERBOSE

The COBOL application could invoke the *CEEENV* function with a function code of ***2*** and add a new environment variable if it did not already exist in the LE enclave. Invoking *CEEENV* with a function code of ***5*** would either replace the value of an existing environment variable or add the environment if is it did not already exist.

Below is an example of a COBOL application using the CEEENV function to set the values for environment variables BAQURI and BAQPORT.

```
       01  functionCode          PIC 9(9) BINARY.
       01  envVariableNameLength PIC 9(9) BINARY.
       01  envVariableName       PIC X(255).
       01  valueLength           PIC 9(9) BINARY.
       01  valuePointer          POINTER.
       01  feedbackCode.
           02  CONDITION-TOKEN-VALUE.
           COPY  CEEIGZCT.
               03  CASE-1-CONDITION-ID.
                  04  SEVERITY     PIC S9(4) BINARY.
                  04  MSG-NO       PIC S9(4) BINARY.
               03  CASE-SEV-CTL    PIC X.
               03  FACILITY-ID     PIC XXX.
           02  I-S-INFO            PIC S9(9) BINARY.
       01  VAL       PIC X(255).
+++++++
       ******************************************************
       **   Set the BAQURI and BAQPORT environment variables
       ******************************************************
            MOVE "BAQURI" TO envVariableName.
            MOVE 6 TO envVariableNameLength.
            MOVE "wg31.washington.ibm.com" TO VAL.
            MOVE 23 TO valueLength.
            PERFORM CALL-CEEENV THRU CALL-CEEENV-END
            MOVE "BAQPORT" TO envVariableName.
            MOVE 7 TO envVariableNameLength.
            MOVE "9120" TO VAL.
            MOVE 4 TO valueLength.
            PERFORM CALL-CEEENV THRU CALL-CEEENV-END
++++++++ CALL BAQCSTUB
       CALL-CEEENV.
           MOVE 5 TO functionCode.
           SET valuePointer to address of val
           CALL "CEEENV" USING functionCode,
                               envVariableNameLength,
                               envVariableName,
                               valueLength,
                               valuePointer,
                               feedbackCode.

       CALL-CEEENV-END.
```

Example JCL for executing the API request application

For example, this technique allows providing the host and port of the z/OS Connect server as JCL parameters.

```
//COMPILE EXEC PGM=GETAPI,PARM='111111,wg31.washington.ibm.com,9120'
//STEPLIB  DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB
//         DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//SYSOUT   DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
```

Providing OAUTH 2.0 and JWT Credentials in an API Requester

This same technique described in the previous sections can be extended to provide security parameters when calling an outbound RESTful API request that is secured with OAUTH 2.0 or a JSON Web Token. In this case just add your own environment variables to the CEEXOPT macro as shown in the example below:

```
          PRINT NOGEN
CEEROPT   CSECT
CEEROPT   AMODE ANY
CEEROPT   RMODE ANY
          CEEXOPT POSIX=((ON),OVR),                                          +
                ENVAR=(('ATSOAUTHUSERNAME=oauthUserName',                    +
                'ATSOAUTHPASSWORD=oauthPassword',                            +
                'ATSOAUTHCLIENTID=oauthClientID',                            +
                'ATSOAUTHCLIENT-SECRET=oauthClientSecret',                   +
                'ATSTOKENUSERNAME=tokenUserName',                            +
                'ATSTOKENPASSWORD=tokenPassword',                            +
                'BAQUSERNAME=USER1',                                         +
                'BAQPASSWORD=USER1'),OVR)
*               'BAQURI=wg31.washington.ibm.com'),                          +
*               'BAQPORT=9120',                                             +
          END
```

The size the ENVAR variable cannot exceed 250 characters, so care should be taken to limit the size of the environment variable names and/or values, so this limit is not exceeded.

Below is a sample program that shows the updates that can be made to an API requester COBOL program to obtaining the environment variables from a CEEROPTS module and placing them in the BAQRINFO structure. This is not a complete example, it does not show initializing the request message, making the communication stub call or processing the response message.

```
CBL QUOTE
      ***************************************************************
      ** Function: ZCEEENV - Process environment variables          *
      ***************************************************************
       IDENTIFICATION DIVISION.
       PROGRAM-ID. ZCEEENV.

       DATA DIVISION.
       WORKING-STORAGE SECTION.

       01  functionCode          PIC 9(9) BINARY.
       01  envVariableNameLength PIC 9(9) BINARY.
       01  envVariableName       PIC X(255).
       01  valueLength           PIC 9(9) BINARY.
       01  valuePointer          POINTER.
       01  ws-length             PIC 9(3).

       01  feedbackCode.
           02  CONDITION-TOKEN-VALUE.
           COPY  CEEIGZCT.
               03  CASE-1-CONDITION-ID.
                  04  SEVERITY     PIC S9(4) BINARY.
                  04  MSG-NO       PIC S9(4) BINARY.
               03  CASE-SEV-CTL    PIC X.
               03  FACILITY-ID     PIC XXX.
           02  I-S-INFO            PIC S9(9) BINARY.
       01  VAL       PIC X(255).

       COPY BAQRINFO.

       LINKAGE SECTION.
       01  VAR       PIC X(5000).

       PROCEDURE DIVISION.
       MAIN-PROG.
      ***************************************************
      **   Get the ATSOAUTHUSERNAME environment variable
      ***************************************************
           MOVE "ATSOAUTHUSERNAME" TO envVariableName.
           PERFORM CALL-CEEENV THRU CALL-CEEENV-END
           IF valueLength NOT = 0 THEN
              MOVE VAR(1:valueLength) TO BAQ-OAUTH-USERNAME 1
              MOVE valueLength TO BAQ-OAUTH-USERNAME-LEN 1
              DISPLAY "BAQ-OAUTH-USERNAME-LEN = " BAQ-OAUTH-USERNAME-LEN
              DISPLAY "BAQ-OAUTH-USERNAME = " BAQ-OAUTH-USERNAME
           ELSE
               DISPLAY envVariableName(1:envVariableNameLength)
                 " NOT FOUND"
           END-IF.
```

1: These instructions place the value of the environment variable and its length into the z/OS Connect communication stub request information area. This same code would be repeated for each variable by varying the environment variable name and the name of the request structure variable.

```
 Not all the code is shown for processing the other variables.

           GOBACK.
       CALL-CEEENV.
           MOVE 1 TO functionCode.
           MOVE ZERO TO ws-length.
           INSPECT FUNCTION REVERSE (envVariableName)
                TALLYING ws-length FOR LEADING SPACES.
           COMPUTE envVariableNameLength =
               LENGTH OF envVariableName - ws-length.
           MOVE " " TO VAL.
           MOVE 0 TO valueLength.
           CALL "CEEENV" USING functionCode,
                               envVariableNameLength,
                               envVariableName,
                               valueLength,
                               valuePointer,
                               feedbackCode.

           IF valueLength NOT = 0 THEN
               SET ADDRESS OF VAR TO valuePointer .
       CALL-CEEENV-END.
```

With this as the results.

```
BAQ-OAUTH-USERNAME-LEN = 0000000013
BAQ-OAUTH-USERNAME = oauthUserName


BAQ-OAUTH-PASSWORD-LEN = 0000000013
BAQ-OAUTH-PASSWORD = oauthPassword


BAQ-OAUTH-CLIENTID-LEN = 0000000013
BAQ-OAUTH-CLIENTID = oauthClientID


BAQ-OAUTH-CLIENT-SECRET-LEN = 0000000017
BAQ-OAUTH-CLIENT-SECRET = oauthClientSecret


BAQ-TOKEN-USERNAME-LEN = 0000000013
BAQ-TOKEN-USERNAME = tokenUserName


BAQ-TOKEN-PASSWORD-LEN = 0000000013
BAQ-TOKEN-PASSWORD = tokenPassword
```

Controlling Dynamic Updates

Various components in the server configuration can be configured so updates, additions, or deletions of the underlying components are applied at a specified time intervals or upon explicit request.

This is controlled by the configuration attribute *updateTrigger* which is valid for the configuration elements shown below.

This attribute can be set to *polled* with means the server will scan and apply changes at an explicit interval. Note that this setting can increase CPU utilization and file I/O because the server will constantly be scanning the file systems looking for changes.

Another option for this attribute is *mbean*. This setting will cause the server to apply updates when initiated by an external request. For z/OS Connect this usually means an MVS modify command but it also can mean by a client using the JMX interface, for more information on the latter see URL https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=demand-using-mbean-trigger-updates

When a server is created using one of the provided templates, a subset of the configuration elements shown below are included in the *server.xml* file automatically. For the configuration elements other than *zosconnect_zosConnectDataXform*, the default value for *updateTrigger* is *disabled.* The configuration element *zosconnect_zosConnectDataXform* has a default value of *updateTrigger* of *polled* with a default *pollingRate* of *2s*. This is something you may want to change. The key is to be aware of this behavior and understand the implication of polling.

```
   <!-- applicationMonitor is not applicable for z/OS Connect EE servers -->
<applicationMonitor updateTrigger="polled" dropinsEnabled="true"/>

<!-- config requires updateTrigger="mbean" for REFRESH command support -->
 <config updateTrigger="polled" monitorInterval="500ms"/>

<!-- zosConnect APIs -->
 <zosconnect_zosConnectAPIs pollingRate="5s" updateTrigger="disabled"    />

<!-- zosConnect API requesters -->
 <zosconnect_apiRequesters updateTrigger="disabled" pollingRate="5s"/>

<!-- zosConnect Services -->
 <zosconnect_services pollingRate="5s" updateTrigger="disabled"/>

<!-- zosConnect policies -->
 <zosconnect_policy pollingRate="1m" updateTrigger="disabled"/>

<!-- zosConnect data transformer -->
 <zosconnect_zosConnectDataXform pollingrate="2s" updateTrigger="polled"/>

<!—A security certificate repository -->
 <keystore pollingrate="500ms" updateTrigger="mbean"/>
```

z/OS Connect and Data Virtualization Manager

This section shows an example of the connectivity requirements for between a DVM server, and a z/OS Connect server. The DVM server should be fully initialized before the client z/OS Connect is started. This sequence is required before the DVM server will establish the WOLA communication area between the two servers. If the z/OS Connect server is started first, it will write error messages indicating that the targeted DVM server is not available.

This section shows an example of what was used in the Washington System Center to configure DVM and z/OS Connect.

DVM configuration

Updates to the DVM configuration are done in server initialization member in the data set identified by DD name *SYSEXEC*. The member name is determined by concatenation the server's subsystem name with the string IN00. So, if the subsystem name is AVZS the server initialization member is the PDS member AZVSIN00 in the data set for DD name *SYSEXEC*.

If the DVM start up procedure has JCL like this example:

```
//AVZS          PROC SSID=AVZS,
//              OPT=INIT,
//              TRACE=B,
//              MSGPFX=AVZ,
//              REG=8M,
//              MEM=32G,
//              HLQ='DVS'
.   .    .

//SYSEXEC       DD   DISP=SHR,DSN=&HLQ..&SSID..SAVZEXEC
```

The server initialization member would be member *AVZSIN00* in data set *DVS.AZVS.SAVZEXEC*.

Enable the z/OS Connect interface facility by location the changing the *DontDoThis* check to *DoThis* and providing values for the NAME, RNAME and WNAME ZCPATH attributes.

```
/*-------------------------------------------------------------------*/
/* Enable z/OS Connect interface facility                            */
/*-------------------------------------------------------------------*/
if DoThis then
  do
   /*----------------------------------------------------------------*/
   /* The following parameter enables the z/OS Connect interface     */
   /* facility.                                                      */
   /*----------------------------------------------------------------*/
   "MODIFY PARM NAME(ZCONNECT)              VALUE(YES)"
   "MODIFY PARM NAME(NETWORKBUFFERSIZE)     VALUE(96K)"
   /*----------------------------------------------------------------*/
   /*----------------------------------------------------------------*/
   /* The "DEFINE ZCPATH" command(s) can be used to define           */
   /* paths to z/OS COnnect regions to handle requests.              */
   /* Use a separate '"DEFINE ZCPATH" command to define each         */
   /* path required (Note that a single path can handle              */
   /* several different requests)                                    */
   /* refer to the documentation for details about the parameters,   */
   /* and information about optional parameters.                     */
   /*----------------------------------------------------------------*/
   "DEFINE ZCPATH",
   "  NAME(ZCEE)                    ",
   "  RNAME(ZCEEDVM)                ",
   "  WNAME(ZCEEDVM)                ",
   ""
  end
```

z/OS Connect server.xml configuration

An OMVS file was created named DVM.xml and included in the base server.xml file. The contents of this file are shown below:

```
    <!-- Enable DVM related features -->
    <featureManager>
      <feature>usr:dvsProvider</feature>
      <feature>zosLocalAdapters-1.0</feature>
    </featureManager>

<!-- Adapter Details with WOLA Group Name (ZCEEDVM) -->
    <zosLocalAdapters wolaName3="NAME3"
      wolaName2="NAME2"
      wolaGroup="ZCEEDVM"/>

<!-- DVS Service Details with Register Name (ZCEEDVM) -->
    <zosconnect_zosConnectService invokeURI="/dvs"
     serviceDescription=""
     serviceRef="dvsService"
     serviceName="dvsService"
     id="zosConnectDvsService"/>

    <usr_dvsService invokeURI="/dvs"
     serviceName="DVSS1"
     registerName="ZCEEDVM"
     connectionFactoryRef="wolaCF"
     id="dvsService"/>

   <connectionFactory jndiName="eis/ola" id="wolaCF">
       <properties.ola/>
   </connectionFactory>

   <zosconnect_zosConnectService serviceRef="svc1"
    serviceAsyncRequestTimeout="600s"
    serviceName="dvs1" id="sdef1"/>

   <zosconnect_localAdaptersConnectService
    connectionWaitTimeout="7200"
    connectionFactoryRef="wolaCF"
    serviceName="DVSS1"
    registerName="ZCEEDVM"
    id="svc1"/>
```

Finally, to allow the two servers to connect using WOLA a CBIND RACF resource was defined and the identity under which the z/OS Connect server was running was permitted READ access:

RDEFINE CBIND BBG.WOLA.ZCEEDVM. UACC(NONE)**

PERMIT BBG.WOLA.ZCEEDVM. CLASS(CBIND) ID(LIBSERV) ACC(READ)**

SETROPTS RACLIST(CBIND) REFRESH

Sample JCL

This section contains sample JCL to perform z/OS Connect EE related functions.

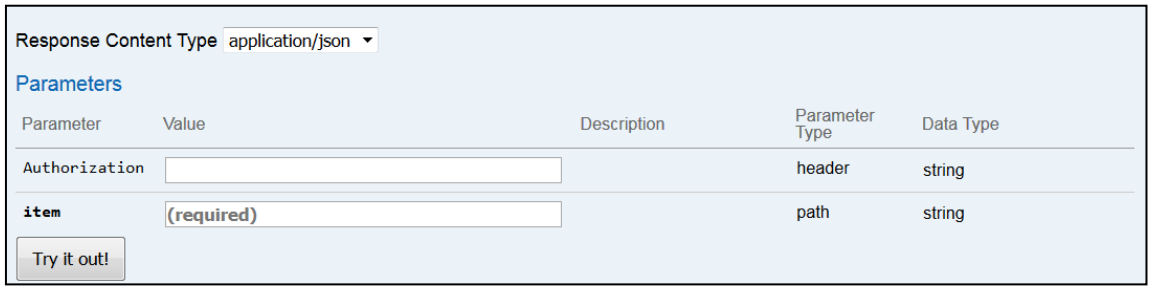
Copy WOLA executables to a load library

The JCL below is an example of how to copy the WOLA executables from WebSphere Liberty directory to an MVS PDSE.

```
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET DSNAME='USER1.WOLA2008.LOADLIB'
// SET ZCEEPATH='/usr/lpp/IBM/zosconnect/v3r0'
// SET JAVAHOME='/usr/lpp/java/J8.0_64'
//*************************************************************
//*  Step ALLOC    - Allocate a PDSE load library
//*************************************************************
//ALLOC EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *,SYMBOLS=EXECSYS
  DELETE '&DSNAME'
  SET MAXCC=0
  ALLOC DSNAME('&DSNAME') -
     NEW CATALOG SPACE(2,1) DSORG(PO) CYLINDERS -
     RECFM(U) DSNTYPE(LIBRARY)
//*************************************************************
//*  Step WOLACOPY - copy the WOLA executables to the PDSE
//*************************************************************
//WOLACOPY EXEC PGM=IKJEFT01,REGION=0M
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSPRT DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
  export JAVA_HOME=&JAVAHOME; +
  export DSNAME=&DSNAME; +
  cp -Xv &ZCEEPATH/wlp/clients/zos/* "//'$DSNAME'"
```

Base64 Encoding and Swagger UI

An authorization token must be provided when using the Swagger UI interface to test an API when security is enabled, see *Authorization* below. The authorization token consists of an encoded string based on a combination of the user identity and password.



The token is not sent in the clear, it is encoded first using a base 64 representation of the concatenation of the user identity, a colon and the password. For example, the encoded representation of string *Fred:fredpwd* is *RnJlZDpmcmVkcHd* and would be entered in the *Authorization* area as ***BASIC RnJlZDpmcmVkcHf***. There are several ways to perform this encoding. The URL https://www.base64encode.org/ provides an internet tool for encoding authorization tokens.

If using an internet tool is not an option, then the sample Java program below can be used to do then encoding locally. To use this program, download an Eclipse package and add the sample Java code below to a Java project and run this Java application to do the encoding locally.

```
package com.ibm.ats.encode;
import org.apache.commons.codec.binary.Base64;
public class EncodeDecode {

      public static void main(String[] args) {
      // encode data on your side using BASE64
      String str = "Fred:fredpwd";
      byte[]   bytesEncoded = Base64.encodeBase64(str .getBytes());

      System.out.println("ecncoded value is " + new String(bytesEncoded
));

      // Decode data on other side, by processing encoded data
      byte[] valueDecoded= Base64.decodeBase64(bytesEncoded );
      System.out.println("decoded value is " + new
String(valueDecoded));
    }
```

Note the imported project *org.apache.commons.codec.binary.Base64* can be found in Eclipse JAR file *commons-codec-1.4.jar* (or its equivalent based on the Eclipse package in use).

RESTful APIs

There are a variety of different IBM Documentation pages around RESTful APIs & z/OS Connect for z/OS Resources (CICS, IMS, DB2, & MQ). Click on the links below to learn more about each topic, please reach out to John Brefach (John.j.brefach@ibm.com) if you are having trouble finding a specific topic around RESTful APIs.

Each z/OS Resource also has z/OS Connect Lab exercises. Please reach out to either Mitch Johnson (mitchj@us.ibm.com) or John Brefach (John.j.brefach@ibm.com) to learn more about how you can access these lab exercises. There are z/OS Connect lab exercises for both OpenAPI 2 and OpenAPI 3.

MVS Batch Lab exercises:

Developing MVS Batch API Requester Applications: https://tinyurl.com/yeyu28fw

CICS RESTful APIs

Below there are IBM Documentation pages about CICS RESTful APIs in reference to z/OS Connect. There is a brief overview attached to each link to give you a preview of the information contained at the link provided.

The WSC GitHub site also has lab exercises around developing RESTful APIs for CICS COMMAREA & CICS Channels. Please reach out to either Mitch Johnson (mitchj@us.ibm.com) or John Brefach (John.j.brefach@ibm.com) to learn more about how you can access these lab exercises. There are z/OS Connect lab exercises for both OpenAPI 2 and OpenAPI 3.

Concepts of JSON Web Services:
https://www.ibm.com/docs/en/cics-ts/6.x?topic=services-concepts-json-web
This page provides an overview of JSON Web Services, JSON Schema, and Implementation of JSON based Web Services all around CICS.

Concepts of RESTful JSON web services:
https://www.ibm.com/docs/en/cics-ts/6.x?topic=services-concepts-restful-json-web
This page provides a more in-depth view into RESTful properties for CICS JSON Web services including HTTP Methods, Request/Response messages, and the Uniform Resource Identifier (URI). There is an attached reference page (https://developer.ibm.com/articles/ws-restful/) around a general overview of RESTful Properties if you want more information.

Call an API from a CICS application (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=sor-call-api-from-cics-application
This page is showing how to call an API from a CICS application through z/OS Connect.

Create a CICS Service (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=services-create-cics-service#toolkit_sar
This page demonstrates how to create a CICS service in order to develop your RESTful API for z/OS Connect (OpenAPI 2 Specification

Creating a CICS z/OS Asset (OpenAPI 3):
https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=asset-creating-cics-zos
This page gives you the option of looking into either creating a CICS COMMAREA z/OS Asset or creating a CICS CHANNEL z/OS Asset for z/OS Connect (OpenAPI 3 Specification)

Migrating a CICS provider API from IBM z/OS Connect OpenAPI 2 to OpenAPI 3:
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=30-migrating-openapi-2-openapi-3
This page teaches you how to migrate your existing APIs running on a z/OS Connect OpenAPI 2 server to an OpenAPI 3 z/OS Connect server without changing the exposed API.

OpenAPI 2 Labs:
Developing RESTful APIs for a CICS COMMAREA: https://tinyurl.com/24f8br8f
Developing RESTful APIs for a CICS Channel: https://tinyurl.com/nnrah2ak
Developing CICS API Requester Applications: https://tinyurl.com/yjtymbs2
OpenAPI 3 Labs:
Developing Native Server RESTful APIs for accessing a CICS Program:
https://tinyurl.com/y9cuv5h8

IMS TM & DB RESTful APIs

This section contains IBM Documentation around IMS RESTful APIs in reference to z/OS Connect. There is a brief overview attached to each link to give you a preview of the information contained at the link provided.

The WSC GitHub site also has lab exercises around developing RESTful APIs for IMS. Please reach out to either Mitch Johnson (mitchj@us.ibm.com) or John Brefach (John.j.brefach@ibm.com) to learn more about how you can access these lab exercises. There are z/OS Connect lab exercises for both OpenAPI 2 and OpenAPI 3.

Create an API to invoke the IMS phone book service (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=apis-create-api-invoke-ims-phone-book-service
This page will demonstrate how to utilize the z/OS Connect API Toolkit to develop a REST API for an IMS phonebook service. There are several tasks you are recommended to follow that will be listed as additional pages to help you with this development.

Mobile and REST API solution with IBM z/OS Connect Enterprise Edition:
https://www.ibm.com/docs/en/ims/15.6.0?topic=fisi1-mobile-rest-api-solution-zos-connect-enterprise-edition
This page provides an overview of using z/OS Connect REST services and APIs in order to access your IMS assets. There is a general overview of utilizing IMS as an API Provider or as an API Consumer.

Using the IMS service provider (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=20-using-ims-service-provider
Learn how to create a service to enable RESTful access to IMS transactions. There are several sub-topics including how to set up your server to use the IMS service provider for the first time as well as security configurations and more.

Configuring IMS to access IBM z/OS Connect for API calls (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=requesters-configuring-ims-access-zos-connect-api-calls
This page will show you how to enable RESTful API calls for IMS applications through z/OS Connect by configuring the API requester communication stub in your IMS system.

Creating an IMS z/OS Connect API (OpenAPI 3):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=project-creating-ims-zos-connect-api
This page will teach you how to use the z/OS Connect designer and create an API project to call an example IMS Program.

Creating an IMS z/OS Asset (OpenAPI 3):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=asset-creating-ims-zos
This page shows you how to develop an IMS z/OS Asset using the z/OS Connect Designer for OpenAPI 3. The two options this page will direct you to is either creating an IMS Transaction z/OS Asset or an IMS Large Data Set Asset.

OpenAPI 2 Lab:
Developing RESTful APIs for IMS Transactions: https://tinyurl.com/3xwmz7jm
Developing IMS/TM API Requesters Applications: https://tinyurl.com/4a2f7j89
OpenAPI 3 Lab:
z/OS Connect and IMS OpenAPI 3 – Part 1(GET): https://tinyurl.com/29kde7cp
z/OS Connect and IMS OpenAPI 3 – Part 2(POST): https://tinyurl.com/yckf8sar
z/OS Connect and IMS OpenAPI 3 – Part 3(PUT): https://tinyurl.com/4s9mnp94
z/OS Connect and IMS OpenAPI 3 – Part 4(DELETE): https://tinyurl.com/bby2735r

Db2 RESTful APIs

Below there are IBM Documentation pages about Db2 REST APIs in reference to z/OS Connect. There is a brief overview attached to each link to give you a preview of the information contained at the link provided.

The WSC GitHub site also has lab exercises around developing REST APIs for Db2 REST Services. Please reach out to either Mitch Johnson (mitchj@us.ibm.com) or John Brefach (John.j.brefach@ibm.com) to learn more about how you can access these lab exercises. There are z/OS Connect lab exercises for both OpenAPI 2 and OpenAPI 3.

Creating a Db2 z/OS Asset (OpenAPI 3):
https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=asset-creating-db2-zos
This page is showing how to create a Db2 z/OS Asset in the z/OS Connect Designer for OpenAPI 3.

Create a Db2 API to invoke the Db2 employee services (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=apis-create-db2-api-invoke-db2-employee-services
This page is showing how to create an API to invoke the Db2 employee services example. It has procedures for you to follow as well as a list of additional steps you have to take in order to create this template API.

Create a Db2 service (OpenAPI 2):
https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=services-create-db2-service
This page is showing you how to create the Db2 employee list service using the Db2 service manager in the API Toolkit. This relates to the link above to create the sample API you need to build the Db2 service first.

Db2 REST Services:
https://www.ibm.com/docs/en/db2-for-zos/13.0.0?topic=db2-rest-services
This page provides a general overview of REST and how it relates to Db2. It is the parent topic to a variety of subtopics around REST and Db2 including; Enabling Db2 REST Services, REST Services versioning, Creating a Db2 Rest service, Troubleshooting REST service requests and many more.

Accessing Db2 from z/OS Connect EE differs from the way z/OS Connect EE accesses other z/OS subsystems. The other subsystems are accessed by using standard subsystem interfaces (e.g., OTMA, IPIC, JMS, etc.). A z/OS Connect EE server accesses Db2 not as a Db2 client using JDBC but rather as a RESTful client accessing a Db2 native REST service.

This may raise the question as to what value-add does z/OS Connect EE provide if a Db2 native REST services are still required for z/OS Connect EE. 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 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. A Swagger document (3) used for integration into API management products or development tools is available from z/OS Connect EE whereas Db2 only provides a JSON document describing its service. If a full function RESTful API with support for the major HTTP methods (POST, PUT, GET and DELETE) and transforming JSON payloads and generating a Swagger document is required then z/OS Connect EE is the solution. Finally (4), Db2 native REST services seems to only support basic authentication. Adding a z/OS Connect EE server in front of Db2 provides support for third party authentication tokens and asserting identities using client certificates.

Using RESTful services for Db2 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 for V12 and UI51795 for V11.

OpenAPI 2 Labs:

Developing RESTful APIs for Db2 Native REST Services: https://tinyurl.com/bdhtcdj7

OpenAPI 3 Lab:

Developing Native server RESTful APIs for accessing Db2 REST Services: https://tinyurl.com/2jrff84v

IBM MQ RESTful APIs

Below there are IBM Documentation pages about MQ RESTful APIs. There is a brief overview attached to each link to give you a preview of the information contained at the link provided. As of now, MQ does not support the OpenAPI 3 Specification and is only available with OpenAPI 2.

The WSC GitHub site also has lab exercises around developing RESTful APIs for MQ. Please reach out to either Mitch Johnson (mitchj@us.ibm.com) or John Brefach (John.j.brefach@ibm.com) to learn more about how you can access these lab exercises. There is a z/OS Connect lab exercise for OpenAPI 2.

Create an API to invoke the IBM MQ stock query service:

https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=apis-create-api-invoke-mq-stock-query-service

This page will teach you how to create a stock manager API that will call a MQ Stock query service. There are different steps to follow which this page will direct you to in order to develop a fully functional example stock manager API.

Messaging using the REST API:

https://www.ibm.com/docs/en/ibm-mq/9.4.x?topic=mq-messaging-using-rest-api

This page provides a table of contents to a variety of sub-topics including getting started with messaging REST APIs, using the messaging REST API, error handling, and more.

IBM MQ Console and REST API:

https://www.ibm.com/docs/en/ibm-mq/9.4.x?topic=mq-console-rest-api-security

This page lays out the installation options to run the MQ Console and REST API in a WebSphere Liberty server.

MQ Console and REST API Security:

https://www.ibm.com/docs/en/ibm-mq/9.4?topic=mq-console-rest-api-security

This page provides a general procedure for MQ Console security as well as subtopics around MQ Console security.

Configuring the messaging REST API:

https://www.ibm.com/docs/en/ibm-mq/9.4.x?topic=api-configuring-messaging-rest

This page shows the different ways to configure the messaging REST API. The topics include Enabling the messaging API, Configuring connection pooling, Configuring the connection mode, and Configuring the user context this is used for authorization.

OpenAPI 2 Lab:

Developing RESTful APIs for MQ Services: https://tinyurl.com/4udm2bcb

OpenAPI 3

OpenAPI 3 is a new OpenAPI Specification that clients and IBMers can utilize. z/OS Connect initially supported OpenAPI Specification 2 (formally known as Swagger 2.0). The interactions with the z/OS resource, z/OS Connect, and the REST API were driven by the layout of the CICS COMMAREA/CONTAINER, the IMS or MQ messages or the DB2 REST Service. The details of the interactions with the z/OS resource determined the contents of the API Request and Response messages and the specification document. z/OS Connect will produce the OpenAPI 2 Specification document that describes the methods and the request and response messages (somewhat limited to the nature of the z/OS Asset). The creation of the OpenAPI 3 specification was driven by the desire for standardization and regulation within the API realm known as 'API First' Development. The API details the methods and layouts of the request and response messages which is consumed by z/OS Connect to describe the z/OS resource interactions. For OpenAPI 3 you have a bit more flexibility around your methods/request & response messages since you are starting with the development of the OpenAPI 3 specification document instead of it being driven by the nature of the z/OS resource (OpenAPI 2).

z/OS Connect OpenAPI3 support is being provided via the continuous developer roadmap. The API Provider for OpenAPI 3 is only available for CICS, DB2 & IMS/TM and API requester for OpenAPI 3 is only available in a CICS program but the roadmap does include support for MVS batch, IMS BMPs and MPPs. As we understand the plan, eventually support execution environment for OpenAPI 3 will duplicate the support provided for Swagger 2.0 (OpenAPI 2) but will include additional execution environment (i.e., non z/OS started tasks).

Note every z/OS resource accessed by a Swagger 2.0 server version of the product will be accessible by the OpenAPI 3 server. These resources are not mainstream resources and usually required cross memory access meaning the z/OS Connect server must be located on the same LPAR as the resource.

The point is that we have been conditioned to think that when a new version or release of a product is released there is a need to migrate to take advantage of an enhancement or because of the anticipation of end of service of the existing product. This conditioning does not apply in the case of z/OS Connect's support of Swagger 2.0 (OpenAPI 2) and OpenAPI 3. In this case this is not a new version of the product but rather as we would call it in the past, a small programming enhancement (SPE). z/OS Connect added concurrent support for developing, deploying, and running RESTful API which were documented using the OpenAPI 3 specification.

There is no technical need to migrate existing API, services, etc. to the OpenAPI 3 tooling and runtime. But there are factors to consider regarding moving existing APIs to OpenAPI 3 (notice **move** not **migrate**). First, the OpenAPI3 tooling requires an OpenAPI 3 specification document. If you wanted to move an existing "Swagger 2.0" API to using the OpenAPI 3 tooling, you would need take the Swagger 2.0 document generated by the Eclipse tooling and use one of the available tools to convert it to OpenAPI 3. If you use this new document as is, the APIs behavior and look would be the same as it did when under the OpenAPI 2 support in z/OS Connect. The request and response messages contents would be the same. The runtime would support only one response message format and security for an API would be global and not method specific. To really take advantage of moving to OpenAPI 3, someone would have to edit the converted

OpenAPI3 specification document and add additional response message formats and other OpenAPI3 related enhancements, e.g., roles.

For example, compare the response message in this Swagger 2.0 document generate by z/OS Connect versus the response messages in the OpenAPI 3 document.

A Swagger 2.0 example of a method:

```
"paths" : {
 "/employee" : {
  "post" : {
   "tags" : [ "cscvinc" ],
   "operationId" : "postCscvincInsertService",
   "parameters" : [ {
    "name" : "Authorization",
    "in" : "header",
    "required" : false,
    "type" : "string",
          "maxLength" :  512
   }, {
    "name" : "accessToekn",
    "in" : "header",
    "required" : false,
    "type" : "string",
          "maxLength" :  1024
   }, {
    "in" : "body",
    "name" : "postCscvincInsertService_request",
    "description" : "request body",
    "required" : true,
    "schema" : {
     "$ref" : "#/definitions/postCscvincInsertService_request"
    }
   } ],
   "responses" : {
    "200" : {
     "description" : "OK",
     "schema" : {
      "$ref" : "#/definitions/postCscvincInsertService_response_200"
     }
    }
   }
  }
```

Versus the OpenAPI3 equivalent:

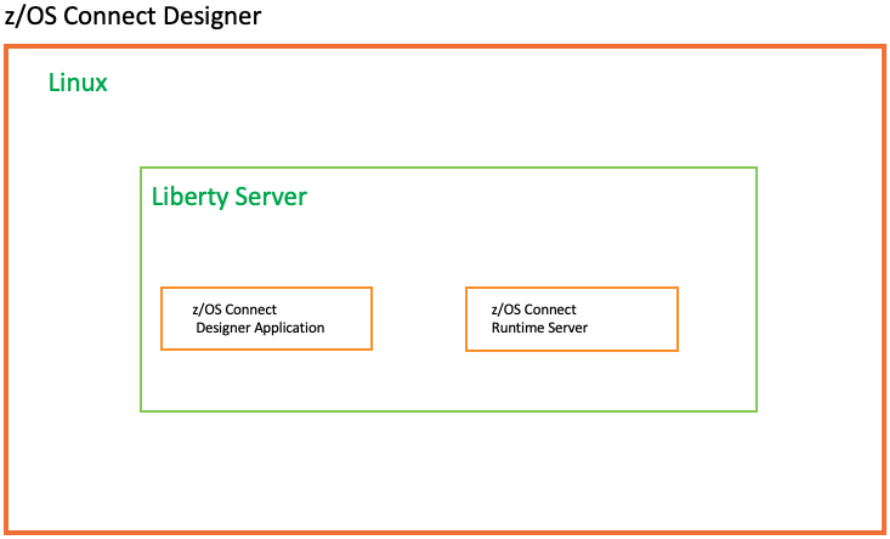
```
x-ibm-zcon-roles-allowed:
- Manager
```

```
paths: /employee:
   post:
    tags:
     - Employee
    operationId: postEmployeeInsertService
    parameters:
     - name: Authorization
       in: header
       required: false
       schema:
         type: string
    requestBody:
     content:
       application/json:
         schema:
           $ref: "#/components/schemas/postEmployeeInsertService_request"
     description: request body
     required: true
    responses:
     "200":
      description: OK
      content:
        application/json:
          schema:
            $ref: "#/components/schemas/postEmployeeInsertService_response_200"
     "400":
      description: Bad Request
      content:
        application/json:
          schema:
            $ref: "#/components/schemas/postEmployeeInsertService_response_400"
     "500":
      description: Sever Error
      content:
        application/json:
          schema:
            $ref: "#/components/schemas/postEmployeeInsertService_response_500"
```

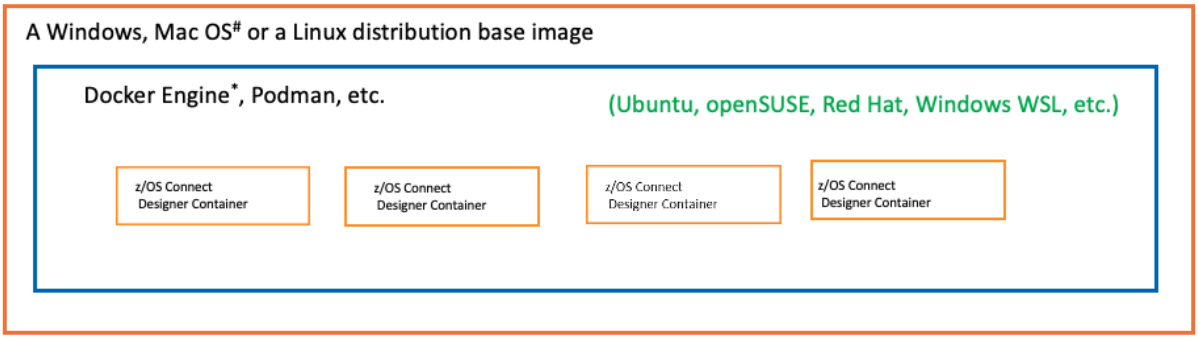
These differences may be of value and make moving worthwhile but don't move existing working Swagger 2.0 API to OpenAPI3 just for sake of moving. Do it to take advantage of the more robust OpenAPI3 specification.

The z/OS Connect Designer for OpenAPI 3 is a container-based platform in comparison to the OpenAPI 2 API Toolkit which is Eclipse based. A z/OS Connect Designer (OAS3) is composed of a self-contained Linux environment configured with a Liberty server running a z/OS Connect Designer application and a z/OS Connect runtime server, in total, known as a "container".

Running a Designer container requires a container runtime environment.



The z/OS Connect runtime options are shown in the graphic below. There should only be one API per container so multiple Designer Containers may be required. As you can see from the graphic you may run this container within Docker Engine or Podman which is running within a Windows, Mac OS or Linux Distribution base image.



The Washington Systems Center provides our recommendations for best practices for configuring and managing Designer containers at URL https://ibm.biz/BdvrZh

- For basic setup and management of the Designer environment, see *z/OS Connect Designer and Native Experiences*
- For a Podman example, see *Developing and Administering RESTful APIs for CICS REST Services*
- For a Docker engine example, *Developing and Administering RESTful APIs for Db2 REST Services*

For Outbound Requests with the OpenAPI 3 specification (API Requester feature), the z/OS Connect designer utilizes the Gradle toolkit to generate the artifacts (Web archive file (.war file) & COBOL Copybooks (API Info structures, Request structures, Response structures).
The link below provides an overview of building z/OS Connect APIs with Gradle including how to install Gradle, how to use Gradle with z/OS Connect, and more.
https://tinyurl.com/3tfynnzv

The z/OS Connect WSC Wildfire workshops (Inbound and Outbound) provide a more robust overview of the differences between the solutions provided by z/OS Connect using each specification (OpenAPI 2 and OpenAPI 3).

End of document