



IBM z/OS Connect Enterprise Edition

Introduction and Overview

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Agenda

- z/OS Connect Introduction and overview
- Discuss enabling RESTful API to various sub-systems, e.g.
 - CICS
 - Db2
 - IMS/TM
 - IMS/DB
 - MQ
 - MVS Batch
 - Outbound REST APIs
 - 3270 screen based applications (HATS)
 - IBM DVM
 - IBM File Manager
- z/OS Connect Security

z/OS Connect EE exposes z/OS resources to the “cloud” via RESTful APIs



z/OS Connect EE

CICS

IMS/TM

IMS/DB

Db2

MQ

IBM File Manager

3270

IBM DVM

MVS⁺

WAS

Custom*

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* Other Vendors or your own implementation

/but_first, what_is_REST?

What makes an API “RESTful”?

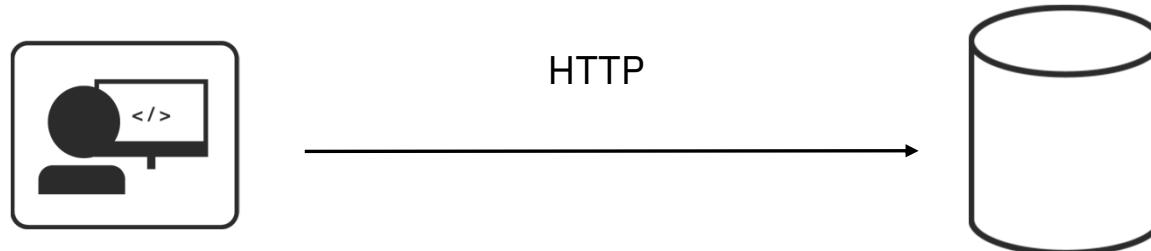
REST is an Architectural Style

REST stands for **R**epresentational **S**tate **T**ransfer.

An architectural style for **accessing** and **updating** data.

Typically using HTTP... but not all HTTP interfaces are “RESTful”.

Simple and intuitive for the end consumer (**the developer**).



Roy Fielding defined REST in his 2000 PhD dissertation "Architectural Styles and the Design of Network-based Software Architectures" at UC Irvine. He developed the REST architectural style in parallel with HTTP 1.1 of 1996-1999, based on the existing design of HTTP 1.0 of 1996.

Key Principles of REST

Use HTTP verbs for Create, Read, Update, Delete (CRUD) operations

GET
POST
PUT
DELETE

http://<host>:<port>/path/parameter?name=value&name=value

Path and Query parameters are used for refinement of the request

URI path identifies a resource (or lists of resources)

Request/Response Body is used to represent the data object

```
GET http://www.acme.com/customers/12345?personalDetails=true
RESPONSE: HTTP 200 OK
BODY { "id" : 12345
        "name" : "Joe Bloggs",
        "address" : "10 Old Street",
        "tel" : "01234 123456",
        "dateOfBirth" : "01/01/1980",
        "maritalStatus" : "married",
        "partner" : "http://www.acme.com/customers/12346" }
```



REST vs RESTful

- REST is an architectural style of development having these principles plus..
- It should be stateless
- It should access all the resources from the server using only URI
- For performing CRUD operations, it should use HTTP verbs such as get, post, put and delete
- It should return the result only in the form of JSON
- REST based services follow some of the above principles and not all, whereas RESTful means it follows all the above principles.
- Remember - Not all REST APIs are RESTful APIs
- The key is consistency, RESTful APIs are consistent, REST APIs are not

RESTful Examples



z/OS Connect EE

z/OS Connect Enterprise Edition:

POST /account/Fred +  (*JSON with Fred's information*)

GET /account?number=1234

PUT /account/1234 +  (*JSON with dollar amount of deposit*)

HTTP Verb conveys the method against the resources; i.e., POST is for create, GET is for balance, etc.

URI conveys the resource to be acted upon; i.e., Fred's account with number 1234

The JSON body carries the specific data for the action (verb) against the resource (URI)

REST APIs are increasingly popular as an integration pattern because it is stateless, relatively lightweight, is relatively easy to program

<https://martinfowler.com/articles/richardsonMaturityModel.html>

Not every REST API is a RESTful API

(How to know if you are doing it wrong)

1. Different URIs with the same method for operations on the same object

POST http://www.acme.com/customers/**GetCustomerDetails**/12345

POST http://www.acme.com/customers/**UpdateCustomerAddress**/12345?**address=**

2. Different representations of the same objects between request and response messages

POST http://www.acme.com/customers
BODY { "firstName": "Joe",
 "lastName" : "Bloggs",
 "addr" : "10 Old Street",
 "phoneNo" : "01234 0123456" }



RESPONSE HTTP 201 CREATED
BODY { "id" : "12345",
 "name" : "Joe Bloggs",
 "address" : "10 New Street"
 "tel" : "01234 0123456" }

3. Operational data embedded in the request body

POST http://www.acme.com/customers/12345
BODY { "updateField": "address",
 "newValue" : "10 New Street" }



RESPONSE HTTP 200 OK
BODY { "id" : "12345",
 "name" : "Joe Bloggs",
 "address" : "10 New Street"
 "tel" : "01234 123456" }

Why is REST popular?

Ubiquitous Foundation	<p>It's based on HTTP, which operates on TCP/IP, which is a ubiquitous networking topology.</p>
Relatively Lightweight	<p>Compared to other technologies (for example, SOAP/WSDL), the REST/JSON pattern is relatively light protocol and data model, which maps well to resource-limited devices.</p>
Relatively Easy Development	<p>Since the REST interface is so simple, developing the client involves very few things: an understanding of the URI requirements (path, parameters) and any JSON data schema.</p>
Increasingly Common	<p>REST/JSON is becoming more and more a de facto "standard" for exposing APIs and Microservices. As more adopt the integration pattern, the more others become interested.</p>
Stateless	<p>REST is by definition a stateless protocol, which implies greater simplicity in topology design. There's no need to maintain, replicate or route based on state.</p>

How do we describe a REST API?



/swagger/open_api

The industry standard framework for describing RESTful APIs.

Why use Swagger?

It is more than just an API framework



There are a number of tools available to aid consumption:

Consume Swagger

Swagger Codegen create stub code to consume APIs from various languages



Read Swagger

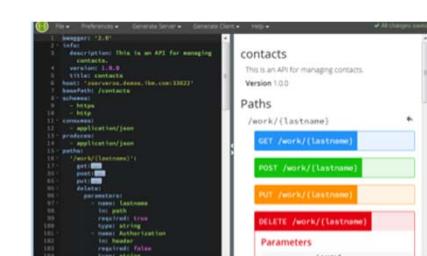
Swagger UI allows API consumers to easily browse and try APIs based on Swagger Doc.



The screenshot shows the Swagger UI interface for a 'contacts' API. It displays a list of operations under the 'default' path: GET /work/{lastname}, GET /work/{lastname}, POST /work/{lastname}, and PUT /work/{lastname}. The UI includes a sidebar with navigation links like 'Explore', 'ShowHide', and 'Expand Operations'. At the bottom, it shows the base URL as 'https://server001.demos.ibm.com:33622/contacts/api-docs' and the API version as '1.0.0'.

Write Swagger

Swagger Editor allows API developers to design their swagger documents.



The screenshot shows the Swagger Editor interface. On the left, there is a large JSON editor pane displaying the Swagger specification. On the right, there are two panes: 'Paths' which lists the four contact management operations, and 'Parameters' which shows the parameters for each operation. The 'Paths' pane also includes a 'Responses' section.

<https://blog.readme.io/what-is-swagger-and-why-it-matters/>



Swagger Example

The image shows two side-by-side screenshots of the Swagger UI interface, displaying API definitions for a service named "Miniloan".

Left Window (API Definition):

- host:** localhost:8080 (highlighted with a red oval)
- paths:** /loan
- parameters:**
 - 0:** Authorization (highlighted with a red oval)
 - 1:** postMiniloanService_request (highlighted with a red oval)

Right Window (Request Schema Definition):

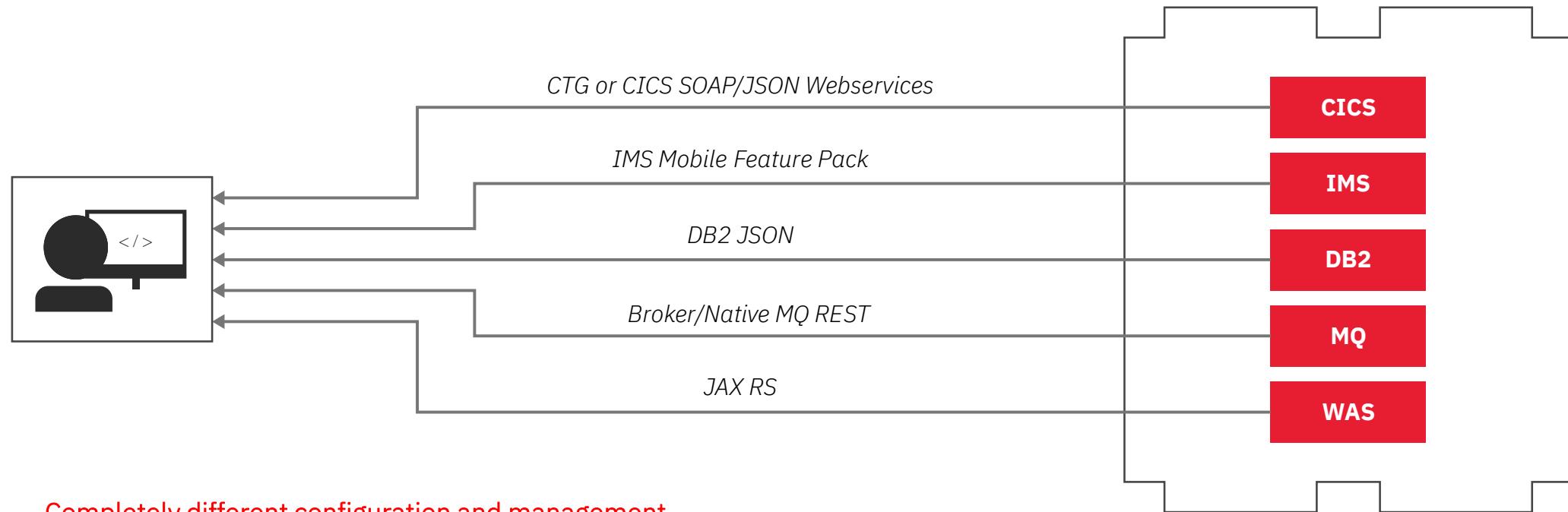
- definitions:**
 - postMiniloanService_request:** object type
- properties:**
 - MINILOAN_COMMAREA:** object type
 - name:** string type, maxLength: 20, creditscore: integer type, minimum: 0, maximum: 10000000000000000000
 - yearlyIncome:** integer type, minimum: 0, maximum: 10000000000000000000
 - age:** integer type, minimum: 0, maximum: 9999999999
 - amount:** integer type, minimum: 0, maximum: 10000000000000000000
 - effectiveDate:** string type, maxLength: 8
 - yearlyRepayment:** integer type, minimum: 0, maximum: 10000000000000000000
- responses:**
 - 200:** OK (highlighted with a red oval)



Why /zos_connect_ee?

Truly RESTful APIs to and from your mainframe.

Could we not do REST before z/OS Connect? Yes, but....



Completely different configuration and management.

Multiple endpoints for developers to call/maintain access to.

These are typically not RESTful!

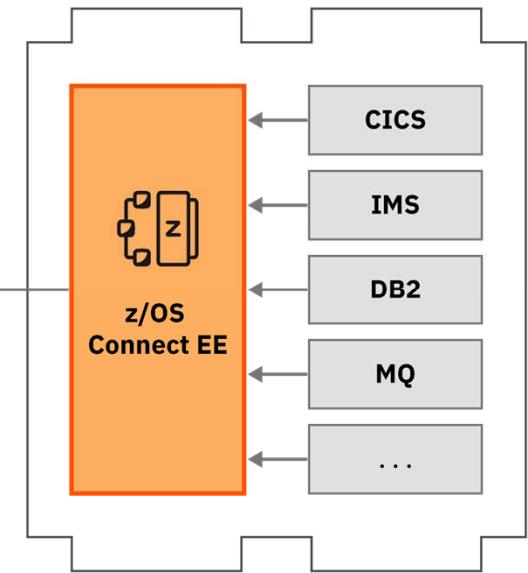
A single entry point was needed

Expose z/OS resources without writing any code.



z/OS Connect EE provides

- Single Configuration Administration
- Single Security Administration
- With sophisticated mapping of truly RESTful APIs to existing mainframe and services data without writing any code.

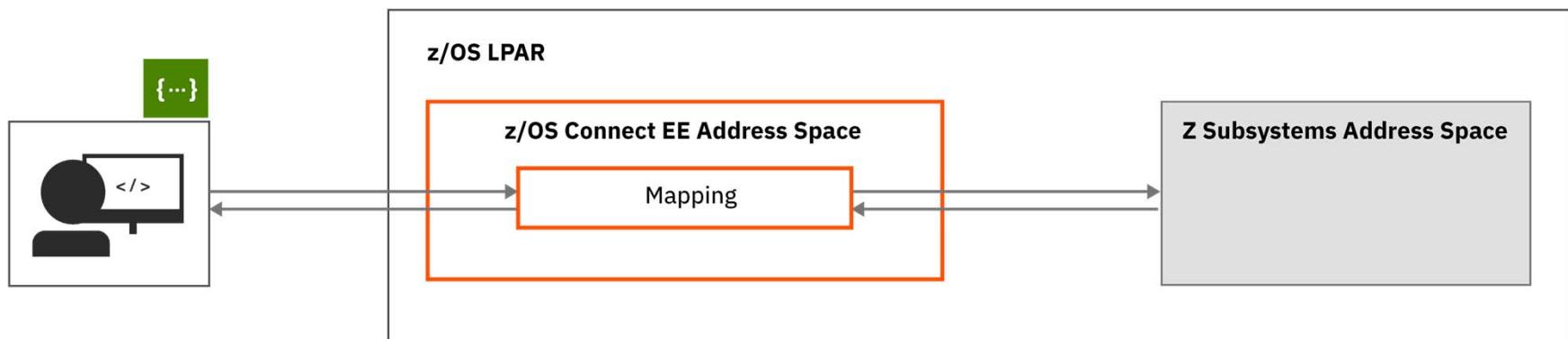




**Other than a RESTful interface,
what does z/OS Connect provide?**

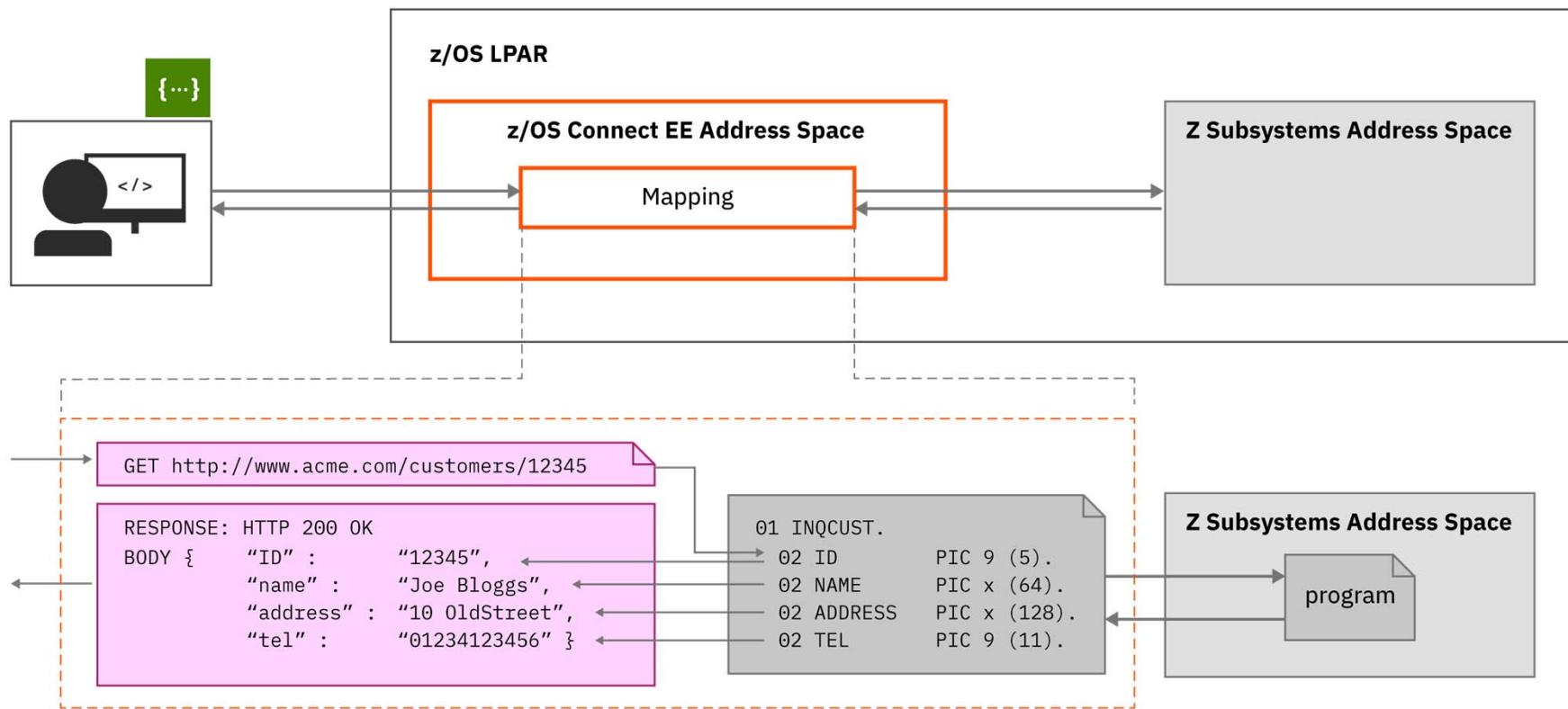
Let's Start with Data mapping

Converting JSON to the target's subsystem's normal format



Data mapping Example

A closer look



COBOL versus JSON Example



```

01 MINILOAN-COMMAREA.
 10 name pic X(20).
 10 creditScore pic 9(16)v99.
 10 yearlyIncome pic 9(16)v99.
 10 age pic 9(10).
 10 amount pic 9999999v99.
 10 approved pic X.
    88 BoolValue value 'T'.
 10 effectDate pic X(8).
 10 yearlyInterestRate pic S9(5).
 10 yearlyRepayment pic 9(18).
 10 messages-Num pic 9(9).
 10 messages pic X(60) occurs 1 to 10 times
      depending on messages-Num.

```

```

"MINILOAN_COMMAREA" : {
  "type" : "object",
  "properties" : {
    "NAME" : {
      "maxLength" : 20,
      "type" : "string"
    },
    "CREDITSCORE" : {
      "multipleOf" : 0.01,
      "minimum" : 0,
      "maximum" : 99999999999999.99,
      "type" : "number",
      "format" : "decimal"
    },

```

```

<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<ns2:message xmlns:ns2="http://www.ibm.com/ims/Transaction" transactionCode="" messageName="miniloanRequest" direction="0" serviceType="0">
  <message id="1" name="miniloanRequest">
    <segment id="1" name="COMMAREA" originalName="COMMAREA" included="Y" path="MINILOAN_COMMAREA">
      <field name="NAME" originalName="NAME" included="Y" path="MINILOAN_COMMAREA.NAME">
        <startPos>1</startPos>
        <bytes>20</bytes>
        <maxBytes>20</maxBytes>
        <applicationDatatype datatype="CHAR"/>
      </field>
      <field name="CREDITSCORE" originalName="CREDITSCORE" included="Y" path="MINILOAN_COMMAREA.CREDITSCORE">
        <startPos>21</startPos>
        <bytes>18</bytes>
        <maxBytes>18</maxBytes>
        <marshaller isSigned="N" isSignLeading="N" isSignSeparate="N" isWCHAROnly="N">
          <typeConverter>ZONEDDECIMAL</typeConverter>
        </marshaller>
        <applicationDatatype datatype="DECIMAL" precision="18" scale="2"/>
      </field>
    </segment>
  </message>
</ns2:message>

```

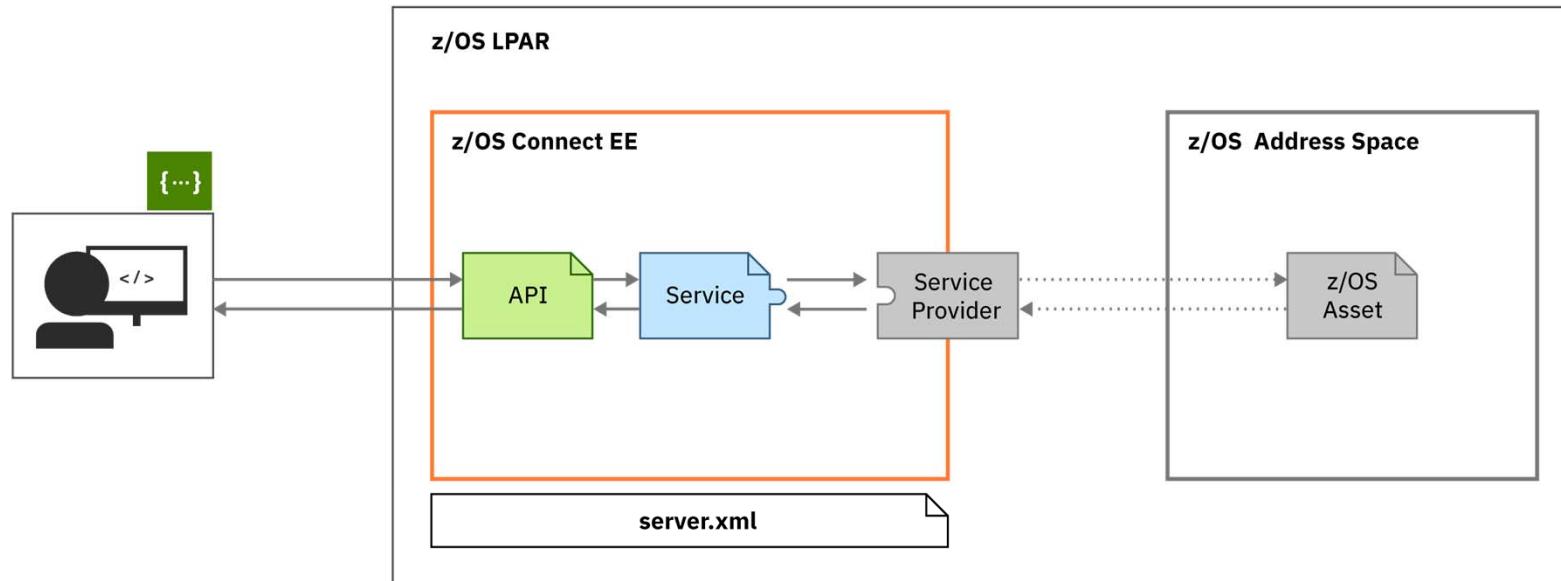
“name”：“Mitch Johnson”，
“creditScore”：“72000”

All data is sent as character strings,
removing the big v. little endian and +/-
issue

Slide 21

MJ1 Mitch Johnson, 6/16/2020

Steps to expose a z/OS application



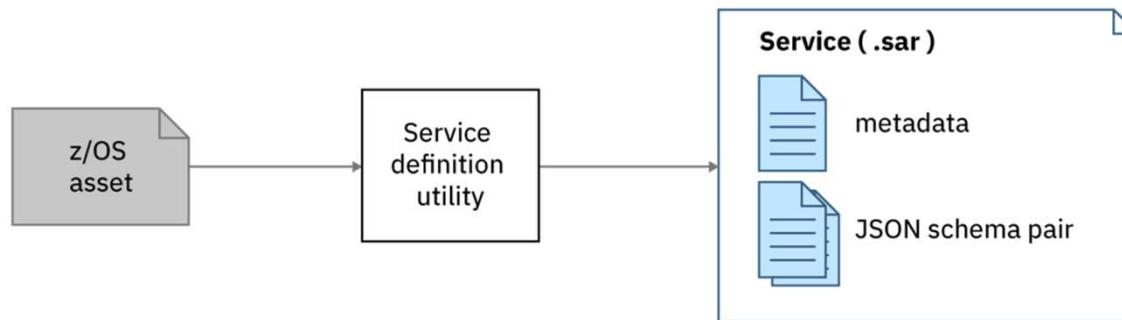
- The API provides the RESTful interface is ready to be consumed by a client and it requires no knowledge that a z/OS resource is being accessed
- The Service provides meta data specific to the z/OS Asset (e.g. CICS program, MQ queue manager, etc.)
- The Service Provider is tightly coupled to a specific instance of a resource (e.g. host and port)

Steps to expose a z/OS application

1. Create a service

To start mapping an API, z/OS Connect EE needs a representation of the underlying z/OS application: in a **Service Archive file (.sar)**.

The metadata consists of data mapping XML and provider specific configuration information



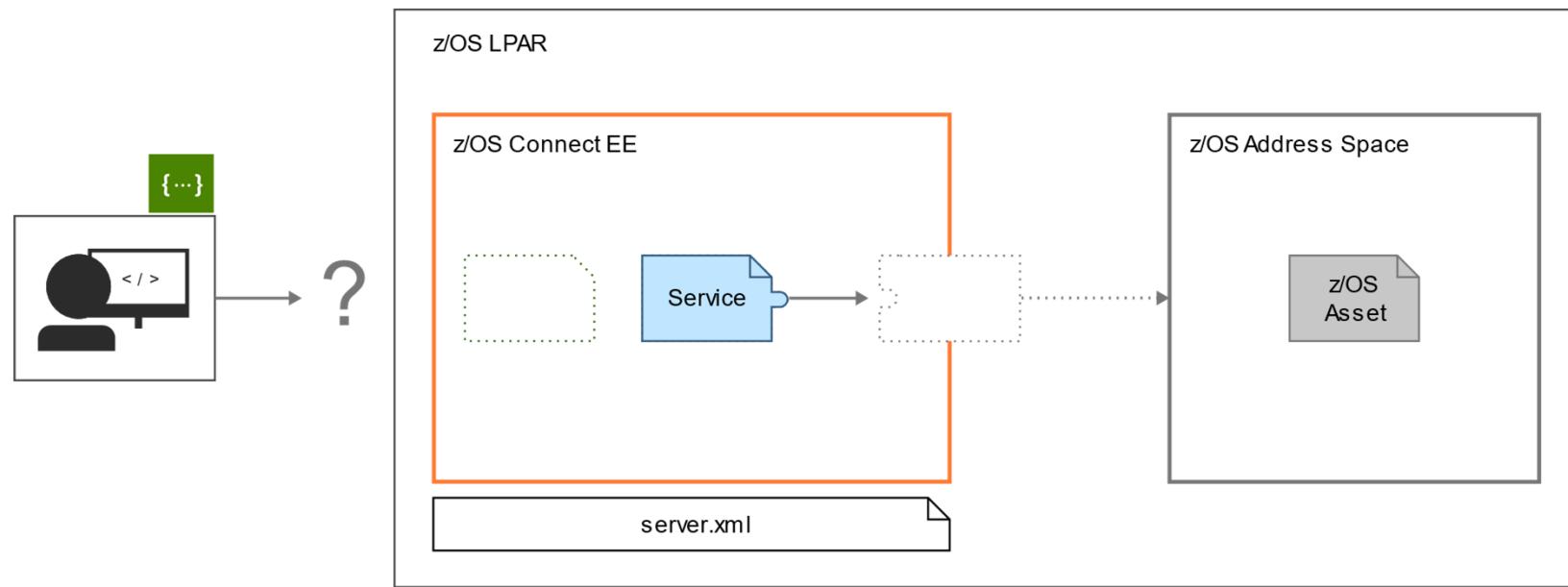
Use a system-appropriate utility to generate a `.sar` file for the z/OS application

- Eclipse based - API Toolkit (CICS, IMS TM, IMS DB, Db2 and MQ)
- Command line - z/OS Connect EE Build Toolkit (MVS Batch, IBM File Manager and HATS)
- Eclipse based - DVM Toolkit

 ibm.biz/zosconnect-sar-creation

Steps to expose a z/OS application

2. Deploy and export the service

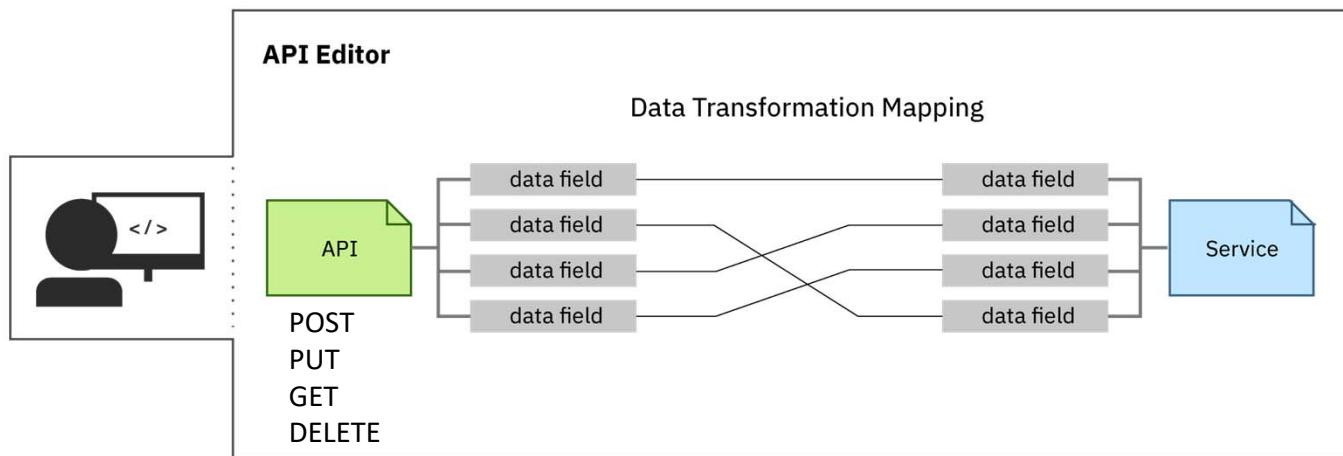


Deploy the service archive file generated in **Step 1** using the right-click deploy in **the API toolkit**.

 ibm.biz/zosconnect-define-services

Steps to expose a z/OS application

3. Create an API using exported services

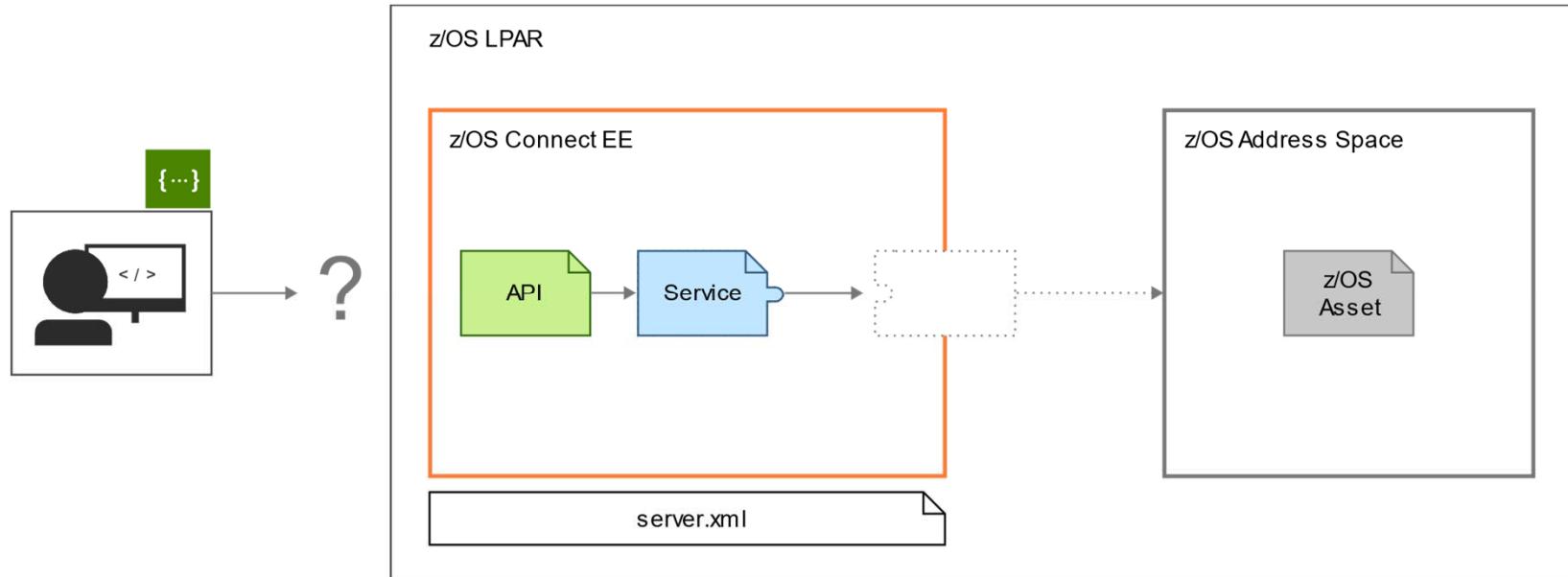


- Import the service archive file into the **API toolkit**, and start designing the RESTful API.
- Provides additional data mapping
- Use the editor to describe the API and how it maps to underlying services.

 ibm.biz/zosconnect-create-api

Steps to expose a z/OS application

4. Deploy the API

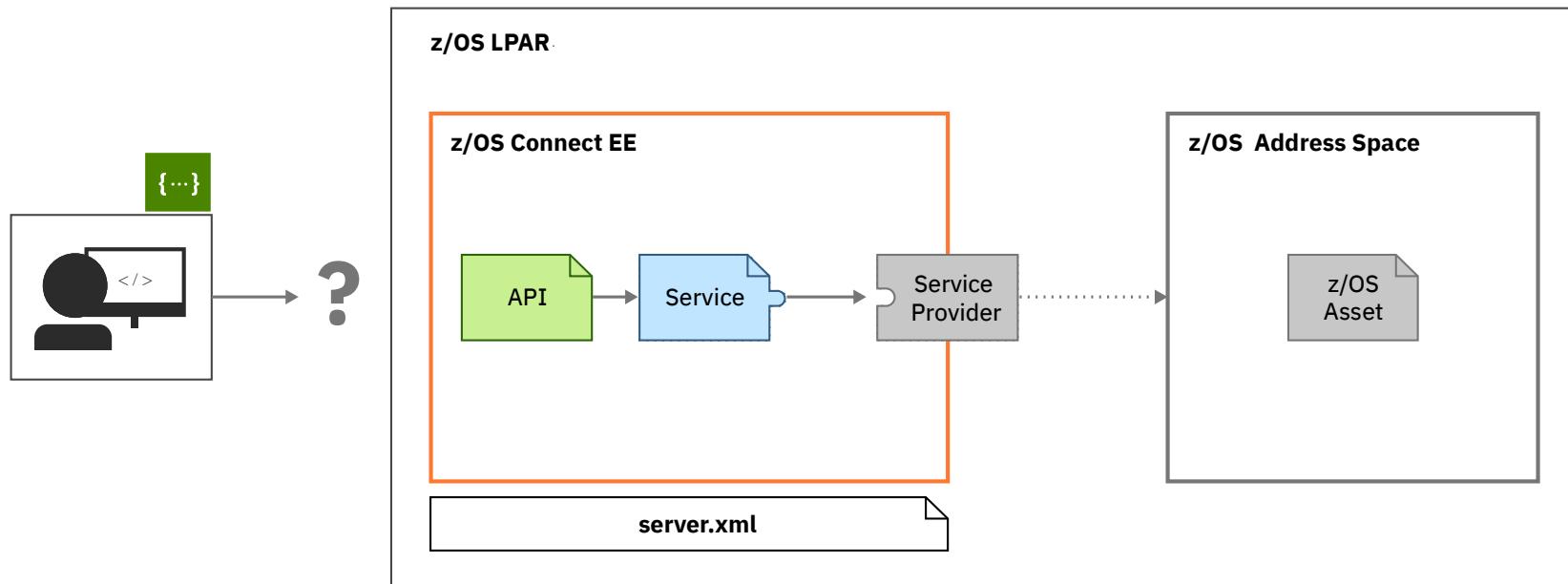


Deploy your API using the right-click deploy in **the API toolkit**

 ibm.biz/zosconnect-deploy-api

Steps to expose a z/OS application

5. Configure the service provider

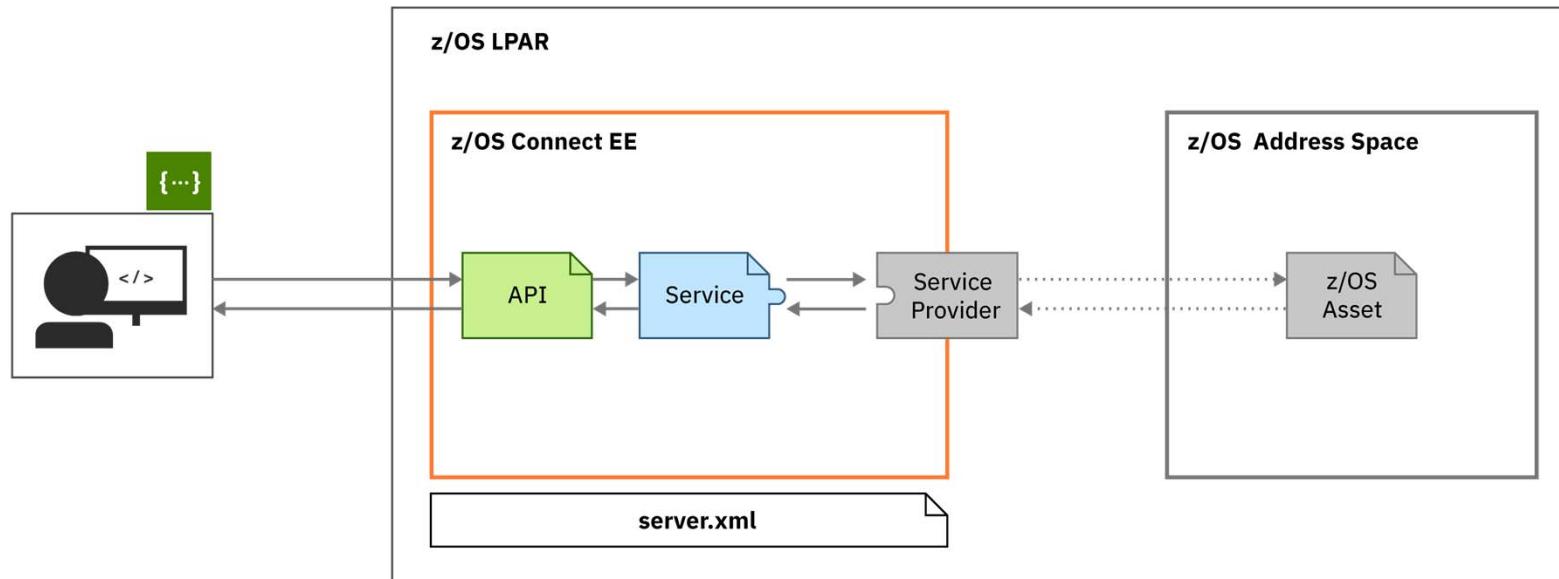


Configure the system-appropriate service provider to connect to your backend system in your `server.xml`.

 ibm.biz/zosconnect-configuring

Steps to expose a z/OS application

6. Done



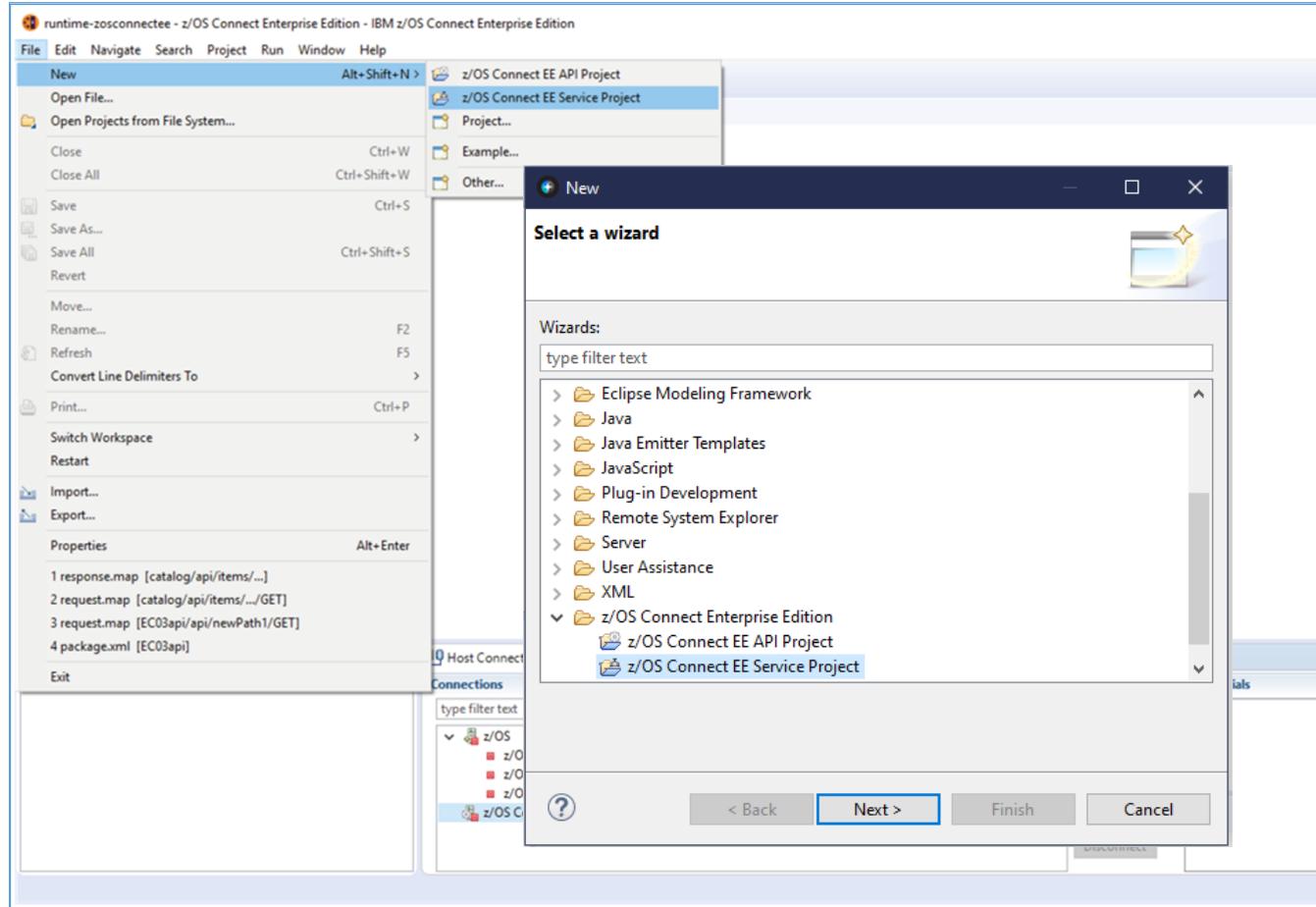
- The API is ready to be consumed and requires no knowledge that a z/OS resource is being accessed
- The Service provides meta data specific to the z/OS Asset (e.g. CICS program, MQ queue manager, etc.)
- The Service Provider is tightly coupled to a specific instance of a resource (e.g. host and port)



/api_toolkit/services

Simple **service creation.**

API toolkit – Creating Services for CICS, IMS TM, IMS DB, Db2 and MQ

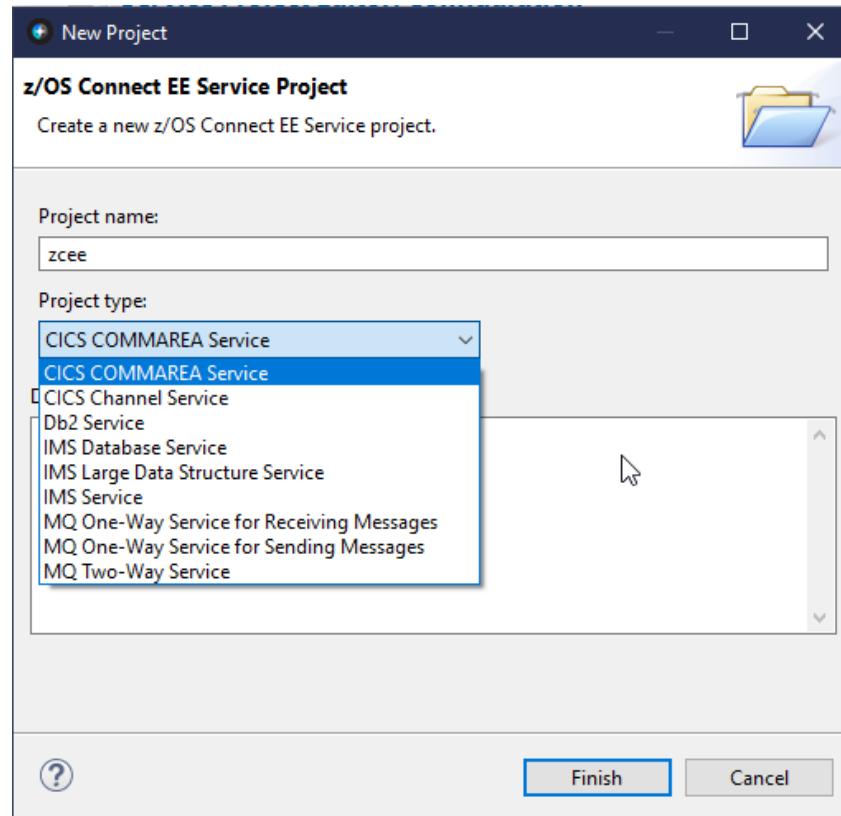


Use the **API toolkit** to create services through Eclipse-based tooling.

Services are described as Eclipse **Projects**, so they can be easily managed in source control.

API toolkit – Creating Services for CICS, IMS TM, IMS DB, Db2 and MQ

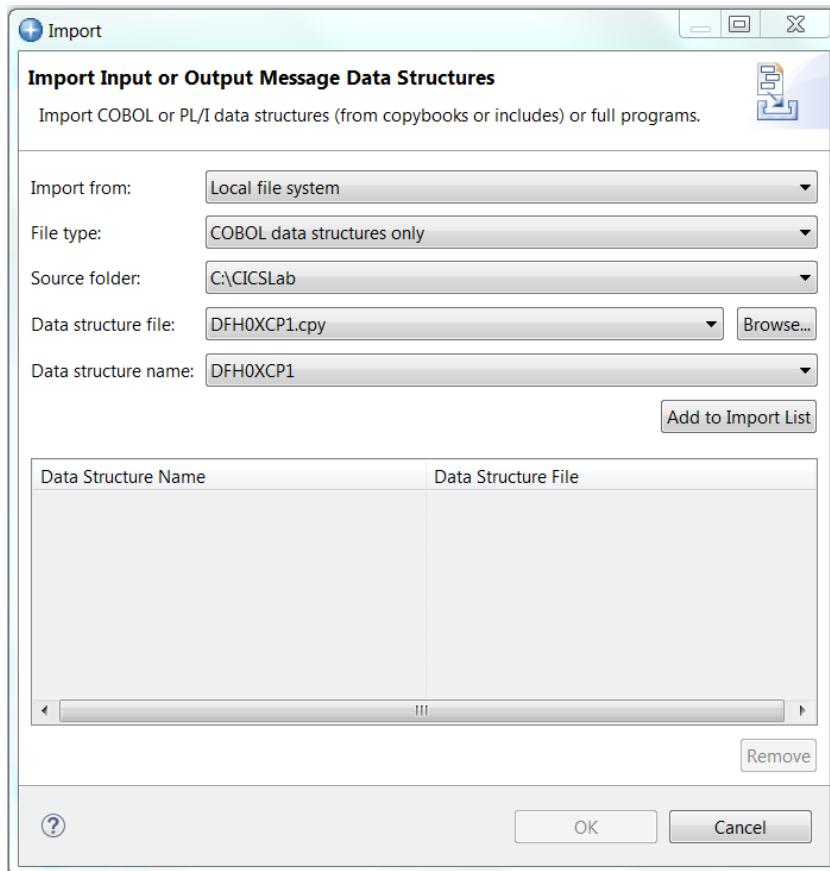
Service creation – a common interface



A common interface for service creation, agnostic of back end subsystem.

API toolkit – Creating Services for CICS, IMS TM and MQ

Creating a service project from source for a COMMAREA, Container or Message

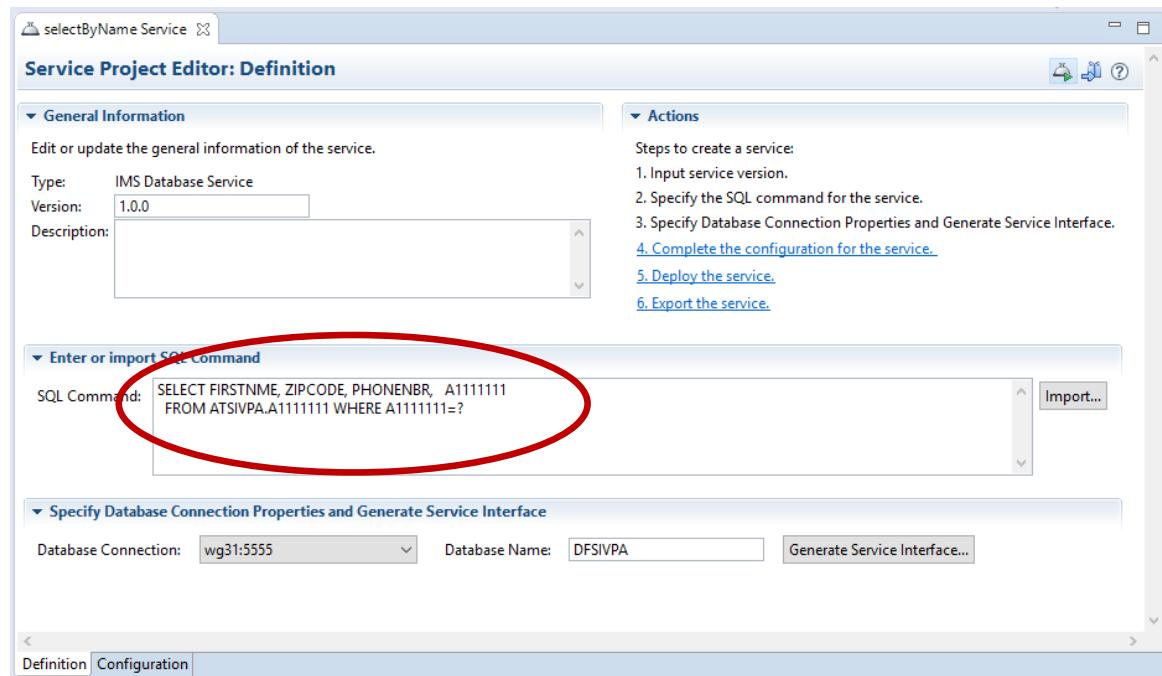


Start by importing data structures into the service interface from the local file system or the workspace.

The service interface supports complex data structures, including OCCURS DEPENDING ON and REDEFINES clauses.

API toolkit – Creating Services for IMS DB

Creating a service project from the IMS Catalog



Use the IMS Catalog to assist with developing and testing SQL SELECT commands used for accessing IMS databases.

API toolkit – Creating Services for CICS, IMS TM, IMS DB and MQ

Regardless, either allows editing a service interface definition

*inquireSingle Service *inquireSingleRequest

Service Interface Definition

Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte	
COMMAREA							
DFH0XCP1							
CA_REQUEST_ID	<input type="checkbox"/>	CA_REQUEST_ID	01INQS	CHAR	6	1	
CA_RETURN_CODE	<input type="checkbox"/>	CA_RETURN_CODE		DECIMAL	2	7	
CA_RESPONSE_MESSAGE	<input type="checkbox"/>	CA_RESPONSE_MESSAGE		CHAR	79	9	
CA_REQUEST_SPECIFIC (Redefine)	<input type="checkbox"/>	CA_REQUEST_SPECIFIC		CHAR	911	88	
CA_INQUIRE_REQUEST redefines CA_INQUIRE_SINGLE	<input type="checkbox"/>	CA_INQUIRE REQUEST		STRUCT	911	88	
CA_INQUIRE_SINGLE redefines CA_ORDER_REQUEST	<input checked="" type="checkbox"/>	inquireSingle		STRUCT	911	88	
CA_ITEM_REF_REQ	<input checked="" type="checkbox"/>	itemID		DECIMAL	4	88	
FILL_0	<input type="checkbox"/>	FILL_0		DECIMAL	4	92	
FILL_1	<input type="checkbox"/>	FILL_1		DECIMAL	3	96	
CA_SINGLE_ITEM	<input type="checkbox"/>	CA_SINGLE_ITEM		STRUCT	60	99	
FILL_2	<input type="checkbox"/>	FILL_2		CHAR	840	159	
CA_ORDER_REQUEST redefines CA_INQUIRE_SINGLE	<input type="checkbox"/>	CA_ORDER_REQUEST		STRUCT	911	88	

See the imported data structure and then can **redact fields, rename fields, and add default values to fields** to make the service more consumable for an API developer.

API toolkit – Creating Services for CICS, IMS TM, IMS DB and MQ

Editing a response message

*inquireSingleResponse

Service Interface Definition

Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
COMMAREA						
DFH0XCP1						
CA_REQUEST_ID	<input type="checkbox"/>	CA.REQUEST_ID		CHAR	6	1
CA_RETURN_CODE	<input checked="" type="checkbox"/>	returnCode		DECIMAL	2	7
CA_RESPONSE_MESSAGE	<input checked="" type="checkbox"/>	responseMessage		CHAR	79	9
CA_REQUEST_SPECIFIC (Redefine)	<input type="checkbox"/>	CA.REQUEST_SPECIFIC		CHAR	911	88
CA_INQUIRE_REQUEST redefines CA_INQUIRE_SINGLE	<input type="checkbox"/>	CA_INQUIRE_REQUEST		STRUCT	911	88
CA_INQUIRE_SINGLE redefines CA_INQUIRE_REQUEST	<input checked="" type="checkbox"/>	inquireSingle		STRUCT	911	88
CA_ITEM_REF_REQ	<input type="checkbox"/>	CA.ITEM_REF_REQ		DECIMAL	4	88
FILL_0	<input type="checkbox"/>	FILL_0		DECIMAL	4	92
FILL_1	<input type="checkbox"/>	FILL_1		DECIMAL	3	96
CA_SINGLE_ITEM	<input checked="" type="checkbox"/>	singleItem		STRUCT	60	99
CA_SNGL_ITEM_REF	<input checked="" type="checkbox"/>	itemReference		DECIMAL	4	99
CA_SNGL_DESCRIPTION	<input checked="" type="checkbox"/>	description		CHAR	40	103
CA_SNGL_DEPARTMENT	<input checked="" type="checkbox"/>	department		DECIMAL	3	143
CA_SNGL_COST	<input checked="" type="checkbox"/>	cost		CHAR	6	146
IN_SNGL_STOCK	<input checked="" type="checkbox"/>	inStock		DECIMAL	4	152
ON_SNGL_ORDER	<input checked="" type="checkbox"/>	onOrder		DECIMAL	3	156
FILL_2	<input type="checkbox"/>	FILL_2		CHAR	840	159
CA_ORDER_REQUEST redefines CA_INQUIRE_ORDER	<input type="checkbox"/>	CA.ORDER_REQUEST		STRUCT	911	88
CA_USERID	<input type="checkbox"/>	CA.USERID		CHAR	8	88
CA_CHARGE_DEPT	<input type="checkbox"/>	CA.CHARGE_DEPT		CHAR	8	96
CA_ITEM_REF_NUMBER	<input type="checkbox"/>	CA.ITEM_REF_NUMBER		DECIMAL	4	104
CA_QUANTITY_REQ	<input type="checkbox"/>	CA.QUANTITY_REQ		DECIMAL	3	108
FILL_3	<input type="checkbox"/>	FILL_3		CHAR	888	111

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See the imported data structure and can **redact fields** and **rename fields**

API toolkit – Creating Services for CICS



Creating multiple services to the same resource

*cscvincSelectService Service *cscvincSelectRequest

Service Interface Editor

Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

Fields	Include	Interface Rename	Default Field Value	Data Type	Field Length
Channel		CSCCINCContainer			
@ Container1		REQUEST_CONTAINER			
ACTION	<input type="checkbox"/>	ACTION	S	CHAR	1
USERID	<input type="checkbox"/>	USERID		CHAR	8
FILEA_AREA	<input checked="" type="checkbox"/>	FILEA_AREA		STRUCT	80
STAT	<input type="checkbox"/>	STAT		CHAR	1
NUMB	<input checked="" type="checkbox"/>	NUMB		CHAR	6
NAME	<input type="checkbox"/>	NAME		CHAR	20
ADDRX	<input type="checkbox"/>	ADDRX		CHAR	20
PHONE	<input type="checkbox"/>	PHONE		CHAR	8
DATEX	<input type="checkbox"/>	DATEX		CHAR	8
AMOUNT	<input type="checkbox"/>	AMOUNT		CHAR	8
COMMENT	<input type="checkbox"/>	COMMENT		CHAR	9

Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

*cscvincSelectService Service *cscvincInsertRequest

Service Interface Editor

Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

Fields	Include	Interface Rename	Default Field Value	Data Type	Field Length
Channel		cscvincInsertContainer			
@ Container1		REQUEST_CONTAINER			
ACTION	<input type="checkbox"/>	ACTION	I	CHAR	1
USERID	<input type="checkbox"/>	USERID		CHAR	8
FILEA_AREA	<input checked="" type="checkbox"/>	FILEA_AREA		STRUCT	80
STAT	<input checked="" type="checkbox"/>	status		CHAR	1
NUMB	<input checked="" type="checkbox"/>	employeeNumber		CHAR	6
NAME	<input checked="" type="checkbox"/>	employeeName		CHAR	20
ADDRX	<input checked="" type="checkbox"/>	address		CHAR	20
PHONE	<input checked="" type="checkbox"/>	phoneNumber		CHAR	8
DATEX	<input checked="" type="checkbox"/>	startDate		CHAR	8
AMOUNT	<input checked="" type="checkbox"/>	amount		CHAR	8
COMMENT	<input checked="" type="checkbox"/>	comment		CHAR	9

Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

CICS Meta Data

Service Project Editor: Definition

General Information

Type: CICS Channel Service
Version: 1.0.0
Description:

Actions

Steps to create a service:
1. Input service version.
2. Specify the program for the service.
3. Create or import a service interface for the request and response in your service.
4. Complete the configuration for the service.
5. Deploy the service.
6. Export the service.

Program: CSCVINC (circled)

Define Request and Response Service Interface

Create new request and response service interface
Create Service Interface... Import

Request service interface: cscvinc
Response service interface: cscvinc

Set advanced data conversion options Advanced

Service Project Editor: Configuration

Required Configuration

Enter the required configuration for this service.
Coded character set identifier (CCSID): 37
Connection reference: cscvinc

Optional Configuration

Enter the optional configuration for this service.
Transaction ID: CSMI (circled)
Transaction ID usage: EIB_ONLY (circled)
Use context containers:
Context containers HTTP headers: Add another

The service developer creates distinct services for each function by setting the ACTION field to S for select, I for insert, U for update or D for delete

API toolkit – Creating Services for IMS

Creating a “GET” service interface request definition

*invtoDisplayService Service *ivtnoDisplayRequest

Service Interface Definition

Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

Search:

Fields	Include	Interface rename	Default Field
ivtnoDisplayRequest			cscvincSelectService Service
Segment 1			*ivtnoDisplayService Service
INPUT_MSG			
IN_LL	<input type="checkbox"/>	IN_LL	
IN_ZZ	<input type="checkbox"/>	IN_ZZ	
IN_TRANCDE	<input type="checkbox"/>	IN_TRANCDE	
IN_COMMAND	<input type="checkbox"/>	IN_COMMAND	IVTNO
IN_LAST_NAME	<input checked="" type="checkbox"/>	lastName	DISPLAY
IN_FIRST_NAME	<input type="checkbox"/>	IN_FIRST_NAME	
IN_EXTENSION	<input type="checkbox"/>	IN_EXTENSION	
IN_ZIP_CODE	<input type="checkbox"/>	IN_ZIP_CODE	

ivtnoDisplayService Service

Service Project Editor: Definition

General Information
Edit or update the general information of the service.
Type: IMS Service
Version: 1.0.0
Description:

Transaction code
Transaction code: IVTNO

Define Request and Response Service Interfaces
Create new request and response service interfaces or select existing ones.
Create Service Interface... Import Service Interface...
Request service interface: ivtnoDisplayRequest.si
Response service interface: ivtnoDisplayResponse.si
Set advanced data conversion options Advanced Options...

Service Project Editor: Configuration

Required Configuration
Enter the required configuration for this service.
Connection profile: IMSCONN
Interaction profile: IMSINTER

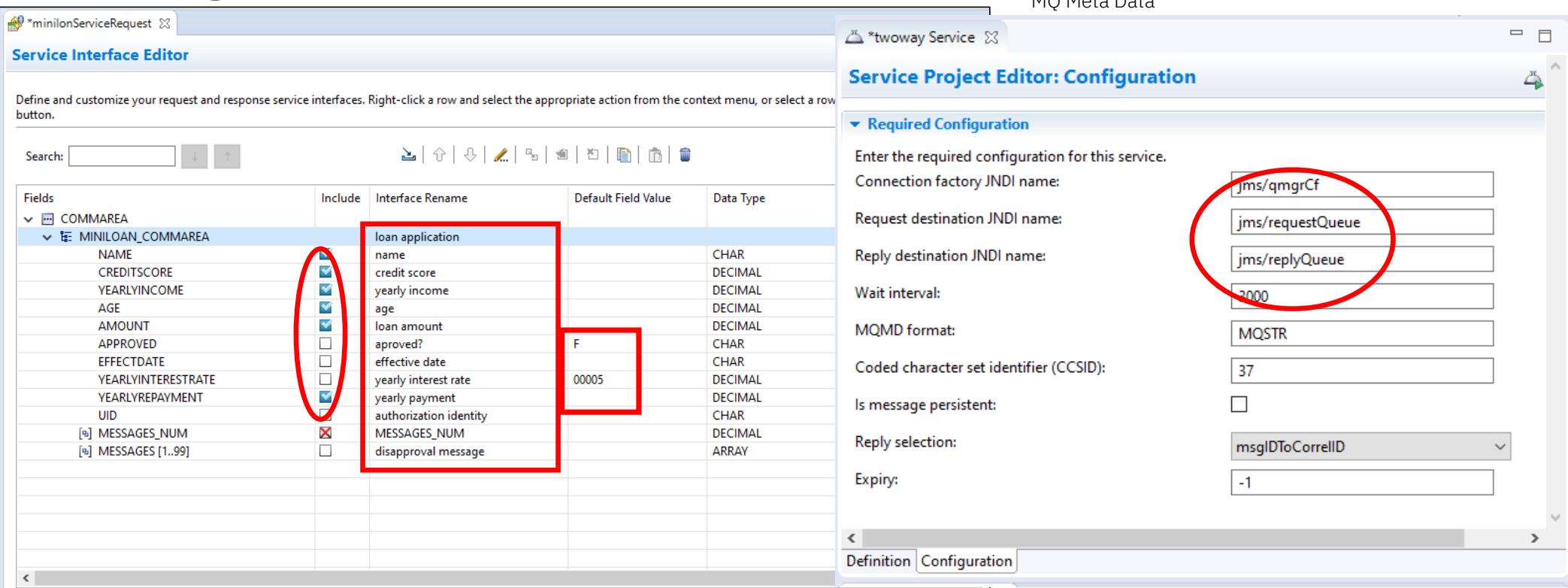
Optional Configuration
Enter the optional configuration for this service.
IMS destination override:
Program name:

The service developer creates distinct services for each function.

DISPLAY (GET)
DELETE (DELETE)
ADD (POST)
UPDATE (PUT)

API toolkit – Creating Services for MQ

Creating a service interface definition



The screenshot shows two windows from the API toolkit:

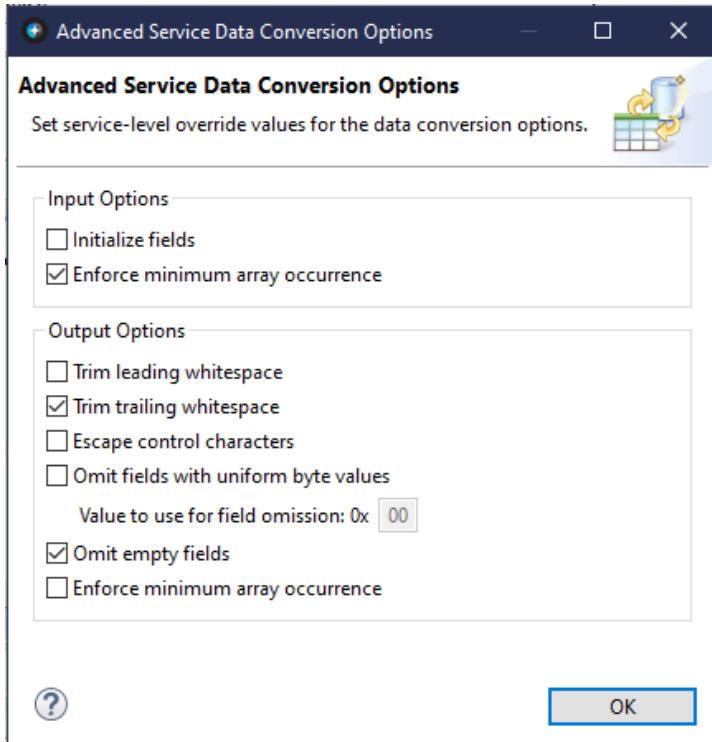
- Service Interface Editor:** This window displays a table of fields for a service interface named "minilnServiceRequest". The table columns are: Fields, Include, Interface Rename, Default Field Value, and Data Type. A red box highlights the "Interface Rename" column for the "loan application" row, which contains the values: name, credit score, yearly income, age, loan amount, approved?, effective date, yearly interest rate, yearly payment, authorization identity, MESSAGES_NUM, and disapproval message. A red circle highlights the "Include" checkbox for the "NAME" field.
- Service Project Editor: Configuration:** This window shows configuration settings for a service named "twoWay Service". The "Required Configuration" section includes fields for Connection factory JNDI name (jms/qmgrCf), Request destination JNDI name (jms/requestQueue), Reply destination JNDI name (jms/replyQueue), Wait interval (3000), MQMD format (MQSTR), Coded character set identifier (CCSID) (37), Is message persistent (unchecked), Reply selection (msgIDToCorrelID), and Expiry (-1). A red circle highlights the "Request destination JNDI name" field.

Again the service developer can then see the imported data structure and can **redact fields**, **rename fields**, and **add default values to fields** to make the service more consumable for an API developer.



z/OS Connect EE

API toolkit – Advanced Data Conversion Options



Request Messages:

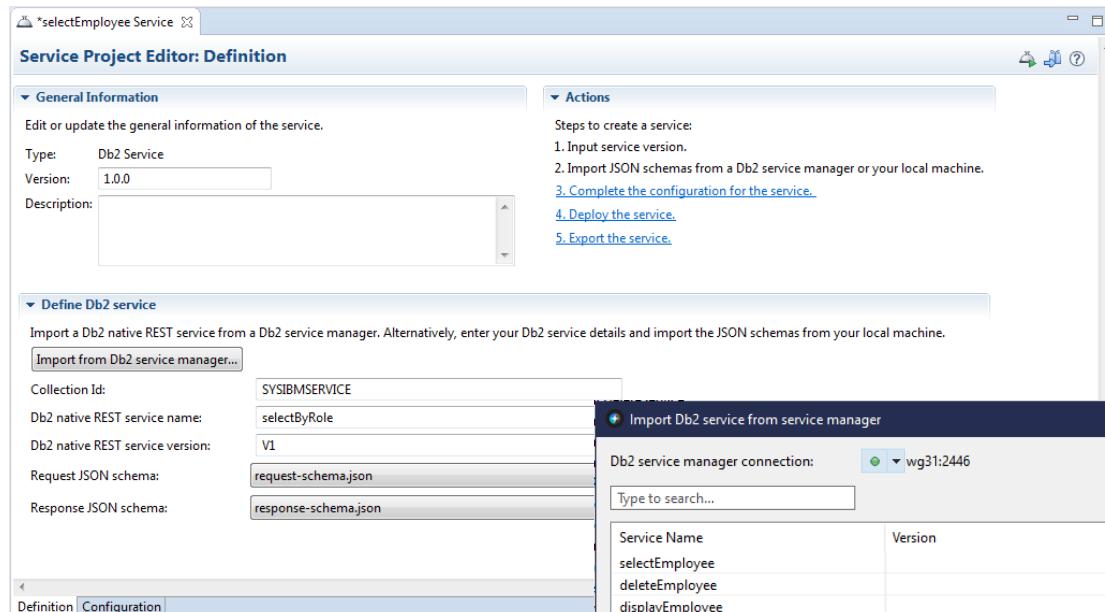
- Initialize fields
- Enforce minimum array occurrence

Response Messages:

- Trim leading whitespace
- Trim trailing whitespace
- Escape control characters
- Omit fields with uniform byte values
- Omit empty fields
- Enforce minimum array occurrence

API toolkit – Creating Services for Db2

Creating a service project from Db2 REST service

 *selectEmployee Service

Service Project Editor: Definition

General Information

Edit or update the general information of the service.

Type: Db2 Service
Version: 1.0.0
Description:

Actions

Steps to create a service:

1. Input service version.
2. Import JSON schemas from a Db2 service manager or your local machine.
3. Complete the configuration for the service.
4. Deploy the service.
5. Export the service.

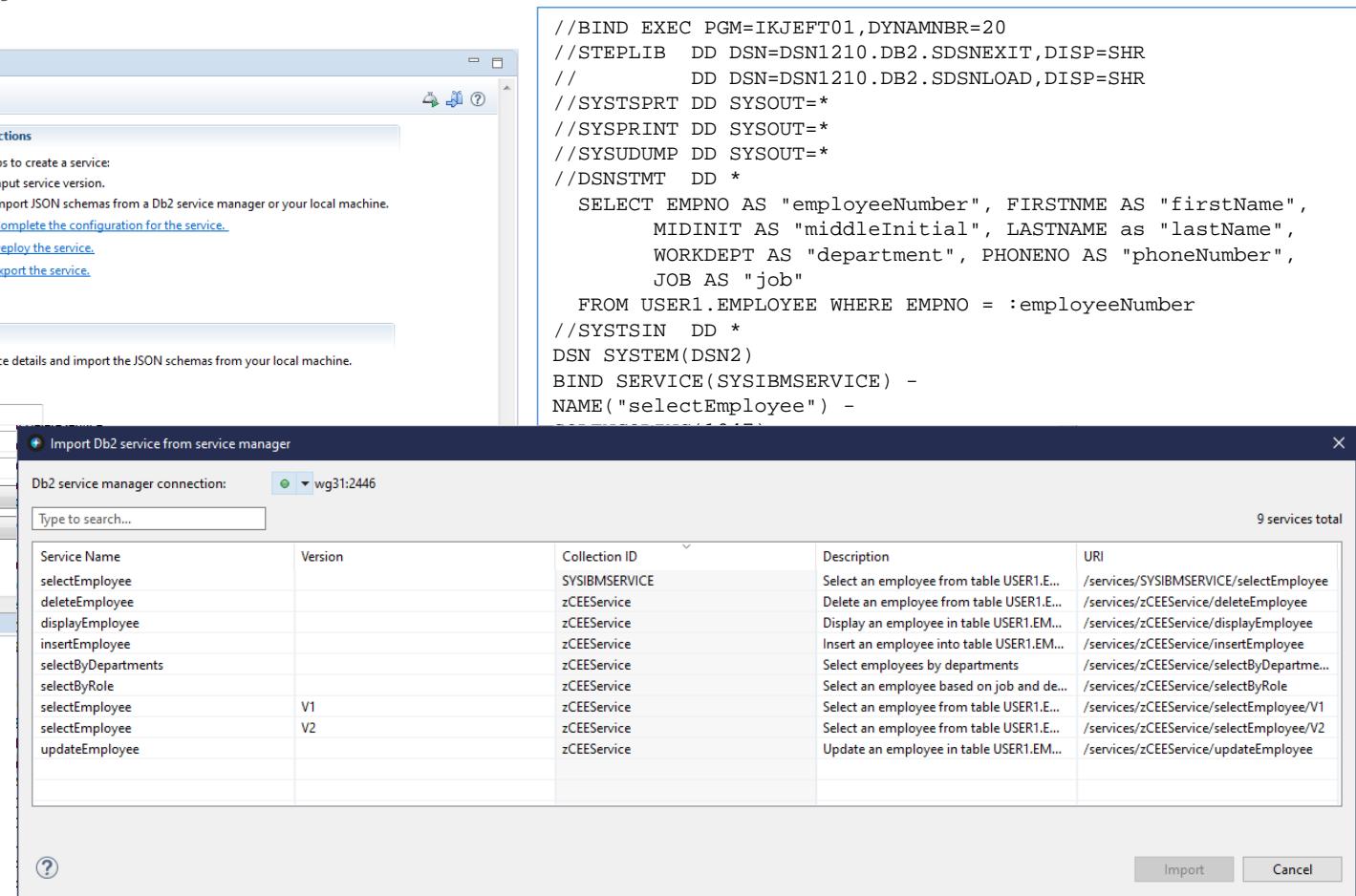
Define Db2 service

Import a Db2 native REST service from a Db2 service manager. Alternatively, enter your Db2 service details and import the JSON schemas from your local machine.

Import from Db2 service manager...

Collection Id: SYSIBMSERVICE
Db2 native REST service name: selectByRole
Db2 native REST service version: V1
Request JSON schema: request-schema.json
Response JSON schema: response-schema.json

Definition Configuration



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

Service Name	Version	Collection ID	Description	URI
selectEmployee		SYSIBMSERVICE	Select an employee from table USER1.E...	/services/SYSIBMSERVICE/selectEmployee
deleteEmployee		zCEEService	Delete an employee from table USER1.E...	/services/zCEEService/deleteEmployee
displayEmployee		zCEEService	Display an employee in table USER1.EM...	/services/zCEEService/displayEmployee
insertEmployee		zCEEService	Insert an employee into table USER1.EM...	/services/zCEEService/insertEmployee
selectByDepartments		zCEEService	Select employees by departments	/services/zCEEService/selectByDepartme...
selectByRole		zCEEService	Select an employee based on job and de...	/services/zCEEService/selectByRole
selectEmployee	V1	zCEEService	Select an employee from table USER1.E...	/services/zCEEService/selectEmployee/V1
selectEmployee	V2	zCEEService	Select an employee from table USER1.E...	/services/zCEEService/selectEmployee/V2
updateEmployee		zCEEService	Update an employee in table USER1.EM...	/services/zCEEService/updateEmployee

Import Cancel

The service developer retrieves the Db2 REST services

API toolkit – Deploying Services for CICS and IMS TM, IMS DB, Db2 and MQ

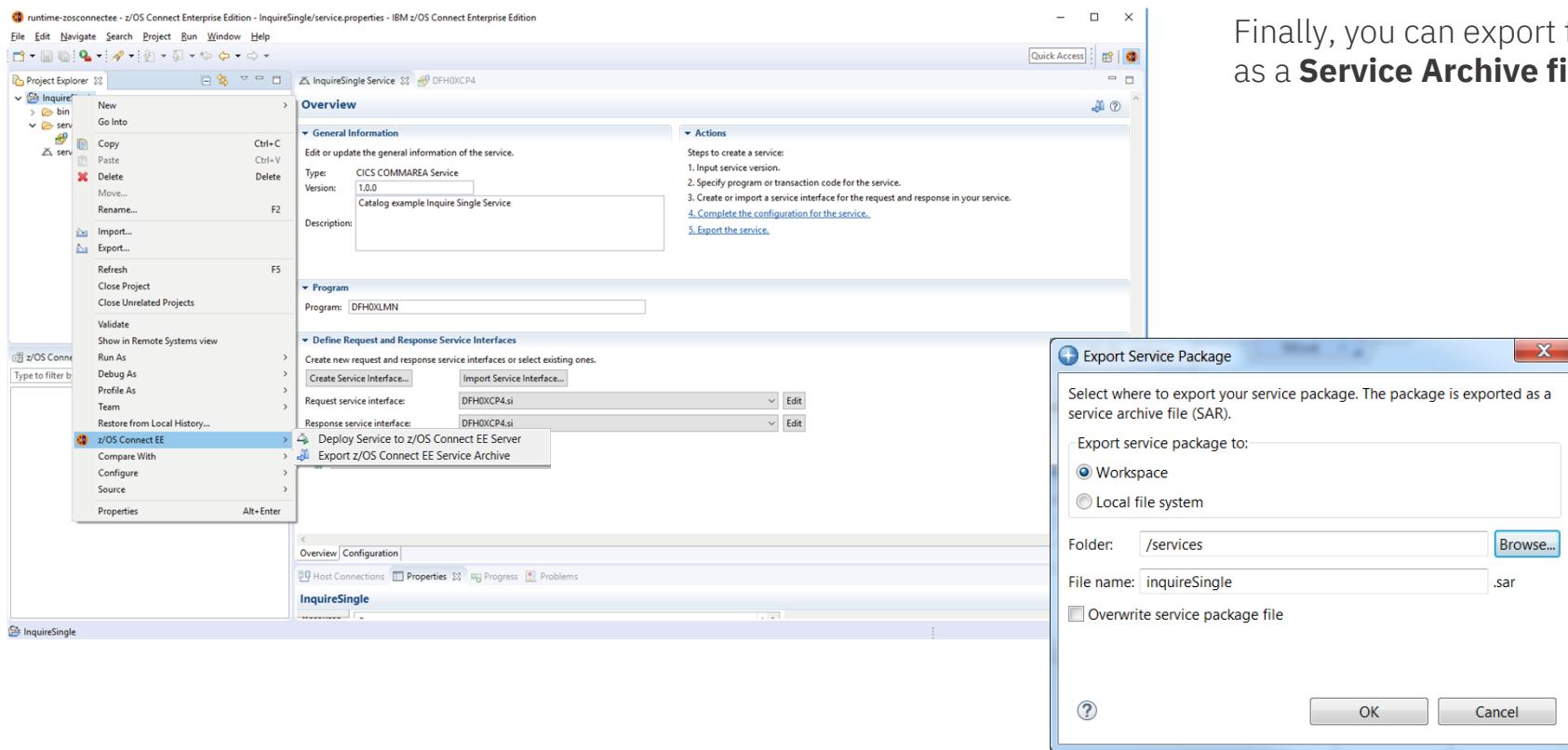


z/OS Connect EE

The screenshot shows the IBM z/OS Connect Enterprise Edition interface. On the left, the Project Explorer displays a service named 'InquireSingle'. The main window shows the 'Overview' tab of the 'InquireSingle Service' configuration. Under 'General Information', the 'Type' is set to 'CICS COMMAREA Service' and 'Version' is '1.0.0'. The 'Program' field contains 'DFH0XLMN'. Under 'Actions', steps for creating a service are listed: 1. Input service version, 2. Specify program or transaction code for the service, 3. Create or import a service interface for the request and response in your service, 4. Complete the configuration for the service, and 5. Export the service. A 'Define Request and Response Service Interfaces' section shows 'Request service interface' as 'DFH0XCP4.si' and 'Response service interface' as 'DFH0XCPA.si'. On the right, a 'Deploy Service' dialog box is open, showing the 'z/OS Connect EE Server' as 'wg31:9453'. It lists the service 'inquireSingle' with Version '13.00' and Type 'CICS COMMAREA Se...'. The dialog has 'OK' and 'Cancel' buttons.

Finally, you can deploy the service project as a **Service Archive file (.sar)**

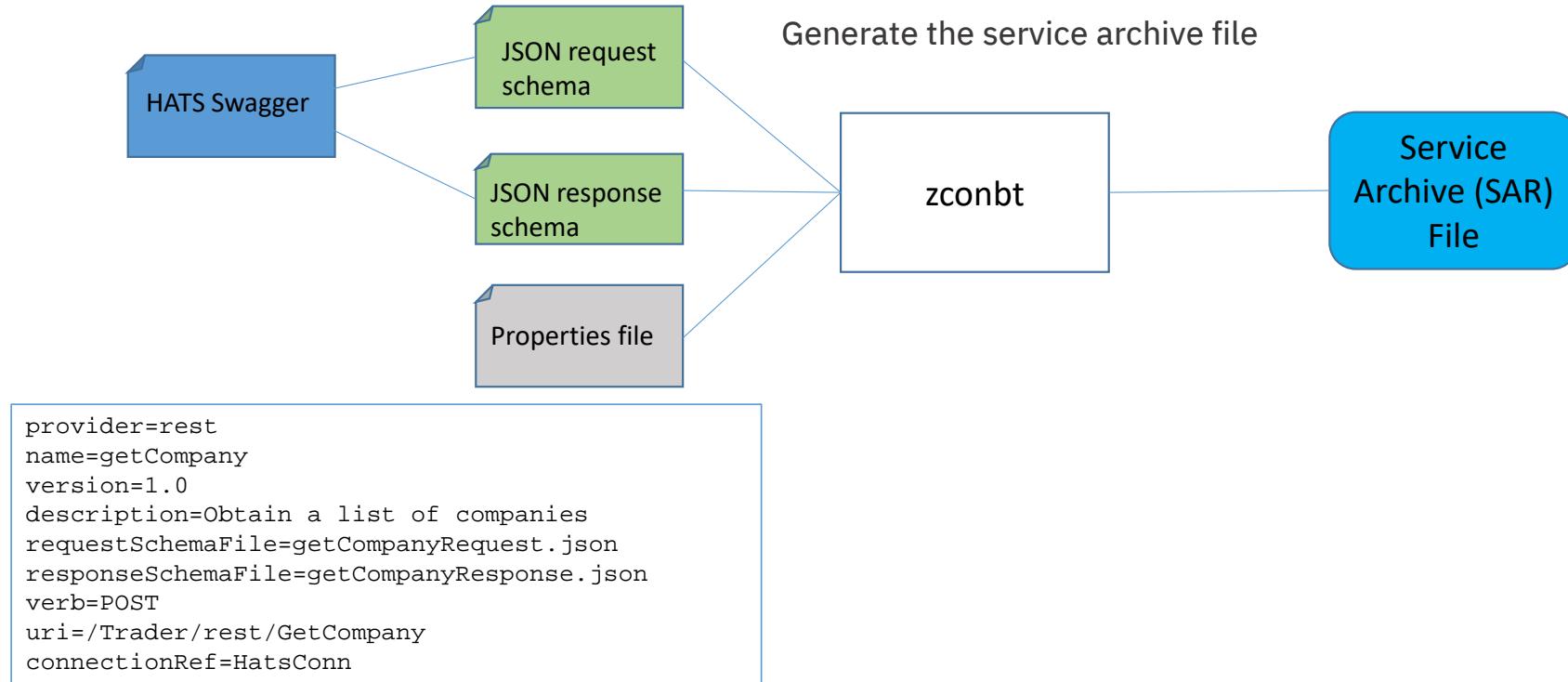
API toolkit – Exporting Services for CICS, IMS TM, IMS DB, Db2 and MQ



Finally, you can export the service project as a **Service Archive file (.sar)**.

Creating Services without the Toolkit – REST

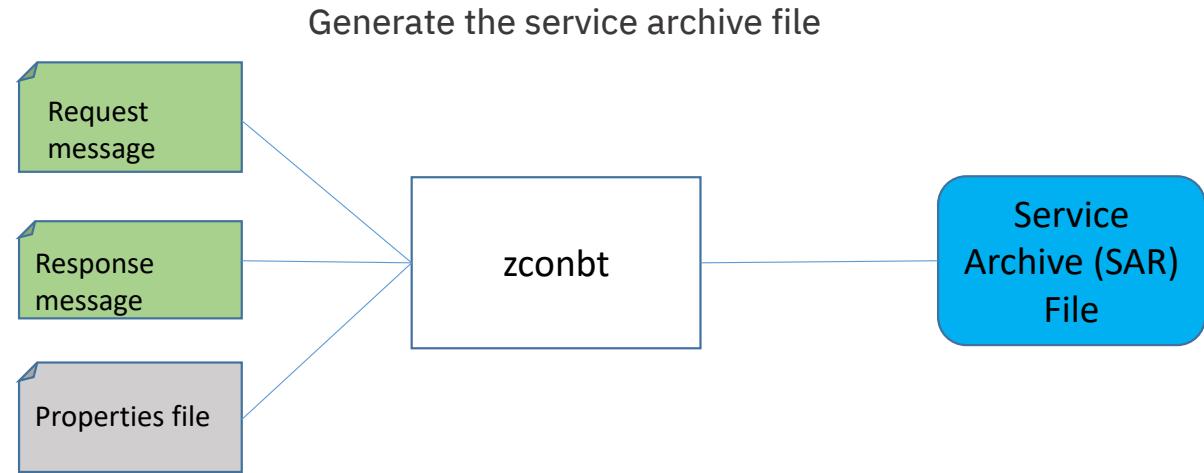
For HATS REST Services use the z/OS Connect Build toolkit (zconbt)



Creating Services without the Toolkit – MVS Batch

For batch WOLA services use the z/OS Connect Build toolkit (zconbt)

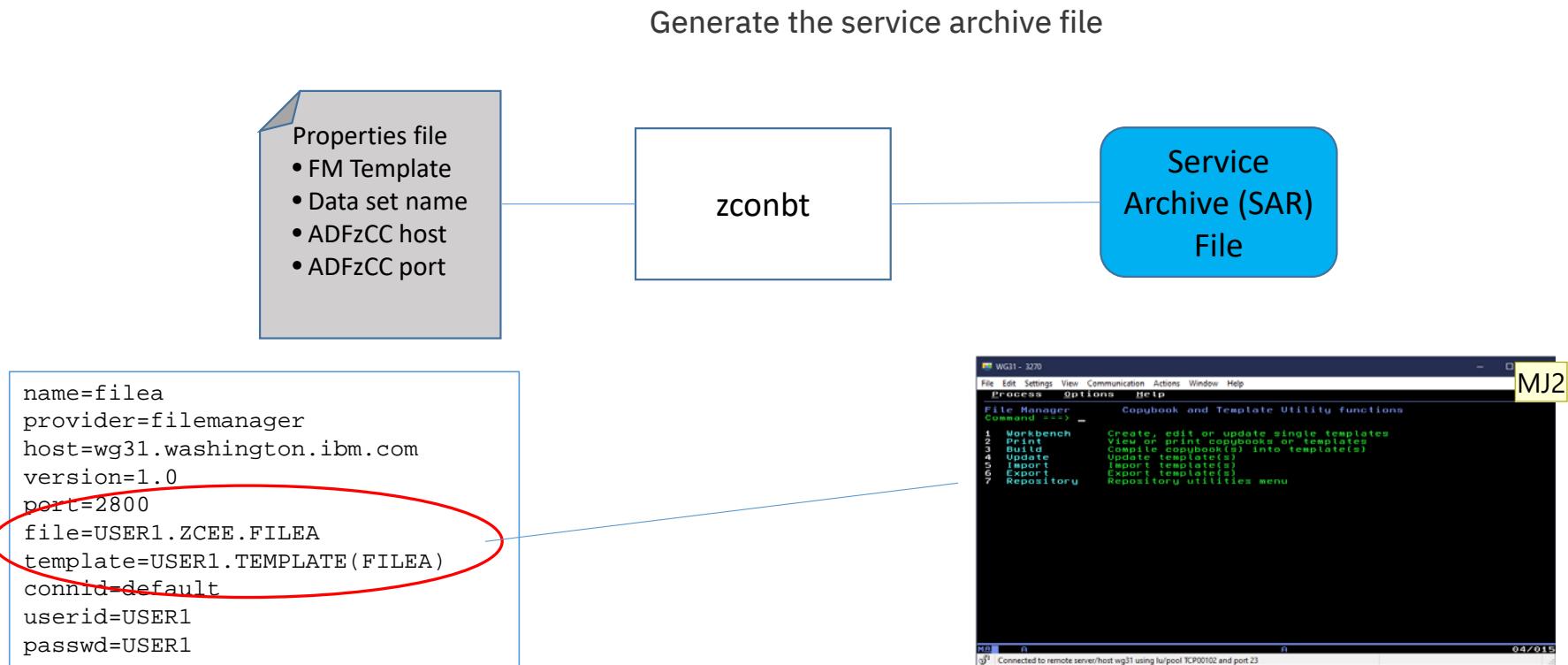
```
name=Filea
version=1.0
provider=wola
description=COBOL batch program
language=COBOL
program=ATSFIL
register=FILEAZCON
connectionRef=wolaCF
requestStructure=fileareq.cpy
responseStructure=filearsp.cpy
```



WebSphere Optimized Local Adapter – a protocol for cross memory communications between address spaces

Creating Services without the Toolkit – FM

For File Manager Services use the z/OS Connect Build toolkit (zconbt)



Slide 45

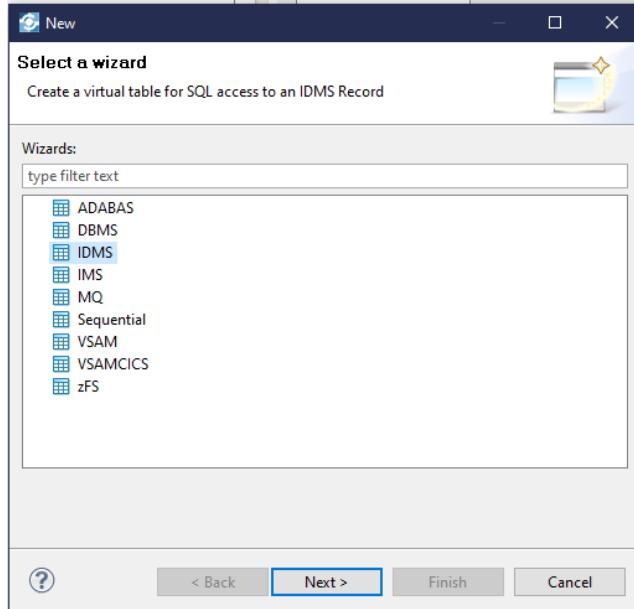
MJ2 Mitch Johnson, 9/2/2020

Creating Services without the Toolkit



z/OS Connect EE

For DVM use the DVM Studio



DV Data - Data Virtualization Manager/SQL Samples/Generated.sql - IBM Data Virtualization Manager for z/OS

File Edit Navigate Search Project SQL Run Window Help

Host: wg31.washington.ibm.com (Port 12) Server: AVZS Version: 01.01.00.01 Set Server ...

Navigator Data Sources Edit SQL Set Current Server

Services

- Web Services
 - Create Directory
 - /REST/
 - Create Service
 - INSERT
 - UPD
 - Set Tree Filter
 - Target System
 - WSC
 - Admin

*Generated.sql

```
-- FILE LOCATION: wg31.washington.ibm.com/1200/SQL/Data/AVZS/V100
-- REMARKS: VSAMCICS - USER1.OFFICE.SUPPLIES
SELECT WS_ITEM_REF, WS_DESCRIPTION, WS_DEPARTMENT, WS_COST, WS_IN_
WS_ON_ORDER
FROM EXMPCAT LIMIT 1000;

INSERT INTO EXMPCAT WHERE (WS_ITEM_REF, WS_DESCRIPTION, WS_DEPARTM_
WS_ON_ORDER) VALUES('9997','Mitch Johnson','010','002.90','0106'
INSERT INTO EXMPCAT WHERE (WS_ITEM_REF, WS_DESCRIPTION, WS_DEPARTM_
WS_ON_ORDER) VALUES('9998','Mitch Johnson','010','002.90','0106'
INSERT INTO EXMPCAT WHERE (WS_ITEM_REF, WS_DESCRIPTION, WS_DEPARTM_
WS_ON_ORDER) VALUES('9999','Mitch Johnson','010','002.90','0106'

UPDATE EXMPCAT SET WS_COST = '003.90' WHERE WS_ITEM_REF = 9999
```

Server Trace Console

WS_DESCRIPTION	WS_DEPARTMENT	WS_C
Mitch Johnson	10	002.
Mitch Johnson	10	002.
Mitch Johnson	10	002.

z/OS Connect REST Interface

DSN Name: AVZS

Execute Query

Refresh

Generate SAR File(s)

Columns Group: 1 or 1

3 rows SQL Messages

Columns per group: 25



Once we have a Service Archive (SAR) What's next?

Quick and easy **API mapping**.

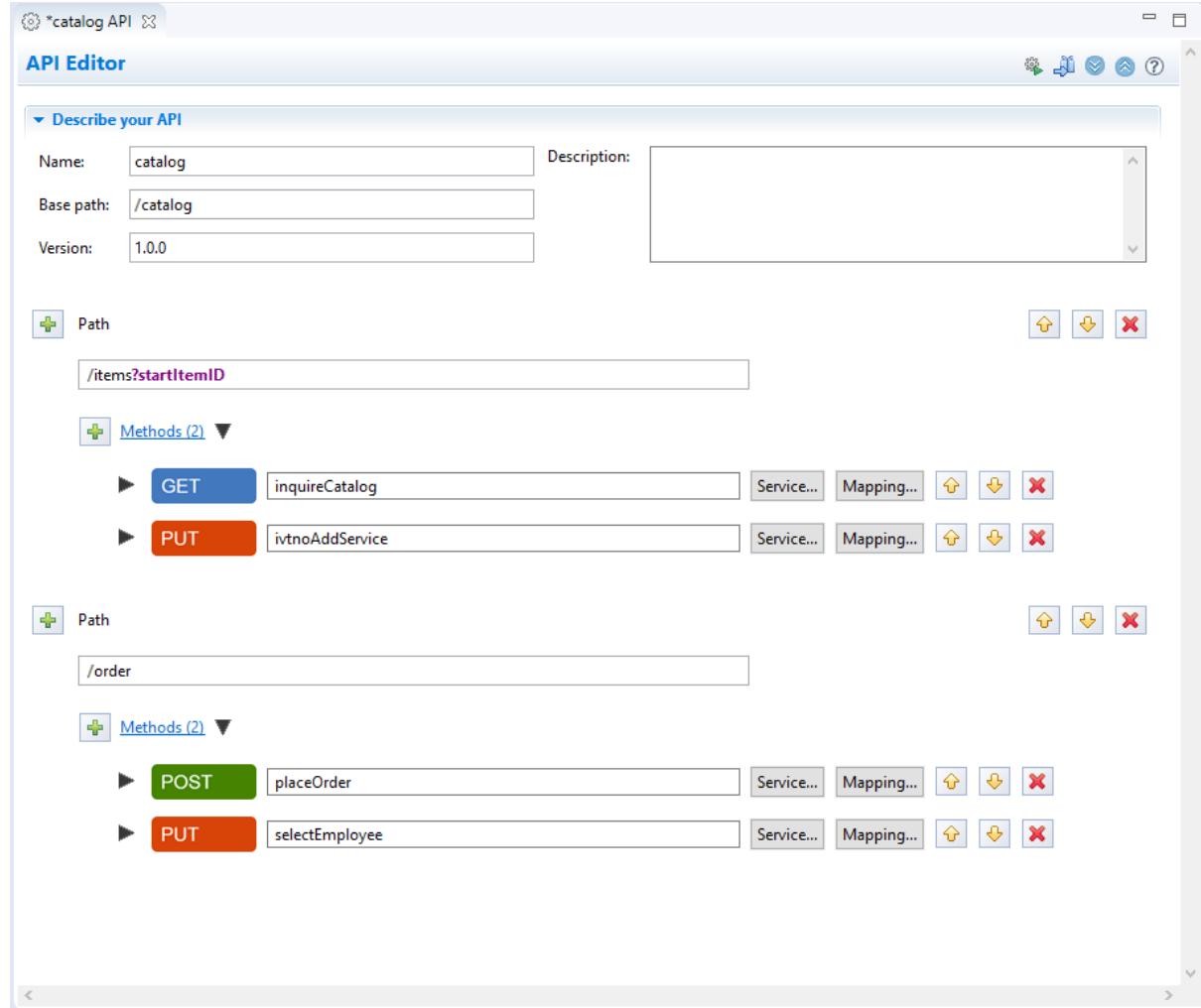
Remember: All service archives files are functionally equivalent regardless of how they are created



/api_toolkit/api_editor

Quick and easy **API mapping**.

API toolkit – API Editor



The screenshot shows the API toolkit API Editor interface. It displays two API definitions:

- catalog API**:
 - Path**: /items?startItemID
 - Methods (2)**:
 - ▶ **GET** inquireCatalog
 - ▶ **PUT** ivtnoAddService
- order**:
 - Path**: /order
 - Methods (2)**:
 - ▶ **POST** placeOrder
 - ▶ **PUT** selectEmployee

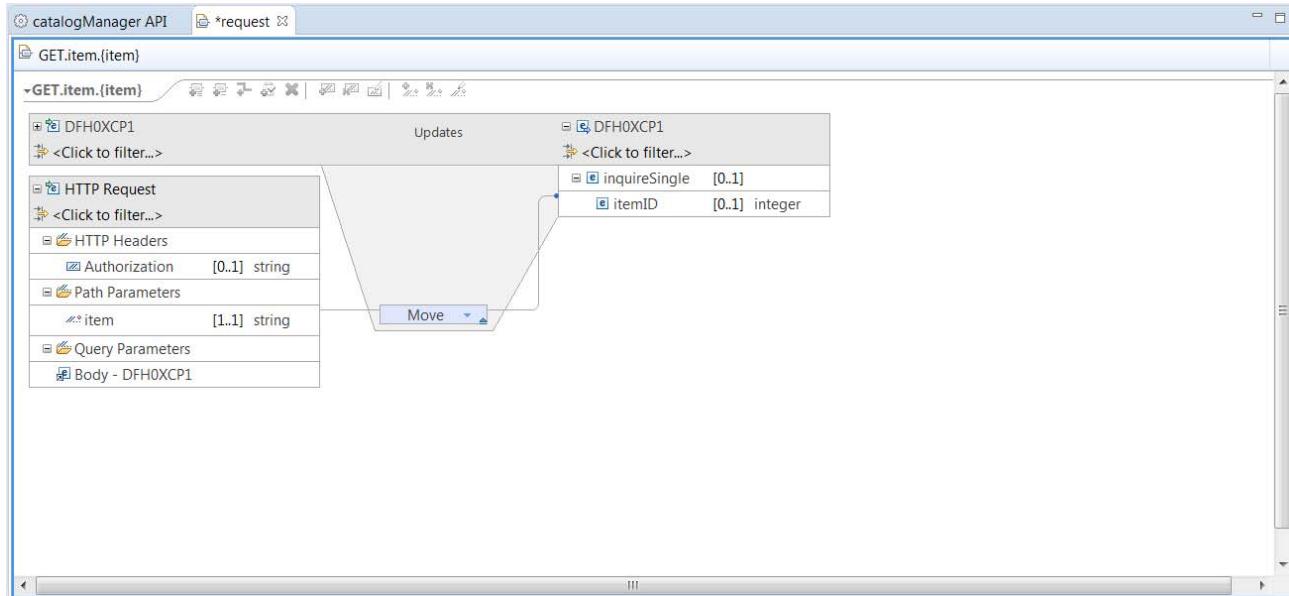
The **API toolkit** is designed to encourage RESTful API design.

Once you define your API, you can map backend services to each request.

Your services are represented by **.sar** files, which you import into the **API toolkit**, regardless of how the .sar was generated.

API toolkit – API Editor

API mapping: Point-and-click interface



Map both the request and response for each API.

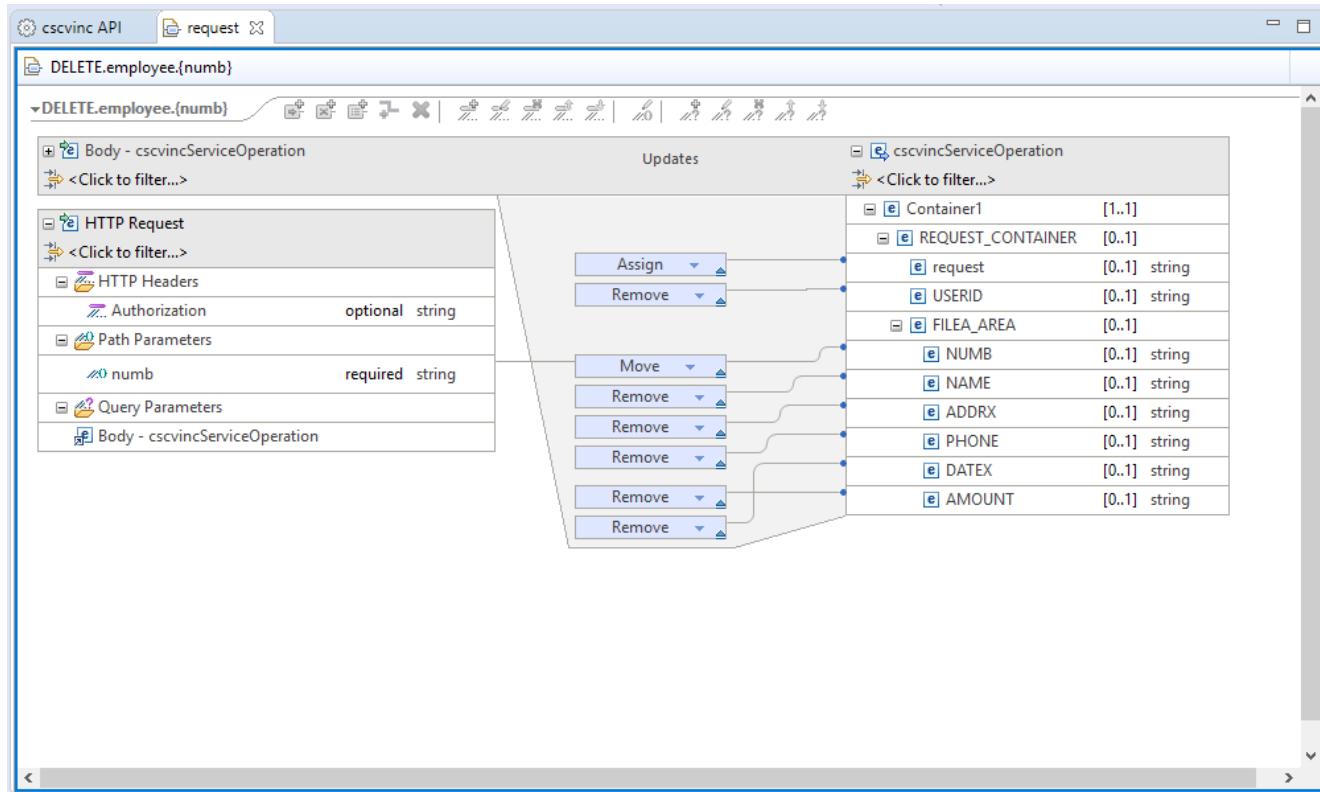
Map path and query parameters to native data structures.

Assign static values to fields, useful for Op codes.

Remove unwanted fields to simplify the API (remember request was set to 01INQC in the SAR).

API toolkit – API Editor

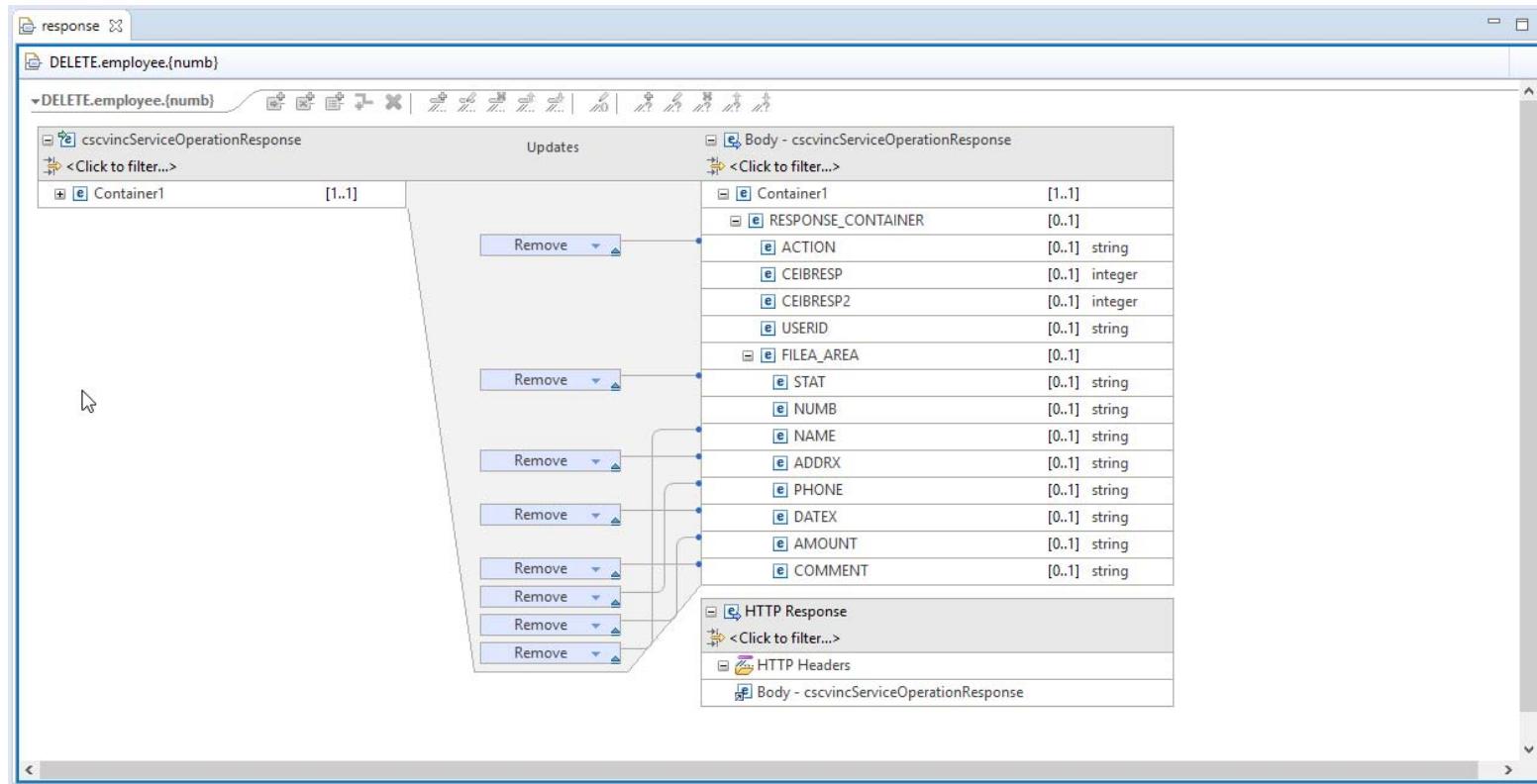
API mapping: Point-and-click interface



API toolkit – API Editor

API mapping: Point-and-click interface

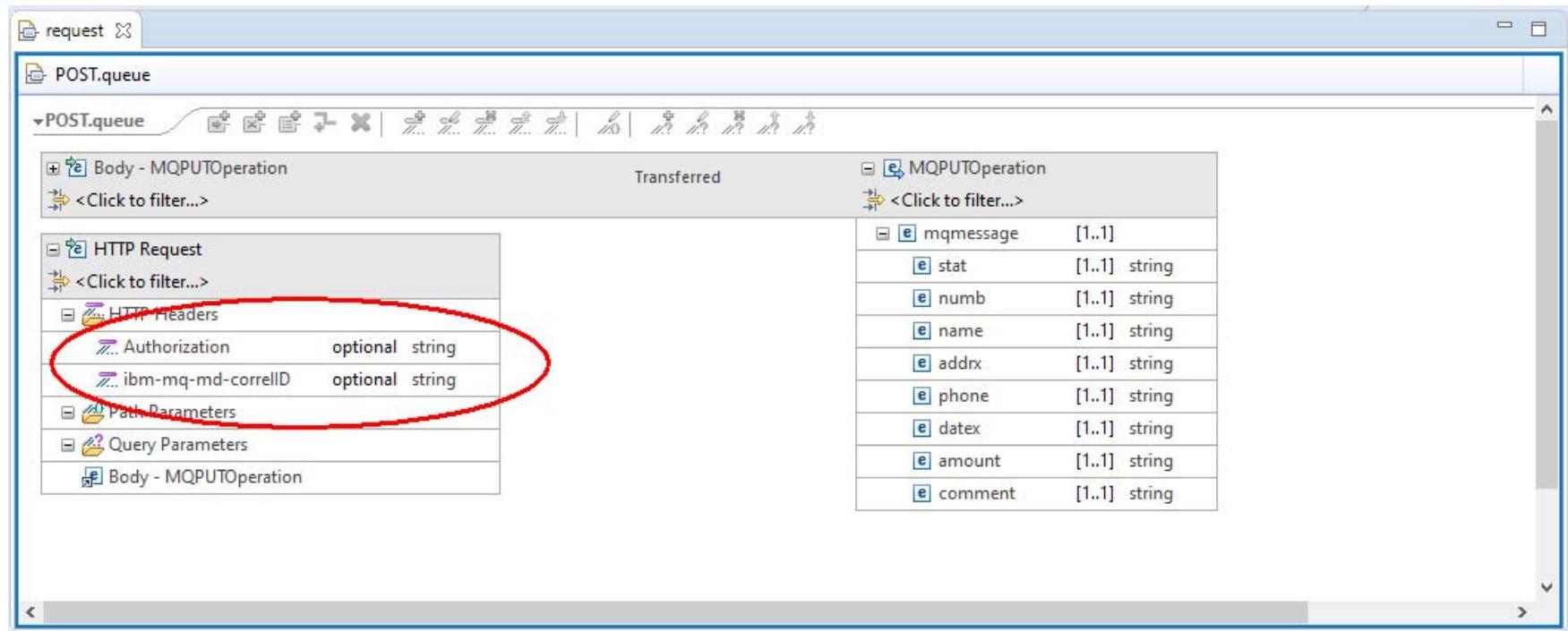
Allows the API Developer to remove fields from the response to simplify the API



API toolkit – API Editor

API mapping: Adding HTTP header properties

Allows the API Developer to remove fields to the request.

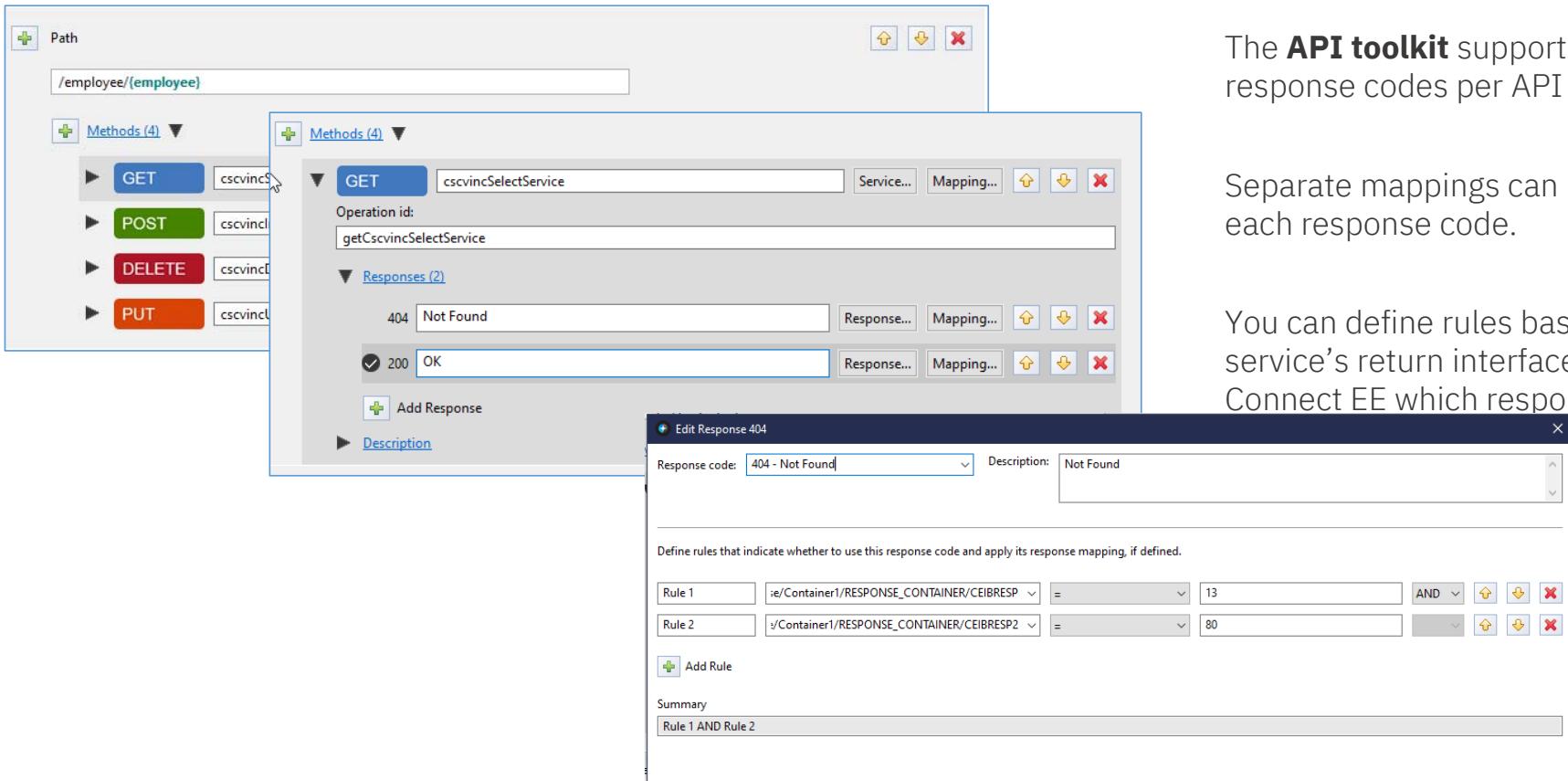


The screenshot shows the API toolkit - API Editor interface. The left pane displays the 'Body - MQPUTOperation' section, specifically the 'HTTP Request' and 'HTTP Headers' subsections. The 'HTTP Headers' section is circled in red and contains two entries: 'Authorization' (optional string) and 'ibm-mq-md-correlID' (optional string). The right pane shows the 'MQPUTOperation' section with a list of fields:

Field	Type
mqmessage	[1..1]
stat	[1..1] string
numb	[1..1] string
name	[1..1] string
addrx	[1..1] string
phone	[1..1] string
datex	[1..1] string
amount	[1..1] string
comment	[1..1] string

API toolkit

API definition with multiple response codes



The screenshot shows the API toolkit interface for defining an API operation. The path is set to `/employee/{employee}`. The Methods section lists four methods: GET, POST, DELETE, and PUT, each associated with a service name like `cscvincS...`.

For the GET method, the operation ID is `getCscvincSelectService`. The Responses section defines two response codes: 404 Not Found and 200 OK. A modal window titled "Edit Response 404" is open, showing the response code as "404 - Not Found" and the description as "Not Found". Below this, rules are defined to apply this response code:

- Rule 1: `ie/Container1/RESPONSE_CONTAINER/CEIBRESP` = 13
- Rule 2: `y/Container1/RESPONSE_CONTAINER/CEIBRESP2` = 80

The summary for these rules is "Rule 1 AND Rule 2".

The **API toolkit** supports defining multiple response codes per API operation.

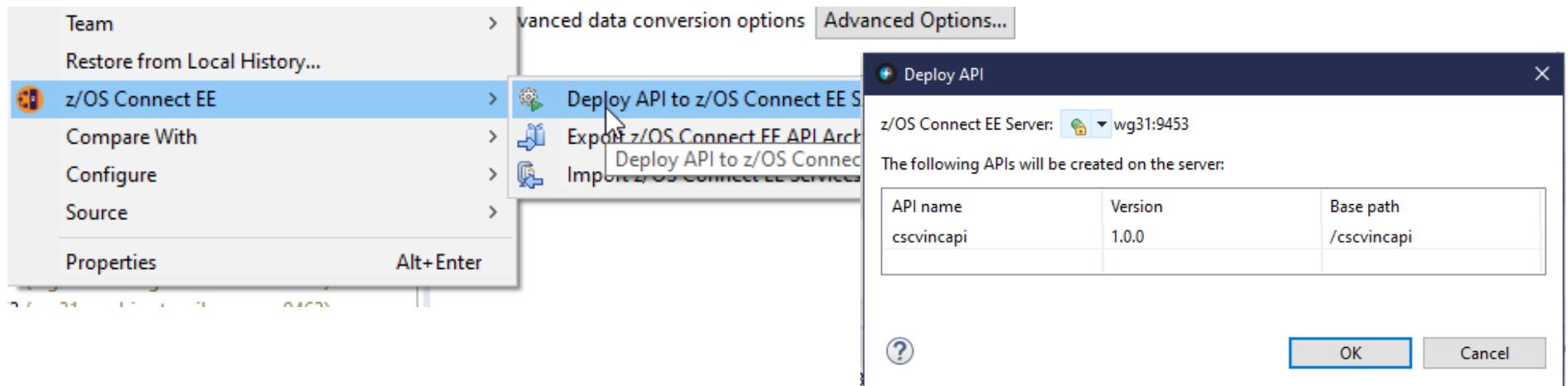
Separate mappings can be defined for each response code.

You can define rules based on fields in the service's return interface to tell z/OS Connect EE which response code to return

API toolkit – API Editor

Server connection and API deployment

Manage z/OS Connect EE server connections in the **Host Connections** view:

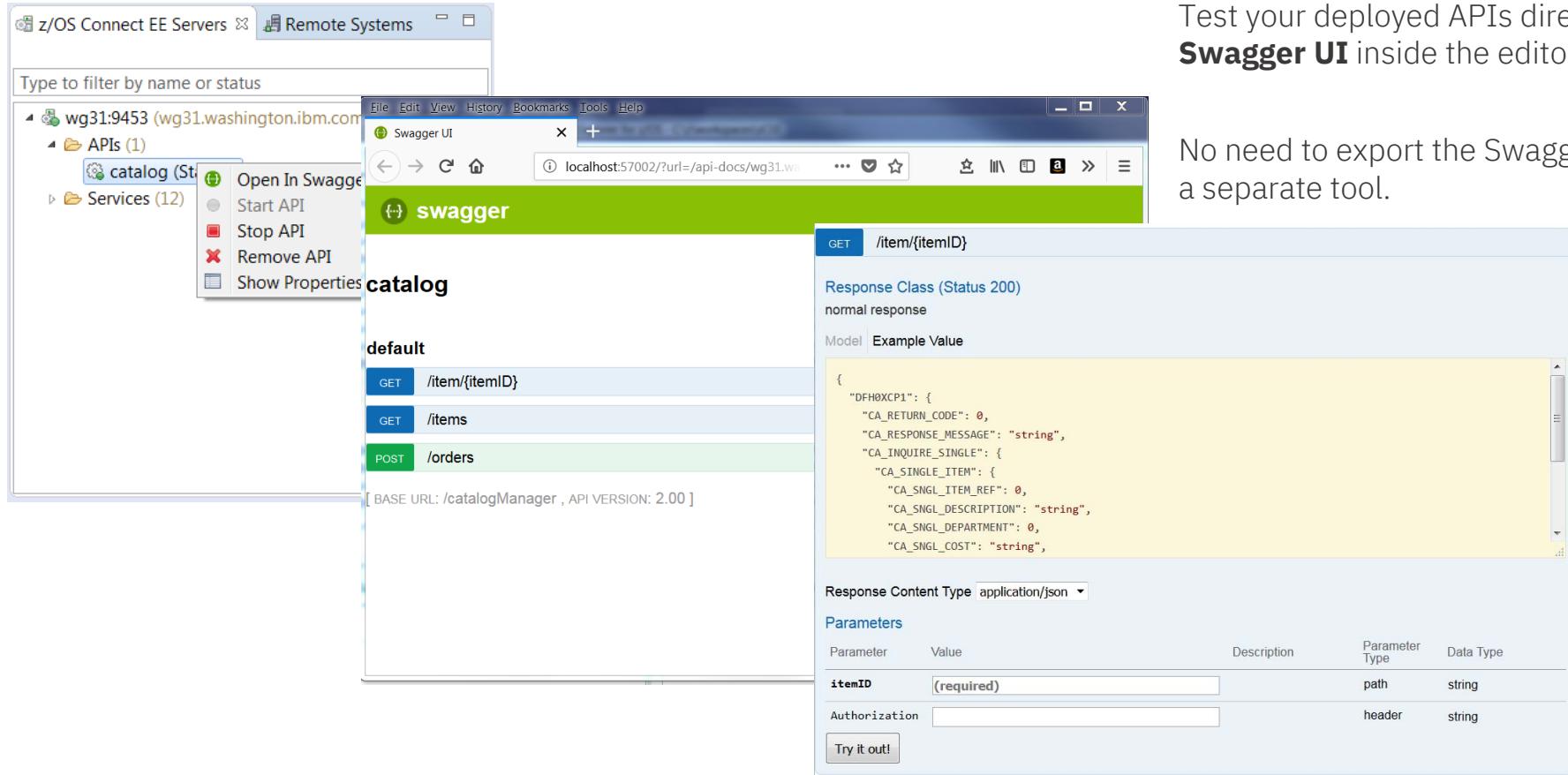


Right-click deploy to server enables developers to quickly deploy, test, and iterate on their APIs.

z/OS Connect EE servers view allows you to start, stop, and remove APIs from a running server.

API toolkit – API Editor

Testing with Swagger UI



The screenshot shows the z/OS Connect EE API Editor interface. On the left, there's a sidebar with 'z/OS Connect EE Servers' and 'Remote Systems' tabs, and a search bar. Below that, it lists 'APIs (1)' containing a 'catalog' entry, and 'Services (12)'. A context menu is open over the 'catalog' entry with options: 'Open In Swagger', 'Start API', 'Stop API', 'Remove API', and 'Show Properties'. The main area is titled 'swagger' and shows a 'catalog' section. It lists 'default' with three operations: 'GET /item/{itemID}', 'GET /items', and 'POST /orders'. The 'POST /orders' operation is highlighted with a green background. Below the operations, it says '[BASE URL: /catalogManager , API VERSION: 2.00]'. To the right, a detailed view of the 'POST /orders' operation is shown. It has a 'Model' tab selected, displaying a JSON schema:

```
{
  "DFH0XCP1": {
    "CA_RETURN_CODE": 0,
    "CA_RESPONSE_MESSAGE": "string",
    "CA_INQUIRE_SINGLE": {
      "CA_SINGLE_ITEM": {
        "CA_SNGL_ITEM_REF": 0,
        "CA_SNGL_DESCRIPTION": "string",
        "CA_SNGL_DEPARTMENT": 0,
        "CA_SNGL_COST": "string"
      }
    }
  }
}
```

Below the model, the 'Response Content Type' is set to 'application/json'. Under 'Parameters', there are two entries: 'itemID' (required, path, string) and 'Authorization' (header, string). At the bottom is a 'Try it out!' button.

Test your deployed APIs directly with **Swagger UI** inside the editor.

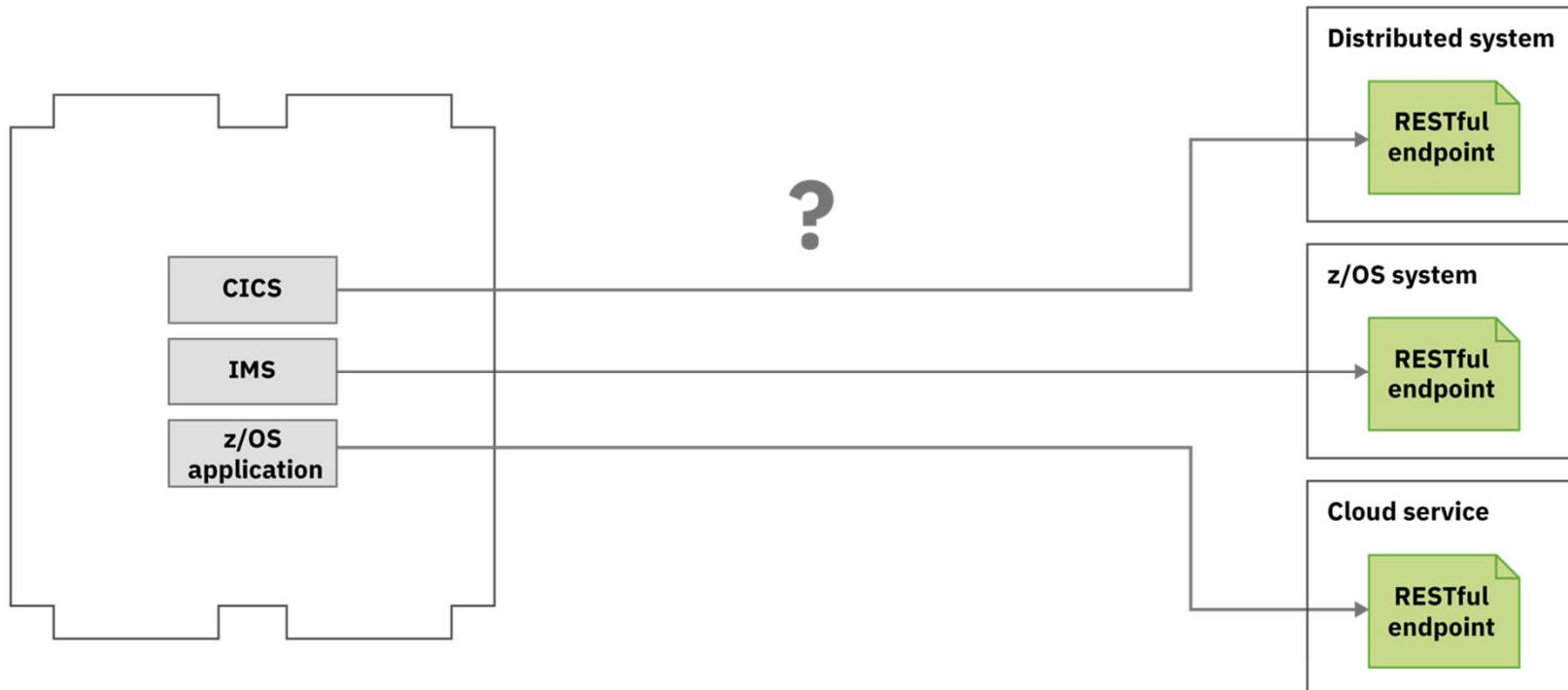
No need to export the Swagger doc to a separate tool.



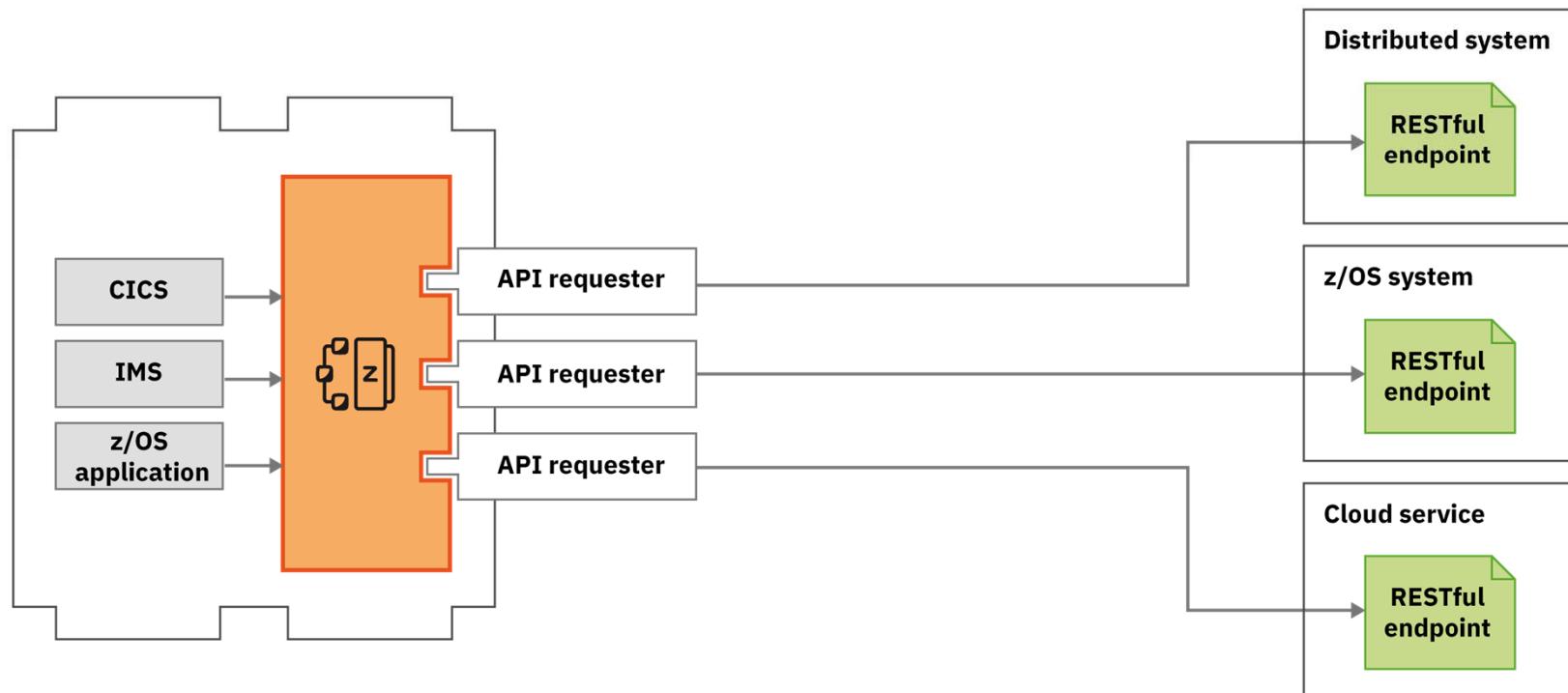
/api_toolkit/apiRequesters

Quick and easy **API mapping**.

What about calling external APIs from my z/OS assets?

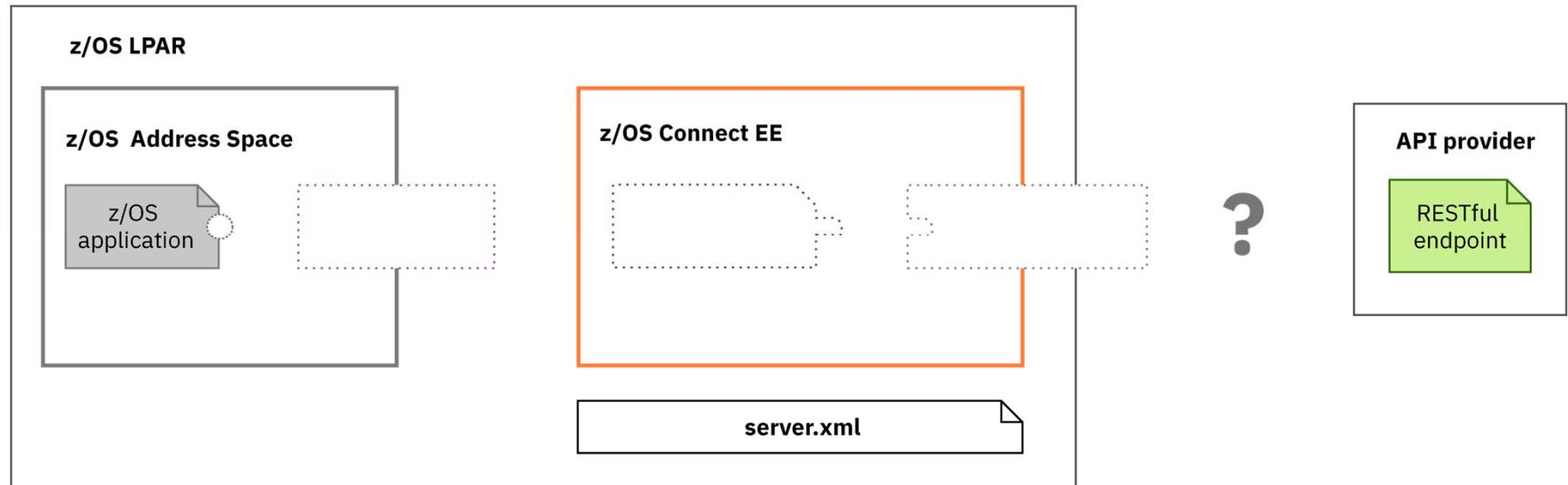


Use API requester to call external APIs from z/OS assets



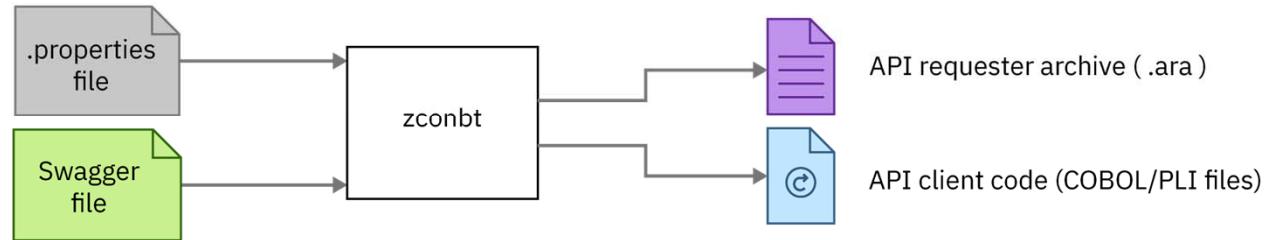
Steps to calling an external API

Starting point



Steps to calling an external API

Step 1. Generate API requester archive from Swagger



Generate the API requester archive file, and API client code.

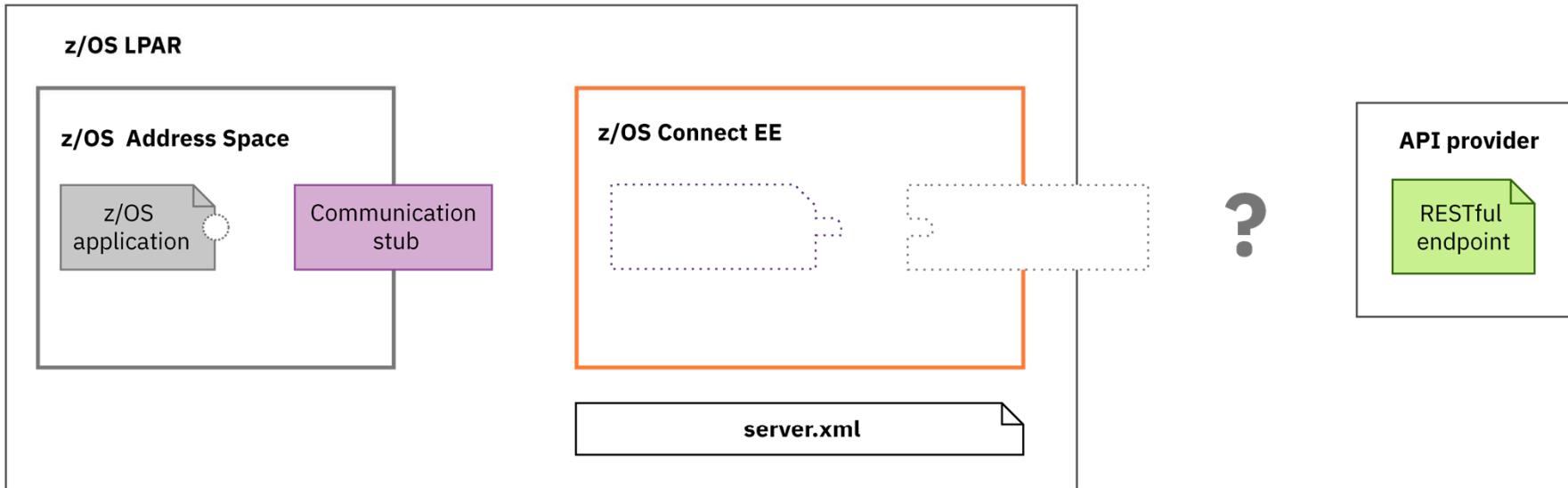
 ibm.biz/zosconnect-generate-ara



z/OS Connect EE

Steps to calling an external API

Step 2. Configure communication stub



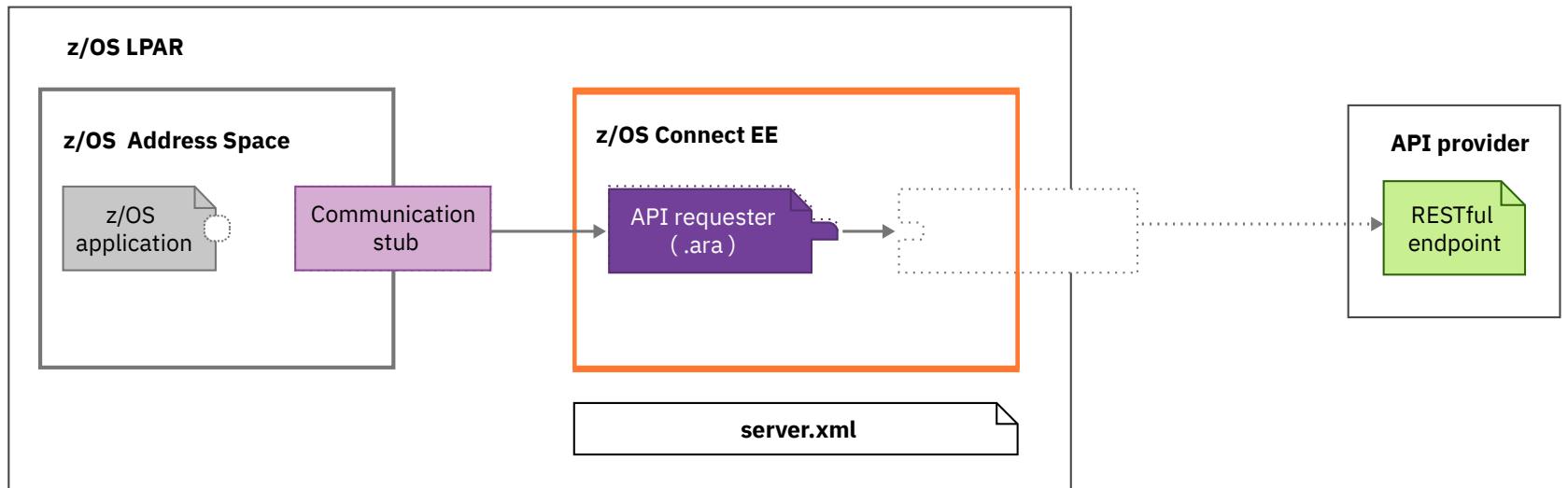
Configure a communication stub.

- Once per CICS region system using a URIMAP resource
- For non CICS client the configuration is done via environment variables

 ibm.biz/zosconnect-configure-comms-stub

Steps to calling an external API

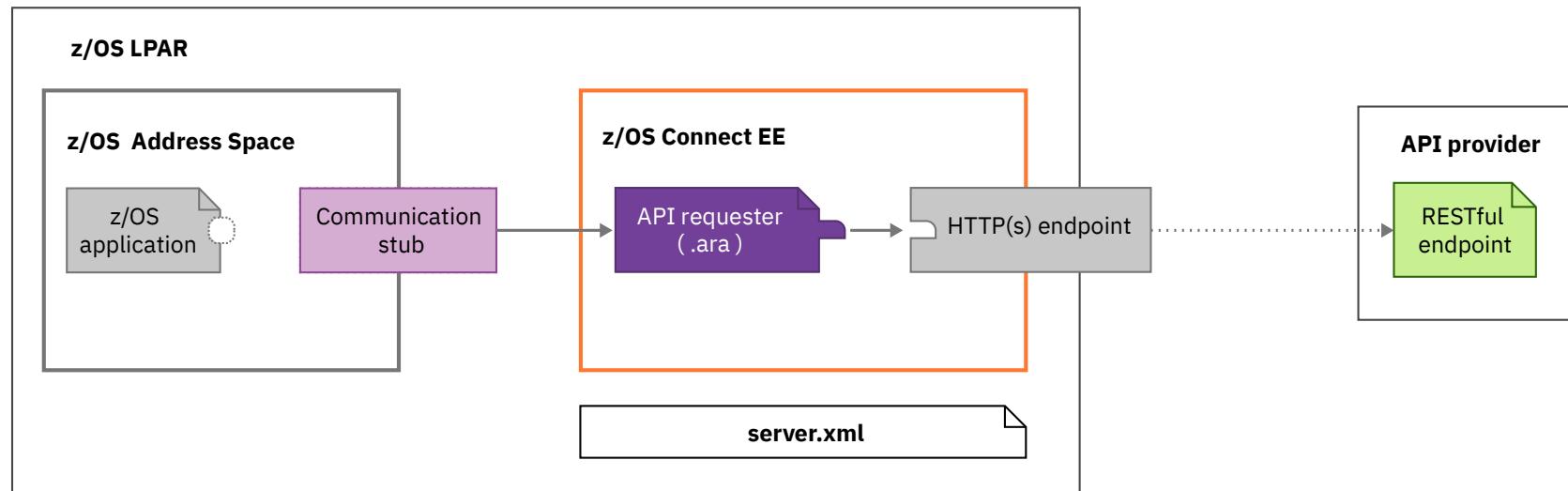
Step 3. Deploy API requester (.ara) archive



Deploy your API requester archive to the *apiRequesters* directory.

Steps to calling an external API

Step 4. Configure HTTP(S) endpoint



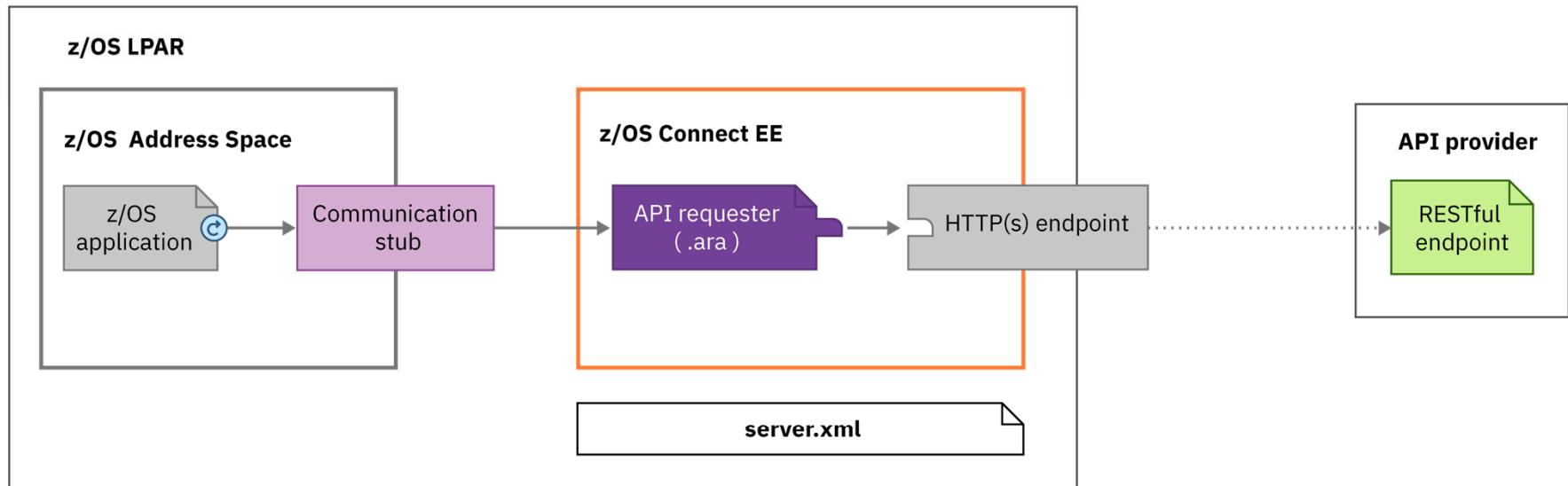
Configure the connection between z/OS Connect EE and the external API.

 ibm.biz/zosconnect-configure-endpoint-connection

© 2018, 2020 IBM Corporation

Steps to calling an external API

Step 5. Update z/OS application



Finally, add the generated API client code to your existing application and use it to make the external API call.

 ibm.biz/zosconnect-configure-requester-zos-application

Steps to calling an external API

Step 5a. Update the z/OS application to include new copy books

The screenshot shows three windows in IBM Rational Application Developer:

- GETAPI**: A source editor window containing COBOL code. It includes sections for ERROR MESSAGE STRUCTURE, API Requester required copybook (COPY BAQRINFO), Request and Response (COPY CSC02Q01 and COPY CSC02P01), and a structure with the API (COPY CSC02I01). A red arrow points to the COPY CSC02I01 line.
- apis.xml**: An XML configuration file for the API requester. It defines a server with a featureManager and a zosconnect_apiRequesters section. A connection endpoint is defined with host="http://wg31.washington.ibm.com", port="9120", basicAuthRef="myBasicAuth", connectionTimeout="10s", and receiveTimeout="20s". A red oval highlights this section. Below it is a zosconnect_authData entry for user "Fred" and password "fredpwd".
- CSC02I01**: A source editor window containing COBOL code for the structure defined in the GETAPI window. It lists fields such as BAQ-APINAME, BAQ-APINAME-LEN, BAQ-APIPATH, BAQ-APIPATH-LEN, BAQ-APIMETHOD, and BAQ-APIMETHOD-LEN with their respective PIC and VALUE definitions. A red arrow points to the first line of this code.

On the right side of the interface, there is a preview pane showing configuration parameters:

```
apiDescriptionFile=../cscvinc.swagger
dataStructuresLocation=../syslib
apiInfoFileLocation=../syslib
logFileDirectory=../logs
language=COBOL
connectionRef=cscvincAPI
requesterPrefix=csc
```

Steps to calling an external API

Step 5b. Update the z/OS application to call the stub

```
*-----*
* Set up the data for the API Requester call *
*-----*
      MOVE numb      of PARM-DATA TO numb IN API-REQUEST.
      MOVE LENGTH of numb in API-REQUEST to
            numb-length IN API-REQUEST.

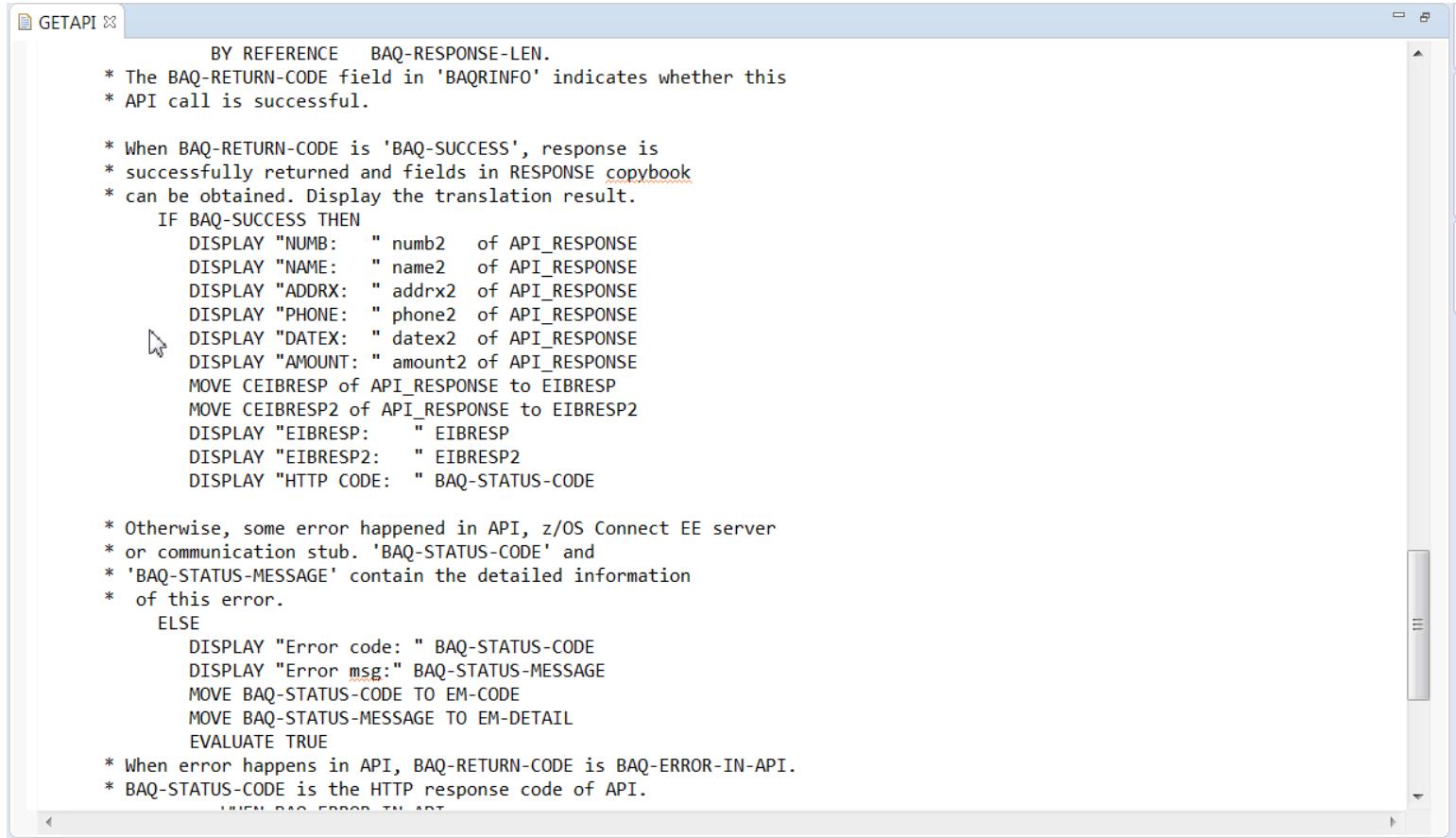
*-----*
* Initialize API Requester PTRs & LENs          *
*-----*
* Use pointer and length to specify the location of
* request and response segment.
* This procedure is general and necessary.
      SET BAQ-REQUEST-PTR TO ADDRESS OF API-REQUEST.
      MOVE LENGTH OF API-REQUEST TO BAQ-REQUEST-LEN.
      SET BAQ-RESPONSE-PTR TO ADDRESS OF API_RESPONSE.
      MOVE LENGTH OF API_RESPONSE TO BAQ-RESPONSE-LEN.

*-----*
* Call the communication stub                      *
*-----*
* Call the subsystem-supplied stub code to send
* API request to zCEE
      CALL COMM-STUB-PGM-NAME USING
            BY REFERENCE API-INFO-OPER1
            BY REFERENCE BAQ-REQUEST-INFO
            BY REFERENCE BAQ-REQUEST-PTR
            BY REFERENCE BAQ-REQUEST-LEN
            BY REFERENCE BAQ-RESPONSE-INFO
            BY REFERENCE BAQ-RESPONSE-PTR
            BY REFERENCE BAQ-RESPONSE-LEN.

* The BAQ-RETURN-CODE field in 'BAQRINFO' indicates whether this
* API request was successful.
```

Steps to calling an external API

Step 5c. Update the z/OS application to access the results

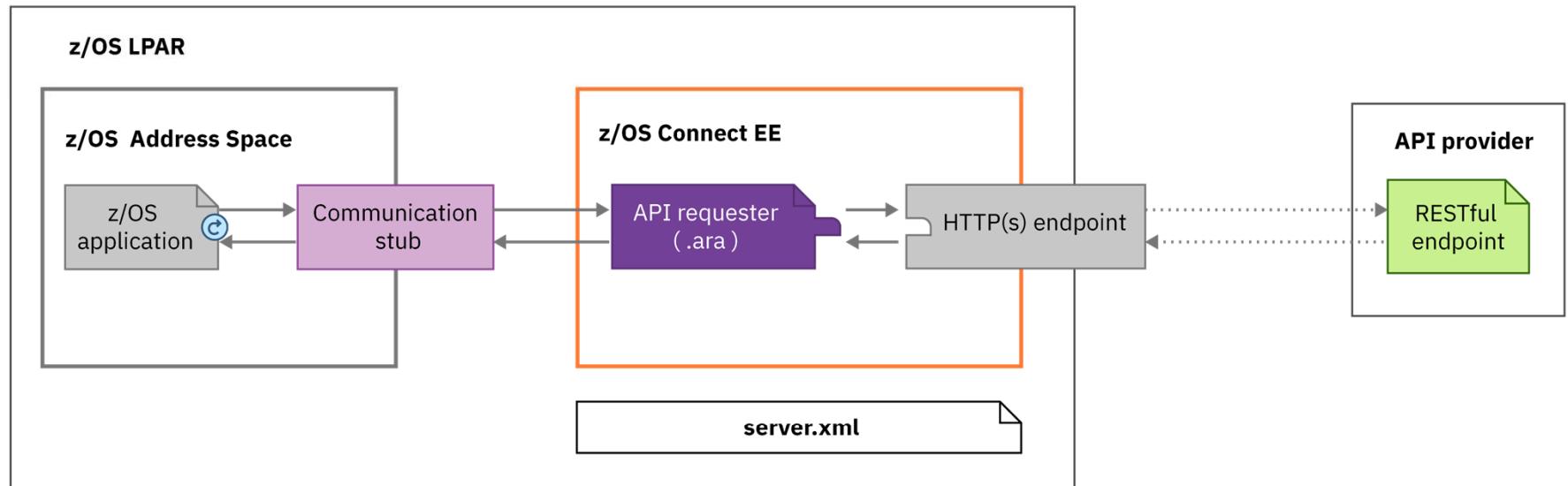


The screenshot shows the GETAPI editor window with the following AS/400 JCL code:

```
BY REFERENCE BAQ-RESPONSE-LEN.  
* The BAQ-RETURN-CODE field in 'BAQRINFO' indicates whether this  
* API call is successful.  
  
* When BAQ-RETURN-CODE is 'BAQ-SUCCESS', response is  
* successfully returned and fields in RESPONSE copybook  
* can be obtained. Display the translation result.  
IF BAQ-SUCCESS THEN  
  DISPLAY "NUMB: " numb2 of API_RESPONSE  
  DISPLAY "NAME: " name2 of API_RESPONSE  
  DISPLAY "ADDRX: " addrx2 of API_RESPONSE  
  DISPLAY "PHONE: " phone2 of API_RESPONSE  
  DISPLAY "DATEX: " datex2 of API_RESPONSE  
  DISPLAY "AMOUNT: " amount2 of API_RESPONSE  
  MOVE CEIBRESP of API_RESPONSE to EIBRESP  
  MOVE CEIBRESP2 of API_RESPONSE to EIBRESP2  
  DISPLAY "EIBRESP: " EIBRESP  
  DISPLAY "EIBRESP2: " EIBRESP2  
  DISPLAY "HTTP CODE: " BAQ-STATUS-CODE  
  
* Otherwise, some error happened in API, z/OS Connect EE server  
* or communication stub. 'BAQ-STATUS-CODE' and  
* 'BAQ-STATUS-MESSAGE' contain the detailed information  
* of this error.  
ELSE  
  DISPLAY "Error code: " BAQ-STATUS-CODE  
  DISPLAY "Error msg: " BAQ-STATUS-MESSAGE  
  MOVE BAQ-STATUS-CODE TO EM-CODE  
  MOVE BAQ-STATUS-MESSAGE TO EM-DETAIL  
  EVALUATE TRUE  
  
* When error happens in API, BAQ-RETURN-CODE is BAQ-ERROR-IN-API.  
* BAQ-STATUS-CODE is the HTTP response code of API.  
  WHEN BAQ-ERROR-IN-API
```

Steps to calling an external API

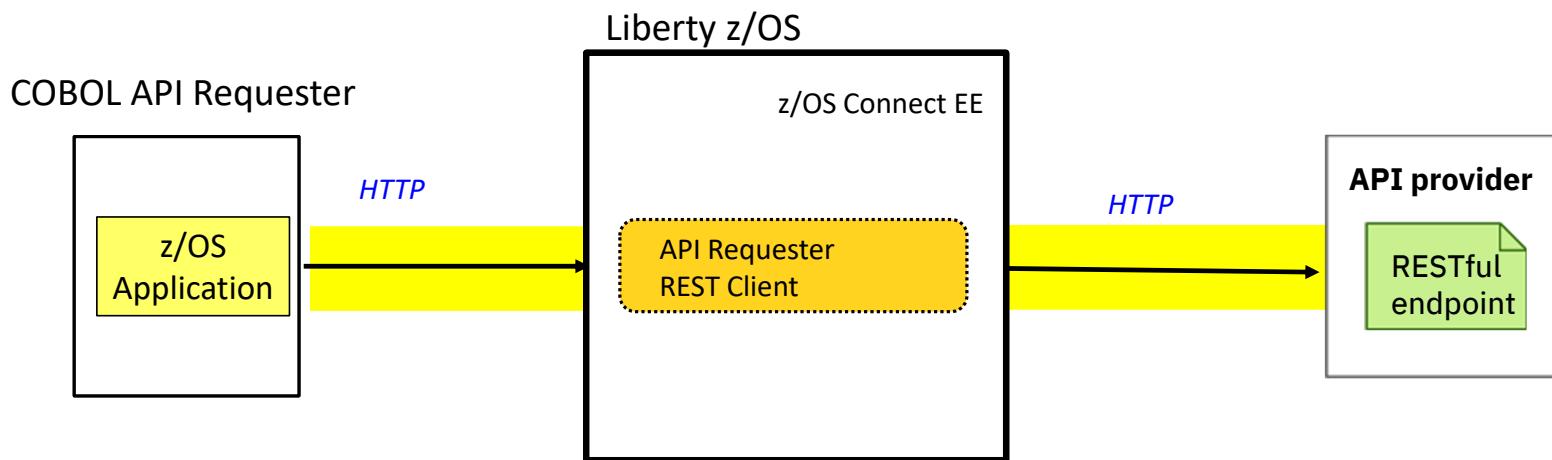
Done





z/OS Connect EE

API requester to API Provider connection overview



MVS Batch and IMS HTTP connection details provided by:

- Environment Variables (BAQURI, BAQPORT)
 - Via JCL
 - LE Options (CEEROPTS)
 - Programmatically (CEEENV)
- HTTP or HTTPS

CICS HTTP connection details provided by:

- BAQURIMP CICS URIMAP resource
 - HOST
 - PORT
 - SCHEME (HTTP/HTTPS)

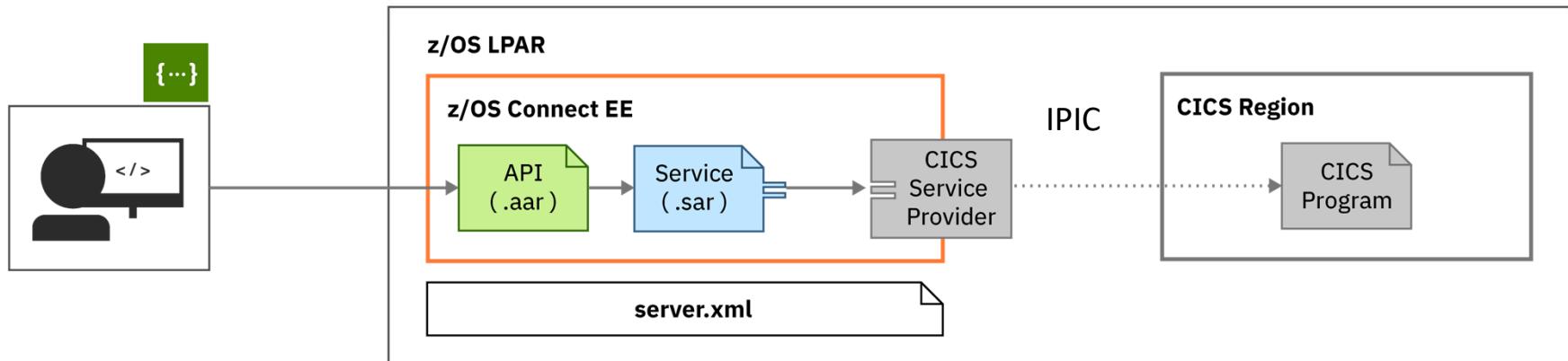


/common_scenarios

Typical connection patterns to different subsystems.

Connections to CICS

Topology



Connection to CICS is configured in `server.xml`.

An IPIC connection must be configured in CICS.

 ibm.biz/zosconnect-scenarios

CICS IPIC (server.xml)



z/OS Connect EE

The server.xml file is the key configuration file:

inquireSingle Service

Configuration

Required Configuration

Enter the required configuration for this service.

Coded character set identifier (CCSID): 37

Connection reference: catalog

Optional Configuration

Enter the optional configuration for this service.

Transaction ID: [empty]

Transaction ID usage: [dropdown]

WG31

File Edit Settings View Communication Actions Window Help

OVERTYPE TO MODIFY
CEDA ALTER TCpipservice(IPIC)
TCpipservice : IPIC
GR0up : SYSGRP
DEscription ==> DFHISAPIP
UrM ==> 01491
POrtnumber ==> 1-65535
Status ==> Open
PROtocol ==> IPic
TRansaction ==> CISS
Backlog ==> 00000
TSqprefix :
Host ==> ANY
(Mixed Case) ==>
Ipaddress ==> ANY
SPecifTCPs ==>
SOcketclose ==> No
MAXPersist ==> No
+ MAXDataLen ==> 000032
CICS RELEASE = 0710
1-65535
Open | Closed
Http Eci | User | IPic
0-32767
SYSID=CICS APPLID=CICS53Z
PF 1 HELP 2 COM 3 END 6 CRSR 7 SBH 8 SFH 9 MSG 10 SB 11 SF 12 CNCL
M A E 06/022
Connected to remote server/host wg31 using lu/pool TCP00104 and port 23

Features are functional building blocks. When configured here, that function becomes available to the Liberty server

catalog.xml

Design Source

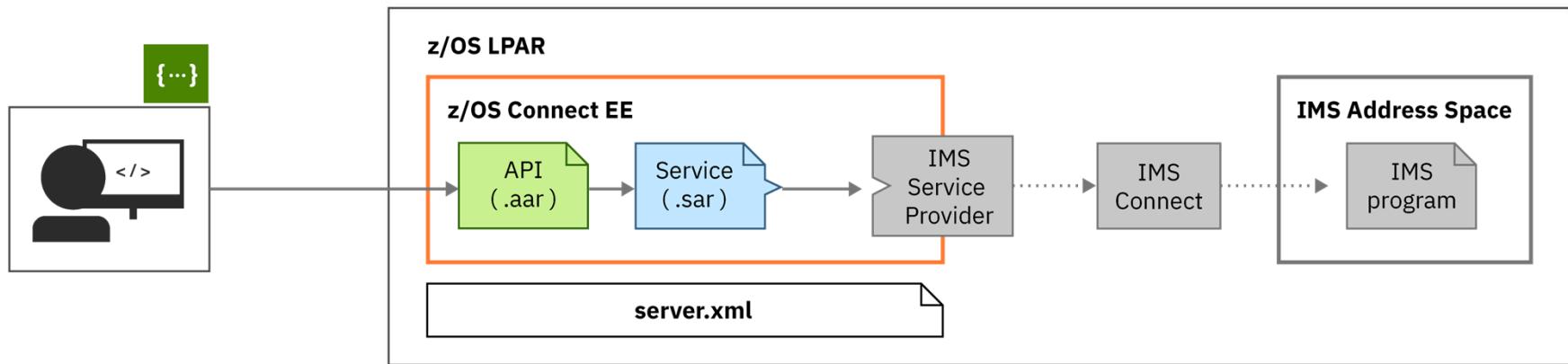
```
1<server description="CICS IPIC - catalog">
2
3<!-- Enable features -->
4<featureManager>
5  <feature>zosconnect:cicsService-1.0</feature>
6</featureManager>
7
8<zosconnect_cicsIpicConnection id="catalog">
9  host="wg31.washington.ibm.com"
10 port="1491"
11 transid="CSMI"
12 transidUsage="EIB_AND_MIRROR"/>
13
14</server>
15
```

Define IPIC connection to CICS

Connections to IMS TM



Topology



Configure the connection to IMS through `ims-connections.xml` and `ims-interactions.xml` in the IMS service registry.

i ibm.biz/zosconnect-scenarios

IMS Connections and Interactions



z/OS Connect EE

ivtnoService Service Configuration

Required Configuration

Enter the required configuration for this service.

Connection profile: **IMSCONN**

Interaction profile: **IMSINTER**

Optional Configuration

Enter the optional configuration for this service.

IMS destination override:

Program name:

Overview Configuration

IMS Connect HWSCFG

```
HWS=( ID=IMS14HWS , XIBAREA=100 , RACF=Y , RRS=N )
TCPIP=( HOSTNAME=TCPIP , PORTID=( 4000 , LOCAL ) , RACFID=JOHNSON , TIMEOUT=
5000 )
DATASTORE=( GROUP=OTMAGRP , ID=IVP1 , MEMBER=HWSMEM , TMEMBER=OTMAMEM )
IMSPLEX=( MEMBER=IMS14HWS , TMEMBER=PLEX1 )
ODACCESS=( ODBMAUTOCONN=Y ,
DRDAPORT=( ID=5555 , PORTTMOT=6000 ) , ODBMTMOT=6000 )
```

Connection

```
<server>
<imsmobile_imsConnection comment="" connectionFactoryRef="CF1" connectionTimeout="-1" connectionType="IMSCONNECT" id="IMSCONN" />
<connectionFactory containerAuthDataRef="Connection1_Auth" id="CF1">
    <properties.gmoa hostName="wg31.washington.ibm.com" portNumber="4000" />
</connectionFactory>

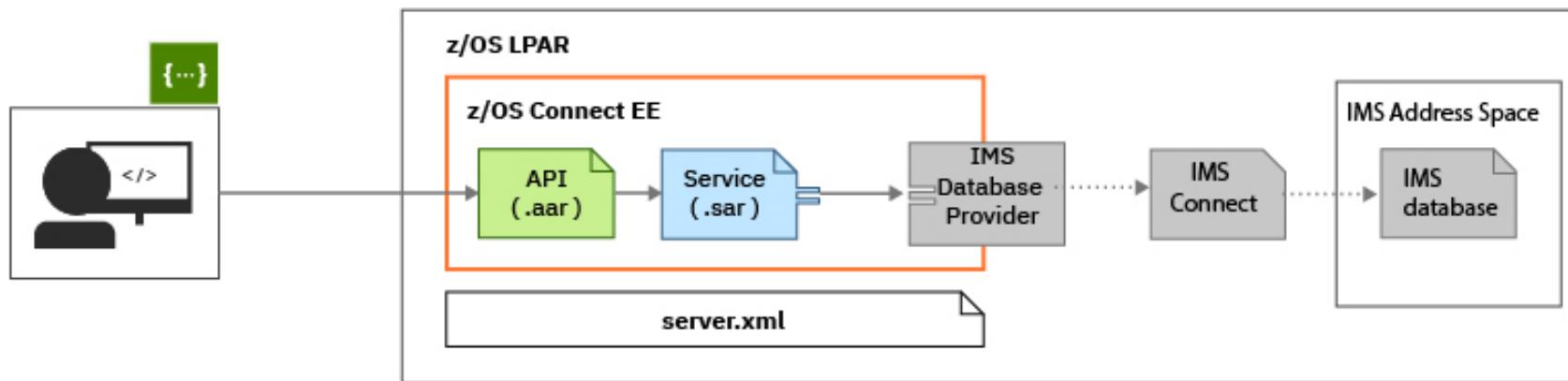
<authData id="Connection1_Auth" password="encryptedPassword1" user="userName1" />
</server>
```

Interaction

```
<server>
<imsmobile_interaction comment="" commitMode="1" id="IMSINTER" imsConnectCodepage="Cp1047" imsConnectTimeout="0"
    imsDatastoreName="IVP1" interactionTimeout="-1" ltermOverrideName="" syncLevel="0" />
</server>
```

Connections to IMS DB

Topology



Configure the connection to IMS using a Connection Factory in server.xml

Use the **API toolkit** to configure the service.

 ibm.biz/zosconnect-scenarios

IMS Connection Factory



z/OS Connect EE

Service Project Editor: Configuration

Required Configuration

Enter the required configuration for this service.

Connection profile: DFSIVPACConn

ConnectionFactory

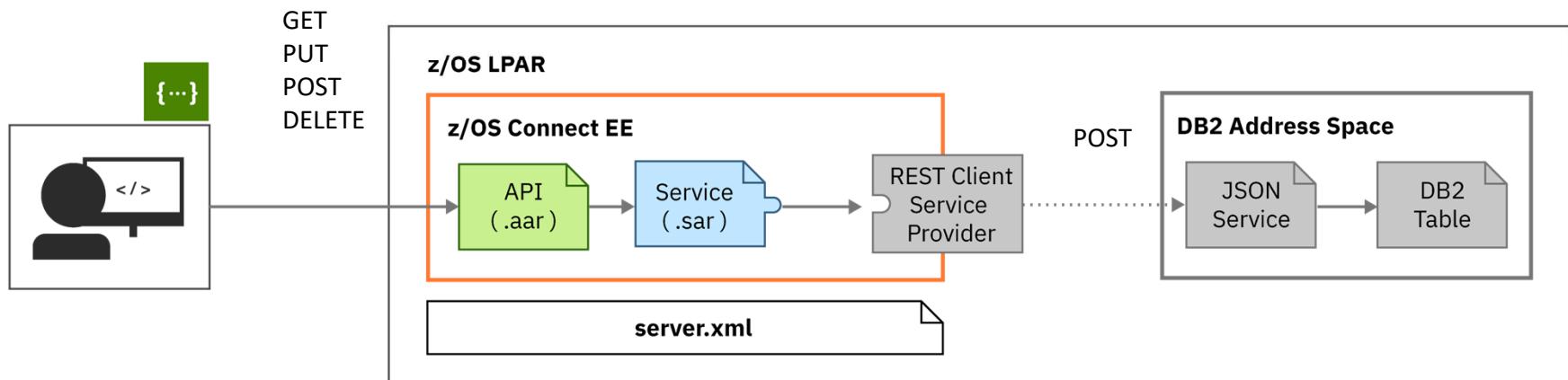
```
<connectionFactory id="DFSIVPACConn">
<properties.imsudbJLocal
  databaseName="DFSIVPA"
  datastoreName="IVP1"
  datastoreServer="wg31.washington.ibm.com"
  driverType="4"
  portNumber="5555"
  user="USER1"
  password="password"
  flattenTables="True" />
</connectionFactory>
```

IMS Connect HWSCFG

```
HWS=( ID=IMS14HWS , XIBAREA=100 , RACF=N , RRS=N )
TCPIP=( HOSTNAME=TCPIP , PORTID=( 4000 , LOCAL ) , RACFID=JOHNSON , TIMEOUT=5000 )
DATASTORE=( GROUP=OTMAGRP , ID=IVP1 , MEMBER=HWSMEM , TMEMBER=OTMAMEM )
IMSPLEX=( MEMBER=IMS14HWS , TMEMBER=PLEX1 )
ODACCESS=( ODBMAUTOCONN=Y ,
DRDAPORT=( ID=5555 , PORTTMOT=6000 ) , ODBMTMOT=6000 )
```

Connections to Db2

Topology



Connection to the JSON Service is configured in `server.xml`.

A Db2 REST Service must be configured in DB2.

 ibm.biz/zosconnect-db2-rest-services

The server.xml File (Db2)



z/OS Connect EE

The server.xml file is the key configuration file:

The screenshot shows the Service Project Editor interface with a configuration for a 'selectEmployee Service'. On the left, there's a log window displaying various system messages. The main area shows the configuration for the 'db2pass.xml' file, which defines a server with a specific connection reference.

Log messages (left side):

- DSNL004I -DSN2 DDF START
- COMPLETE
- LOCATION
- DSN2LOC
- LU
- USIBMWZ.DSN2APPL
- GENERICLU -NONE
- DOMAIN
- WG31.WASHINGTON.IBM.COM
- TCPPORT 2446
- SECPORT 2445
- RESPORT 2447

Configuration (right side):

Service Project Editor: Configuration

Required Configuration

Enter the required configuration for this service.

Connection reference: db2conn

db2pass.xml

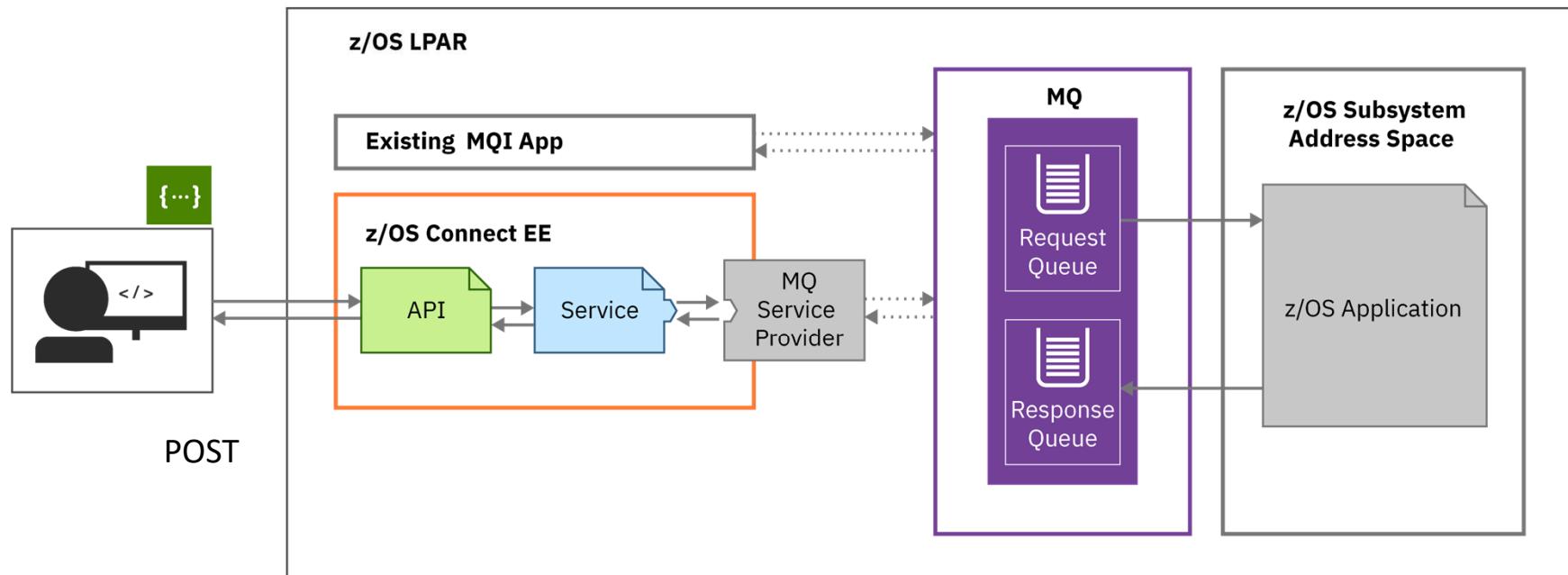
Design Source

```
1 <server description="DB2 REST">
2
3   <zosconnect_zosConnectServiceRestClientConnection id="db2conn"
4     host="wg31.washington.ibm.com"
5     port="2446"
6     basicAuthRef="dsn2Auth" />
7
8   <zosconnect_zosConnectServiceRestClientBasicAuth id="dsn2Auth"
9     applName="DSN2APPL"/>
10
11</server>
12
```

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Connections to MQ

Topology (Two-way service example)

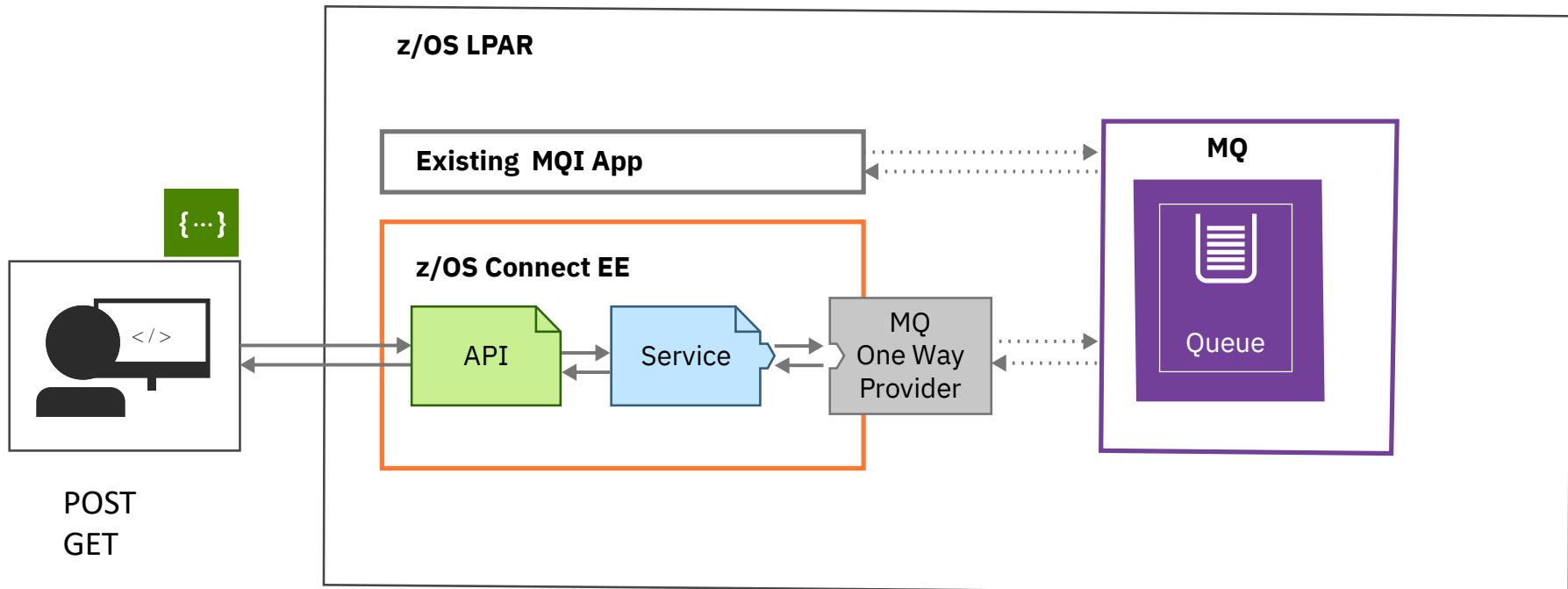


You can also configure one-way services.

 ibm.biz/zosconnect-mq-service-provider

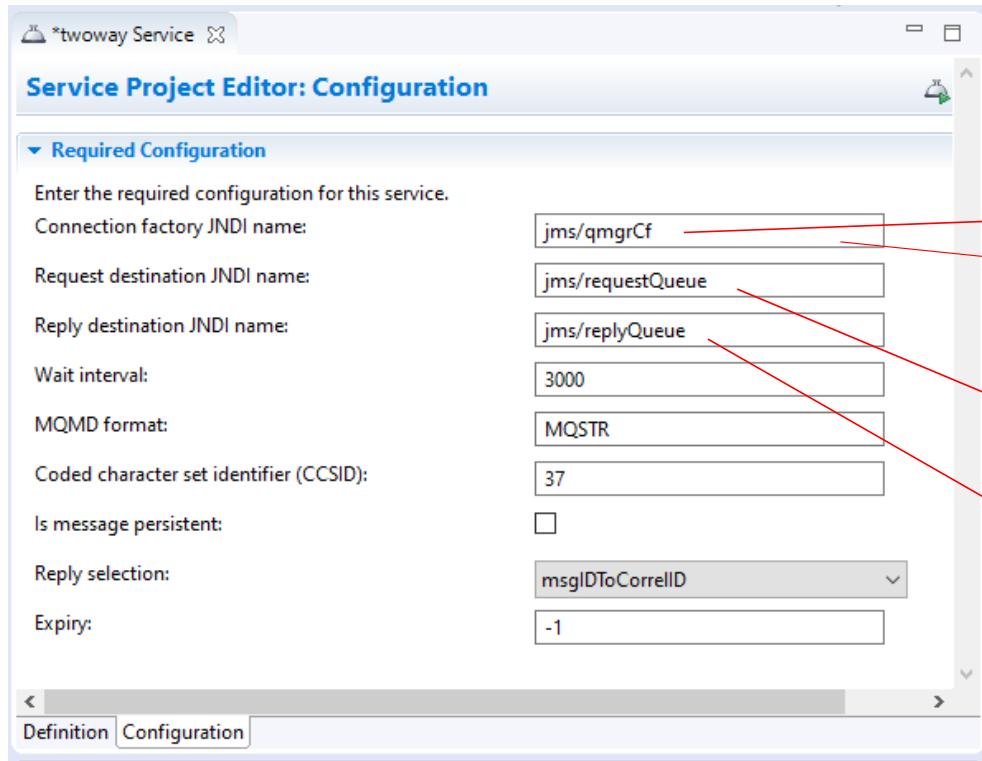
Connections to MQ

Topology (One-way service example)



 ibm.biz/zosconnect-mq-service-provider

The server.xml File (MQ)



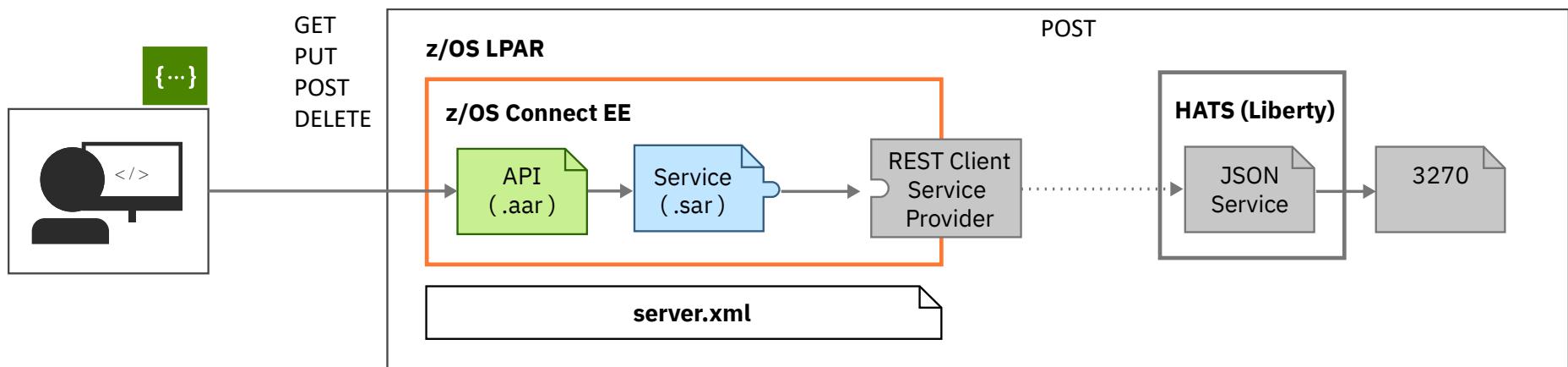
```
mq.xml
Read only Close
Design Source
2
3 <featureManager>
4   <feature>zosconnect:mqService-1.0</feature>
5 </featureManager>
6
7 <variable name="wmqJmsClient.rar.location"
8   value="/usr/lpp/mqm/V9R1M1/java/lib/jca/wmq.jmsra.rar"/>
9 <wmqJmsClient nativeLibraryPath="/usr/lpp/mqm/V9R1M1/java/lib"/>
10
11 <connectionManager id="ConMgr1" maxPoolSize="5"/>
12
13 <jmsConnectionFactory id="qmgrCf" jndiName="jms/qmgrCf"
14   connectionManagerRef="ConMgr1">
15   <properties.wmqJMS transportType="BINDINGS"
16     queueManager="QM21" />
17 </jmsConnectionFactory>
18
19 <jmsConnectionFactory id="qmgrCf2" jndiName="jms/qmgrCf2"
20   connectionManagerRef="ConMgr1">
21   <properties.wmqJMS transportType="CLIENT"
22     queueManager="ZMQ1"
23     channel="LIBERTY.DEF.SVRCONN"
24     hostName="wg31.washington.ibm.com"
25     port="1422" />
26 </jmsConnectionFactory>
27
28 <jmsQueue id="q1" jndiName="jms/default">
29   <properties.wmqJms
30     baseQueueName="ZCONN2.DEFAULT.MQZCEE.QUEUE"
31     CCSID="37"/>
32 </jmsQueue>
33
34 <jmsQueue id="requestQueue" jndiName="jms/request">
35   <properties.wmqJms
36     baseQueueName="ZCONN2.TRIGGER.REQUEST"
37     targetClient="MQ"
38     CCSID="37"/>
39 </jmsQueue>
40
41 <jmsQueue id="replyQueue" jndiName="jms/replyQueue">
42   <properties.wmqJms
43     baseQueueName="ZCONN2.TRIGGER.RESPONSE"
44     targetClient="MQ"
45     CCSID="37"/>
46 </jmsQueue>
47
```

MQ V9.1.1 Added support for remote queue managers.

Connection to HATS



Topology

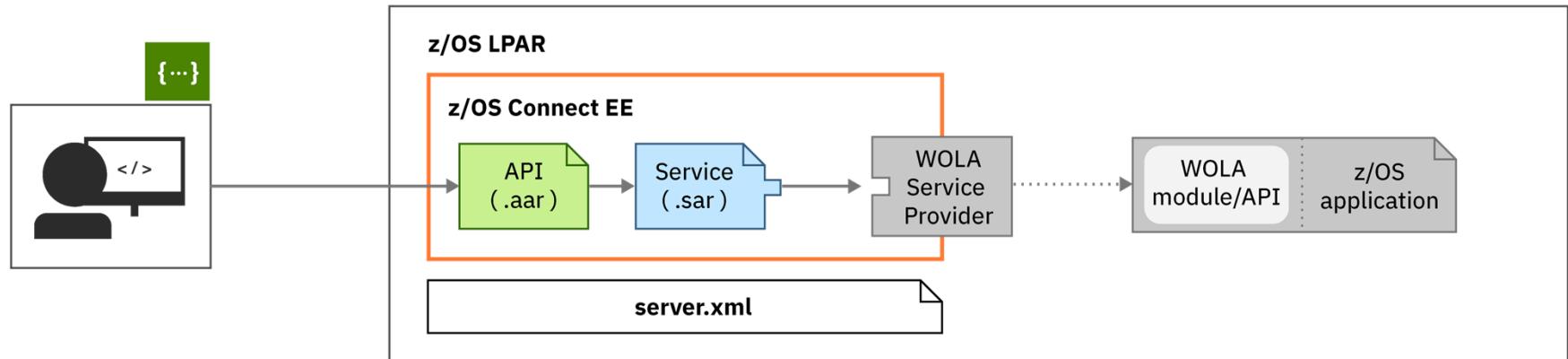


Connection to the HATS REST Service is configured in `server.xml`.

ibm.biz/zosconect-db2-rest-services

Connections to a MVS batch application

Topology



Connection to WOLA is configured in `server.xml`.

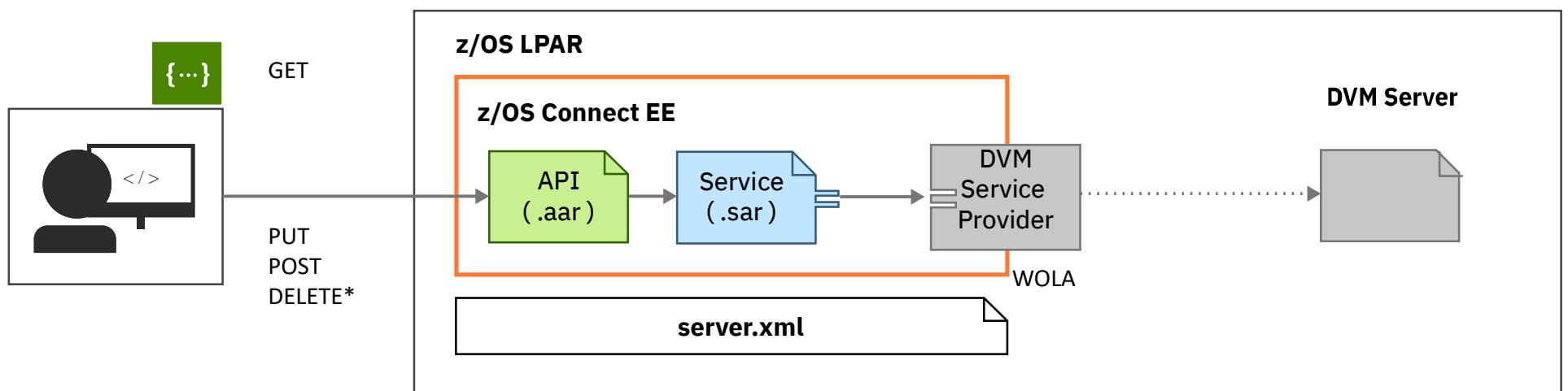
The z/OS application must be WOLA-enabled.

Connections to DVM



z/OS Connect EE

Topology



The DVM service provider uses WOLA

* Requires a resource manager (e.g. RLS, VSAMCICS, etc.)

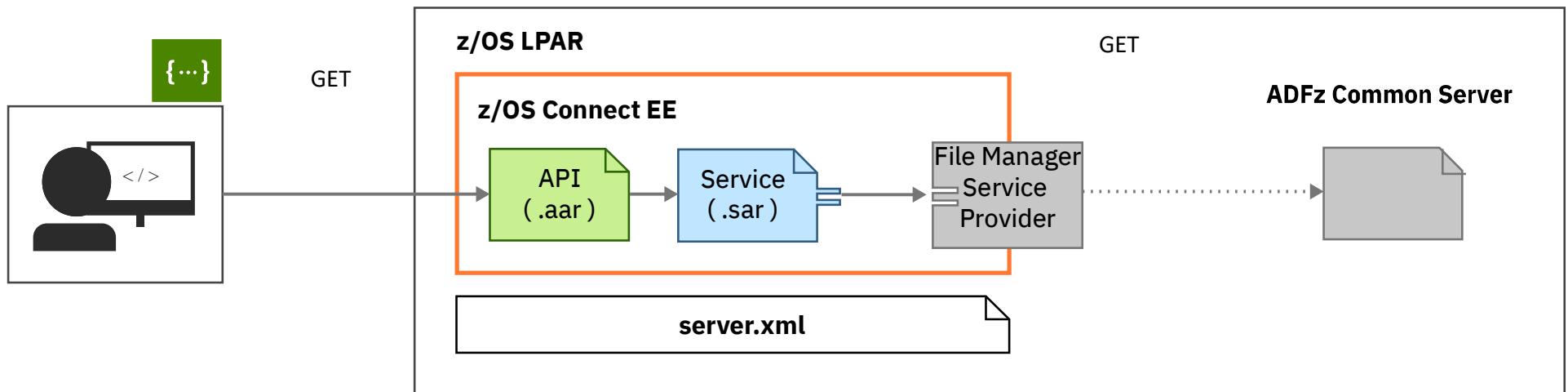
 ibm.biz/zosconnect-db2-rest-services

Connections to File Manager



z/OS Connect EE

Topology



Connection to the Application Delivery Foundation for z (ADFz) common server is over TCP/IP

A File Manager Template is required .



/miscellaneousTopics

performance, high availability, Liberty

A Tour of Server Configuration Directories and Files



z/OS Connect EE

A z/OS Connect EE V3.0 server configuration structure looks like this:

```
/var/zosconnect
  /servers
    /zceesrv1
      /logs
        messages.log
  /resources
    /zosconnect
      /apis
      /apiRequesters
      /rules
      /services
        server.xml
        server.env
    /workarea
```

The messages.log file is the key output file for messages about Liberty and the processing taking place in the Liberty server.

The /zosconnect directory is where we will place the deployed APIs, services, and API requester files

The server.xml file is the key configuration file. It is here that z/OS Connect EE V3.0 definitions go which define the essential backend connectivity.

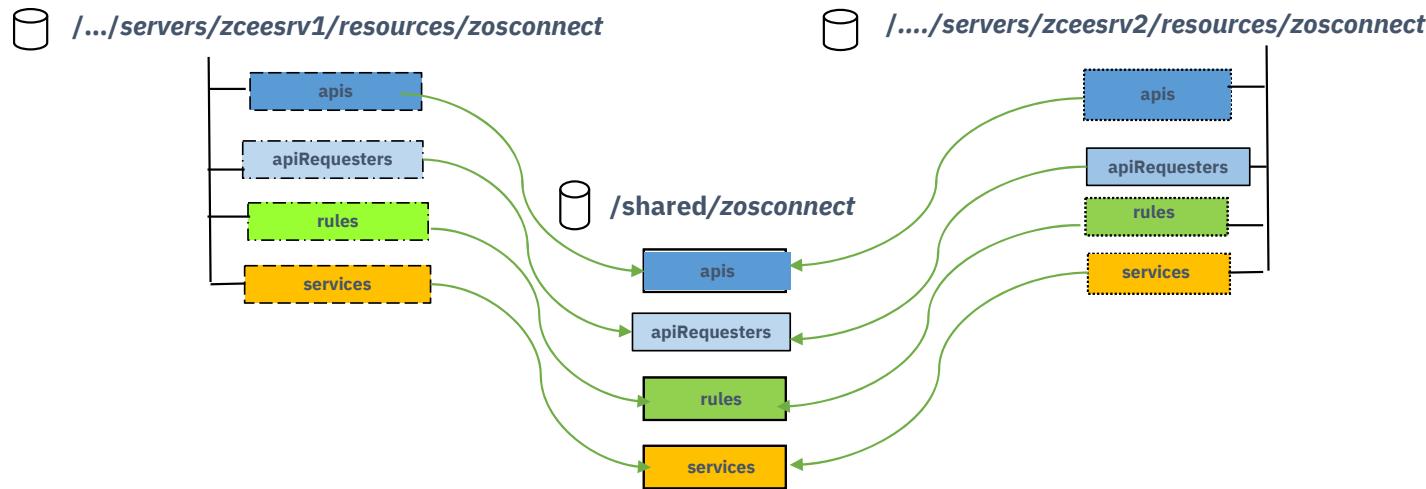
server.xml

```
<server description="zCEE Server">
<include location="${server.config.dir}/includes/safSecurity.xml"/>
<include location="${server.config.dir}/includes/ipicIDProp.xml"/>
<include location="${server.config.dir}/includes/keyringOutboundMutual.xml"/>
<include location="${server.config.dir}/includes/groupAccess.xml"/>
<include location="${server.config.dir}/includes/shared.xml"/>
<include location="${server.config.dir}/includes/apiRequesterHTTPS.xml"/>
<include location="${server.config.dir}/includes/imsDatabase.xml"/>
```

-Dcom.ibm.ws.logging.log.directory=/u/johnson/logs

Tour of Server Configuration Directories and Files

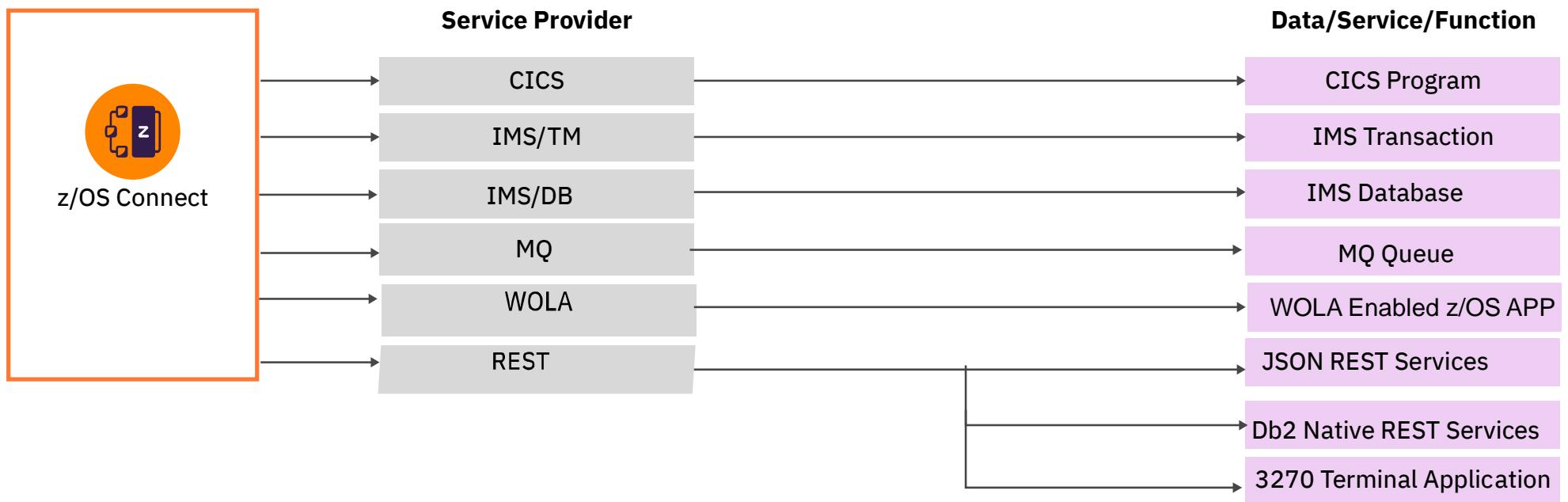
Using symbolic links to share application artifacts between servers:



```
cd /shared/zosconnect
ln -s ../../servers/zceesrv1/resources/zosconnect/apis apis
ln -s ../../servers/zceesrv1/resources/zosconnect/apiRequesters apiRequesters
ln -s ../../servers/zceesrv1/resources/zosconnect/rules rules
ln -s ../../servers/zceesrv1/resources/zosconnect/services services
ln -s ../../servers/zceesrv2/resources/zosconnect/apis apis
ln -s ../../servers/zceesrv2/resources/zosconnect/apiRequesters apiRequesters
ln -s ../../servers/zceesrv2/resources/zosconnect/rules rules
ln -s ../../servers/zceesrv2/resources/zosconnect/services services
```

What assets can z/OS Connect EE map to?

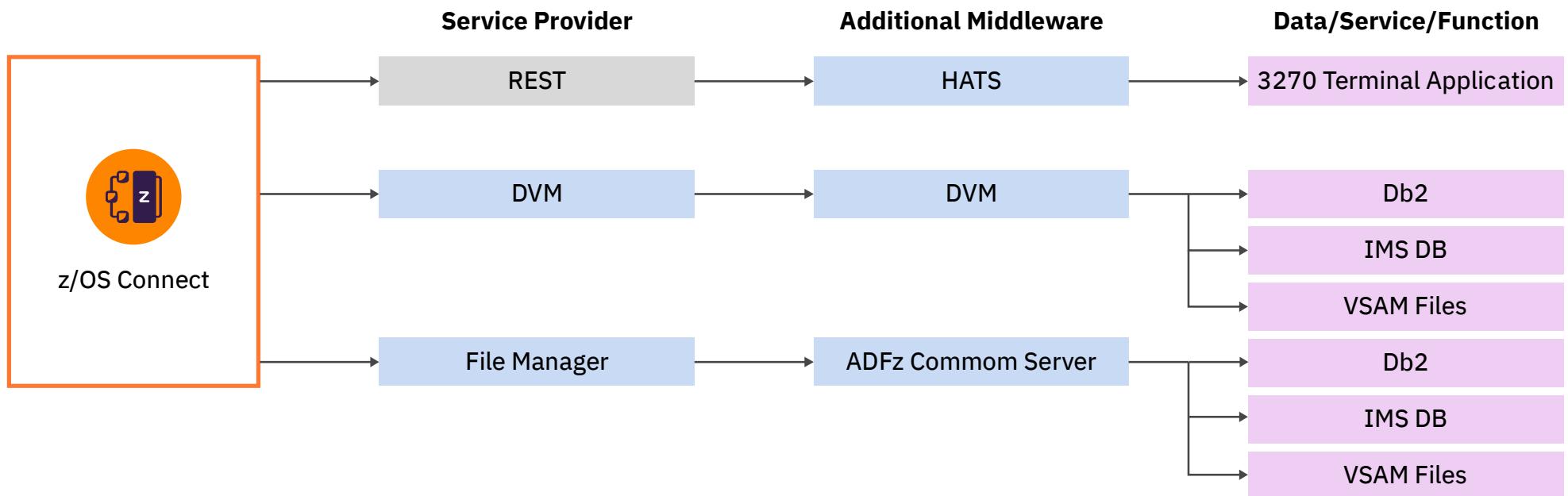
And which service provider could I use?



The core **service providers** included with z/OS Connect EE provide API access to a wide range of z/OS assets.

Additional Middleware

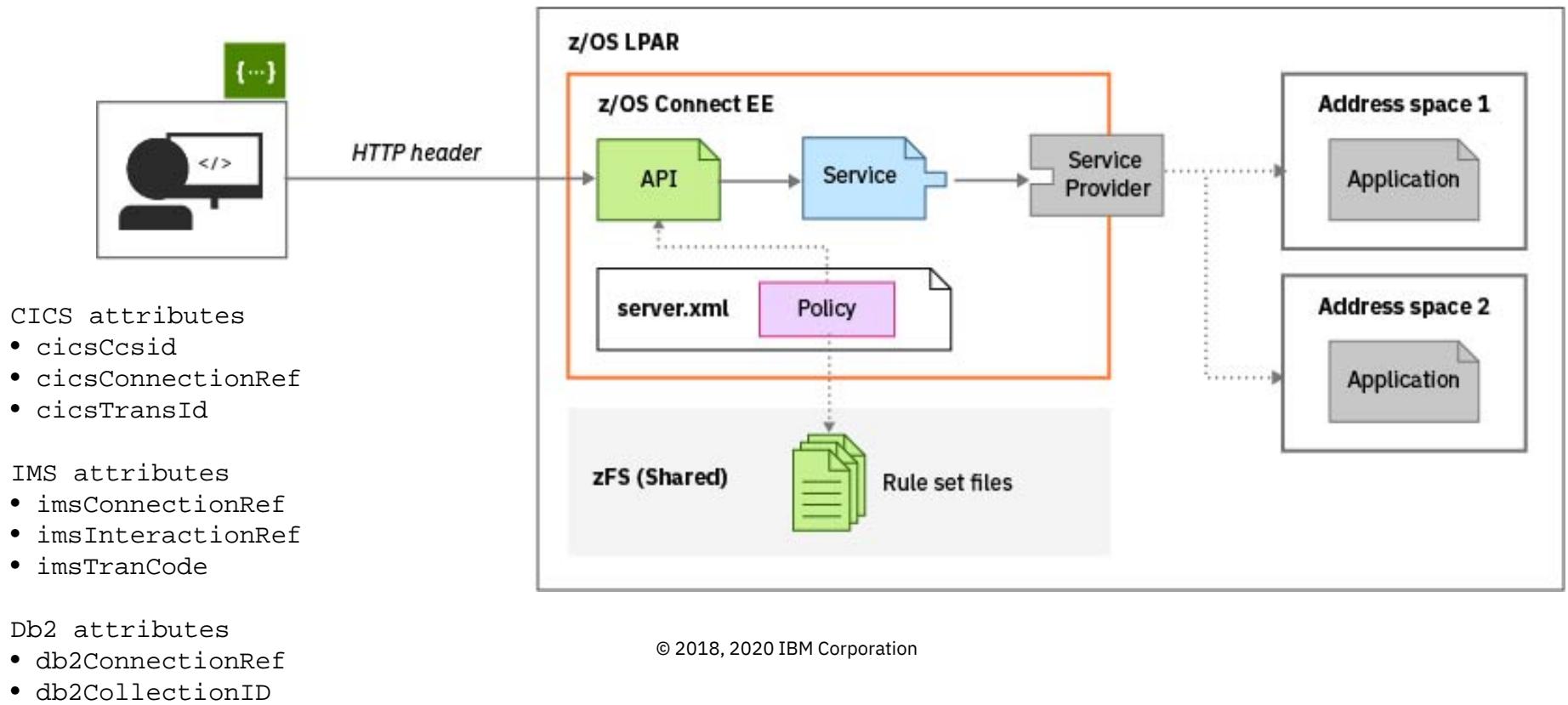
Additional value from the ecosystem



z/OS Connect EE is **pluggable** and **extensible** allowing the use of additional middleware to expand the list of z/OS assets you can expose as APIs

API Policies

- HTTP header properties can be used to select alternative for IMS (V3.0.4) , CICS (V3.0.10) or Db2 (V3.0.36)
- Policies can be configured globally for every API in the server or for individual APIs (V3.0.11)





z/OS Connect EE

A sample API Policies for CICS

```
<ruleset name="CICS rules">
    <rule name="csmi-rule">
        <conditions>
            <header name="cicsMirror" value="CSMI,MIJO"/>1
        </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>
```

GET.employee.{numb}

GET.employee.{numb}

HTTP Request

HTTP Headers

cicsMirror optional string

cicsConnection optional string

Path Parameters

{numb} Required string

Query Parameters

Body - cscvincServiceOperation

Curl

```
curl -X GET --header 'Accept: application/json' --header 'cicsMirror: MIJO' --header 'cicsConnection: cscvinc' 'https://m...
```

¹Transaction MIJO needs to be a clone of CSMI (e.g. invoke program DFHMIRS)



z/OS Connect EE

Displaying zCEE messages on the console and/or spool

server.xml

```
<zosLogging wtoMessage=
  "BAQR0657E,BAQR0658E,BAQR0660E,BAQR0686E,BAQR0687E"
  hardCopyMessage=
  "BAQR0657E,BAQR0658E,BAQR0660E,BAQR0686E,BAQR0687E"/>
```

MVS Console

```
18.12.02 STC00137 +BAQR0686E: Program CSCVINC is not available in the CICS region with
  811           connection ID cscvinc; service cscvincService failed.
18.12.02 STC00137 +BAQR0686E: Program CSCVINC is not available in the CICS region with
  812           connection ID cscvinc; service cscvincService failed.
19.07.12 STC00137 +BAQR0657E: Transaction abend MIJO occurred in CICS while using
  745           connection cscvinc and service cscvincService.
```

STDERR

```
ÝERROR    " BAQR0686E: Program CSCVINC is not available in the CICS region with connection cscvinc and service cscvincService.
ÝERROR    " BAQR0686E: Program CSCVINC is not available in the CICS region with connection cscvinc and service cscvincService.
ÝERROR    " BAQR0657E: Transaction abend MIJO occurred in CICS while using CICS connection cscvinc and service cscvincService.
```



Liberty's “adminCenter” Feature

Web browser interface to the server's configuration files

The image shows two side-by-side configuration interfaces for z/OS Connect.

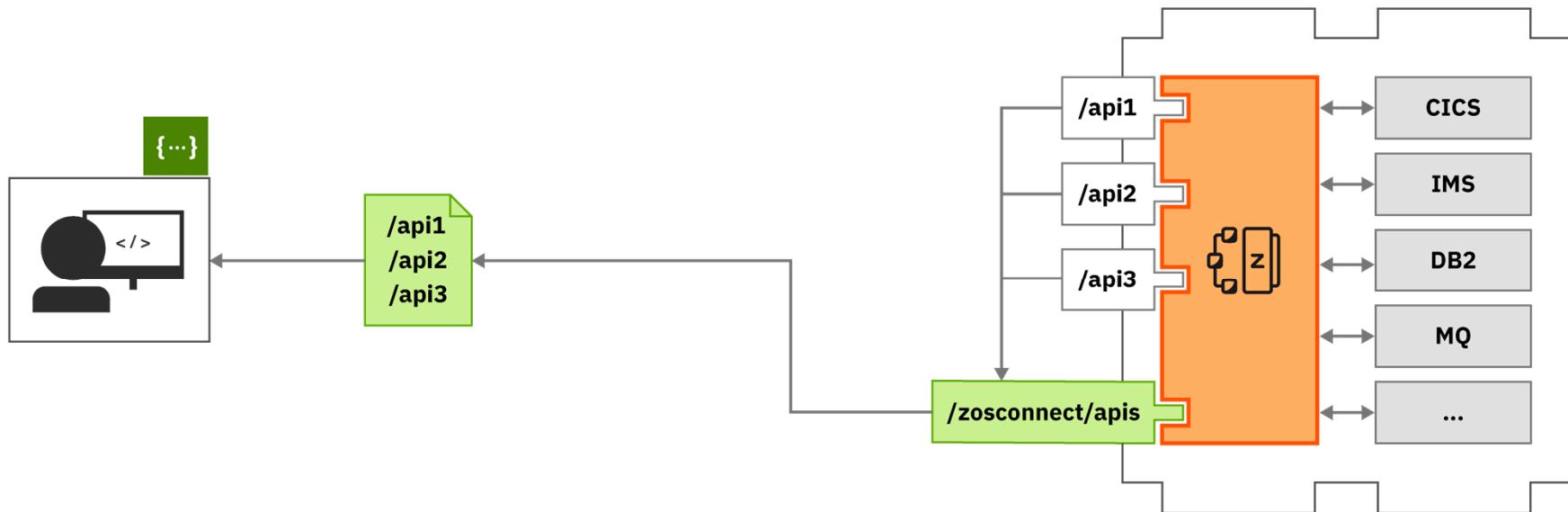
Left Window (server.xml):

- Design:** Shows configuration for various endpoints and features.
- Source:** XML snippets for `wola.xml`, `hats.xml`, `ipic.xml`, `mq.xml`, and `db2.xml`.
- Require request authentication:** Set to "false".
- Preserve JSON object payload order:** Set to "false (default)".
- Preserve JSON payload character format:** Set to "false (default)".
- Set response encoding to UTF-8:** Set to "false (default)".
- Return all errors in JSON format:** Set to "true (default)".

Right Window (ipic.xml):

- Design:** Shows configuration for a CICS IPIC connection.
- Source:** XML snippet for `catalog` under `zosconnect:cicsService-1.0`.
- z/OS Connect CICS IPIC connection:** Four entries listed: `cscvinc`, `miniloan`, `miniloan1`, and `miniloan2`.
- ID:** Set to `catalog`.
- Host:** Set to `wg31.washington.ibm.com`.
- Port:** Set to `1491`.
- Shared port:** Set to "false (default)".
- z/OS Connect APPLID:** Set to "(no value)".
- z/OS Connect network ID:** Set to "(no value)".

API Documentation



APIs are discoverable via Swagger docs served from **z/OS Connect EE**.

RESTful Administrative Interface for Services

The administration interface for services is available in paths under /zosConnect/services.

Most administration tasks are supported by the RESTful administration interface

Method	Administrative Task
GET	Get details of a service
	Get the status of a service
	Get the request schema of a service
	Get the response schema of a service
POST	Deploy a service*
PUT	Update a service
	Change the status of a service
DELETE	Delete a service

```

POST  /zosConnect/services inquireSingle.sar
PUT   /zosConnect/services/{serviceName}?status=started|stopped
PUT   /zosConnect/services inquireSingle.sar
GET   /zosConnect/services
GET   /zosConnect/services/{serviceName}
DELETE /zosConnect/services/{serviceName}
  
```

*Useful for deploying service archive files, service archives generated by zconbt, e.g. HATS

RESTful Administrative Interface for APIs

The administration interface for services is available in paths under /zosConnect/apis.

Most administration tasks are supported by the RESTful administration interface

Method	Administrative Task
GET	Get a list of APIs
	Get the details of an API
POST	Deploy an API
PUT	Update an API
	Change the status of an API
DELETE	Delete an API

```
POST  /zosConnect/apis CatalogManager.aar
PUT   /zosConnect/apis/{apiName}?status=started|stopped
PUT   /zosConnect/apis CatalogManager.aar
GET   /zosConnect/apis
GET   /zosConnect/apis/{apiName}
DELETE /zosConnect/apis/{apiName}
```

RESTful Administrative Interface for API Requesters

The administration interface for services is available in paths under `/zosConnect/apisRequesters`.

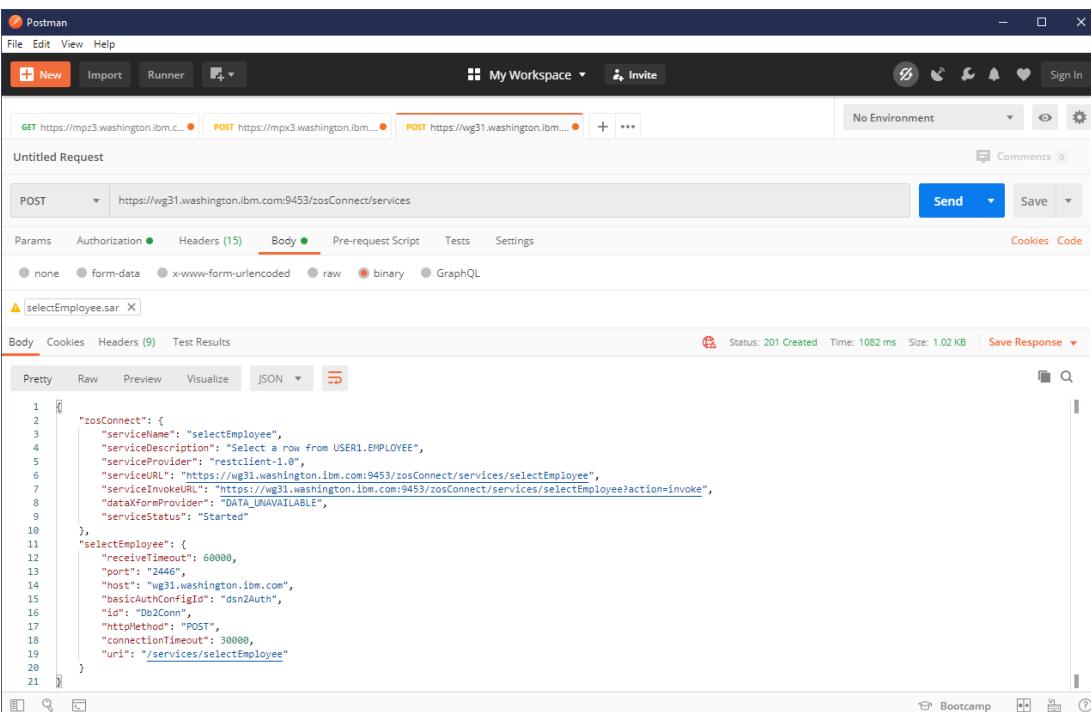
Most administration tasks are supported by the RESTful administration interface

Method	Administrative Task
GET	Get a list of API Requesters
	Get the details of an API Requester
POST	Deploy an API Requester
PUT	Update an API Requester
	Change the status of an API Requester
DELETE	Delete an API Requester

```
GET /zosConnect/apiRequesters cscvinc.aar
PUT /zosConnect/apiRequesters/{apiRequesterName}?status=started|stopped
PUT /zosConnect/apiRequesters cscvinc.aar
GET /zosConnect/apiRequesters
GET /zosConnect/apiRequesters/{apRequesterName}
DELETE /zosConnect/apiRequesters
```

Deploying Service Archive options

- Use SAR as request message and use HTTP POST
- Use URI path /zosConnect/services
- Postman or cURL



The screenshot shows the Postman application interface. A POST request is being made to <https://wg31.washington.ibm.com:9453/zosConnect/services>. The 'Body' tab is selected, and a file named 'selectEmployee.sar' is attached. The file content is displayed as a JSON object:

```

1  {
2   "zosConnect": {
3     "serviceName": "SelectEmployee",
4     "serviceDescription": "Select a row from USER1.EMPLOYEE",
5     "serviceProvider": "restclient-1.0",
6     "serviceURL": "https://wg31.washington.ibm.com:9453/zosConnect/services/selectEmployee",
7     "serviceInvokeURL": "https://wg31.washington.ibm.com:9453/zosConnect/services/selectEmployee?action=invoke",
8     "dataXformProvider": "DATA_UNAVAILABLE",
9     "serviceStatus": "Started"
10 },
11   "selectEmployee": {
12     "receiveTimeout": 60000,
13     "port": "2446",
14     "host": "wg31.washington.ibm.com",
15     "basicAuthConfigId": "dsn2Auth",
16     "id": "Db2Conn",
17     "httpMethod": "POST",
18     "connectionTimeout": 30000,
19     "uri": "/services/selectEmployee"
20 }

```

Command:

```
curl --data-binary @selectEmployee.sar
--header "Content-Type: application/zip"
https://mpxm:9453/zosConnect/services
```

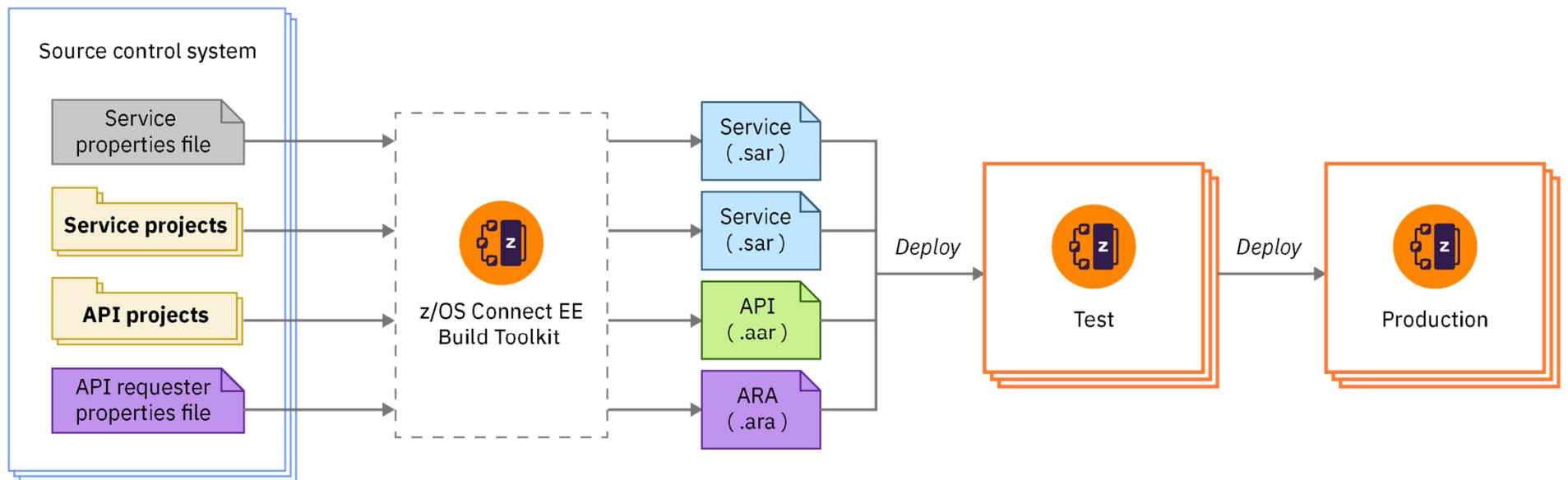
Results:

```
{
  "zosConnect": {
    "serviceName": "selectEmployee",
    "serviceDescription": "Select a row from
USER1.EMPLOYEE",
    "serviceProvider": "IBM_ZOS_CONNECT_SERVICE_RE
ST_CLIENT-1.0
    ",
    "serviceURL": "https://mpxm:9453/zosConnect/services/selectE
mployee",
    "serviceInvokeURL": "https://mpxm:9453/zosConnect/ser
vices/selectEmployee?action=invoke",
    "dataXformProvider": "DATA
_UNAVAILABLE",
    "serviceStatus": "Started"
  },
  "selectEmployee": {
    "receiveTimeout": 0,
    "port": null,
    "host": null,
    "httpMethod": "PO
ST",
    "connectionTimeout": 0,
    "uri": "/services/selectEmployee"
  }
}
```

DevOps using z/OS Connect EE

Automate the development and deployment of services, APIs, and API requesters for continuous integration and delivery.

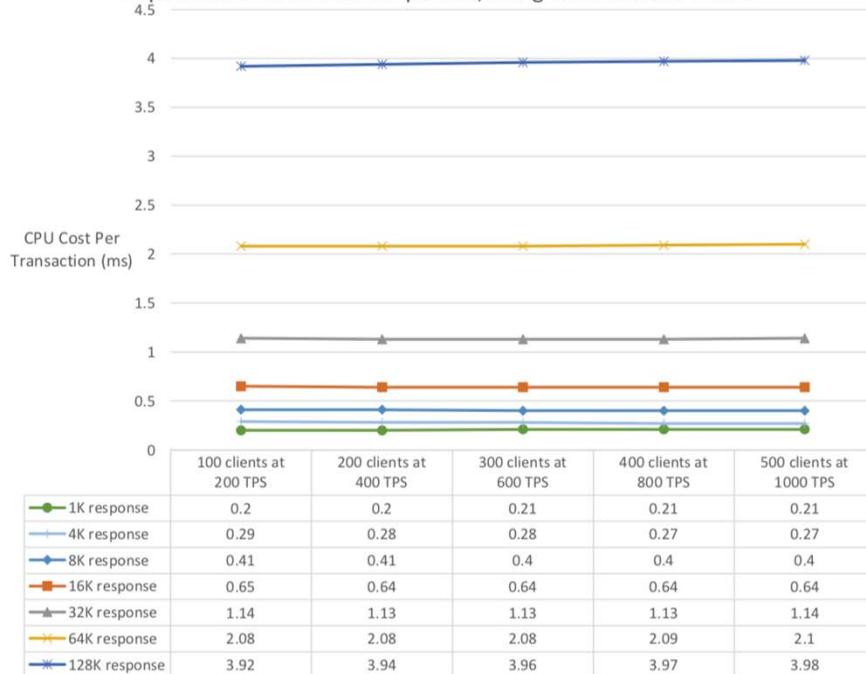
- The build toolkit supports the generation of service archives and API archives from projects created in the z/OS Connect EE API toolkit
- The build toolkit also supports the use of properties files to generate API requester archives
- Run the build toolkit from a build script to generate these archive files
- Deploy them to z/OS Connect servers by copying them to their dropins folders or by using the REST Admin API



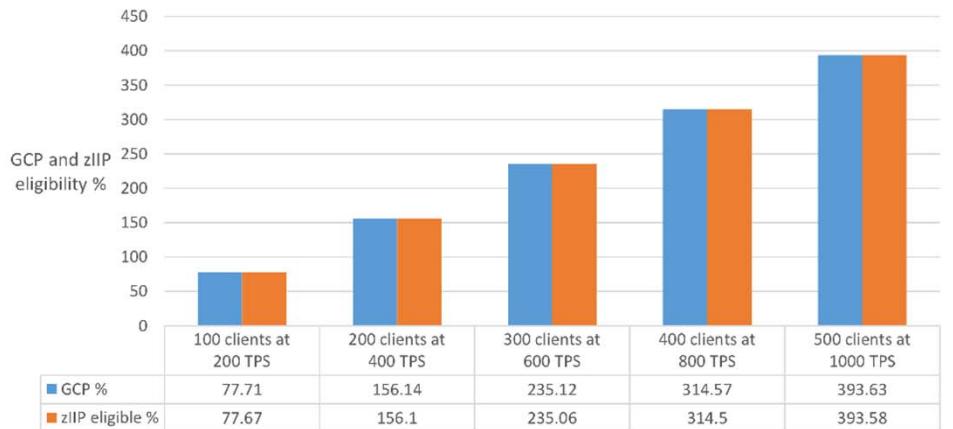
Performance: API Provider

High Speed, High Throughput, Low Cost

CPU Cost Per Transaction - increasing number of clients with 50 byte requests and 1K to 128K responses, using channels and CICS SP



zIIP eligibility - increasing number of clients with 50 byte requests and 128K responses, using channels and CICS SP

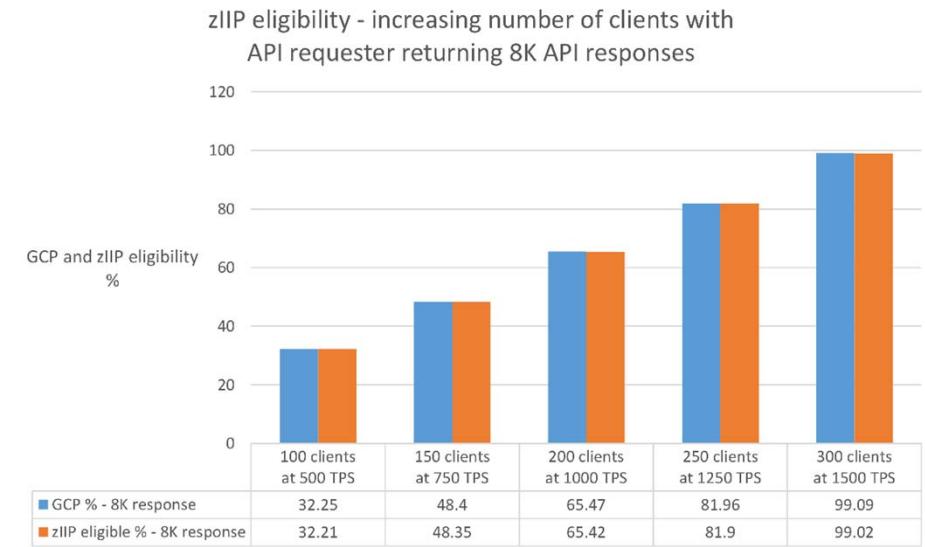
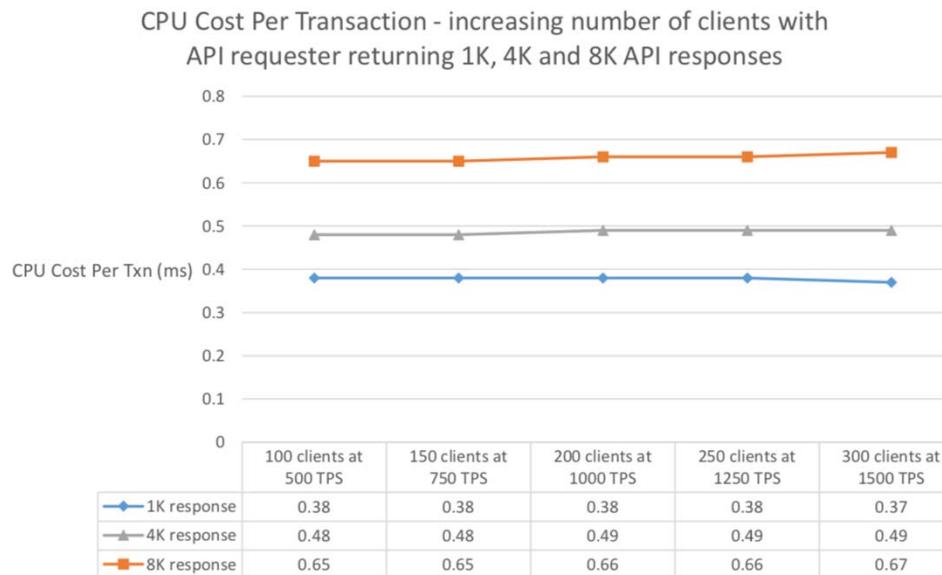


z/OS Connect EE is a Java-based product:
Over **99%** of its MIPs are **eligible for ZIIP offload**.



Performance: API Requester

High Speed, High Throughput, Low Cost



z/OS Connect EE is a Java-based product:
Over **99%** of its MIPs are **eligible for ZIIP offload**.



ibm.biz/zosconnect-performance-report

IBM z Omegamon for JVM



z/OS Connect EE

The screenshot displays four windows from the IBM z Omegamon for JVM interface:

- WG31 - 3270**: Shows the "z/OS Connect Request Summary". It includes a summary table with columns for APIName, Service, SoR ID, Reference, and Resource, and a detailed table for the "cscvinc" service.
- WG31 - 3270**: Shows the "Requests by Service Name" report for the "cscvinc" service, listing requests for "inquireSingle", "cscvincService", and "selectEmployee".
- WG31 - 3270**: Shows the "z/OS Connect Request Detail" for a specific request. The details include:
 - Event time: 04/02/19 18:47:54.267
 - Request Type: API
 - API name: cscvinc
 - Request URI: /cscvinc/employee/444444
 - Method: GET
 - Port: 9453
 - HTTP code: 200 (OK)
 - Timeout: No
 - Service Name: cscvincService
 - Total Req Time: 0.008006s
 - z/OS Conn Time: 0.005515s
 - SoR Resp Time: 0.002491s
 - SoR ID: USIBMWZ.CICS58Z
 - SoR Ref: cscvinc
 - SoR Resource: CSMI,CSCVINC
 - Remote Address: 192.168.0.141
 - Request Length: 0
 - Response Length: 302
 - Correlator: e6e2d3d7d3c5e7400011000010d5ea50
 - Operation: getCsCvincService
 - Provider: CICS-1.0
 - User ID: Fred
- CMS on platform WG31(z/OS)**: A terminal window showing the command "tel TCP00109 and port 23".

IBM z Omegamon for JVM



WG31 - 3270

File Edit View Communication Actions Window Help

File Edit View Tools Navigate Help 04/02/2019 18:59:29
Auto Update : Off
SMF ID : WG31
Coll ID : KJJ1

Command ==> z/OS Connect Request Detail

```

Event time..... 04/02/19 18:49:14.525
Request Type... API
API name..... filequeue
Request URI.... /filequeue/mq
Query String...
Method..... GET
Port..... 9453
HTTP code.... 200 (OK)
Timeout..... No
Service Name... FileaQueue
Total Req Time. 0.016206s
z/OS Conn Time. 0.016206s
SoR Resp Time. 0.000000s
SoR ID..... NONE
SoR Ref.... NONE
SoR Resource.. NONE
Remote Address.. 192.168.0.141
Request Length.. 0
Response Length. 191
Correlator.... e6e2d3d7d3c5e7400011000010d5ea51
Operation.... getFilea
Provider..... IBM MQ for z/OS
User ID..... Fred

```

VERIFY BACK HOME Hub WG31:CMS on platform WG31(z/OS) 01/002

Connected to remote server/host wg31a using lu/pool TCP00109 and port 23

```

Request Type... API
API name..... db2employee
Request URI.... /db2/employee/000020
Query String...
Method..... GET
Port..... 9453
HTTP code.... 200 (OK)
Timeout..... No
Service Name... selectEmployee
Total Req Time. 0.022592s
z/OS Conn Time. 0.022592s
SoR Resp Time. 0.000000s
SoR ID..... NONE
SoR Ref.... NONE
SoR Resource.. NONE
Remote Address.. 192.168.0.141
Request Length.. 0
Response Length. 326
Correlator.... e6e2d3d7d3c5e7400011000010d5ea50
Operation.... getSelectEmployee
Provider..... restclient-1.0
User ID..... Fred

```

VERIFY BACK HOME Hub WG31:CMS on platform WG31(z/OS) 01/002

Connected to remote server/host wg31a using lu/pool TCP00109 and port 23

WG31 - 3270

File Edit View Communication Actions Window Help

File Edit View Tools Navigate Help 04/02/2019 19:00:52
Auto Update : Off
SMF ID : WG31
Coll ID : KJJ1

Command ==> z/OS Connect Request Detail

```

Event time..... 04/02/19 18:47:54.267
Request Type... API
API name..... cscvinc
Request URI.... /cscvinc/employee/444444
Query String...
Method..... GET
Port..... 9453
HTTP code.... 200 (OK)
Timeout..... No
Service Name... cscvincService
Total Req Time. 0.000006s
z/OS Conn Time. 0.005515s
SoR Resp Time. 0.002491s
SoR ID..... USIBMWZ.CICS532
SoR Ref.... cscvinc
SoR Resource.. CSM1,CSCVINC
Remote Address.. 192.168.0.141
Request Length.. 0
Response Length. 302
Correlator.... e6e2d3d7d3c5e7400011000010d5ea50
Operation.... getGscvincService
Provider..... CICS-1.0
User ID..... Fred

```

VERIFY BACK HOME Hub WG31:CMS on platform WG31(z/OS) 01/002

Connected to remote server/host wg31a using lu/pool TCP00109 and port 23

```

Request Type... API
API name..... phonebook
Request URI.... /phonebook/contacts/LAST1
Query String...
Method..... GET
Port..... 9453
HTTP code.... 200 (OK)
Timeout..... No
Service Name... ivtnoService
Total Req Time. 0.345265s
z/OS Conn Time. 0.163460s
SoR Resp Time. 0.181805s
SoR ID..... IVP1
SoR Ref.... IMSCONN
SoR Resource.. IVTNO
Remote Address.. 192.168.0.141
Request Length.. 0
Response Length. 158
Correlator.... e6e2d3d7d3c5e7400011000010d5ea55
Operation.... getPhoneBookService1
Provider..... imsmobile-2.0
User ID..... Fred

```

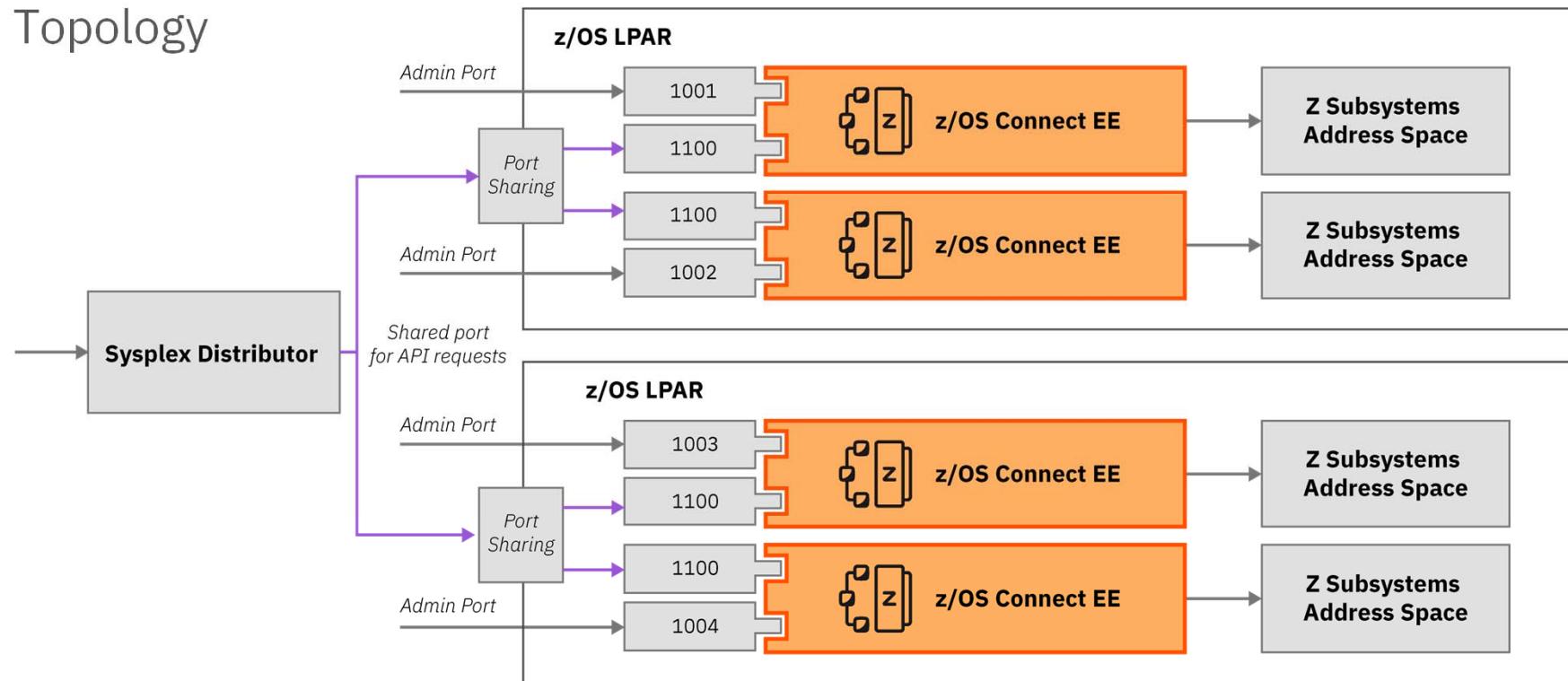
VERIFY BACK HOME Hub WG31:CMS on platform WG31(z/OS) 01/002

Connected to remote server/host wg31a using lu/pool TCP00109 and port 23



High Availability

Topology



i ibm.biz/zosconnect-ha-concepts

i ibm.biz/zosconnect-scenarios



/security

How is security implement?



Common security challenges

- **End-to-end security** is hampered by the issue of how to provide secure access between middleware components that use disparate security technologies e.g. registries
 - › This is a driver for implementing open security models like OAuth and OpenID Connect and standard tokens like JWT
- Security when using z/OS Connect is implemented in many products including z/OS Connect, WebSphere Liberty Profile on z/OS, SAF/RACF*, CICS, IMS, Db2, MQ ...
 - › And these are all documented in different places
- Often security is at odds with **performance**, because the most secure techniques often involve the most processing overhead especially if not configured optimally

*<https://knowledge.broadcom.com/external/article/128597/what-acf2-security-setup-is-needed-for-i.html>

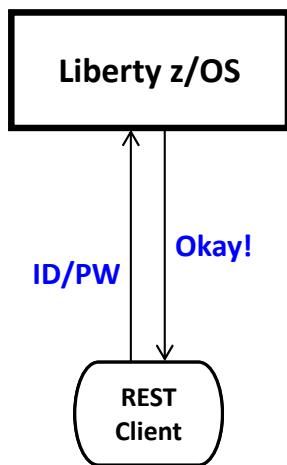
Authentication



z/OS Connect EE

Several different ways this can be accomplished:

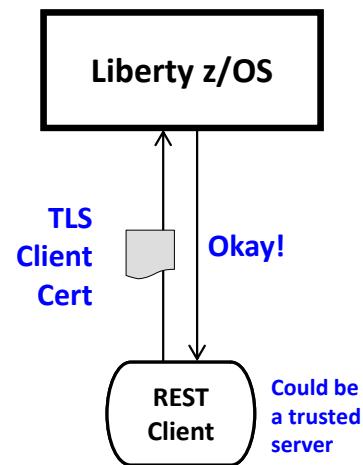
Basic Authentication



Server prompts for ID/PW
Client supplies ID/PW or ID/Passticket
Server checks registry:

- Basic (server.xml)
- LDAP
- SAF

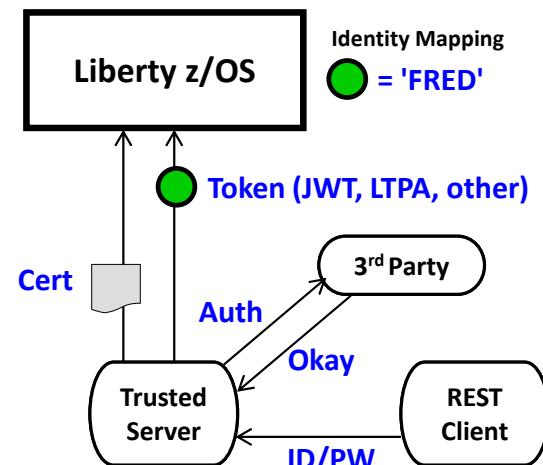
Client Certificate



Server prompts for cert.
Client supplies certificate
Server validates cert and maps to an identity
Registry options:

- LDAP
- SAF

Third Party Authentication



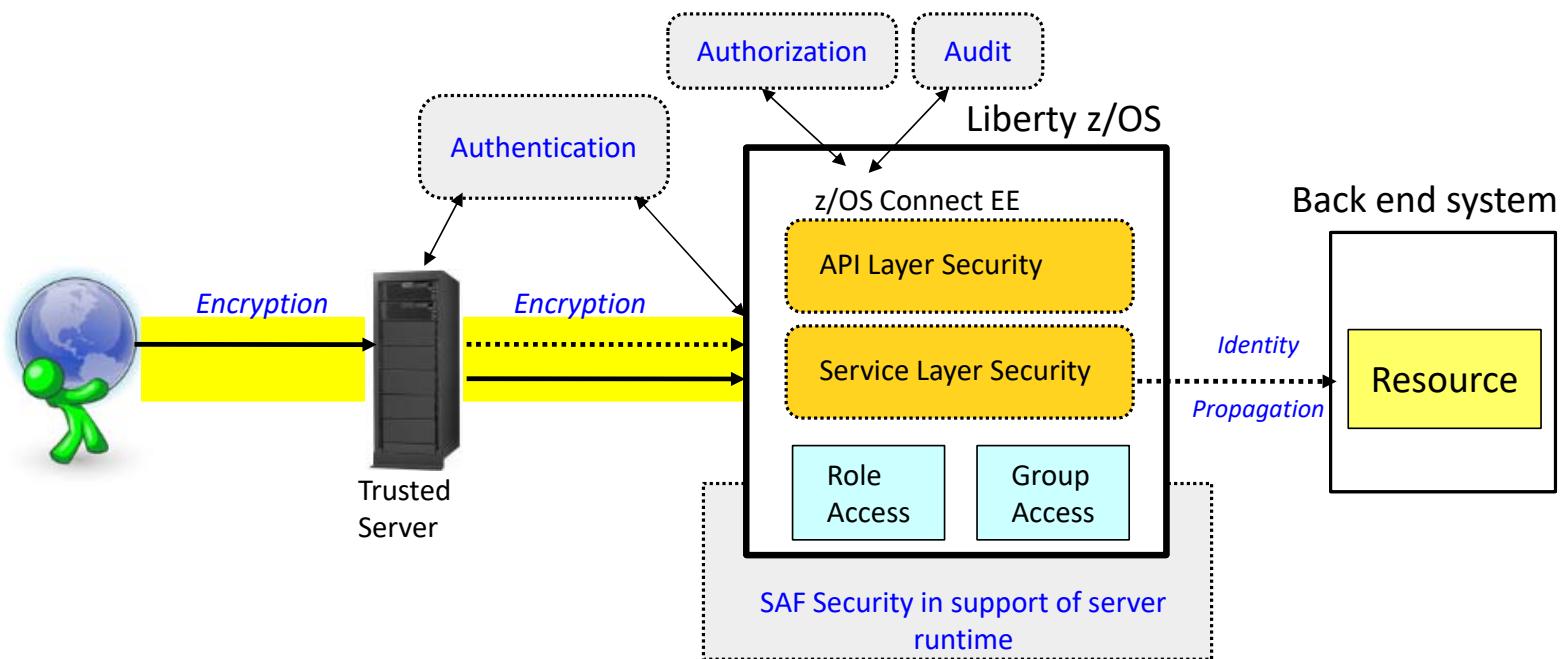
Client authenticates to 3rd party sever
Client receives a trusted 3rd party token
Token flows to Liberty z/OS and is mapped to an identity
Registry options:

- LDAP
- SAF

z/OS Connect EE API provider security overview



z/OS Connect EE

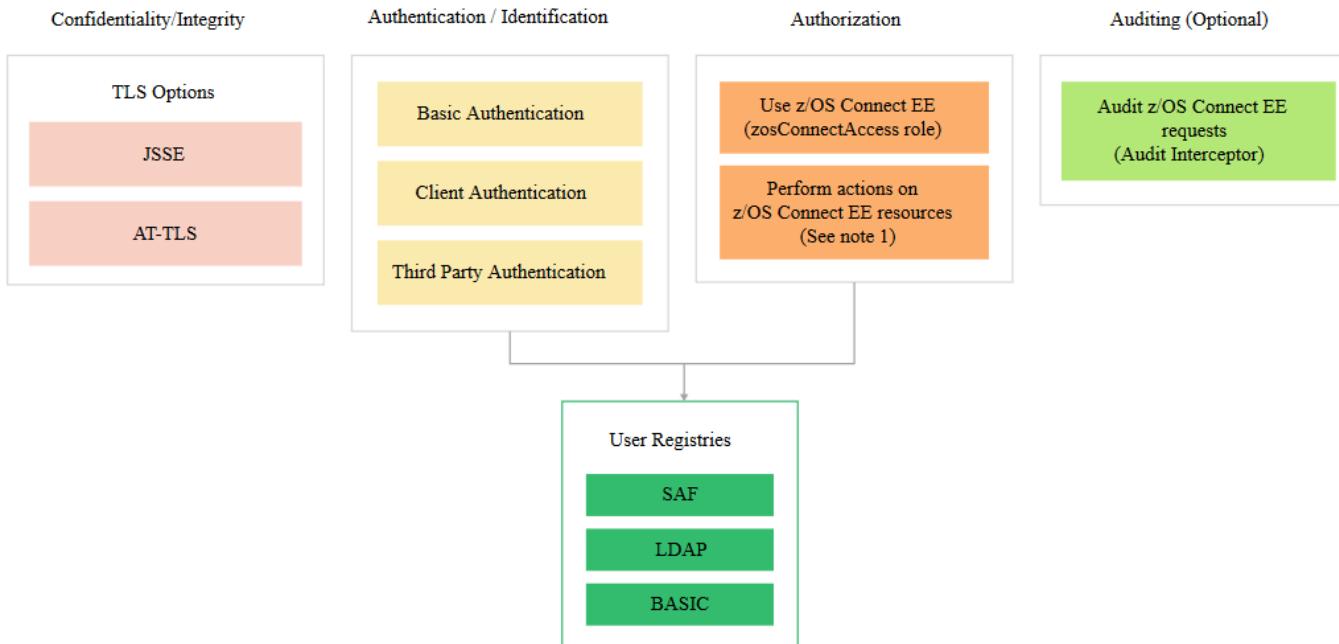


1. Authentication (basic, client certificates, 3rd party authentication)
2. Encryption (aka "SSL" or "TLS")
3. Authorization (role and group access)
4. Audit
5. Configuring security with SAF
6. Back end identity propagation (CICS, IMS, Db2, MQ)

See Dev Center article "Securing APIs with z/OS Connect EE" overview of z/OS Connect EE security

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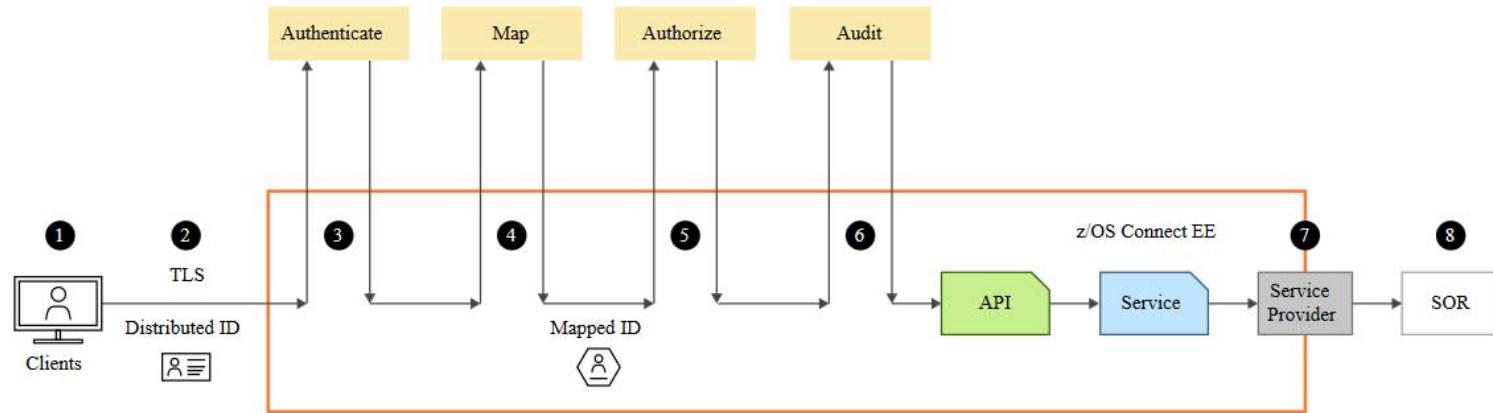
z/OS Connect EE security options



 <http://ibm.biz/zosconnect-security>

The actions which can be controlled by authorization (see Note 1 in the diagram above) are: deploying, querying, updating, starting, stopping and deleting of APIs, services and API requesters.

Typical z/OS Connect EE security flow



1. The credentials provided by the client
2. Secure the connection to the z/OS Connect EE server
3. Authenticate the client. This can be within the z/OS Connect EE server or by requesting verification from a third party server
4. Map the authenticated identity to a user ID in the user registry
5. Authorize the mapped user ID to connect to z/OS Connect EE and optionally authorize user to invoke actions on APIs
6. Audit the API request
7. Secure the connection to the System of Record (SoR) and provide security credentials to be used to invoke the program or to access the data resource
8. The program or database request may run in the SoR under the mapped ID

Security token types by z/OS Connect EE



z/OS Connect EE

Token type	How used	Pros	Cons
LTPA	Authentication technology used in IBM WebSphere	<ul style="list-style-type: none">Easy to use with WebSphere and DataPower	<ul style="list-style-type: none">IBM Proprietary token
SAML	XML-based security token and set of profiles	<ul style="list-style-type: none">Token includes user id and claimsUsed widely with SoR applications	<ul style="list-style-type: none">Tokens can be heavy to processNo refresh token
OAuth 2.0 access token	Facilitates the authorization of one site to access and use information related to the user's account on another site	<ul style="list-style-type: none">Used widely for SoE applications e.g with Google, Facebook, Microsoft, Twitter ...	<ul style="list-style-type: none">Needs introspection endpoint to validate token
JWT	JSON security token format	<ul style="list-style-type: none">More compact than SAMLEase of client-side processing especially mobile	

See the YouTube video *OAuth 2.0 and OpenID Connect (in plain English)*

<https://www.youtube.com/watch?v=996OjexHze0> © 2018, 2020 IBM Corporation



JWT (JSON Web Token)

- JWT is a compact way of representing claims that are to be transferred between two parties
- Normally transmitted via HTTP header
- Consists of three parts
 - Header
 - Payload
 - Signature

The screenshot shows the jwt.io website interface. On the left, under 'Encoded', is a long string of characters: eyJhbGciOiJSUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiJkaXN0dXNlciIsInRva2VuX3R5cGUiOiJCZWFyZXIiLCJhenAiOiJycFNzbCIIsImlzcyI6Imh0dHBzOi8vd2czMS53YXNoaW5ndG9uLmlibSSjb206MjYyMTMvb21kYy9lbnRwb2ludC9PUHNzbCisImF1ZC16Im15WnN1ZSIsImV4cCI6MTU2OTY3NTY50CwiaWF0IjoxNTY5NjctInjM4LCJyZWFsbU5hbWUiOj6Q0VFUmVhbG0iLCJ1bmIxWVTZWN1cm10eU5hbWUiOjJkaXN0dXNlciJ9.a_G_1f_vhD1u6_z6-Kg5cprxPqkVe1K6-ngswuv4ZGecRdF9AU3E5Ig4o8qo0vmk_0msqHu65Xe-Lxp0lo6Do1YZHI-cJg1jrrrnE6WMwdIUDi_ayTTtGnMRYMeDdweE9eljgKZ3X2ChoYnm13p8V_A7mIxuyomD6Vnsx4R1H0rwF4AS2RYHq3mBucK8vD-KZN0Z3eh307tg0ikD8Hadg3vhGvxd0Poh89ijQ7xgD0jg2ZG2Vuy0AdNeTRB2Gp5DP17s3aPzidMaDEFrUfn3GWknE07ylzW45NB1b1xSuVPP3HYssa3rvHBqrnl3bekIL2aF12dauaFogq7i-Cg. On the right, under 'Decoded', are the three parts:

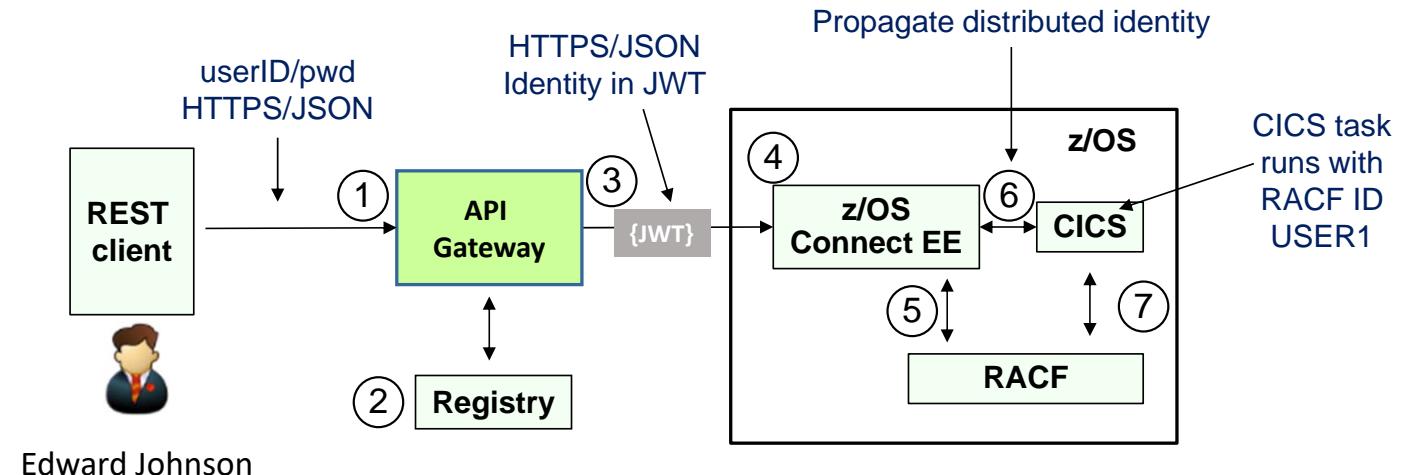
```

HEADER: ALGORITHM & TOKEN TYPE
{
  "alg": "RS256",
  "typ": "JWT"
}

PAYLOAD: DATA
{
  "sub": "distuser",
  "token_type": "Bearer",
  "azp": "rp0s1",
  "iss": "https://wg31.washington.ibm.com:26213/.oidc/endpoint/0/pss1",
  "aud": "myZee",
  "exp": 1569675698,
  "iat": 1569675638,
  "realmName": "zCEERealm",
  "uniqueSecurityName": "distuser"
}

VERIFY SIGNATURE
RSASHA256(
base64UrlEncode(header) + "." +
base64UrlEncode(payload),
-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIIBCgKCAQEAmyz1sTjfNBbbbgKFMSv
vkTrwlvRsaIn7S5wA+kzeVOvnVWwk
-----END PUBLIC KEY-----
)
  
```

Example scenario – security flow



RACMAP ID(**USER1**) MAP USERIDFILTER(NAME('auser')) REGISTRY(NAME('*'))

1. User authenticates with the managed API using a "distributed" identity and a password
2. An external registry is used as the user registry for distributed users and groups
3. API Gateway generates a JWT and forwards the token with the request to z/OS Connect EE
4. z/OS Connect EE validates JWT
5. z/OS Connect EE calls RACF to map distributed ID to RACF user ID and authorizes access to API
6. z/OS Connect EE CICS service provider propagates distributed ID to CICS
7. CICS calls RACF to map distributed ID to RACF user ID and performs resource authorization checks

JWT used in scenario

```
{  
  "alg": "RS256"  
}  
{  
  "sub": "auser",  
  "token_type": "Bearer",  
  "azp": "rpSsl",  
  "iss": "https://wg31.washington.ibm.com:26213/oidc/endpoint/OPssl",  
  "aud": "myZcee",  
  "realmName": "zCEERealm",  
  "uniqueSecurityName": "auser"  
}  
RSASHA256(base64UrlEncode(header)+ base64UrlEncode(payload))
```

- The header contains an **alg** (algorithm) element value **RS256**
 - **RS256** (RSA Signature with SHA-256) is an asymmetric algorithm which uses a **public/private** key pair
 - **ES512** (Elliptic Curve Digital Signature Algorithm with SHA-512) [link for more info](#)
 - **HS256** (HMAC with SHA-256) is a symmetric algorithm with only one (**secret**) key
- The **iss** (issuer) claim identifies the principal that issued the JWT
- The **sub** (subject) claim **distuser** identifies the principal that is the subject of the JWT
- The **aud** (audience) claim **myZcee** identifies the recipients for which the JWT is intended



Configuring authentication with JWT

z/OS Connect EE can perform user authentication with JWT using the support that is provided by the *openidConnectClient-1.0* feature. The **<openidConnectClient>** element is used to accept a JWT token as an authentication token

```
<openidConnectClient id="RPssl" inboundPropagation="required"
    signatureAlgorithm="RS256" trustAliasName="JWT-Signer"
    trustStoreRef="jwtTrustStore"
    userIdentityToCreateSubject="sub" mapIdentityToRegistryUser="true"
    issuerIdentifier="https://wg31.washington.ibm.com:26213/oidc/endpoint/OPssl"
    authnSessionDisabled="true" audiences="myZcee" />
```

- ***inboundPropagation*** is set to required to allow z/OS Connect EE to use the received JWT as an authentication token
- ***signatureAlgorithm*** specifies the algorithm to be used to verify the JWT signature
- ***trustStoreRef*** specifies the name of the keystore element that defines the location of the validating certificate
- ***trustAliasName*** gives the alias or label of the certificate to be used for signature validation
- ***userIdentityToCreateSubject*** indicates the claim to use to create the user subject
- ***mapIdentityToRegistryUser*** indicates whether to map the retrieved identity to the registry user
- ***issuerIdentifier*** defines the expected issuer
- ***authnSessionDisabled*** indicates whether a WebSphere custom cookie should be generated for the session
- ***audiences*** defines a list of target audiences

See Dev Center article "Using a JWT with z/OS Connect EE" for full description of scenario



Using authorization filters with z/OS Connect EE

Authentication filter can be used to filter criteria that are specified in the **authFilter** element to determine whether certain requests are processed by certain providers, such as OpenID Connect, for authentication.

```
<openidConnectClient id="RPssl" inboundPropagation="required"
    signatureAlgorithm="RS256" trustAliasName="JWT-Signer"
    trustStoreRef="jwtTrustStore"
    userIdentityToCreateSubject="sub" mapIdentityToRegistryUser="true"
    issuerIdentifier="https://wg31.washington.ibm.com:26213/oidc/endpoint/OPssl"
    authnSessionDisabled="true" audiences="myZcee"
    authFilterRef="JwtAuthFilter"/>
<authFilter id="API Gateway">
    <remoteAddress id="ApiAddress" ip="10.7.1.*" matchType="equals" />
</authFilter>
<authFilter id="Cscvinc">
    <requestUrl id="URL" urlPattern="/cscvinc/employee/*" matchType="equals" />
</authFilter>
<authFilter id="JwtAuthFilter" >
    <requestHeader id="authHeader" name="Authorization" value="Bearer" matchType="contains" />
</authFilter>
```

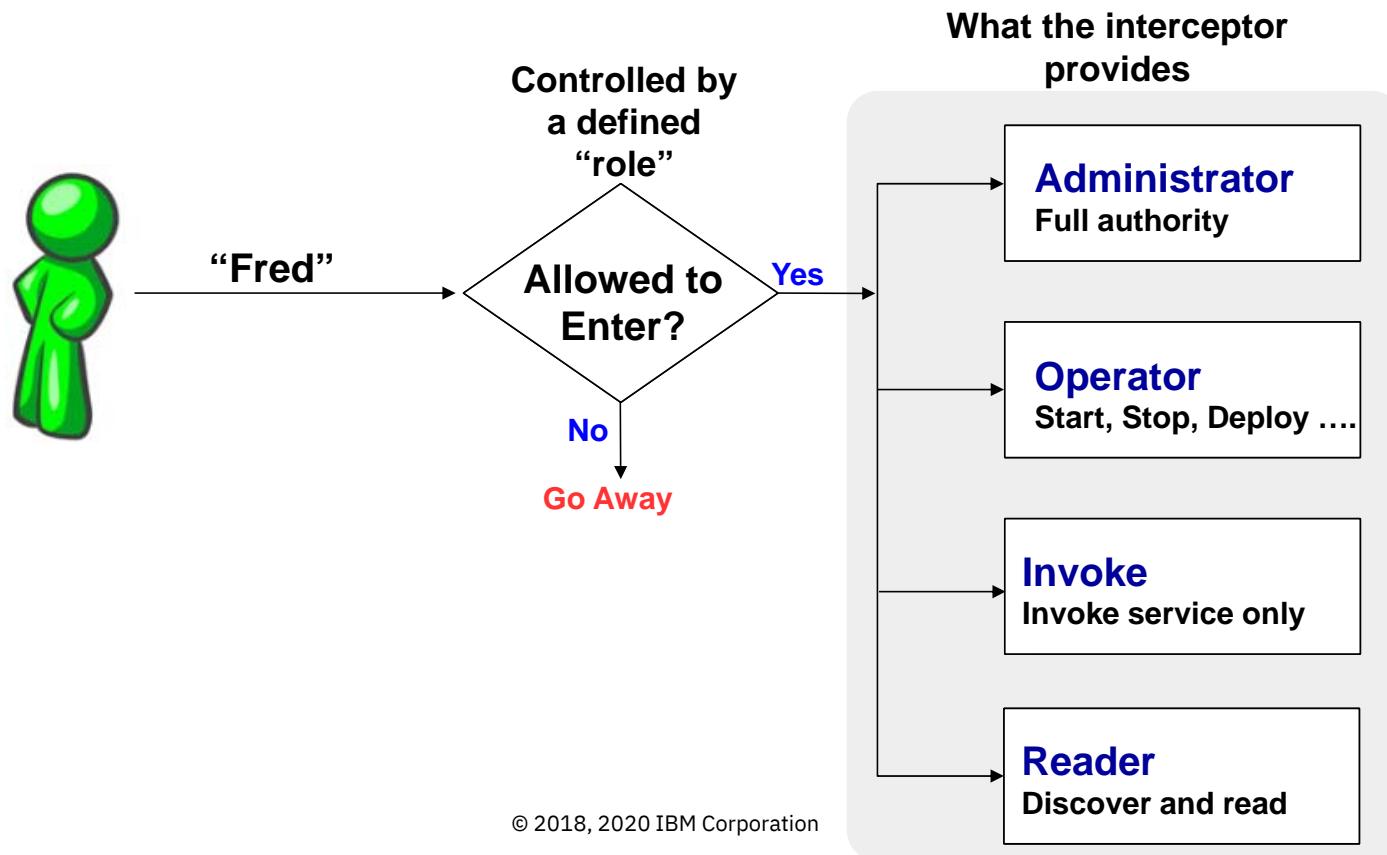
Some alternative filter types

- A **remoteAddress** element is compared against the TCP/IP address of the client that sent the request.
- The **host** element is compared against the "Host" HTTP request header, which identifies the target host name of the request.
- The **requestUrl** element is compared against the URL that is used by the client application to make the request.



Authorization interceptor

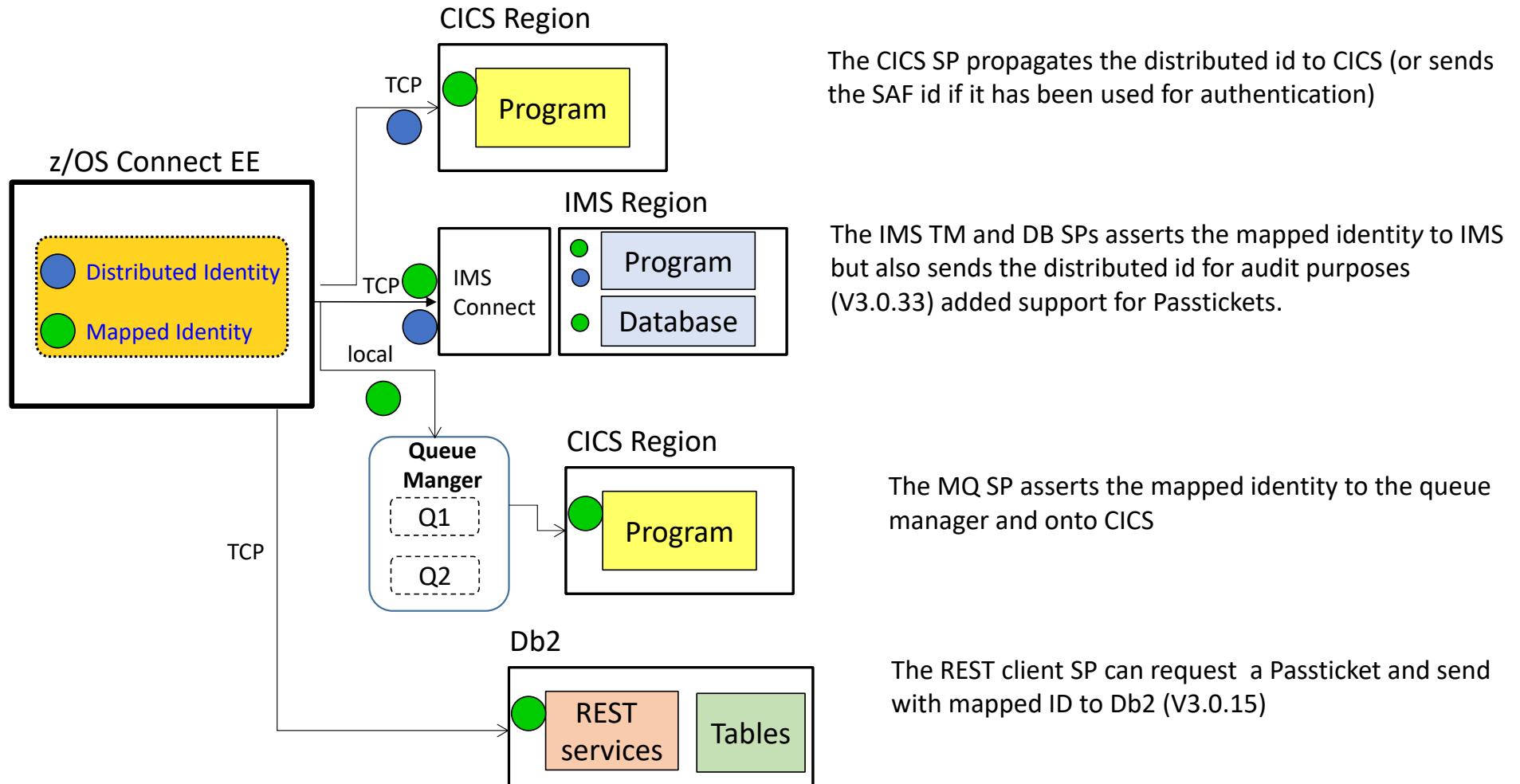
The “authorization interceptor” is a supplied piece of interceptor code that will check to see if the user has the authority to perform the action requested:



Flowing an identity to the back end



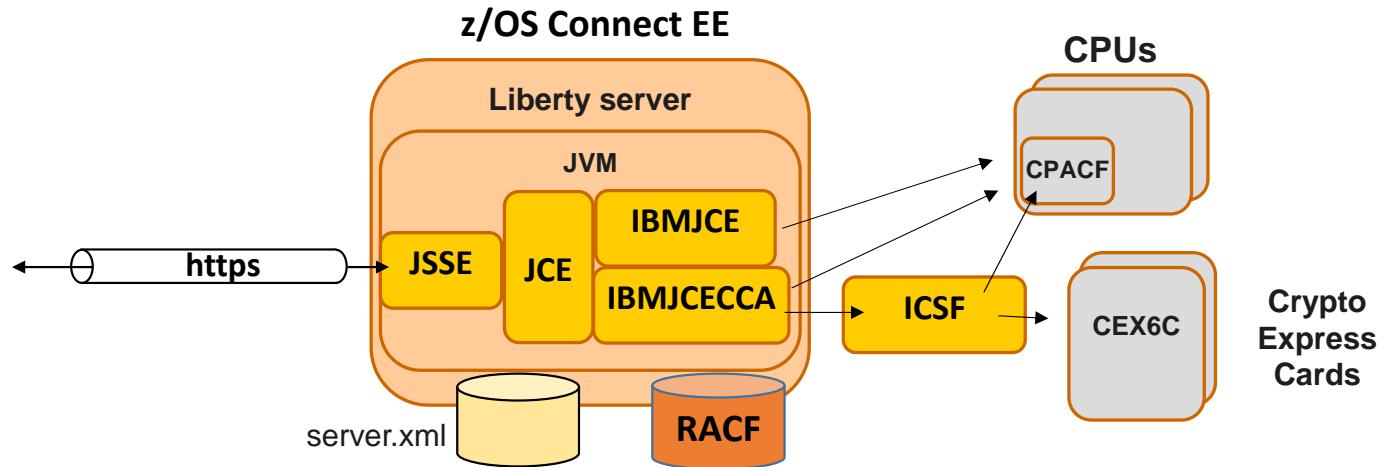
z/OS Connect EE



Using JSSE with z/OS Connect EE

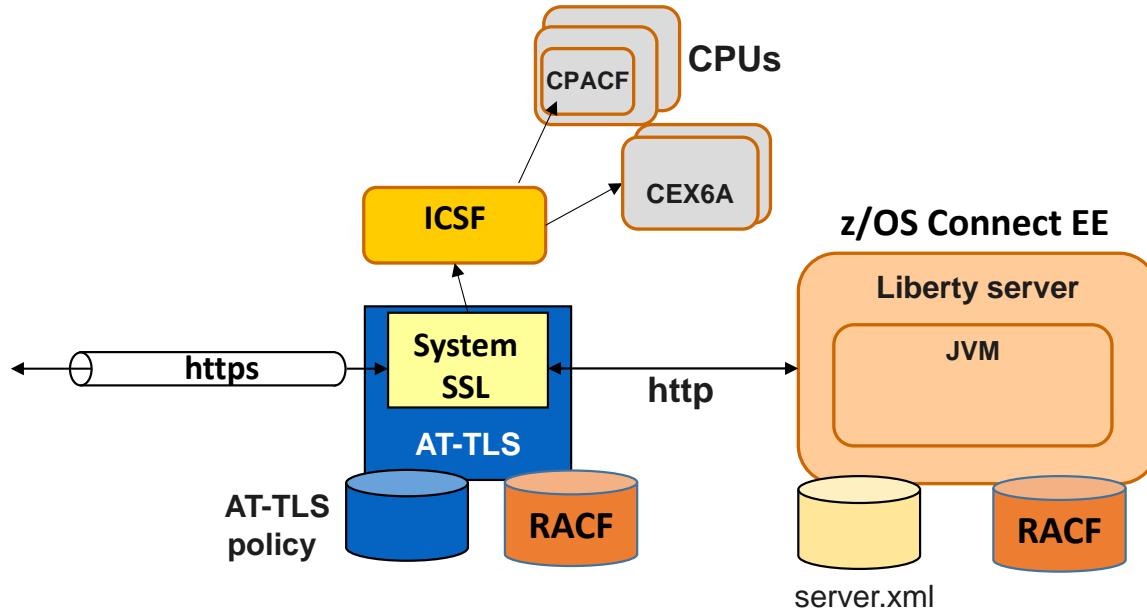


z/OS Connect EE



- z/OS Connect EE support for SSL/TLS is based on **Liberty server** support
- **Java Secure Socket Extension (JSSE)** API provides framework and Java implementation of SSL and TLS protocols used by Liberty HTTPS support
- **Java Cryptography Extension (JCE)** is standard extension to the Java Platform that provides implementation for cryptographic services
- **IBM Java SDK** for z/OS provides two different JCE providers, **IBMJCE** and **IBMJCECCA**

Using AT-TLS with z/OS Connect EE

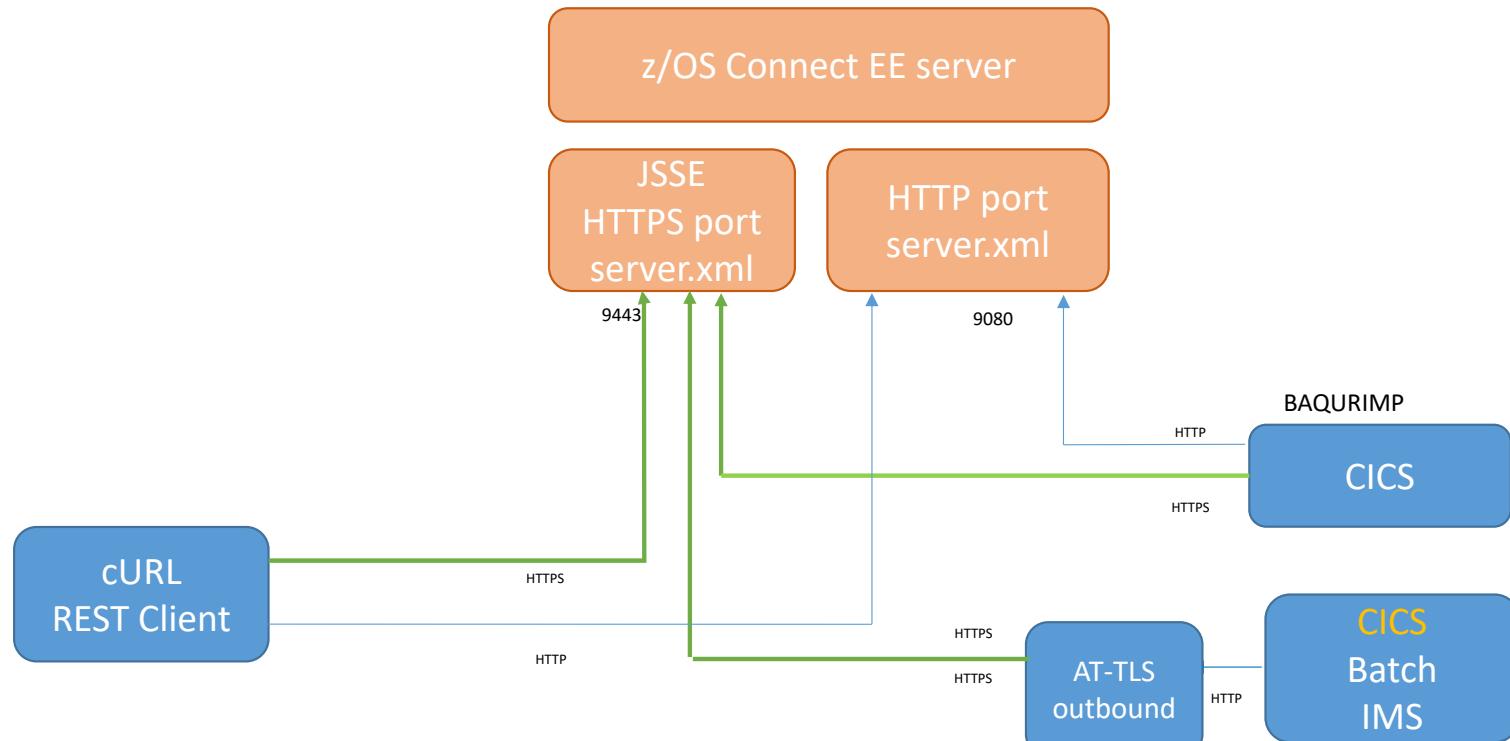


- **Application Transparent TLS (AT-TLS)** creates a secure session on behalf of z/OS Connect
- Only define http ports in **server.xml** (z/OS Connect does not know that TLS session exists)
- Define TLS protection for all applications (including z/OS Connect) in **AT-TLS policy**
- AT-TLS uses **System SSL** which exploits the CPACF and Crypto Express cards via ICSF

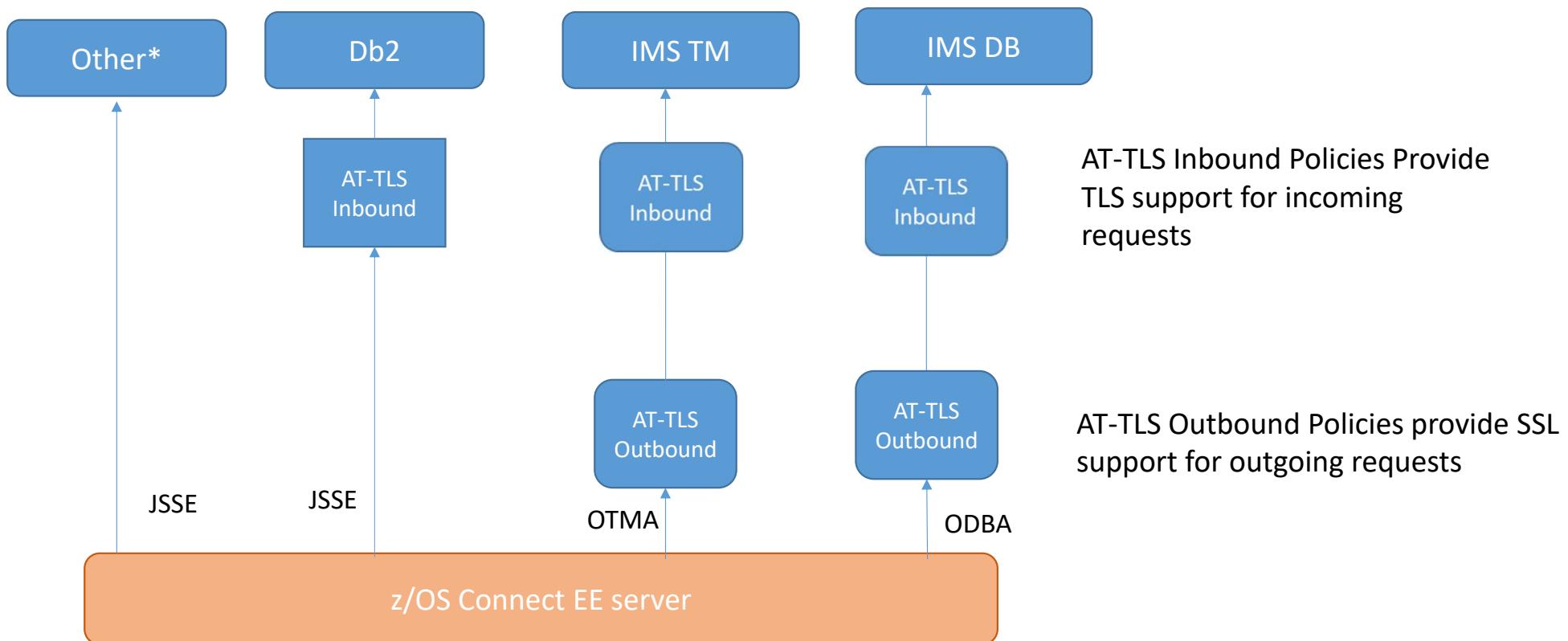


z/OS Connect EE

TLS Inbound to zCEE Scenarios



TLS Outbound from zCEE Scenarios (HTTPS/OTMA/ODBA)



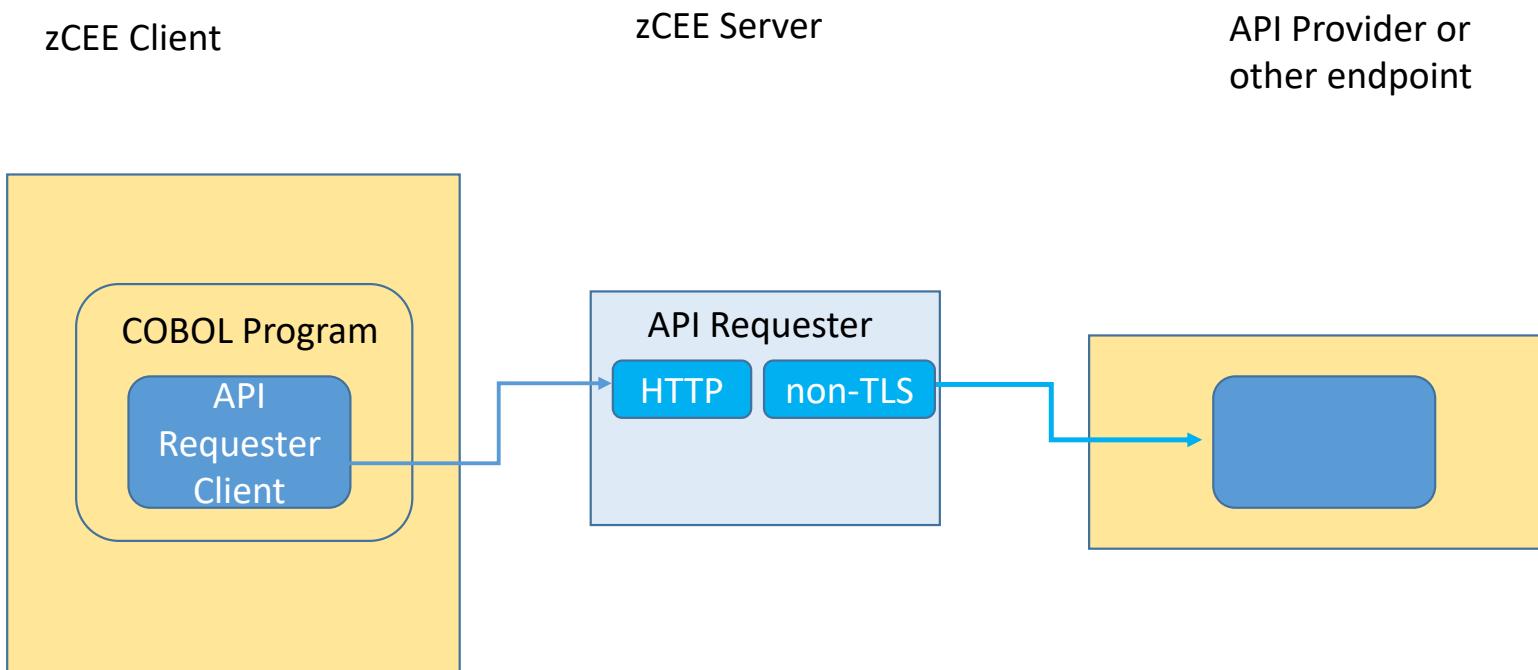
* REST endpoints, CICS, MQ, etc.

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Non-TLS Flow



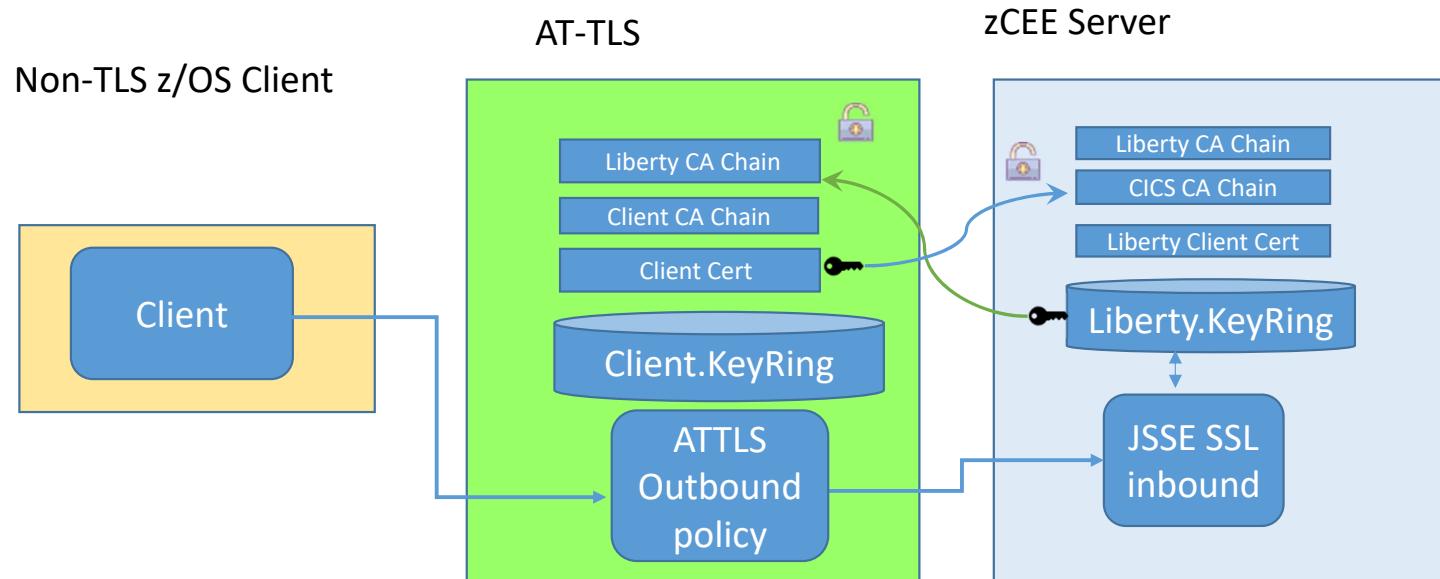
z/OS Connect EE



Non-TLS Client with zCEE Inbound TLS Handshake



z/OS Connect EE

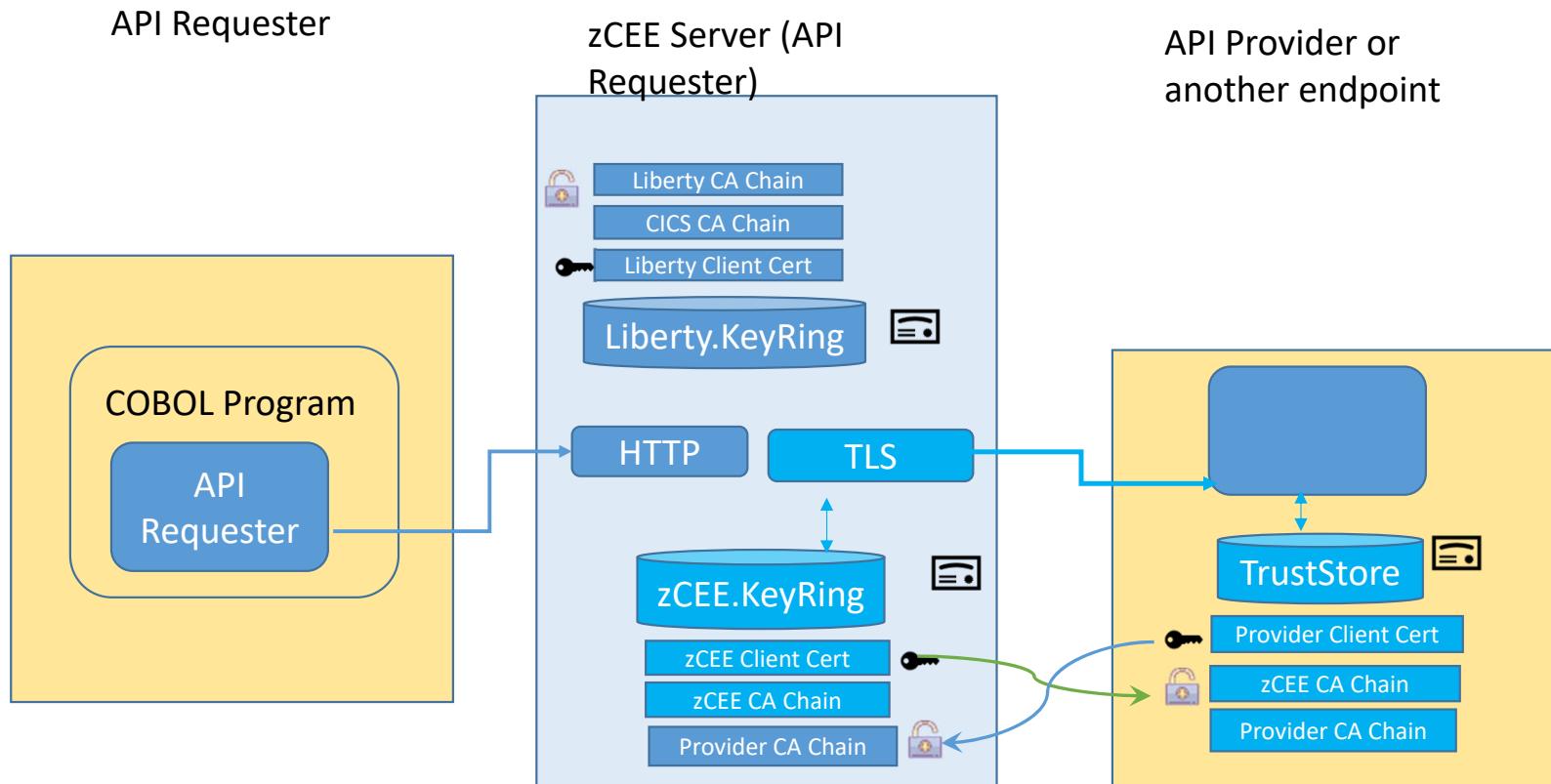


Outbound Policy acts a surrogate SSL client

Non-TLS Client with zCEE Outbound TLS Handshake



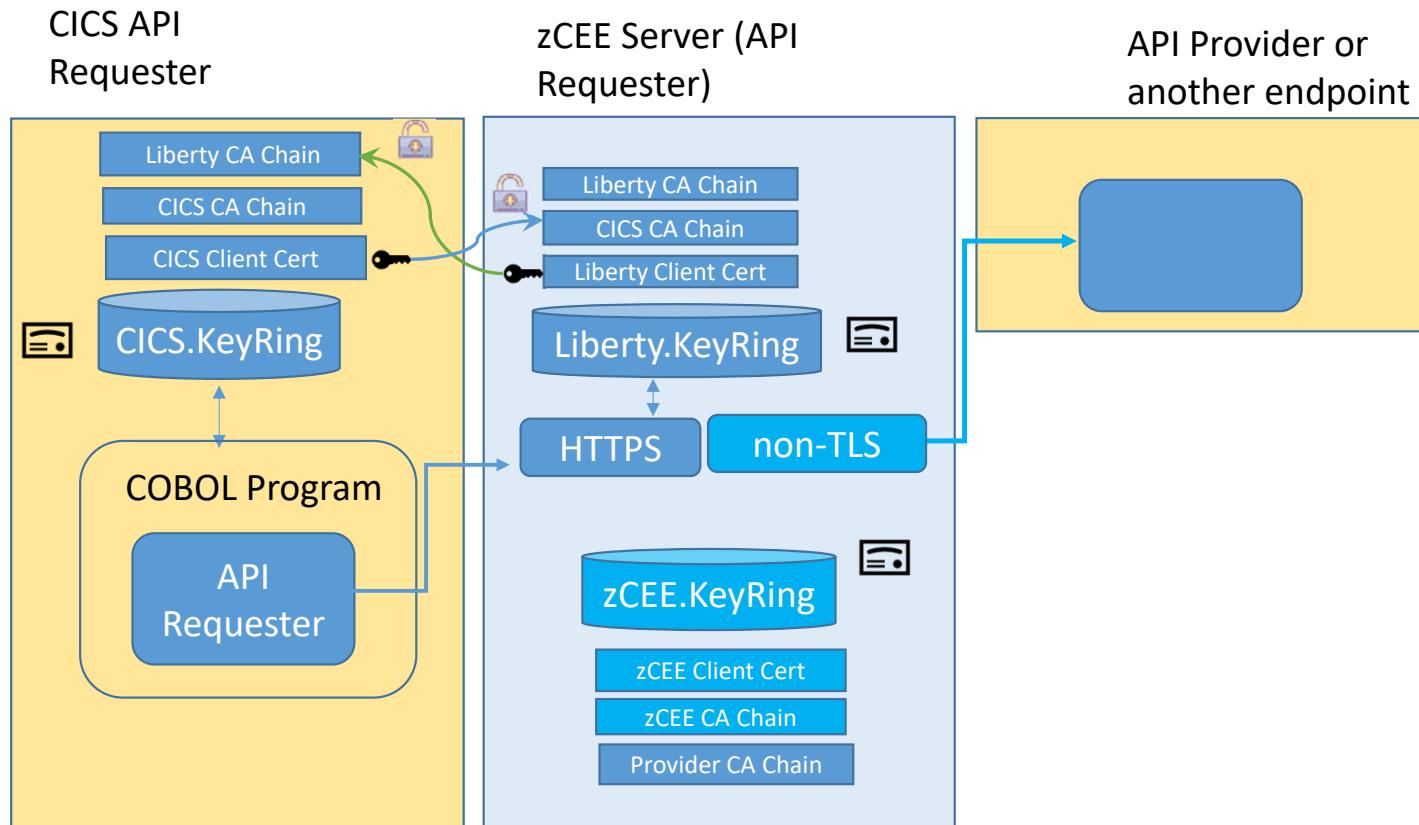
z/OS Connect EE



TLS Client with zCEE non-TLS outbound



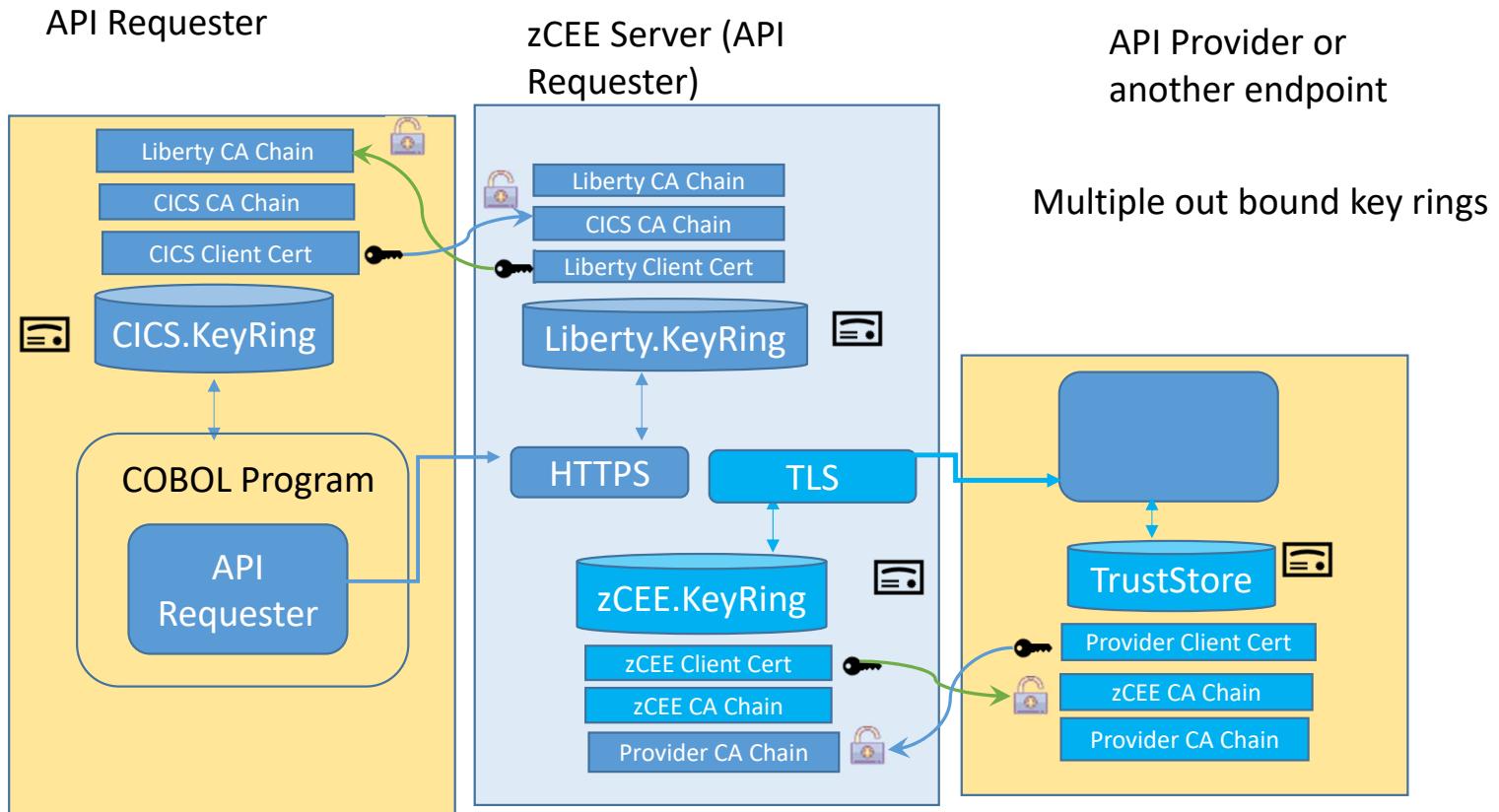
z/OS Connect EE



TLS Client with zCEE inbound and outbound TLS Handshakes



z/OS Connect EE





Creating a Key Ring

```
/* Import certificates obtained from a Certificate Authority
racdcert CERTAUTH withlabel('CICS CA') add('USER1.CICSCA.PEM')
racdcert id(cicsstc) withlabel('CICS Client Cert') add('USER1.CICS.P12') password('secret')
/* Create CICS key ring and connect CA and personal certificates */
racdcert id(cicsstc) addring(CICS.KeyRing)
racdcert id(cicsstc) connect(ring(CICS.KeyRing) label('CICS CA') certauth usage(certauth))
racdcert id(cicsstc) connect(ring(CICS.KeyRing) label('Liberty CA') certauth usage(certauth))
/* Connect default personal certificate */
racdcert id(cicsstc) connect(ring(CICS.KeyRing) label('CICS Client Cert') default
setropts raclist(digtring,digtnmap) refresh
```

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>



- During the TLS handshake, the TLS protocol and data exchange cipher are negotiated
- Choice of cipher and key length has an impact on performance
- You can restrict the protocol (SSL or TLS) and ciphers to be used
- Example setting server.xml file

```
<ssl id="DefaultSSLSettings" keyStoreRef="defaultKeyStore"  
sslProtocol="TLSv1.2" enabledCiphers="TLS_RSA_WITH_AES_256_CBC_SHA256  
TLS_RSA_WITH_AES_256_GCM_SHA384" />
```

- This configures use of TLS 1.2 and two supported ciphers
- It is recommended to control what ciphers can be used in the server rather than the client

Persistent connections



z/OS Connect EE

- Persistent connections can be used to avoid too many handshakes
- Configured by setting the `keepAliveEnabled` attribute on the `httpOptions` element to **true**
- Example setting `server.xml` file

```
<httpEndpoint host="*" httpPort="80" httpsPort="443"  
id="defaultHttpEndpoint" httpOptionsRef="httpOpts" />  
  
<httpOptions id="httpOpts" keepAliveEnabled="true"  
maxKeepAliveRequests="500" persistTimeout="1m" />
```

- This sets the connection timeout to **1 minute** (default is 30 seconds) and sets the maximum number of persistent requests that are allowed on a single HTTP connection to **500**
- It is recommended to set a maximum number of persistent requests when connection workload balancing is configured
- It is also necessary to configure the client to support persistent connections



SSL sessions

- When connections timeout, it is still possible to avoid the impact of full handshakes by reusing the SSL session id
- Configured by setting the `sslSessionTimeout` attribute on the `sslOptions` element to an amount of time
- Example setting `server.xml` file

```
<httpEndpoint host="*" httpPort="80" httpsPort="443"  
id="defaultHttpEndpoint" httpOptionsRef="httpOpts"  
sslOptionsRef="mySSLOptions"/>  
  
<httpOptions id="httpOpts" keepAliveEnabled="true"  
maxKeepAliveRequests="100" persistTimeout="1m"/>  
  
<sslOptions id="mySSLOptions" sslRef="DefaultSSLSettings"  
sslSessionTimeout="10m"/>
```

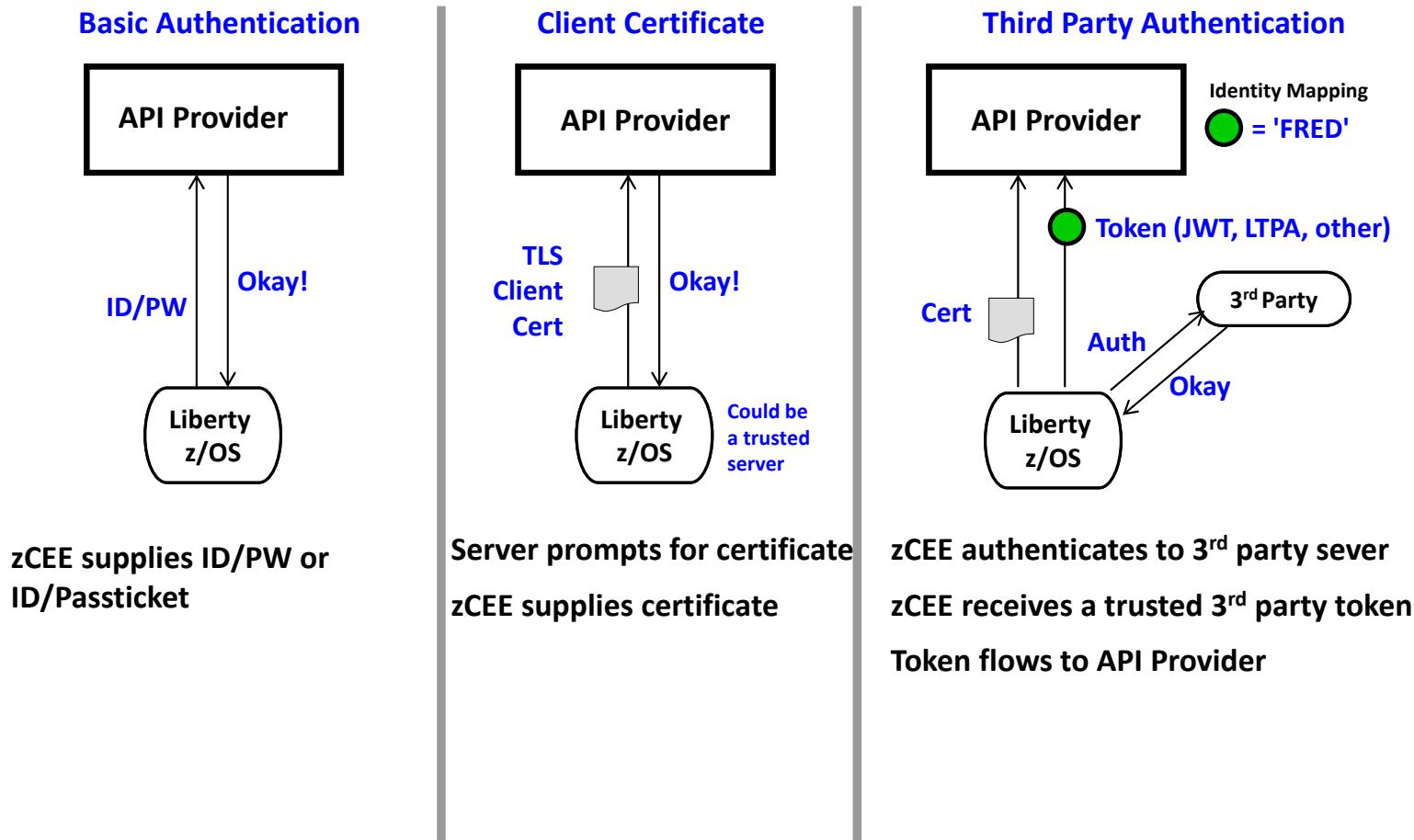
- This sets the timeout limit of an SSL session to **10 minutes** (default is 8640ms)
- SSL session ids are not shared across z/OS Connect servers

API Provider Authentication

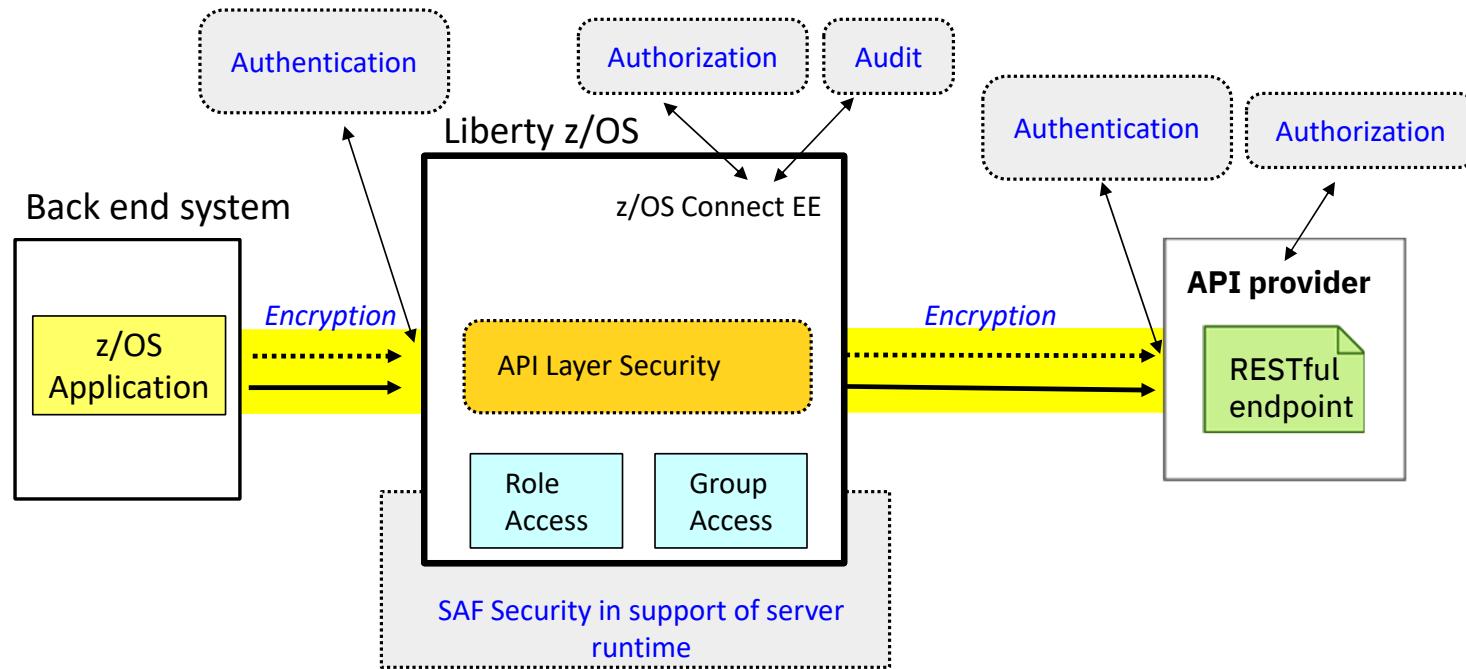


z/OS Connect EE

Several different ways this can be accomplished:



API requester security – overview

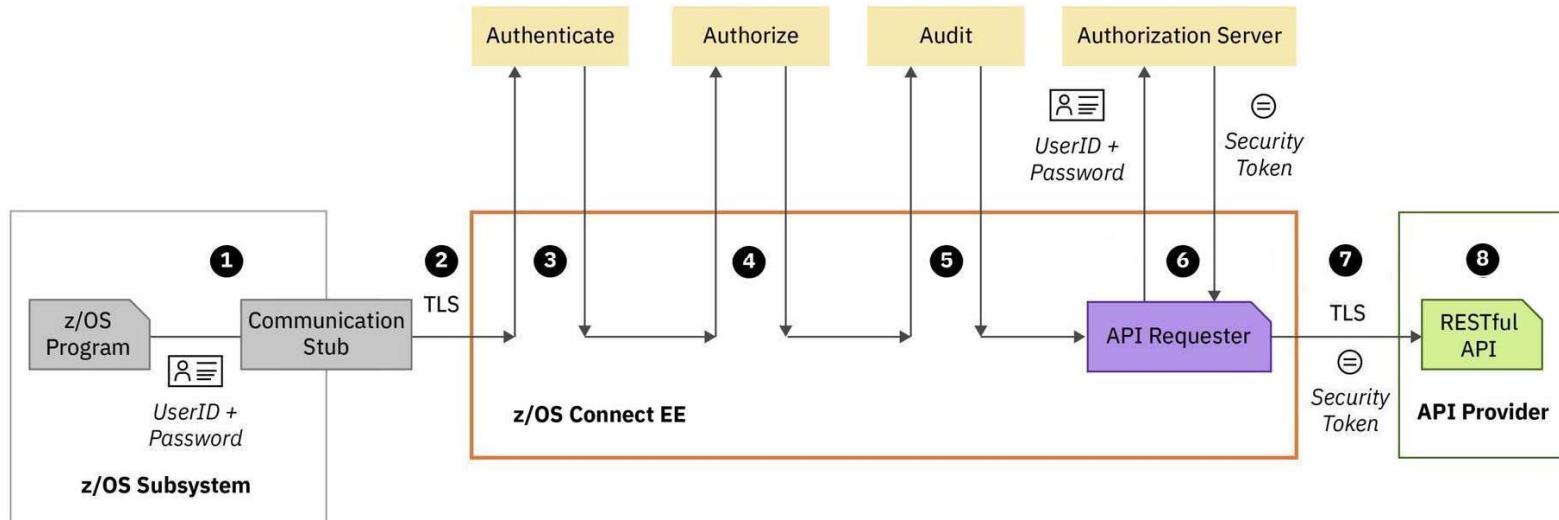


1. Authentication (basic, client certificate)
2. Encryption (aka "SSL" or "TLS")
3. Authorization (OAuth)
4. Audit
5. Configuring security with SAF

Typical z/OS Connect EE security flow



z/OS Connect EE

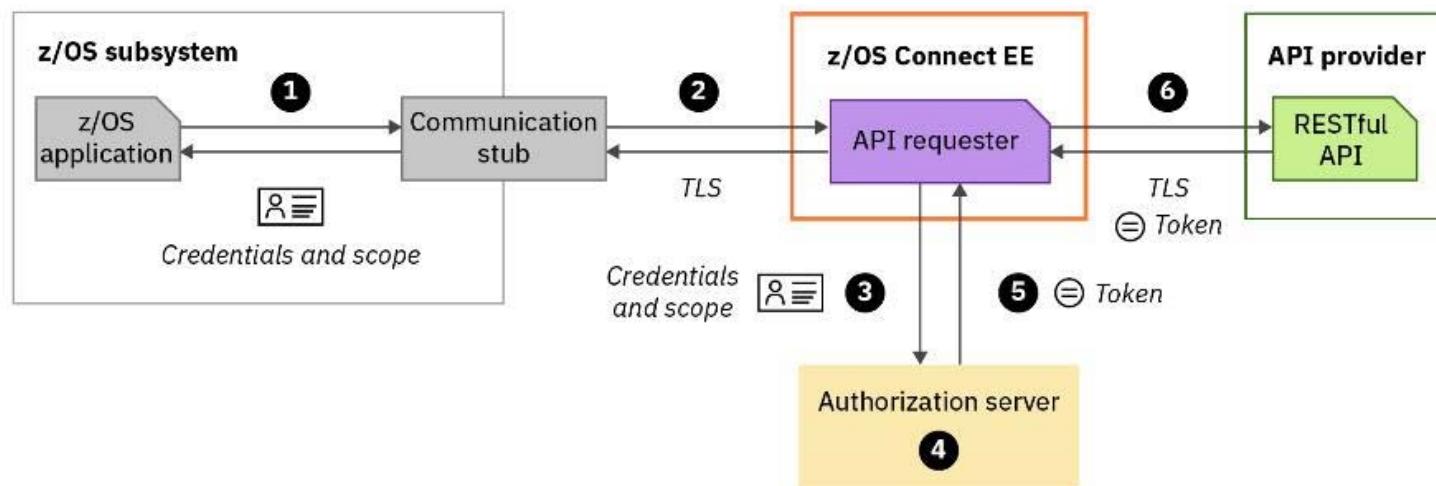


1. A user ID and password can be used for basic authentication by the z/OS Connect EE server
2. Connection between the CICS, IMS, or z/OS application and the z/OS Connect EE server can use TLS
3. Authenticate the CICS, IMS, or z/OS application.
4. Authorize the authenticated user ID to connect to z/OS Connect EE and to perform specific actions on z/OS Connect EE API requesters
5. Audit the API requester request
6. Pass the user ID and password credentials to an authorization server to obtain a security token.
7. Secure the connection to the external API provider, and provide security credentials such as a **security token to be used to invoke the RESTful API**
8. The RESTful API runs in the external API provider

Calling an API with OAuth 2.0 support



z/OS Connect EE

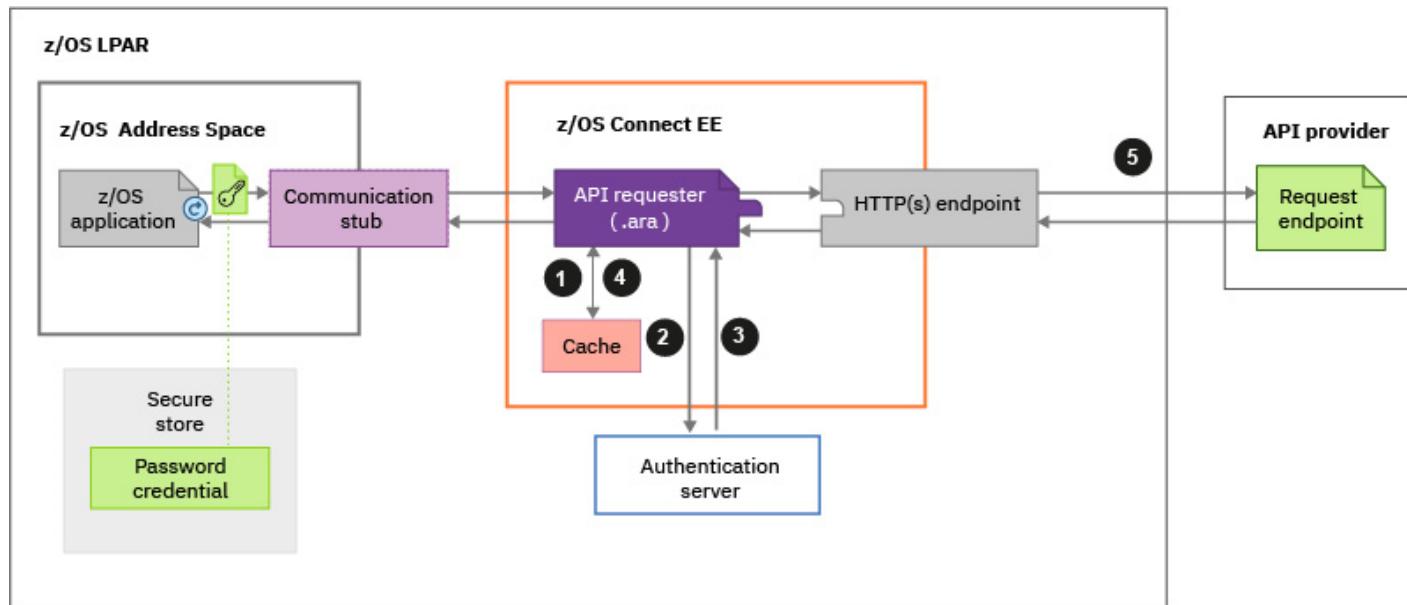


```
MOVE user TO BAQ-OAUTH-USERNAME  
MOVE password TO BAQ-OAUTH-PASSWORD  
MOVE clientid TO BAQ-OAUTH-CLIENTID  
MOVE secret TO BAQ-OAUTH-CLIENT-SECRET
```

Calling an API with JWT support



z/OS Connect EE



MOVE user TO BAQ-TOKEN-USERNAME

MOVE password TO BAQ-TOKEN-PASSWORD

Getting Started Guide



WP102724 - z/OS Connect EE Getting Started

z/OS Connect Enterprise Edition V3.0

Getting Started Guide
for CICS, IMS, Db2 and MQ

Version Date: June 9, 2020



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Version Date: Tuesday, June 09, 2020

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Github Site



Screenshot of the GitHub interface for the z/OS Connect EE Wildfire Workshop repository.

The main repository page shows:

- Branch: master
- Commits: 162
- Branches: 2
- Packages: 0
- Releases: 0
- Contributors: 1

Recent activity:

- emitchj Add files via upload (Latest commit dd35210 2 days ago)
- Misc Presentations Delete tmp (4 days ago)
- cobol Delete PUTAPI.cbl (15 days ago)
- exercises Add files via upload (7 days ago)
- security Add files via upload (2 days ago)
- Introduction to zOS Connect EE .pdf Add files via upload (4 days ago)
- README.md Update README.md (2 years ago)
- WP102724 - zOS Connect EE V3 Getting Started.pdf Add files via upload (7 days ago)
- WSC Wildfire zOS Primer.pdf Add files via upload (10 months ago)

Collateral related to the Washington System Center z/OS Connect Wildfire Workshop:

- o 162 commits
- Branch: master
- New pull request
- Create new file
- Upload files
- Find file
- Clone or download

The repository contains material from the z/OS Connect EE Wildfire workshops run by the IBM Washington Systems Center.

Two additional tabs are visible on the right:

- exercises /** Branch: master (Latest commit 4b21589 7 days ago)
 - Developing Outbound APIs Requesters Applications.pdf
 - Developing RESTful APIs for a CICS COMMAREA program.pdf
 - Developing RESTful APIs for DVM Services.pdf
 - Developing RESTful APIs for DB2 REST Services.pdf
 - Developing RESTful APIs for HATS REST Services.pdf
 - Developing RESTful APIs for IMS Database REST Services.pdf
 - Developing RESTful APIs for IMS Transactions.pdf
 - Developing RESTful APIs for MQ.pdf
 - Developing RESTful APIs for MVS Batch.pdf
 - Developing RESTful APIs for a CICS program.pdf
 - zCEE Customization Basic Configuration.pdf
 - zCEE Customization Basic Security.pdf
- security /** Branch: master (Latest commit dd35210 2 days ago)
 - zCEE Customization Basic Configuration.pdf
 - zCEE Customization Basic Security.pdf
 - zCEE Customization Security and CICS.pdf
 - zCEE Customization Security and DB2.pdf
 - zCEE Customization Security when accessing an IMS Database.pdf
 - zCEE Customization Security when accessing an IMS Transaction.pdf
 - zCEE Customization Security with MVS Batch.pdf

- <http://tinyurl.com/y28fsezs>



/questions?thanks=true

Thank you for listening.

- z/OS Connect EE Users Group: <https://www.linkedin.com/groups/8731382/>