



# 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
  - IBM DVM
  - IBM File Manager
  - MVS Batch
  - Outbound REST APIs
  - 3270 screen based applications
- 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”?

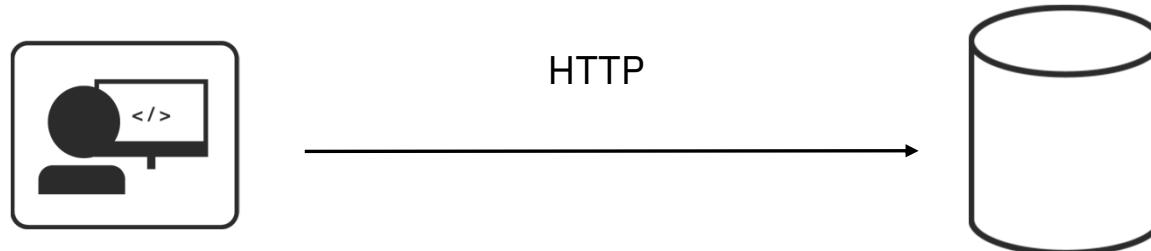
# REST is an Architectural Style

**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

URIs represent things (or lists of things)

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?name=Fred +  (*JSON with Fred's information*)

**GET** /account?number=1234

**PUT** /account?number=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?

<b>Ubiquitous Foundation</b>	<p>It's based on HTTP, which operates on TCP/IP, which is a ubiquitous networking topology.</p>
<b>Relatively Lightweight</b>	<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>
<b>Relatively Easy Development</b>	<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>
<b>Increasingly Common</b>	<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>
<b>Stateless</b>	<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

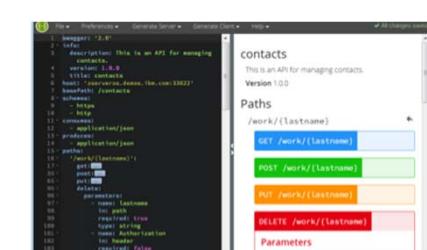
**Swagger UI** allows API consumers to easily browse and try APIs based on Swagger Doc.



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 'POST' and 'PUT' operations are highlighted in green, indicating they are the most recent or recommended. Below the operations, there is a 'Basic URL' field set to 'https://server001.demos.ibm.com:33622/contacts/api-docs' and a 'Value' button.

## Write Swagger

**Swagger Editor** allows API developers to design their swagger documents.



The screenshot shows the Swagger Editor interface for a 'contacts' API. On the left, the Swagger document is displayed in JSON format. On the right, the 'Paths' section shows four operations: /work/{lastname} (GET, POST, PUT, DELETE). Each operation has its corresponding color-coded button: blue for GET, green for POST, orange for PUT, and red for DELETE. Below the paths, there is a 'Parameters' section.

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

Example: <https://developer.psa-peugeot-citroen.com/inc/>



z/OS Connect EE

# Swagger Example

The screenshot shows a Swagger JSON editor window with the following content:

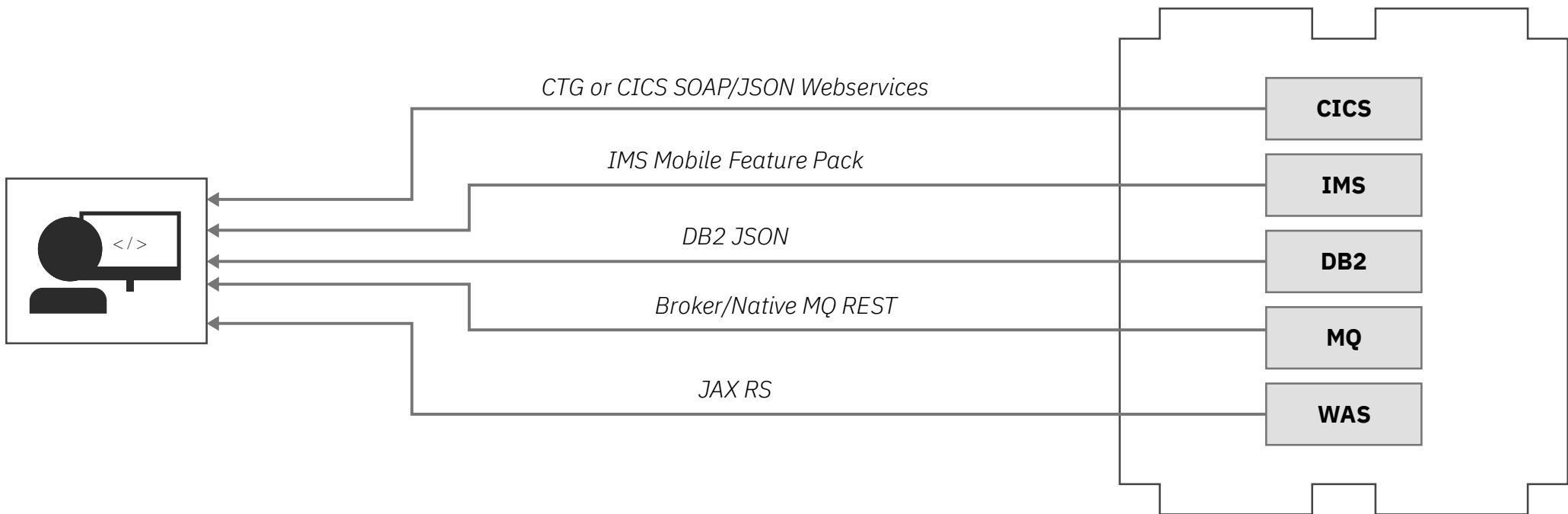
```
swagger: "2.0"
info:
  description: ""
  version: "1.0.0"
  title: "miniloan"
host: "localhost:8080"
basePath: "/miniloan"
schemes:
  0: "https"
  1: "http"
consumes:
  0: "application/json"
produces:
  0: "application/json"
paths:
  /loan:
    post:
      tags:
        0: "miniloan"
      operationId: "postMiniloan"
      parameters:
        0:
          name: "Authorization"
          in: "header"
          required: false
          type: "string"
        1:
          in: "body"
          name: "postMiniloanService_request"
          description: "request body"
          required: true
          schema:
            $ref: "#/definitions/postMiniloanService_request"
      responses:
        200:
          description: "OK"
definitions: {}
```



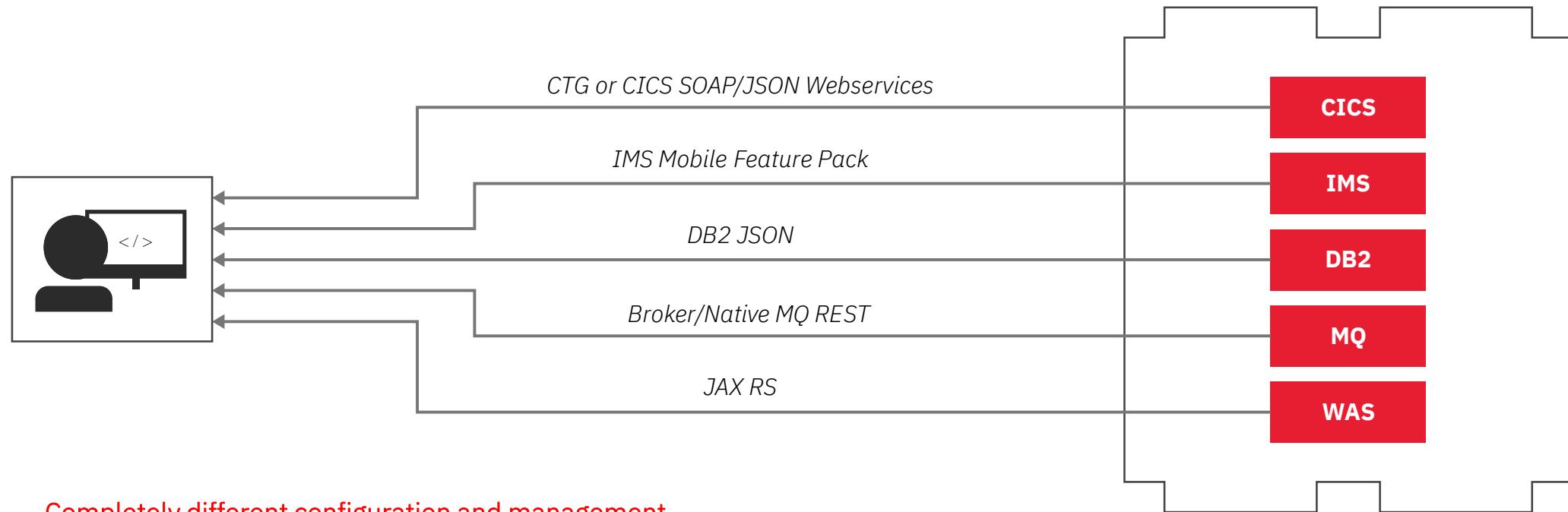
## Why /zos\_connect\_ee?

Truly RESTful APIs to and from your mainframe.

# First, can't we already do REST and JSON today?



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



Completely different configuration and management.

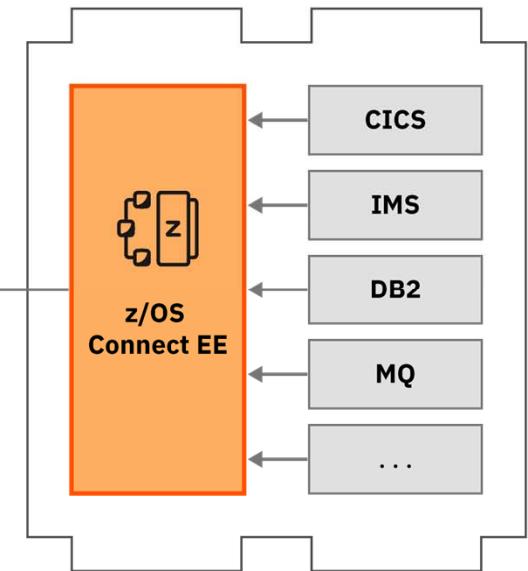
Multiple endpoints for developers to call/maintain access to.

These are typically not RESTful!



# A single entry point was needed

Expose z/OS resources without writing any code.



**z/OS Connect EE provides**

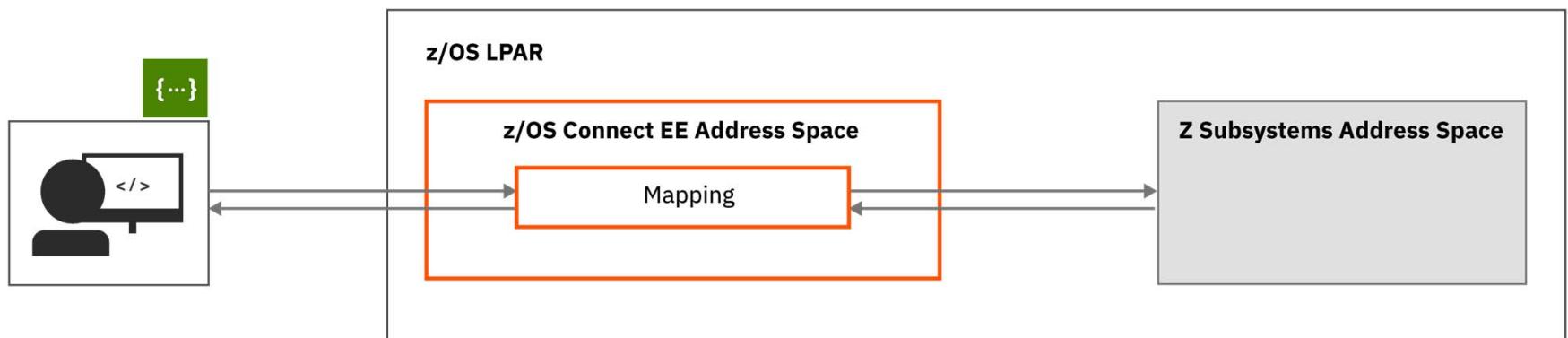
- Single Configuration Administration
- Single Security Administration
- With sophisticated mapping of truly RESTful APIs to existing mainframe and services data without writing any code.



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

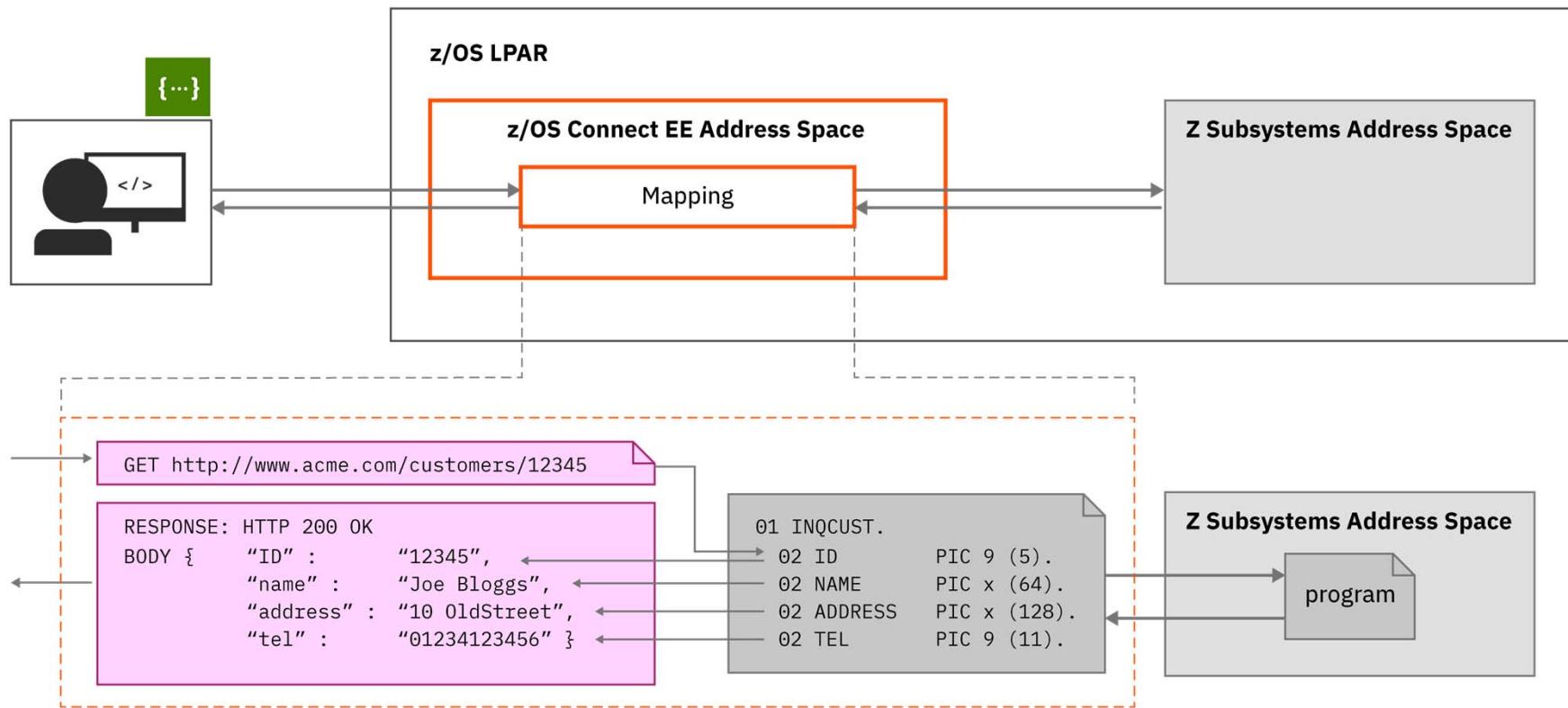
# Let's Start with Data mapping

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



# Data mapping Example

A closer look



# COBOL versus JSON Example

```

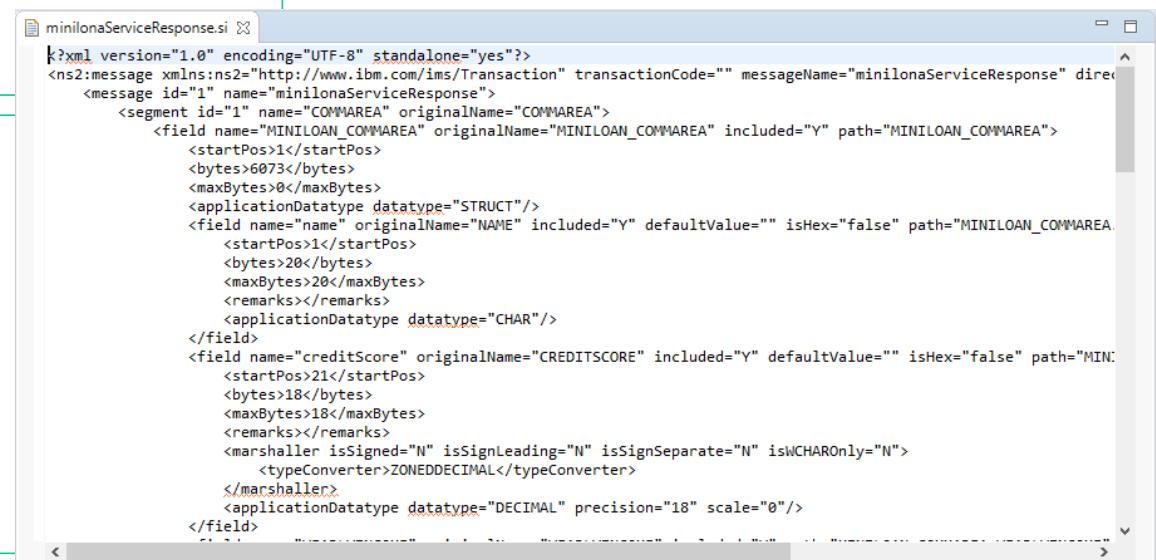
01 MINILOAN-COMMAREA.
10 name pic X(20).
10 creditScore pic 9(16)v99.
10 yearlyIncome pic 9(16)v99.
10 age pic 9(10).
10 amount pic 9999999v99.
10 approved pic X.
     88 BoolValue value 'T'.
10 effectDate pic X(8).
10 yearlyInterestRate pic S9(5).
10 yearlyRepayment pic 9(18).
10 messages-Num pic 9(9).
10 messages pic X(60) occurs 1 to 99 times
      depending on messages-Num.

```

```

"miniloan_commarea": {
    "type": "object",
    "properties": {
        "name": {
            "type": "string",
            "maxLength": 20
        },
        "creditScore": {
            "type": "number",
            "format": "decimal",
            "multipleOf": 0.01,
            "maximum": 99999999999999.99,
            "minimum": 0
        }
    }
},

```



```

<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<ns2:message xmlns:ns2="http://www.ibm.com/ims/Transaction" transactionCode="" messageName="minilonaServiceResponse" direction="Request">
    <message id="1" name="minilonaServiceResponse">
        <segment id="1" name="COMMAREA" originalName="COMMAREA" included="Y" path="MINILOAN_COMMAREA">
            <field name="MINILOAN_COMMAREA" originalName="MINILOAN_COMMAREA" included="Y" path="MINILOAN_COMMAREA">
                <startPos>1</startPos>
                <bytes>6073</bytes>
                <maxBytes>0</maxBytes>
                <applicationDatatype datatype="STRUCT"/>
                <field name="name" originalName="NAME" included="Y" defaultValue="" isHex="false" path="MINILOAN_COMMAREA">
                    <startPos>1</startPos>
                    <bytes>20</bytes>
                    <maxBytes>20</maxBytes>
                    <remarks></remarks>
                    <applicationDatatype datatype="CHAR"/>
                </field>
                <field name="creditScore" originalName="CREDITSCORE" included="Y" defaultValue="" isHex="false" path="MINILOAN_COMMAREA">
                    <startPos>21</startPos>
                    <bytes>18</bytes>
                    <maxBytes>18</maxBytes>
                    <remarks></remarks>
                    <marshaller isSigned="N" isSignLeading="N" isSignSeparate="N" isWCHAROnly="N">
                        <typeConverter>ZONEDDECIMAL</typeConverter>
                    </marshaller>
                    <applicationDatatype datatype="DECIMAL" precision="18" scale="0"/>
                </field>
            </field>
        </segment>
    </message>
</ns2:message>

```

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

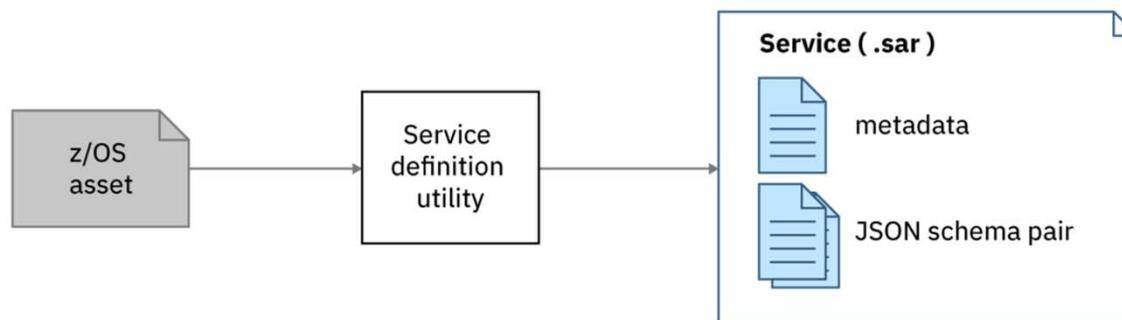
All data is sent as character strings and numeric precision and sign bit is removed as an issue

# 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

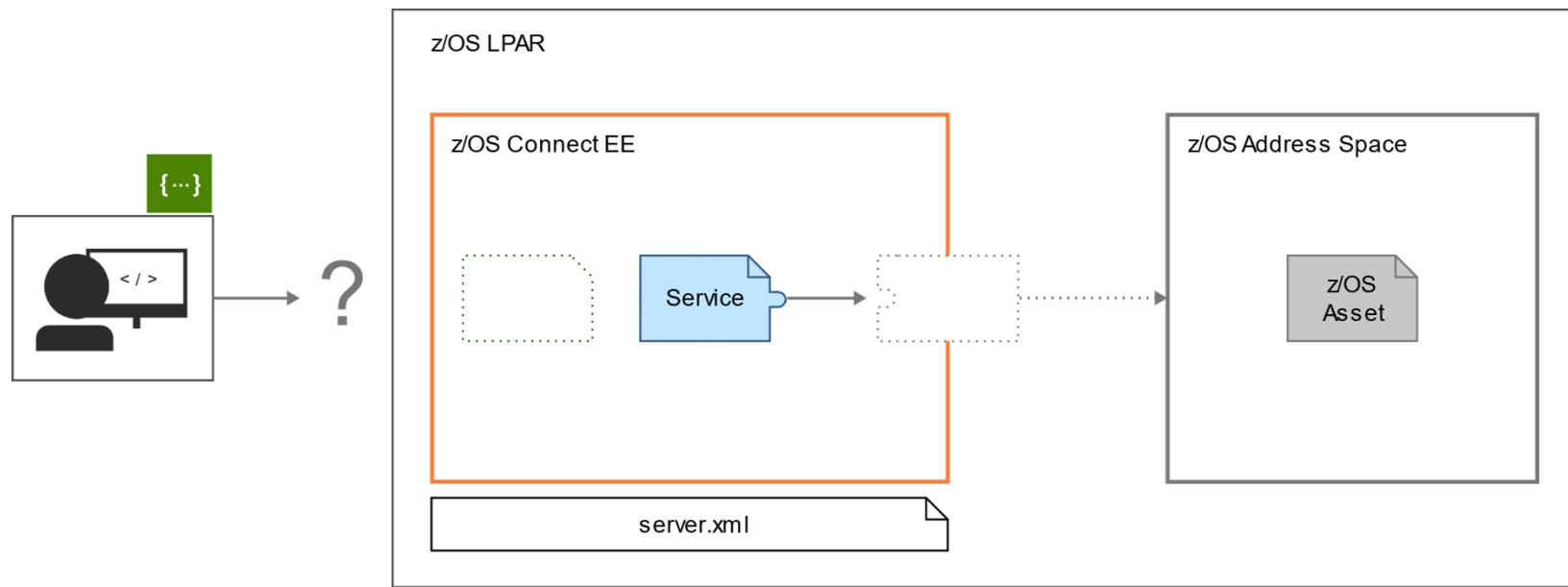
- API Toolkit (CICS, IMS TM, IMS DB, Db2 and MQ)
- z/OS Connect EE Build Toolkit (MVS Batch, IBM File Manager and HATS)
- DVM Toolkit

 [ibm.biz/zosconnect-sar-creation](http://ibm.biz/zosconnect-sar-creation)



# Steps to expose a z/OS application

## 2. Deploy the service

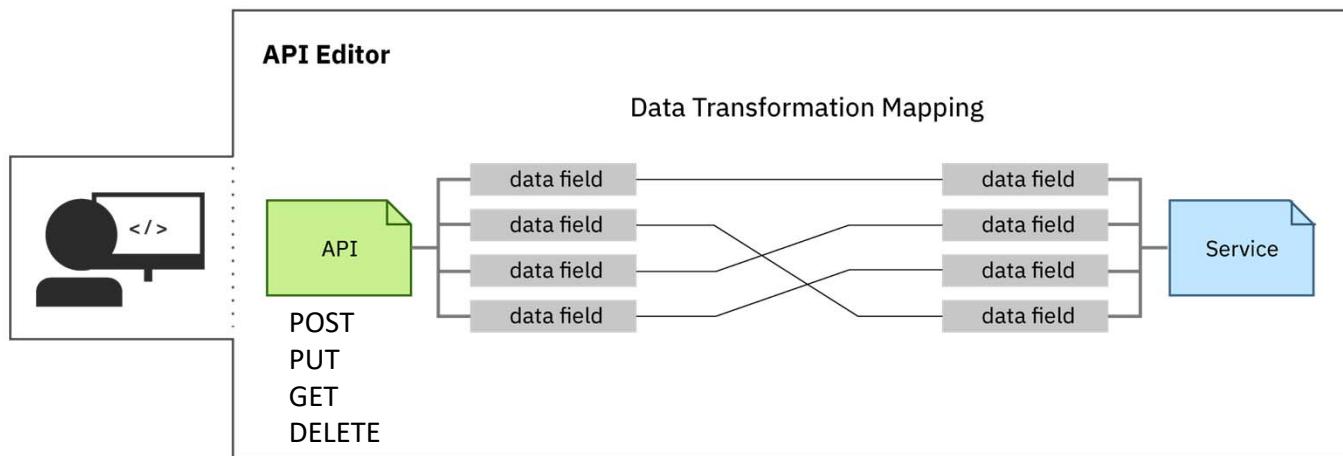


Deploy the `.sar` file generated in **Step 2** using the right-click deploy in **the API toolkit**, or by copying the `.sar` file to the services directory.

 [ibm.biz/zosconnect-define-services](http://ibm.biz/zosconnect-define-services)

# Steps to expose a z/OS application

## 3. Create an API

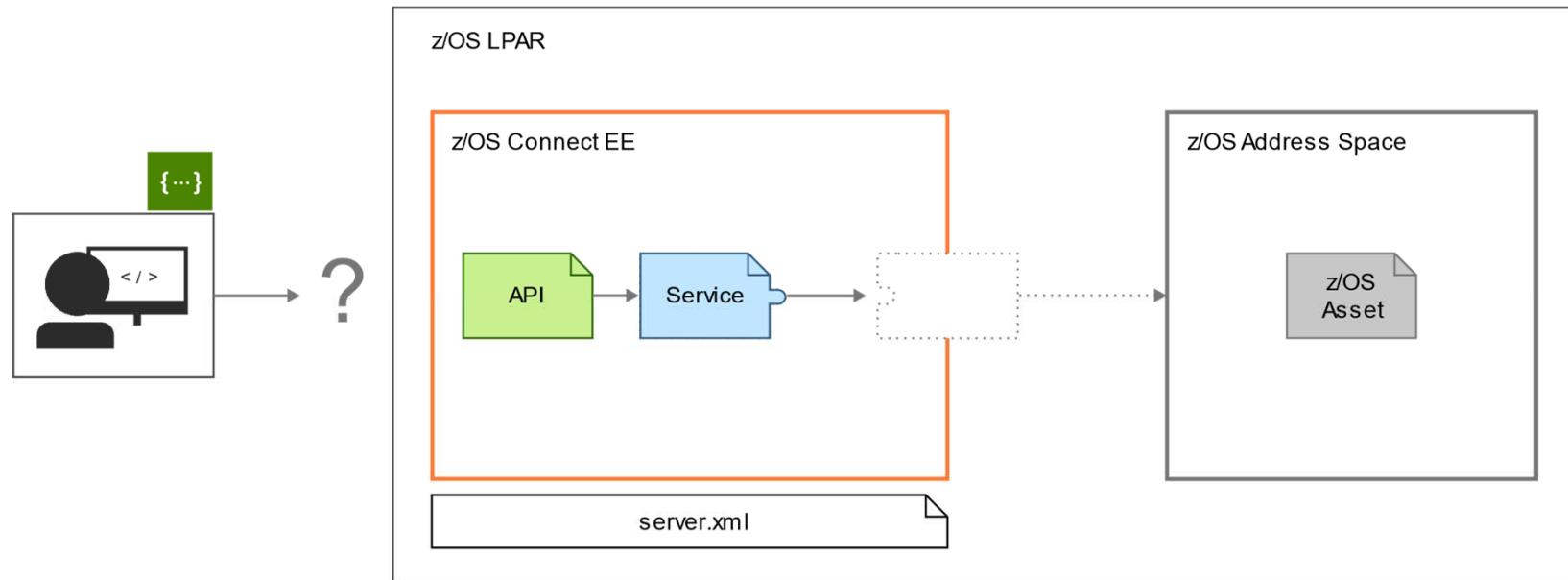


- Import your `.sar` file into the **API toolkit**, and start designing your RESTful API.
- Provides additional data mapping
- From the editor, create an **API Archive file** (`.aar`), which describes your API and how it maps to underlying services.

 [ibm.biz/zosconnect-create-api](http://ibm.biz/zosconnect-create-api)

# Steps to expose a z/OS application

## 4. Deploy the API

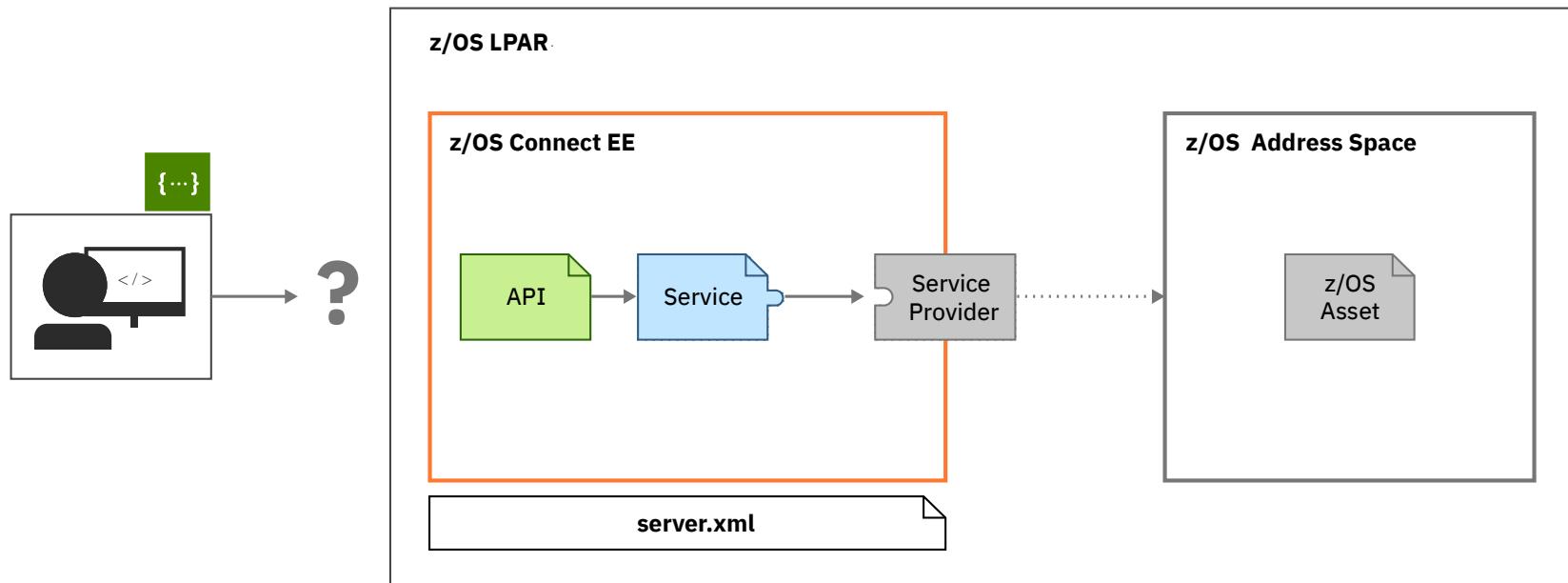


Deploy your API using the right-click deploy in **the API toolkit**, or by copying the `.aar` file to the `apis` directory.

 [ibm.biz/zosconnect-deploy-api](http://ibm.biz/zosconnect-deploy-api)

# Steps to expose a z/OS application

## 5. Configure the service provider

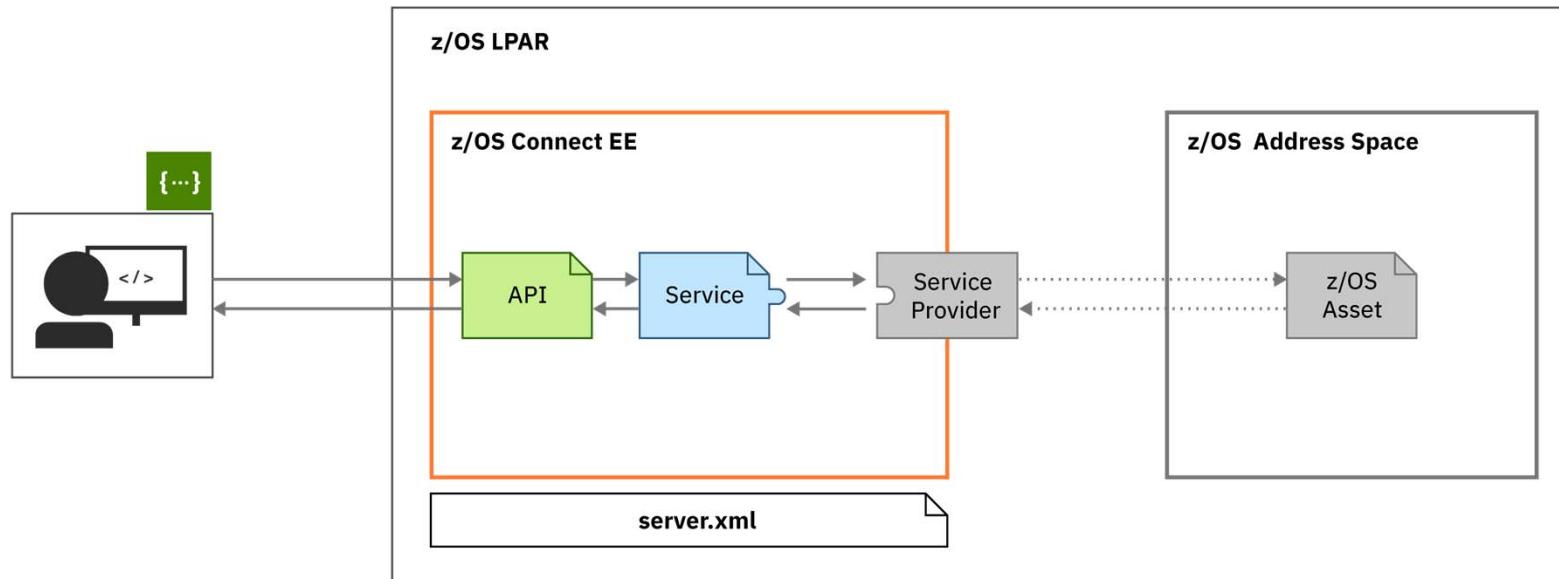


Configure the system-appropriate service provider to connect to your backend system in your `server.xml`.

 [ibm.biz/zosconnect-configuring](http://ibm.biz/zosconnect-configuring)

# Steps to expose a z/OS application

6. Done



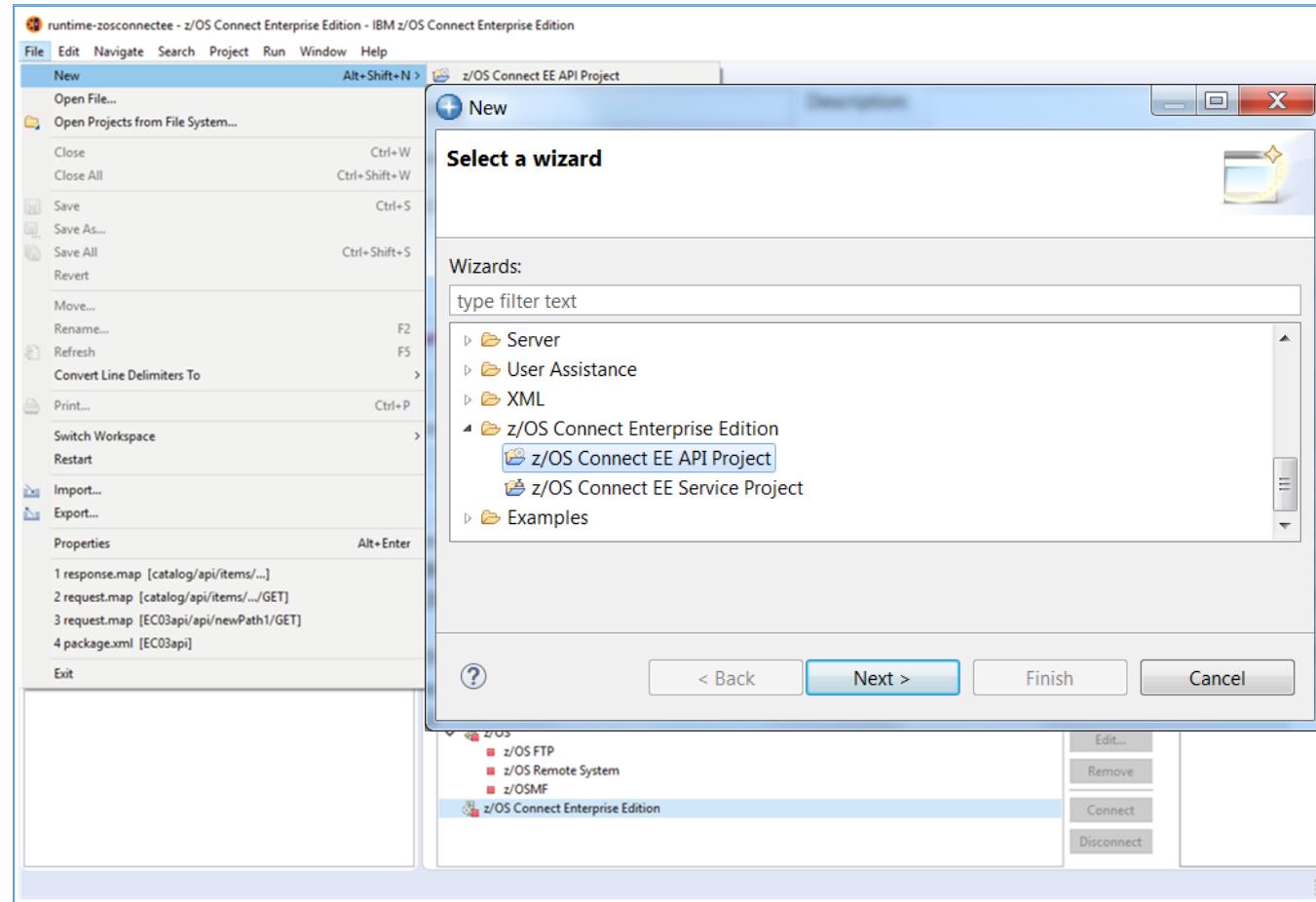
The API is ready to be consumed that requires no knowledge that a z/OS recourse is being accessed



# /api\_toolkit/services

Simple **service creation.**

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

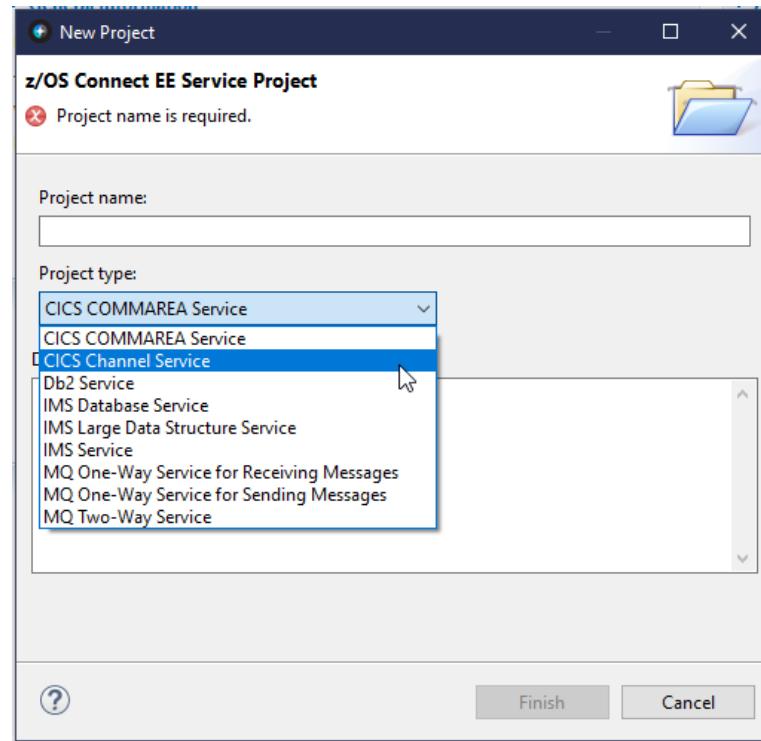


Use the **API toolkit** to create services through Eclipse-based tooling.

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

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

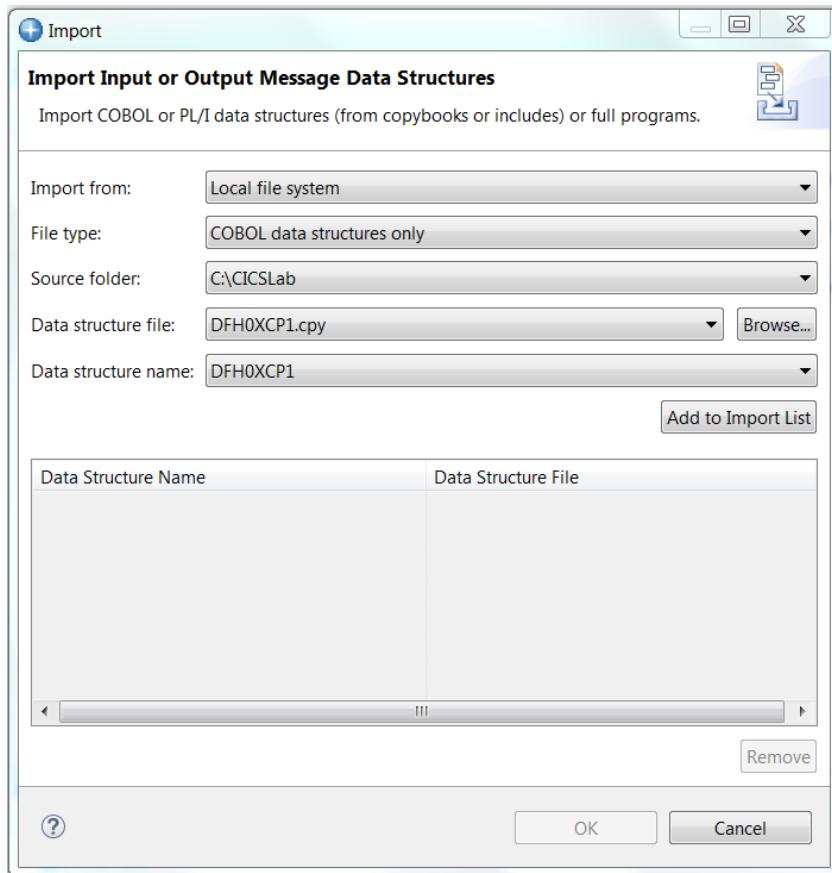
## Service creation – a common interface



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

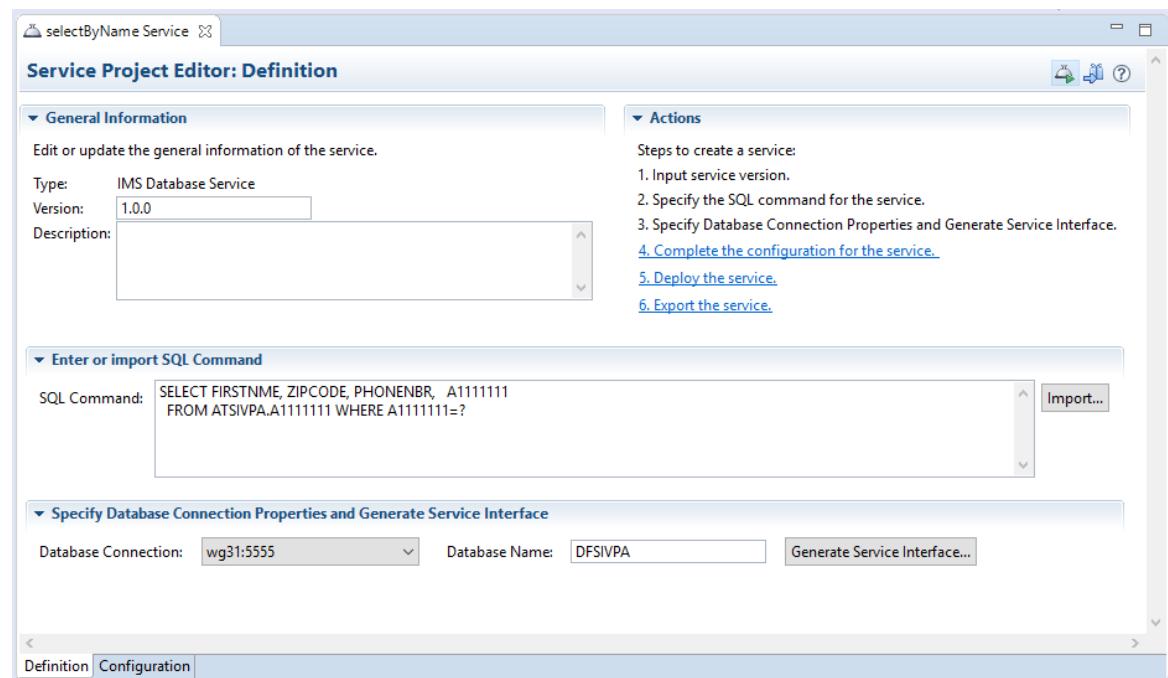


You start by importing data structures into the service interface from the local file system or the workspace.

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

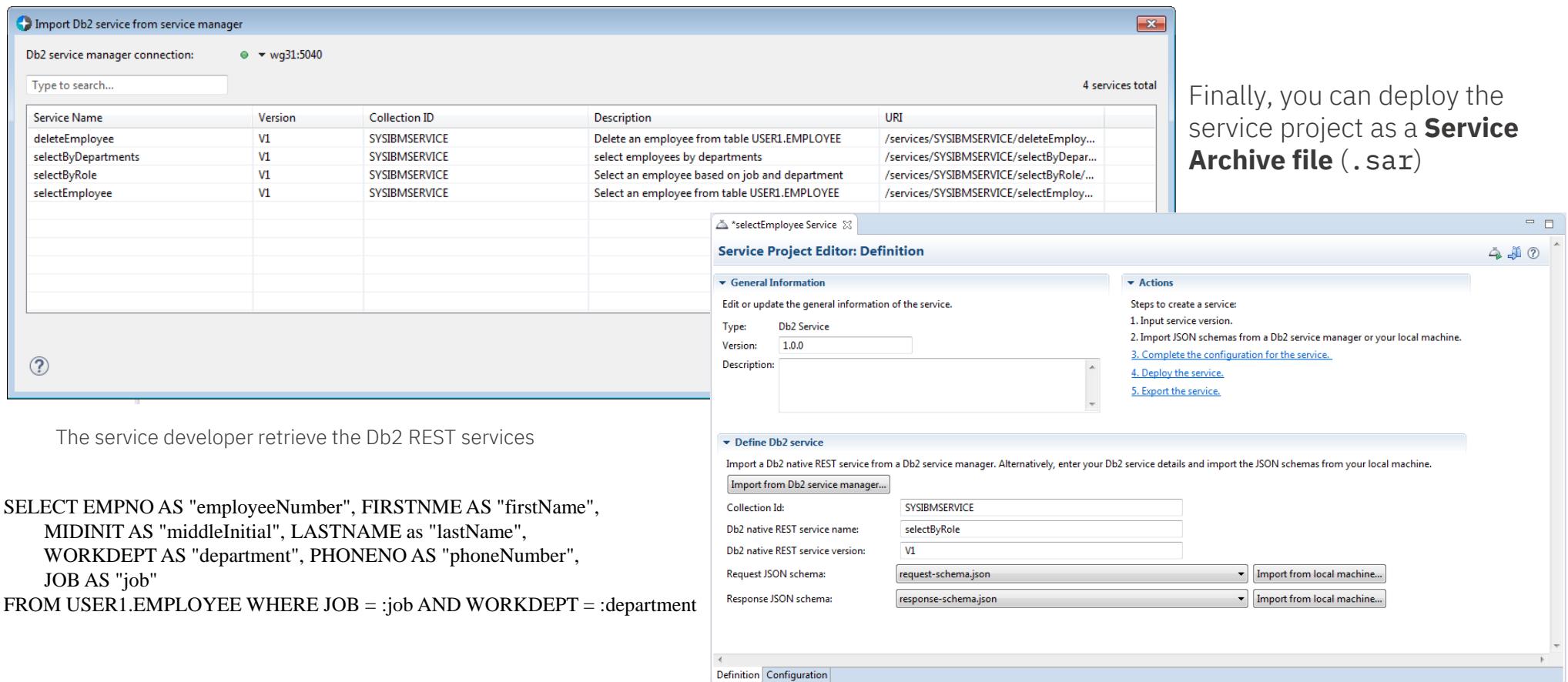


You start use the IMS Catalog to assist with developing and testing SQL SELECT commands used for accessing IMS databases.

# API toolkit – Creating Services for Db2

The service developer retrieve the Db2 REST services

```
SELECT EMPNO AS "employeeNumber", FIRSTNME AS "firstName",
       MIDINIT AS "middleInitial", LASTNAME AS "lastName",
       WORKDEPT AS "department", PHONENO AS "phoneNumber",
       JOB AS "job"
  FROM USER1.EMPLOYEE WHERE JOB = :job AND WORKDEPT = :department
```



The screenshot shows two windows from the API toolkit:

- Import Db2 service from service manager**: A dialog showing a list of services from a Db2 service manager connection named "wg31:5040". The table includes columns: Service Name, Version, Collection ID, Description, and URI. Four services are listed:
 

Service Name	Version	Collection ID	Description	URI
deleteEmployee	V1	SYSIBMSERVICE	Delete an employee from table USER1.EMPLOYEE	/services/SYSIBMSERVICE/deleteEmployee...
selectByDepartments	V1	SYSIBMSERVICE	select employees by departments	/services/SYSIBMSERVICE/selectByDepar...
selectByRole	V1	SYSIBMSERVICE	Select an employee based on job and department	/services/SYSIBMSERVICE/selectByRole/...
selectEmployee	V1	SYSIBMSERVICE	Select an employee from table USER1.EMPLOYEE	/services/SYSIBMSERVICE/selectEmploy...
- \*selectEmployee Service**: A dialog titled "Service Project Editor: Definition" for the "selectEmployee" service. It has sections for General Information (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.), and Define Db2 service (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).

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

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

## Creating 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 C	<input type="checkbox"/>	CA_INQUIRE REQUEST		STRUCT	911	88
CA_INQUIRE_SINGLE redefines C	<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 C	<input type="checkbox"/>	CA_ORDER_REQUEST		STRUCT	911	88

You 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.

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

## Creating a service – 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	<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_SINGLE	<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

You can then see the imported data structure and can **redact fields** and **rename fields**

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



## Creating multiple service to the same resource

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

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 project.
4. Complete the configuration for the service.
5. Deploy the service.
6. Export the service.

Program

Program: CSCVINC

Define Request and Response Service Interfaces

Create new request and response service interfaces or select existing ones.

Request service interface: cscvincSelectRequest

Response service interface: cscvincSelect

Set advanced data conversion options Advanced Options

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:

Transaction ID usage:

Use context containers:

Context containers HTTP headers:

Add another

# API toolkit – Creating Services for IMS

## Creating a “GET” service interface request definition

\*ivtnoDisplayService 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	<input type="checkbox"/>		cscvincSelectService Service
Segment 1	<input type="checkbox"/>		ivtnoDisplayService Service
INPUT_MSG	<input type="checkbox"/>	IVTNO DISPLAY	
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	
IN_LAST_NAME	<input checked="" type="checkbox"/>	lastName	
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	

The service developer creates distinct services for each function.

DISPLAY  
DELETE  
ADD  
UPDATE

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

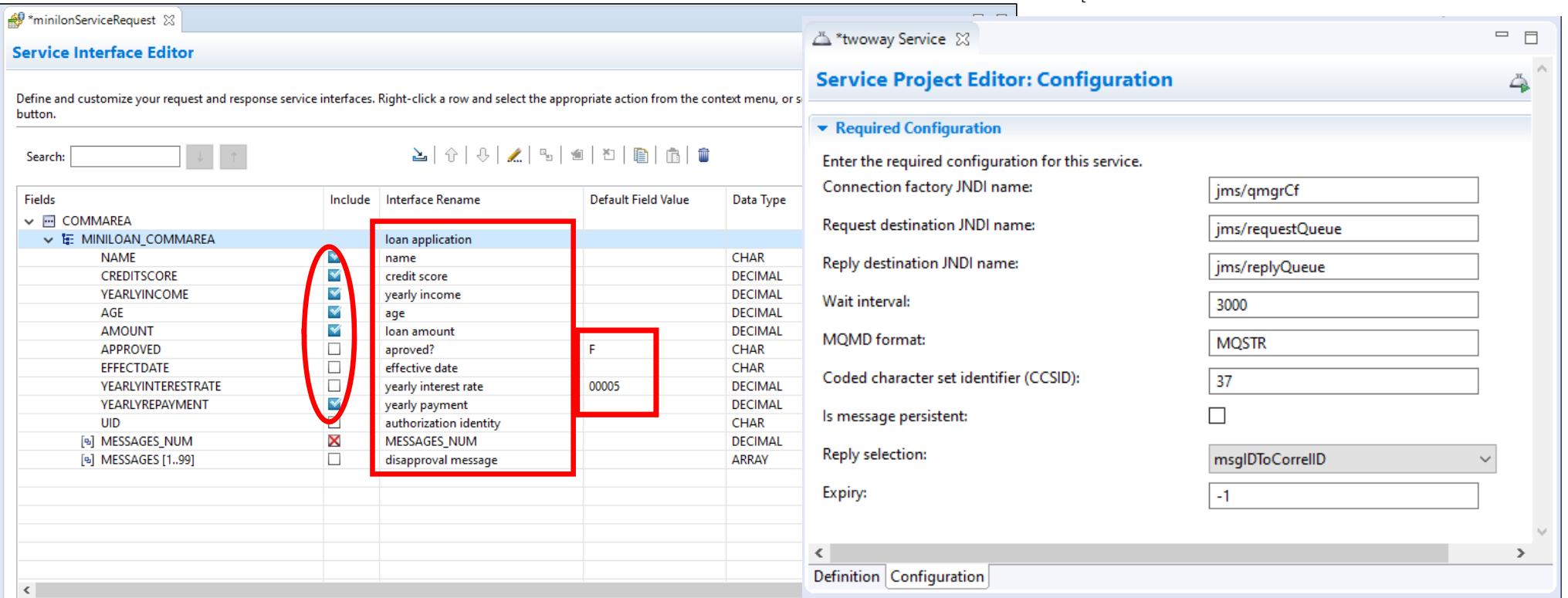
**Optional Configuration**  
Enter the optional configuration for this service.  
IMS destination override:  
Program name:

IMS/TM Meta Data

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# API toolkit – Creating Services for MQ

## Creating a service interface definition



The screenshot shows two windows from the API toolkit:

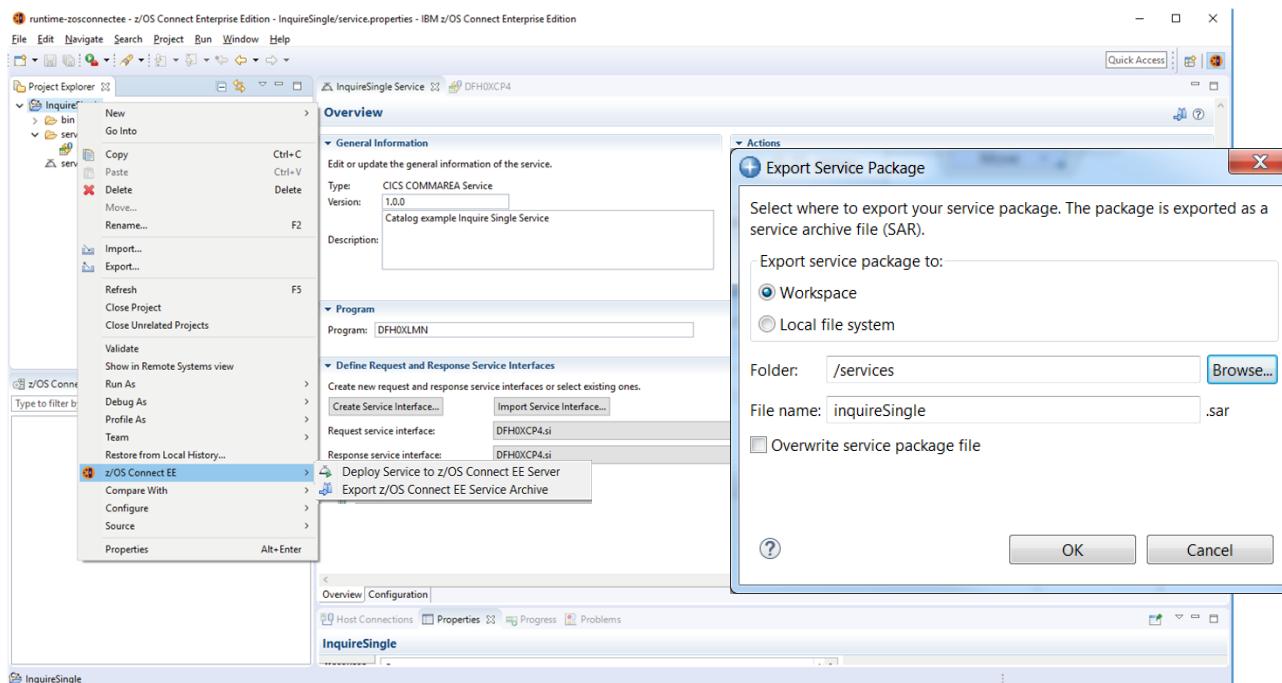
- Service Interface Editor:** This window displays a table of fields from a source system (COMMAREA) and their mapping to a target service (MINILOAN\_COMMAREA). A red box highlights the 'Interface Rename' column, which shows how fields like 'name' and 'credit score' are renamed to 'loan application' and 'credit score' respectively. Another red box highlights the 'Default Field Value' column, showing a value 'F' for the 'name' field.
- Service Project Editor: Configuration:** This window shows configuration settings for a service named 'twoWay Service'. It 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'), message persistence ('Is message persistent:'), reply selection ('Reply selection: msgIDToCorrelID'), and expiry ('Expiry: -1').

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.

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



z/OS Connect EE



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

# 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 is the Project Explorer, which contains a service named 'InquireSingle'. The main window displays 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'. In the 'Actions' section, there are five steps 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. Below this, under 'Define Request and Response Service Interfaces', there are fields for 'Request service interface' (set to 'DFH0XCP4.si') and 'Response service interface' (set to 'DFH0XCPA.si'). A context menu is open over the 'Request service interface' field, with options 'Create Service Interface...' and 'Import Service Interface...'. At the bottom of the main window, there are tabs for 'Overview' and 'Configuration', along with 'Properties', 'Host Connections', 'Properties', 'Progress', and 'Problems' buttons. To the right of the main window, a 'Deploy Service' dialog box is open. It shows the 'z/OS Connect EE Server' dropdown set to 'wg31:9453'. Below it, a message states 'The following services will be created on the server:' followed by a table:

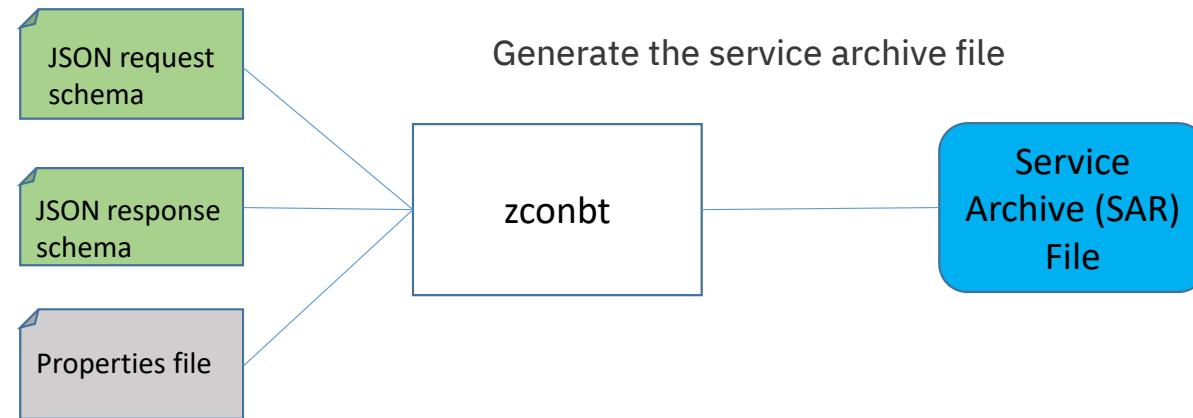
Service name	Version	Type
inquireSingle	13.00	CICS COMMAREA Se...

The dialog box has 'OK' and 'Cancel' buttons at the bottom.

Finally, you can deploy 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)



```
provider=rest
name=getCompany
version=1.0
description=Obtain a list of companies
requestSchemaFile=getCompanyRequest.json
responseSchemaFile=getCompanyResponse.json
verb=POST
uri=/Trader/rest/GetCompany
connectionRef=HatsConn
```

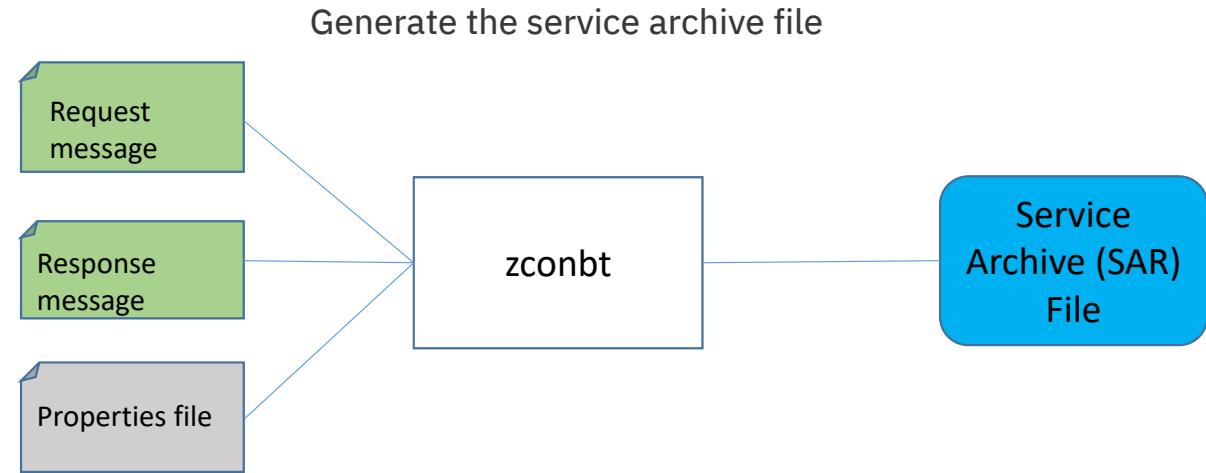
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# Creating Services without the Toolkit – MQ

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

```
provider=mq
name=mcPut
version=1.0
description=MQ put one-way
destination=jms/default
connectionFactory=jms/qmgrCf
language=COBOL
requestStructure=FILEAMQ.CPY
operationName=mcPut
messagingAction=mcput/mqget
```

```
provider=mc
name=miniloan
version=1.0
description=MQ two-way
destination=jms/request
replyDestination=jms/response
connectionFactory=jms/qmgrCf
language=COBOL
requestStructure=miniloan.cpy
responseStructure=miniloan.cpy
operationName=miniloan
waitInterval=10
```

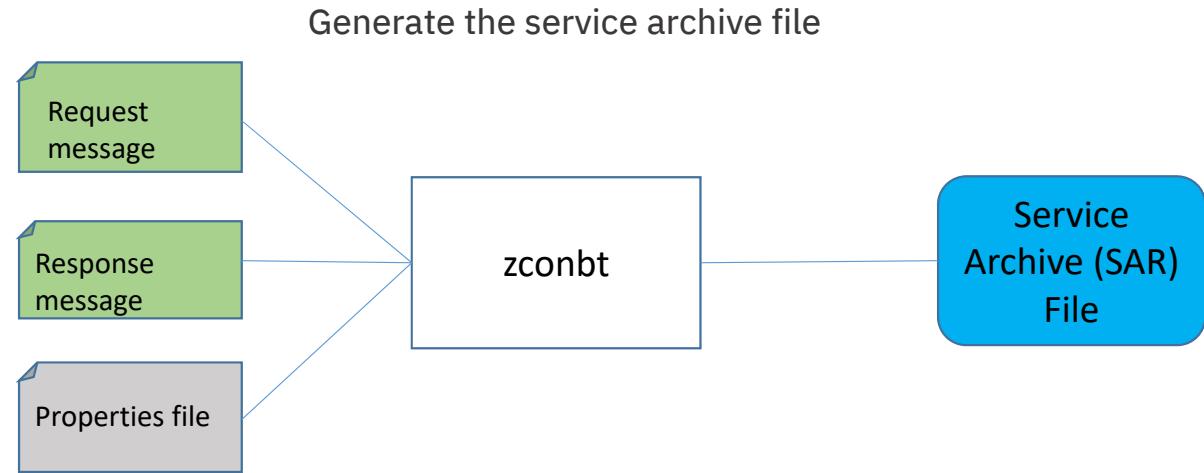


This technique will soon be replaced by  
the Eclipse tooling

# Creating Services without the Toolkit – Batch

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

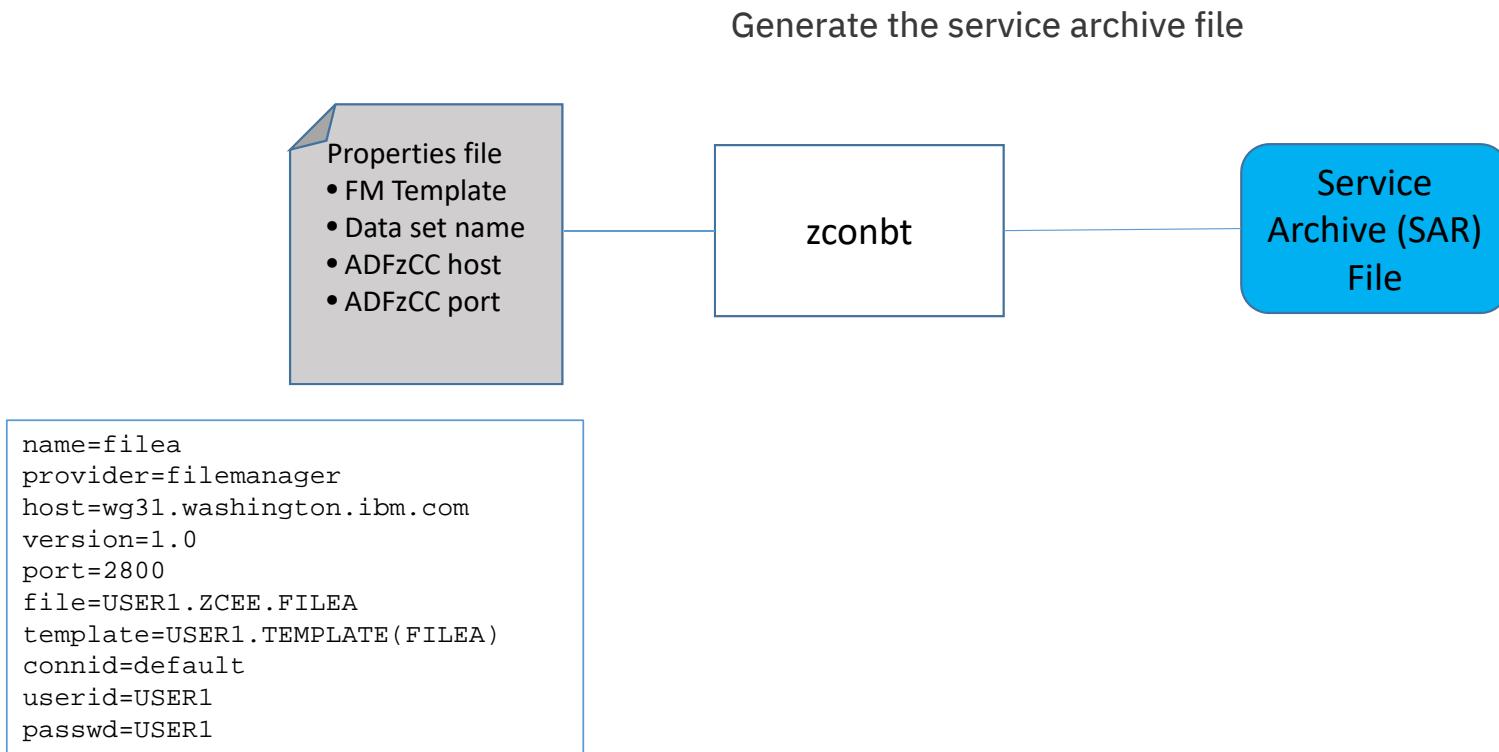
```
name=Filea
version=1.0
provider=wola
description=COBOL batch program
language=COBOL
program=ATSFIL
register=FILEAZCON
connectionRef=wolaCF
requestStructure=fileareq.cpy
responseStructure=filearsp.cpy
```



**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)



# Creating Services without the Toolkit



z/OS Connect EE

For DVM use the DVM Studio

The screenshot shows the DVM Studio interface with a red border around the main window. On the left, the navigation pane is open, showing categories like Services, New Target System, New Web Services Directory, z/OS Connect Configuration, and Screen Logic Configurator. Under Services, a context menu is open over the 'Services' icon, with options like 'Create Directory', 'Create Service', and 'INQUIRIESINGEL'. The central workspace displays two SQL scripts:

```
-- Description: Retrieve the result set for CATALOG (up to 1000 rows)
-- Tree Location: wg31.washington.ibm.com/1200/SQL/Data/AVZS/Virtual Table
-- Remarks: VSAM - USER1.EXAMPLAPP.EXMPCAT
SELECT WS_ITEM_REF, WS_DESCRIPTION, WS_DEPARTMENT, WS_COST, WS_IN_STOCK,
WS_ON_ORDER
FROM CATALOG LIMIT 1000;

-- Description: Retrieve the result set for CATALOG (up to 1000 rows)
-- Tree Location: wg31.washington.ibm.com/1200/SQL/Data/AVZS/Virtual Table
-- Remarks: VSAM - USER1.EXAMPLAPP.EXMPCAT
SELECT WS_ITEM_REF, WS_DESCRIPTION, WS_DEPARTMENT, WS_COST, WS_IN_STOCK,
WS_ON_ORDER
FROM CATALOG LIMIT 1000;
```

Below the scripts, a table view shows data from the CATALOG table:

VS_DESCRIPTION	WS_DEPARTMENT	WS_COST	WS_IN_STOCK	WS_ON_ORDER
All Pens ...	10	002.90	135	0
All Pens ...	10	002.90	6	50
All Pens ...	10	002.90	106	0
Pencil wit...	10	002.90	80	0
Pencil wit...	10	001.78	83	0
Highlighter	10	003.89	12	40

A context menu is open over the table, with options like 'Execute Query', 'Refresh', and 'Generate SAR File(s)'.



## 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

\*catalog API X

## API Editor

Describe your API

Name: catalog Description:

Base path: /catalog

Version: 1.0.0

Path: /items?startItemID

Methods (2)

- ▶ GET inquireCatalog Service... Mapping...
- ▶ PUT ivtnoAddService Service... Mapping...

Path: /order

Methods (2)

- ▶ POST placeOrder Service... Mapping...
- ▶ PUT selectEmployee Service... Mapping...

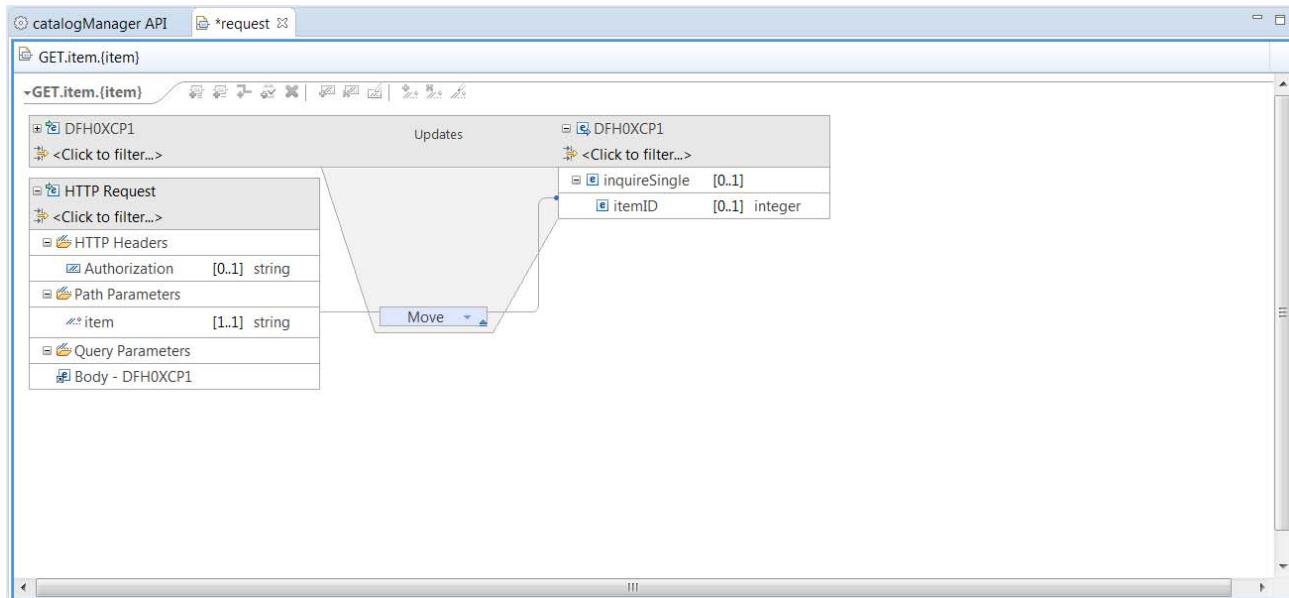
The **API toolkit** is designed to encourage RESTful API design.

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.

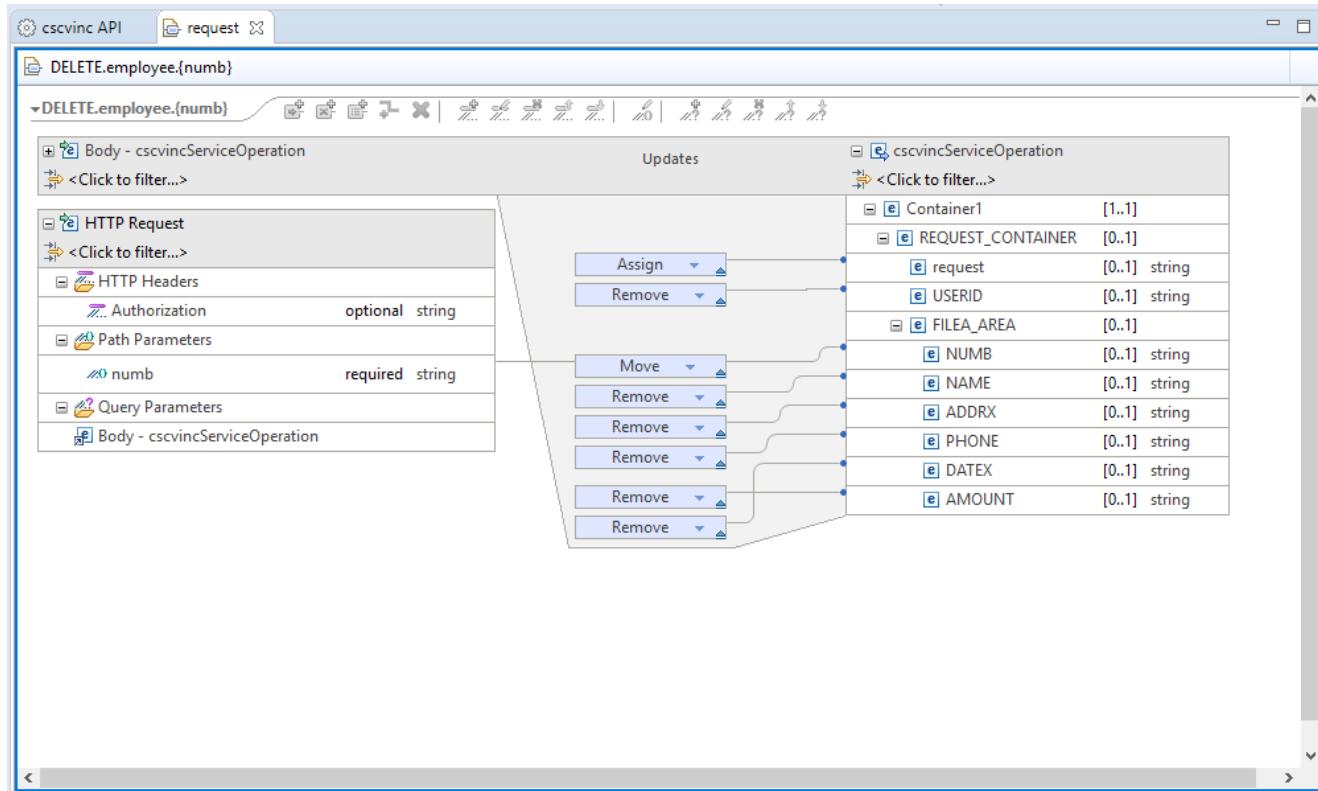
Map path and query parameters to native data structures.

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

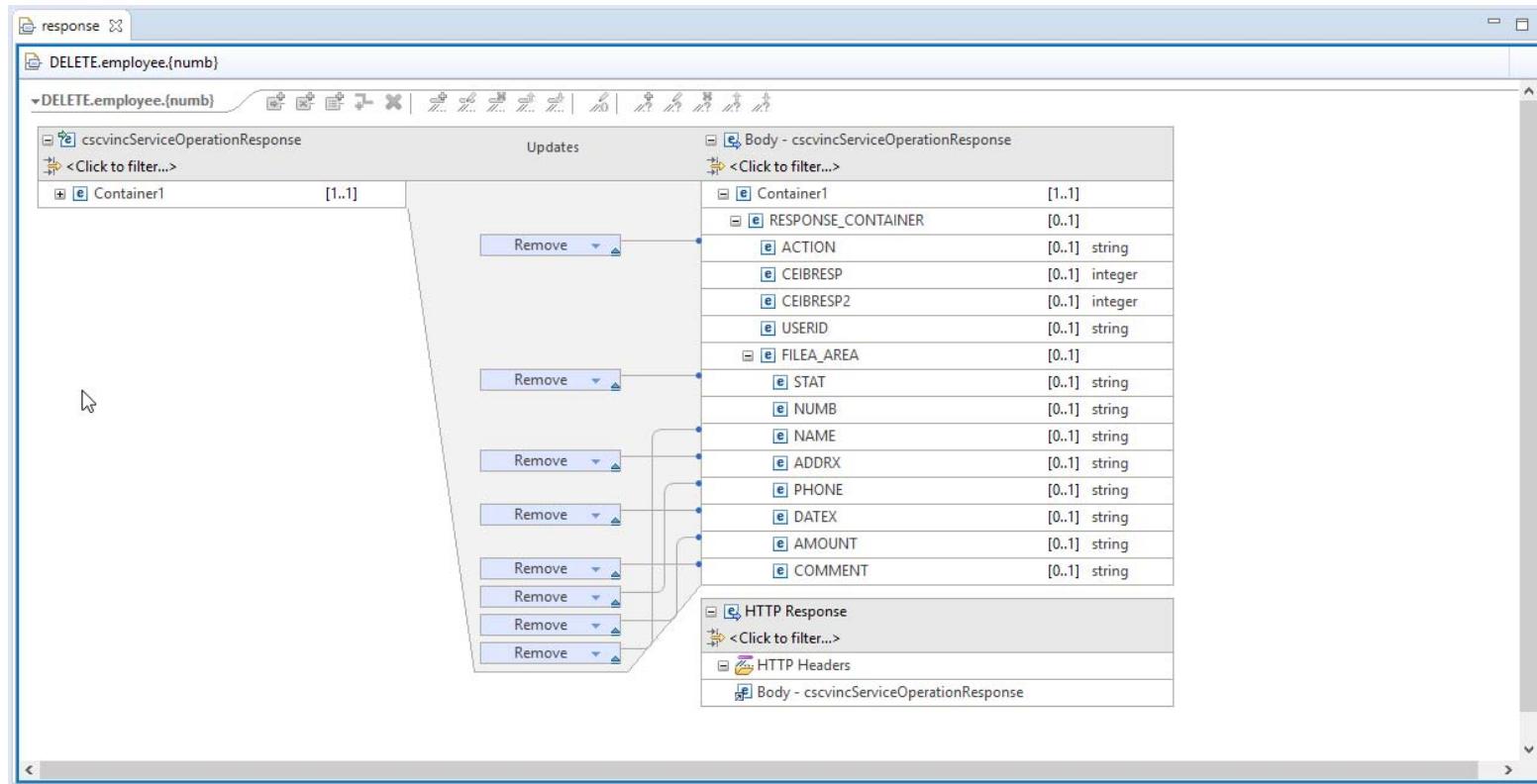
API mapping: Point-and-click interface



# API toolkit – API Editor

## API mapping: Point-and-click interface

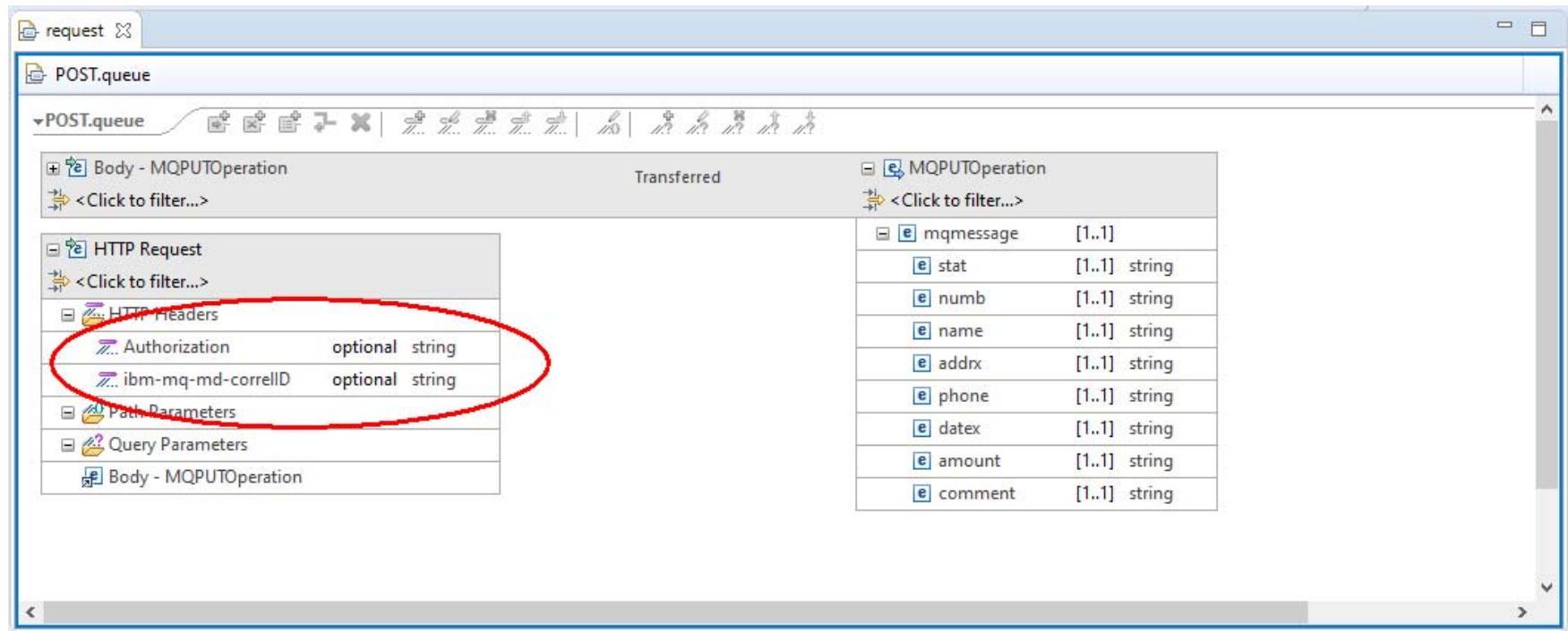
Allows the API Developer to remove fields to simplify the API



# API toolkit – API Editor

## API mapping: Adding HTTP header properties

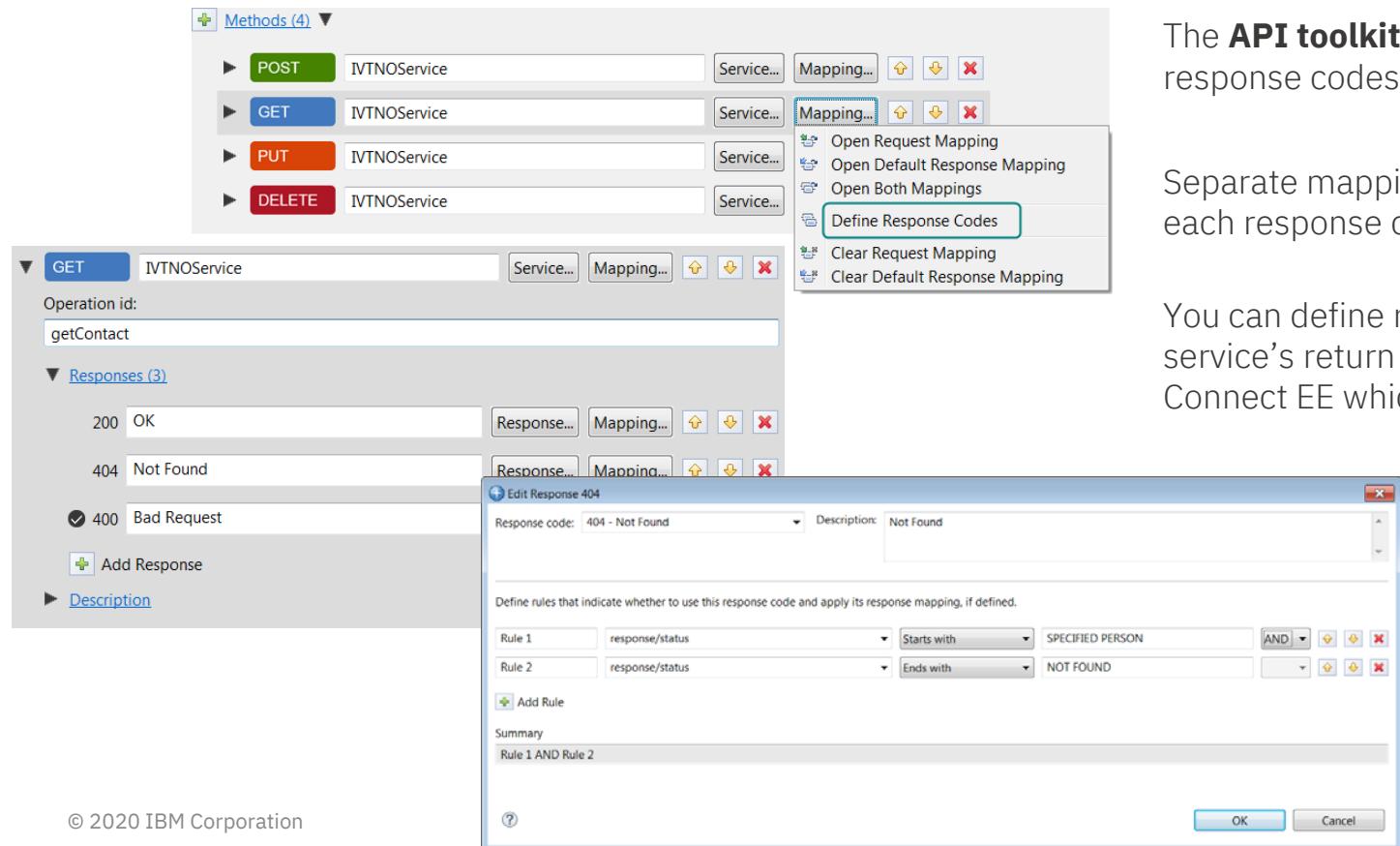
Allows the API Developer to remove fields to simplify the API



The screenshot shows the API toolkit - API Editor interface. On the left, under 'POST.queue', there is a 'Body - MQPUTOperation' section with a 'Transferred' status. Below it, the 'HTTP Request' section is expanded, showing 'HTTP Headers' with two entries: 'Authorization' (optional string) and 'ibm-mq-md-correlID' (optional string). These two entries are circled in red. Further down are sections for 'Path Parameters' and 'Query Parameters'. On the right, under 'MQPUTOperation', there is another 'Transferred' status section. Below it, the 'mqmessage' section is expanded, listing several fields: stat, numb, name, addrx, phone, datex, amount, and comment, each with a [1..1] string type. The entire interface has a standard Windows-style window title bar and scroll bars.

# API toolkit

## API definition with multiple response codes



The screenshot shows the API toolkit interface for defining an API. At the top, under 'Methods (4)', there are four entries: POST, GET, PUT, and DELETE, all pointing to 'IVTNOService'. The 'GET' entry is expanded, showing its 'Operation id' is 'getContact'. Below this, under 'Responses (3)', three response codes are defined: 200 OK, 404 Not Found, and 400 Bad Request. The '400 Bad Request' entry is selected, opening a dialog titled 'Edit Response 400'. In this dialog, the 'Response code' is set to '404 - Not Found' and the 'Description' is 'Not Found'. The 'Edit Response 400' dialog also contains a section for defining rules based on service return fields. Two rules are defined: 'Rule 1' (response/status starts with 'SPECIFIED PERSON') and 'Rule 2' (response/status ends with 'NOT FOUND'). A summary at the bottom indicates 'Rule 1 AND Rule 2'.

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

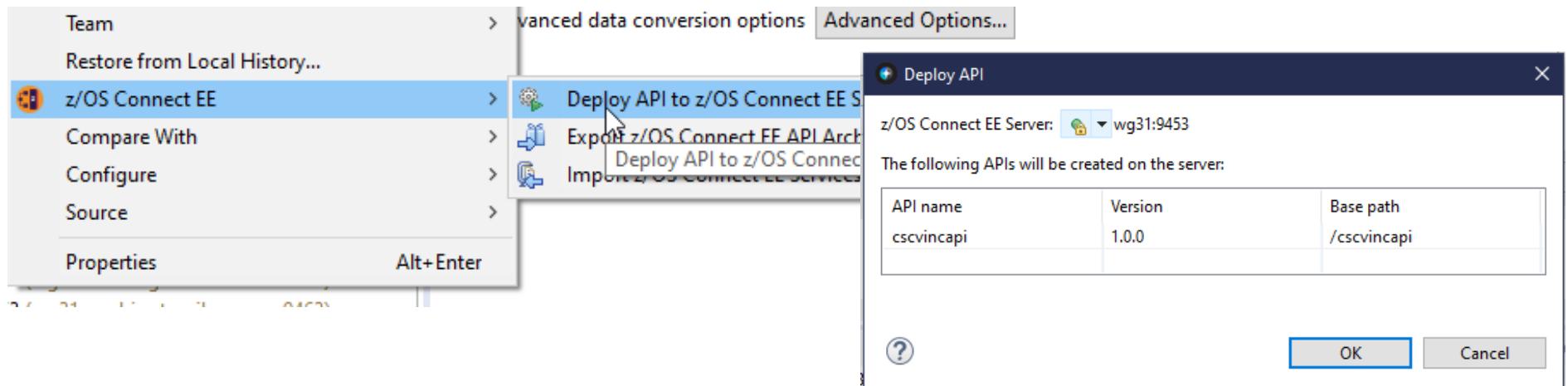
Separate mappings can be defined for each response code.

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:

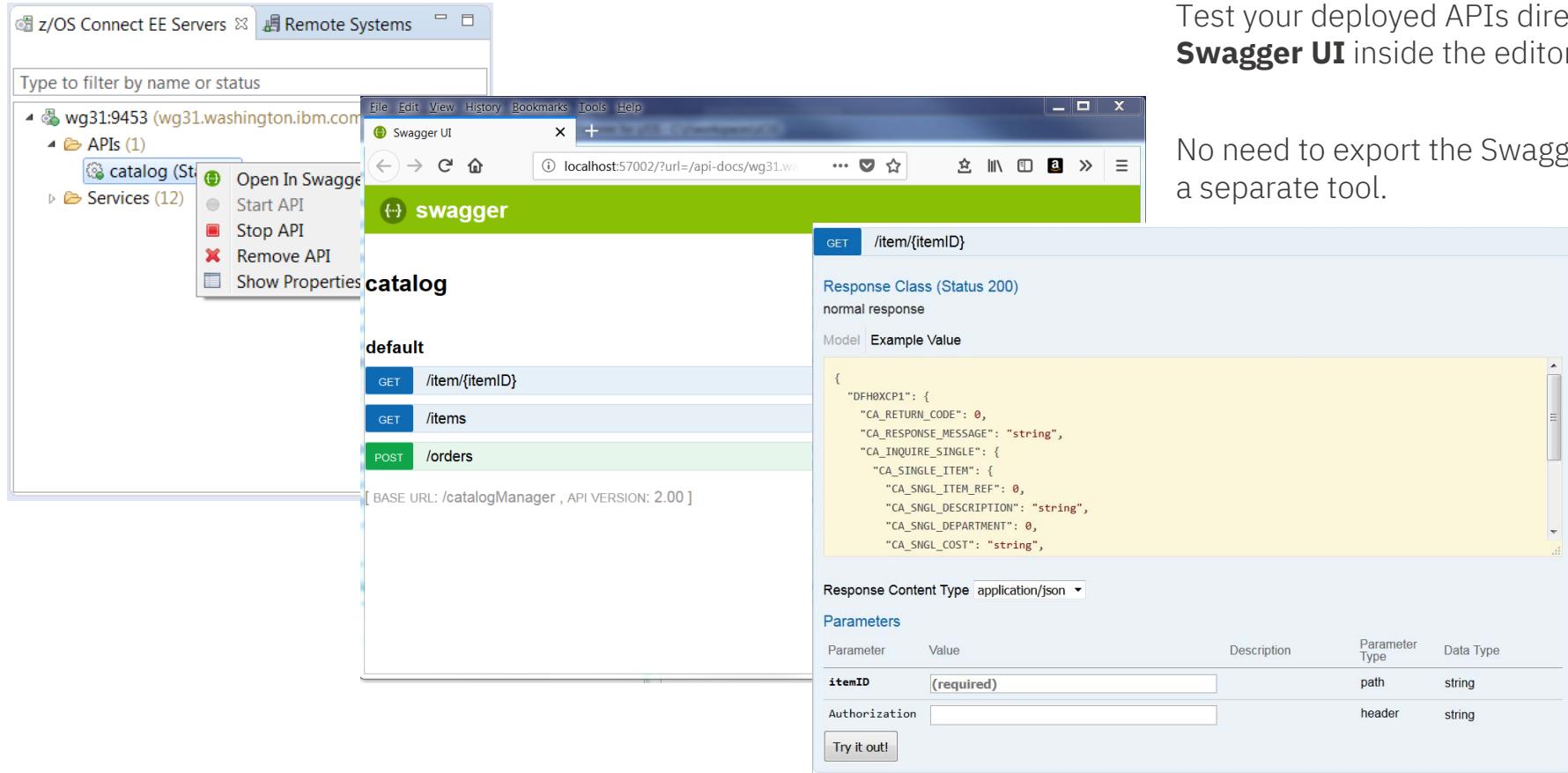


**Right-click deploy to server** enables developers to quickly deploy, test, and iterate on their APIs.

**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 tree view of servers and services. A context menu is open over an API entry, with options like 'Open In Swagger', 'Start API', 'Stop API', 'Remove API', and 'Show Properties'. The main area displays the Swagger UI for the 'catalog' service. It shows a 'catalog' section with 'default' endpoints: GET /item/{itemID}, GET /items, and POST /orders. The 'POST /orders' endpoint is highlighted with a green background. To the right, a detailed view of the 'POST /item/{itemID}' endpoint is shown. It includes a 'Model' tab with a JSON schema, an 'Example Value' tab with a JSON example, and a 'Parameters' table:

Parameter	Value	Description	Parameter Type	Data Type
itemID	(required)		path	string
Authorization			header	string

A 'Try it out!' button is at the bottom of the parameters table.

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

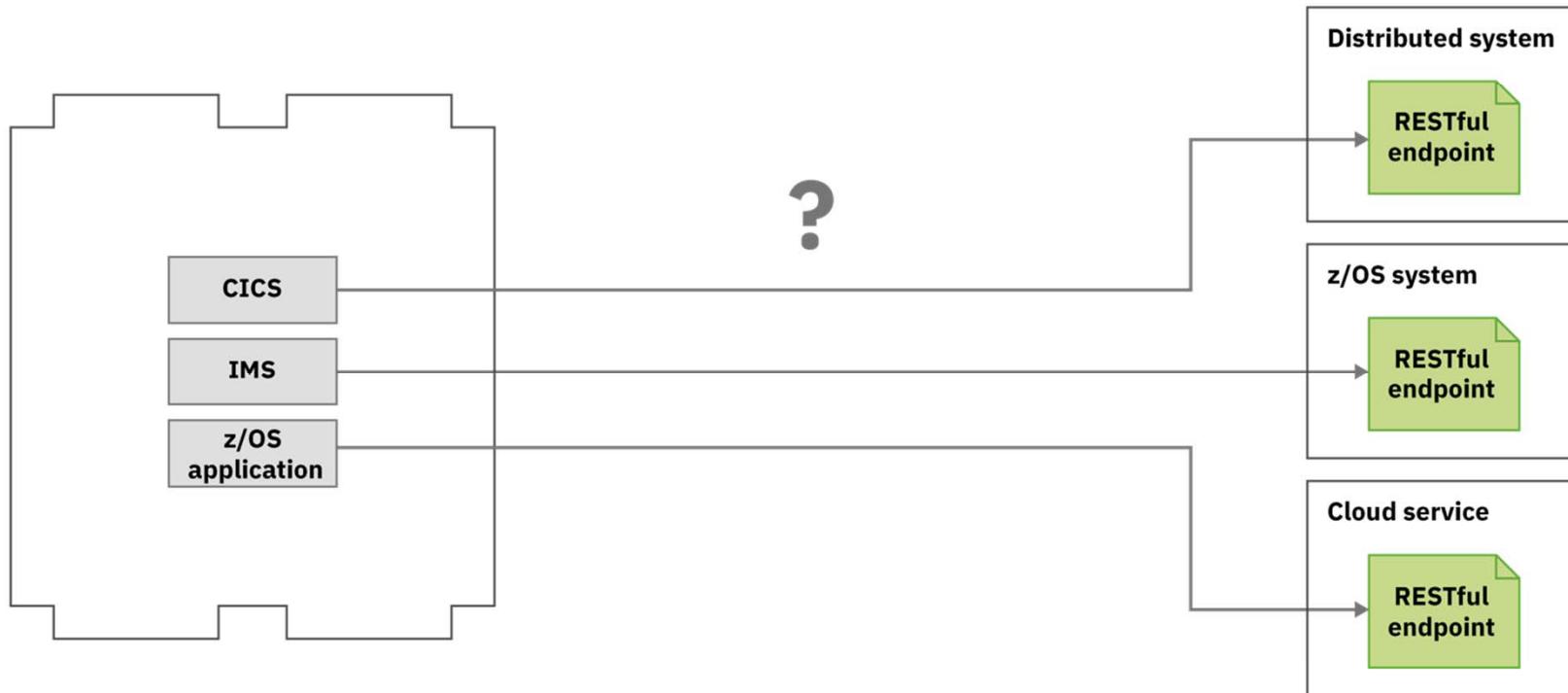
No need to export the Swagger doc to a separate tool.



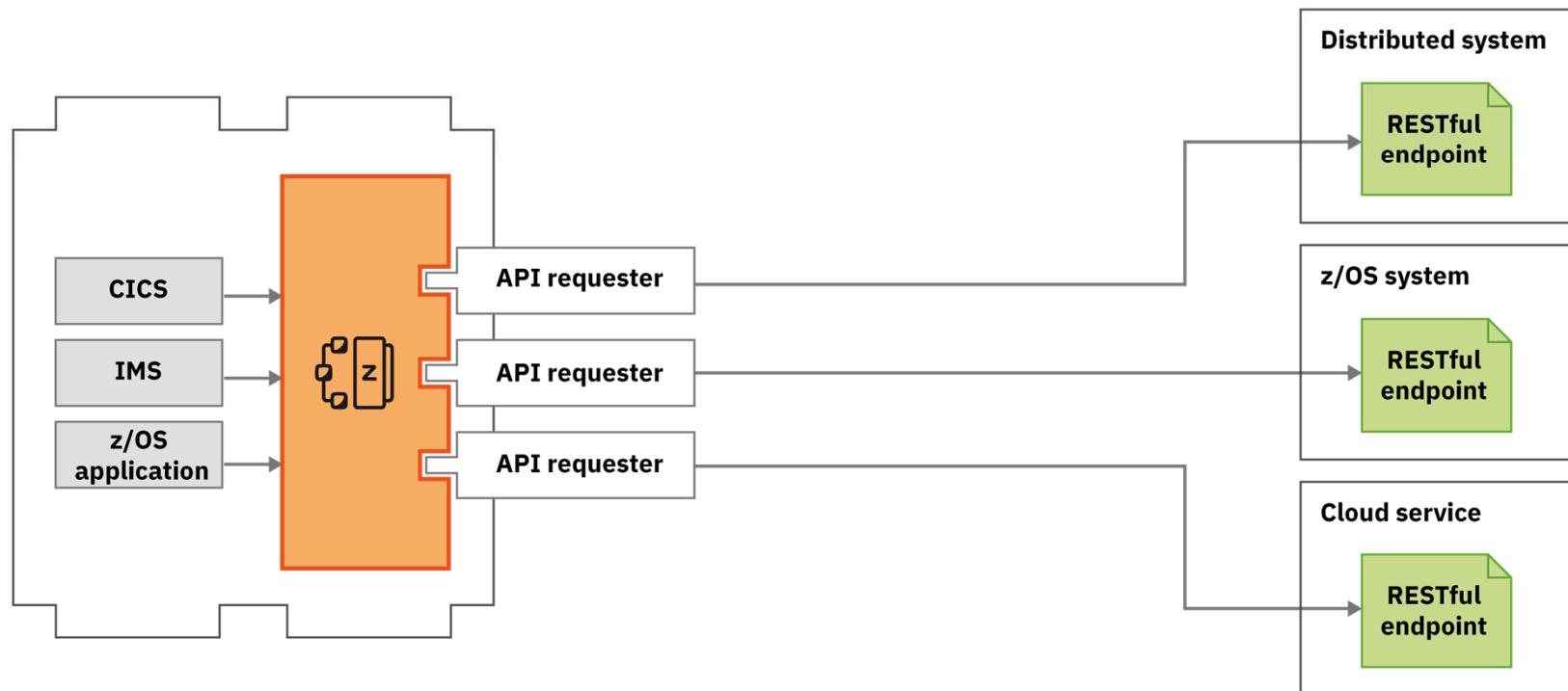
## **/api\_toolkit/apiRequesters**

Quick and easy **API mapping**.

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



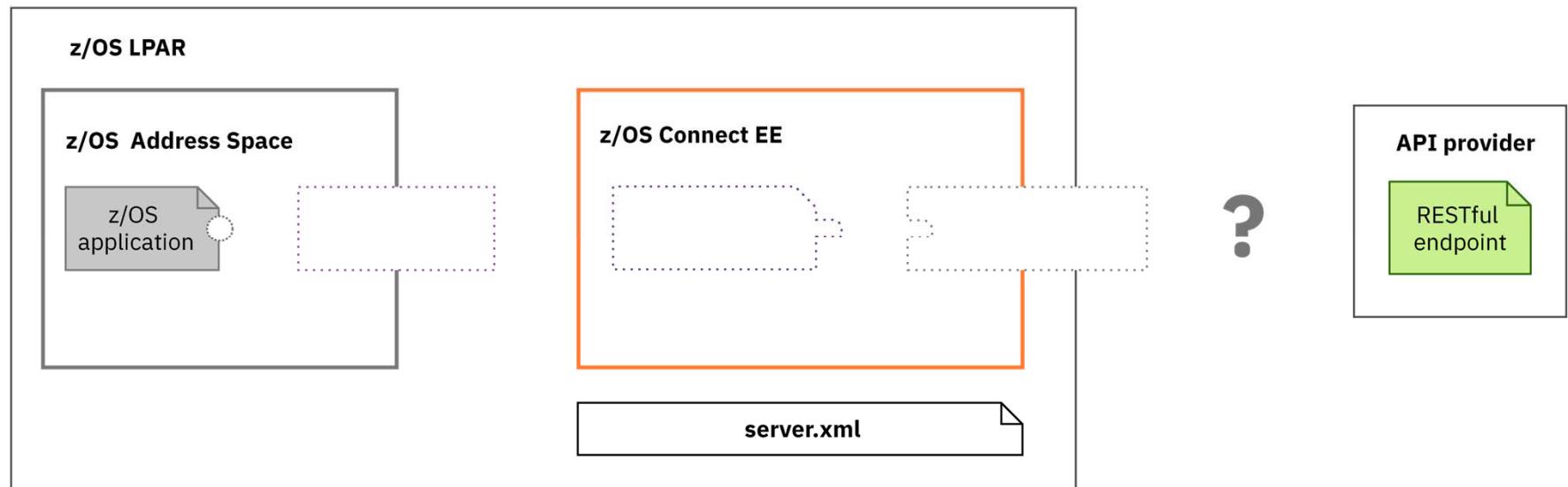
# Use API requester to call external APIs from z/OS assets





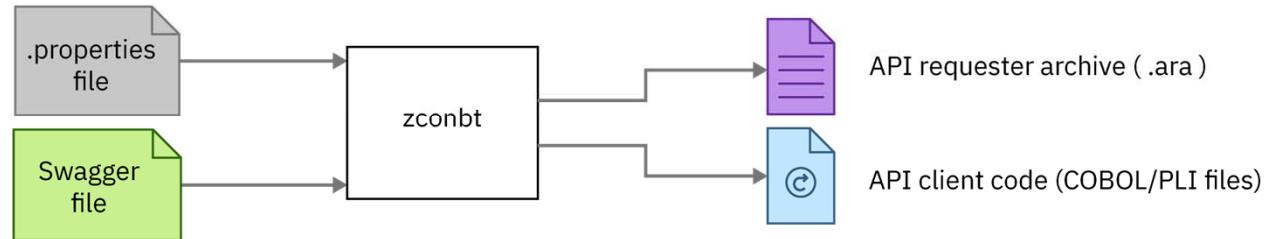
# Steps to calling an external API

Starting point



# Steps to calling an external API

Step 1. Generate API requester archive from Swagger

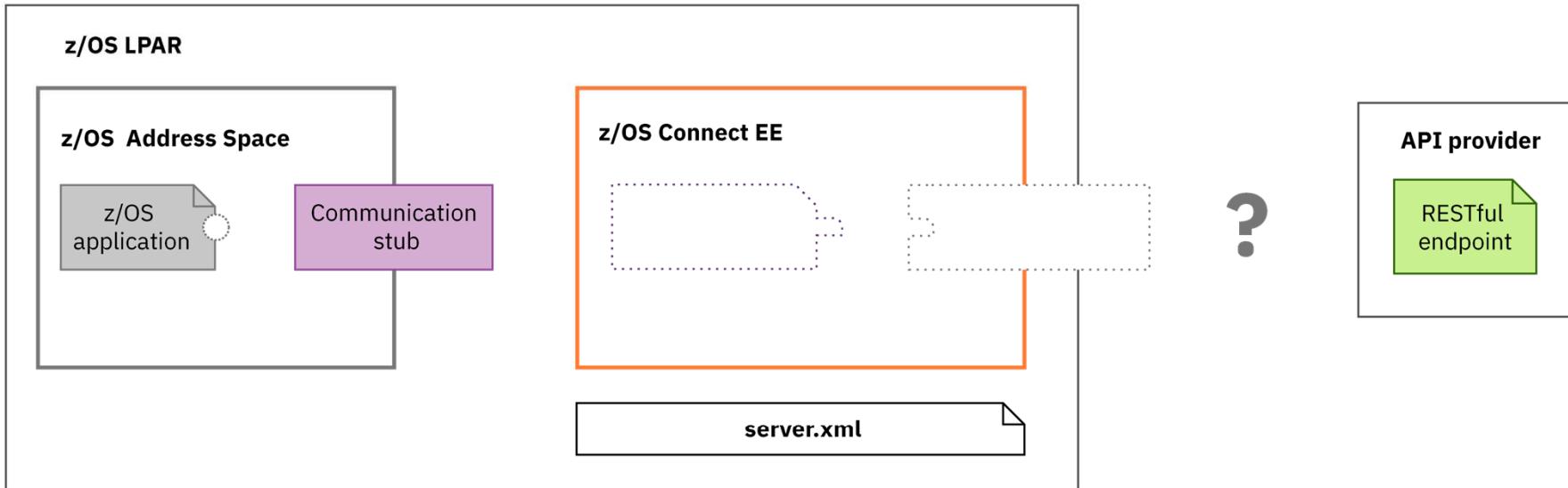


Generate your `.ara` file, and API client code.

 [ibm.biz/zosconnect-generate-ara](http://ibm.biz/zosconnect-generate-ara)

# Steps to calling an external API

## Step 2. Configure communication stub

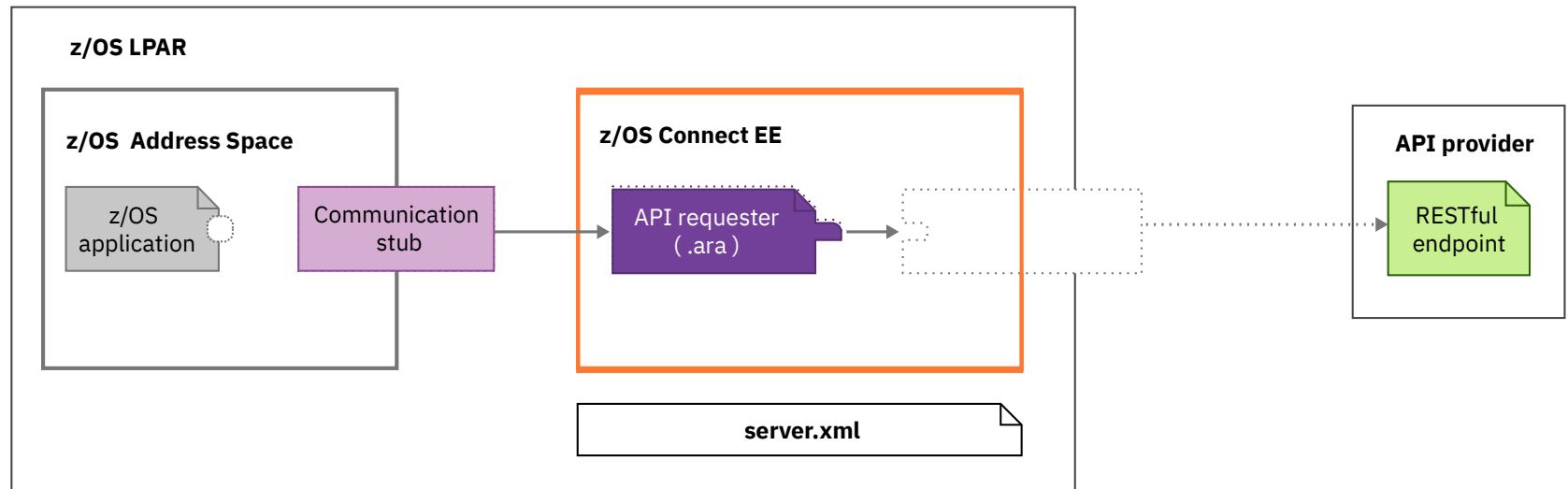


Configure a communication stub. You only need to do this once per system.

 [ibm.biz/zosconnect-configure-comms-stub](http://ibm.biz/zosconnect-configure-comms-stub)

# Steps to calling an external API

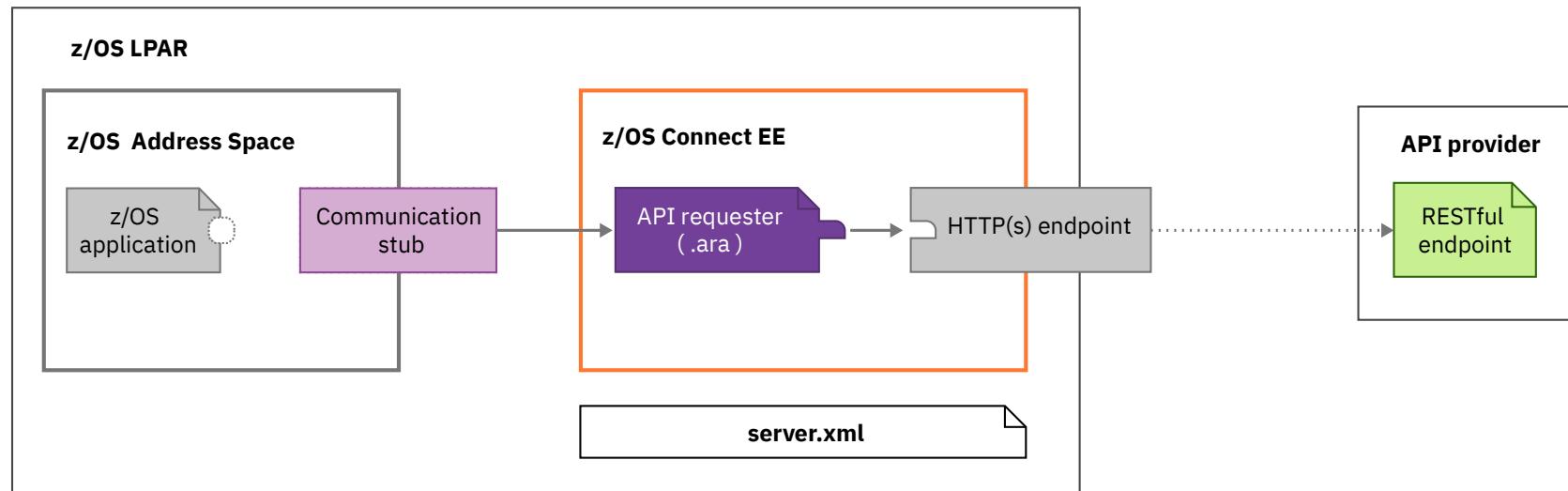
## Step 3. Deploy API requester (.ara) archive



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

# Steps to calling an external API

## Step 4. Configure HTTP(S) endpoint



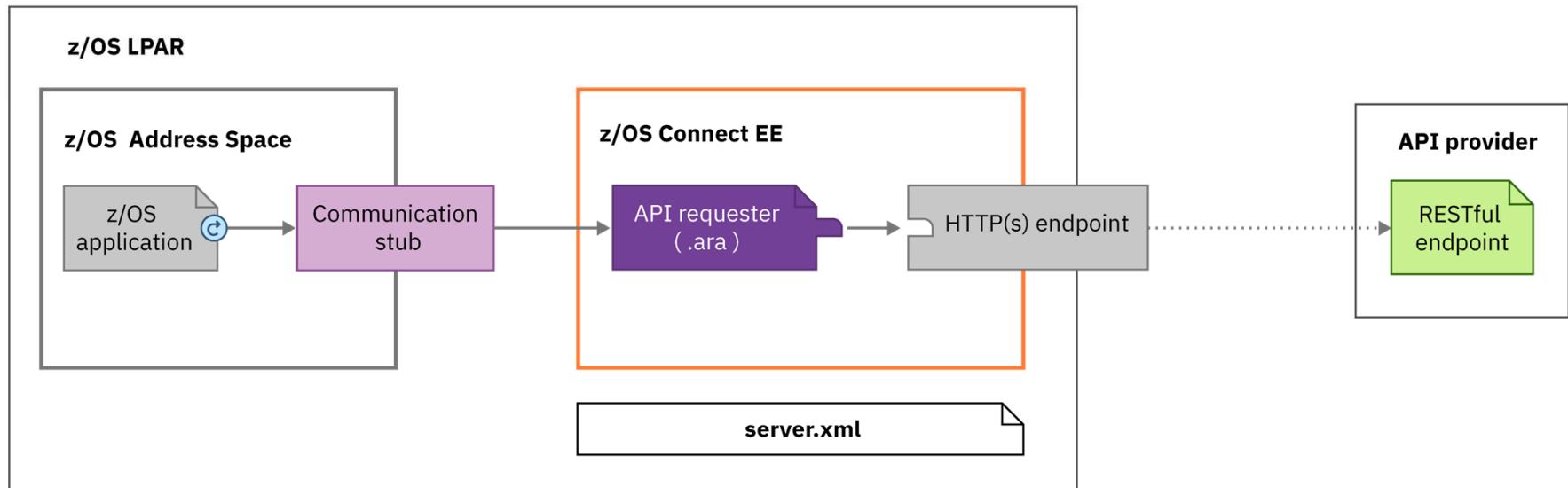
Configure the connection between z/OS Connect EE and the external API.

 [ibm.biz/zosconnect-configure-endpoint-connection](http://ibm.biz/zosconnect-configure-endpoint-connection)

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# 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](http://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 the Rational Application Developer interface with three windows:

- GETAPI**: A COBOL editor window showing the definition of an error message structure. It includes fields like ERROR-MSG, EM-ORIGIN, EM-CODE, and EM-DETAIL.
- apirs.xml**: An XML configuration file for the API Requester. It defines a server named "API Requester" with a featureManager containing a zosconnect:apiRequester feature. It also defines a zosconnect\_apiRequesters section with a location and a specific requester named "cscvinc\_1.0.0". It includes endpointConnection and authData definitions.
- CSC02I01**: A COBOL editor window showing the definition of a structure with API information. It includes fields like BAQ-APINAME, BAQ-APIPATH, BAQ-APIMETHOD, and BAQ-APIMETHOD-LEN.

A red arrow points from the "COPY CSC02I01." line in the GETAPI window to the "CSC02I01" window, indicating the inclusion of the structure definition.

```
apirs.xml
<server description="API Requester">
  <!-- Enable features -->
  <featureManager>
    <feature>zosconnect:apiRequester-1.0</feature>
  </featureManager>

  <zosconnect_apiRequesters location="">
    <zosconnect_apiRequester name="cscvinc_1.0.0"/>
  </zosconnect_apiRequesters>

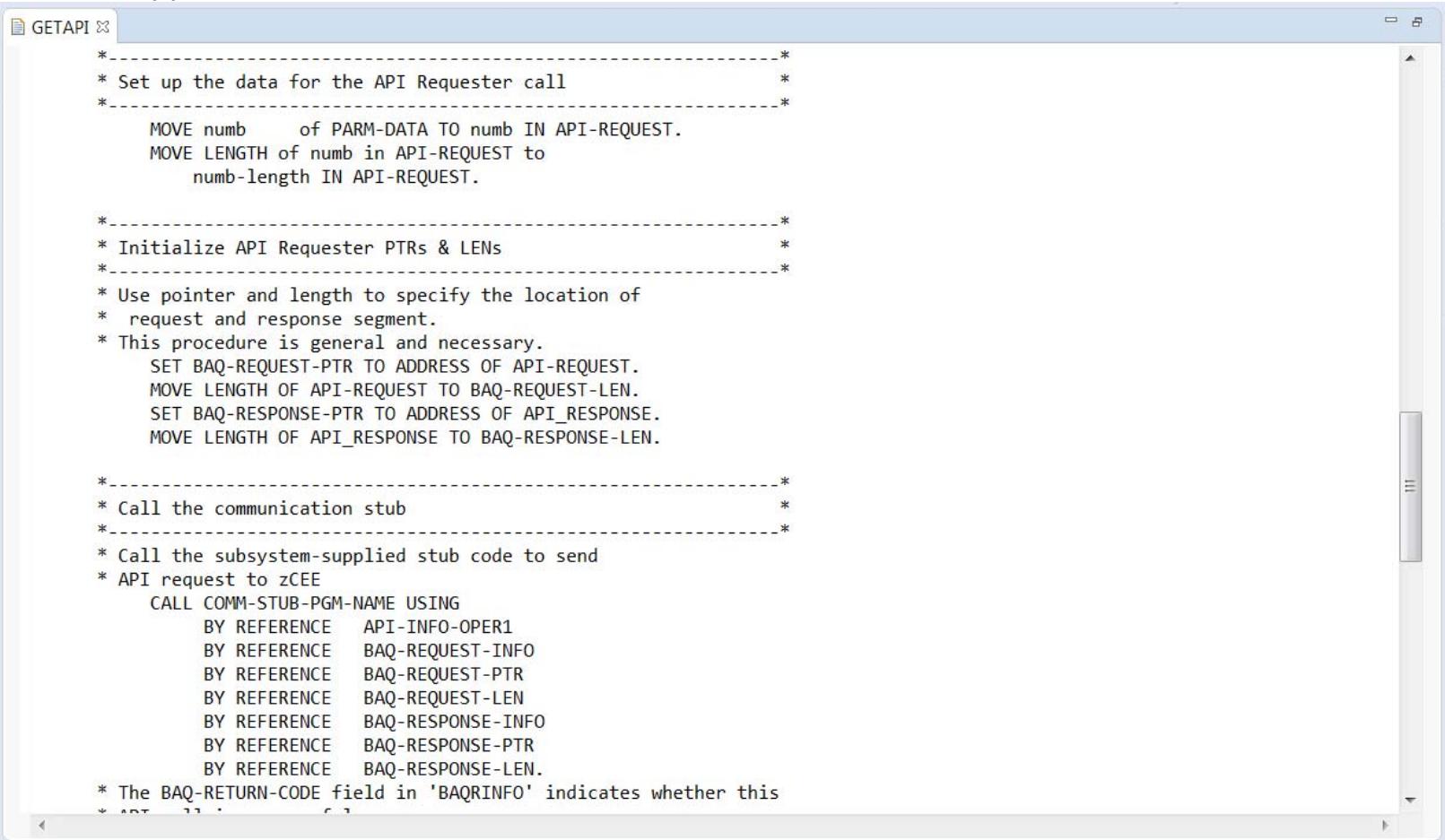
  <zosconnect_endpointConnection id="cscvincAPI">
    host="http://wg31.washington.ibm.com"
    port="9120"
    basicAuthRef="myBasicAuth"
    connectionTimeout="10s"
    receiveTimeout="20s" />

  <zosconnect_authData id="myBasicAuth">
    user="Fred"
    password="fredpwd" />
</server>
```

```
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



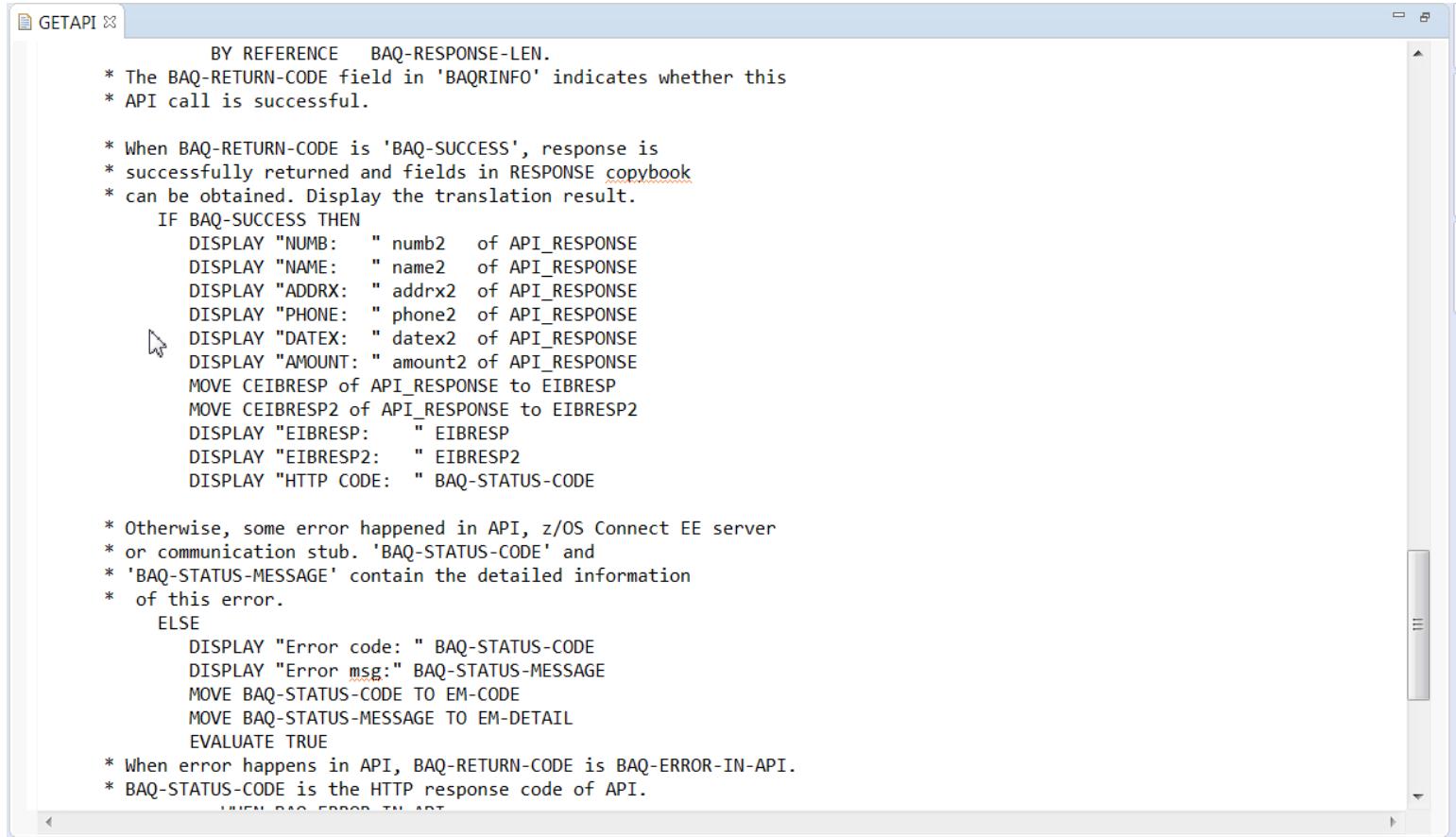
```
*-----*
* Set up the data for the API Requester call *
*-----*
      MOVE numb      of PARM-DATA TO numb IN API-REQUEST.
      MOVE LENGTH of numb in API-REQUEST to
            numb-length IN API-REQUEST.

*-----*
* 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

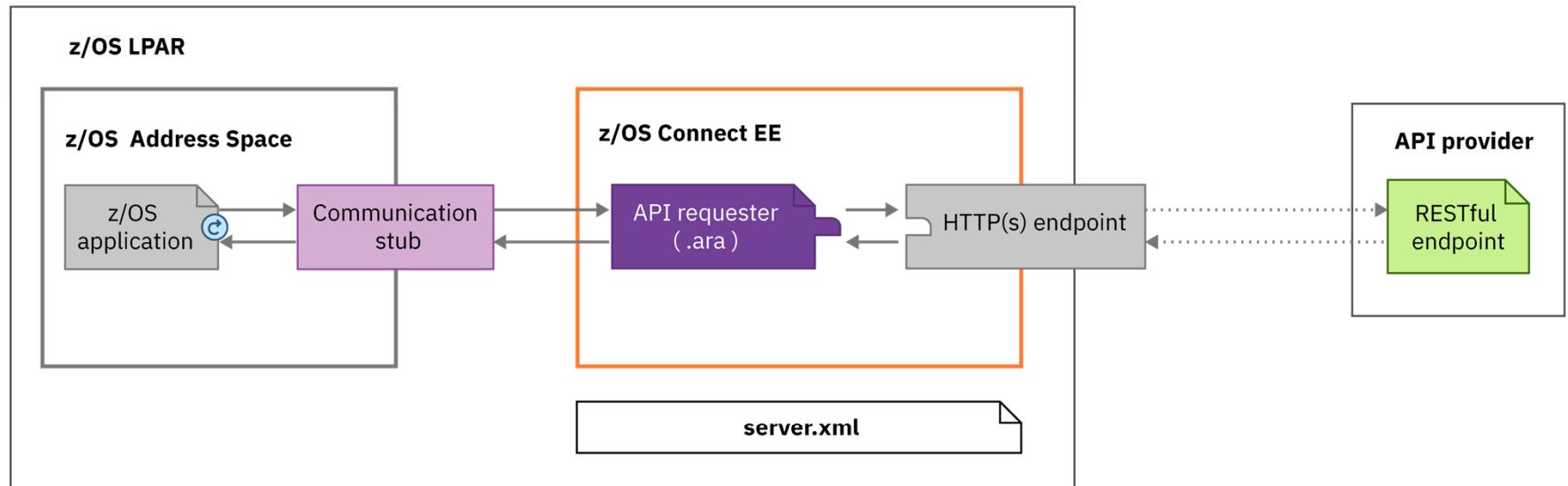


The screenshot shows the GETAPI editor window with the following AS/400 JCL code:

```
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





## **/common\_scenarios**

Typical connection patterns to different subsystems.

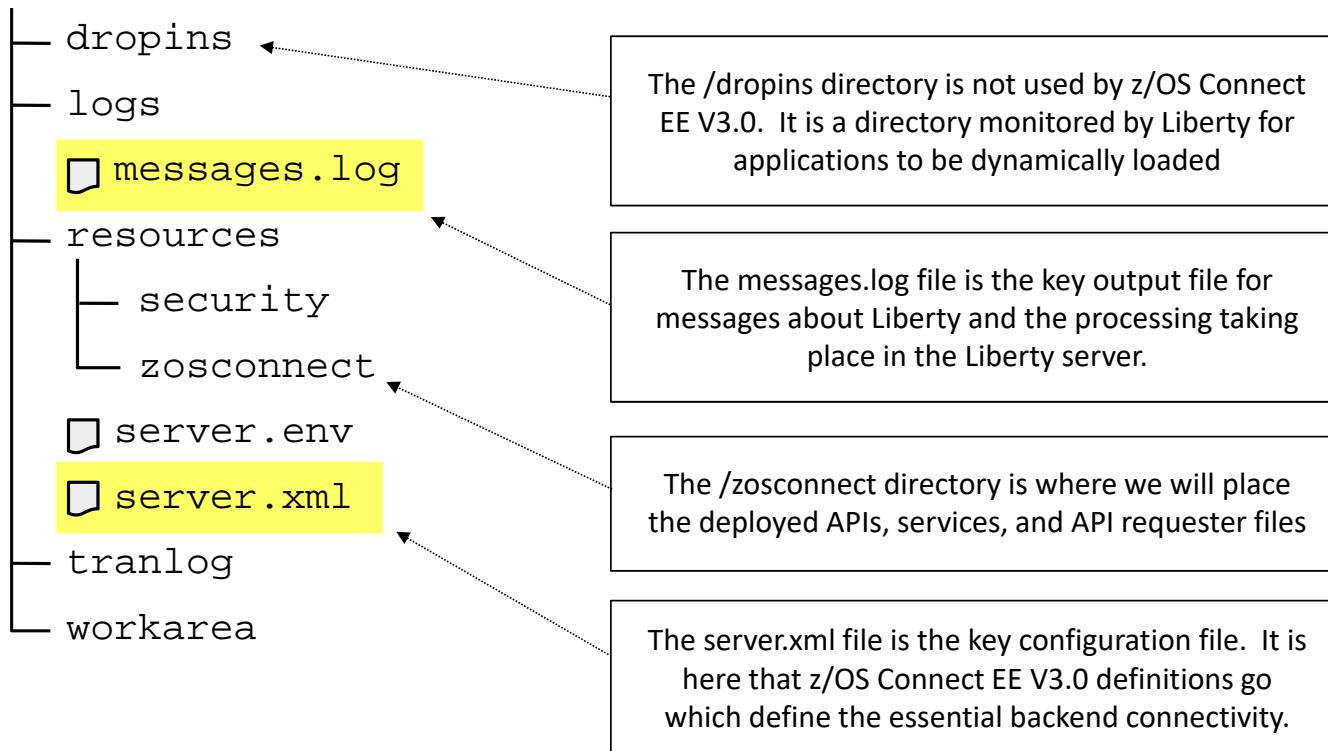
# Tour of Server Configuration Directories and Files



z/OS Connect EE

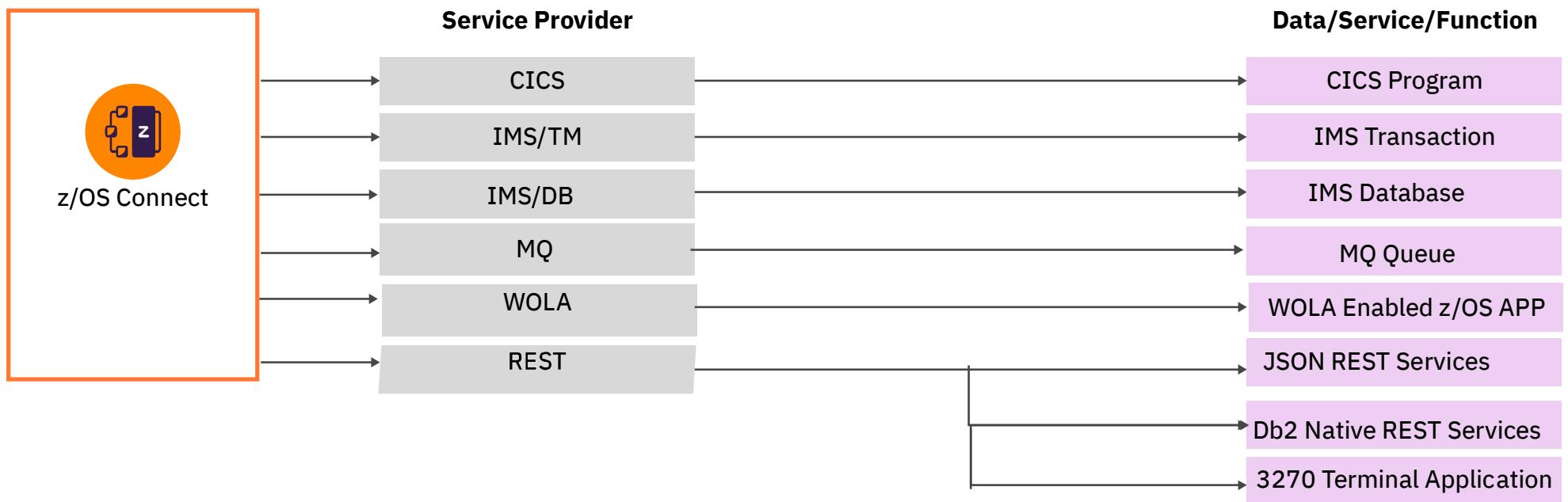
A z/OS Connect EE V3.0 server configuration structure looks like this:

/var/zosconnect/servers/<server\_name>



# What assets can z/OS Connect EE map to?

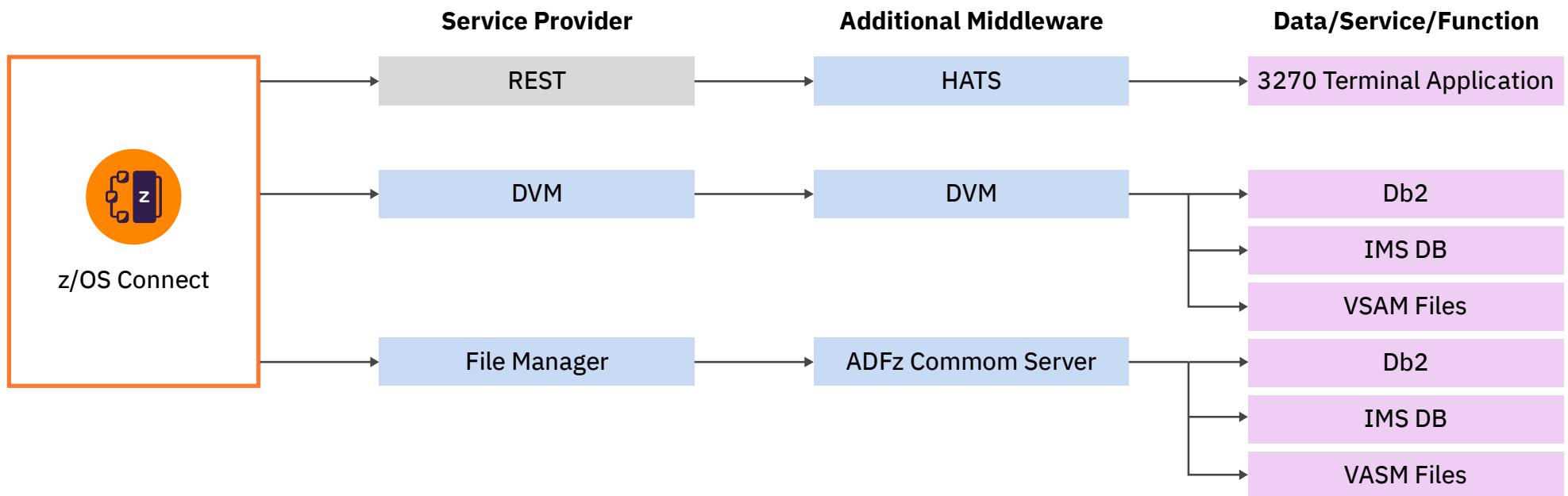
And which service provider could I use?



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

# Additional Middleware

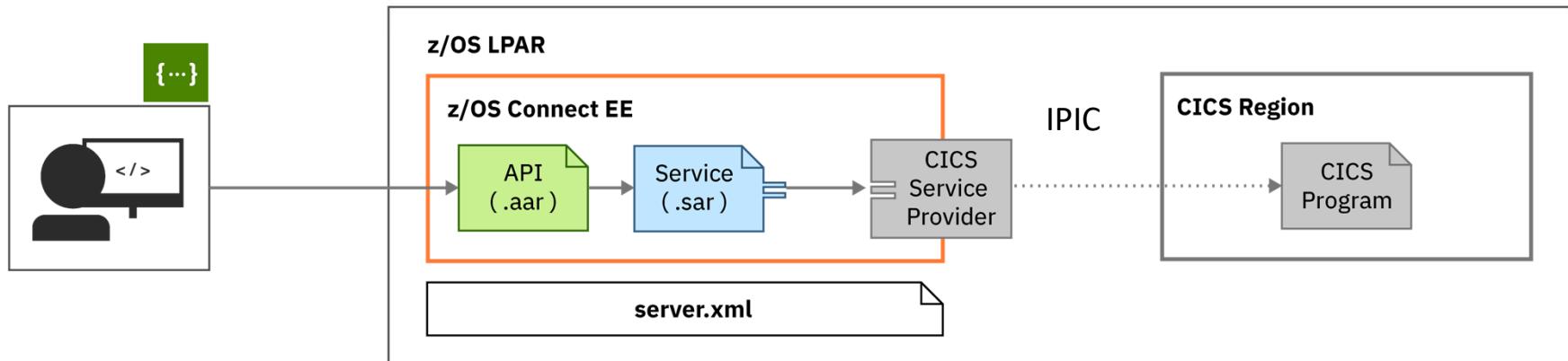
Additional value from the ecosystem



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

# Connections to CICS

## Topology



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

An IPIC connection must be configured in CICS.

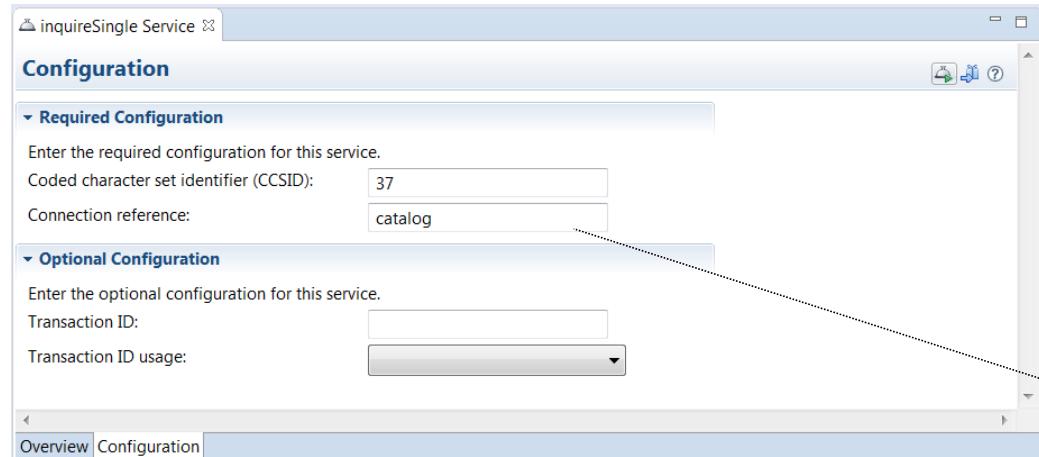
 [ibm.biz/zosconnect-scenarios](http://ibm.biz/zosconnect-scenarios)

# CICS IPIC (server.xml)



z/OS Connect EE

The server.xml file is the key configuration file:



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

## catalog.xml

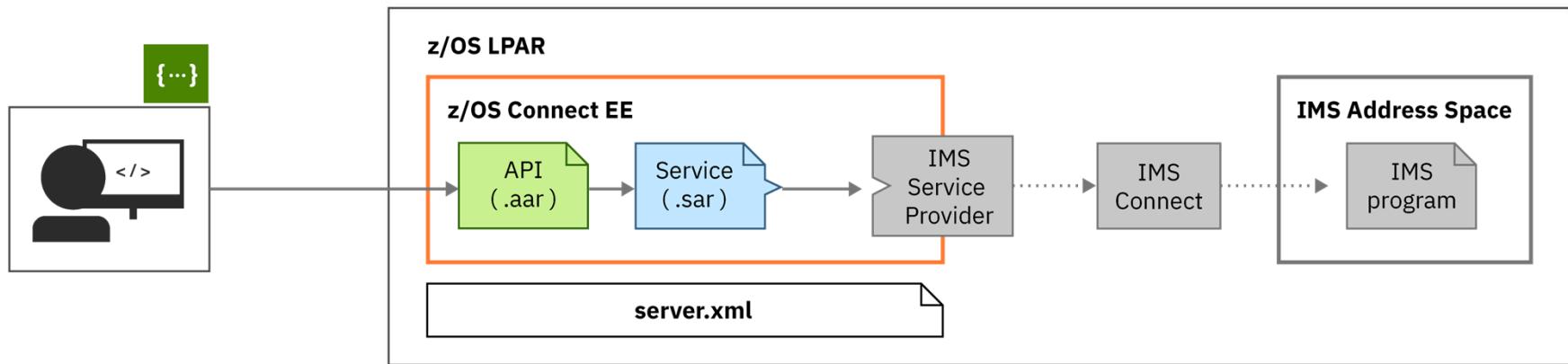
Design      Source

```
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
```

# Connections to IMS TM



## Topology



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

[ibm.biz/zosconnect-scenarios](http://ibm.biz/zosconnect-scenarios)

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# IMS Connections and Interactions



ivtnoService Service Configuration

**Required Configuration**

Enter the required configuration for this service.

Connection profile:

Interaction profile:

**Optional Configuration**

Enter the optional configuration for this service.

IMS destination override:

Program name:

Overview Configuration

## Connection

```
<server>
<imsmobile_imsConnection comment="" connectionFactoryRef="IVP1" connectionTimeout="-1" connectionType="IMSCONNECT" id="IMSCONN"/>
<connectionFactory containerAuthDataRef="Connection1_Auth" id="IVP1">
    <properties.gmoa hostName="wg31.washington.ibm.com" portNumber="4000"/>
</connectionFactory>

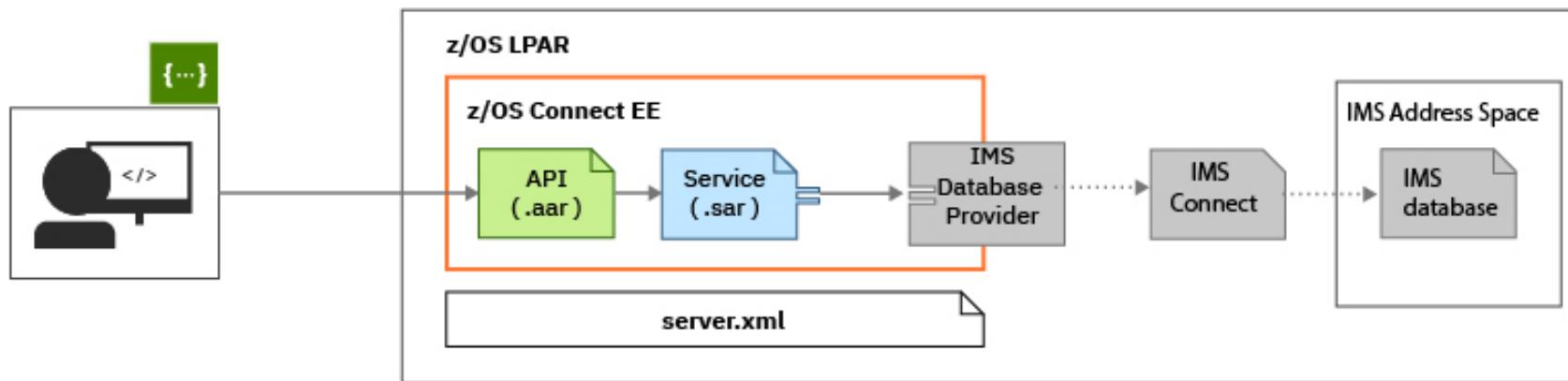
<authData id="Connection1_Auth" password="encryptedPassword1" user="userName1"/>
</server>
```

## 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](http://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

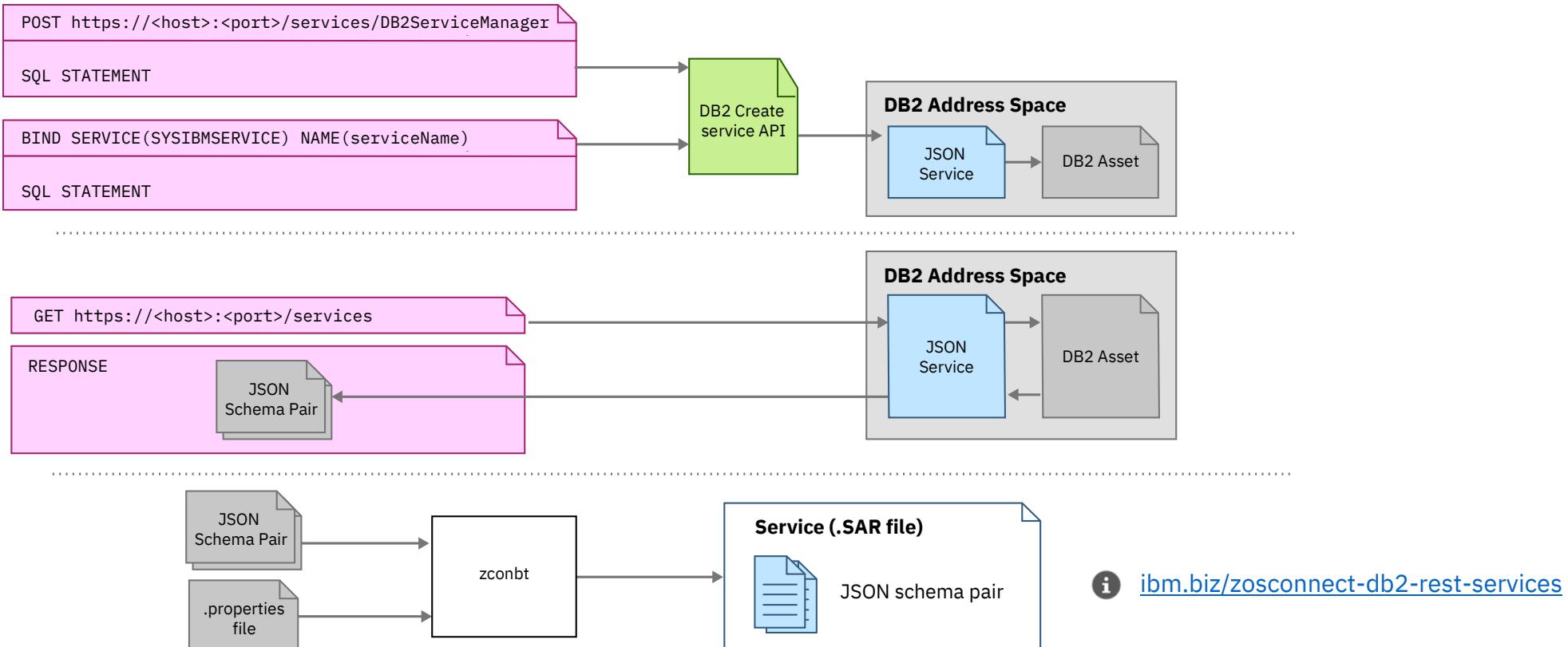
```
<connectionFactory id="DFSIVPACConn">
<properties.imsudbJLocal
  databaseName="DFSIVPA"
  datastoreName="IVP1"
  datastoreServer="wg31.washington.ibm.com"
  driverType="4"
  portNumber="5555"
  user="USER1"
  password="password"
  flattenTables="True" />
</connectionFactory>
```

## 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 )
```

# Connect to Db2

## Create the service definition

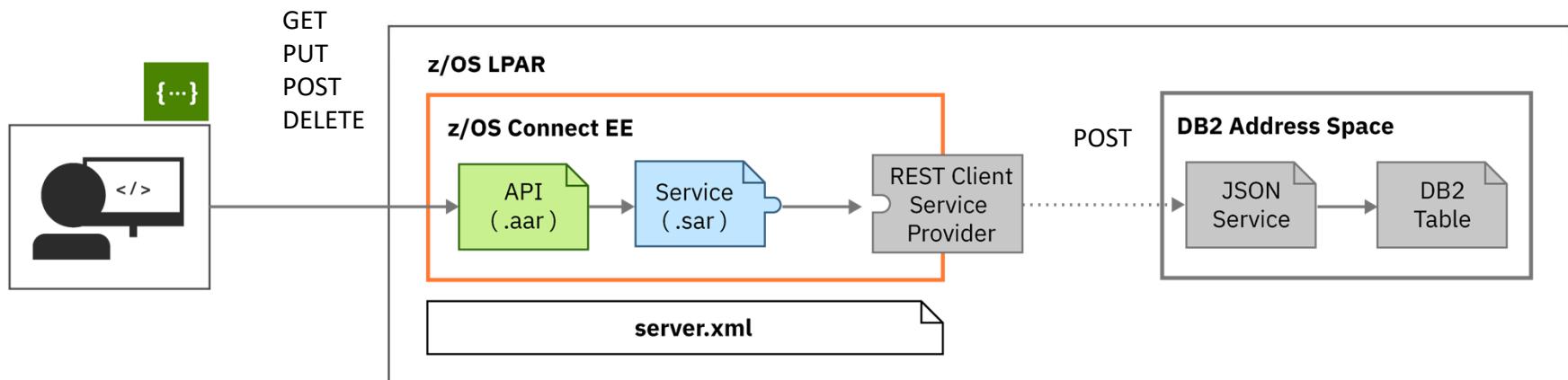


.sar file is created from the JSON schema of the DB2 service using the **zconbt utility**.



# 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](http://ibm.biz/zosconnect-db2-rest-services)

# The server.xml File (Db2)



z/OS Connect EE

The server.xml file is the key configuration file:

Service Project Editor: Configuration

Required Configuration

Enter the required configuration for this service.

Connection reference: db2conn

Definition Configuration

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

db2pass.xml

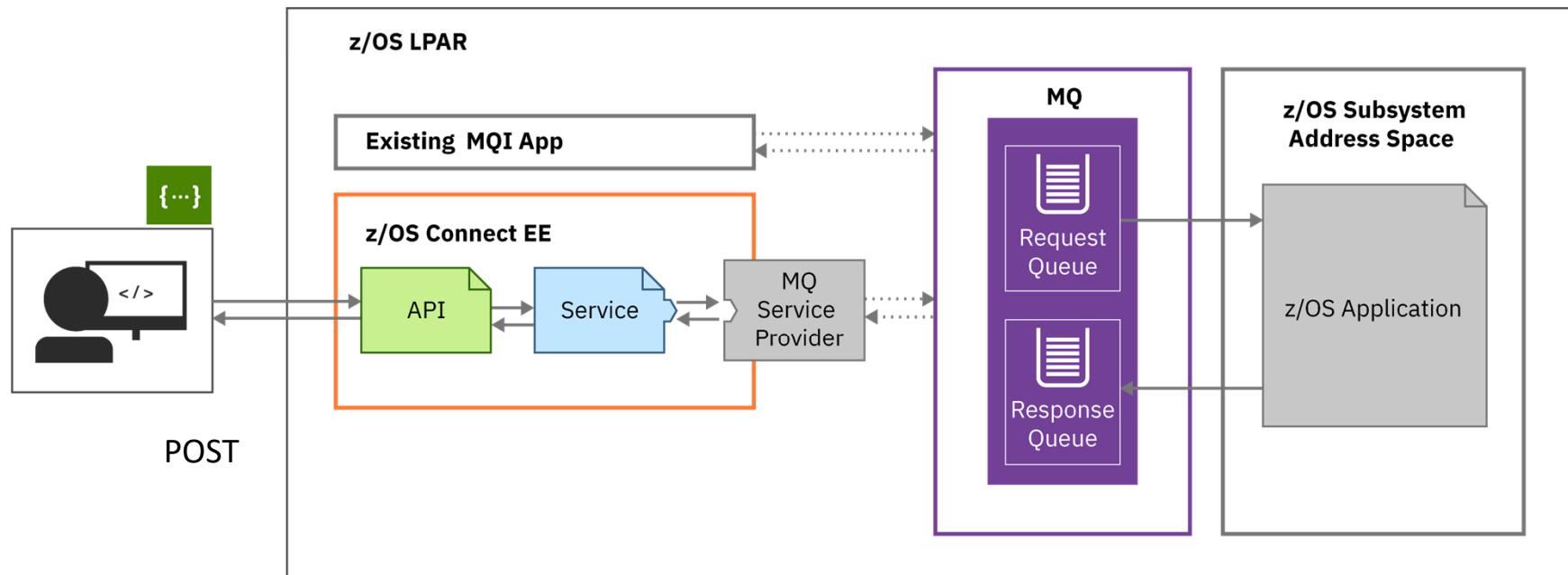
Design Source

```
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)

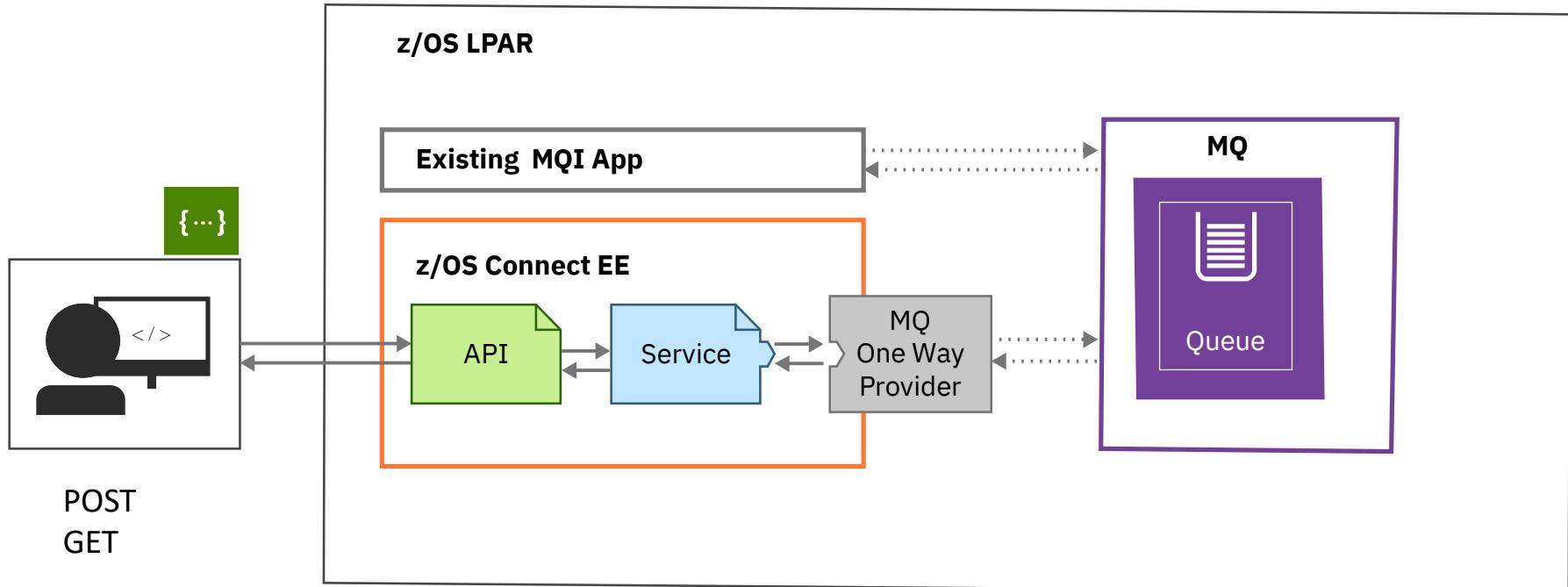


You can also configure one-way services.

 [ibm.biz/zosconnect-mq-service-provider](http://ibm.biz/zosconnect-mq-service-provider)

# Connections to MQ

Topology (One-way service example)



 [ibm.biz/zosconnect-mq-service-provider](http://ibm.biz/zosconnect-mq-service-provider)

# The server.xml File (MQ)



z/OS Connect EE

Read only Close

\*twoway Service

## Service Project Editor: Configuration

### Required Configuration

Enter the required configuration for this service.

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:

Reply selection:

msgIDToCorrelID

Expiry:

-1

mq.xml

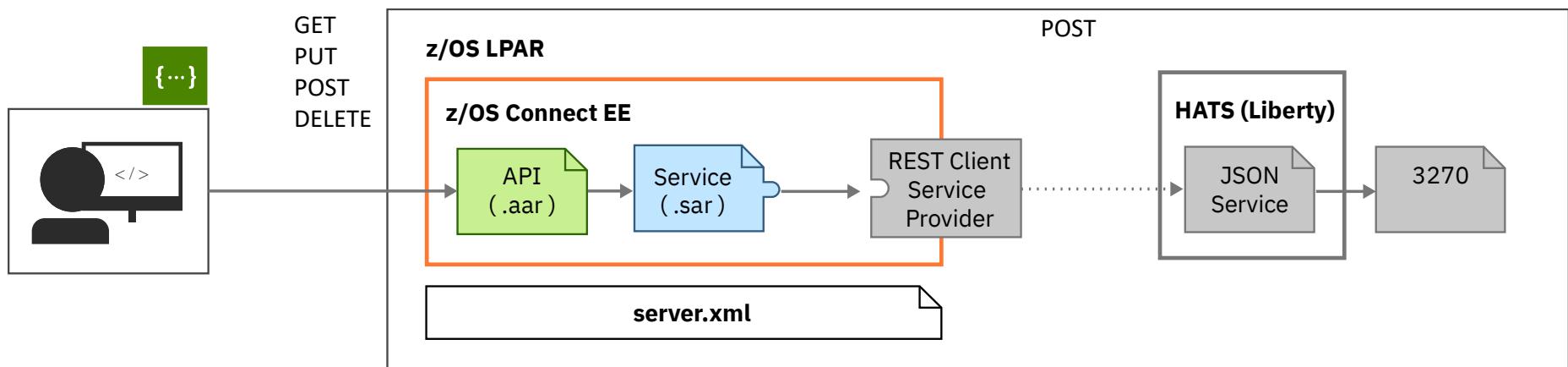
Design    Source

```
1<server description="MQ Service Provider">
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="QMZ1" />
17 </jmsConnectionFactory>
18
19 <jmsQueue id="default" jndiName="jms/default">
20     <properties.wmqJms
21         baseQueueName="ZCONN2.DEFAULT.MQZCEE.QUEUE"
22         CCSID="37"/>
23 </jmsQueue>
24
25 <jmsQueue id="request" jndiName="jms/request">
26     <properties.wmqJms
27         baseQueueName="ZCONN2.TRIGGER.REQUEST"
28         targetClient="MQ"
29         CCSID="37"/>
30 </jmsQueue>
31
32 <jmsQueue id="response" jndiName="jms/response">
33     <properties.wmqJms
34         baseQueueName="ZCONN2.TRIGGER.RESPONSE"
35         targetClient="MQ"
36         CCSID="37"/>
37 </jmsQueue>
38
```

# Connection to HATS



## Topology

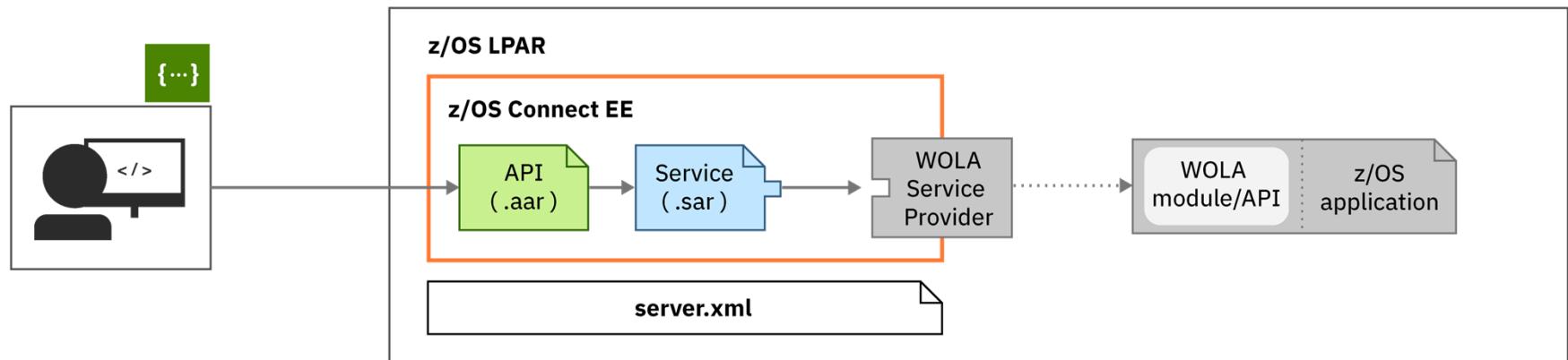


Connection to the HATS REST Service is configured in `server.xml`.

[ibm.biz/zosconect-db2-rest-services](http://ibm.biz/zosconect-db2-rest-services)

# Connections to a MVS batch application

## Topology



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

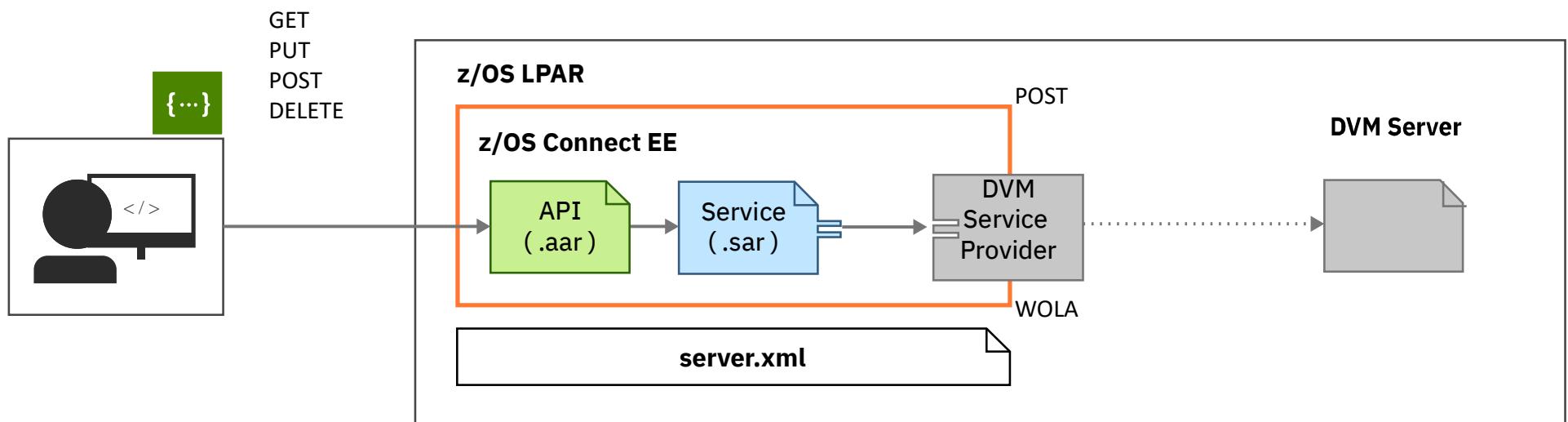
The z/OS application must be WOLA-enabled.

# Connections to DVM



z/OS Connect EE

## Topology



The DVM service provider uses WOLA

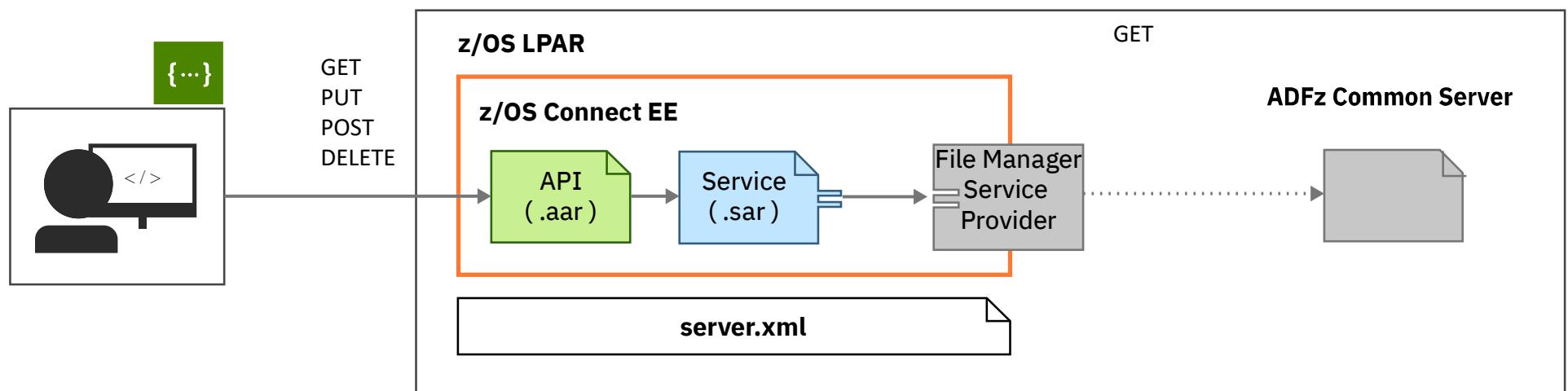
[ibm.biz/zosconnect-db2-rest-services](http://ibm.biz/zosconnect-db2-rest-services)

# 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 .

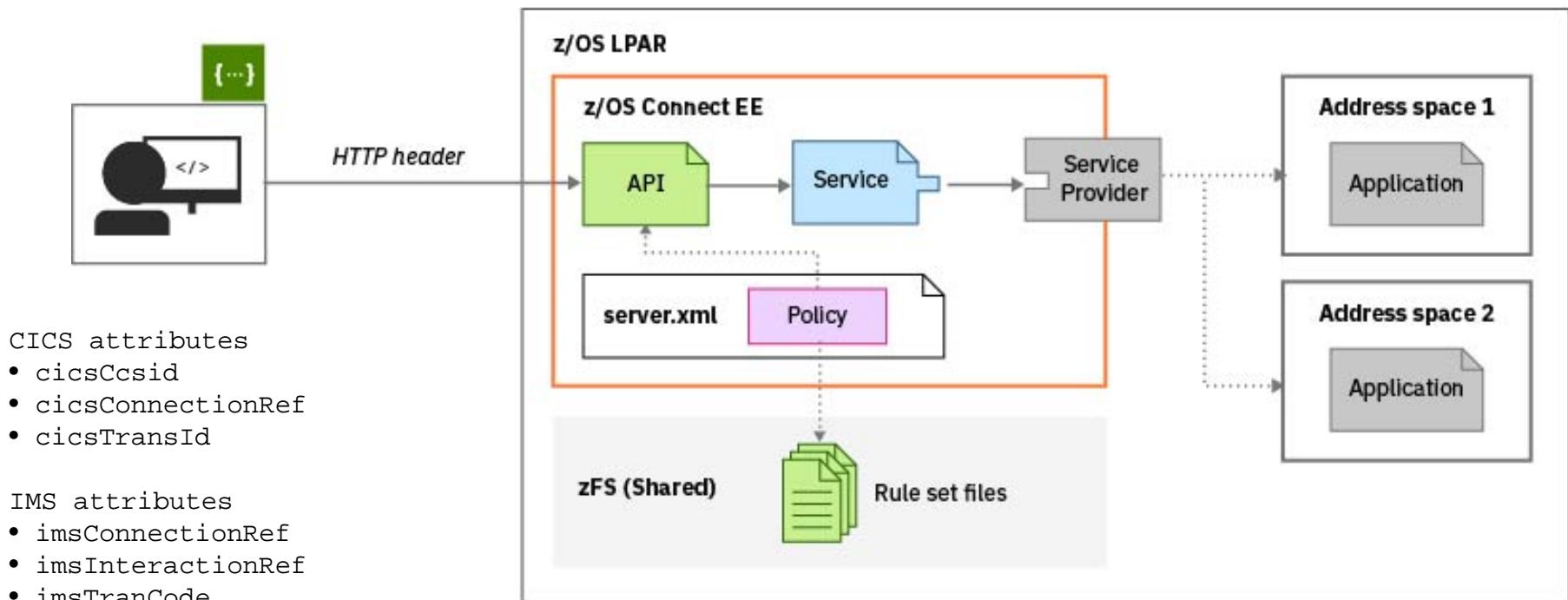


## /miscellaneousTopics

performance, high availability, Liberty

# API Policies

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



# A sample API Policies for CICS



z/OS Connect EE

```
<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>
```

The screenshot shows the z/OS Connect API designer interface. A red oval highlights the 'Path Parameters' section under the 'HTTP Request' configuration. The configuration pane shows:

- Body - cscvincServiceOperation
- 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...
```

<sup>1</sup>Transaction 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 screenshot shows the "Server Config" interface for the "server.xml" file. The left sidebar lists various configuration sections under "Remote File Access". The "z/OS Connect Manager" section is currently selected. In the main pane, there are four configuration groups:

- Global asynchronous request timeout:** Set to "(no value)".

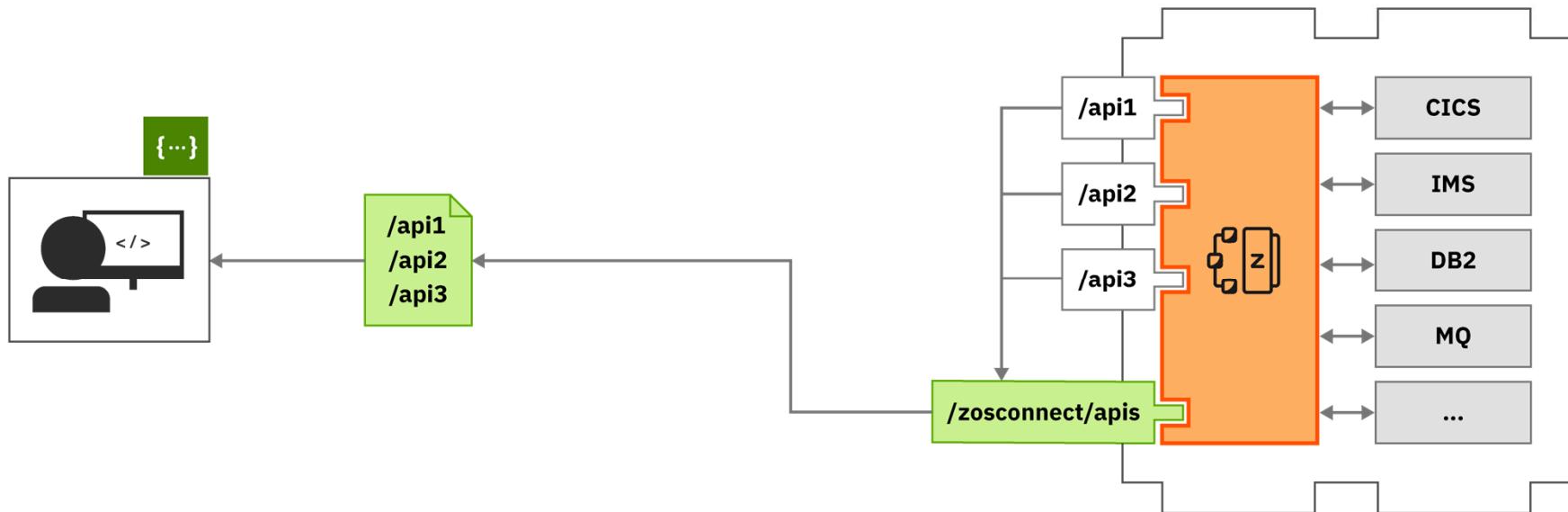
Specifies the mode in which all z/OS Connect requests are processed.
- Global administrative group:** Set to "GADMIN".

Administrative group name that is associated with all service endpoints. It is the name of the security group that the user needs to be in before administrative functions are permitted.
- Global operations group:** Set to "GOPER".

Operations group name that is associated with all service endpoints. It is the name of the security group that the user needs to be in before operations such as start, stop, or status is permitted.
- Global invoke group:** Set to "GINVOKE".

Invoke group name that is associated with all service endpoints. It contains the name of the security group that the user needs to be in before invoke calls are permitted.

# 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

\*Useful for deploying DB2 and HATS  
service archive files

PUT /zosConnect/services inquireSingle.sar

GET /zosConnect/services

GET /zosConnect/services/{serviceName}

DELETE /zosConnect/services/{serviceName}

# 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`.

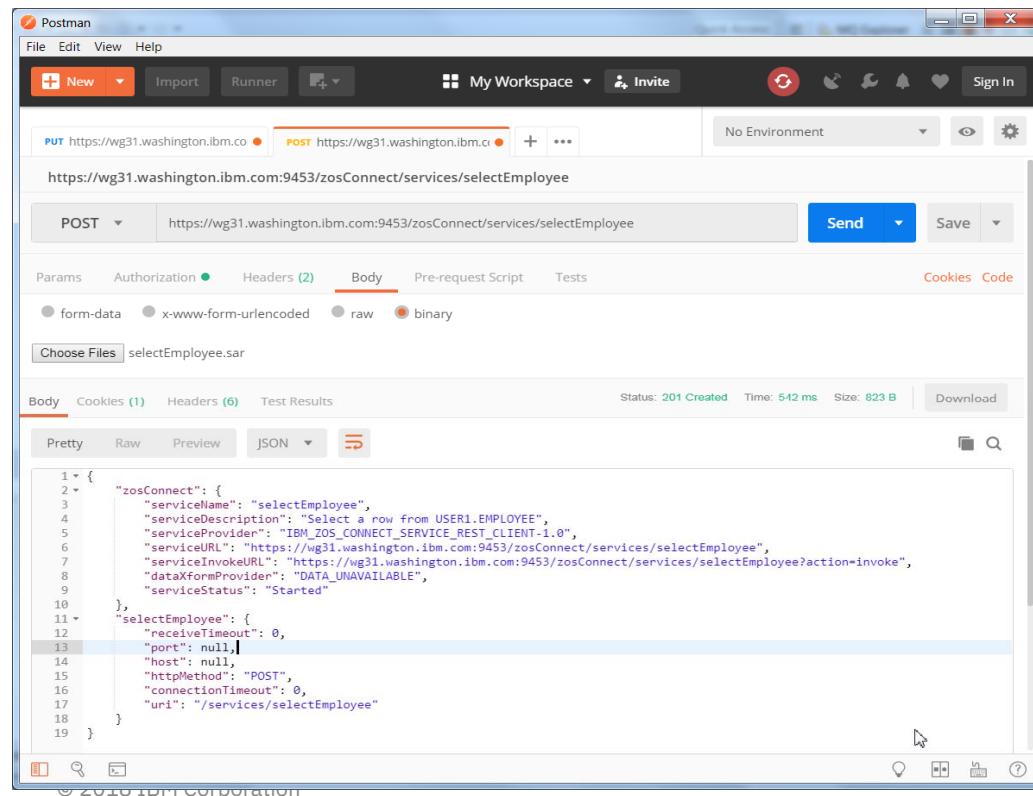
Most administration tasks are supported by the RESTful administration interface

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 Db2 Service Archive Options

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



```

{
  "zosConnect": {
    "serviceName": "selectEmployee",
    "serviceDescription": "Select a row from USER1.EMPLOYEE",
    "serviceProvider": "IBM_ZOS_CONNECT_SERVICE_REST_CLIENT-1.0",
    "serviceURL": "https://wg31.washington.ibm.com:9453/zosConnect/services/selectEmployee",
    "serviceInvokeURL": "https://wg31.washington.ibm.com:9453/zosConnect/services/selectEmployee?action=invoke",
    "dataXformProvider": "DATA_UNAVAILABLE",
    "serviceStatus": "Started"
  },
  "selectEmployee": {
    "receiveTimeout": 0,
    "port": null,
    "host": null,
    "httpMethod": "POST",
    "connectionTimeout": 0,
    "uri": "/services/selectEmployee"
  }
}

```

## Command:

```

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

```

## Results:

```

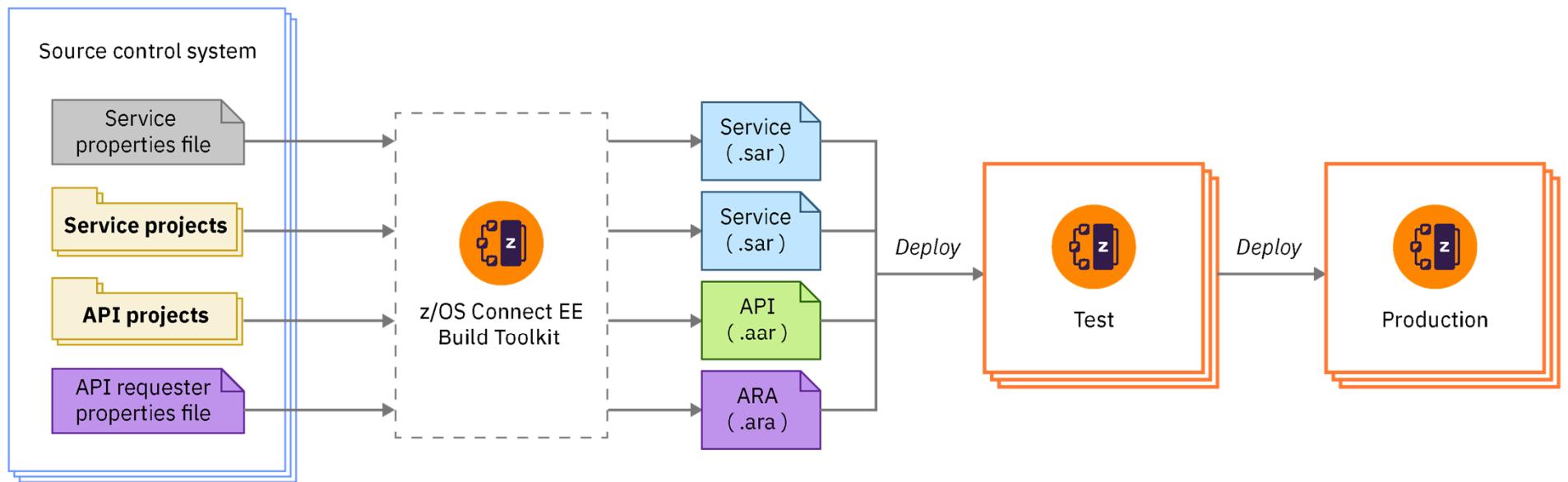
{
  "zosConnect": {
    "serviceName": "selectEmployee",
    "serviceDescription": "Select a row from USER1.EMPLOYEE",
    "serviceProvider": "IBM_ZOS_CONNECT_SERVICE_REST_CLIENT-1.0",
    "serviceURL": "https://mpxm:9453/zosConnect/services/selectEmployee",
    "serviceInvokeURL": "https://mpxm:9453/zosConnect/services/selectEmployee?action=invoke",
    "dataXformProvider": "DATA_UNAVAILABLE",
    "serviceStatus": "Started"
  },
  "selectEmployee": {
    "receiveTimeout": 0,
    "port": null,
    "host": null,
    "httpMethod": "POST",
    "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.

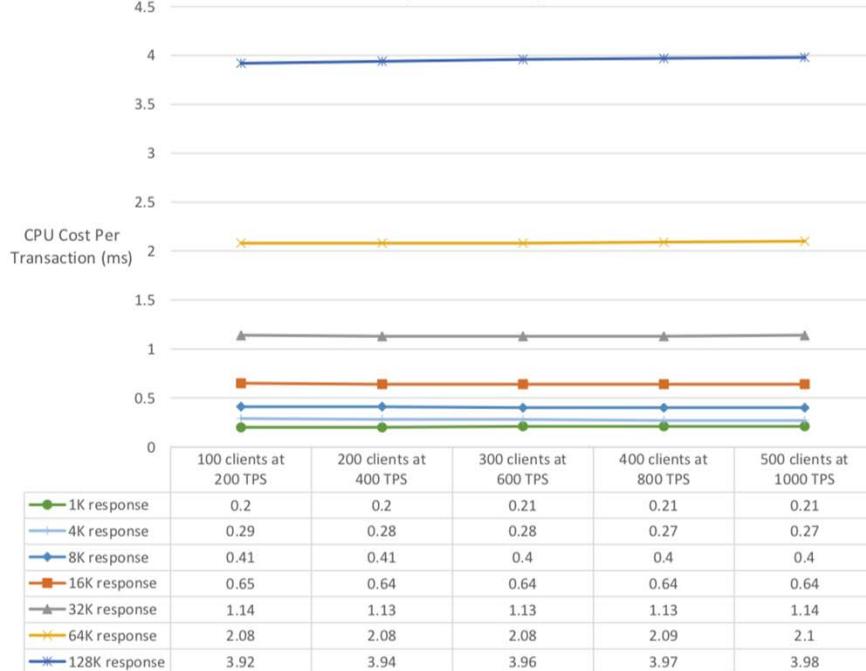
- The build toolkit supports the generation of service archives and API archives from projects created in the z/OS Connect EE API toolkit
- The build toolkit also supports the use of properties files to generate API requester archives
- Run the build toolkit from a build script to generate these archive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



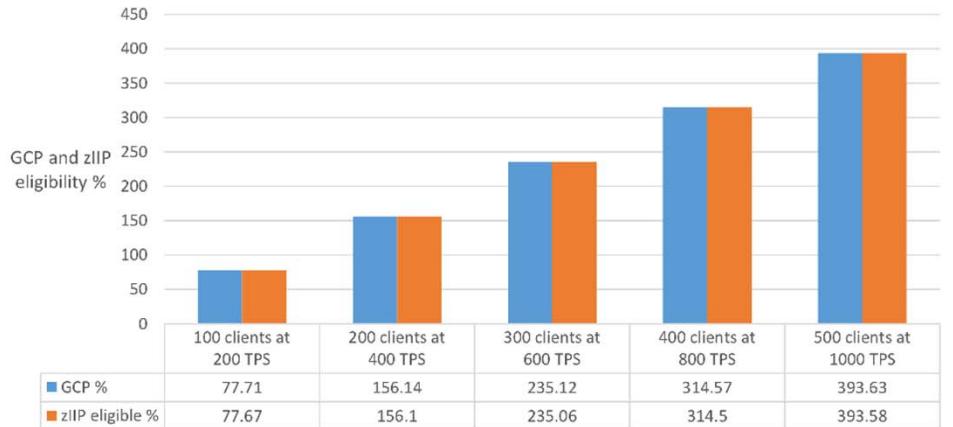
# Performance: API Provider

## 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



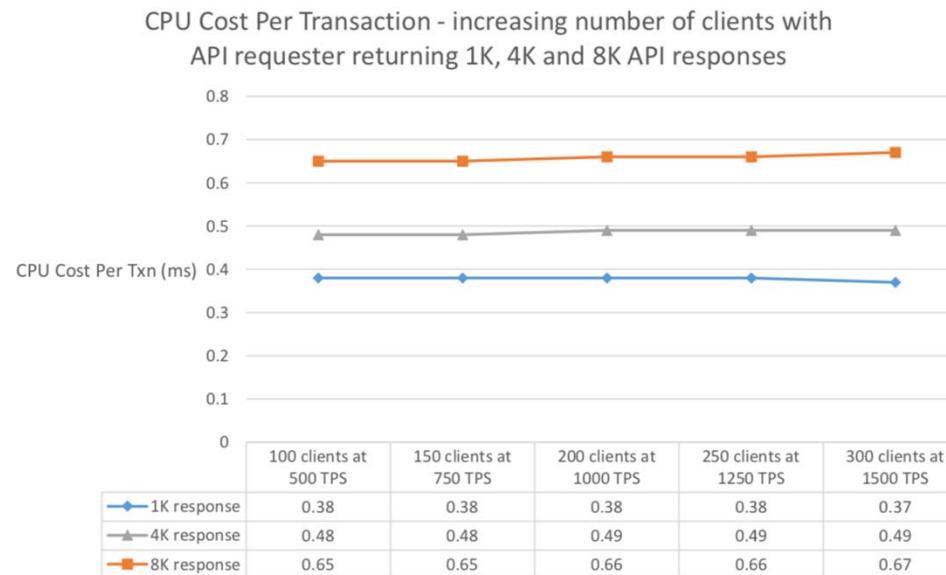
zIIP eligibility - increasing number of clients with 50 byte requests and 128K responses, using channels and CICS SP



**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 z Omegamon for JVM



**WG31 - 3270**

File Edit View Communication Actions Window Help

File Edit View Tools Navigate Help 04/02/2019 19:10:36  
Command ==> KJJZCSA z/OS Connect Request Summary  
Auto Update : Off  
SMF ID : WG31 Coll ID : KJJ1

APIName	Service	SoR ID	Reference	Resource
1. Last 30 Minute(s)	(HH:MM:SS.mmm)	(MM/DD/YYYY)		
2. Last 1 Hour(s)	Start Time 18:40:36.491 Date 04/02/2019			
3. Date/Time Range	End Time 19:10:36.491 Date 04/02/2019			

Columns 3 to 6 of 17 ← → ↑ ↓ Rows 1 to 8 of 8

ΔAPI VName	ΔHTTP VMethod	ΔRequest VCount	ΔError VCount	ΔTimeout VCount	ΔResp Time VAvg
*ADMIN*	GET	28	0	0	.000887s
catalog	GET	1	0	0	.019334s
cscvinc	GET	1	0	0	.008006s
db2employee	GET	2	0	0	.021797s
filea	GET	1	0	0	.005971s
filequeue	GET	1	0	0	.016206s
*ADMIN*	POST	1	0	0	.777651s
phonebook	GET	1	0	0	.345265s

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 04/02/2019 19:09:41  
Command ==> KJJZCSS Requests by Service Name  
Auto Update : Off  
SMF ID : WG31 Coll ID : KJJ1

APIName	Service	SoR ID	Reference	Resource
1. Last 30 Minute(s)	(HH:MM:SS.mmm)	(MM/DD/YYYY)		
2. Last 1 Hour(s)	Start Time 18:39:41.193 Date 04/02/2019			
3. Date/Time Range	End Time 19:09:41.193 Date 04/02/2019			

Columns 2 to 6 of 16 ← → ↑ ↓ Rows 1 to 6 of 6

ΔService VName	ΔRequest VCount	ΔError VCount	ΔTimeout VCount	ΔResp Time VAvg	ΔzOS Conne VAvg
inquireSingle	1	0	0	.019334s	.017995s
cscvincService	1	0	0	.008006s	.005515s
selectEmployee	2	0	0	.021797s	.021797s
Filea	1	0	0	.005971s	.005971s
FileaQueue	1	0	0	.016206s	.016206s
ivtnoService	1	0	0	.345265s	.163460s

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 04/02/2019 18:48:18.198  
Command ==> KJJZCSA z/OS Connect Event Summary  
Auto Update : Off  
SMF ID : WG31 Coll ID : KJJ1

ΔEvent VTime	ΔProvider VName	ΔUser ID V	ΔQuery VString
04/02/19 18:48:18.198	restclient-1.0	Fred	
04/02/19 18:48:34.790	restclient-1.0	Fred	
04/02/19 18:48:57.786	WOLA-1.0	Fred	
04/02/19 18:49:14.525	IBM MQ for z/OS	Fred	

VERIFY BACK HOME Hub WG31:CMS on platform WG31(z/OS) 12/034  
Connected to remote server/host wg31a using lu/pool TCP00109 and port 23

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# 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

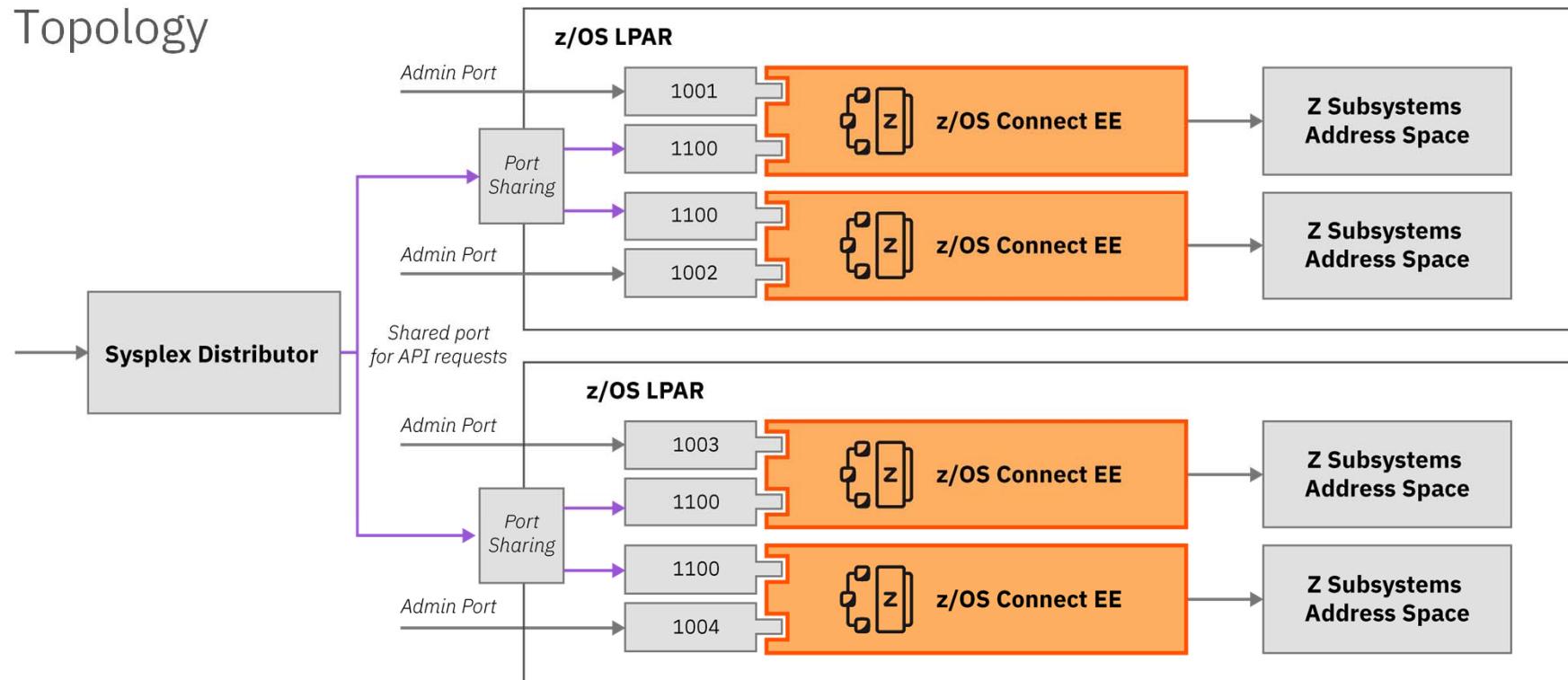
VERIFY BACK HOME Hub WG31:CMS on platform WG31(z/OS) 01/002

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



# High Availability

## Topology



**i** [ibm.biz/zosconnect-ha-concepts](http://ibm.biz/zosconnect-ha-concepts)

**i** [ibm.biz/zosconnect-scenarios](http://ibm.biz/zosconnect-scenarios)



# **/security**

How is security implement?



z/OS Connect EE

## 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

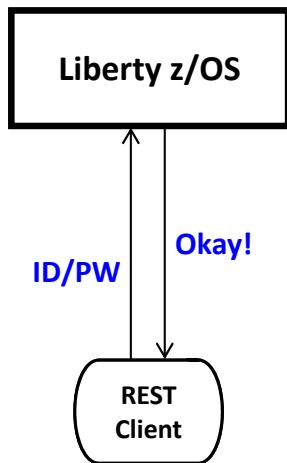
# Authentication



z/OS Connect EE

Several different ways this can be accomplished:

## Basic Authentication



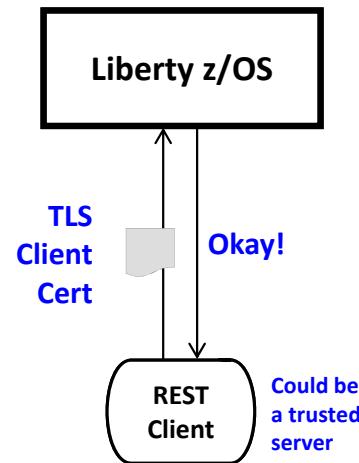
Server prompts for ID/PW

Client supplies ID/PW

Server checks registry:

- Basic (server.xml)
- LDAP
- SAF

## Client Certificate



Server prompts for cert.

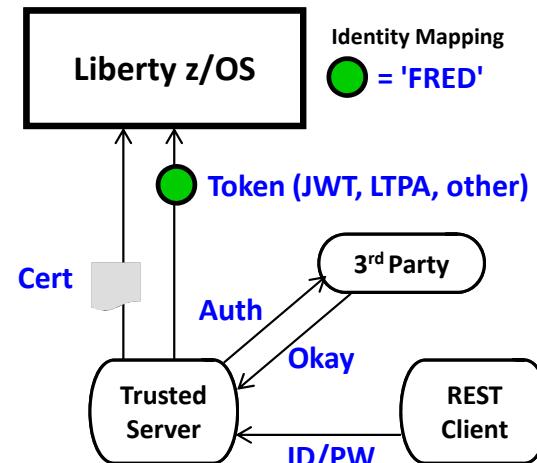
Client supplies certificate

Server validates cert and maps to an identity

Registry options:

- LDAP
- SAF

## Third Party Authentication



Client authenticates to 3<sup>rd</sup> party sever

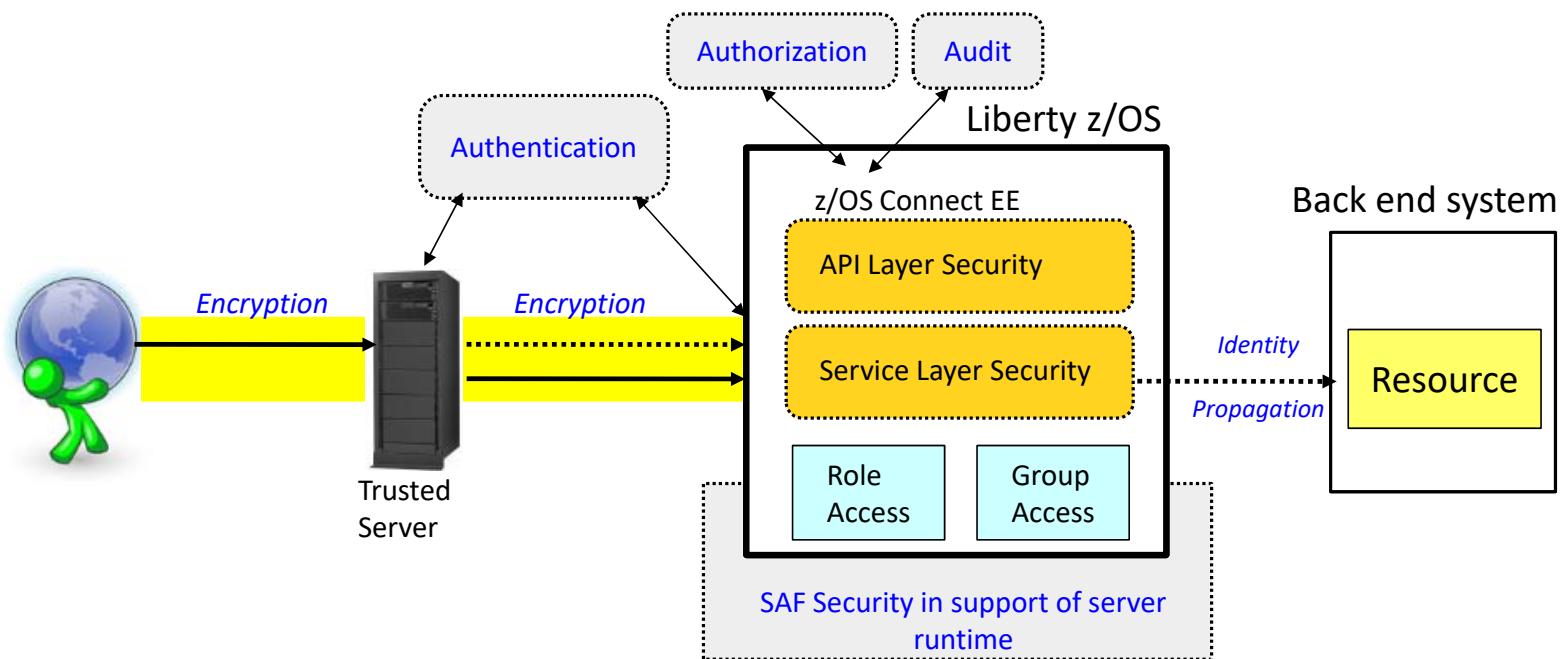
Client receives a trusted 3<sup>rd</sup> party token

Token flows to Liberty z/OS and is mapped to an identity

Registry options:

- LDAP
- SAF

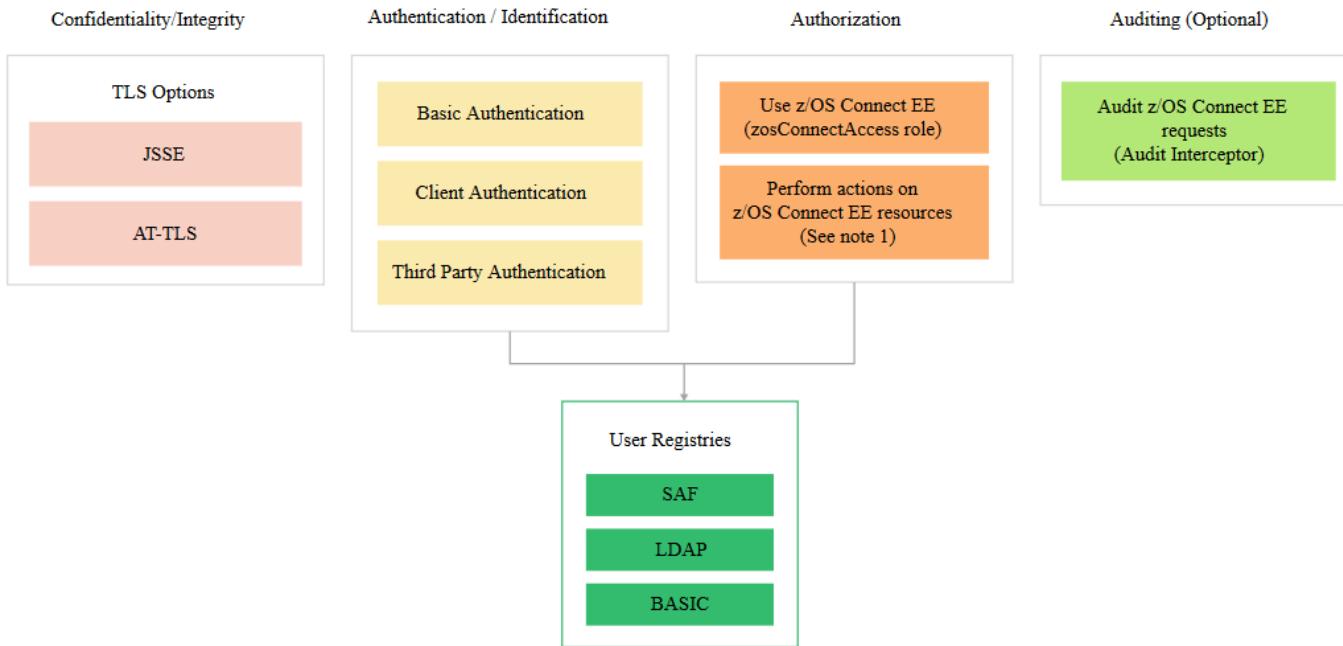
# z/OS Connect EE API provider security overview



1. Authentication (basic, client certificates, 3<sup>rd</sup> 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

# z/OS Connect EE security options

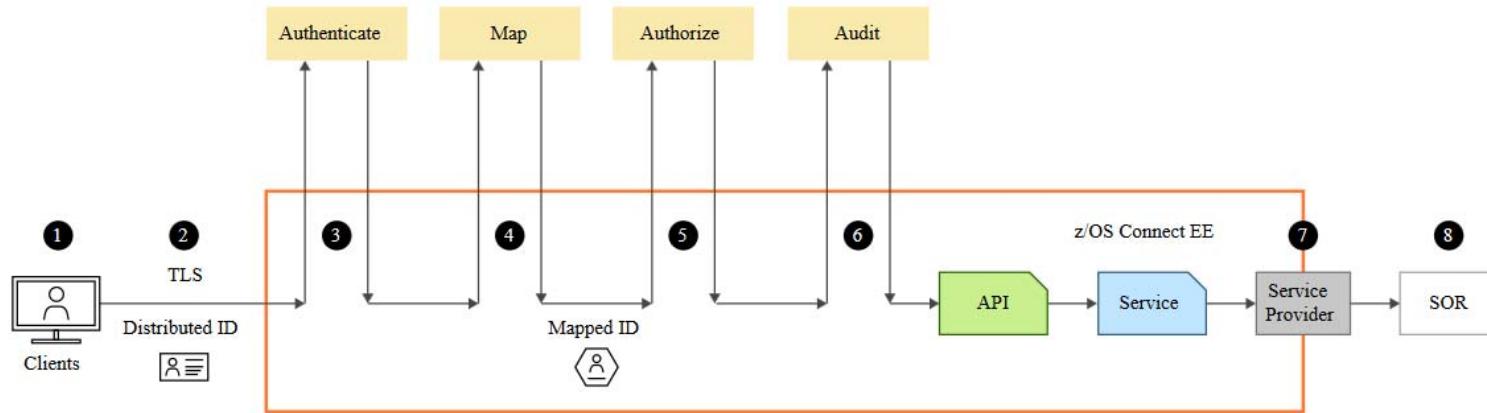


 <http://ibm.biz/zosconnect-security>

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"><li>Easy to use with WebSphere and DataPower</li></ul>	<ul style="list-style-type: none"><li>IBM Proprietary token</li></ul>
SAML	XML-based security token and set of profiles	<ul style="list-style-type: none"><li>Token includes user id and claims</li><li>Used widely with SoR applications</li></ul>	<ul style="list-style-type: none"><li>Tokens can be heavy to process</li><li>No refresh token</li></ul>
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"><li>Used widely for SoE applications e.g with Google, Facebook, Microsoft, Twitter ...</li></ul>	<ul style="list-style-type: none"><li>Needs introspection endpoint to validate token</li></ul>
JWT	JSON security token format	<ul style="list-style-type: none"><li>More compact than SAML</li><li>Ease of client-side processing especially mobile</li></ul>	



# 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 interface. On the left, under 'Encoded', a long JWT token is pasted. On the right, under 'Decoded', the token is split into three sections: 'HEADER: ALGORITHM & TOKEN TYPE', 'PAYLOAD: DATA', and 'VERIFY SIGNATURE'. The 'HEADER' section contains:

```
{
  "alg": "RS256",
  "typ": "JWT"
}
```

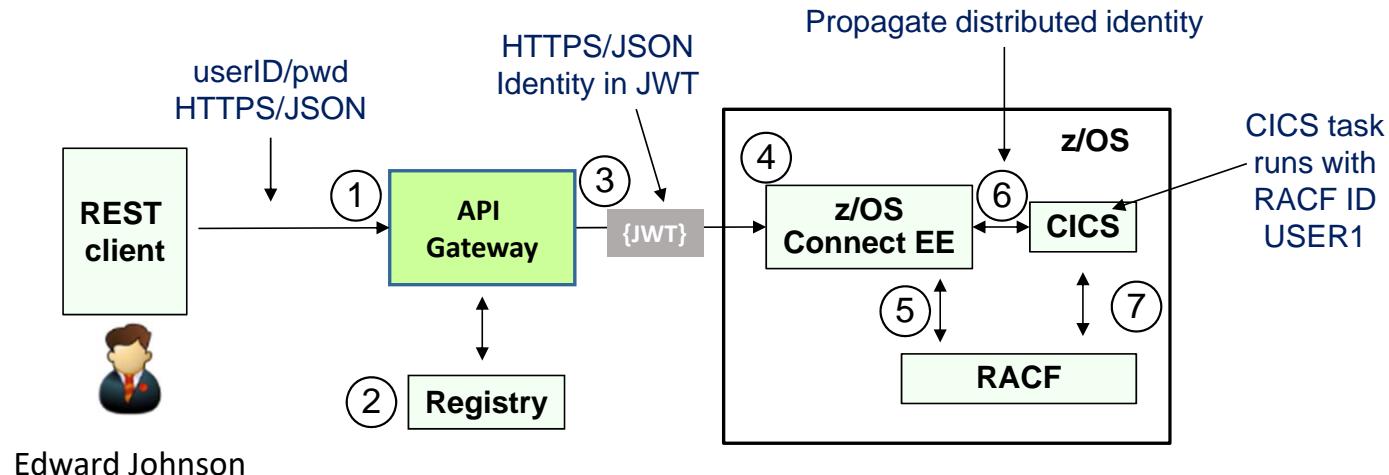
The 'PAYLOAD' section contains:

```
{
  "sub": "distuser",
  "token_type": "Bearer",
  "azp": "rp0s1",
  "iss": "https://wg31.washington.ibm.com:26213",
  "oidc/endpoint/Ops1",
  "aud": "myZee",
  "exp": 1569675698,
  "iat": 1569675638,
  "realmName": "zCEERealm",
  "uniqueSecurityName": "distuser"
}
```

The 'VERIFY SIGNATURE' section shows the RSASHA256 algorithm and the base64url-encoded header and payload, followed by a public key block:

```
-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ
Q8AMIIIBCgKCAQEAnzy1s1ZjfNBbb
gKFMsv
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="PhoneBook">
    <requestUrl id="URL" urlPattern="/phoneBook/*" matchType="equals" /> </authFilter>
<authFilter id="JwtAuthFilter" >
    <requestHeader id="authHeader" name="Authorization" value="Bearer" matchType="contains" />
</authFilter>
```

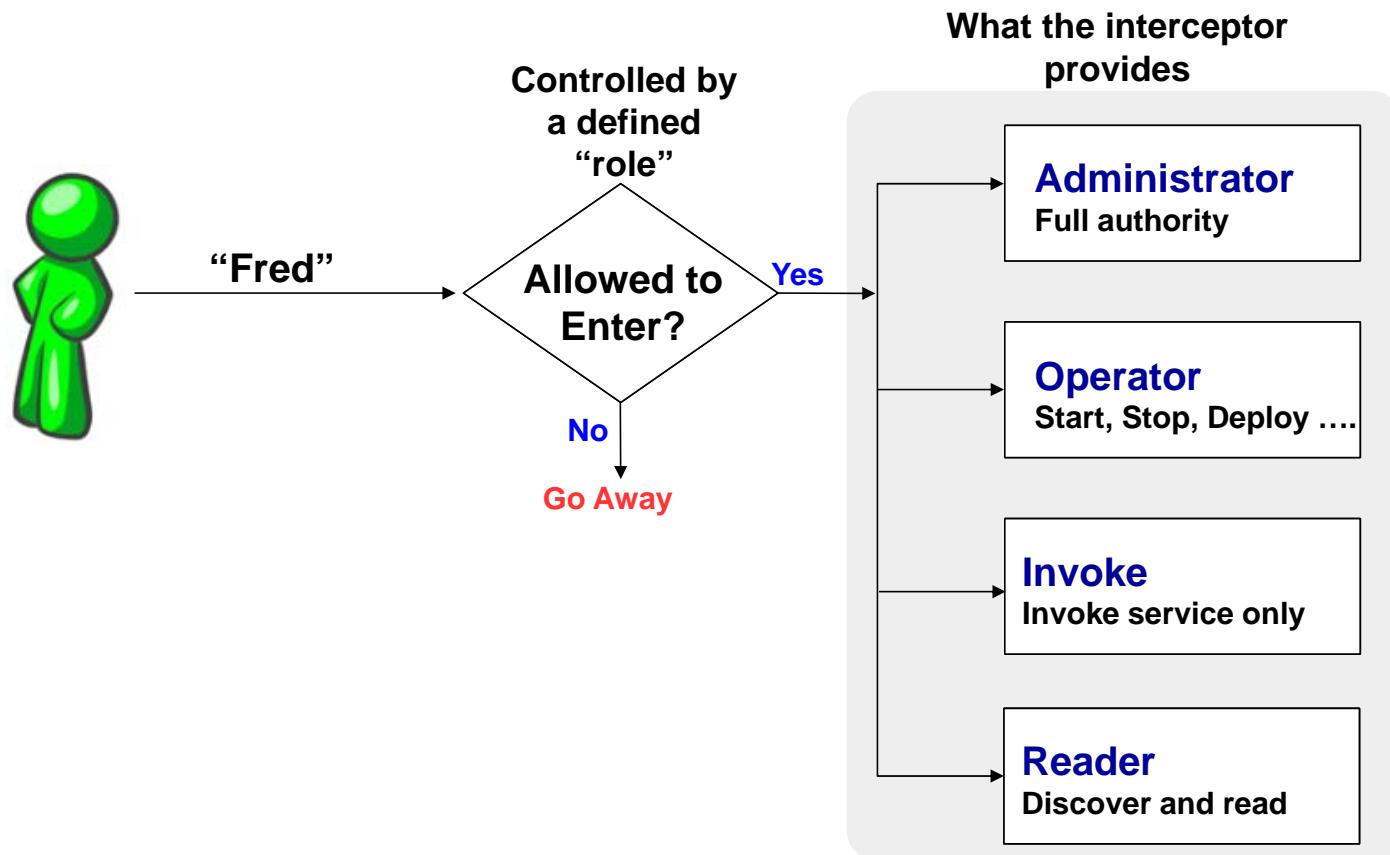
### Some alternative filter types

- 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:

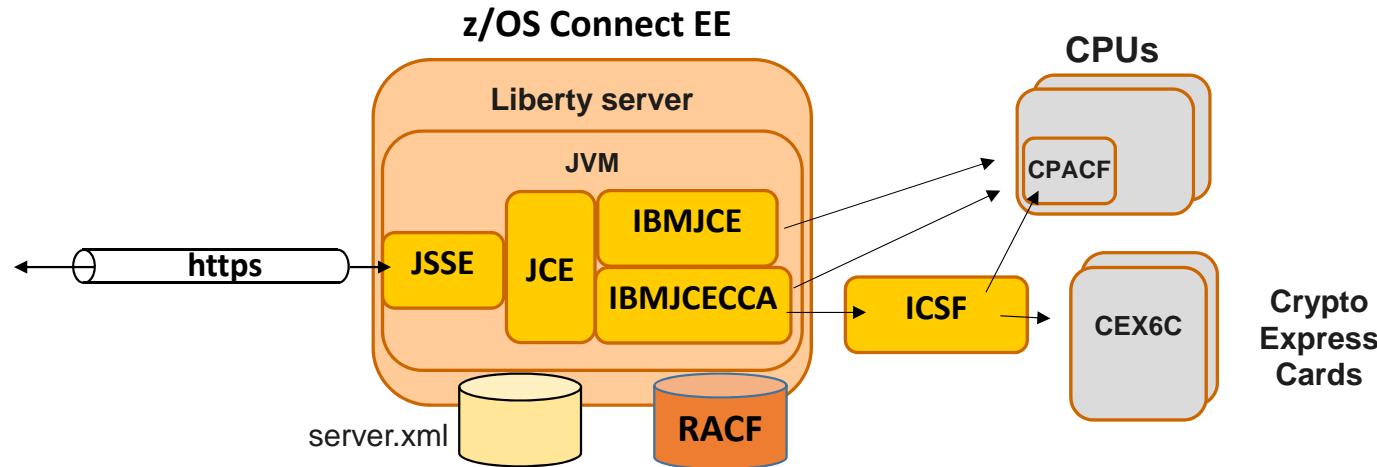




z/OS Connect EE

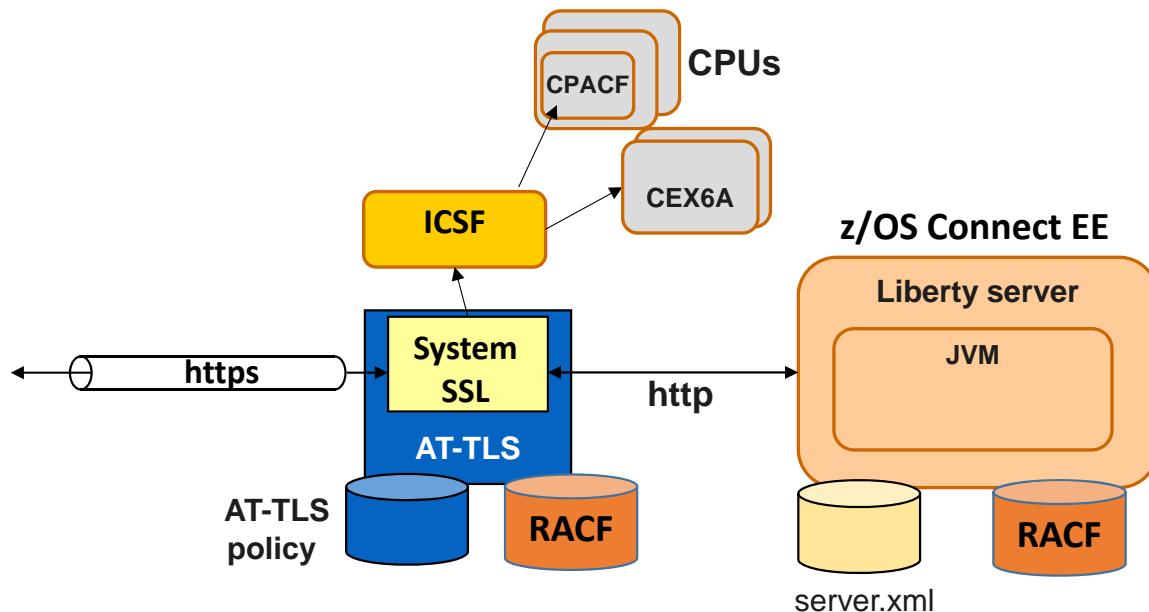
# Encryption

## Using JSSE with z/OS Connect EE



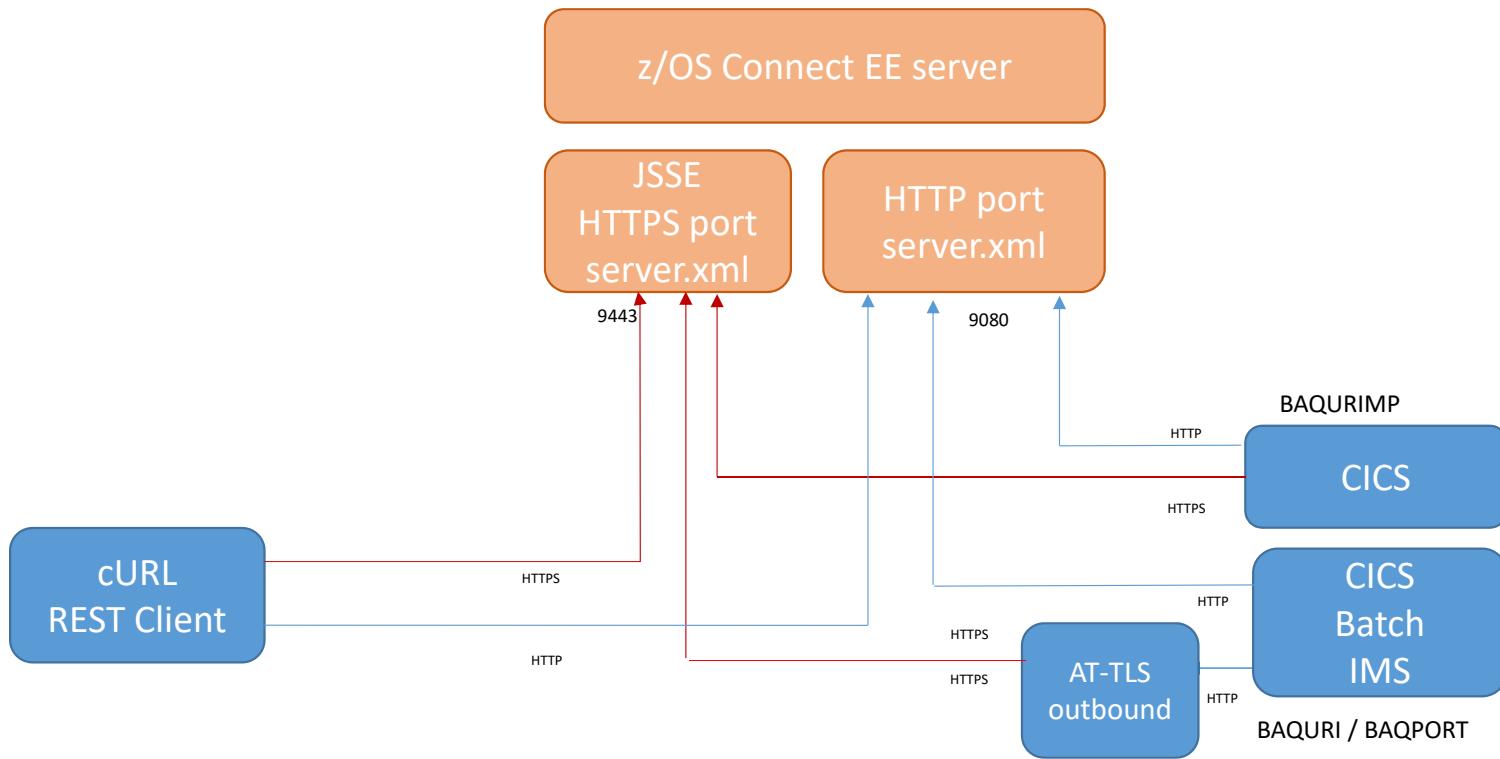
- z/OS Connect EE support for SSL/TLS is based on **Liberty server** support
- **Java Secure Socket Extension (JSSE)** API provides framework and Java implementation of SSL and TLS protocols used by Liberty HTTPS support
- **Java Cryptography Extension (JCE)** is standard extension to the Java Platform 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

## AT-TLS Inbound to zCEE Scenarios

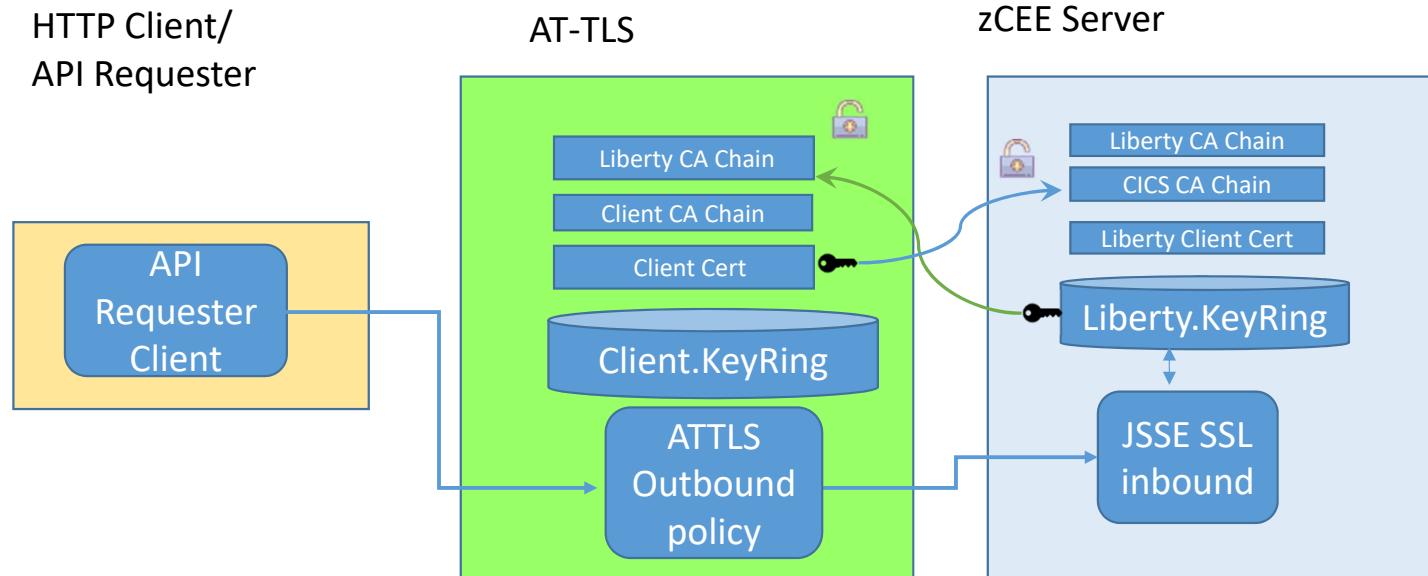


A Outbound Policy allows non-SSL clients to connection to HTTPS ports

## AT-TLS Handshake Flow

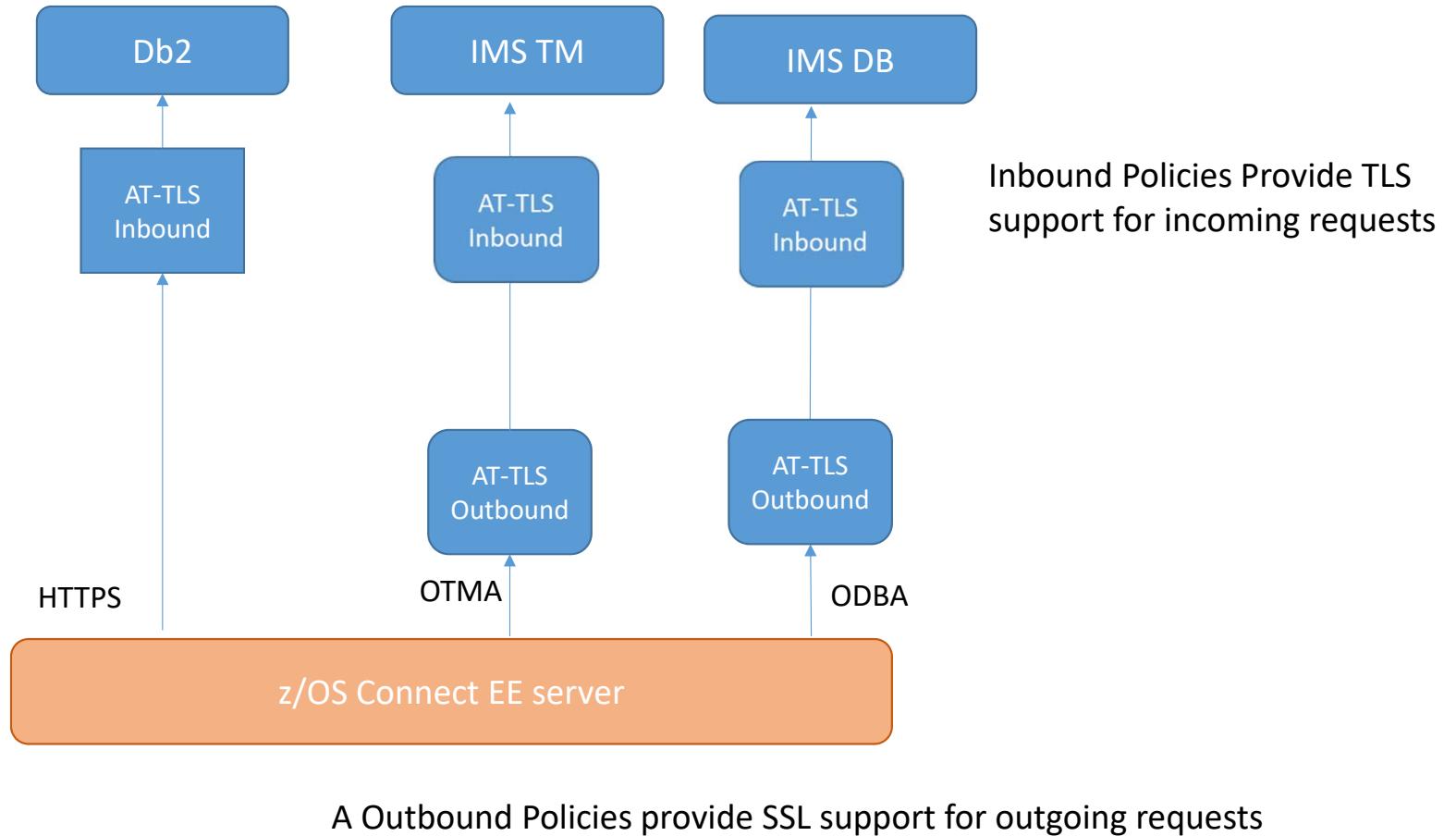


z/OS Connect EE



Outbound Policy acts a surrogate SSL client

## AT-TLS Outbound from zCEE Scenarios (HTTPS/OTMA/ODBA)



## Non-TLS Handshake Flow

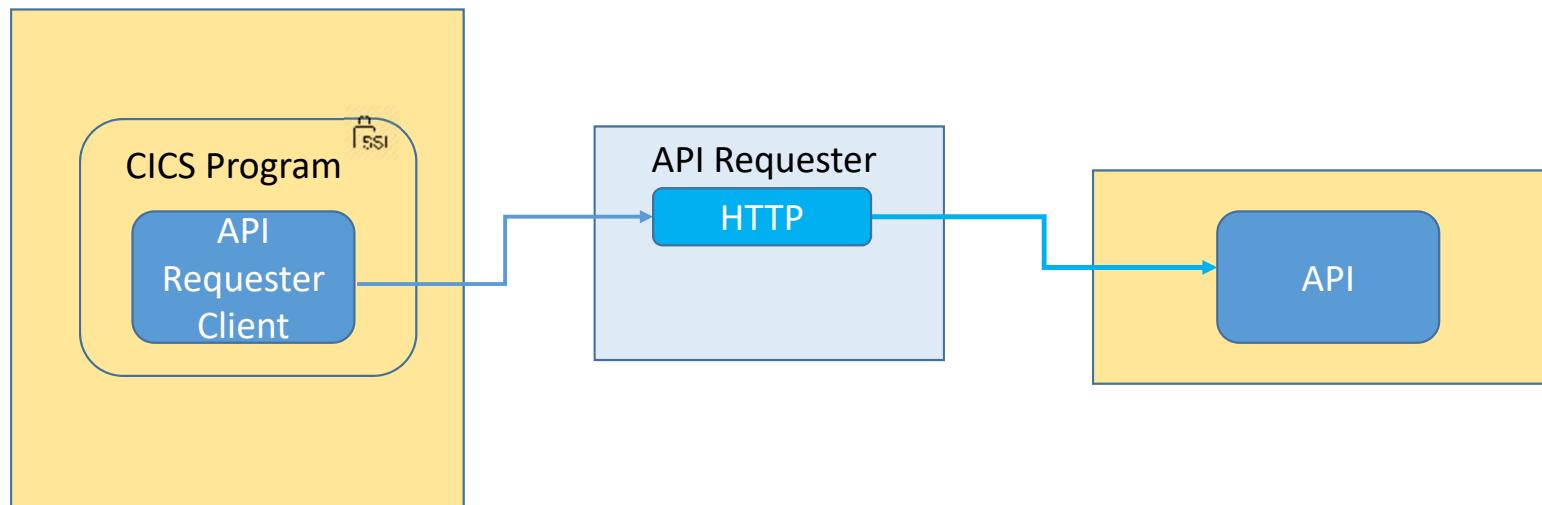


z/OS Connect EE

CICS API  
Requester

zCEE Server

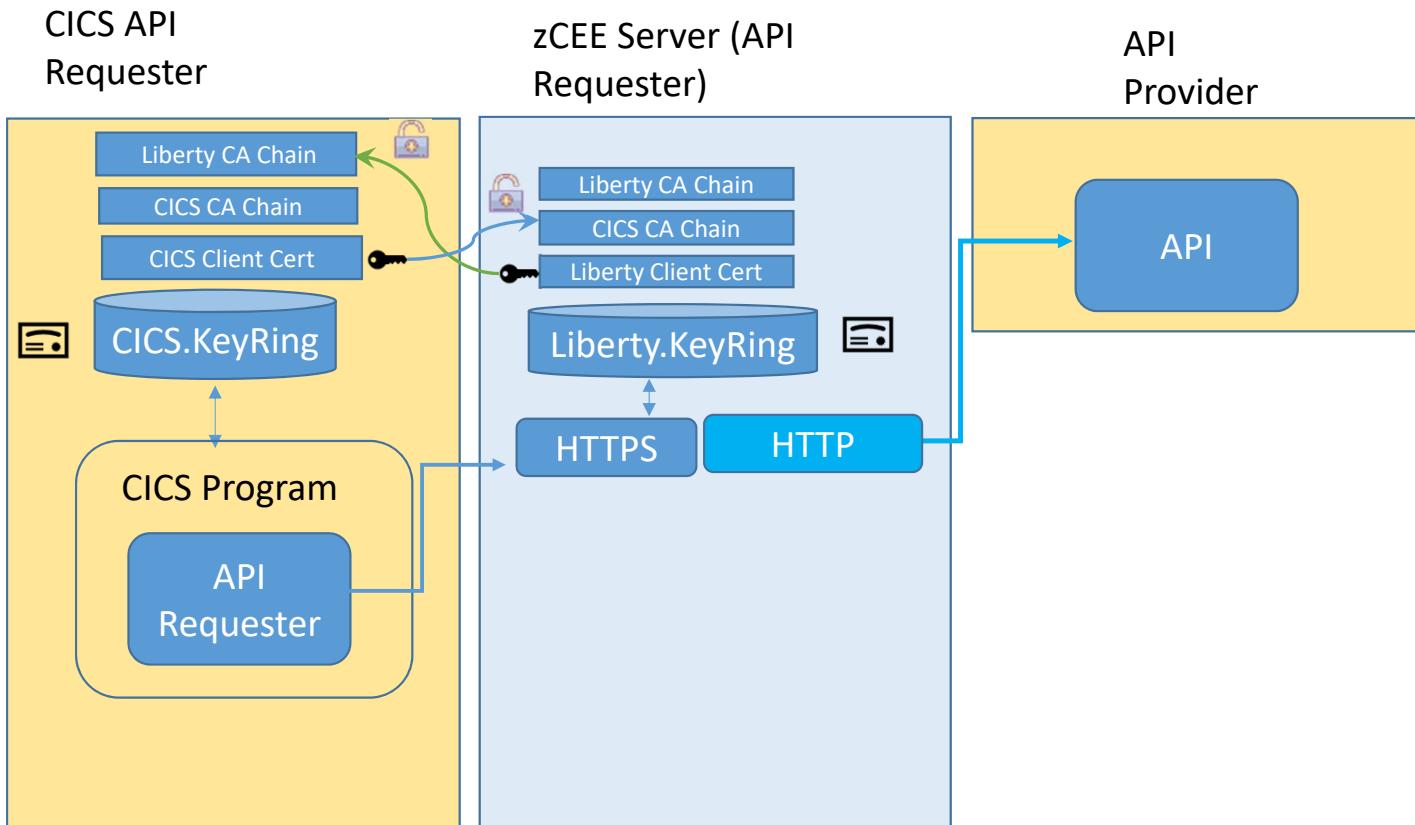
API Provider



# TLS Handshake Flow



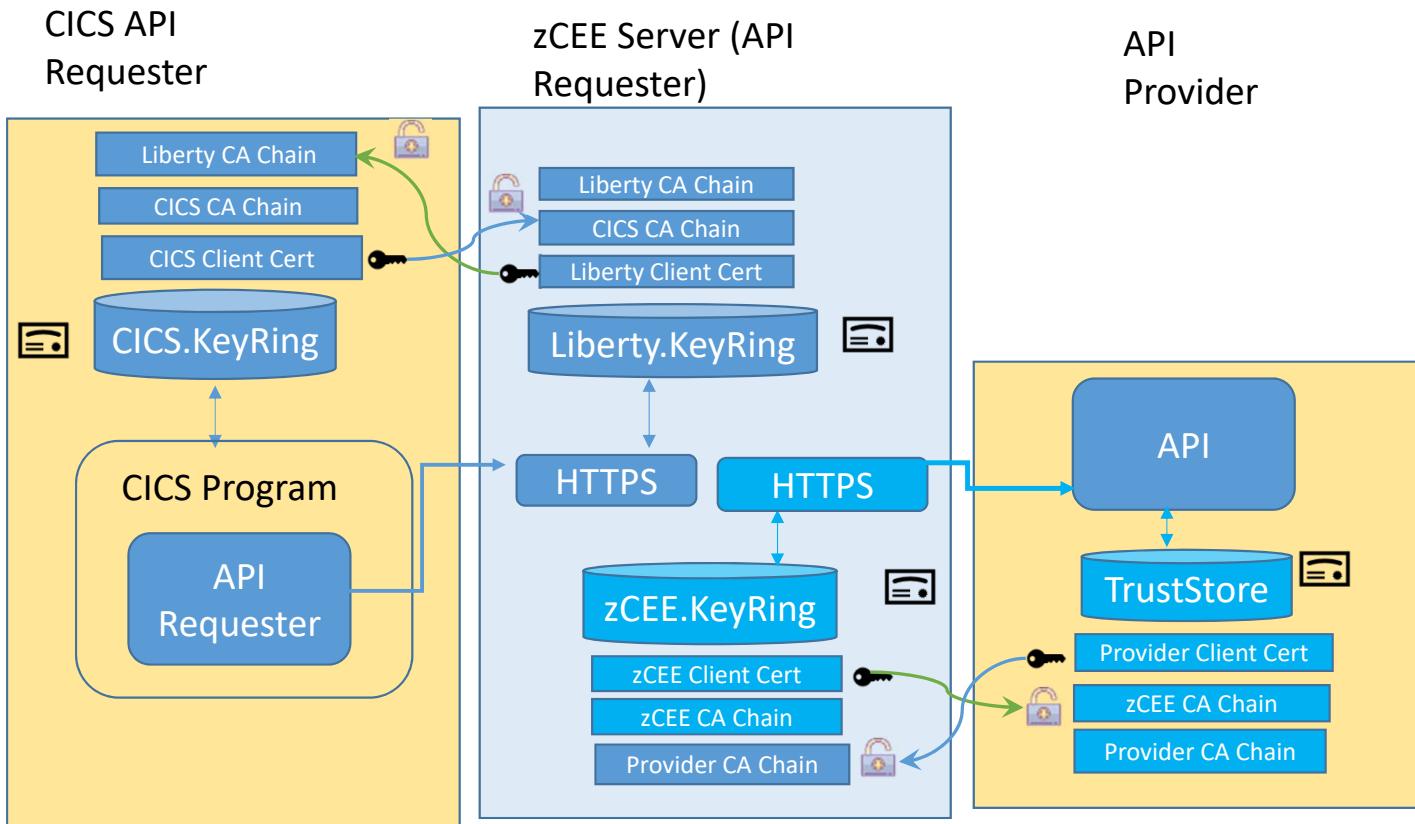
z/OS Connect EE



# TLS Handshake Flow



z/OS Connect EE



# Cyphers



z/OS Connect EE

- 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

- 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"/>

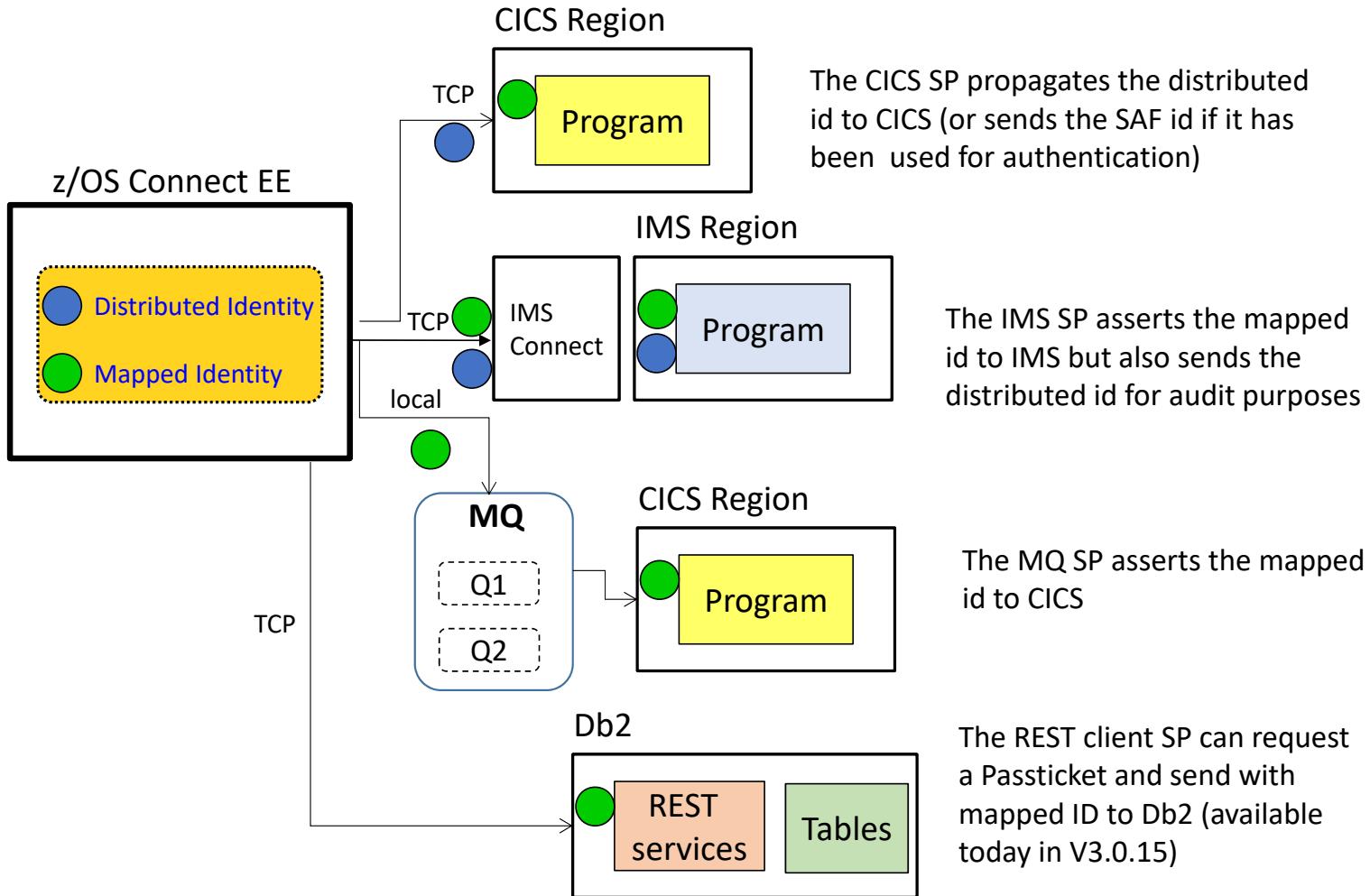
<sslOptions id="mySSLOptions" sslRef="DefaultSSLSettings"
sslSessionTimeout="10m" />
```

- 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

## Flowing an identity to the back end



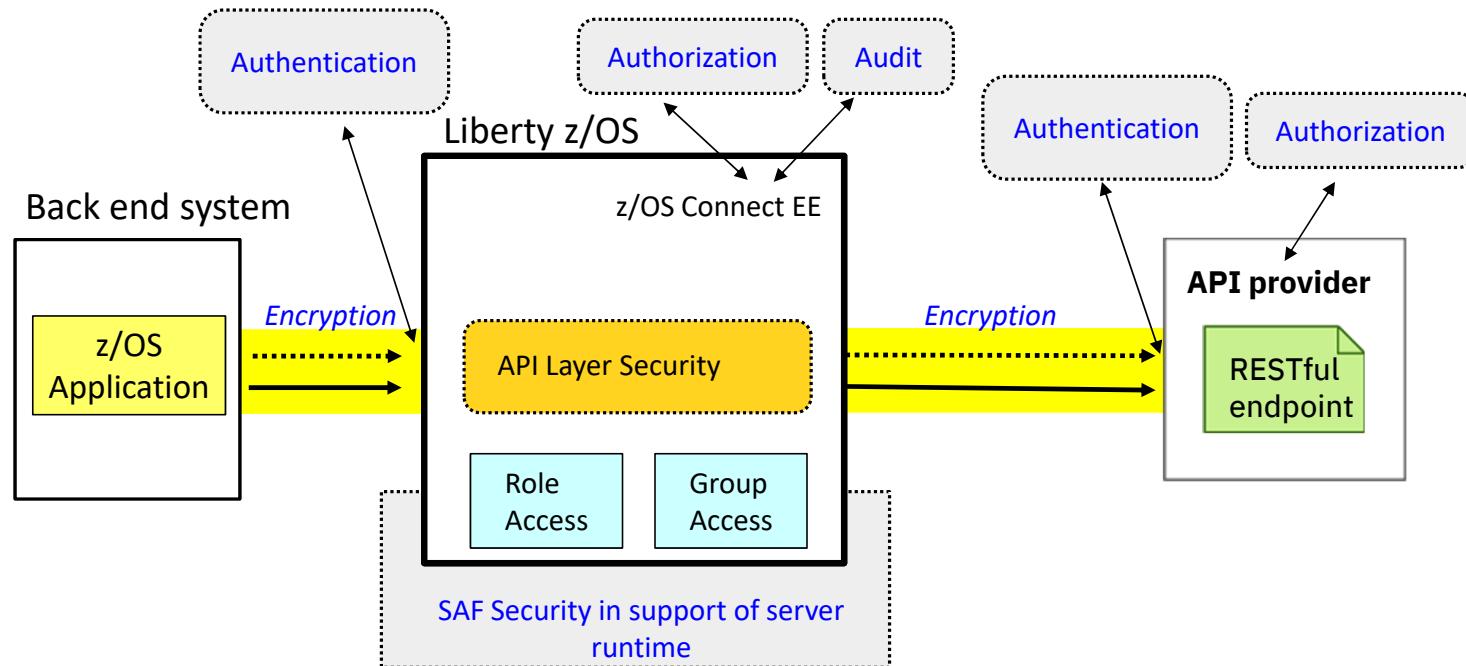
z/OS Connect EE



# API requester security – overview

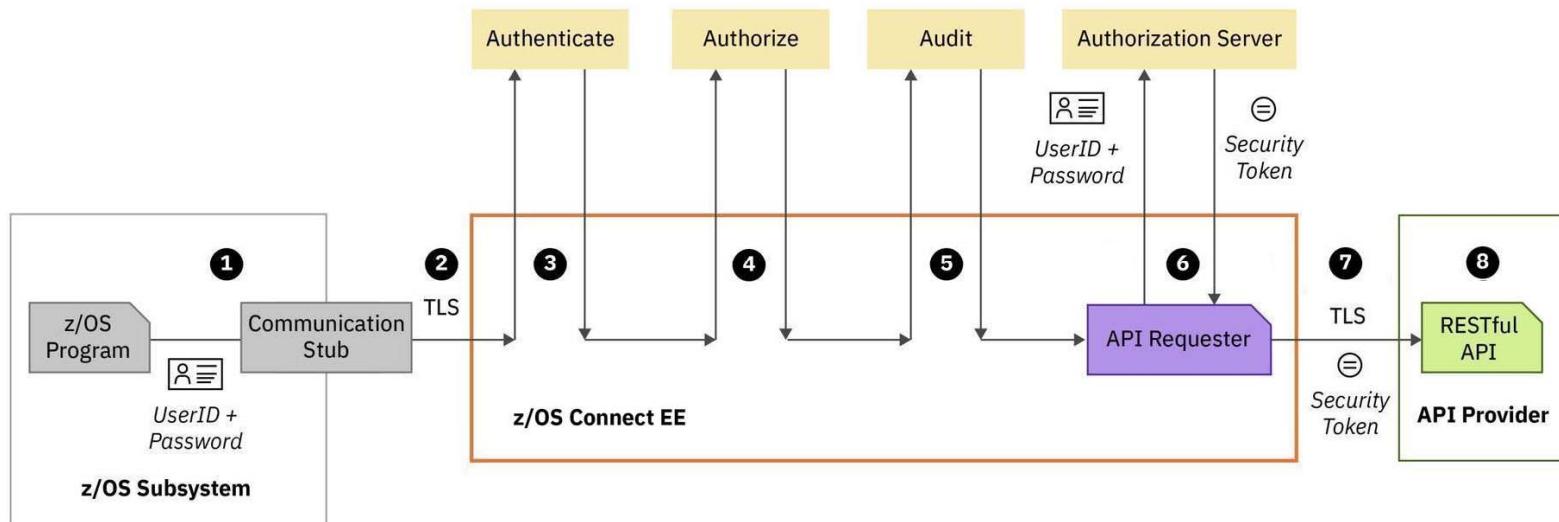


z/OS Connect EE



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

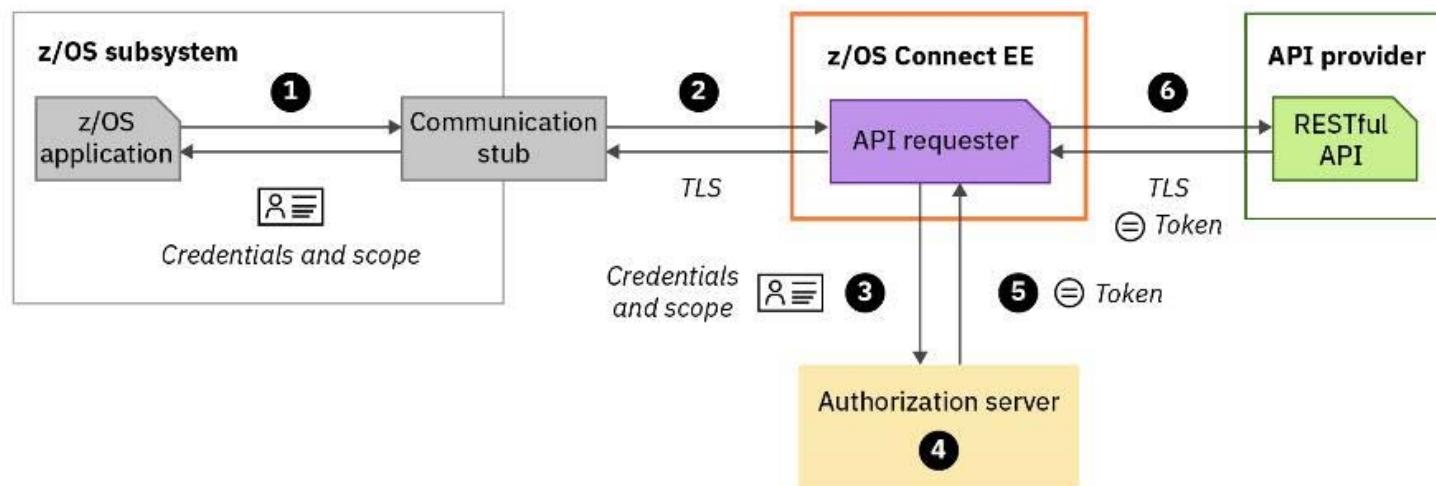


1. A user ID and password can be used for basic authentication by the z/OS Connect EE server
2. Connection between the CICS, IMS, or z/OS application and the z/OS Connect EE server can use TLS
3. Authenticate the CICS, IMS, or z/OS application.
4. Authorize the authenticated user ID to connect to z/OS 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

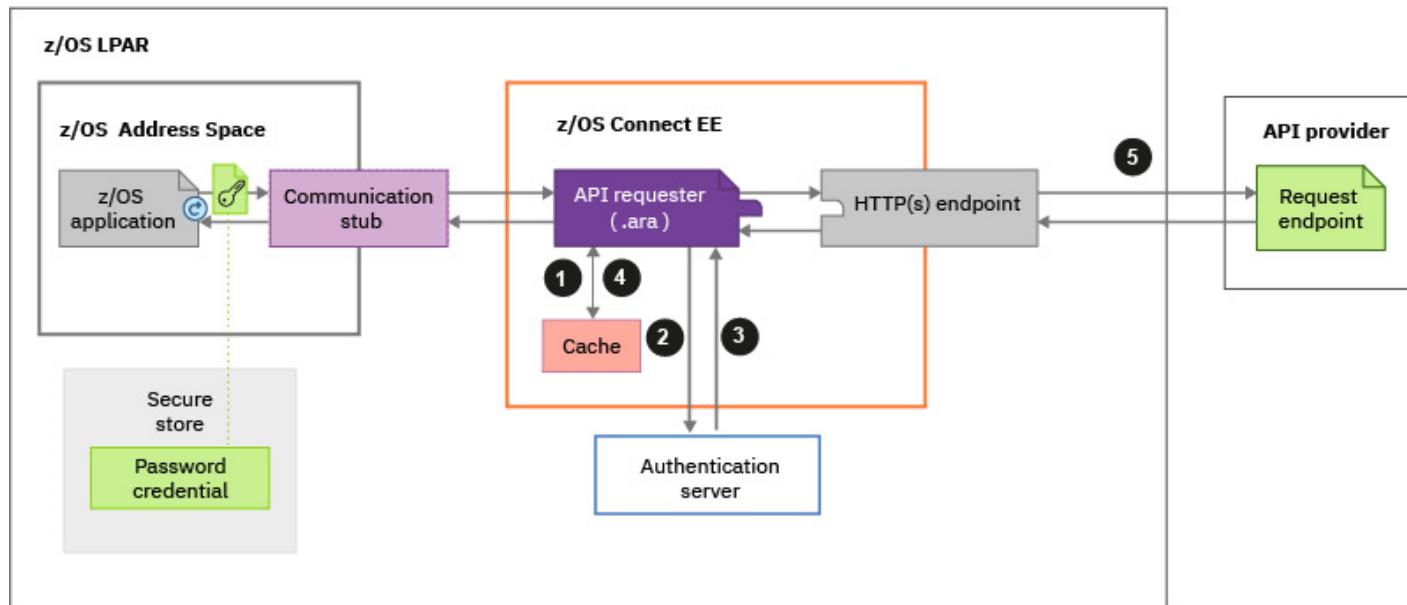


MOVE user TO BAQ-OAUTH-USERNAME  
MOVE password TO BAQ-OAUTH-PASSWORD

# Calling an API with JWT support



z/OS Connect EE



MOVE user TO BAQ-TOKEN-USERNAME

MOVE password TO BAQ-TOKEN-PASSWORD



## /questions?thanks=true

Thank you for listening.

- Material can be downloaded from:  
<http://tinyurl.com/y28fsezs>
- z/OS Connect EE Users Group  
<https://www.linkedin.com/groups/8731382/>