



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 z/OS resources, e.g.
 - CICS
 - Db2
 - IMS/TM
 - IMS/DB
 - MQ
 - MVS Batch
 - Outbound REST APIs
 - IBM DVM
 - Host Access Transformation Services (3270 screen-based applications)
 - IBM File Manager
- A brief overview of z/OS Connect Security*

*For more on security, contact your local IBM rep regarding the schedule of workshop *zOSSEC1 IBM z/OS Connect Administration/Security Wildfire Workshop*

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⁺

HATS(3270)

IBM DVM⁺

MVS

WAS

Custom*

+ HCL and Rocket Software

*Other Vendors or your own implementation

/but_first, what_is_REST?

What makes an API “RESTful”?

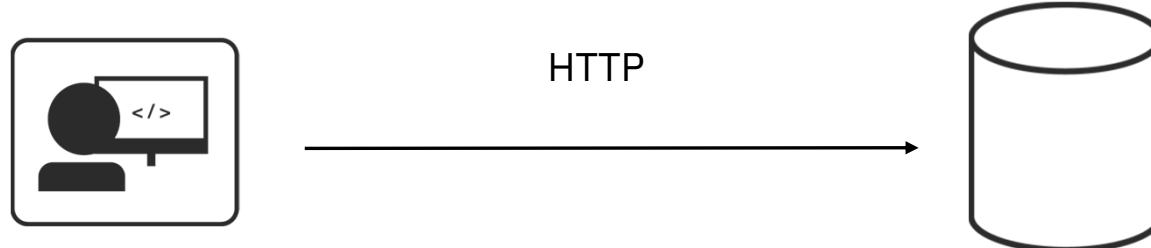
REST is architectural programming style

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

An architectural programming style for **accessing** and **updating** data over the internet.

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

Use Path and Query parameters to refine the request

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

URI path identifies a resource (or lists of resources)

Request/Response Body is used to represent the data object

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



REST vs RESTful

REST is an architectural style of development having these principles plus..

- It should be stateless (transaction management should be managed by the client)
- It should access and/or identify all server resources using only a single 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 consistent and simple JSON

When an API follows these basic principles, it is considered a RESTful API, whereas a REST API only follows some but not all of the above principles

- Remember - Not all REST APIs are RESTful APIs
- The key is consistency, RESTful APIs are consistent with these basic principles, REST APIs are not

RESTful Examples



z/OS Connect EE

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

GET /account?number=1234

PUT /account/1234 +  (*a JSON request message 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 an API is not RESTful)

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 (update, etc.) embedded in the request body

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



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

Why is REST popular?

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

How do we describe a REST API?



/swagger/open_api

The industry standard framework for describing RESTful APIs is by a
Swagger document

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



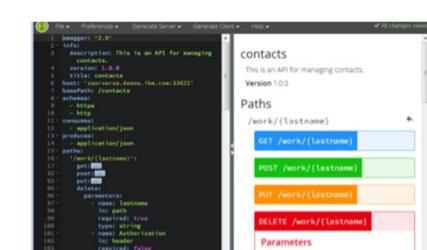
Read Swagger⁺

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



Write Swagger

Swagger Editor allows API developers to design their swagger documents.



* z/OS Connect API Requester

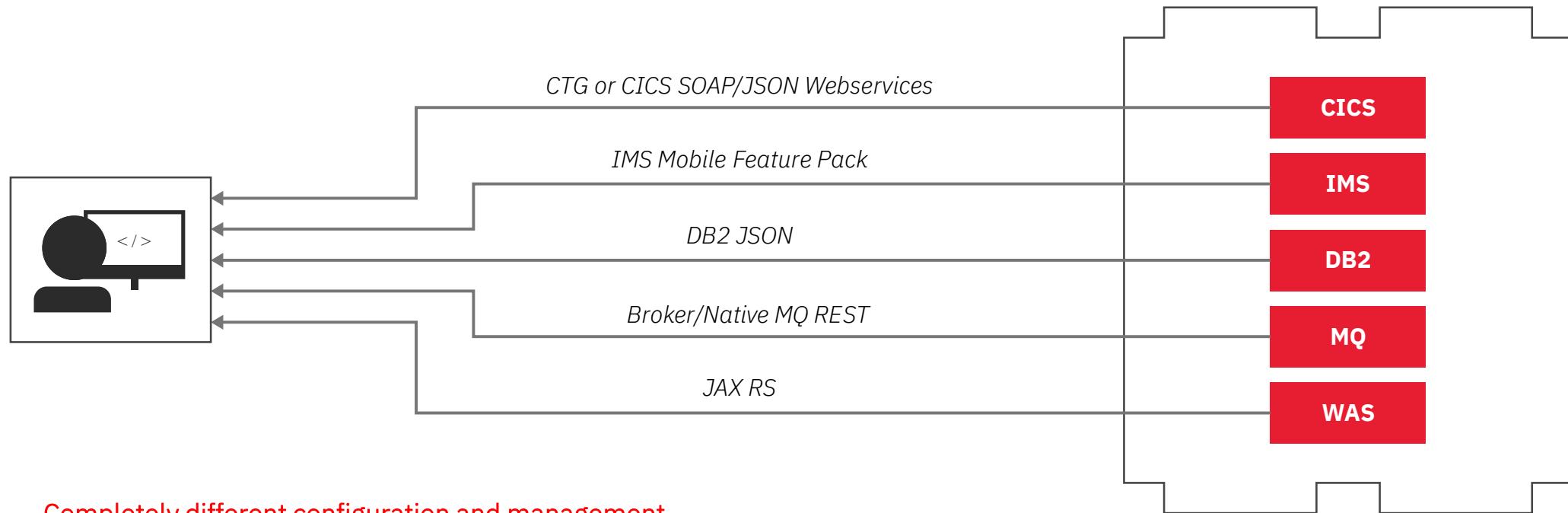
+z/OS Connect, MQ REST support, Zowe



Why /zos_connect_ee?

Truly RESTful APIs to and from your mainframe.

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



Completely different configuration and management.

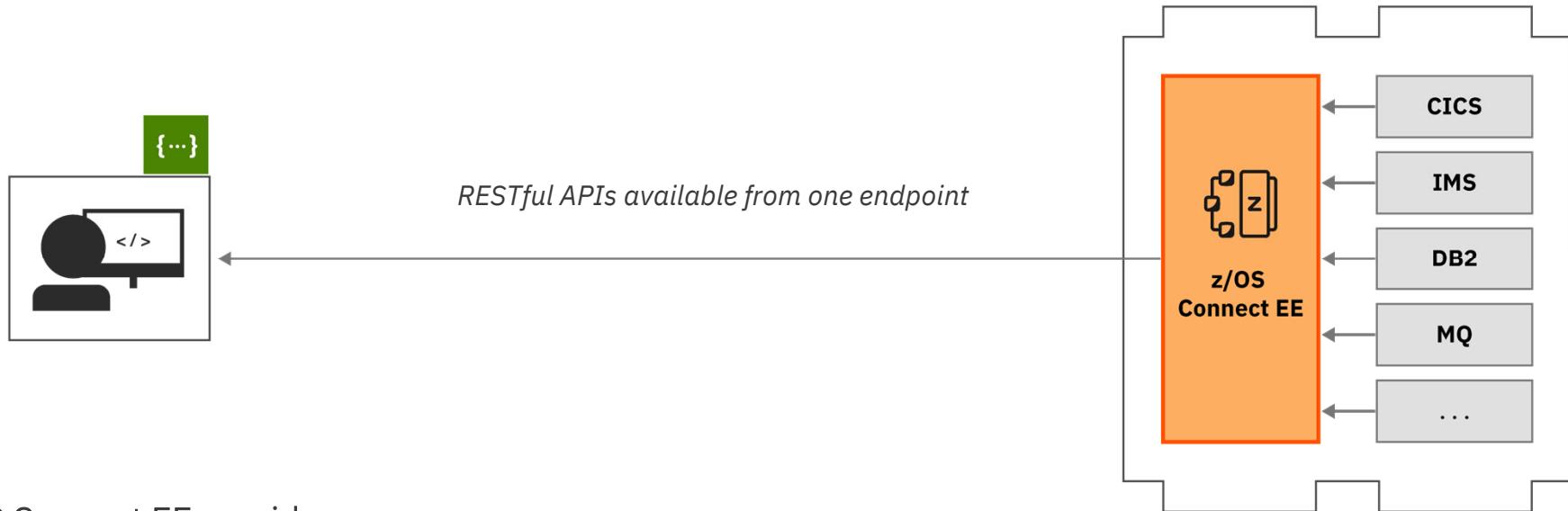
Multiple endpoints for developers to call/maintain access to.

These are typically not RESTful!



z/OS Connect provides a single-entry point

To expose z/OS resources without writing any code.



z/OS Connect EE provides

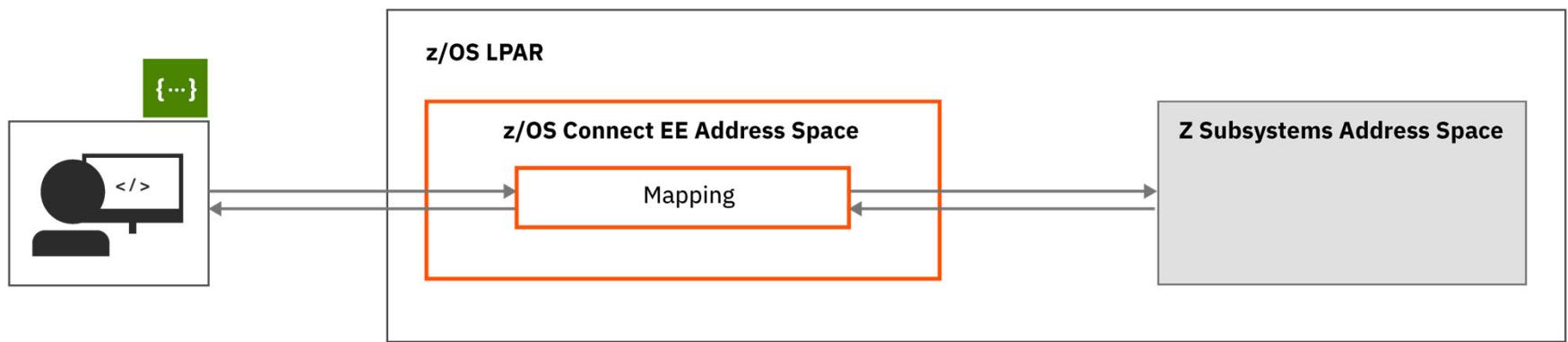
- Single Configuration Administration
- Single Security Administration
- With sophisticated mapping of truly RESTful APIs to existing mainframe and services data without writing any code.



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

Let's Start with Data mapping

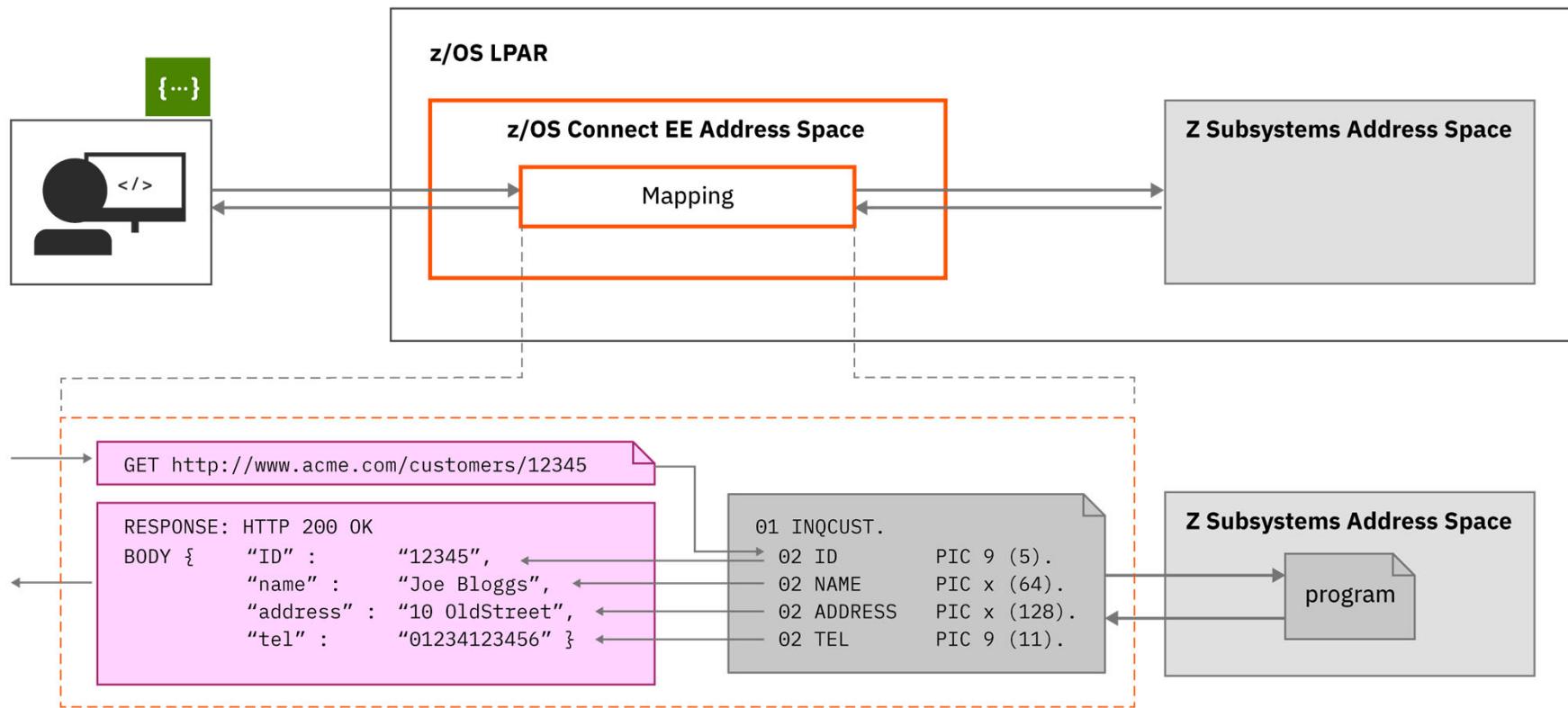
Converting the JSON message to the format the target's subsystem expects*.



* Most z/OS subsystems depend on information in a serial data format and do not normally work with JSON request/response messages. Examples of non-JSON formats are CICS COMMAREAAs and CONTAINERS, IMS or MQ messages, or records stored in sequential or VSAM data sets. Data mapping and transformation refers to the process of converting JSON messages to a serialized layout (e.g., sequentially arranged in storage).

Data mapping Example

A closer look



Tech-Tip: Behind the curtains, COBOL to JSON schema example



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

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

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>  
<ns2:message xmlns:ns2="http://www.ibm.com/ims/Transaction" transactionCode="" messageName="miniloanRequest" direction="0" serviceType="0">  
    <message id="1" name="miniloanRequest">  
        <segment id="1" name="COMMAREA" originalName="COMMAREA" included="Y" path="MINILOAN_COMMAREA">  
            <field name="MINILOAN_COMMAREA" originalName="MINILOAN_COMMAREA" included="Y" path="MINILOAN_COMMAREA.NAME">  
                <startPos>1</startPos>  
                <bytes>736</bytes>  
                <maxBytes>0</maxBytes>  
                <applicationDatatype datatype="STRUCT"/>  
                <field name="NAME" originalName="NAME" included="Y" path="MINILOAN_COMMAREA.NAME">  
                    <startPos>1</startPos>  
                    <bytes>20</bytes>  
                    <maxBytes>20</maxBytes>  
                    <applicationDatatype datatype="CHAR"/>  
                </field>  
                <field name="CREDITSCORE" originalName="CREDITSCORE" included="Y" path="MINILOAN_COMMAREA.CREDITSCORE">  
                    <startPos>21</startPos>  
                    <bytes>18</bytes>  
                    <maxBytes>18</maxBytes>  
                    <marshaller isSigned="N" isSignLeading="N" isSignSeparate="N" isWCHAROnly="N">  
                        <typeConverter>ZONEDDECIMAL</typeConverter>  
                    </marshaller>  
                    <applicationDatatype datatype="DECIMAL" precision="18" scale="2"/>  
                </field>
```

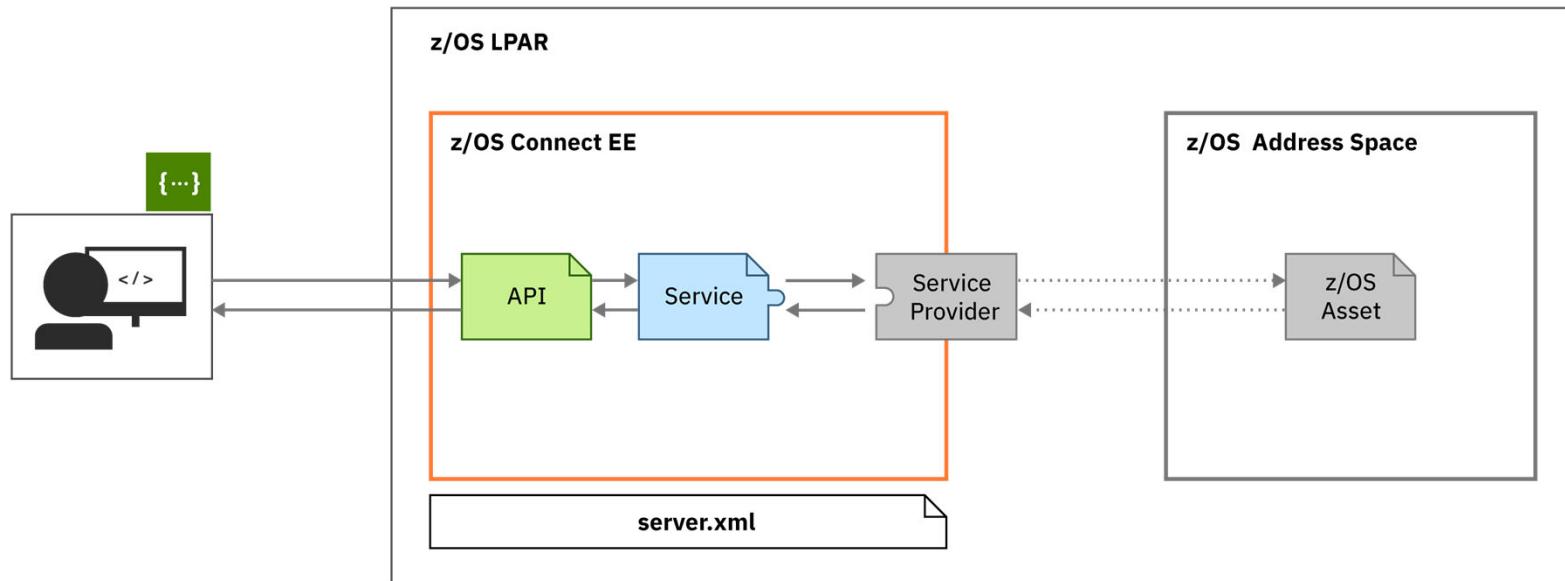
```
    "name": "Mitch Johnson",  
    "creditScore": "72000"
```

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

https://www.ibm.com/support/knowledgecenter/en/SSEPEK_10.0.0/char/src/tpc/db2z_endianness.html

Steps to expose a z/OS application

z/OS Connect does not use a single monolithic interface – but rather separate plug-and-play components



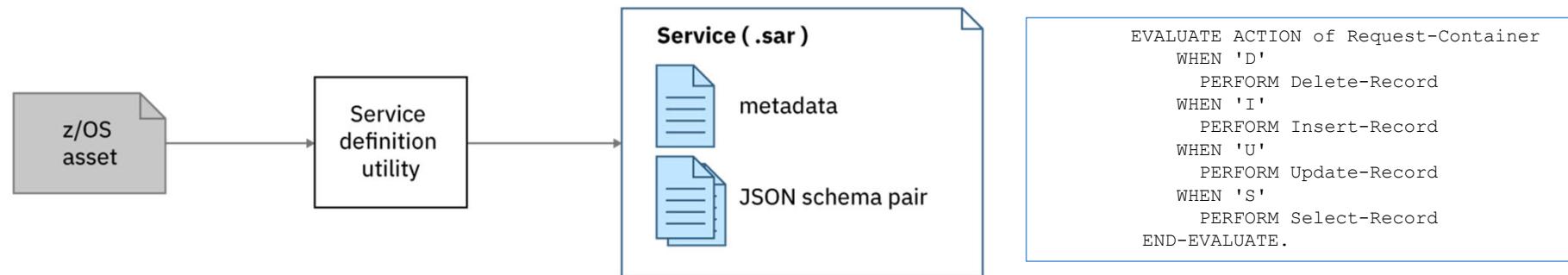
- The API provides the RESTful interface is ready to be consumed by a client and it requires no knowledge that a z/OS resource is being accessed
- The Service provides meta data specific to the z/OS Asset (e.g., CICS program, MQ queue manager, etc.)
- The Service Provider is tightly coupled to a specific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

Steps to expose a z/OS application

1. Start by creating a service to represent an interaction with the resource

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

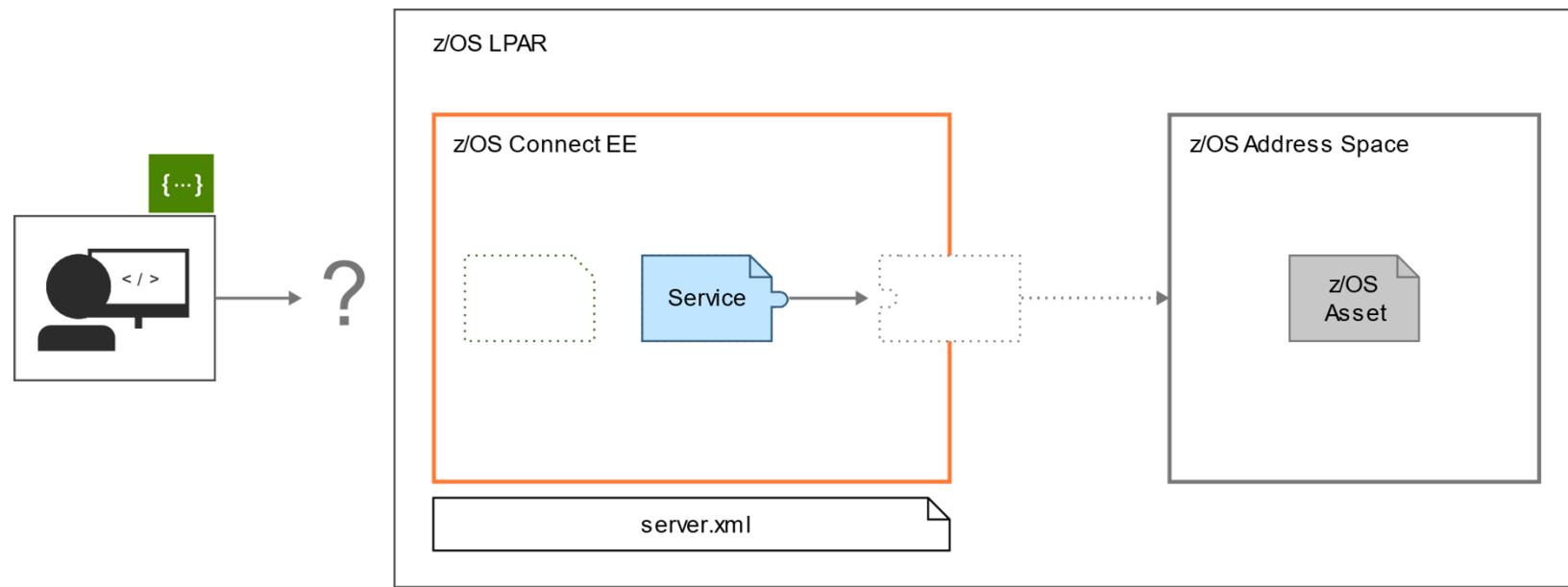


Use a system-appropriate utility to generate a service archive file for the z/OS application

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

Steps to expose a z/OS application

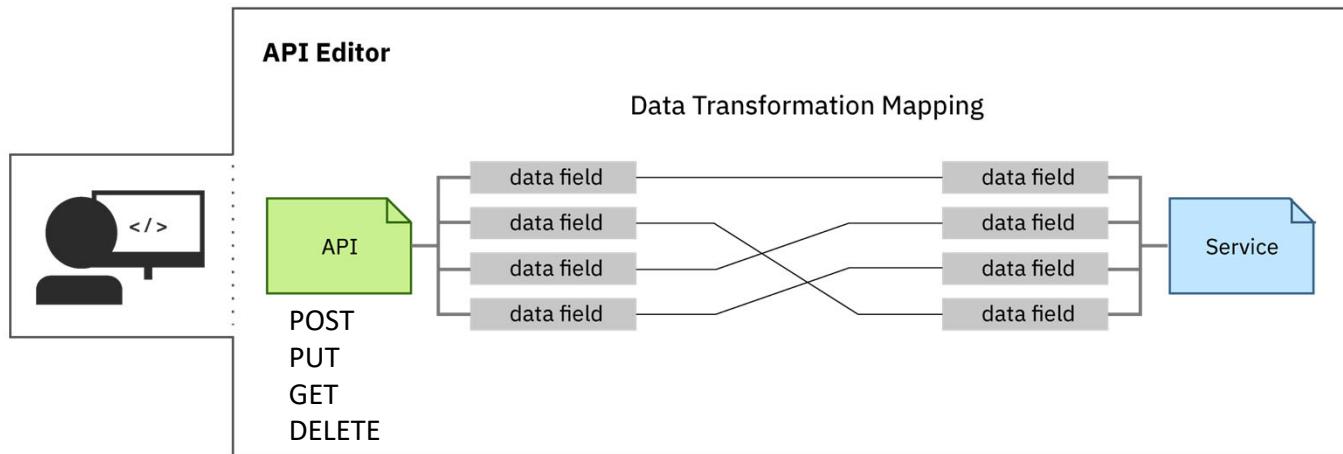
2. Deploy and export the service



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

Steps to expose a z/OS application

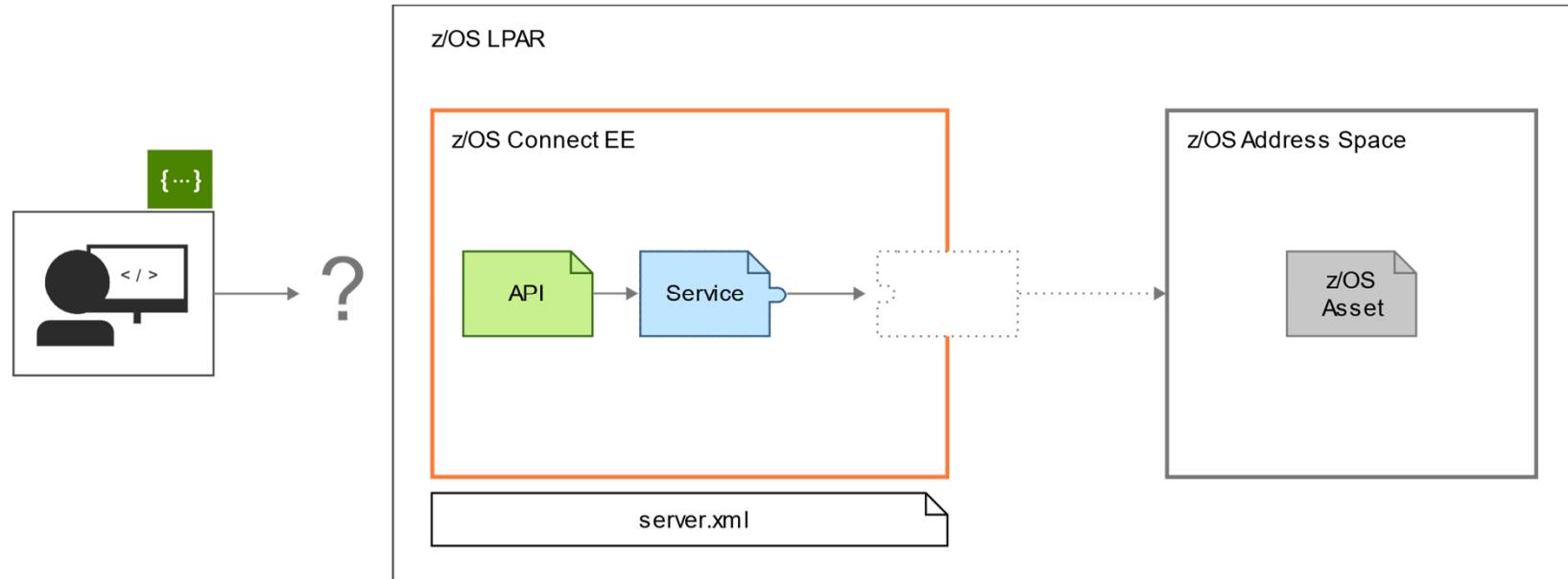
3. Export the service and then import it to create an API that consumes the service



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

Steps to expose a z/OS application

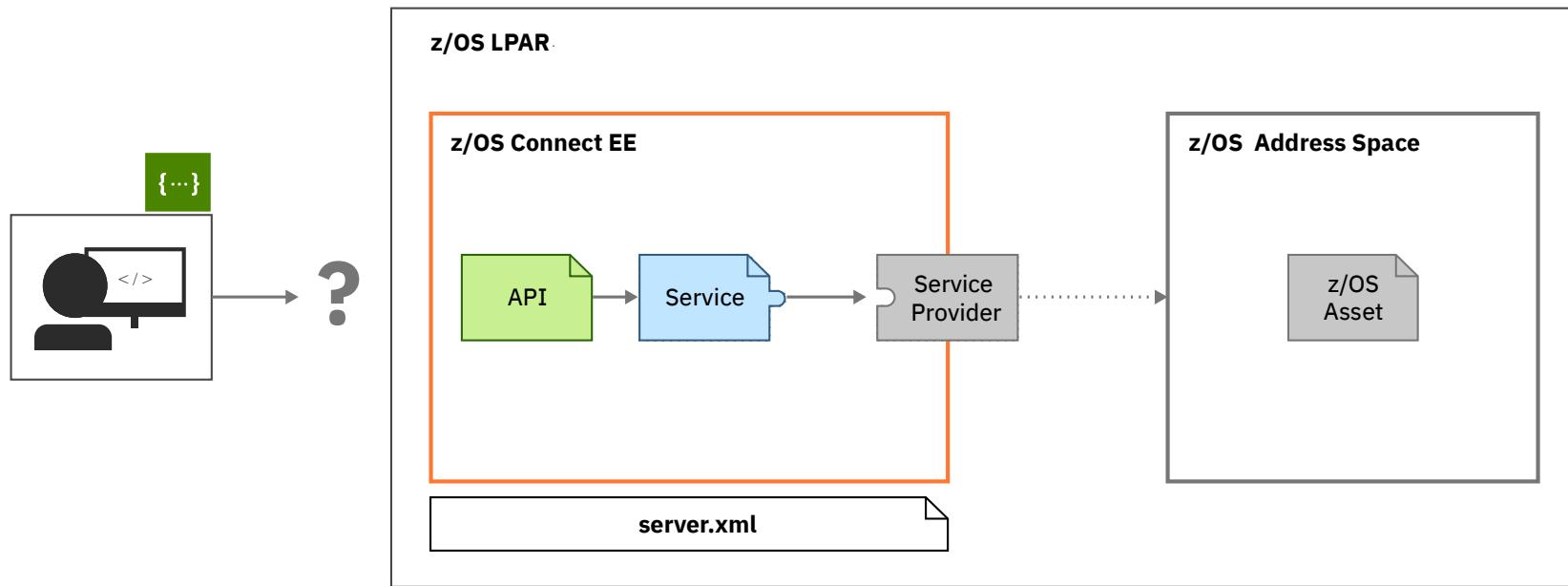
4. Deploy the API



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

Steps to expose a z/OS application

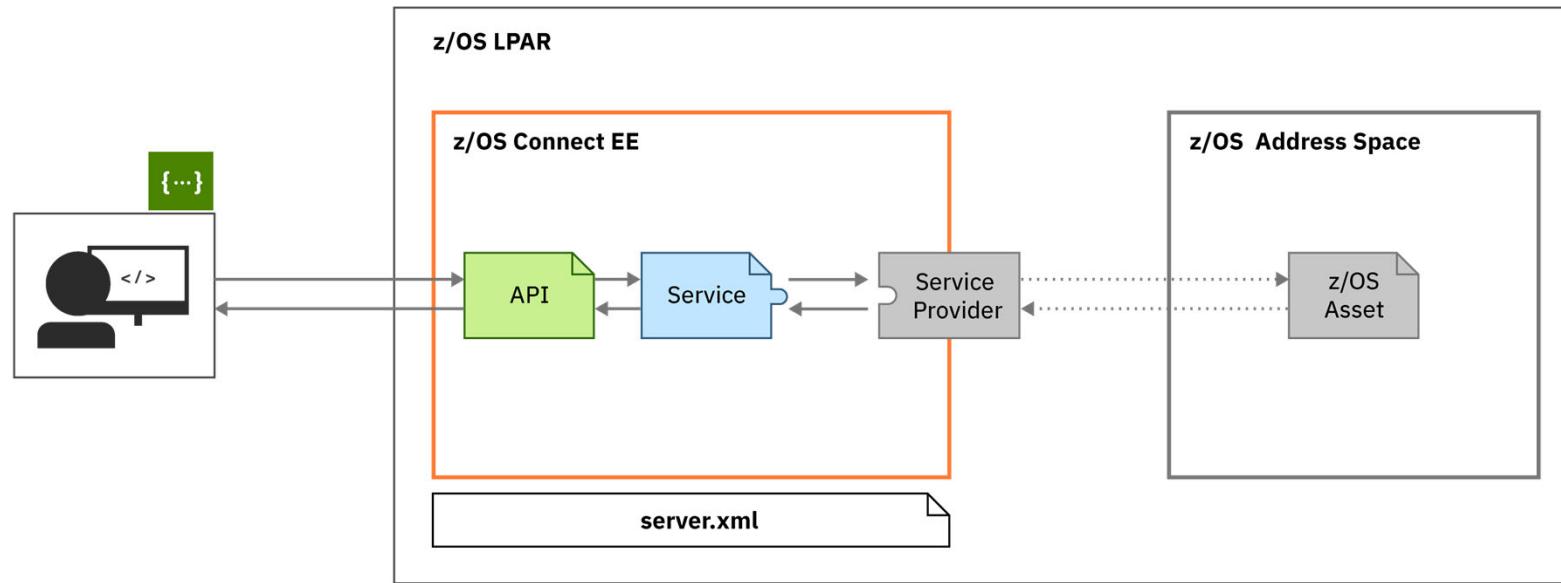
5. Configure the service provider



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

Steps to expose a z/OS application

6. Done



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

Results: the client code is totally unaware of the z/OS infrastructure



z/OS Connect EE

CICS

```

55 // Invoke the REST API using a GET method
56 URL url = new URL("https://wg31.washington.ibm.com:9453/cscvinc/employee/" + args[1]);
57 System.out.println("URL: " + url);
58 HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();
59 conn.setRequestMethod("GET");
60 conn.setRequestProperty("Content-Type", "application/json");
61 byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());
62 conn.addRequestProperty("Authorization", "Basic " + new String(bytesEncoded));
63 try {
64     if (conn.getResponseCode() != 200) {
65         throw new RuntimeException("Failed : HTTP error code : " + conn.getResponseCode());
66     }
67     BufferedReader bufferReader = new BufferedReader(new InputStreamReader((conn.getInputStream())));
68     while ((output = bufferReader.readLine()) != null) {
69         System.out.println(output);
70     }
71 }
72 
```

Problems @ Javadoc Declaration Console Coverage

<terminated> ZceeCICSGet [Java Application] C:\Program Files\IBM\Java80\jre\bin\javaw.exe (May 7, 2021, 2:54:24 PM)

URL: https://wg31.washington.ibm.com:9453/cscvinc/employee/22222

USERID: CICSUMER

CEIBRESP0: 0

CEIBRESP2: 0

name: DR E. GRIFFITHS

employeeNumber: 22222

amount: \$0022.00

address: FRANKFURT, GERMANY

phoneNumber: 20034151

date: 26 11 81

Response Message: {"cscvincSelectServiceOperationResponse": {"cscvincContainer": {"response": {"CEIBRESP0": "0", "USERID": "CICSUMER", "CEIBRESP2": "0", "name": "DR E. GRIFFITHS", "employeeNumber": "22222", "amount": "\$0022.00", "address": "FRANKFURT, GERMANY", "phoneNumber": "20034151", "date": "26 11 81"}}}

Db2

```

52 // Invoke the REST API using a GET method
53 URL url = new URL("https://wg31.washington.ibm.com:9453/db2/employee/" + args[1]);
54 System.out.println("URL: " + url);
55 HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();
56 conn.setRequestMethod("GET");
57 conn.setRequestProperty("Content-Type", "application/json");
58 byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());
59 conn.addRequestProperty("Authorization", "Basic " + new String(bytesEncoded));
60 try {
61     if (conn.getResponseCode() != 200) {
62         throw new RuntimeException("Failed : HTTP error code : " + conn.getResponseCode());
63     }
64     BufferedReader bufferReader = new BufferedReader(new InputStreamReader((conn.getInputStream())));
65     while ((output = bufferReader.readLine()) != null) {
66         System.out.println(output);
67     }
68 }
69 
```

Problems @ Javadoc Declaration Console Coverage

<terminated> ZceeMqPut [Java Application] C:\Program Files\IBM\Java80\jre\bin\javaw.exe (May 7, 2021, 2:56:06 PM)

URL: https://wg31.washington.ibm.com:9453/db2/employee/000010

Employee Number: 000010

First Name : CHRISTINE

Last Name: HAAS

Middle Initial: I

Phone Number: 3200

IMS

```

53 URL url = new URL("https://wg31.washington.ibm.com:9453/phonebook/contacts/" + args[1]);
54 System.out.println("URL: " + url);
55 HttpURLConnection conn = (HttpURLConnection) url.openConnection();
56 conn.setRequestMethod("GET");
57 conn.setRequestProperty("Content-Type", "application/json");
58 byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());
59 conn.addRequestProperty("Authorization", "Basic " + new String(bytesEncoded));
60 
```

Problems @ Javadoc Declaration Console Coverage

<terminated> ZceeIMSGet [Java Application] C:\Program Files\IBM\Java80\jre\bin\javaw.exe (May 7, 2021, 8:53:07 AM)

URL: https://wg31.washington.ibm.com:9453/mqapi/

NAME: TINA J YOUNG

NUMB: 001781

ADDRX: SINDELINGEN, GERMANY

PHONE: 70319990

DATEX: 21 06 77

AMOUNT: \$0009.99

message: ENTRY WAS DISPLAYED

HTTP code: 200



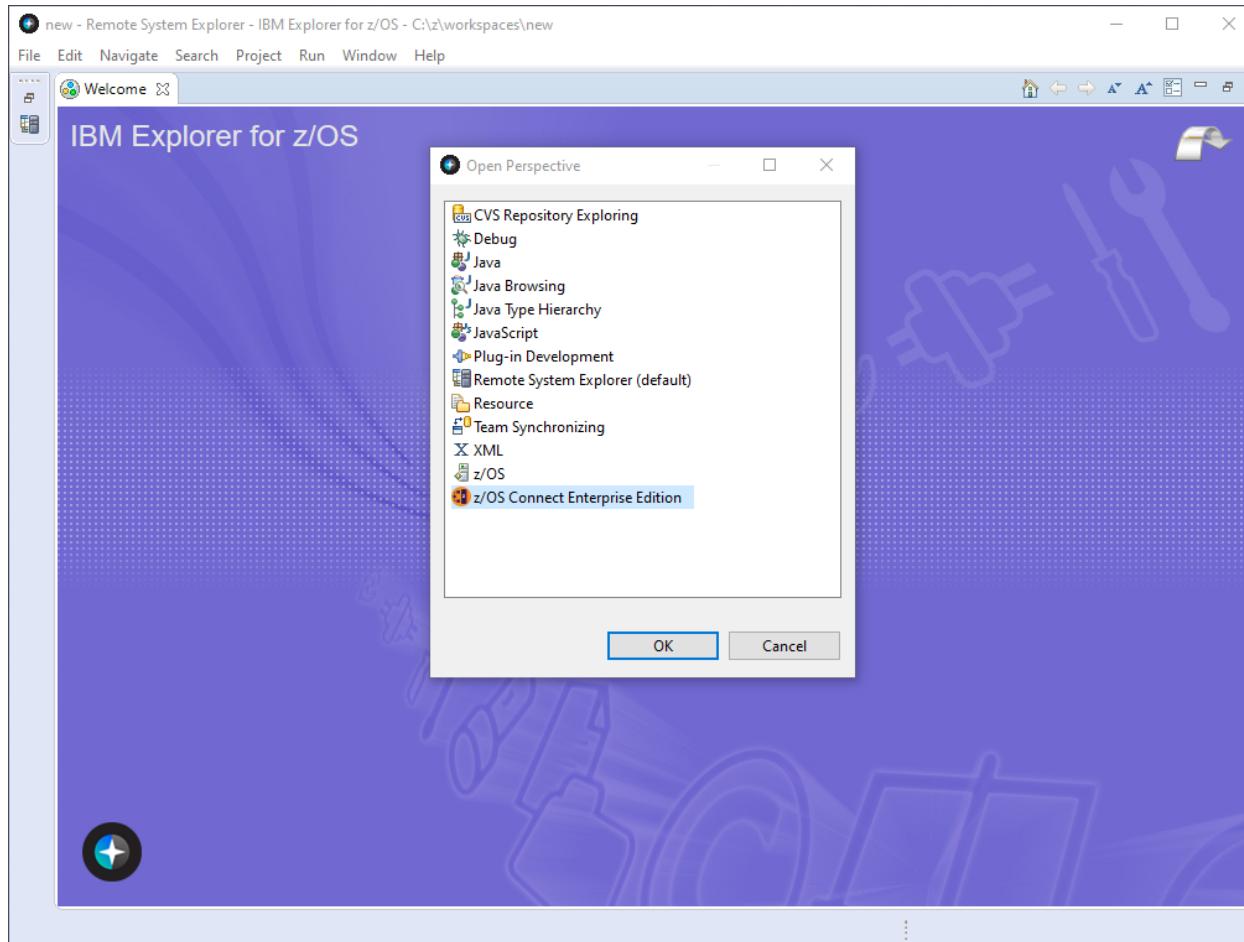
/api_toolkit/services

Simple **service creation.**

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



z/OS Connect EE



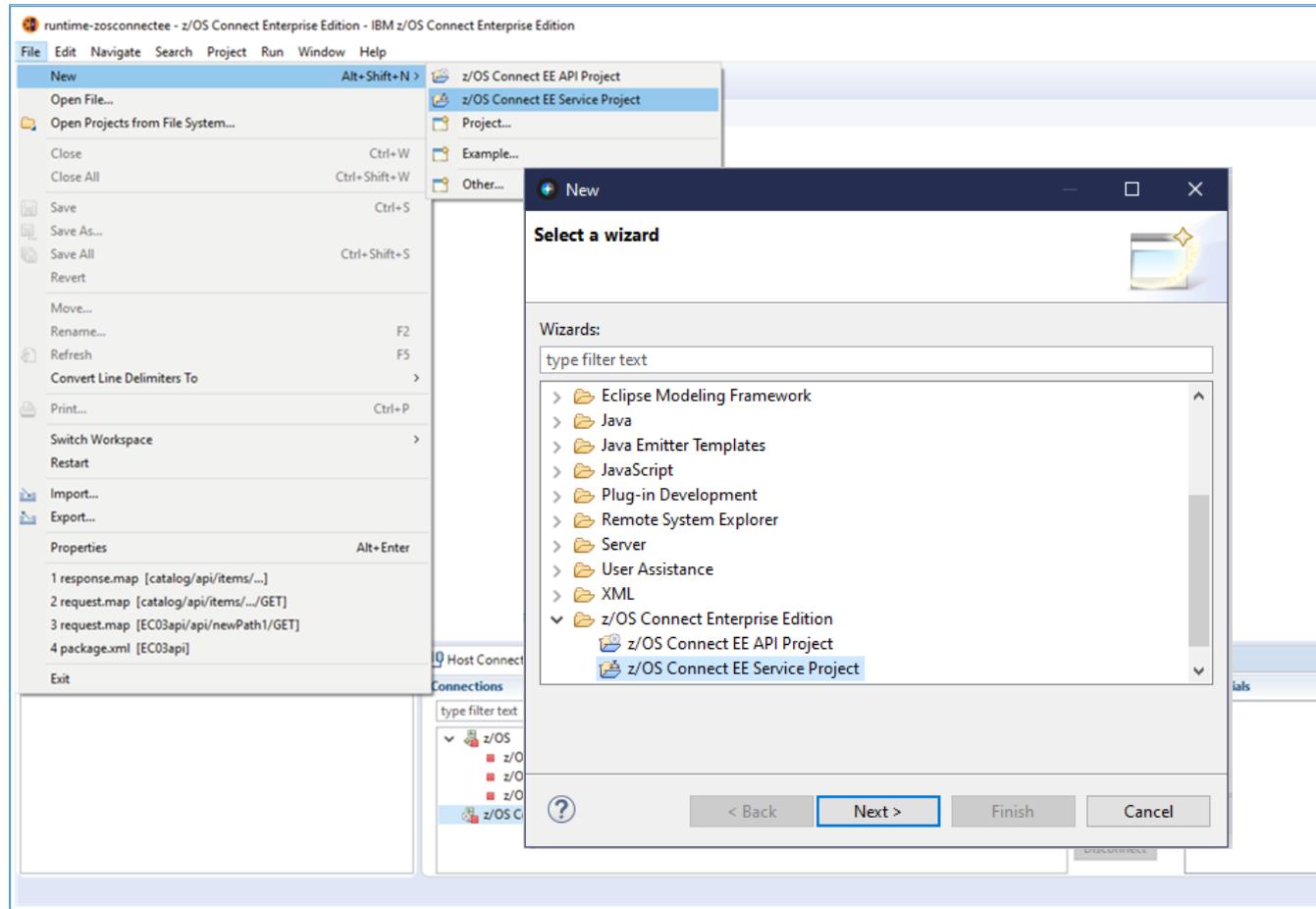
Use the **API toolkit** to create services through Eclipse-based tooling.

The API toolkit is available in the z/OS Connect Enterprise Edition Perspective in an Eclipse environment.

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



z/OS Connect EE

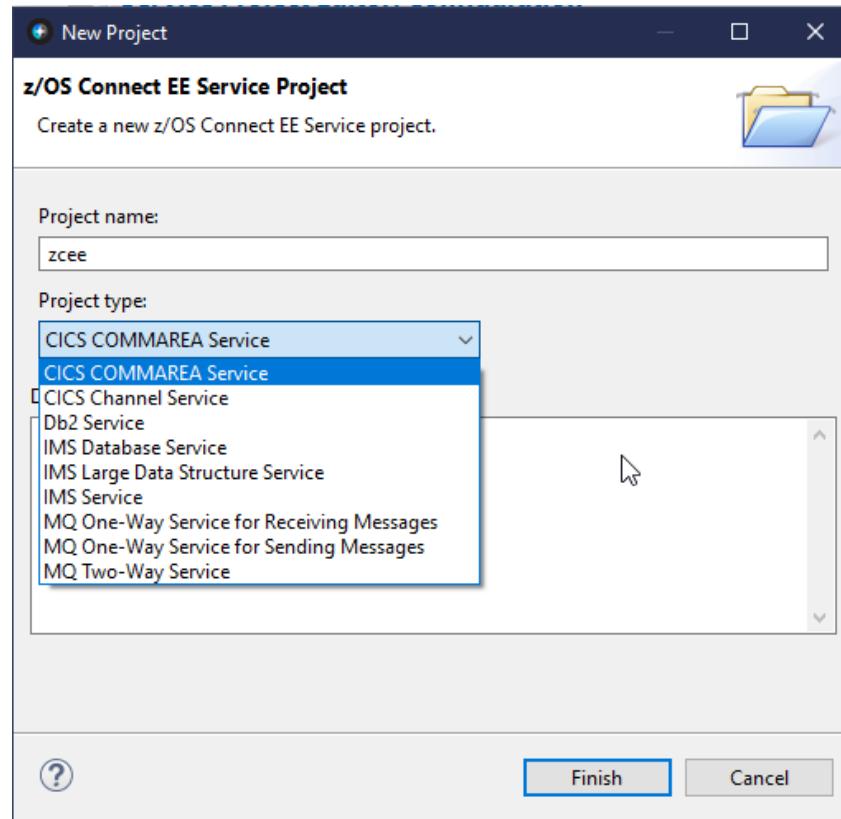


Use the **API toolkit** to create services through Eclipse-based tooling.

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

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

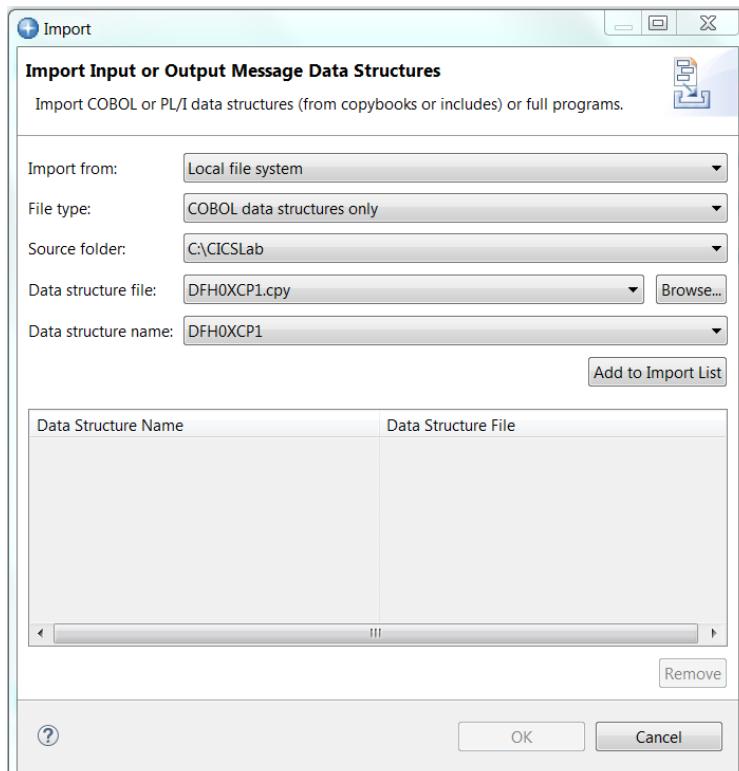
Service creation – a common interface



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

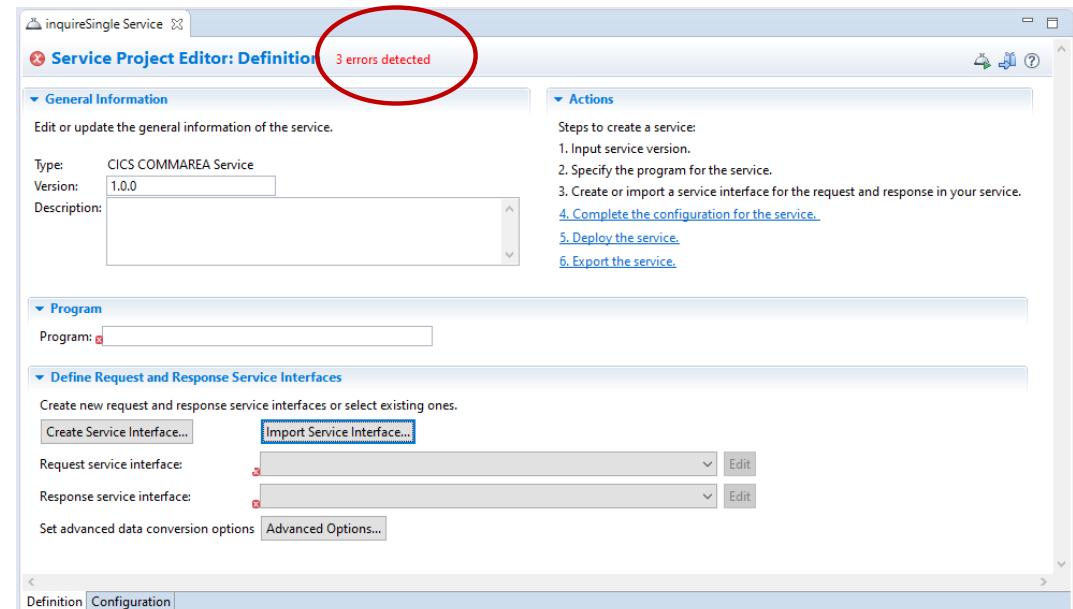
API toolkit – Creating Services for CICS, IMS TM and MQ

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



Start by importing data structures into the service interface from the local file system or the workspace to create the request and response service interfaces.

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

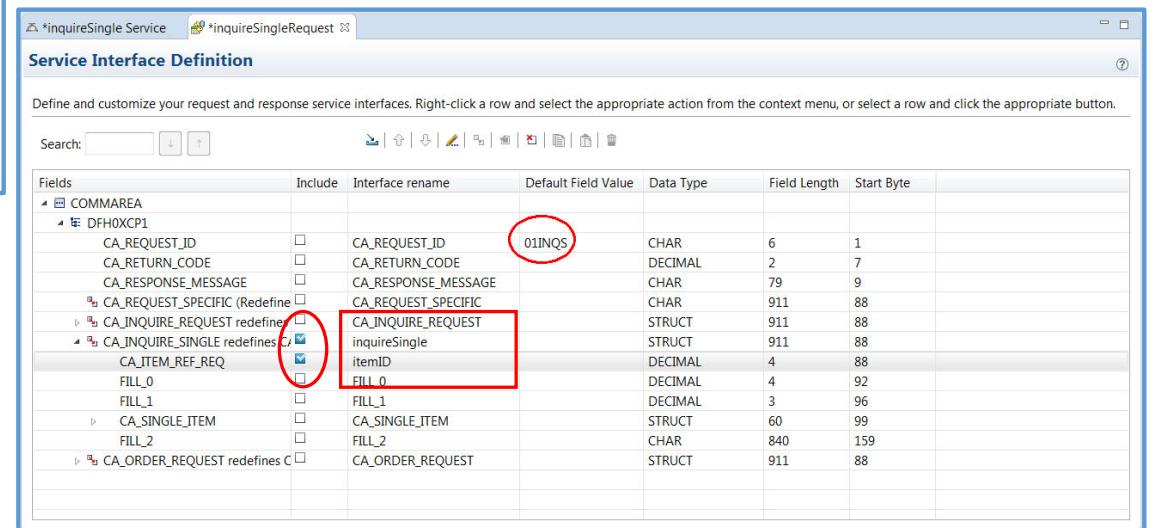


API toolkit – Creating Services for CICS, IMS TM and MQ

Allows editing a request service interface definition

```
-----*
* Check which operation is being requested
*-----*
* Uppercase the value passed in the Request Id field
  MOVE FUNCTION UPPER-CASE(CA-REQUEST-ID) TO CA-REQUEST-ID
  EVALUATE CA-REQUEST-ID
    WHEN '01INQC'
      Call routine to perform for inquire
      PERFORM CATALOG-INQUIRE
    WHEN '01INQS'
      Call routine to perform for inquire for single item
      PERFORM CATALOG-INQUIRE-SINGLE
    WHEN '01ORDR'
      Call routine to place order
      PERFORM PLACE-ORDER
    WHEN OTHER
      Request is not recognised or supported
      PERFORM REQUEST-NOT-RECOGNISED
  END-EVALUATE
```

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



The screenshot shows a software interface titled "Service Interface Definition". It displays a table of fields for a service named "*inquireSingle Service". The table has columns for Fields, Include, Interface rename, Default Field Value, Data Type, Field Length, and Start Byte. A red box highlights the "Interface rename" column for the CA_INQUIRE_REQUEST field, which is set to "inquireSingle". Another red box highlights the "Default Field Value" column for the same field, which is set to "01INQS". The table also lists other fields like CA_REQUEST_ID, CA_RETURN_CODE, CA_RESPONSE_MESSAGE, CA_REQUEST_SPECIFIC, CA_ITEM_REF_REQ, and CA_ORDER_REQUEST.

Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
COMMAREA						
DFHXCPI						
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 redefine	<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"/>	itemID		DECIMAL	4	88
FILL_0	<input type="checkbox"/>	FILL_0		DECIMAL	4	92
FILL_1	<input type="checkbox"/>	FILL_1		DECIMAL	3	96
CA_SINGLE_ITEM	<input type="checkbox"/>	CA_SINGLE_ITEM		STRUCT	60	99
FILL_2	<input type="checkbox"/>	FILL_2		CHAR	840	159
CA_ORDER_REQUEST redefines CA_INQUIRE_REQUEST	<input type="checkbox"/>	CA_ORDER_REQUEST		STRUCT	911	88

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

And editing a response message service interface definition

*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	<input type="checkbox"/>					
DFH0XCP1	<input type="checkbox"/>					
CA_REQUEST_ID	<input checked="" 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 (Redefines CA_INQUIRE_REQUEST)	<input type="checkbox"/>	CA_REQUEST_SPECIFIC		CHAR	911	88
CA_INQUIRE_REQUEST redefines CA_INQUIRE_SINGLE	<input type="checkbox"/>	CA_INQUIRE_REQUEST		STRUCT	911	88
CA_INQUIRE_SINGLE redefines CA_ITEM_REF_REQ	<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_USERID	<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

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



API toolkit – Creating Services for CICS

Creating multiple services definitions to the same resource

The screenshot shows the Service Interface Editor with two tabs: "cscvincSelectService Service" and "cscvincSelectRequest". The "cscvincSelectRequest" tab is active. It displays a table of fields under the "REQUEST_CONTAINER" section. One row has the "ACTION" field checked and its value is circled in red as 'S'.

The screenshot shows the Service Project Editor: Definition for the "cscvincSelectService Service". Under the "General Information" tab, the "Type" is listed as "CICS Channel Service" and the "Version" is "1.0.0". In the "Program" field, the value "CSCVINC" is circled in red.

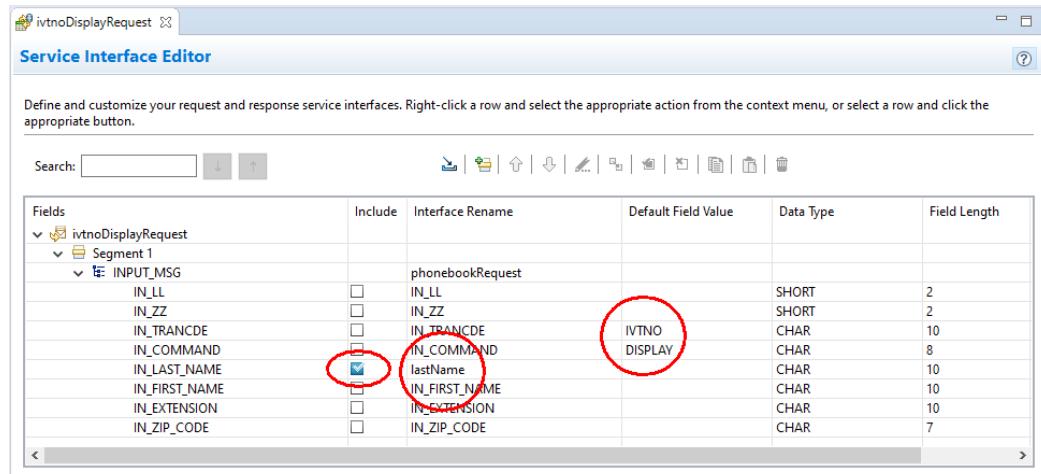
```
EVALUATE ACTION of Request-Container
WHEN 'D'
    PERFORM Delete-Record
WHEN 'I'
    PERFORM Insert-Record
WHEN 'U'
    PERFORM Update-Record
WHEN 'S'
    PERFORM Select-Record
END-EVALUATE.
```

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

API toolkit – Creating Services for IMS

Creating a “GET” service interface request definition

```
*-----*
*      ROUTE TO REQUEST HANDLER
*-----*
SPACE 1
CLC KADD,IOCMD    IF COMMAND ADD ENTERED ?
BE TOADD     ...THEN, GOTO INSERT ENTRY
CLC KUPD,IOCMD    IF COMMAND UPDATE ENTERED ?
BE TOUPD     ...THEN, GOTO UPDATE ENTRY
CLC KDEL,IOCMD    IF COMMAND DEL ENTERED ?
BE TODEL     ...THEN, GOTO DELETE ENTRY
CLC KDIS,IOCMD    IF COMMAND DIS ENTERED ?
BE TODIS     ...THEN, GOTO DISPLAY ENTRY
CLC KTAD,IOCMD    IF TEST ADD WITH REPLY ?
BE TOTAD     ...THEN,
B  INVREQ1   INVALID REQUEST
```

 ivtnoDisplayRequest Service Interface Editor

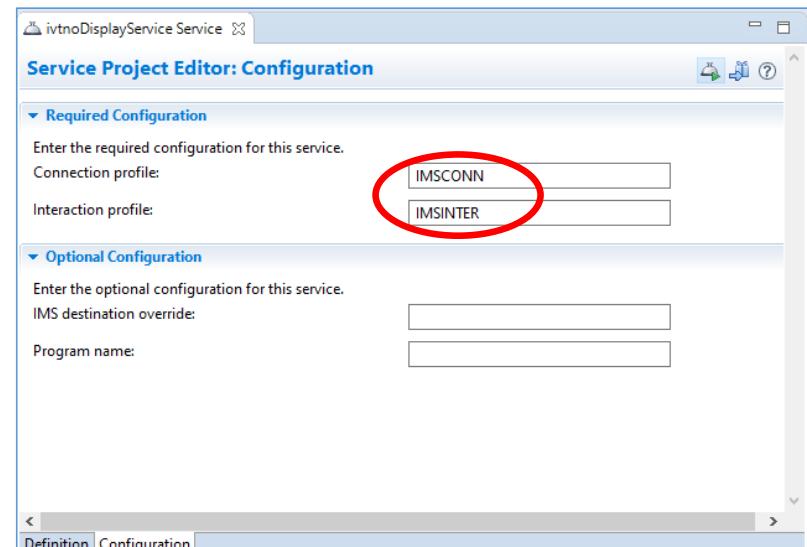
Define and customize your request and response service interfaces. Right-click a row and select the appropriate action from the context menu, or select a row and click the appropriate button.

Fields	Include	Interface Rename	Default Field Value	Data Type	Field Length
ivtnoDisplayRequest					
Segment 1					
INPUT_MSG		phonebookRequest			
IN_LL	<input type="checkbox"/>	IN_LL		SHORT	2
IN_ZZ	<input type="checkbox"/>	IN_ZZ		SHORT	2
IN_TRANCDE	<input type="checkbox"/>	IN_TRANCDE		CHAR	10
IN_COMMAND	<input checked="" type="checkbox"/>	IN_COMMAND	IVTNO DISPLAY	CHAR	8
IN_LAST_NAME	<input type="checkbox"/>	lastName		CHAR	10
IN_FIRST_NAME	<input type="checkbox"/>	IN_FIRST_NAME		CHAR	10
IN_EXTENSION	<input type="checkbox"/>	IN_EXTENSION		CHAR	10
IN_ZIP_CODE	<input type="checkbox"/>	IN_ZIP_CODE		CHAR	7

mitchj@us.ibm.com

The service developer creates distinct services for each function.

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

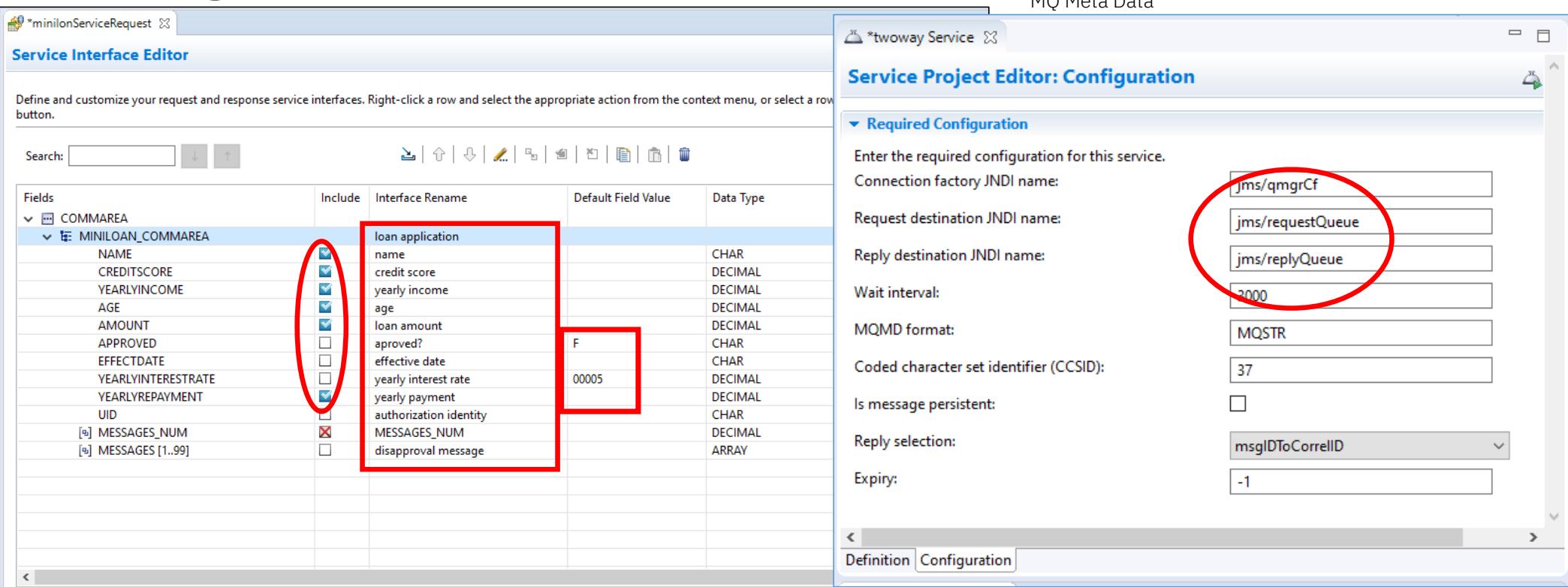


IMS/TM Meta Data

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API toolkit – Creating Services for MQ

Creating a “POST” service interface definition



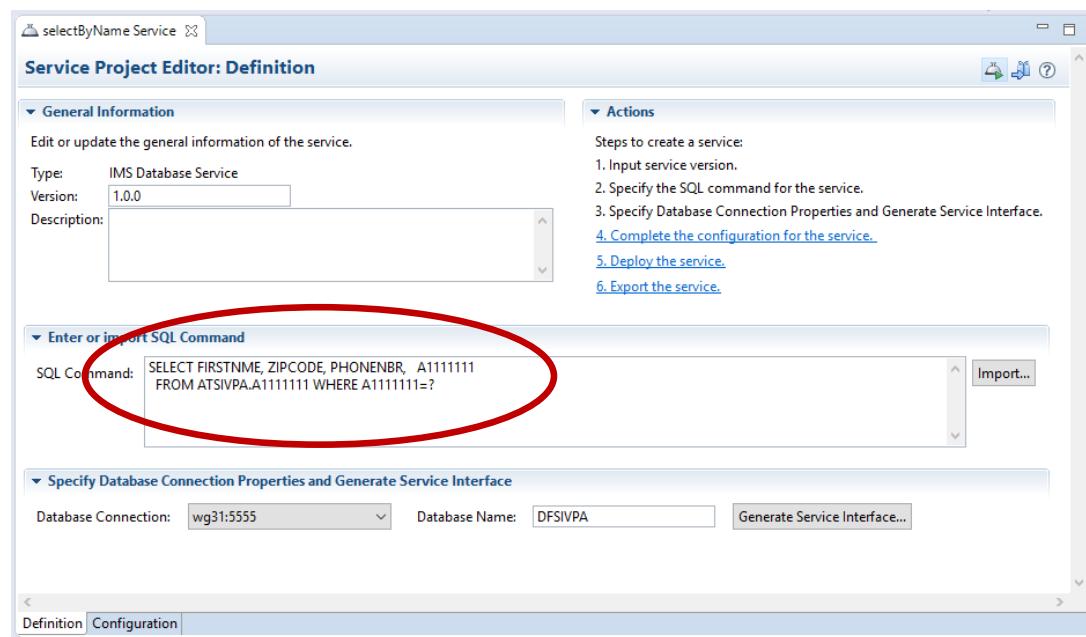
The screenshot displays two windows side-by-side:

- Service Interface Editor:** Shows a table of fields for a service named "minilonServiceRequest". A red box highlights the "Interface Rename" column for the "loan application" row, which contains the values "name", "credit score", "yearly income", "age", "loan amount", "aprov?", "effective date", "yearly interest rate", "yearly payment", "authorization identity", "MESSAGES_NUM", and "disapproval message". A red circle highlights the "Include" checkbox for this row.
- Service Project Editor: Configuration:** Shows configuration settings for a service named "twoWay Service". A red circle highlights the "jms/qmgrCf" field. The configuration includes:
 - 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

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 – Creating Services for IMS DB

Creating a service project from the IMS Catalog

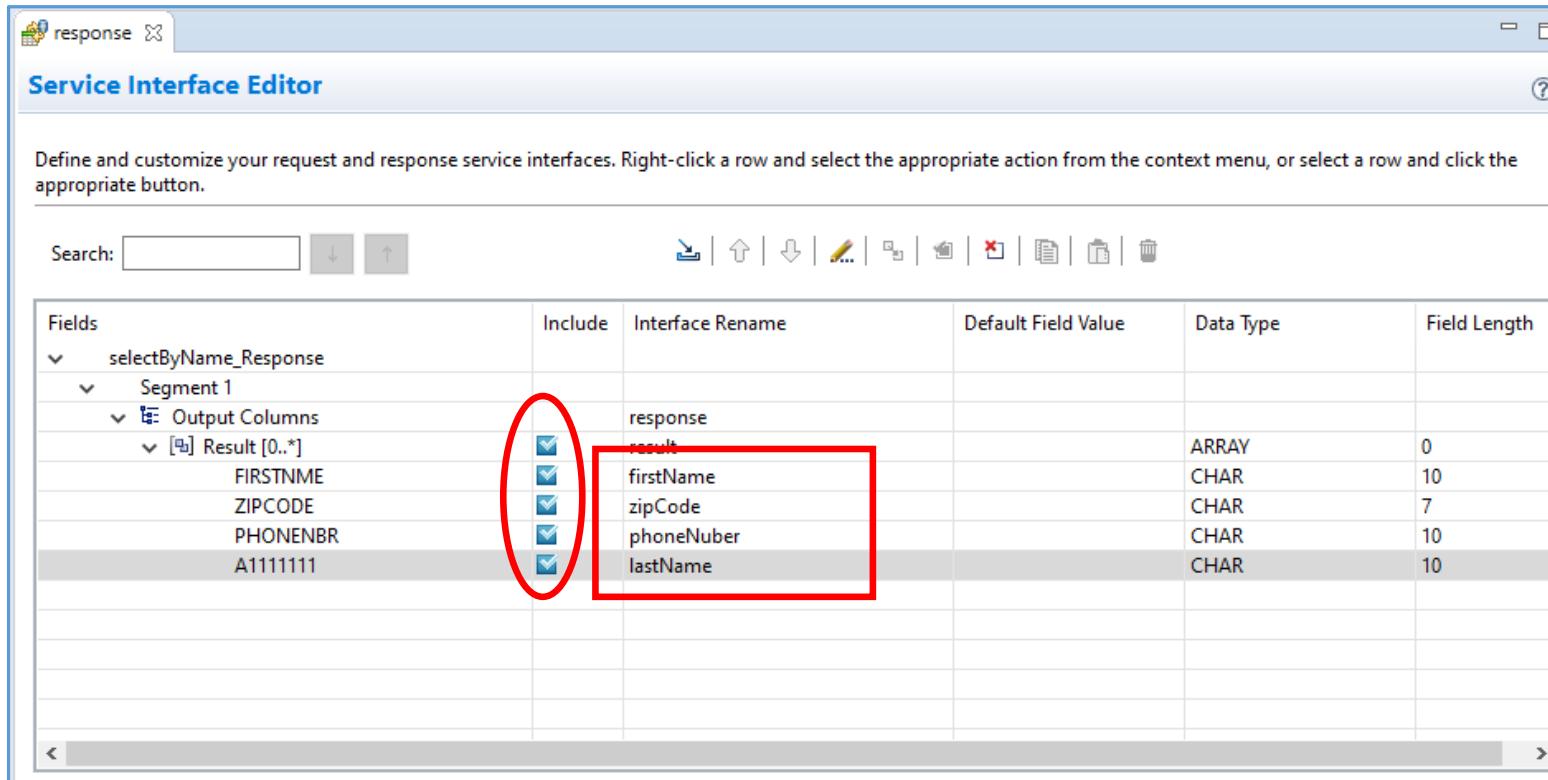


Use the IMS Catalog to assist with developing and testing SQL SELECT commands used for accessing IMS databases.

```
*-----*
* SEGMENT DESCRIPTION *
* ROOT ONLY DATABASE
*   BYTES 1-10 LAST NAME (CHARACTER) - KEY
*   BYTES 11-20 FIRST NAME (CHARACTER)
*   BYTES 21-30 INTERNAL PHONE NUMBER (NUMERIC)
*   BYTES 31-37 INTERNAL ZIP (CHARACTER)
*   BYTES 38-40 RESERVED
*
-----*
DBD      NAME=IVPDB1,ACCESS=(HIDAM,OSAM)
DATASET  DD1=DFSVVD1,DEVICE=3380,SIZE=2048
SEGM    NAME=A1111111,PARENT=0,BYTES=40,RULES=(LLV,LAST),
        PTR=(TB,CTR)
FIELD   NAME=(A1111111,SEQ,U),BYTES=010,START=00001,TYPE=C
FIELD   NAME=FIRSTNME,BYTES=010,START=00011,TYPE=C
FIELD   NAME=PHONENBR,BYTES=010,START=00021,TYPE=C
FIELD   NAME=ZIPCODE,BYTES=7,START=00031,TYPE=C
LCHILD  NAME=(A1,IVPDB1I),POINTER=INDX,RULES=LAST
DBDGEN
FINISH
END
```

API toolkit – Creating Services for IMS DB

The Toolkit allows editing a service interface definitions*



The screenshot shows the Service Interface Editor window. The title bar says "Service Interface Editor". The main area has a heading "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." Below this is a search bar and a set of toolbar icons. The main content is a table with the following columns: Fields, Include, Interface Rename, Default Field Value, Data Type, and Field Length. The table data is as follows:

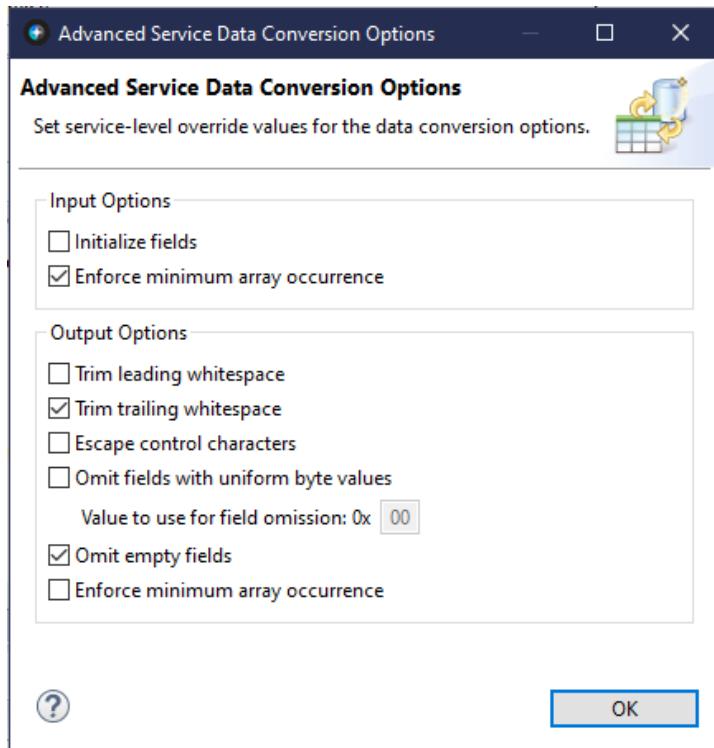
Fields	Include	Interface Rename	Default Field Value	Data Type	Field Length
selectByName_Response					
Segment 1					
Output Columns					
Result [0..*]					
FIRSTNAME		response			
ZIPCODE		result		ARRAY	0
PHONENBR		firstName		CHAR	10
A1111111		zipCode		CHAR	7
		phoneNuber		CHAR	10
		lastName		CHAR	10

*Using a slightly different process

API toolkit – Advanced Data Conversion Options



z/OS Connect EE



Request Messages:

- Initialize fields
- Enforce minimum array occurrence

Response Messages:

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

API toolkit – Creating Services for Db2

Creating a service project from Db2 REST service

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

 Import Db2 service from service manager

Db2 service manager connection:  wg31:2446

Type to search...

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

Definition Configuration

Import Cancel

 *selectEmployee Service

Service Project Editor: Definition

General Information
Edit or update the general information of the service.

Type: Db2 Service
Version: 1.0.0
Description:

Actions
Steps to create a service:
1. Input service version.
2. Import JSON schemas from a Db2 service manager or your local machine.
[3. Complete the configuration for the service.](#)
[4. Deploy the service.](#)
[5. Export the service.](#)

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

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

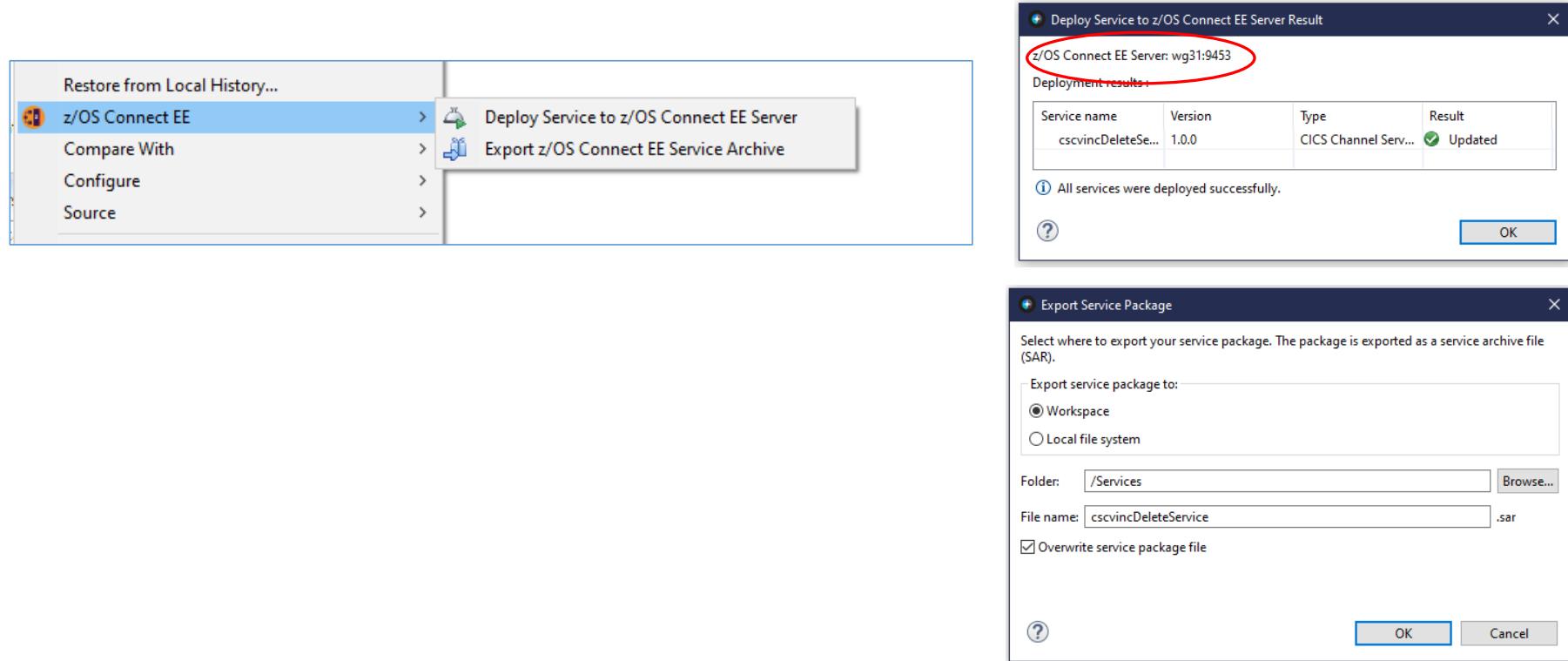
The service developer retrieves details about the Db2 REST services

Note there is no service interface editor available

API toolkit – Services Editor

Server connection and Services deployment

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



The screenshot shows the API toolkit interface with the "z/OS Connect EE" server selected in the "Host Connections" view. A context menu is open, showing options like "Deploy Service to z/OS Connect EE Server" and "Export z/OS Connect EE Service Archive". To the right, two dialogs are displayed: "Deploy Service to z/OS Connect EE Server Result" and "Export Service Package".

Deploy Service to z/OS Connect EE Server Result

z/OS Connect EE Server: wg31:9453

Deployment results:

Service name	Version	Type	Result
cscvincDeleteSe...	1.0.0	CICS Channel Serv...	Updated

All services were deployed successfully.

Export Service Package

Select where to export your service package. The package is exported as a service archive file (SAR).

Export service package to:

Workspace

Local file system

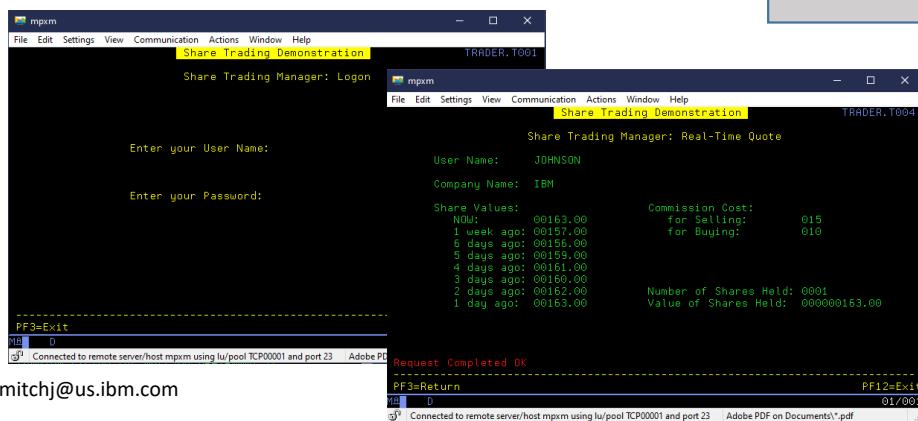
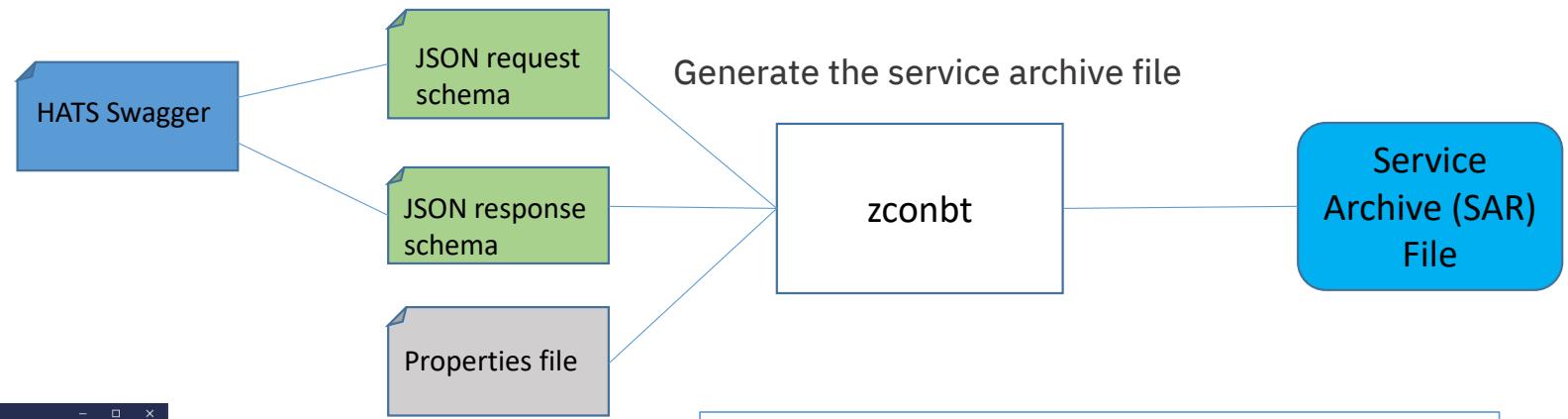
Folder: /Services

File name: cscvincDeleteService.sar

Overwrite service package file

Command line(zconbt) – REST Services

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



```

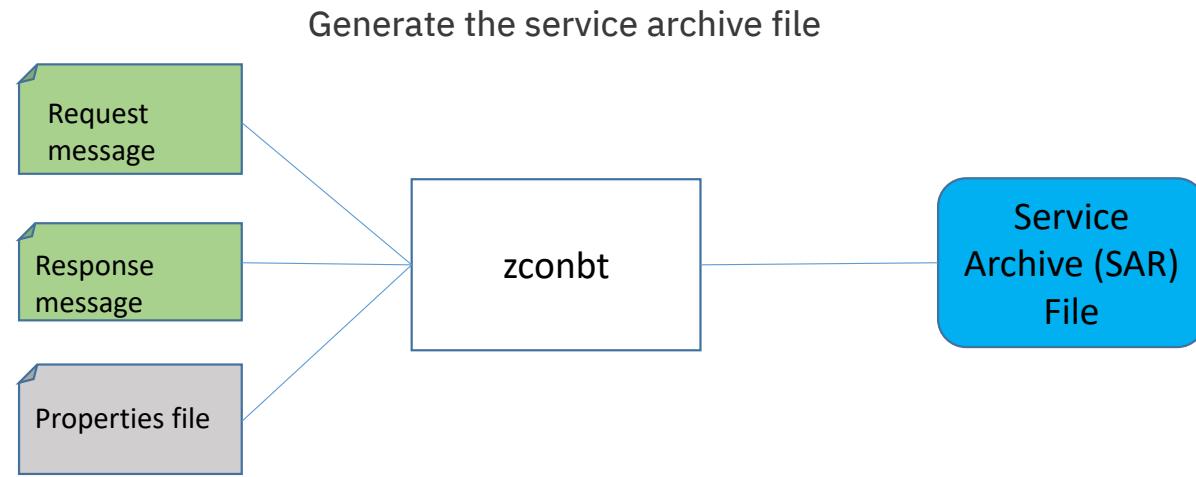
provider=rest
name=getCompany
version=1.0
description=Obtain a list of companies
requestSchemaFile=getCompanyRequest.json
responseSchemaFile=getCompanyResponse.json
verb=POST
uri=/Trader/rest/GetCompany
connectionRef=HatsConn

```

Command line(zconbt) – MVS Batch

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

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



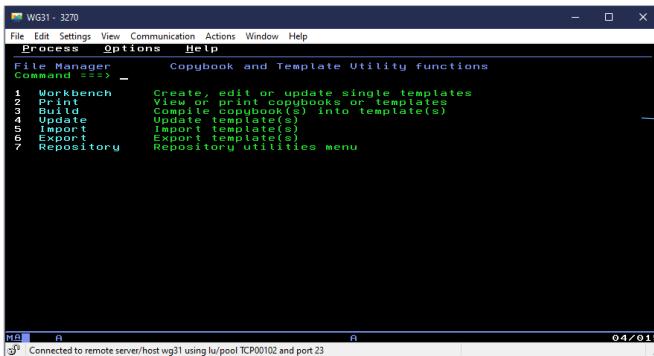
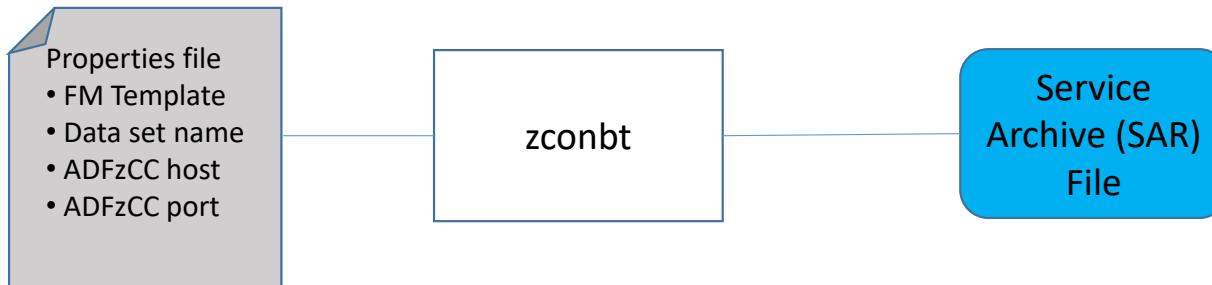
WebSphere Optimized Local Adapter – a protocol for cross memory communications between address spaces



Command line(zconbt) – File Manager

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

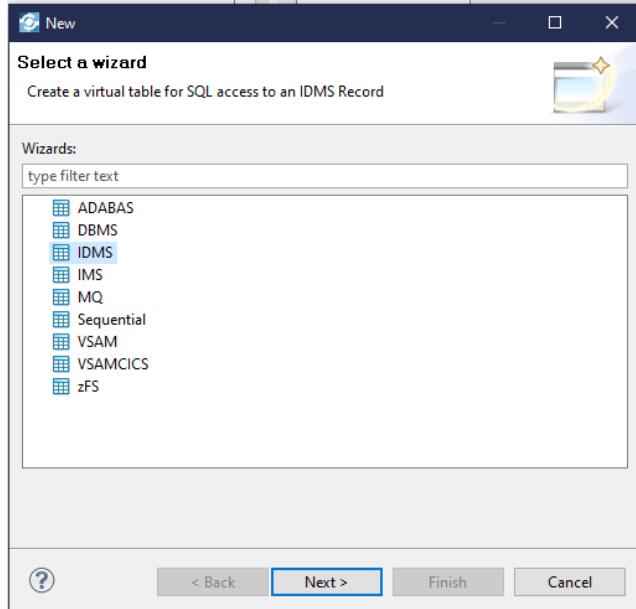
Generate the service archive file



```
name=filea
provider=filemanager
host=wg31.washington.ibm.com
version=1.0
port=2800
file=USER1.ZCEE.FILEA
template=USER1 TEMPLATE(FILEA)
connid=default
userid=USER1
passwd=USER1
```

DVM Studio

For DVM use the DVM Studio



The screenshot shows the main DVM Studio interface. On the left is a navigation pane with 'Data' selected, showing options like Navigator, JDBC, Data Sources, Edit SQL, and Services. Under Services, 'Web Services' is expanded, showing 'Create Directory', '/REST/' (with 'INSERT' selected), 'Create Service', 'Set Tree Filter', 'Target System', 'WSC', and 'Admin'. To the right is a code editor window titled 'Generated.sql' containing SQL queries for creating and inserting data into an EXMPCAT table. Below the code editor is a 'Server Trace' and 'Console' window showing log messages. At the bottom is a results viewer titled 'z/OS Connect REST Interface' displaying a table of data with columns WS_DESCRIPTION, WS_DEPARTMENT, and WS_C. A red circle highlights the 'Generate SAR File(s)' button in the toolbar below the results viewer.

z/OS Resources accessible from DVM using SQL*



z/OS Connect EE

Data Source	SELECT	INSERT	UPDATE	DELETE	CALL Statement
CA IDMS	Yes	No	No	No	N/A
CICS COMMAREA	N/A	N/A	N/A	N/A	Yes
DB2 for z/OS	Yes	Yes	Yes	Yes	Yes
Db2 Direct	Yes	No	No	No	N/A
Db2 other platforms	Yes	Yes	Yes	Yes	Yes
IMS DBCTL	Yes	Yes	Yes	Yes	N/A
IMS Direct	Yes	No	No	No	N/A
IMS OTMA	N/A	N/A	N/A	N/A	Yes
MQ	Yes	No	No	No	N/A
Natural	N/A	N/A	N/A	N/A	Yes
SMF	Yes	No	No	No	N/A
Sequential data set	Yes	Yes	No	No	N/A
VSAM data set*	Yes	Yes	Yes	Yes	N/A
z/OS Syslog	Yes	No	No	No	N/A
OMVS files	Yes	No	No	No	Yes

*Administrating IBM DVM Manager, SC27-9303

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

Quick and easy **API mapping**.

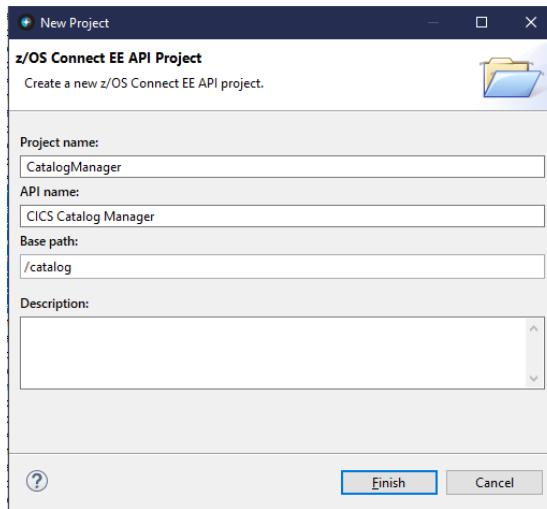
Remember: All service archives files are functionally equivalent regardless of how they are created



/api_toolkit/api_editor

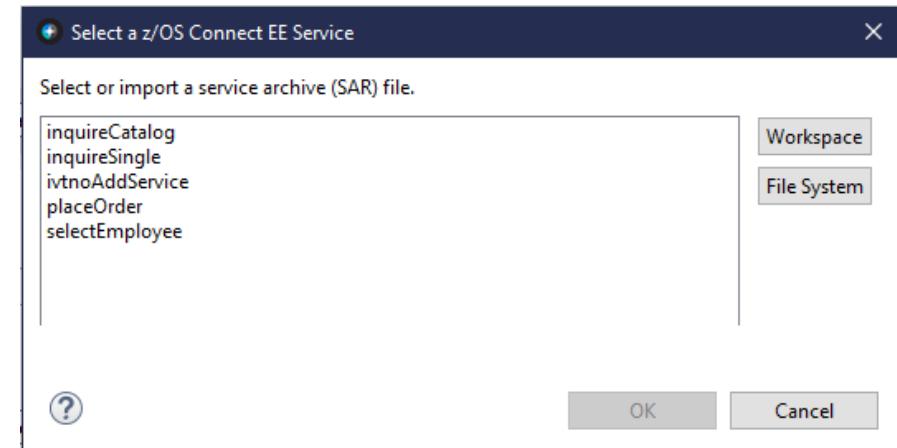
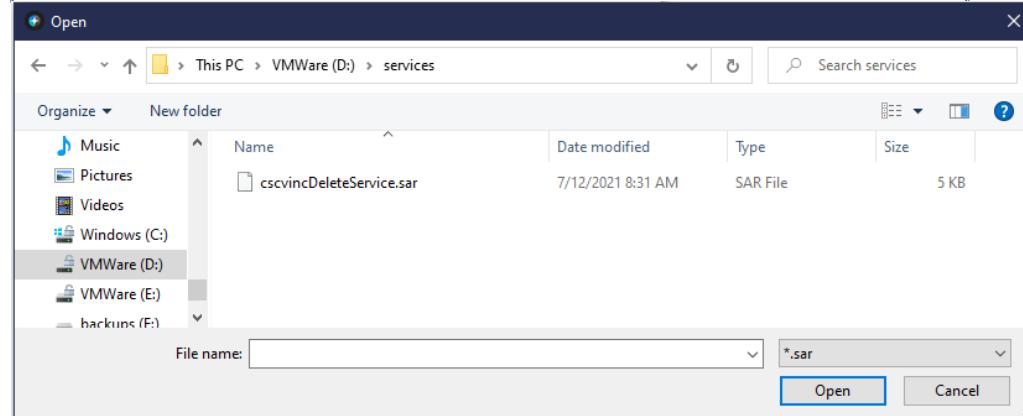
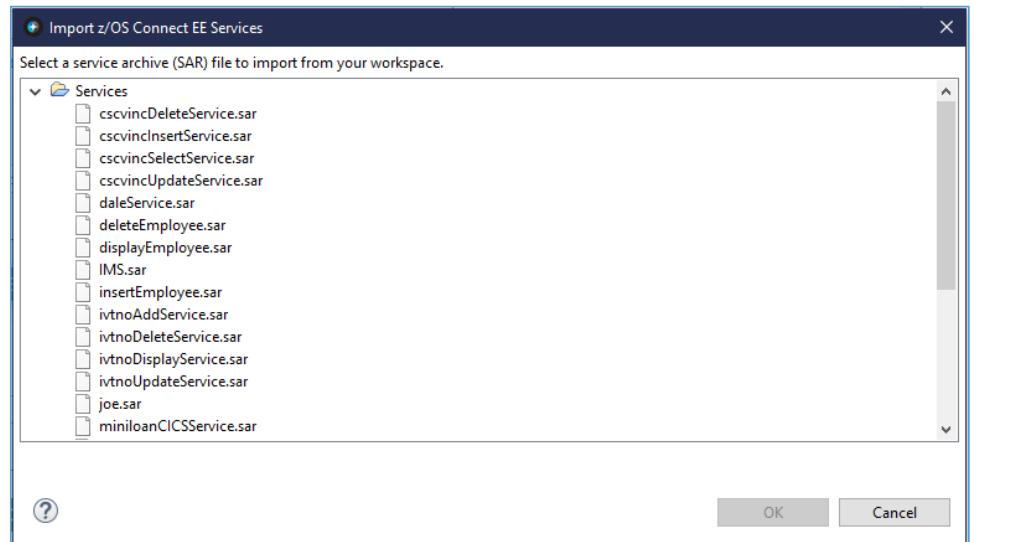
Quick and easy **API mapping**.

API toolkit – API Editor



A screenshot of the API Editor interface for the CICS Catalog Manager API. The "Describe your API" section includes fields for Name (CICS Catalog Manager), Description, Base path (/catalog), and Version (1.0.0). The "Contact Information" section is collapsed. Below, the "Path" section shows a path entry field with /newPath1 and a delete icon. The "Methods (4)" section is expanded, showing four methods: POST, GET, PUT, and DELETE, each with a service selection field, a mapping selection field, and up/down arrows for reordering. A large red circle highlights the entire Methods section.

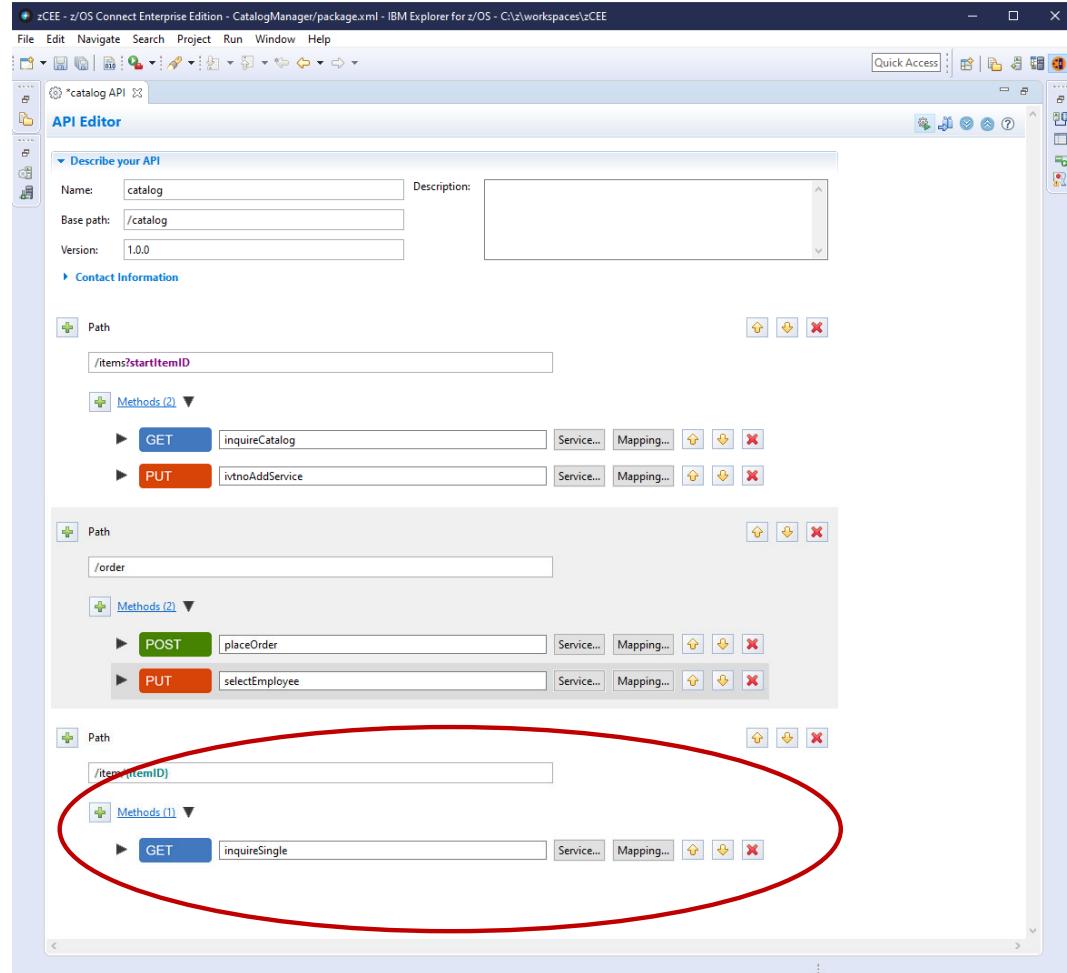
Importing the service archives files



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API toolkit – API Editor



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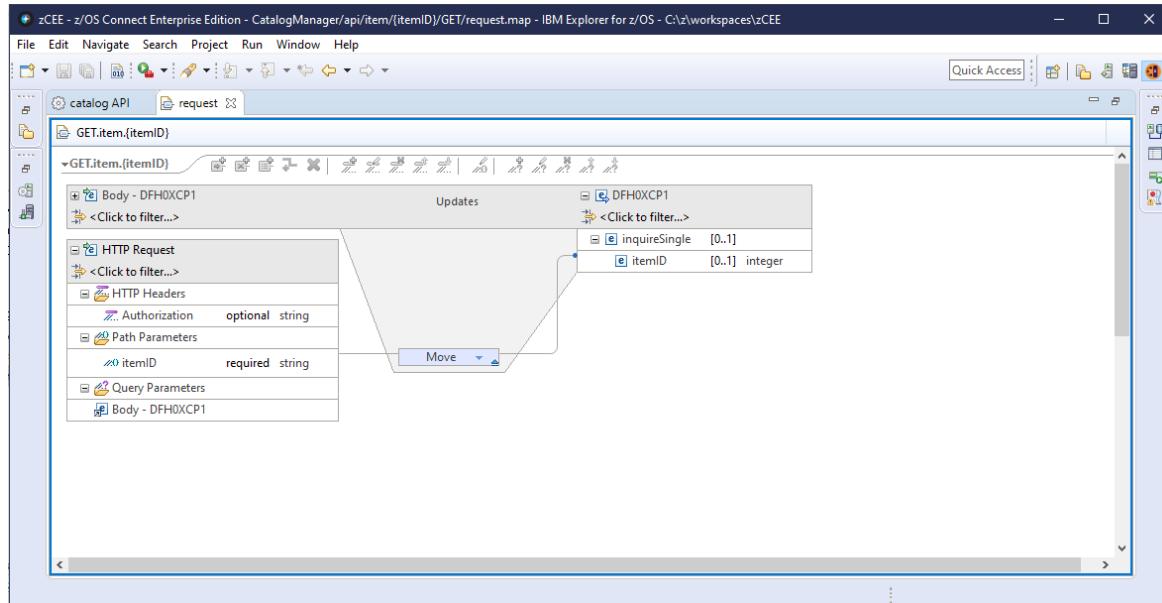
The **API toolkit** is designed to encourage RESTful API design.

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

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

API toolkit – API Editor

API mapping: Assign values to the interface fields exposed by the service developer



Map both the request and response for each API.

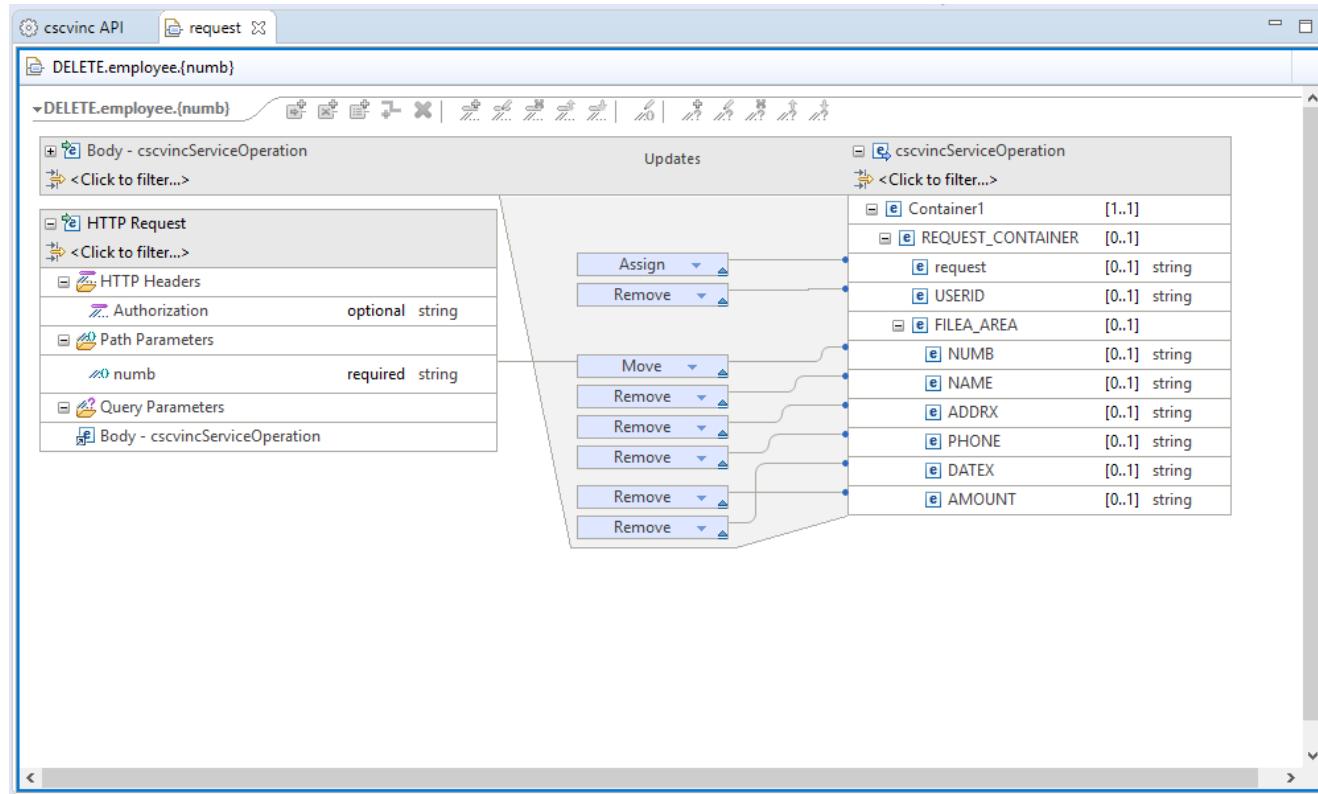
Map path and query parameters to native data structures.

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).

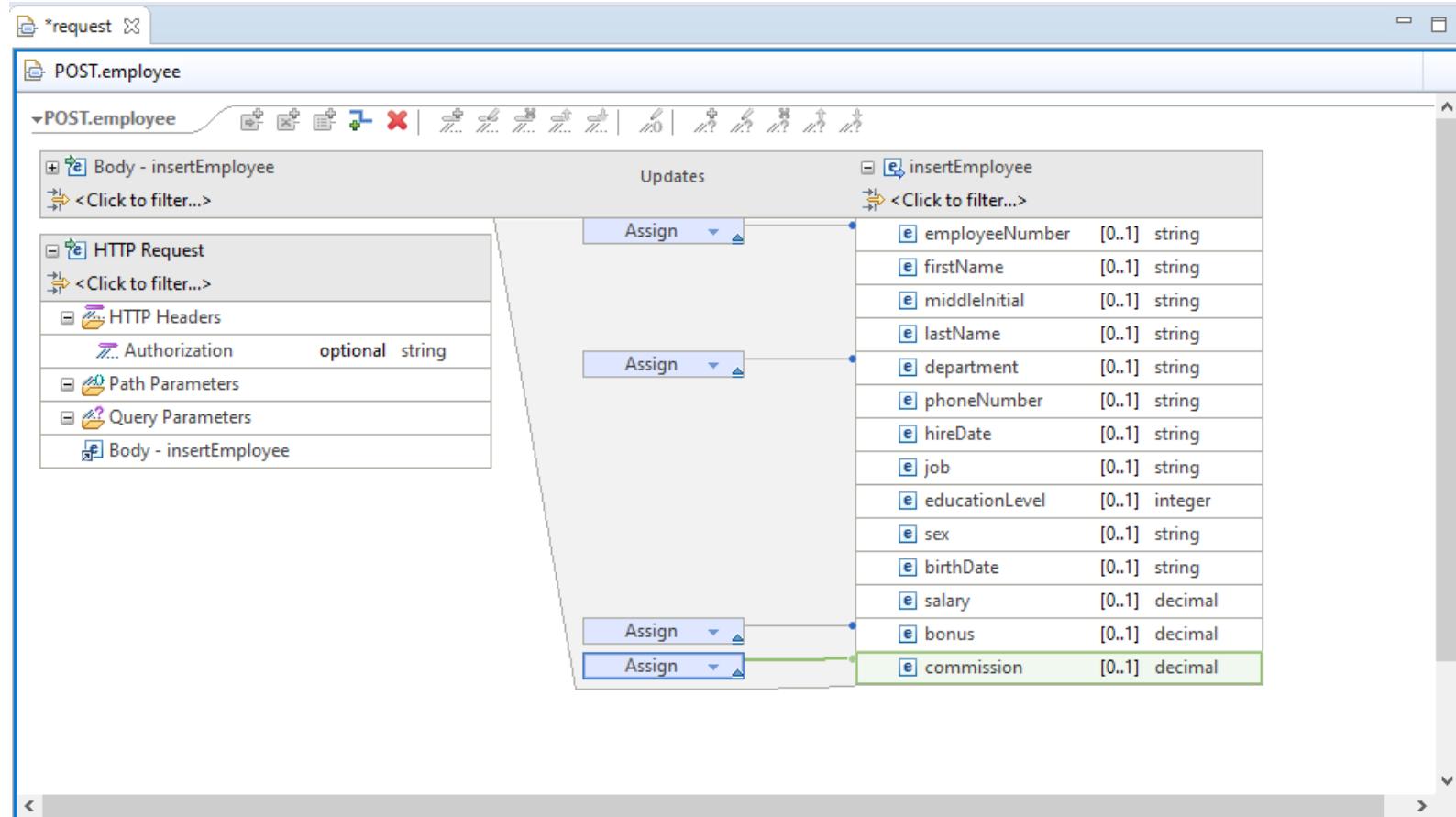
API toolkit – API Editor

API mapping: Remove or assign values to the fields exposed by service developer



API toolkit – API Editor and Db2 REST service

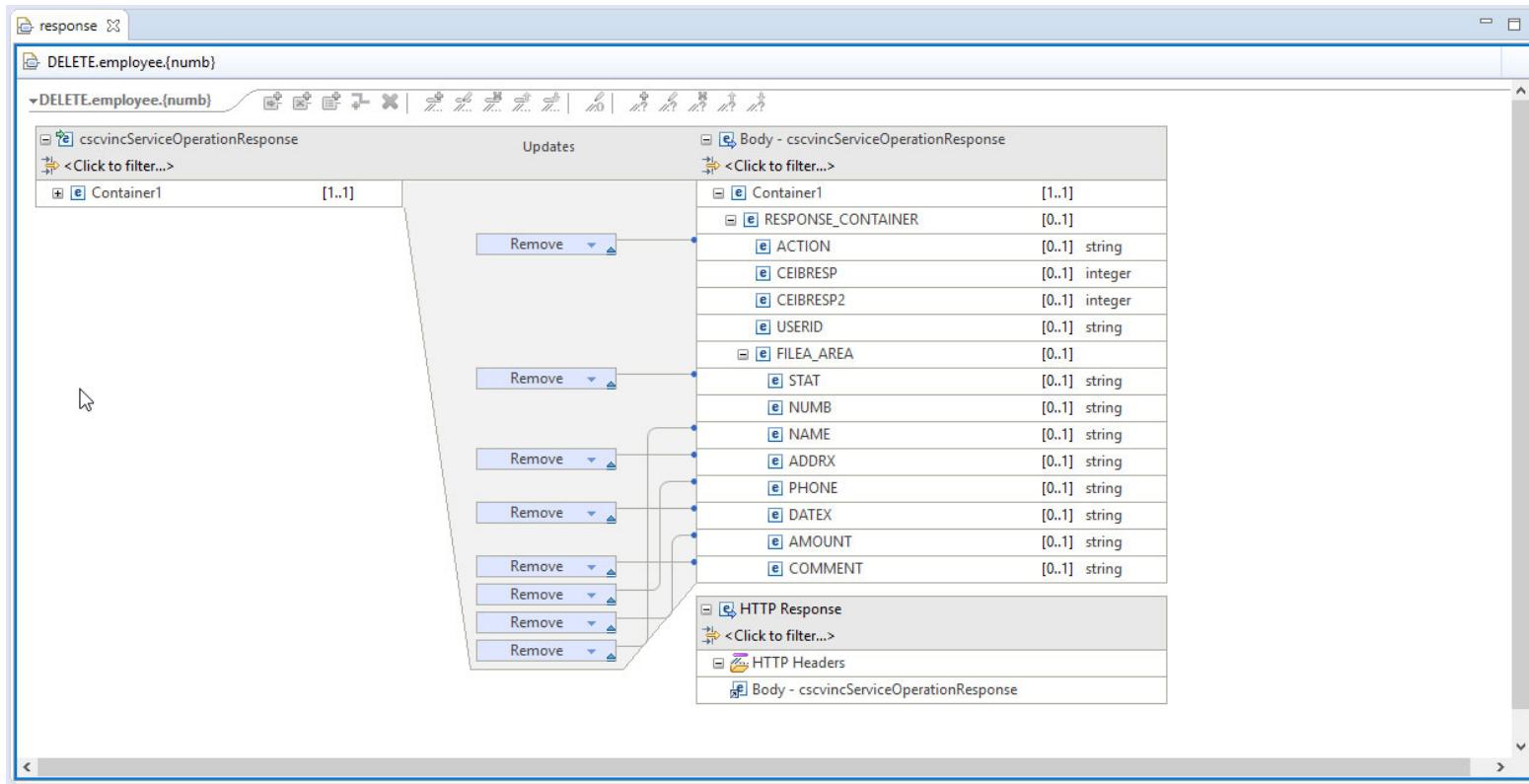
API mapping: Remove/Assign values columns exposed in Db2 REST service



API toolkit – API Editor

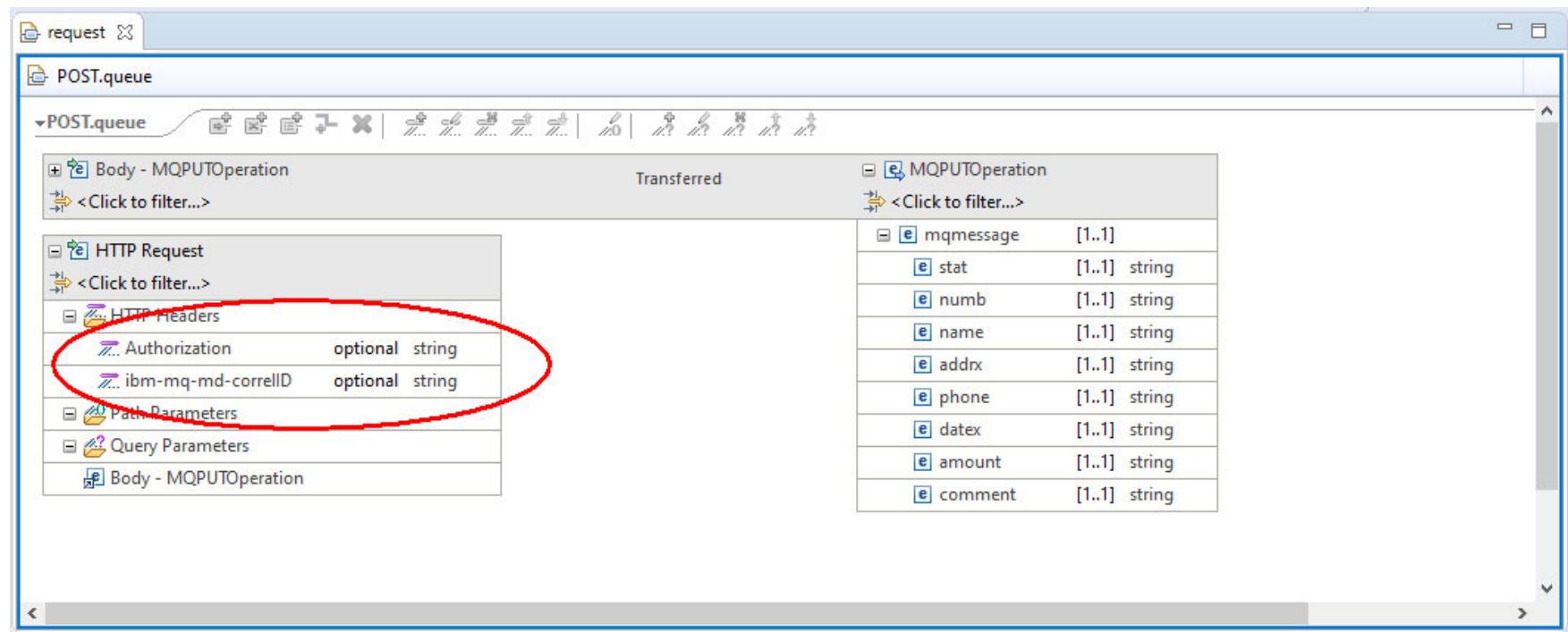


API mapping: Allows the API Developer to remove fields from the response to tailor the API



API toolkit – API Editor

API mapping: Allows adding HTTP header properties



The screenshot shows the API Editor interface with two main sections: 'POST.queue' on the left and 'MQPUTOperation' on the right.

POST.queue (Left):

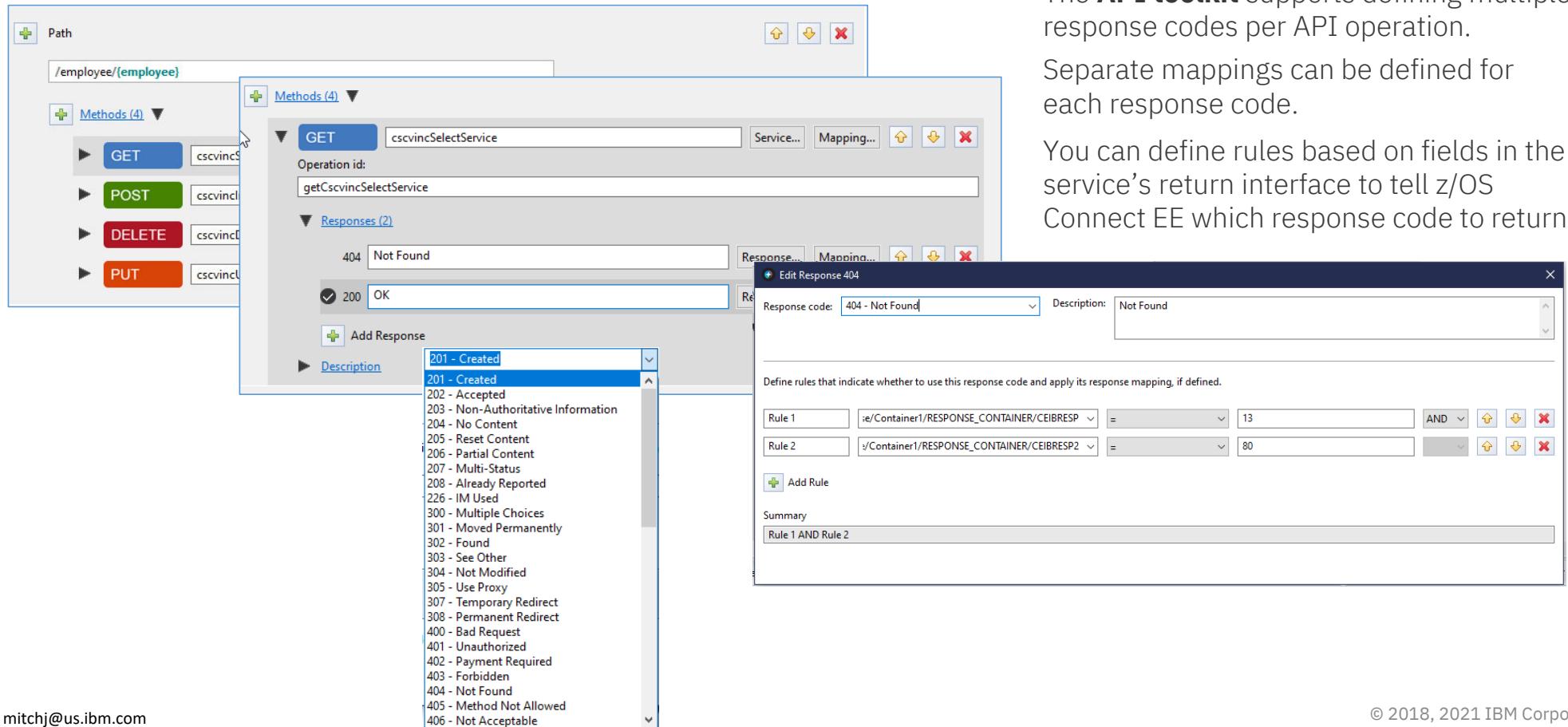
- Body - MQPUTOperation
- HTTP Request
 - HTTP Headers
 - Authorization optional string
 - ibm-mq-md-correlID optional string
 - Path Parameters
 - Query Parameters
 - Body - MQPUTOperation

MQPUTOperation (Right):

- MQPUTOperation
- mqmessage [1..1]
 - stat [1..1] string
 - numb [1..1] string
 - name [1..1] string
 - addrx [1..1] string
 - phone [1..1] string
 - datex [1..1] string
 - amount [1..1] string
 - comment [1..1] string

API toolkit

API mapping: API definition with multiple response codes



The screenshot shows the API toolkit interface for defining API mappings. On the left, the API path `/employee/{employee}` is selected. Under the `Methods (4)` section, a `GET` method is highlighted, pointing to the service `cscvincSelectService`. The `getCscvincSelectService` operation is defined. In the `Responses (2)` section, two responses are listed: `404 Not Found` and `200 OK`. A context menu is open over the `404 Not Found` response, displaying the `Edit Response 404` dialog. This dialog shows the response code as `404 - Not Found` and the description as `Not Found`. It also contains a rule editor with two rules:

- `Rule 1`: `se/Container1/RESPONSE_CONTAINER/CEIBRESP` = 13
- `Rule 2`: `z/Container1/RESPONSE_CONTAINER/CEIBRESP2` = 80

The summary of the rules is `Rule 1 AND Rule 2`.

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

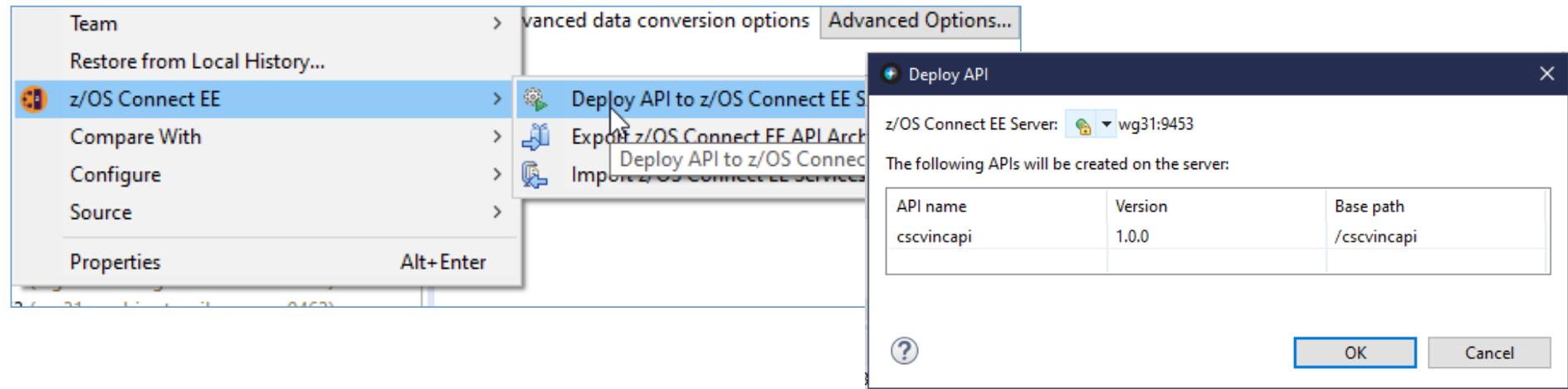
Separate mappings can be defined for each response code.

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

API toolkit – API Editor

Server connection and API deployment

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



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

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



API toolkit – API Editor

Testing with Swagger UI

Test your deployed APIs directly with **Swagger UI** inside the editor.
No need to export the Swagger doc to a separate tool.

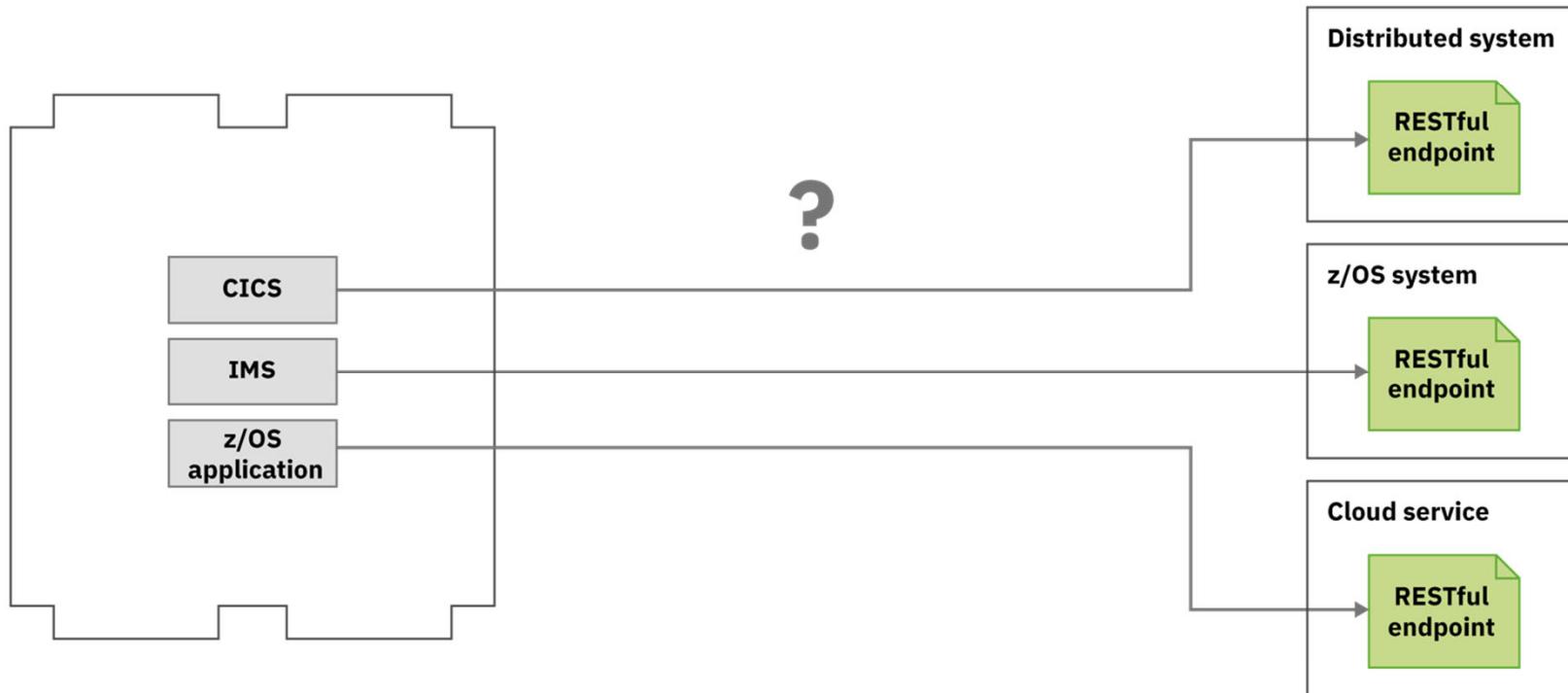
The screenshot shows the z/OS Connect EE API Editor interface. On the left, the 'API Catalog' window displays a tree view of deployed services and APIs. A context menu is open over the 'cscvinc' service, showing options like 'Open In Swagger UI'. Two separate browser windows are shown in the center-right, both titled 'Swagger UI'. The left window shows the Swagger UI for the 'cscvinc' service, listing four endpoints: POST /employee, DELETE /employee/{employee}, GET /employee/{employee}, and PUT /employee/{employee}. The right window shows a detailed view of the GET /employee/{employee} endpoint, including the response model (a JSON object with properties like 'CEIBRESP', 'CEIBRESP2', 'USERID', 'file', 'employeeNumber', and 'name'), parameters (Authorization header and employee path parameter), and response messages (HTTP 404 Not Found). The base URL for the API is listed as /cscvinc, API VERSION: 1.0.0.]



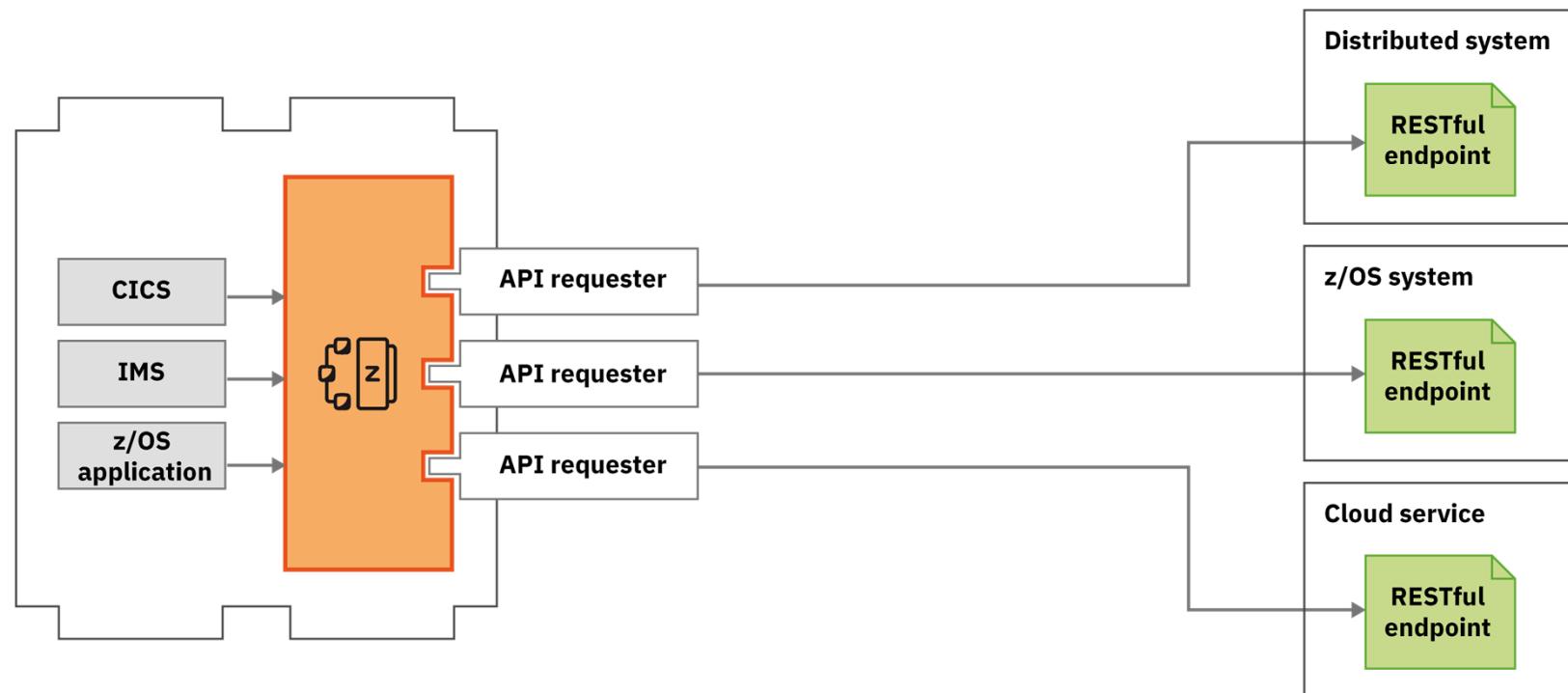
/api_toolkit/apiRequesters

Quick and easy **API mapping**.

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



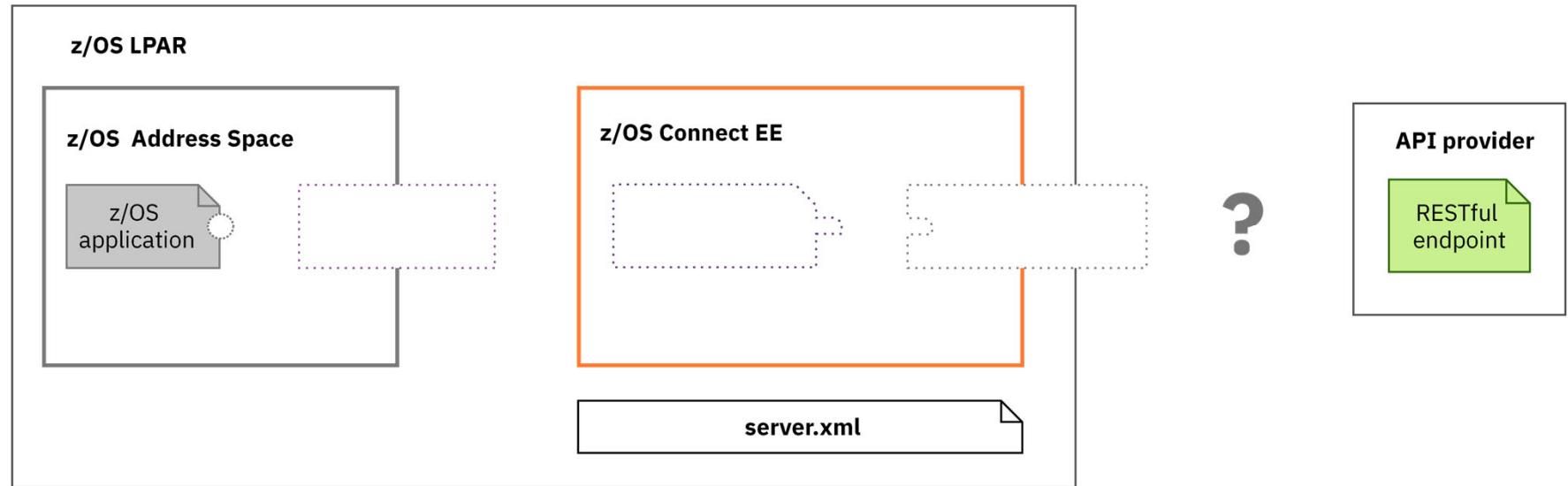
Use API requester to call external APIs from z/OS assets





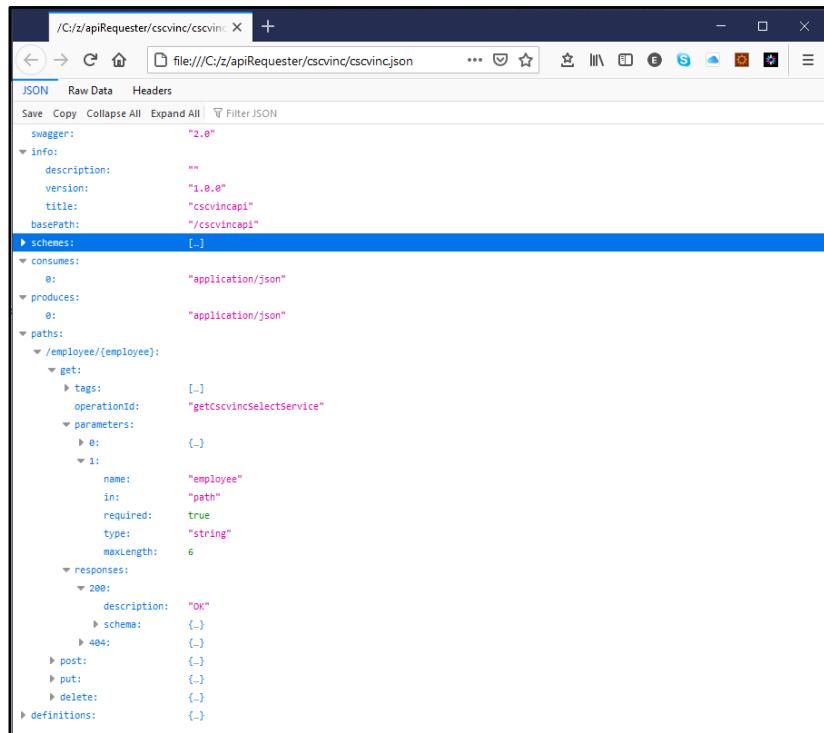
Steps to calling an external API

Starting point



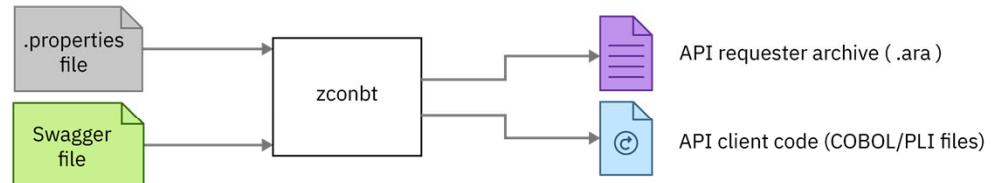
Steps to calling an external API

Generate API requester archive and API client code from Swagger



```

{
  "swagger": "2.0",
  "info": {
    "description": "",
    "version": "1.0.0",
    "title": "cscvincapi",
    "basePath": "/cscvincapi"
  },
  "schemes": [],
  "consumes": [
    {
      "o": "application/json"
    }
  ],
  "produces": [
    {
      "o": "application/json"
    }
  ],
  "paths": {
    "/employee/{employee}": {
      "get": {
        "tags": [
          "getCscvincSelectService"
        ],
        "parameters": [
          {
            "o": {}
          },
          {
            "name": "employee",
            "in": "path",
            "required": true,
            "type": "string",
            "maxLength": 6
          }
        ],
        "responses": {
          "200": {
            "description": "OK",
            "schema": {}
          },
          "404": {}
        }
      }
    }
  }
}
  
```



```

.properties file#
apiDescriptionFile=./cscvinc.json
dataStructuresLocation=./syslib
apiInfoFileLocation=./syslib
logFileDirectory=./logs
language=COBOL
connectionRef=cscvincAPI
requesterPrefix=csc
  
```

#Additional property file attributes, e.g., *defaultCharacterMaxLength*, *defaultArrayMaxItems*, etc. are described at **The build toolkit properties file** article at URL <https://www.ibm.com/docs/en/zosconnect/3.0?topic=toolkit-build-properties-file>

Steps to calling an external API

Using `zconbt` to generate API requester archive and API client code from Swagger

```
zconbt.bat -p=./cscvinc.properties -f=./cscvinc.ara
BAQB0000I: z/OS Connect Enterprise Edition 3.0 Build Toolkit Version 1.5 (20210816-0926).
BAQB0008I: Creating API requester archive from configuration file ./cscvinc.properties.
BAQB0040I: The generated API requester is automatically named cscvincapi_1.0.0 based on the title cscvincapi and version 1.0.0 of the API to be called.
. . .
Total 4 operation(s) (success: 4, ignored: 0) defined in api description file: ./cscvinc.json
----- Successfully processed operation(s) -----
operationId: getCsvincSelectService, basePath: /cscvincapi, relativePath: /employee/{employee}, method: GET
- request data structure : CSC00Q01
- response data structure : CSC00P01
- api info file : CSC00I01

operationId: putCsvincUpdateService, basePath: /cscvincapi, relativePath: /employee/{employee}, method: PUT
- request data structure : CSC01Q01
- response data structure : CSC01P01
- api info file : CSC01I01

operationId: postCsvincInsertService, basePath: /cscvincapi, relativePath: /employee/{employee}, method: POST
- request data structure : CSC02Q01
- response data structure : CSC02P01
- api info file : CSC02I01

operationId: deleteCsvincDeleteService, basePath: /cscvincapi, relativePath: /employee/{employee}, method: DELETE
- request data structure : CSC03Q01
- response data structure : CSC03P01
- api info file : CSC03I01

BAQB0009I: Successfully created API requester archive file ./cscvinc.ara.
```

Tech-Tip: Copy books names



z/OS Connect EE

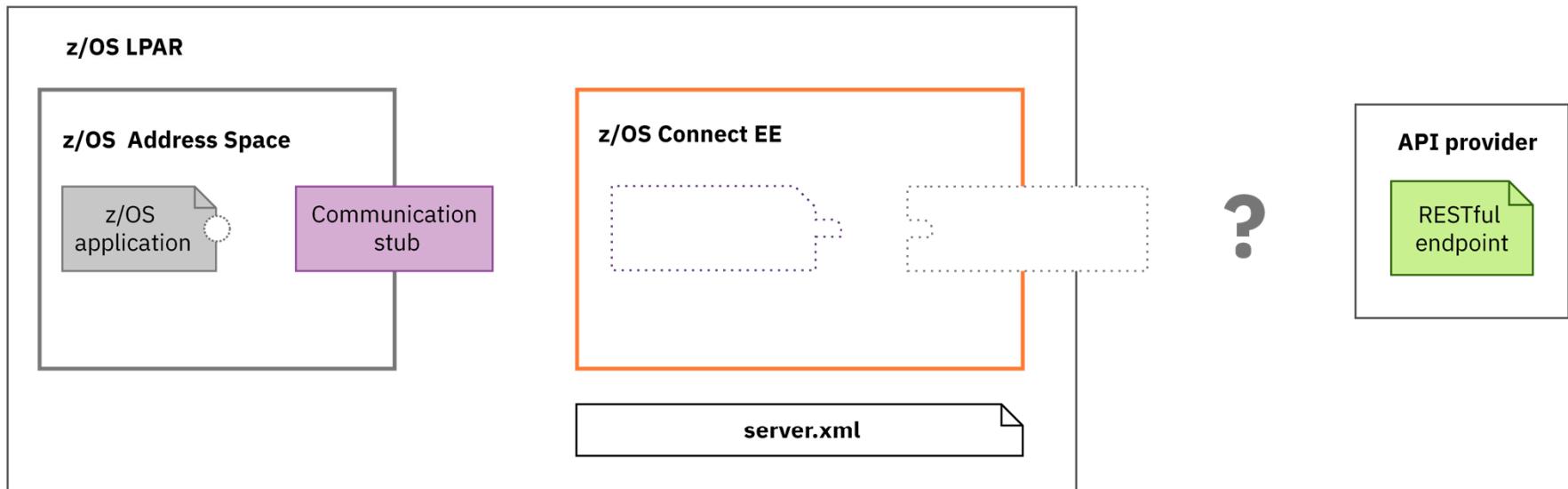
- Up to three copy books are generated for each method of each API found in the Swagger document. In the previous example, there were 4 APIs with each having 1 method for a total of 12 copy books.
- The naming convention for the generated COBOL copy books is based on the *requesterPrefix* value specified in the properties file. That value was set to API in this case, e.g., CSC#####. The next 2 characters in the name are assigned sequentially as each API and method is processed, e.g., CSC00### and CSC01###, CSC02### and CSC03CSC.
- The next character will be either a Q, P or an I. A “Q” for a **request** copy book, the “P” for a **response** copy book and the “I” for the copy book which contains **information**, e.g., method, path name etc. derived from the Swagger document



z/OS Connect EE

Steps to calling an external API

Update the application by adding the copy books and a call to communication stub



Configure a communication stub.

- For CICS region systems using URIMAP resources
- For non CICS client the configuration is done via environment variables

 ibm.biz/zosconnect-configure-comms-stub

Steps to calling an external API

Include the generated copy books in a COBOL program

```
GETAPI ✘
  ERROR MESSAGE STRUCTURE
  01  ERROR-MSG.
      03  EM-ORIGIN          PIC X(8)  VALUE SPACES.
      03  EM-CODE            PIC S9(9) COMP-5 SYNC VALUE 0.
      03  EM-DETAIL          PIC X(1024) VALUE SPACES.

  * Copy API Requester required copybook
  COPY BAQRINFO.

  * Request and Response
  01 API-REQUEST.
    COPY CSC02Q01.
  01 API_RESPONSE.
    COPY CSC02P01.
  * Structure with the API information
  01 API-INFO-OPER1.
    COPY CSC02I01.

  * Request and Response segment used to store request and
```

API-REQUEST

```
CSC00I01  CSC00Q01 ✘
  * JSON schema keyword 'minLength' value: '0'.
  * JSON schema keyword 'maxLength' value: '6'.
  * This field contains a varying length array of characters or
  * binary data.
  *   09 employee-length          PIC S9999 COMP-5 SYNC.
  *   09 employee                PIC X(6).

  * ++++++
  06 ReqPathParameters.
    09 employee-length          PIC S9999 COMP-5 SYNC.
    09 employee                PIC X(6).
```

API-RESPONSE

```
CSC00I01  CSC00Q01  CSC00P01 ✘
  * ++++++
  06 RespBody.
    09 cscvincSelectServiceOp-num  PIC S9(9) COMP-5 SYNC.
    09 cscvincSelectServiceOperatio.
        12 Container1.

    15 RESPONSE-CONTAINER2-num  PIC S9(9) COMP-5
      SYNC.
```

API-INFO-OPER1

```
CSC00I01 ✘
  03 BAQ-APINAME          PIC X(255)
    VALUE 'cscvincapi_1.0.0'.
  03 BAQ-APINAME-LEN        PIC S9(9) COMP-5 SYNC
    VALUE 16.
  03 BAQ-APIPATH           PIC X(255)
    VALUE '%2Fcvincapi%2Femployee%2F%7Bemployee%7D'.
  03 BAQ-APIPATH-LEN        PIC S9(9) COMP-5 SYNC
    VALUE 41.
  03 BAQ-APIMETHOD         PIC X(255)
    VALUE 'GET'.
  03 BAQ-APIMETHOD-LEN      PIC S9(9) COMP-5 SYNC
    VALUE 3.
```

Steps to calling an external API

Add a call to the communication stub passing pointers to working storage of the copy books

The diagram illustrates the steps to calling an external API by comparing the source code in the `GETAPI` program with the definitions in three copy books: `CSC00101`, `CSC00Q01`, and `CSC00P01`.

GETAPI Program:

```
*-----*
* 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
*-----*
```

Copy Book CSC00101:

03 BAQ-APINAME	PIC X(255)
VALUE 'cscvincap1_1.0.0'.	
03 BAQ-APINAME-LEN	PIC S9(9) COMP-5 SYNC
VALUE 16.	
03 BAQ-APIPATH	PIC X(255)
VALUE 'S2cscvincap1%2Femployee%7D'.	
03 BAQ-APIPATH-LEN	PIC S9(9) COMP-5 SYNC
VALUE 41.	
03 BAQ-APIMETHOD	PIC X(255)
VALUE 'GET'.	
03 BAQ-APIMETHOD-LEN	PIC S9(9) COMP-5 SYNC
VALUE 3.	

Copy Book CSC00Q01:

* JSON schema keyword 'minLength' value: '0'.	
* JSON schema keyword 'maxLength' value: '6'.	
* This field contains a varying length array of characters or	
* binary data.	
* 09 employee-length	PIC S9999 COMP-5 SYNC.
* 09 employee	PIC X(6).

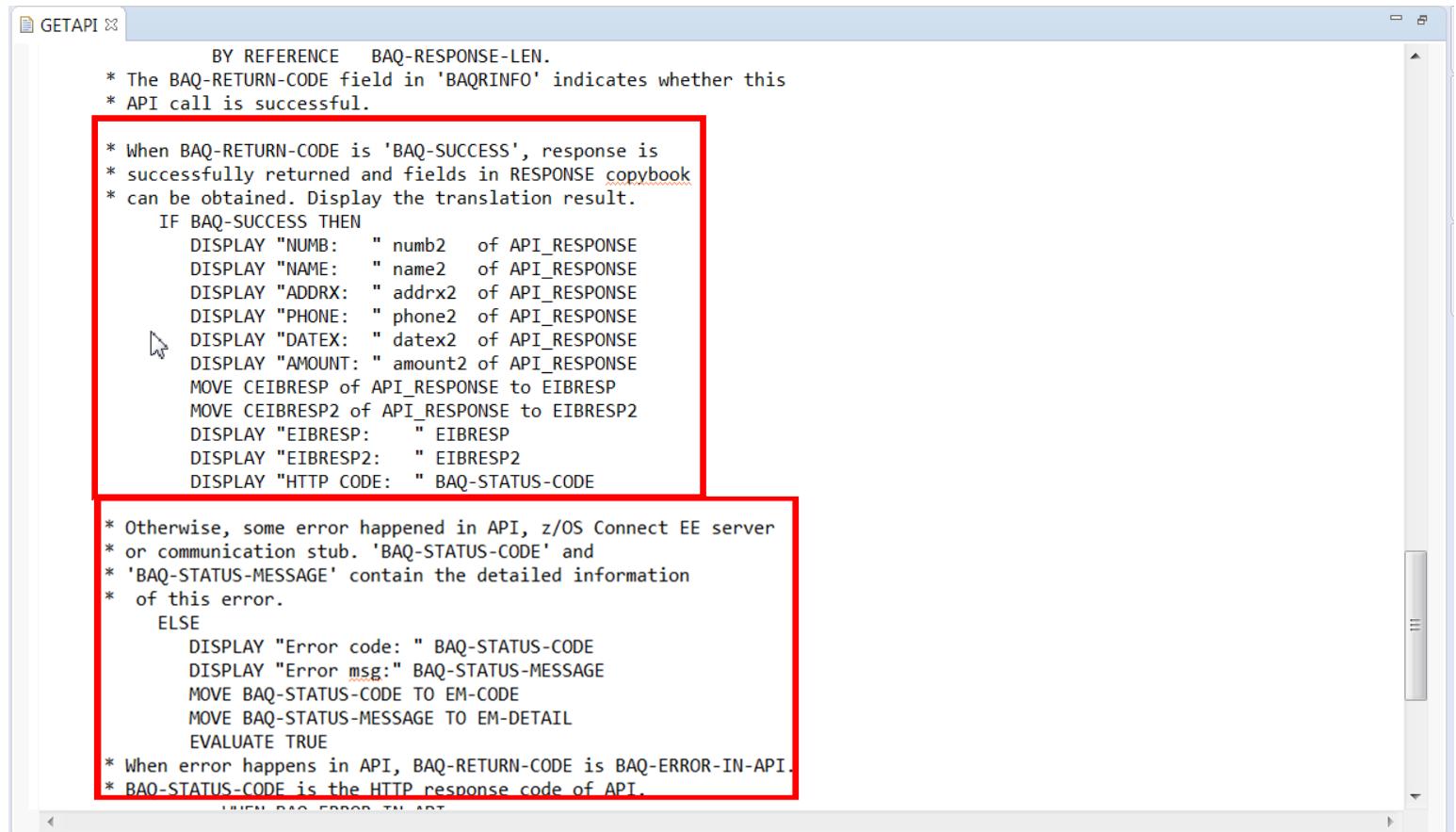
06 ReqPathParameters.	
09 employee-length	PIC S9999 COMP-5 SYNC.
09 employee	PIC X(6).

Copy Book CSC00P01:

06 RespBody.	
09 cscvincSelectServiceOp-num	PIC S9(9) COMP-5 SYNC.
09 cscvincSelectServiceOperatio.	
12 Container1.	
15 RESPONSE-CONTAINER2-num	PIC S9(9) COMP-5
SYNC.	

Steps to calling an external API

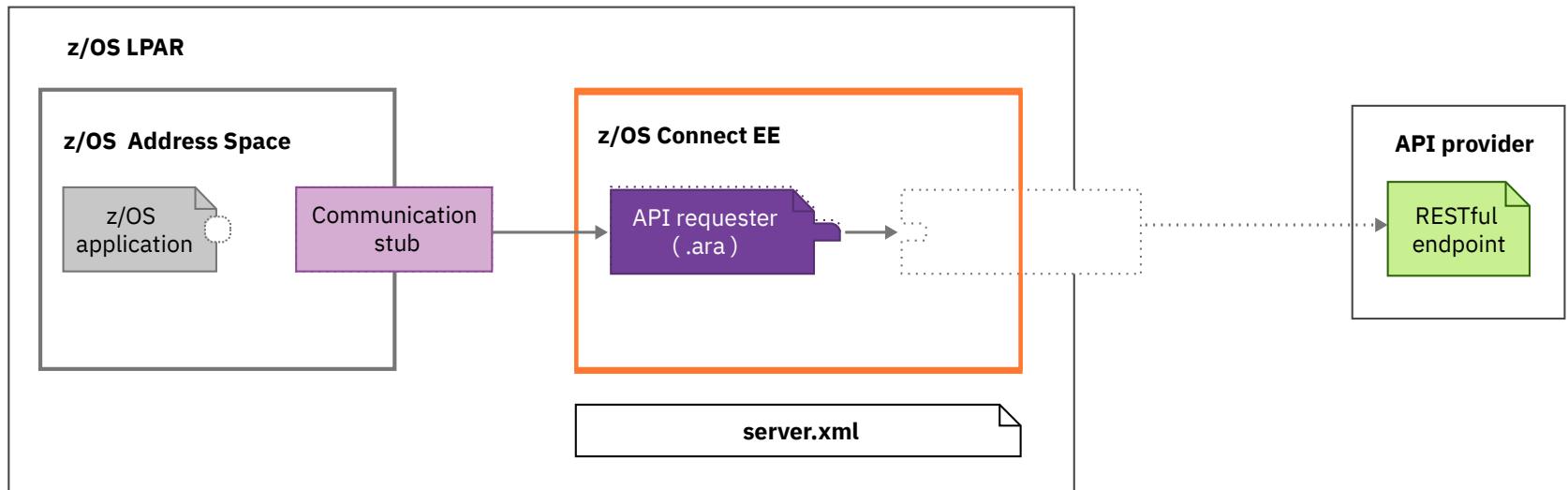
Access the results



```
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

Deploy API requester (.ara) archive



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

Steps to calling an external API

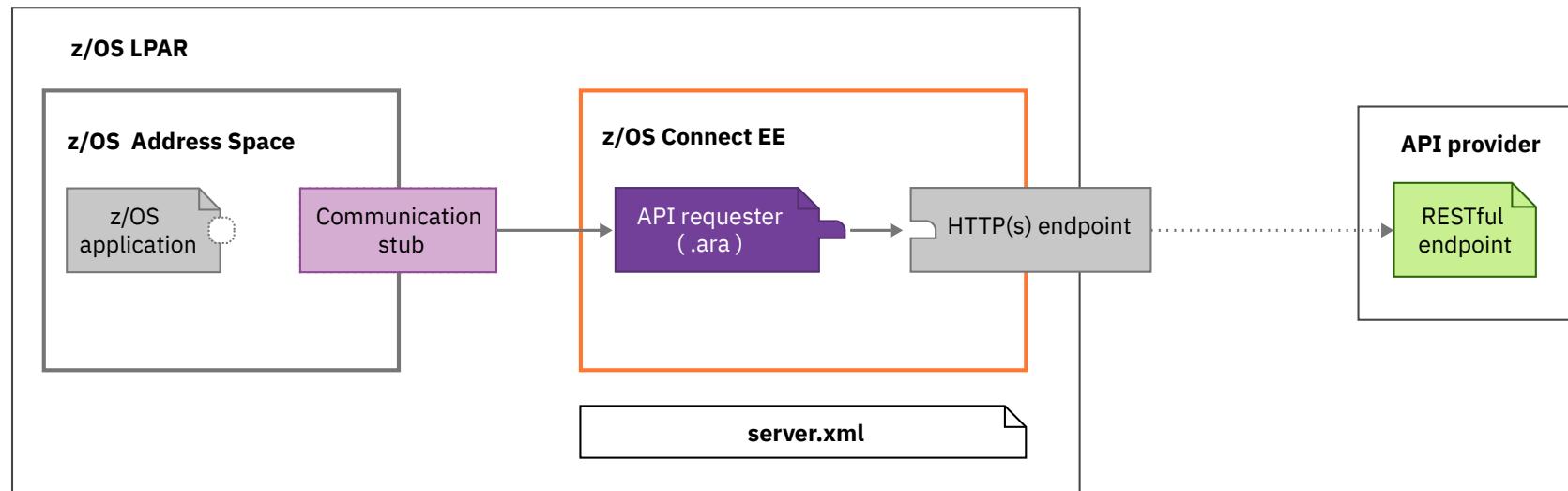
- Deploy the API requester (.ara) archive using cURL or Postman

```
curl -X POST --user fred:fred --data-binary @cscvinc.ara --header "Content-Type: application/zip" --insecure  
https://wg31.washington.ibm.com:9443/zosConnect/apiRequesters
```

```
{"name":"cscvincapi_1.0.0","version":"1.0.0","description":"","status":"Started","apiRequesterUrl":"https:\/\/wg31.washington.ibm.com:9443\/zosConnect\/apiRequesters\/cscvincapi_1.0.0","connection":"cscvincAPI"}
```

Steps to calling an external API

Configure HTTP(S) endpoint configuration element



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

 ibm.biz/zosconnect-configure-endpoint-connection

Steps to calling an external API

Update the server XML configuration for the endpoint

```
File Edit View History Bookmarks Tools Help
/C:/z/apiRequester/csvinc/swagger + 
← → ⌂ file:///C:/z/apiRequester/csvinc/swagger.json ⌂ ⌂ ⌂
JSON Raw Data Headers
Save Copy Collapse All Expand All Filter JSON
swagger: "2.0"
info:
  description: ""
  version: "1.0.0"
  title: "csvinc"
  host: "localhost:8080"
  basePath: "/csvinc"
schemes:
  0: "https"
  1: "http"
consumes:
  0: "application/json"
produces:
  0: "application/json"
paths:
  /employee:
    post:
```

```
03 BAQ-APINAME          PIC X(255)
      VALUE 'cscvinc_1.0.0'.
03 BAQ-APINAME-LEN      PIC S9(9) COMP-5 SYNC
      VALUE 13.
03 BAQ-APIPATH          PIC X(255)
      VALUE '/cscvinc/employee/{numb}'.
03 BAQ-APIPATH-LEN      PIC S9(9) COMP-5 SYNC
      VALUE 24.
03 BAQ-APIMETHOD        PIC X(255)
      VALUE 'GET'.
03 BAQ-APIMETHOD-LEN    PIC S9(9) COMP-5 SYNC
      VALUE 3.
```

cscvinc.properties

Server Config

apiRequesterHTTPS.xml Read only Close

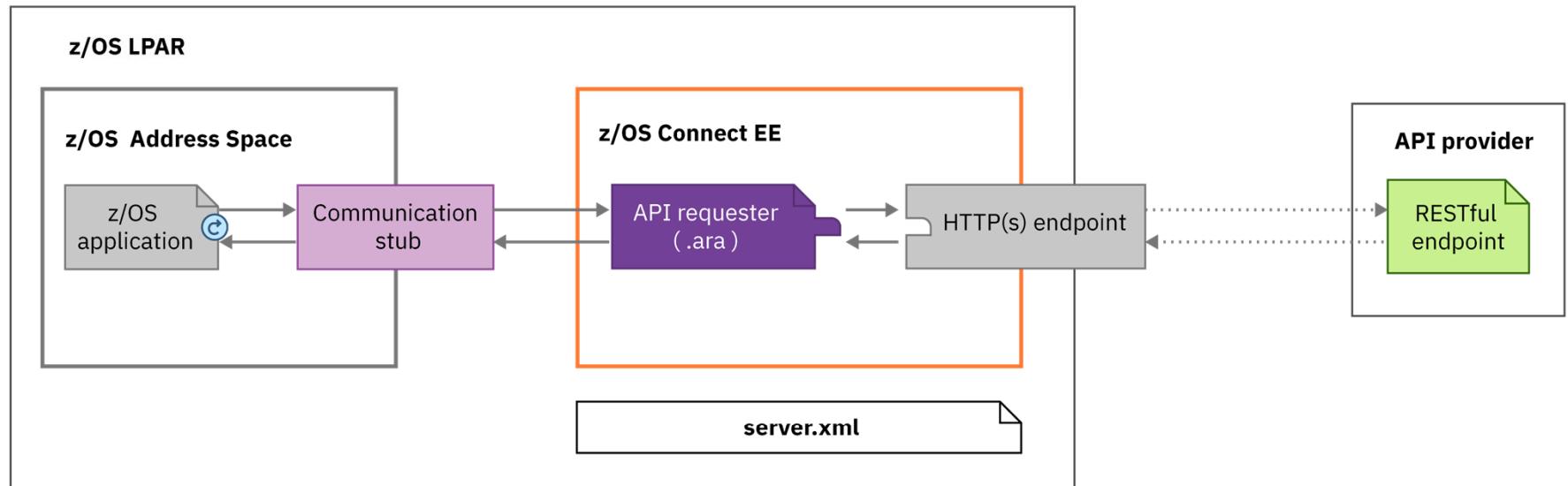
Design Source 

```
<zosconnect_endpointConnection id="cscvincAPI"
    host="https://dvipa.washington.ibm.com"
    port="9443"
    authenticationConfigRef="mySAFAuth"
    connectionTimeout="10s"
    receiveTimeout="40s" />
<zosconnect_authData id="mySAFAuth"
    user="USER1"
    password="user1" />
</server>
```

<http://dvipa.washington.ibm.com:9443/cscvincapi/employee/{numb}>

Steps to calling an external API

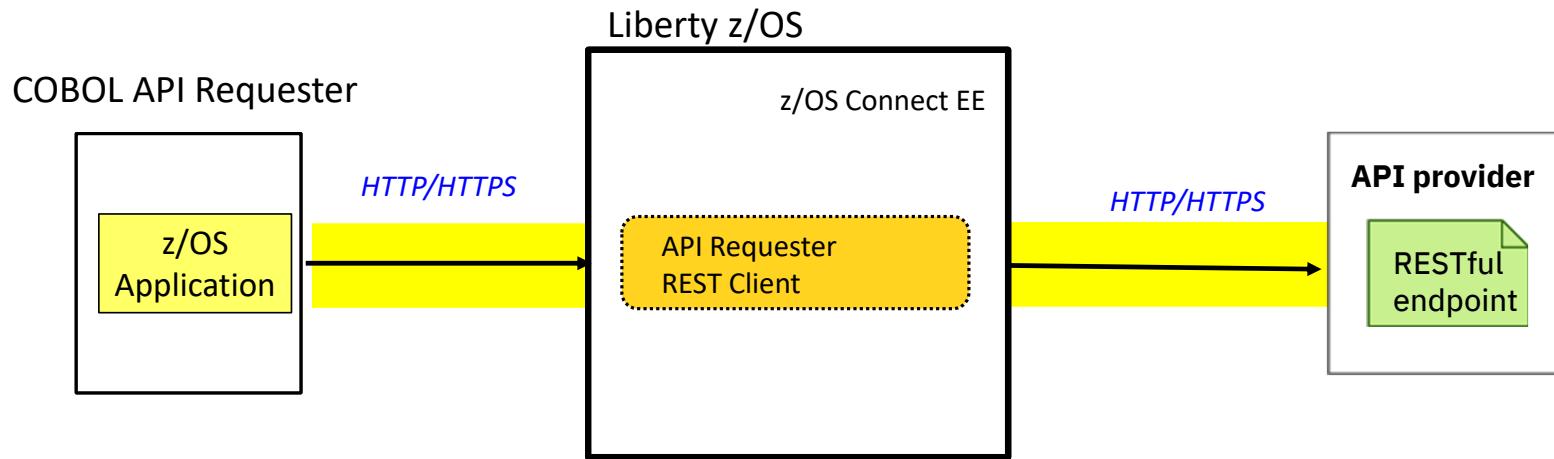
Done





z/OS Connect EE

API requester to API Provider connection overview



MVS Batch and IMS HTTP connection details provided by:

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

CICS HTTP connection details provided by:

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



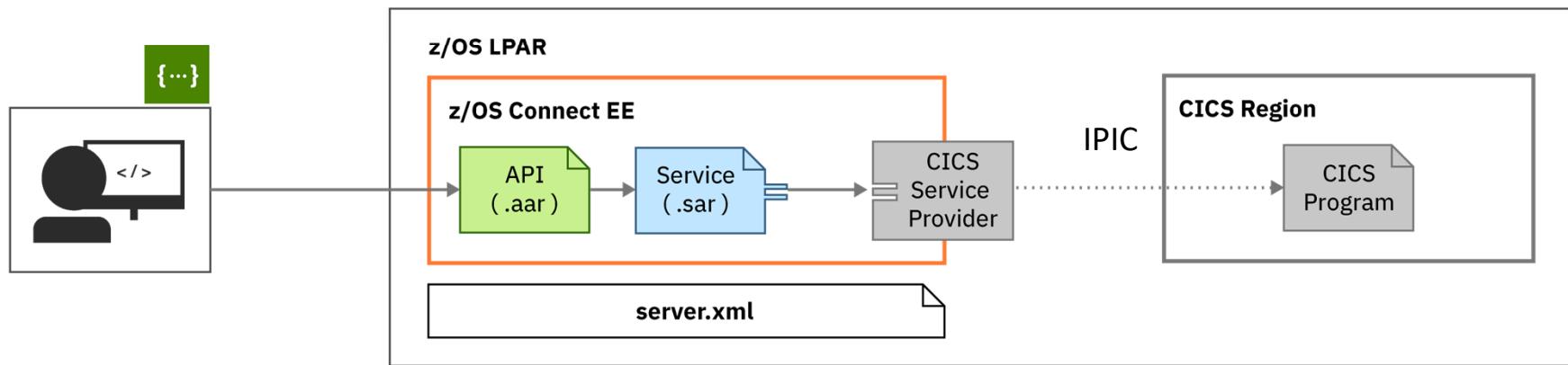
/common_scenarios

Typical connection patterns to different subsystems.



Accessing a CICS program

Topology



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

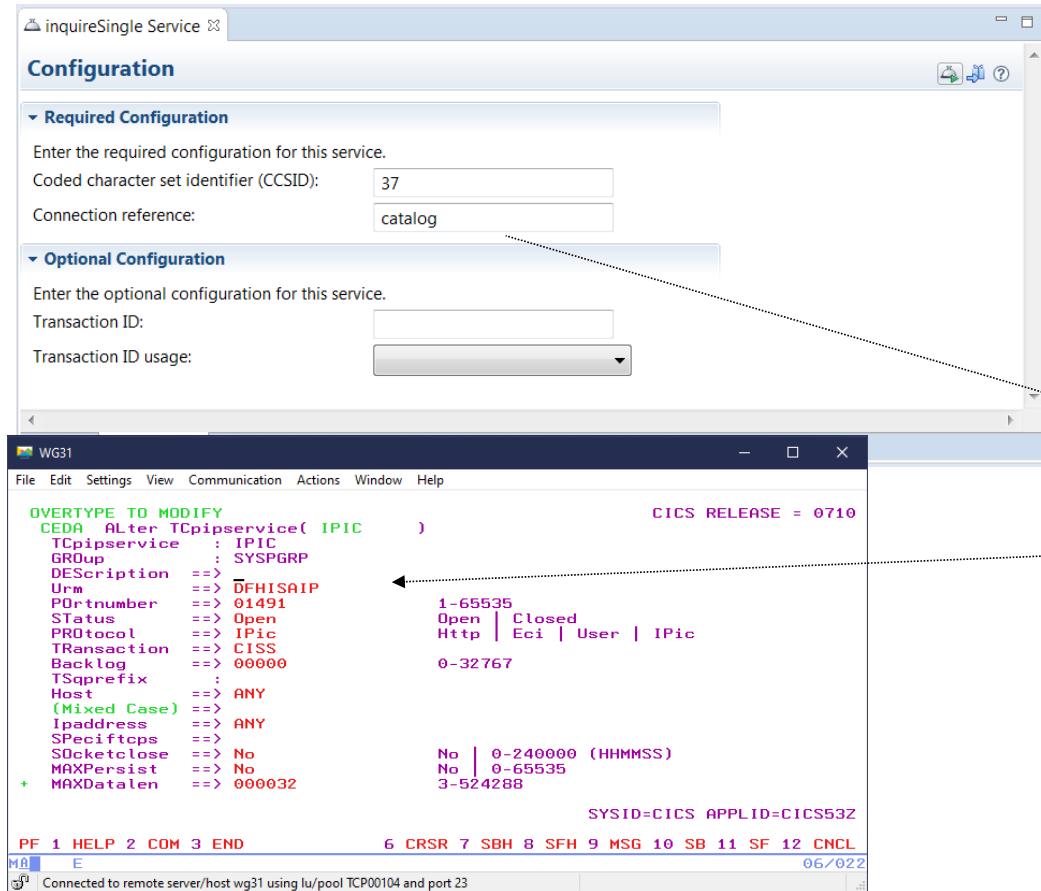
An IPIC connection must be configured in CICS.

i ibm.biz/zosconnect-scenarios



Accessing a CICS program using IPIC

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

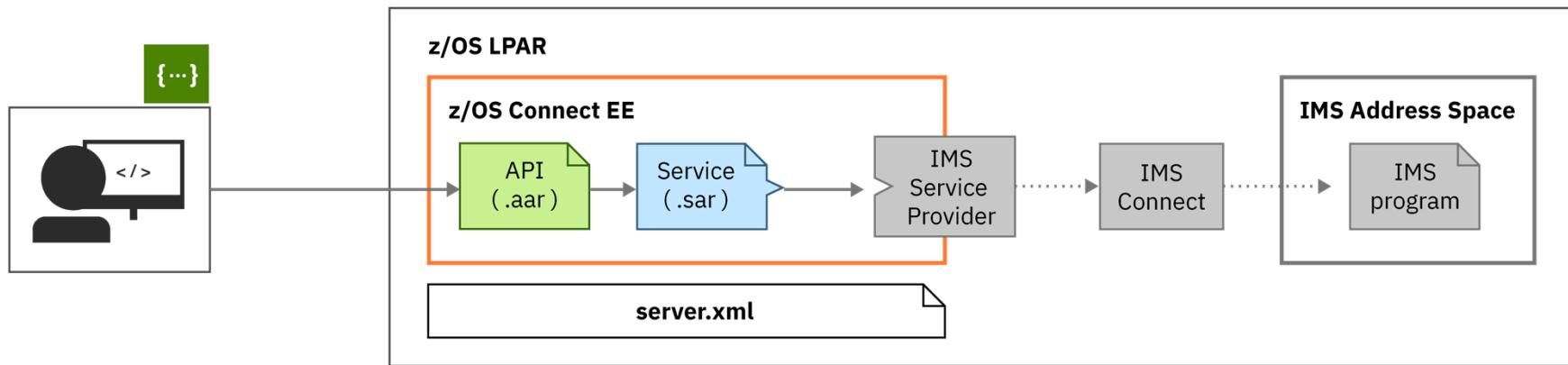
```
catalog.xml
Design Source
1 <server description="CICS IPIC - catalog">
2
3 <!-- Enable features -->
4 <featureManager>
5   <feature>zosconnect:cicsService-1.0</feature>
6 </featureManager>
7
8 <zosconnect_cicsIpicConnection id="catalog">
9   host="wg31.washington.ibm.com"
10  port="1491"
11  transid="CSMI"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

Define IPIC connection to CICS



Accessing an IMS transaction using OTMA

Topology



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

ibm.biz/zosconnect-scenarios

IMS Connections and Interactions (server XML)



ivtnoService Service Configuration

Required Configuration

Enter the required configuration for this service.

Connection profile: **IMSCONN**

Interaction profile: **IMSINTER**

Optional Configuration

Enter the optional configuration for this service.

IMS destination override:

Program name:

Overview Configuration

IMS Connect HWSCFG

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

Connection

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

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

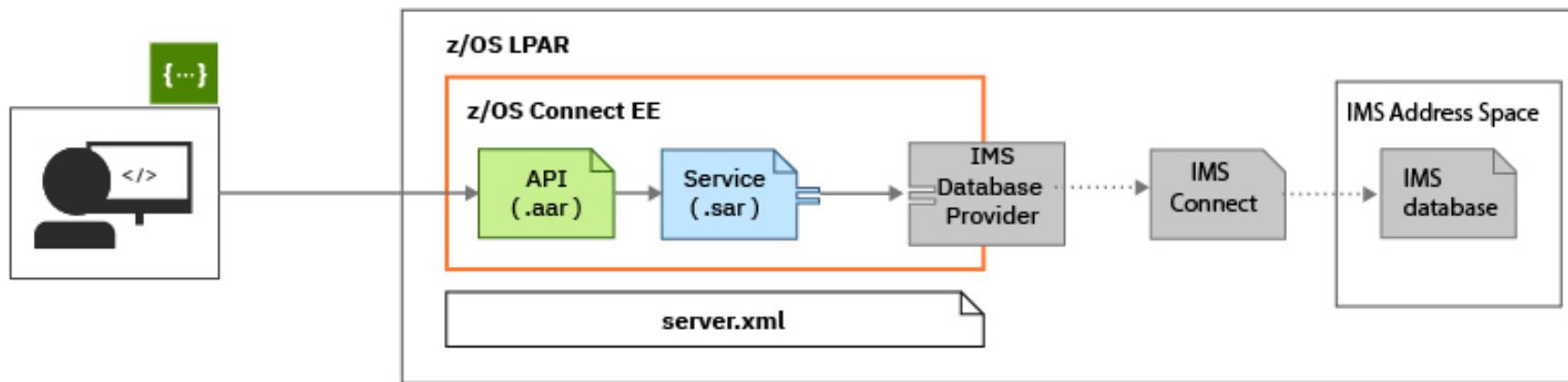
Interaction

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



Accessing an IMS data base using ODBA

Topology



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

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



IMS Connection Factory in the server XML

Service Project Editor: Configuration

Required Configuration

Enter the required configuration for this service.

Connection profile:

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>
```

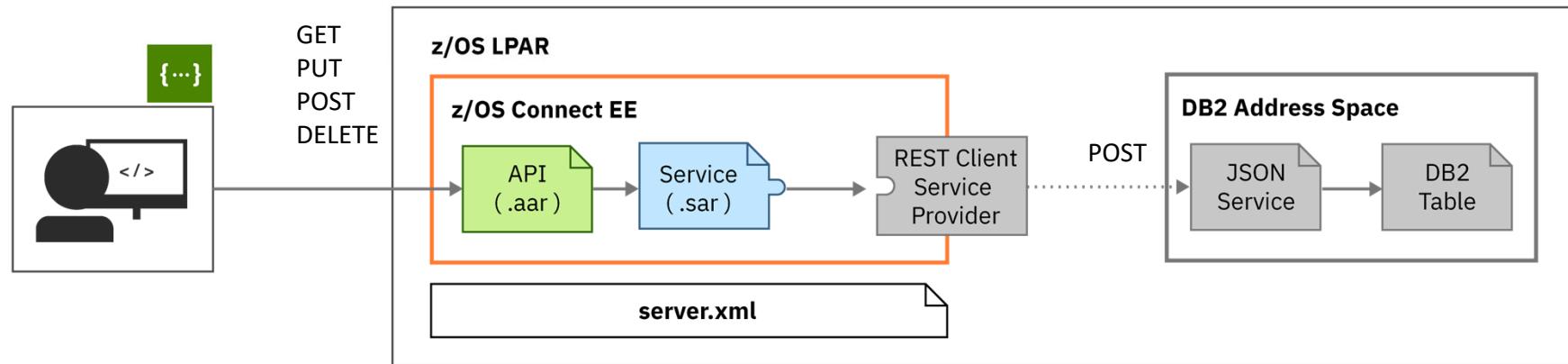
IMS Connect HWSCFG

```
HWS=(ID=IMS14HWS,XIBAREA=100,RACE=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)
```



Accessing a Db2 resources

Topology



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

A Db2 REST Service must be configured in DB2.

Accessing a Db2 REST service resource



*selectEmployee Service X

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

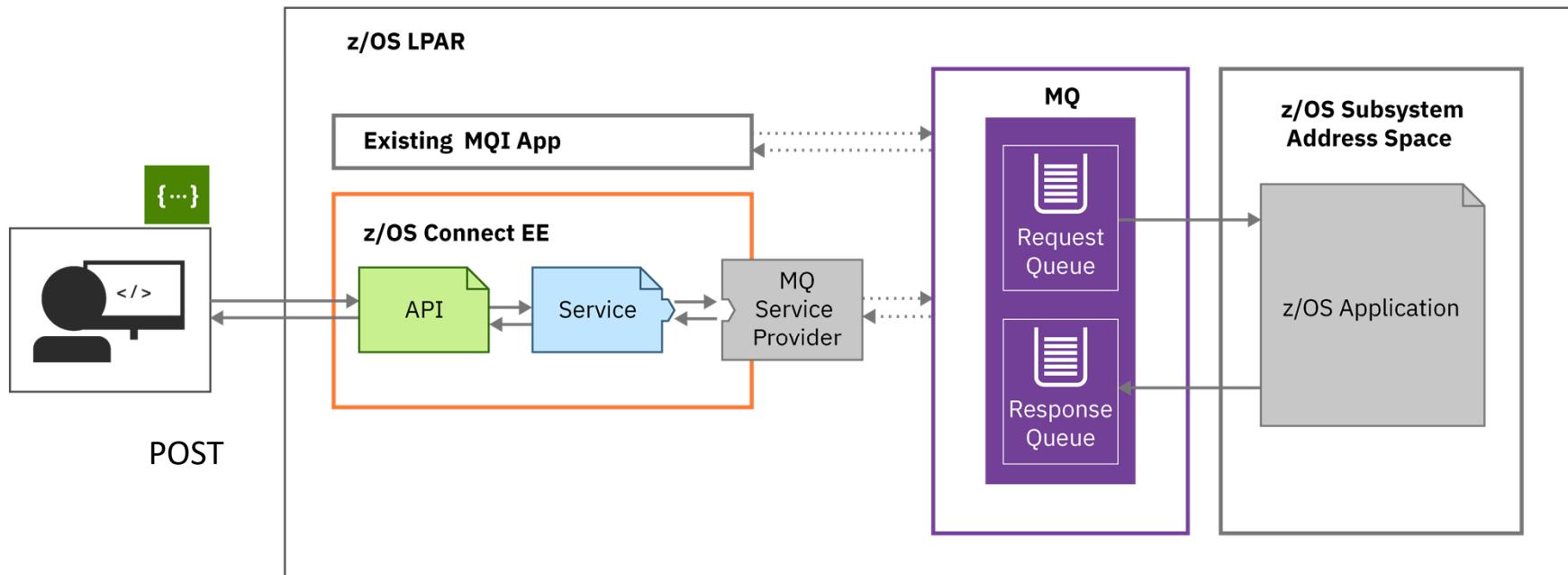
```
1 <server description="DB2 REST">
2
3   <zosconnect_zosConnectServiceRestClientConnection id="db2conn"
4     host="wg31.washington.ibm.com"
5     port="2446"
6     basicAuthRef="dsn2Auth" />
7
8   <zosconnect_zosConnectServiceRestClientBasicAuth id="dsn2Auth"
9     applName="DSN2APPL"/>
10
11</server>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

The diagram illustrates the configuration of a Db2 REST service. On the left, the 'Service Project Editor: Configuration' window shows a 'Required Configuration' section with a 'Connection reference' input field containing 'db2conn'. A red arrow points from this field to the 'basicAuthRef="dsn2Auth"' line in the XML code on the right. The XML code defines a server with a specific description and connects it to a basic authentication reference named 'dsn2Auth'.



Accessing a MQ queue manager and request/reply queues

Topology (Two-way service example)

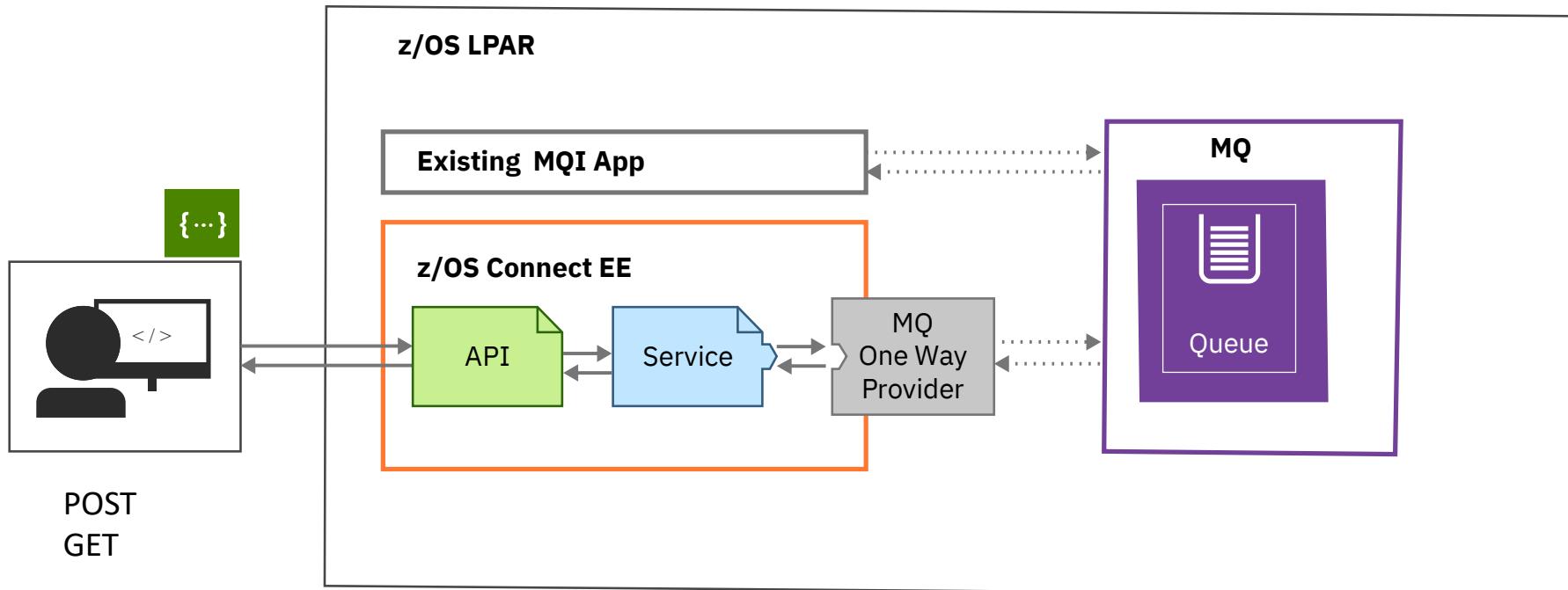


You can also configure one-way services.



Accessing a MQ queue

Topology (One-way service example)



Using JMS to access MQ

*twoWay Service X

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

Definition Configuration

mq.xml

Read only Close

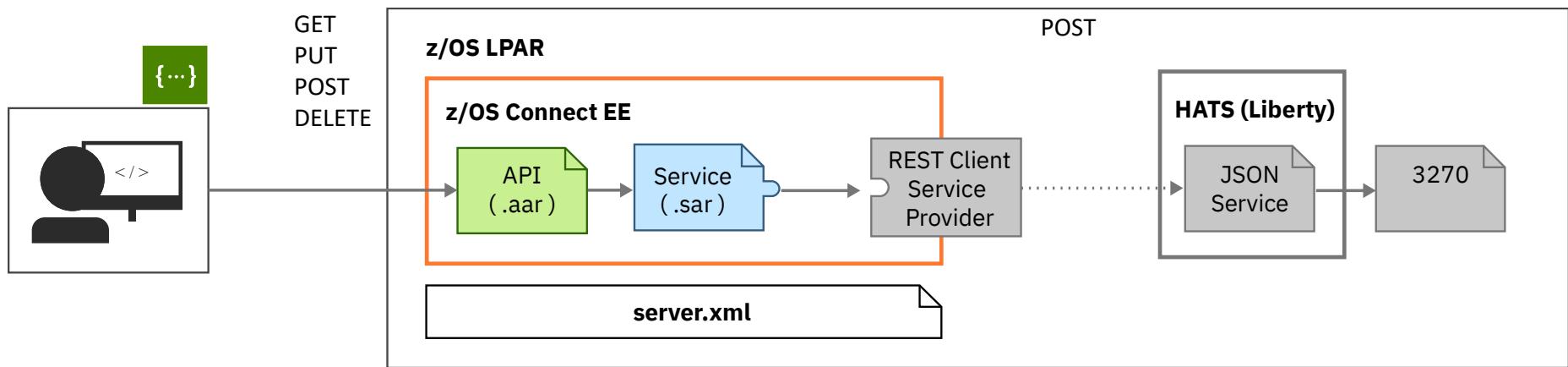
Design Source

```
2 <featureManager>
3   <feature>zosconnect:mqService-1.0</feature>
4 </featureManager>
5
6 <variable name="wmqJmsClient.rar.location"
7   value="/usr/lpp/mqm/V9R1M1/java/lib/jca/wmq.jmsra.rar"/>
8 <wmqJmsClient nativeLibraryPath="/usr/lpp/mqm/V9R1M1/java/lib"/>
9
10 <connectionManager id="ConMgr1" maxPoolSize="5"/>
11
12 <jmsConnectionFactory id="qmgrCf" jndiName="jms/qmgrCf"
13   connectionManagerRef="ConMgr1">
14   <properties.wmqJMS transportType="BINDINGS"
15     queueManager="QMZ1" />
16 </jmsConnectionFactory>
17
18 <jmsConnectionFactory id="qmgrCf2" jndiName="jms/qmgrCf2"
19   connectionManagerRef="ConMgr1">
20   <properties.wmqJMS transportType="CLIENT"
21     queueManager="ZMQ1"
22       channel="LIBERTY.DEF.SVRCONN"
23       hostName="wg31.washington.ibm.com"
24       port="1422" />
25 </jmsConnectionFactory>
26
27 <jmsQueue id="q1" jndiName="jms/default">
28   <properties.wmqJms
29     baseQueueName="ZCONN2.DEFAULT.MQZCEE.QUEUE"
30     CCSID="37"/>
31 </jmsQueue>
32
33 <jmsQueue id="requestQueue" jndiName="jms/request">
34   <properties.wmqJms
35     baseQueueName="ZCONN2.TRIGGER.REQUEST"
36     targetClient="NO"
37     CCSID="37"/>
38 </jmsQueue>
39
40 <jmsQueue id="replyQueue" jndiName="jms/replyQueue">
41   <properties.wmqJms
42     baseQueueName="ZCONN2.TRIGGER.RESPONSE"
43     targetClient="MQ"
44     CCSID="37"/>
45 </jmsQueue>
46
47
```



Accessing a HATS server

Topology



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

HATS server XML configuration



```
getCompany.properties - Notepad
File Edit Format View Help
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
```

Server Config

hats.xml

Read only Close

Design Source

```
<server description="HATS">
  <zosconnect_zosConnectServiceRestClientConnection id="HatsConn">
    host="wg31.washington.ibm.com"
    port="29080" />
</server>
```

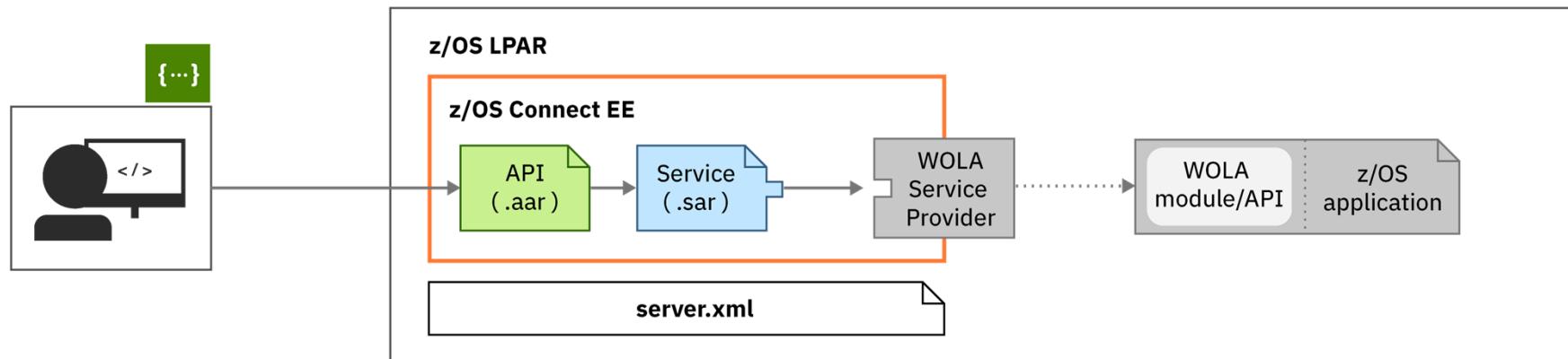
HATS Liberty server.xml

```
<!-- To access this server from a remote client, add a host attribute to the following element, e.g. host="*" -->
<httpEndpoint id="defaultHttpEndpoint"
  httpPort="29080" host="*"
  httpsPort="29443" />
```



Accessing a MVS batch application

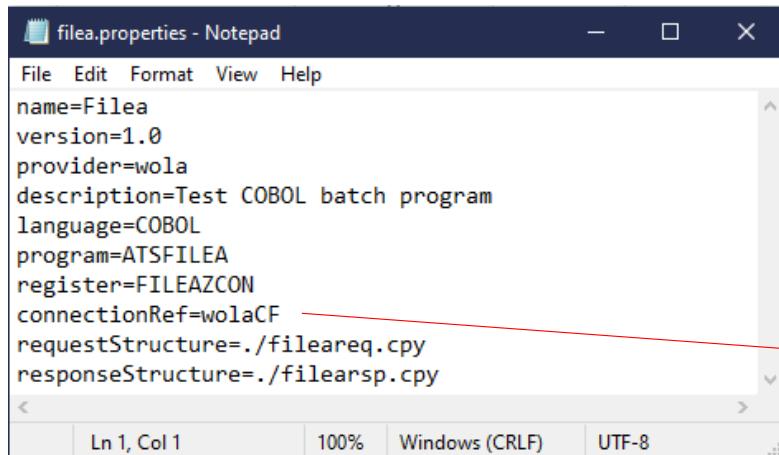
Topology



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

The z/OS application must be WOLA-enabled.

MVS batch server XML



```
filea.properties - Notepad
File Edit Format View Help
name=Filea
version=1.0
provider=wola
description=Test COBOL batch program
language=COBOL
program=ATSFIL
register=FILEAZCON
connectionRef=wolaCF
requestStructure=./fileareq.cpy
responseStructure=./filearsp.cpy
```

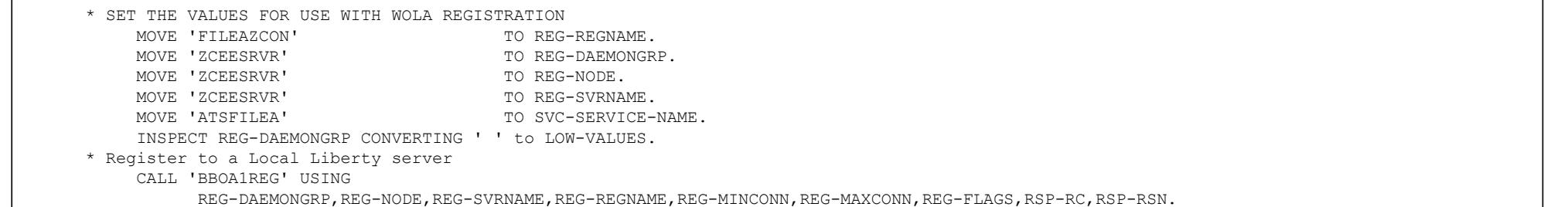


Server Config

wola.xml

Design Source

```
<server description="WOLA">
  <featureManager>
    <feature>zosLocalAdapters-1.0</feature>
  </featureManager>
  <zosLocalAdapters wolaGroup="ZCEESRVR">
    wolaName2="ZCEESRVR"
    wolaName3="ZCEESRVR"/>
  <connectionFactory id="wolaCF">
    jndiName="eis/ola">
      <properties.ola/>
    </connectionFactory>
  </server>
```

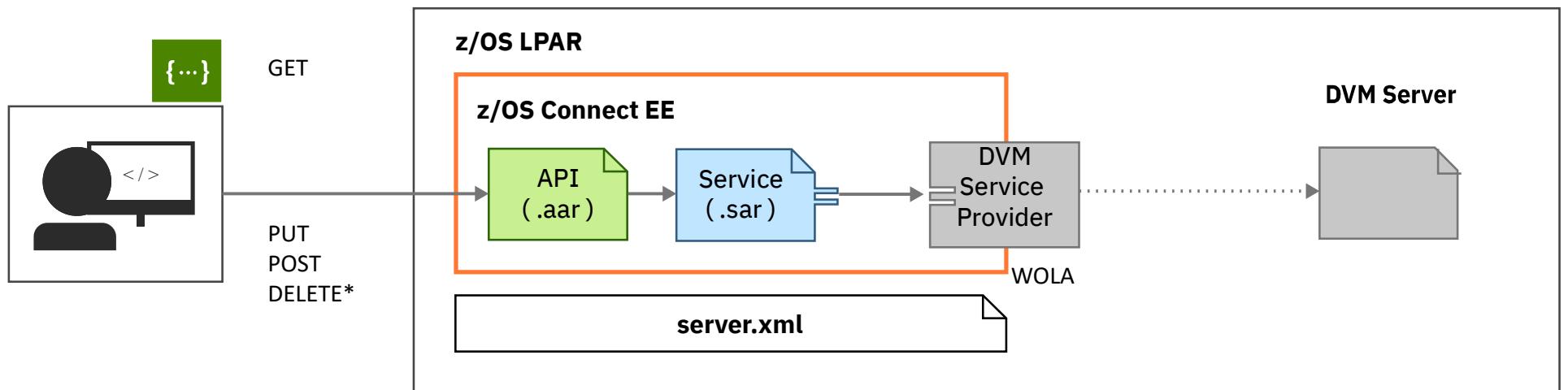


```
* SET THE VALUES FOR USE WITH WOLA REGISTRATION
MOVE 'FILEAZCON'          TO REG-REGNAME.
MOVE 'ZCEESRVR'            TO REG-DAEMONGRP.
MOVE 'ZCEESRVR'            TO REG-NODE.
MOVE 'ZCEESRVR'            TO REG-SVRNAME.
MOVE 'ATSFIL'              TO SVC-SERVICE-NAME.
INSPECT REG-DAEMONGRP CONVERTING ' ' to LOW-VALUES.
* Register to a Local Liberty server
CALL 'BBOA1REG' USING
  REG-DAEMONGRP,REG-NODE,REG-SVRNAME,REG-REGNAME,REG-MINCONN,REG-MAXCONN,REG-FLAGS,RSP-RC,RSP-RSN.
```



Accessing a DVM server

Topology



The DVM service provider uses WOLA

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



DVM server XML

Server Config

dvs.xml

Read only Close

Design Source

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="new server">
  <!-- Enable features -->
  <featureManager>
    <feature>usr:dvsProvider</feature>
    <feature>zosLocalAdapters-1.0</feature>
  </featureManager>
  <!-- Adapter Details with WOLA Group Name (ZCEEDVM) -->
  <zosLocalAdapters wolaName3="NAME3"
    wolaName2="NAME2"
    wolaGroup="ZCEEDVM"/>
  <!-- DVS Service Details with Register Name (ZCEEDVM) -->
  <zosconnect_zosConnectService invokeURI="/dvs"
    serviceDescription=""
    serviceRef="dvsService"
    serviceName="dvsService"
    id="zosConnectDvsService"/>
  <usr_dvsService invokeURI="/dvs"
    serviceName="DVSS1"
    registerName="ZCEEDVM"
    connectionFactoryRef="wolaCF"
    id="dvsService"/>
  <connectionFactory jndiName="eis/ola" id="wolaCF">
    <properties.ola/>
  </connectionFactory>
  <zosconnect_zosConnectService serviceRef="svc1"
    serviceAsyncRequestTimeout="600s"
    serviceName="dvs1" id="sdef1"/>
  <zosconnect_localAdaptersConnectService
    connectionWaitTimeout="7200"
    connectionFactoryRef="wolaCF"
    serviceName="DVSS1"
    registerName="ZCEEDVM"
    id="svc1"/>
</server>
```

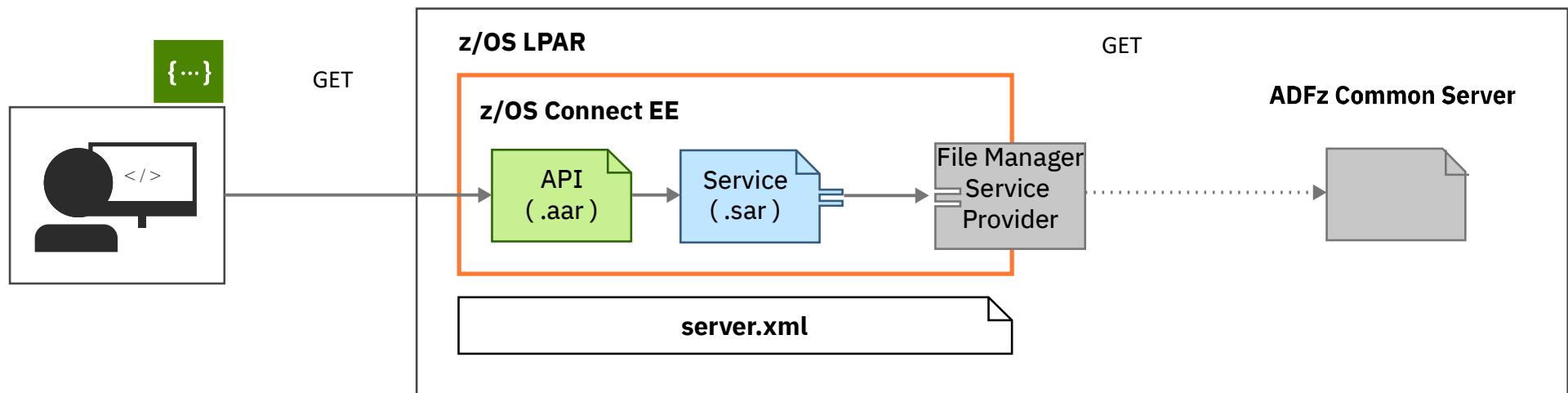
DVS . AVZS . SAVZEXEC (AVZSIN00)

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



Accessing a File Manager server

Topology



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

A File Manager Template is required .

File Manager server XML



```
filea.properties - Notepad
File Edit Format View Help
name=filea
provider=filemanager
host=wg31.washington.ibm.com
version=1.0
port=2800
file=USER1.ZCEE.FILEA
template=USER1.ZCEE.TEMPLATE(FILEA)
connid=default
userid=USER1
passwd=USER1

<
Ln 1, Col 1 100% Windows (CRLF) UTF-8 ..>
```

Server Config

filemgr.xml

Read only Close

Design Source

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="new server">
  <!-- Enable features -->
  <featureManager>
    <feature>filemanager:fmProvider-2.0</feature>
  </featureManager>
  <FileManager_Connection id="default"
    runport="2800"
    max_timeout="1800"/>
</server>
```

SYS1.PROCLIB(IPVSRV1)

```
//IPVSRV1 PROC PORT=2800,FAMILY='AF_INET',TRACE=N
//      SET ENV=''
//RUN      EXEC PGM=IPVSRV,REGION=40M,
//          PARM=('&ENV/&PORT &FAMILY &TRACE')
// SET IPV=SYSP.ADFZ.JCL           <== Update HLQ
//** Common component authorised library
//STEPLIB  DD DISP=SHR,DSN=ADFZ.SIPVMODA      <== ADFzCC APF LIBRARY
//SYSPRINT DD SYSOUT=*
//IPVTRACE DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//** Server wide, then participating product configurations
//CONFIG   DD DISP=SHR,DSN=&IPV.(IPVCFG)
```

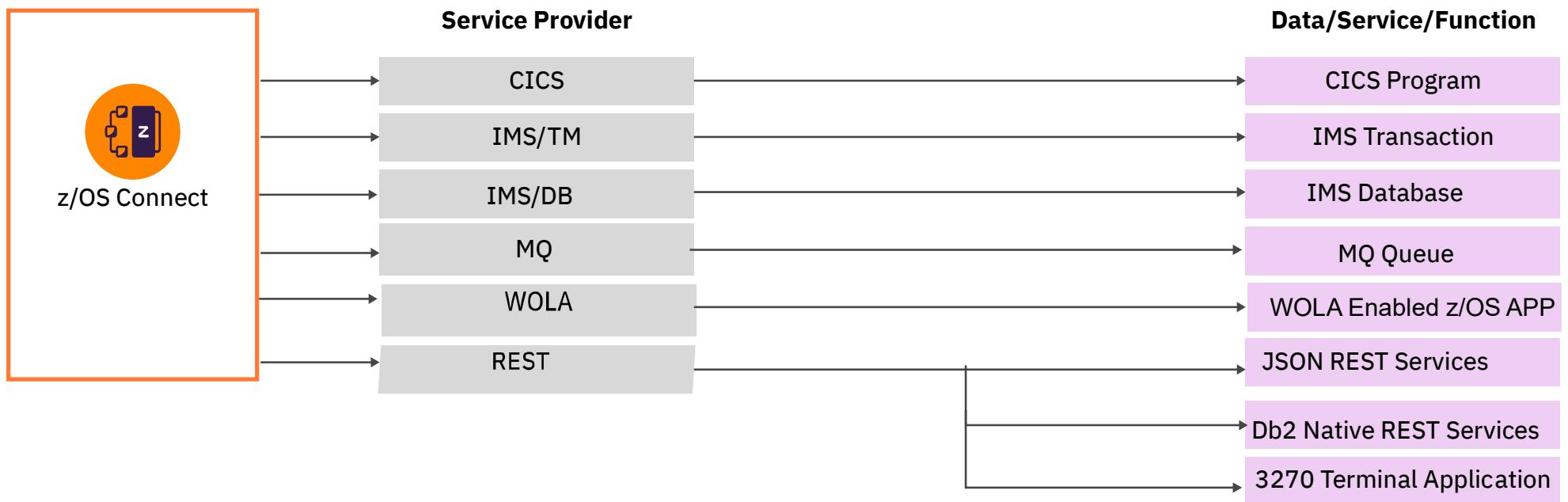


/miscellaneousTopics

performance, high availability, Liberty

What assets can z/OS Connect EE map to?

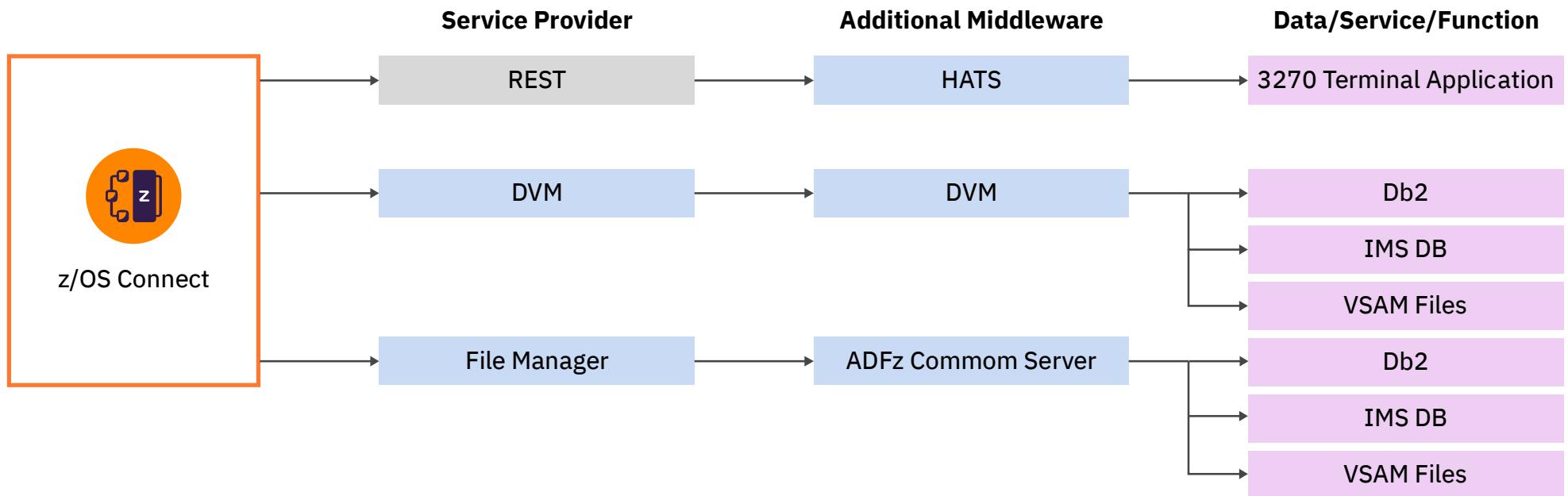
And which service provider could I use?



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

Additional Middleware

Additional value from the ecosystem



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

API Policies

- HTTP header properties can be used to select alternative for IMS (V3.0.4) , CICS (V3.0.10), Db2 (V3.0.36) or MQ (V3.0.39)
- Policies can be configured globally for every API in the server or for individual APIs (V3.0.11)

CICS attributes

- cicsCcsid
- cicsConnectionRef
- cicsTransId

IMS attributes

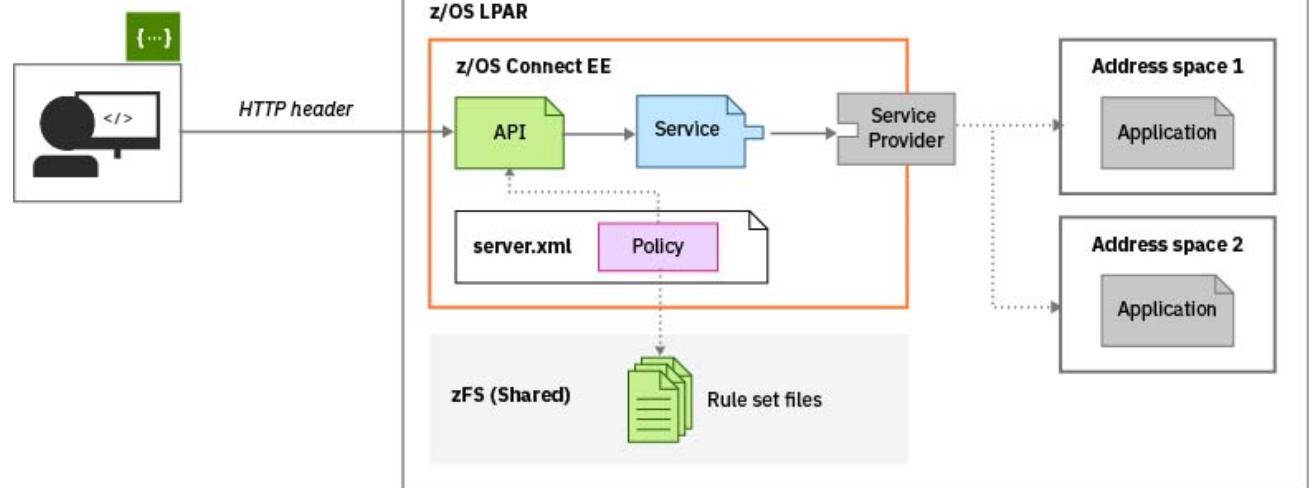
- imsConnectionRef
- imsInteractionRef
- imsInteractionTimeout
- imsLtermOverrideName
- imsTranCode
- imsTranExpiration

Db2 attributes

- db2ConnectionRef
- db2CollectionID

MQ attributes

- mqConnectionFactory
- mqDestination
- mqReplyDestination



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"/> *
    </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, specifically the 'numb' entry which is labeled as 'Required string'. Other sections shown include 'HTTP Headers' (with 'cicsMirror' and 'cicsConnection' listed as 'optional string'), 'Query Parameters', and 'Body - cscvincServiceOperation'.

Curl

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

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

Tech/Tip: Providing access to service archives files



Name	Last Modified	Size	Description
apis	Fri Feb 19 13:46:13 GMT 2021	-	Directory
services	Sat Feb 20 20:54:41 GMT 2021	-	Directory
apiRequesters	Wed Feb 07 17:59:04 GMT 2018	-	Directory
rules	Tue Jan 26 20:34:05 GMT 2021	-	Directory

```
<webApplication id="resources-location" name="resources" location="${server.config.dir}/resources/zosconnect">
<web-ext context-root="/resources/zosConnect" enable-file-serving="true" enable-directory-browsing="true">
<file-serving-attribute name="extendedDocumentRoot" value="${server.config.dir}/resources/zosconnect" />
</web-ext>
</webApplication>
```

Name	Last Modified	Size	Description
cscvincDeleteService.sar	Thu Feb 18 18:02:19 GMT 2021	4362	File
cscvincInsertService.sar	Thu Feb 18 18:02:19 GMT 2021	4491	File
cscvincSelectService.sar	Thu Feb 18 18:02:19 GMT 2021	4590	File

Opening cscvincSelectService.sar

You have chosen to open:
cscvincSelectService.sar
which is: SAR file (4.5 KB)
from: https://wg31.washington.ibm.com:9453

What should Firefox do with this file?
 Open with Applications\WINZIP32.EXE (default)
 Save File

OK Cancel



Tech/Tip: Providing access to configuration/log information

wg31.washington.ibm.com:9443/se X +

This XML file does not appear to have any style information associated with it. The document tree is shown below.

```
<server description="new server">
<include location="${server.config.dir}/includes/safSecurity.xml"/>
<include location="${server.config.dir}/includes/ipicSSLIDProp.xml"/>
<include location="${server.config.dir}/includes/keyringOutbound.xml"/>
<include location="${server.config.dir}/includes/groupAccess.xml"/>
<include location="${server.config.dir}/includes/shared.xml"/>
<include location="${server.config.dir}/includes/oauth.xml"/>
<include location="${server.config.dir}/includes/adminCenter.xml"/>
<include location="${server.config.dir}/includes/mqClientTLS.xml"/>
<include location="${server.config.dir}/includes/web.xml"/>
<!-- Enable features -->
<featureManager>
<feature>zosconnect:zosConnect-2.0</feature>
<feature>zosconnect:zosConnectCommands-1.0</feature>
</featureManager>
<!--
   To access this server from a remote client add a host at
-->
<httpEndpoint id="defaultHttpEndpoint" host="*" httpPort="9080" ht
<!--
   add cors to allow cross origin access, e.g. when using s
-->
```

```
<webApplication id="serverConfig-location" name="serverConfig"
location="${server.config.dir}">
<web-ext context-root="/server/config"
enable-file-serving="true" enable-directory-browsing="true">
<file-serving-attribute name="extendedDocumentRoot"
value="${server.config.dir}" />
</web-ext>
</webApplication>
```

wg31.washington.ibm.com:9443/se X +

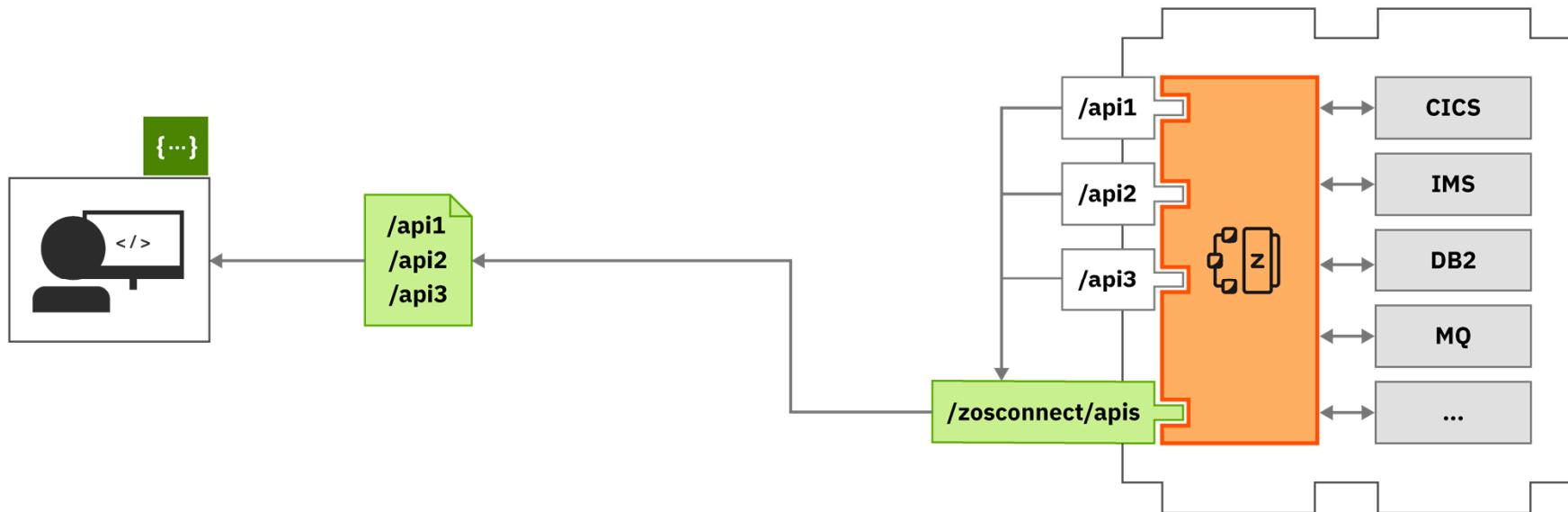
https://wg31.washington.ibm.com:9443/server/config/logs/messages.log

```
*****
product = WAS FOR z/OS 20.0.0.6, z/OS Connect 03.00.41 (wlp-1.0.41.cl200620200528-0414)
wlp.install.dir = /shared/IBM/zosconnect/v3r0/wlp/
server.config.dir = /var/zosconnect/servers/myServer/
java.home = /shared/java/J8_0_64
java.version = 1.8.0_261
java.runtime = Java(TM) SE Runtime Environment (8.0.6.15 - pmz6480sr6fp15-20200724_01(SR6 FP15))
os = z/OS (02.03.00; s390x) (en_US)
process = 16778879@wg31
*****
```

```
[2/19/21 15:48:18:901 GMT] 0000000b com.ibm.ws.kernel.launch.internal.FrameworkManager
[2/19/21 15:48:19:869 GMT] 00000017 com.ibm.ws.config.xml.internal.XMLConfigParser
/var/zosconnect/servers/myServer/includes/safSecurity.xml
/var/zosconnect/servers/myServer/includes/ipicIDProp.xml
/var/zosconnect/servers/myServer/includes/oauth.xml
/var/zosconnect/servers/myServer/includes/test.xml
/var/zosconnect/servers/myServer/includes/keyringOutbound.xml
[2/19/21 15:48:19:904 GMT] 00000017 com.ibm.ws.config.xml.internal.XMLConfigParser
/var/zosconnect/servers/myServer/includes/groupAccess.xml
[2/19/21 15:48:19:906 GMT] 00000017 com.ibm.ws.config.xml.internal.XMLConfigParser
/var/zosconnect/servers/myServer/includes/shared.xml
[2/19/21 15:48:19:907 GMT] 00000017 com.ibm.ws.config.xml.internal.XMLConfigParser
/var/zosconnect/servers/myServer/includes/oauth.xml
[2/19/21 15:48:19:911 GMT] 00000017 com.ibm.ws.config.xml.internal.XMLConfigParser
/var/zosconnect/servers/myServer/includes/test.xml
[2/19/21 15:48:19:994 GMT] 00000016 com.ibm.ws.zos.core.internal.NativeServiceTracker
below-the-line storage limit is 8MB and the above-the-line storage limit is 1729MB.
[2/19/21 15:48:19:997 GMT] 00000016 com.ibm.ws.zos.core.internal.NativeServiceTracker
[2/19/21 15:48:20:012 GMT] 00000016 com.ibm.ws.zos.core.internal.NativeServiceTracker
process.
[2/19/21 15:48:20:089 GMT] 00000016 com.ibm.ws.zos.core.internal.NativeServiceTracker
[2/19/21 15:48:20:091 GMT] 00000016 com.ibm.ws.zos.core.internal.NativeServiceTracker
```

A CNWKE0001I: The server myServer has been launched.
A CNWKG0028A: Processing included configuration resource:
I CNWKB0125I: This server requested a REGION size of 0KB. The
I CNWKB0126I: MEMLIMIT=1000. MEMLIMIT CONFIGURATION SOURCE=JCL.
I CNWKB0122I: This server is connected to the default angel
I CNWKB0103I: Authorized service group KERNEL is available.
I CNWKB0103I: Authorized service group LOCALCOM is available

API Documentation



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



z/OS Connect administration API

Interface providing meta-data and life-cycle operations for z/OS Connect services, APIs and API requesters.

APIs : Operations for working with APIs

Show/Hide | List Operations | Expand Operations

GET	/apis	Returns a list of all the deployed z/OS Connect APIs
POST	/apis	Deploys a new API into z/OS Connect
DELETE	/apis/{apiName}	Undeploys an API from z/OS Connect
GET	/apis/{apiName}	Returns detailed information about a z/OS Connect API
PUT	/apis/{apiName}	Updates an existing z/OS Connect API

Services : Operations for working with services

Show/Hide | List Operations | Expand Operations

GET	/services	Returns a list of all the deployed z/OS Connect services
POST	/services	Deploys a new service into z/OS Connect
DELETE	/services/{serviceName}	Undeploys a service from z/OS Connect
GET	/services/{serviceName}	Returns detailed information about a z/OS Connect service
PUT	/services/{serviceName}	Updates an existing z/OS Connect service
GET	/services/{serviceName}/schema/{schemaType}	Returns the request or response schema for a z/OS Connect service

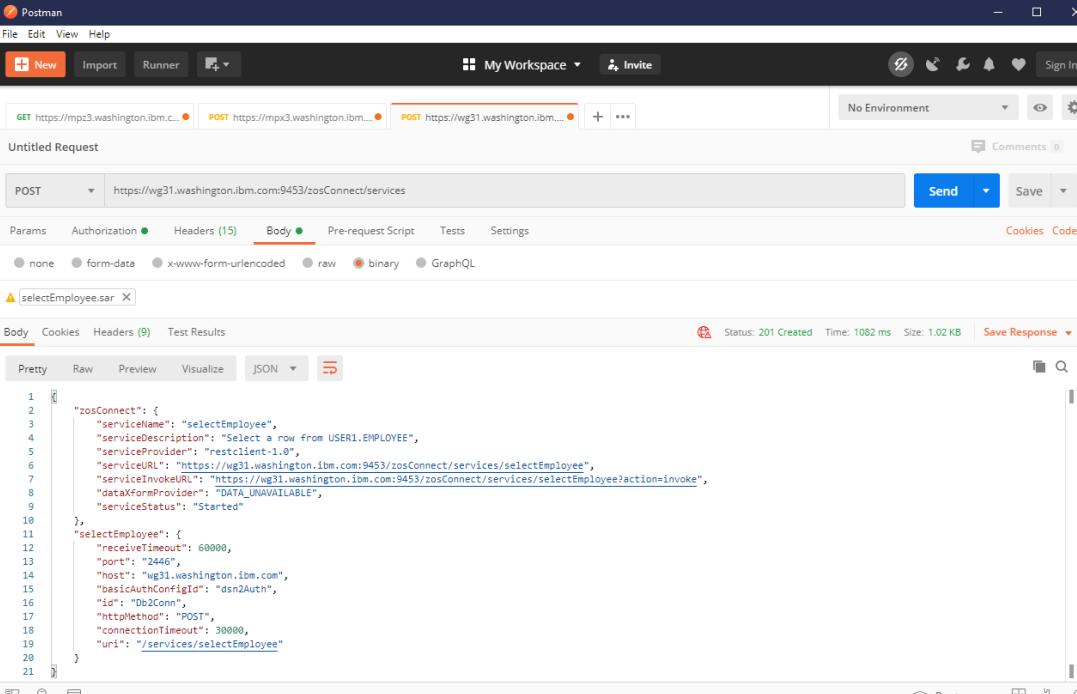
API Requesters : Operations that work with API Requesters.

Show/Hide | List Operations | Expand Operations

GET	/apiRequesters	Returns a list of all the deployed z/OS Connect API Requesters
POST	/apiRequesters	Deploys a new API Requester into z/OS Connect and invoke an API Requester call
DELETE	/apiRequesters/{apiRequesterName}	Undeploys an API Requester from z/OS Connect
GET	/apiRequesters/{apiRequesterName}	Returns the detailed information about a z/OS Connect API Requester
PUT	/apiRequesters/{apiRequesterName}	Updates an existing z/OS Connect API Requester

Deploying Service Archive options

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



The screenshot shows the Postman application interface. At the top, there are three tabs: 'GET https://mpx3.washington.ibm.com...', 'POST https://mpx3.washington.ibm.com...', and 'POST https://wg31.washington.ibm.com:9453/zosConnect/services'. The third tab is selected. Below the tabs, the URL 'https://wg31.washington.ibm.com:9453/zosConnect/services' is entered again. The 'Body' tab is selected, showing a file named 'selectEmployee.sar' with a binary content type. The file content is displayed as JSON code:

```

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
{
  "zosConnect": {
    "serviceName": "selectEmployee",
    "serviceDescription": "Select a row from USER1.EMPLOYEE",
    "serviceProvider": "restclient-1.0",
    "serviceURL": "https://wg31.washington.ibm.com:9453/zosConnect/services/selectEmployee",
    "serviceInvokeURL": "https://wg31.washington.ibm.com:9453/zosConnect/services/selectEmployee?action=invoke",
    "dataFormProvider": "DATA_UNAVAILABLE",
    "serviceStatus": "Started"
  },
  "selectEmployee": {
    "receiveTimeout": 60000,
    "port": "2446",
    "host": "wg31.washington.ibm.com",
    "basicAuthConfigId": "dsn2Auth",
    "id": "Db2Conn",
    "httpMethod": "POST",
    "connectionTimeout": 30000,
    "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"
  }
}

```



Deploying Service Archive – z/OS options

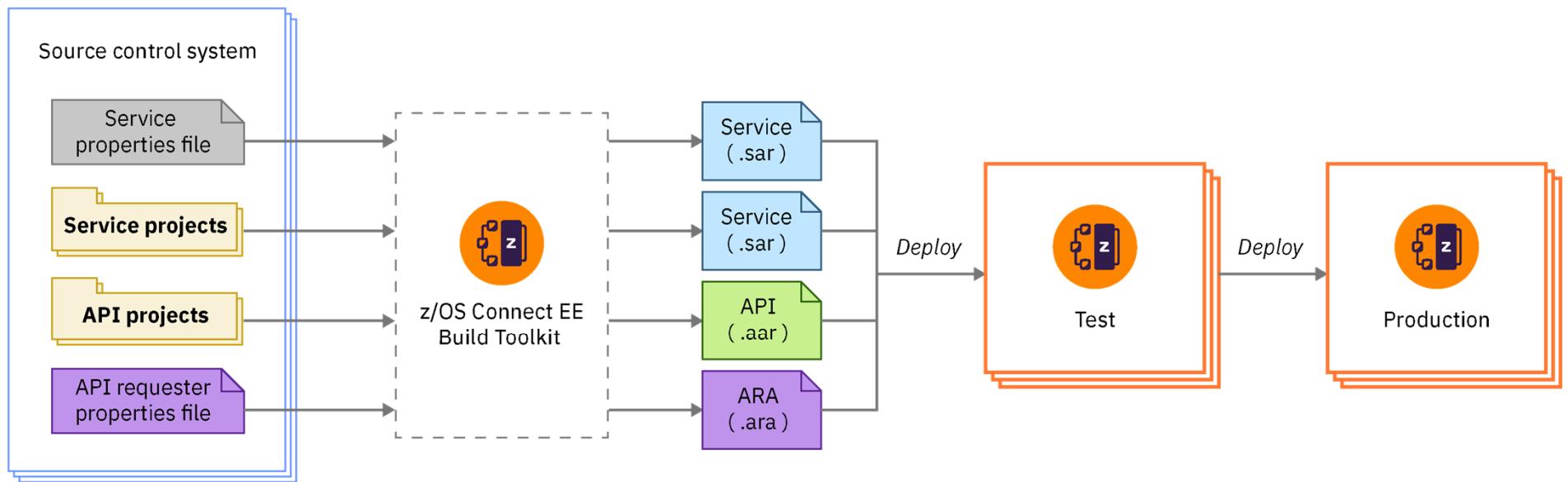
```
//*****
///* SET SYMBOLS
//*****
//EXPORT EXPORT SYMLIST=(*)
// SET CURL='/usr/lpp/rocket/curl'
//*****
///* CURL Procedure
//*****
//CURL PROC
//CURL EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//SYSERR DD SYSOUT=*
//STDOUT DD SYSOUT=*
// PEND
//*****
///* STEP CURL - use cURL to stop API cscvinc
//*****
//LIST EXEC CURL
//SYSTSIN DD *,SYMBOLS=EXECSYS
BPXBATCH SH export CURL=&CURL; $CURL/bin/curl -X PUT +
--cacert /u/johnson/CERTAUTH.PEM --user FRED:FRED +
https://wg31.washington.ibm.com:9443/zosConnect/apis/cscvinc?status=stoped
//*****
///* STEP CURL - use cURL to delete the API cscvinc
//*****
//DELETE EXEC CURL
//SYSTSIN DD *,SYMBOLS=EXECSYS
BPXBATCH SH export CURL=&CURL; $CURL/bin/curl -X DELETE +
--cacert /u/johnson/CERTAUTH.PEM --user FRED:FRED +
https://wg31.washington.ibm.com:9443/zosConnect/apis/cscvinc
//*****
///* STEP CURL - use curl to deploy the API cscvinc
//*****
//DEPLOY EXEC CURL
//SYSTSIN DD *,SYMBOLS=EXECSYS
BPXBATCH SH export CURL=&CURL; $CURL/bin/curl -X POST +
--cacert /u/johnson/CERTAUTH.PEM --user FRED:FRED +
--data-binary @/u/johnson/cscvinc.aar +
--header "Content-Type: application/zip" +
https://wg31.washington.ibm.com:9443/zosConnect/apis
```

<https://www.rocketsoftware.com/platforms/ibm-z/curl-for-zos>

DevOps using z/OS Connect EE

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

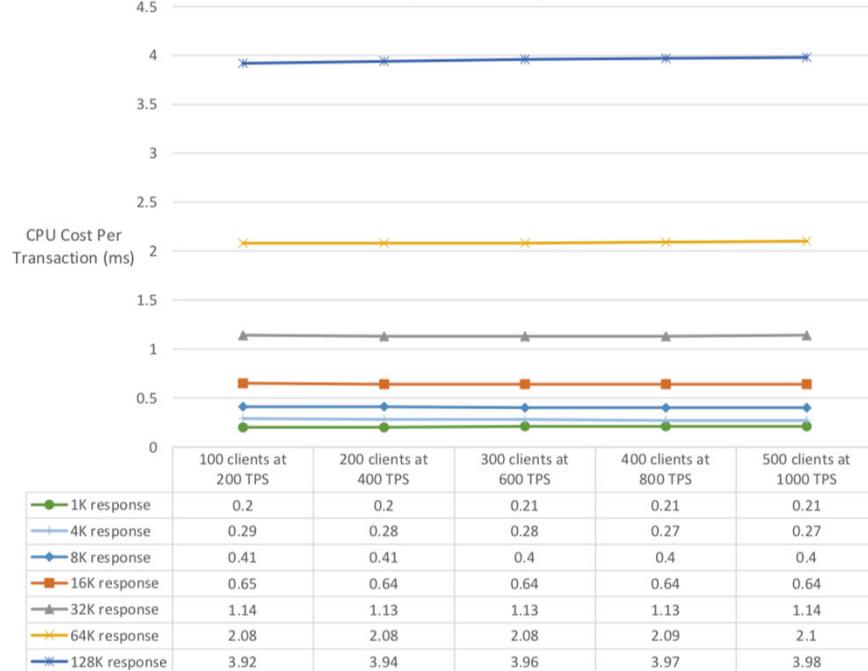
- The build toolkit supports the generation of service archives and API archives from projects created in the z/OS Connect EE API toolkit
- The build toolkit also supports the use of properties files to generate API requester archives
- Run the build toolkit from a build script to generate these archive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



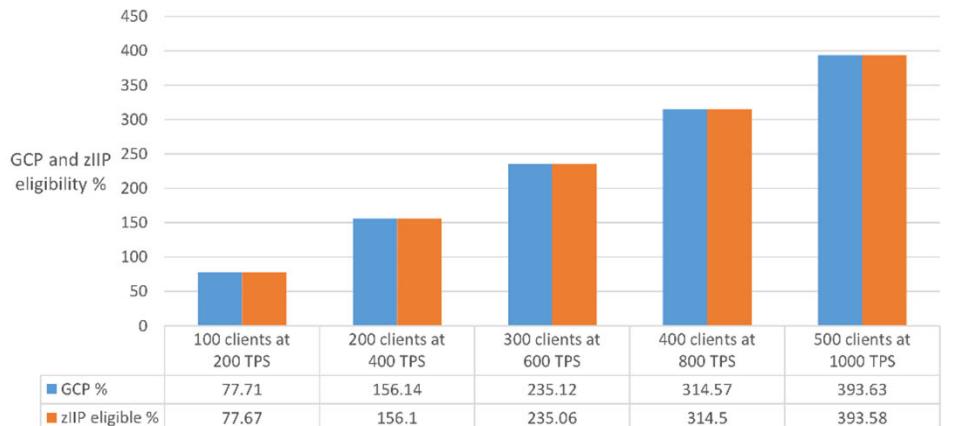
Performance: API Provider

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



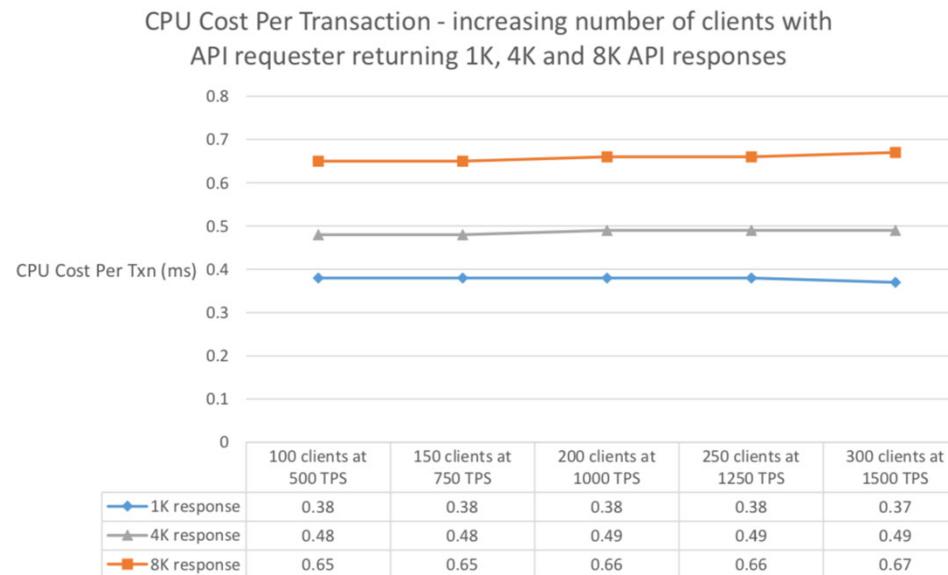
zIIP eligibility - increasing number of clients with 50 byte requests and 128K responses, using channels and CICS SP



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**.



/security

How is security implement?

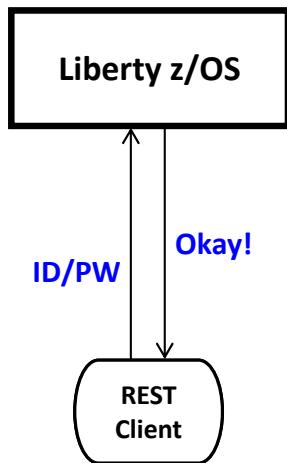
API Provider Authentication



z/OS Connect EE

Several different ways this can be accomplished:

Basic Authentication



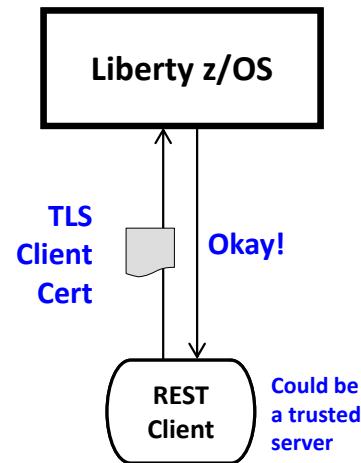
Server prompts for ID/PW

Client supplies ID/PW or
ID/Passticket

Server checks registry:

- Basic (server.xml)
- LDAP
- SAF

Client Certificate



Server prompts for cert.

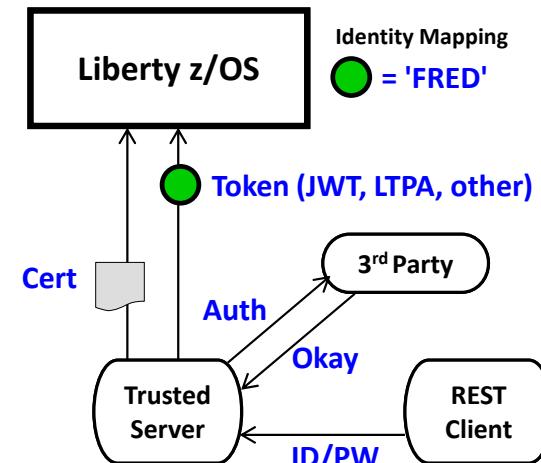
Client supplies certificate

Server validates cert and
maps to an identity

Registry options:

- LDAP
- SAF

Third Party Authentication



Client authenticates to 3rd party sever

Client receives a trusted 3rd party token

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

Registry options:

- LDAP
- SAF



Third Party Authentication Examples

The image displays two side-by-side screenshots of web pages illustrating third-party authentication.

Left Screenshot: UPS Sign Up

This screenshot shows the UPS "Sign Up" page. At the top, there's a banner stating "UPS is open for business: Service impacts related to Coronavirus ...More". Below the banner, the UPS logo is displayed. A "Sign Up / Log in" link and a "Search or Track" input field are visible. The main section is titled "Sign Up" and includes a link for users who already have an ID. It provides several options for creating an account using external services: Google, Facebook, Amazon, Apple, and Twitter. Below these, there's a section for entering personal information: Name*, Email*, User ID*, Password*, and Phone. The password field includes a "Show" link. A "Feedback" button is located on the right side of the form.

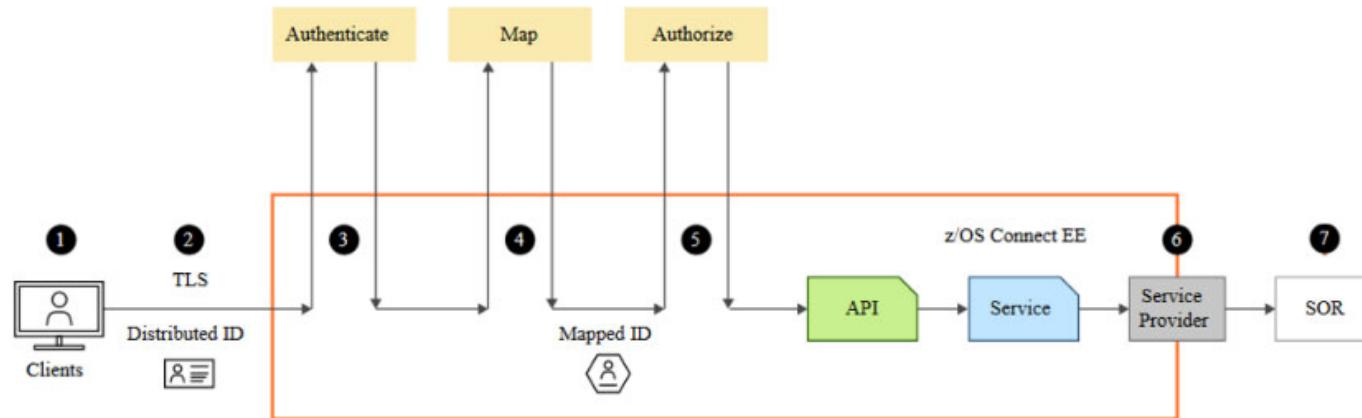
Right Screenshot: myNCDMV Log In

This screenshot shows the "Log In" page for myNCDMV. The background features a scenic view of autumn foliage. The page has "Log In" and "Sign Up" tabs at the top. The "Log In" tab is selected. It contains fields for "Email Address" (with placeholder "name@example.com") and "Password" (with placeholder "*****"). There's also a "Remember Me" checkbox. Below the password field are "Log In" and "Forgot Password" buttons. Further down, there are three social media login options: "Continue with Apple", "Continue with Facebook", and "Continue with Google". A "Continue as Guest" link is also present. At the bottom, a notice for public computer users states: "NOTICE FOR PUBLIC COMPUTER USERS - If you sign in with Google, Apple, or Facebook you are also signing into that account on this computer. Remember to sign out when you're done." The page is powered by "payit".

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Typical z/OS Connect EE API Provider 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. 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
7. The program or database request may run in the SoR under the mapped ID

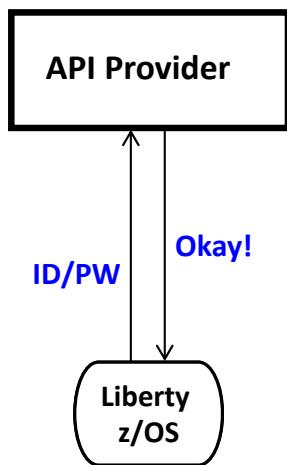
API Requester Authentication



z/OS Connect EE

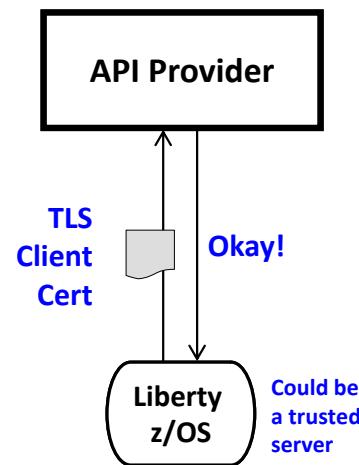
Several different ways this can be accomplished:

Basic Authentication



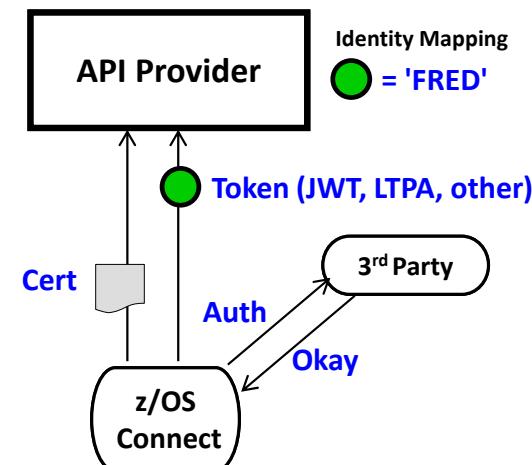
zCEE supplies ID/PW or
ID/Passticket

Client Certificate



Server prompts for certificate
zCEE supplies certificate

Third Party Authentication

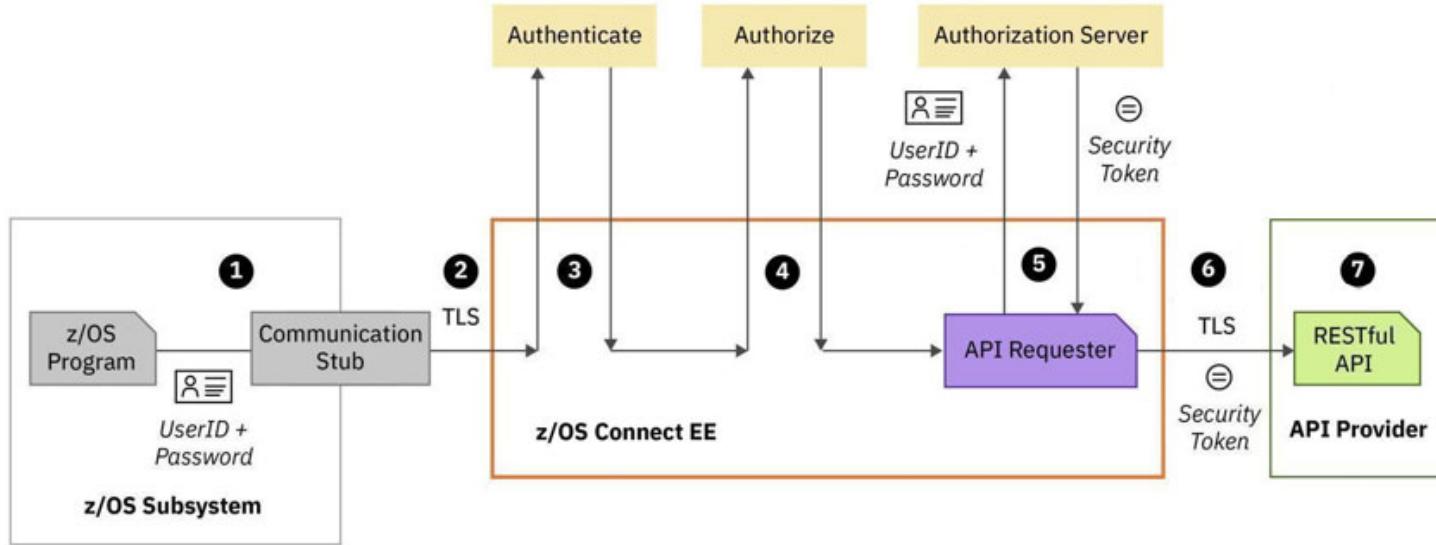


zCEE authenticates to 3rd party sever
zCEE receives a trusted 3rd party token
Token flows to API Provider

Typical z/OS Connect EE API Requester security flow



z/OS Connect EE



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

z/OS Connect Wildfire Github Site

<https://ibm.biz/Bdf8BZ>



The screenshot shows a GitHub repository page for 'ibm-wsc/zCONNEE-Wildfire-Workshop'. The left sidebar lists various branches and topics, with 'exercises' highlighted and circled in red. The main content area shows a list of files under the 'master' branch, all uploaded by user 'emitchj'. The files are primarily PDFs related to developing APIs for various IBM services like CICS, IMS, MVS, RESTful APIs, and MQ.

File Name	Description	Last Updated
Developing CICS API Requester Applications.pdf	Add files via upload	2 months ago
Developing IMS API Requester Applications.pdf	Add files via upload	2 months ago
Developing MVS Batch API Requester Applications.pdf	Add files via upload	2 months ago
Developing RESTful APIs for DVM VSAM Services.pdf	Add files via upload	20 days ago
Developing RESTful APIs for DVM VSAMCICS Services.pdf	Add files via upload	20 days ago
Developing RESTful APIs for Db2 REST Services.pdf	Add files via upload	2 months ago
Developing RESTful APIs for HATS REST Services.pdf	Add files via upload	2 months ago
Developing RESTful APIs for IMS Database REST Services....	Add files via upload	2 months ago
Developing RESTful APIs for IMS Transactions.pdf	Add files via upload	2 months ago
Developing RESTful APIs for MQ.pdf	Add files via upload	2 months ago
Developing RESTful APIs for MVS Batch.pdf	Add files via upload	2 months ago
Developing RESTful APIs for a CICS COMMAREA program.pdf	Add files via upload	2 months ago
Developing RESTful APIs for a CICS Container program.pdf	Add files via upload	2 months ago

- Contact your IBM representative to schedule access to these exercises

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/questions?thanks=true

Thank you for listening.

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