ZCINTRO - IBM z/OS Connect
An introduction and overview

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Agenda

- An Introduction and Overview of using REST API
- Enabling RESTful API to various z/OS resources, e.g.
  - CICS
  - Db2
  - IMS/TM
  - IMS/DB
  - MQ

- Accessing RESTful API from z/OS COBOL Applications
- A brief introduction to z/OS Connect Security

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

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Notes and Disclaimers

- The information in this presentation was derived from various product documentation web sites.
- Additional information included in this presentation was distilled from years of experience implementing security using RACF with z/OS products like CICS, IMS, Db2, MQ, etc. as well as Java runtimes environments like WebSphere Application Server and WebSphere Application Server Liberty which is commonly called Liberty.
- There will be additional information on slides that will designated as Tech/Tips. These contain information that at perhaps at least interesting and hopefully, useful to the reader.
- **IBM z/OS Connect (OpenAPI 2)** refers the z/OS Connect EE product prior to service level V3.0.55. **IBM z/OS Connect (OpenAPI 3)** refers to the additional functions and features added with service level V3.0.55. Important - servers configured for OpenAPI 2 can will continue to operate as is with service level V3.0.55 and later.
- A z/OS Connect OpenAPI 2, or a z/OS Connect OpenAPI 3 icon will appear on slides where the information is specific to these products. Don't hesitate to ask questions as to why the icon does or does not appear on certain slides.
- The examples, tips, etc. present in this material are based on firsthand experiences and are not necessarily sanctioned by Liberty or z/OS Connect development.

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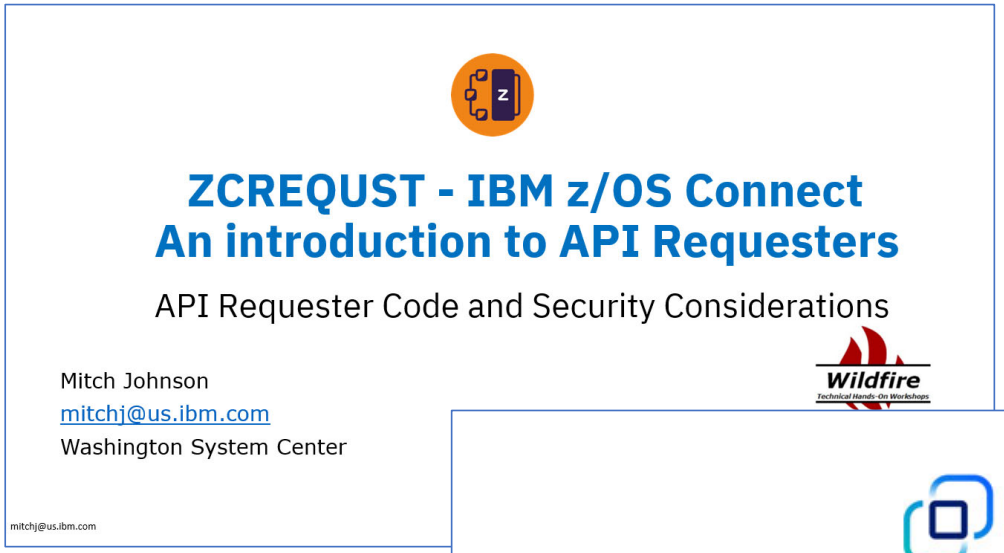
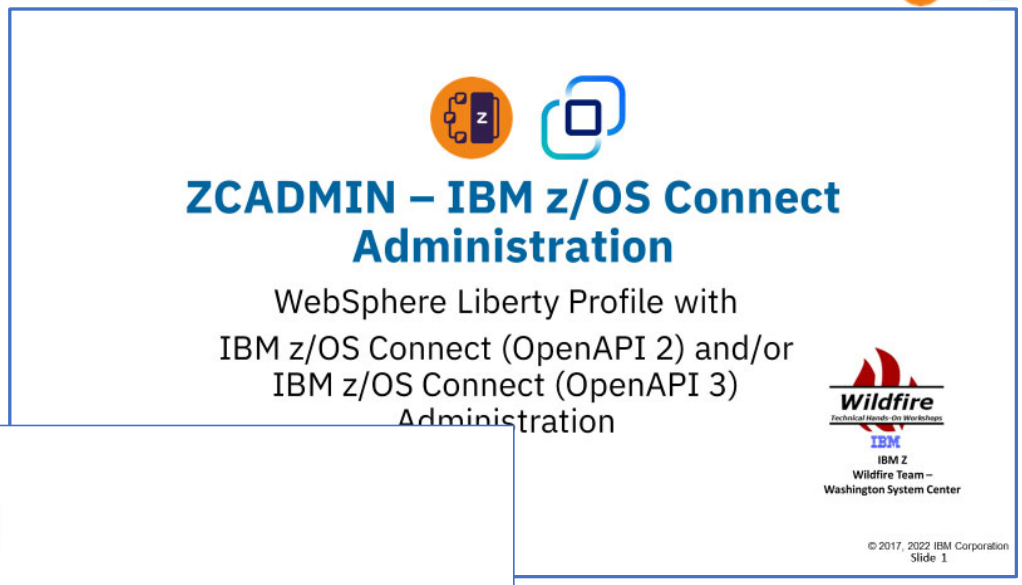
This session is part of a series of z/OS Connect workshops. . .

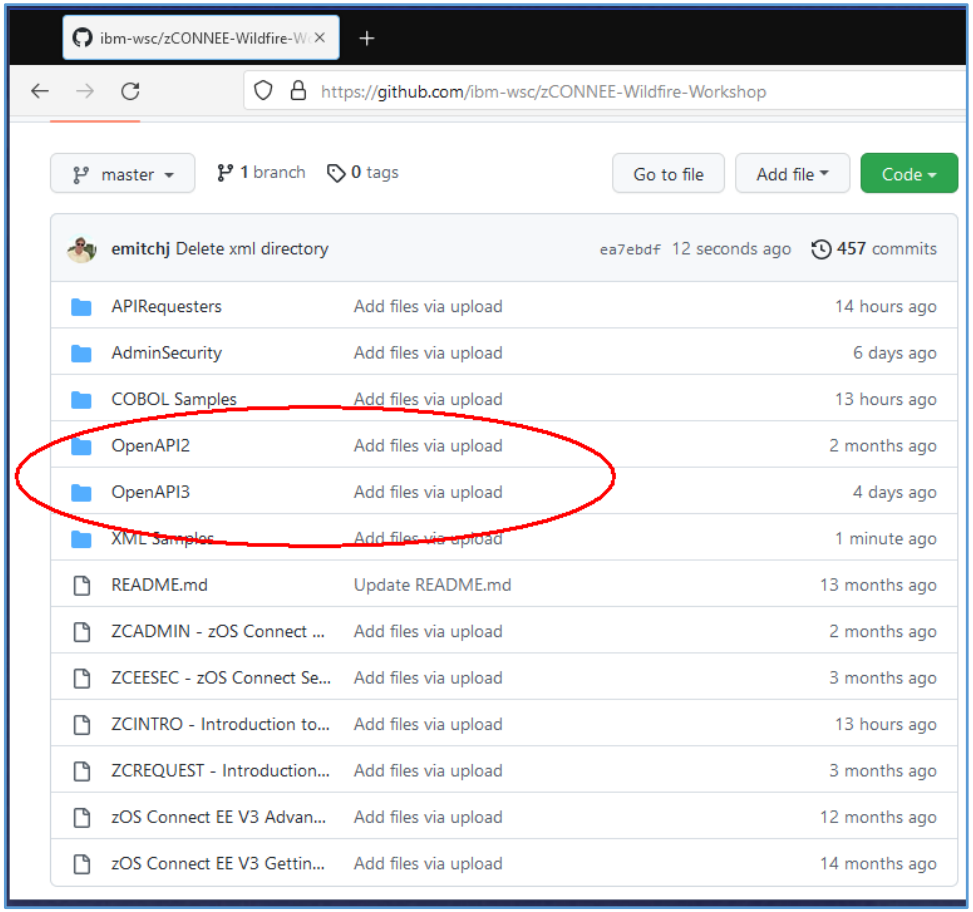


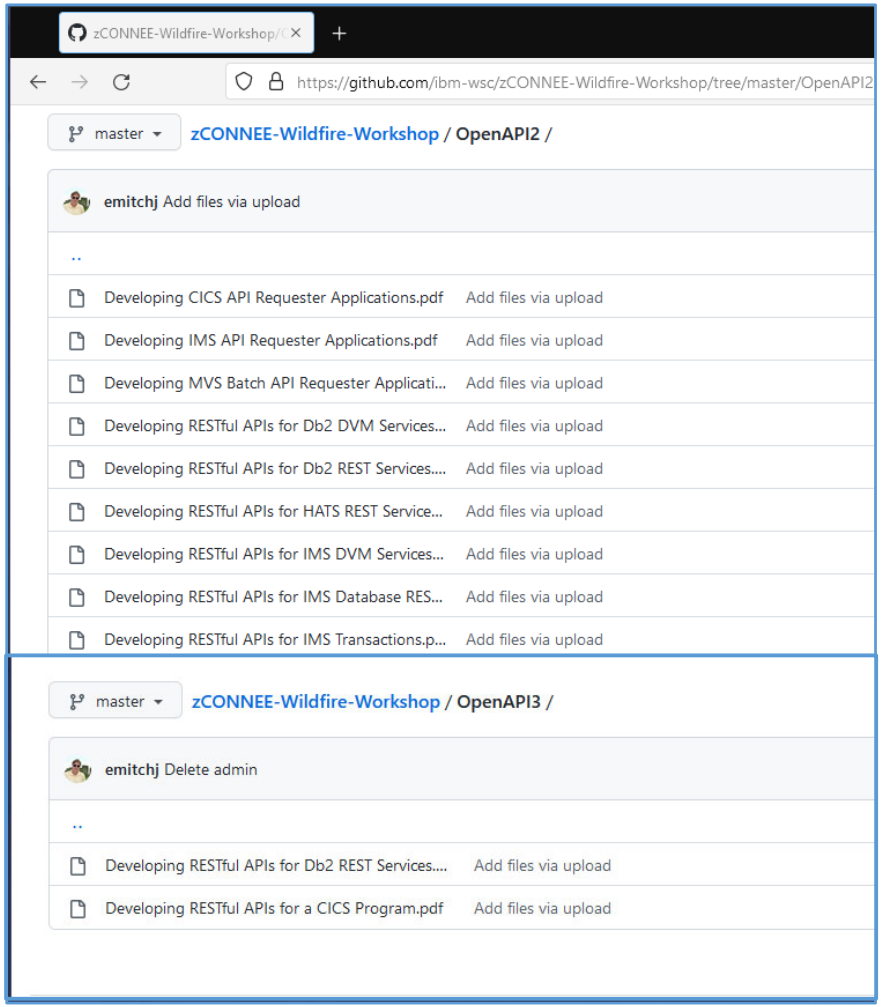


https://www.ibm.com/support/pages/mainframe-system-education-wildfire-workshops

z/OS Connect Wildfire Github Site

https://ibm.biz/zCEEWorkshopMaterial





- **Contact your IBM representative to request access to these exercises**

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

IBM z/OS Connect (an API Gateway)

- 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

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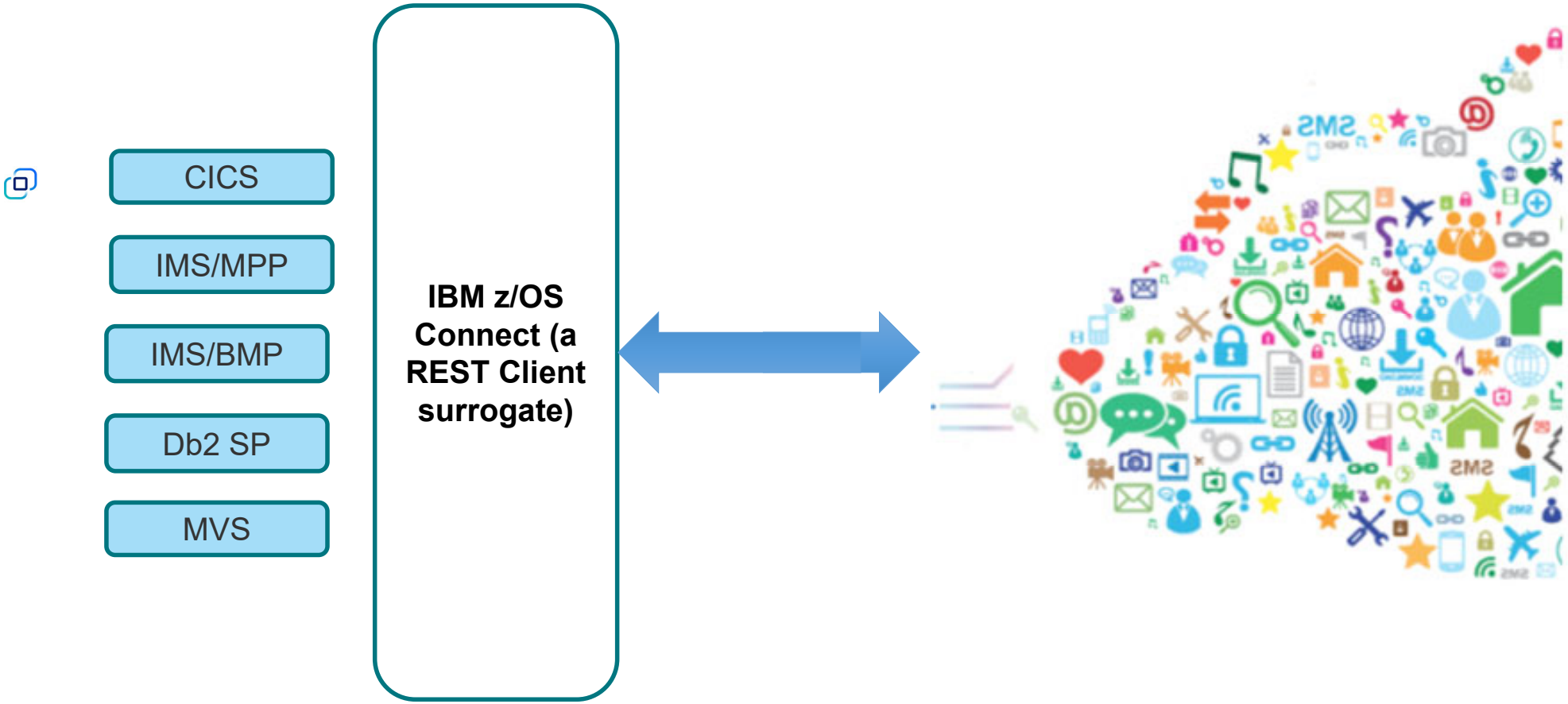
z/OS Connect EE exposes external REST APIs in the “cloud” to z/OS applications



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Before we go any further, let ask

/what_is_REST?

And what makes an API “RESTful”?

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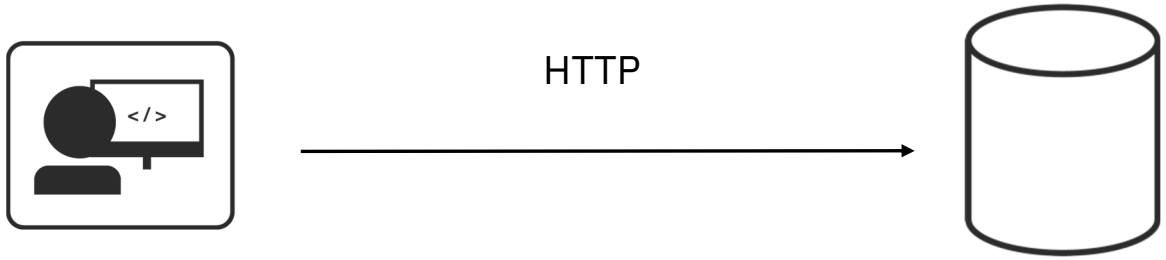
REST is architectural programming style

REST is acronym standing for **Re**presentational **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.

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Key Principles of the REST API

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

```
POST
GET     http://<host>:<port>/path/parameter?name=value&name=value
PUT
DELETE
```

Use Path and Query parameters to refine the request

URI path identifies a resource (or lists of resources)

URL identifies the protocol, host and port and includes the URI Path

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” }
```

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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 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

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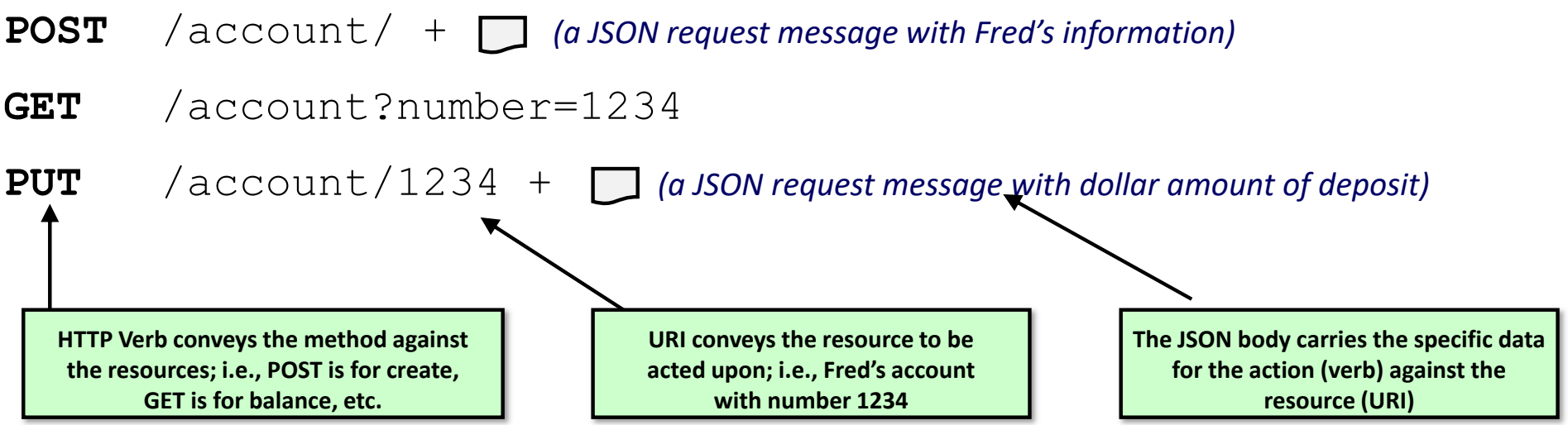
RESTful Examples



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

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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" }
```

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The goal is to strive to design API to use RESTful properties

1. Use the same URIs for the same resource with the appropriate method for operations

```
GET  http://www.acme.com/customers/12345
PUT  http://www.acme.com/customers/12345?address=10%20New%20Street
```

2. Use the same JSON property names between request and response messages

```
POST http://www.acme.com/customers/12345
BODY { "name": "Joe Bloggs",
       "address": "10 Old Street",
       "phoneNo": "01234 0123456" }
```



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

3. Use JSON name/value pairs

```
PUT http://www.acme.com/customers/12345
BODY { "address"    : "10 New Street"}
```



```
RESPONSE HTTP 200 OK
```

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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.

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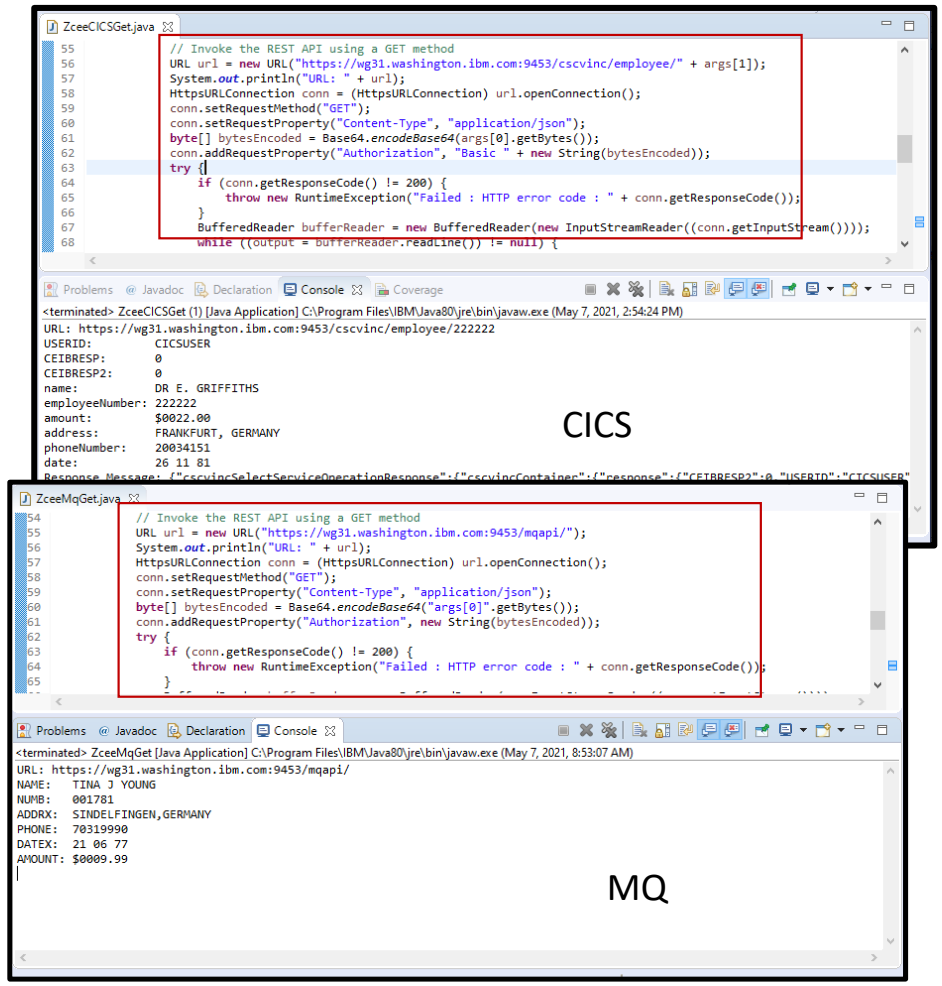
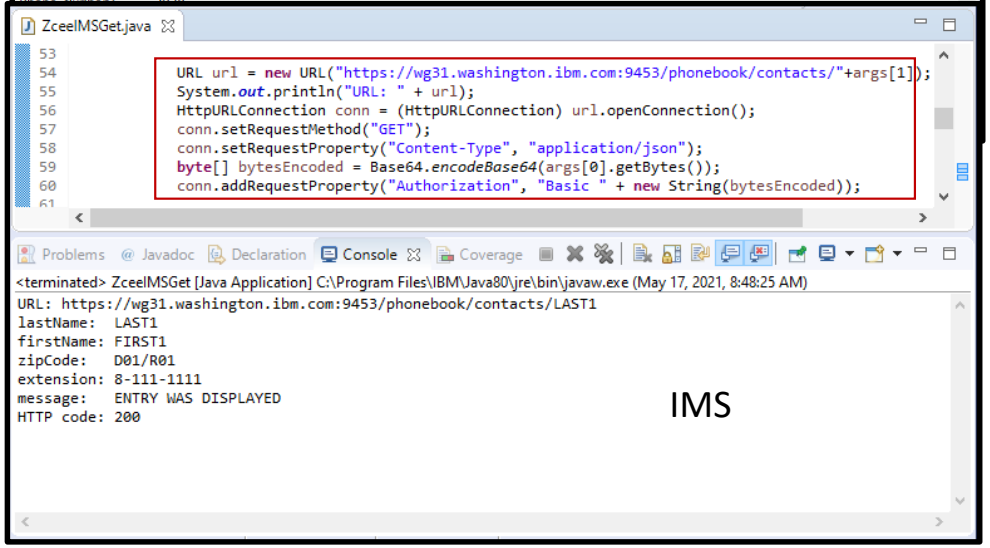
Goal: To have client code that is unaware of the z/OS infrastructure





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How do we describe and/or document an API?

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/oai/open_api_initiative

The industry standard framework for describing REST APIs

The OpenAPI Initiative (OAI) was created by a consortium of forward-looking industry experts who recognize the immense value of standardizing on how APIs are described. As an open governance structure under the Linux Foundation, the OAI is focused on creating, evolving and promoting a vendor neutral description format. The OpenAPI Specification was originally based on the Swagger Specification, donated by SmartBear Software.

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We use an Open API specification

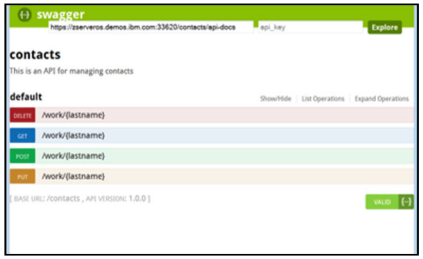
- It is more than just an API framework

OPEN API INITIATIVE

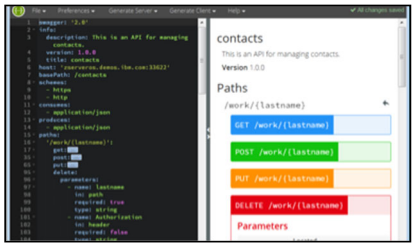
There are a number of tools available to aid consumption:

Code Generation* - create stub code to consume APIs from various languages

Test UIs - allows API consumers to easily browse and try APIs based on an OpenAPI document.



Editors - allows API developers to design their OpenAPI documents.



* z/OS Connect API Requester

+z/OS Connect, MQ REST support, Zowe

Important - You may have used or heard of the term Swagger with the use of APIs. As the use of APIs has grown this term has become in some respects misleading. To be more precise, OpenAPI refers to the API specifications (OpenAPI 2 and OpenAPI3) where Swagger refers to the tooling used to implement the specifcations.

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Let's stop and ask what is the significance of the OpenAPI Specification to z/OS Connect?

The industry standard framework for describing REST APIs

- **z/OS Connect and Swagger 2.0 (Open API Specification 2), supported initially by z/OS Connect**
  Initially, accessing z/OS resources was the only desire for developing APIs .The interactions with the z/OS resources was driven by the layout of the CICS COMMAREA or CONTAINER, the IMS or MQ messages or the Db2 REST service.
  - The details of the interactions with the z/OS resource determined the contents of the API request and response messages and the subsequent specification document.
  - **z/OS Connect produces the specification document that describes the methods and request and response messages.**

- **z/OS Connect and Open API Specification 3, supported by z/OS Connect starting in March 2022 service, V3.0.55**
  As companies mature their API strategy, they begin to introduce API governance boards to drive consistency in their API design. As more public APIs are created, government and industry standards bodies begin to regulate and drive for standardization. This drives the need for "API first" functional mapping capabilities within the integration platform. The external API design determined the layouts of the API request and response messages provided by the specification documents which was consumes by z/OS Connect to describe the z/OS resource interactions.
  - The API details of the methods and layouts of request and response messages are provided in advance and access to the z/OS resource is driven by the API design
  - **z/OS Connect consumes the specification document that describes the methods and request and response messages**

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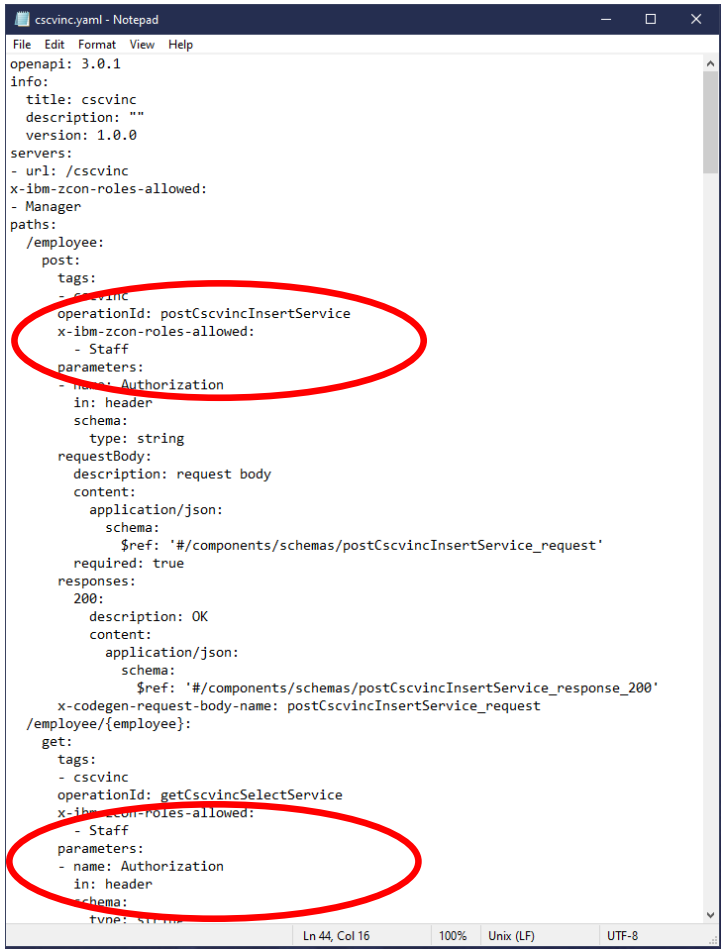
Contrast the z/OS Connect OpenAPI 2 /OpenAPI 3 differences

z/OS Connect OpenAPI2 tooling **produces** an OpenAPI 2 specification document, where the details of the methods and request/response messages in the API specification are driven by the nature of the z/OS asset (JSON format).



z/OS Connect OpenAPI3 tooling **consumes** an OpenAPI3 specification document and the details of the methods and request/response messages are driven by the API specification (YAML format*) and not the nature of the z/OS asset. Also, JSONata can be used to augment the API response

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https://swagger.io/blog/api-strategy/difference-between-swagger-and-openapi/

*Yet Another Markup Language

Why /zos_connect?

Truly RESTful APIs to and from your mainframe.

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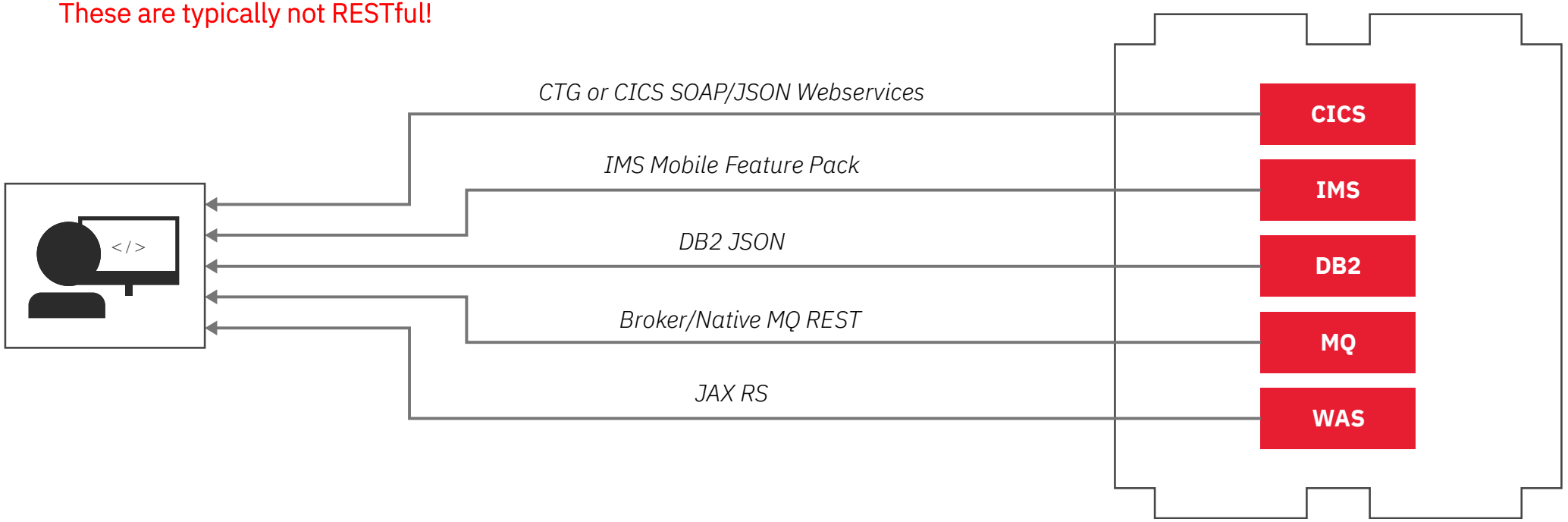
There was support for REST before z/OS Connect but..

Completely different configuration and management.

Multiple endpoints for developers to call/maintain access to.

These are typically not RESTful!



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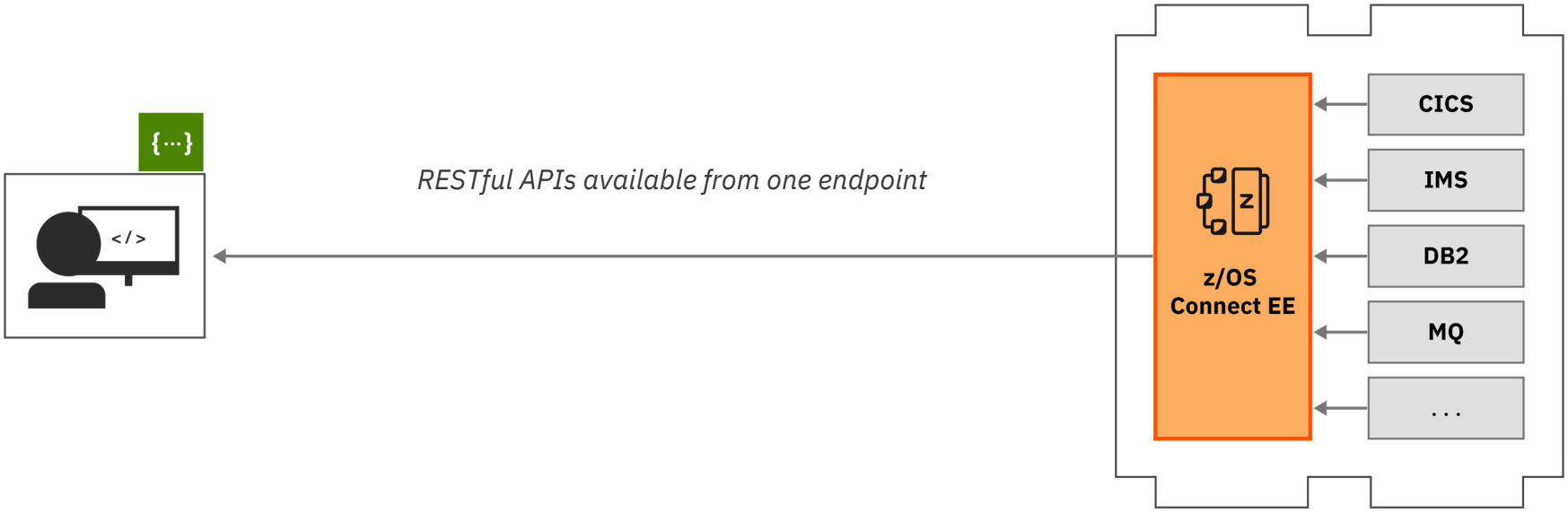
z/OS Connect provides a single-entry point

- And exposes 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.



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

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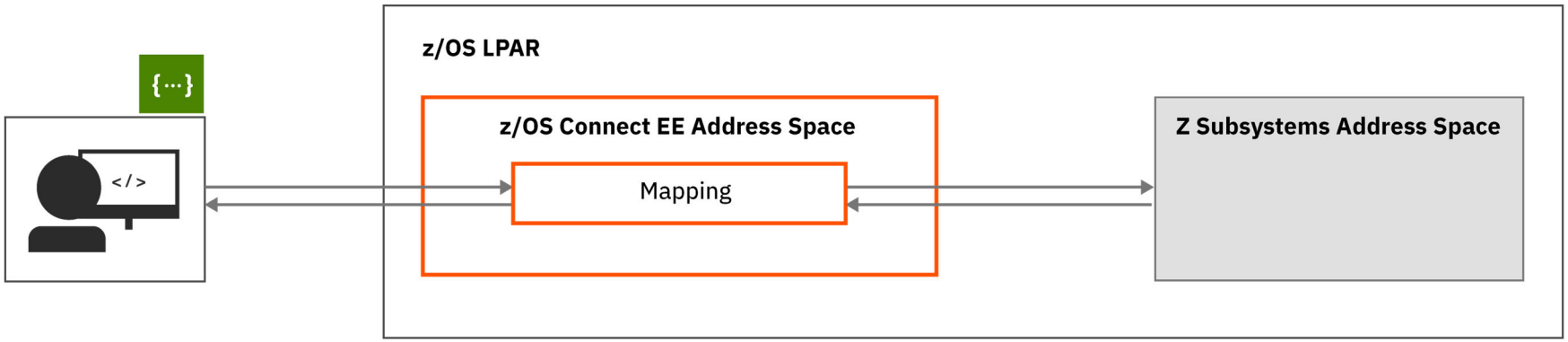
Data mapping/transformation

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



* Most z/OS subsystems depend information in a serial data format and do not normally work with JSON request/response messages. Examples of serialized messages are CICS COMMAREAs 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).

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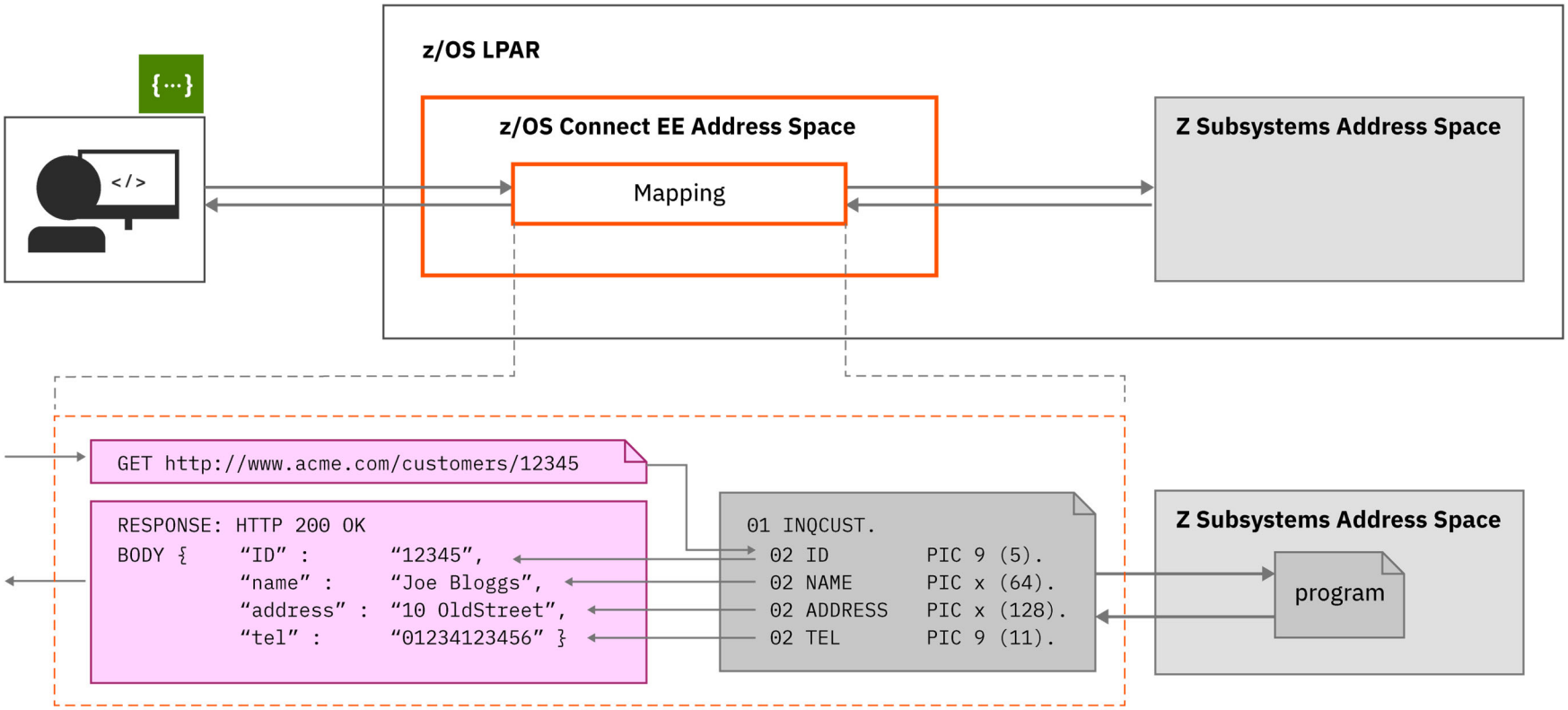
Data mapping and transformation example

- A closer look



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z/OS Connect OpenAPI Tooling

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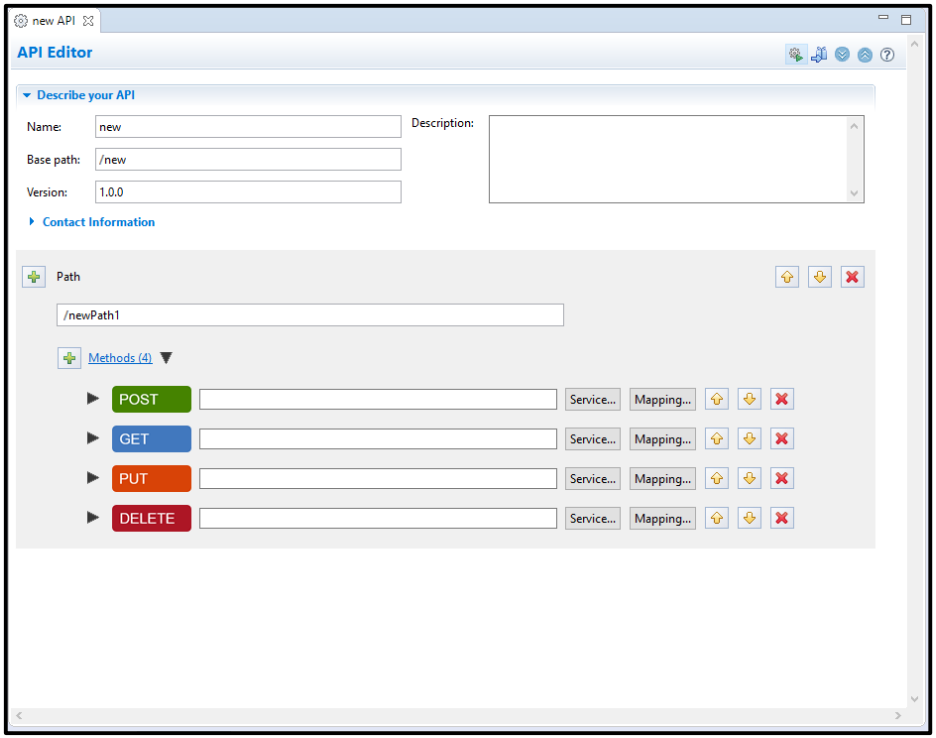
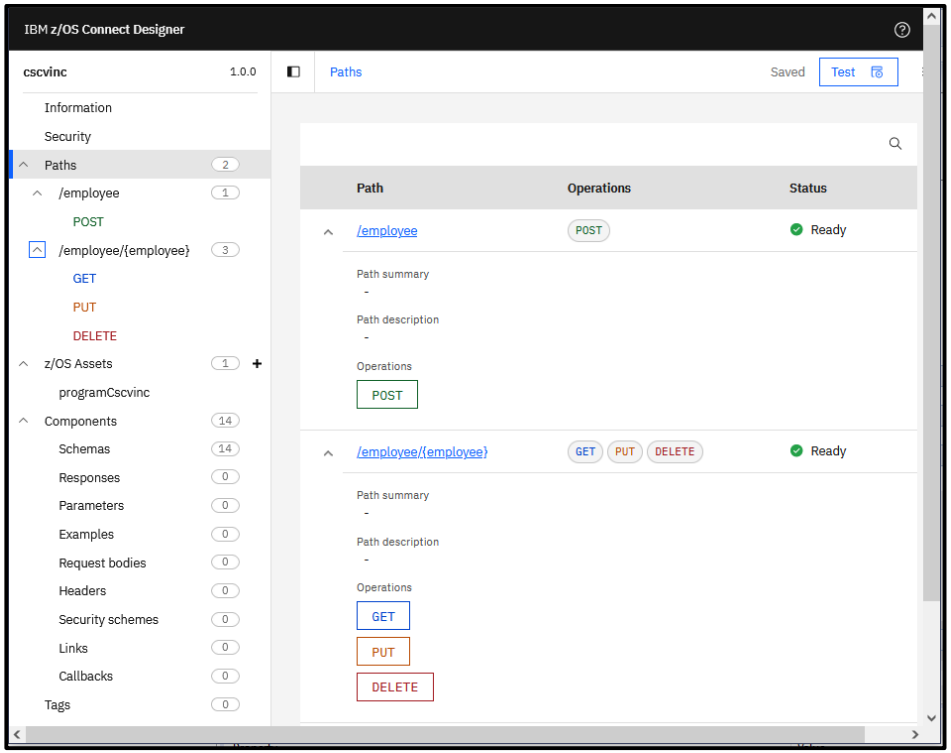
zCEE - OpenAPI 2 Palette versus the OpenAPI 3 API Designer

z/OS Connect API Toolkit (Eclipse)



z/OS Connect Designer (Designer Container)



The API toolkit is used to define the URI paths and methods.

The API specification provides predefined URI Paths and methods.

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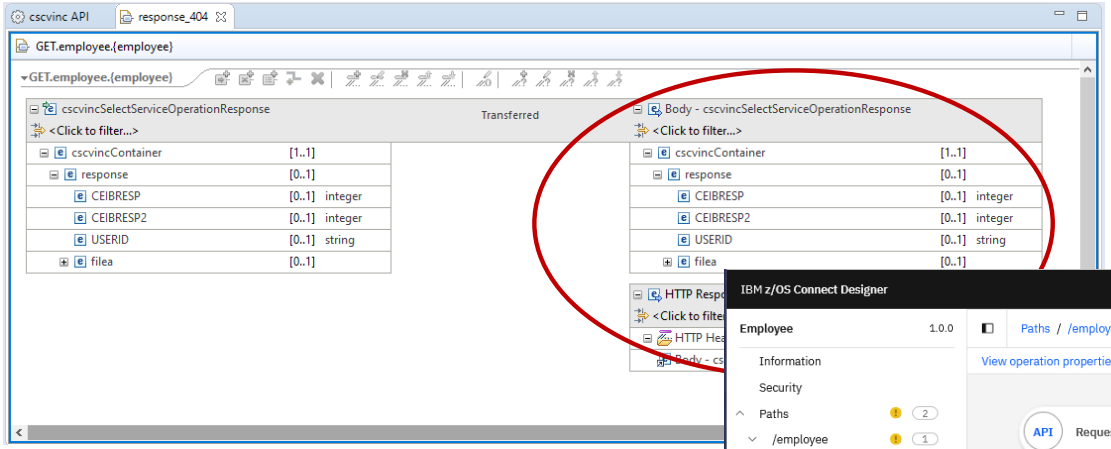
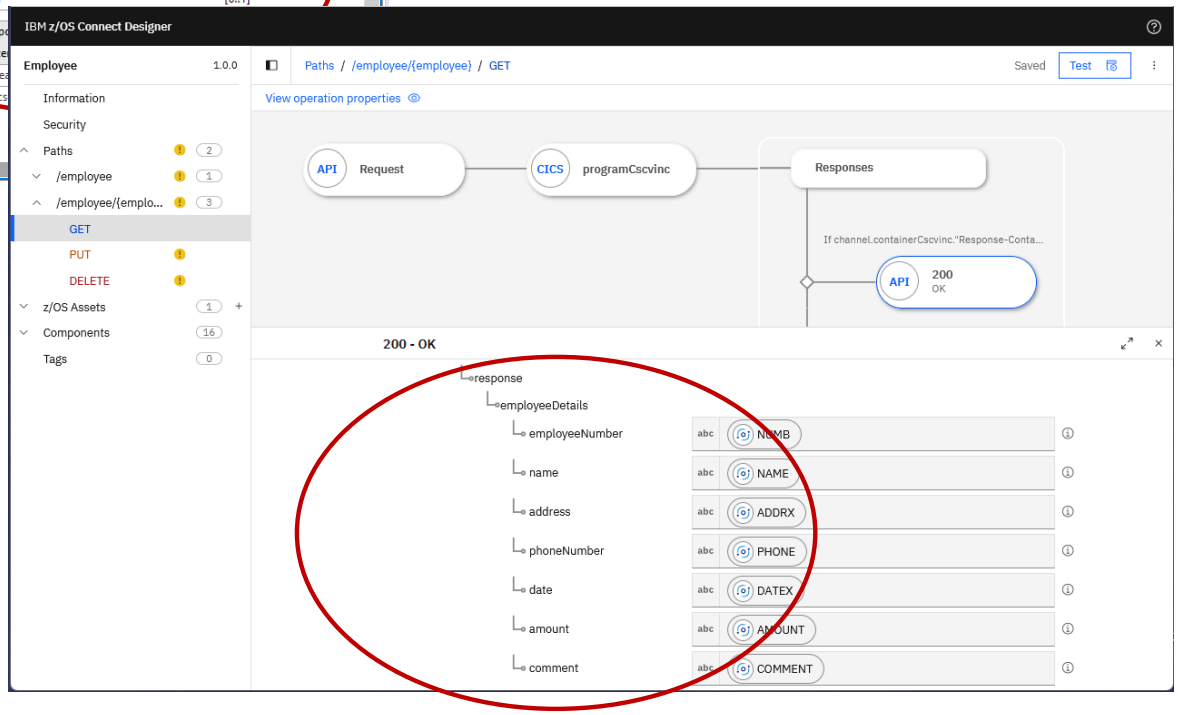
An OpenAPI 2 versus an OpenAPI 3 Response Message



Eclipse based - z/OS Connect API Toolkit -
The contents of the API's response message are directly derived from the z/OS asset's response



Web browser - z/OS Connect Designer – The contents of the API's response message are derived from the z/O asset's response and JSONata coding, see URL https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=concepts-what-is-jsonata for more information on JSONata.

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OpenAPI 2

Simple **service creation** not using the Eclipse Toolkit

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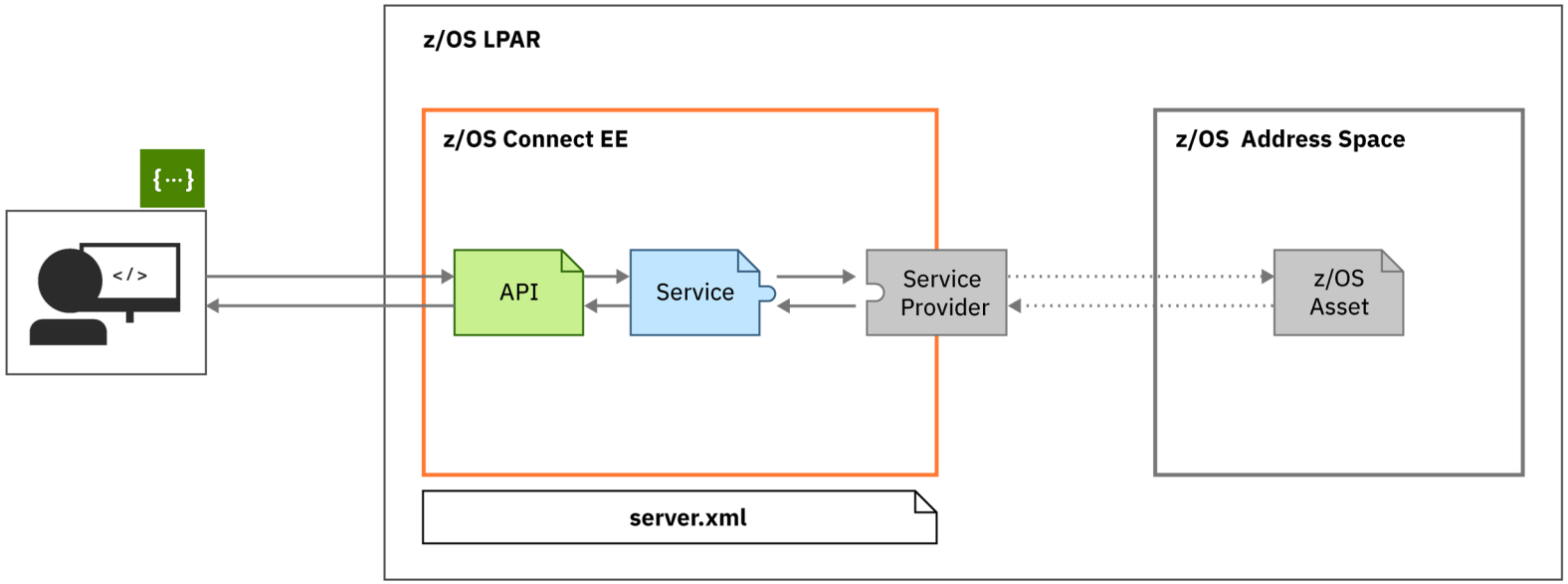
Accessing a z/OS asset (Open API 2)

z/OS Connect OpenAPI 2 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)

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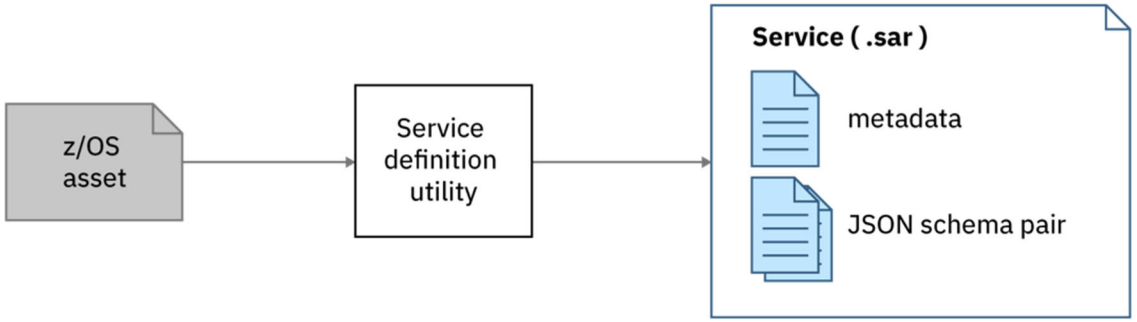
Describing the interaction (service) with the z/OS resource (OpenAPI 2)

Start by creating a service to represent an interaction with the z/OS 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




```
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.
```

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

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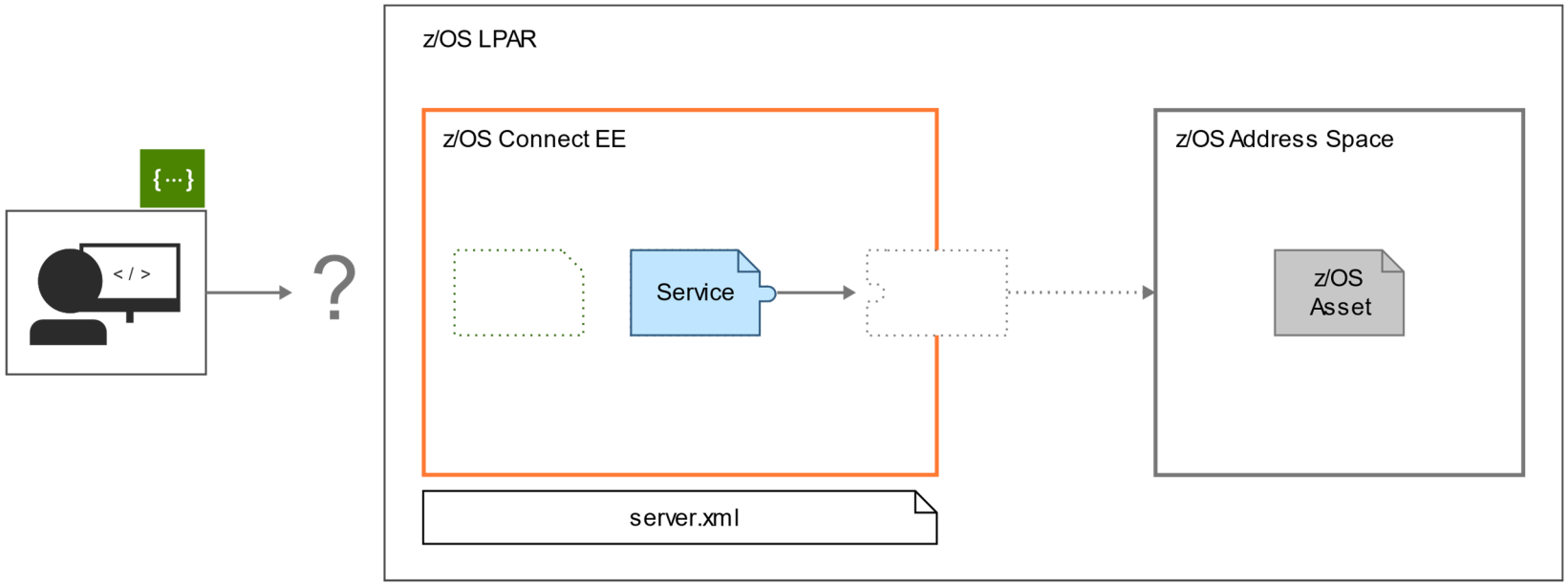
Deploy and export the service archive (OpenAPI 2)

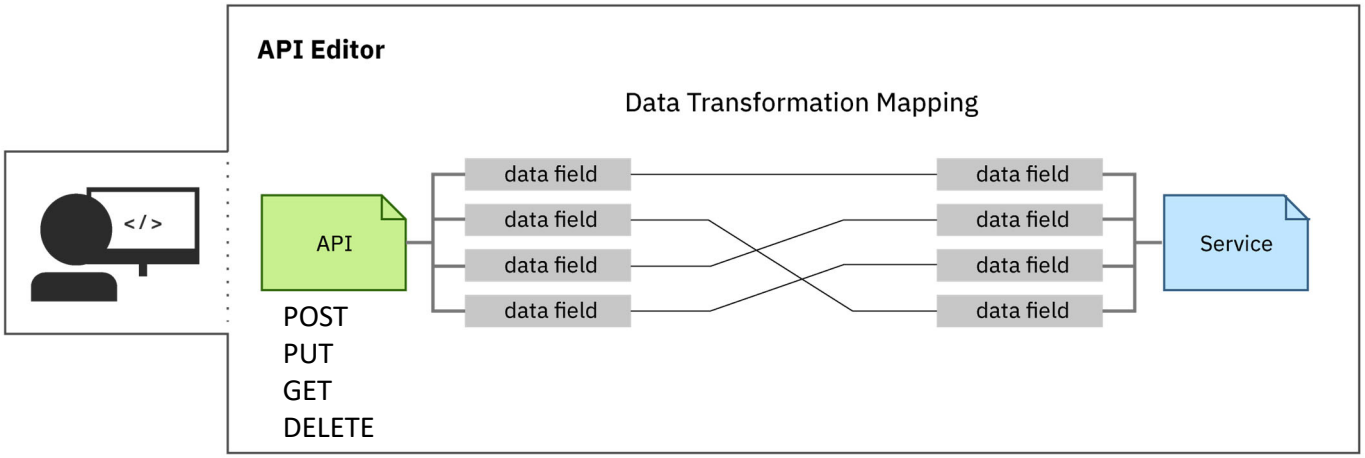
Deploy and export the service archive file



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

Develop an API using the service interactions (Open API 2)

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.

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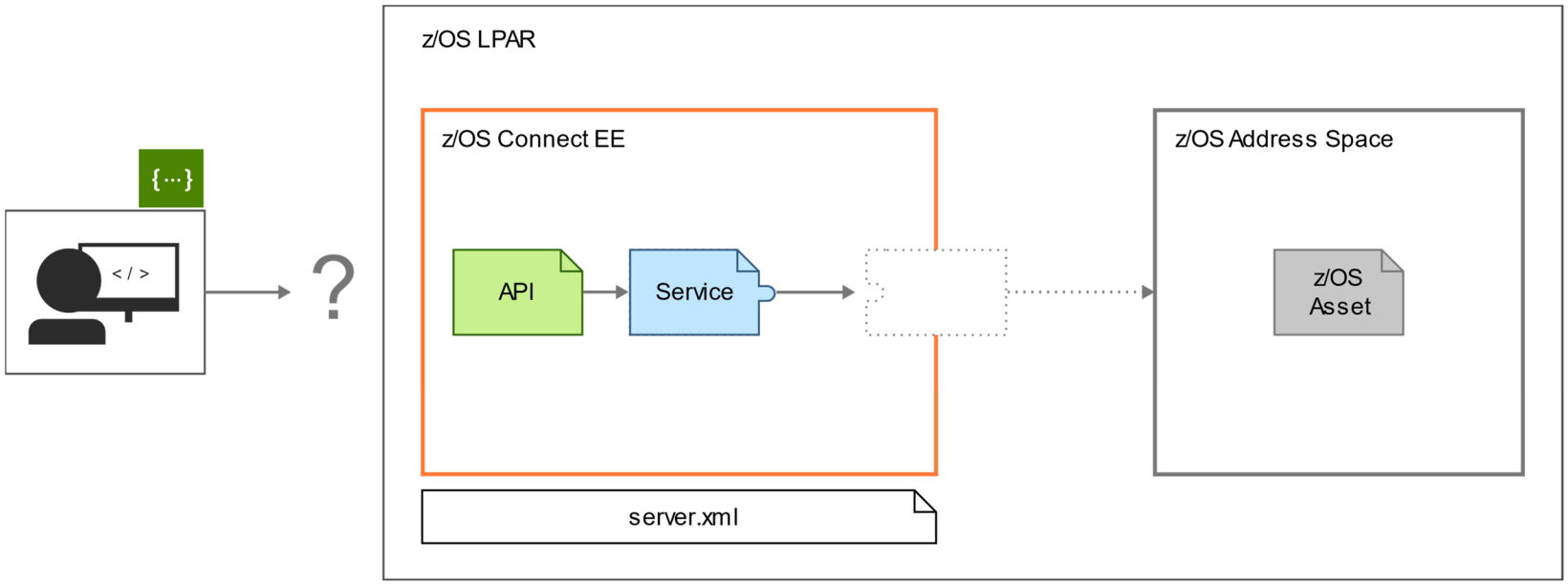
Deploy the API (Open API 2)

Deploy the API archive file



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

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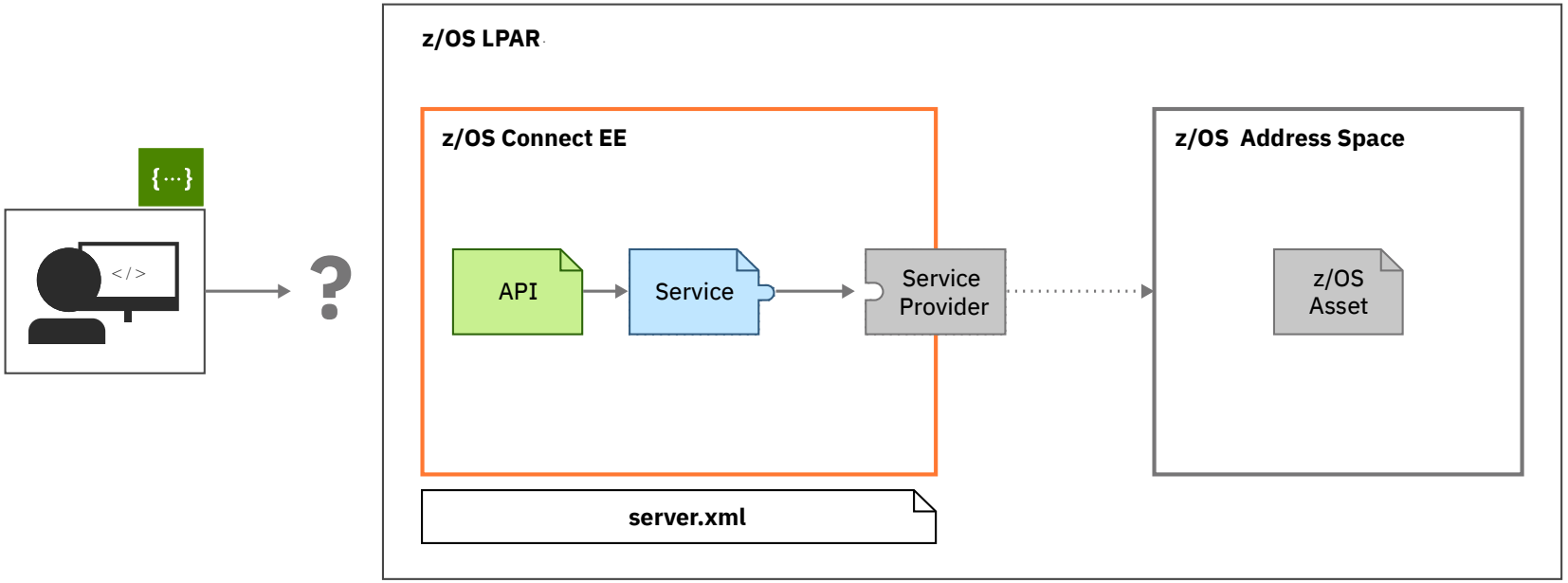
Configure access the z/OS sub system (Open API 2)

Configure the service provider



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

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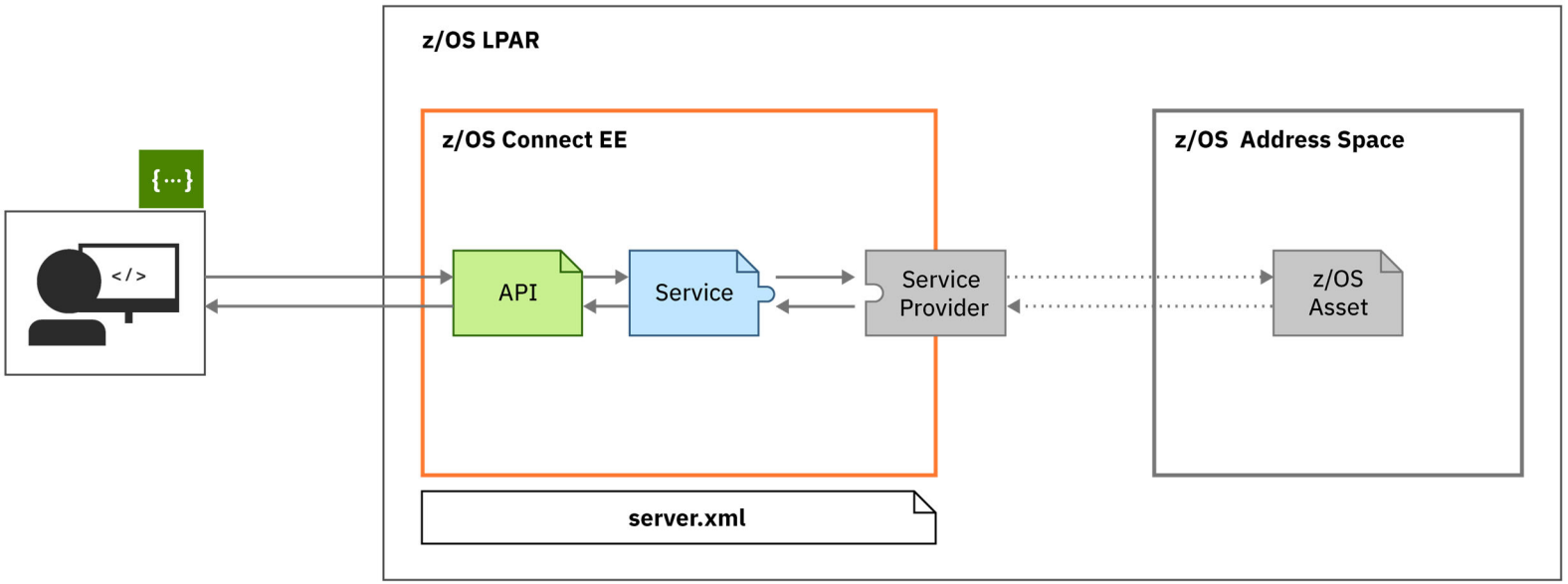
Complete access to a z/OS Asset (Open API 2)

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)

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OpenAPI2

Simple service creation for OpenAPI 2 APIs

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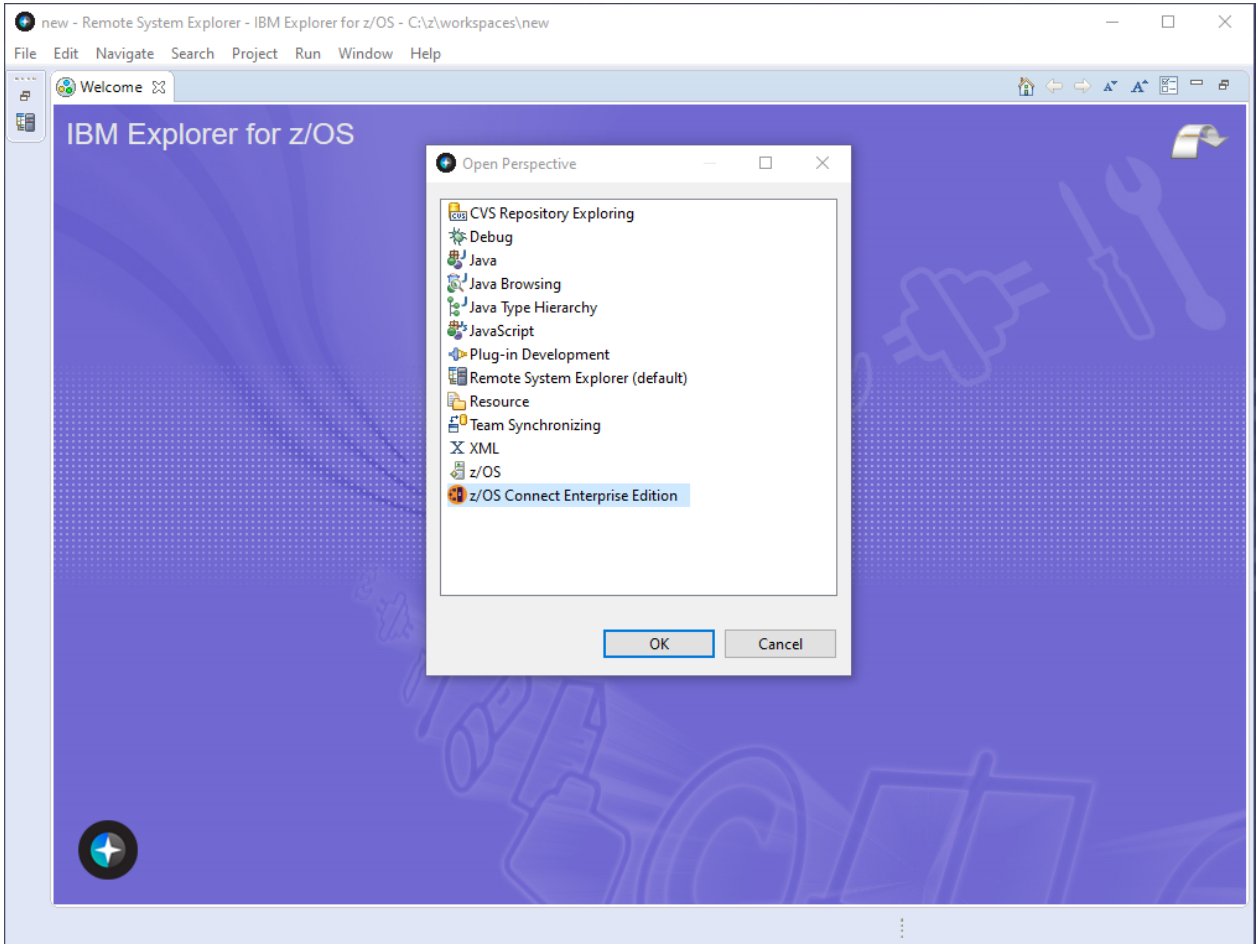
Eclipse API toolkit – Creating Services for CICS, IMS TM, IMS DB, Db2 and MQ



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.

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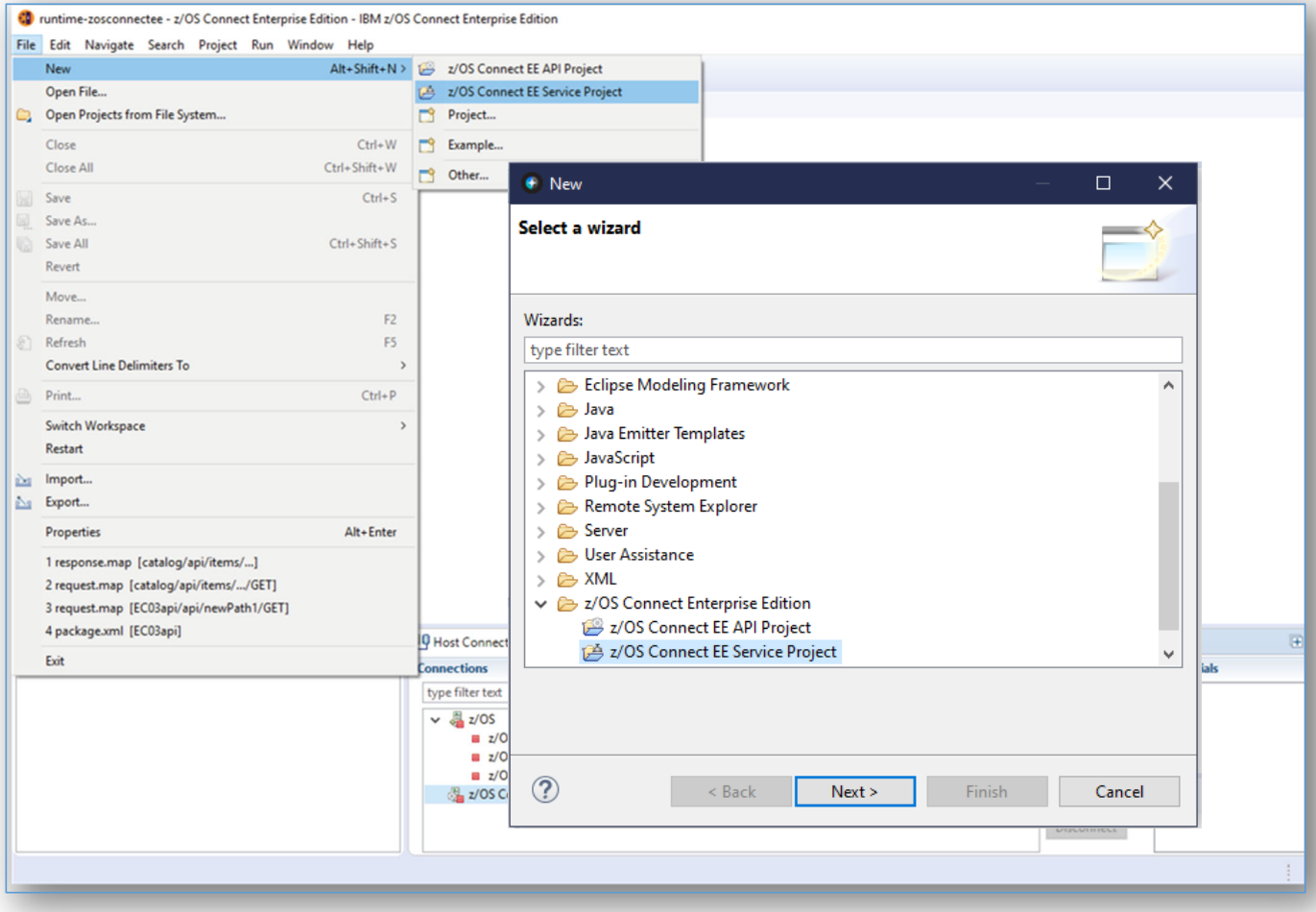
API toolkit – Creating Services for CICS, IMS TM, IMS DB, Db2 and MQ



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

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

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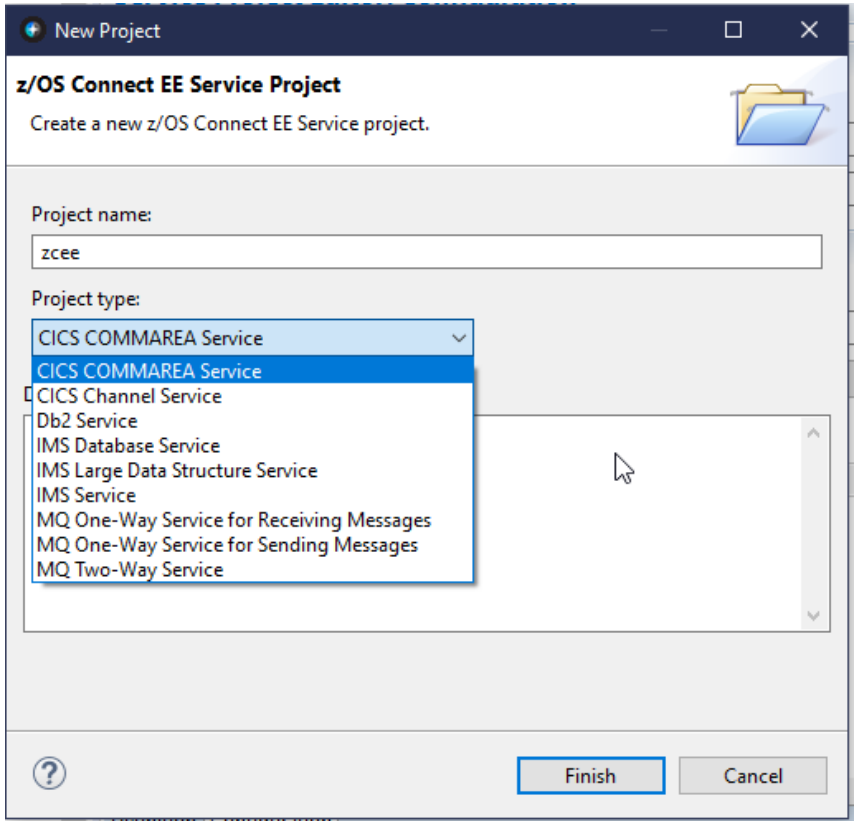
API toolkit – Creating Services for CICS, IMS TM, IMS DB, Db2 and MQ

Service creation – a common interface



- CICS services that can invoke almost any CICS programs accessed by EXEC CICS LINK request (COMMAREA or CHANNEL). See URL http://www.ibm.com/docs/en/cics-ts/5.6?topic=link-exception-conditions-command for a list of EXEC CICS APIs not allowed in a program when invoked using a CICS Dynamic Program Link request.
- Db2 services that invoke a Db2 REST service.
- IMS DB services that access an IMS database.
- IMS TM services that sends a messages on an IMS message processing region.
- MQ services that use MQ request/reply queues for two-way services or access a single queue for MQ PUTs and MQ GETs on a either a local or remote queue manager

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

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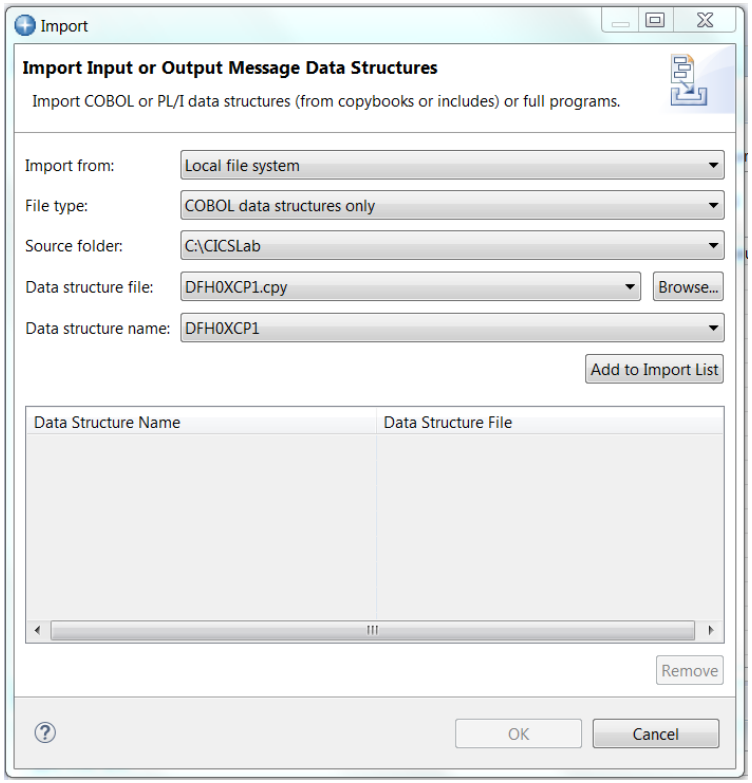
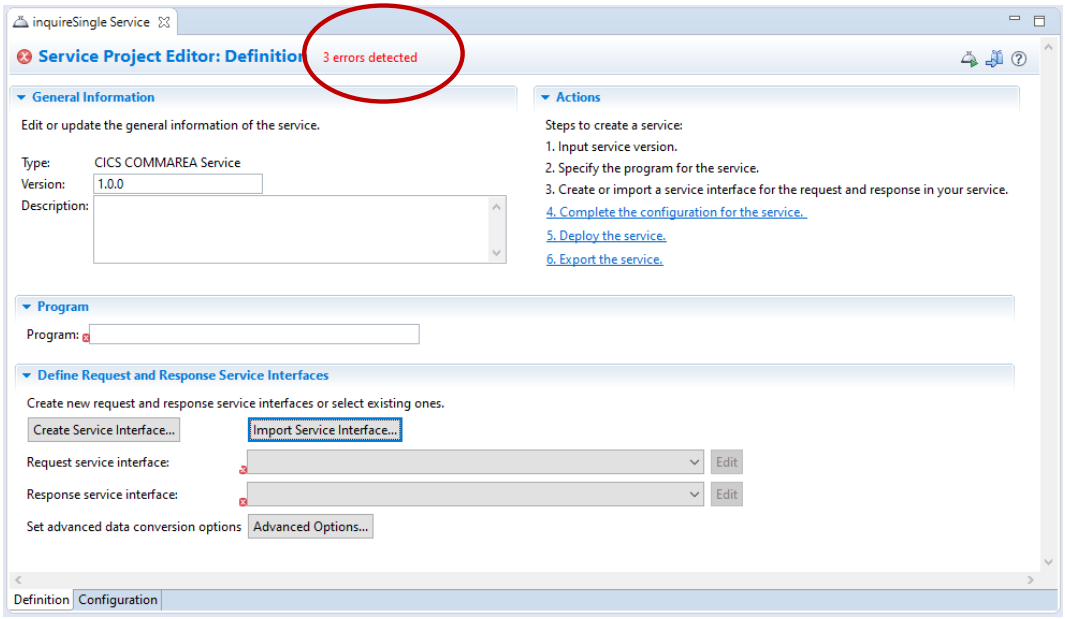
API toolkit – Creating Services for CICS, IMS TM and MQ

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.



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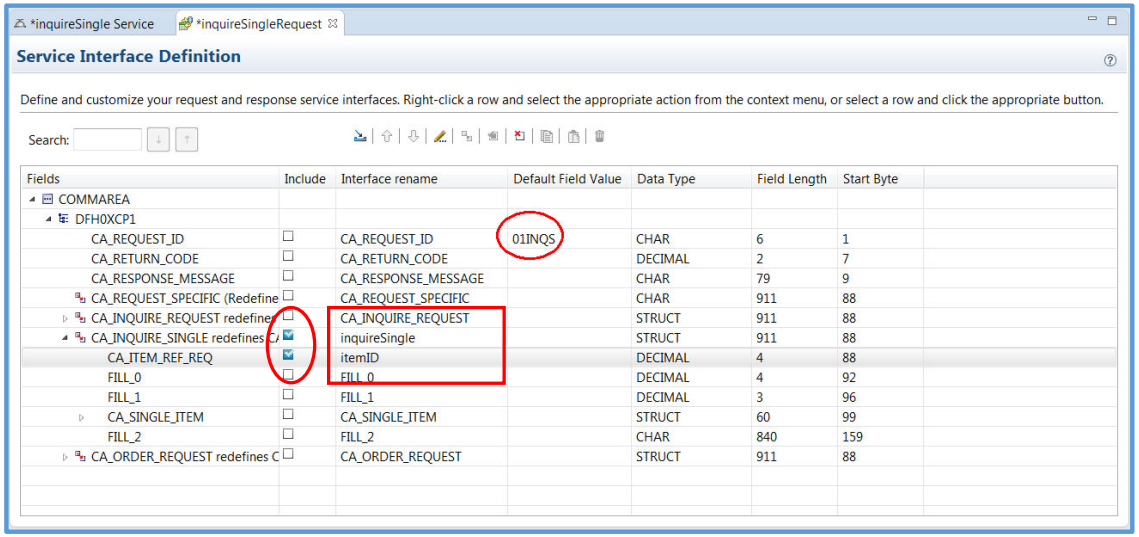
API toolkit – Creating Services for CICS, IMS TM and MQ

Allows editing a request service interface definition

```
*---------------------------------------------------------------*
* Check which operation in 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.



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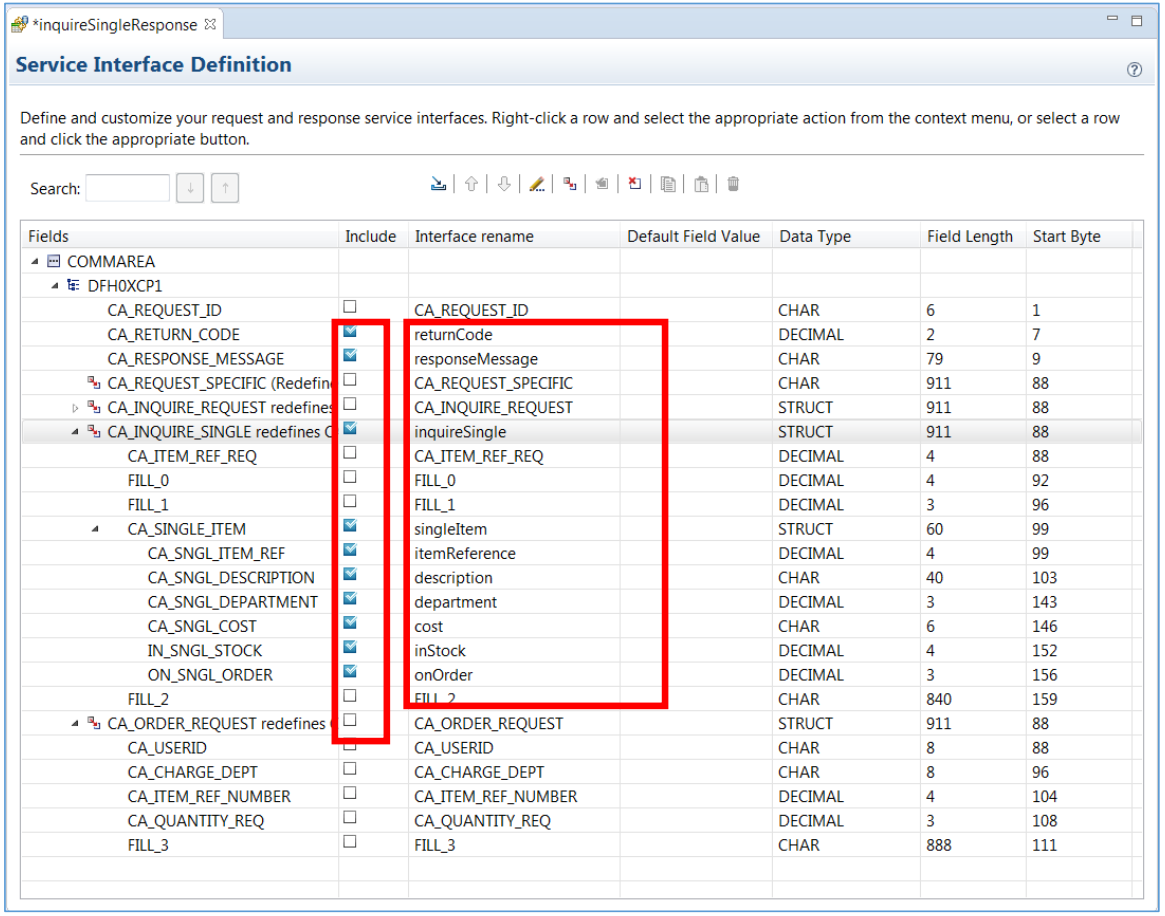
API toolkit – Creating Services for CICS, IMS TM, IMS DB and MQ

And editing a response message service interface definition



Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
COMMAREA						
DFH0XCP1						
CA_REQUEST_ID	☐	CA_REQUEST_ID		CHAR	6	1
CA_RETURN_CODE	☑	returnCode		DECIMAL	2	7
CA_RESPONSE_MESSAGE	☑	responseMessage		CHAR	79	9
CA_REQUEST_SPECIFIC (Redefin	☐	CA_REQUEST_SPECIFIC		CHAR	911	88
CA_INQUIRE_REQUEST redefines	☐	CA_INQUIRE_REQUEST		STRUCT	911	88
CA_INQUIRE_SINGLE redefines C	☑	inquireSingle		STRUCT	911	88
CA_ITEM_REF_REQ	☐	CA_ITEM_REF_REQ		DECIMAL	4	88
FILL_0	☐	FILL_0		DECIMAL	4	92
FILL_1	☐	FILL_1		DECIMAL	3	96
CA_SINGLE_ITEM	☑	singleItem		STRUCT	60	99
CA_SNGL_ITEM_REF	☑	itemReference		DECIMAL	4	99
CA_SNGL_DESCRIPTION	☑	description		CHAR	40	103
CA_SNGL_DEPARTMENT	☑	department		DECIMAL	3	143
CA_SNGL_COST	☑	cost		CHAR	6	146
IN_SNGL_STOCK	☑	inStock		DECIMAL	4	152
ON_SNGL_ORDER	☑	onOrder		DECIMAL	3	156
FILL_2	☐	FILL_2		CHAR	840	159
CA_ORDER_REQUEST redefines (	☐	CA_ORDER_REQUEST		STRUCT	911	88
CA_USERID	☐	CA_USERID		CHAR	8	88
CA_CHARGE_DEPT	☐	CA_CHARGE_DEPT		CHAR	8	96
CA_ITEM_REF_NUMBER	☐	CA_ITEM_REF_NUMBER		DECIMAL	4	104
CA_QUANTITY_REQ	☐	CA_QUANTITY_REQ		DECIMAL	3	108
FILL_3	☐	FILL_3		CHAR	888	111

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

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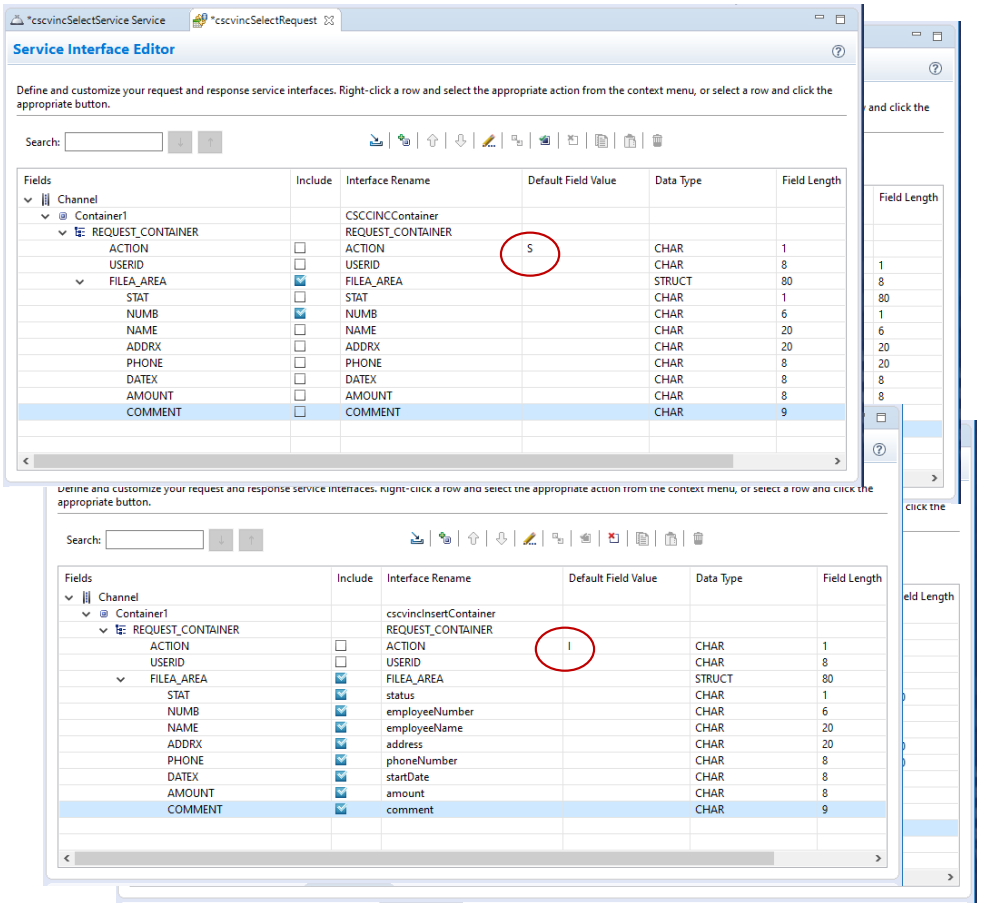
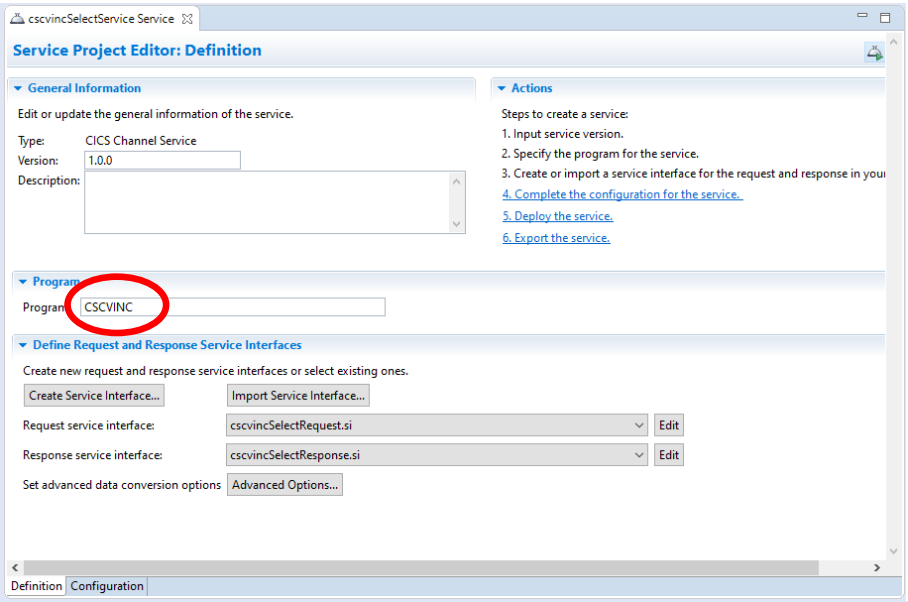
API toolkit – Creating Services for CICS

Creating multiple services definitions to the same resource






```
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

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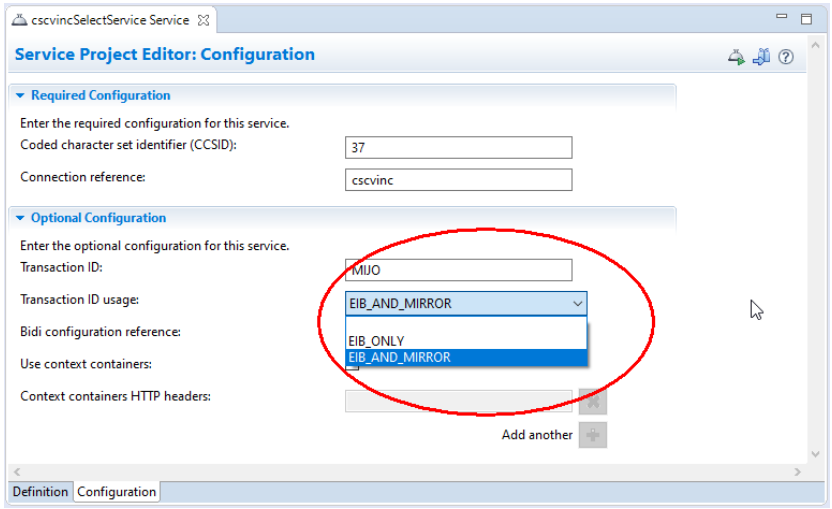
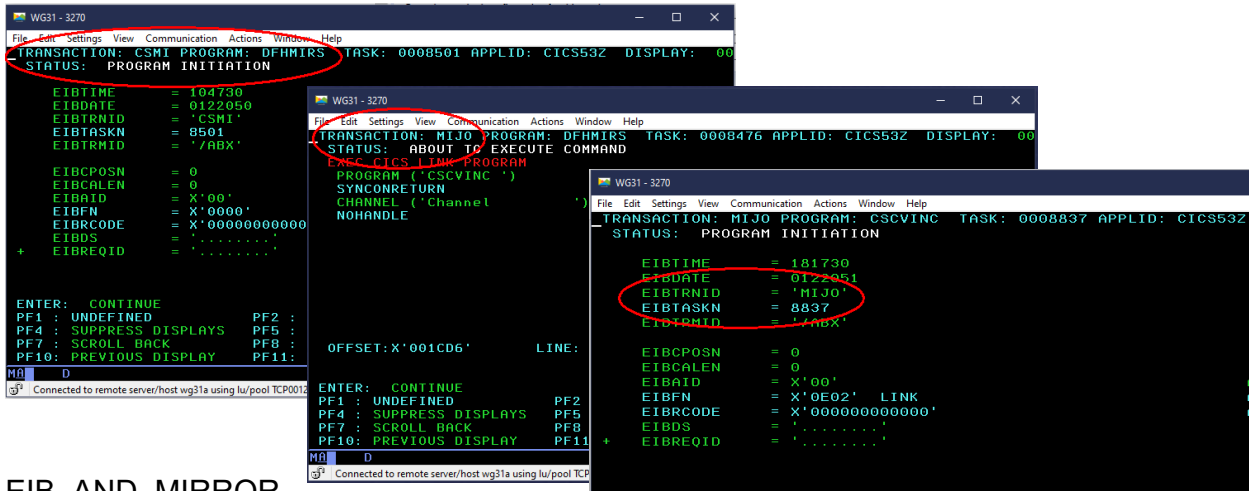
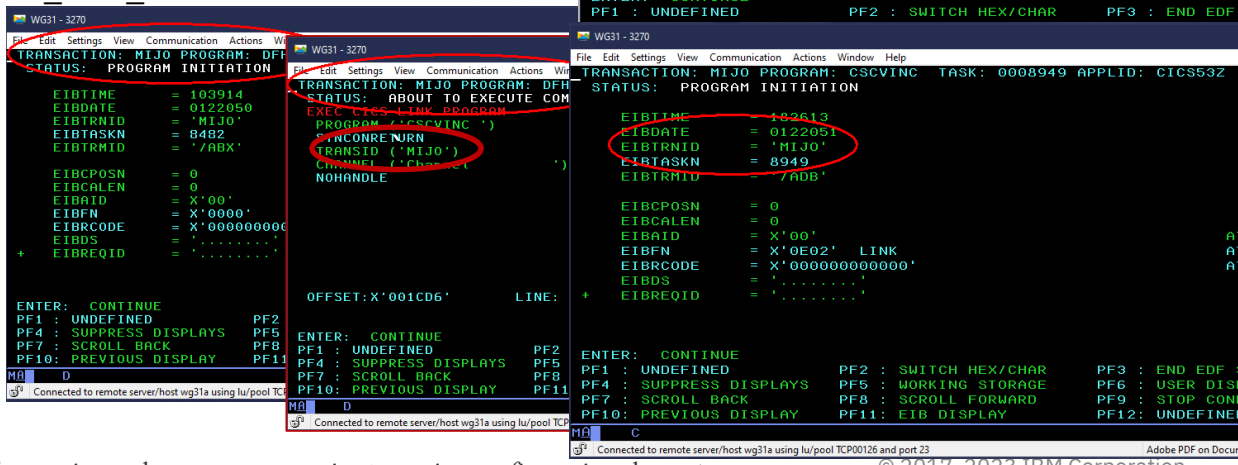
Accessing a CICS program – The significance of Transaction ID Usage



EIB_ONLY



EIB_AND_MIRROR



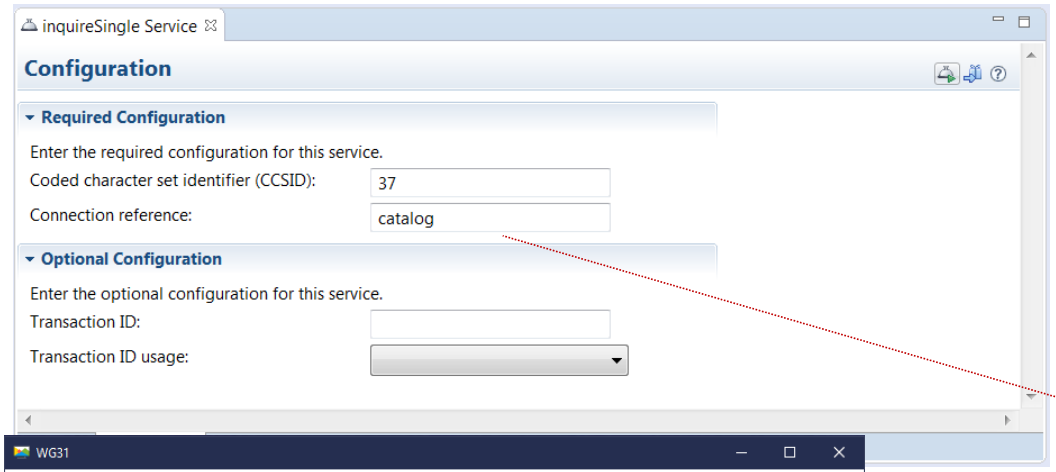
- **Transaction ID** attaches a CICS transaction (CSMI is the default) that starts the CICS DFHMIRS program.

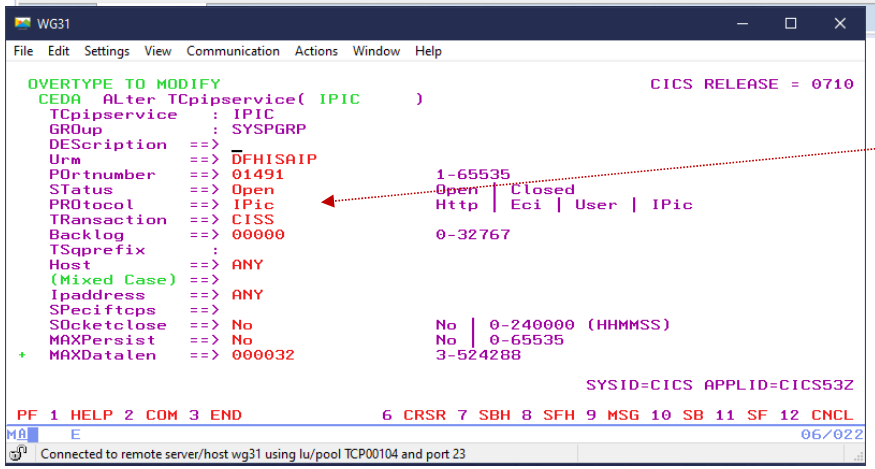
- **Transaction ID Usage** attribute useful for:
  - Transaction security requirements
  - Db2 plan selection
  - Transaction classification and reporting

These attributes also be used in *zosconnect_cicsIpicConnection* and *zosconnect_services>service configuration* elements.

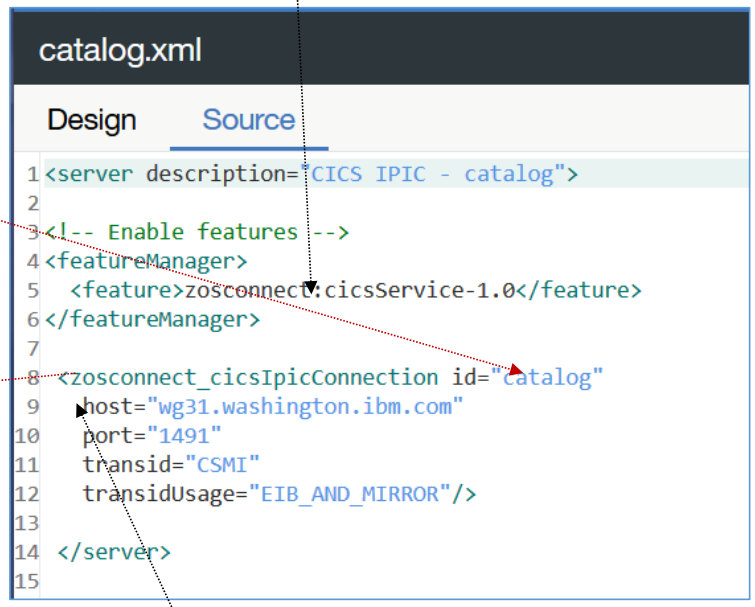
Accessing a CICS program uses CICS IP interconnectivy (IPIC)

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



Define IPIC connection to CICS

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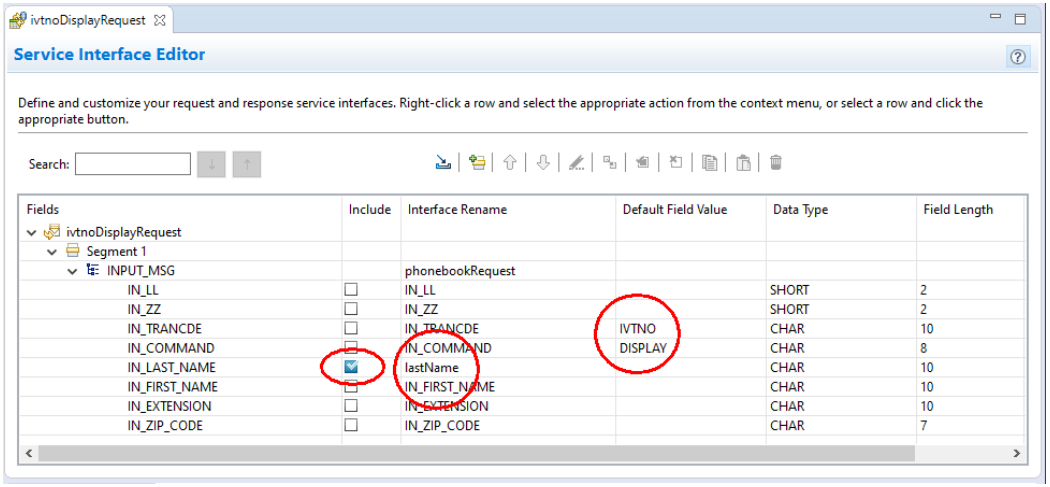
API toolkit – Creating Services for IMS

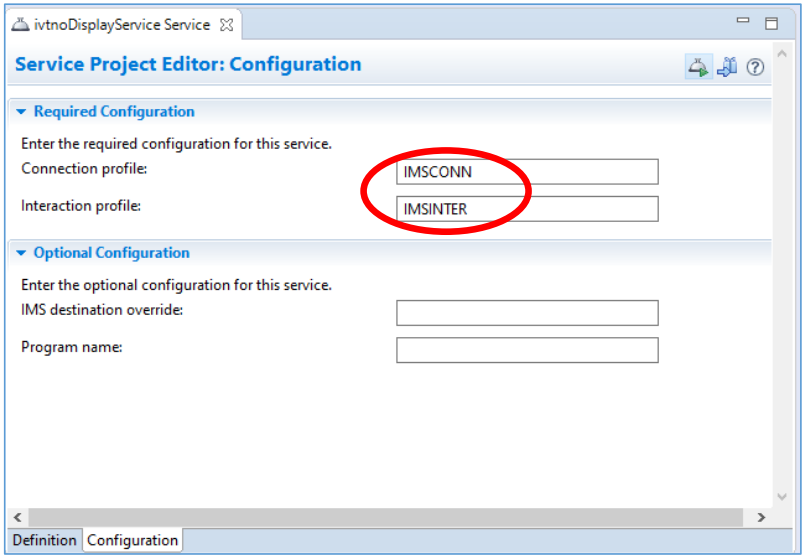
Creating a “GET” service interface request definition

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

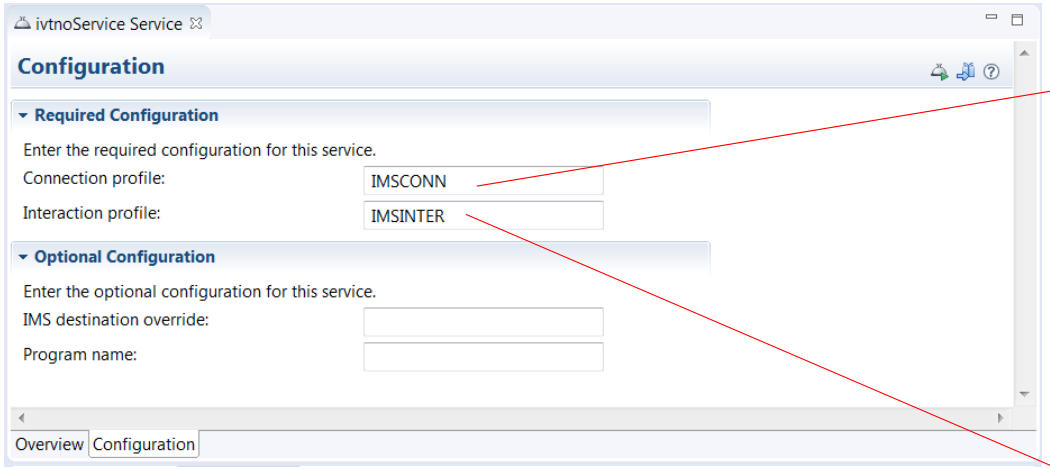


The service developer creates distinct services for each function.

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



IMS Connections and Interactions



Connection Profile

```
<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 Profile

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

IMS Connect HWSCFG

```
HWS=(ID=IMS14HWS,XIBAREA=100,RACF=Y,RRS=N)
TCPIP=(HOSTNAME=TCPIP,PORTID=(4000,LOCAL),RACFID=JOHNSON,
TIMEOUT=5000)
DATASTORE=(GROUP=OTMAGRP,ID=IVP1,MEMBER=HWSMEM,TMEMBER=OT
MAMEM)
```

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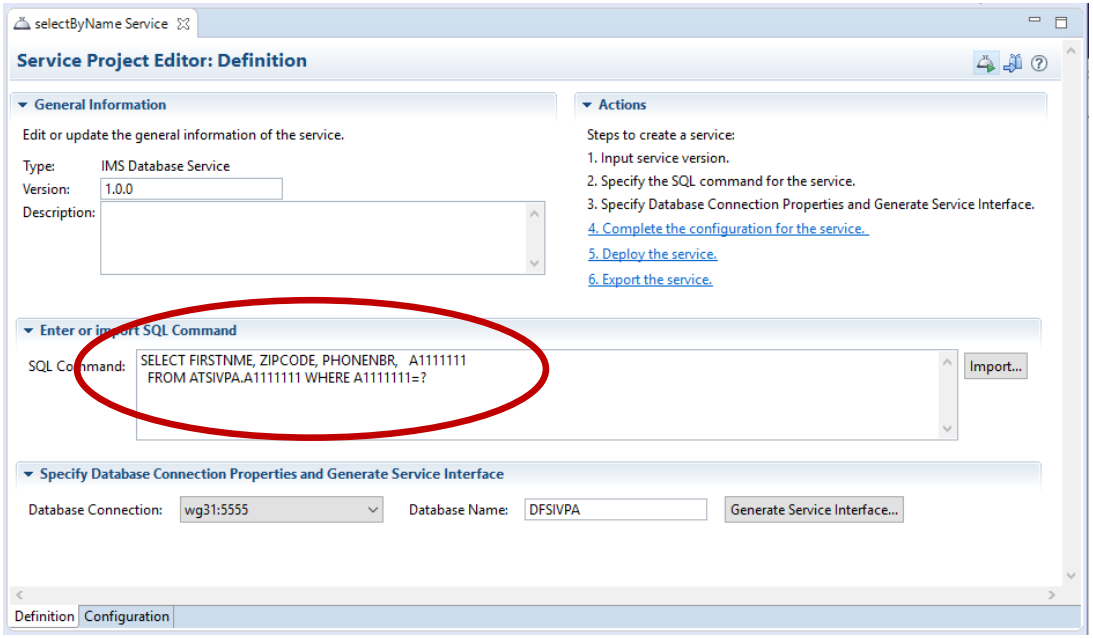
API toolkit – Creating Services for IMS DB

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=DFSIVD1,DEVICE=3380,SIZE=2048
         SEGM   NAME=A1111111,PARENT=0,BYTES=40,RULES=(LLV,LAST),      x
               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
```

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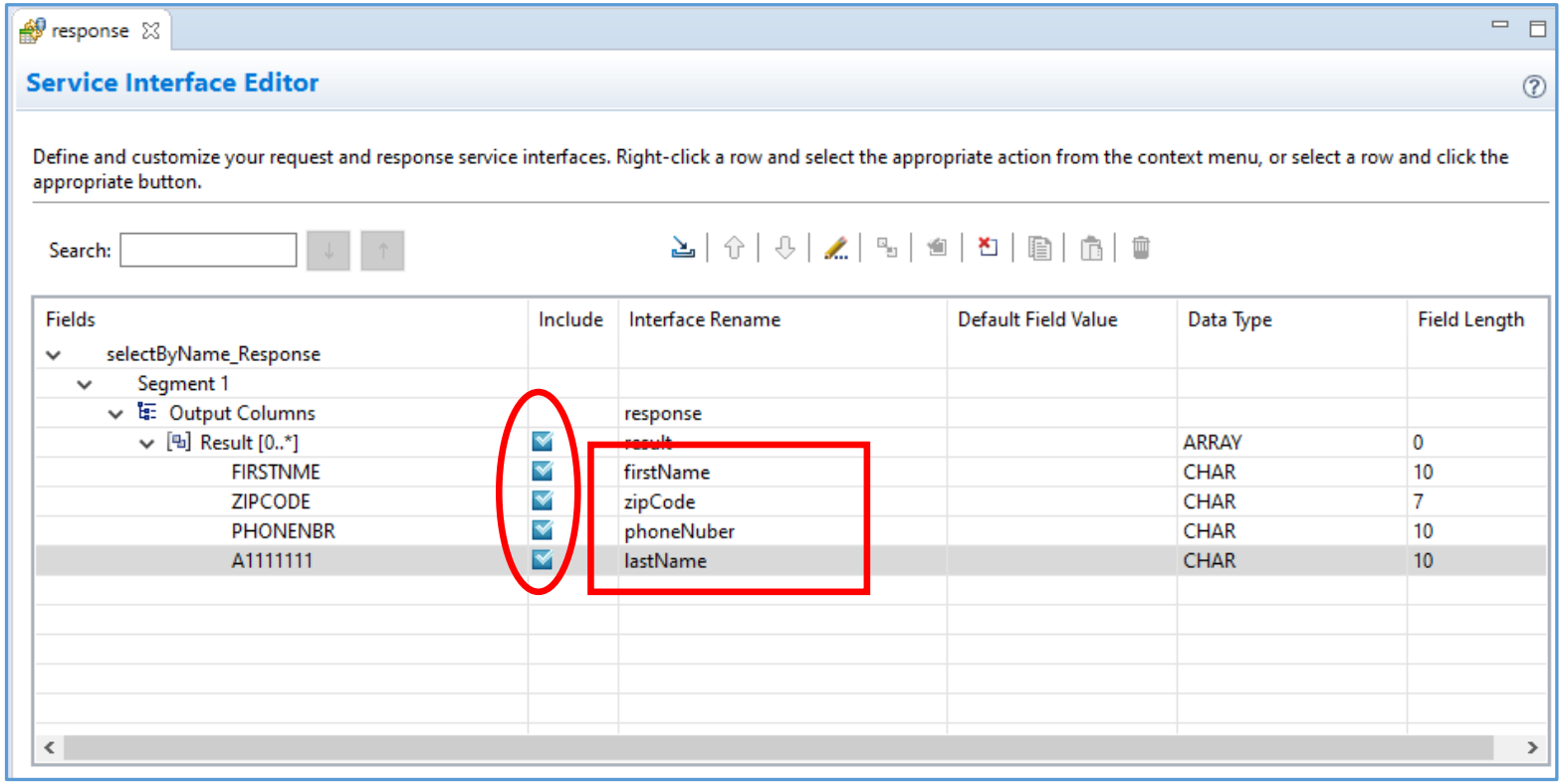
API toolkit – Creating Services for IMS DB

The Toolkit allows editing a service interface definitions*



*Using a slightly different process

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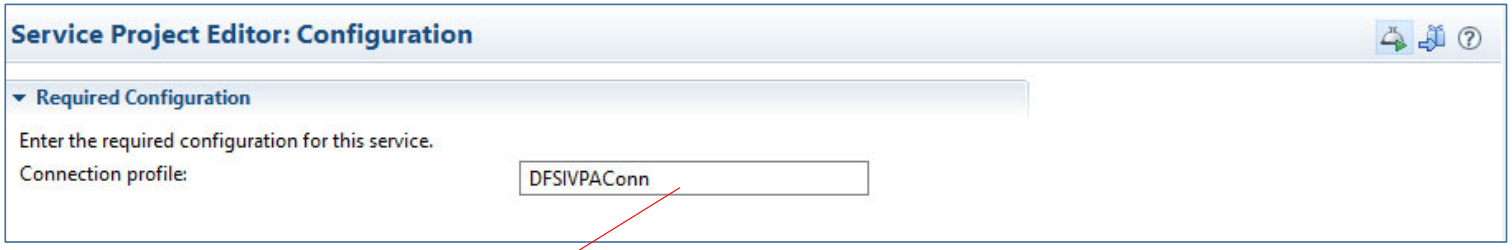
IMS Connection Factory in the server XML



ConnectionFactory

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

IMS Connect HWSCFG

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

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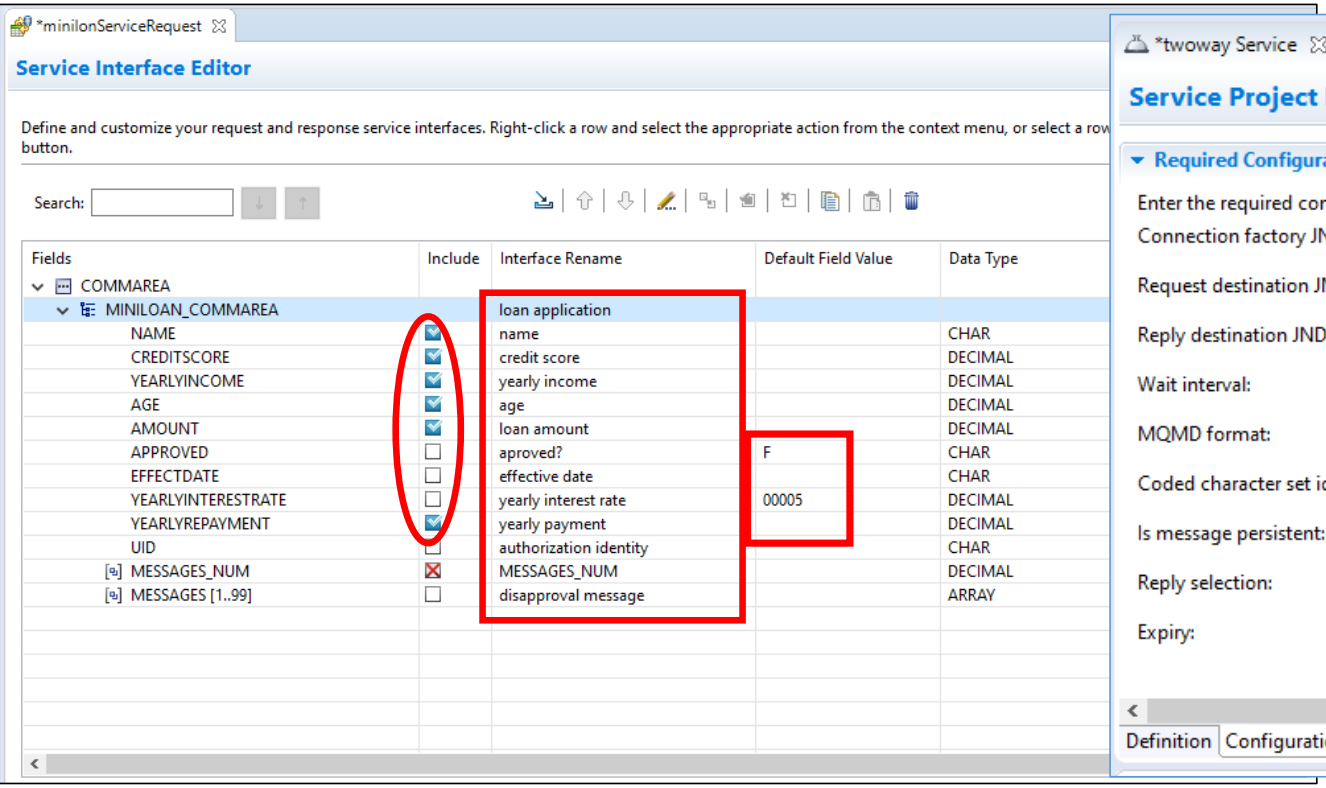
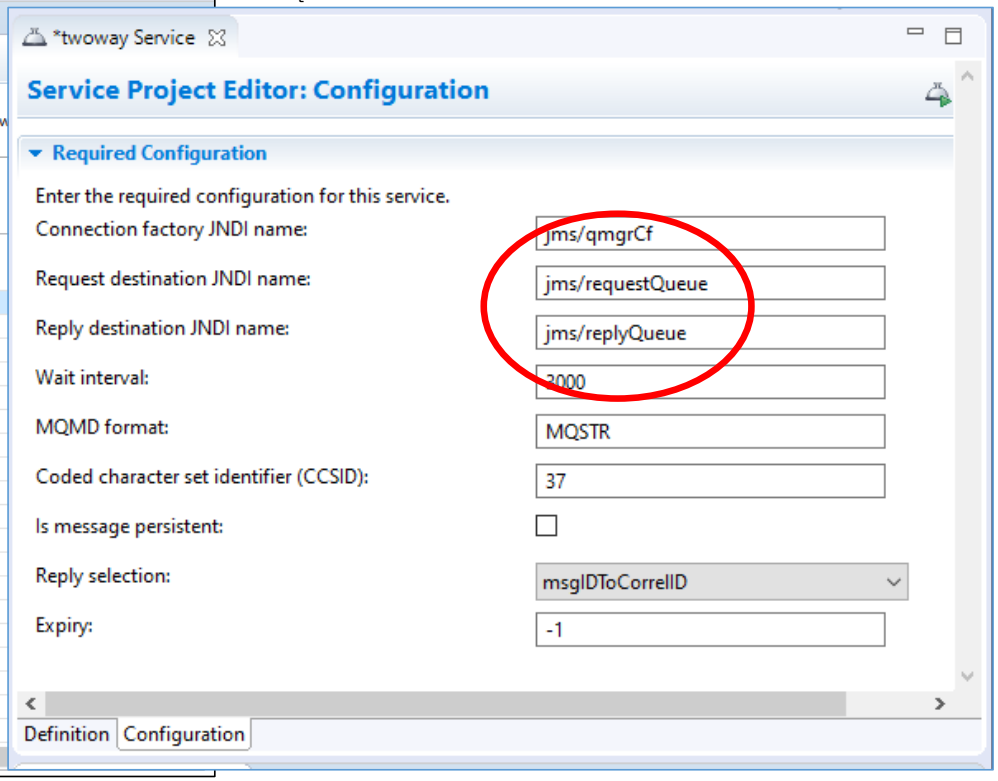
API toolkit – Creating Services for MQ

Creating a MQ PUT (“POST”) service interface definition

MQ Meta Data





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.

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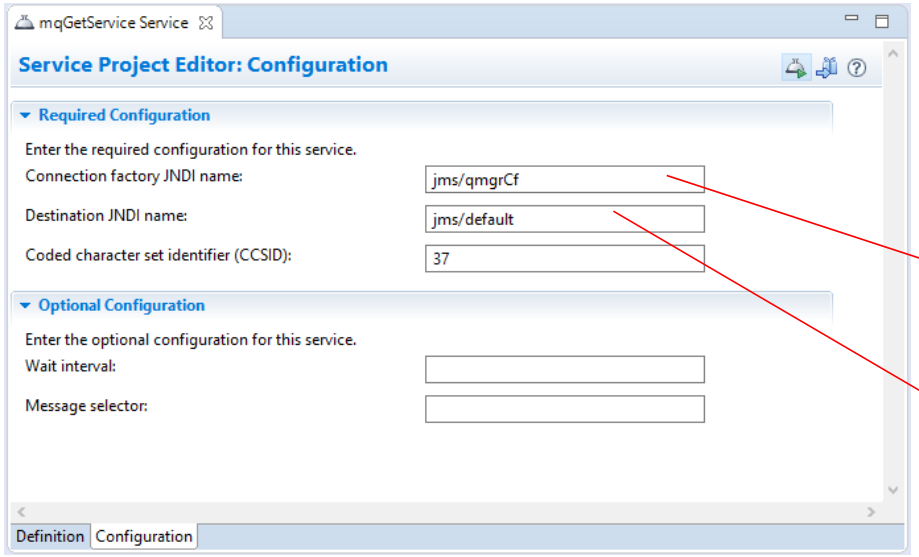
Using JMS to access MQ (One-Way)



mqClient.xml — Read only — Close

Design | Source

```
1  <server description="MQ Service Provider">
2
3   <featureManager>
4         <feature>zosconnect:mqService-1.0</feature>
5   </featureManager>
6
7   <variable name="wmqJmsClient.rar.location"
8             value="/usr/lpp/mqm/V9R1M1/java/lib/jca/wmq.jmsra.rar"/>
9   <wmqJmsClient nativeLibraryPath="/usr/lpp/mqm/V9R1M1/java/lib"/>
10
11  <zosconnect_services>
12        <service name="mqPutService">
13              <property name="useCallerPrincipal" value="false"/>
14        </service>
15  </zosconnect_services>
16
17   <connectionManager id="ConMgr1" maxPoolSize="5"/>
18
19   <jmsConnectionFactory id="qmgrCf" jndiName="jms/qmgrCf"
20          connectionManagerRef="ConMgr1">
21         <properties.wmqJMS transportType="CLIENT"
22                queueManager="ZMQ1"
23                channel="LIBERTY.DEF.SVRCONN"
24                hostName="wg31.washington.ibm.com"
25                port="1422" />
26   </jmsConnectionFactory>
27
28   <jmsQueue id="q1" jndiName="jms/default">
29       <properties.wmqJms
30           baseQueueName="ZCEE.DEFAULT.MQZCEE.QUEUE"
31           CCSID="37"/>
32   </jmsQueue>
33
34 </server>
35
```

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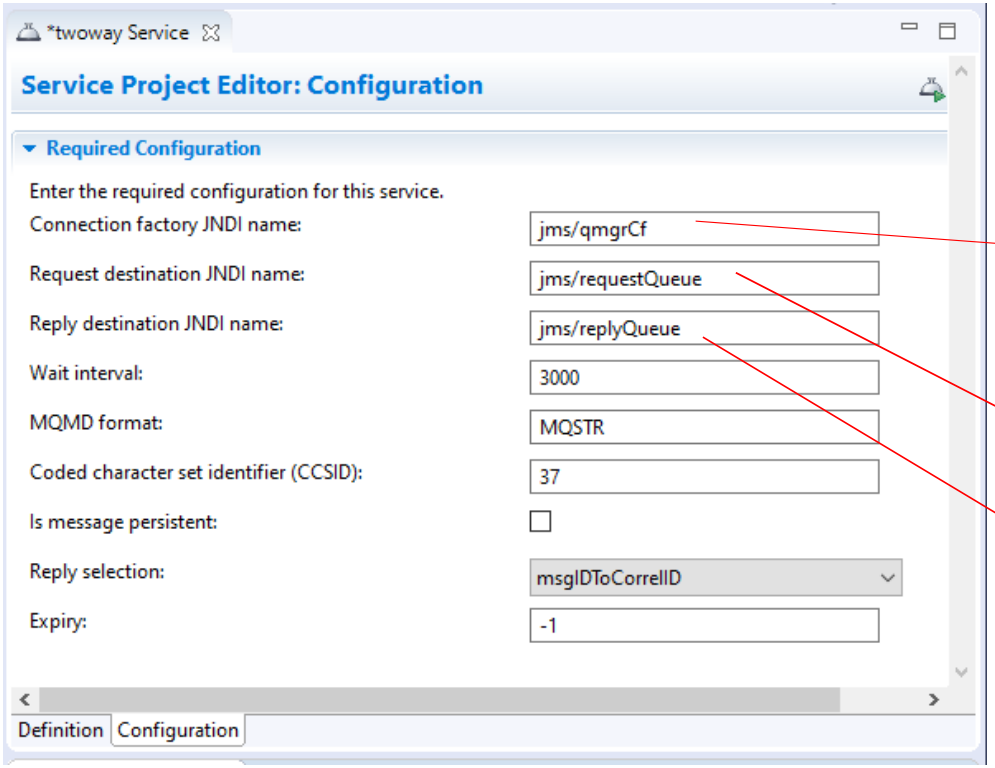
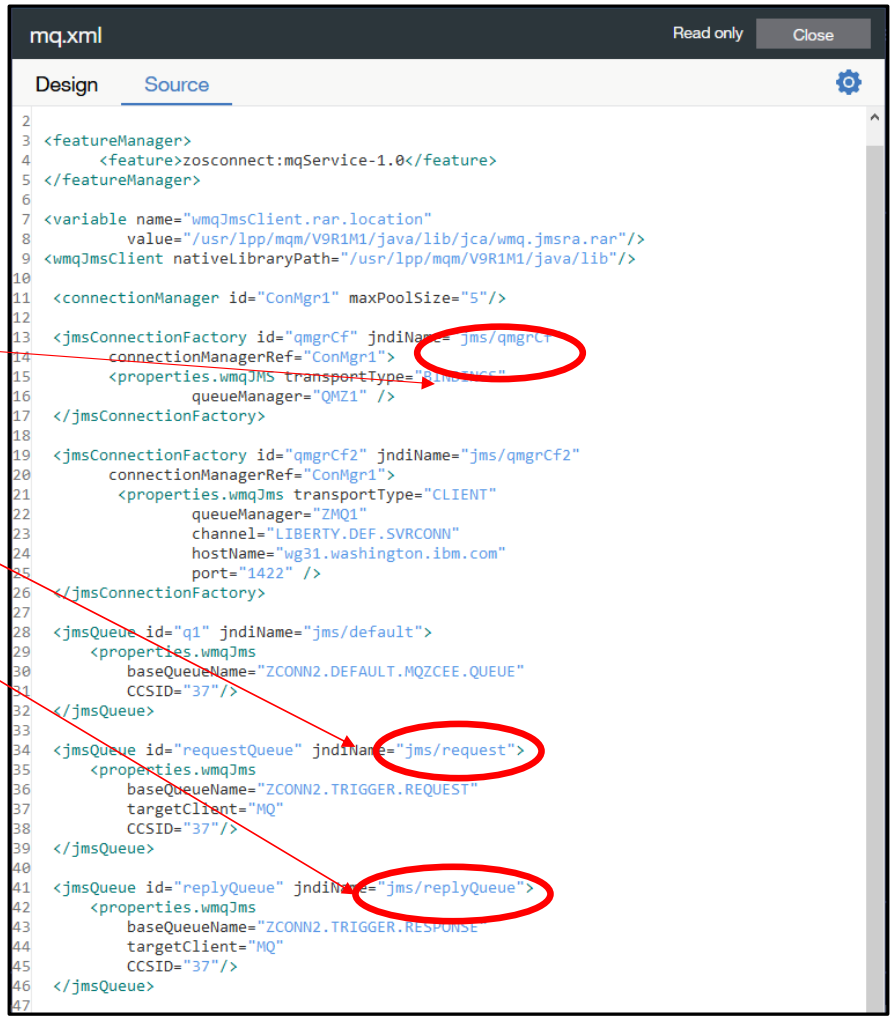
Using JMS to access MQ (Two-Way)





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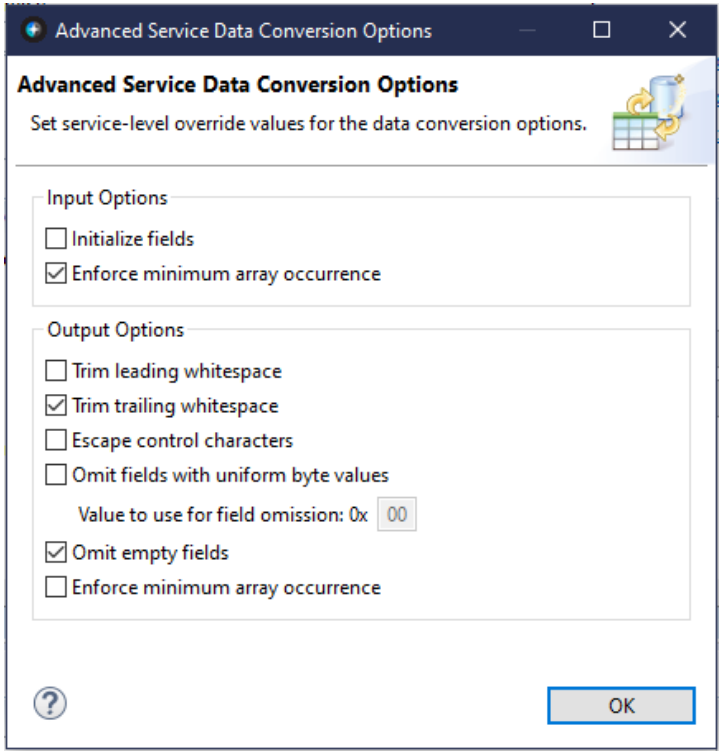
API toolkit – Advanced Data Conversion Options



Request Messages:

- Initialize fields
- Enforce minimum array occurrence

Response Messages:

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

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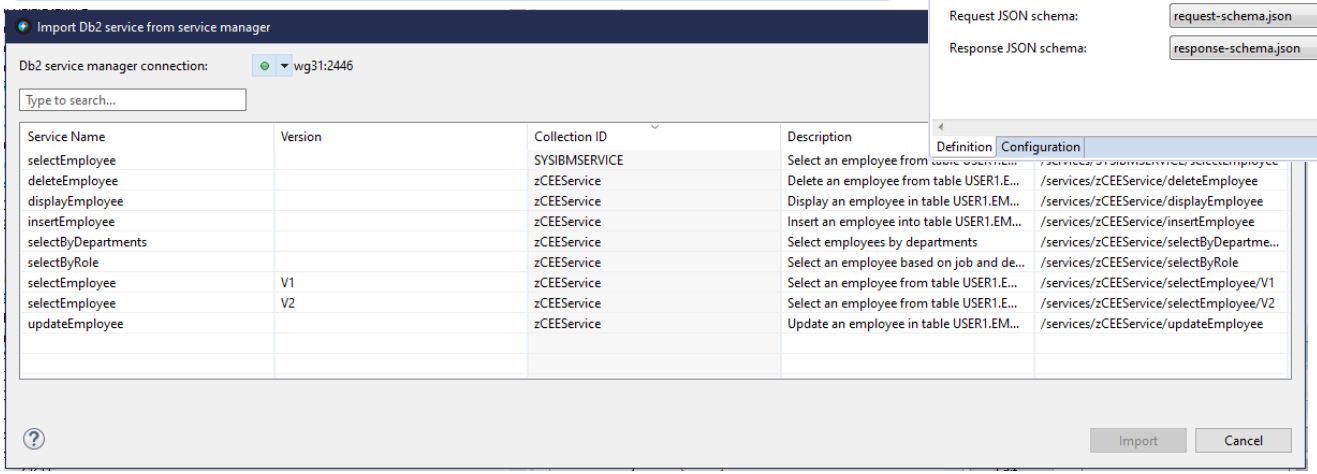
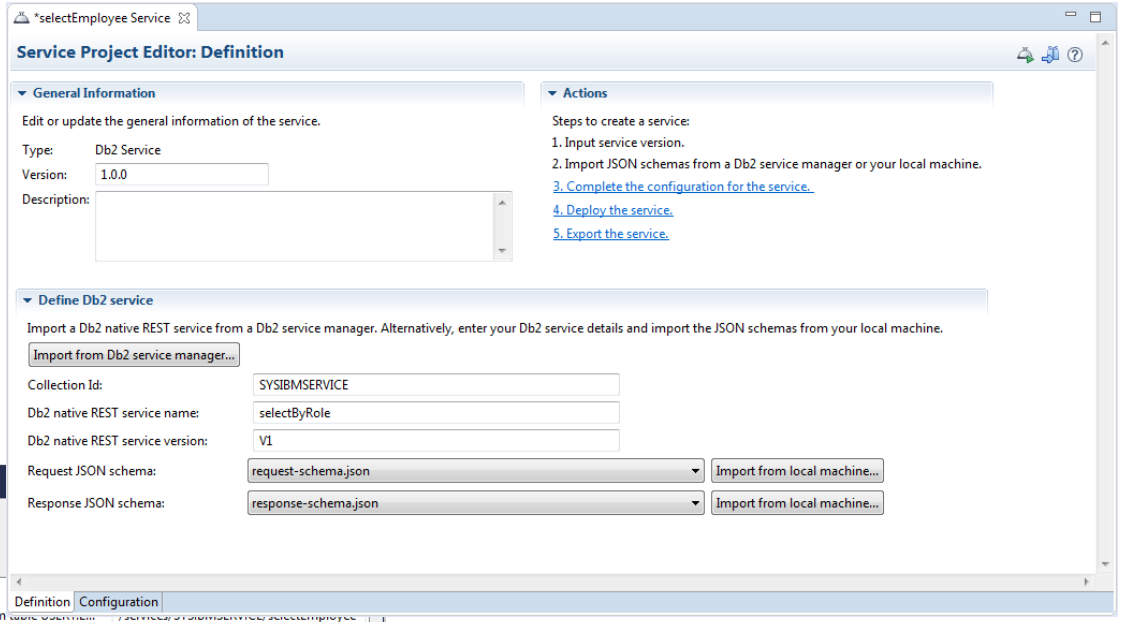
API toolkit – Creating Services for Db2

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", FIRSTNME AS "firstName",
        MIDINIT AS "middleInitial", LASTNAME as "lastName",
        WORKDEPT AS "department", PHONENO AS "phoneNumber",
        JOB AS "job"
  FROM USER1.EMPLOYEE WHERE EMPNO = :employeeNumber
//SYSTSIN  DD *
DSN SYSTEM(DSN2)
BIND SERVICE(SYSIBMSERVICE) -
NAME("selectEmployee") -
SQLENCODING(1047) -
DESCRIPTION('Select an employee from table USER1.EMPLOYEE')
```





The service developer retrieves details about the Db2 REST services

Note there is no service interface editor available

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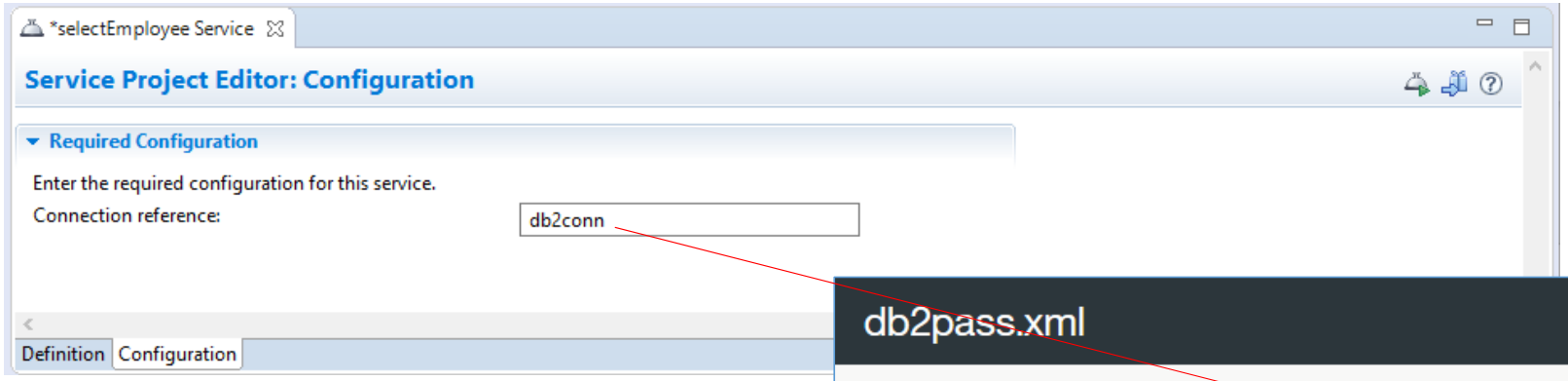
Accessing a Db2 REST service resource




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

db2pass.xml

Design | Source

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

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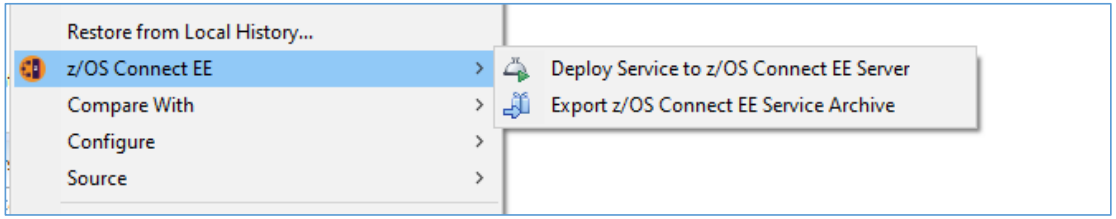
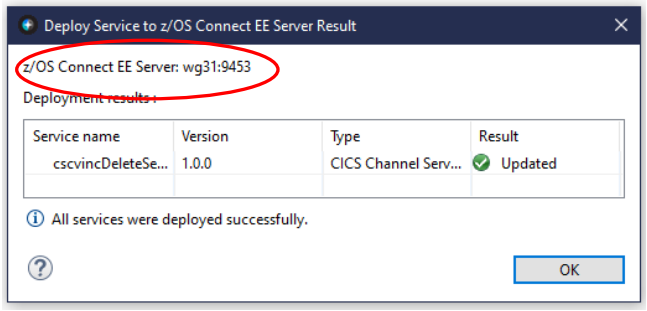
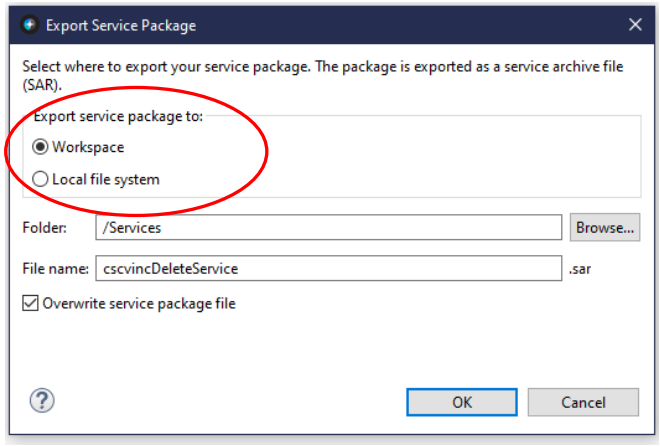
API toolkit – Services Editor

Server connection and Services deployment

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







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/api_toolkit/services

Simple **service creation** not using the Eclipse Toolkit

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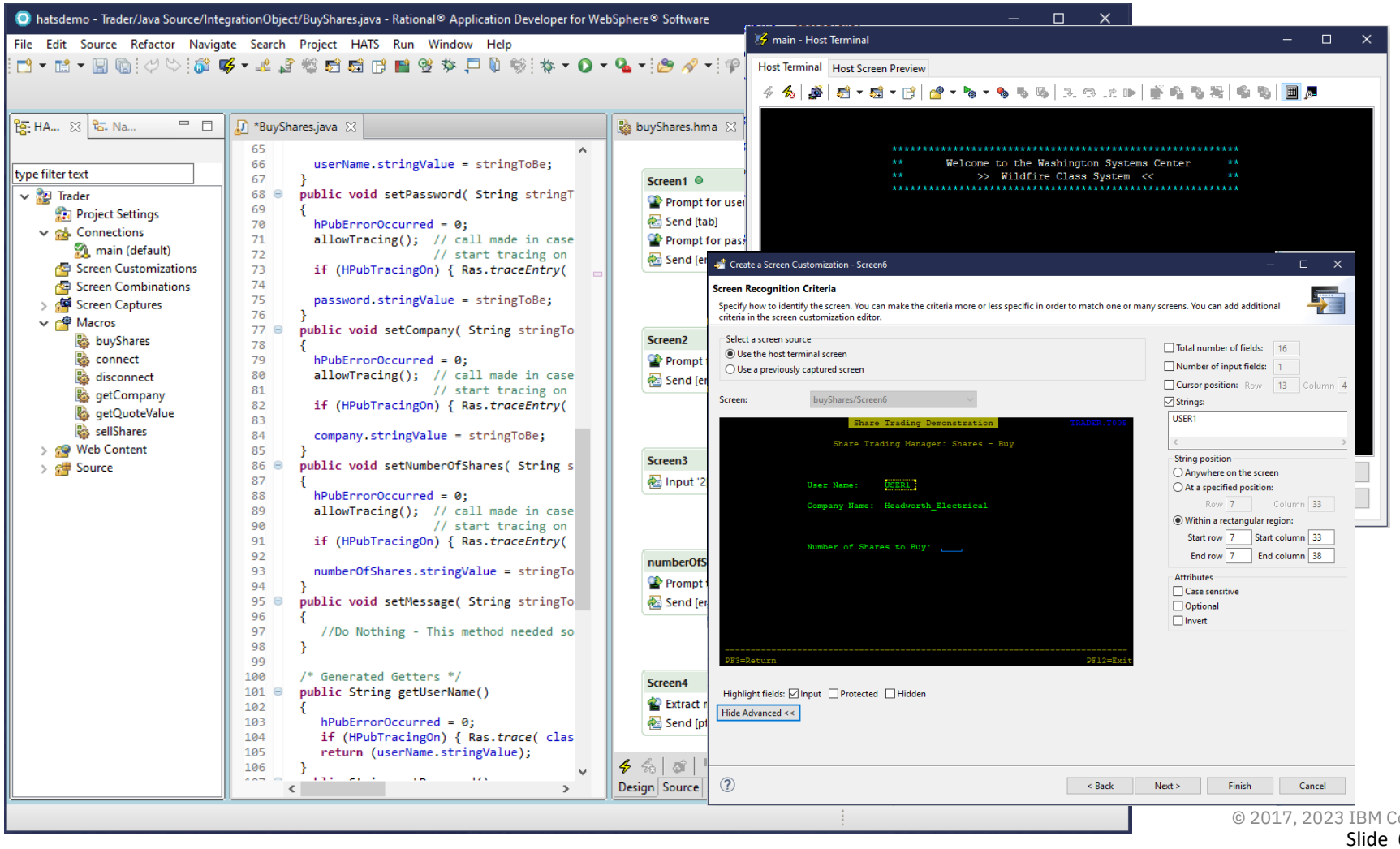
Use HATS to capture screen flows and input/output fields



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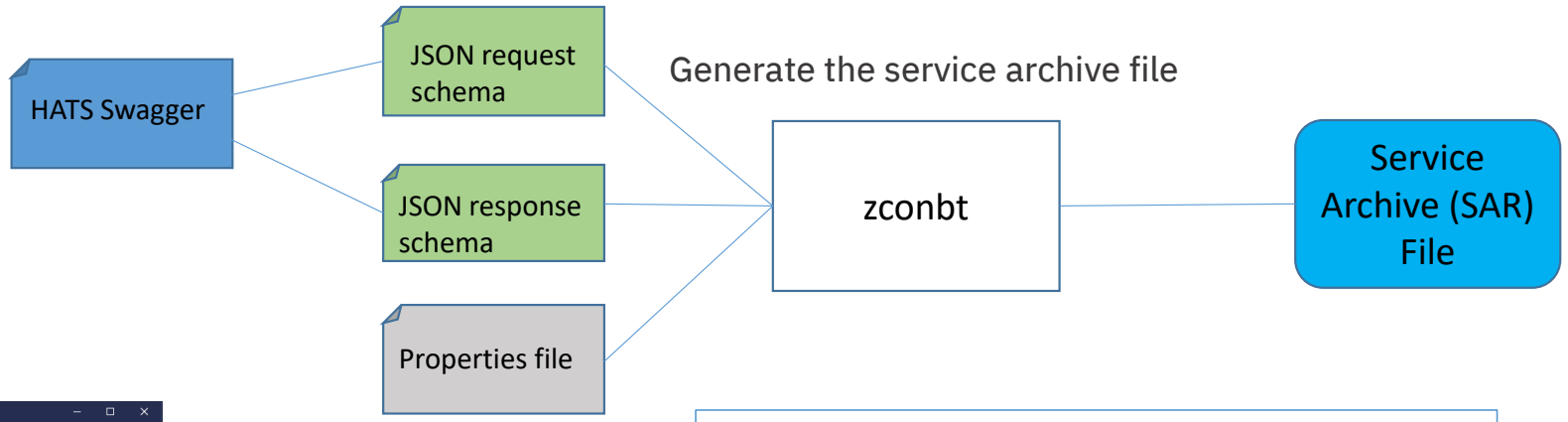
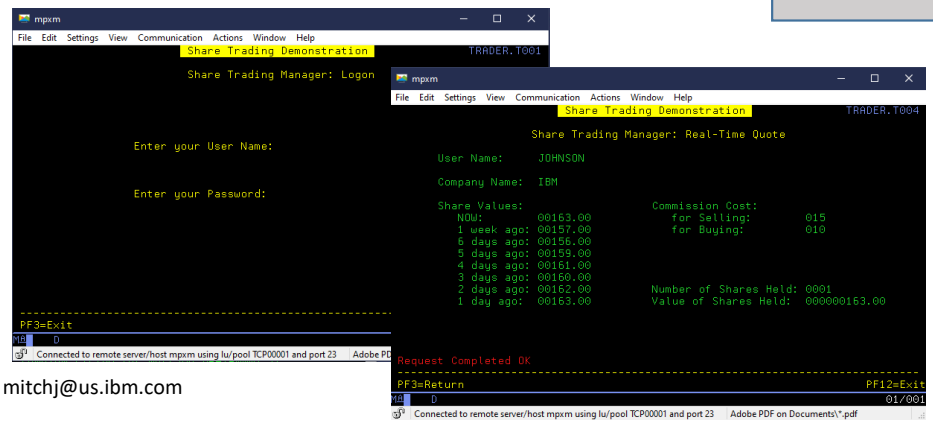
Command line(zconbt) – REST Services

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
```

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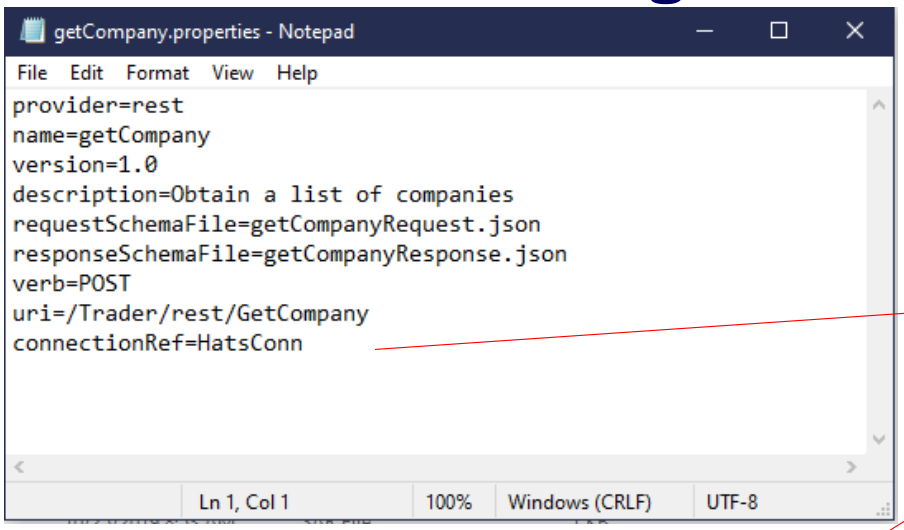
HATS server XML configuration



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" />
```

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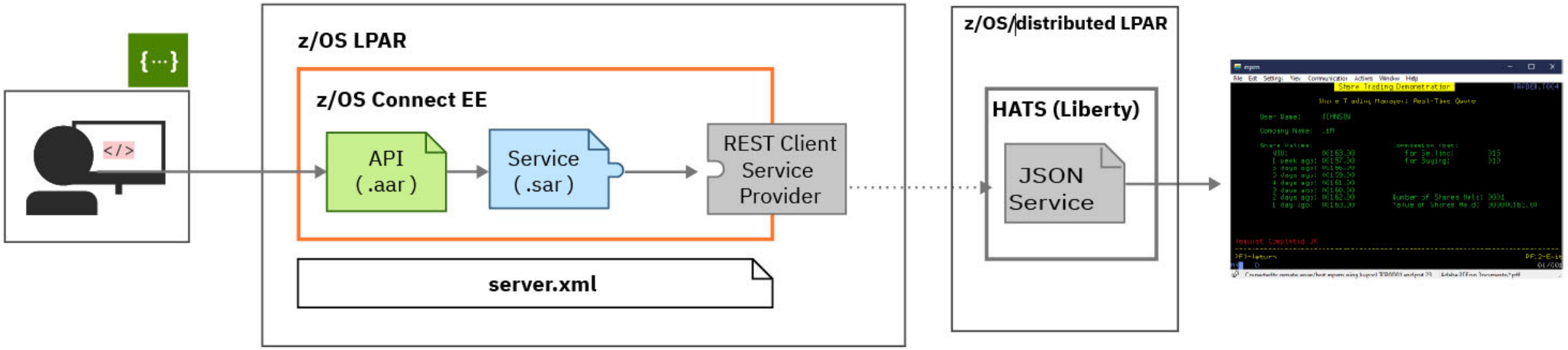
Using HATS to access a 3270 application



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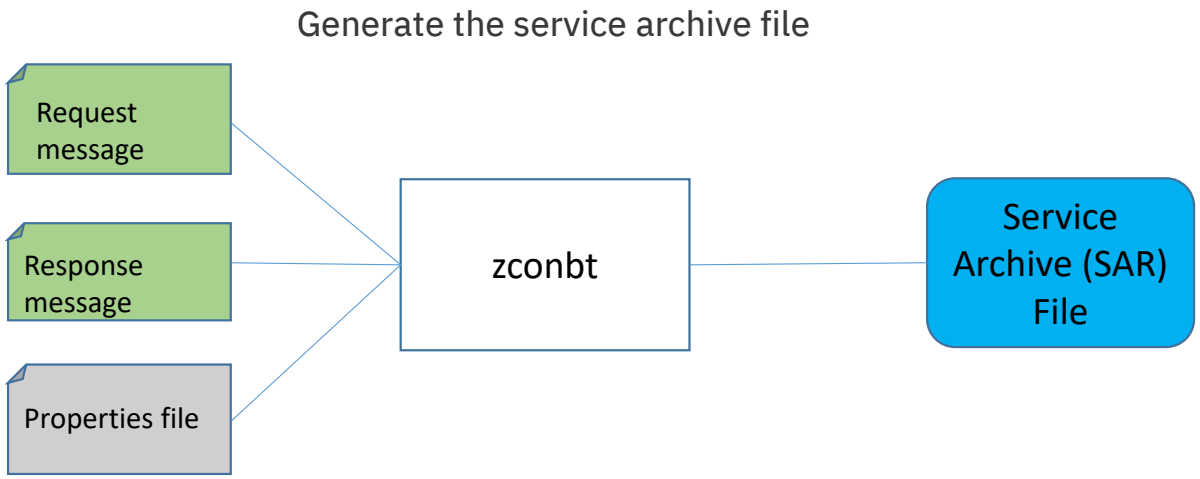
Command line(zconbt) – MVS Batch

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=ATSFILEA
register=FILEAZCON
connectionRef=wolaCF
requestStructure=fileareq.cpy
responseStructure=filearsp.cpy
```



WebSphere **O**ptimized **L**ocal **A**dapter – a protocol for cross memory communications between address spaces

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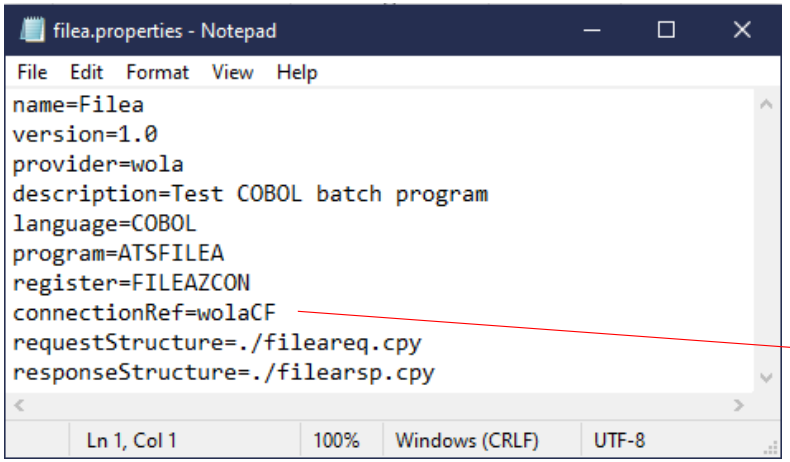
MVS batch server XML




```
      * 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 'ATSFILEA'                     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.
```

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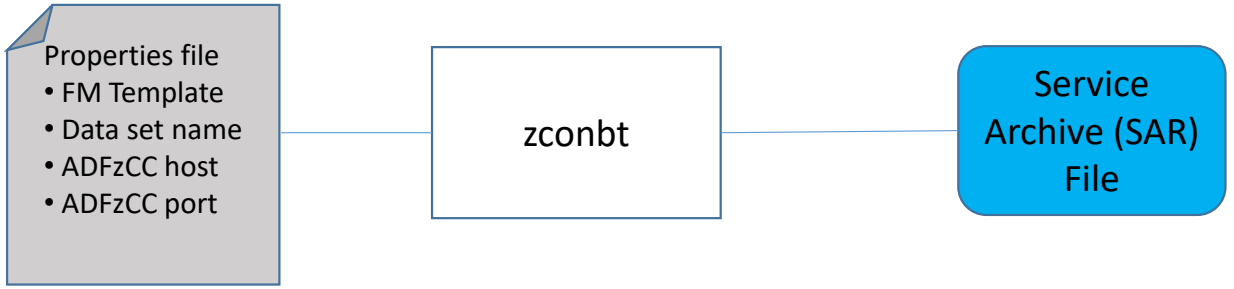
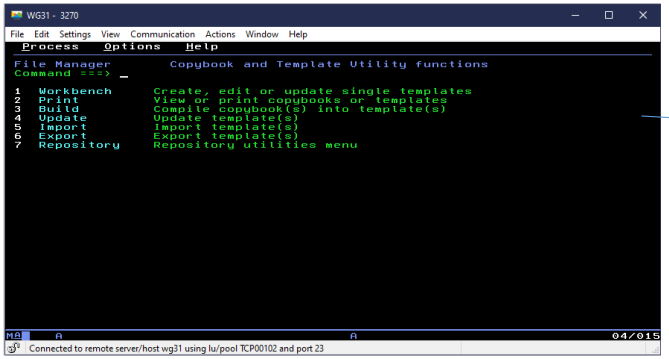
Command line(zconbt) – File Manager

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
```

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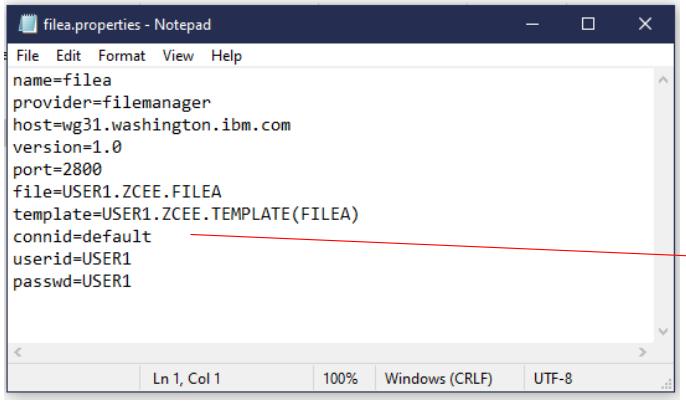
File Manager server XML



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=*                           <== OUTPUT if Tracing
//STDOUT   DD SYSOUT=*
//* Server wide, then participating product configurations
//CONFIG   DD DISP=SHR,DSN=&IPV.(IPVCONFG)
```

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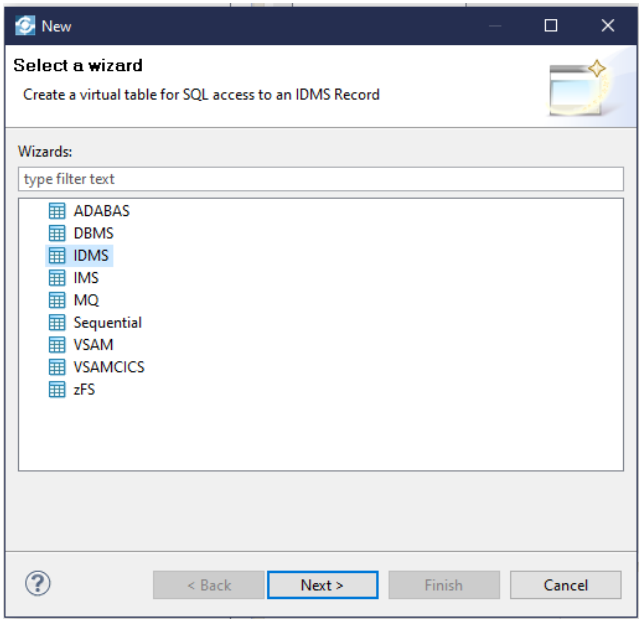
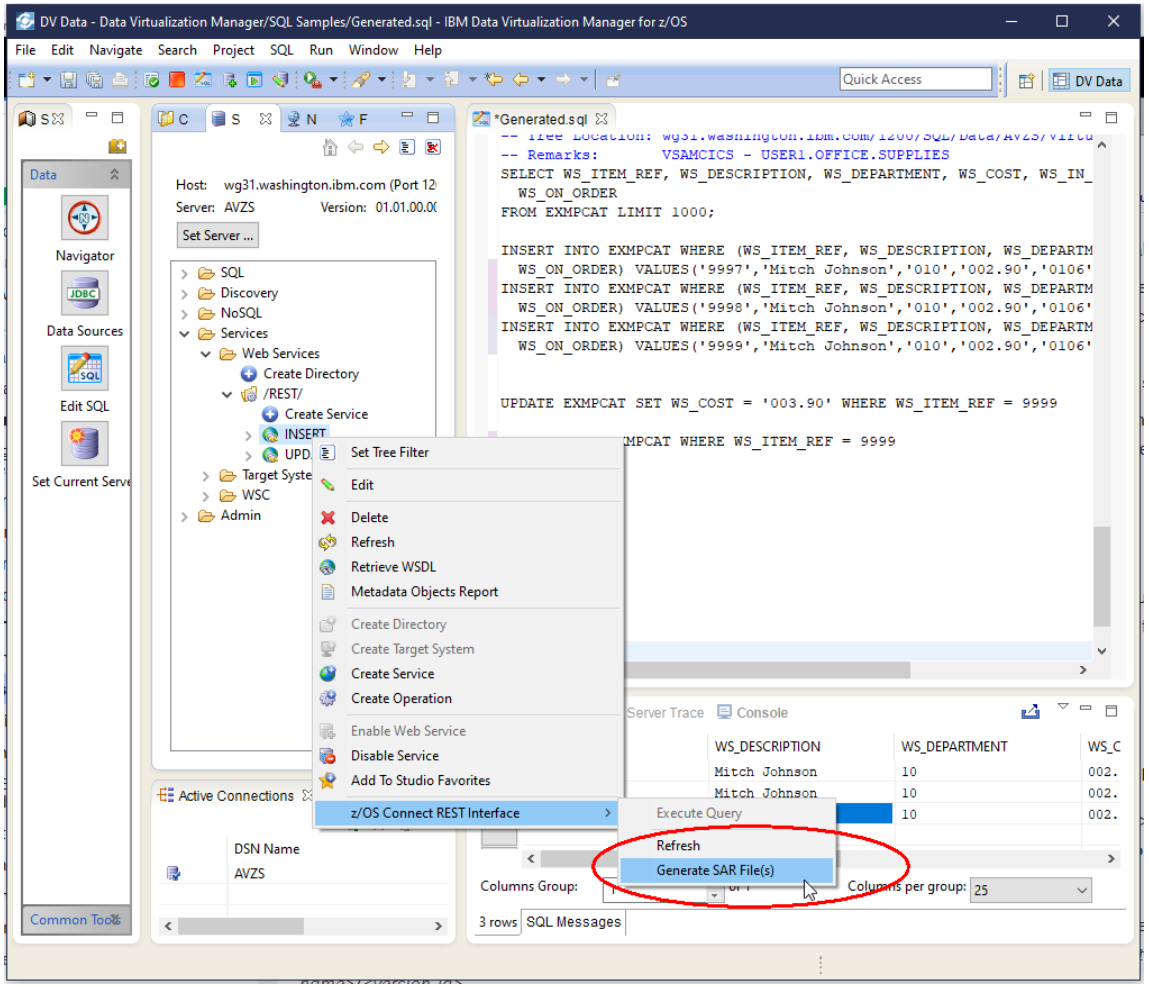
DVM Studio

DVM uses the DVM Studio





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z/OS Resources accessible from DVM using SQL*

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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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
```

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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 there are created

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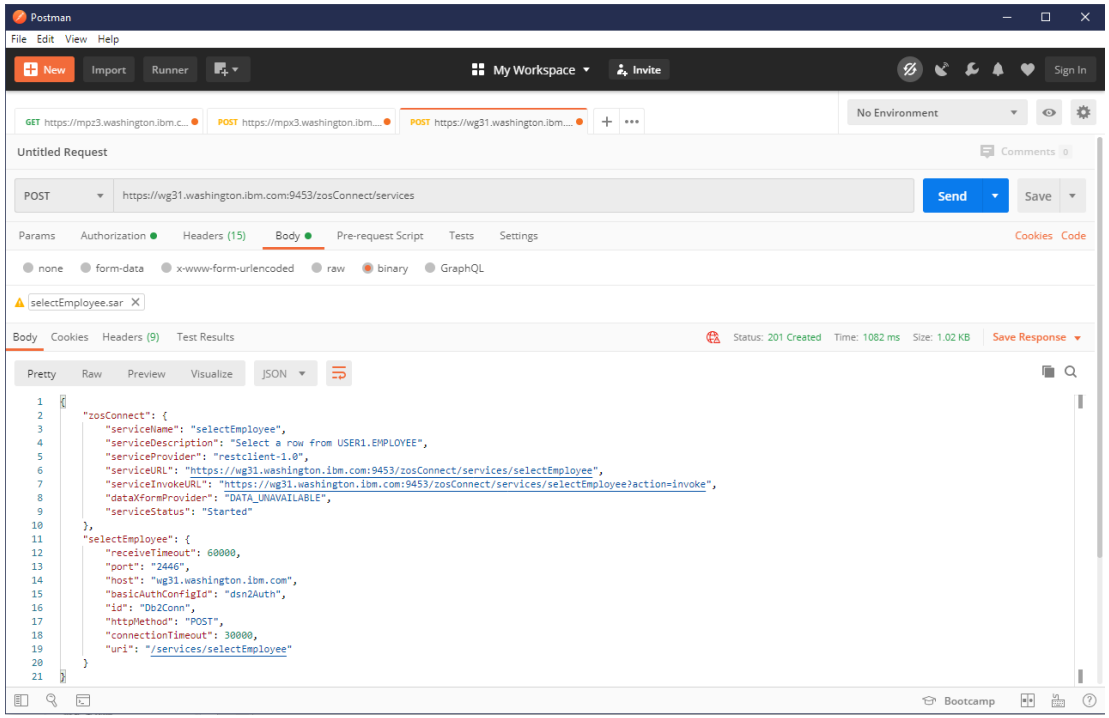
Deploying Service Archive files outside of the Eclipse tooling

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



Command:

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

Results:


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

Quick and easy **API mapping.**

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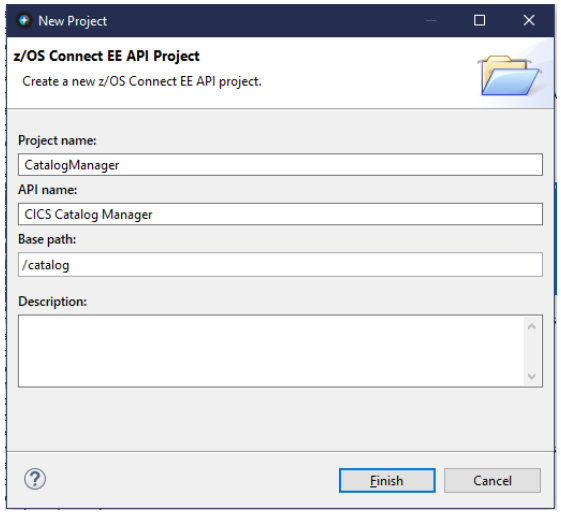
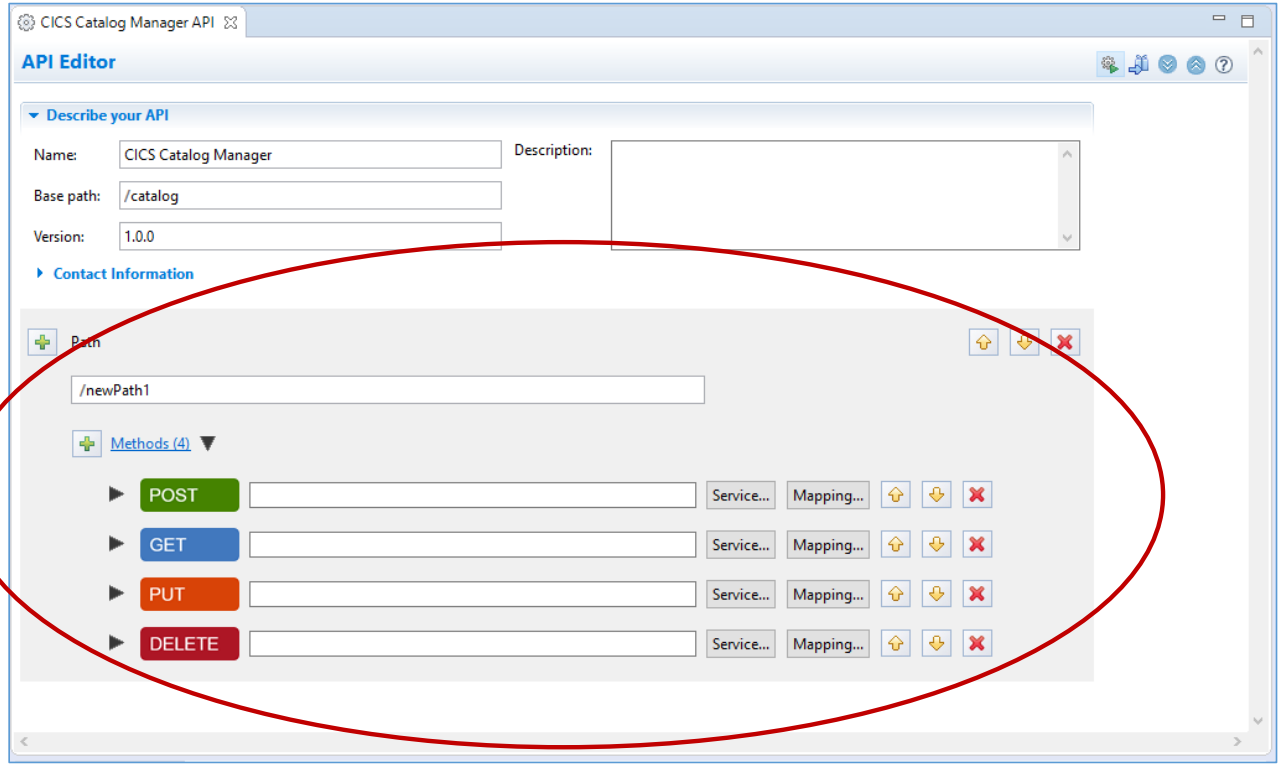
API toolkit – API Editor





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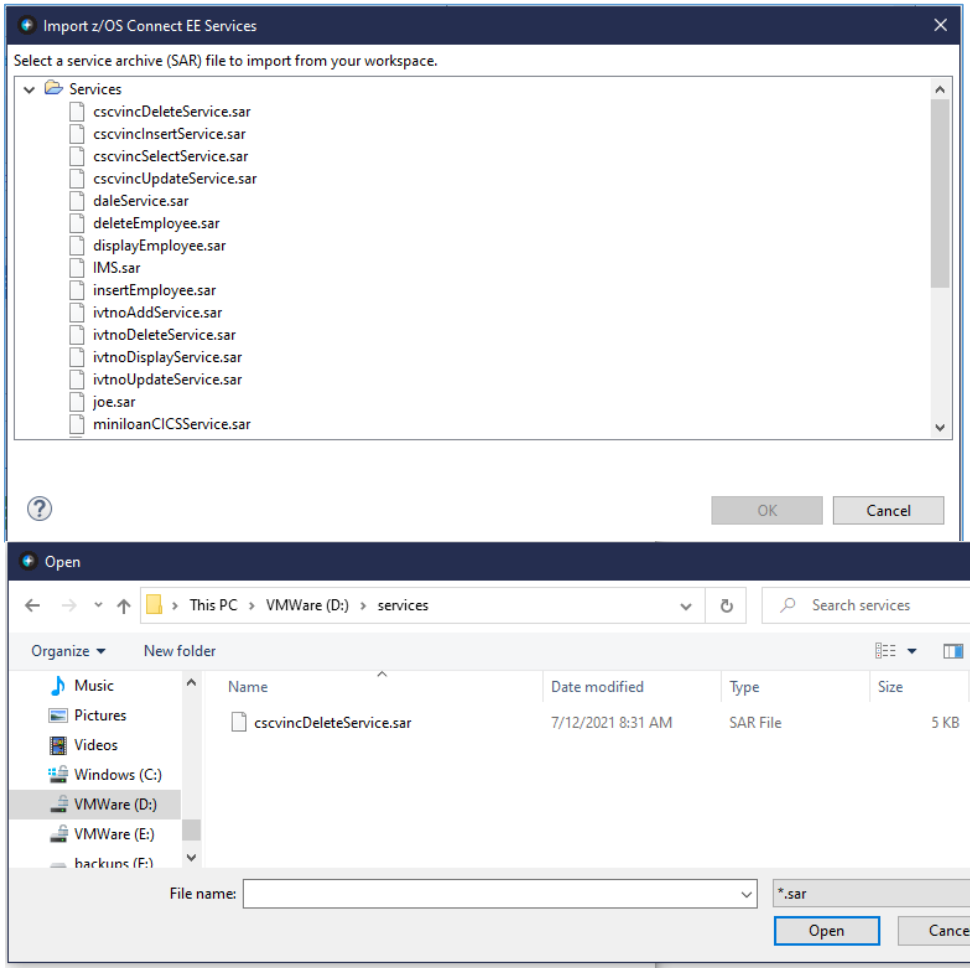
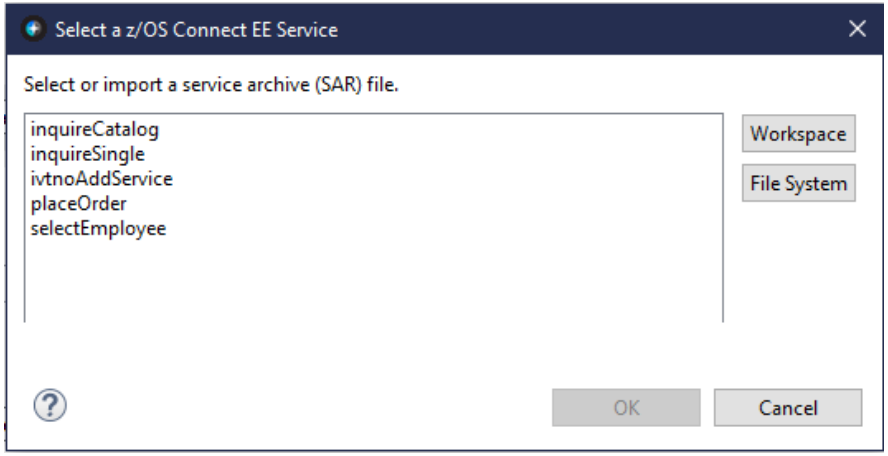
Importing the service archives files





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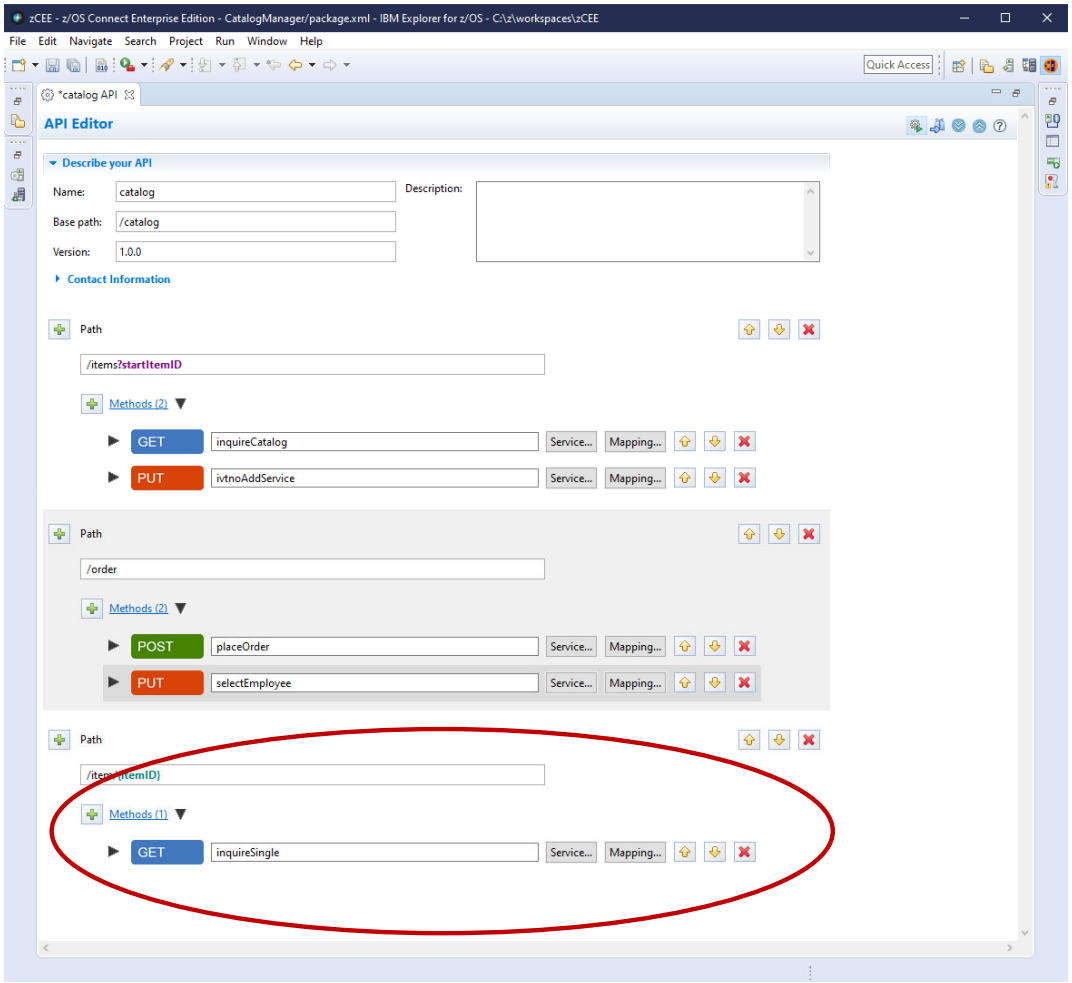
API toolkit – API Editor



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.

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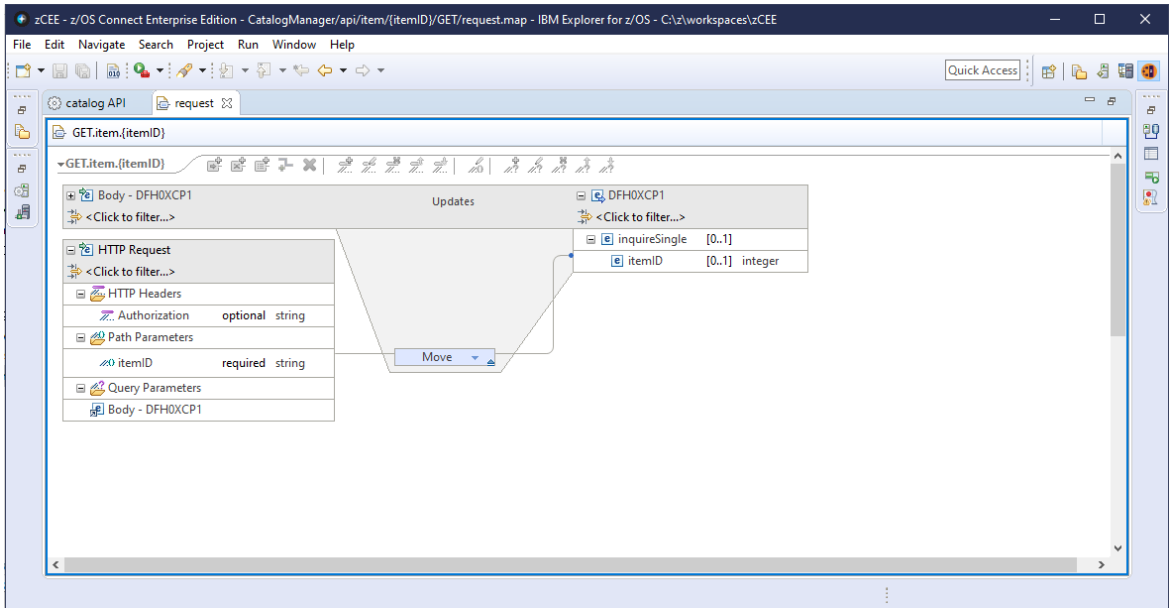
API toolkit – API Editor

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).

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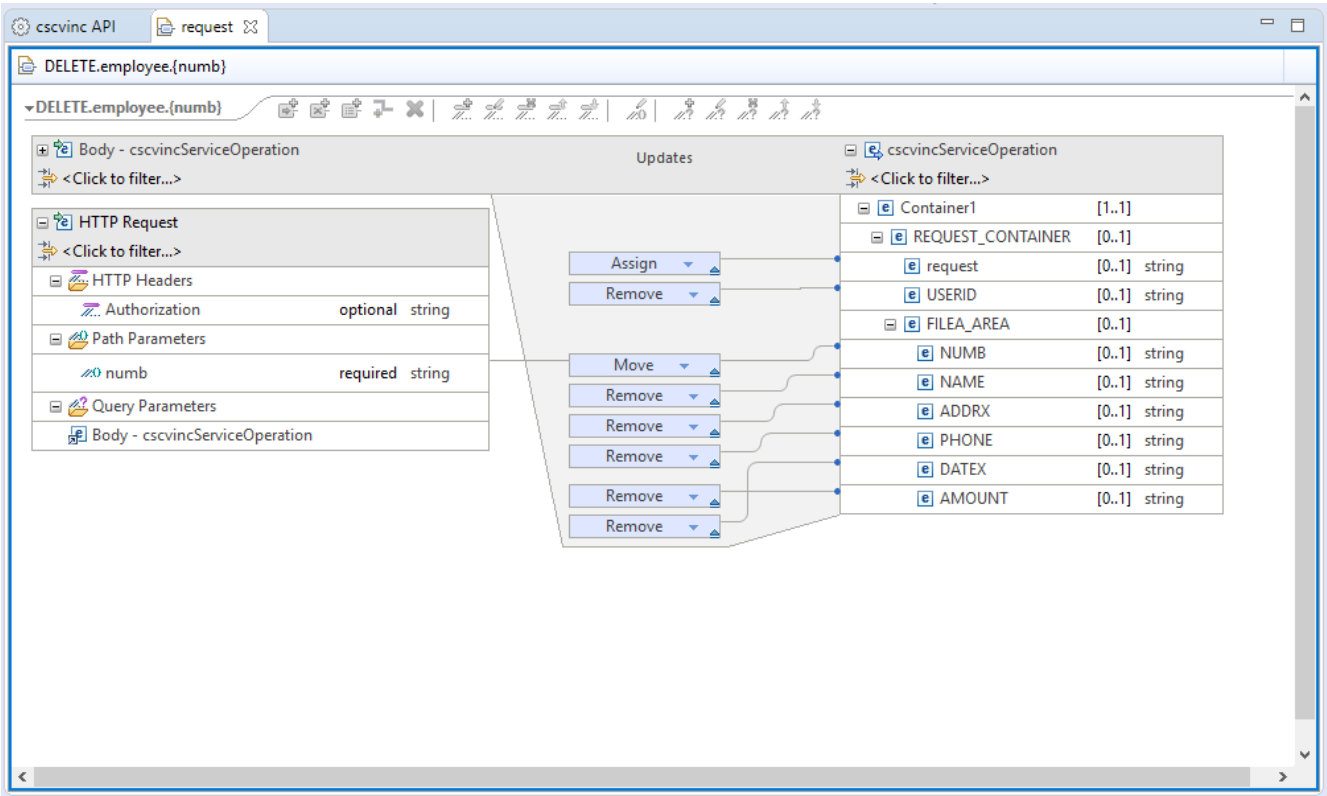
API toolkit – API Editor

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



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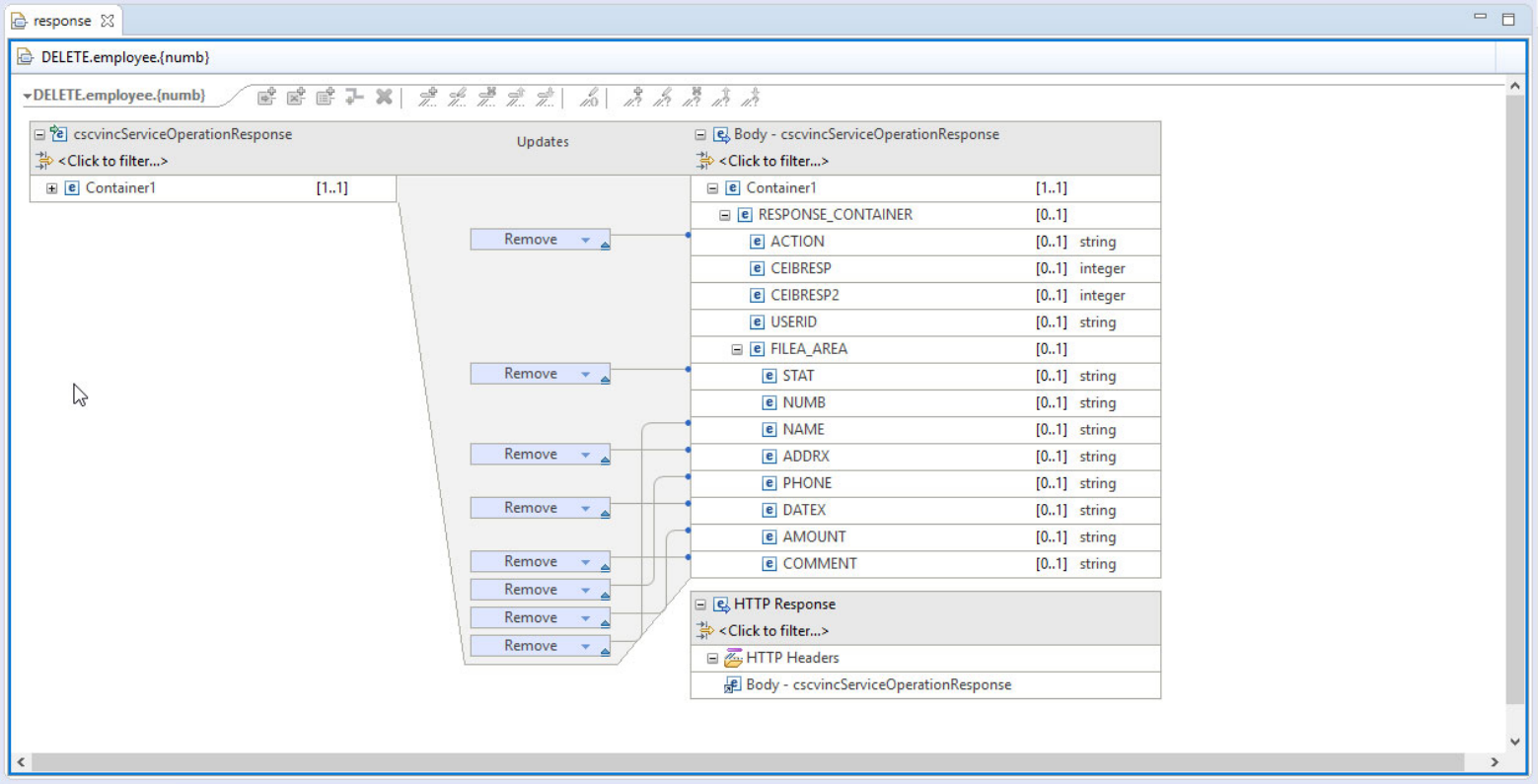
API toolkit – API Editor

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



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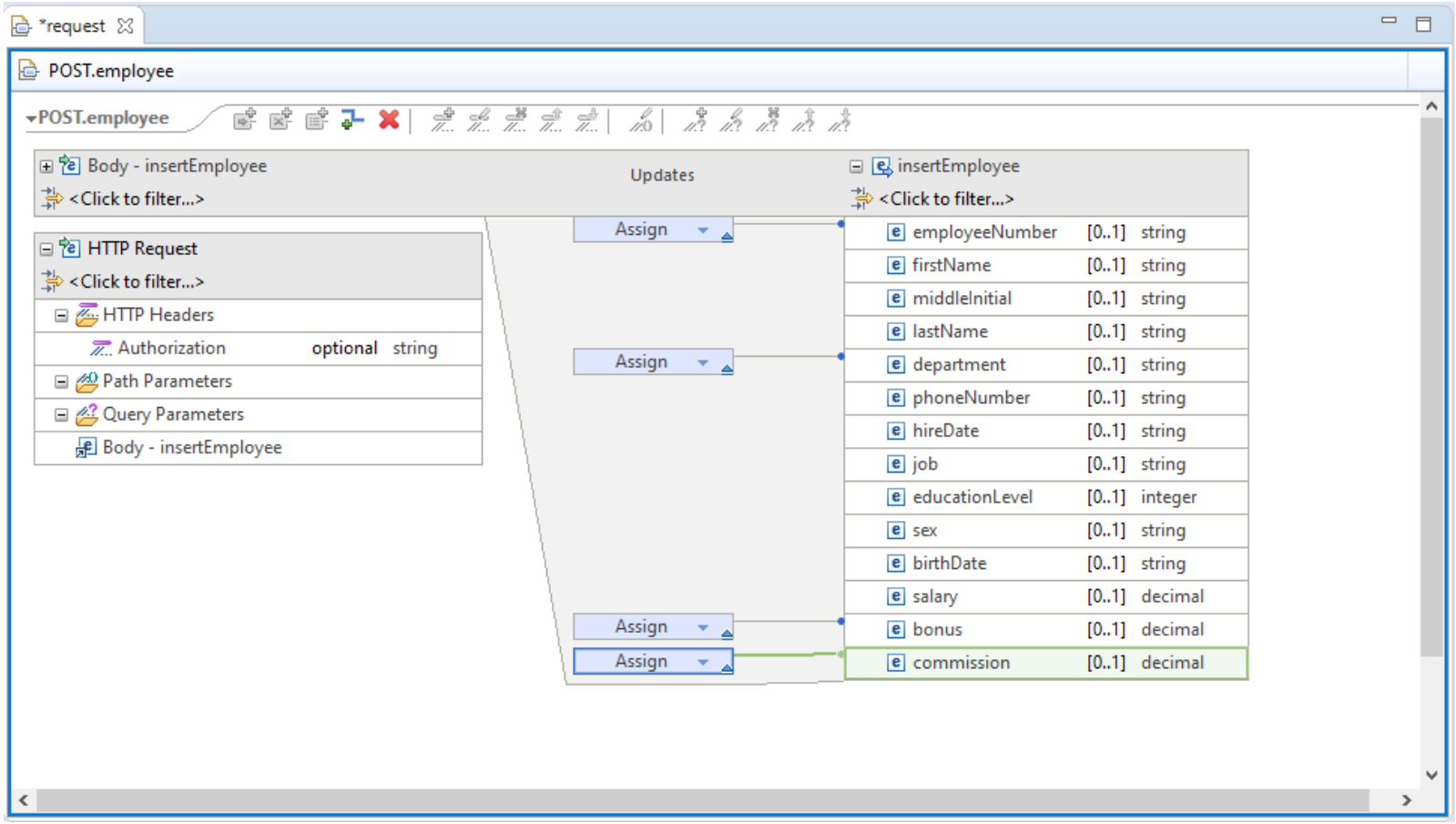
API toolkit – API Editor and Db2 REST service

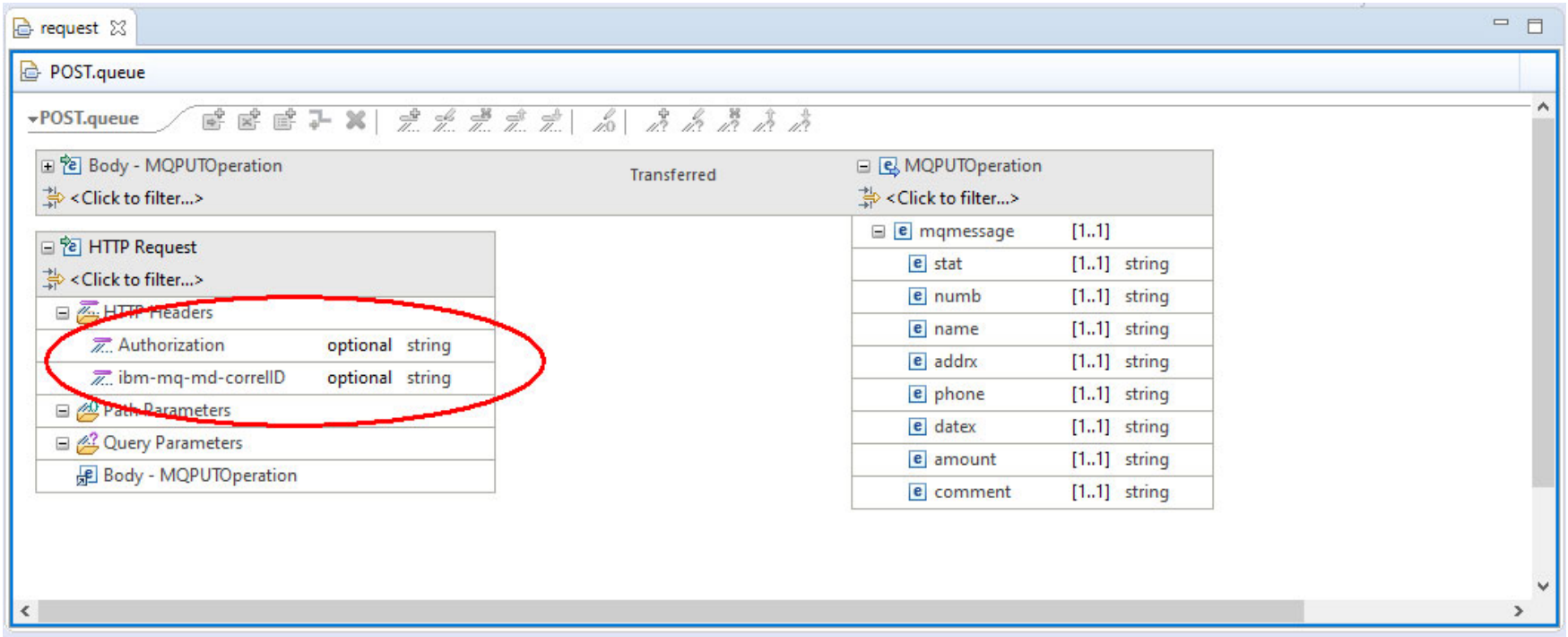
API mapping: Remove/Assign values columns exposed in Db2 REST service



mitchj@us.ibm.com

API toolkit – Header properties

API mapping: Allows adding HTTP header properties



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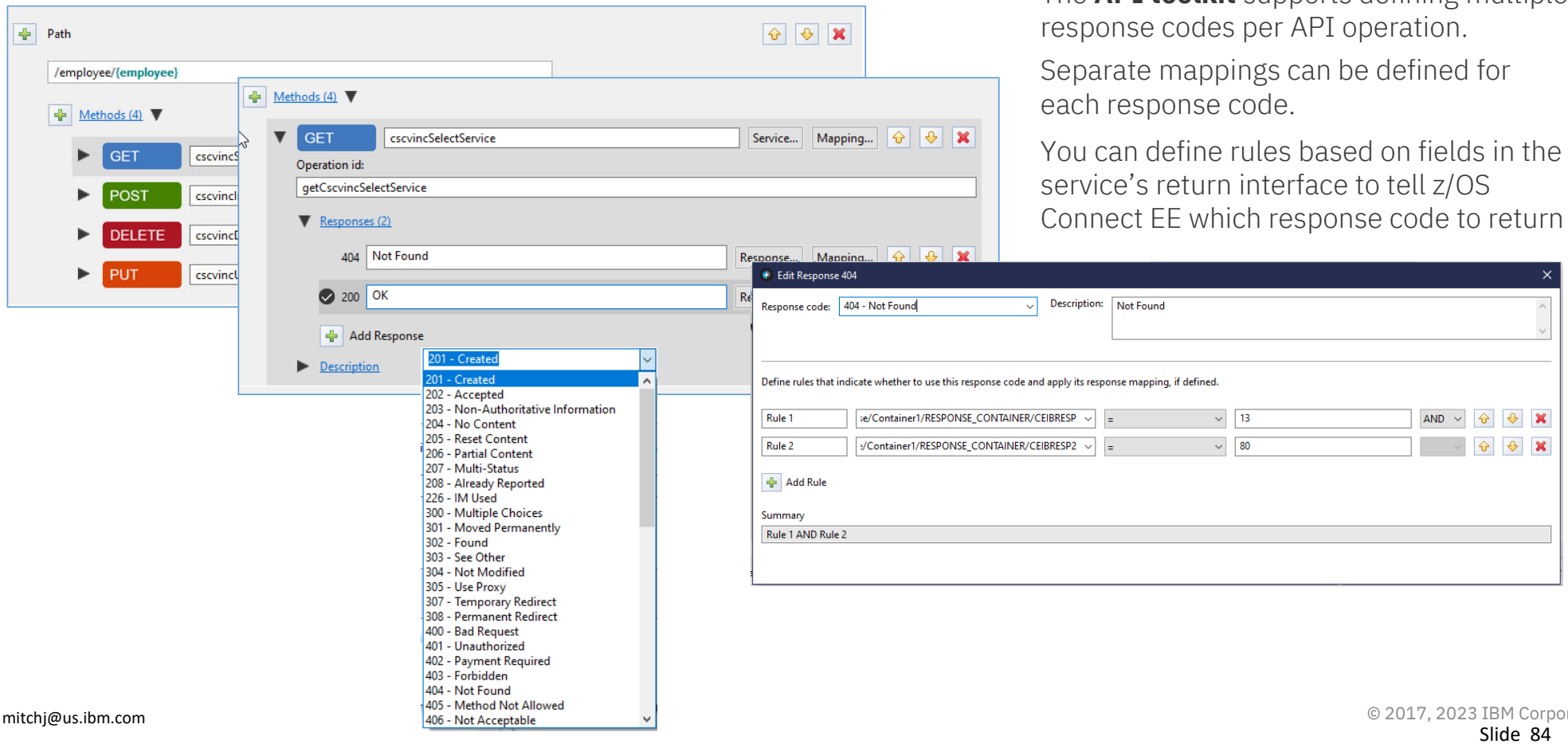
API toolkit

API mapping: API definition with multiple response codes



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

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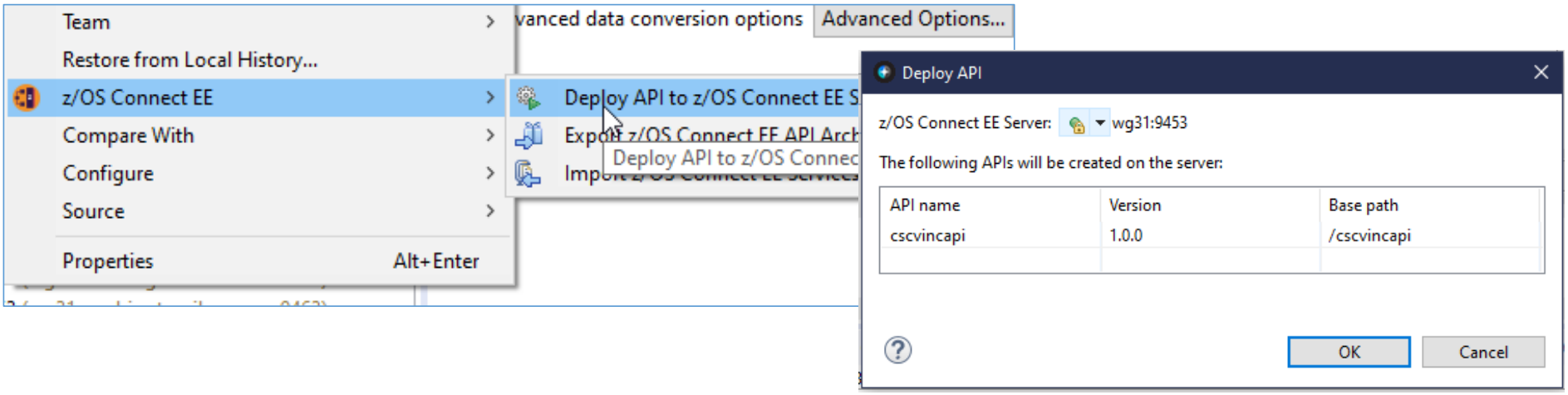
API toolkit – API Editor

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.

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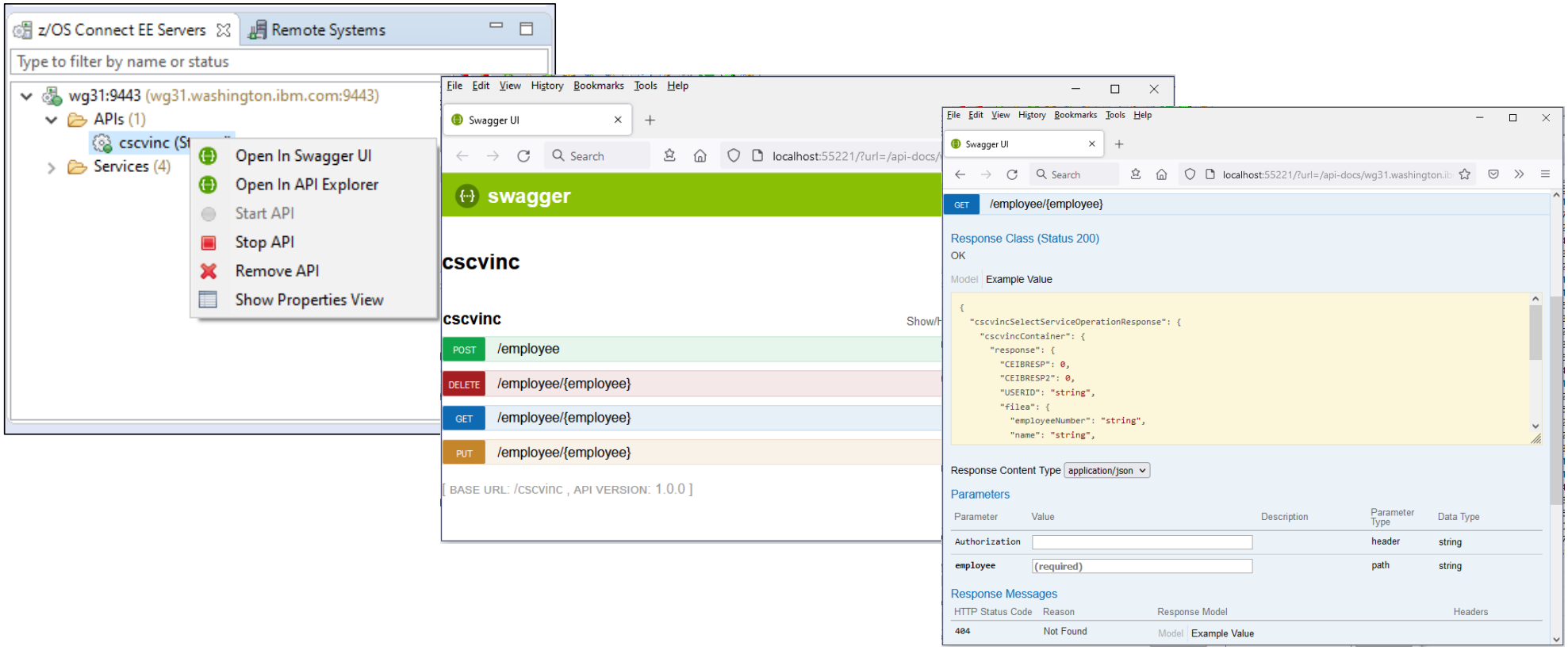
API toolkit – API Editor

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.



mitchj@us.ibm.com

/zosConnect/designer

API Development using the z/OS Connect Designer

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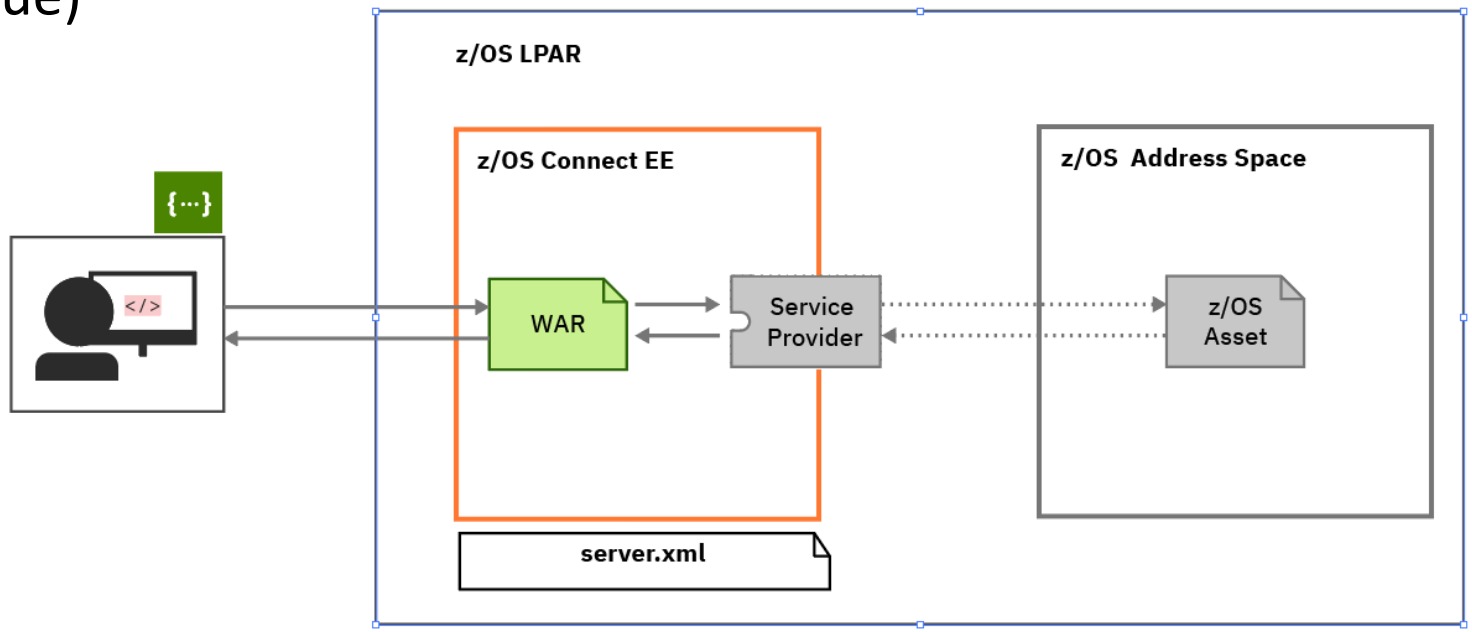
Accessing the CICS or Db2 asset (Open API 3)

- z/OS Connect OpenAPI 3 APIs are developed using a z/OS Connect Designer web browser tool to developer Web ARchive (WAR) files (a traditional Java packaging technique)



- The WAR provides the RESTful interface is ready to be consumed by a client and it requires the client to have no knowledge that a z/OS resource is being accessed as well as the mapping and transformation for accessingg the resource.
- The Service Provider is tightly coupled to a specific instance of a resource (e.g., host and port)

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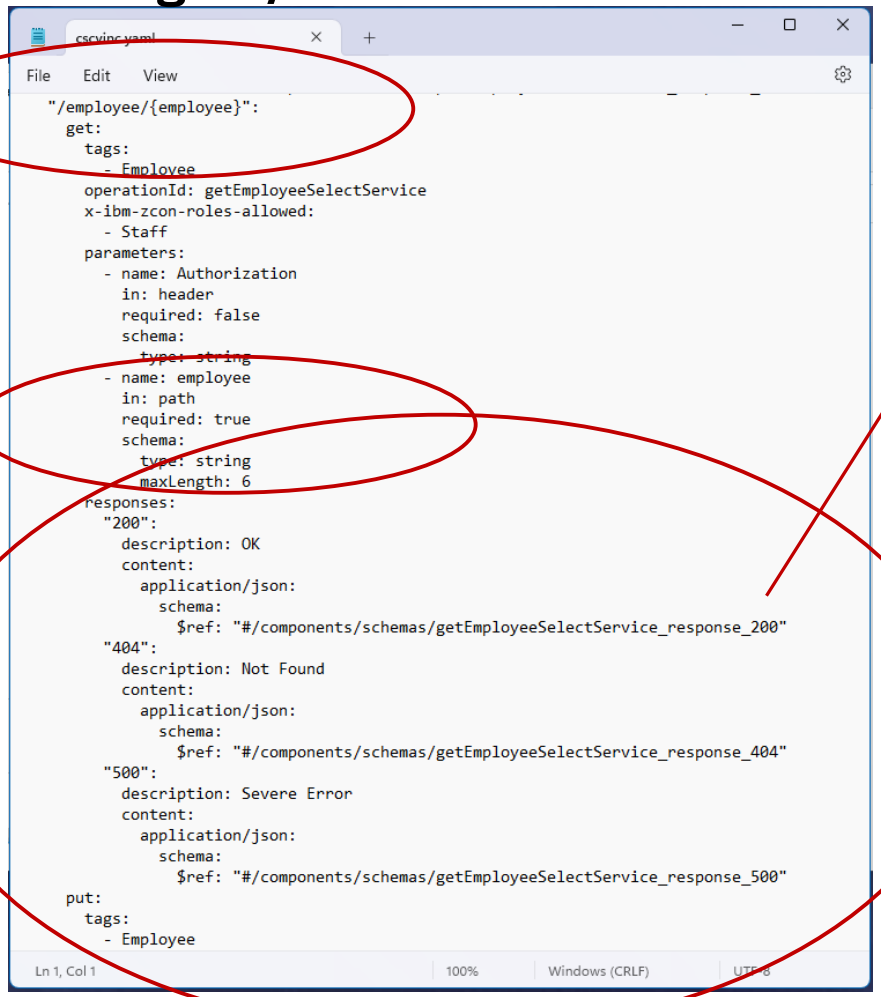
Accessing a z/OS asset starts with a description of an API (OpenAPI 3)



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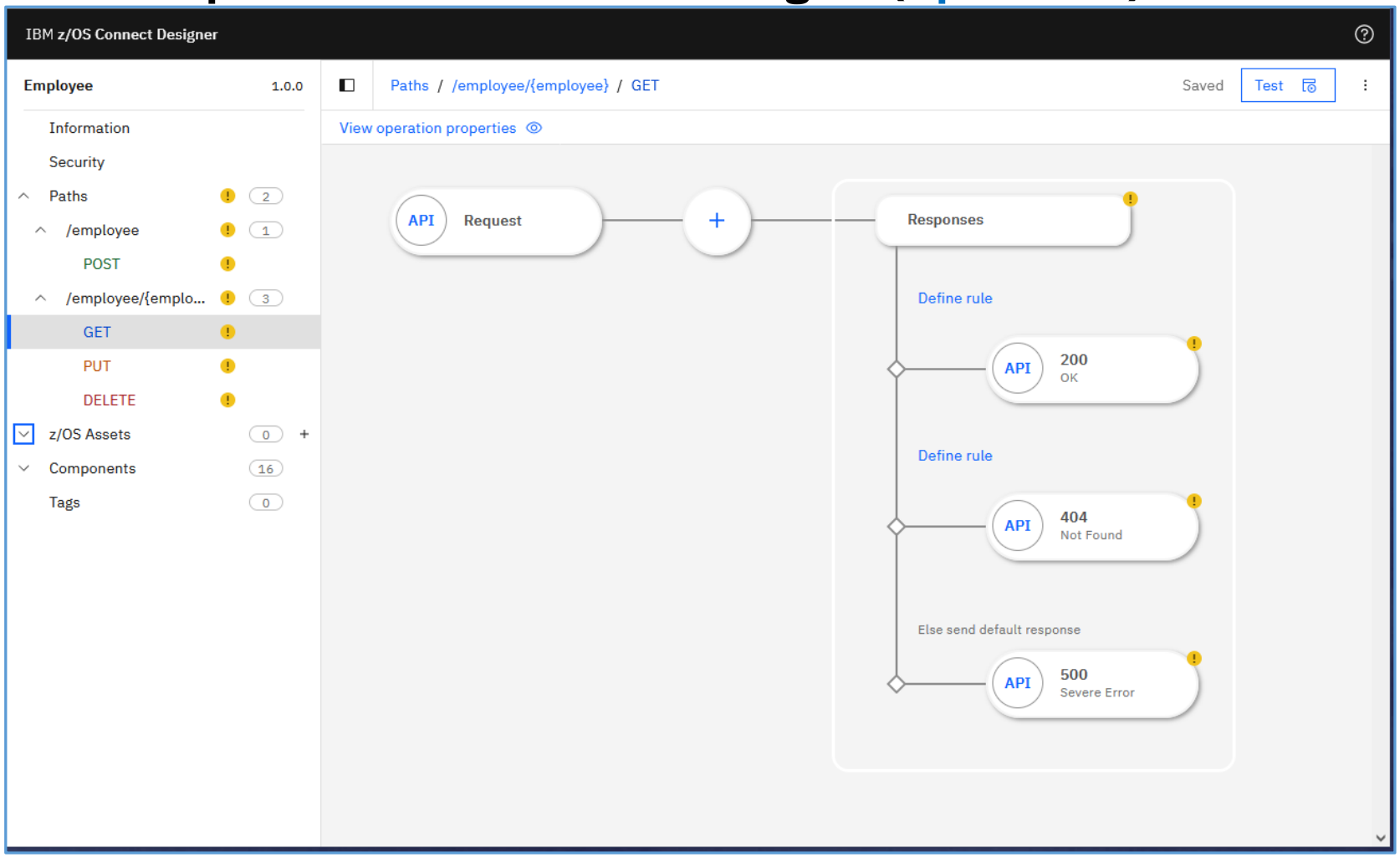
Import the description of an API into the Designer (OpenAPI 3)



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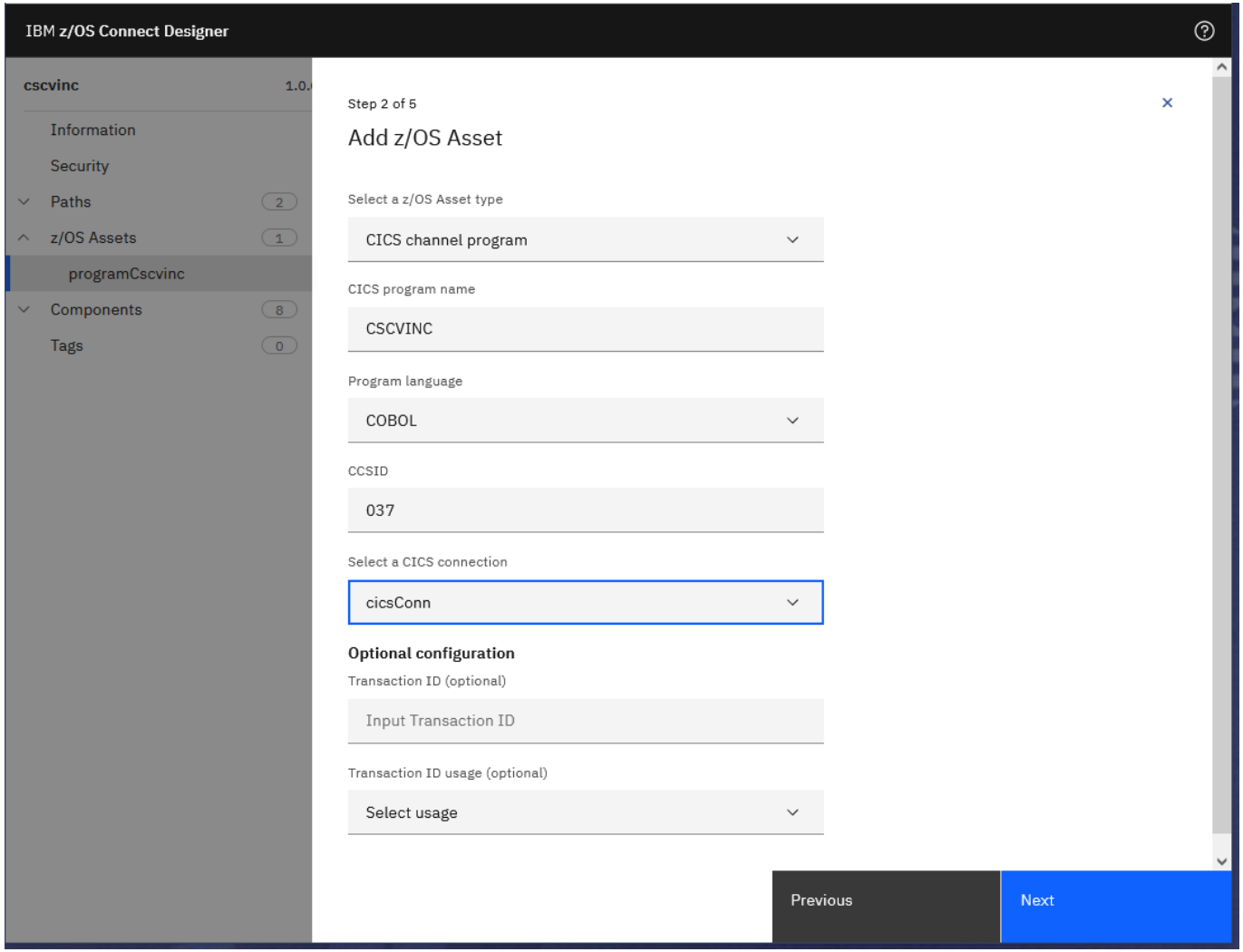
Describe the z/OS asset, by accessing a CICS program (OpenAPI 3)



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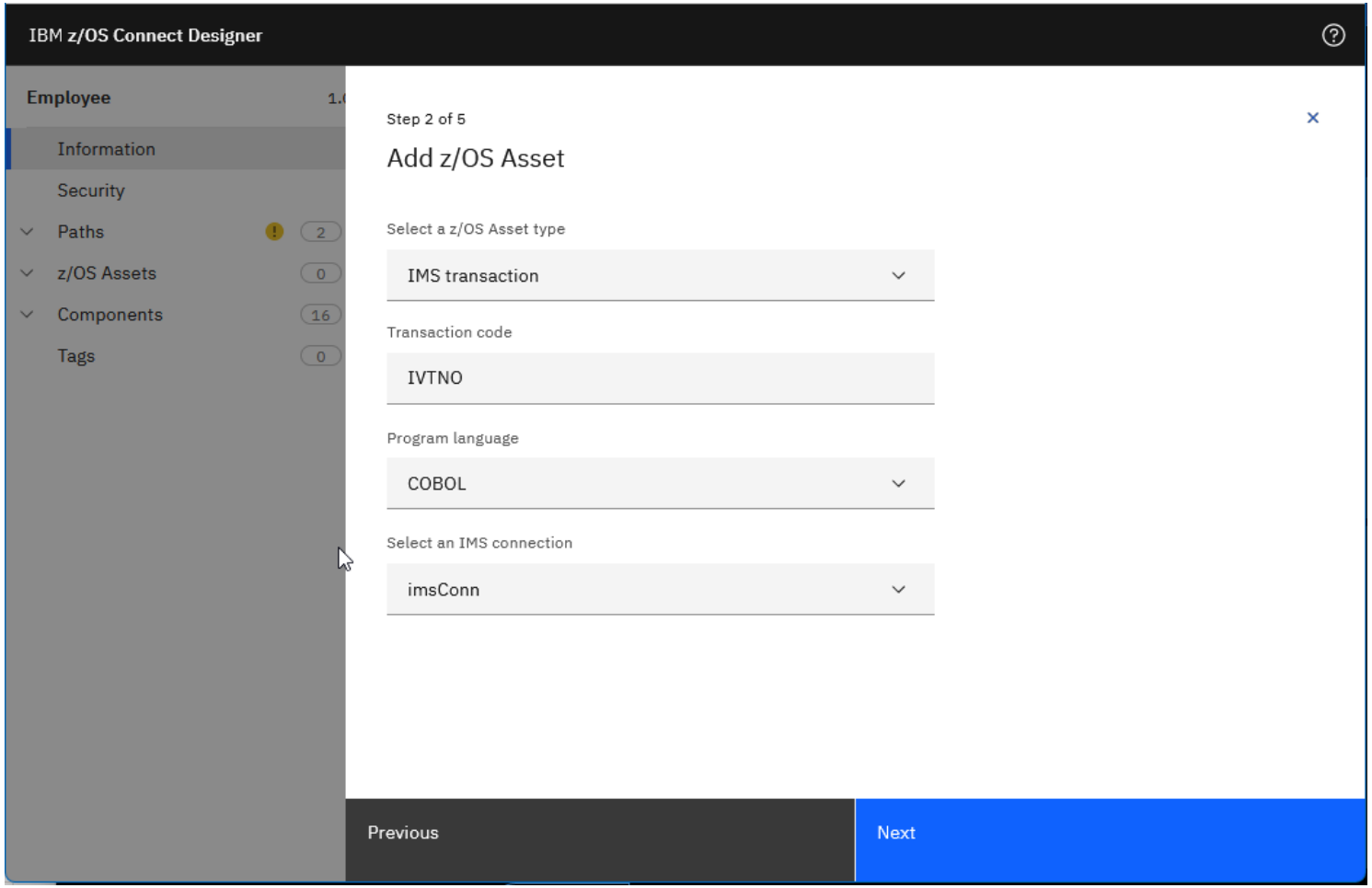
Or by accessing an IMS transaction (OpenAPI 3)



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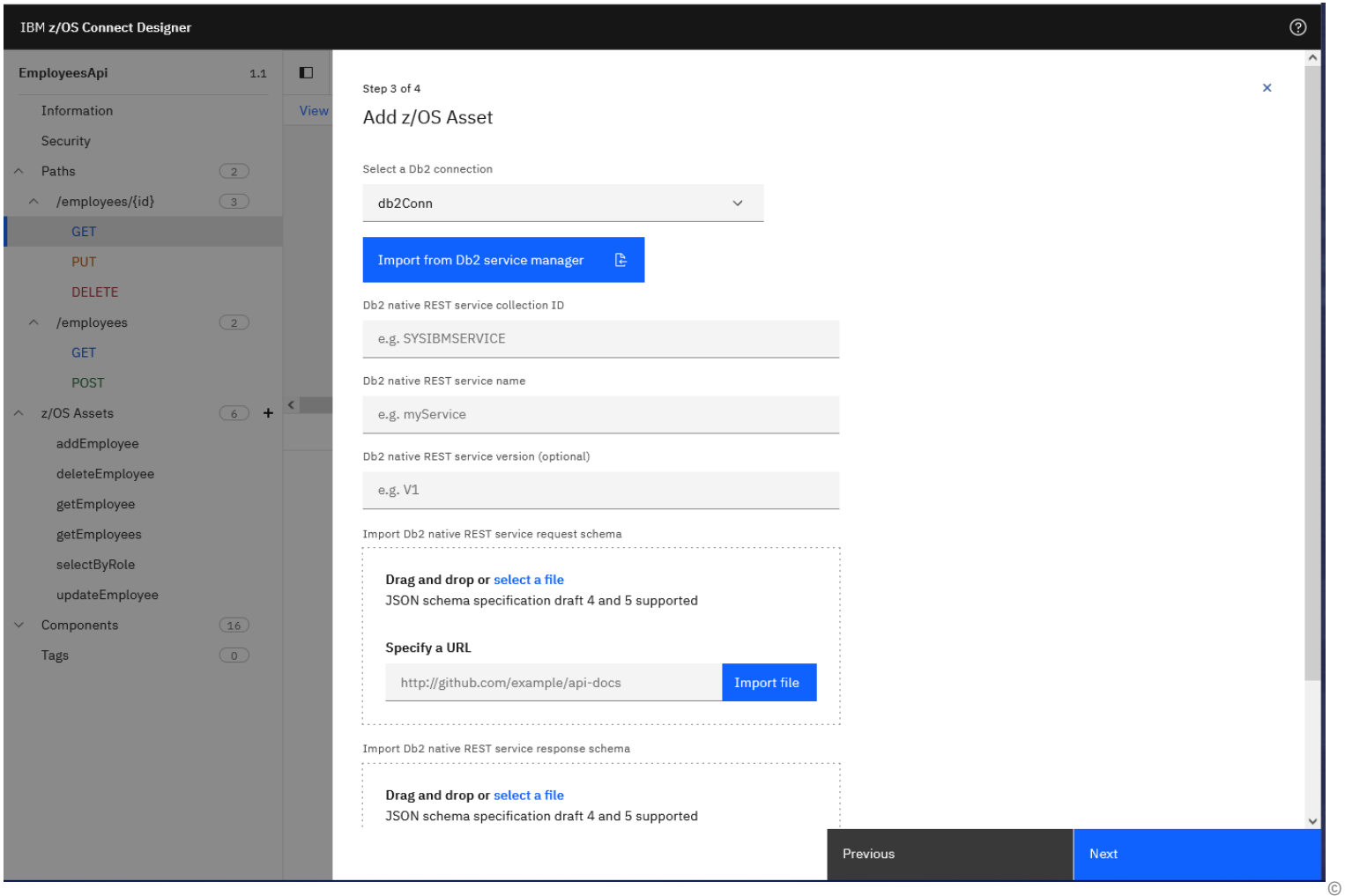
Or by accessing a Db2 REST service (OpenAPI 3)



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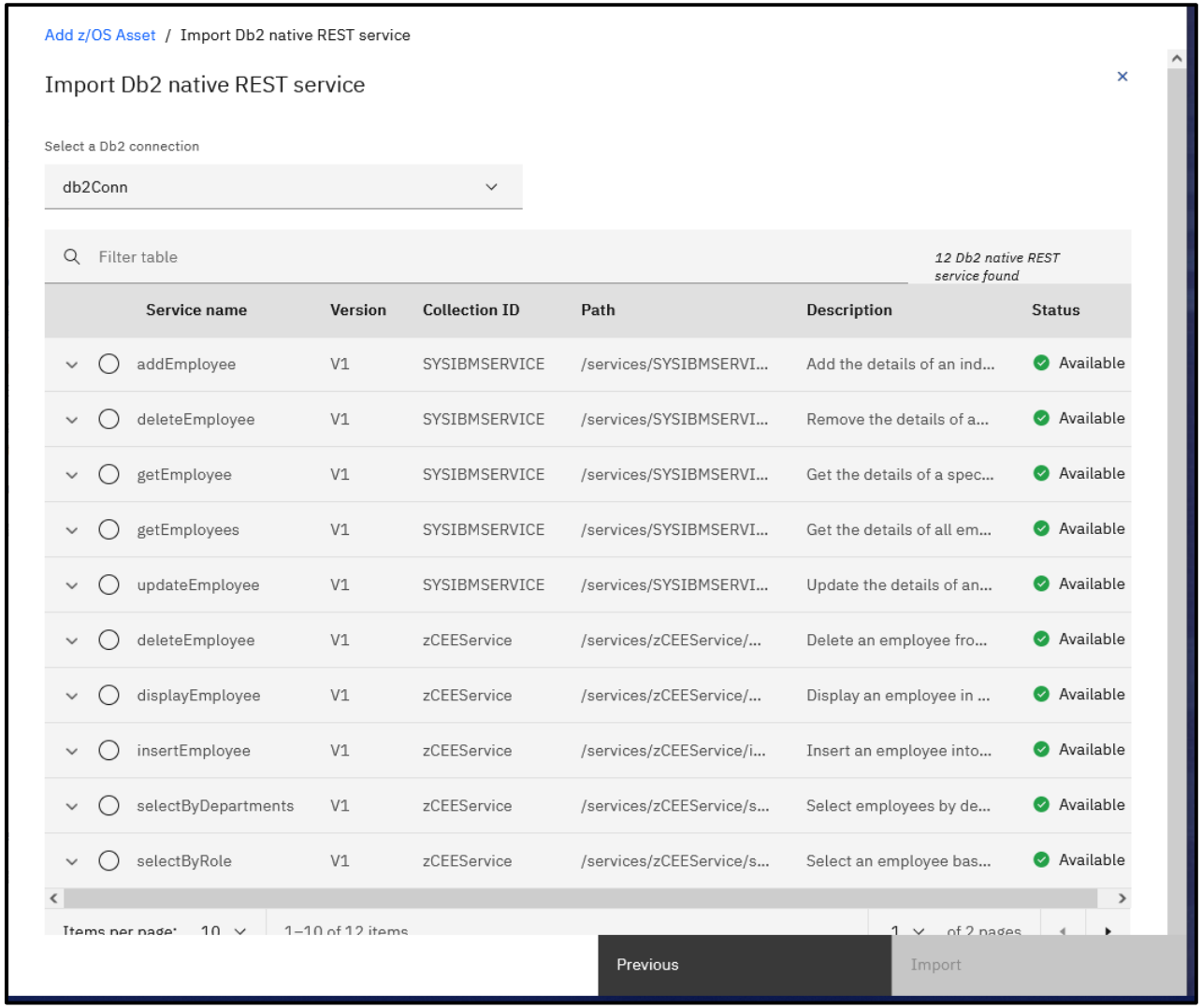
Select the z/OS Db2 REST Service (OpenAPI 3)



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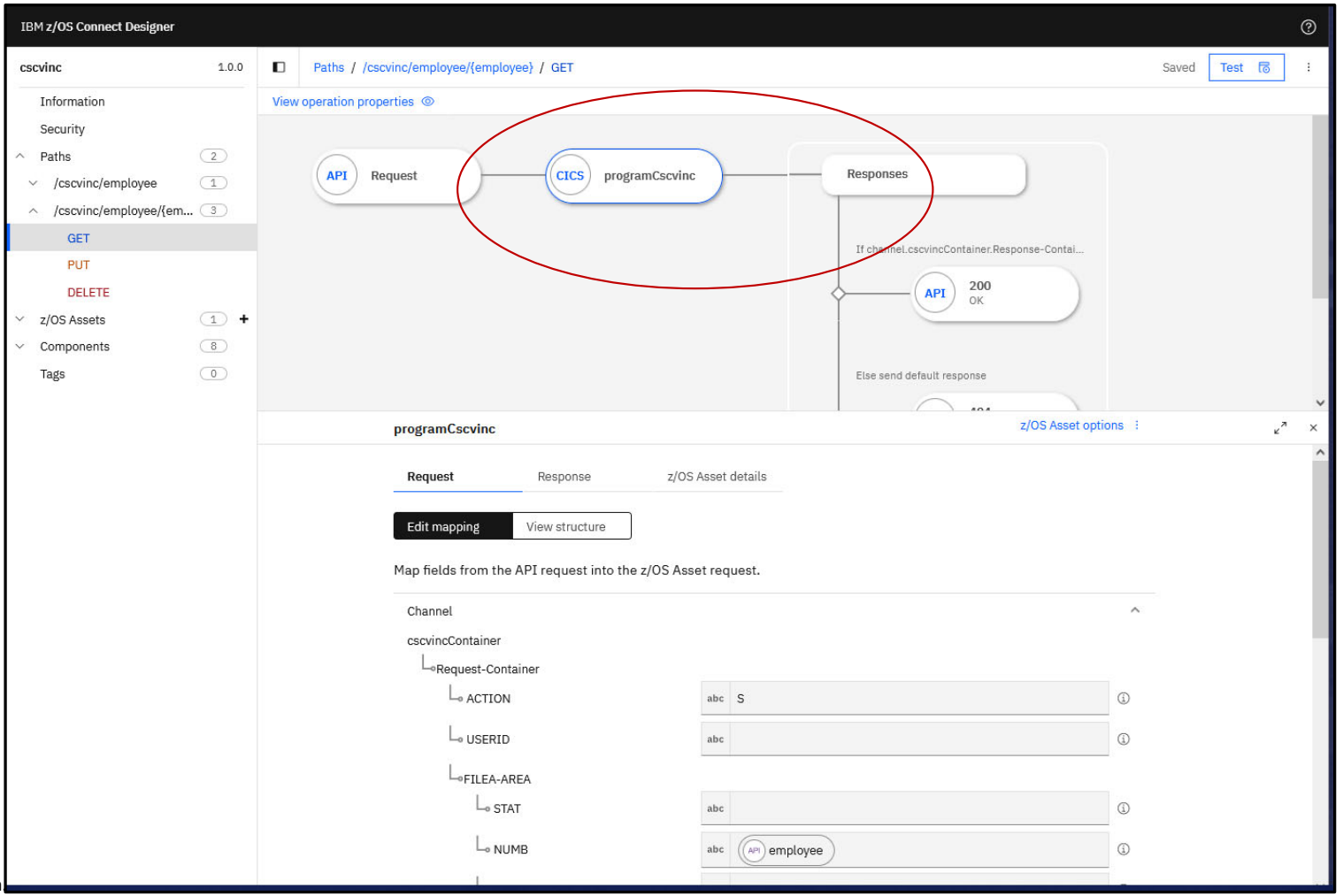
Map the method and request message with the resource's message (OpenAPI 3)



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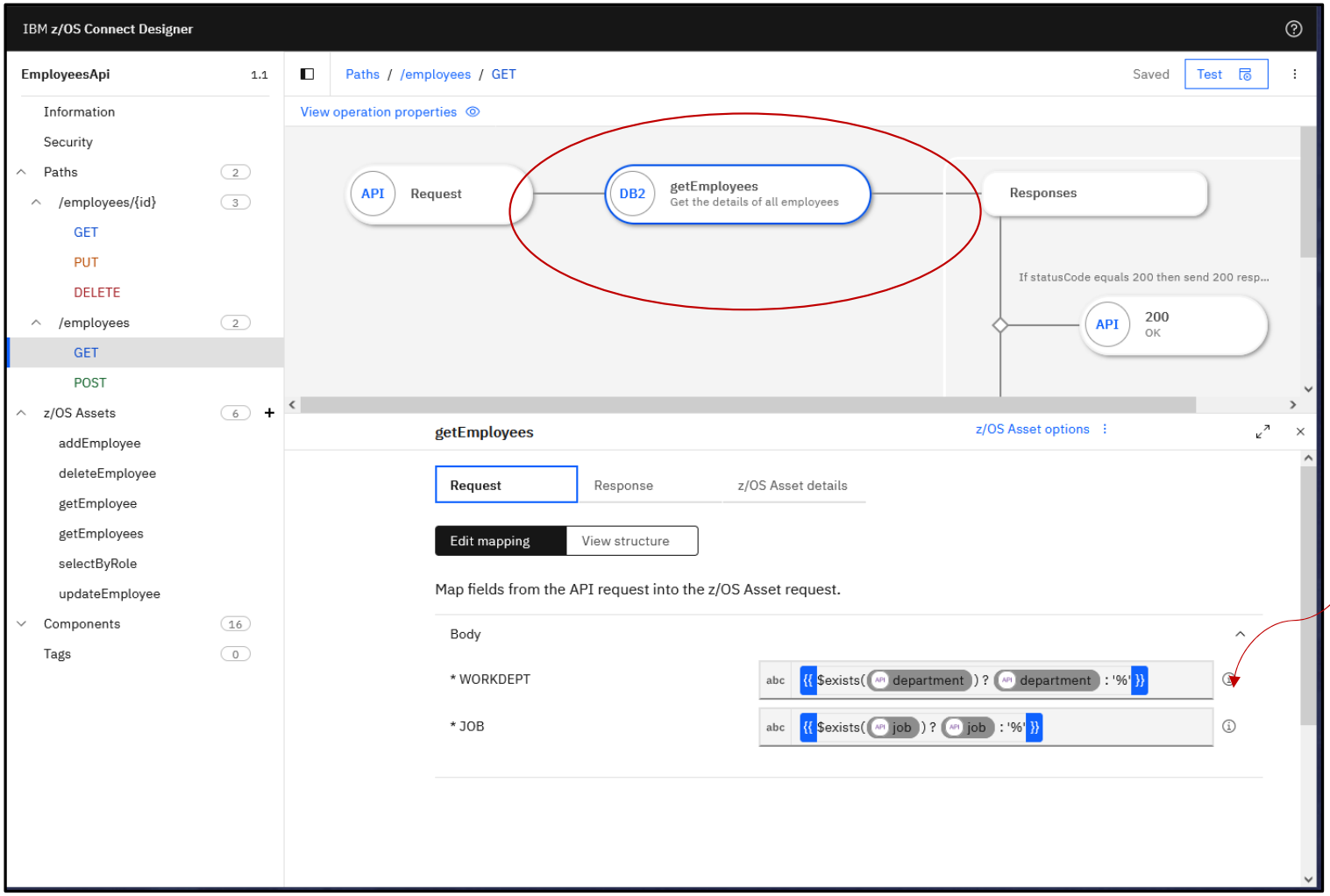
Map the method and the response message with a Db2 REST service (OpenAPI 3)



JSONata example

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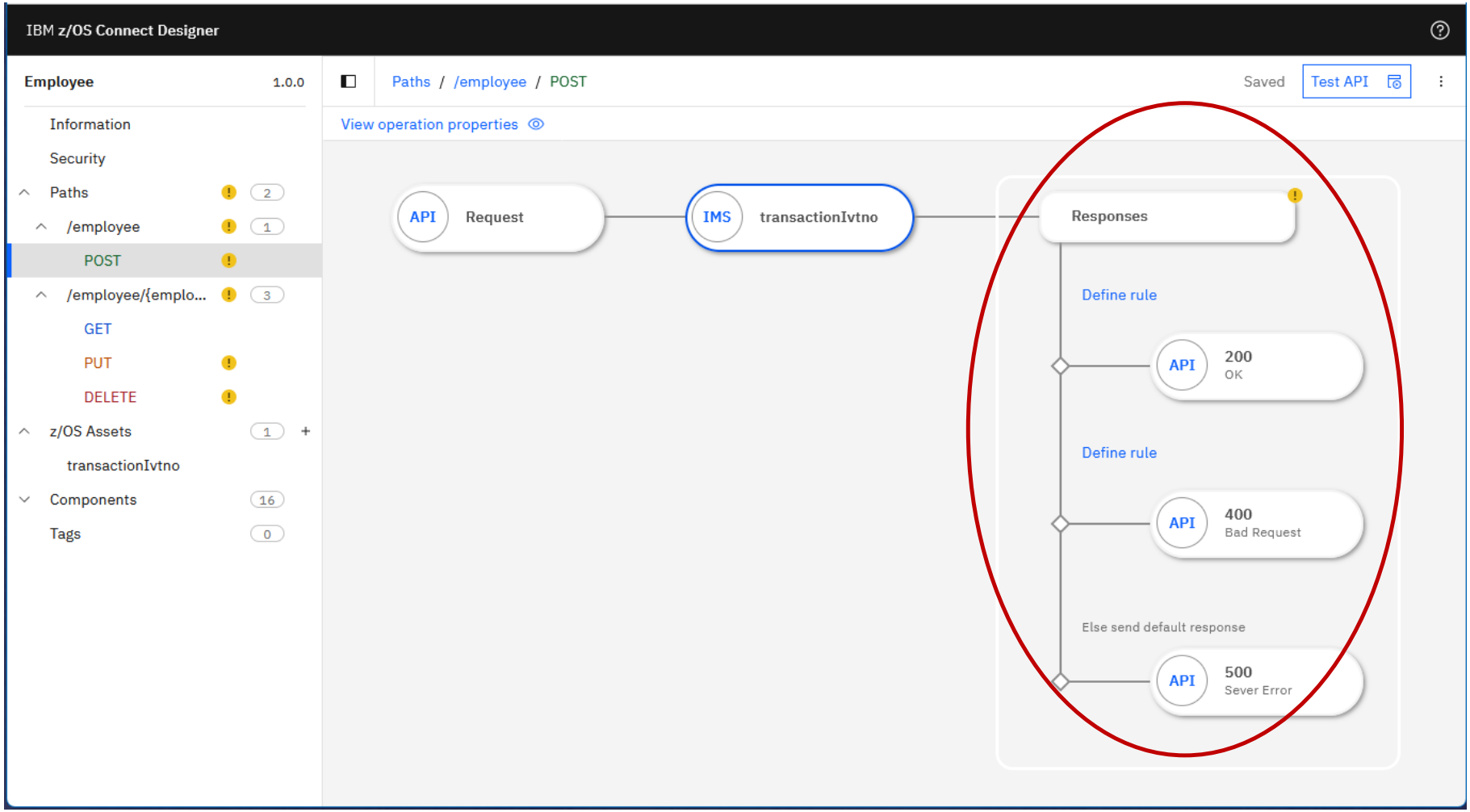
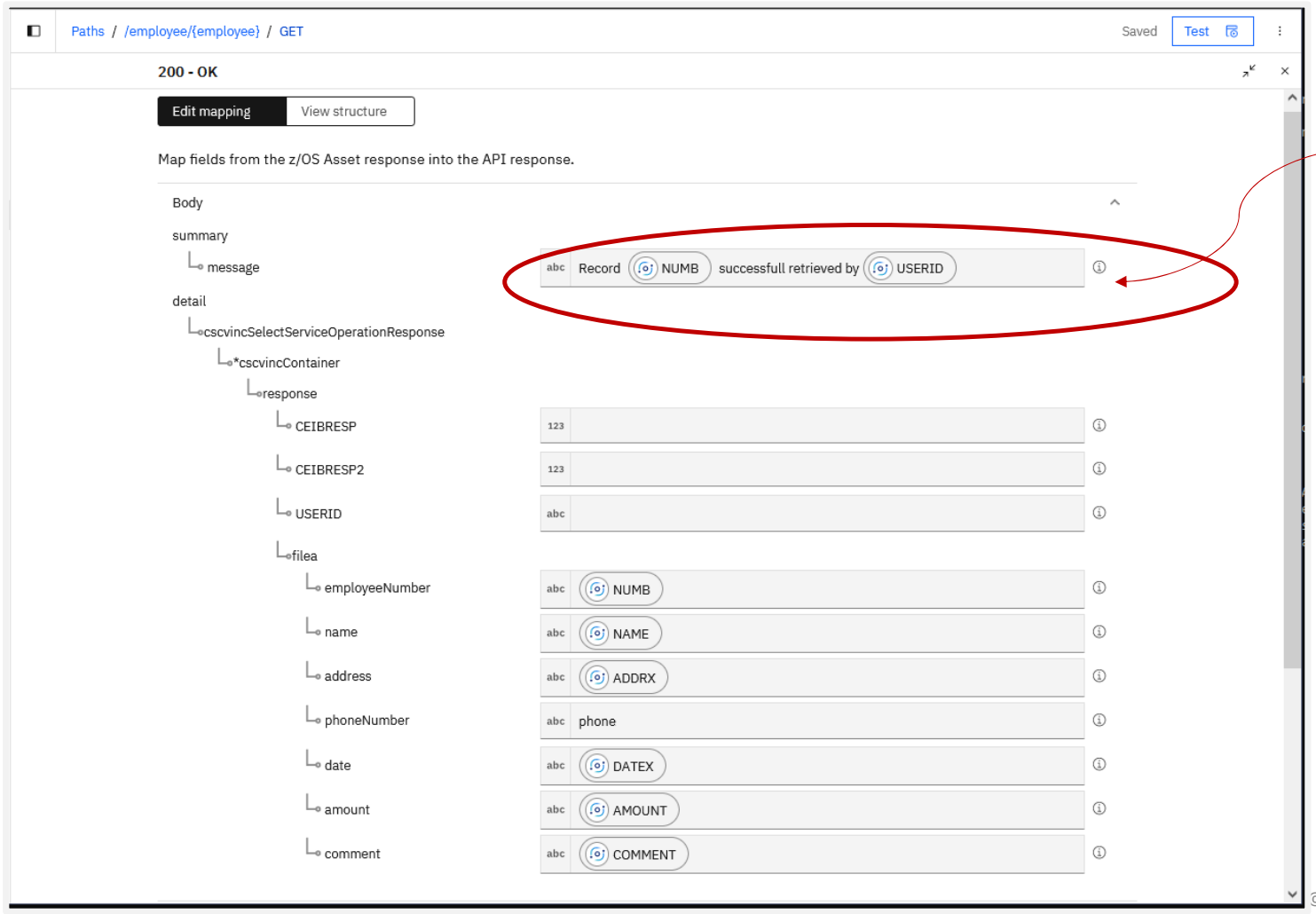
Map the resource's results to the specification's response (OpenAPI 3)



mitchj@us.ibm.com

Map the serialzied response message (OpenAPI 3)



JSONata example

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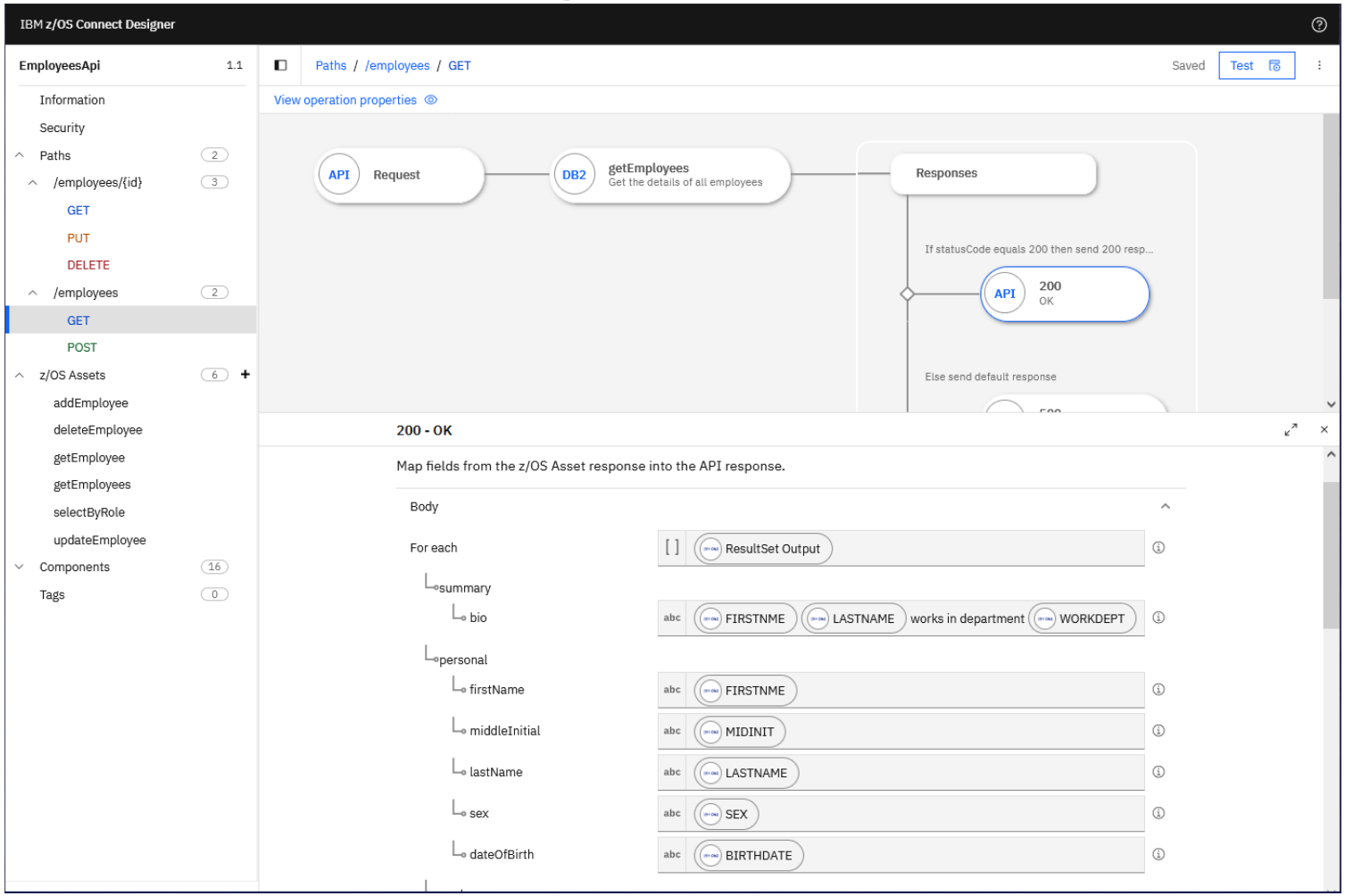
Map the response message (OpenAPI 3)



ResutSet Output is a list or array of results and the "For each" processes each element in the list.

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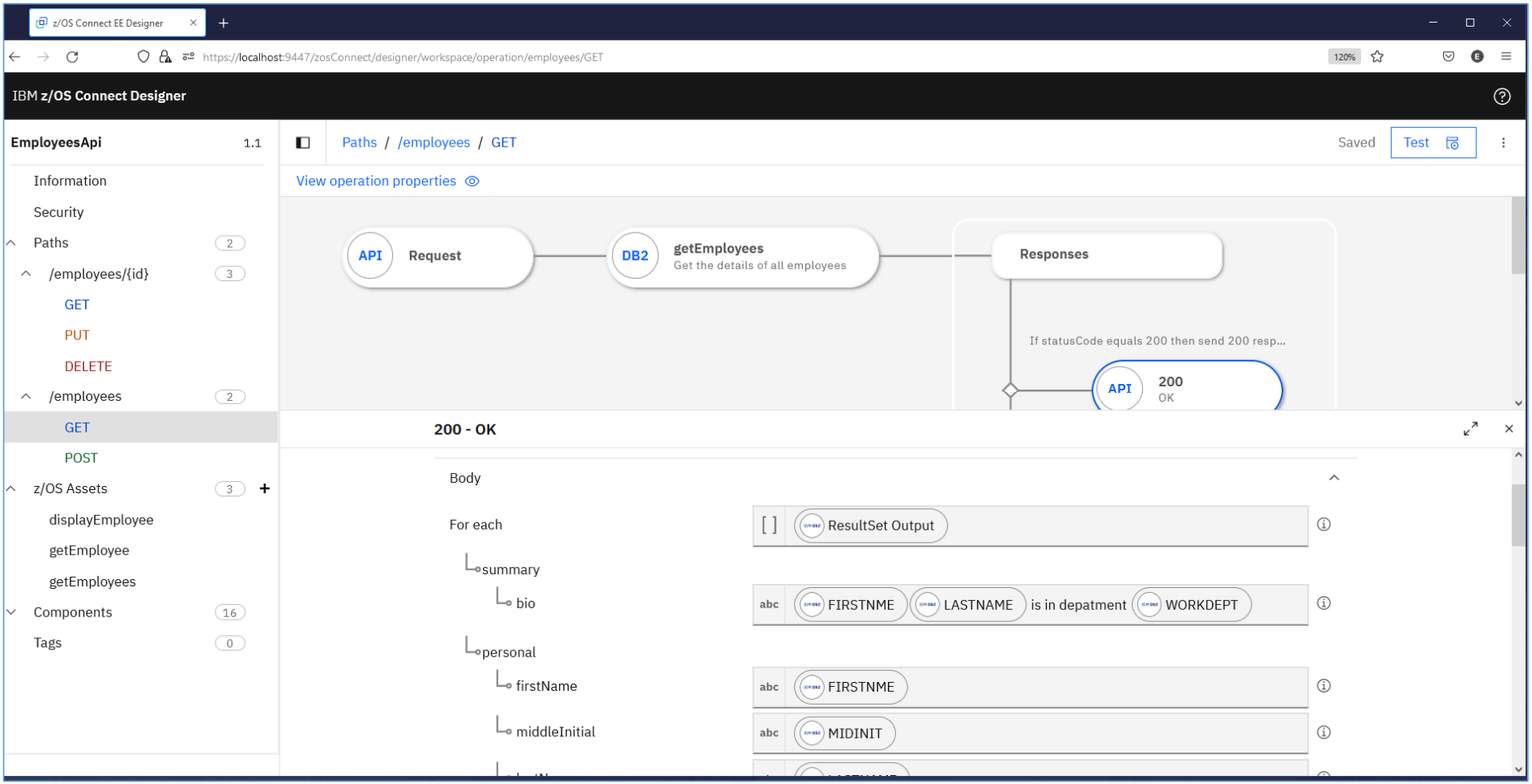
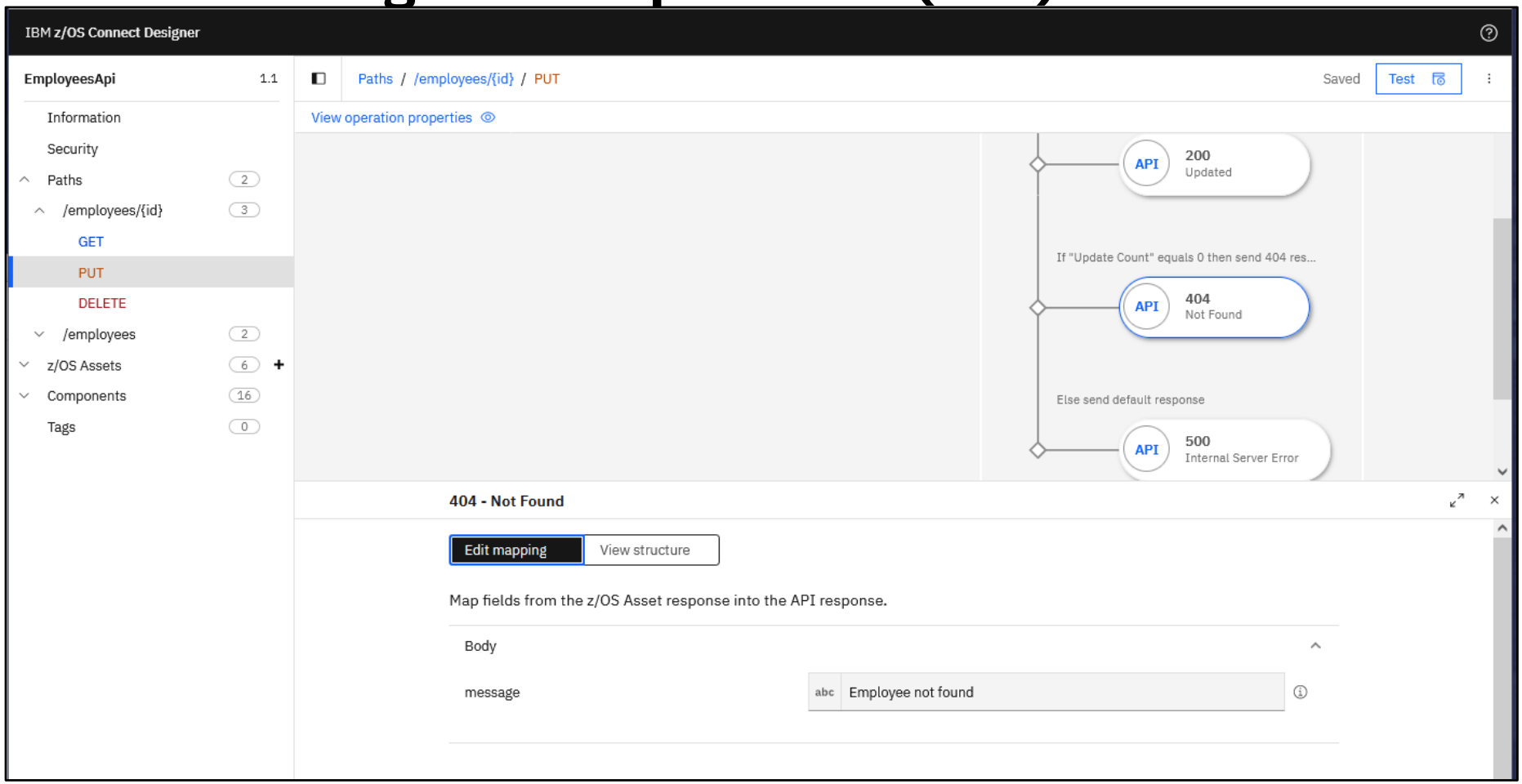
z/OS Connect Designer for OpenAPI 3 (200)



mitchj@us.ibm.com

z/OS Connect Designer for OpenAPI 3 (404)



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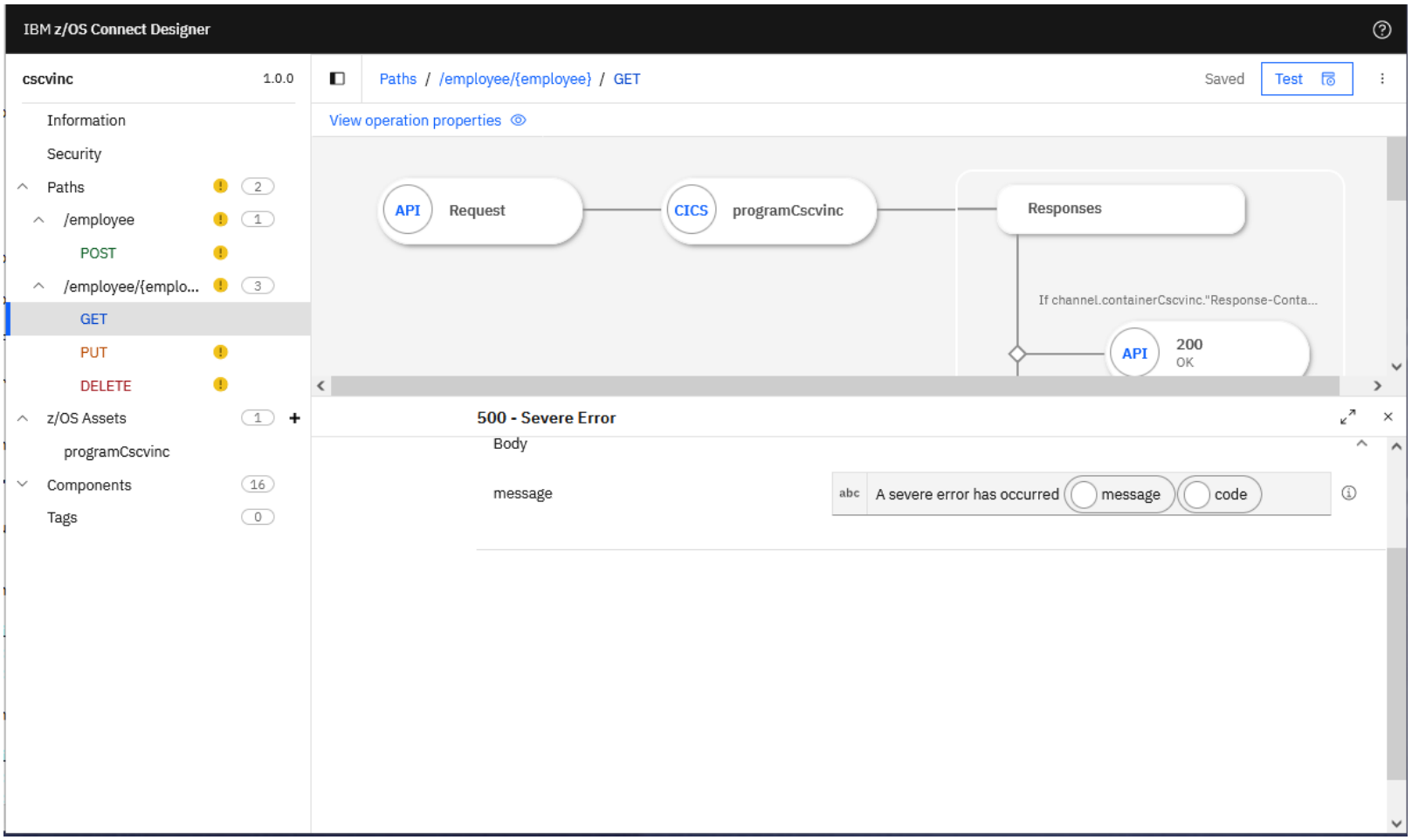
z/OS Connect Designer for OpenAPI 3 (500)



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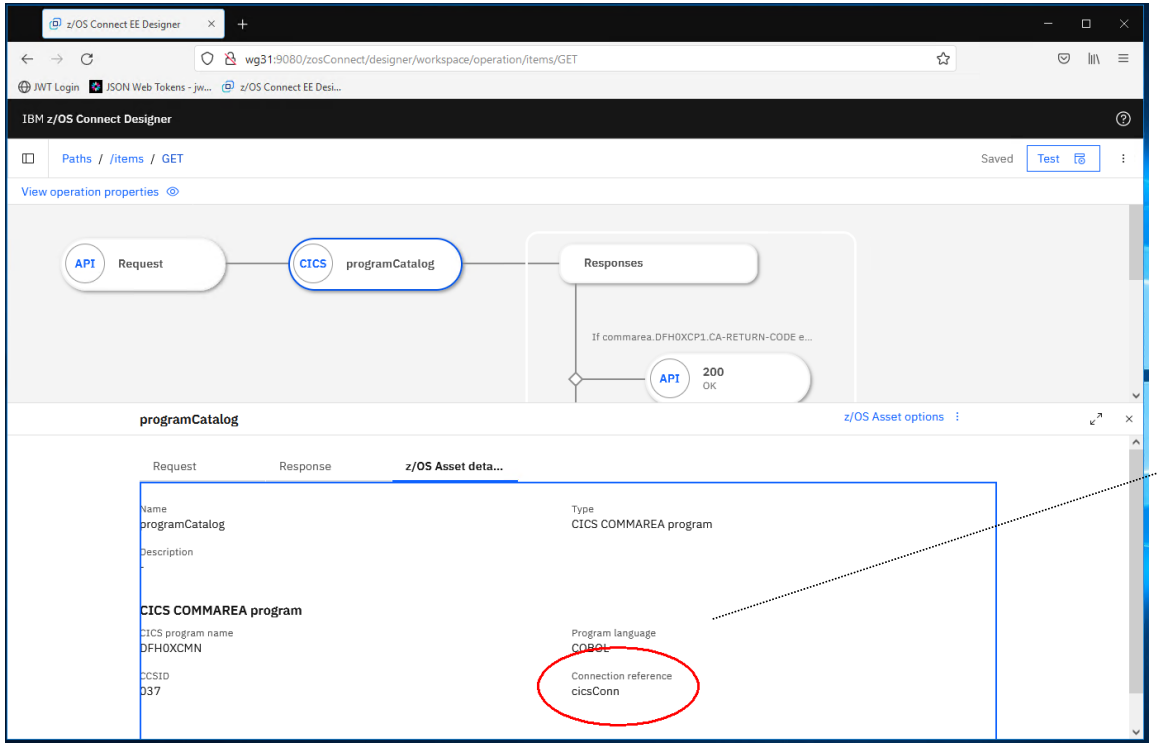
Server XML - Accessing a CICS program using IPIC (OpenAPI 3)



The connection references identifies a zosconnect_cicsIpicConnection configuration element.
Which provides the connection details to a CICS region.

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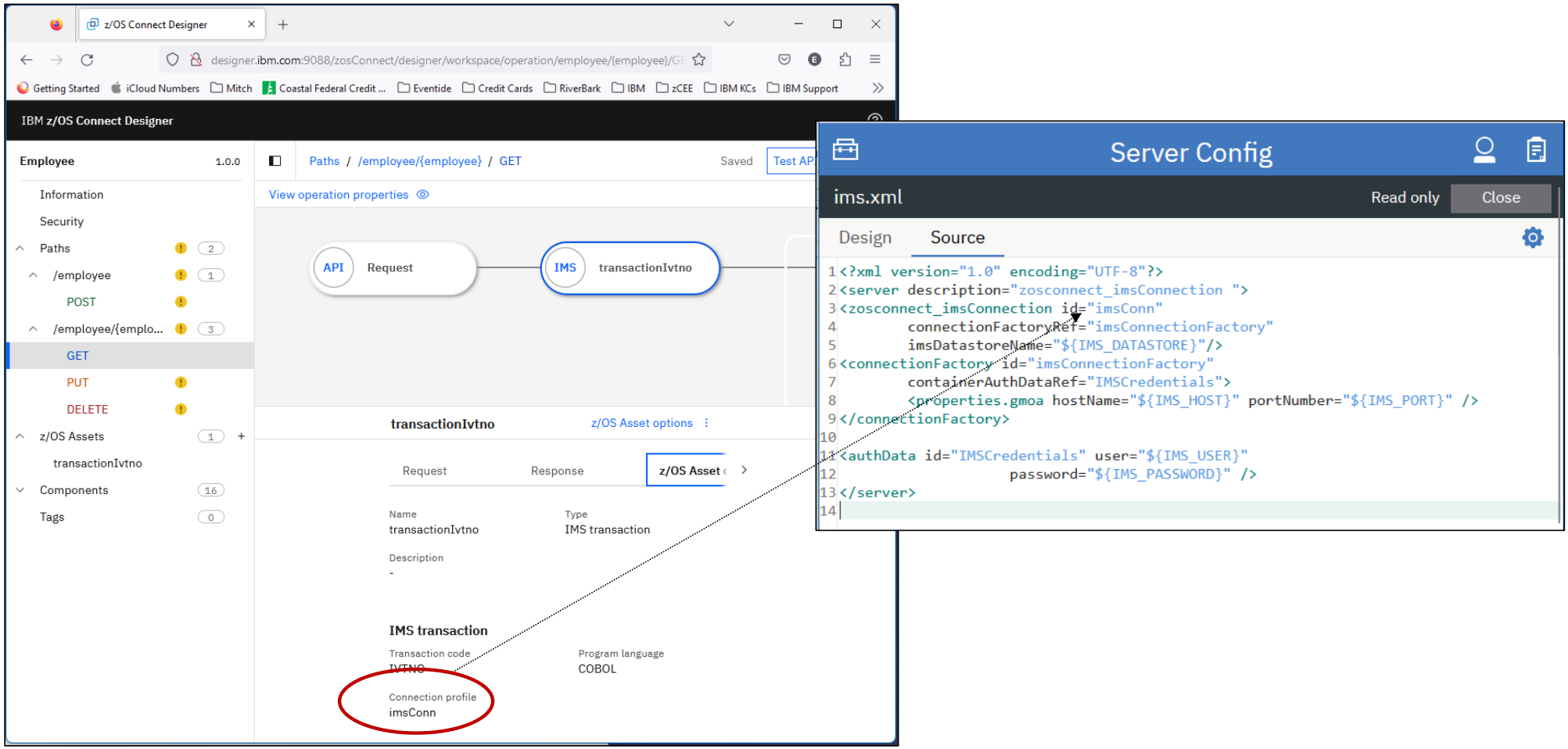
Server XML - Accessing an IMS transaction(OpenAPI 3)



The connection references identifies a zosconnect_imsConnection element. Which provides the connection details to IMS.

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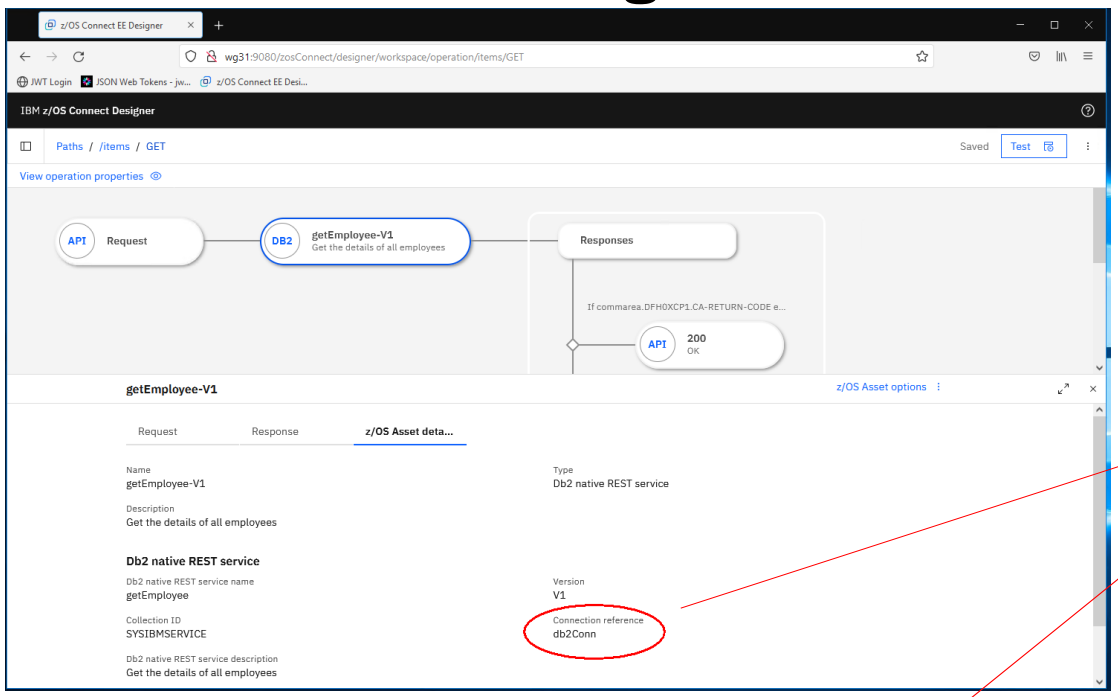
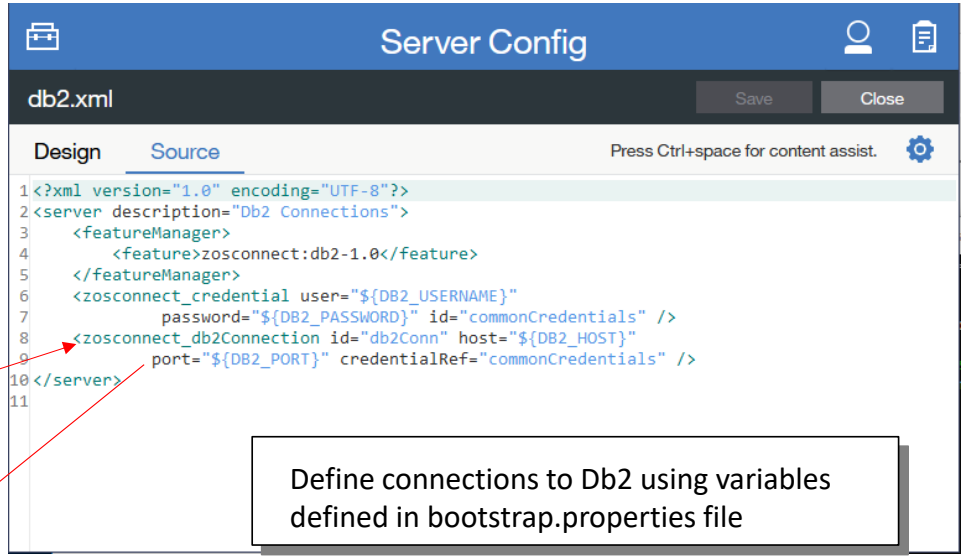
Server XML - Accessing a Db2 REST service (OpenAPI 3)





Define connections to Db2 using variables defined in bootstrap.properties file

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

The connection references identifies a zosconnect_db2Connection configuration element. Which provides the connection details to a DB2 DDF task.

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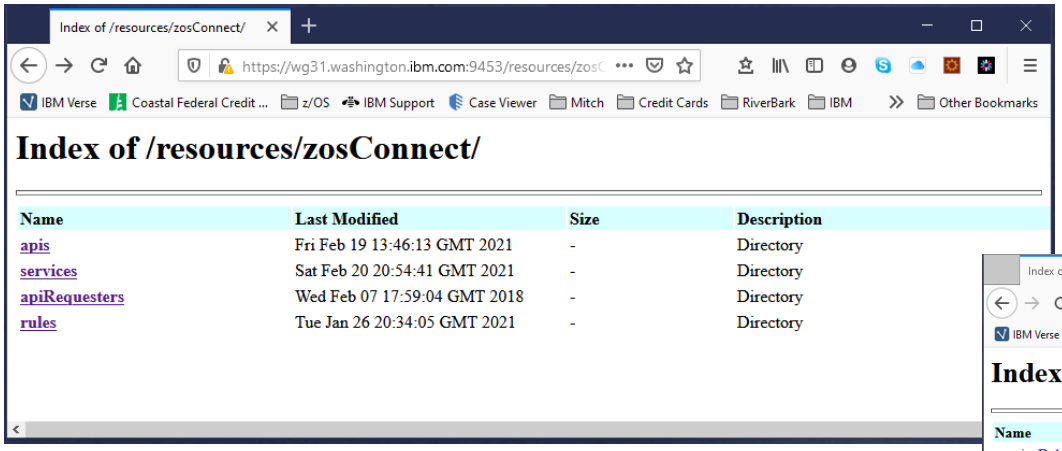
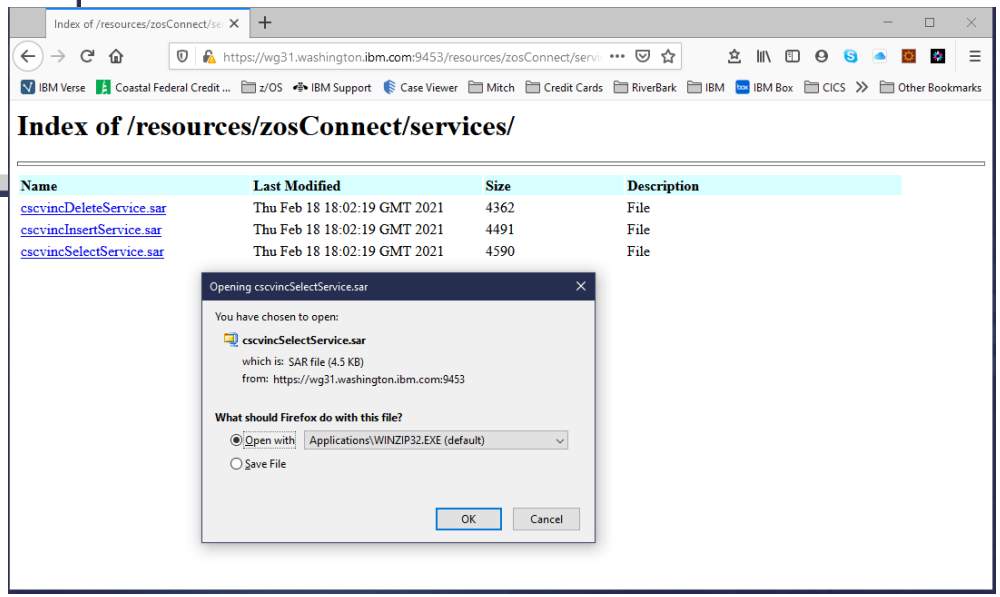
Provide remote access to z/OS Connect OPENAPI 2 archives files






```
<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>
```

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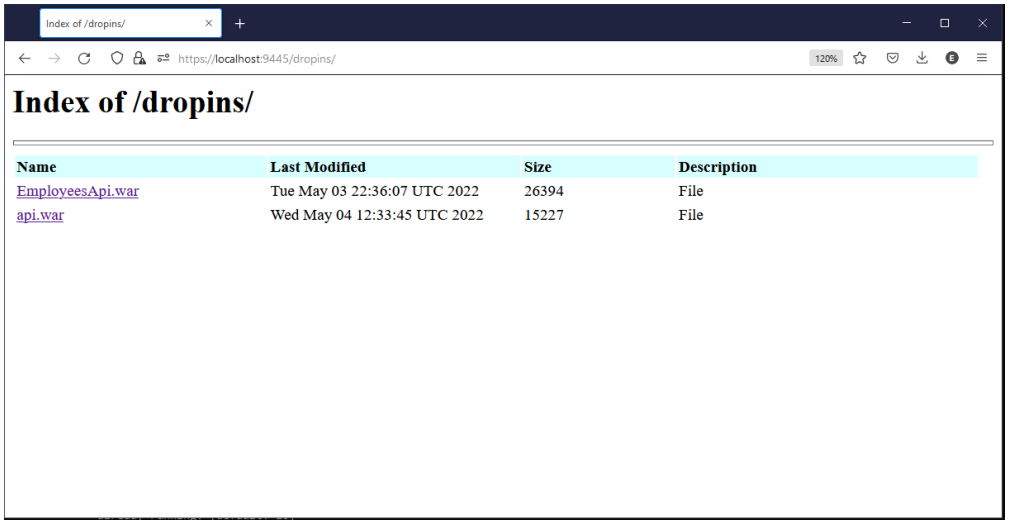
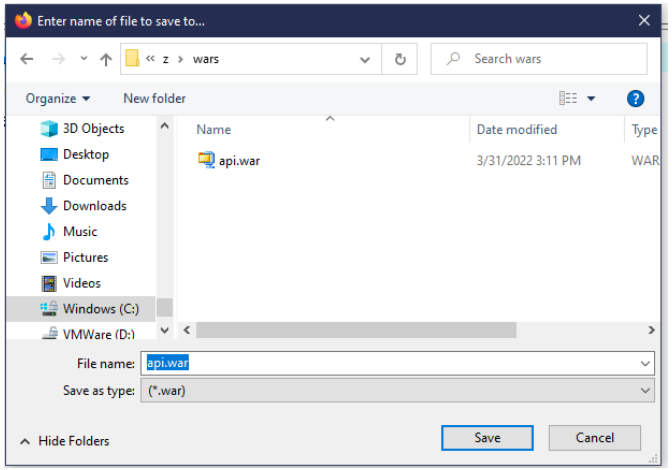
Provide remote access to z/OS Connect Designer OPENAPI 3 web archives files




```
<webApplication id="resoures-location" name="resources"
   location="/opt/ibm/wlp/usr/servers/defaultServer/dropins">
    <web-ext context-root="dropins"
      enable-file-serving="true" enable-directory-browsing="true">
      <file-servering-attribute name="extendDocumentRoot"
       value="/opt/ibm/wlp/usr/servers/defaultServer/dropins" />
    </web-ext>
</webApplication> >
```



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EJB roles for z/OS Connect (OpenAPI 3)

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

<webApplication id="CatalogManager" location="${server.config.dir}/apps/api.war" contextRoot="catalog"
name="CatalogManager"/>

<safRoleMapper profilePattern=%profilePrefix%.%resourceName%.%role%
```

```
openapi: 3.0.0
. . .
servers:
- url: /
x-ibm-zcon-roles-allowed:
- Manager
. . .
paths:
  /items:
    get:
     operationId: itemsGet
     . . .
  /items/{id}:
    get:
     . . .
     operationId: itemsIdGet
     x-ibm-zcon-roles-allowed:
        - Staff
 /orders:
    post:
     . . .
     operationId: ordersPost
     x-ibm-zcon-roles-allowed:
       - Staff
```

*From the OpenApi document, the value for %role% would be either **Manager** or **Staff**.*

So, the required SAF EJB roles to be defined would be:

- *BBGZDFLT.CatalogManager.**Manager***
- *BBGZDFLT.CatalogManager.**Staff***

```
REDFINE EJBROLE BBGZDFLT.CatalogManager.Manager
REDFINE EJBROLE BBGZDFLT.CatalogManager.Staff
```

Access to use the GET method to invoke /items would require read access to EJB role *BBGZDFLT.CatalogManager.Manager.*
Access to use the GET method to invoke /items/{id} and the POST method to invoke /orders would require read access to EJB role *BBGZDFLT.CatalogManager.Staff.*

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z/OS Server Issues and Considerations – API Deployment

https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=server-devops-overview

Important: In order for multiple API project `.war` files to function when deployed to a single z/OS Connect native server, you must ensure that your OpenAPI specification includes a `contextRoot` defined within the `servers` section. The `contextRoot` attribute specifies the entry point of the deployed application. For example, to use a context root of `/myContextRoot` in the API's OpenAPI definition server's section:

```
openapi: 3.0.0
...
servers:
url: "https://localhost:9443/myContextRoot"
...
```

This definition must match the `contextRoot` attribute value of the `webApplication` element in your `server.xml` file. An example of the configuration might be:

```
<webApplication location="${server.config.dir}/apps/api.war" name="EmployeesApi" contextRoot="/myContextRoot"/>
```

If the server entry in the server section of the OpenAPI definition includes a `contextRoot` value, then this value must be specified in the `contextRoot` attribute of the corresponding `webApplication` element, even when only a single API is deployed to the z/OS Connect server.

Each API deployed to the same IBM z/OS Connect server requires a unique context root.

4. Copy the server configuration.
   Copy the server configuration files from the API project `/scr/main/liberty/config` directory into the `${server.config.dir}/configDropins/overrides` directory of the server or another directory via FTP. For more information, see Overview of IBM z/OS Connect Server configuration
5. Deploy the generated API files to the z/OS Connect native server
   Deploy API `.war` files into a permanent USS directory. An example directory, such as the one provided by the z/OS Connect native server template, is `${server.config.dir}/apps`. API files can also be deployed to other directories, such as in separately mounted zFS file systems.

   For each deployed API define a webApplication element in the configuration file. An example element is included in the supplied openApi3 server template. An example element might be the following:

```
<webApplication id="My API" location="${server.config.dir}/apps/api.war" name="MyAPI"/>
```

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z/OS Server Issues and Considerations – Context Root

https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=image-devops-overview

The drop-ins directory

The *drop-ins* directory, `/config/dropins` is a special directory that is supported by WebSphere® Application Server for Liberty. It allows `.war` files to be deployed and dynamically loaded into the running IBM z/OS Connect with no additional definitions that are required in the configuration file.

By default, z/OS Connect Designer deploys the API `.war` file to this directory. Using the same directory in your API container image simplifies the creation of that image because the configuration remains the same.

A directory other than drop-ins

This is required in any of the following situations:

- The API's OpenAPI definition server's section contains server entry that includes a context root value, which is not just `/`.
- Multiple APIs are to be deployed to the same IBM z/OS Connect container. Because the API `.war` file will be generated with a context root of `/`, and multiple API `.war` files in the same server must have unique context root values.
  You need to include a context root value (not `/`) in the API's OpenAPI definition server's section, for example to use a context root of `/MyCompany`:

```
openapi: 3.0.0
   ...
   servers:
      url: https://localhost:9443/MyCompany
   ...
```

- Requests to start an API require authentication only, without authorization, so the authorization roles need to be mapped to the WebSphere Application Server for Liberty special subject ALL_AUTHENTICATED_USERS. For more information, see How to define authorization roles.

If you choose not to use the drop-ins directory, you must alter the configuration that is used in z/OS Connect Designer during the creation of the API container image.

- **Required to define applications and add context root**

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

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Connection Reference Consideration

Carefully consider the names used for connections

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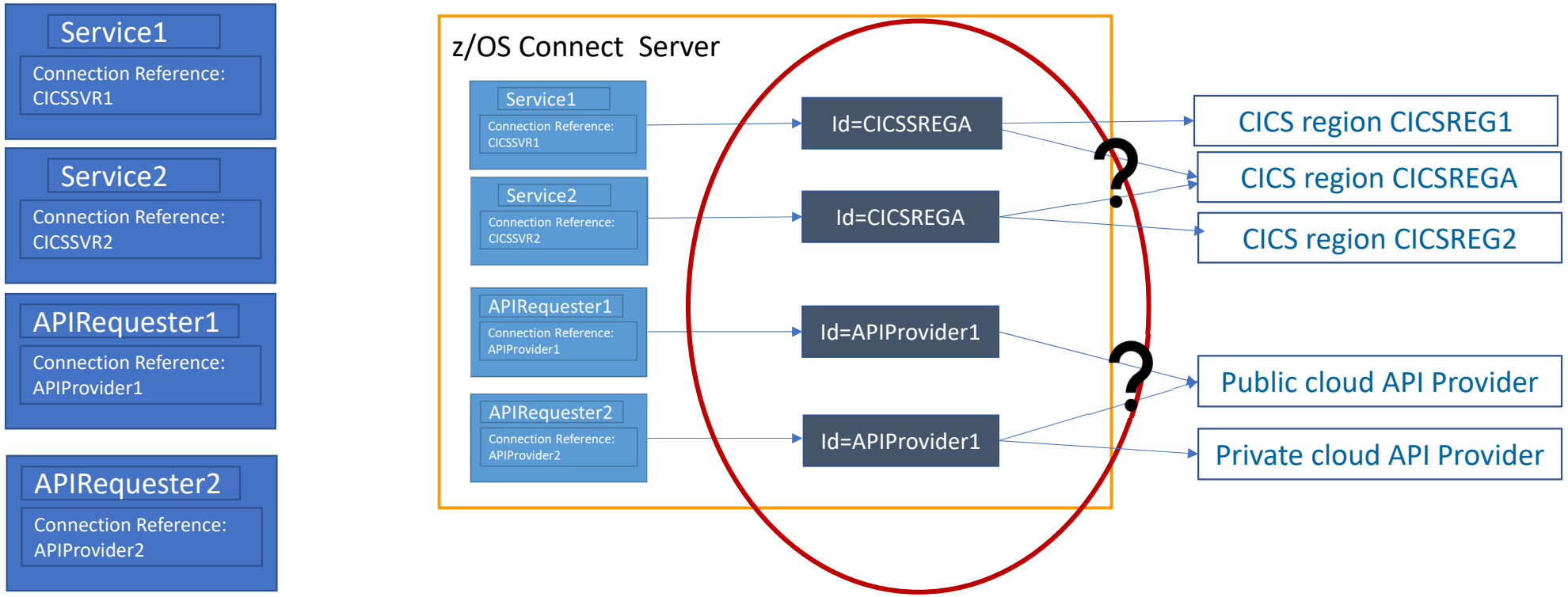
Use naming conventions for connection references

Use application meaningful names or an extendable convention for connection reference names



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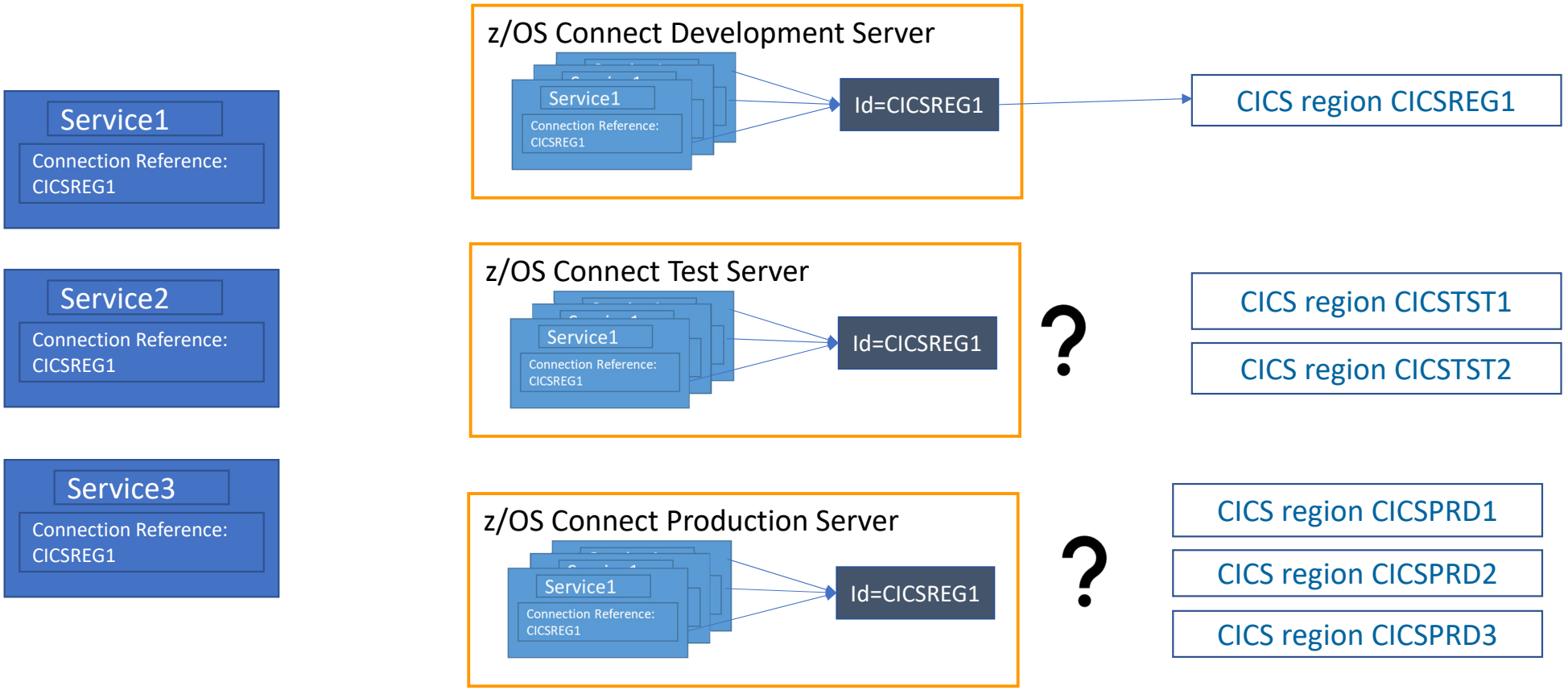
Use naming conventions for service/endpoint connection references (OpenAPI 2)

Don’t couple service and API requester connection names to specific systems or endpoints

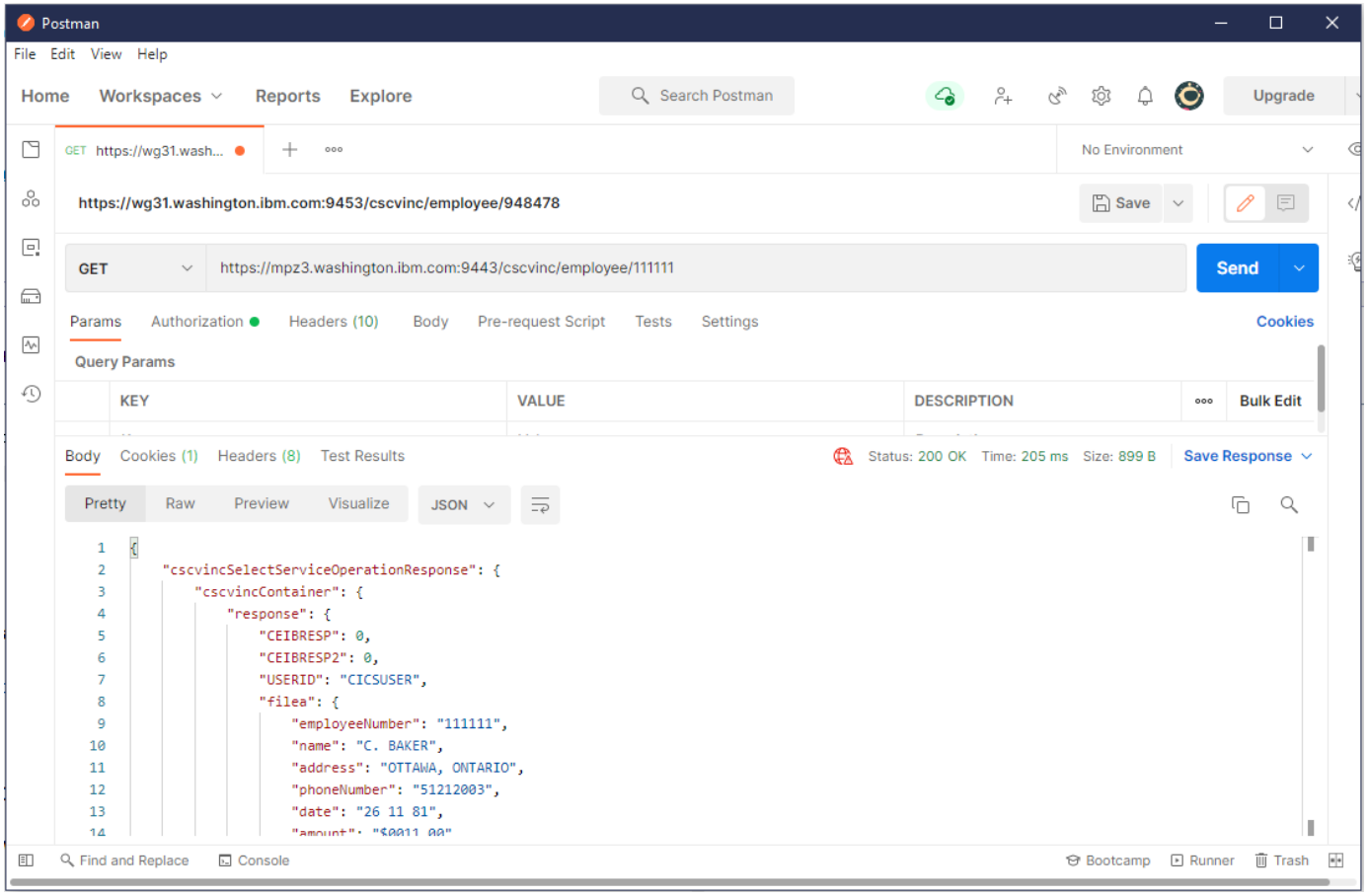


mitchj@us.ibm.com

What REST test tooling is available?

mitchj@us.ibm.com

Testing an API with Postman



https://www.postman.com/downloads/

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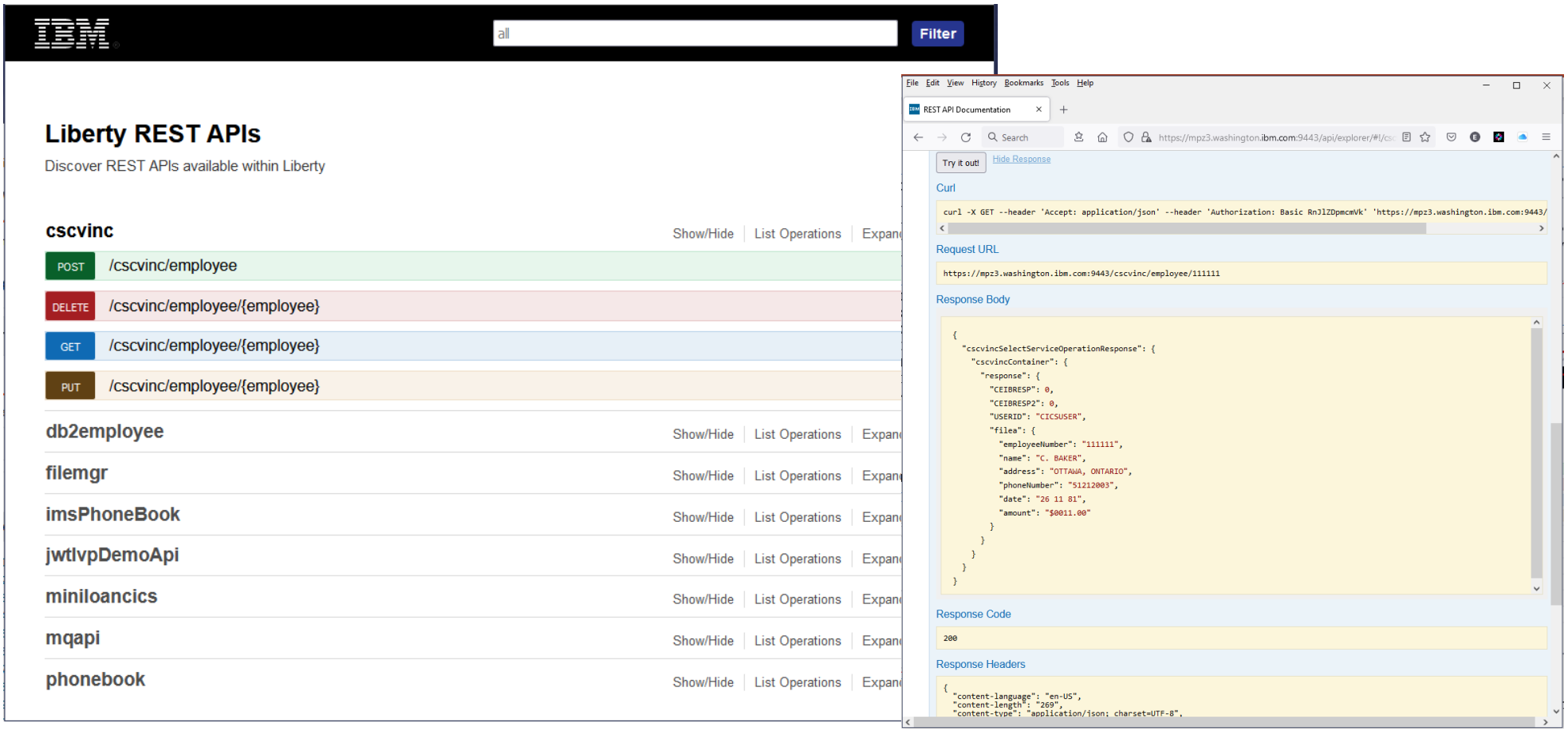
Testing an API with the API Explorer (zCEE V3.0.48)



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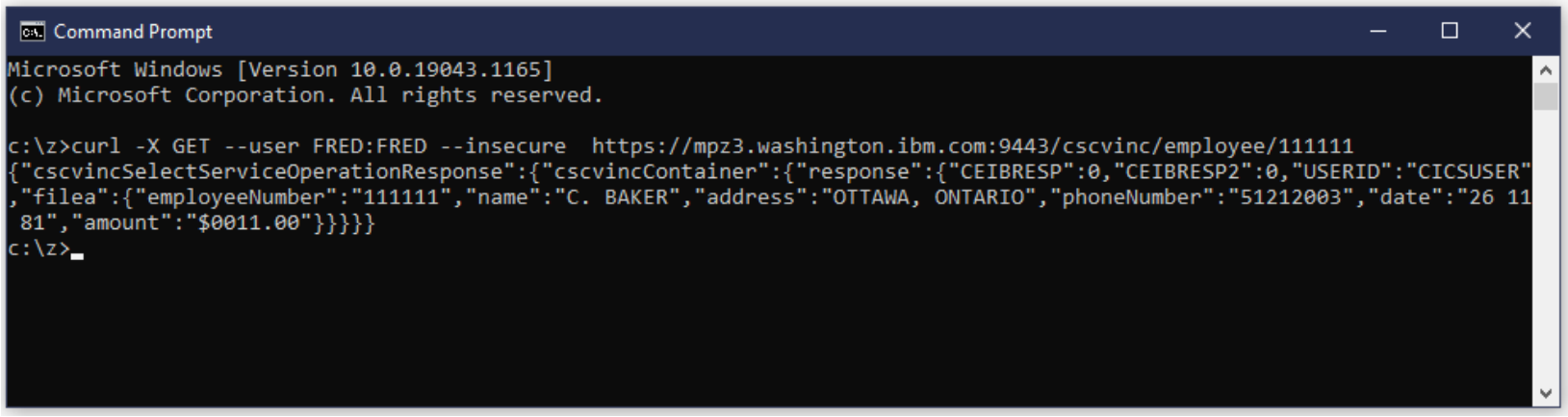
Testing an API using the cURL tool



https://curl.se/download.html

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

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Examples of curl in JCL or in scripts, bat or command files

```
//*************************************************************
//*  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 deploy API cscvinc
//*************************************************************
//DEPLOY EXEC CURL
BPXBATCH SH export CURL=&CURL; +
$CURL/bin/curl -X PUT -s +
--cacert /u/johnson/CERTAUTH.PEM --user FRED:FRED +
https://wg31.washington.ibm.com:9445/zosConnect/apis/cscvinc?status=sto+
pped > null; +
$CURL/bin/curl -X DELETE -s +
--cacert /u/johnson/CERTAUTH.PEM --user FRED:FRED +
https://wg31.washington.ibm.com:9445/zosConnect/apis/cscvinc > null; +
$CURL/bin/curl -X POST -s +
--cacert /u/johnson/CERTAUTH.PEM --user FRED:FRED +
--data-binary @/u/johnson/cscvinc.aar +
--header "Content-Type: application/zip" +
https://wg31.washington.ibm.com:9445/zosConnect/apis
//*************************************************************
//*  STEP CURL - use cURL to invoke the API cscvinc
//*************************************************************
//INVOKE EXEC CURL
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH export CURL=&CURL; $CURL/bin/curl -X GET -s +
--cacert /u/johnson/CERTAUTH.PEM --user FRED:FRED +
https://wg31.washington.ibm.com:9445/cscvinc/employee/000100
```

```
@echo off
set TARGET=wg31.washington.ibm.com
set FILE=cscvinc_1.0.0
curl -X PUT --user user1:user1 --insecure
https://%TARGET%:9483/zosConnect/apiRequesters/%FILE%?status=stopped
curl -X DELETE --user user1:user1 --insecure
https://%TARGET%:9483/zosConnect/apiRequesters/%FILE%
curl -X POST --user user1:user1 --data-binary @%FILE%.ara  --header
"Content-Type: application/zip" --insecure
https://%TARGET%:9483/zosConnect/apiRequesters
curl -X GET –user user1:user1 --insecure
https://%TARGET%:9483/zosConnect/cscvinc/employee/000100
echo ''
```

Stop an API

Delete or remove the API from the server

Deploy the API to the server

Execute the API

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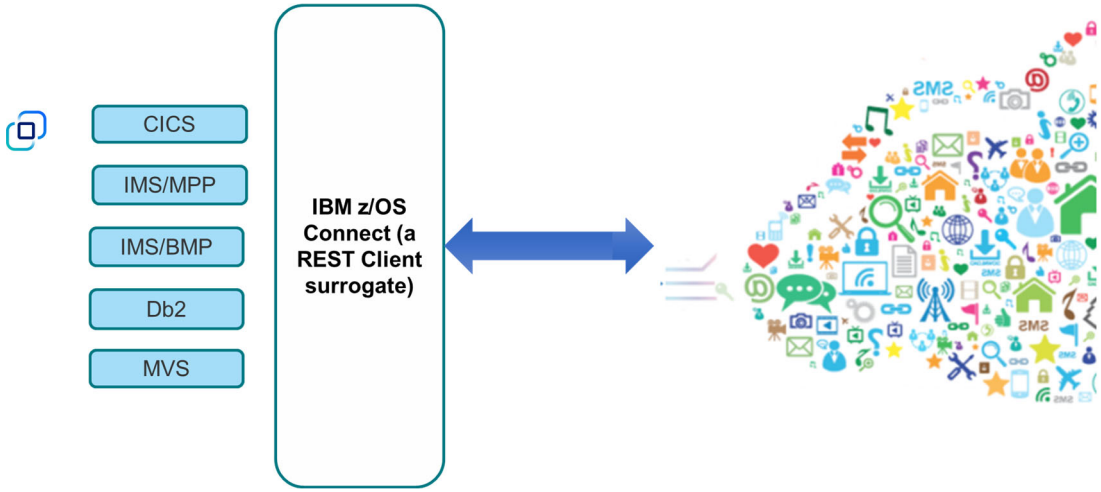
https://www.rocketsoftware.com/platforms/ibm-z/curl-for-zos

/api_toolkit/apiRequesters

Quick and easy **API mapping.**



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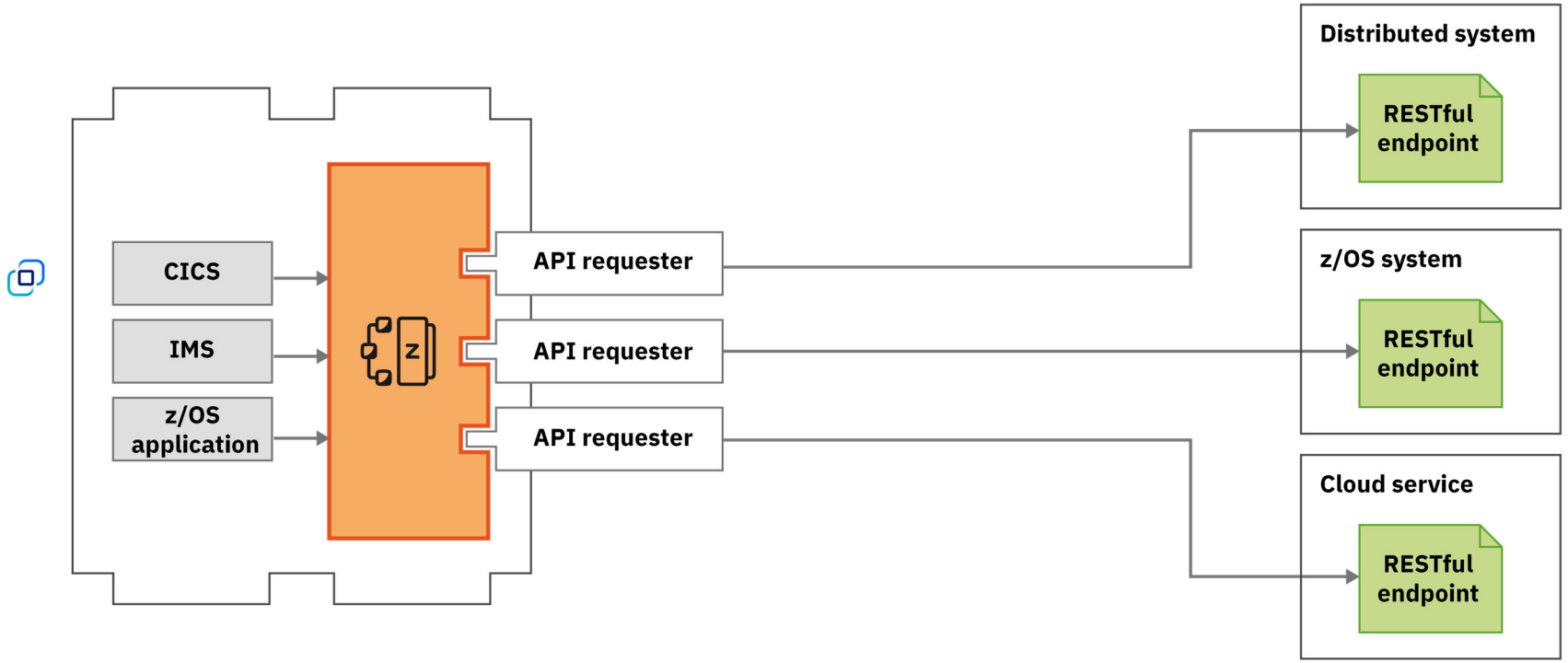
Use API requester to call external APIs from z/OS assets



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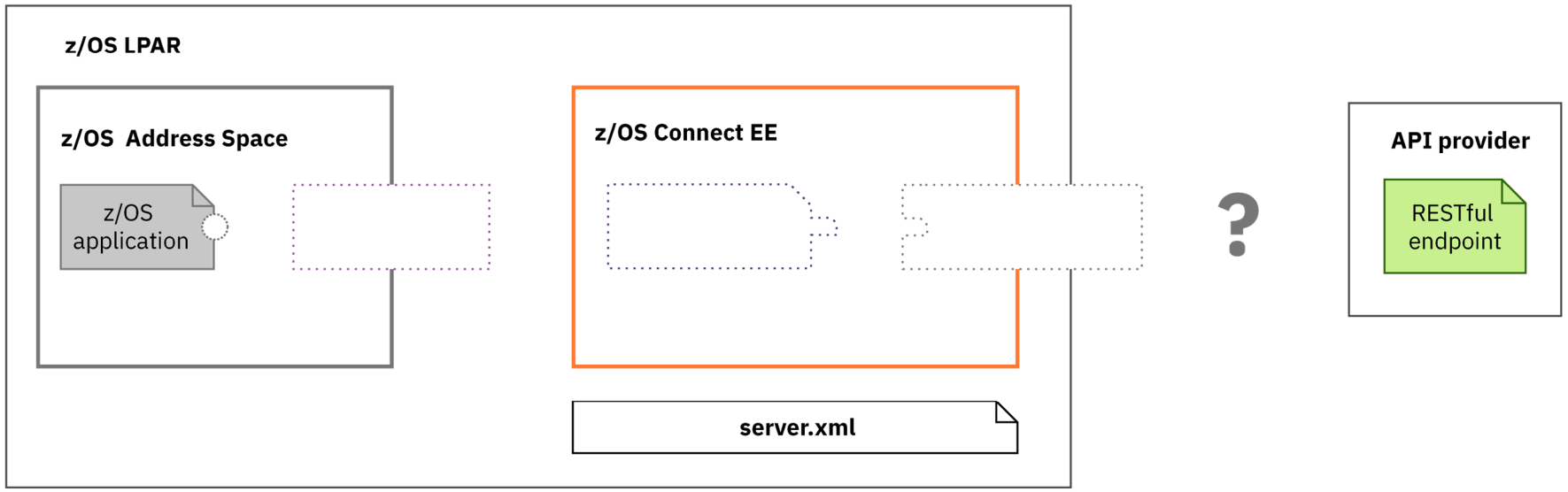
Calling an external API



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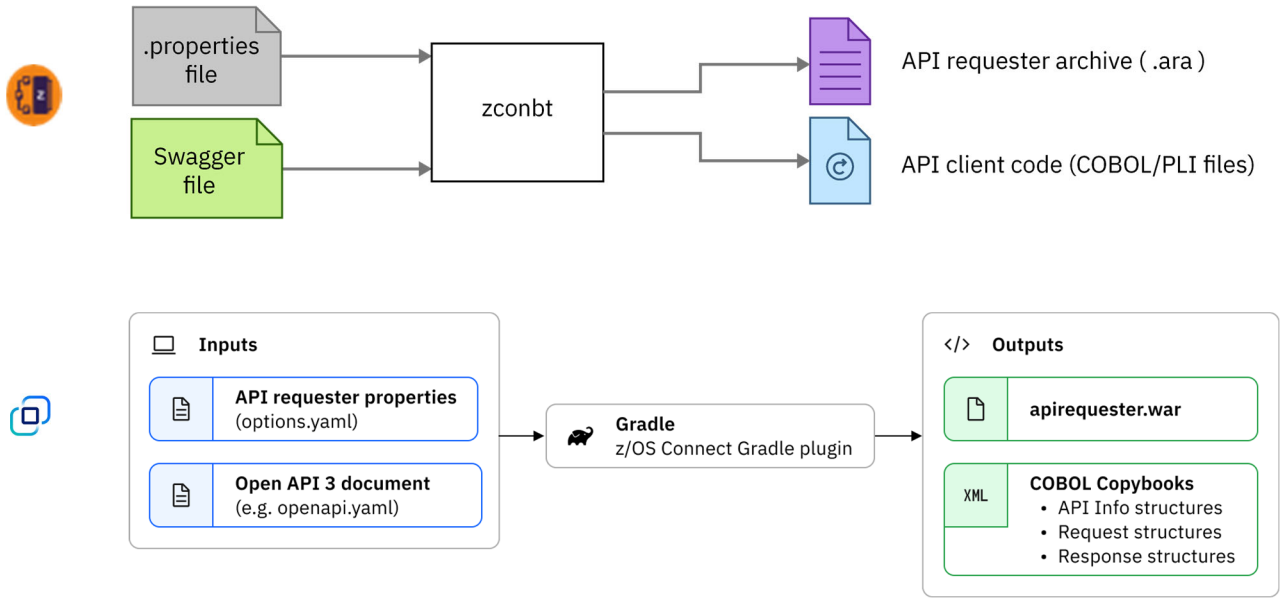
Calling an external API starts with the specification document

- Use the API's specification and generate COBOL copy books for the API requester archive file for an OpenAPI2 API or a web archive file for an OpenAPI3 API



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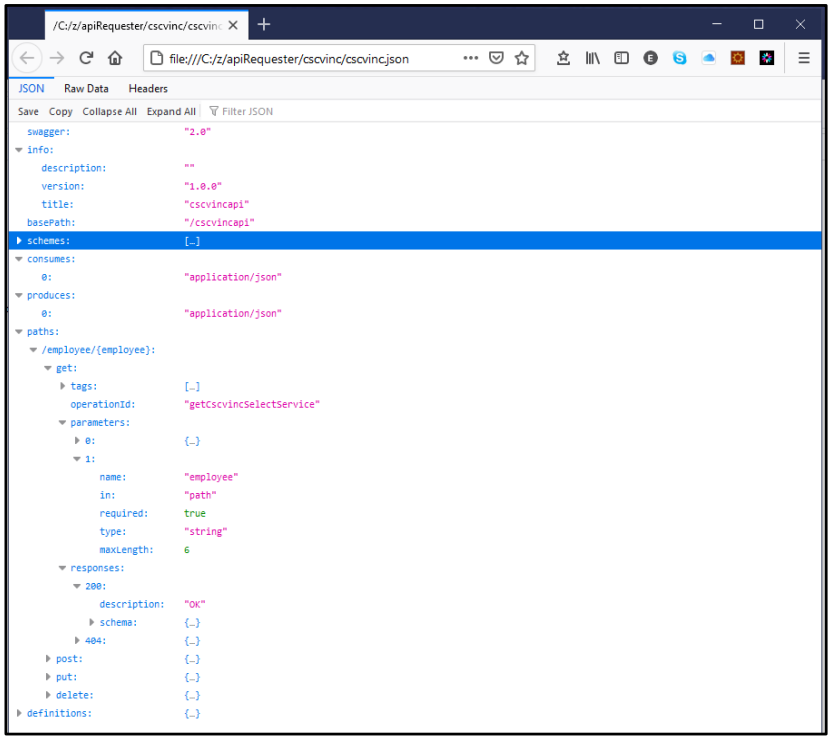
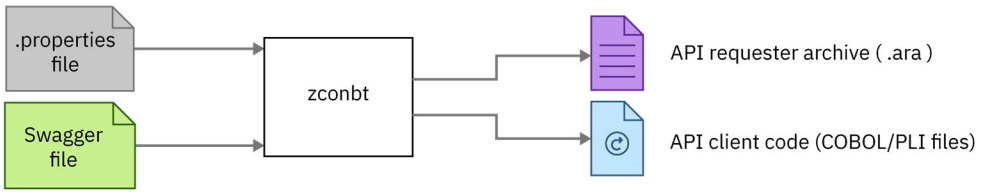
For an OpenAPI2 API, use the zconbt tooling





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

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Generates an API requester archive and COBOL copybooks

Use the z/OS Connect build toolkit, e.g., *zconbt*, to generate an API requester archive file and at most, 3 copy books per method found in the 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: getCscvincSelectService, basePath: /cscvincapi, relativePath: /employee/{employee}, method: GET
- request data structure  : CSC00Q01
- response data structure : CSC00P01
- api info file           : CSC00I01

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

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

operationId: deleteCscvincDeleteService, 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.
```

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https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=installing-build-toolkit

BTW, the z/OS Connect Build Toolkit can be executed on z/OS

```
//JOHNSONS JOB (ACCOUNT),JOHNSON,NOTIFY=&SYSUID,REGION=0M,
// CLASS=A,MSGCLASS=H,MSGLEVEL=(1,1)
//*****************************************************************
//*  SET SYMBOLS
//*****************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET WORKDIR='/u/johnson/zconbt'
// SET ZCONDIR='/usr/lpp/IBM/zosconnect/v3r0/zconbt/bin'
//ZCONBT   EXEC PGM=IKJEFT01,REGION=0M,MEMLIMIT=4G
//SYSTSPRT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
  export WORKDIR=&WORKDIR; +
  export ZCONDIR=&ZCONDIR; +
  cd $WORKDIR; +
  $ZCONDIR/zconbt.zos -p cscvinc.properties -f=cscvinc.ara; +
  cp -v $WORKDIR/syslib/* "//'JOHNSON.ZCONBT.COPYLIB'"
```

cscvinc.properties

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

This assumes the zconbt.zip files was expanded into directory /usr/lpp/IBM/zosconnect/v3r0/zconbt using command *jar –tf zconbt.zip* and that the property file and Swagger JSON document are encoded in ASCII in directory /u/johnson/zconbt.

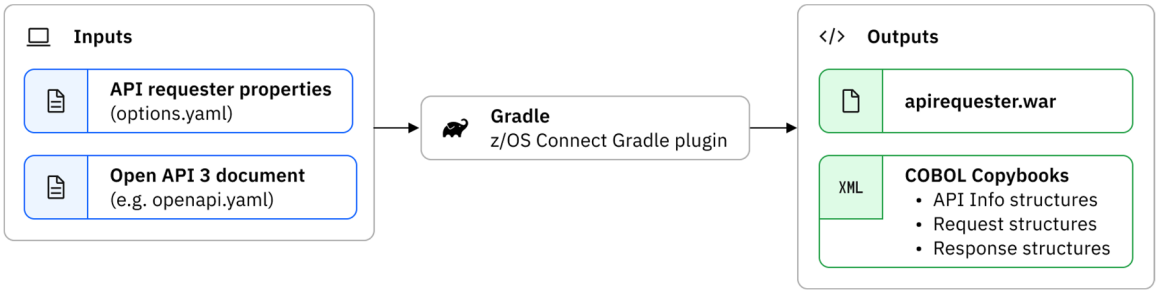
For an OpenAPI3 API, use Gradle

PhonebookApi.yaml

File Edit View

```
openapi: 3.0.0
info:
  title: Phonebook
  description: Manage phonebook contacts through an API for IMS.
  version: '2.0'
  license:
    name: Apache-2.0
    url: https://opensource.org/licenses/Apache-2.0
servers:
- url: /
security:
  - BasicAuth: []
  - BearerAuth: []
paths:
  /phonebook/contacts:
    post:
      tags:
        - Contacts
      summary: Add a contact to the phonebook
      description: Uses the phonebook IMS Transaction z/OS asset
      operationId: phonebookContactsPost
      requestBody:
        description: The contact to add to the phonebook.
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Contact'
      responses:
        '201':
          description: Created
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/NormalResponse'
        '409':
          description: Conflict
          content:
            application/json:
              schema:
```

Ln 1, Col 1 100% Unix (LF) UTF-8



Gradle plug-in properties and options[#]

```
apiKeyMaxLength=255
characterVarying=NO
defaultRequestMediaType="application/json"
defaultResponseMediaType="application/json"
language=COBOL
operations=GetEmployee,UpdateEmployee
connectionRef=cscvincAPI
requesterPrefix=csc
```

[#]Additional property file attributes, e.g., *defaultCharacterMaxLength*, *inlineMaxOccursLimit*, etc. are described at **The API requester Gradle plug-in properties and options** article at URL https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=requester-gradle-plug-in-properties-options

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Tech-Tip: Copy books naming convention

- 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 CSC 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###, and CSC02###.

- 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
- 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.
  - If there is no request message or no response message, then no copy book will be generated. But the messages stills need to have addressable storage in the application's working area.

```
      * Request and Response
       01 GET-REQUEST.
          10  FILLER                    PIC X(1).
       01 GET-RESPONSE.
           COPY MQ000P01 SUPPRESS.
      * Structure with the API information
       01 GET-INFO-OPER1.
           COPY MQ000I01 SUPPRESS.
```

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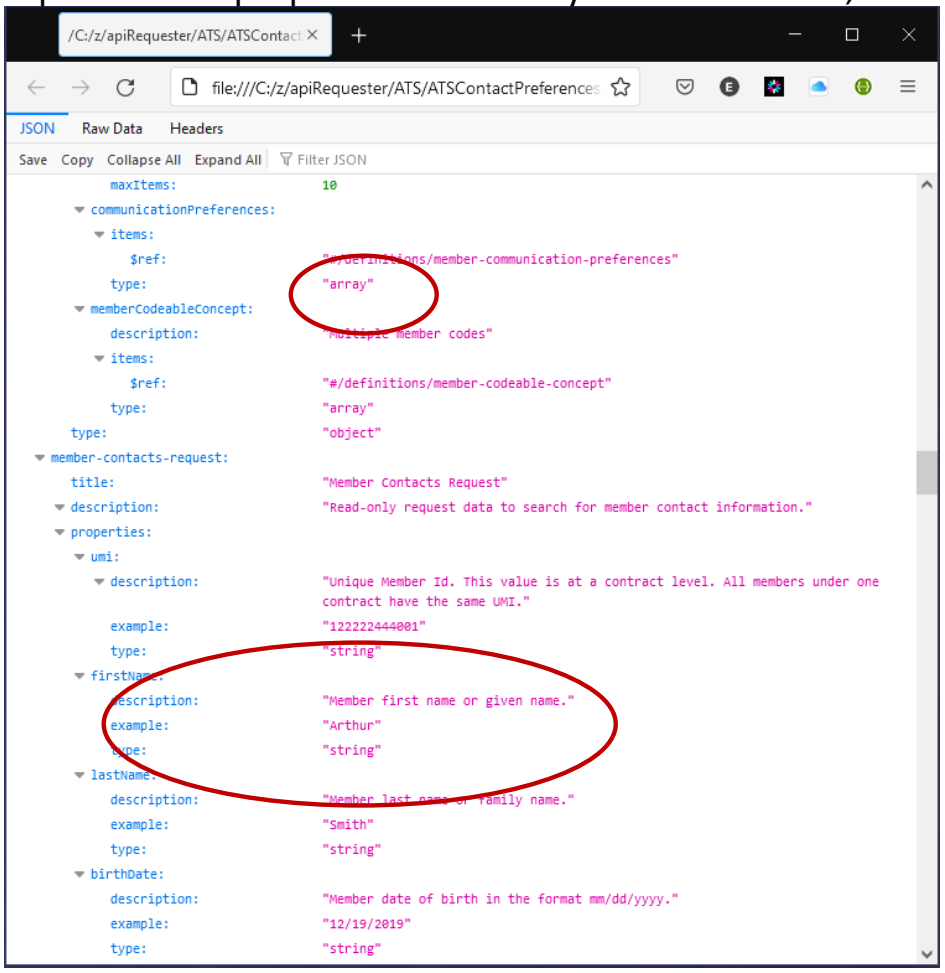
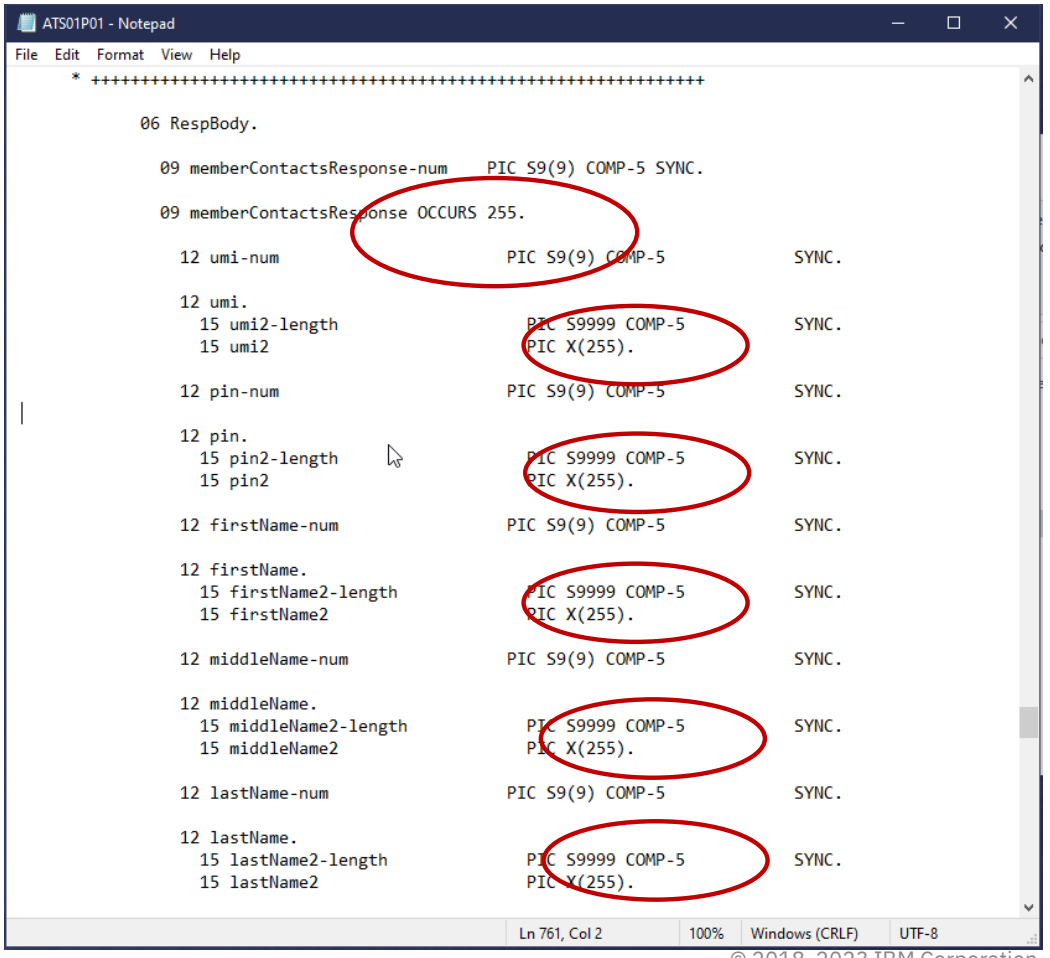
COBOL working storage implications

Specification properties are usually not constrained, this can lead to excessive working storage consumption#





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#Addressed in OpenAPI3 tooling

There are API Requester generation properties are available

Use these generation properties to set default array size and string field sizes

- **defaultArrayMaxItems -** Specify the maximum array boundary to apply when no maximum occurrence information (maxItems) is implied in the Swagger. The value of this parameter can be a positive integer in the range 1 - 32767. By default, **defaultArrayMaxItems** is set to **255.**
- **inlineMaxOccursLimit -** Specifies the size limit for an array before it is upgraded to a data area. If you specify inlineMaxOccursLimit=5, and the array has three elements, it remains an array. If the array has seven elements, it is transformed into a data area instead. See HOST API.
- **defaultCharacterMaxLength -** Specify the default array length of character data in characters for mappings where no length is implied in the JSON schema document. When **characterVarying** is set to YES, the value of this parameter can be a positive integer in the range of 1 to 32767. When **characterVarying** is set to NO or NULL the value of this parameter can be a positive integer in the range of 1 to 16777214 By default, **defaultCharacterMaxLength** is set to **255**.
- **characterVarying -** Specifies how variable-length character data is mapped to the language structure.
  - NO - Variable-length character data is mapped as fixed-length strings.
  - NULL - Variable-length character data is mapped to null-terminated strings (defaultCharacterMaxLength + 1)
  - YES - Variable-length character data is mapped to a CHAR VARYING data type in PL/I. In COBOL variable-length character data is mapped to an equivalent representation that consists of two related elements: the **data-length** and the **data**. By default, **characterVarying** is set to **YES**.

```
12 firstName-num                PIC S9(9) COMP-5            SYNC.

12 firstName.
   15 firstName2-length         PIC S9999 COMP-5            SYNC.
   15 firstName2                PIC X(30).
```

```
12 firstName-num                PIC S9(9) COMP-5      SYNC.

12 firstName                    PIC X(31).
```

```
MOVE 0 to ws-length
MOVE LENGTH OF firstName2 to firstName2-length.
INSPECT FUNCTION REVERSE (firstName2)
       TALLYING ws-length FOR ALL SPACES.
SUBTRACT ws-length FROM firstName2-length.
```

```
*-----------------------------------------------------------------*
* Add null termination character to strings                       *
*-----------------------------------------------------------------*
     STRING firstName delimited by size
          X'00' delimited by size into firstName.
```

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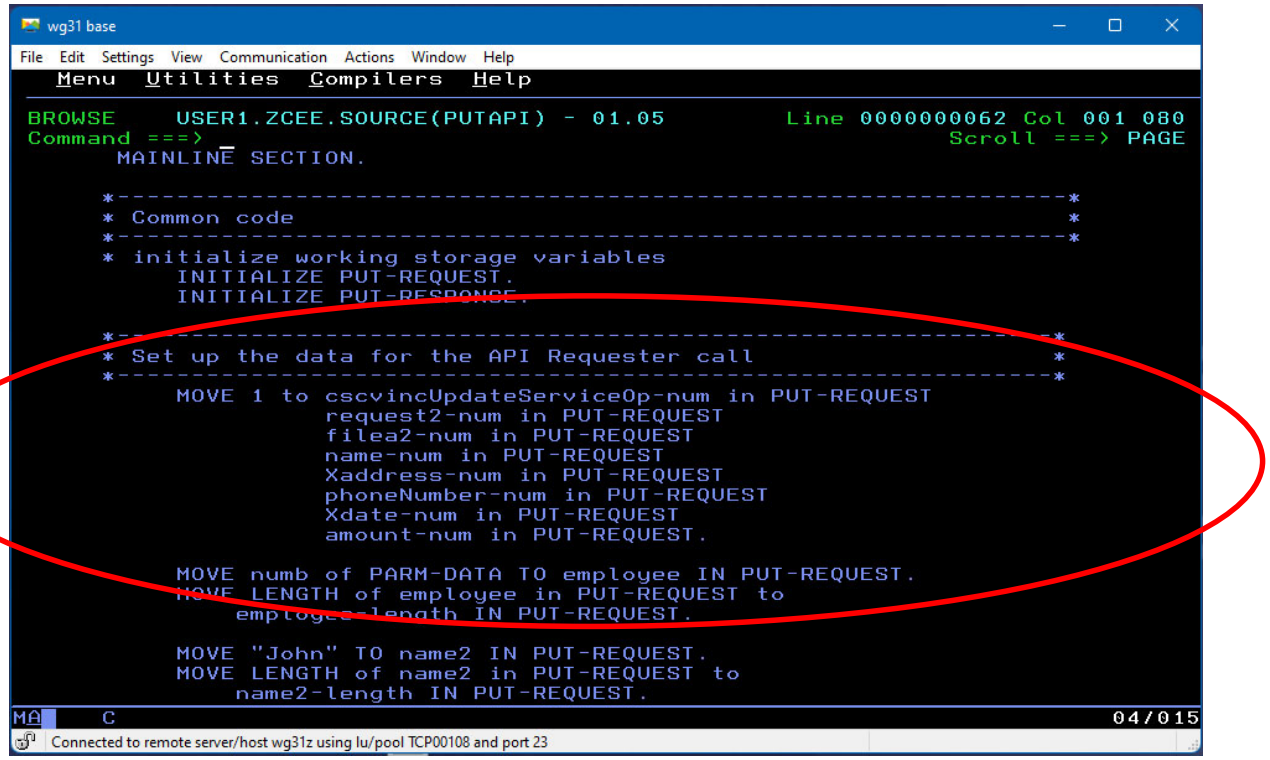
The number of occurrences of an entry can be ambiguous

In this case the COBOL copy book will include a counter variable (*variable*-num) for each variable whose number of occurrences is ambiguously defined in the specification document. Review the generated COBOL and provide the number of occurrences of these variables



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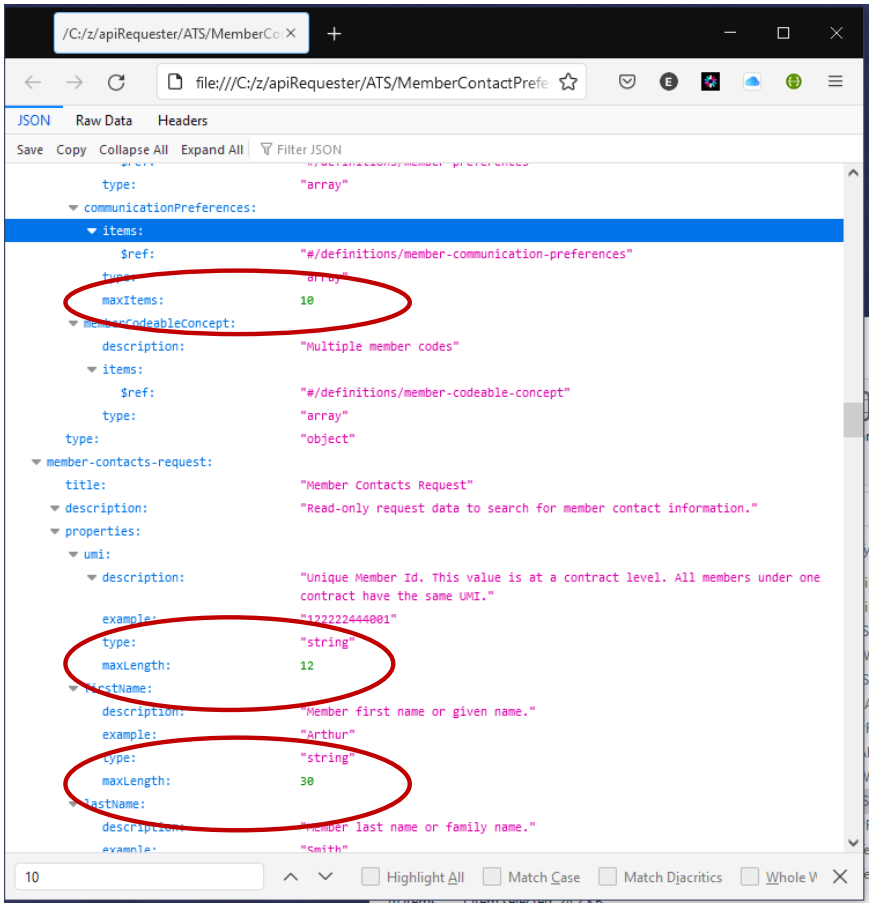
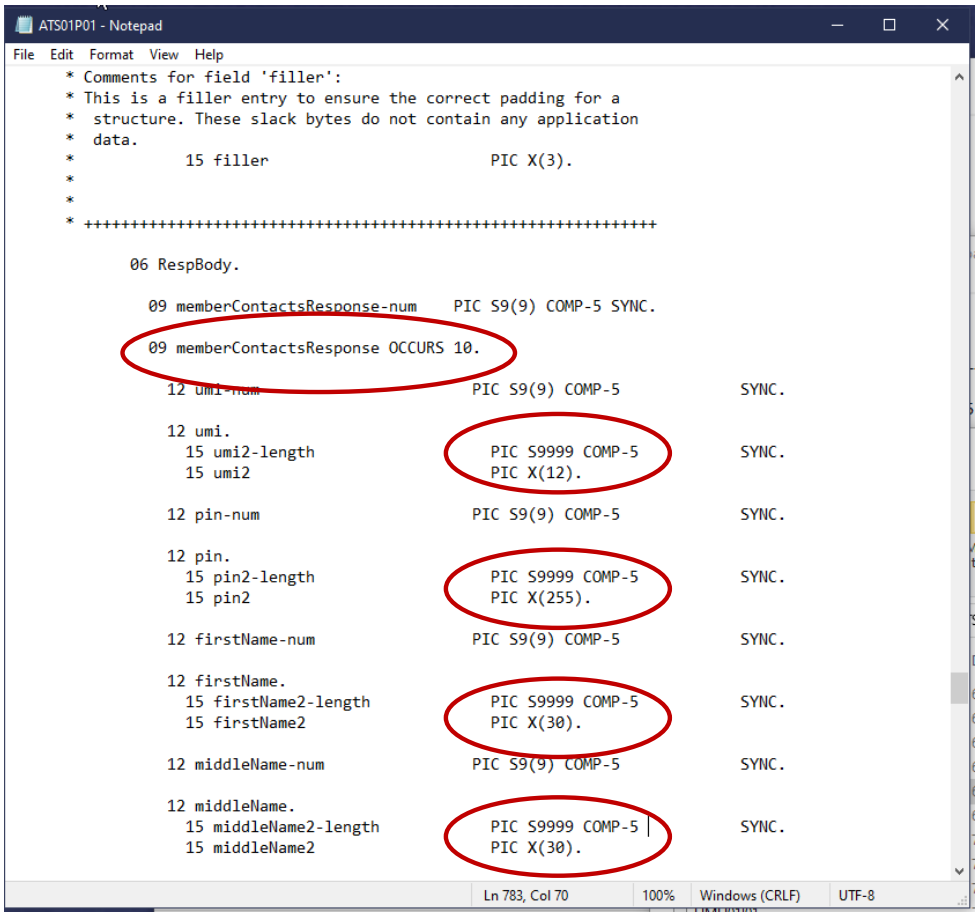
Alternatively, consider adding constraints to the properties

Use the *maxItems* and *maxLength* attributes to set realistic maximum array and field sizes





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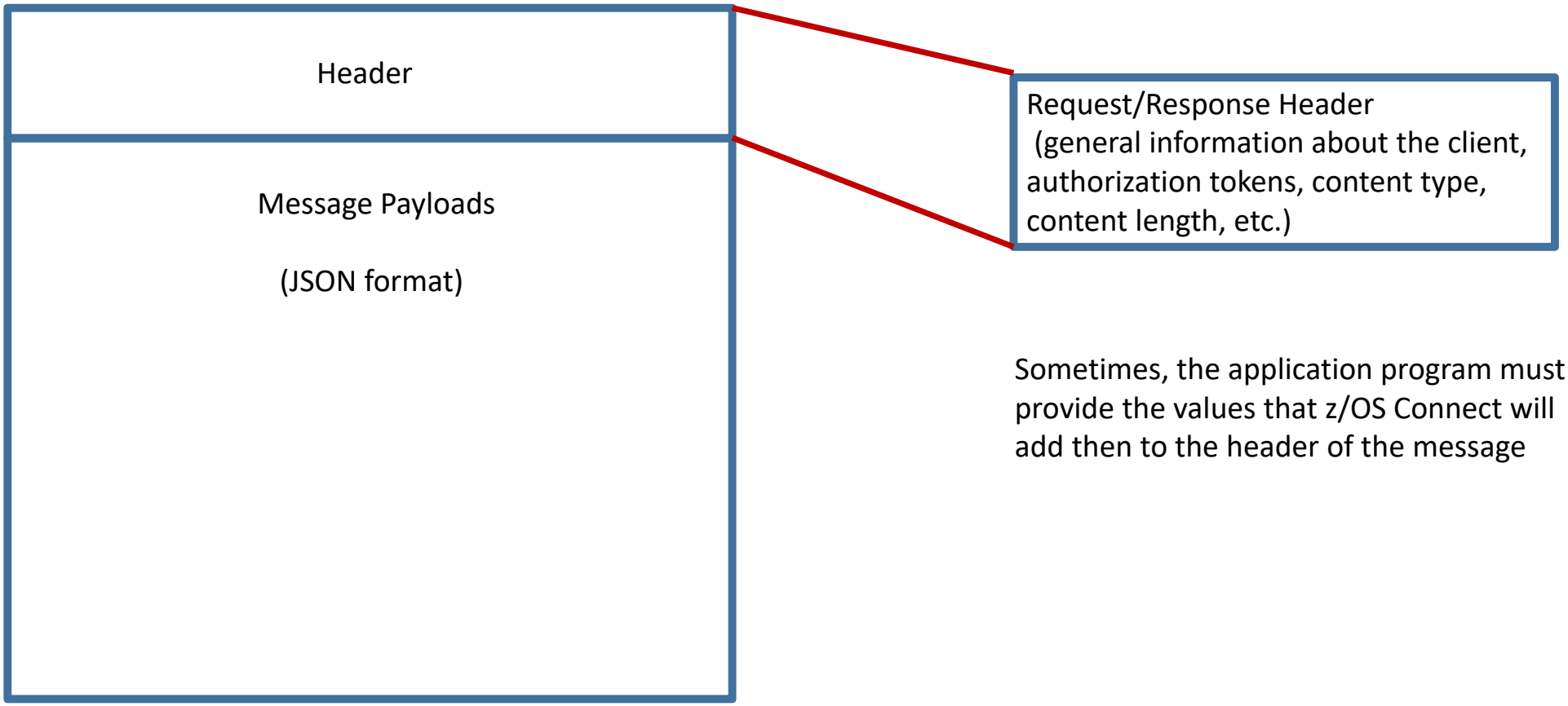
Request and Response Message Layout



Sometimes, the application program must provide the values that z/OS Connect will add then to the header of the message

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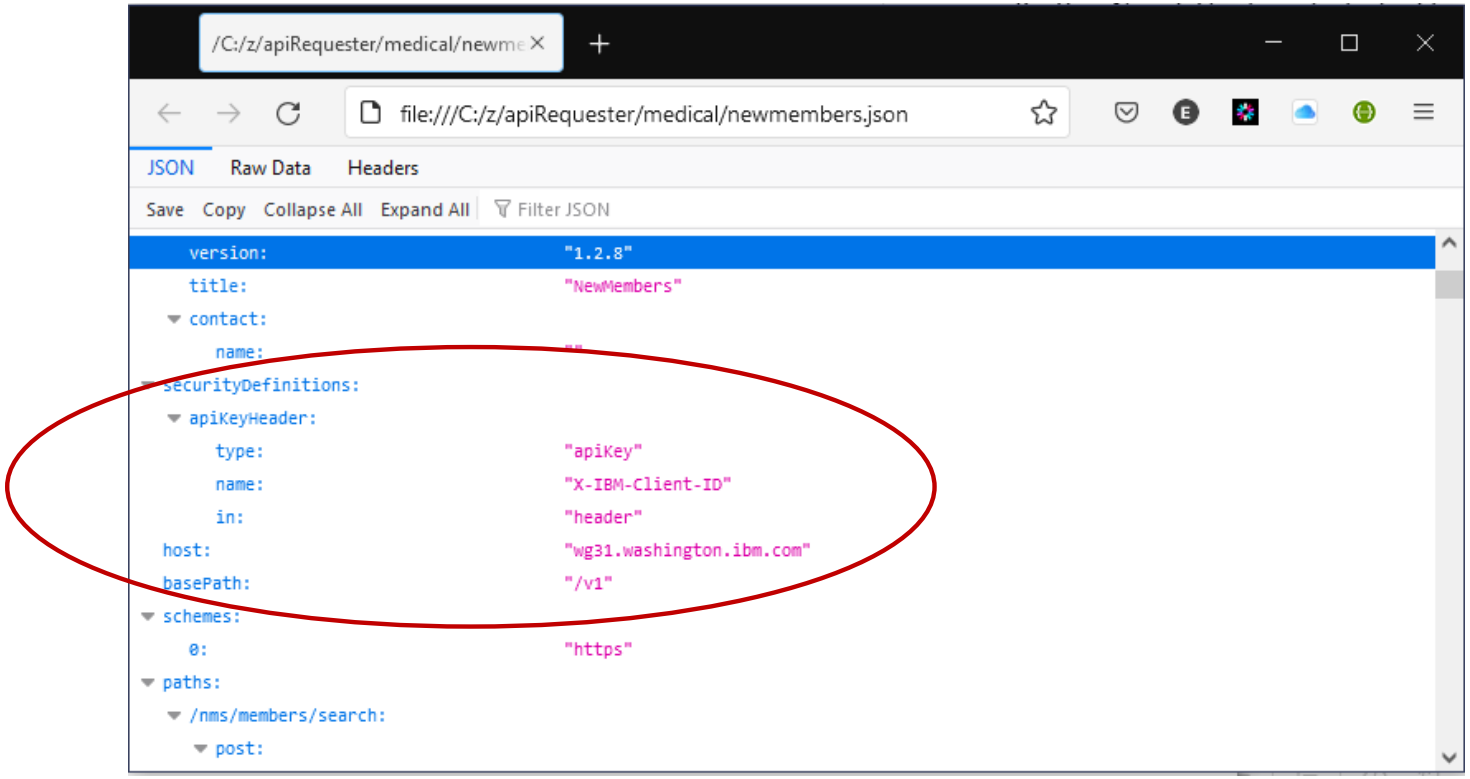
For security, an API key(aka password) may be required

The details can be provided in the specification document as shown below or . . .



Via a HTTP header
GET /something HTTP/1.1
X-API-Key: abcdef12345

Or via a query parameter
GET /something?**api_key=abcdef12345**

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The application provides th API key to the request header

Either way, the generated request copy book includes a ReqHeaders structure which can be used to provide values for header properties

request.cpy - Notepad

```
File  Edit  Format  View  Help
      *          12 dob2-length                  PIC S9999 COMP-5
      *  SYNC.
      *          12 dob2                         PIC X(255).
      *
      *
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

           06 ReqHeaders.
             09 X-IBM-Client-ID-length          PIC S9999 COMP-5 SYNC.
             09 X-IBM-Client-ID                 PIC X(255).
             09 X-HZN-ClientName-length         PIC S9999 COMP-5 SYNC.
             09 X-HZN-ClientName                PIC X(255).
             09 X-HZN-ClientSubmitDateTime      PIC S9(15) COMP-3.

             09 X-HZN-ClientTransactID-num      PIC S9(9) COMP-5 SYNC.

             09 X-HZN-ClientTransactionId.
               12 X-HZN-ClientTransact-length   PIC S9999 COMP-5
           SYNC.
               12 X-HZN-ClientTransactionId2    PIC X(255).

             09 X-HZN-ClientSessionId-num       PIC S9(9) COMP-5 SYNC.

             09 X-HZN-ClientSessionId.
               12 X-HZN-ClientSessionI-length   PIC S9999 COMP-5
           SYNC.
               12 X-HZN-ClientSessionId2        PIC X(255).

             09 X-HZN-UserRole-num              PIC S9(9) COMP-5 SYNC.

             09 X-HZN-UserRole.
               12 X-HZN-UserRole2-length        PIC S9999 COMP-5
           SYNC.
               12 X-HZN-UserRole2               PIC X(255).

             09 X-HZN-UserAssociationI-num      PIC S9(9) COMP-5 SYNC.

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

mpz3

```
File  Edit  Settings  View  Communication  Actions  Window  Help
  File  Edit  Edit_Settings  Menu  Utilities  Compilers  Test  Help
EDIT       USER1.ZCEE.SOURCE(GETAPIEN) - 01.01            Columns 00001 00072
Command ===>                                               Scroll ===> PAGE
000081        *-------------------------------------------------------------*
000082        * Common code                                                 *
000083        *-------------------------------------------------------------*
000084        * initialize working storage variables
000085             INITIALIZE GET-REQUEST.
000086             INITIALIZE GET-RESPONSE.
000087             MOVE "abcdef12345" to X-IBM-Client-ID
000088             MOVE 11 to X-IBM-Client-ID-length
000089
000090        *-------------------------------------------------------------*
000091        * Set up the data for the API Requester call                  *
000092        *-------------------------------------------------------------*
000093             MOVE employee of PARM-DATA TO employee IN GET-REQUEST.
000094             MOVE LENGTH of employee in GET-REQUEST to
000095                 employee-length IN GET-REQUEST.
000096
000097        *-------------------------------------------------------------*
000098        * Initialize API Requester PTRs & LENs                        *
000099        *-------------------------------------------------------------*
000100        * Use pointer and length to specify the location of
000101        *  request and response segment.
000102        * This procedure is general and necessary.
000103             SET BAQ-REQUEST-PTR TO ADDRESS OF GET-REQUEST.
000104             MOVE LENGTH OF GET-REQUEST TO BAQ-REQUEST-LEN.
000105             SET BAQ-RESPONSE-PTR TO ADDRESS OF GET-RESPONSE.
000106             MOVE LENGTH OF GET-RESPONSE TO BAQ-RESPONSE-LEN.
000107
000108        *-------------------------------------------------------------*
MA    A                                                          13/002
Connected to remote server/host mpz3 using lu/pool MPZ30019 and port 23
```

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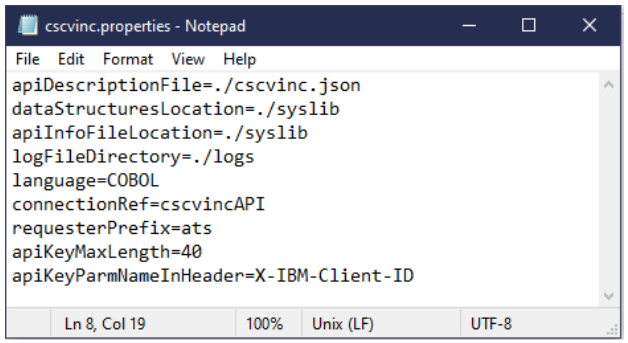
Or by including generation properties related to API keys

Use these generation properties to add API key information to the request message when not defined in specification document

apiKeyMaxLength - Specify the maximum length of the values set for API keys. The value of this parameter can be a positive integer in the range 1 - 32767. By default, **apiKeyMaxLength** is set to 255.

apiKeyParmNameInHeader - Specify the name of an API key that is sent as a request header. The value of this parameter can be set in a comma separated list of a combination of client ID and client secret. For example, you can set **apiKeyParmNameInHeader** =header-IBM-Client-ID, header-IBM-Client-secret when a client ID and a client secret are used to protect an API.

apiKeyParmNameInQuery - Specify the name of an API key that is sent in a query string. The value of this parameter can be set in a comma separated list of a combination of client ID and client secret. For example, you can set apiKeyParmNameInQuery=query-IBM-Client-ID, query-IBM-Client-secret when a client ID and a client secret are used to protect an API.



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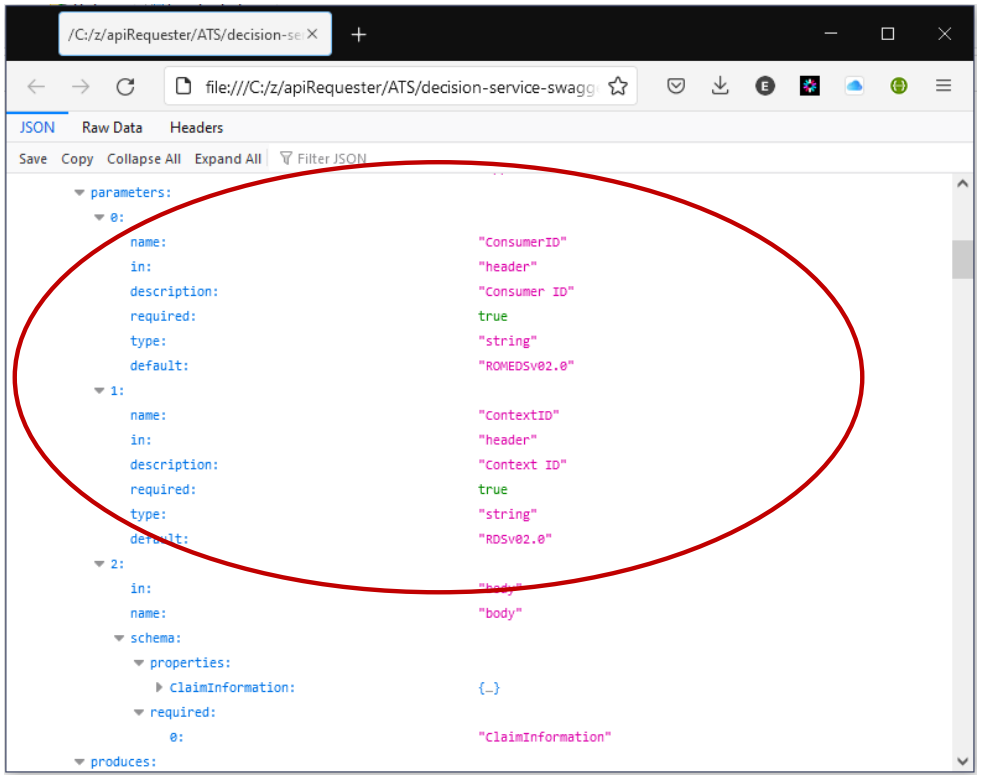
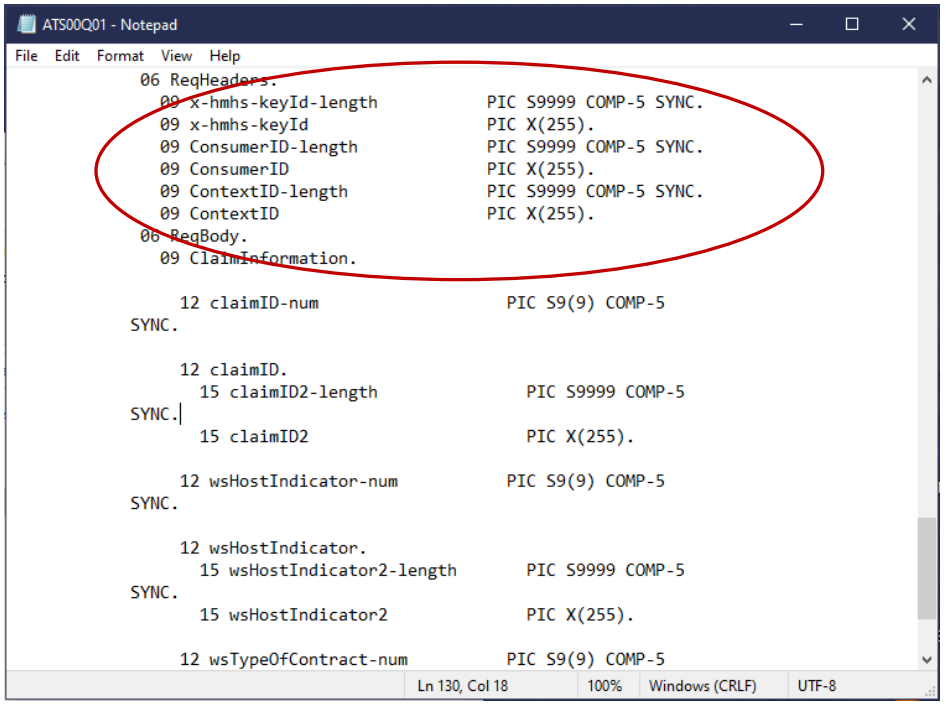
And there may be other header properties can be required

The application can also set the values for other header properties that may be required by the API





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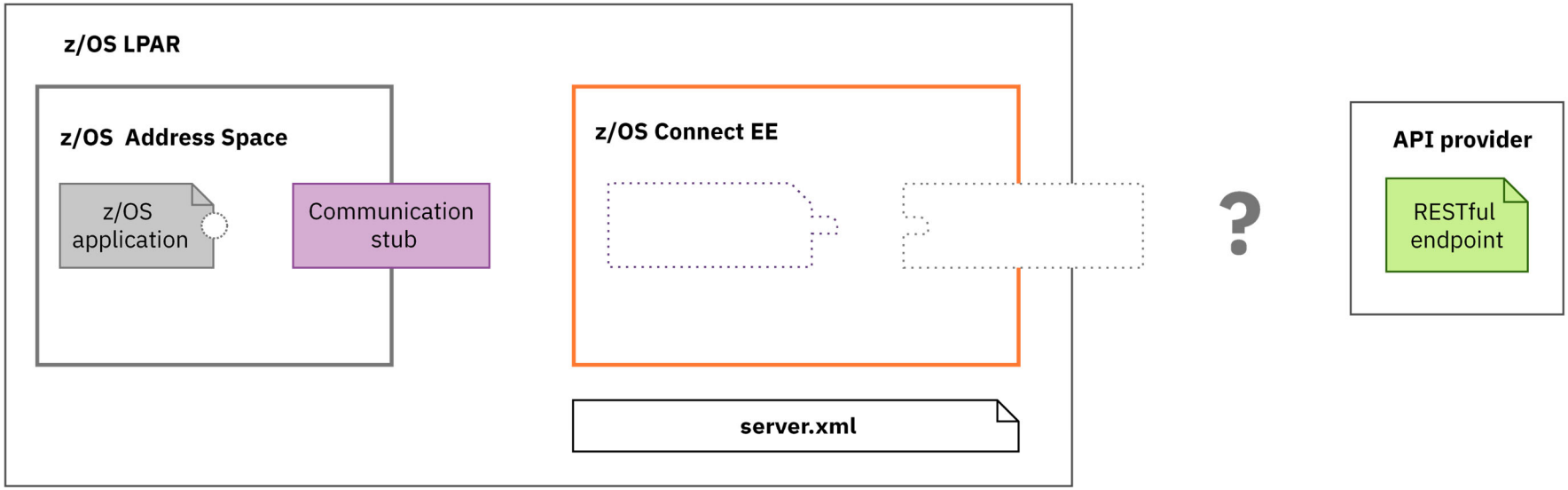
Involving an external API from a COBOL program (OpenAPI2)

Update the application by adding the generated copy books, a common BAQRINFO copy book 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

```
      *---------------------------------------------------------------*
      * Call the communication stub                                   *
      *---------------------------------------------------------------*
      * Call the subsystem-supplied stub code to send
      * API request to zCEE
           CALL  COMM-STUB-PGM-NAME USING
                 BY REFERENCE    GET-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.
```

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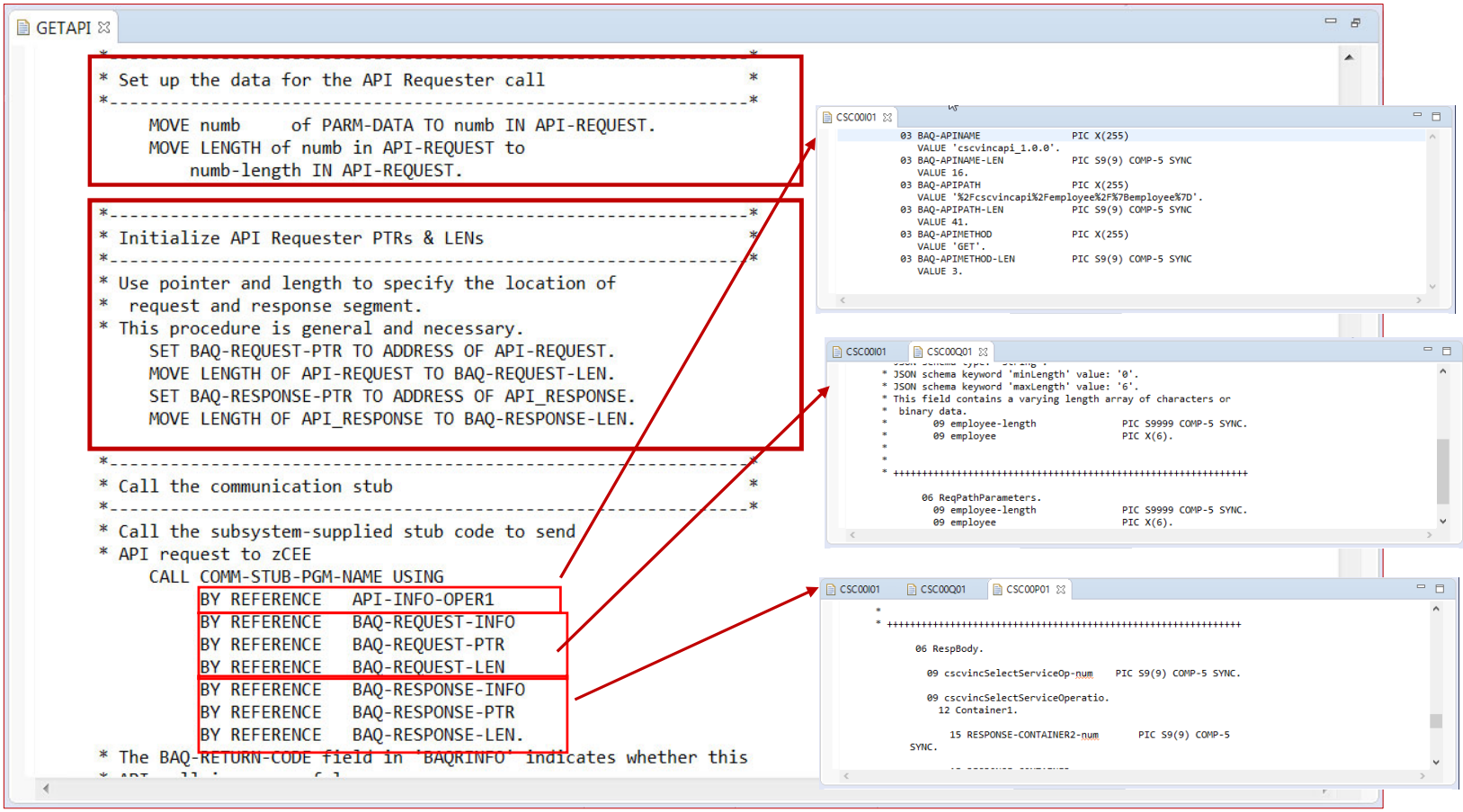
ibm.biz/zosconnect-configure-comms-stub

Call the communication stub

Add a call to the communication stub use pointers to pass working storage addresses of the copy books



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Response come back into working storage

Accessing the results that have been stored in working storage

GETAPI

```
            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.
```

mpz3

```
File  Edit  Settings  View  Communication  Actions  Window  Help
  Menu  Utilities  Compilers  Help
BROWSE    ZCEE30.SBAQCOB(BAQRINFO)                Line 0000000066 Col 001 080
Command ===>                                        Scroll ===> PAGE

      01  BAQ-RESPONSE-INFO.
        03 BAQ-RESPONSE-INFO-COMP-LEVEL PIC S9(9) COMP-5 SYNC VALUE 0.
        03 BAQ-STUB-NAME                PIC X(8).
        03 BAQ-RETURN-CODE              PIC S9(9) COMP-5 SYNC.
           88 BAQ-SUCCESS                 VALUE 0.
           88 BAQ-ERROR-IN-API            VALUE 1.
           88 BAQ-ERROR-IN-ZCEE           VALUE 2.
           88 BAQ-ERROR-IN-STUB           VALUE 3.
           88 BAQ-ERROR-NO-RESPONSE       VALUE 4.
        03 BAQ-STATUS-CODE              PIC S9(9) COMP-5 SYNC.
        03 BAQ-STATUS-MESSAGE           PIC X(1024).
        03 BAQ-STATUS-MESSAGE-LEN       PIC S9(9) COMP-5 SYNC.
****************************** Bottom of Data ********************************
MA  B                                                              18/058
Connected to remote server/host mpz3 using lu/pool MPZ30021 and port 23
```

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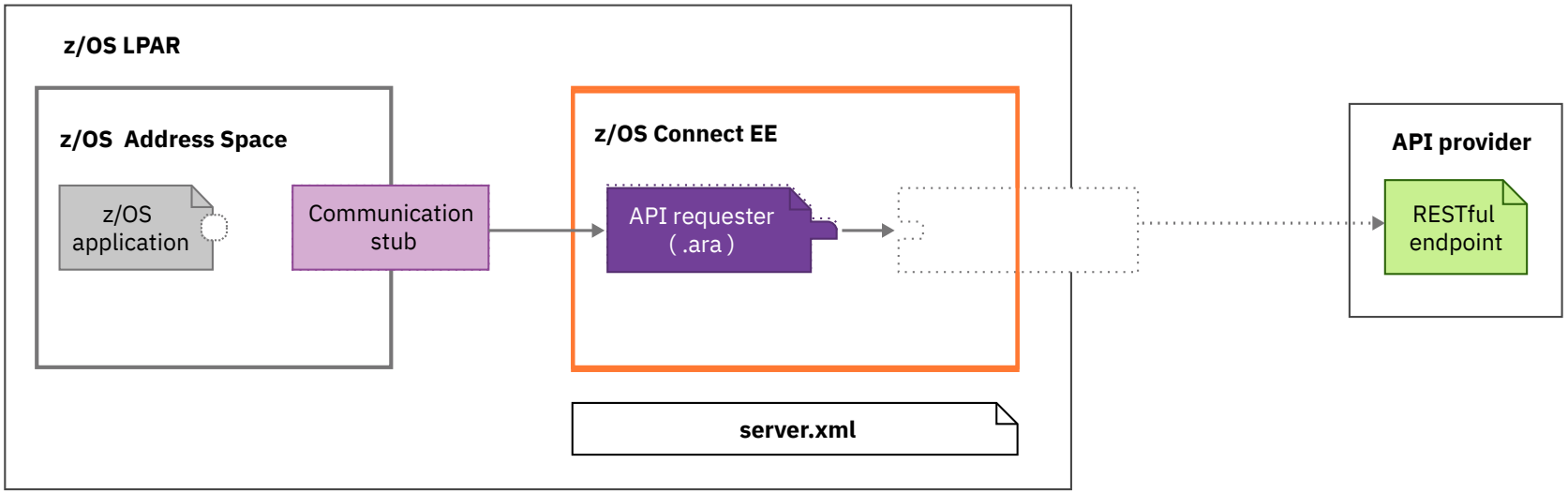
Deploy the API requester (.ara) archive



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

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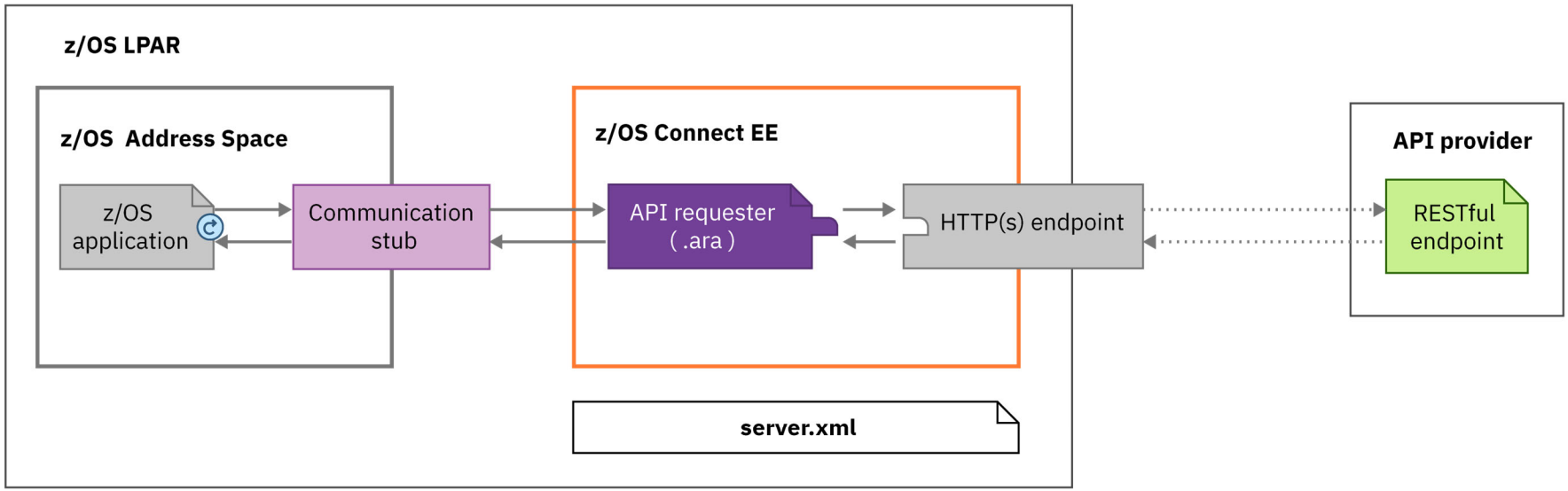
Calling an external OpenAPI2 API

Done



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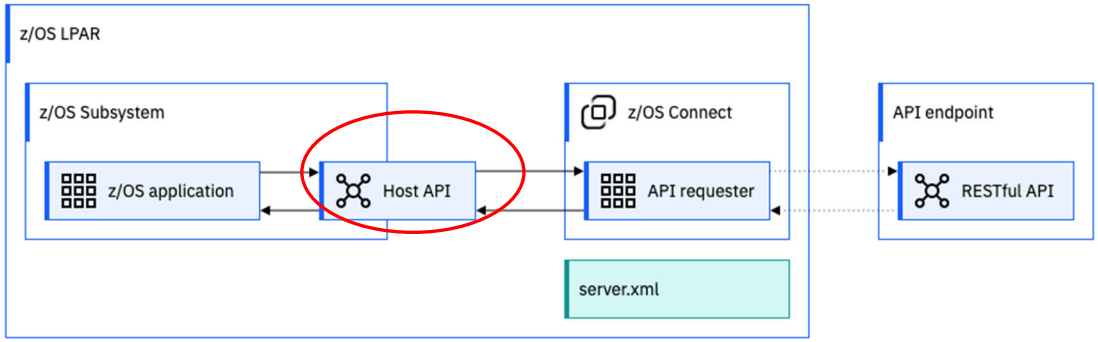
What is different with OpenAPI3 requester support?

In this case, the **z/OS Applications** calls z/OS Connect provided APIs to address issues encountered with the OpenAPI2 solution



- The Host API callable interface is a replacement for the IBM z/OS Connect OpenAPI 2.0 specification communication stub. It enables COBOL applications to call OpenAPI 3.0 specification RESTful APIs.

- The Host API has an extended set of callable verbs to support the richer set of features available in the OpenAPI 3.0 specification. For example, the Host API supports receiving **dynamically sized arrays** and/or **multiple mapped HTTP response codes** from the API endpoint. This capability enables a different response payload to be received by the COBOL program depending on whether the HTTP status code is 200 (OK), 201 (CREATED), or 404 (NOTFOUND. Each of the response payloads that are documented in the OpenAPI 3.0 definition operation are mapped to a different COBOL language structure.

- To support these new features, a ***data area*** is used. A data area is a location in the LINKAGE section of program storage that contains data *elements* that can be accessed sequentially by the COBOL program. Each dynamic array and each return response code has its own data area. To manage these data areas, and to manage IBM z/OS Connect connections, a set of Host API verbs is defined that are collectively known as the *Host API callable interface*.

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The Host API Verbs

BAQINIT

- **INIT**ialize the storage required by the Host API and establish a connection to z/OS Connect

BAQEXEC

- **EXEC**ute the call to the desired API taking request data as input and providing response data as output

BAQGETN

- *[Optional]* - **GET** the **N**ext data element from a named Data Area in the response

BAQFREE

- *[Optional]* - **FREE** the storage currently in use by the Host API

BAQTERM

- **TERM**inate the connection to z/OS Connect and free all storage currently in use by the Host API

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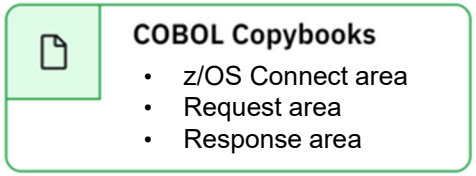
COBOL copybooks

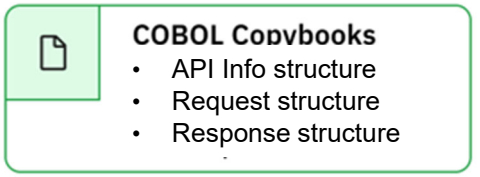
z/OS Connect provides two copybooks that are required to interface with the Host API and tooling to generate application specific copybooks

1. Product provided static structures



- BAQHAREC provides the 3 communication areas listed above
- BAQHCONC provides useful constants for the COBOL developer

2. Generated dynamic structures



- Output from running the API requester Gradle plug-in
- Maximum of 3 per operation
- Contents vary based on the OAS3 document and Gradle plug-in options specified

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BAQHAREC
z/OS Connect area

BAQ-ZCONNECT-AREA

Input & Output interface for all Host API verbs

- z/OS Connect parameters
  - e.g., URIMAP, z/OS Connect credentials
- Completion and Reason codes
- Service ID and Service Codes
- Return Message

```
01 BAQ-ZCONNECT-AREA.
  03 BAQ-ZCON-AREA-EYE            PIC X(4) VALUE 'BAQZ'.
  03 BAQ-ZCON-AREA-LENGTH         PIC 9(8) COMP-5 VALUE 4648.
  03 BAQ-ZCON-AREA-VERSION        PIC 9(8) COMP-5 VALUE 1.
  03 BAQ-ZCON-RESERVED-01         PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-ZCON-PARM-INIT           VALUE LOW-VALUES.
    05 BAQ-ZCON-RESERVED-02        PIC X(3584).
  03 BAQ-ZCON-PARAMETERS          REDEFINES BAQ-ZCON-PARM-INIT.
    05 BAQ-ZCON-PARMS              OCCURS 64.
      07 BAQ-ZCON-PARM-NAME         PIC X(48).
      07 BAQ-ZCON-PARM-ADDRESS      USAGE POINTER.
      07 BAQ-ZCON-PARM-LENGTH       PIC 9(9) BINARY.
  03 BAQ-ZCON-RETURN-CODES.
    05 BAQ-ZCON-COMPLETION-CODE    PIC 9(8) COMP-5 VALUE 0.
      88 BAQ-SUCCESS                VALUE 0.
      88 BAQ-WARNING                VALUE 4.
      88 BAQ-ERROR                  VALUE 8.
      88 BAQ-SEVERE                 VALUE 12.
      88 BAQ-CRITICAL               VALUE 16.
    05 BAQ-ZCON-REASON-CODE        PIC 9(8) COMP-5 VALUE 0.
    05 BAQ-ZCON-SERVICE-ID         PIC 9(8) COMP-5 VALUE 0.
    05 BAQ-ZCON-SERVICE-CODE       PIC 9(8) COMP-5 VALUE 0.
    05 BAQ-ZCON-RESERVED-03        PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-ZCON-RETURN-MESSAGE-LEN  PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-ZCON-RETURN-MESSAGE      PIC X(1024).
```

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BAQHAREC

Request area

BAQ-REQUEST-AREA

Input to the BAQEXEC for an API call

- Provide the Host API with the address and length of the request data
- Set any parameters required for calling the API
  - e.g., For OAuth or Token authentication with API endpoint

```
01 BAQ-REQUEST-AREA.
  03 BAQ-REQ-AREA-EYE              PIC X(4)  VALUE 'BAQR'.
  03 BAQ-REQ-AREA-LENGTH           PIC 9(8) COMP-5 VALUE 3608.
  03 BAQ-REQ-AREA-VERSION          PIC 9(8) COMP-5 VALUE 1.
  03 BAQ-REQ-RESERVED-01           PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-REQ-BASE-ADDRESS          USAGE POINTER.
  03 BAQ-REQ-BASE-LENGTH           PIC 9(8) BINARY.
  03 BAQ-REQ-PARM-INIT             VALUE LOW-VALUES.
    05 BAQ-REQ-RESERVED-02          PIC X(3584).
  03 BAQ-REQ-PARAMETERS            REDEFINES BAQ-REQ-PARM-INIT.
    05 BAQ-REQ-PARMS               OCCURS 64.
      07 BAQ-REQ-PARM-NAME          PIC X(48).
      07 BAQ-REQ-PARM-ADDRESS       USAGE POINTER.
      07 BAQ-REQ-PARM-LENGTH        PIC 9(9) BINARY.
```

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BAQHAREC
Response area

BAQ-RESPONSE-AREA

Output from the BAQEXEC call

- Provides the address and length of the response BASE area
- The status code received from the API endpoint
- Any status message received from the API endpoint
  - Contains response payload when z/OS connect could not handle the API endpoint HTTP response code

```
01 BAQ-RESPONSE-AREA.
  03 BAQ-RESP-AREA-EYE            PIC X(4)  VALUE 'BAQP'.
  03 BAQ-RESP-AREA-LENGTH         PIC 9(8) COMP-5 VALUE 1060.
  03 BAQ-RESP-AREA-VERSION        PIC 9(8) COMP-5 VALUE 1.
  03 BAQ-RESP-RESERVED-01         PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-RESP-BASE-ADDRESS        USAGE POINTER.
  03 BAQ-RESP-BASE-LENGTH         PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-RESP-RESERVED-02         PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-RESP-STATUS-CODE         PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-RESP-STATUS-MESSAGE-LEN  PIC 9(8) COMP-5 VALUE 0.
  03 BAQ-RESP-STATUS-MESSAGE      PIC X(1024).
```

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BAQHCONC

Product provided constants for convenience

- Host API entry point names for dynamic calling
- Host API Request specific parameters
- Host API z/OS Connect parameters

```
Host API entry point names
77 BAQ-INIT-NAME          PIC X(8) VALUE 'BAQINIT'.
77 BAQ-EXEC-NAME          PIC X(8) VALUE 'BAQEXEC'.
77 BAQ-GETN-NAME          PIC X(8) VALUE 'BAQGETN'.
77 BAQ-FREE-NAME          PIC X(8) VALUE 'BAQFREE'.
77 BAQ-TERM-NAME          PIC X(8) VALUE 'BAQTERM'.

Host API Request parameter names
77 BAQR-OAUTH-USERNAME       PIC X(22)
   VALUE 'BAQHAPI-oAuth-Username’.
77 BAQR-OAUTH-PASSWORD       PIC X(22)
   VALUE 'BAQHAPI-oAuth-Password'.
77 BAQR-OAUTH-SCOPE          PIC X(19)
   VALUE 'BAQHAPI-oAuth-Scope’.
……

Host API ZCON parameter names
77 BAQZ-SERVER-URIMAP        PIC X(21)
   VALUE 'BAQHAPI-Server-URIMAP'.
77 BAQZ-SERVER-USERNAME      PIC X(23)
   VALUE 'BAQHAPI-Server-Username'.
77 BAQZ-SERVER-PASSWORD      PIC X(23)
   VALUE 'BAQHAPI-Server-Password'.
……
```

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The API information (“I”) copybook

- Static structure required by the Host API BAQEXEC call
- Contains information about the API to be called
- **Must not** be changed!

```
01 BAQ-API-INFO-RBK02I01.
  03 BAQ-API-INFO-EYE            PIC X(4)
     VALUE 'BAQA'.
  03 BAQ-API-INFO-LENGTH         PIC 9(9) COMP-5 SYNC
     VALUE 1052.
  03 BAQ-API-INFO-VERSION        PIC 9(9) COMP-5 SYNC
     VALUE 1.
  03 BAQ-API-INFO-RESERVED01     PIC 9(9) COMP-5 SYNC
     VALUE 0.
  03 BAQ-API-NAME                PIC X(255)
     VALUE 'RedbookApi'.
  03 BAQ-API-NAME-LEN            PIC 9(9) COMP-5 SYNC
     VALUE 10.
  03 BAQ-API-PATH                PIC X(255)
     VALUE '%2Fredbooks'.
  03 BAQ-API-PATH-LEN            PIC 9(9) COMP-5 SYNC
     VALUE 11.
  03 BAQ-API-METHOD              PIC X(255)
     VALUE 'GET'.
  03 BAQ-API-METHOD-LEN          PIC 9(9) COMP-5 SYNC
     VALUE 3.
  03 BAQ-API-OPERATION           PIC X(255)
     VALUE 'getAllRedbooks'.
  03 BAQ-API-OPERATION-LEN       PIC 9(9) COMP-5 SYNC
     VALUE 14.
```

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The Request message (“Q”) copybook

- Working storage structure required by the Host API BAQEXEC call
- Contains request data to be sent to the API
- Must be initialized by the calling COBOL program
  - Avoid random data being sent in the request
  - e.g.,

```
INITIALIZE BAQBASE-RBK02Q01.
```

```
01 BAQBASE-RBK02Q01.
  03 requestQueryParameters.

    06 Xauthor-existence              PIC S9(9) COMP-5 SYNC.

    06 Xauthor.
      09 Xauthor2-length             PIC S9999 COMP-5 SYNC.
      09 Xauthor2                    PIC X(40).
```

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The Response message (“P”) copybook

- Multiple dynamic structures which live in the LINKAGE SECTION of the COBOL program
- Each structure must be addressed before being accessed
  - BAQ-RESP-BASE-ADDRESS
  - BAQGETN
- Every 01 level structure beyond BAQBASE is considered a Data Area

```
01 BAQBASE-RBK02P01.
  03 responseCode200-num          PIC S9(9) COMP-5 SYNC.
  03 responseCode200-dataarea     PIC X(16).

  03 responseCode404-existence    PIC S9(9) COMP-5 SYNC.
  03 responseCode404-dataarea     PIC X(16).


01 RBK02P01-responseCode200.
  03 responseCode200.
    06 Xtitle-length                 PIC S9999 COMP-5 SYNC.
    06 Xtitle                        PIC X(80).

    06 authors-num                   PIC S9(9) COMP-5 SYNC.
    06 authors-dataarea              PIC X(16).

    06 Xstatus-length                PIC S9999 COMP-5 SYNC.
    06 Xstatus                       PIC X(9).
    06 formNumber                    PIC X(12).

......

01 RBK02P01-authors.
  03 authors-length               PIC S9999 COMP-5 SYNC.
  03 authors                      PIC X(40).
......
```

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Host API Verbs – INIT & EXEC

1. Initialize the Host API and fail if the initialization was not successful

```
Initialise the Host API
CALL BAQ-INIT-NAME USING
                   BY REFERENCE BAQ-ZCONNECT-AREA.

Exit if initialisation fails
IF NOT BAQ-SUCCESS THEN GO TO EXIT-PROGRAM.
```

2. Ensure the request data is initialized and then call the API endpoint

1. If the call succeeded, address the response BAQBASE structure

```
Prepare the request data
INITIALIZE BAQBASE-RBK02Q01.
SET BAQ-REQ-BASE-ADDRESS TO ADDRESS OF BAQBASE-RBK02Q01.
MOVE LENGTH OF BAQBASE-RBK02Q01 TO BAQ-REQ-BASE-LENGTH.

Call the API
CALL BAQ-EXEC-NAME USING
                   BY REFERENCE BAQ-ZCONNECT-AREA
                   BY REFERENCE BAQ-API-INFO-RBK02I01
                   BY REFERENCE BAQ-REQUEST-AREA
                   BY REFERENCE BAQ-RESPONSE-AREA.

Address the response data
SET ADDRESS OF BAQBASE-RBK02P01 TO BAQ-RESP-BASE-ADDRESS.
```

Host API Verbs - GETN

4. Prepare the length and get the address of the next element from the Data Area

5. Use this address to access the Data Area element

6. Process the data in the Data Area element

```
Element length as input to Host API
MOVE LENGTH OF RBK02P01-responseCode200 TO WS-ELEMENT-LENGTH.

Get the next element
CALL BAQ-GETN-NAME USING
                   BY REFERENCE BAQ-ZCONNECT-AREA
                   BY REFERENCE responseCode200-dataarea
                   BY REFERENCE WS-ELEMENT
                   BY REFERENCE WS-ELEMENT-LENGTH.

Address the element
SET ADDRESS OF RBK02P01-responseCode200 TO WS-ELEMENT.
```

```
Print the title of the Redbook
STRING 'Title -> '
  Xtitle OF RBK02P01-responseCode200
      (1:Xtitle-length OF RBK02P01-responseCode200)
  DELIMITED BY SIZE
  INTO WS-TERMINAL-MSG.

PERFORM WRITE-RESPONSE-MSG.
```

Host API Verbs – FREE & TERM

7. Free the storage in use by the Host API if we have a long running transaction

```
Optionally free the storage in use by the Host API
CALL BAQ-FREE-NAME USING
                   BY REFERENCE BAQ-ZCONNECT-AREA.
```

8. Disconnect from the z/OS Connect server and free all storage in use by the Host API

```
Terminate the connection
CALL BAQ-TERM-NAME USING
                   BY REFERENCE BAQ-ZCONNECT-AREA.
```

Host API Parameters

9. Specify z/OS Connect parameters for example when overriding the URIMAP or providing authentication credentials

```
Specify a URIMAP to use
MOVE BAQZ-SERVER-URIMAP TO BAQ-ZCON-PARM-NAME(1)
SET BAQ-ZCON-PARM-ADDRESS(1) TO ADDRESS OF WS-URIMAP
MOVE LENGTH OF WS-URIMAP to BAQ-ZCON-PARM-LENGTH(1).

Initialise the Host API
```

10. Specify request parameters for example when obtaining a JWT for authenticating with the API endpoint

```
Authentication server credentials
01 JWT-USER PIC X(10) VALUE 'myUsername'.
01 JWT-PSWD PIC X(10) VALUE 'myPassword'.

Send JWT credentials to z/OS Connect
MOVE BAQR-TOKEN-USERNAME TO BAQ-REQ-PARM-NAME OF BAQ-REQ-PARMS(1)
SET BAQ-REQ-PARM-ADDRESS OF BAQ-REQ-PARMS(1) TO ADDRESS OF JWT-USER
MOVE LENGTH OF JWT-USER TO BAQ-REQ-PARM-LENGTH OF BAQ-REQ-PARMS(1)

MOVE BAQR-TOKEN-PASSWORD TO BAQ-REQ-PARM-NAME OF BAQ-REQ-PARMS(2)
SET BAQ-REQ-PARM-ADDRESS OF BAQ-REQ-PARMS(2) TO ADDRESS OF JWT-PSWD
MOVE LENGTH OF JWT-PSWD TO BAQ-REQ-PARM-LENGTH OF BAQ-REQ-PARMS(2)

Call the API endpoint using BAQEXEC
```

Host API Completion Codes

0000 - 1999

- z/OS Connect runtime messages
  - Review documentation and z/OS Connect server logs for further details

```
BAQ-ZCON-COMPLETION-CODE = 8
BAQ-ZCON-REASON-CODE = 1095
BAQ-ZCON-RETURN-MESSAGE = BAQR1095E The user credentials required to
                          request a token from the authorization
                          server, were not supplied.
```

2000 - 2999

- Host API messages
  - More details on the next slide

```
BAQ-ZCON-COMPLETION-CODE = 8
BAQ-ZCON-REASON-CODE = 2008
BAQ-ZCON-RETURN-MESSAGE = BAQH2008E: BAQINIT must be called at the
                          start of the program.
```

3000 - 3999

- Host API running in CICS
  - CICS specific messages

```
BAQ-ZCON-COMPLETION-CODE = 8
BAQ-ZCON-REASON-CODE = 3008
BAQ-ZCON-RETURN-MESSAGE = BAQH3008E: Socket error when using
                          URIMAP(BAQHZCON)
```

Host API Completion and Reason Codes

- 2000 - 2999

- **Warning** – The COBOL program can continue to use the Host API.

```
BAQ-ZCON-COMPLETION-CODE = 4
BAQ-ZCON-REASON-CODE = 2007
BAQ-ZCON-RETURN-MESSAGE = BAQH2007W: BAQINIT has already been called.
```

- **Error** – The COBOL program must take an action to continue. Review the message for required action.

```
BAQ-ZCON-COMPLETION-CODE = 8
BAQ-ZCON-REASON-CODE = 2008
BAQ-ZCON-RETURN-MESSAGE = BAQH2008E: BAQINIT must be called at the
                          start of the program.
```

- **Severe** – The COBOL program must call the BAQTERM verb immediately. Contact IBM support if the problem persists.

```
BAQ-ZCON-COMPLETION-CODE = 12
BAQ-ZCON-REASON-CODE = 2001
BAQ-ZCON-RETURN-MESSAGE = BAQH2001S: The call to BAQINIT for the
                          initialization of the Host API failed
                          unexpectedly. Service ID=16843008. Service
                          Code=1536950272.
```

/miscellaneousTopics

performance, high availability, Liberty

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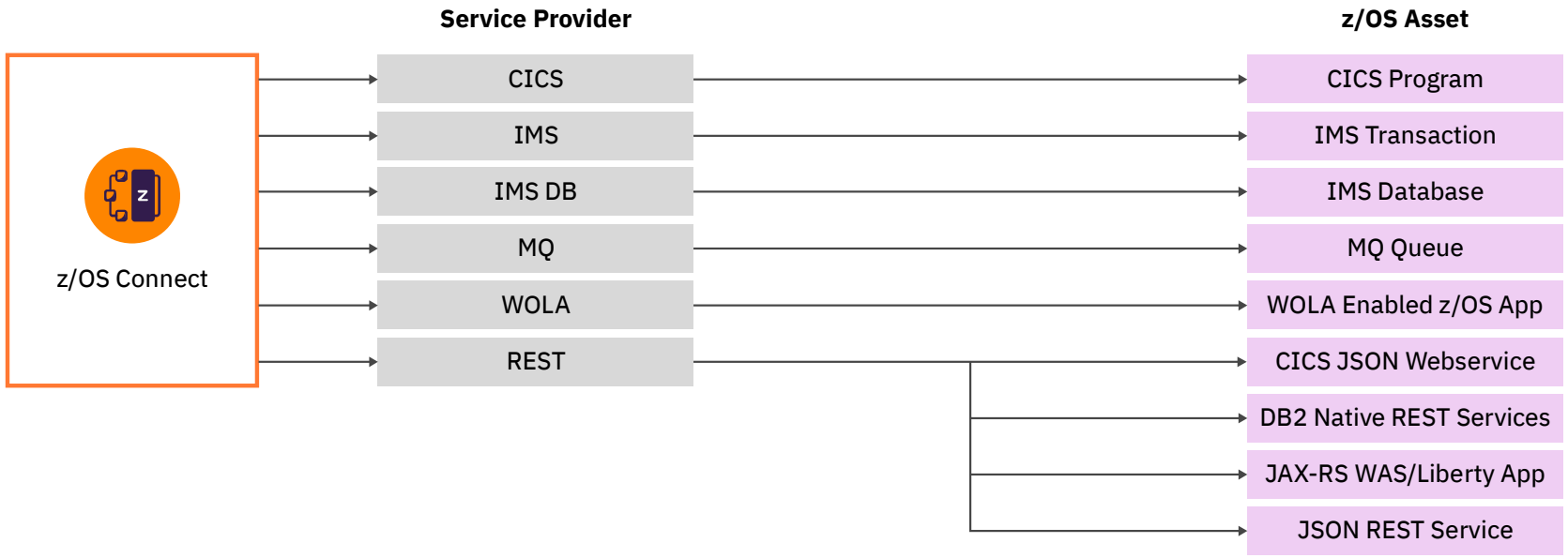
What assets can z/OS Connect EE map to?

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.

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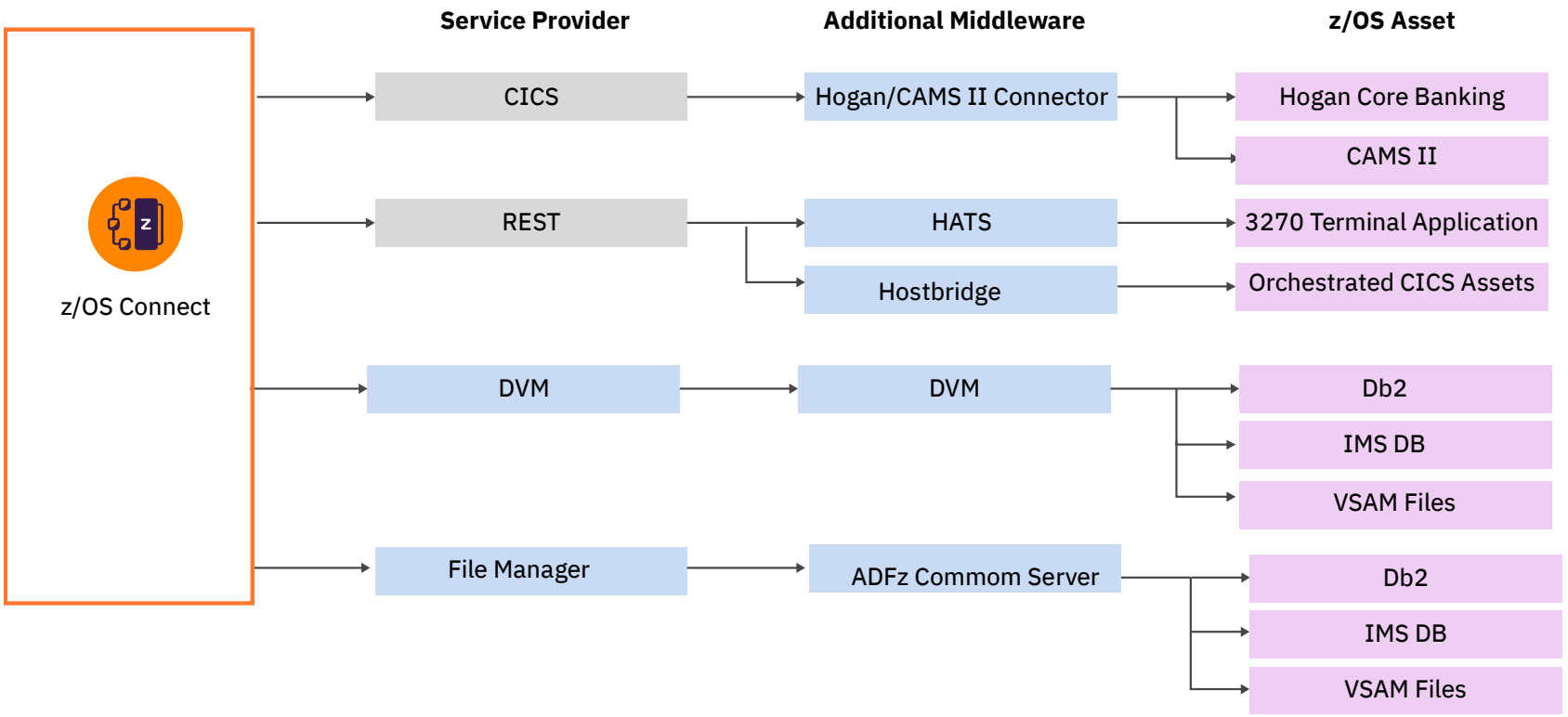
Additional Middleware

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

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API Policies

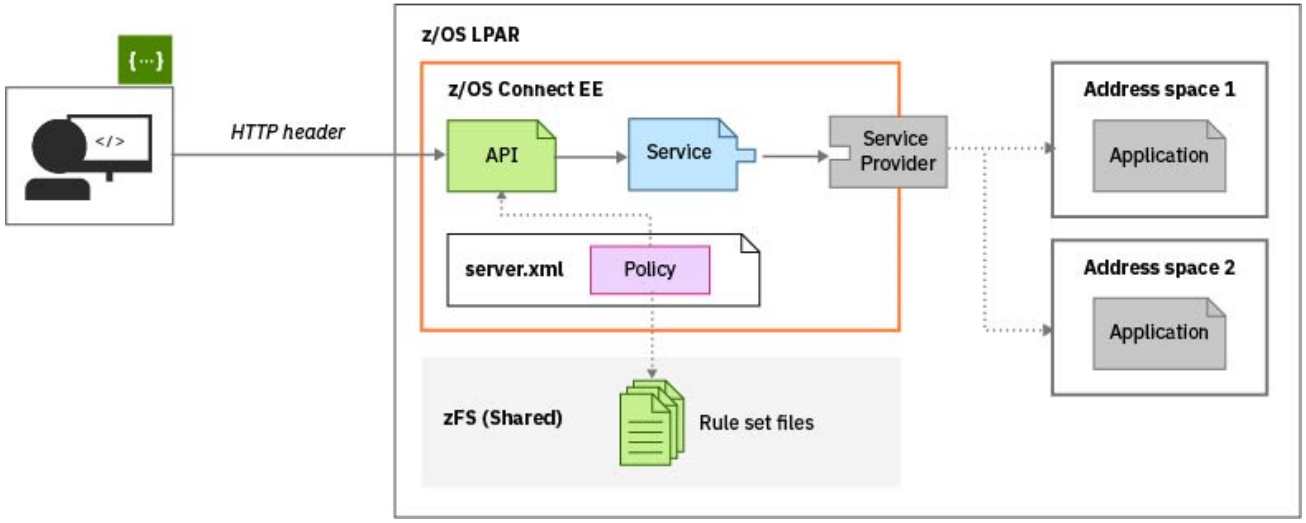
- HTTP header properties can be used to select alternative for IMS (V3.0.4) , CICS (V3.0.10), Db2 (V3.0.36) or MQ (V3.0.39)
- Policies can be configured globally for every API in the server or for individual APIs (V3.0.11)

CICS attributes
- cicsCcsid
- cicsConnectionRef
- cicsTransId

IMS attributes
- imsConnectionRef
- imsInteractionRef
- imsInteractionTimeout
- imsLtermOverrideName
- imsTranCode
- imsTranExpiration

Db2 attributes
- db2ConnectionRef
- db2CollectionID

MQ attributes
- mqConnectionFactory
- mqDestination
- mqReplyDestination



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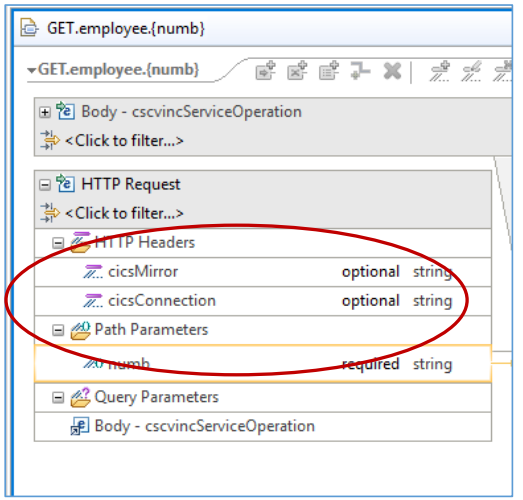
A sample API Policies for CICS

```
<ruleset name="CICS rules">
     <rule name="csmi-rule">
         <conditions>
             <header name="cicsMirror" match="ANY_VALUE"/> *
         </conditions>
         <actions>
             <set property="cicsTransId" value="${cicsMirror}"/>
         </actions>
     </rule>
     <rule name="connection-rule">
         <conditions>
             <header name="cicsConnection" value=" match="ANY_VALUE"/>
         </conditions>
         <actions>
             <set property="cicsConnectionRef" value="${cicsConnection}"
         </actions>
     </rule>
 </ruleset>
```



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)

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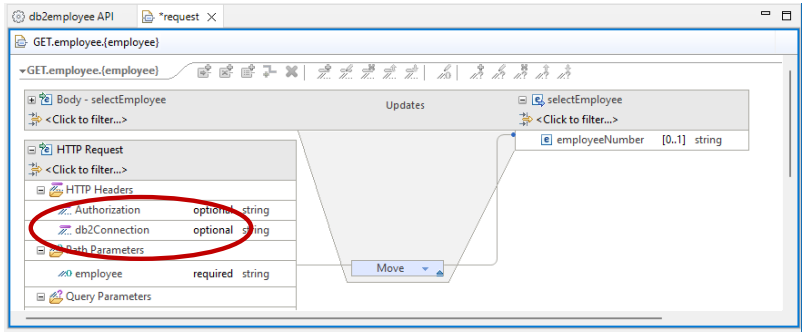
A sample API Policies for Db2

```
<ruleset name="Db2 rules">
     <rule name="connection-rule">
       <conditions>
           <header name="db2Connection" value="" match="ANY_VALUE"/>
       </conditions>
       <actions>
           <set property="db2ConnectionRef" value="${db2Connection}"/>
       </actions>
     </rule>
 </ruleset>
```




```
<zosconnect_zosConnectServiceRestClientConnection id="Db2Conn"
       sslCertsRef="db2SSLSettings" host="wg31.washington.ibm.com" port="2445" basicAuthRef="dsn2Auth" />
<zosconnect_zosConnectServiceRestClientBasicAuth id="dsn2Auth" applName="DSN2APPL"/>
<ssl id="db2SSLSettings"  keyStoreRef="Db2KeyStore"  trustStoreRef="Db2KeyStore"/>

<zosconnect_zosConnectServiceRestClientConnection id="fred"
       sslCertsRef="fredSSLSettings"  host="wg31.washington.ibm.com" port="2445" />
<ssl id="fredSSLSettings" keyStoreRef="Db2KeyStore"  trustStoreRef="Db2KeyStore" clientKeyAlias="FRED"/>

<zosconnect_zosConnectServiceRestClientConnection id="user1"
       sslCertsRef="user1SSLSettings"  host="wg31.washington.ibm.com"  port="2445" />
<ssl id="user1SSLSettings" keyStoreRef="Db2KeyStore"  trustStoreRef="Db2KeyStore" clientKeyAlias="USER1"/>

<keyStore id="Db2KeyStore" location="safkeyring:///zCEE.Db2.KeyRing"
       password="password" type="JCERACFKS" fileBased="false" readOnly="true" />
```

Requires APAR PH53162

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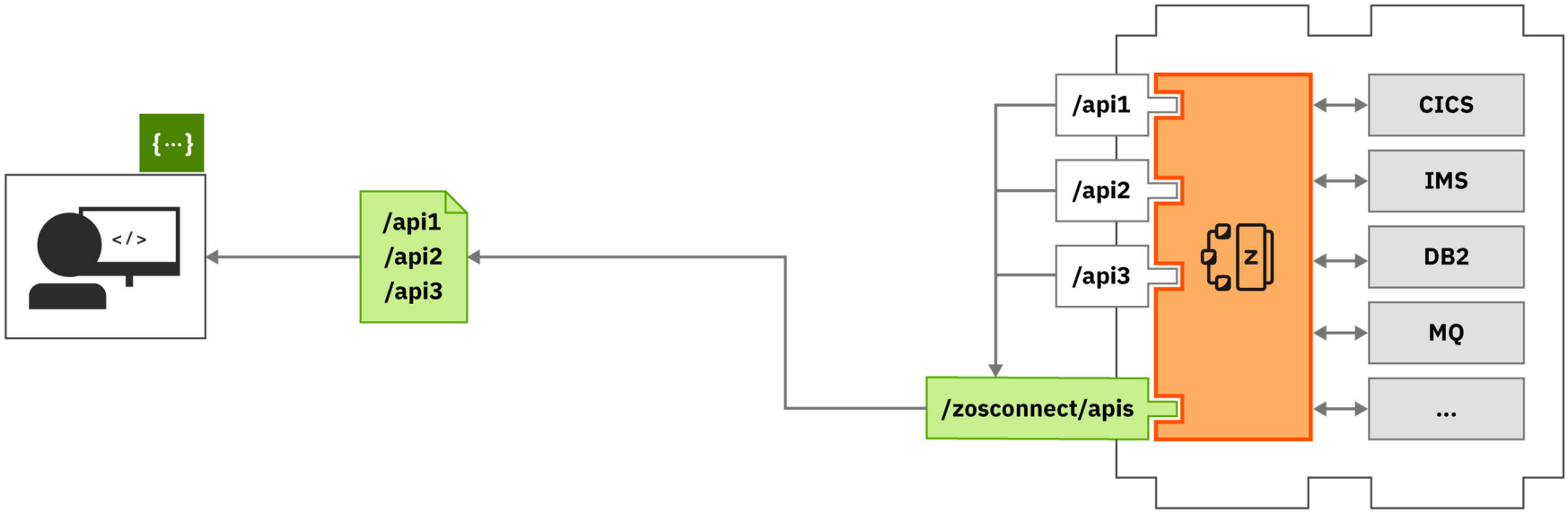
API Documentation



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

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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

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RESTful Administrative Interface for Services

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

Most administration tasks are supported by the RESTful administration interface

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

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

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

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RESTful Administrative Interface for APIs

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

Most administration tasks are supported by the RESTful administration interface

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

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

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RESTful Administrative Interface for API Requesters

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

Most administration tasks are supported by the RESTful administration interface

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

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

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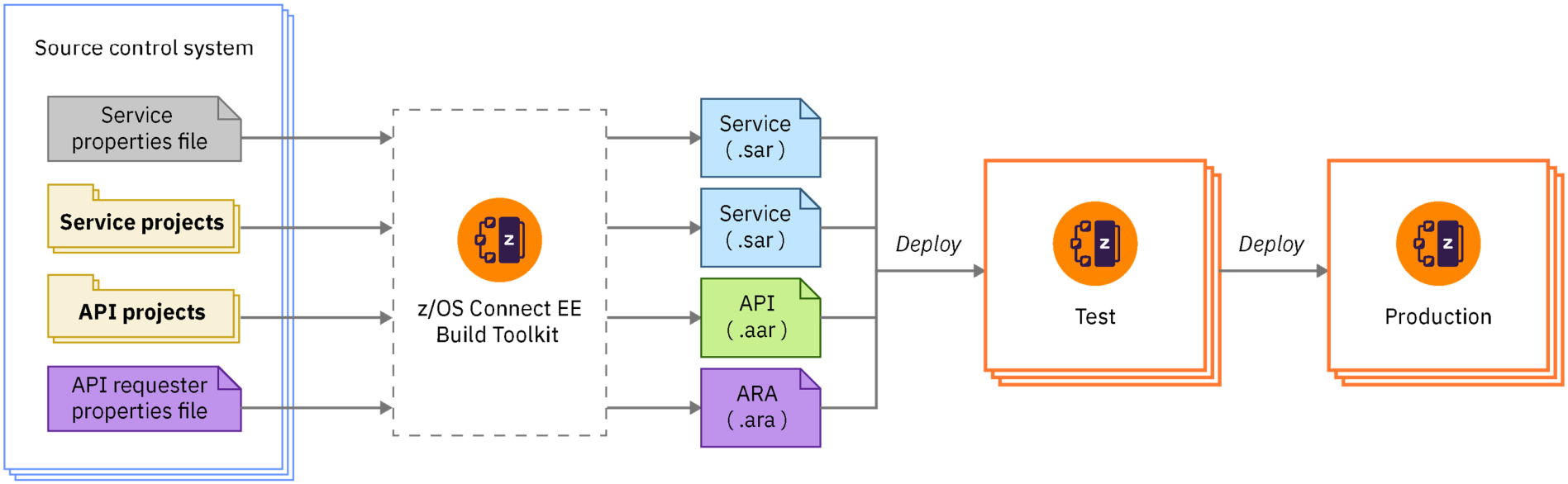
DevOps using z/OS Connect EE

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 deployment directories or by using the REST Admin API



/security

How is security implement?

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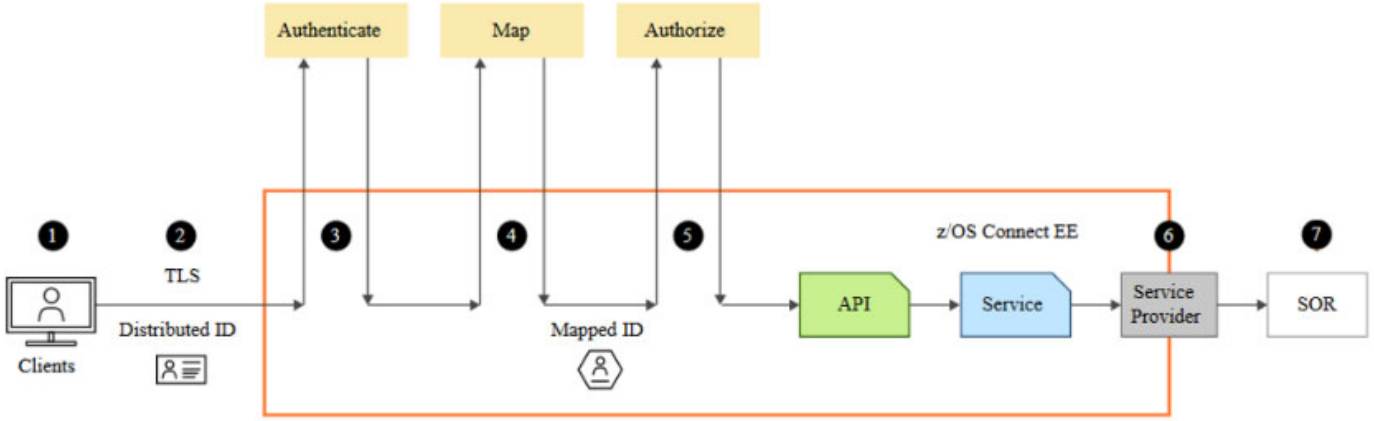
Typical z/OS Connect EE API Provider security flow



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

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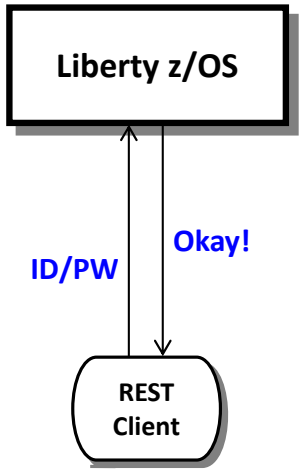
API Provider Authentication

Several different ways this can be accomplished:

Basic Authentication



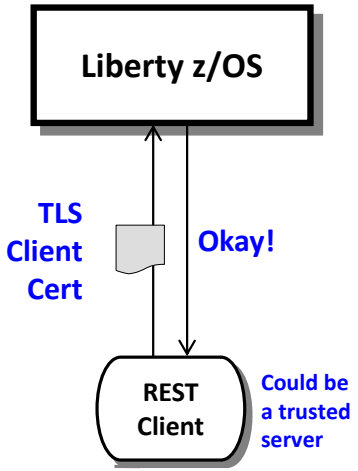
Server prompts for ID/PW

Client supplies ID/PW or ID/Passticket

Server checks registry:

- Basic (server.xml)
- LDAP
- SAF

Client Certificate



Server prompts for cert.

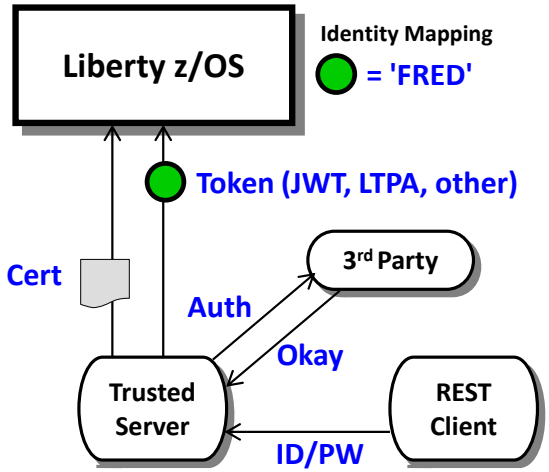
Client supplies certificate

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

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OPENAPI 3 roles

cscvinc.yaml - Notepad

File Edit Format View Help

```
openapi: 3.0.1
info:
  title: cscvinc
  description: ""
  version: 1.0.0
servers:
- url: /cscvinc
x-ibm-zcon-roles-allowed:
- Manager
paths:
  /employee:
    post:
      tags:
      - cscvinc
      operationId: postCscvincInsertService
      x-ibm-zcon-roles-allowed:
        - Staff
      parameters:
      - name: Authorization
        in: header
        schema:
          type: string
      requestBody:
        description: request body
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/postCscvincInsertService_request'
        required: true
      responses:
        200:
          description: OK
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/postCscvincInsertService_response_200'
      x-codegen-request-body-name: postCscvincInsertService_request
  /employee/{employee}:
    get:
      tags:
      - cscvinc
      operationId: getCscvincSelectService
      x-ibm-zcon-roles-allowed:
        - Staff
      parameters:
      - name: Authorization
        in: header
        schema:
          type: string
```

Ln 44, Col 16 100% Unix (LF) UTF-8

```
<!-- Enable features -->
   <featureManager>
       <feature>appSecurity-2.0</feature>
   </featureManager>
   <webAppSecurity allowFailOverToBasicAuth="true" />

   <basicRegistry id="basic" realm="zosConnect">
       <user name="Fred" password="fredpwd" />
       <user name="user1" password="user1" />
       <user name="user2" password="user2" />
       <user name="user3" password="user3" />
    <group name="Manager">
          <member name="Fred"/>
    </group>
    <group name="Staff">
          <member name="Fred"/>
          <member name="user1"/>
          <member name="user2"/>
    </group>
   </basicRegistry>

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

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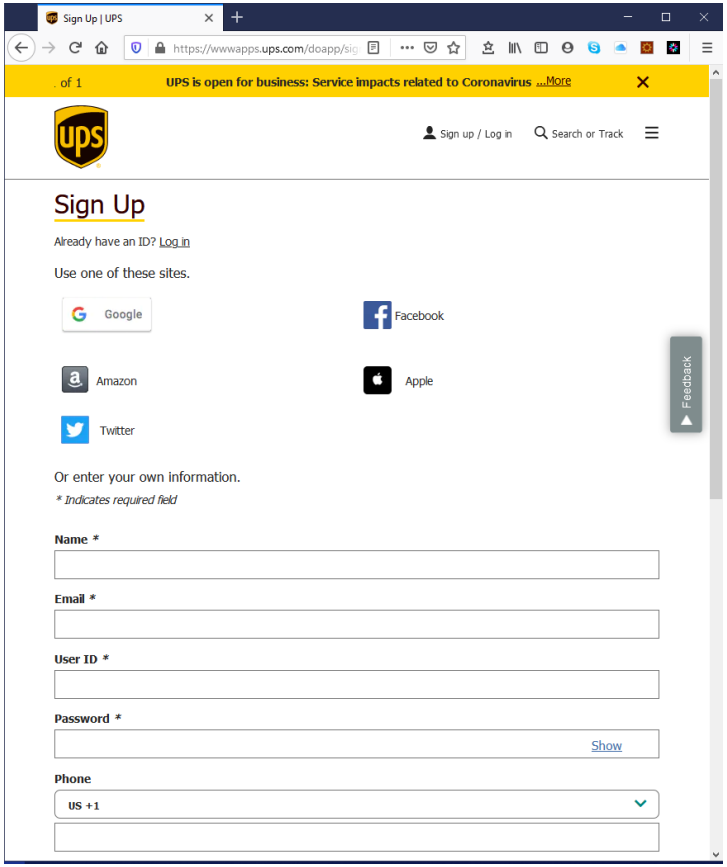
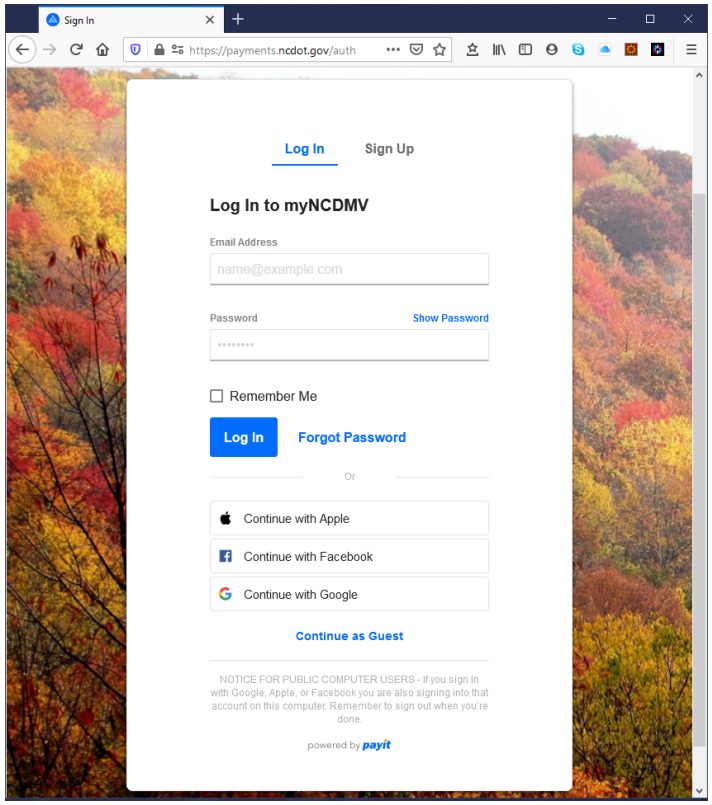
Third Party Authentication Examples





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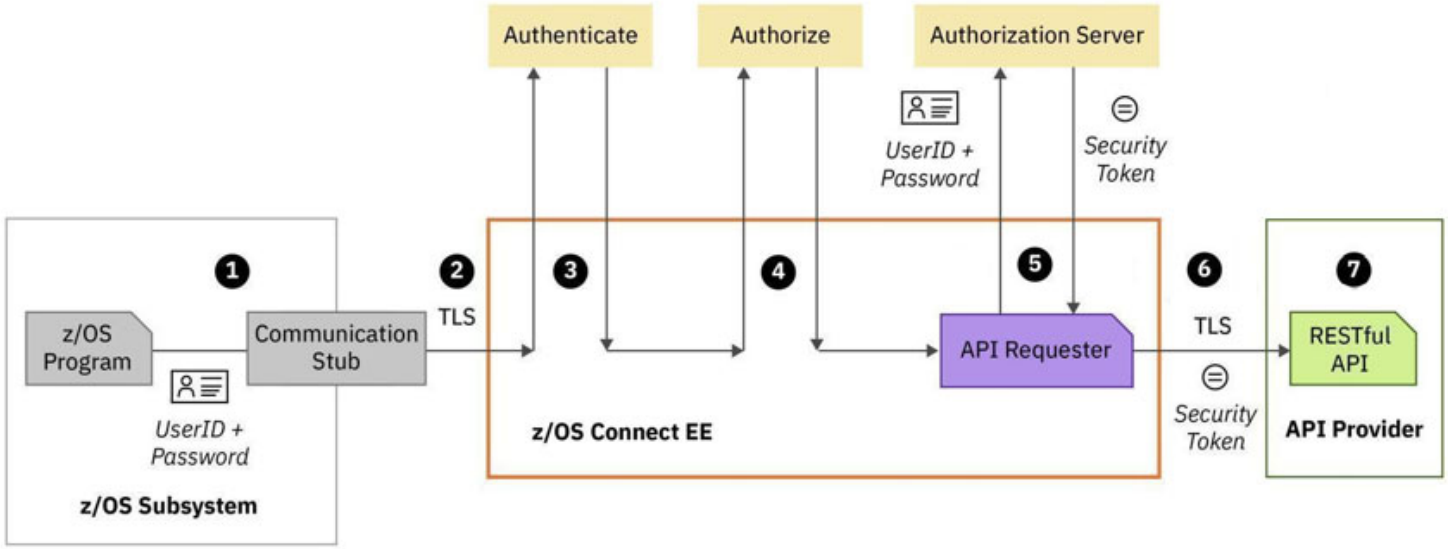
Typical z/OS Connect EE API Requester security flow



1. A user ID and password can be used for basic authentication by the z/OS Connect EE server
2. Connection between the CICS, IMS, or z/OS application and the z/OS Connect EE server can use TLS
3. Authenticate the CICS, IMS, or z/OS application.
4. Authorize the authenticated user ID to connect to z/OS Connect EE and to perform specific actions on z/OS Connect EE API requesters
5. 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

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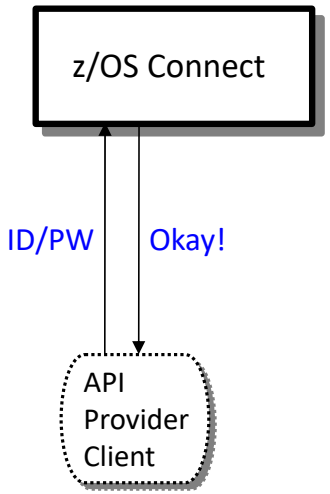
z/OS Application to z/OS Connect API Requester

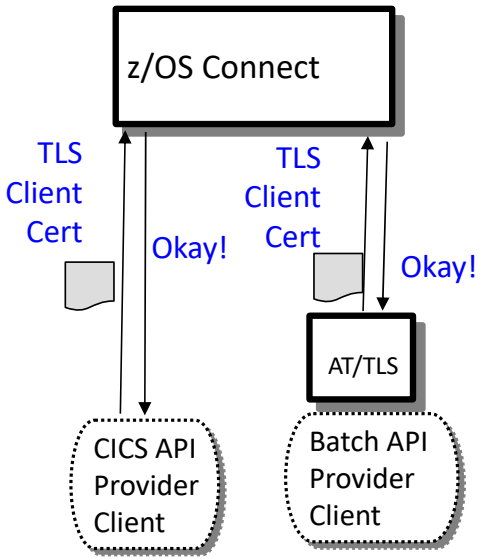
Two options for providing credentials for authentication

Basic Authentication



Application provides ID/PW or ID/PassTicket

Client Certificate



z/OS Connect requests a client certificate

CICS or AT/TLS supplies a client certificate

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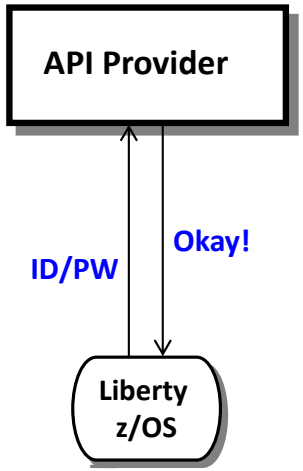
mitchj@us.ibm.com

API Requester - API Provider Authentication

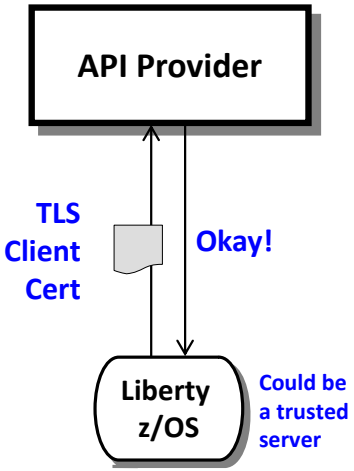
Several different ways this can be accomplished:

Basic Authentication



zCEE supplies ID/PW or ID/Passticket

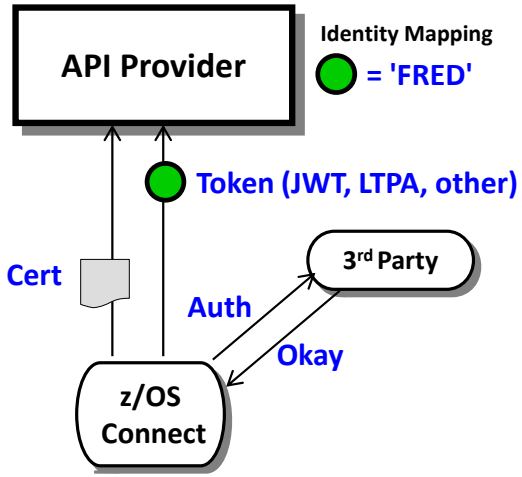
Client Certificate



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

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Basic authentication – non-CICS COBOL API Requester

- A MVS batch, IMS or Db2 stored procedure requester application sends basic authentication information (identity and password) by using environment variables.
  - BAQUSERNAME
  - BAQPASSWORD

- The variables can be provided in JCL using CEEOPTS DD statement:

```
//CEEOPTS  DD *
     POSIX(ON),
     ENVAR("BAQURI=wg31.washington.ibm.com",
    "BAQPORT=9080",
    "BAQUSERNAME=USER1",
    "BAQPASSWORD=USER1")
```

- Or, provided by using a CEEROPT or CEEUOPT module:

```
CEEROPT CSECT
CEEROPT AMODE ANY
CEEROPT RMODE ANY
CEEXOPT POSIX=((ON),OVR),                                          +
               ENVAR=(('BAQURI=wg31.washington.ibm.com',           +
               'BAQPORT=9120',                                     +
               'BAQUSERNAME=USER1',                                +
               'BAQPASSWORD=USER1'),OVR),                          +
               RPTOPTS=((ON),OVR)
       END
```

Tech/Tip: This is good opportunity to use a pass ticket rather than a password

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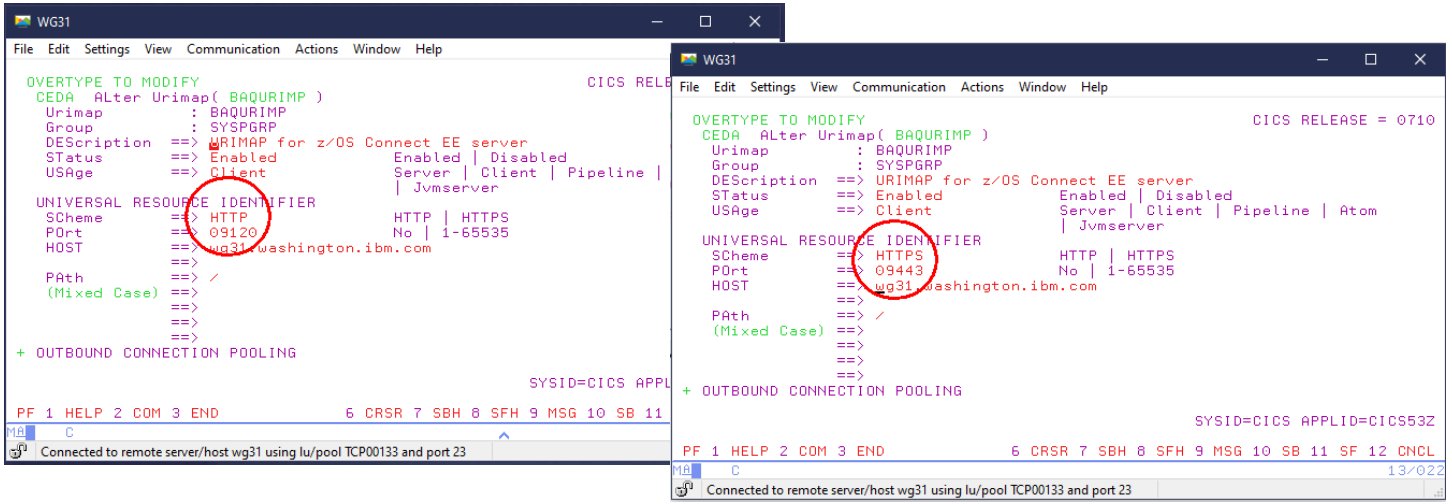
Tech/Tip: API Requester - HTTP v HTTPS

MVS Batch and IMS with and without an outbound AT-TLS policy

```
CEEOPTS DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9080")
```

```
CEEOPTS DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9443")
```

CICS URIMAPs



Field BAQ-ZCON-SERVER-URI was added to BAQRINFO in V3.0.37.

MOVE "URIMAP01" TO BAQ-ZCON-SERVER-URI.

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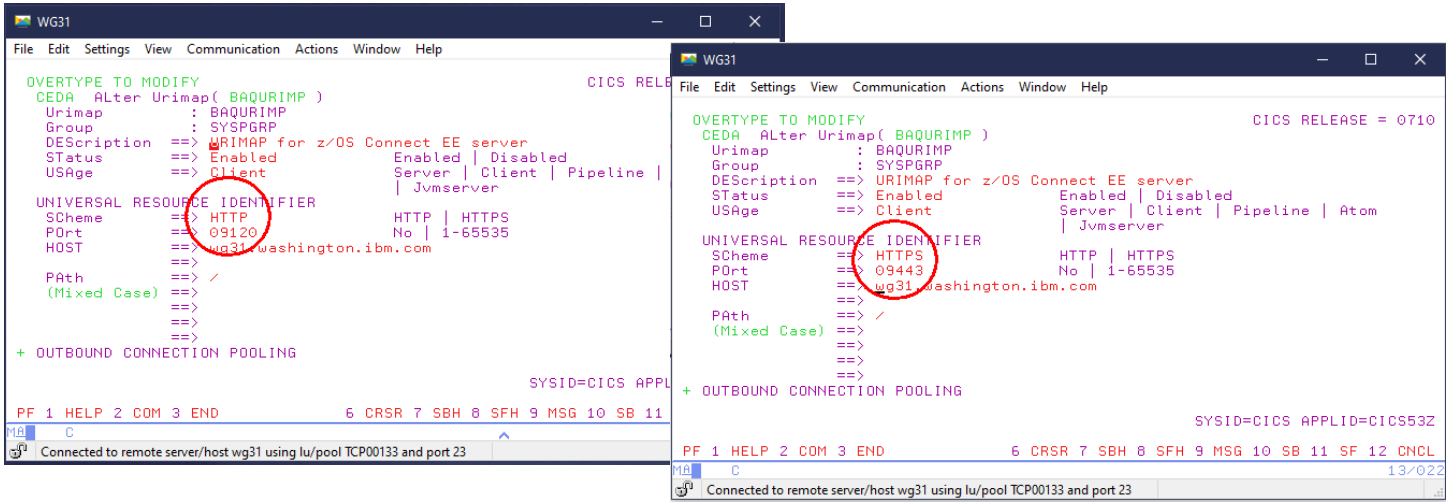
Tech/Tip: API Requester - HTTP v HTTPS

MVS Batch and IMS with and without an outbound AT-TLS policy

```
CEEOPTS DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9080")
```

```
CEEOPTS DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9443")
```

CICS URIMAPs



Field BAQ-ZCON-SERVER-URI was added to BAQRINFO in V3.0.37.

MOVE "URIMAP01" TO BAQ-ZCON-SERVER-URI.

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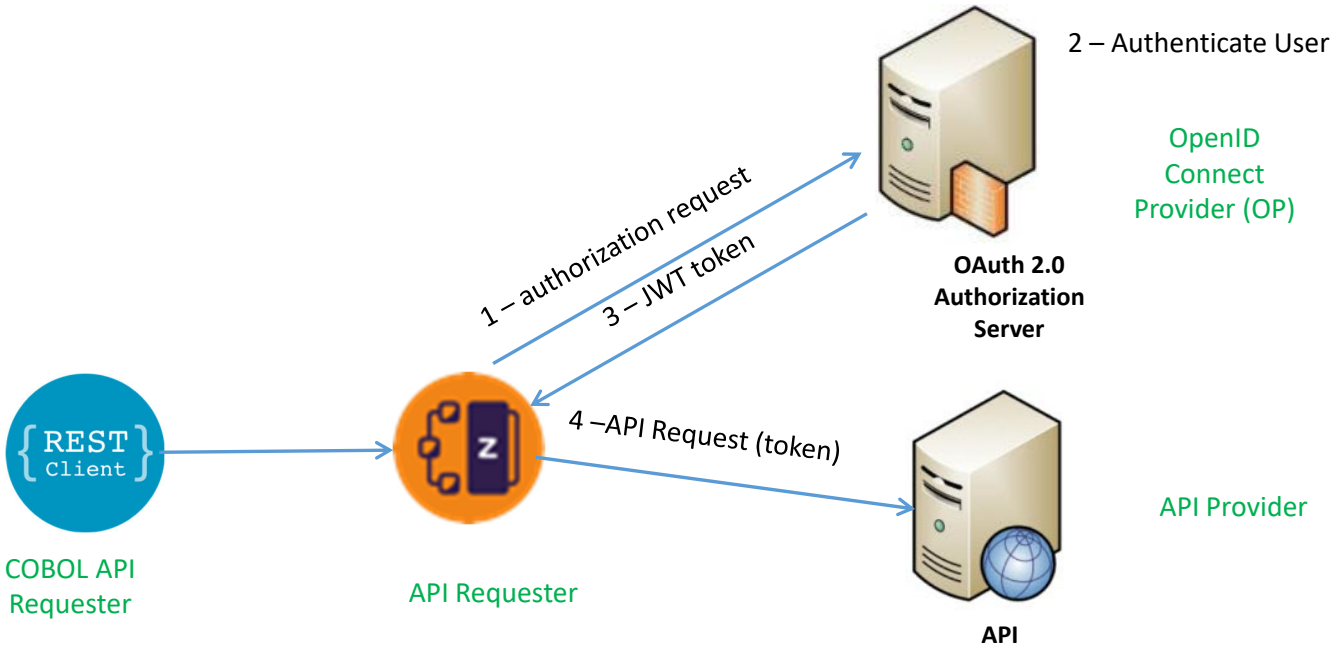
z/OS Connect OAuth Flow for API requester



Grant Types:

- client_credentials
- password

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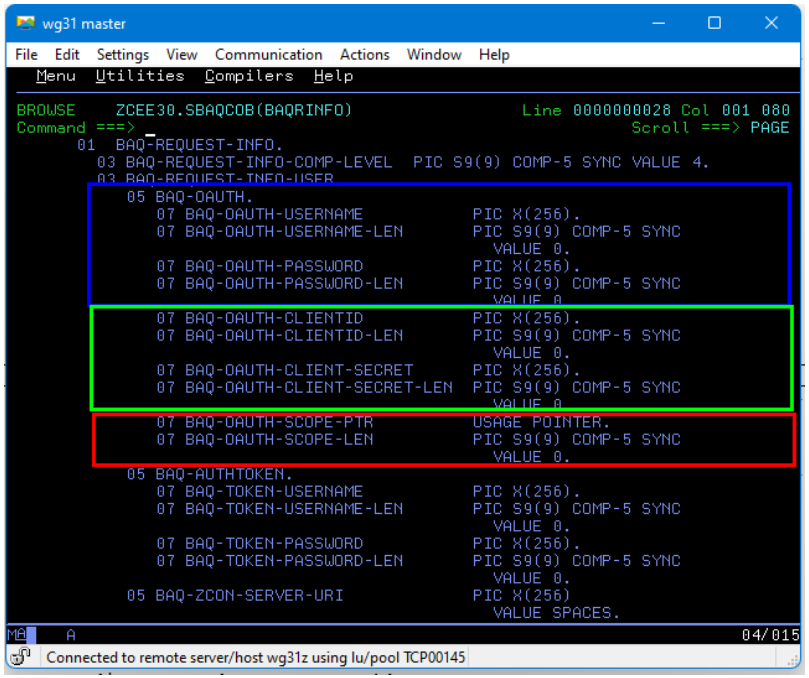
Configuring OAuth support – BAQRINFO copy book



Grant Type: *password* - The identity of the user provided by the CICS, IMS, or z/OS application, or it might be another entity. Client_credentials can be supplied by the program or in the server XML configuration.

Grant Type: *client_credentials* - the identity associated with the combination of the CICS, IMS, or z/OS application, and the z/OS Connect EE server that calls the RESTful API on behalf of the CICS, IMS, or z/OS application

Scope is always required.

OAuth 2.0 specification entity	password	client_credentials	Where Set
Client ID	required	Required	server.xml or by application
Client Secret	optional	Required	server.xml or by application
Username	required	N/A	by application
Password	required	N/A	by application

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Agenda

- An Introduction and Overview of using REST API
- Enabling RESTful API to various z/OS resources, e.g.
  - CICS
  - Db2
  - IMS/TM
  - IMS/DB
  - MQ
  - Outbound REST APIs

- Accessing RESTful API from z/OS COBOL Applications
- 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*

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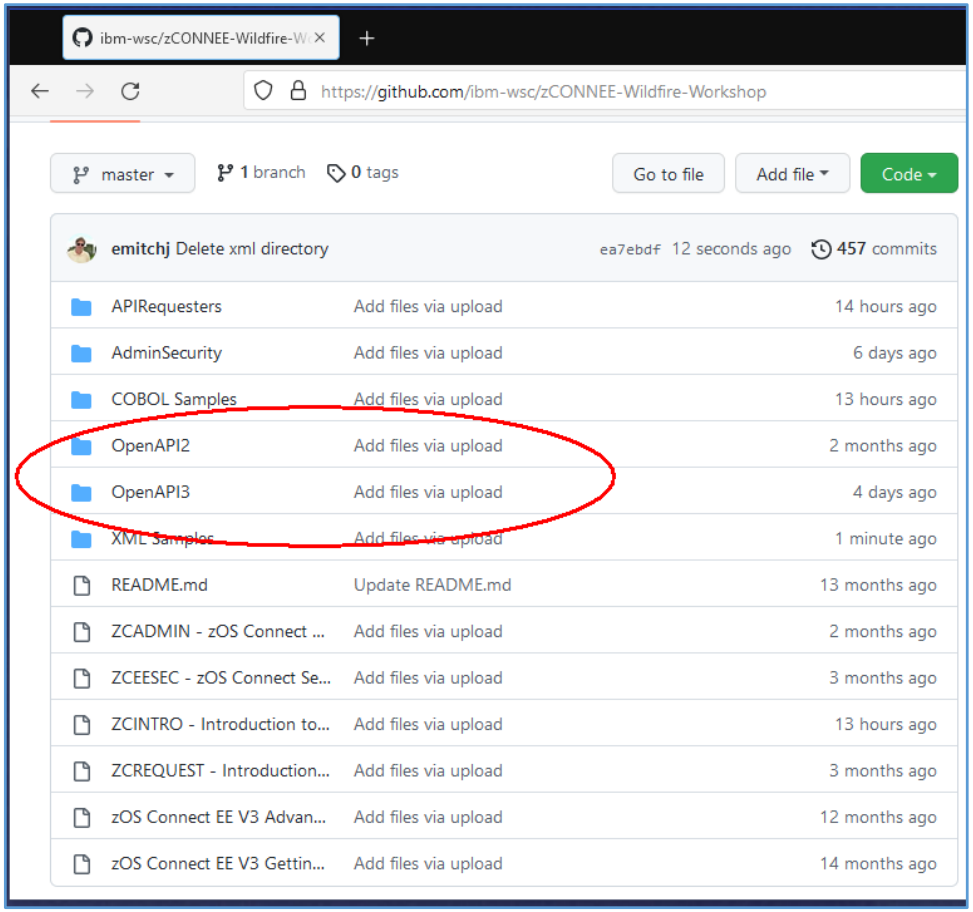
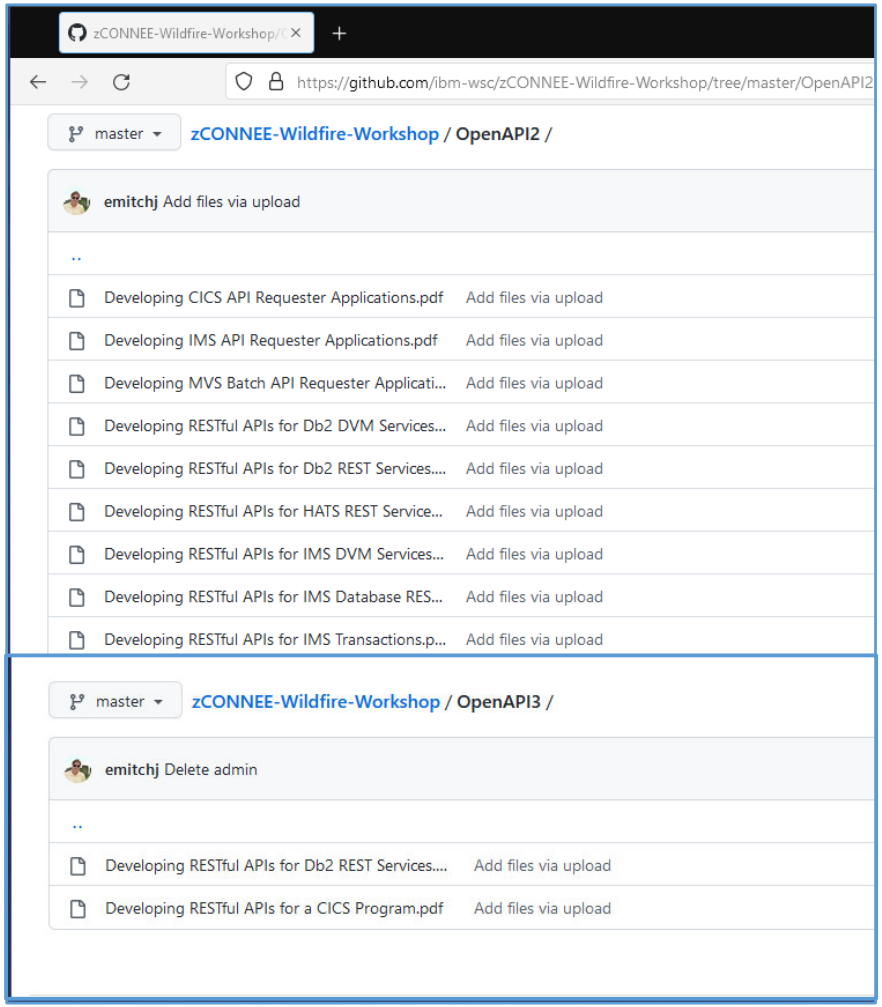
z/OS Connect Wildfire Github Site

https://ibm.biz/zCEEWorkshopMaterial





- **Contact your IBM representative to schedule access to these exercises**

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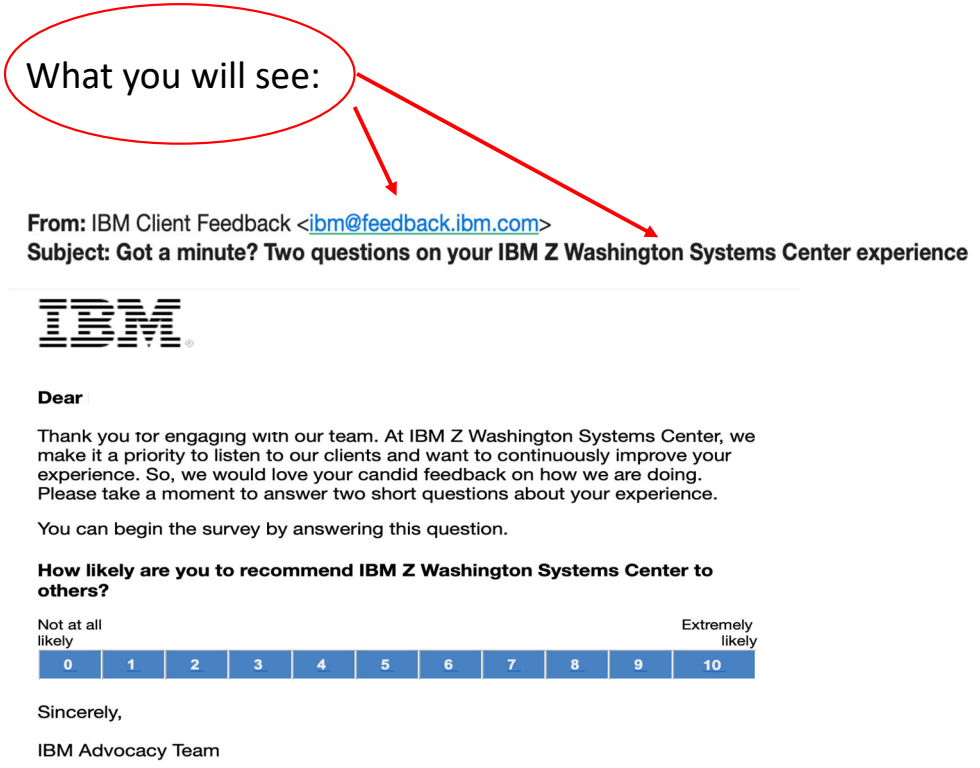
WSC wants your feedback!

What you will see:



From: IBM Client Feedback <ibm@feedback.ibm.com>
Subject: Got a minute? Two questions on your IBM Z Washington Systems Center experience

IBM

Dear

Thank you for engaging with our team. At IBM Z Washington Systems Center, we make it a priority to listen to our clients and want to continuously improve your experience. So, we would love your candid feedback on how we are doing. Please take a moment to answer two short questions about your experience.

You can begin the survey by answering this question.

How likely are you to recommend IBM Z Washington Systems Center to others?

Not at all likely										Extremely likely
0	1	2	3	4	5	6	7	8	9	10

Sincerely,

IBM Advocacy Team

you will NOT receive a new survey if you already responded to an IBM Survey from Medallia in the last **60 days OR if you haven't responded within the last **30 days****

Thank you for listening and your questions

And thank you for completing the Medallia survey

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