IBM z/OS Connect Enterprise Edition

Introduction and Overview

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Agenda

- z/OS Connect Introduction and overview
- Self paced, hands-on exercises to API enable z application from various sub-systems, e.g.
  - CICS
  - DB2
  - IMS/TM
  - MQ
  - IBM DVM
  - IBM File Manager
  - MVS Batch
  - Outbound REST APIs
  - 3270 screen based applications
- z/OS Connect Security

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

z/OS Connect EE

z/OS Connect EE

- CICS
- IMS
- DB2
- MQ
- IBM File Manager
- 3270
- IBM DVM
- MVS
- WAS
- Custom*

* Other Vendors or your own implementation

/but_first, what_is_REST?

What makes an API "RESTful"?

REST is an Architectural Style

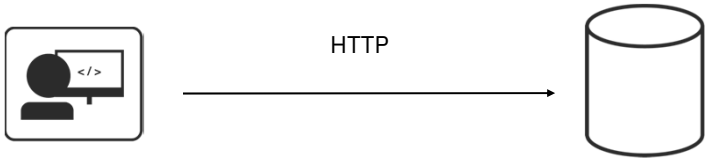
z/OS Connect EE

REST stands for **Re**presentational **S**tate **T**ransfer.

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

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

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



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

Key Principles of REST

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

GET
POST
PUT
DELETE

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

Path and Query parameters are used for refinement of the request

URIs represent things (or lists of things)

Request/Response Body is used to represent the data object

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

REST vs RESTful

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- REST is an architectural style of development having these principles plus..
- It should be stateless
- It should access all the resources from the server using only URI
- For performing CRUD operations, it should use HTTP verbs such as get, post, put and delete
- It should return the result only in the form of JSON

- REST based services follow some of the above principles and not all, whereas RESTful means it follows all the above principles.

- Remember - Not all REST APIs are RESTful APIs
- The key is consistency, RESTful APIs are consistent, REST APIs are not

7

RESTful Examples

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POST `/account?name=Fred` + *(JSON with Fred's information)*

GET `/account?number=1234`

PUT `/account?number=1234` + *(JSON with dollar amount of deposit)*

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

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

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

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

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

Not every REST API is a RESTful API

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(How to know if you are doing it wrong)

1. Unique URIs for different 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

```
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 in the request body

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

→

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


Why is REST popular?

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

How do we describe a REST API?

/swagger/open_api

The industry standard framework for describing RESTful APIs.

Why use Swagger?

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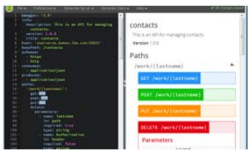
It is more than just an API framework

OPEN API INITIATIVE

There are a number of tools available to aid consumption:

Write Swagger

Swagger Editor allows API developers to design their swagger documents.



Read Swagger

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

Consume Swagger

Swagger Codegen create stub code to consume APIs from various languages

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

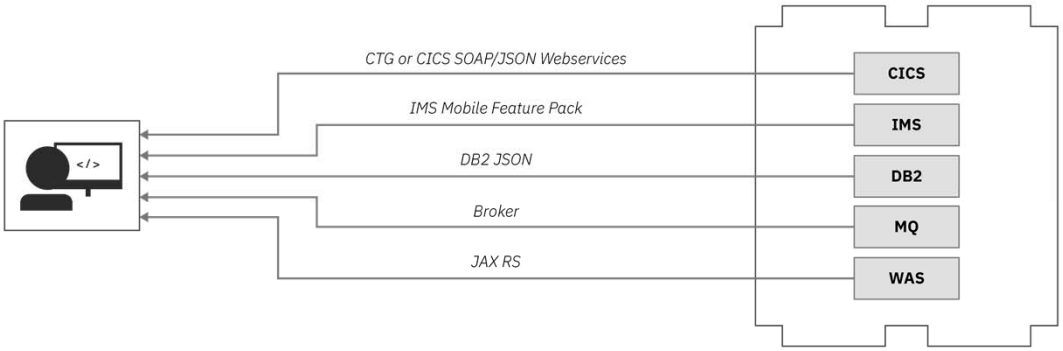
Example: https://developer.psa-peugeot-citroen.com/inc/

Why /zos_connect_ee?

Truly RESTful APIs to and from your mainframe.

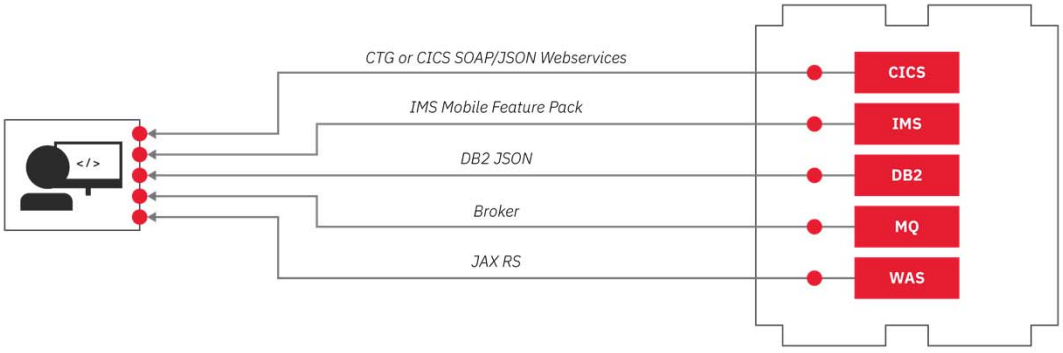
Can't we do REST and JSON today?

z/OS Connect EE



Yes, but....

z/OS Connect EE



Completely different configuration and management.

Multiple endpoints for developers to call/maintain access to.

These are typically not RESTful!

A single entry point is needed

z/OS Connect EE

Expose z/OS resources without writing any code.

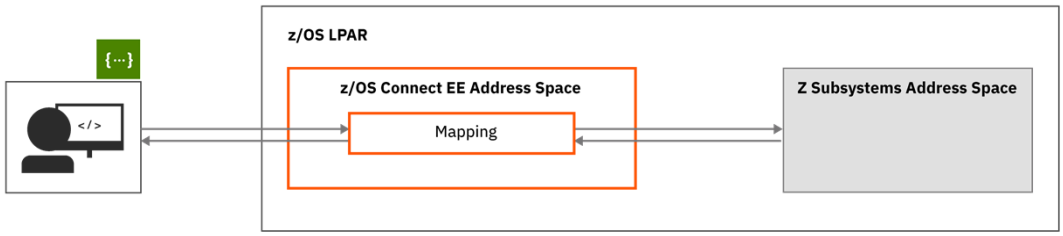
- Single Configuration Administration
- Single Security Administration
- With sophisticated mapping of truly RESTful APIs to existing mainframe and services data without writing any code.

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

Let's Start with Data mapping

z/OS Connect EE

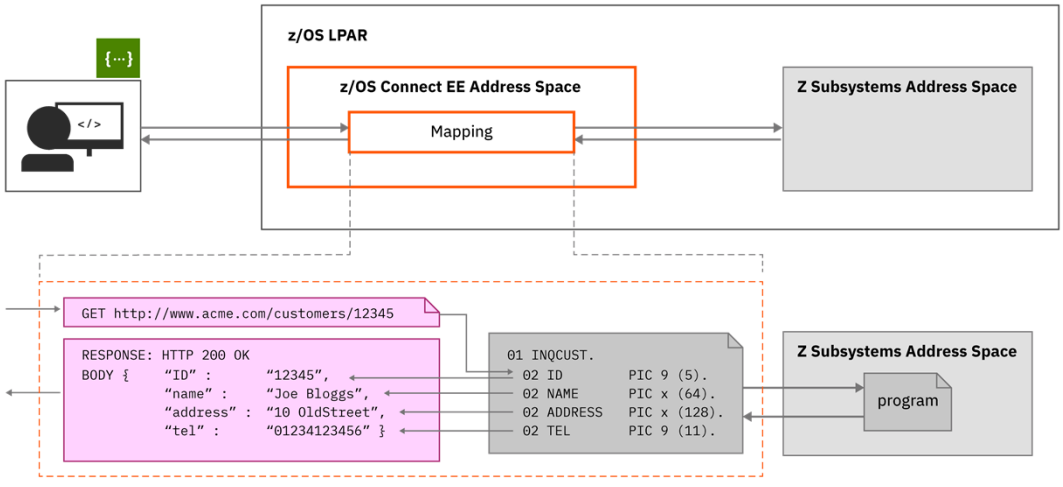
Converting from JSON to the target's subsystem's format



Data mapping Example

z/OS Connect EE

A closer look



COBOL versus JSON Example

z/OS Connect EE

```
01 MINILOAN-COMMAREA.
          10 name pic X(20).
          10 creditScore pic 9(16)V99.
          10 yearlyIncome pic 9(16)v99.
          10 age pic 9(10).
          10 amount pic  9999999v99.
          10 approved pic X.
              88 BoolValue value 'T'.
          10 effectDate pic X(8).
          10 yearlyInterestRate pic S9(5).
          10 yearlyRepayment pic 9(18).
          10 messages-Num pic 9(9).
          10 messages pic X(60) occurs 1 to 99 times
                        depending on messages-Num.
```

```
"miniloan_commarea":{
              "type":"object",
              "properties":{
                 "name":{
                    "type":"string",
                    "maxLength":20
                 },
                 "creditScore":{
                    "type":"number",
                    "format":"decimal",
                    "multipleOf":0.01,
                    "maximum":9999999999999999.99,
                    "minimum":0
                 },
```

COBOL Source v JSON

“name”:”Mitch Johnson”,
“creditScore”:100

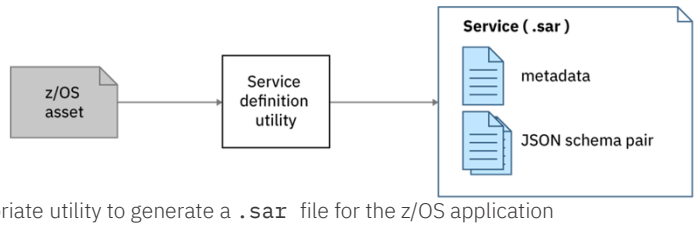
All data is sent as character strings and numeric precision and sign bit is removed as an issue

Steps to expose a z/OS application

z/OS Connect EE

1. Create a service definition

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



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

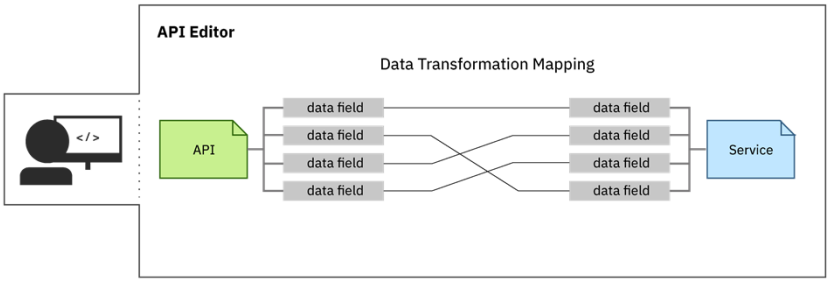
- API Toolkit (CICS and IMS)
- BAQLS2JS (MQ and WOLA)
- z/OS Connect EE Build Toolkit (DB2 and HATS)
- DVM Toolkit

ibm.biz/zosconnect-sar-creation

Steps to expose a z/OS application

z/OS Connect EE

2. Create an API



Import your `.sar` file into the **API toolkit**, and start designing your API.

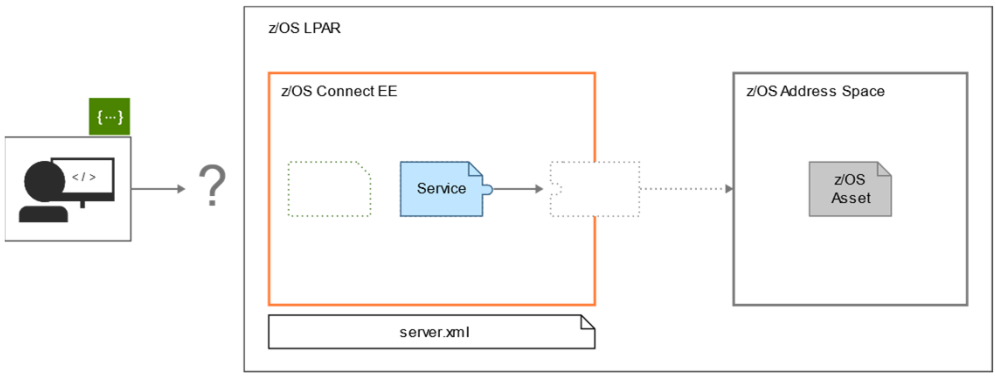
From the editor, create an **API Archive file** (`.aar`), which describes your API and how it maps to underlying services.

ibm.biz/zosconnect-create-api

Steps to expose a z/OS application

z/OS Connect EE

3. Deploy your service



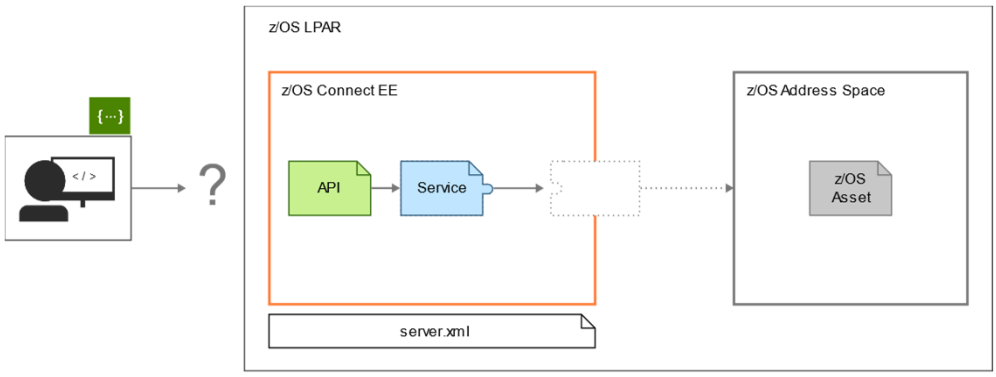
Deploy the `.sar` file generated in **Step 2** using the right-click deploy in **the API toolkit**, or by copying the `.sar` file to the services directory.

ibm.biz/zosconnect-define-services

Steps to expose a z/OS application

z/OS Connect EE

4. Deploy your API



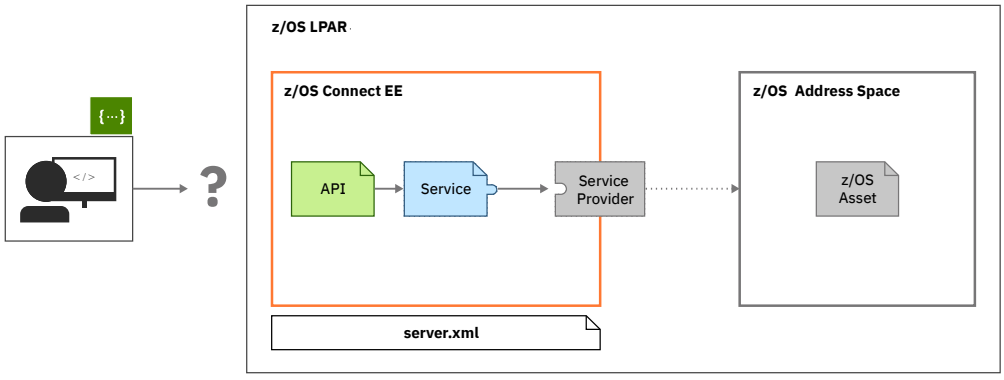
Deploy your API using the right-click deploy in **the API toolkit**, or by copying the `.aar` file to the *apis* directory.

ibm.biz/zosconnect-deploy-api

Steps to expose a z/OS application

z/OS Connect EE

5. Configure your service provider



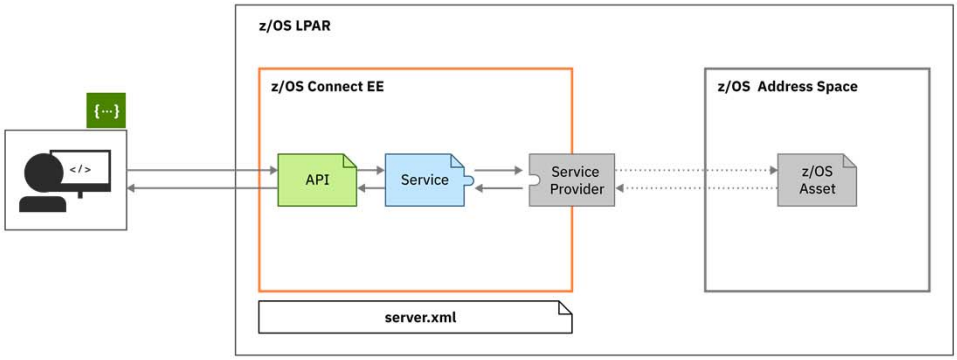
Configure the system-appropriate service provider to connect to your backend system in your `server.xml`.

ibm.biz/zosconnect-configuring

Steps to expose a z/OS application

z/OS Connect EE

6. Done



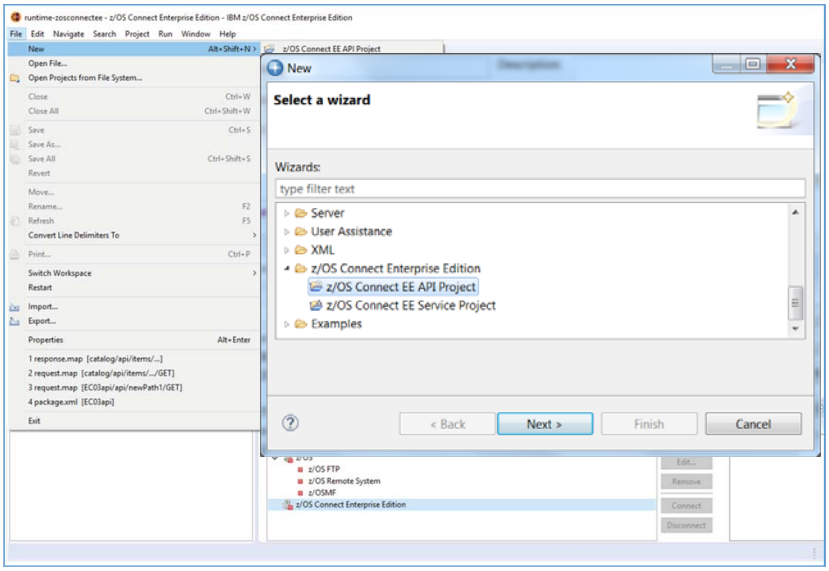
Your API is ready to be consumed: go tell your developers!

/api_toolkit/services

Simple **service creation**.

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE



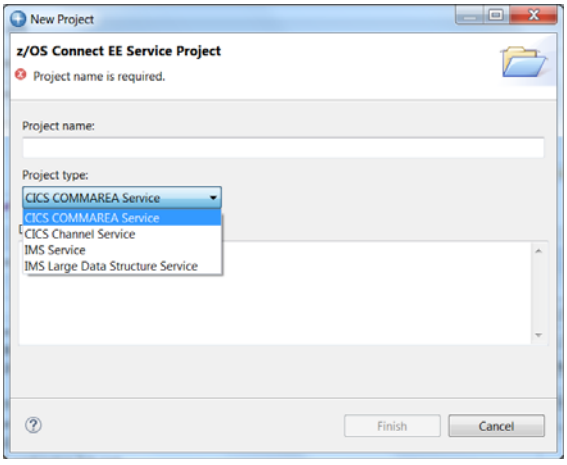
Use the **API toolkit** to create services through Eclipse-based tooling.

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

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Service creation – a common interface

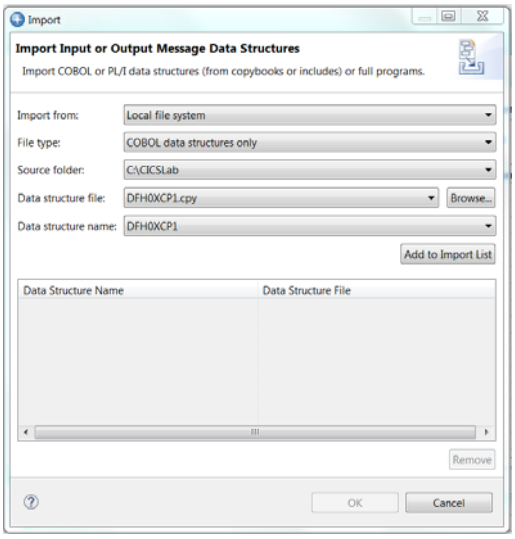


A common interface for service creation, agnostic of back end subsystem.

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Creating a service project



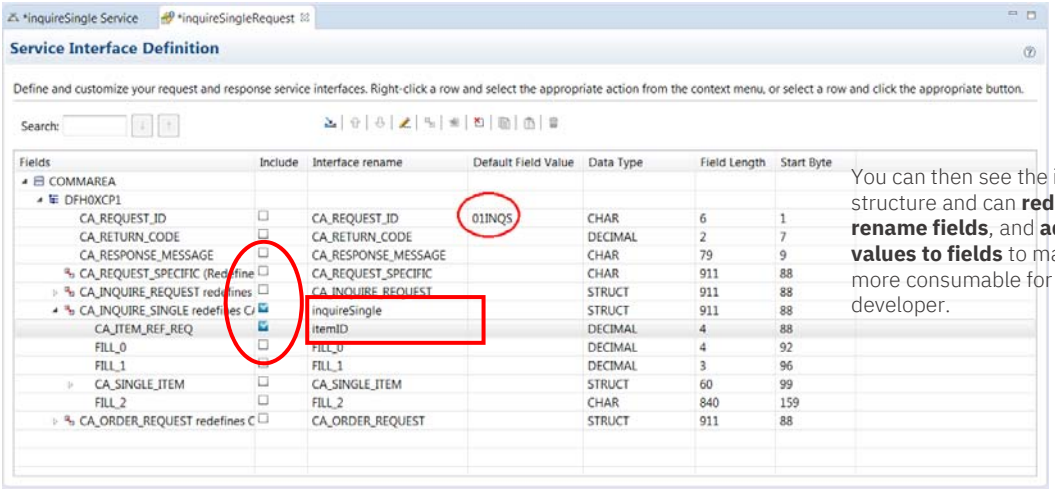
You start by importing data structures into the service interface from the local file system or the workspace.

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

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Creating a service interface definition

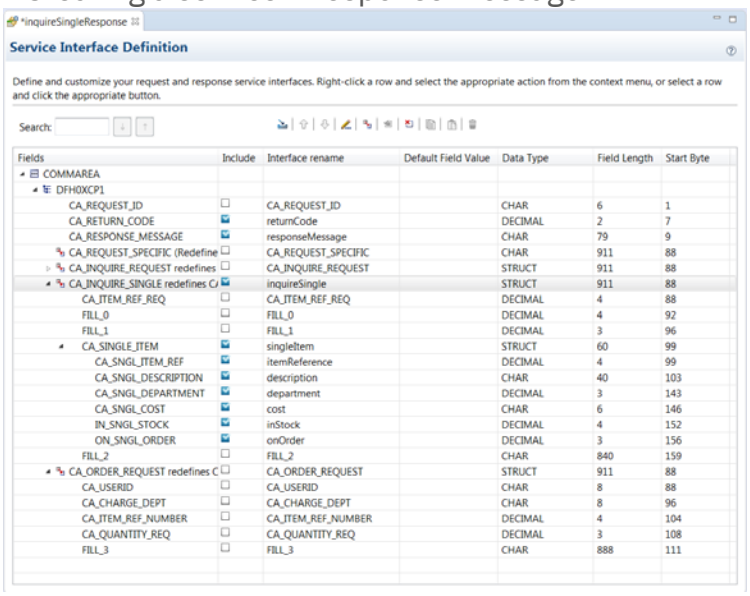


You can then see the imported data structure and can **redact fields**, **rename fields**, and **add default values to fields** to make the service more consumable for an API developer.

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Creating a service – response message



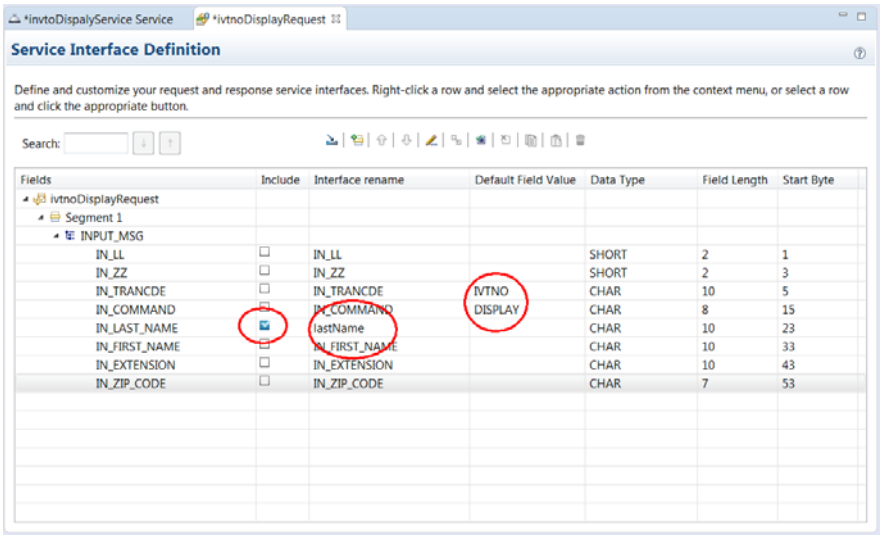
Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
COMMAREA						
DFH0XCP1						
CA_REQUEST_ID	☐	CA_REQUEST_ID		CHAR	6	1
CA_RETURN_CODE	☑	returnCode		DECIMAL	2	7
CA_RESPONSE_MESSAGE	☑	responseMessage		CHAR	79	9
CA_REQUEST_SPECIFIC (Redefine	☐	CA_REQUEST_SPECIFIC		CHAR	911	88
CA_INQUIRE_REQUEST redefines	☐	CA_INQUIRE_REQUEST		STRUCT	911	88
CA_INQUIRE_SINGLE redefines CA	☑	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 C	☐	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

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

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Creating a "GET" service interface request definition



Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
ivtnoDisplayRequest						
Segment 1						
INPUT_MSG						
IN_LL	☐	IN_LL		SHORT	2	1
IN_ZZ	☐	IN_ZZ		SHORT	2	3
IN_TRANCDE	☐	IN_TRANCDE	IVTNO	CHAR	10	5
IN_COMMAND	☐	IN_COMMAND	DISPLAY	CHAR	8	15
IN_LAST_NAME	☑	lastName		CHAR	10	23
IN_FIRST_NAME	☐	IN_FIRST_NAME		CHAR	10	33
IN_EXTENSION	☐	IN_EXTENSION		CHAR	10	43
IN_ZIP_CODE	☐	IN_ZIP_CODE		CHAR	7	53

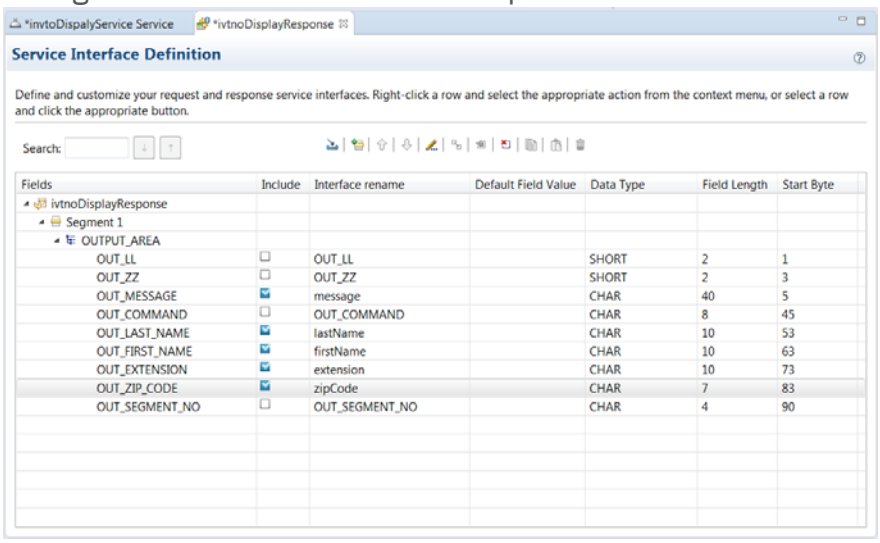
The service developer creates distinct services for each function.

DISPLAY
DELETE
ADD
UPDATE

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Creating a "GET" service interface response definition

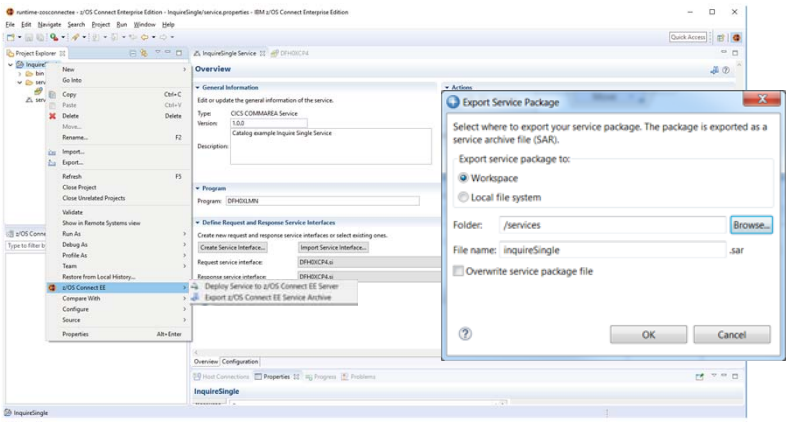


Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
ivtnoDisplayResponse						
Segment 1						
OUTPUT_AREA						
OUT_LL	☐	OUT_LL		SHORT	2	1
OUT_ZZ	☐	OUT_ZZ		SHORT	2	3
OUT_MESSAGE	☑	message		CHAR	40	5
OUT_COMMAND	☐	OUT_COMMAND		CHAR	8	45
OUT_LAST_NAME	☑	lastName		CHAR	10	53
OUT_FIRST_NAME	☑	firstName		CHAR	10	63
OUT_EXTENSION	☑	extension		CHAR	10	73
OUT_ZIP_CODE	☑	zipCode		CHAR	7	83
OUT_SEGMENT_NO	☐	OUT_SEGMENT_NO		CHAR	4	90

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Creating a service for CICS and IMS

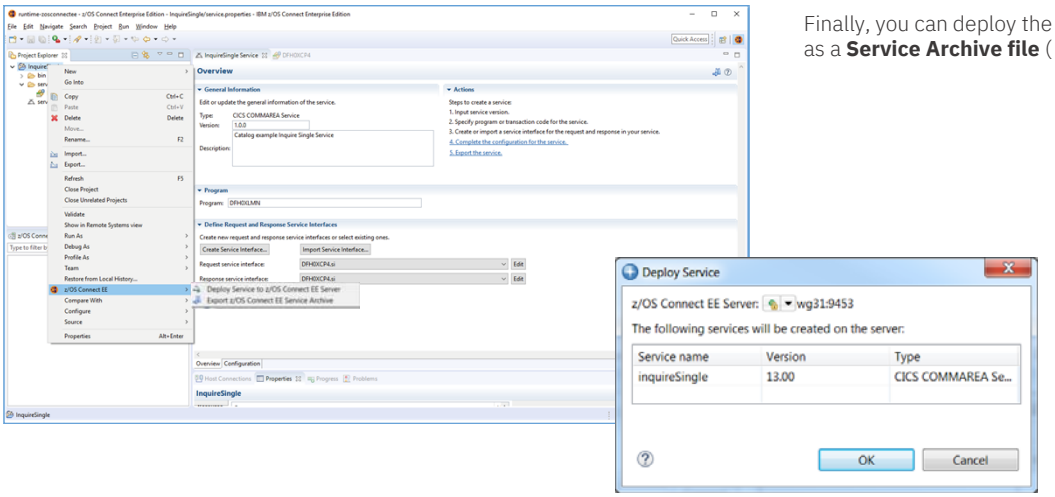


Finally, you can export the service project as a **Service Archive file** (`.sar`).

API toolkit – Creating Services for CICS and IMS

z/OS Connect EE

Creating a service for CICS and IMS

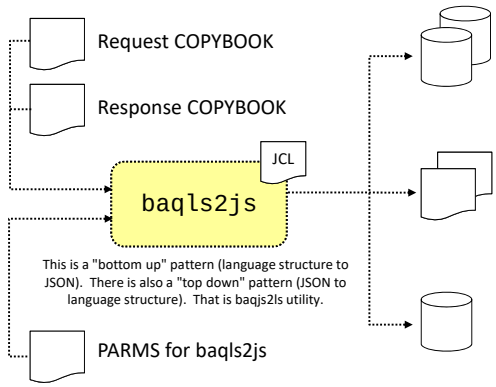


Finally, you can deploy the service project as a **Service Archive file** (`.sar`)

Creating Services without the Toolkit - 1

z/OS Connect EE

For MQ and MVS Batch use the supplied conversion utility BAQLS2JS



BIND Files

These are binary-format files that contain information about the field definitions and the data transformation requirements.

These are placed in a USS file system location based on input parms you specify.

JSON Schema Files

These provide the JSON schema used to interact with the backend program based on the COPYBOOK data requirements.

These are placed in a USS file system location based on input parms you specify.

Service Archive (SAR) File

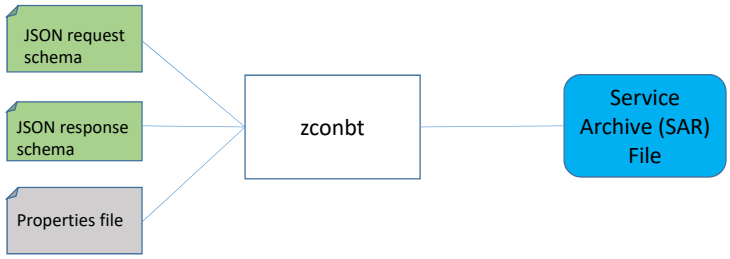
This is a ZIP-format file that contains the JSON schema and some meta-data. This is input to the API Editor (next unit) to create the APIs.

This is placed in a USS file system location based on input parms you specify.

Creating Services without the Toolkit – 2a

z/OS Connect EE

For DB2 and HATS REST Services use the z/OS Connect Build toolkit (zconbt)

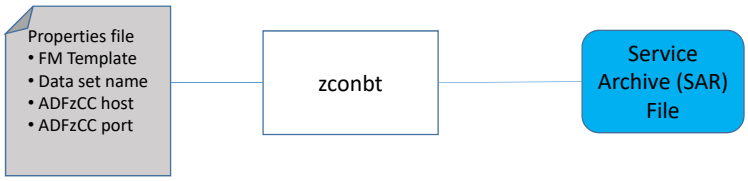


Generate the service archive file

Creating Services without the Toolkit – 2b

z/OS Connect EE

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

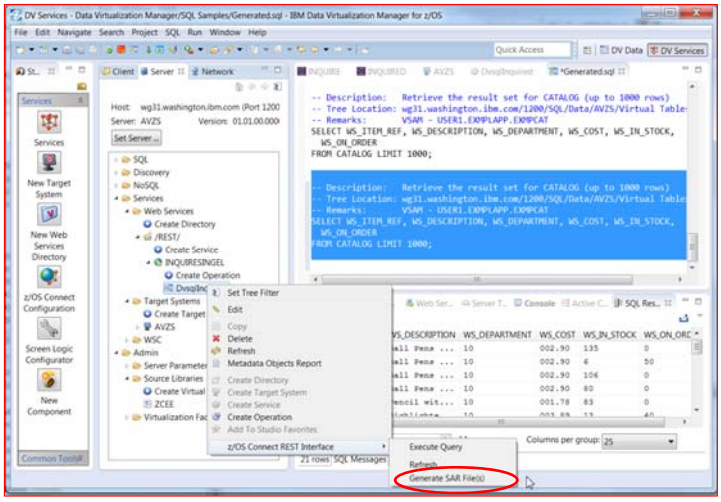


Generate the service archive file

Creating Services without the Toolkit – Part 3

z/OS Connect EE

For DVM use the DVM Studio



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

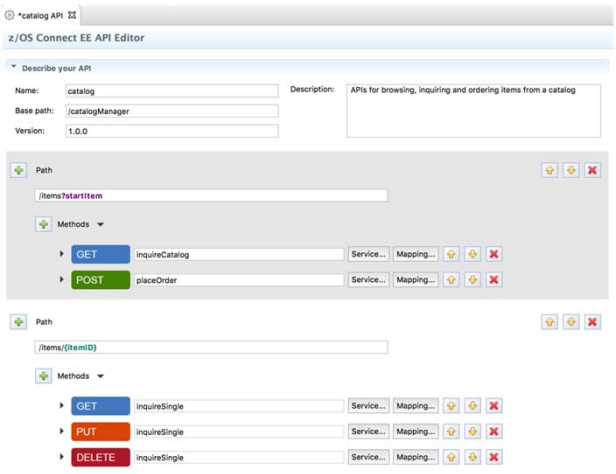
/api_toolkit/api_editor

Quick and easy **API mapping.**

API toolkit – API Editor

z/OS Connect EE

API definition



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

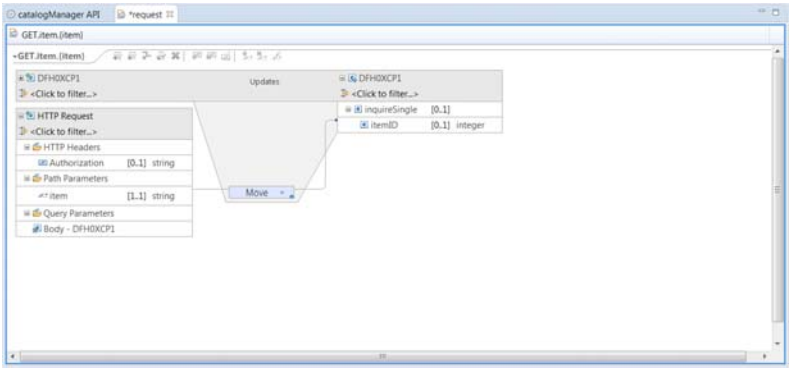
Once you define your API, you can map backend services to each request.

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

API toolkit – API Editor

z/OS Connect EE

API mapping: Point-and-click interface



Map both the request and response for each API.

Map path and query parameters to native data structures.

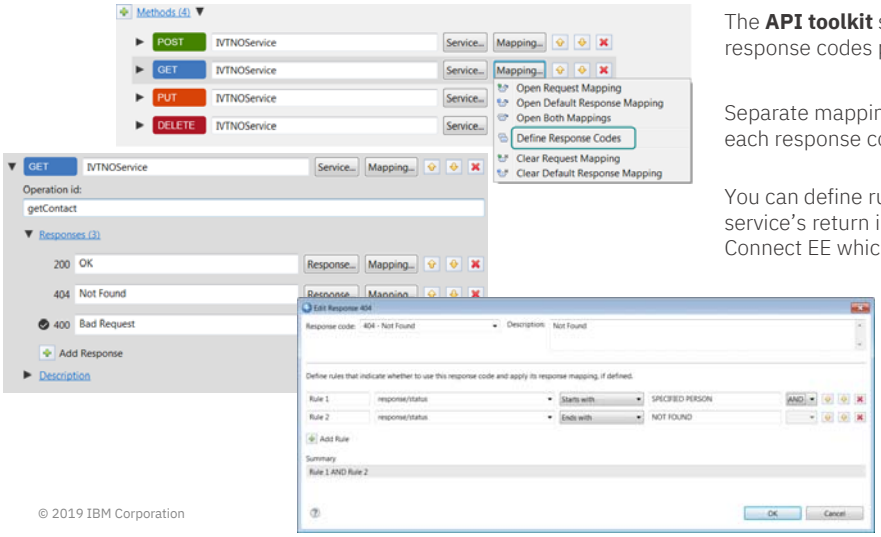
Assign static values to fields, useful for Op codes.

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

API toolkit

z/OS Connect EE

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.

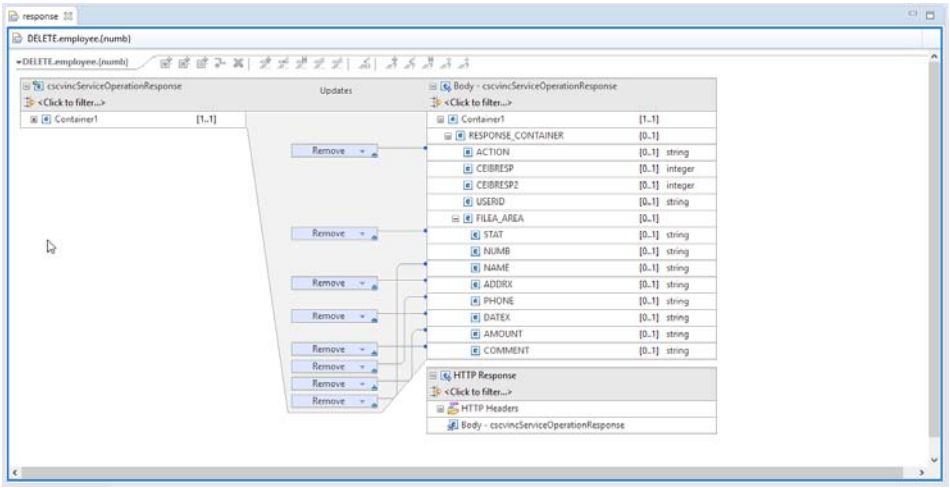
You can define rules based on fields in the service's return interface to tell z/OS Connect EE which response code to return

API toolkit – API Editor

z/OS Connect EE

API mapping: Point-and-click interface

Allows the API Developer to remove fields to simplify the API

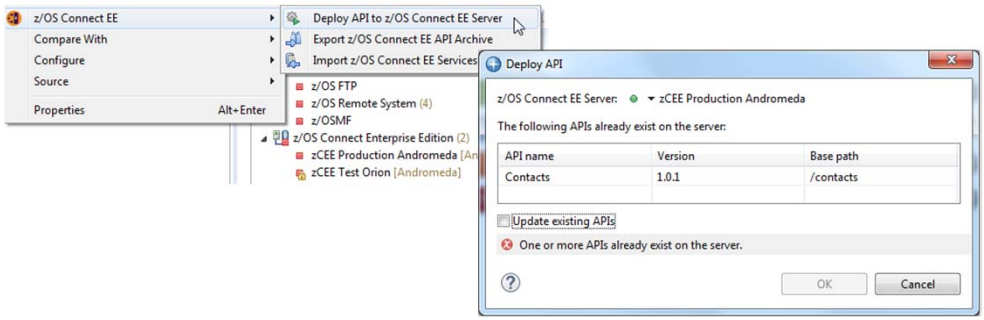


API toolkit – API Editor

z/OS Connect EE

Server connection and API deployment

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



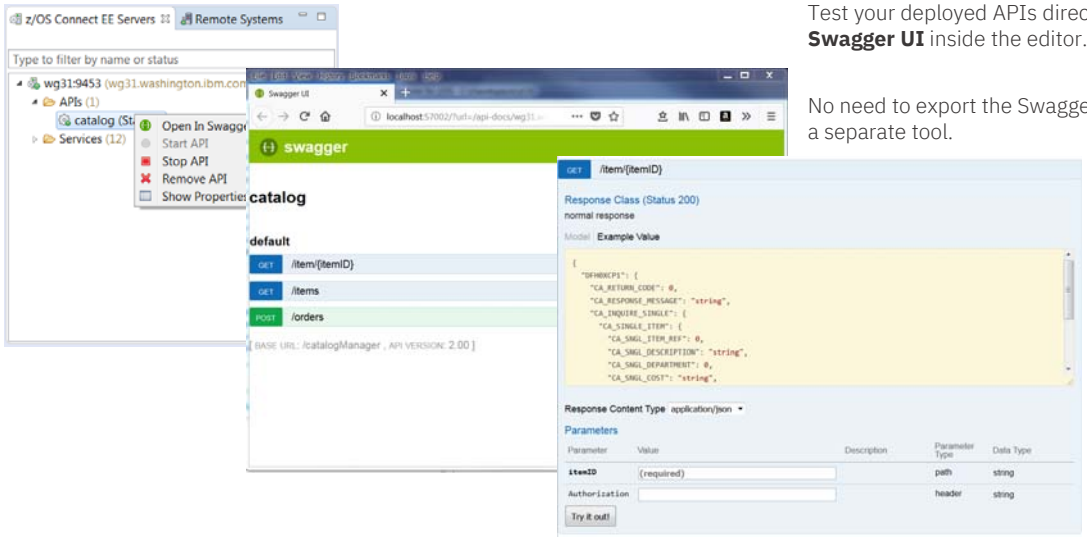
Right-click deploy to server enables developers to quickly deploy, test, and iterate on their APIs.

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

API toolkit – API Editor

z/OS Connect EE

Testing with Swagger UI

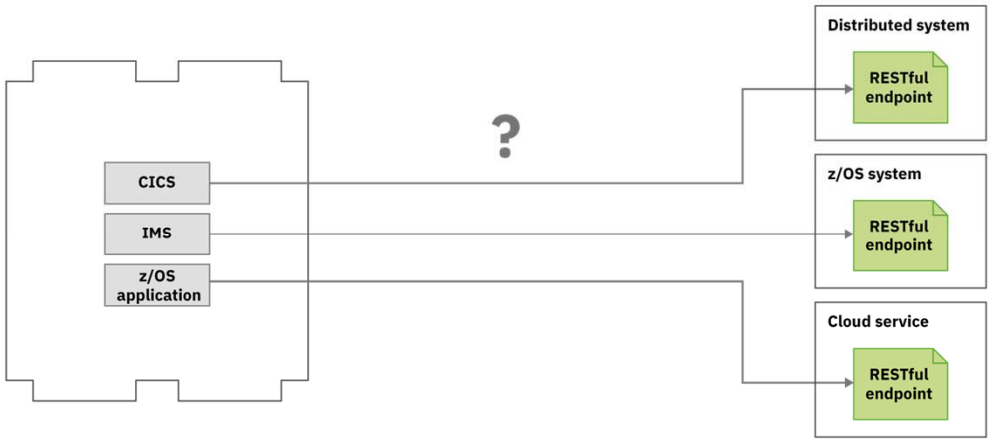


Test your deployed APIs directly with **Swagger UI** inside the editor.

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

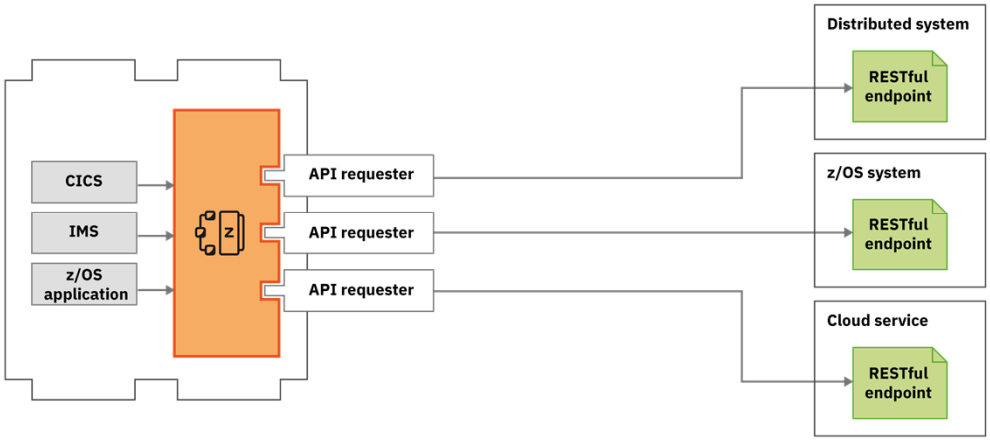
What about calling external APIs from my z/OS assets?

z/OS Connect EE



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

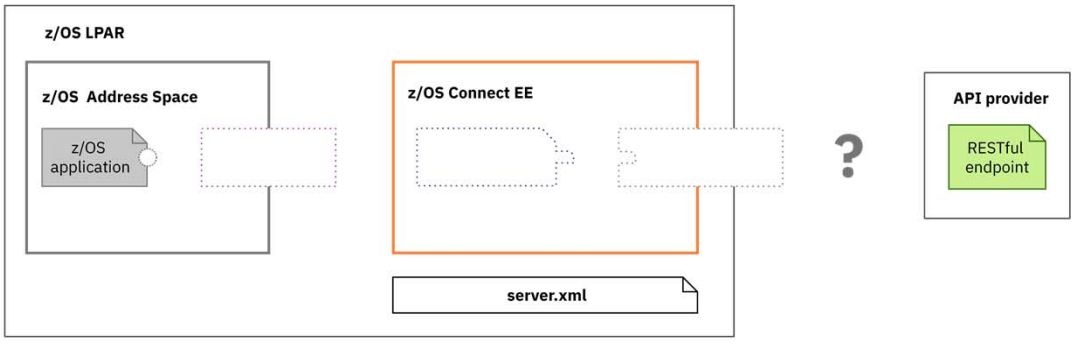
z/OS Connect EE



Steps to calling an external API

Starting point

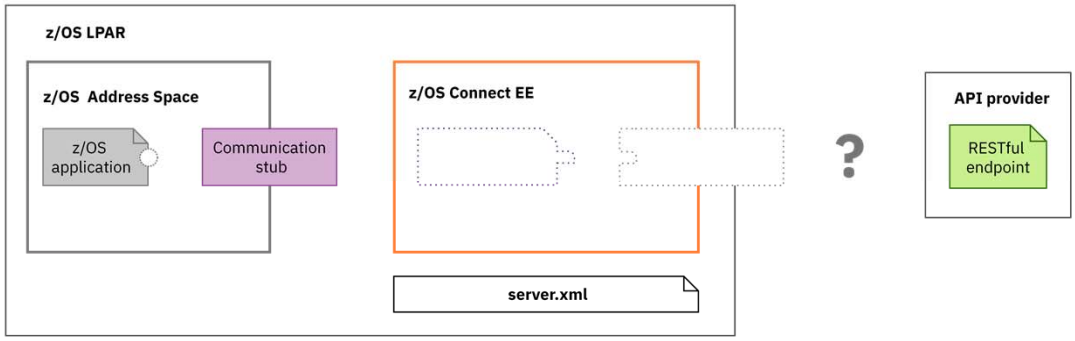
z/OS Connect EE



Steps to calling an external API

z/OS Connect EE

Step 1. Configure communication stub



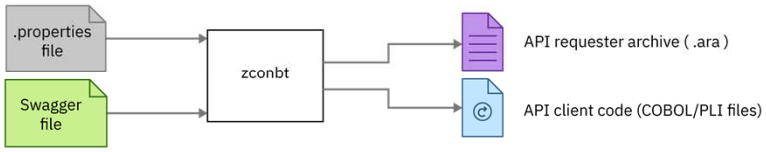
Configure a communication stub. You only need to do this once per system.

ibm.biz/zosconnect-configure-comms-stub

Steps to calling an external API

z/OS Connect EE

Step 2. Generate API requester archive from Swagger



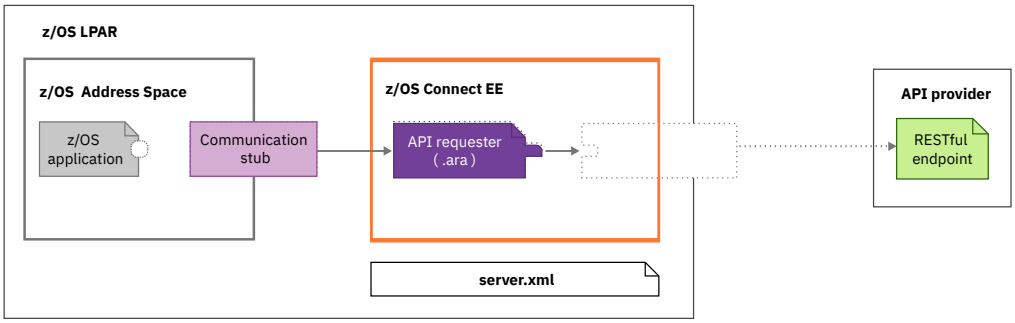
Generate your `.ara` file, and API client code.

ibm.biz/zosconnect-generate-ara

Steps to calling an external API

z/OS Connect EE

Step 3. Deploy API requester (.ara) archive

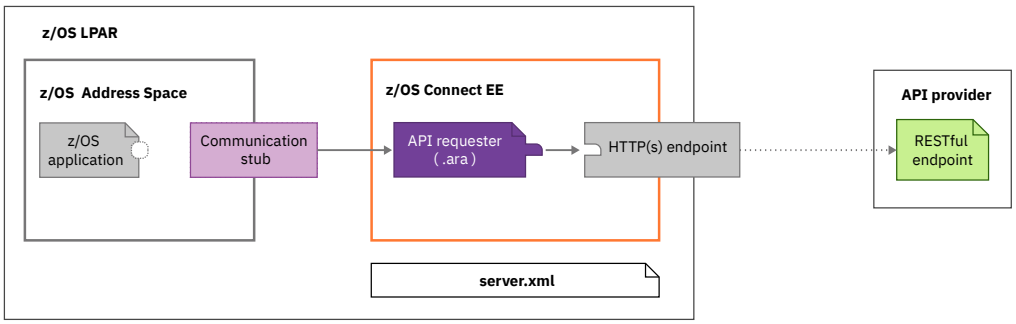


Deploy your API requester archive to the *apiRequester* directory.

Steps to calling an external API

z/OS Connect EE

Step 4. Configure HTTP(S) endpoint



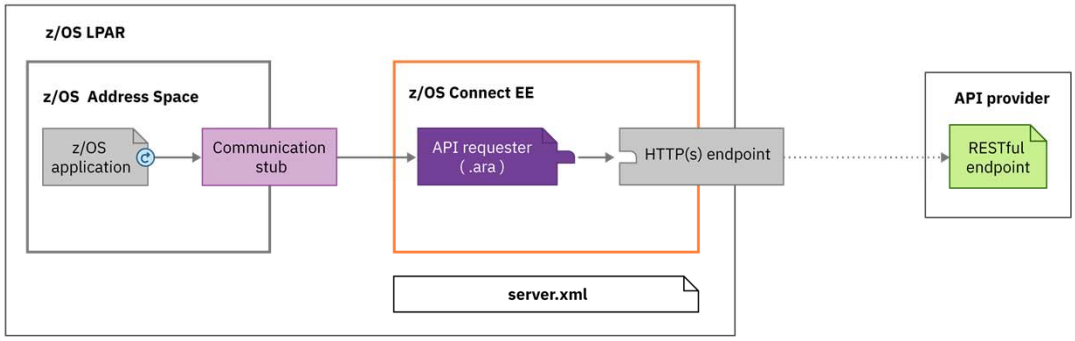
Configure the connection between z/OS Connect EE and the external API.

ibm.biz/zosconnect-configure-endpoint-connection

Steps to calling an external API

z/OS Connect EE

Step 5. Update z/OS application



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

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

Steps to calling an external API

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

GETAPI

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

* Copy API Requester required copybook
 COPY BAQRINFO.

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

apis.xml

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

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

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

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

</server>
```

CSC02I01

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

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

Steps to calling an external API

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

GETAPI

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

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

*-------------------------------------------------------------*
* Call the communication stub                                 *
*-------------------------------------------------------------*
* Call the subsystem-supplied stub code to send
* API request to zCEE
     CALL COMM-STUB-PGM-NAME USING
          BY REFERENCE   API-INFO-OPER1
          BY REFERENCE   BAQ-REQUEST-INFO
          BY REFERENCE   BAQ-REQUEST-PTR
          BY REFERENCE   BAQ-REQUEST-LEN
          BY REFERENCE   BAQ-RESPONSE-INFO
          BY REFERENCE   BAQ-RESPONSE-PTR
          BY REFERENCE   BAQ-RESPONSE-LEN.
* The BAQ-RETURN-CODE field in 'BAQRINFO' indicates whether this
```


Steps to calling an external API

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

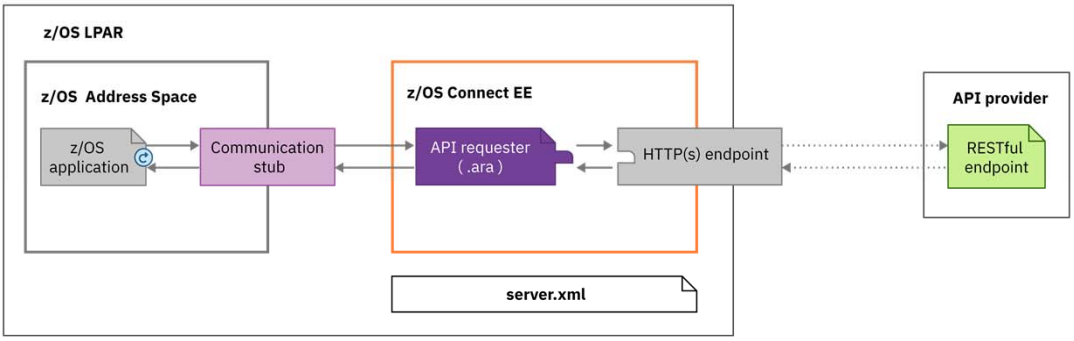
GETAPI

```
          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.
```

Steps to calling an external API

z/OS Connect EE

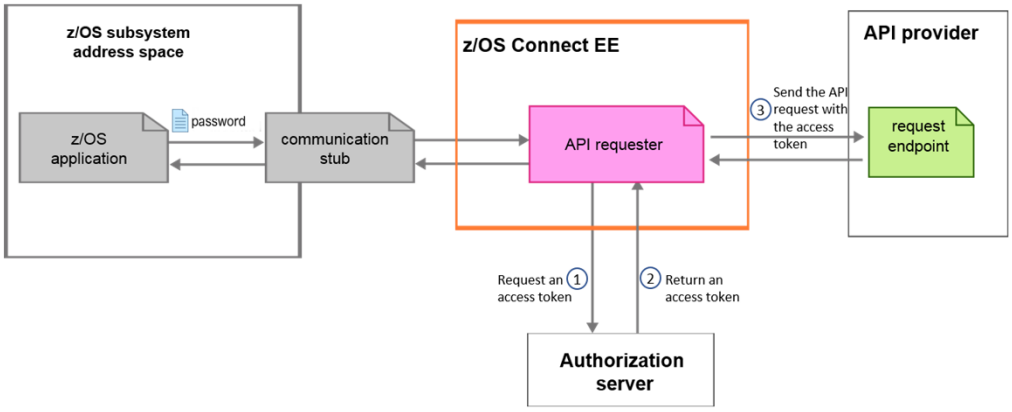
Done



API endpoint secured by OAuth 2.0?

z/OS Connect EE

Not a problem



More information ibm.biz/zosconnect-oauth2

/common_scenarios

Typical connection patterns to different subsystems.

Tour of Server Configuration Directories and Files

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

```
/var/zosconnect/servers/<server_name>
├─ dropins
├─ logs
│  └ messages.log
├─ resources
│  ├─ security
│  └─ zosconnect
├ server.env
├ server.xml
├─ tranlog
└─ workarea
```

The /dropins directory is not used by z/OS Connect EE V3.0. It is a directory monitored by Liberty for applications to be dynamically loaded

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

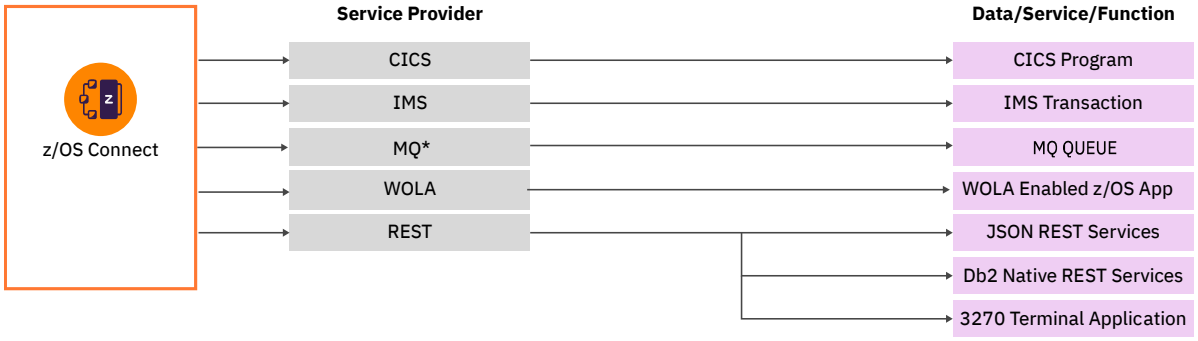
The /zosconnect directory is where we will place the deployed APIs, services, and API requester files

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

What assets can z/OS Connect EE map to?

z/OS Connect EE

And which service provider could I use?

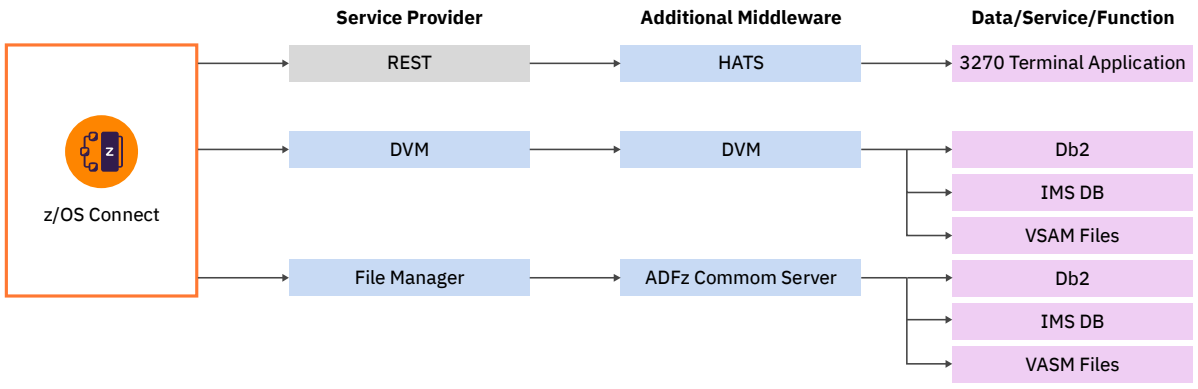


The core **service providers** included with z/OS Connect EE provide API access to a wide range of z/OS assets.
*The MQ service provided is provided by IBM MQ or from Fix Central

Additional Middleware

z/OS Connect EE

Additional value from the ecosystem

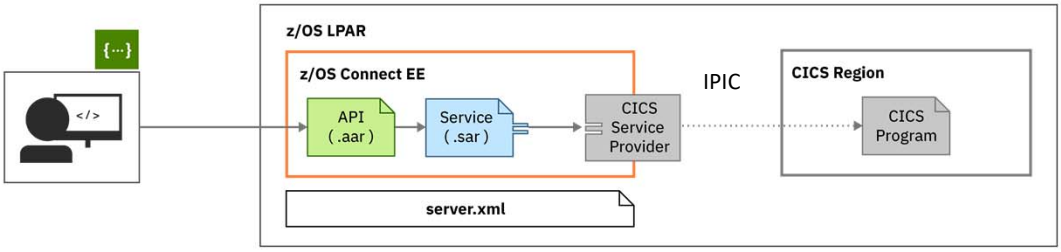


z/OS Connect EE is **pluggable** and **extensible** allowing the use of additional middleware to expand the list of z/OS assets you can expose as APIs

Connections to CICS

z/OS Connect EE

Topology



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

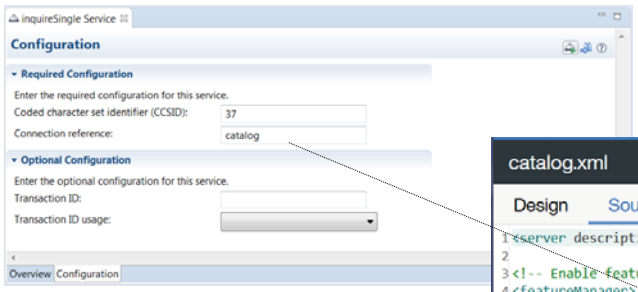
An IPIC connection must be configured in CICS.

ibm.biz/zosconnect-scenarios

CICS IPIC (server.xml)

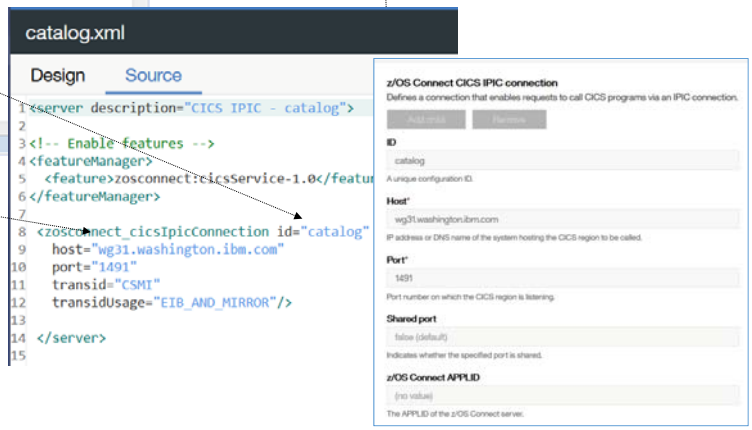
z/OS Connect EE

The server.xml file is the key configuration file:



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

Define IPIC connection to CICS

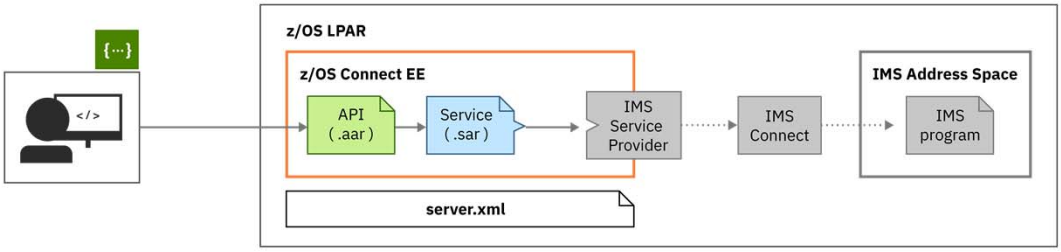


The IMS server.xml file …

Connections to IMS

z/OS Connect EE

Topology



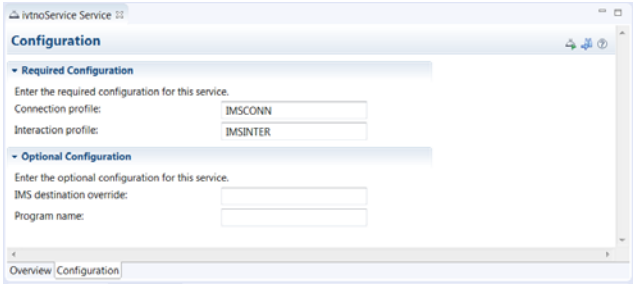
Configure the connection to IMS through `ims-connections.xml` and `ims-interactions.xml` in the IMS service registry.

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

ibm.biz/zosconnect-scenarios

IMS Connections and Interactions

z/OS Connect EE



Connection

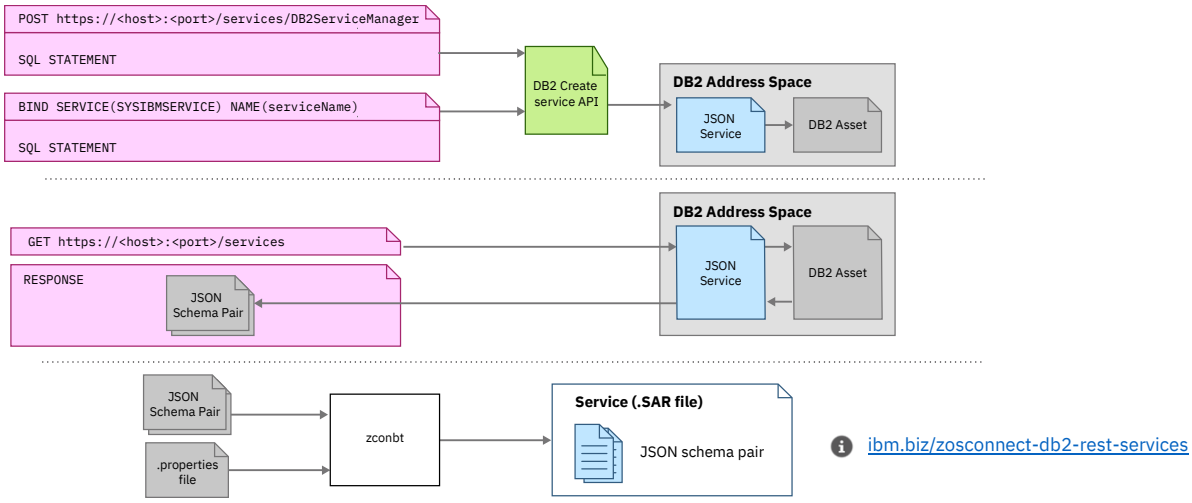
```
<server>
<imsmobile_imsConnection comment="" connectionFactoryRef="IVP1" connectionTimeout="-1" connectionType="IMSCONNECT" id="IMSCONN"/>
<connectionFactory containerAuthDataRef="Connection1_Auth" id="IVP1">
          <properties.gmoa hostName="wg31.washington.ibm.com" portNumber="4000"/>
</connectionFactory>

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

Interaction

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

Connect to Db2

Create the service definition



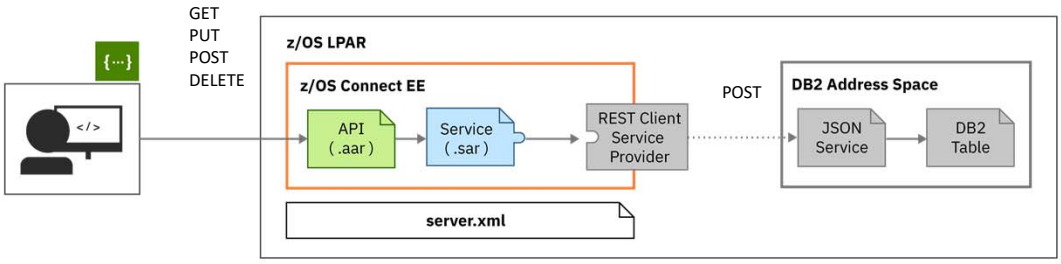
ibm.biz/zosconnect-db2-rest-services

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

Connections to Db2

z/OS Connect EE

Topology



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

A Db2 REST Service must be configured in DB2.

ibm.biz/zosconnect-db2-rest-services

The server.xml File (Db2)

z/OS Connect EE

The server.xml file is the key configuration file:

db2pass.xml

Design | Source

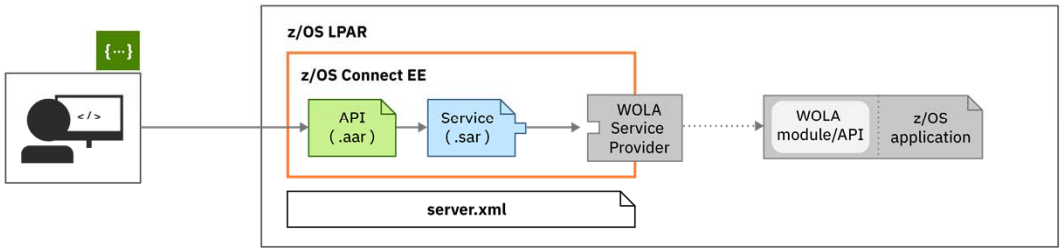
```
1 <server description="DB2 REST">
2
3  <zosconnect_zosConnectServiceRestClientConnection id="db2conn"
4        host="wg31.washington.ibm.com"
5        port="2446"
6        basicAuthRef="dsn2Auth" />
7
8  <zosconnect_zosConnectServiceRestClientBasicAuth id="dsn2Auth"
9        applName="DSN2APPL"/>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

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


Connections to a MVS batch application

z/OS Connect EE

Topology



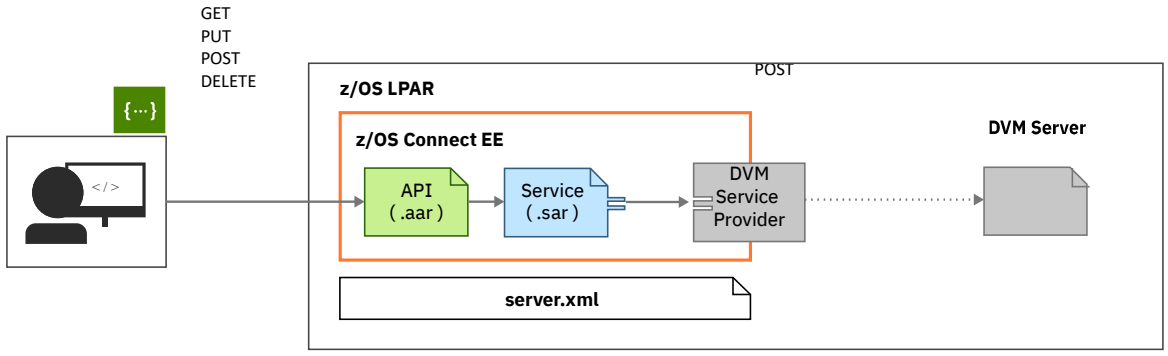
Connection to WOLA is configured in `server.xml`.

The z/OS application must be WOLA-enabled.

Connections to DVM

z/OS Connect EE

Topology



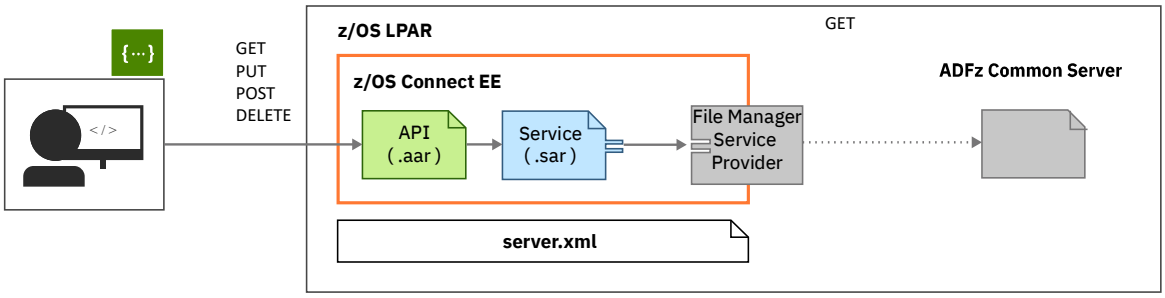
The DVM service provider uses WOLA

ibm.biz/zosconect-db2-rest-services

Connections to File Manager

z/OS Connect EE

Topology



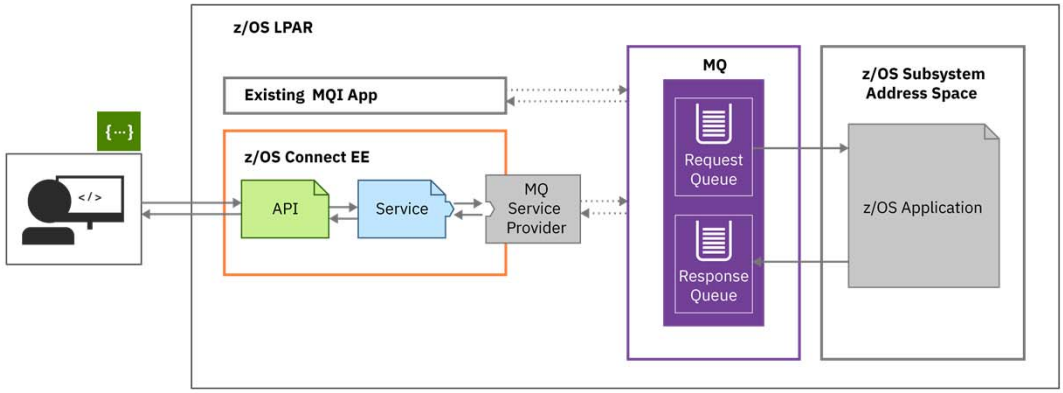
Connection to the Application Delivery Foundation for z (ADFz) common server is over TCP/IP

A File Manager Template is required .

Connections to MQ

z/OS Connect EE

Topology (Two-way service example)



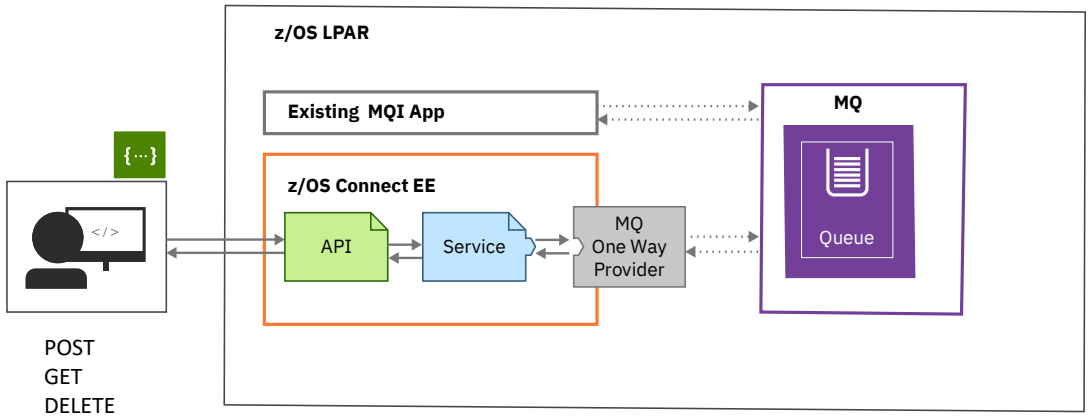
You can also configure one-way services.

ibm.biz/zosconnect-mq-service-provider

Connections to MQ

z/OS Connect EE

Topology (One-way service example)

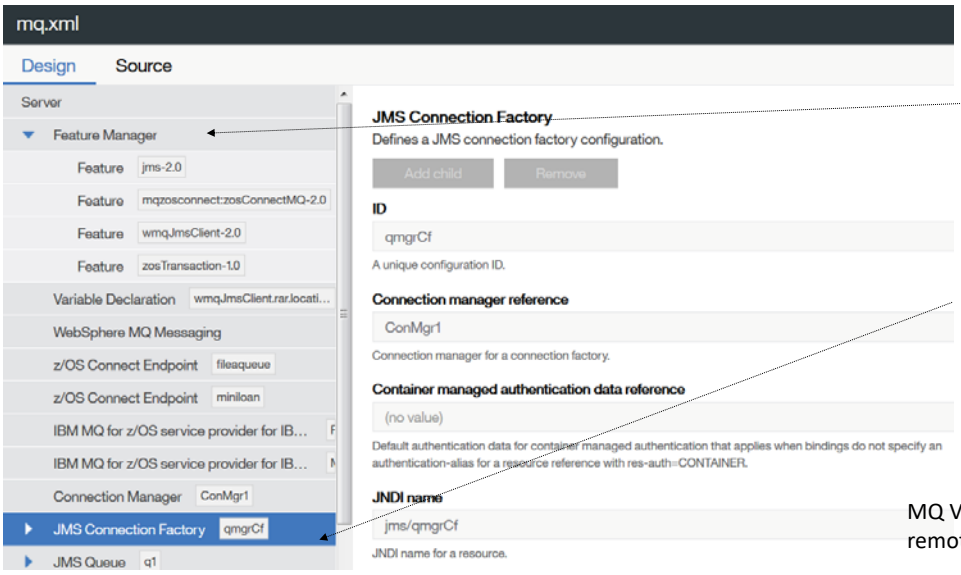


POST
GET
DELETE

ibm.biz/zosconnect-mq-service-provider

The server.xml File (MQ)

z/OS Connect EE



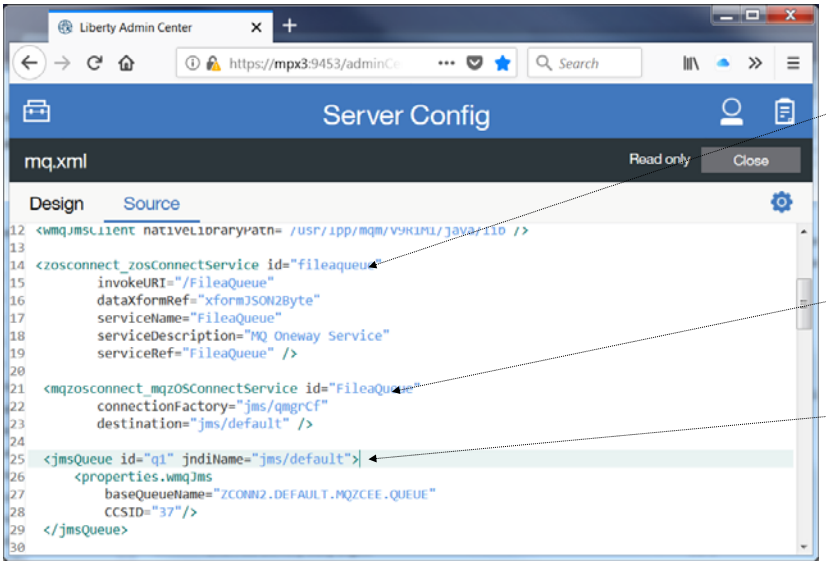
Features related to JMS Support

JMS Connection Factories,

MQ V9.1.1 Added support for remote queue managers.

The server.xml File (one-way MQ service)

z/OS Connect EE



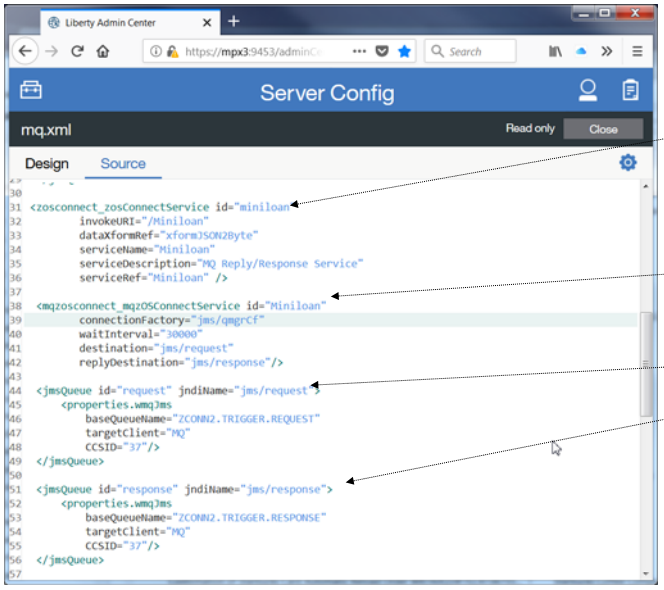
z/OS Connect service

MQ z/OS Connect service

JMS Destination (queue)

The server.xml File (two-way MQ service)

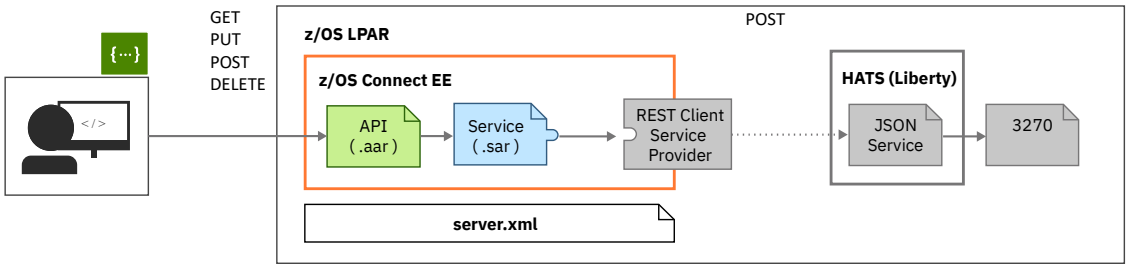
z/OS Connect EE



Connection to HATS

Topology

z/OS Connect EE



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

ibm.biz/zosconect-db2-rest-services

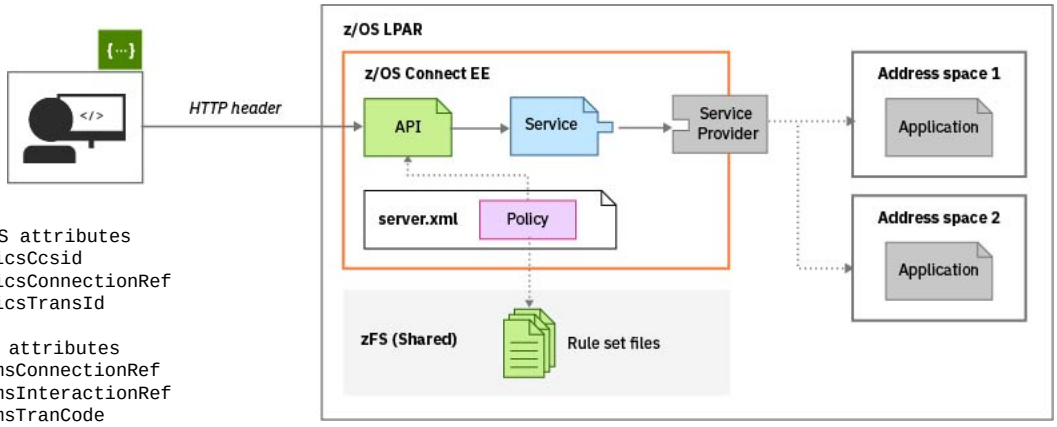
/miscellaneousTopics

performance, high availability, Liberty

API Policies

z/OS Connect EE

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



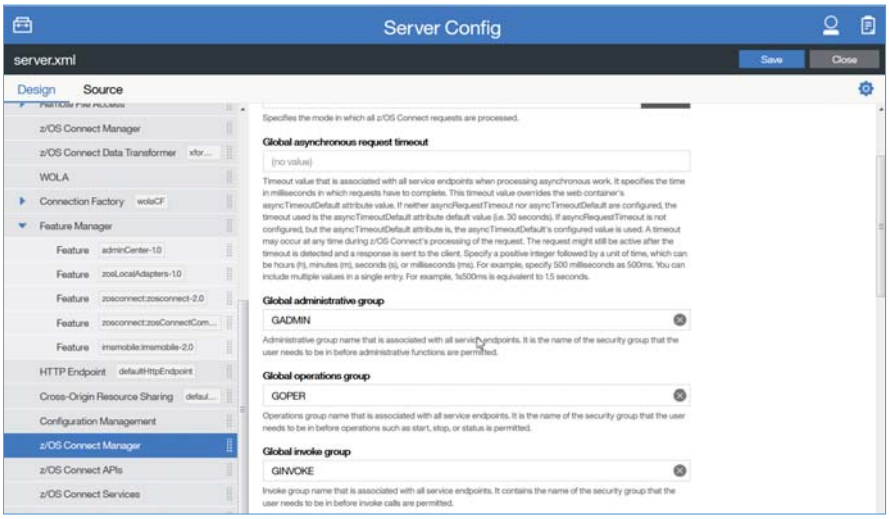
CICS attributes
- cicsCcsid
- cicsConnectionRef
- cicsTransId

IMS attributes
- imsConnectionRef
- imsInteractionRef
- imsTranCode

Liberty's "adminCenter" Feature

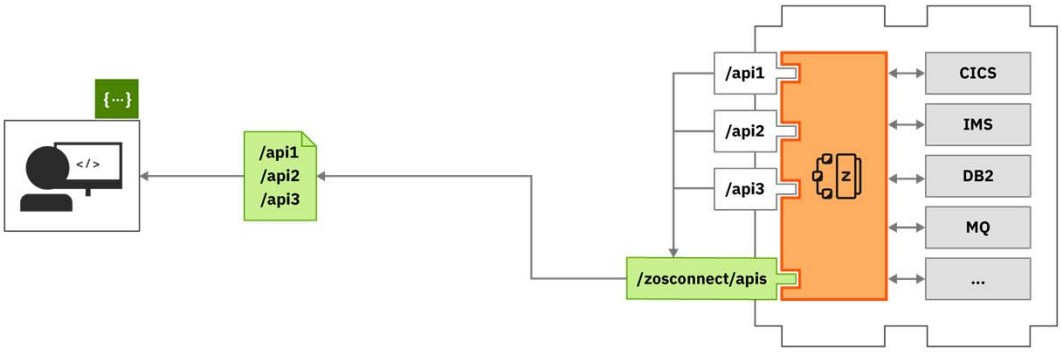
z/OS Connect EE

Web browser interface to the server's configuration files



API Documentation

z/OS Connect EE



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

RESTful Administrative Interface for Services

z/OS Connect EE

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 DB2 and HATS service archive files

RESTful Administrative Interface for APIs

z/OS Connect EE

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

Most administration tasks are supported by the RESTful administration interface

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

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

RESTful Administrative Interface for API Requesters

z/OS Connect EE

The administration interface for services is available in paths under /zosConnect/apisRequesters.
Most administration tasks are supported by the RESTful administration interface

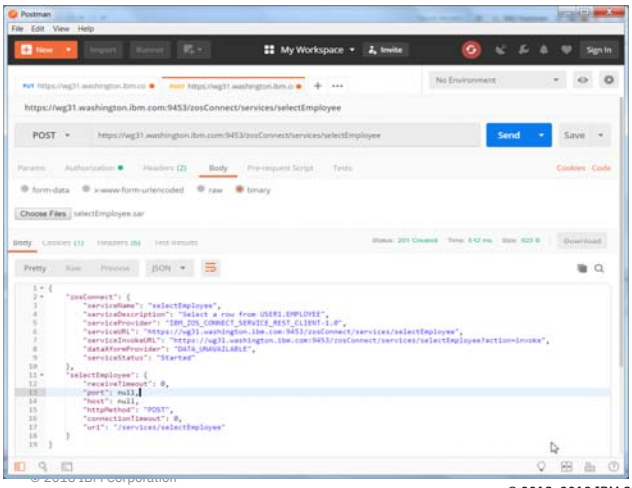
Method	Administrative Task
GET	Get a list of API Requesters
	Get the details of an API Requester
POST	Deploy an API Requester
PUT	Update an API Requester
	Change the status of an API Requester
DELETE	Delete an API Requester

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

Deploying Db2 Service Archive Options

z/OS Connect EE

- 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:

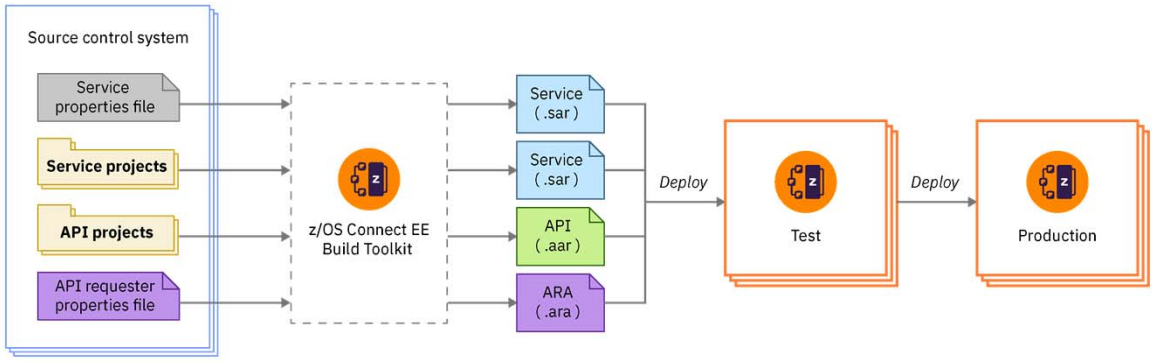
```
{"zosConnect":{"serviceName":"selectEmployee","serviceDescrip
tion":"Select a row from
USER1.EMPLOYEE","serviceProvider":"IBM_ZOS_CONNECT_SERVICE_RE
ST_CLIENT-1.0
","serviceURL":"https://mpxm:9453/zosConnect/services/selectE
mployee","serviceInvokeURL":"https://mpxm:9453/zosConnect/ser
vices/selectEmployee?action=invoke","dataXformProvider":"DATA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

DevOps using z/OS Connect EE

z/OS Connect EE

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

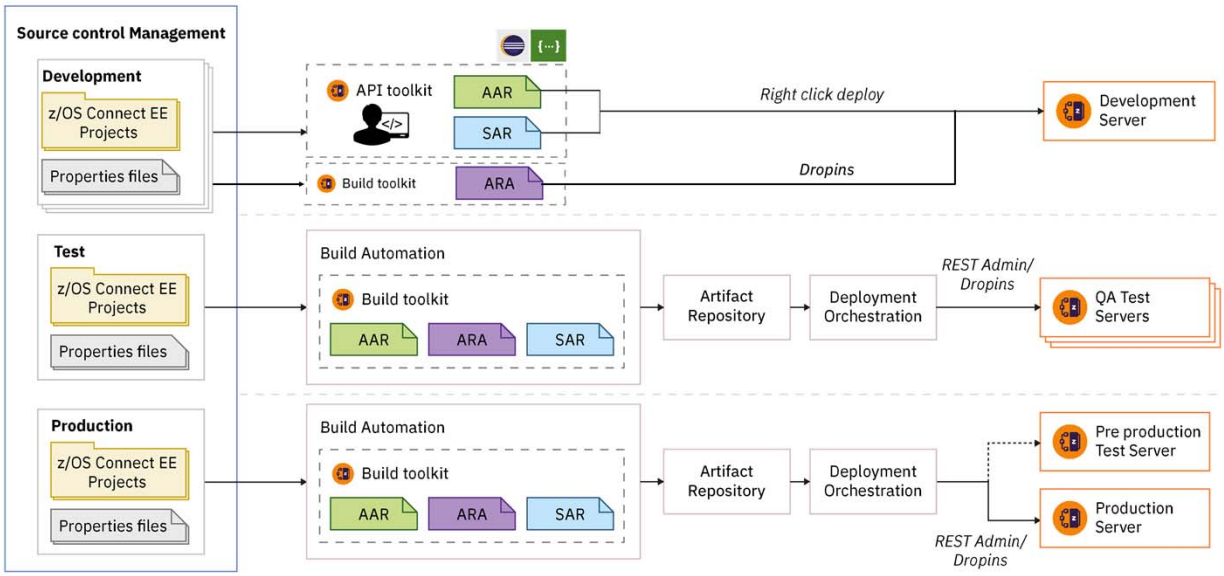
- The build toolkit supports the generation of service archives and API archives from projects created in the z/OS Connect EE API toolkit
- The build toolkit also supports the use of properties files to generate API requester archives
- Run the build toolkit from a build script to generate these archive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



ibm.biz/zosconnect-devops

DevOps Pipeline using z/OS Connect EE

z/OS Connect EE



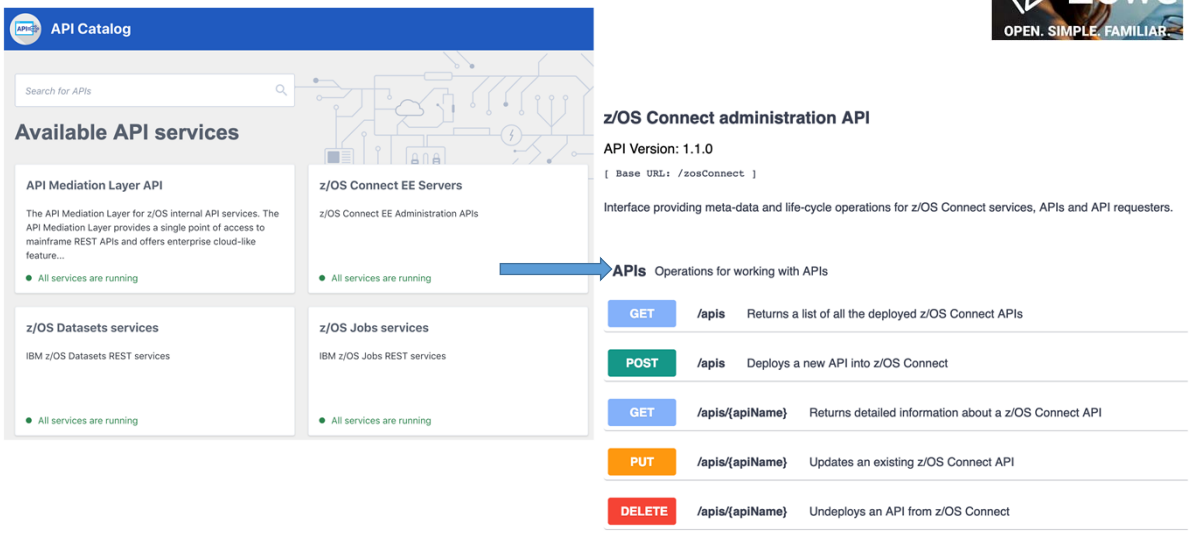
ibm.biz/zosconnect-devops

z/OS Connect EE integration with Zowe

z/OS Connect EE and Zowe API Catalog – Administration API

z/OS Connect EE

Zowe
OPEN. SIMPLE. FAMILIAR.

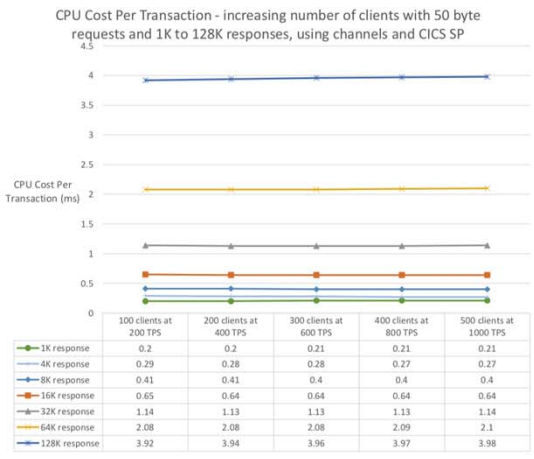


Blogpost: Expose z/OS Connect EE APIs in Zowe API mediation layer
developer.ibm.com/mainframe/2019/04/01/expose-z-os-connect-ee-apis-in-zowe-api-mediation-layer

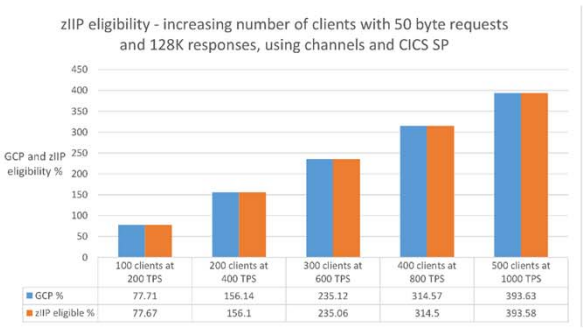
Performance: API Provider

High Speed, High Throughput, Low Cost

z/OS Connect EE



	100 clients at 200 TPS	200 clients at 400 TPS	300 clients at 600 TPS	400 clients at 800 TPS	500 clients at 1000 TPS
1K response	0.2	0.2	0.21	0.21	0.21
4K response	0.29	0.28	0.28	0.27	0.27
8K response	0.41	0.41	0.4	0.4	0.4
16K response	0.65	0.64	0.64	0.64	0.64
32K response	1.14	1.13	1.13	1.13	1.14
64K response	2.08	2.08	2.08	2.09	2.1
128K response	3.92	3.94	3.96	3.97	3.98



	100 clients at 200 TPS	200 clients at 400 TPS	300 clients at 600 TPS	400 clients at 800 TPS	500 clients at 1000 TPS
GCP %	77.71	156.14	235.12	314.57	393.63
zIIP eligible %	77.67	156.1	235.06	314.5	393.58

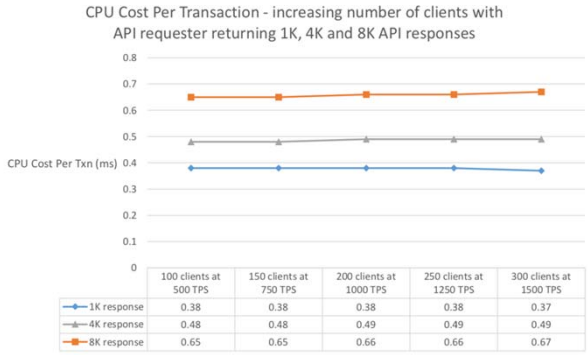
z/OS Connect EE is a Java-based product:
Over **99%** of its MIPs are **eligible for ZIIP offload**.

ibm.biz/zosconnect-performance-report

Performance: API Requester

z/OS Connect EE

High Speed, High Throughput, Low Cost



	100 clients at 500 TPS	150 clients at 750 TPS	200 clients at 1000 TPS	250 clients at 1250 TPS	300 clients at 1500 TPS
1K response	0.38	0.38	0.38	0.38	0.37
4K response	0.48	0.48	0.49	0.49	0.49
8K response	0.65	0.65	0.66	0.66	0.67

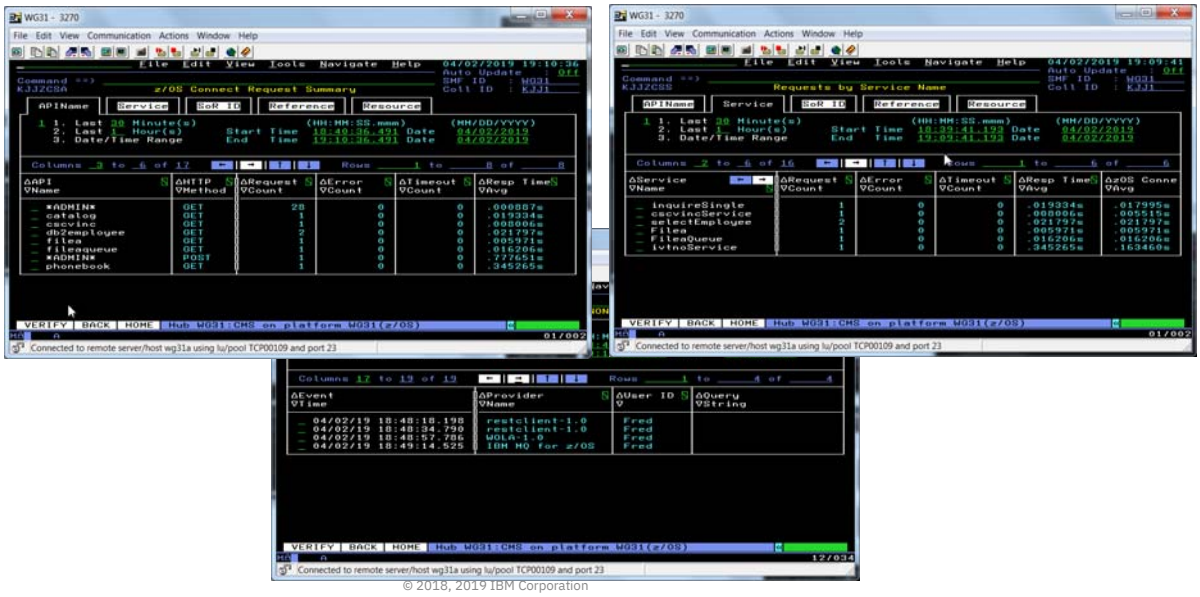
	100 clients at 500 TPS	150 clients at 750 TPS	200 clients at 1000 TPS	250 clients at 1250 TPS	300 clients at 1500 TPS
GCP % - 8K response	32.25	48.4	65.47	81.96	99.09
zIIP eligible % - 8K response	32.21	48.35	65.42	81.9	99.02

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

ibm.biz/zosconnect-performance-report

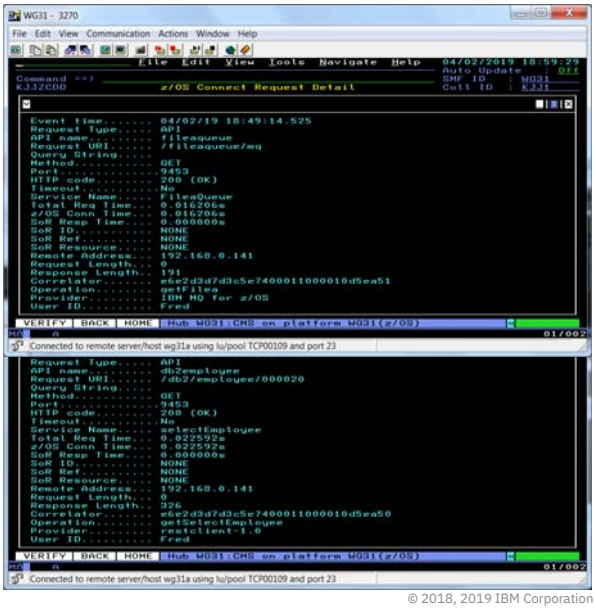
IBM z Omegamon for JVM

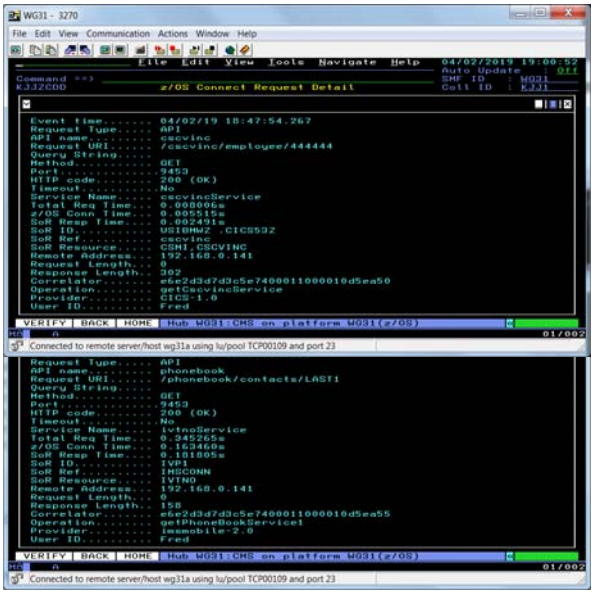
z/OS Connect EE



IBM z Omegamon for JVM

z/OS Connect EE



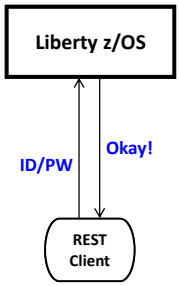


Authentication

z/OS Connect EE

Several different ways this can be accomplished:

Basic Authentication

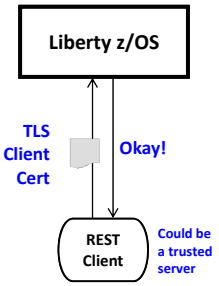


Server prompts for ID/PW

Client supplies ID/PW

Server checks registry:
- Basic (server.xml)
- LDAP
- SAF

Client Certificate



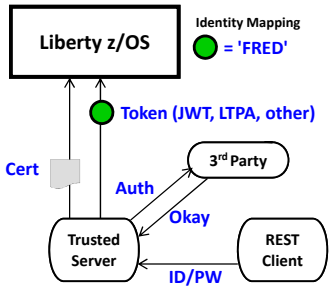
Server prompts for cert.

Client supplies certificate

Server validates cert and maps to an identity

Registry options:
- LDAP
- SAF

Third Party Authentication



Client authenticates to 3rd party sever

Client receives a trusted 3rd party token

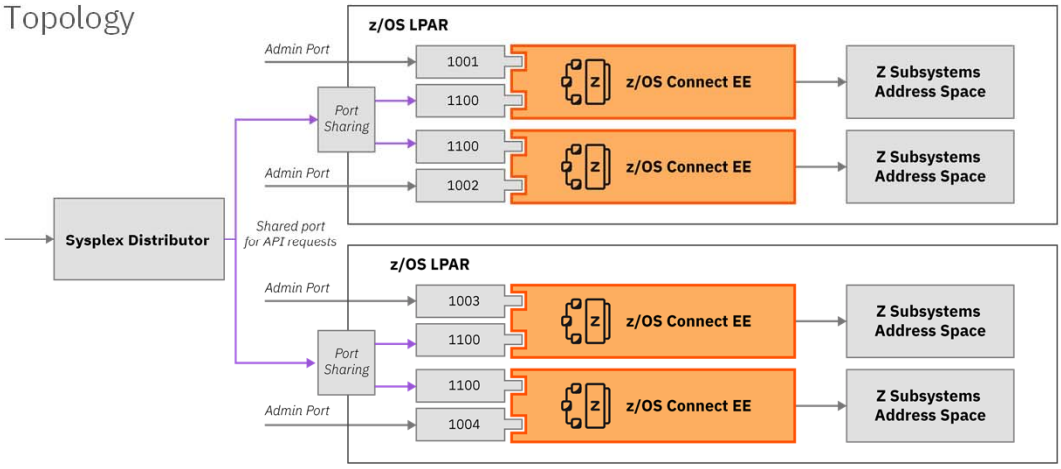
Token flows to Liberty z/OS and is mapped to an identity

Registry options:
- LDAP
- SAF

High Availability

z/OS Connect EE

Topology



ibm.biz/zosconnect-ha-concepts

ibm.biz/zosconnect-scenarios

/questions?thanks=true

Thank you for listening.

/exercises

basic security, exercise paths

Exercises – Two paths or options

z/OS Connect EE

- ❑ Basic Configuration Hands-on Lab
  - ❑ Configure a z/OS Connect Server
  - ❑ Develop and deploy a Service
  - ❑ Develop and deploy an API
  - ❑ Test using Swagger UI
  - ❑ Enable Security (SAF and SSL)

Or one or more of the following:

- ❑ Developing APIs Hands-on Labs
  - ❑ CICS Container/COMMAREA
  - ❑ DB2
  - ❑ IMS Transaction
  - ❑ MQ
  - ❑ MVS Batch
  - ❑ Outbound RESTful applications

- Copy/Paste files on desktop
  - ➢ Basic Configuration CopyPaste
  - ➢ Developing APIs CopyPaste
- Identities:
  - ➢ RACF identity: USER1–> Password: USER1
  - ➢ zCEE identity: Fred –> Password: fredpwd
- 3270 Key Sequences
  - ➢ Clear screen: Fn-P
  - ➢ Enter key: right CTRL
- Material can be downloaded from:

  http://tinyurl.com/y28fsezs
- z/OS Connect EE Users Group

  https://www.linkedin.com/groups/8731382/