



IBM z/OS Connect Enterprise Edition

Introduction and Overview

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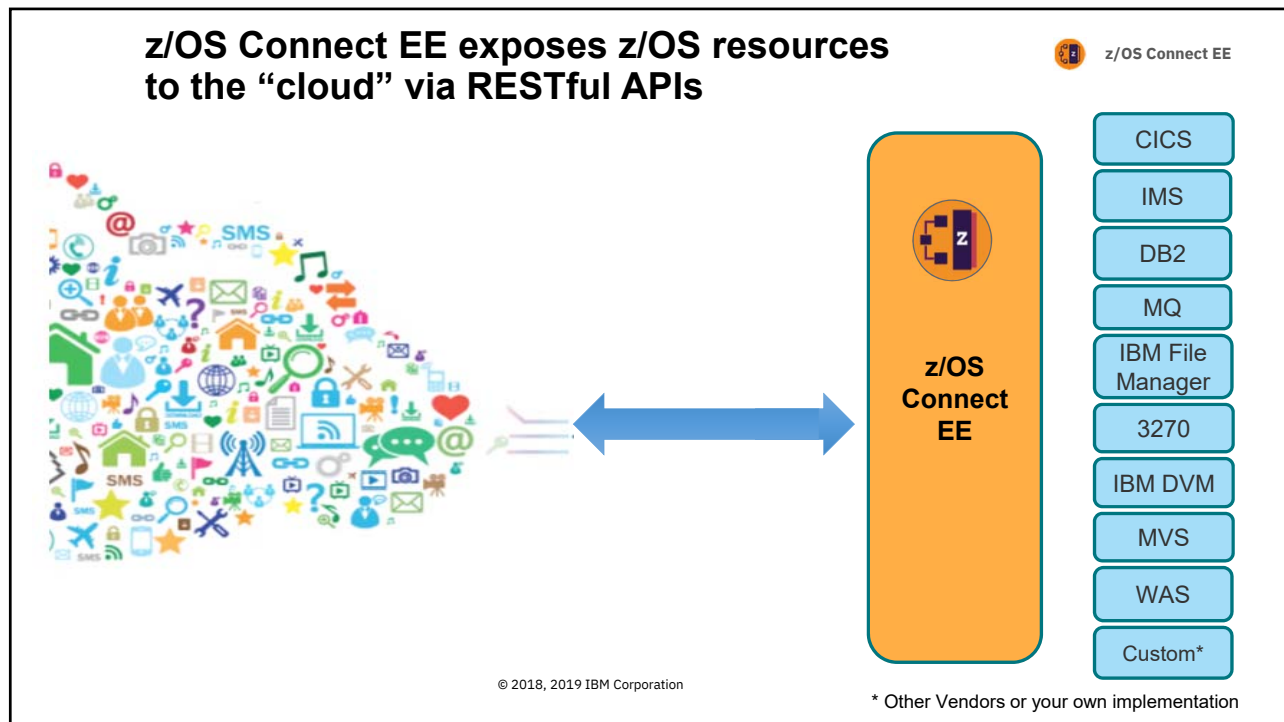


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Agenda

- 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

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/but_first, what_is_REST?

What makes an API “RESTful”?

REST is an Architectural Style

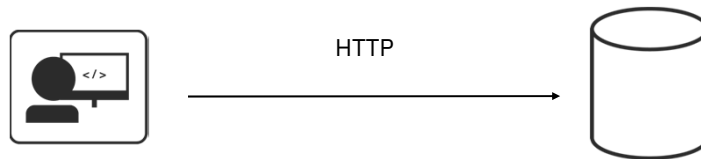


REST stands for **R**epresentational **S**tate **T**ransfer.

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

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

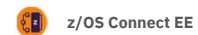
Simple and intuitive for the end consumer (**the developer**).



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

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Key Principles of REST



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

GET
POST
PUT
DELETE

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

Path and Query parameters are used for refinement of the request

URIs represent things (or lists of things)

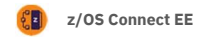
Request/Response Body is used to represent the data object

```

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

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REST vs RESTful



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

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RESTful Examples

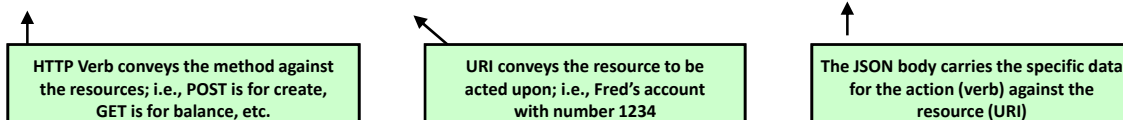


z/OS Connect Enterprise Edition:

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

GET /account?number=1234

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



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 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" }
---	---	--

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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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How do we describe a REST API?

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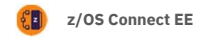
/swagger/open_api

The industry standard framework for describing RESTful APIs.

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Why use Swagger?

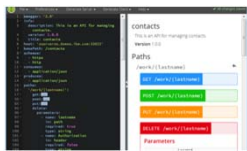
It is more than just an API framework



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/>

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

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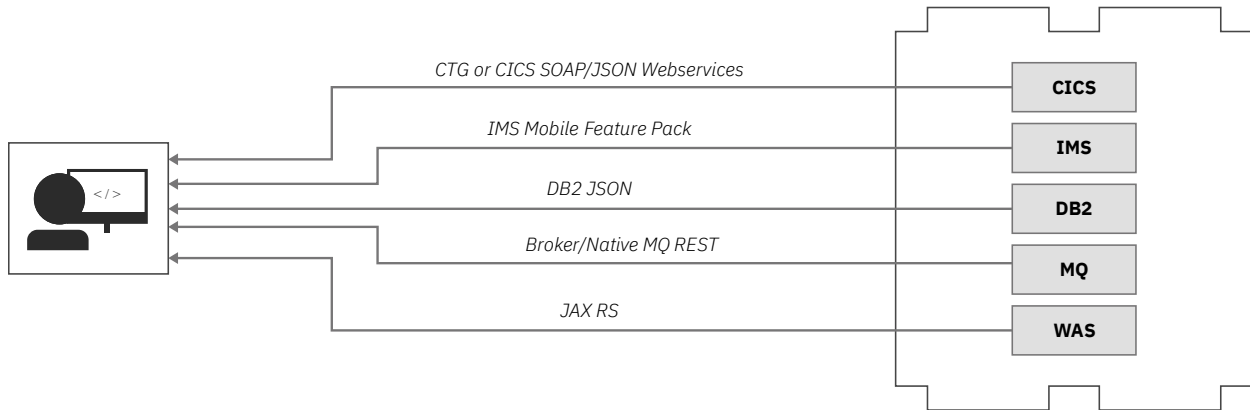
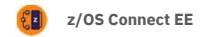


Why /zos_connect_ee?

Truly RESTful APIs to and from your mainframe.

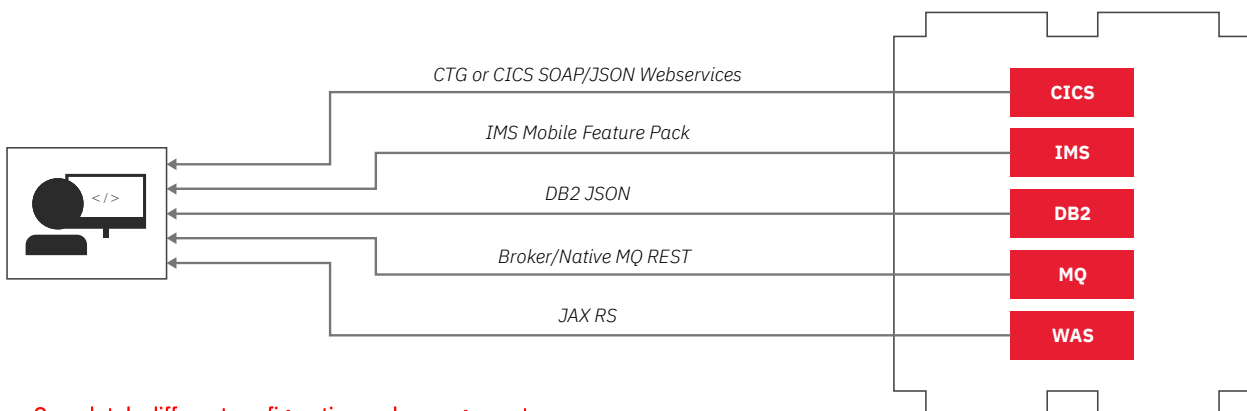
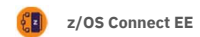
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First, can't we already do REST and JSON today?



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Yes, but....



Completely different configuration and management.

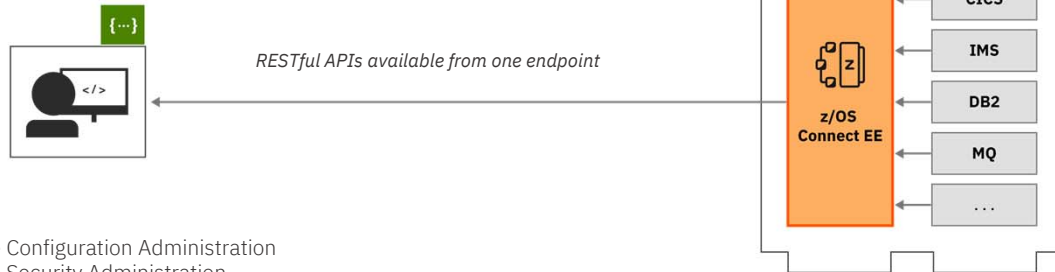
Multiple endpoints for developers to call/maintain access to.

These are typically not RESTful!

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A single entry point is needed

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.

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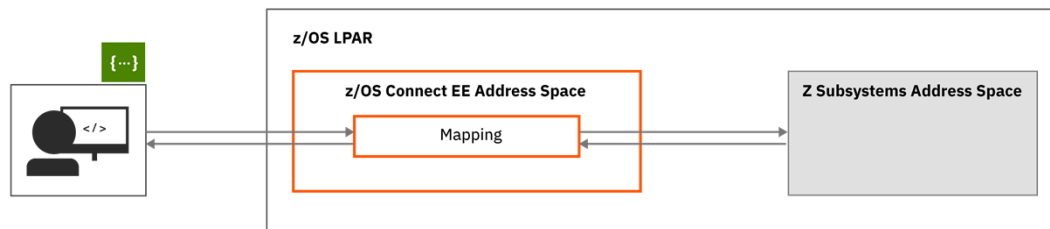
**Other than a RESTful interface,
what does z/OS Connect provide?**

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Let's Start with Data mapping

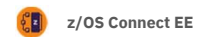


Converting from JSON to the target's subsystem's format

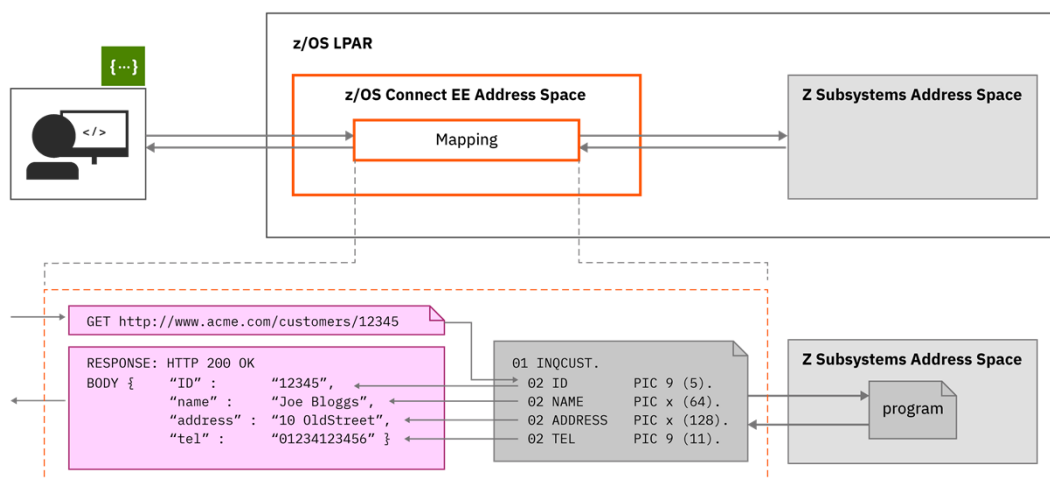


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Data mapping Example

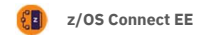


A closer look



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COBOL versus JSON Example



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

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

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

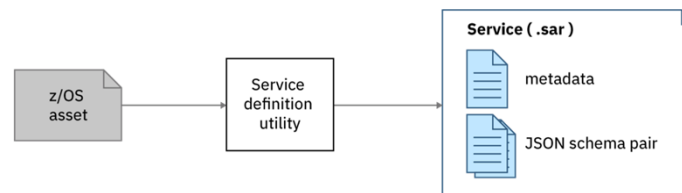
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Steps to expose a z/OS application



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)
- z/OS Connect EE Build Toolkit (Db2, MQ, IBM File Manager and HATS)
- BAQLS2JS (WOLA)
- DVM Toolkit

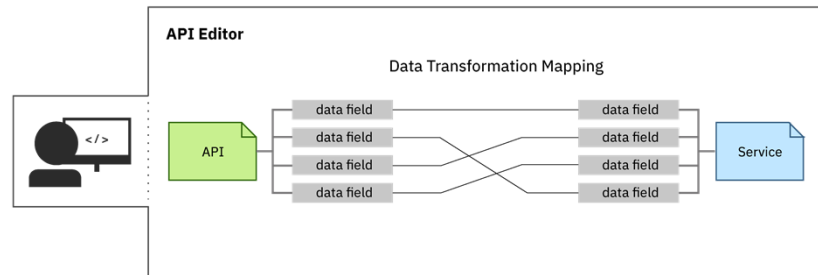
ibm.biz/zosconnect-sar-creation

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Steps to expose a z/OS application



2. Create an API



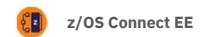
Import your `.sar` file into the **API toolkit**, and start designing your API.

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

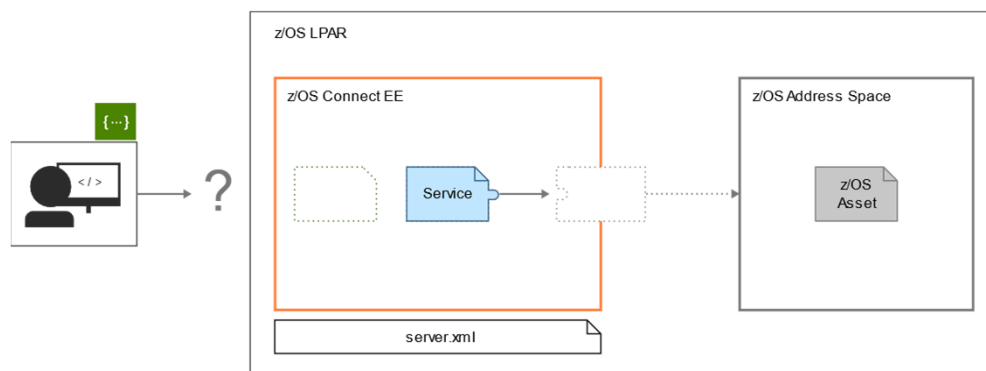
ibm.biz/zosconnect-create-api

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Steps to expose a z/OS application



3. Deploy your service

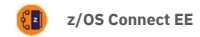


Deploy the `.sar` file generated in **Step 2** using the right-click deploy in the **API toolkit**, or by copying the `.sar` file to the services directory.

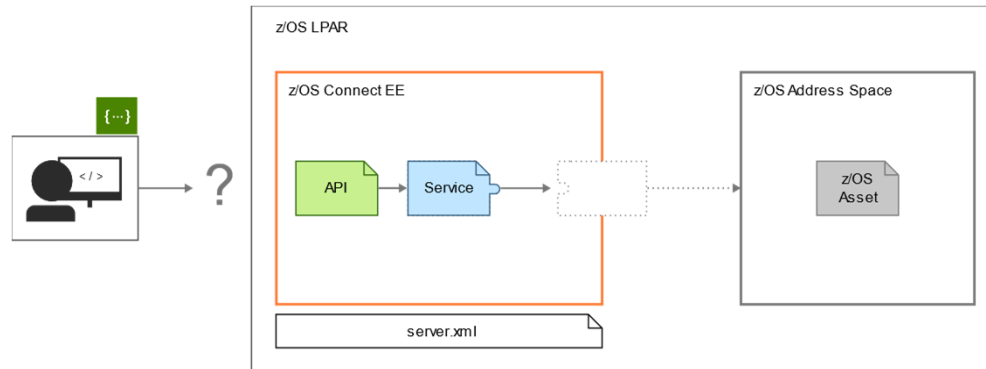
ibm.biz/zosconnect-define-services

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Steps to expose a z/OS application



4. Deploy your API

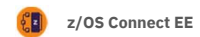


Deploy your API using the right-click deploy in **the API toolkit**, or by copying the `.aar` file to the `apis` directory.

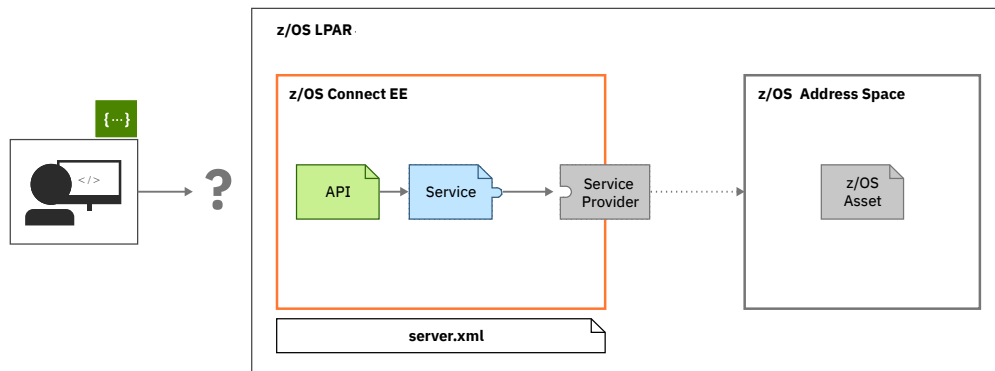
ibm.biz/zosconnect-deploy-api

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Steps to expose a z/OS application



5. Configure your service provider



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

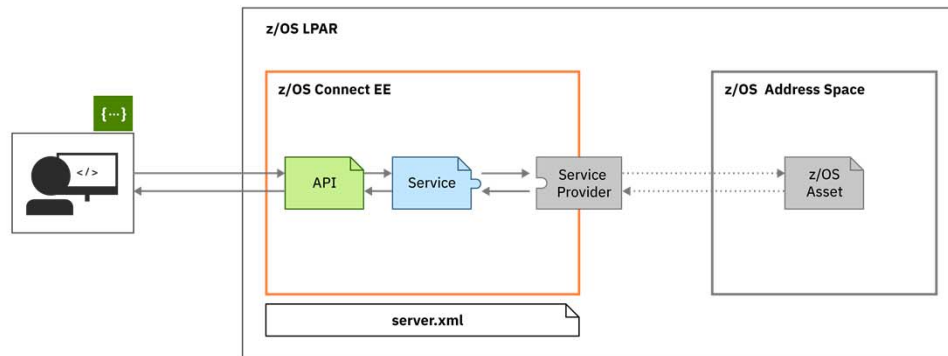
ibm.biz/zosconnect-configuring

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Steps to expose a z/OS application



6. Done



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

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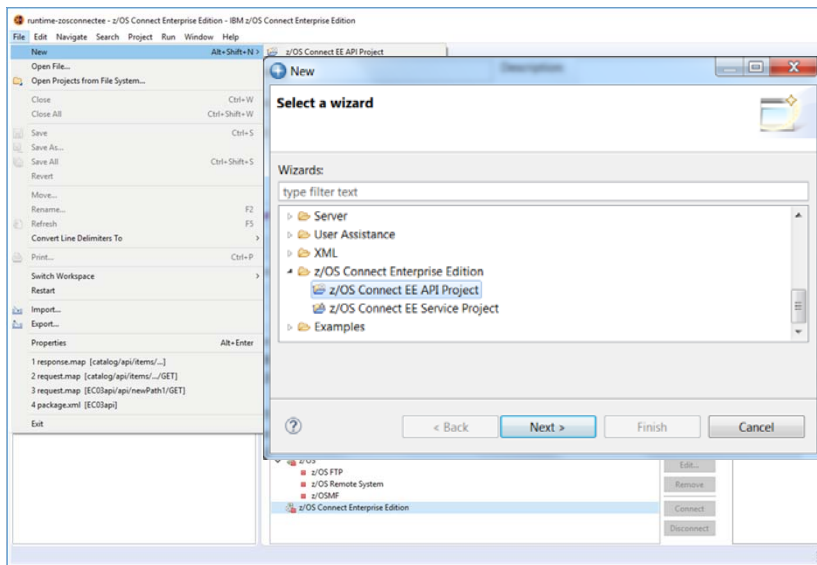
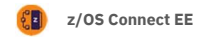


/api_toolkit/services

Simple **service** creation.

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API toolkit – Creating Services for CICS and IMS

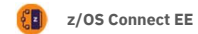


Use the **API toolkit** to create services through Eclipse-based tooling.

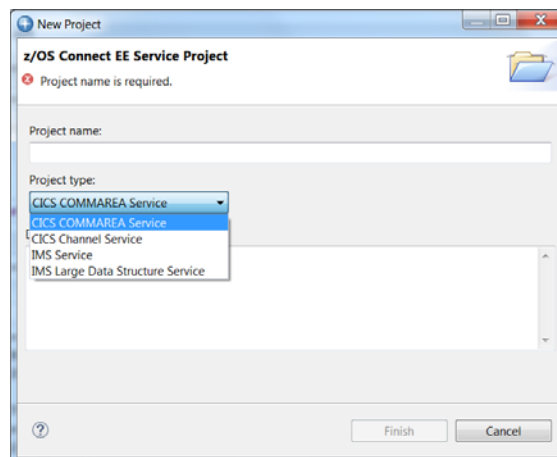
Services are described as **Projects**, so They can be easily managed in source control.

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API toolkit – Creating Services for CICS and IMS



Service creation – a common interface



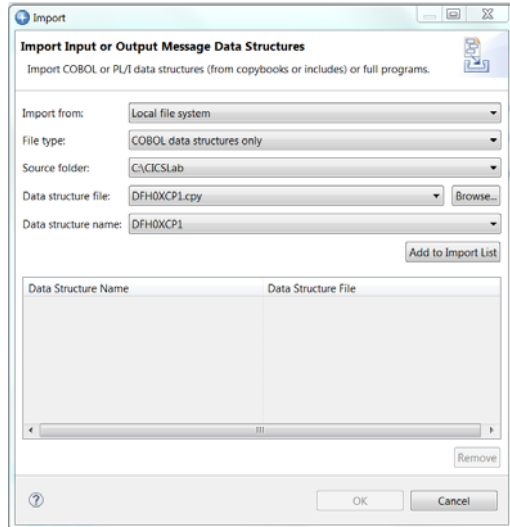
A common interface for service creation, agnostic of back end subsystem.

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API toolkit – Creating Services for CICS and IMS



Creating a service project

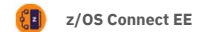


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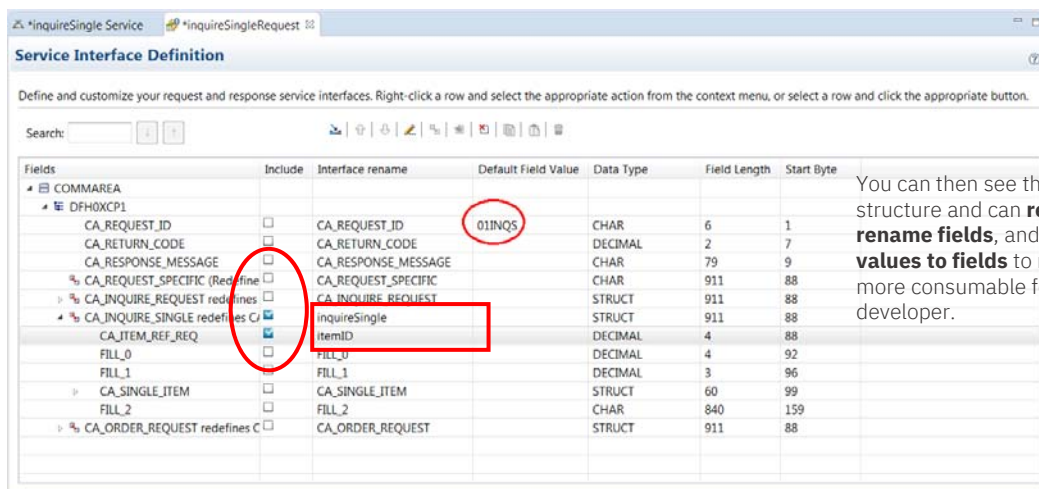
You start by importing data structures into the service interface from the local file system or the workspace.

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

API toolkit – Creating Services for CICS and IMS



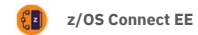
Creating a service interface definition



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.

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Creating a service – response message

Service Interface Definition

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

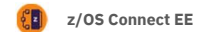
Search:

Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
COMMAREA						
DFH00CP1						
CA_REQUEST_ID	<input type="checkbox"/>	CA_REQUEST_ID		CHAR	6	1
CA_RETURN_CODE	<input checked="" type="checkbox"/>	returnCode		DECIMAL	2	7
CA_RESPONSE_MESSAGE	<input checked="" type="checkbox"/>	responseMessage		CHAR	79	9
CA_REQUEST_SPECIFIC (Redefine)	<input type="checkbox"/>	CA_REQUEST_SPECIFIC		CHAR	911	88
CA_INQUIRE_REQUEST (Redefine)	<input type="checkbox"/>	CA_INQUIRE_REQUEST		STRUCT	911	88
CA_INQUIRE_SINGLE (Redefine)	<input checked="" type="checkbox"/>	InquireSingle		STRUCT	911	88
CA_ITEM_REF_REQ	<input type="checkbox"/>	CA_ITEM_REF_REQ		DECIMAL	4	88
FILL_0	<input type="checkbox"/>	FILL_0		DECIMAL	4	92
FILL_1	<input type="checkbox"/>	FILL_1		DECIMAL	3	96
CA_SINGLE_ITEM	<input checked="" type="checkbox"/>	singleItem		STRUCT	60	99
CA_SNGL_ITEM_REF	<input checked="" type="checkbox"/>	itemReference		DECIMAL	4	99
CA_SNGL_DESCRIPTION	<input checked="" type="checkbox"/>	description		CHAR	40	103
CA_SNGL_DEPARTMENT	<input checked="" type="checkbox"/>	department		DECIMAL	3	143
CA_SNGL_COST	<input checked="" type="checkbox"/>	cost		CHAR	6	146
IN_SNGL_STOCK	<input checked="" type="checkbox"/>	inStock		DECIMAL	4	152
ON_SNGL_ORDER	<input checked="" type="checkbox"/>	onOrder		DECIMAL	3	156
FILL_2	<input type="checkbox"/>	FILL_2		CHAR	840	159
CA_ORDER_REQUEST (Redefine)	<input checked="" type="checkbox"/>	CA_ORDER_REQUEST		STRUCT	911	88
CA_USERID	<input type="checkbox"/>	CA_USERID		CHAR	8	88
CA_CHARGE_DEPT	<input type="checkbox"/>	CA_CHARGE_DEPT		CHAR	8	96
CA_ITEM_REF_NUMBER	<input type="checkbox"/>	CA_ITEM_REF_NUMBER		DECIMAL	4	104
CA_QUANTITY_REQ	<input type="checkbox"/>	CA_QUANTITY_REQ		DECIMAL	3	108
FILL_3	<input type="checkbox"/>	FILL_3		CHAR	888	111

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

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Creating a service interface definition

Service Interface Editor

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

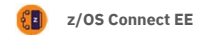
Search:

Fields	Include	Interface Rename	Default Field Value	Data Type	Field Length	Start
COMMAREA						
MINILOAN_COMMAREA						
NAME	<input checked="" type="checkbox"/>	loan application		CHAR	20	1
CREDITSCORE	<input checked="" type="checkbox"/>	name		DECIMAL	18	21
YEARLYINCOME	<input checked="" type="checkbox"/>	credit score		DECIMAL	18	39
AGE	<input checked="" type="checkbox"/>	yearly income		DECIMAL	10	57
AMOUNT	<input checked="" type="checkbox"/>	age		DECIMAL	18	67
APPROVED	<input type="checkbox"/>	loan amount		CHAR	1	85
EFFECTYDATE	<input type="checkbox"/>	approved?	P	CHAR	8	86
YEARLYINTERESTRATE	<input type="checkbox"/>	effective date		DECIMAL	5	94
YEARLYREPAYMENT	<input type="checkbox"/>	yearly interest rate	00005	DECIMAL	18	99
UID	<input type="checkbox"/>	yearly payment		CHAR	8	117
MESSAGES_NUM	<input checked="" type="checkbox"/>	authorization identity		DECIMAL	9	125
MESSAGES (1..99)	<input type="checkbox"/>	MESSAGES_NUM		ARRAY	5940	134
		disapproval message				

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.

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Creating a “GET” service interface request definition

Service Interface Definition

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

Search:

Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
ivtnoDisplayRequest						
Segment 1						
INPUT_MSG						
IN_LL	<input type="checkbox"/>	IN_LL		SHORT	2	1
IN_ZZ	<input type="checkbox"/>	IN_ZZ		SHORT	2	3
IN_TRANCDE	<input type="checkbox"/>	IN_TRANCDE		CHAR	10	5
IN_COMMAND	<input type="checkbox"/>	IN_COMMAND		CHAR	8	15
IN_LAST_NAME	<input checked="" type="checkbox"/>	lastName	VTNO	CHAR	10	23
IN_FIRST_NAME	<input type="checkbox"/>	IN_FIRST_NAME		CHAR	10	33
IN_EXTENSION	<input type="checkbox"/>	IN_EXTENSION		CHAR	10	43
IN_ZIP_CODE	<input type="checkbox"/>	IN_ZIP_CODE		CHAR	7	53

The service developer creates distinct services for each function.

DISPLAY
DELETE
ADD
UPDATE

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Creating a “GET” service interface response definition

Service Interface Definition

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

Search:

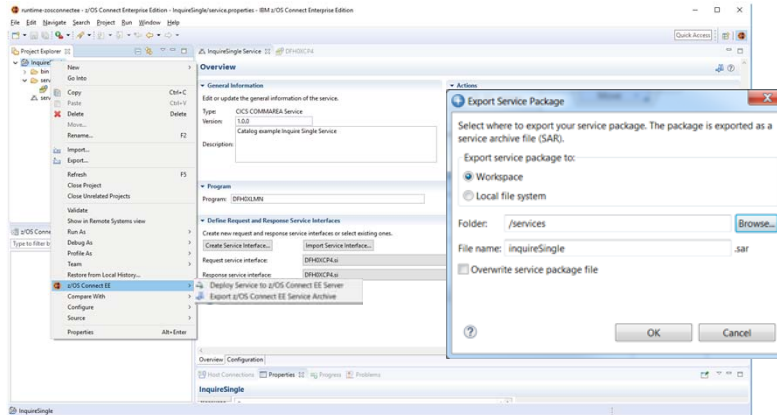
Fields	Include	Interface rename	Default Field Value	Data Type	Field Length	Start Byte
ivtnoDisplayResponse						
Segment 1						
OUTPUT_AREA						
OUT_LL	<input type="checkbox"/>	OUT_LL		SHORT	2	1
OUT_ZZ	<input type="checkbox"/>	OUT_ZZ		SHORT	2	3
OUT_MESSAGE	<input checked="" type="checkbox"/>	message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

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Creating a service for CICS and IMS



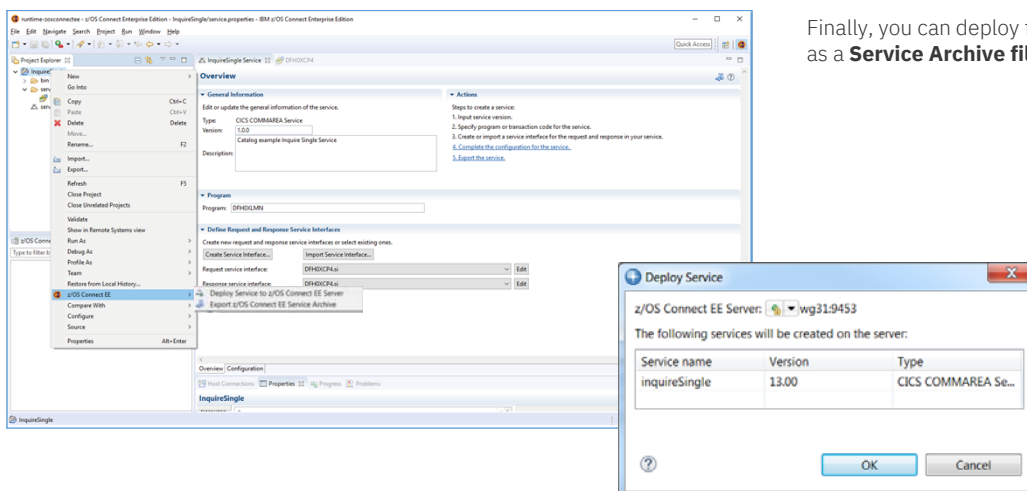
Finally, you can export the service project as a **Service Archive file (.sar)**.

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API toolkit – Creating Services for CICS and IMS



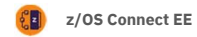
Creating a service for CICS and IMS



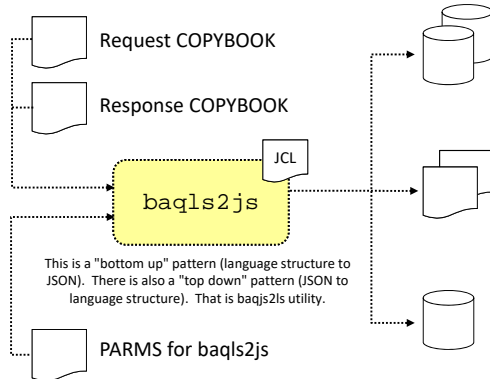
Finally, you can deploy the service project as a **Service Archive file (.sar)**

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Creating Services without the Toolkit - 1



For 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.

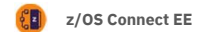
Service Archive (SAR) File

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.

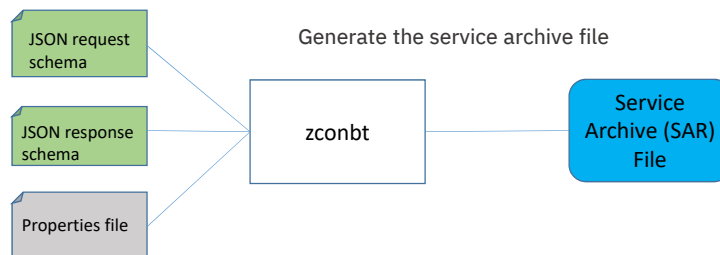
This is placed in a USS file system location based on input parms you specify.

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Creating Services without the Toolkit – 2a



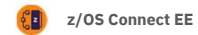
For DB2 and HATS REST Services use the z/OS Connect Build toolkit (zconbt)



```
provider=rest
name=selectEmployee
version=1.0
description=Select a row from USER1.EMPLOYEE
requestSchemaFile=selectEmployeeRequest.json
responseSchemaFile=selectEmployeeResponse.json
verb=POST
uri=/services/selectEmployee
connectionRef=Db2Conn
```

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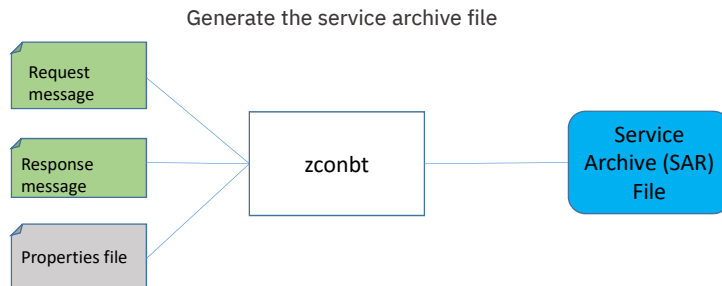
Creating Services without the Toolkit – 2b



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

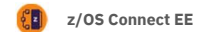
```
provider=mq
name=mqPut
version=1.0
description=MQ put one-way
destination=jms/default
connectionFactory=jms/qmgrCf
language=COBOL
requestStructure=FILEAMQ.CPY
operationName=mqPut
messagingAction=mqput/mqget
```

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



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Creating Services without the Toolkit – 2c



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

Generate the service archive file

Properties file

- FM Template
- Data set name
- ADFzCC host
- ADFzCC port

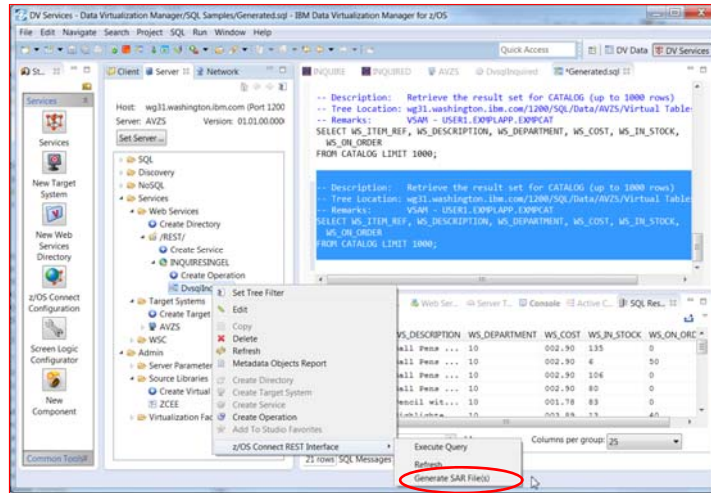
```
name=filea
provider=filemanager
host=wg31.washington.ibm.com
version=1.0
port=2800
file=USER1.ZCEE.FILEA
template=USER1.TEMPLATE(FILEA)
connid=default
userid=USER1
passwd=USER1
```



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Creating Services without the Toolkit – Part 3 z/OS Connect EE

For DVM use the DVM Studio



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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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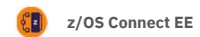


/api_toolkit/api_editor

Quick and easy **API** mapping.

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API toolkit – API Editor



API definition

The screenshot shows the 'z/OS Connect EE API Editor' window. It has a title bar with a file icon and the text '*catalog API 32'. Below the title bar is a menu bar with 'z/OS Connect EE API Editor'. The main area is titled 'Describe your API' and contains several input fields: 'Name' (catalog), 'Base path' (/catalogManager), 'Version' (1.0.0), and 'Description' (APIs for browsing, inquiring and ordering items from a catalog). Below these fields are two sections for defining API methods. The first section is titled 'Path' and contains a table with two methods: 'GET' (InquireCatalog) and 'POST' (placeOrder). The second section is also titled 'Path' and contains a table with three methods: 'GET' (InquireSingle), 'PUT' (InquireSingle), and 'DELETE' (InquireSingle). Each method row has columns for 'Path', 'Method', 'Service...', and 'Mapping...'.

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

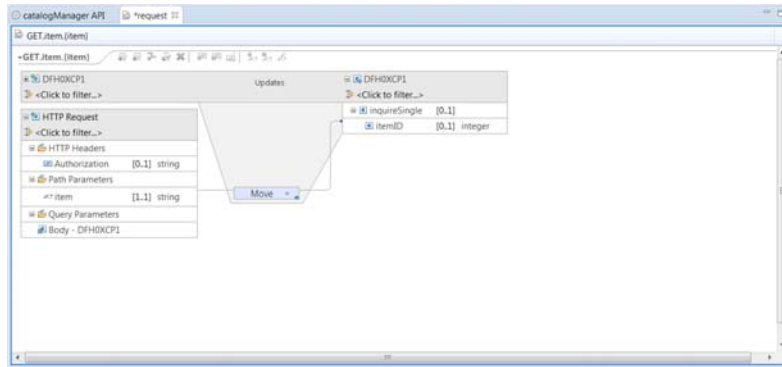
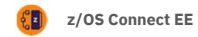
Once you define your API, you can map backend services to each request.

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

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API toolkit – API Editor

API mapping: Point-and-click interface



Map both the request and response for each API.

Map path and query parameters to native data structures.

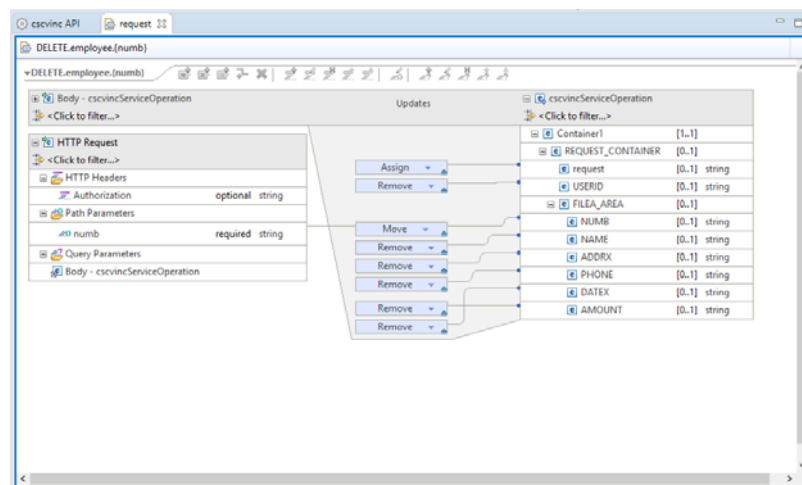
Assign static values to fields, useful for Op codes.

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

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API toolkit – API Editor

API mapping: Point-and-click interface



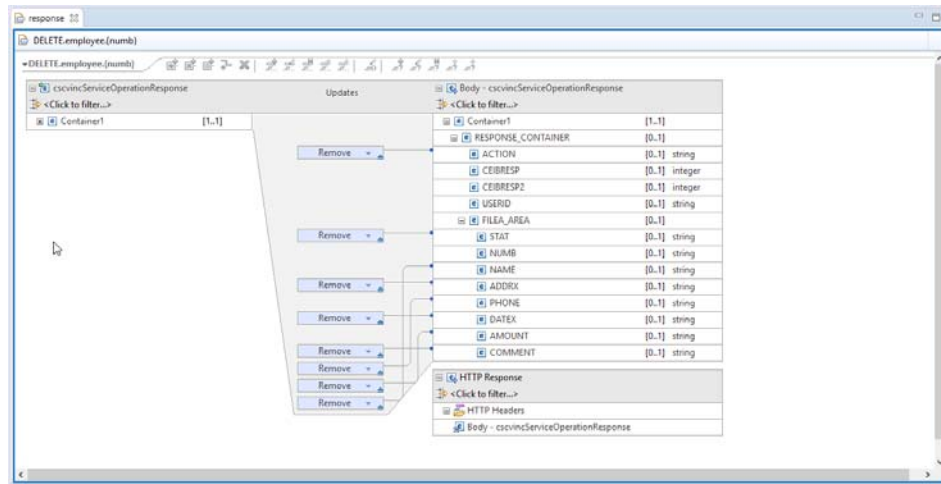
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API toolkit – API Editor



API mapping: Point-and-click interface

Allows the API Developer to remove fields to simplify the API

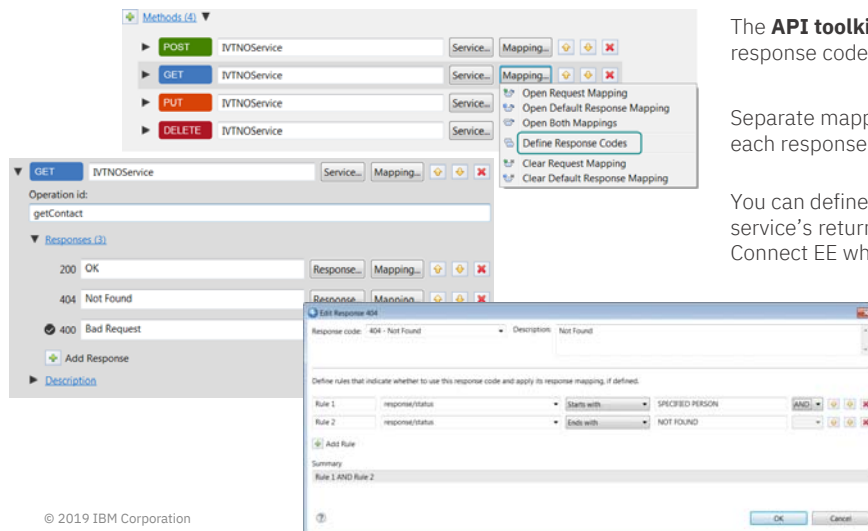


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API toolkit



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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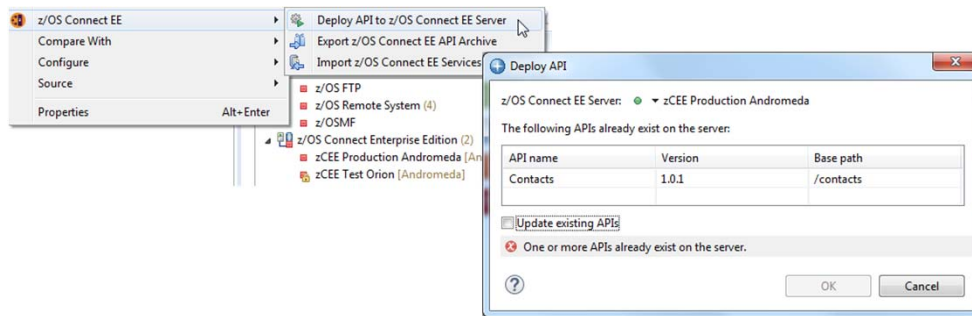
50

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.

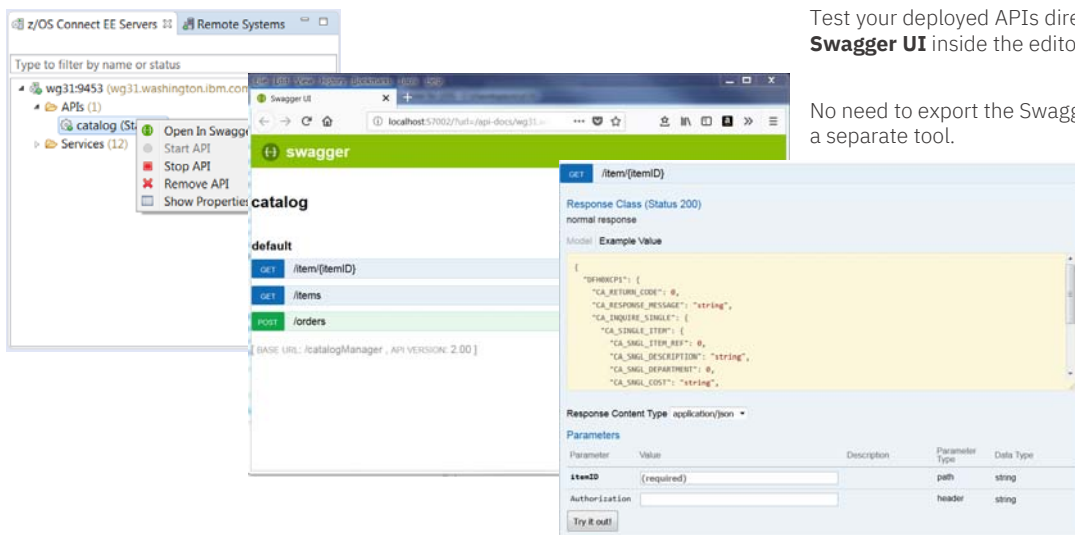
z/OS Connect EE servers view allows you to start, stop, and remove APIs from a running server.

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API toolkit – API Editor

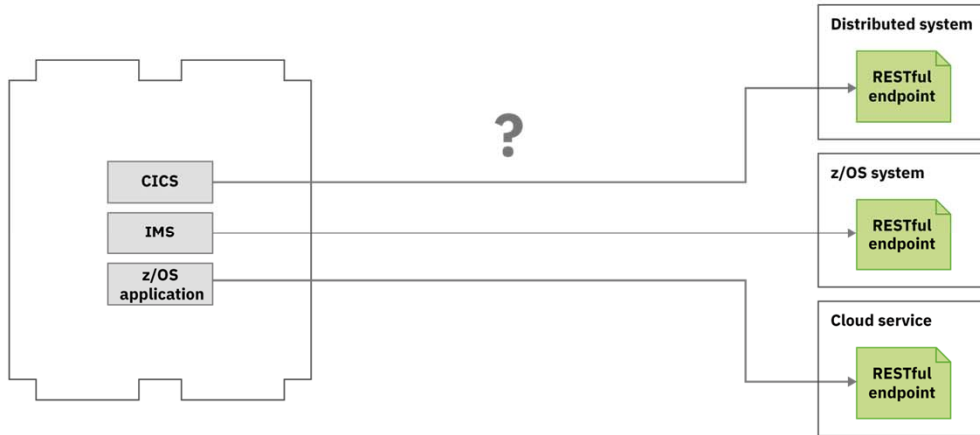


Testing with Swagger UI



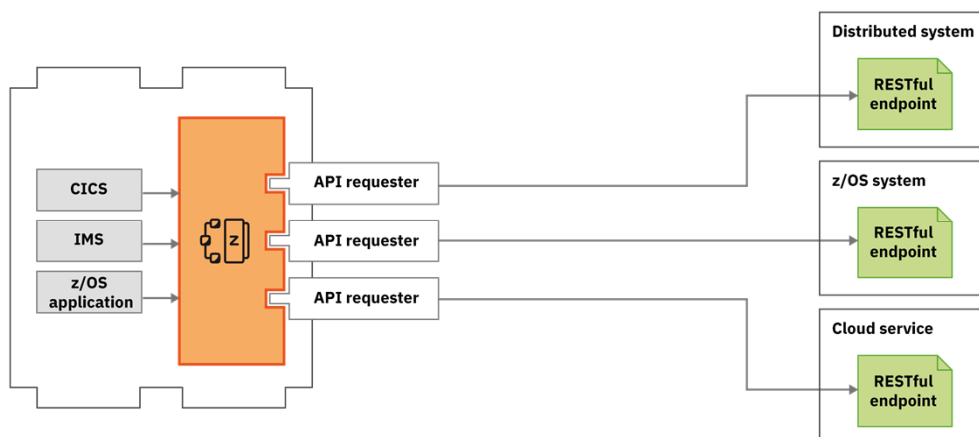
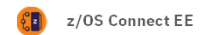
© 2018, 2019 IBM Corporation

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



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

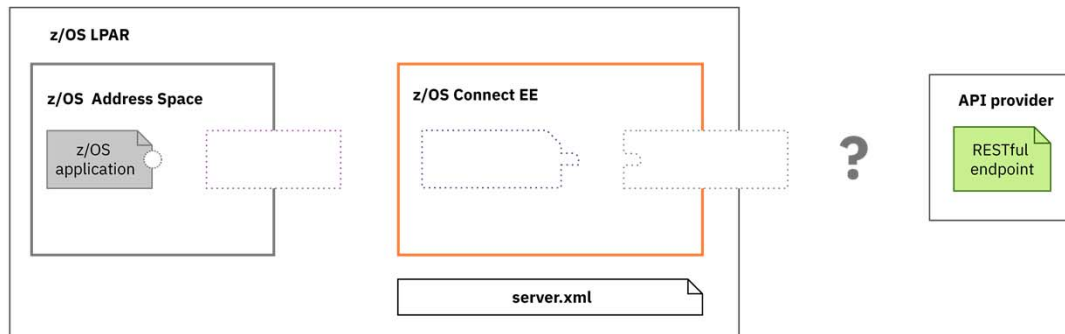


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Steps to calling an external API



Starting point

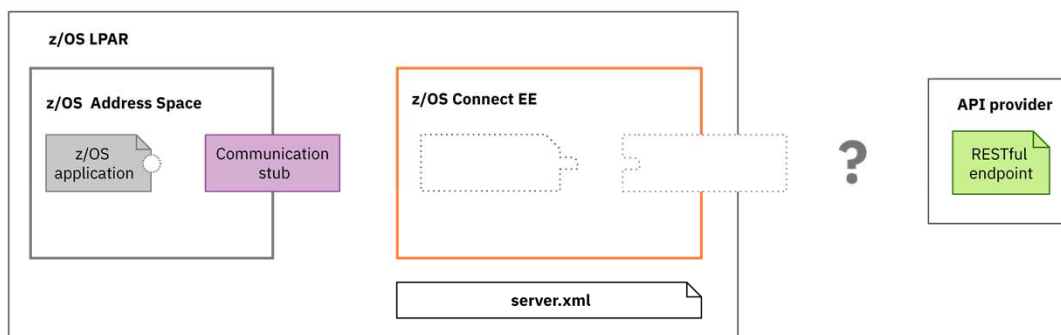


© 2018, 2019 IBM Corporation

Steps to calling an external API



Step 1. Configure communication stub



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

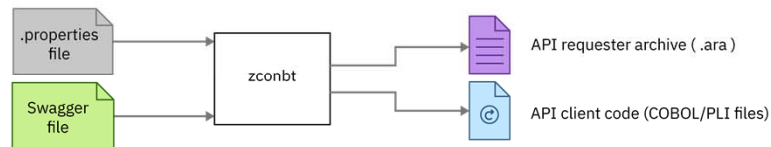
ibm.biz/zosconnect-configure-comms-stub

© 2018, 2019 IBM Corporation

Steps to calling an external API



Step 2. Generate API requester archive from Swagger



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

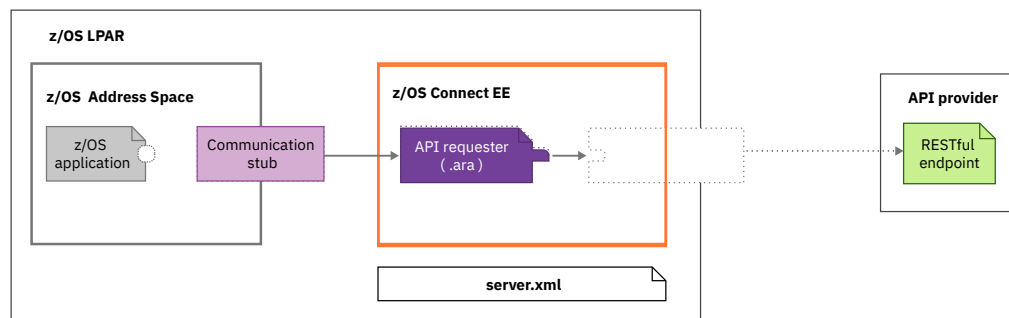
ibm.biz/zosconnect-generate-ara

© 2018, 2019 IBM Corporation

Steps to calling an external API



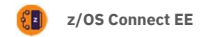
Step 3. Deploy API requester (.ara) archive



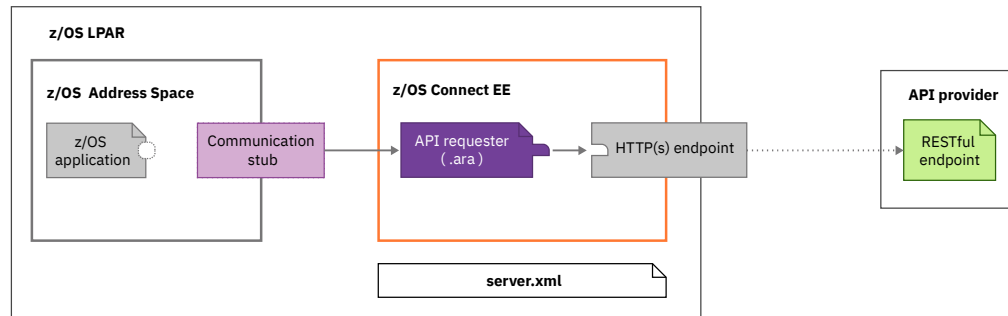
Deploy your API requester archive to the *apiRequester* directory.

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Steps to calling an external API



Step 4. Configure HTTP(S) endpoint



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

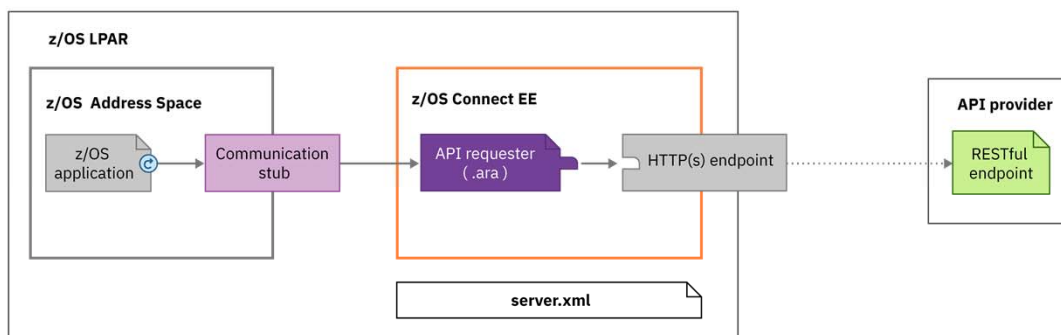
ibm.biz/zosconnect-configure-endpoint-connection

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Steps to calling an external API



Step 5. Update z/OS application



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

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

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Steps to calling an external API

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

The screenshot shows three windows in a z/OS development environment:

- GETAPI**: Contains error message structure definitions and comments.


```

      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.

      * Request and Response segment
      
```
- CSC02I01**: Contains data structure definitions.


```

      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.
      
```
- apis.xml**: Contains API configuration details.


```

      <!-- description="API Requester" -->
      <!-- enable features -->
      <!-- featureManager -->
      <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="9220"
      basicAuthRef="myBasicAuth"
      connectionTimeout="10s"
      receiveTimeout="20s" />

      <zosconnect_authData id="myBasicAuth"
      user="fred"
      password="frednrd" />
      </server>

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

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Steps to calling an external API

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

The screenshot shows the **GETAPI** window with the following COBOL code:

```

*-----*
* 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

```

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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 'BAQINFO' 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: " num2 of API_RESPONSE
  DISPLAY "NAME: " name2 of API_RESPONSE
  DISPLAY "ADDRX: " addr2 of API_RESPONSE
  DISPLAY "PHONE: " phone2 of API_RESPONSE
  DISPLAY "DATEX: " date2 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.

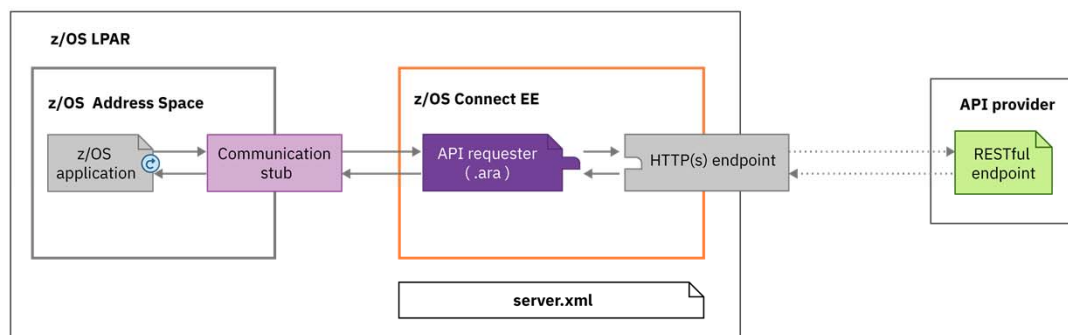
```

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Steps to calling an external API

 z/OS Connect EE

Done



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/common_scenarios

Typical connection patterns to different subsystems.

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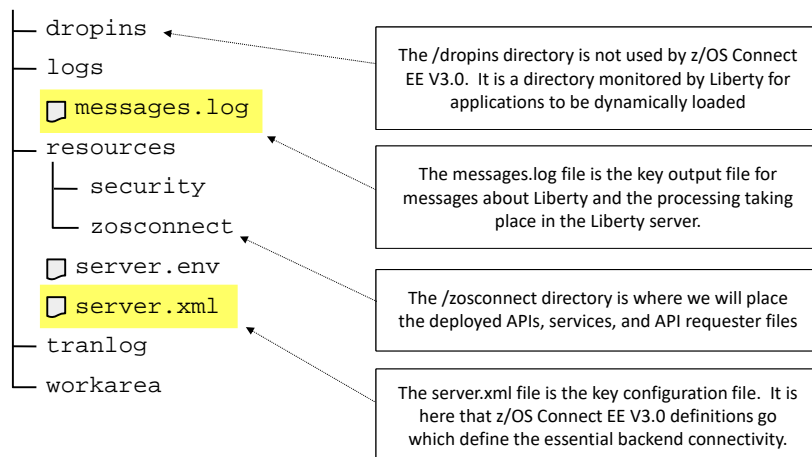
Tour of Server Configuration Directories and Files



z/OS Connect EE

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

`/var/zosconnect/servers/<server_name>`

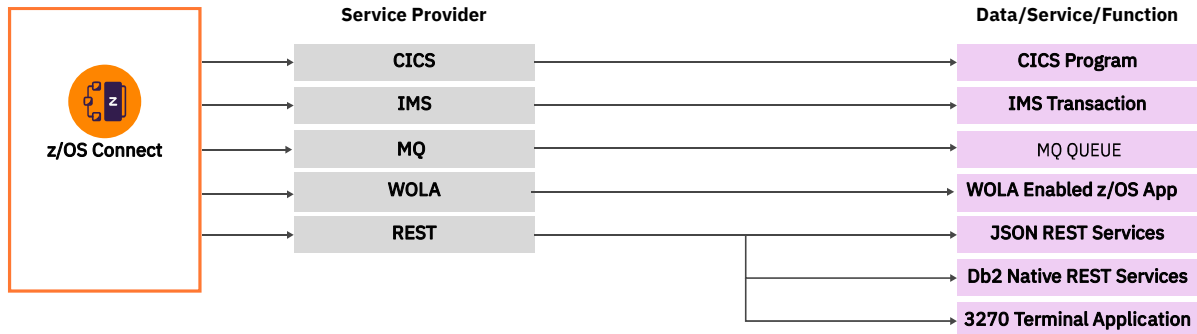


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What assets can z/OS Connect EE map to?



And which service provider could I use?



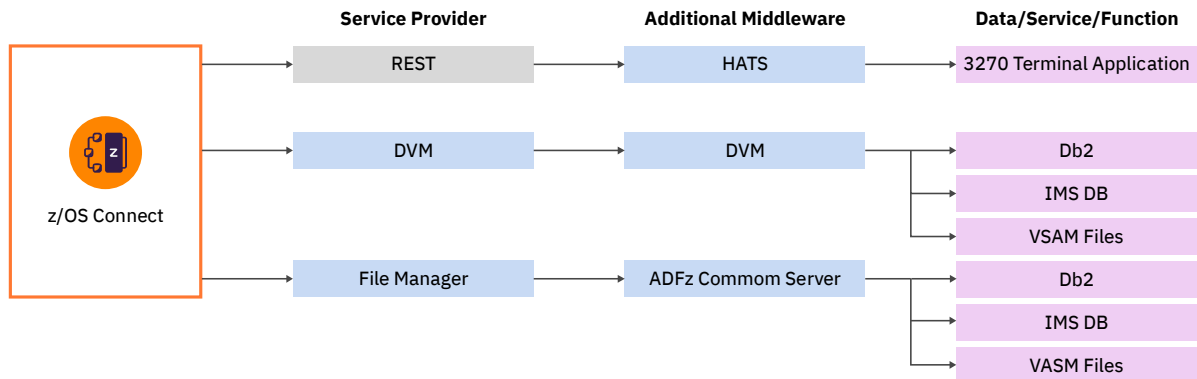
The core **service providers** included with z/OS Connect EE provide API access to a wide range of z/OS assets.

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Additional Middleware



Additional value from the ecosystem

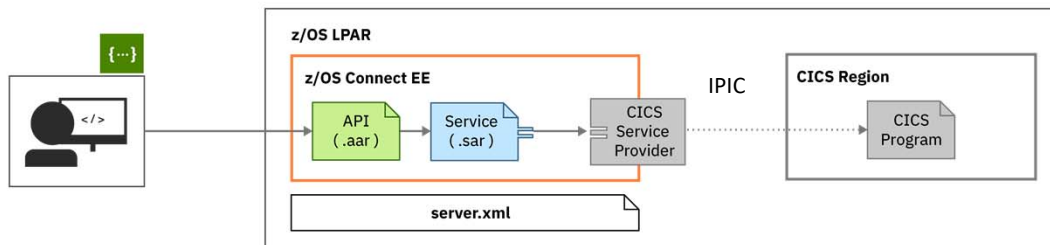


z/OS Connect EE is **pluggable** and **extensible** allowing the use of additional middleware to expand the list of z/OS assets you can expose as APIs

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Connections to CICS

Topology



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

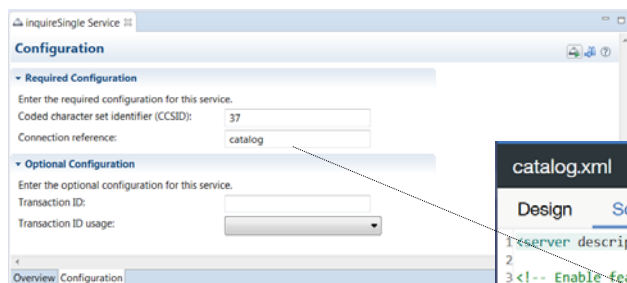
An IPIC connection must be configured in CICS.

ibm.biz/zosconnect-scenarios

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CICS IPIC (server.xml)

The `server.xml` file is the key configuration file:



Define IPIC connection to CICS

catalog.xml

```

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

```

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

z/OS Connect CICS IPIC connection
Defines a connection that enables requests to call CICS programs via an IPIC connection.

ID
catalog
A unique configuration ID.

Host
wg31.washington.ibm.com
IP address or DNS name of the system hosting the CICS region to be called.

Port
1491
Port number on which the CICS region is listening.

Shared port
false (default)
Indicates whether the specified port is shared.

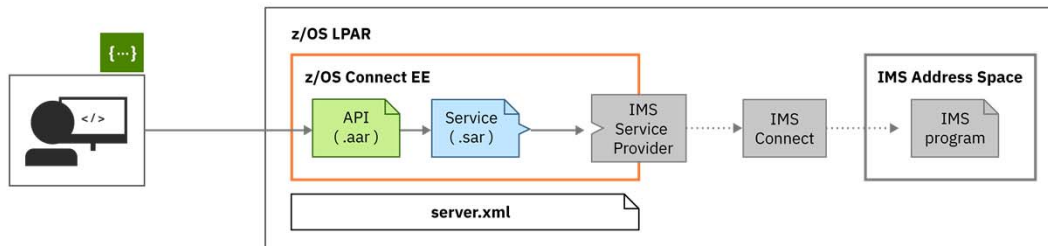
z/OS Connect APPLID
(no value)
The APPLID of the z/OS Connect server.

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The IMS `server.xml` file ...

Connections to IMS

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

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IMS Connections and Interactions



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

```

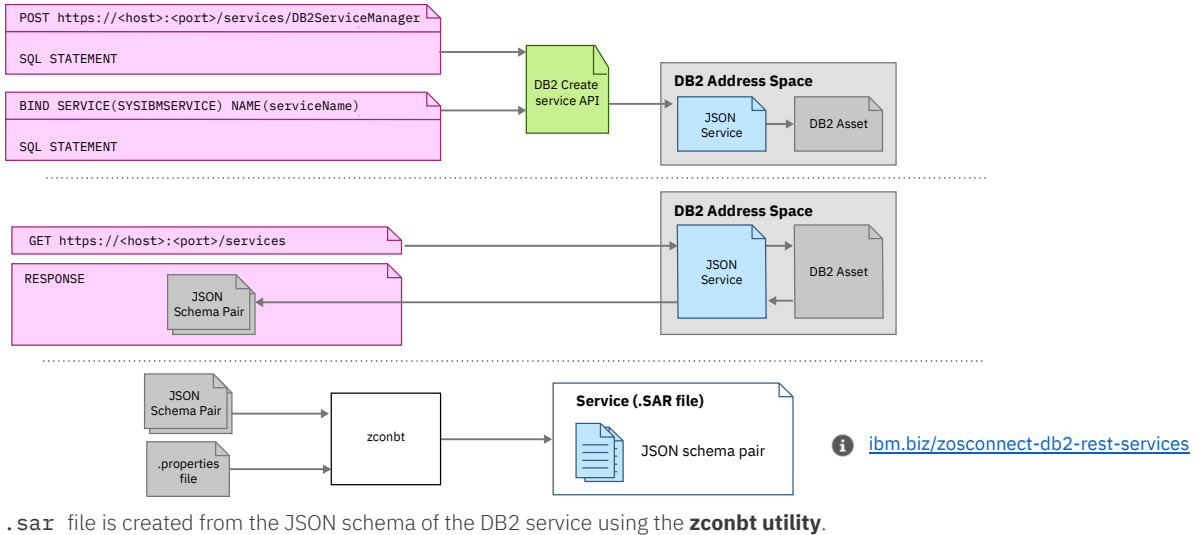
<server>
<imsmobile_interaction comment="" commitMode="1" id="IMSINTER" imsConnectCodepage="Cp1047" imsConnectTimeout="0"
  imsDatastoreName="IVP1" interactionTimeout="-1" ltermOverrideName="" syncLevel="0"/>
</server>

```

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Connect to Db2

Create the service definition

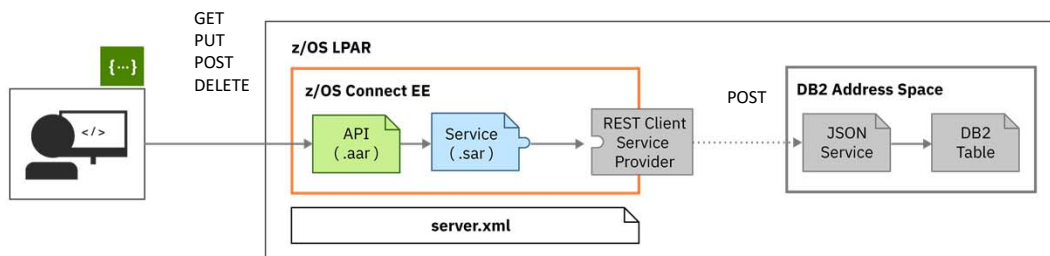


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Connections to Db2

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

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The server.xml File (Db2)



The server.xml file is the key configuration file:

```

db2pass.xml
Design Source
1 <server description="DB2 REST">
2
3 <zoscconnect_zosConnectServiceRestClientConnection id="db2conn"
4   host="wg31.washington.ibm.com"
5   port="2446"
6   basicAuthRef="dsn2Auth" />
7
8 <zoscconnect_zosConnectServiceRestClientBasicAuth id="dsn2Auth"
9   appName="DSN2APPL" />
10
11 </server>
12

```

```

DSNL004I  -DSN2 DDF START
COMPLETE

LOCATION

DSN2LOC

LU

USIBMWZ.DSN2APPL
GENERICLU -NONE
DOMAIN
WG31.WASHINGTON.IBM.COM
TCPPT  2446
SECPT  2445
RESPRT 2447

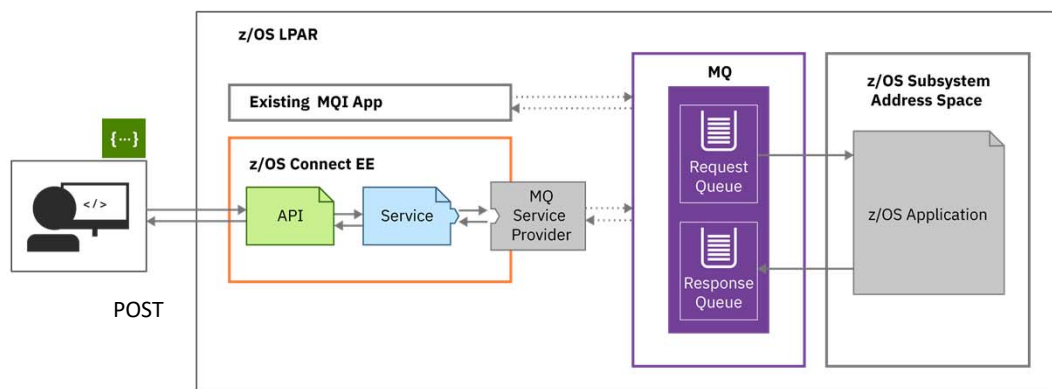
```

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Connections to MQ



Topology (Two-way service example)



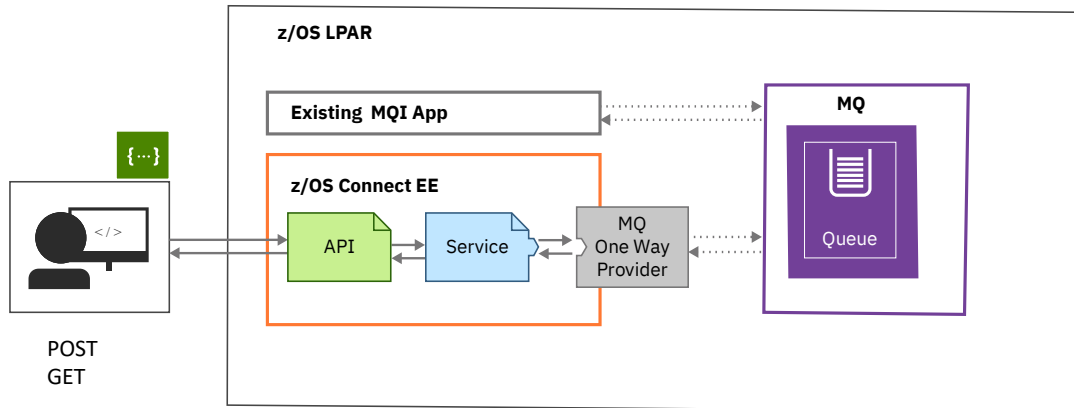
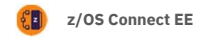
You can also configure one-way services.

ibm.biz/zosconnect-mq-service-provider

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Connections to MQ

Topology (One-way service example)



ibm.biz/zosconnect-mq-service-provider

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The server.xml File (MQ)



```

mq.xml
Design Source
1 <server description="MQ Service Provider">
2
3 <featureManager>
4   <feature>zosconnect:mqService-1.0</feature>
5 </featureManager>
6
7 <variable name="umqJmsClient.rar.location"
8   value="/usr/lpp/mqm/V9R1M1/java/lib/jca/umq-jmsra.rar"/>
9 <umqJmsClient nativeLibraryPath="/usr/lpp/mqm/V9R1M1/java/lib"/>
10
11 <connectionManager id="ConMgr1" maxPoolSize="5"/>
12
13 <jmsConnectionFactory id="qmgrCf" jndiName="jms/qmgrCf"
14   connectionManagerRef="ConMgr1">
15   <properties>umqJms transportType="BINDINGS"
16     queueManager="QM21" />
17 </jmsConnectionFactory>
18
19 <jmsQueue id="default" jndiName="jms/default">
20   <properties>umqJms
21     baseQueueName="ZCONN2.DEFAULT.MQZCEE.QUEUE"
22     CCSID="37"/>
23 </jmsQueue>
24
25 <jmsQueue id="request" jndiName="jms/request">
26   <properties>umqJms
27     baseQueueName="ZCONN2.TRIGGER.REQUEST"
28     targetClient="MQ"
29     CCSID="37"/>
30 </jmsQueue>
31
32 <jmsQueue id="response" jndiName="jms/response">
33   <properties>umqJms
34     baseQueueName="ZCONN2.TRIGGER.RESPONSE"
35     targetClient="MQ"
36     CCSID="37"/>
37 </jmsQueue>
38

```

Features related to JMS Support

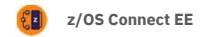
JMS Connection Factories,

JMS Destinations (queues)

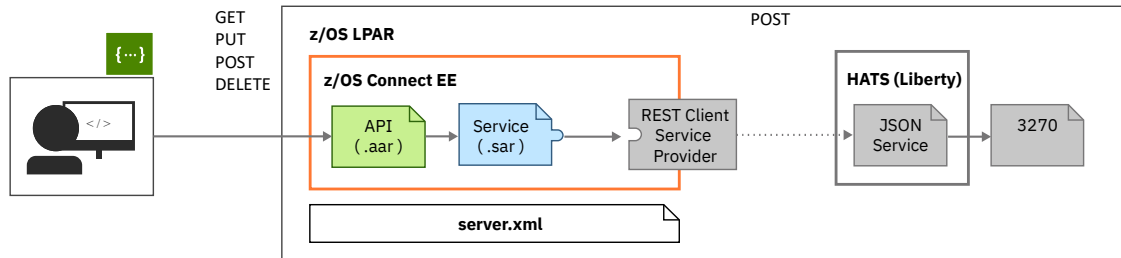
MQ V9.1.1 Added support for remote queue managers.

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Connection to HATS



Topology



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

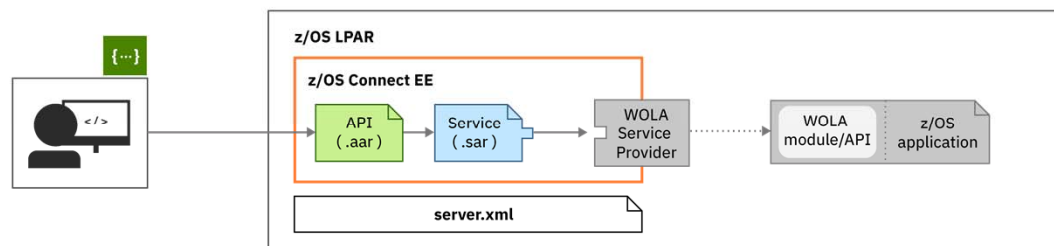
ibm.biz/zosconnect-db2-rest-services

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Connections to a MVS batch application



Topology



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

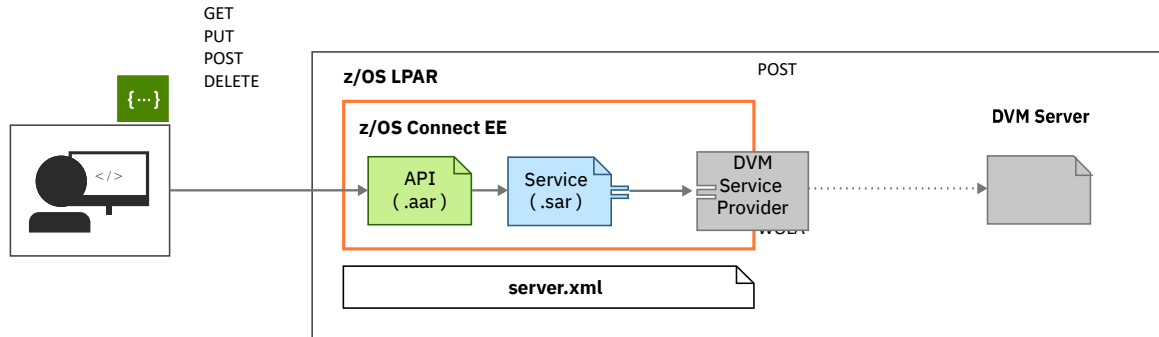
The z/OS application must be WOLA-enabled.

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Connections to DVM



Topology

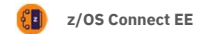


The DVM service provider uses WOLA

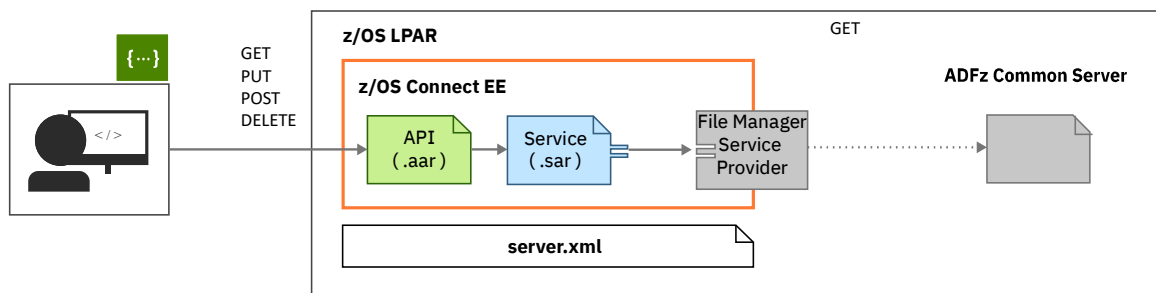
ibm.biz/zosconnect-db2-rest-services

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Connections to File Manager



Topology



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

A File Manager Template is required .

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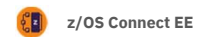


/miscellaneousTopics

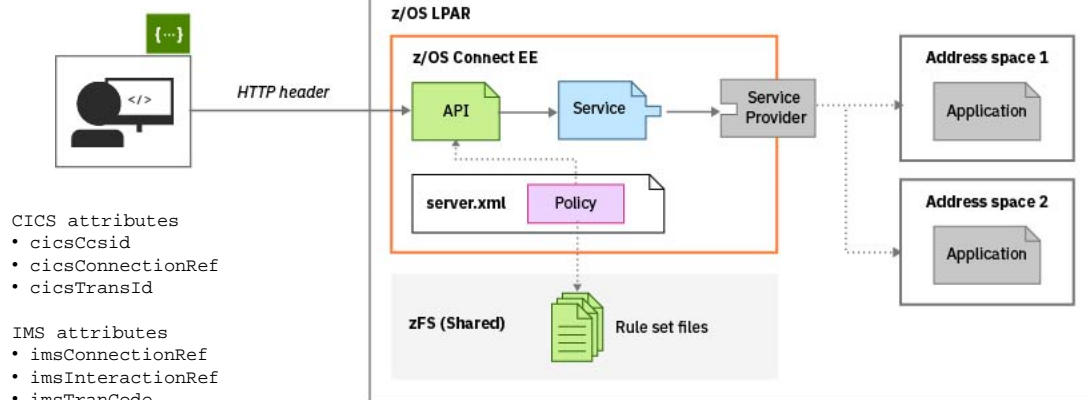
performance, high availability, Liberty

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API Policies



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

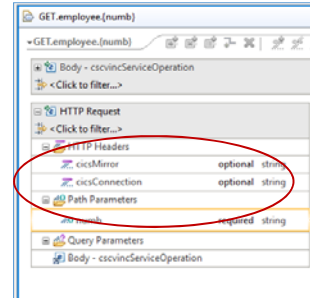


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A sample API Policies for CICS



```
<ruleset name="CICS rules">
  <rule name="csmi-rule">
    <conditions>
      <header name="cicsMirror" value="CSMI,MIJO"/> 1
    </conditions>
    <actions>
      <set property="cicsTransId" value="{cicsMirror}"/>
    </actions>
  </rule>
  <rule name="connection-rule">
    <conditions>
      <header name="cicsConnection"
        value="cscvinc,cics92,cics93"/>
    </conditions>
    <actions>
      <set property="cicsConnectionRef"
        value="{cicsConnection}" />
    </actions>
  </rule>
</ruleset>
```



Curl

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

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

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Displaying zCEE messages on the console and/or spool



server.xml

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

MVS Console

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

STDERR

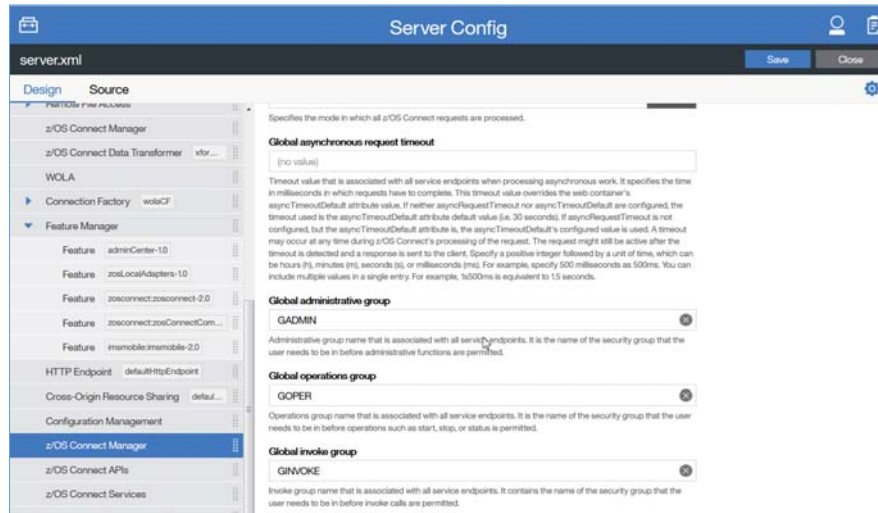
```
ÝERROR " BAQR0686E: Program CSCVINC is not available in the CICS region with connection cscvinc and service cscvincService.
ÝERROR " BAQR0686E: Program CSCVINC is not available in the CICS region with connection cscvinc and service cscvincService.
ÝERROR " BAQR0657E: Transaction abend MIJO occurred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

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Liberty's "adminCenter" Feature

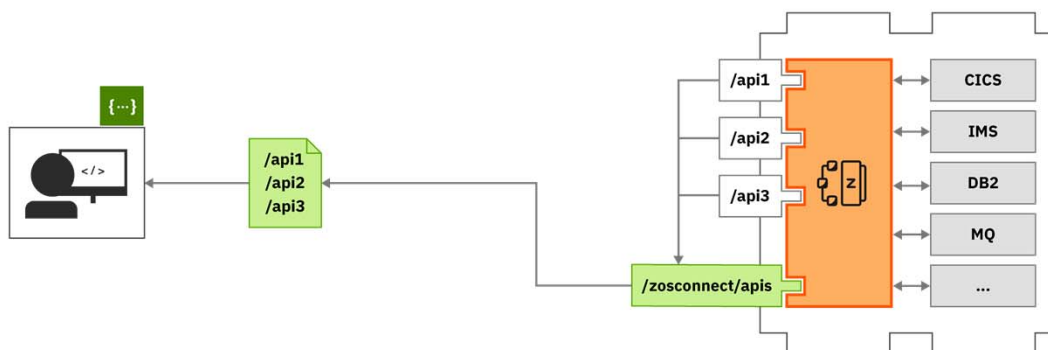


Web browser interface to the server's configuration files



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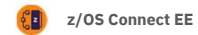
API Documentation



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

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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`

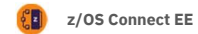
GET `/zosConnect/services/{serviceName}`

DELETE `/zosConnect/services/{serviceName}`

*Useful for deploying DB2 and HATS
service archive files

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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`

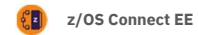
GET `/zosConnect/apis`

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

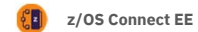
Method	Administrative Task
GET	Get a list of API Requesters
	Get the details of an API Requester
POST	Deploy an API Requester
PUT	Update an API Requester
	Change the status of an API Requester
DELETE	Delete an API Requester

```

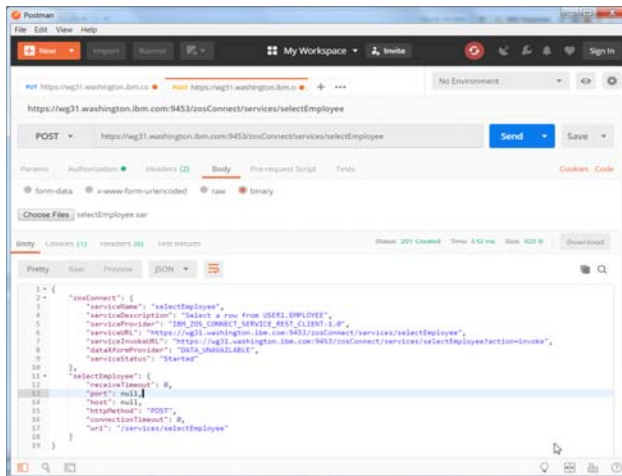
GET    /zosConnect/apisRequesters cscvinc.aar
PUT    /zosConnect/apisRequesters/{apiRequesterName}?status=started|stopped
PUT    /zosConnect/apisRequesters cscvinc.aar
GET    /zosConnect/apisRequesters
GET    /zosConnect/apisRequesters/{apRequesterName}
DELETE /zosConnect/apisRequesters
  
```

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Deploying Db2 Service Archive Options



- 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

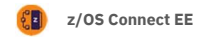
Results:

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

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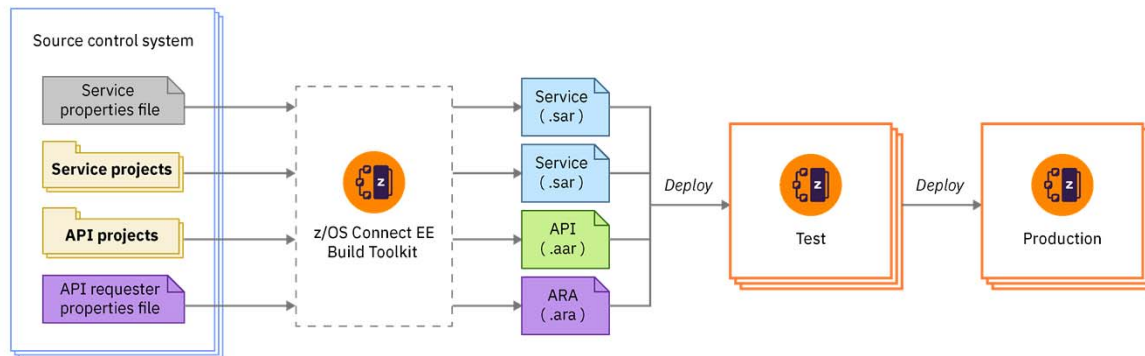
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DevOps using z/OS Connect EE



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 dropins folders or by using the REST Admin API



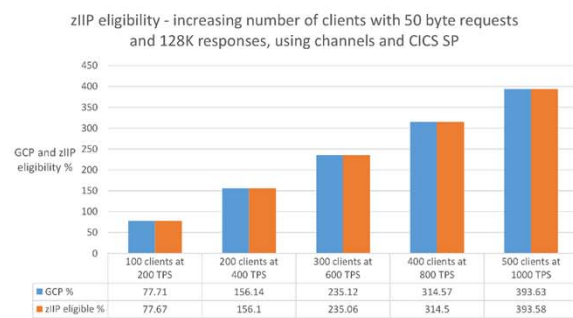
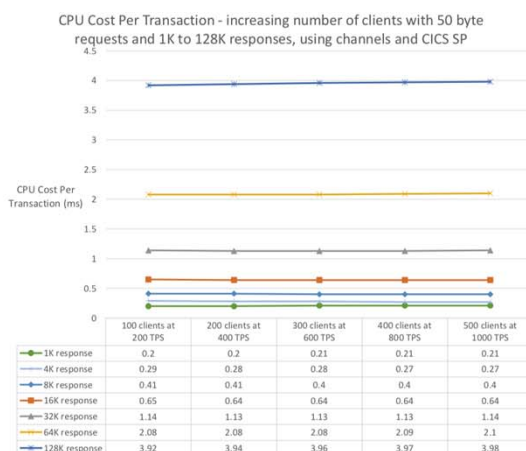
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Performance: API Provider

High Speed, High Throughput, Low Cost



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

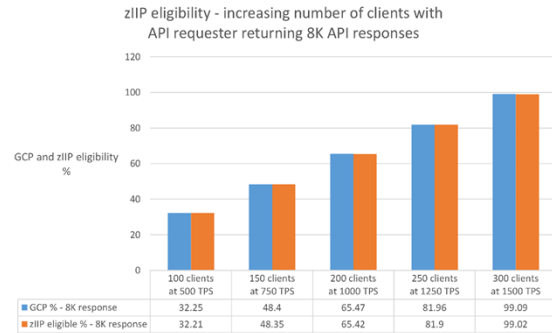
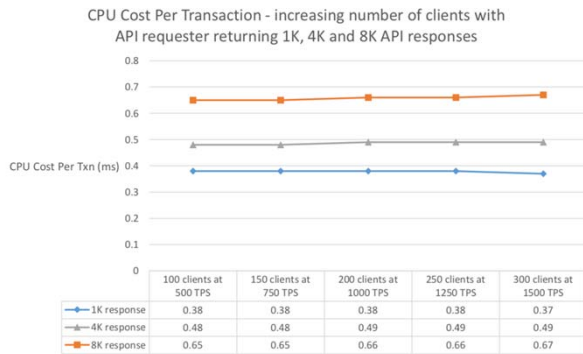
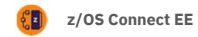
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98

Performance: API Requester

High Speed, High Throughput, Low Cost



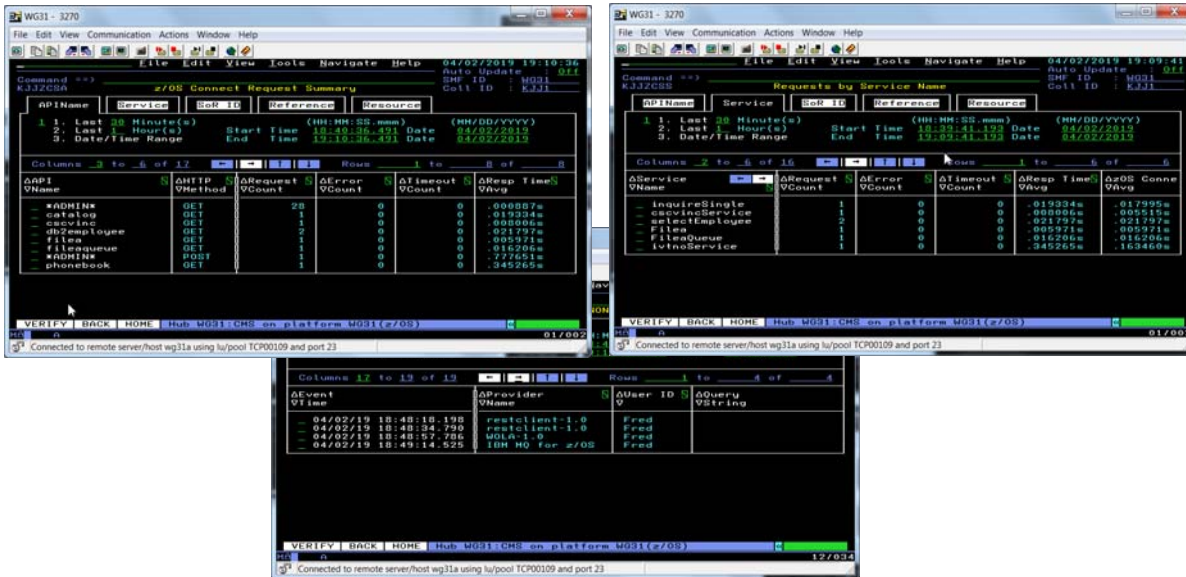
z/OS Connect EE is a Java-based product:
Over **99%** of its MIPs are **eligible for zIIP offload**.

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ibm.biz/zosconnect-performance-report

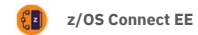
99

IBM z Omegamon for JVM



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IBM z Omegamon for JVM



```

WG31 - 3270
File Edit View Communication Actions Window Help
04/02/2019 18:59:29
Auto Update Off
z/OS Connect Request Detail
Command ==> z/OS Connect Request Detail
Event Time: 04/02/19 18:49:14.525
Request Type: API
API name: filequeue
Request URI: /filequeue/mq
Query String:
Method: GET
Port: 9453
HTTP code: 200 (OK)
Service Name: fileQueue
Total Req Time: 0.01000s
z/OS Conn Time: 0.01620s
SoR Resp Time: 0.00000s
SoR ID: NONE
SoR Resource: NONE
Remote Address: 192.168.0.141
Request Length: 191
Correlator: e6e2d3d7d3c5e7400011000010d5ea51
Operation: getFile
Provider: IBM MQ for z/OS
User ID: Fred
VERIFIED BACK HOME Hub M031:CHS on platform M031(z/OS)
01/002
Connected to remote server/host wg31a using lu/pool TCP00109 and port 23
Request Type: API
API name: db2employee
Request URI: /db2/employee/000020
Query String:
Method: GET
Port: 9453
HTTP code: 200 (OK)
Service Name: selectEmployee
Total Req Time: 0.02259s
z/OS Conn Time: 0.02259s
SoR Resp Time: 0.00000s
SoR ID: NONE
SoR Resource: NONE
Remote Address: 192.168.0.141
Request Length: 0
Correlator: e6e2d3d7d3c5e7400011000010d5ea50
Operation: selectEmployee
Provider: restclient-1.0
User ID: Fred
VERIFIED BACK HOME Hub M031:CHS on platform M031(z/OS)
01/002
Connected to remote server/host wg31a using lu/pool TCP00109 and port 23

```

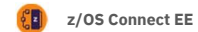
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```

WG31 - 3270
File Edit View Communication Actions Window Help
04/02/2019 19:00:52
Auto Update Off
z/OS Connect Request Detail
Command ==> z/OS Connect Request Detail
Event Time: 04/02/19 18:47:54.267
Request Type: API
API name: cscvinc
Request URI: /cscvinc/employee/444444
Query String:
Method: GET
Port: 9453
HTTP code: 200 (OK)
Service Name: cscvincService
Total Req Time: 0.00000s
z/OS Conn Time: 0.00551s
SoR Resp Time: 0.00240s
SoR ID: 0510002 - CICS532
SoR Resource: CSCI C5GVINC
Remote Address: 192.168.0.141
Request Length: 0
Correlator: e6e2d3d7d3c5e7400011000010d5ea50
Operation: getcscvincService
Provider: CICS-1.0
User ID: Fred
VERIFIED BACK HOME Hub M031:CHS on platform M031(z/OS)
01/002
Connected to remote server/host wg31a using lu/pool TCP00109 and port 23
Request Type: API
API name: phonebook
Request URI: /phonebook/contacts/LAST1
Query String:
Method: GET
Port: 9453
HTTP code: 200 (OK)
Service Name: lvtncService
Total Req Time: 0.24525s
z/OS Conn Time: 0.16346s
SoR Resp Time: 0.10100s
SoR ID: IHS00NN
SoR Resource: IVTNO
Remote Address: 192.168.0.141
Request Length: 0
Correlator: e6e2d3d7d3c5e7400011000010d5ea55
Operation: getPhonebookService1
Provider: imobile-2.0
User ID: Fred
VERIFIED BACK HOME Hub M031:CHS on platform M031(z/OS)
01/002
Connected to remote server/host wg31a using lu/pool TCP00109 and port 23

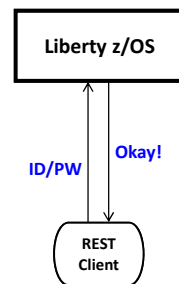
```

Authentication



Several different ways this can be accomplished:

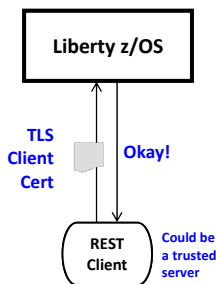
Basic Authentication



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

- Basic (server.xml)
- LDAP
- SAF

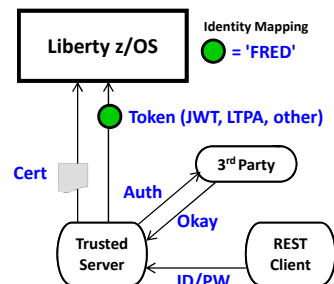
Client Certificate



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

- LDAP
- SAF

Third Party Authentication



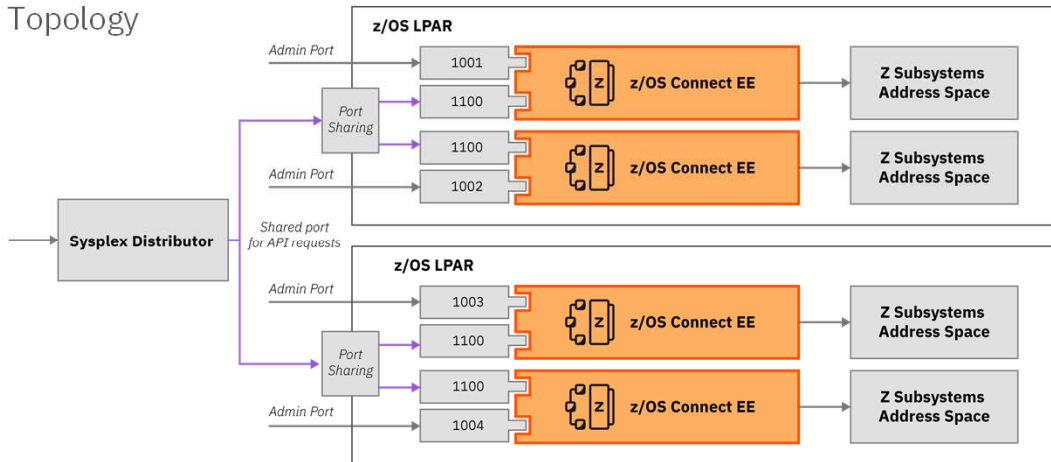
Client authenticates to 3rd party sever
 Client receives a trusted 3rd party token
 Token flows to Liberty z/OS and is mapped to an identity
 Registry options:

- LDAP
- SAF

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High Availability

Topology



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ibm.biz/zosconnect-scenarios

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/questions?thanks=true

Thank you for listening.

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/exercises

basic security, exercise paths

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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
- [z/OS Connect EE Bootcamp Survey](#)
<https://ibm.biz/zconneeAdvSurvey>
- [Material can be downloaded from:](#)
<http://tinyurl.com/y28fsezs>
- [z/OS Connect EE Users Group](#)
<https://www.linkedin.com/groups/8731382/>

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