

# Db2 for z/OS: REST and Hybrid Cloud

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## Virtual Workshop

Keziah Knopp  
Db2 for z/OS Specialist – WSC  
[keziah.knopp@ibm.com](mailto:keziah.knopp@ibm.com)

Thuy-Mi Le  
Z Client Technical Specialist – Public  
[thuy-mi.le@ibm.com](mailto:thuy-mi.le@ibm.com)



# Q: What role most closely aligns with your job?

- A) System admin
- B) DBA
- C) System programmer
- D) Application developer
- E) Other

# Agenda

## **Mobile Trends & the API Economy**

## **RESTful APIs Overview**

## **Db2 for z/OS REST Services**

- Creating, discovering, and invoking Db2 REST services

## **Versioning Db2 REST Services**

## **z/OS Connect EE Overview**

- Service & deployment process, data mapping, and performance

## **Db2 REST & z/OS Connect EE**

**Lab Exercises 1:** Native REST Services

**Lab Exercises 2:** z/OS Connect

# Mobile Trends & the API Economy

*It's not just a fad*

# 5 mobile trends with significant implications for the enterprise

## Mobile enables the Internet of Things

Global machine-to-machine connections increasing dramatically

## Leverage Industry Transformations

Transform the value chain and business operations

## Deepen Engagement

Customers  
Partners  
Employees

## Deliver Contextually Relevant Experience

## Drive Revenue and Productivity

Mobile is about transacting  
Evidence: "Cyber Monday"

## Mobile is primary

91% of mobile users keep their device within arm's reach 100% of the time

## Mobile must create a continuous brand experience

90% of users use multiple screens as channels come together to create integrated experiences

## Insights from mobile data provide new opportunities

75% of mobile shoppers take action after receiving a location-based message



## Expectations of Cloud

- I can connect to whatever I want
- I can try things out without penalty
- I won't be tied to any one single solution
- Everything will be familiar and standard



## Misconceptions of Z

- Doesn't support modern technologies
- Changes take too long
- Security policies seem foreign
- Z doesn't integrate

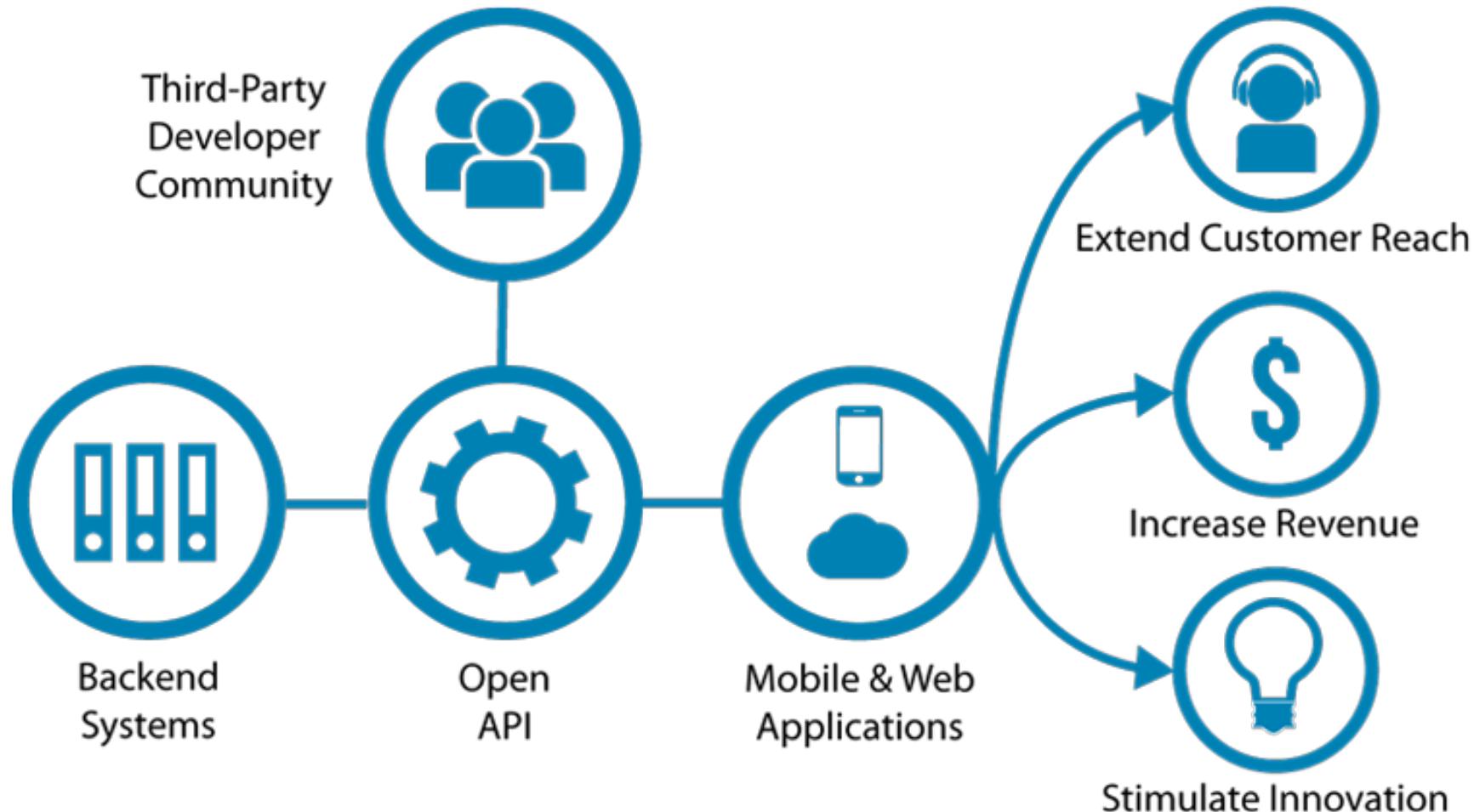
# The Reality

The screenshot shows the IBM API Connect /dev swagger interface. At the top, there is a navigation bar with links for cURL, Ruby, Python, PHP, Java, Node, Go, Swift, and a prominent 'Subscribe' button. Below the navigation bar, the URL 'IBM API Connect /dev' is displayed next to a 'swagger' logo. A large green arrow graphic points from left to right across the middle of the screen. On the left side, the text 'IBM Explorer for z/OS Aqua' is visible. The main content area is titled 'default'. Underneath, a 'GET /hotels' endpoint is listed. Below this, a 'Response Class (Status 200)' section is shown with a 'normal response' example. To the right, a detailed 'Example Response' is provided in JSON format:

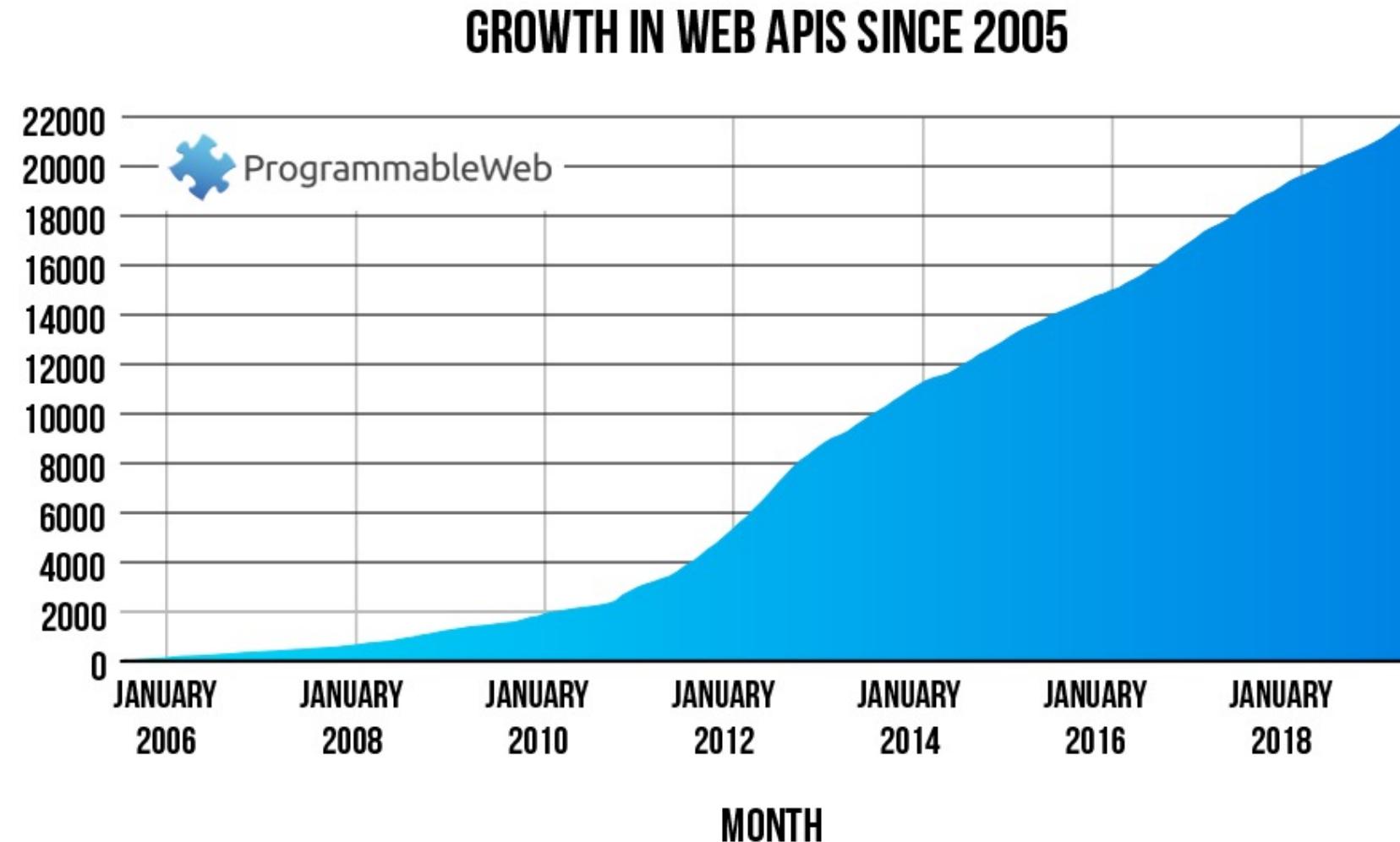
```
Example Response  
Definition  
GET https://api.us.apiconnect.ibmcloud.com/jbistiusibmcom-dev/sb/travel_jbisti/hotels  
Response  
{  
  "HOTEL_LIST_OUT": {  
    "HOTELS": [  
      {  
        "HOTEL_NAME": "Maud Morales",  
        "GEO": {  
          "HOTEL_LAT": "ruhvumcuol",  
          "HOTEL_LNG": "otie"  
        },  
        "HOTEL_LOCATION": "rawinelapraceruduwtefebjujum",  
        "HOTEL_RATING": "duol"  
      }  
    ]  
  }  
}
```

# What is the API economy

The use of “business APIs” to positively affect the company



# REST APIs are not just a fad...



Total new APIs added since 2015	8,076
Average new APIs added yearly	2,019
Average new APIs added monthly	168

- There are about 23,000 public APIs available.
- In the first 6 months of 2019, there was an increase of 30% of API growth, compared to the last four years (220 per month).

# Q: What is your experience level with RESTful APIs?

- A) Very familiar, like the back of my hand
- B) I've worked with them before
- C) I know REST services. Does that count?
- D) APIs, sure. RESTful, maybe not.
- E) This is the first I'm hearing about them

# RESTful APIs

*Technical overview*

# What is a **RESTful API**?

**REST** stands for Representational State Transfer architecture. (It is sometimes spelled "**ReST**".)

- stateless,
- client-server,
- cacheable communications protocol

✓ HTTP protocol is used

A RESTful API is an [application programming interface \(API\)](#) that uses HTTP requests to GET, PUT, POST, and DELETE data.

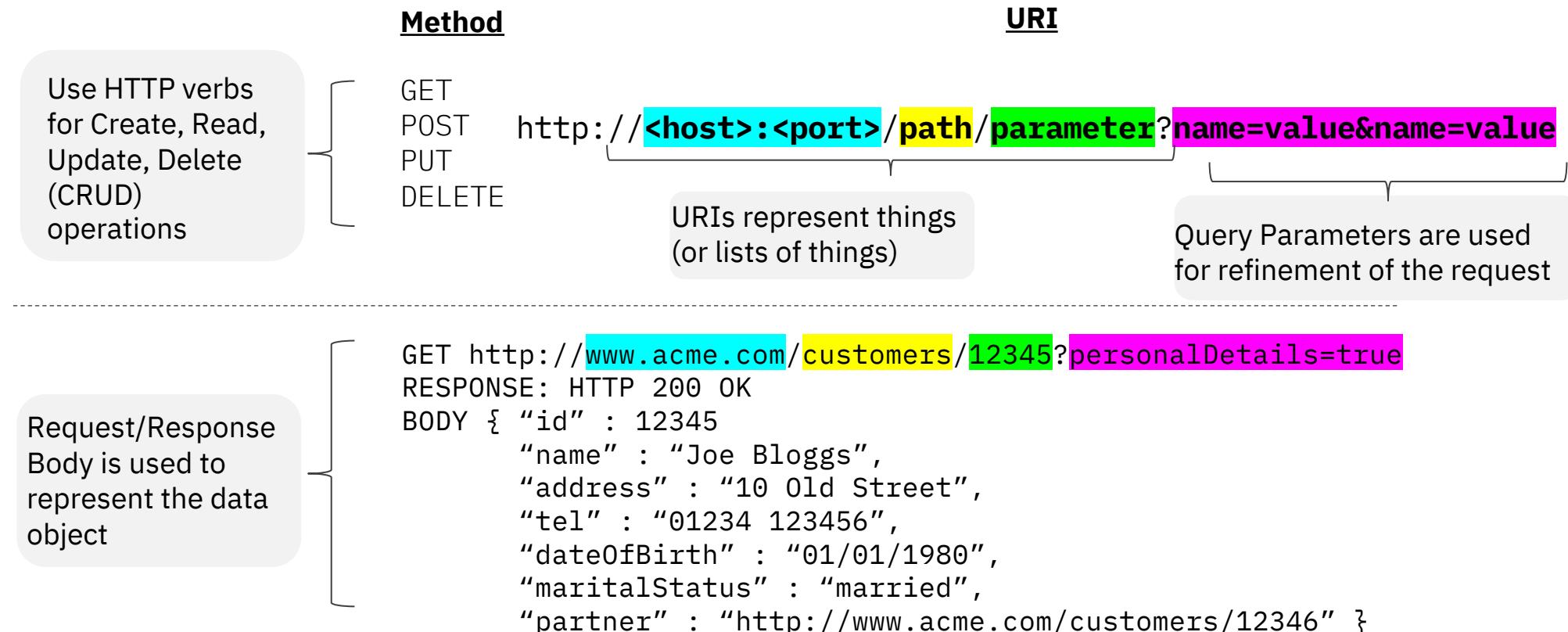
## **NOTE**

Db2 native REST only supports the [POST method](#) for applications.

GET can be used for some system related functions only, not applications. The zCEE API Editor allows you to reassign POST to a different method.

This is why Db2 native REST is REST, while [zCEE is RESTful](#)

# Key principles of REST



# REST and JSON

Throughout this workshop our focus will be on REST and JSON as the interface and data payload format:

## Representational State Transfer (REST)

`http://www.myhost.com:port/account/update`

Using HTTP verbs: GET, PUT, POST, etc.

The application  
understands what to  
do based on the URI

URI=Uniform  
Resource  
Identifier

## JavaScript Object Notation (JSON)

```
{  
  "account": "12345",  
  "lastName": "Smith",  
  "action": "Deposit",  
  "amount": "$1000.00",  
}
```

Data is represented as a series of  
name/value pairs.

This is serialized and passed in  
with the URI or returned with a  
response.

# HTTP Request Method Examples

Using the URL: <https://myhost.com/customer/235>

[GET] = Record for customer #235.

(in SQL terms - **SELECT**)

## **NOTE**

Db2 native REST can only use POST for applications, however this can be paired with SELECT, INSERT, UPDATE, DELETE, TRUNCATE, and WITH. For example, you can use the POST method with the SQL issuing a DELETE.

[PUT] + Info = Updated record for customer #235.

(in SQL terms - **UPDATE**)

[POST] + Info = New record for customer #235.

(in SQL terms - **INSERT**)

[DELETE] = Customer #235 Deleted.

(in SQL terms - **DELETE**)

# Why is REST popular?



**Increasingly Common**



**Relatively Lightweight**



**Relatively Easy Development**



**Ubiquitous Foundation**



**Stateless**

# Db2 for z/OS REST Services

*Technical overview*

# Db2 for z/OS REST objectives

Using REST and  
JSON to invoke one  
SQL statement or  
Stored Procedure

Enabling new  
business value for  
your enterprise data

Modernizing using  
the power of SQL

Unleashing Db2 data  
for the API Economy

# Db2 REST services

## Db2 REST service invocation

- New direct Db2 DDF REST access

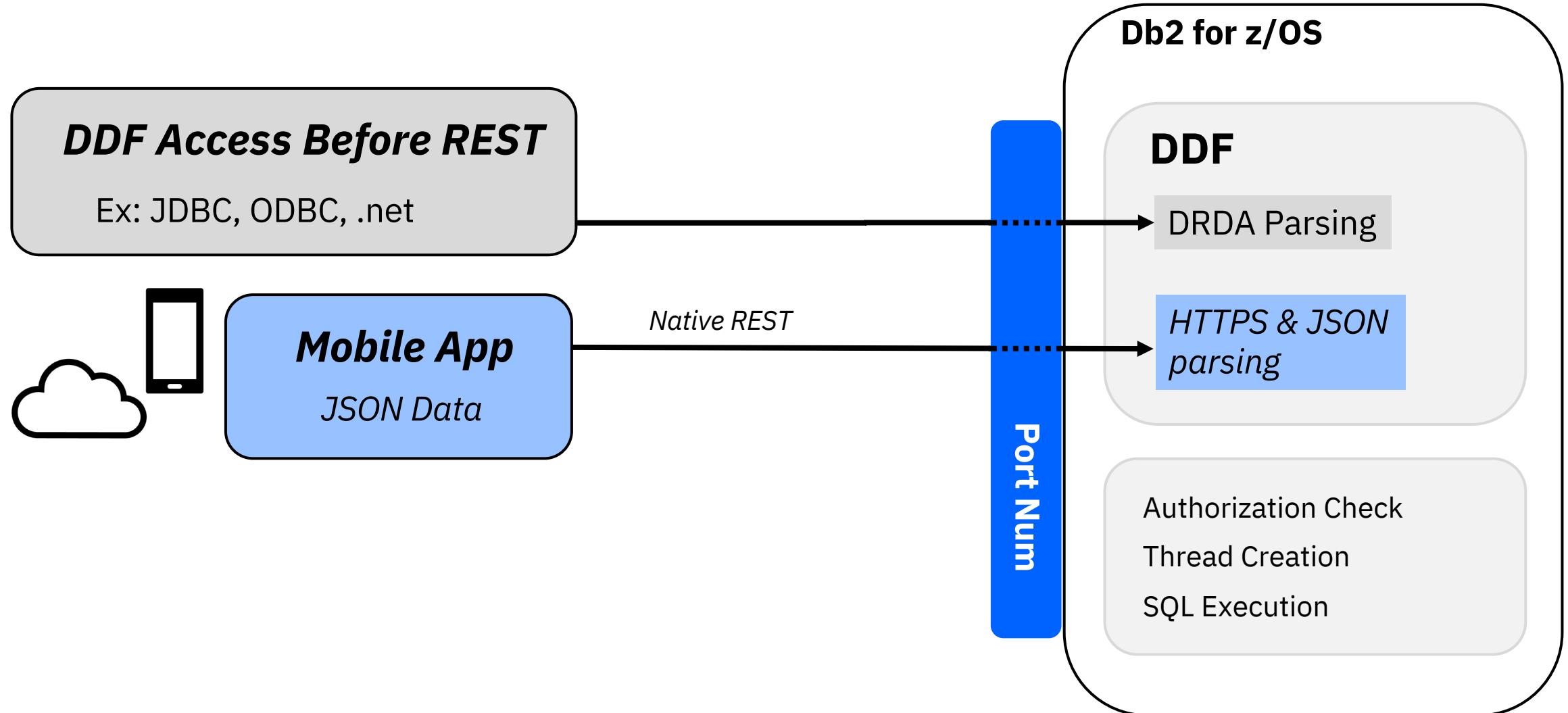
## Service details

- One SQL statement or Stored Procedure call is permitted per service
  - Service is a statically bound package in Db2
  - CALL, DELETE, INSERT, SELECT, TRUNCATE, UPDATE and WITH
  - MERGE can be in a service comprised of a Stored Procedure, not in a service comprised of a single SQL statement

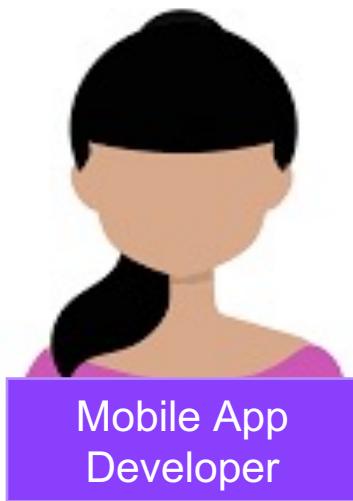
## All of the various Db2 base SQL data types

- Including BLOB, CLOB, DBCLOB and XML

# Architecture Diagram



# When a developer goes to retrieve data



Mobile App Developer

Invokes a Db2 REST service  
- Service consists of Db2 stored procedure or SQL statement

Output returns in JSON format  
Doesn't need to know SQL, nor that the data came from Db2



DBA or Db2 App Developer

Creates a service that consists of a stored procedure or SQL statement

Creates or reuses the stored procedure or SQL statement used in the REST call

Doesn't need to know JSON

## Managing Db2 REST services

### REST client in browser

- Typically a plug-in

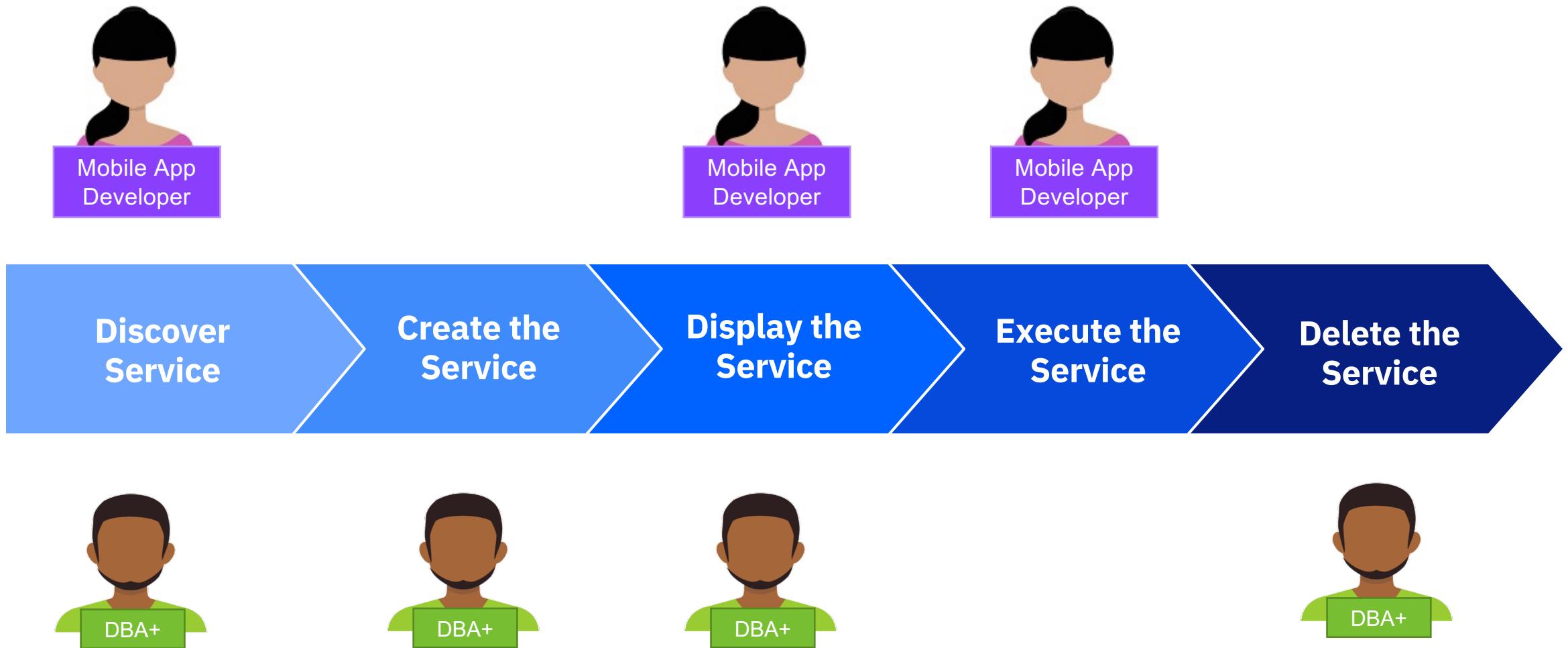
### REST app

- Browser look and feel

### BIND subcommand

- Standard Db2 interaction

# Db2 REST Service Progression



# Db2 REST Service Progression

## Discover Service

## Create the Service

## Display the Service

## Execute the Service

## Delete the Service

### Before you begin

You must have one of the following privileges or authorities to discover all Db2 REST services:

- Execute privilege on the package for the service
- Ownership of the service
- SYSADM or SYSCTRL authority
- System DBADM

### Procedure

To discover all services, issue an HTTP or HTTPS GET or POST request through a REST client with the following URI:

- POST `https://<host>:<port>/services/Db2ServiceDiscover`
  - *Note: Set the HTTP header Accept and Content-Type fields to application/json for the POST request.*
- GET `https://<host>:<port>/services`

To discover all services using a browser use the following URL:

- `https://<host>:<port>/services`

**Successful completion:**  
REST Status Code = 201.

This is an HTTP code - not Db2!

# Db2 REST Service Progression

Discover Service

Create the Service

Display the Service

Execute the Service

Delete the Service

## Before you begin

When you create a service, Db2 identifies you or the authorization ID that you use as the default owner of the service.

Therefore, you must have the required privileges to create a service and bind the associated package into a collection.

For example, you must be authorized to execute the SQL statement that is embedded in the service.

## Procedure

To create a service, issue an HTTP or HTTPS POST request through a REST client with the following URI:

- POST `https://<host>:<port>/services/Db2ServiceManager`
  - *Note: Set the HTTP header Accept and Content-Type fields to application/json for the POST request.*

Specify the following HTTP body for the request – note the JSON name pair format:

```
{ "requestType": "createService",  
  "sqlStmt": "<sqlStatement>",  
  "collectionID": "<serviceCollectionID>",  
  "serviceName": "<serviceName>",  
  "description": "<serviceDescription>",  
  "bindOption": "<bindOption>"}
```

**Successful completion:**  
REST Status Code = 201.

This is an HTTP code - not Db2!

# Creating a Db2 REST Service using JCL

Discover Service

Create the Service

Display the Service

Execute the Service

Delete the Service

## Before you begin

The BIND SERVICE (DSN) subcommand builds an application package that represents a Db2 REST service.

The package owner must have the required authorization, such as SYSADM authority, to execute the SQL statement embedded in a package and to build the package.

## Procedure

To create a service, submit a batch JCL job through a TSO interface with the following format:

Example:

```
//RESTSP   JOB MSGCLASS=H,CLASS=A,NOTIFY=&SYSUID,REGION=0M  
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20  
//STEPLIB  DD DSN=DSN1210.DB2.SDSNEXIT,DISP=SHR  
//          DD DSN=DSN1210.DB2.SDSNLOAD,DISP=SHR  
//SYSTSPRT DD SYSOUT=*  
//SYSPRINT DD SYSOUT=*  
//DSNSTMT  DD *  
CALL EMPL_DEPTS_NAT(:whichQuery,:department1,:department2)  
//SYSTSIN  DD *  
DSN SYSTEM(DSN2)  
BIND SERVICE("SYSIBMService") -  
NAME("selectByDeptSP") -  
SQLENCODING(1047) -  
DESCRIPTION('Select employees by departments or department range')
```

Successful completion:  
0000

This is not an HTTP code!

# Batch JCL: Stored Procedure

A screenshot of a JCL editor interface. The title bar shows tabs for RESTSP.jcl, RESTV1.jcl, RESTV2.jcl, RESTV3.jcl, and RESTFREE.jcl. The main area displays the following JCL code:

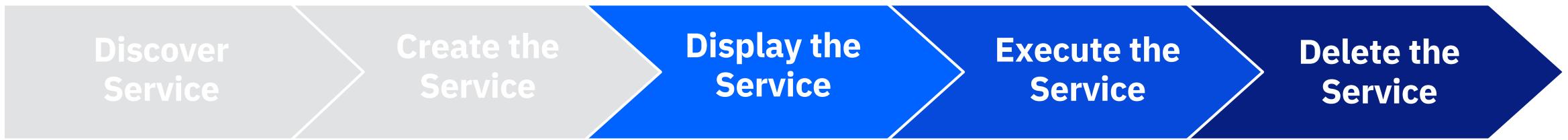
```
-----+---1---+---2---+---3---+---4---+---5---+---6---+---7---+
| //RESTSP   JOB MSGCLASS=H,CLASS=A,NOTIFY=&SYSUID,REGION=0M
| //BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
| //STEPLIB  DD DSN=DSN1210.DB2.SDSNEXIT,DISP=SHR
| //          DD DSN=DSN1210.DB2.SDSNLOAD,DISP=SHR
| //SYSTSPRT DD SYSOUT=*
| //SYSPRINT DD SYSOUT=*
| //DSNSTMT  DD *
CALL EMPL_DEPTS_NAT(:whichQuery,:department1,:department2)
| //SYSTSIN  DD *
DSN SYSTEM(DSN2)
BIND SERVICE("SYSIBMSERVICE") -
NAME("selectByDeptSP") -
SQLENCODING(1047) -
DESCRIPTION('Select employees by departments or department range')
/*
```

# Postman: Stored Procedure

A screenshot of the Postman application. The header bar shows a POST request titled "Create a Db2 REST Service: St...". The main interface shows a "POST" method selected and a URL "http://wg31.washington.ibm.com:2446/services/DB2ServiceManager". Below the URL, there are tabs for Params, Authorization, Headers (12), Body (selected), Pre-request Script, Tests, and Settings. The Body tab contains a JSON payload:

```
1 {
2   "requestType": "createService",
3   "sqlStmt": "call USER1.EMPL_DEPTS_NAT(:whichQuery,:department1,:department2)",
4   "collectionID": "SYSIBMSERVICE",
5   "serviceName": "selectByDeptSP",
6   "bindOption": "ISOLATION(UR)",
7   "description": "Select employees by departments or department range."
8 }
```

# Db2 REST Service Progression



For more information about these steps, please visit the following pages in IBM Docs:

<https://www.ibm.com/docs/en/db2-for-zos/12?topic=db2-rest-services>

# Troubleshooting REST service requests

CATEGORY	DESCRIPTION
1xx: Informational	Communicates transfer protocol-level information.
2xx: Success	Indicates that the client's request was accepted successfully.
3xx: Redirection	Indicates that the client must take some additional action in order to complete their request.
4xx: Client Error	This category of error status codes points the finger at clients.
5xx: Server Error	The server takes responsibility for these error status codes.

Common HTTP status codes for REST service error conditions

For more information on HTTP status codes, please visit:  
<https://restfulapi.net/http-status-codes/>

HTTP status code	Description
HTTP 500 (Internal Server Error)	Indicates that the server could not fulfill a request. In most cases, the HTTP status code is accompanied by a DB2 SQL code that provides more details about the error condition.
HTTP 400 (Bad Request)	Indicates a problem with an input parameter, such as a missing required input parameter, that is detected by the DB2 DDF native REST code prior to executing the DB2 SQL statement.  This code is also used for many DB2ServiceManager failures (for example, Create/Drop service) and DB2DiscoverService failures (discover service/discover service details), which are typically caused by incorrect or missing inputs.
HTTP 401 (Unauthorized)	Indicates that the user could not be successfully authenticated.
HTTP 403 (Forbidden)	Indicates that the user might not have the required permissions to access a resource.

# Versioning Db2 REST Services

*APAR PI98649*

# Versions of REST Services

Allow for development and deployment of new versions of REST Services while existing versions are still being used

Built on existing package versioning support

Use same authorizations

Specify “*version ID*” or accept default “V1”

Select default version

# URI Format

Original

`/services[/<collection id>]<service name>`

Example: `/services/SYSIBMServices/displayEmployee`

Versioning

`/services/<collection id>/<service name>[/<version>]`

Example: `/services/SYSIBMServices/selectByEmpNum/V1`



/services/IBMServices/**displayEmployee**/

*SELECT FNAME, LNAME FROM EMPLOYEE*

Versioning ENABLED

/services/IBMServices/**selectByEmpNum/V1**

*SELECT FIRSTNAME, LASTNAME, PHONENO, WORKDEPT FROM DSN81210.EMP WHERE EMPNO = :EMPNUM*

/services/IBMServices/**selectByEmpNum/V2**

*SELECT E.FIRSTNAME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM and E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

/services/IBMServices/**selectByEmpNum/V3**

*SELECT E.FIRSTNAME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER, M.PHONENO AS MGRPHONE FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM AND E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

EMPLOYEE:

Christine Haas



/services/IBMServices/**displayEmployee**/

*SELECT FNAME, LNAME FROM EMPLOYEE*

Versioning **ENABLED**

/services/IBMServices/**selectByEmpNum/V1**

*SELECT FIRSTNME, LASTNAME, PHONENO, WORKDEPT FROM DSN81210.EMP WHERE EMPNO = :EMPNUM*

/services/IBMServices/**selectByEmpNum/V2**

*SELECT E.FIRSTNME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM and E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

/services/IBMServices/**selectByEmpNum/V3**

*SELECT E.FIRSTNME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER, M.PHONENO AS MGRPHONE FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM AND E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

EMPLOYEE:

Christine Haas



/services/IBMServices/**displayEmployee**/

*SELECT FNAME, LNAME FROM EMPLOYEE*

Versioning ENABLED

/services/IBMServices/**selectByEmpNum**/V1

*SELECT FIRSTNME, LASTNAME, PHONENO, WORKDEPT FROM DSN81210.EMP WHERE EMPNO = :EMPNUM*

/services/IBMServices/**selectByEmpNum**/V2

*SELECT E.FIRSTNME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM and E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

/services/IBMServices/**selectByEmpNum**/V3

*SELECT E.FIRSTNME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER, M.PHONENO AS MGRPHONE FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM AND E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

**EMPLOYEE:**  
10  
Christine Haas



/services/IBMServices/**displayEmployee**/

*SELECT FNAME, LNAME FROM EMPLOYEE*

Versioning ENABLED

/services/IBMServices/**selectByEmpNum**/V1

*SELECT FIRSTNAME, LASTNAME, PHONENO, WORKDEPT FROM DSN81210.EMP WHERE EMPNO = :EMPNUM*

/services/IBMServices/**selectByEmpNum**/V2

*SELECT E.FIRSTNAME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM and E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

/services/IBMServices/**selectByEmpNum**/V3

*SELECT E.FIRSTNAME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER, M.PHONENO AS MGRPHONE FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM AND E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

EMPLOYEE:

10

Christine Haas

Manager: A.B.



/services/IBMServices/**displayEmployee**/

*SELECT FNAME, LNAME FROM EMPLOYEE*

Versioning ENABLED

/services/IBMServices/**selectByEmpNum/V1**

*SELECT FIRSTNME, LASTNAME, PHONENO, WORKDEPT FROM DSN81210.EMP WHERE EMPNO = :EMPNUM*

/services/IBMServices/**selectByEmpNum/V2**

*SELECT E.FIRSTNME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM and E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

/services/IBMServices/**selectByEmpNum/V3**

*SELECT E.FIRSTNME, E.LASTNAME, E.PHONENO, E.WORKDEPT, M.LASTNAME AS MANAGER, M.PHONENO AS MGRPHONE FROM DSN81210.EMP E, DSN81210.EMP M, DSN81210.DEPT D WHERE E.EMPNO = :EMPNUM AND E.WORKDEPT = D.DEPTNO and D.MGRNO = M.EMPNO*

EMPLOYEE:

10

Christine Haas

Manager: A.B.

Manager Phone:  
123-456-7890

# Db2 REST Service Versioning Enablement

Apply Db2 APAR PI98649

Enable versioning by running sample  
job DSNTIJR2

## NOTE

If APAR PI98649 is **removed**, the entire  
Db2 REST service functionality will be  
**UNAVAILABLE**.

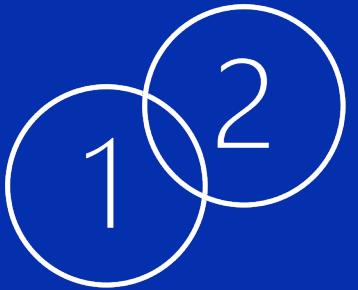
# Versioning Features



No impact to pre-existing, version-less REST services



Empty string value “” version ID for version-less services



Services created after enablement are always versioned



Simplify modification of services; improve time to market

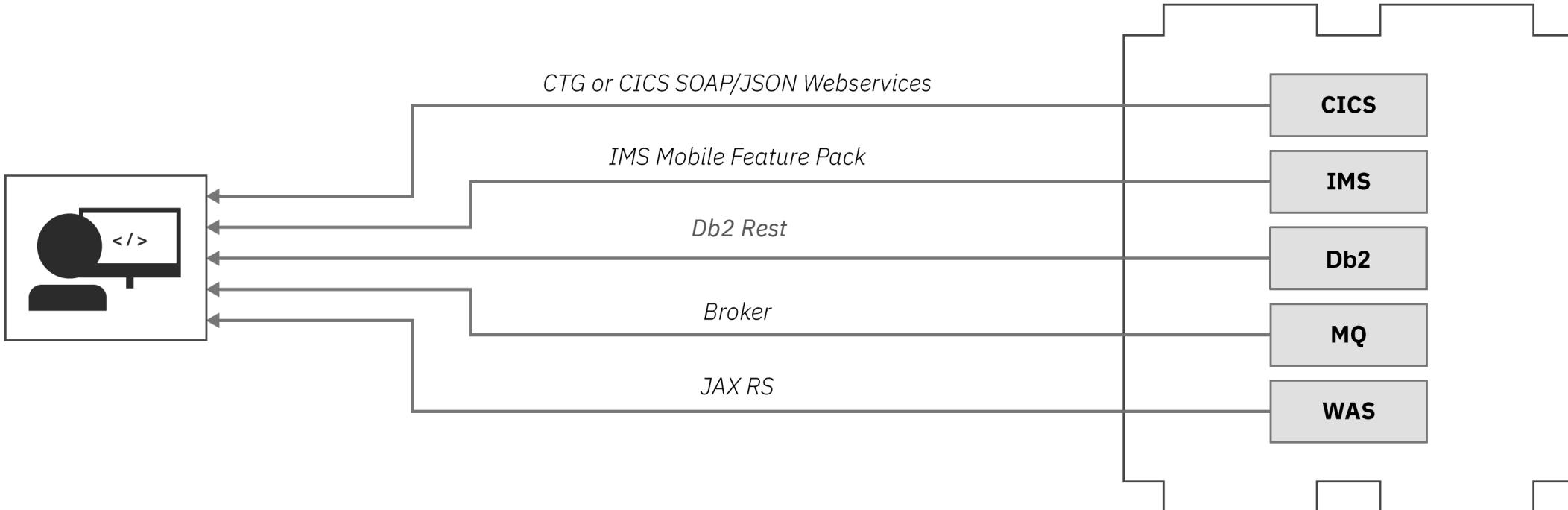
# **z/OS Connect**

*Modernize and transform*

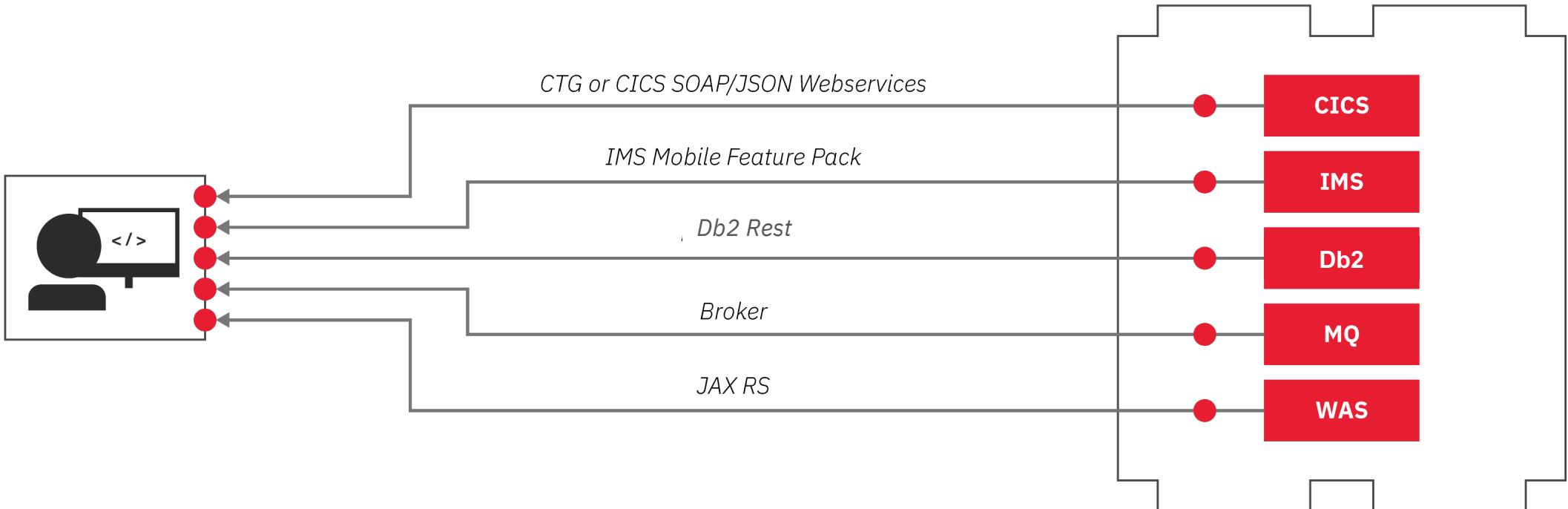
# Q: What is your level of experience with z/OS Connect EE?

- A) I use it regularly!
- B) I've used it before
- C) I've heard of it but haven't used it
- D) I don't know what it is

# Can't we do **JSON** and **REST** already?



# Sort of, but...



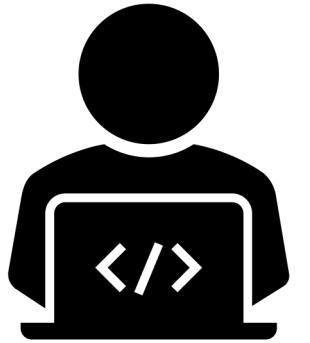
Completely different configuration and management

Multiple endpoints for developers to call/maintain

These are typically not RESTful!

# Single Point of Entry

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



Single Configuration Administration

Single Security Administration

With sophisticated mapping of truly RESTful APIs  
to existing mainframe and services data without  
writing any code

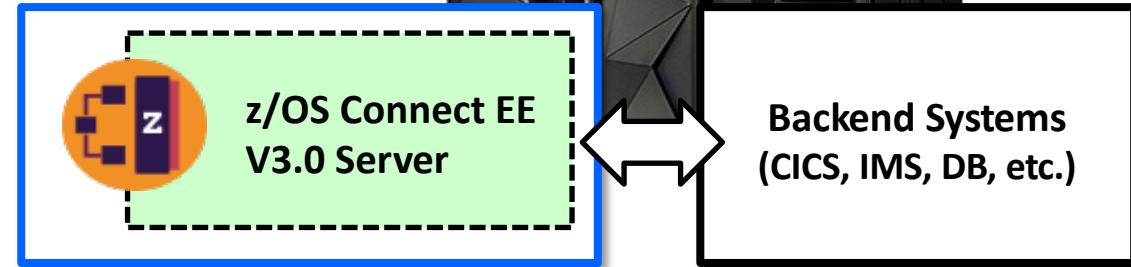
# High Level Overview of z/OS Connect

1

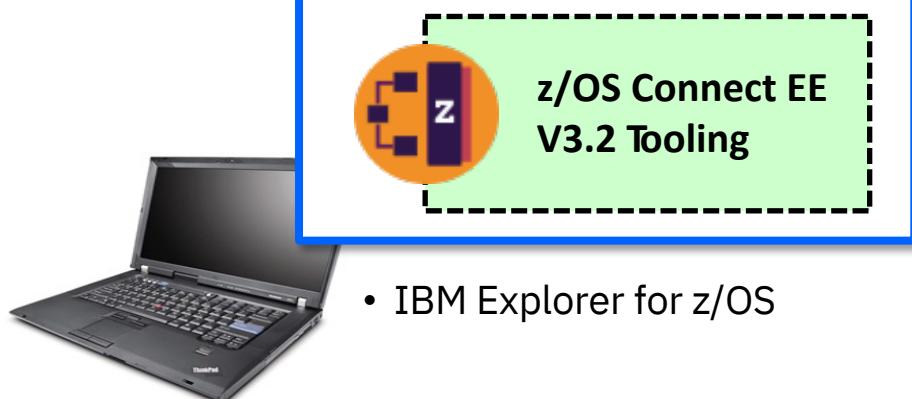
## Runtime Server

- Hosts APIs you define to run
- Connects with backend system
- Allows for multiple instances

*Based on z/OS*



*Eclipse*

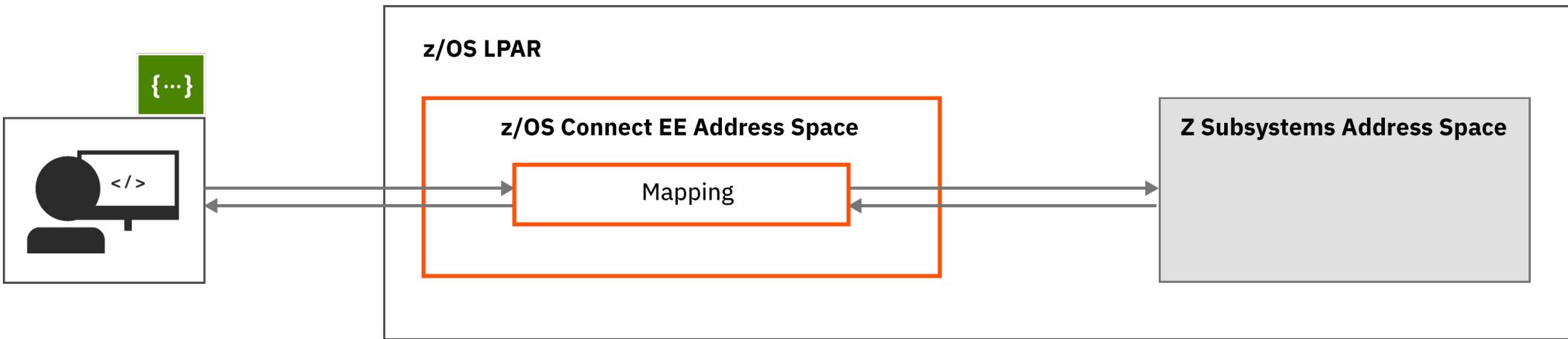


2

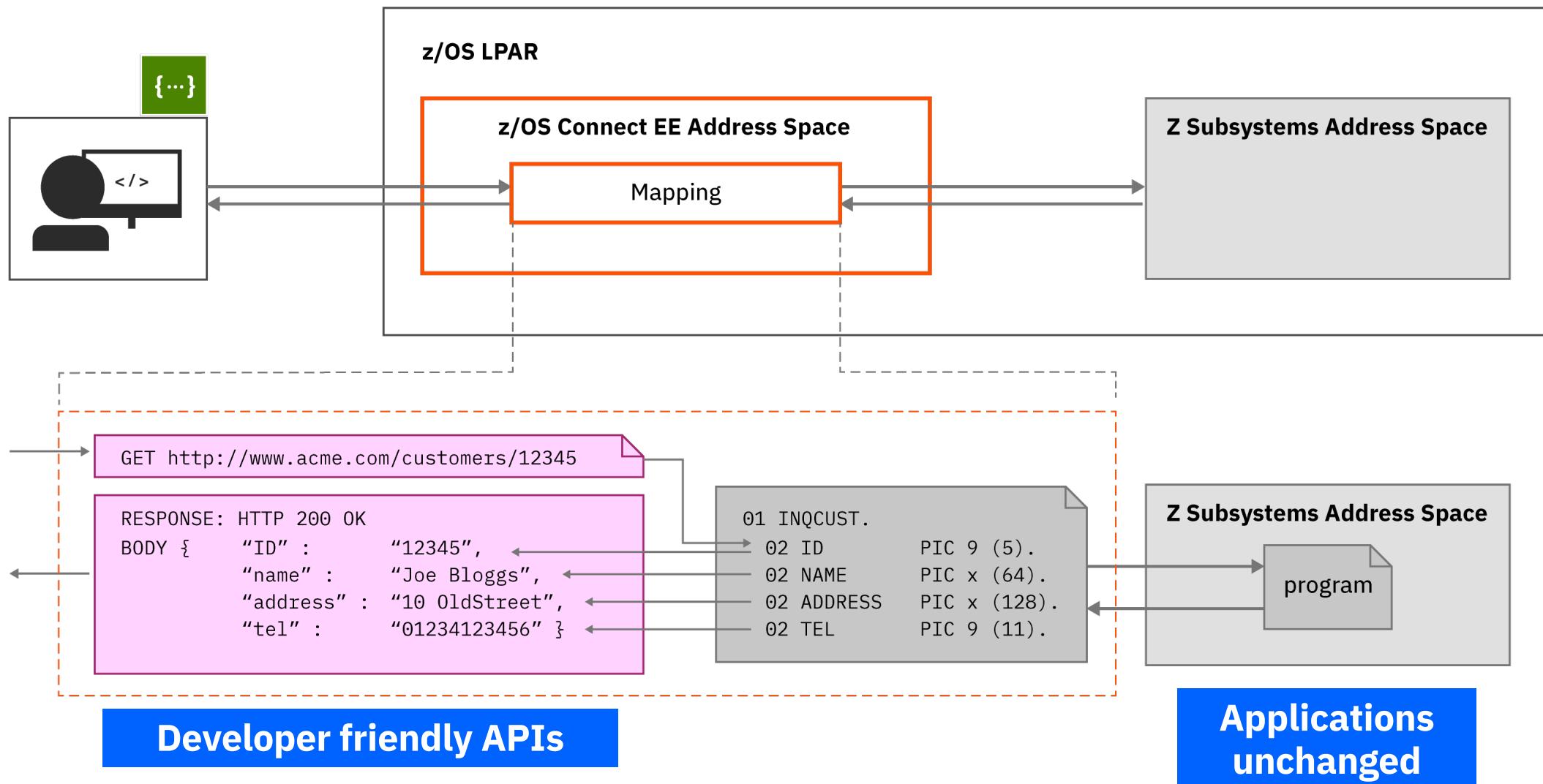
## Tooling Platform – Eclipse based

- Define APIs
- Define data mapping
- Deploy APIs to runtime server
- Export API archive for other tools to deploy

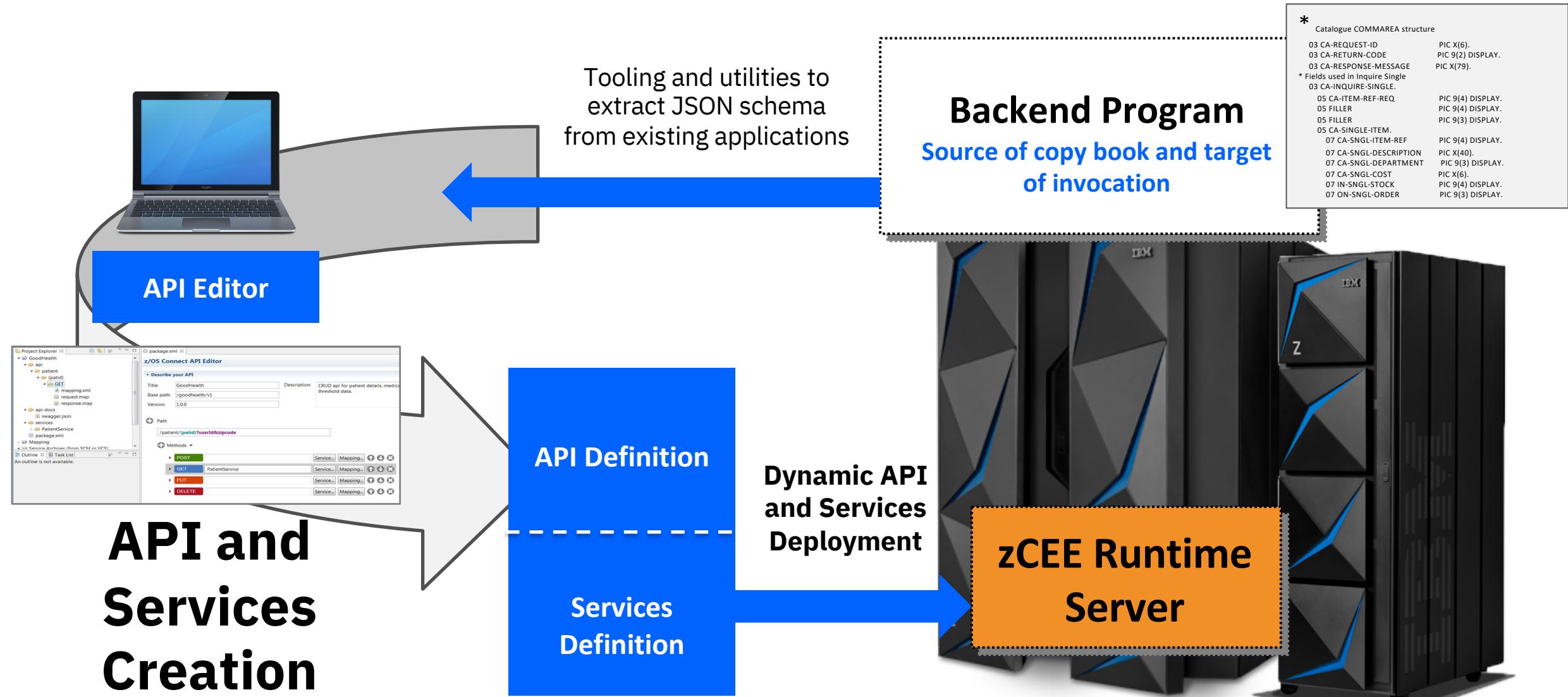
# Data Mapping: Overview



# Data Mapping: A Closer Look



# API, Service Creation, & Deployment Process



# Service Projects & Service Creation

Import the Db2 Rest Service, define the service interface, & configure the service

Import Db2 service from service manager

\*Select Employee Service Service

## Service Project Editor: Definition

**General Information**

Edit or update the general information of the service.

Type: Db2 Service  
Version: 1.0.0  
Description: zCEE Service to drive the Db2 SelectEmployee REST service

**Actions**

Steps to create a service:

1. Input service version.
2. Import JSON schemas from a Db2 service manager or your local machine.
3. Complete the configuration for the service.
4. Deploy the service.
5. Export the service.

**Define Db2 service**

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

Import from Db2 service manager...

Collection ID: SYSIBMSERVICE

Db2 native REST service name: selectEmployee

Db2 native REST service version: V1

Request JSON schema: request-schema.json

Response JSON schema: response-schema.json

**z/OS Connect EE V3 API Toolkit**

1 Import the Db2 Rest Service

2 Request/Response schemas are automatically populated

3 Specify connection reference for the Db2 system



# API Projects & API Creation

Define the URI path, HTTP verbs and JSON mappings for the API

The screenshot shows the 'Path' configuration screen. A blue callout box labeled '1' points to the 'Path' input field containing '/newPath1'. Another blue callout box labeled '2' points to the 'Methods' dropdown menu, which lists four options: POST (highlighted in green), GET, PUT, and DELETE. Each method has associated 'Service...' and 'Mapping...' buttons.

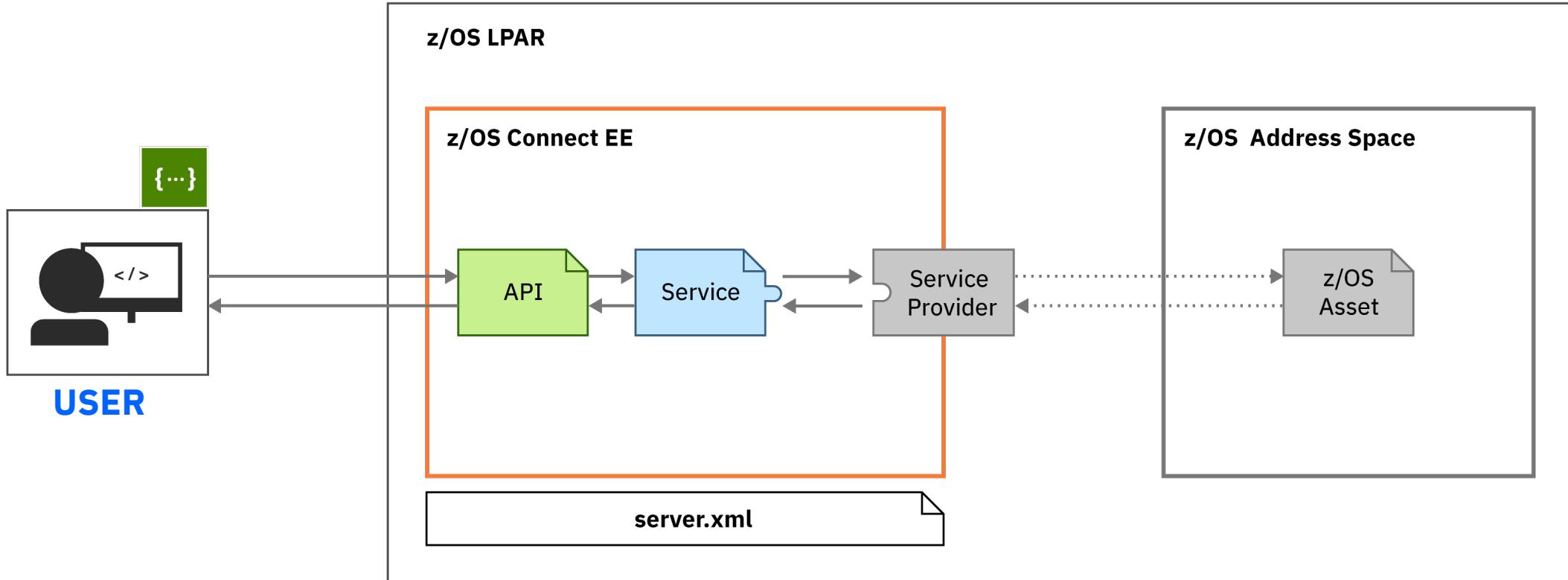
## z/OS Connect EE V3 API Toolkit



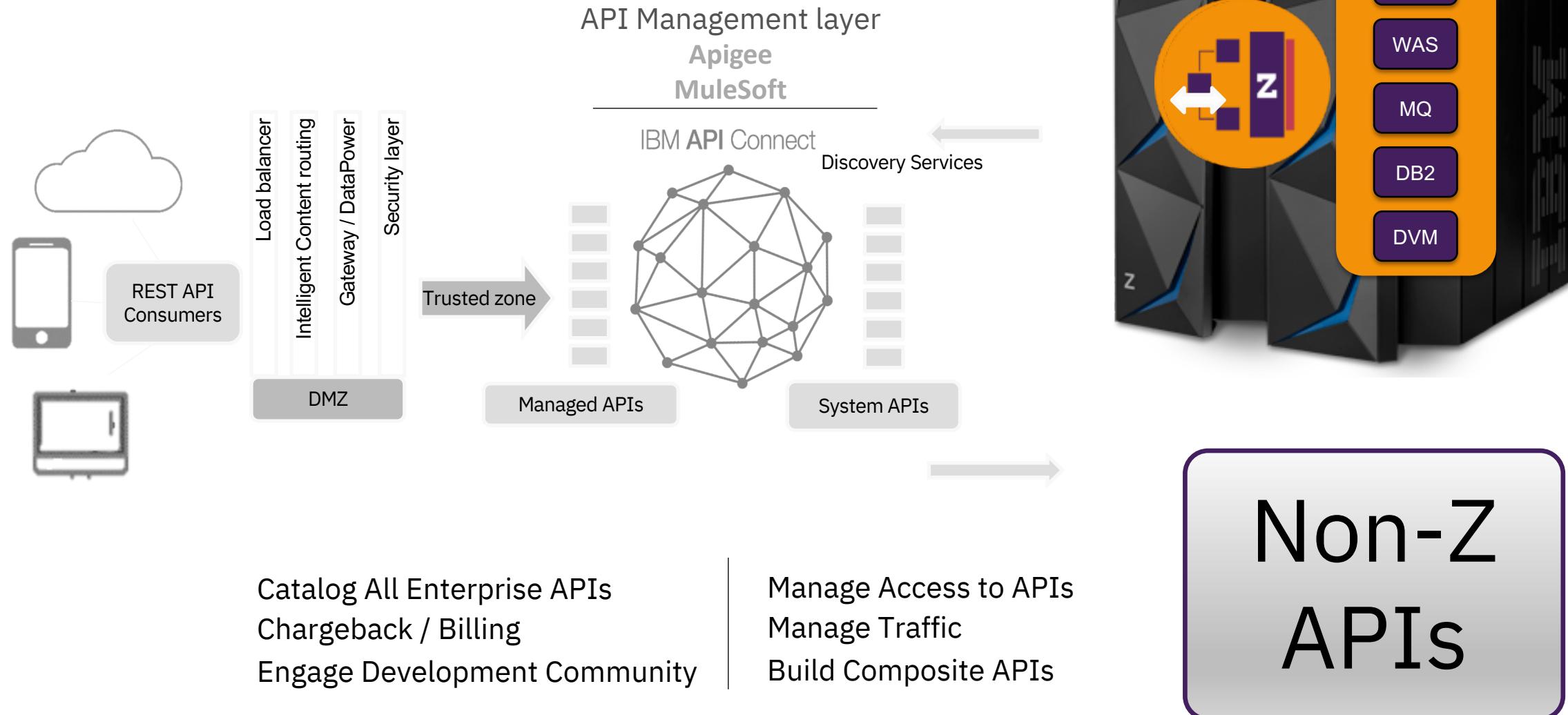
IBM Explorer for z/OS

The screenshot shows the 'GET.items' operation configuration. A blue callout box labeled '3' points to the 'Mapping...' button for the 'Body - DFH0XCMNOperation' section. This section contains fields for Authorization (string, [0..1]), Path Parameters (startItemID, integer, [1..1]), and Query Parameters (startItemID, integer, [1..1]). To the right, a detailed view of the 'DFH0XCMNOperation' mapping is shown, featuring a tree structure of 'Updates' and 'DFH0XCMNOperation' nodes, each with 'Assign', 'Remove', 'Move', and 'Replace' options. A separate 'Updates' section is also visible.

# z/OS Connect Runtime Concepts

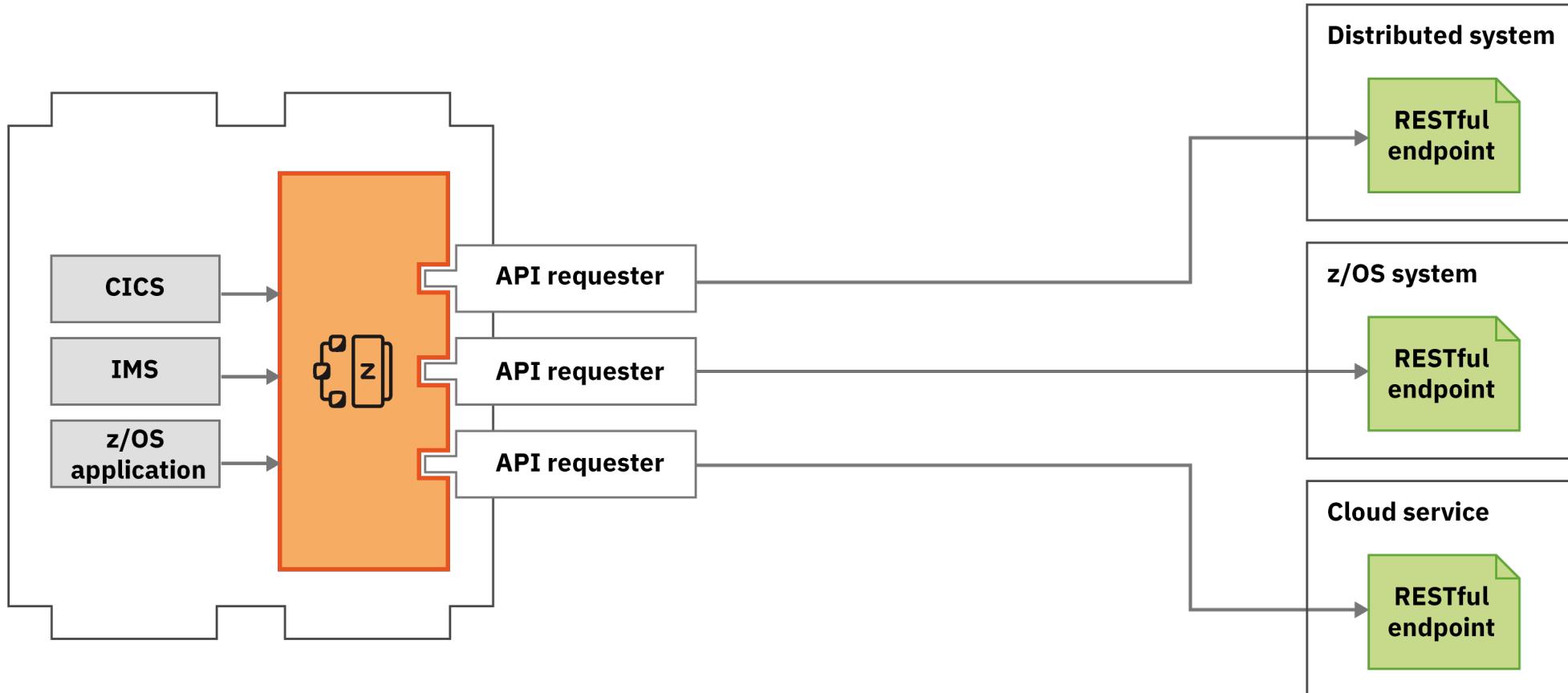


# **z/OS Connect EE in the Big Picture**



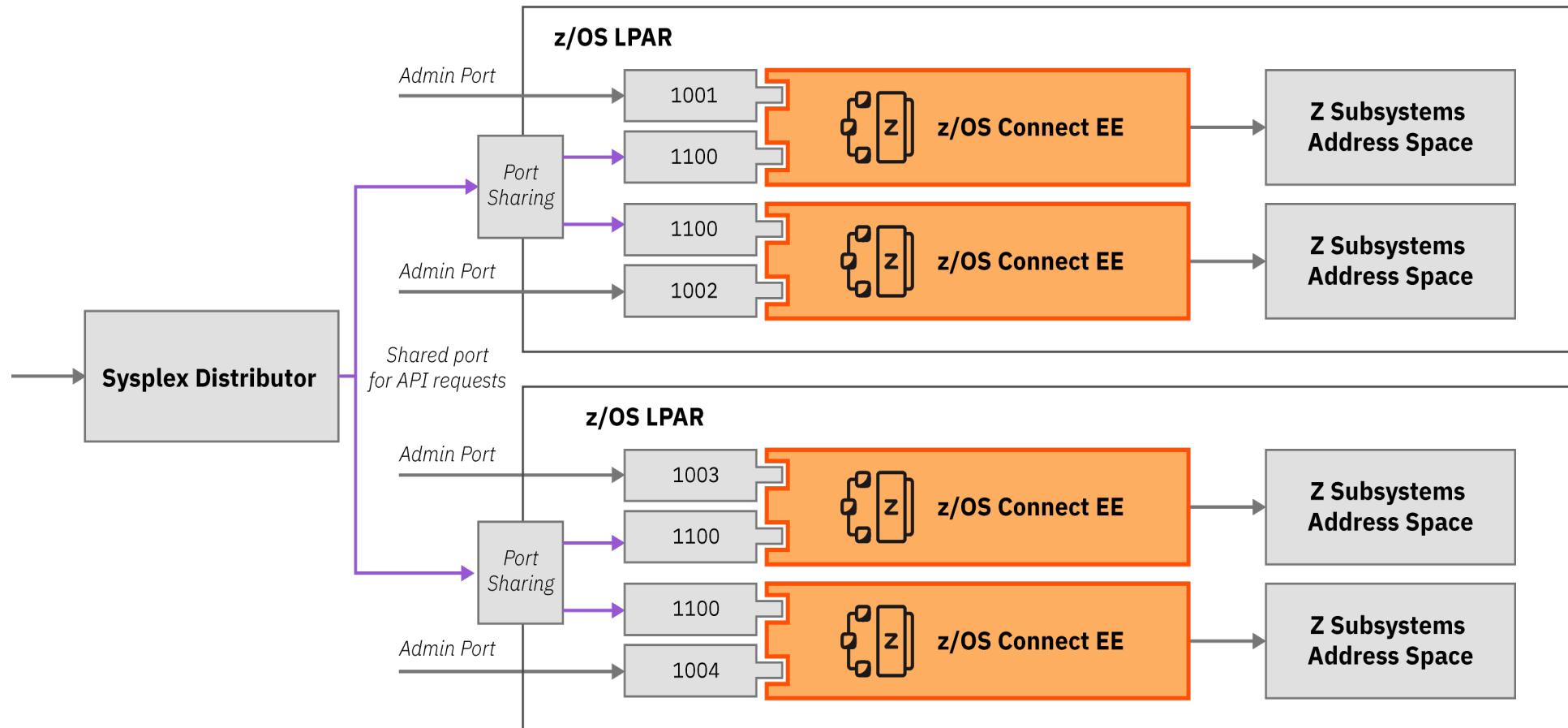
# z/OS Connect EE API Requester

Mainframe applications can easily invoke RESTful APIs



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

# z/OS Connect EE in High Availability Topology

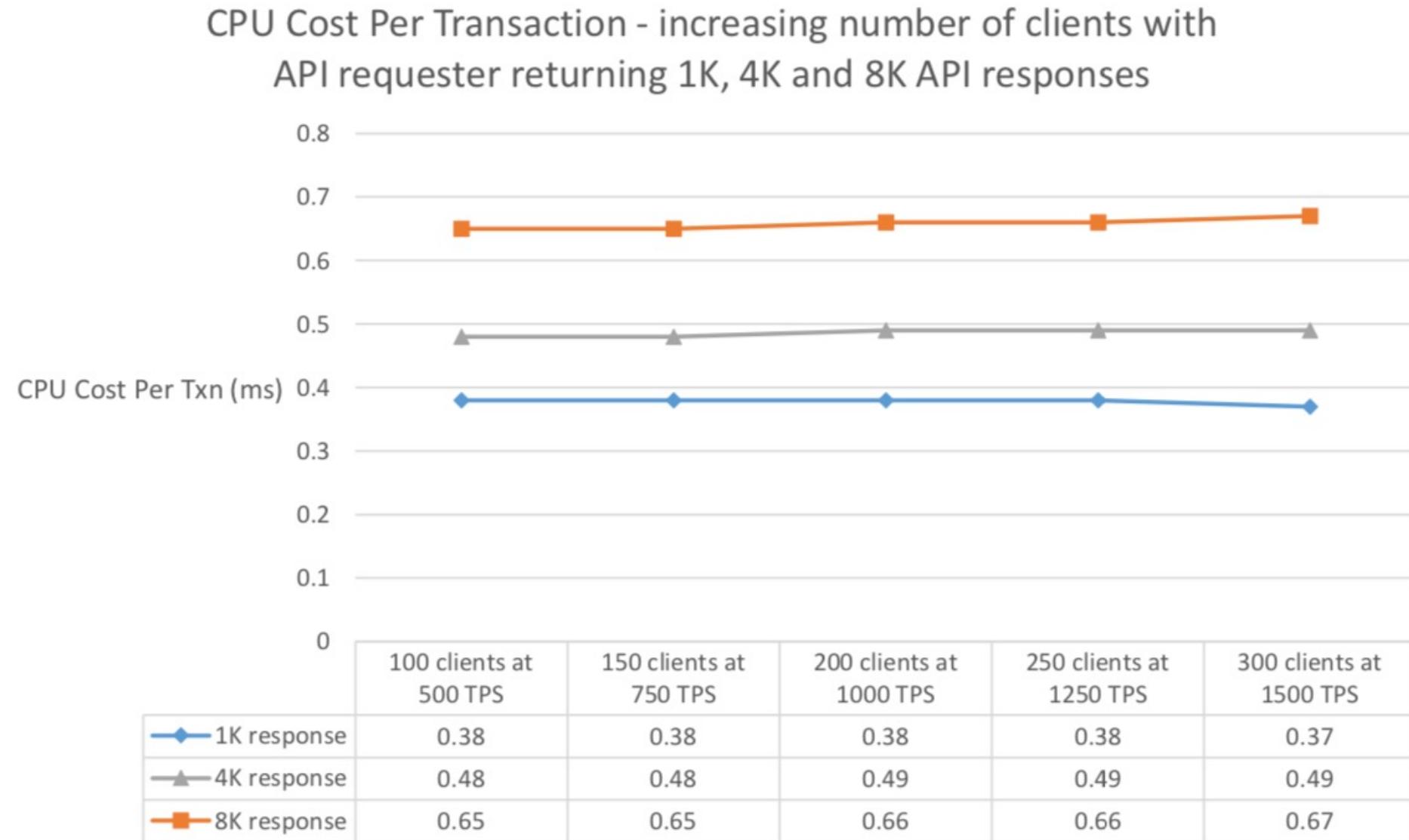


[ibm.biz/zosconnect-ha-concepts](http://ibm.biz/zosconnect-ha-concepts)



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

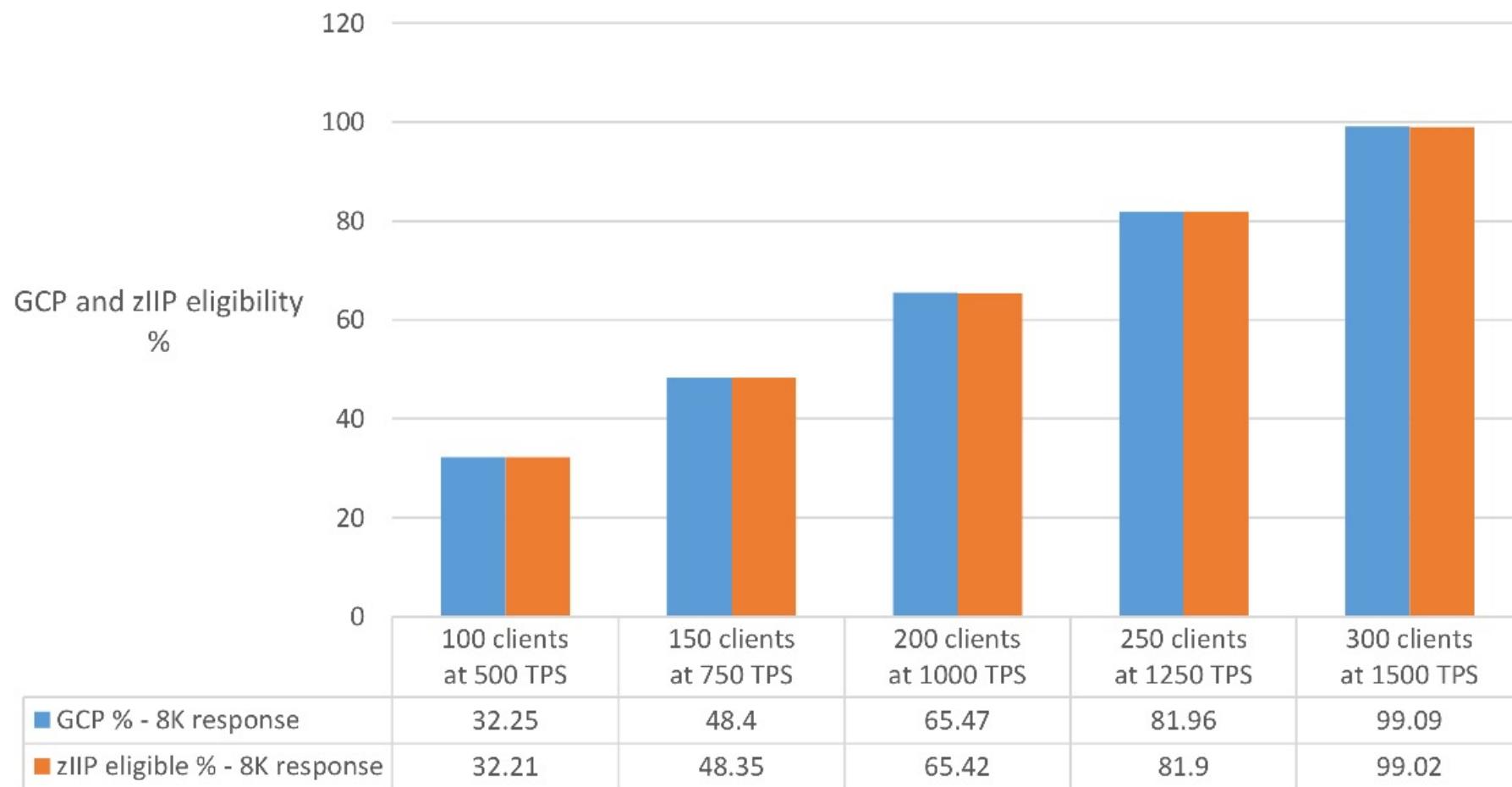
# Performance: z/OS Connect EE scales with increased volumes



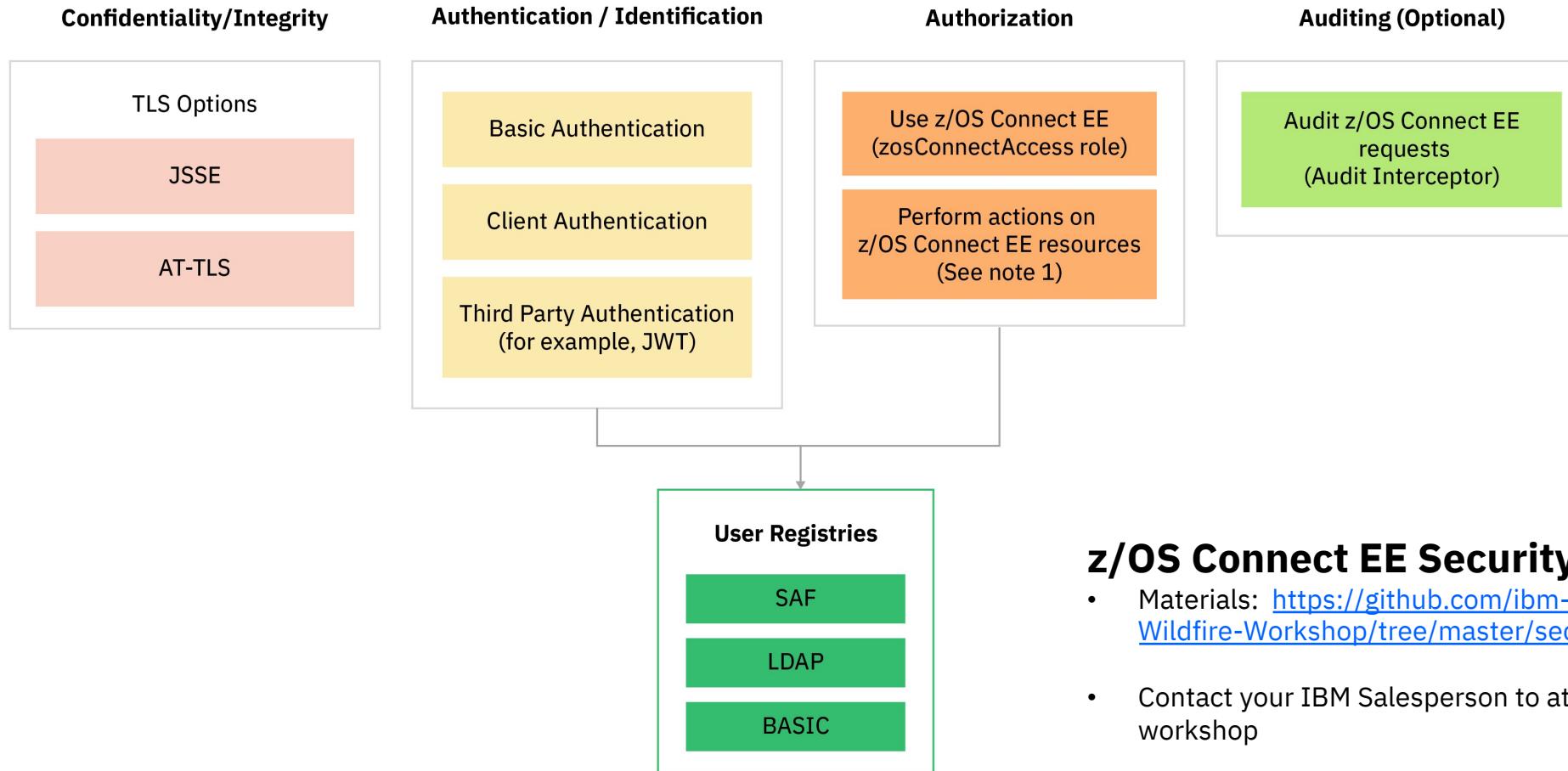
# Performance: zIIP Eligibility

99% zIIP eligible

zIIP eligibility - increasing number of clients with API requester returning 8K API responses



# Security: High level options available in z/OS Connect EE



## **z/OS Connect EE Security Workshop**

- Materials: <https://github.com/ibm-wsc/zCONNEE-Wildfire-Workshop/tree/master/security>
- Contact your IBM Salesperson to attend a future workshop

# Db2 REST & z/OS Connect

## Perfectly paired

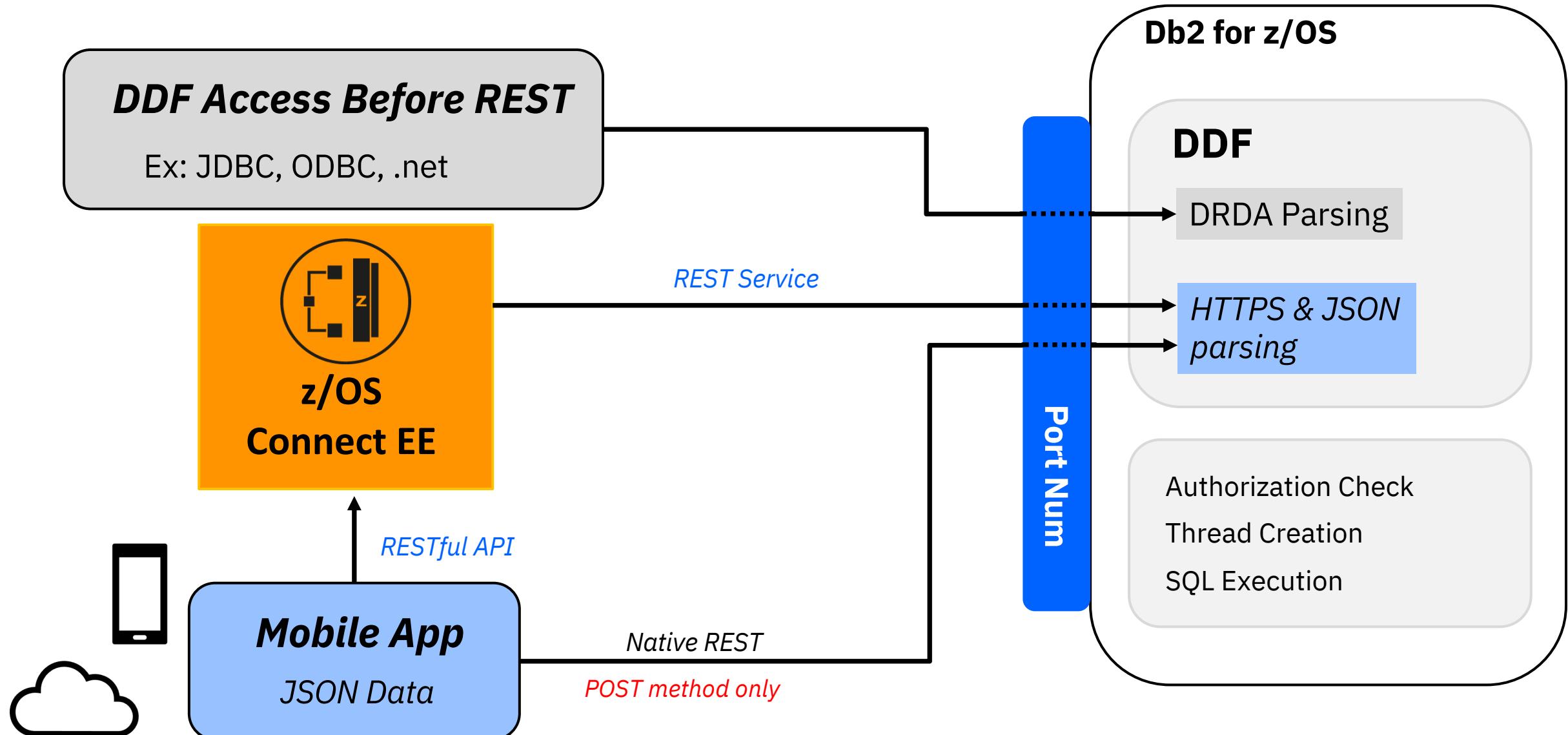
# Db2 REST Services with z/OS Connect EE

Db2 user created native REST services are invoked by the ***POST method only***

Mobile and cloud programmers following the RESTful API design model use the ***HTTP Methods (Verbs): POST, GET, PUT and DELETE***

***z/OS Connect Enterprise Edition's tool “API Editor” can map a Db2 POST method SQL statement to the appropriate RESTful method for a given behavior***

# Architecture Diagram



# Db2 REST service using a stored procedure with select SQL statements (read only)

Db2 REST service

**METHOD |** POST

**URI |** `http://wg31.washington.ibm.com:1446/services/SYSIBMSERVICE/selectByDeptSP`

**HEADERS |** Content-Type = application/json and Accept: application/json

**Body |** `{"WHICHQUERY":1,"DEPT1":"A00"}`

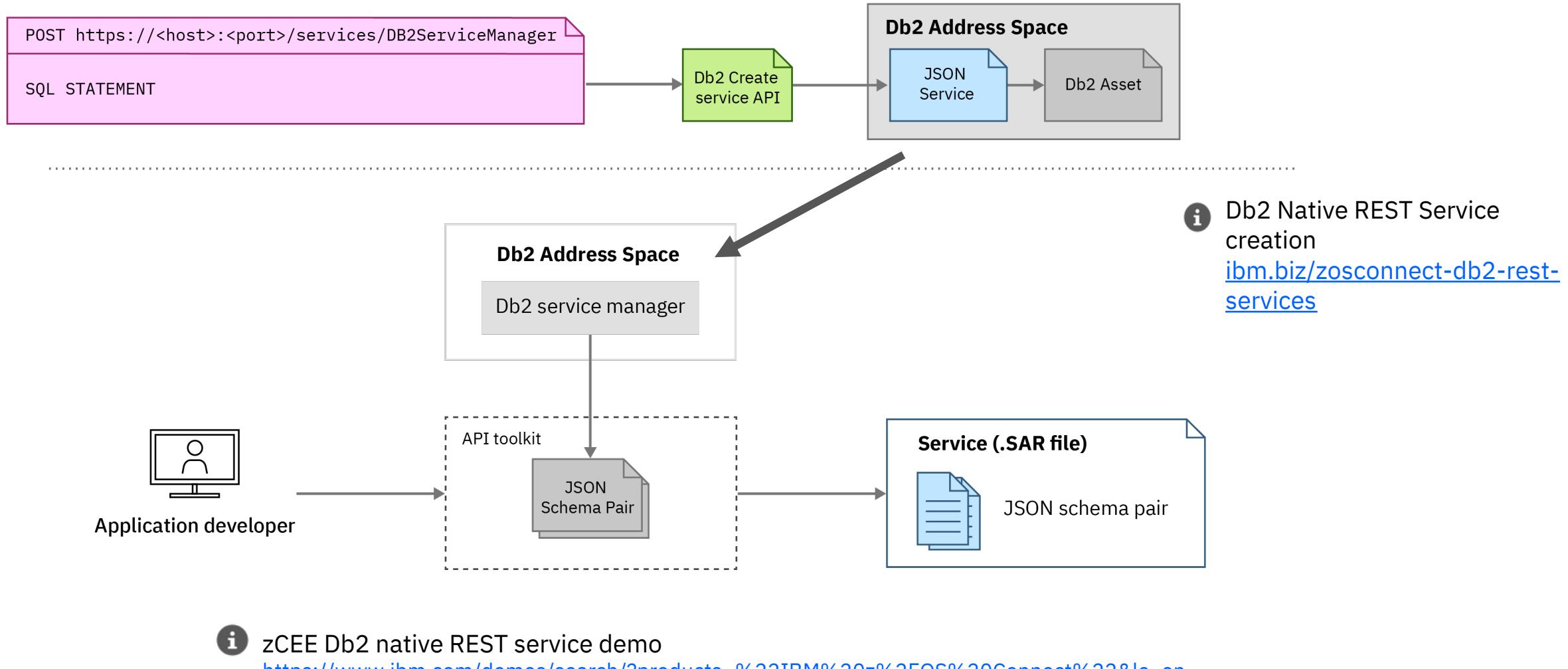
Db2 REST API using z/OS Connect

**METHOD |** GET

**URI |** `https://wg31.washington.ibm.com:9446/employee/deptNo/A00`

- GET method includes input properties within the URI
- API Editor-created constants reduce the number of input parameters
- Both REST statements produce the same output
- z/OS Connect example follows RESTful standard

# Connecting to Db2 with z/OS Connect EE: Create the service definition



# Running on REST: New access with native REST services

## The Customer:

A large US manufacturer

## Business Challenge:

The company needed a simple portal to navigate Db2 for z/OS

## Their Need:

The manufacturer needed an easy access point to navigate around Db2 for z/OS.

## Our Solution:

Db2 native REST services were used to create a web-browser UI and tool for interacting with Db2 for z/OS.

## Customer Benefit:

All DBAs, new and experienced, could smoothly navigate Db2 for z/OS using a familiar interface.



# APIs deliver peace of mind to customers during a global crisis

## The Customer:

A large automotive company

## Business Challenge:

The automotive company wanted to rapidly automate their manual process for loan extensions .

## Their Need:

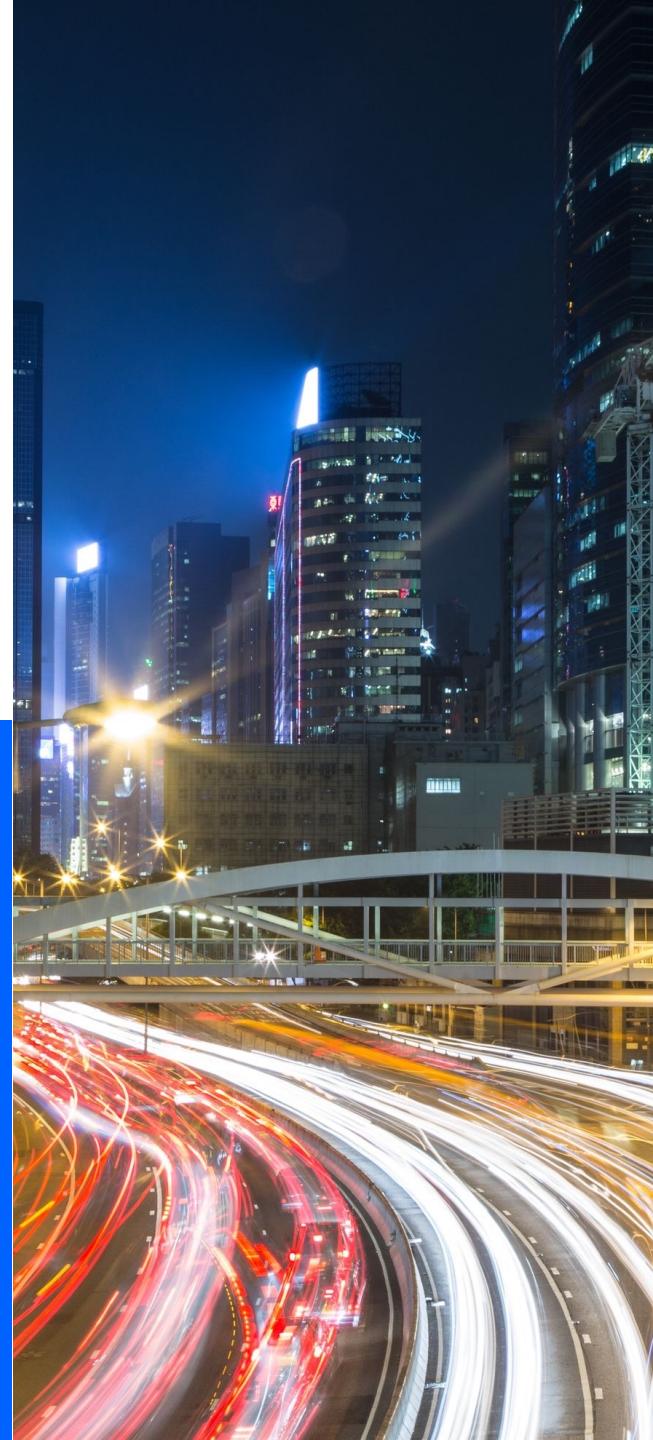
The company needed to rapidly automate their manual loan extension request process to handle at speed the huge increase of finance extension requests (19,000 per day) driven by the COVID-19 outbreak.

## Our Solution:

IBM z/OS Connect EE generated REST APIs that could be easily called from applications on any platform. Kubernetes®, microservices and z/OS Connect EE API enablement enabled unprecedented acceleration to create new user experiences owned by multiple groups within the enterprise.

## Customer Benefit:

Leveraging on z/OS Connect EE's APIs to rapidly innovate processes in days/weeks. Digitization of business processes enables customer needs to be met and the business the capacity to focus resources on processes requiring manual customization.



# Additional Workshops

IBM offers several workshops related to JSON and REST enablement of z assets:

- [Db2 for z/OS: REST and Hybrid Cloud Workshop](#)
- IBM z/OS Connect Wildfire Workshop
- IBM z/OS Connect EE Security Wildfire Workshop
- Db2 12 Technology Update Workshop

Notify your IBM representative if you are interested in any of these workshops.

Look at the following link for more events  
<https://ibm-zcouncil.com/events/>

# Lab Time

# WARNING!

Before beginning, understand that everything you will be working with is **mixed case sensitive**.

You can very easily lose days trying to resolve a problem because a case on just one character was not set correctly.

**NativeREST <> NativeRESt <> NATIVEREST <> nativerest**

# Appendix

# Db2 REST Service Progression

Discover Service

Create the Service

Display the Service

Execute the Service

Delete the Service

## Creating a Db2 REST service – **example SQL statement**

The screenshot shows a REST client interface with the following details:

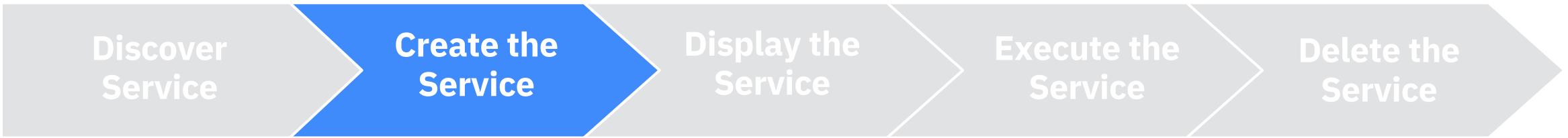
- Method:** POST
- URL:** <http://cmw1.wsclab.washington.ibm.com:1446/services/DB2ServiceManager>
- Headers:** Accept: application/json, Content-Type: application/json
- Body:**

```
{  
  "requestType": "createService",  
  "sqlStmt": "SELECT FIRSTNAME, LASTNAME, PHONENO, WORKDEPT FROM DSN81210.EMP where WORKDEPT = :INDEPTNO",  
  "collectionID": "SYSIBMSERVICE",  
  "serviceName": "USER05SQLSelect",  
  "description": "Select department name based on department number",  
}
```

**Note:** You can also use the IBM Data Studio client to create a Db2 REST service, but Db2 z/OS SSL MUST be operational.

Status Code 201 indicates successful creation

# Db2 REST Service Progression



## Creating a Db2 REST service – **stored procedure (SP)**

Db2 Stored Procedure CALL statement variables:

CALL USER01.USER01EMPL\_DEPTS\_NAT(?,?,?)

“?” – Question mark(s) can be used as input variable placeholder; Db2 will replace “?”s with P1, P2, ... in JSON request.

CALL USER01.USER01EMPL\_DEPTS\_NAT(:WHICHQUERY,:DEPT1,:DEPT2)

Input variable labels “WHICHQUERY”, “DEPT1” and “DEPT2” are created manually, and will be used in the JSON request.

# Db2 REST Service Progression

Discover Service

Create the Service

Display the Service

Execute the Service

Delete the Service

## Creating a Db2 REST service – **example stored procedure (SP)**

The screenshot shows a REST client interface with the following sections:

- Method:** POST
- URL:** <http://cmw1.wsclab.washington.ibm.com:1446/services/DB2ServiceManager>
- Headers:** Accept: application/json, Content-Type: application/json
- Body:** A JSON object representing the service creation request, including fields like requestType, sqlStmt, collectionID, serviceName, bindOption, and description.
- Response:** A table showing the response headers and body. The response body contains a list of status codes and their descriptions.

**Note:**  
Db2 stored procedure call statement host input variables were manually created.

Default host variable name Px, where x = variable number

[-] Response			
Response Headers	Response Body (Raw)	Response Body (Highlight)	Response Body (Preview)
1. Status Code : 201 Created 2. Content-Language : en-US 3. Content-Length : 200 4. Content-Type : application/json; charset=UTF-8 5. Date : Tue, 26 Sep 2017 22:46:18 GMT 6. Location : <a href="http://cmw1.wsclab.washington.ibm.com:1446/services/SYSIBMSERVICE/USER05NativeRESTSP">http://cmw1.wsclab.washington.ibm.com:1446/services/SYSIBMSERVICE/USER05NativeRESTSP</a> 7. Server : DB2 DDF Native REST, DB2MLOC 8. X-Powered-By : DB2 for z/OS			

DB2 for z/OS: REST and Hybrid Cloud / Feb 2022 / © 2022 IBM Corporation

# The Open API Initiative

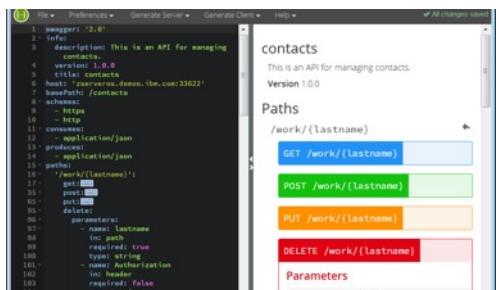
The industry standard framework for describing RESTful APIs, aka **Swagger**



There are a variety 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 creates stub code to consume APIs from various languages



[GitHub Link](#)

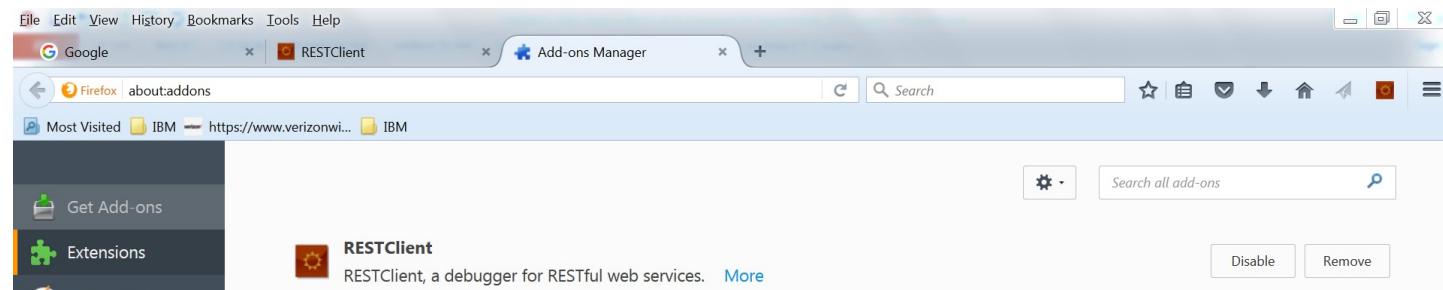
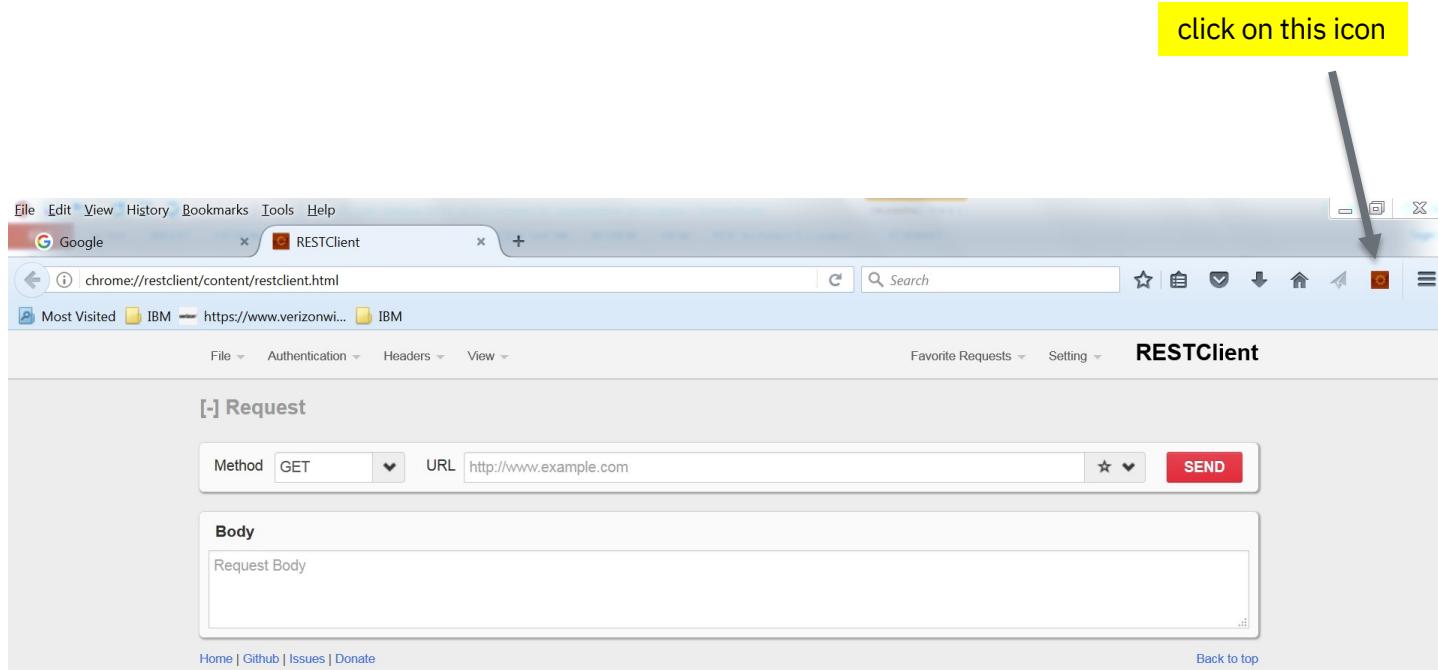
# Browser REST Client extensions

Various browsers provide a REST client extension.

In our example, we use FireFox with RESTClient.

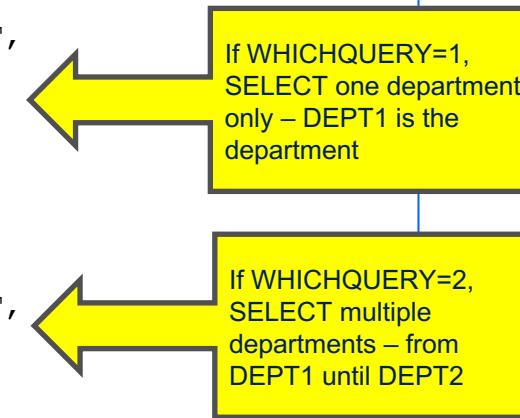
In Firefox, go to add-ons and search for RESTClient.

It will add it as an extension and will be part of your screen



# Example: using Db2 IVP data to create callable SP

```
CREATE PROCEDURE USER05EMPL_DEPTS_NAT
  (IN WHICHQUERY INTEGER, IN DEPT1 CHARACTER(3), IN DEPT2 CHARACTER(3))
VERSION V1
  RESULT SETS 1
  LANGUAGE SQL
  ISOLATION LEVEL CS
  DISABLE DEBUG MODE
P1: BEGIN
  DECLARE CURSOR1 CURSOR WITH RETURN FOR
    SELECT EMPLOYEE.EMPNO, EMPLOYEE.FIRSTNME, EMPLOYEE.MIDINIT,
    EMPLOYEE.LASTNAME,
    EMPLOYEE.WORKDEPT, EMPLOYEE.PHONENO
      FROM DSN81210.EMP AS EMPLOYEE
      WHERE EMPLOYEE.WORKDEPT=DEPT1
      ORDER BY EMPLOYEE.EMPNO ASC;
  DECLARE CURSOR2 CURSOR WITH RETURN FOR
    SELECT EMPLOYEE.EMPNO, EMPLOYEE.FIRSTNME, EMPLOYEE.MIDINIT,
    EMPLOYEE.LASTNAME,
    EMPLOYEE.WORKDEPT, EMPLOYEE.PHONENO
      FROM DSN81210.EMP AS EMPLOYEE
      WHERE EMPLOYEE.WORKDEPT>=DEPT1 AND EMPLOYEE.WORKDEPT<=DEPT2
      ORDER BY EMPLOYEE.WORKDEPT ASC, EMPLOYEE.EMPNO ASC;
  CASE WHICHQUERY
    WHEN 1 THEN
      OPEN CURSOR1;
    ELSE
      OPEN CURSOR2;
  END CASE;
END P1#
```



# For Db2 REST - new catalog table created in installation job DSNTIJRS

The SYSIBM.DSN SERVICE table contains rows that describe Db2 REST services and their corresponding packages.

The following table describes the columns in table SYSIBM.DSN SERVICE:

Column name	Data type	Description
NAME	VARCHAR(128) NOT NULL	Name of the package that contains the service request.
COLLID	VARCHAR(128) NOT NULL	Name of the collection that contains the package.
CONTOKN	CHAR(8) NOT NULL FOR BIT DATA	Consistency token for the package that is generated when the service is created or altered.
ENABLED	VARCHAR(128) NOT NULL	Indicates whether service is enabled: Y - Service is enabled, which is the default setting. N - Service is disabled.
CREATETS	TIMESTAMP NOT NULL	The time when the row is inserted.
ALTEREDTS	TIMESTAMP NOT NULL	The time when the row is last updated.
DESCRIPTION	VARCHAR(250)	A user-specified character string.

Db2 also sets the HOSTLANG column in the SYSIBM.SYSPACKAGE and SYSIBM.SYSPACKCOPY tables to 'R' to mark the package for the REST API

# FAQ: What does **Stateless** mean?

REST itself is **stateless**, meaning that [every request/reply is independent from the next](#).

In Db2 terms, every request/reply is a complete transaction (commit, unless error, then abort), and all of the database locks/resources are freed.

If the request is a SELECT, the entire result set is returned and closed as part of the reply.

For example, you couldn't open a cursor/SELECT in one request, and then try to do a positioned update on that cursor in another request.

# **FAQ:** What type of stored procedures can I use for Db2 REST?

Any type of stored procedure can be used.

# Batch TMP alternative for CREATE and FREE

```
//JOBLIB DD DISP=SHR,  
// DSN=DB2M.SDSNLOAD  
//DSNTIRU EXEC PGM=IKJEFT01,DYNAMNBR=20  
//SYSTSPRT DD SYSOUT=*  
//SYSPRINT DD SYSOUT=*  
//SYSUDUMP DD SYSOUT=*  
//DSNSTMT DD DISP=SHR,DSN=JOHNICZ.JCL(CRES)  
// * NOTE - DSNSTMT CAN ALTERNATELY USE DD * WITH A STATEMENT SUCH AS  
// * CALL EMPL_DEPTS_NAT(:WHICHQUERY,:DEPT1,:DEPT2)  
//SYSTSIN DD *  
  DSN SYSTEM(DB2M)  
  BIND SERVICE(SYSIBMSERVICE) -  
    NAME("SERVICE1") -  
    SOLENCODING(1047) -  
    DESCRIPTION('RETURN A LIST OF DEPTNAME-  
    BASED ON INPUT LOCATION')  
/*
```

```
CALL EMPL_DEPTS_NAT(:WHICHQUERY,:DEPT1,:DEPT2)
```

```
00000010
```

```
//JOBLIB DD DISP=SHR,  
// DSN=DB2M.SDSNLOAD  
//DSNTIRU EXEC PGM=IKJEFT01,DYNAMNBR=20  
//SYSTSPRT DD SYSOUT=*  
//SYSPRINT DD SYSOUT=*  
//SYSUDUMP DD SYSOUT=*  
//SYSTSIN DD *  
  DSN SYSTEM(DB2M)  
  FREE SERVICE("SYSIBMSERVICE","SERVICE1")  
/*
```

DSNSTMT input cannot include numbers at the end of the statement.  
Create or Free will fail.  
Use NUM OFF.



# The Other Connects

*A little clarity on what does what*

## DB2 Connect

*Provides ODBC/JDBC access to DB2-housed data.*

*Clients/users would use SQL to formulate requests*

*No REST access*

## IMS Connect

*THE way to reach IMS Subsystem*

*OTMA client that provides TCP/IP connectivity to IMS applications/data.*

*Local access for WAS on z/OS*

*No REST access*

## App Connect

*Formerly known as IIB or Message Broker*

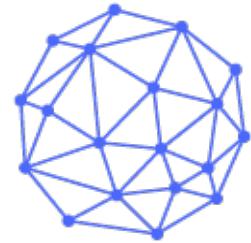
*Any-any-connectivity between entities*

*Orchestration capability*

*REST access is possible*

*Typically requires specialist skills*

# API Connect & z/OS Connect



IBM apiconnect

Create APIs and microservices that consume IBM Z APIs

Manage and secure IBM Z APIs created by z/OS Connect

Comprehensive tooling that enables API developers to create RESTful APIs from z/OS-based assets

Delivers APIs as a discoverable resource using the OpenAPI specification (formerly Swagger)

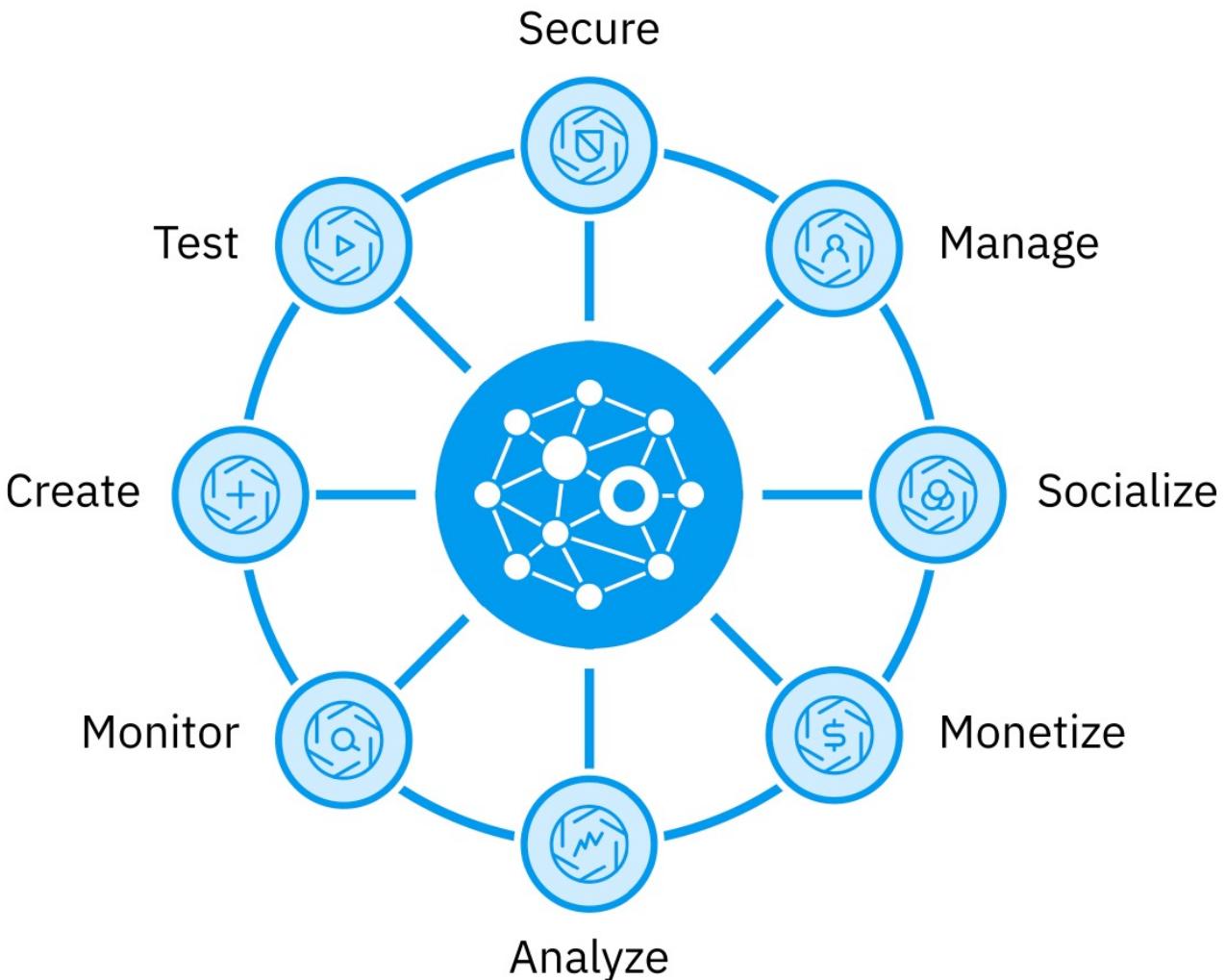
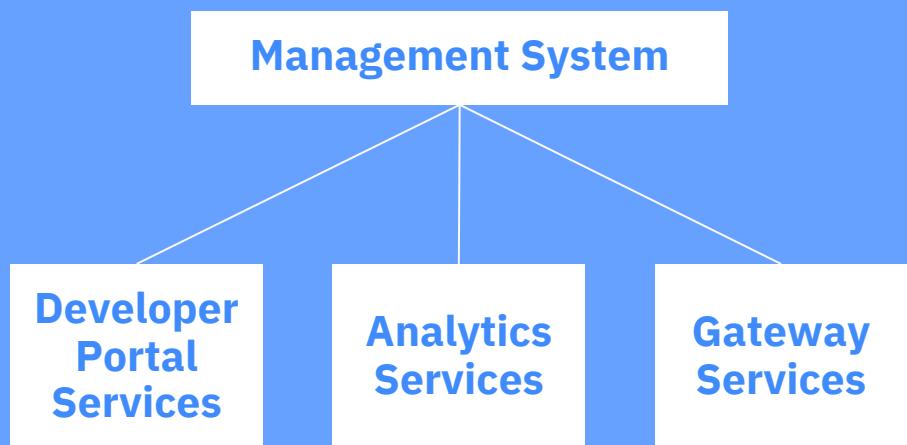


# IBM API Connect

## The Scalable Multi-Cloud API Platform

A complete, modern and intuitive API lifecycle platform to create, securely expose and manage APIs across clouds to power digital applications

### API Connect Components



# z/OS Connect EE vs. Db2 Connect

## **z/OS Connect EE**

- ✓ REST APIs are simple
- ✓ Minimum business logic on client
- ✓ No SQL skills needed
- ✓ APIs are more consistent
- ✓ Widespread acceptance
- ✓ Supports Mobile platforms
- ✓ Stateless

## **Db2 Connect**

- ✓ Contains Complex Business logic
- ✓ SQL Skills required
- ✓ Better Isolation
- ✓ Transaction Processing
- ✓ Resource Pooling
- ✓ Sysplex Scalability
- ✓ Transaction Fault-tolerance

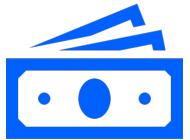
# Further Use Cases



## Scale

### Large US Bank

Serves **150 million API requests** per day from z/OS Connect EE to support fintech startups



## ROI

### Financial organisation

Savings account creation from 3 days to less than a second through APIs resulting in over **5000 new accounts and \$150m** in deposits within 3 months



## Speed

### European Bank

Reduced API development time from **3 months to less than a day**



## Expanding Z

### Spanish Insurance

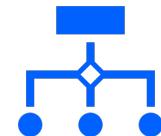
**Called an external vehicle lookup API from CICS** to provide quick quotes based on just registration number. Resulted in 30% more conversions from their quotation website



## Time to value

### Australian Bank

Transformed their core banking application with APIs on Z in **half the time and for a fraction of the cost**



## Simplification

### UK Bank

**Removed 60% of the time, effort and money** required to integrate PSD2 APIs with their core banking system on Z