Db2 for z/OS: REST and Hybrid Cloud

Virtual Workshop

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Q: What role most closely aligns with your job?

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

Q1. What is your experience level with RESTful APIs?

1 – First time I’m hearing about them

2 – Sort of familiar with them

3 – I use them all the time!

Q2. What is your experience level with z/OS Connect?

1 – First time I’m hearing about them

2 – Sort of familiar with them

3 – I use them all the time!

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 Overview
- Service & deployment process, data mapping, and performance
Db2 REST & z/OS Connect

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

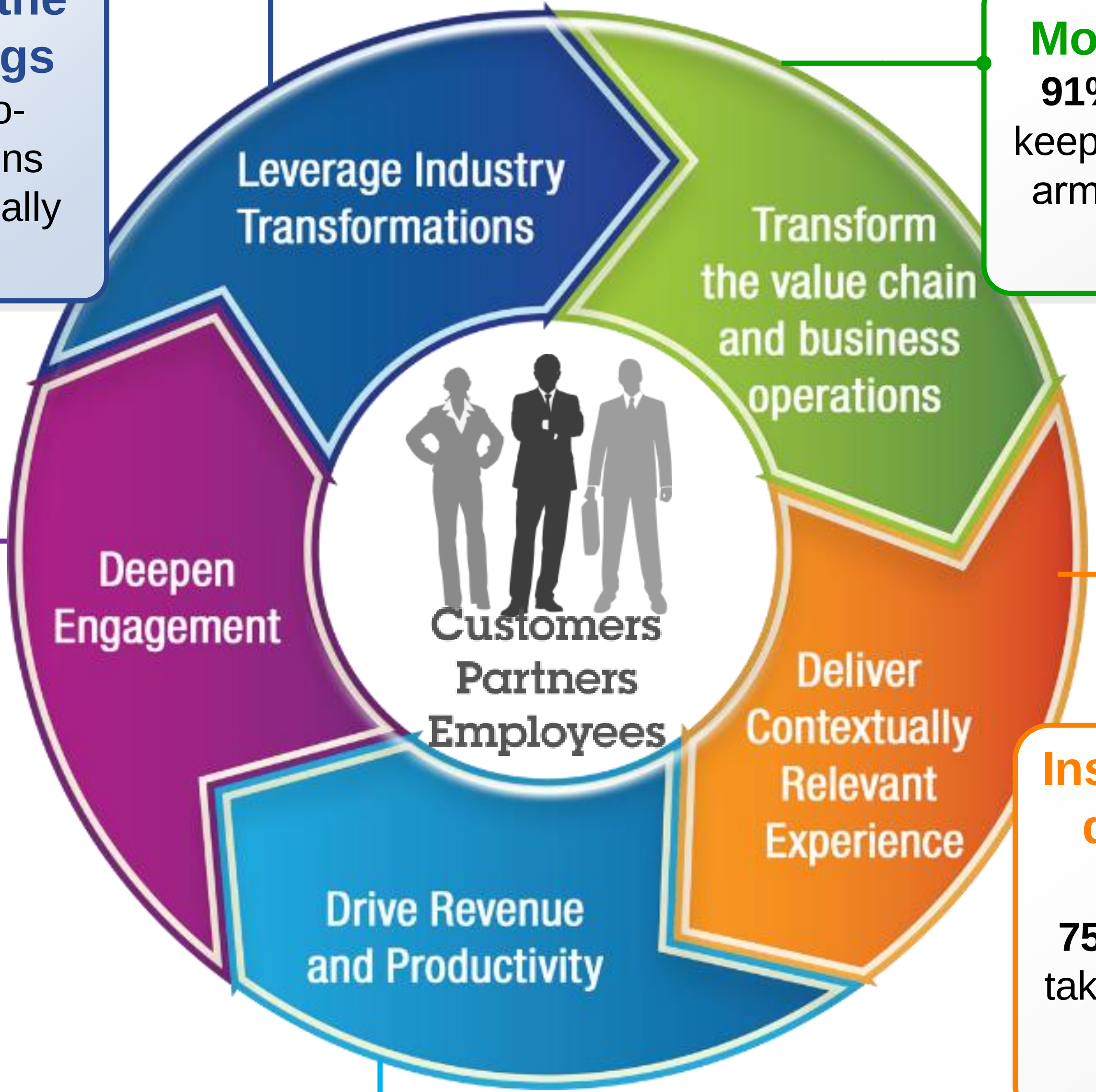
Mobile enables the Internet of Things
Global machine-to-machine connections increasing dramatically

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 messages

Mobile is about transacting
Evidence: "Cyber Monday"


Leverage Industry Transformations
Transform the value chain and business operations
Deliver Contextually Relevant Experience
Drive Revenue and Productivity
Deepen Engagement
Customers
Partners
Employees

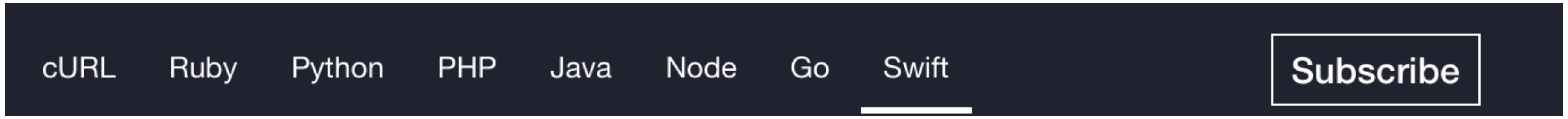
Expectations of Cloud

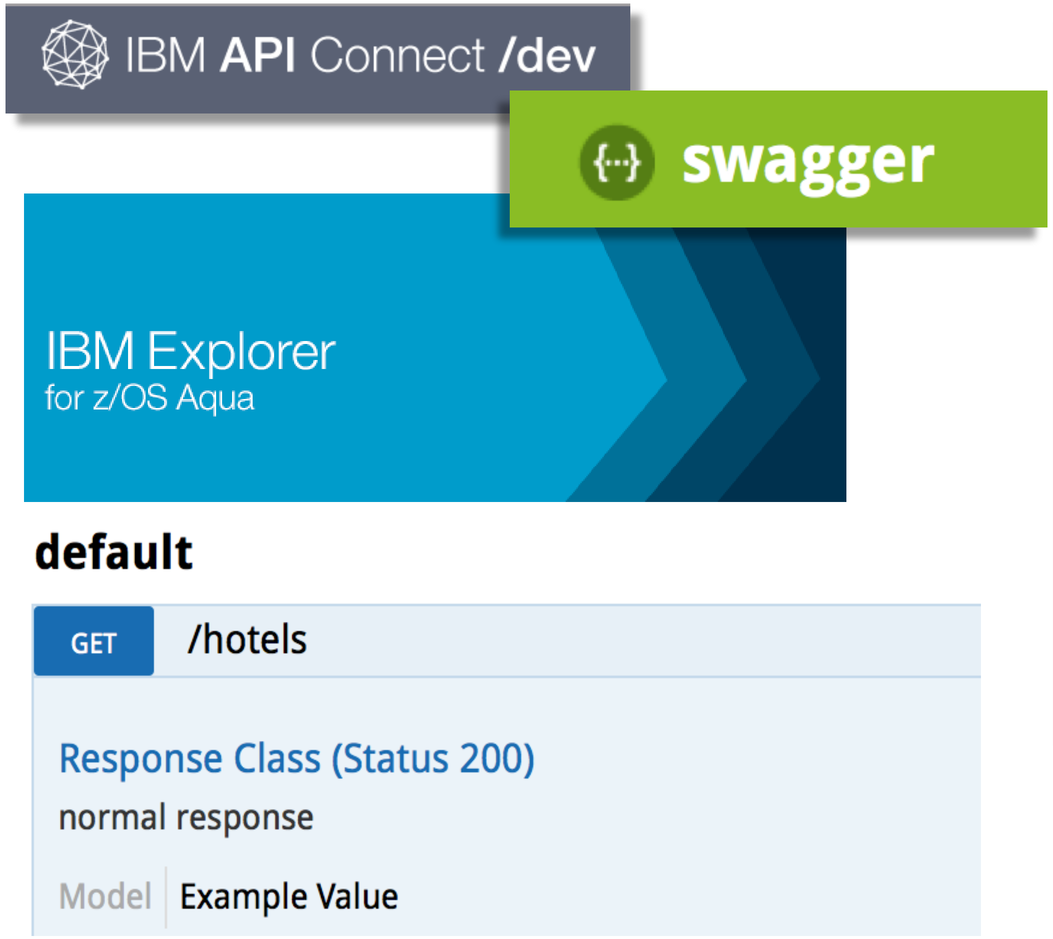
- I can connect to whatever I want
- I can try things out without penalty
- I won't be tied to any one single solution
- Everything will be familiar and standard

Misconceptions of z/OS

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

The Reality





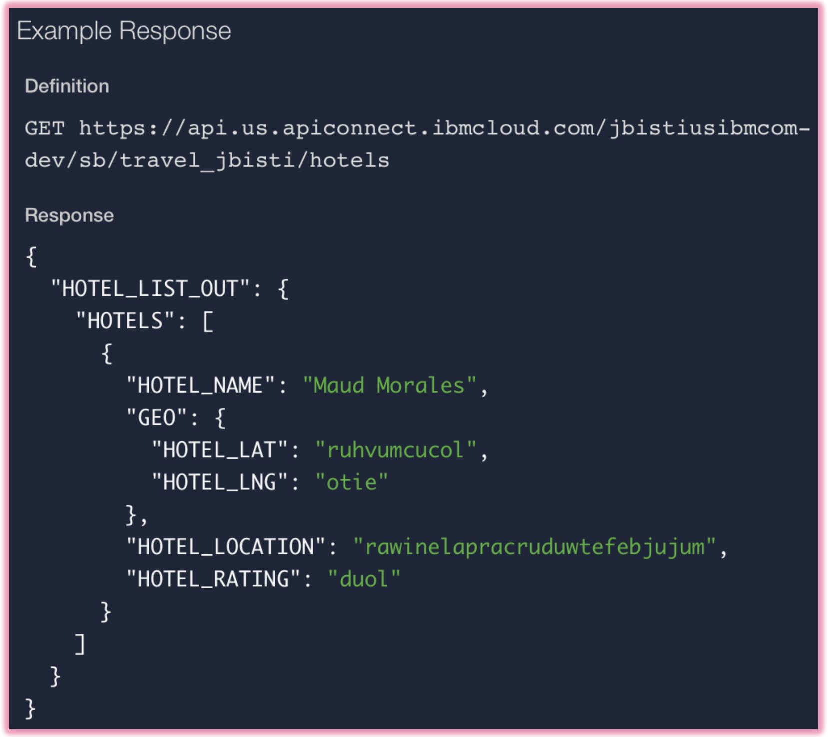
default

GET /hotels

Response Class (Status 200)

normal response

Model | Example Value



Example Response

Definition

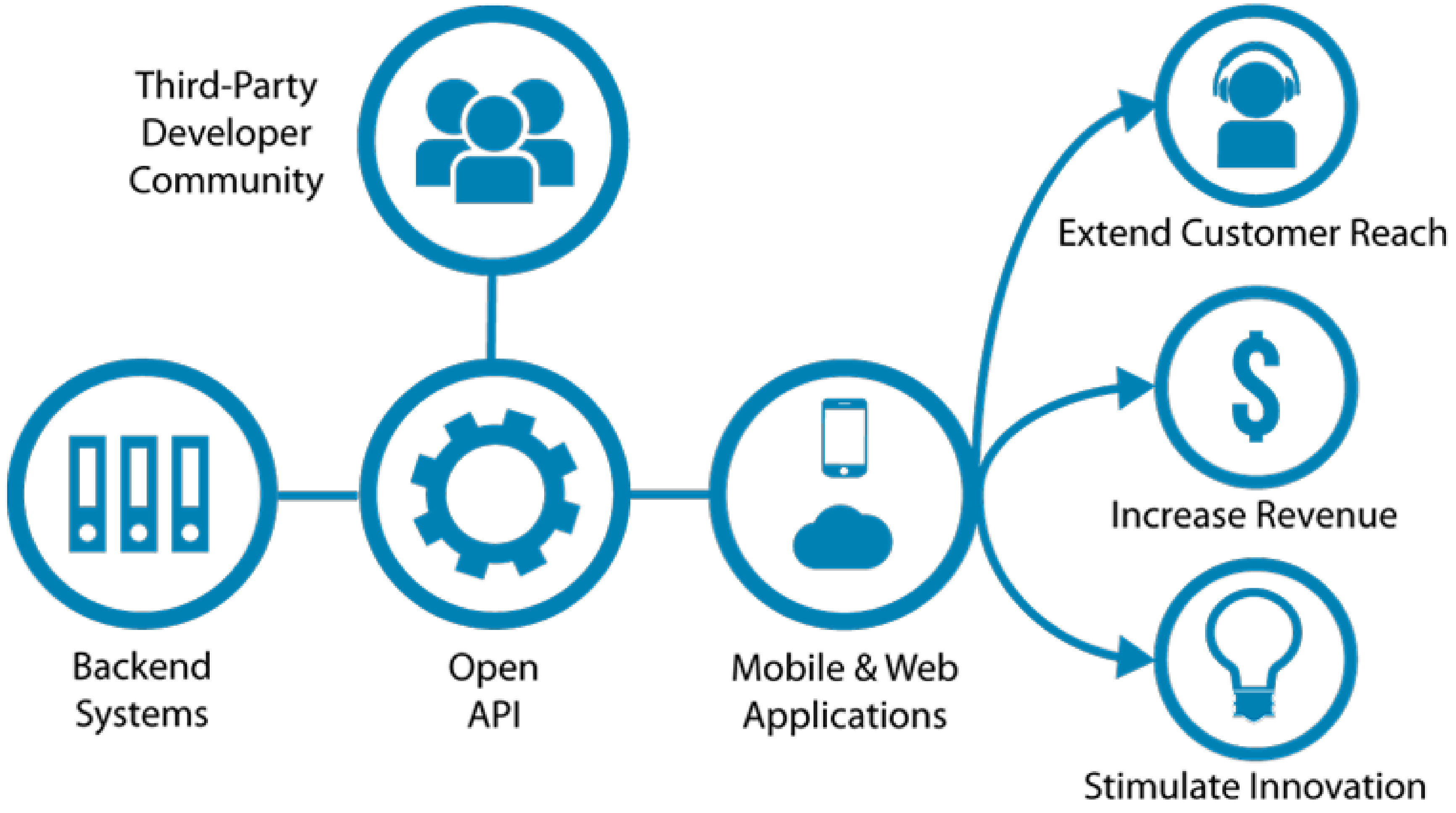
```
GET https://api.us.apiconnect.ibmcloud.com/jbistiusibmcom-
dev/sb/travel_jbisti/hotels
```

Response

```
{
  "HOTEL_LIST_OUT": {
    "HOTELS": [
      {
        "HOTEL_NAME": "Maud Morales",
        "GEO": {
          "HOTEL_LAT": "ruhvumcucol",
          "HOTEL_LNG": "otie"
        },
        "HOTEL_LOCATION": "rawinelapracruduwtefebjujum",
        "HOTEL_RATING": "duol"
      }
    ]
  }
}
```

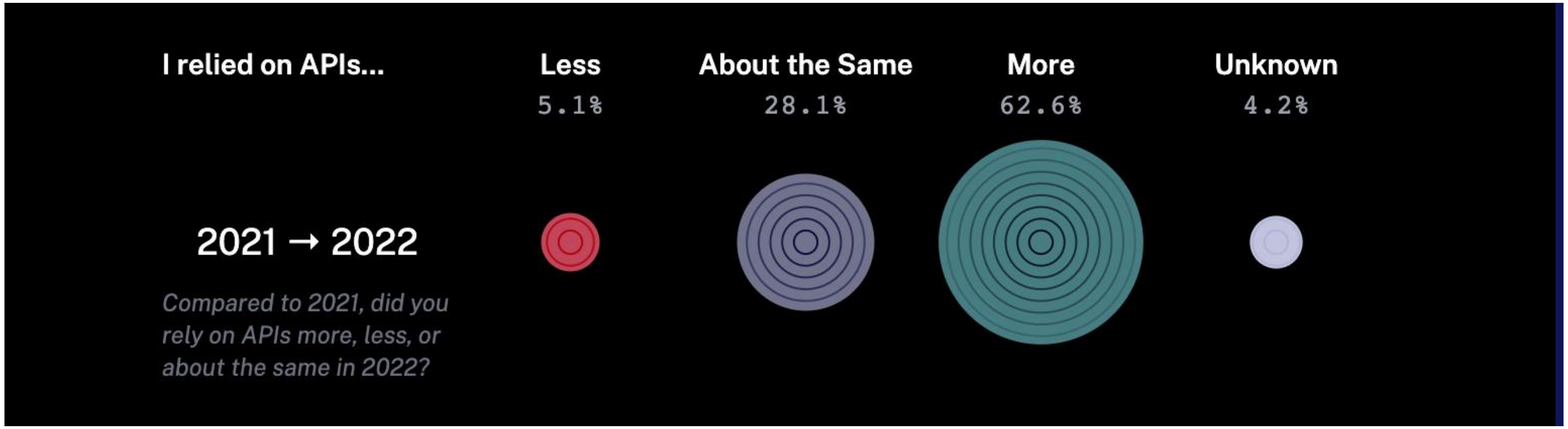
What is the API economy

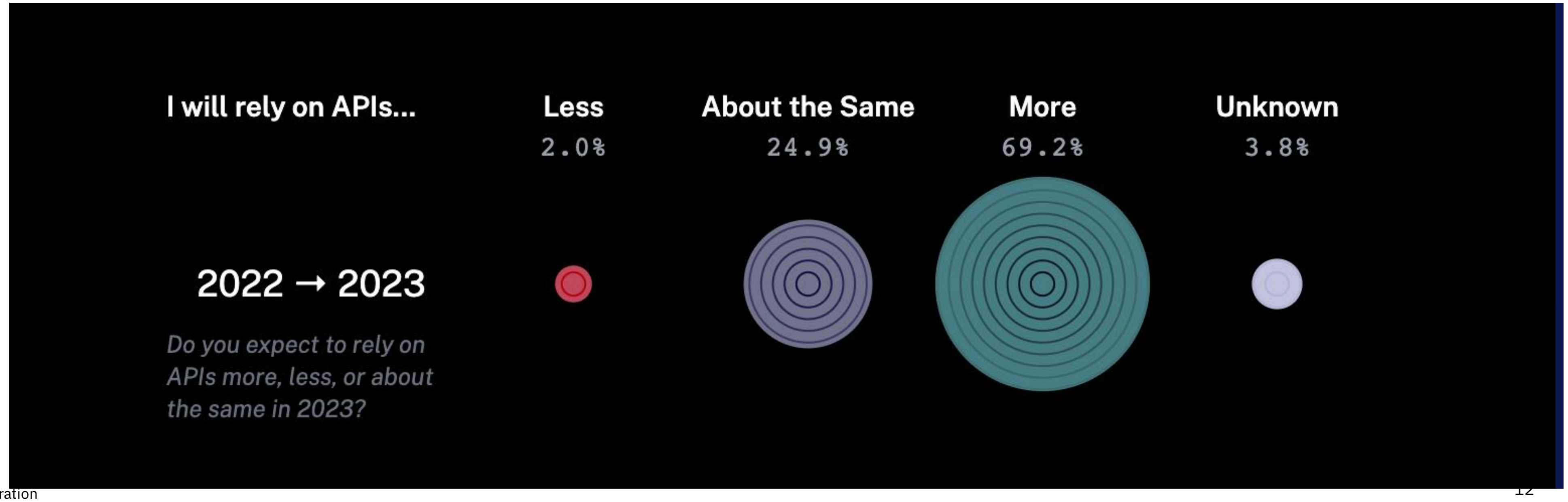
The use of “business APIs” to positively affect the company



Relying on APIs

Over 62.6% of developers reported relying on APIs more in 2022 than they did in 2021. Additionally, 69.2% expect to rely on APIs even more in 2023.





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.

<u>NOTE</u>

Db2 native REST <u>only</u> supports the <u>POST method</u> for applications.

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

This is why Db2 native REST is REST, while <u>z/OS Connect is RESTful</u>

Key principles of REST

Method **URI** URI=Uniform Resource Identifier

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

```
GET
POST
PUT
DELETE
```

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

URIs represent things (or lists of things)

Query Parameters are used for refinement of the request

Request/Response Body is used to represent the data object

```
GET http://www.acme.com/customers/12345?personalDetails=true


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

REST and JSON

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

Representational **S**tate **T**ransfer **(REST)**

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

← The application understands what to do based on the URI.

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

Java**S**cript **O**bject **N**otation **(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)
[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)

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.

Why is REST so popular?

Increasingly Common

Relatively Lightweight

Ubiquitous Foundation

Stateless

Relatively Easy Development

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 service properties

Db2 REST service invocation

- Direct Db2 DDF REST access

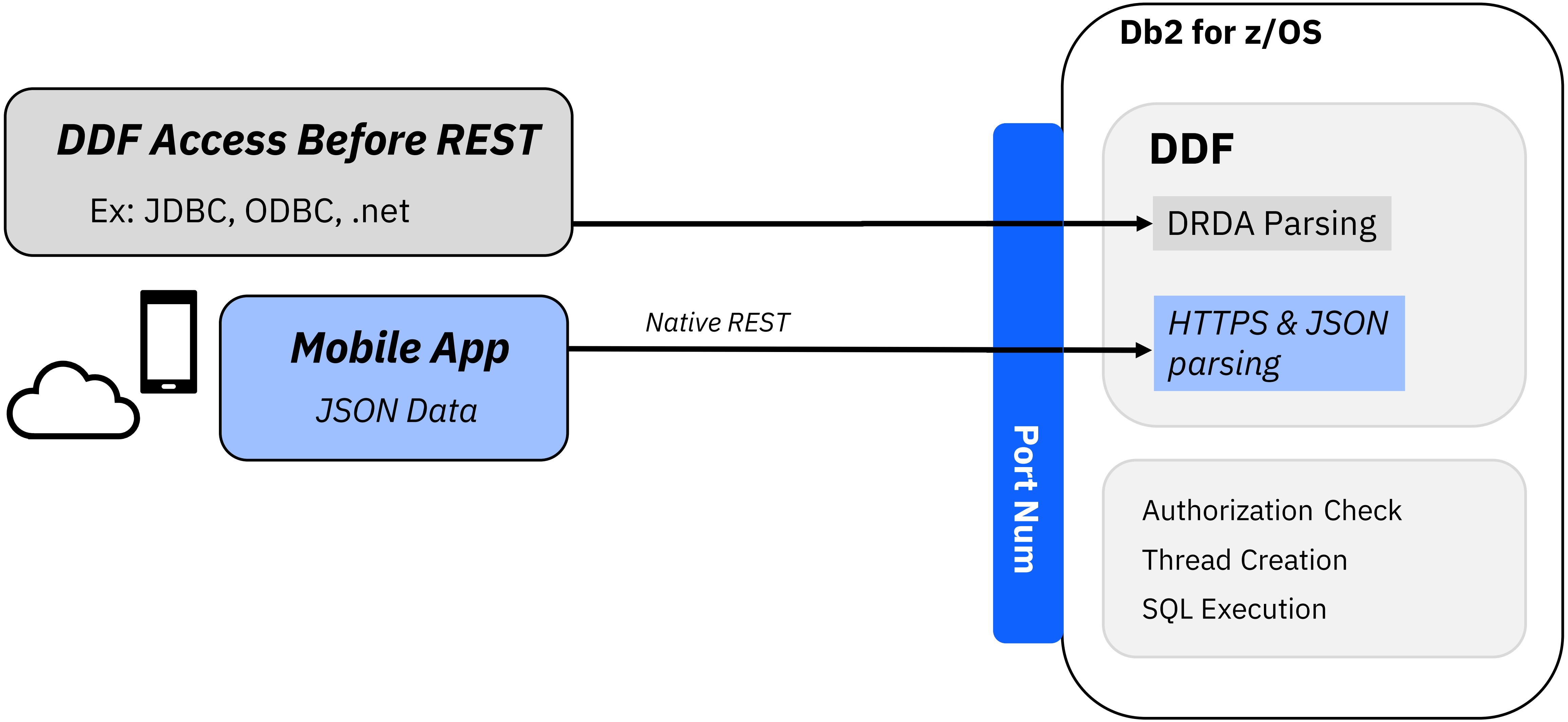
Service details

- 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

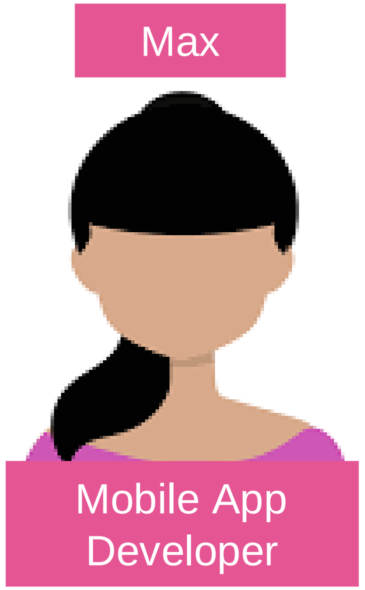
All of the various Db2 base SQL data types

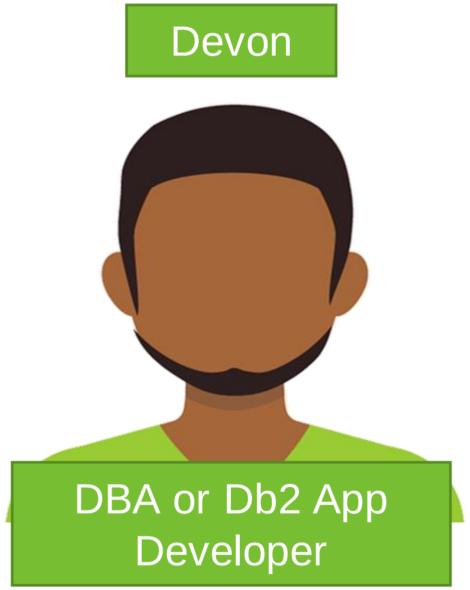
- Including BLOB, CLOB, DBCLOB and XML

Architecture Diagram



When a developer goes to retrieve data





Invokes a Db2 REST service

- Service consists of stored procedure or SQL statement

Output returns in JSON format

Doesn't need to know SQL, nor that the data came from Db2

Creates a Db2 REST service

- Service 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

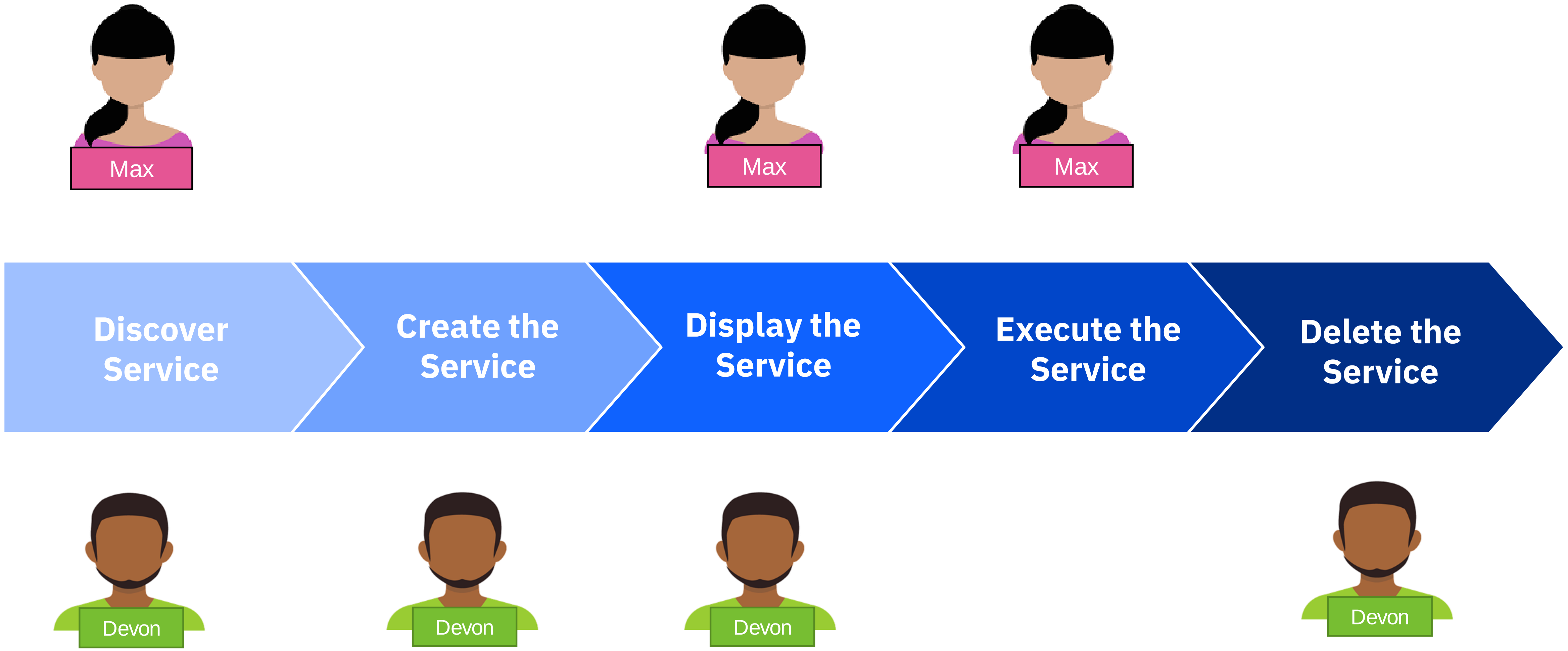
REST app

- Browser look and feel

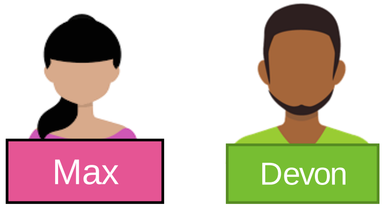
BIND subcommand

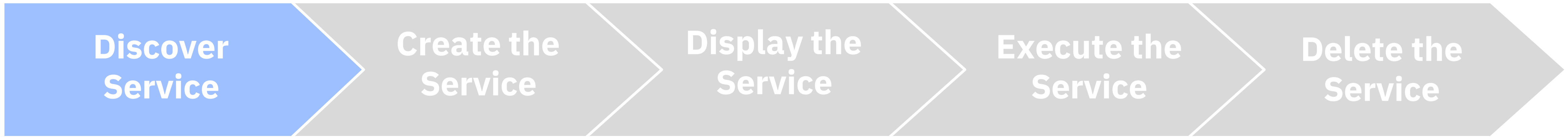
- Standard Db2 interaction

Db2 REST Service Progression



Db2 REST Service Progression





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:

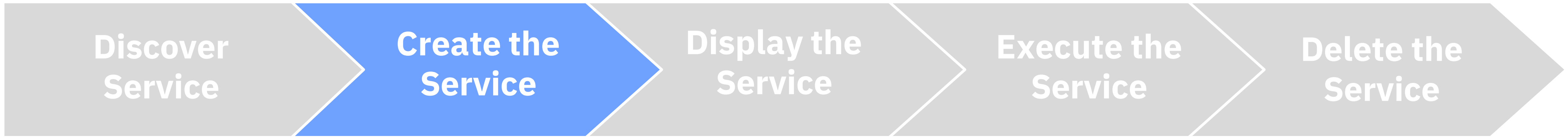
- https://<host>:<port>/services

Successful completion:

REST Status Code = 201.

This is an HTTP code - not Db2!

Db2 REST Service Progression



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

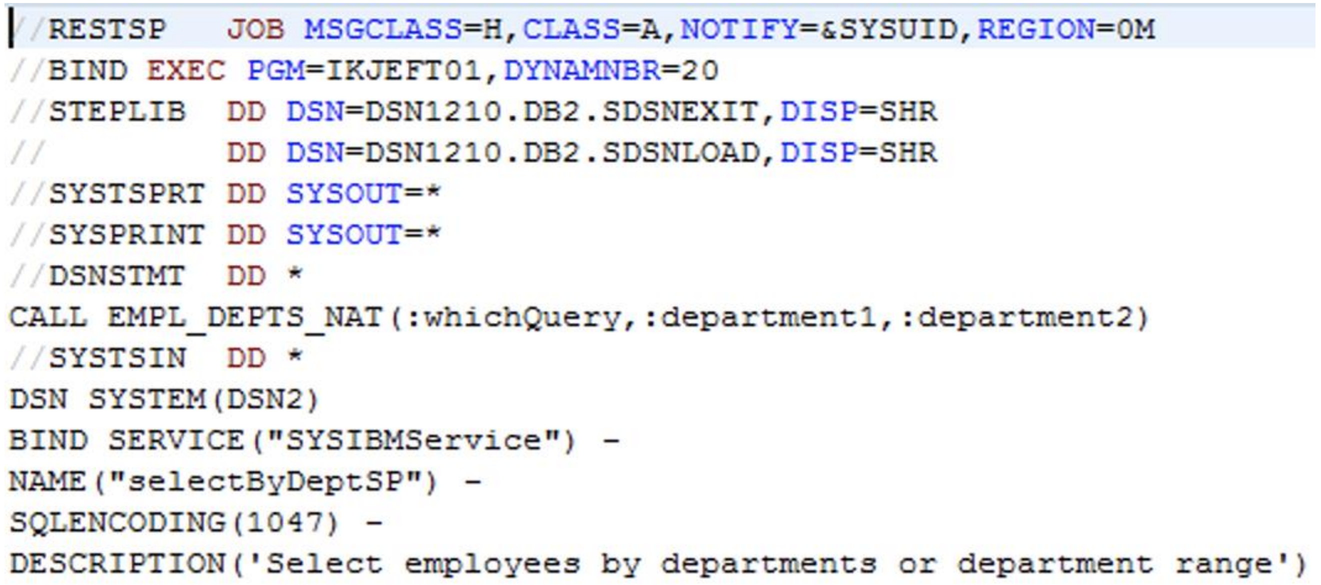
The BIND SERVICE (DSN) subcommand builds an application package that represents a Db2 REST service.

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:



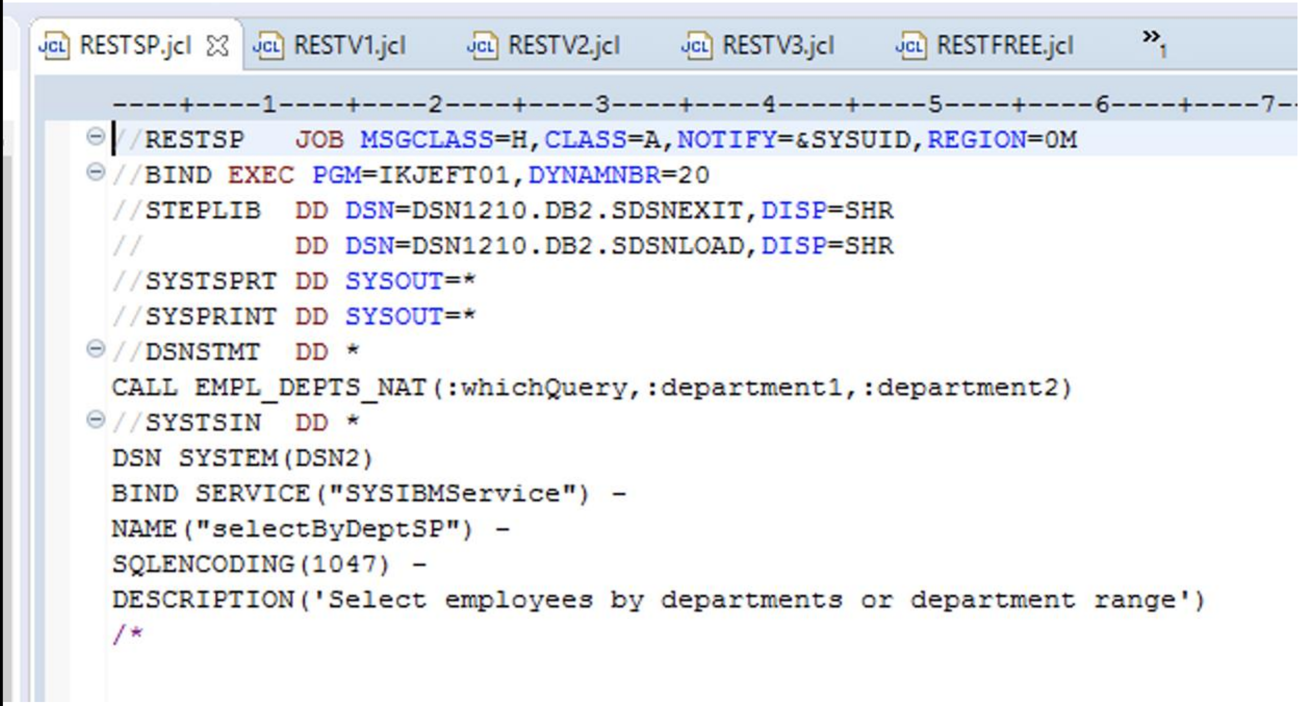
```
//RESTSP   JOB MSGCLASS=H,CLASS=A,NOTIFY=&SYSUID,REGION=0M
//BIND EXEC PGM=IKJEFT01,DYNAMNBR=20
//STEPLIB  DD DSN=DSN1210.DB2.SDSNEXIT,DISP=SHR
//         DD DSN=DSN1210.DB2.SDSNLOAD,DISP=SHR
//SYSTSPRT DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//DSNSTMT  DD *
CALL EMPL_DEPTS_NAT(:whichQuery,:department1,:department2)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

Successful completion:

0000

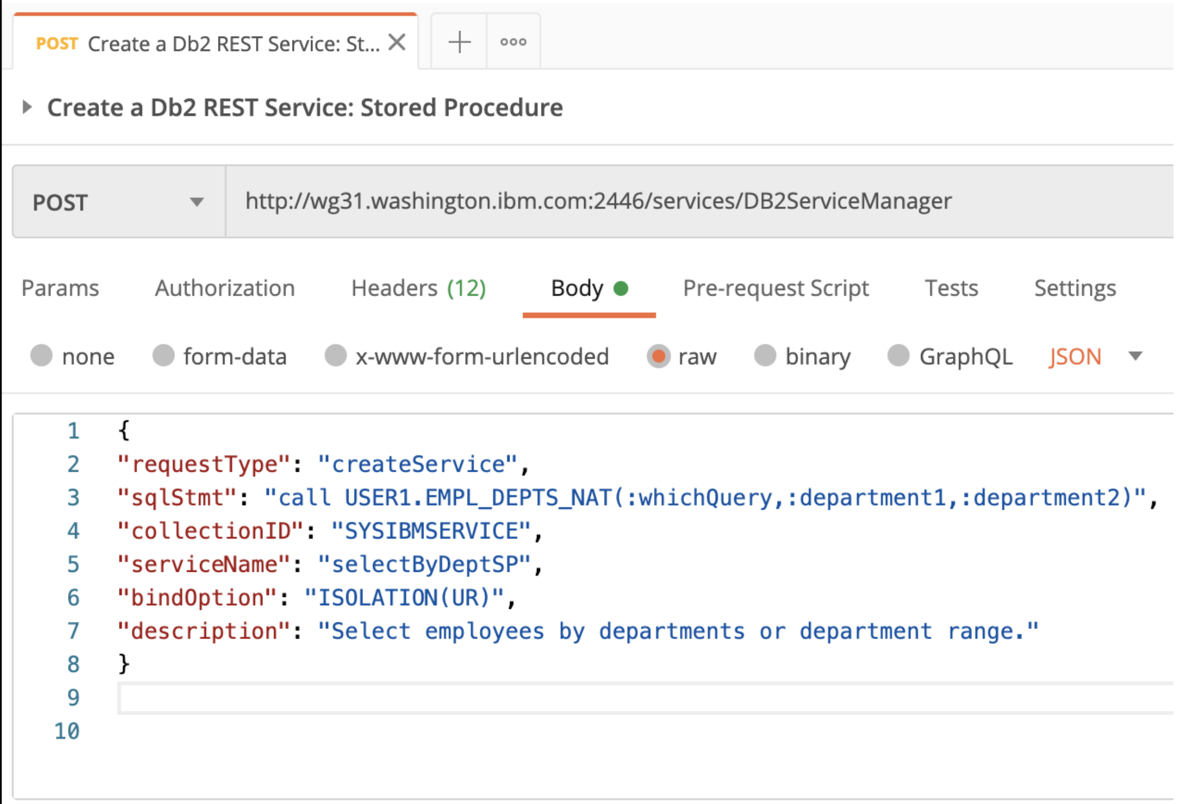
This is not an HTTP code!

Batch JCL:
Stored Procedure



```
----+----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

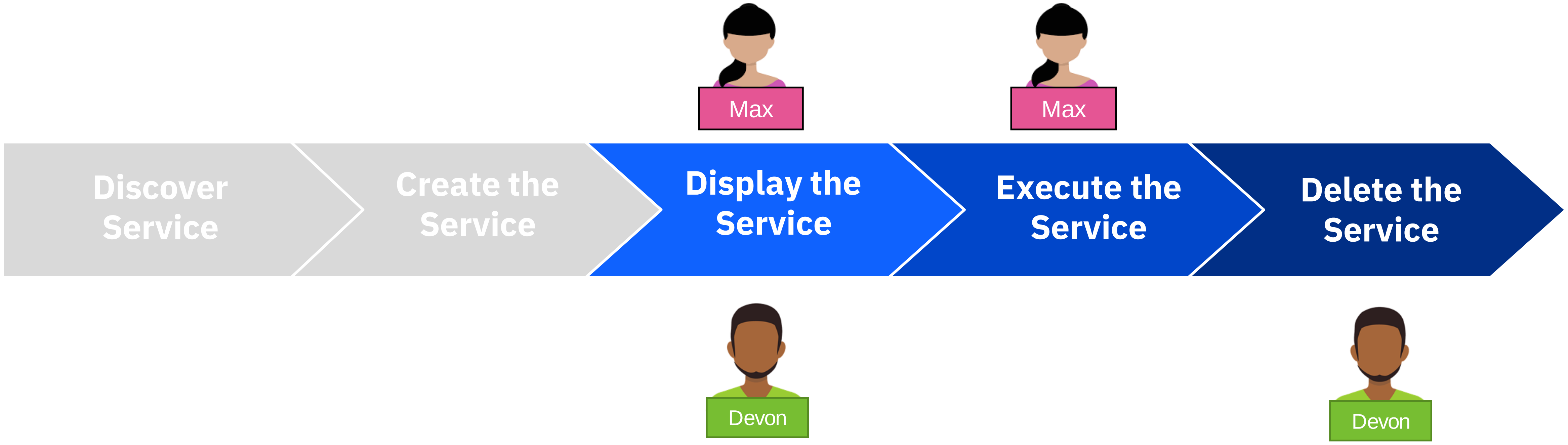


POST http://wg31.washington.ibm.com:2446/services/DB2ServiceManager

[✓ raw] JSON

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

Db2 REST Service Progression



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

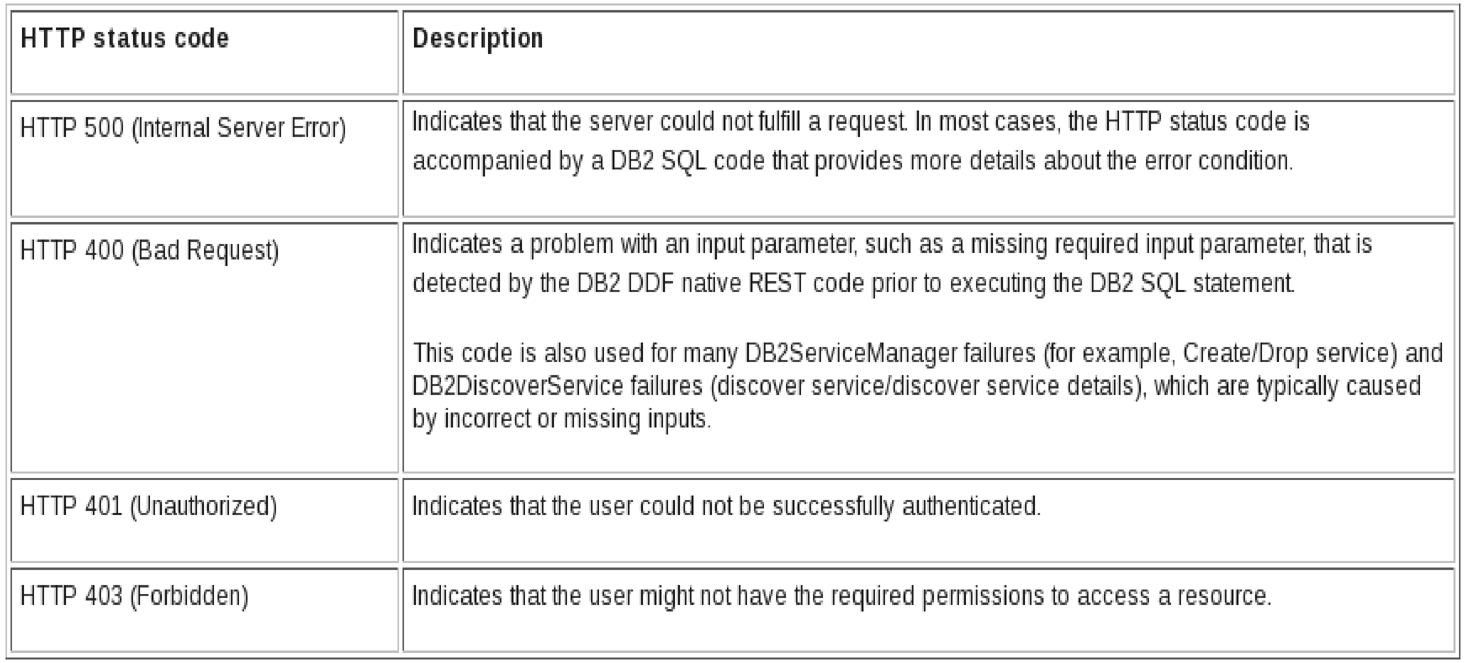
https://www.ibm.com/docs/en/db2-for-zos/12?topic=db2-rest-services

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

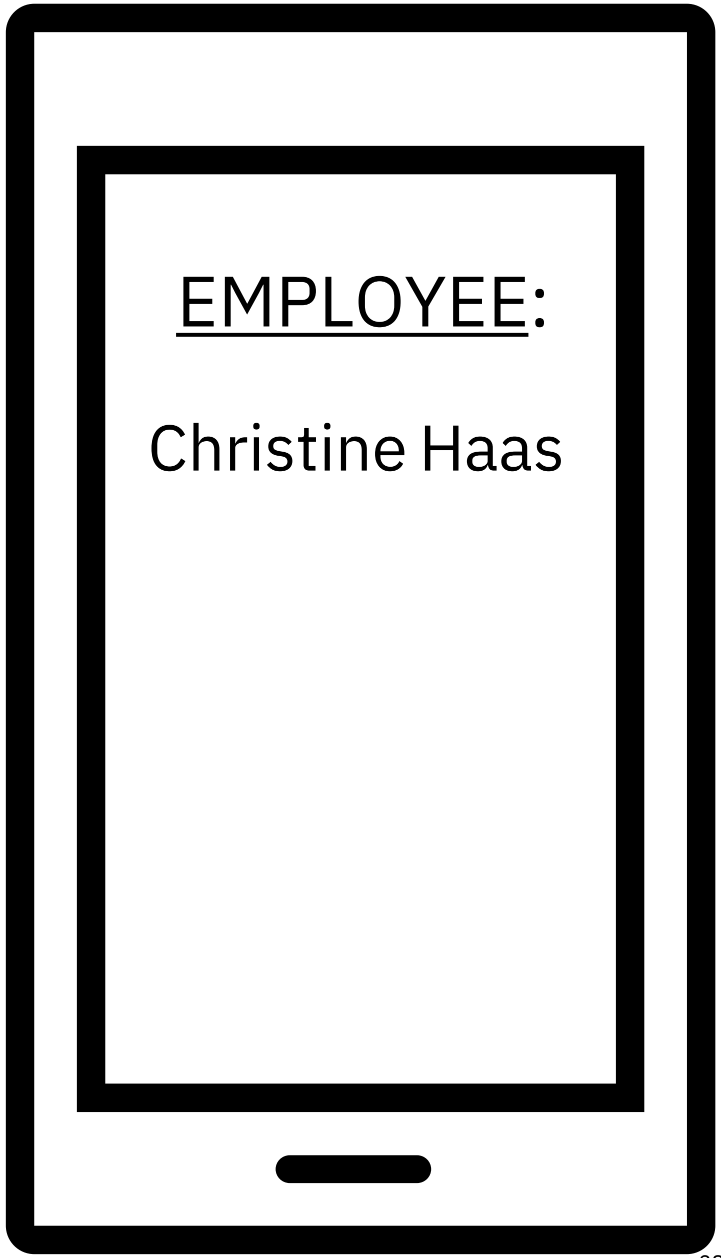
SELECT FIRSTNME, LASTNAME, PHONENO, WORKDEPT FROM DSN81210.EMP WHERE EMPNO = :EMPNUM

/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



<u>EMPLOYEE</u>:

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

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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

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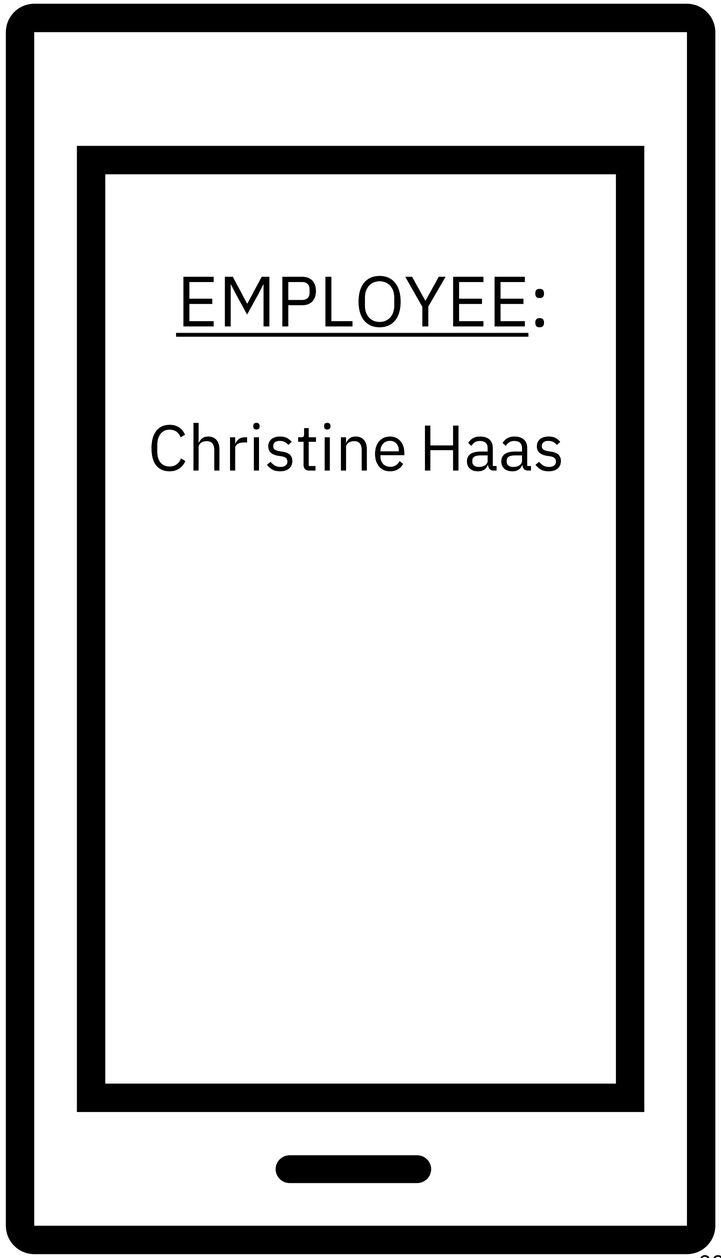

/services/IBMServices/displayEmployee/

SELECT FNAME, LNAME FROM EMPLOYEE

Versioning ENABLED

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

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/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/

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Versioning ENABLED

/services/IBMServices/selectByEmpNum/V1

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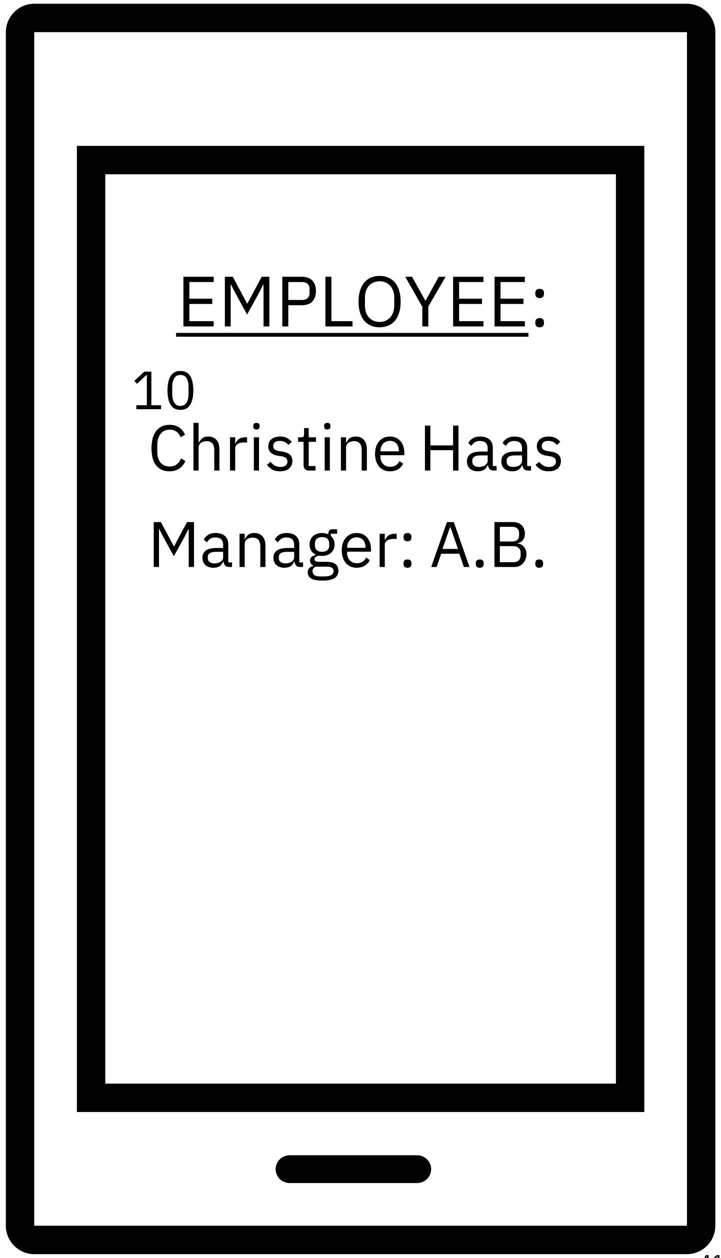
/services/IBMServices/selectByEmpNum/V3

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.

/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

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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

Let’s review!

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 Overview

Db2 REST & z/OS Connect

APIs provide a more efficient way to connect, supporting mobile trends

A RESTful APIs provide stateless, relatively lightweight, easy development

Db2 Native REST Services expose Db2 data to the API economy

Versioning in Db2 REST services simplify modification of services, improving time to market

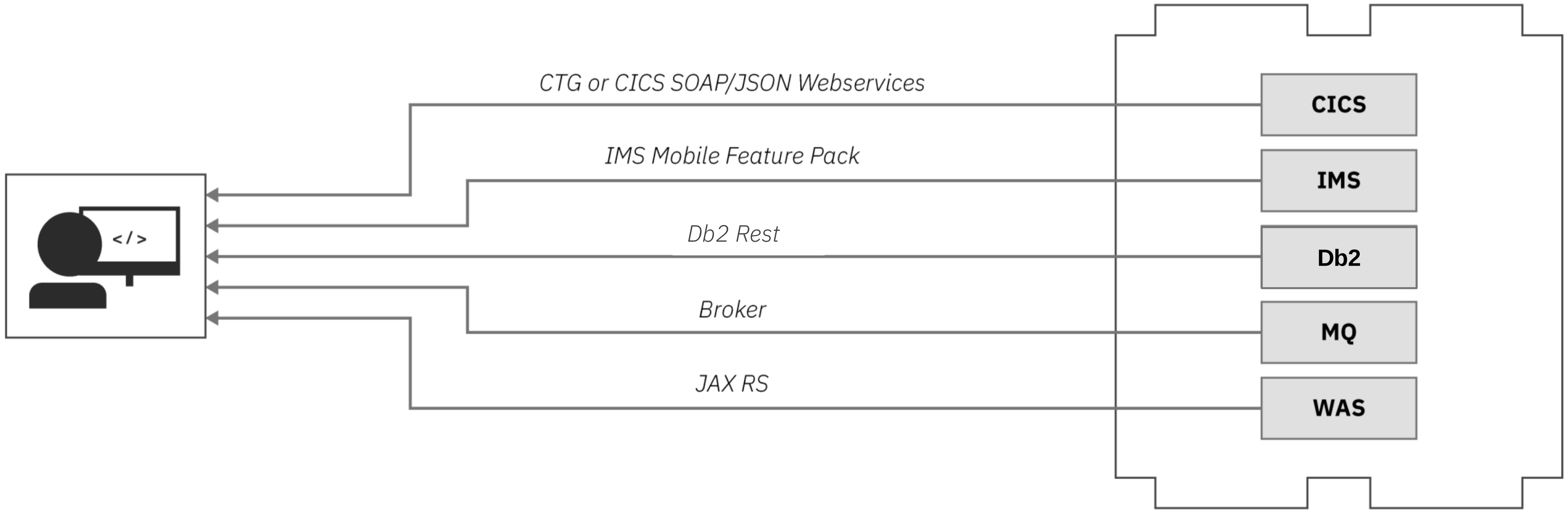
z/OS Connect

Modernize and transform

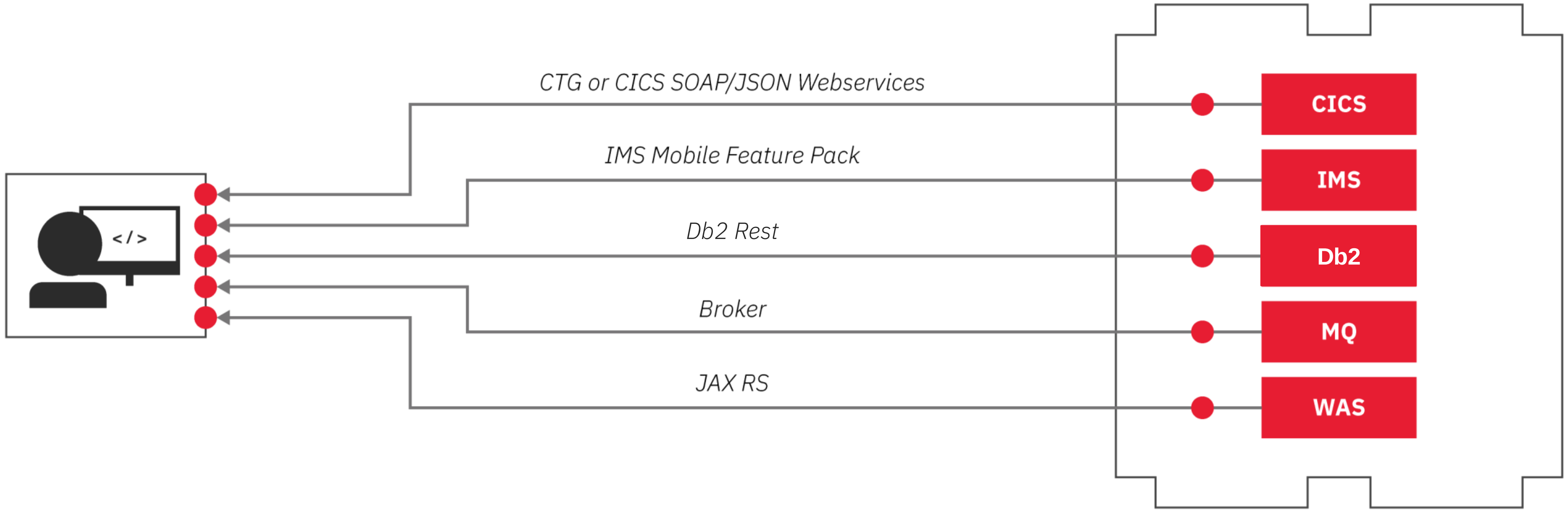
Q: What is your level of experience with z/OS Connect?

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...



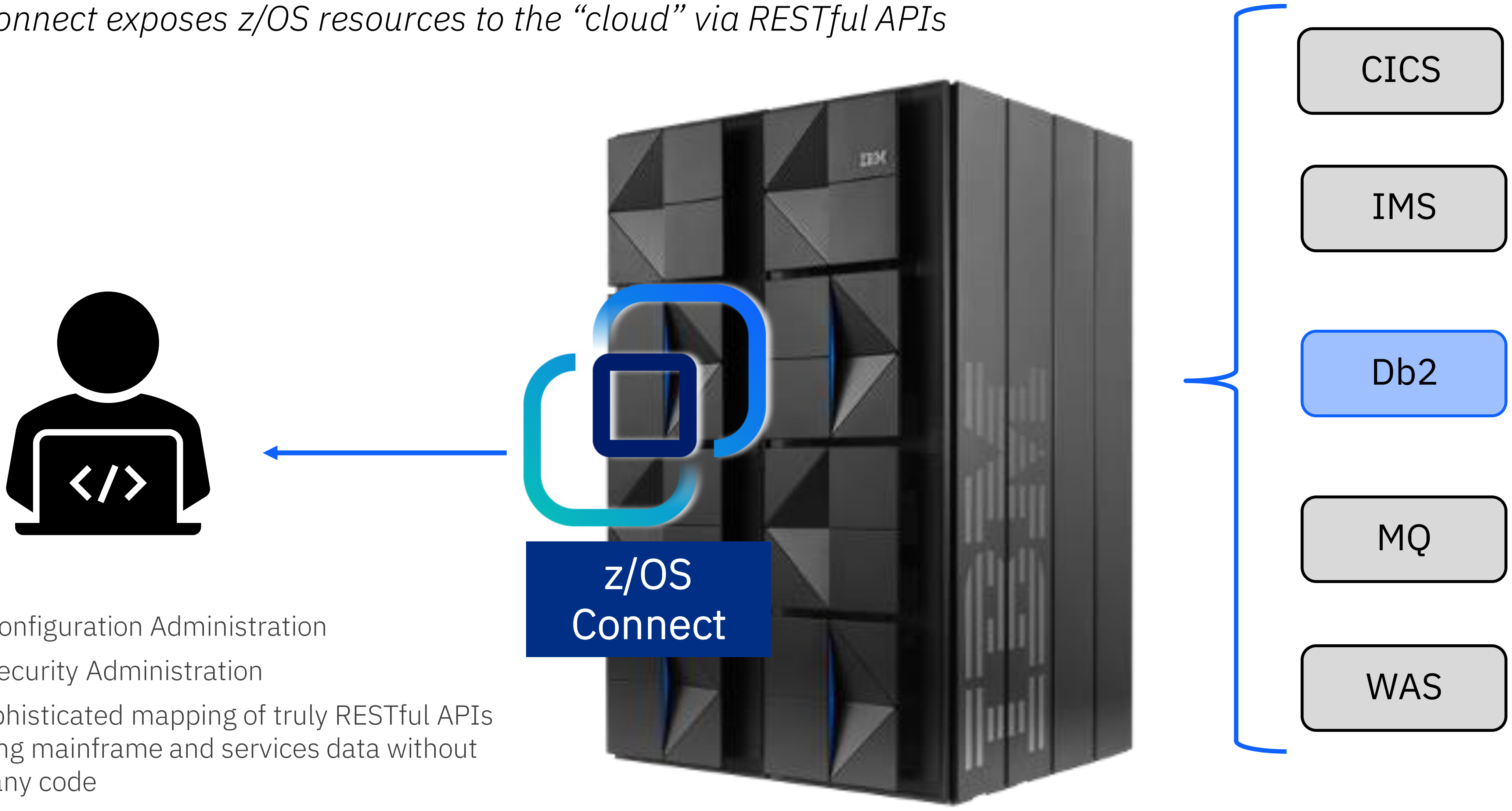
Completely different configuration and management

Multiple endpoints for developers to call/maintain

These are typically not RESTful!

Single Point of Entry

z/OS Connect 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

The Open API Initiative

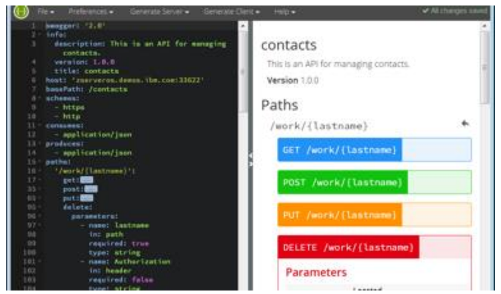
The industry standard framework for describing RESTful APIs, aka **Swagger**

https://www.openapis.org/

There are a variety of tools available to aid consumption:

Write Swagger

Swagger Editor allows API developers to design their swagger documents



```
swagger: '2.0'
info:
  description: This is an API for managing
    contacts.
  version: 1.0.0
  title: contacts
host: 'zserveros.demos.ibm.com:33622'
basePath: /contacts
schemes:
  - https
  - http
consumes:
  - application/json
produces:
  - application/json
paths:
  '/work/{lastname}':
    get:
    post:
    put:
    delete:
      parameters:
        - name: lastname
          in: path
          required: true
          type: string
        - name: Authorization
          in: header
          required: false
```

contacts

This is an API for managing contacts.

Version 1.0.0

Paths

/work/{lastname}

GET /work/{lastname}

POST /work/{lastname}

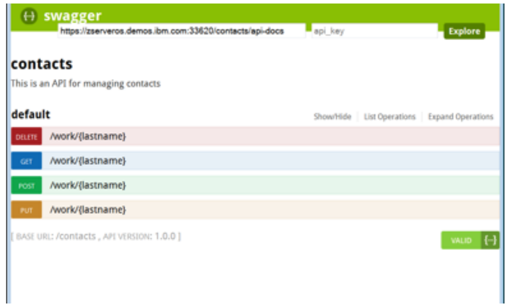
PUT /work/{lastname}

DELETE /work/{lastname}

Parameters

Read Swagger

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



contacts

This is an API for managing contacts

default

DELETE /work/{lastname}

GET /work/{lastname}

POST /work/{lastname}

PUT /work/{lastname}

[BASE URL: /contacts , API VERSION: 1.0.0]

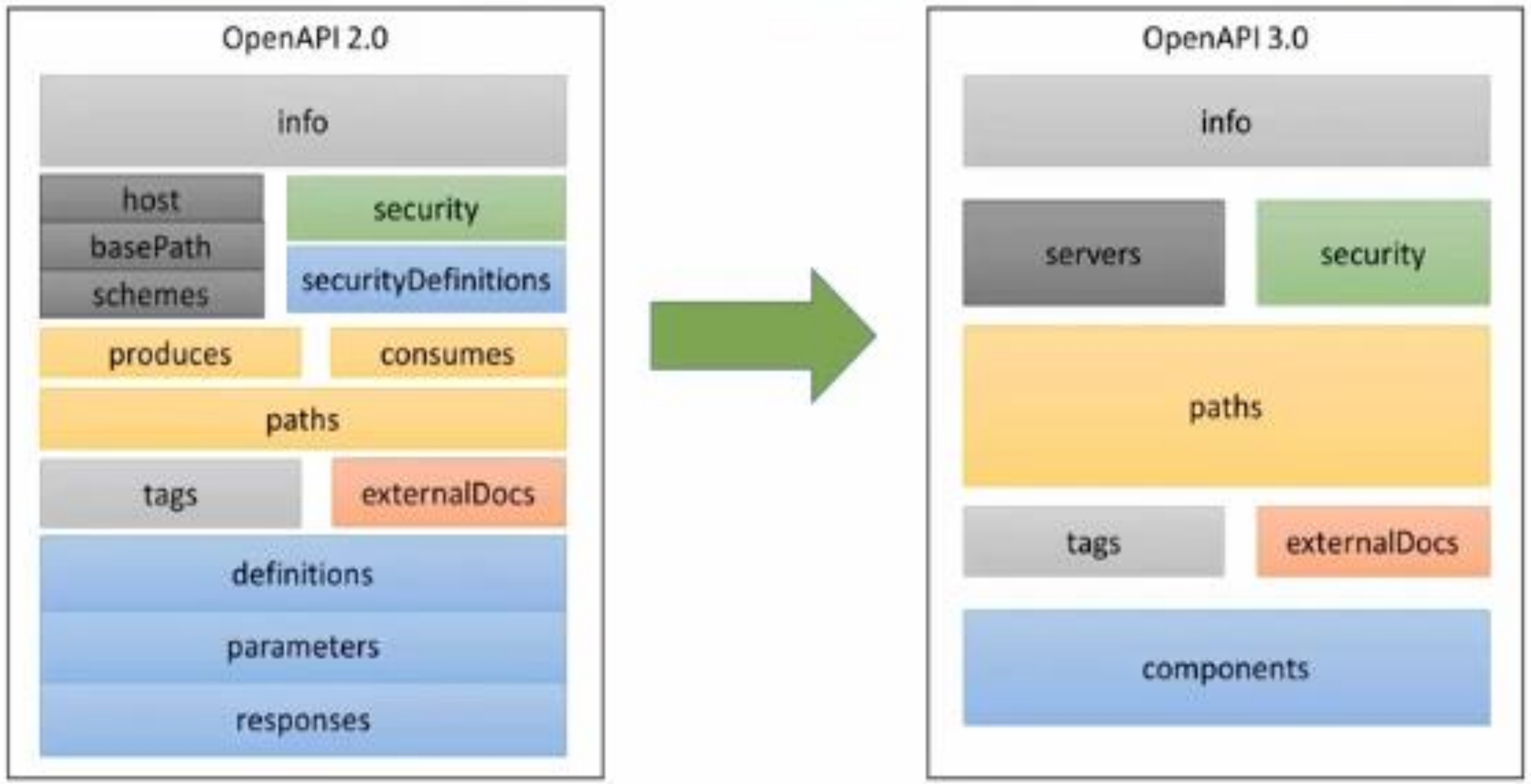
Consume Swagger

Swagger Codegen creates stub code to consume APIs from various languages

[GitHub Link]()

Open API Specifications

- The OpenAPI Specification 3.0 (OAS 3.0) has matured and has been widely adopted.
- OAS 3.0 is governed by the Linux foundation.
- OAS 2.0 has been widely used for several years. Many organizations are now using the OAS 3.0 specification.
- OAS 3.1 was published February 2021
- **z/OS Connect** has support for OAS 2.0 and OAS 3.0 *(different tooling and runtimes*)

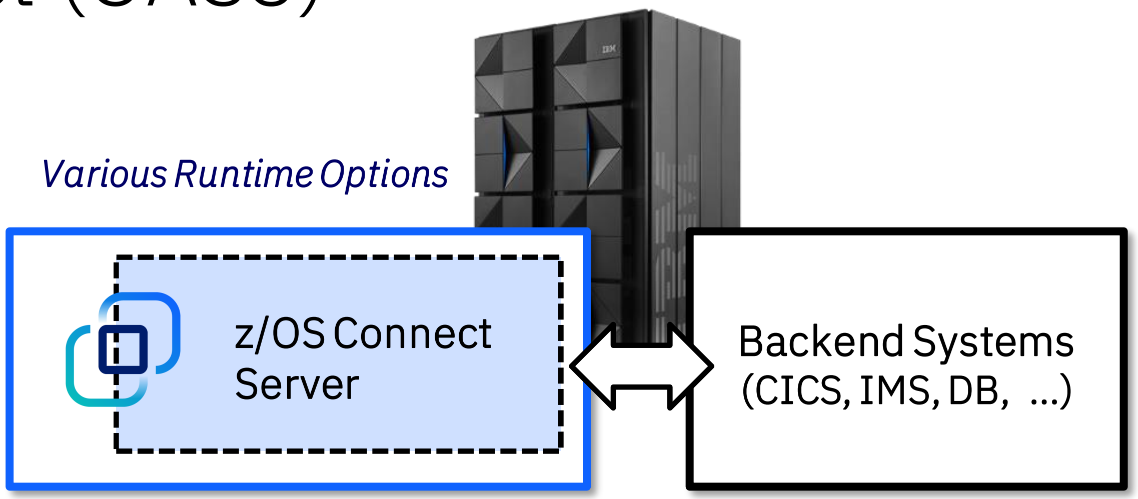


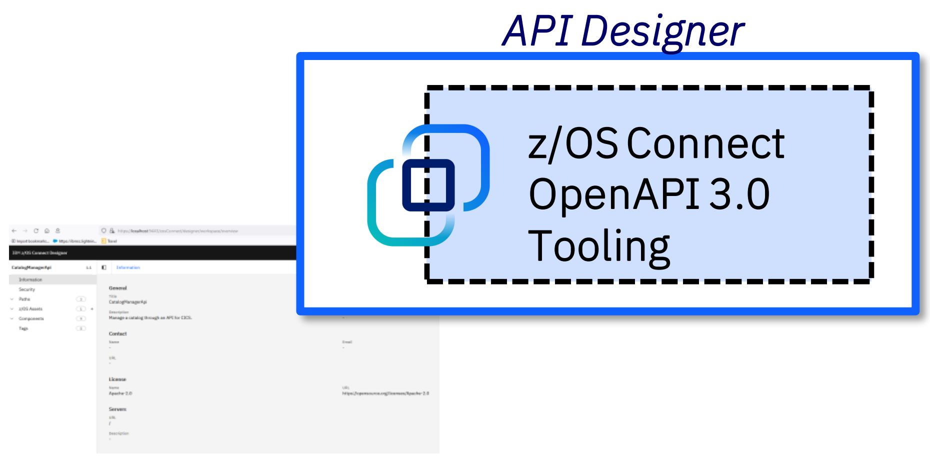
https://swagger.io/blog/news/whats-new-in-openapi-3-0/

High Level Overview of z/OS Connect (OAS3)

1 Runtime Server

- Hosts APIs you define to run
- Connects with backend system
- Allows for multiple instances
- Run as a traditional z/OS started task
- or run as a container image on zCX or any Linux container AMD 64 platform

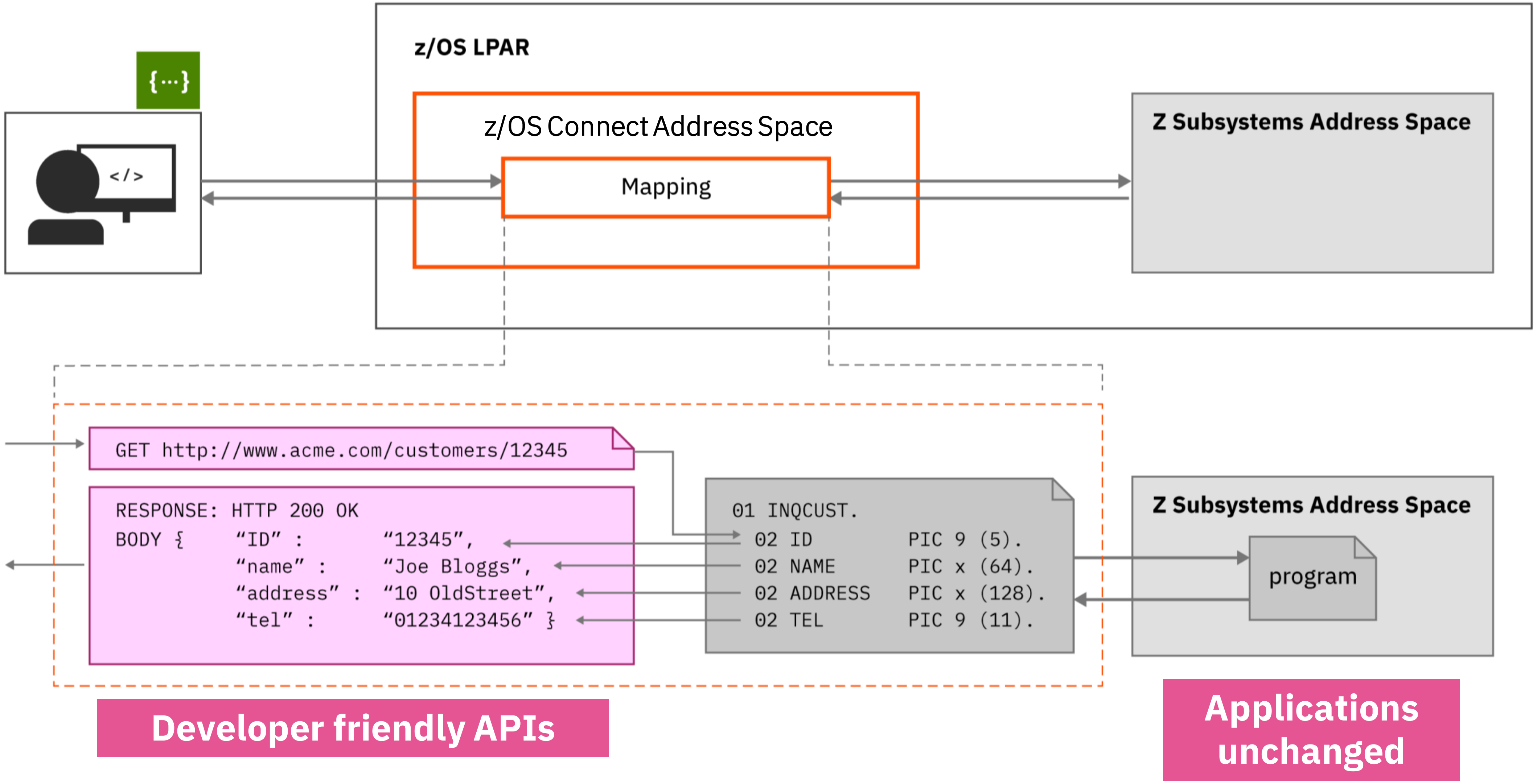

Various Runtime Options
z/OS Connect Server
Backend Systems (CICS, IMS, DB, ...)



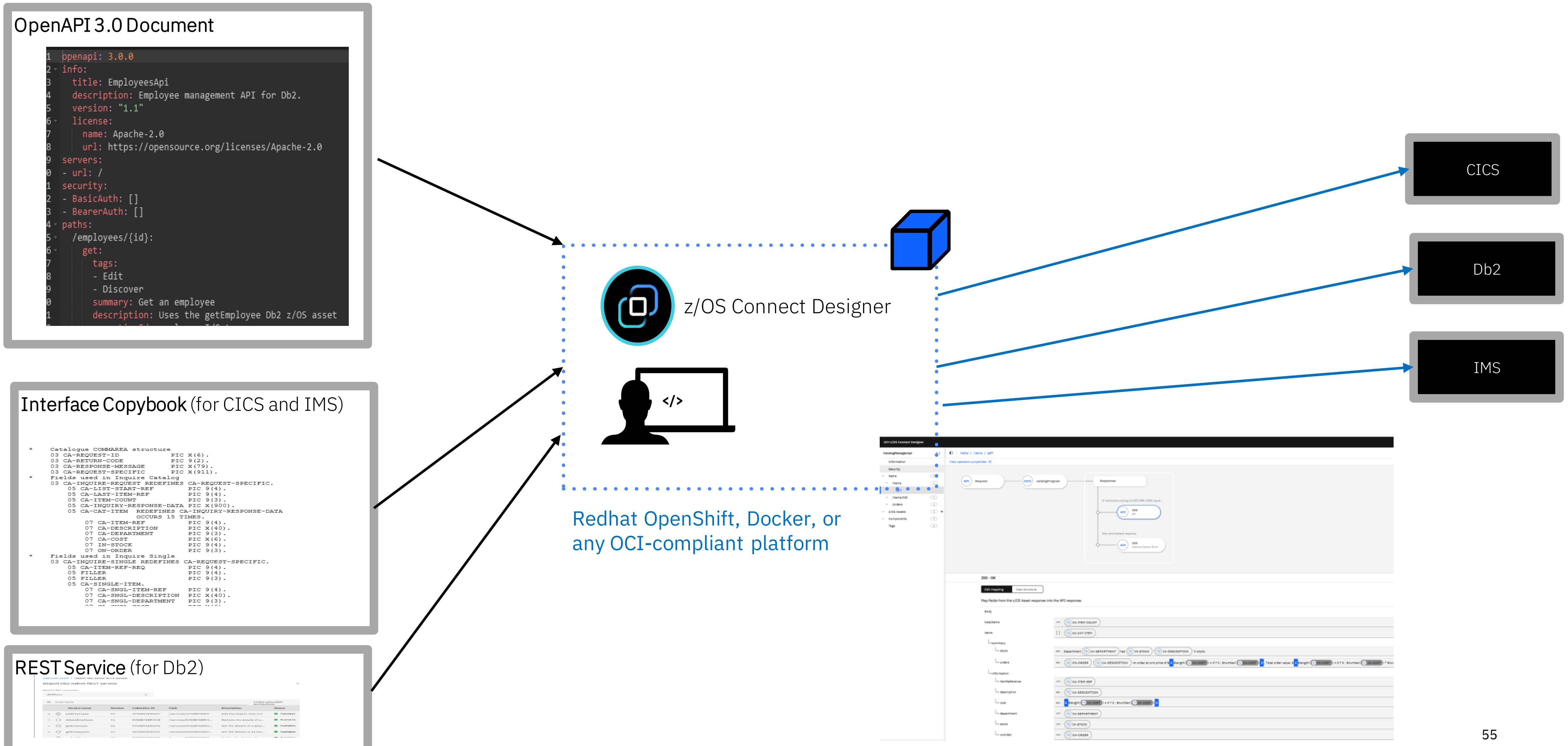
2 Tooling – API Designer

- Containerized Web-based user interface
- API-first functional mapping
- Rich data mapping capabilities
- Test without the need for a dedicated test server
- Create .war archive for other tools to deploy

Data Mapping:



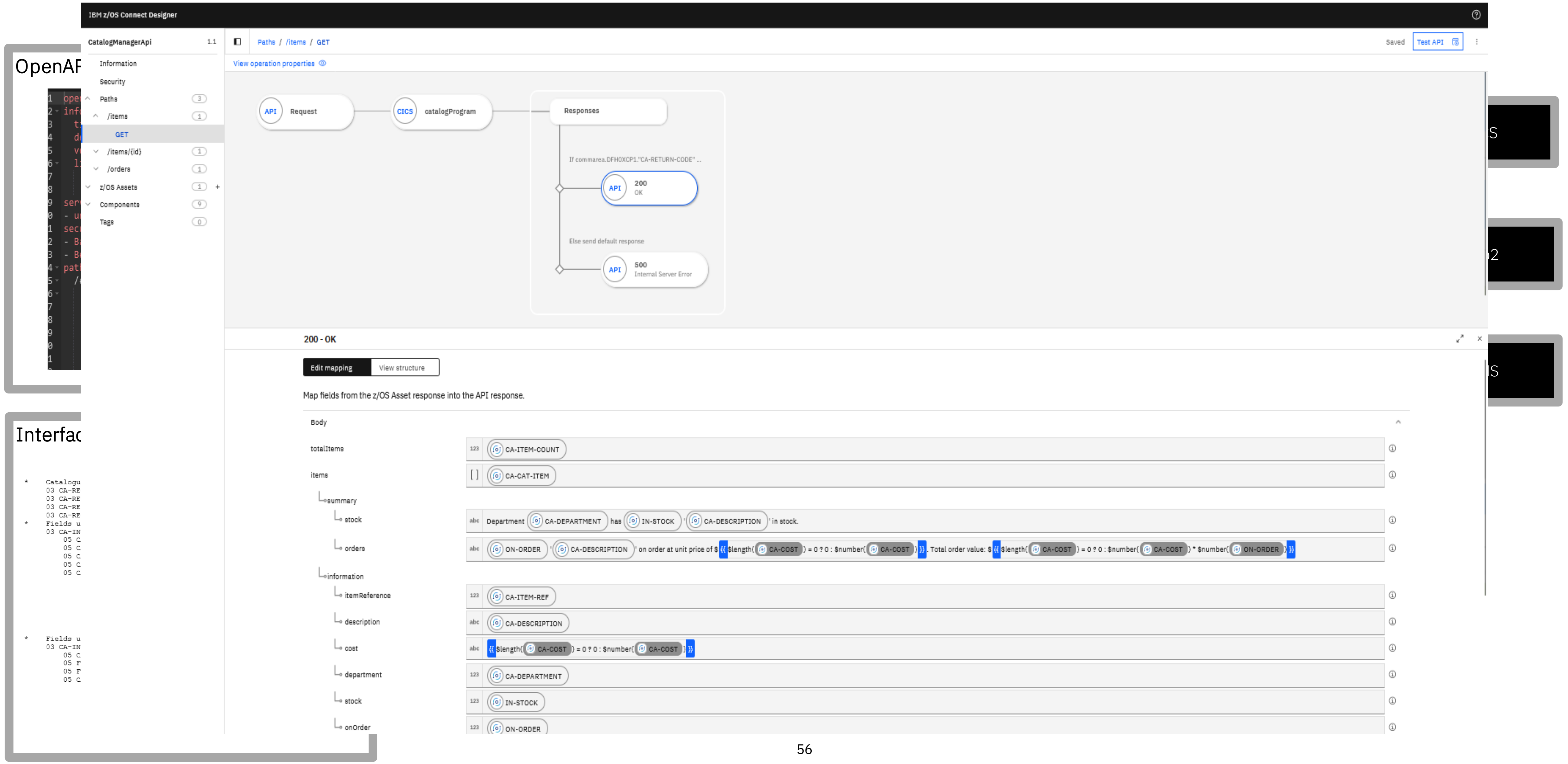
z/OS Connect API Creation for OAS 3.0


OpenAPI 3.0 Document
Interface Copybook (for CICS and IMS)
REST Service (for Db2)
z/OS Connect Designer
Redhat OpenShift, Docker, or any OCI-compliant platform
CICS
Db2
IMS

```
openapi: 3.0.0
info:
  title: EmployeesApi
  description: Employee management API for Db2.
  version: "1.1"
  license:
    name: Apache-2.0
    url: https://opensource.org/licenses/Apache-2.0
servers:
- url: /
security:
- BasicAuth: []
- BearerAuth: []
paths:
  /employees/{id}:
    get:
      tags:
      - Edit
      - Discover
      summary: Get an employee
      description: Uses the getEmployee Db2 z/OS asset
```

```
*    Catalogue COMMAREA structure
     03 CA-REQUEST-ID            PIC X(6).
     03 CA-RETURN-CODE           PIC 9(2).
     03 CA-RESPONSE-MESSAGE      PIC X(79).
     03 CA-REQUEST-SPECIFIC      PIC X(911).
*    Fields used in Inquire Catalog
     03 CA-INQUIRE-REQUEST REDEFINES CA-REQUEST-SPECIFIC.
         05 CA-LIST-START-REF        PIC 9(4).
         05 CA-LAST-ITEM-REF         PIC 9(4).
         05 CA-ITEM-COUNT            PIC 9(3).
         05 CA-INQUIRY-RESPONSE-DATA PIC X(900).
         05 CA-CAT-ITEM  REDEFINES CA-INQUIRY-RESPONSE-DATA
                         OCCURS 15 TIMES.
             07 CA-ITEM-REF          PIC 9(4).
             07 CA-DESCRIPTION       PIC X(40).
             07 CA-DEPARTMENT        PIC 9(3).
             07 CA-COST              PIC X(6).
             07 IN-STOCK             PIC 9(4).
             07 ON-ORDER             PIC 9(3).
*    Fields used in Inquire Single
     03 CA-INQUIRE-SINGLE REDEFINES CA-REQUEST-SPECIFIC.
         05 CA-ITEM-REF-REQ          PIC 9(4).
         05 FILLER                   PIC 9(4).
         05 FILLER                   PIC 9(3).
         05 CA-SINGLE-ITEM.
             07 CA-SNGL-ITEM-REF     PIC 9(4).
             07 CA-SNGL-DESCRIPTION  PIC X(40).
             07 CA-SNGL-DEPARTMENT   PIC 9(3).
```

z/OS Connect API Creation for OAS 3.0 - mapping



CatalogManagerApi 1.1

- Information
- Security
- Paths (3)
  - /items (1)
    - GET
  - /items/{id} (1)
  - /orders (1)
- z/OS Assets (1)
- Components (9)
- Tags (0)

Paths / /items / GET

View operation properties

If commarea.DFH0XCP1."CA-RETURN-CODE" ...

Else send default response

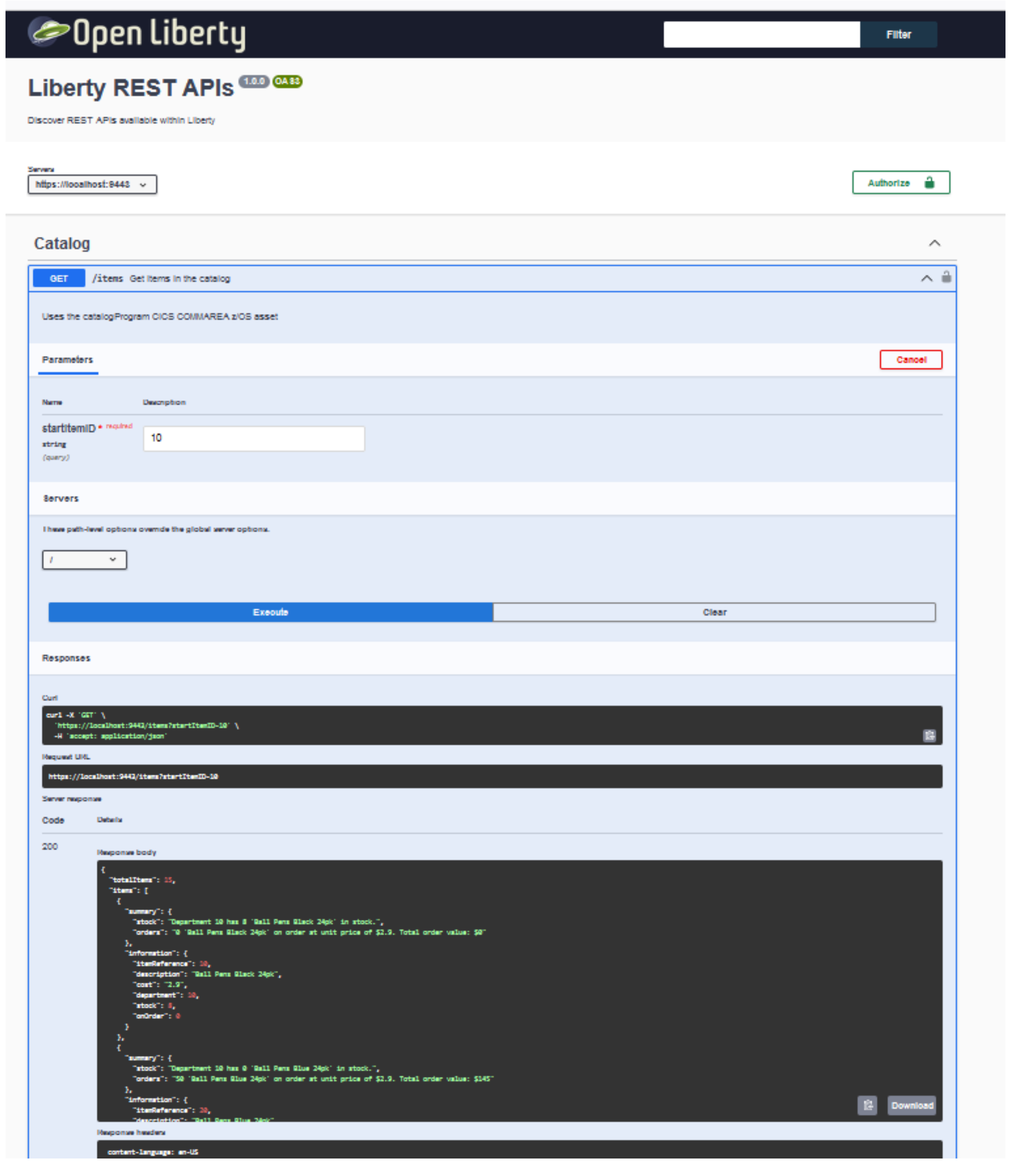
200 - OK

Map fields from the z/OS Asset response into the API response.

Body

totalItems	CA-ITEM-COUNT
items	CA-CAT-ITEM
summary	
stock	Department CA-DEPARTMENT has IN-STOCK ' CA-DESCRIPTION ' in stock.
orders	ON-ORDER ' CA-DESCRIPTION ' on order at unit price of $ {{ $length(CA-COST) = 0 ? 0 : $number(CA-COST) }}. Total order value: $ {{ $length(CA-COST) = 0 ? 0 : $number(CA-COST) * $number(ON-ORDER) }}
information	
itemReference	CA-ITEM-REF
description	CA-DESCRIPTION
cost	{{ $length(CA-COST) = 0 ? 0 : $number(CA-COST) }}
department	CA-DEPARTMENT
stock	IN-STOCK
onOrder	ON-ORDER

z/OS Connect API Creation for OAS 3.0 – unit testing



Open Liberty

Filter

Liberty REST APIs 1.0.0 OAS3

Discover REST APIs available within Liberty

Servers

https://localhost:9443

Authorize

Catalog

GET /items Get items in the catalog

Uses the catalogProgram CICS COMMAREA z/OS asset

Parameters

Cancel

Name	Description
startItemID * required string (query)	10

Servers

These path-level options override the global server options.

/

Execute

Clear

Responses

Curl

```
curl -X 'GET' \
  'https://localhost:9443/items?startItemID=10' \
  -H 'accept: application/json'
```

Request URL

```
https://localhost:9443/items?startItemID=10
```

Server response

Code Details

200

Response body

```
{
  "totalItems": 15,
  "items": [
    {
      "summary": {
        "stock": "Department 10 has 8 'Ball Pens Black 24pk' in stock.",
        "orders": "0 'Ball Pens Black 24pk' on order at unit price of $2.9. Total order value: $0"
      },
      "information": {
        "itemReference": 10,
        "description": "Ball Pens Black 24pk",
        "cost": "2.9",
        "department": 10,
        "stock": 8,
        "onOrder": 0
      }
    },
    {
      "summary": {
        "stock": "Department 10 has 0 'Ball Pens Blue 24pk' in stock.",
        "orders": "50 'Ball Pens Blue 24pk' on order at unit price of $2.9. Total order value: $145"
      },
      "information": {
        "itemReference": 20,
        "description": "Ball Pens Blue 24pk"
```

Download

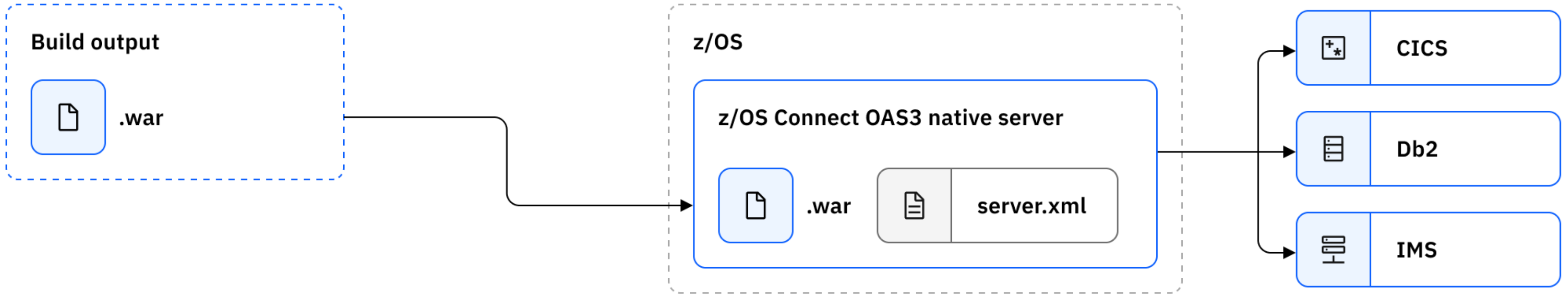
Response headers

```
content-language: en-US
```

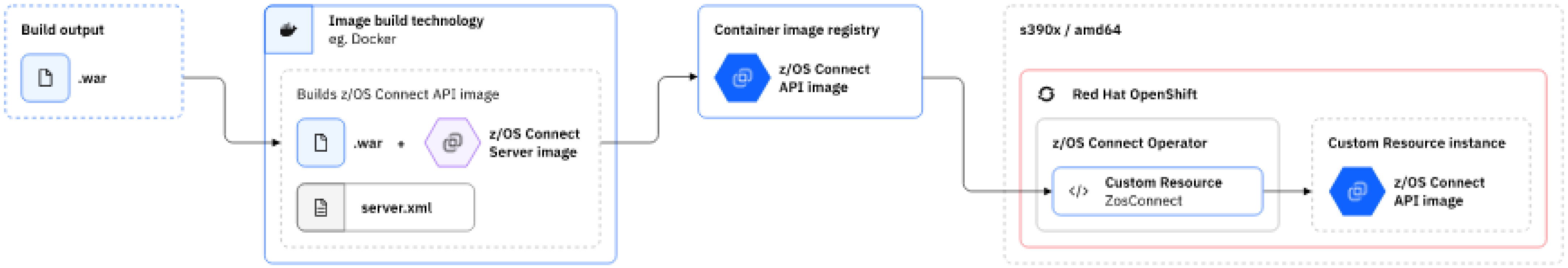
[z/OS Connect Education Channel](https://mediacenter.ibm.com/playlist/dedicated/1_ykaqj9pe/1_ldh1byk5)

- Contains a series of tutorial videos on how to use the z/OS Connect API Designer
- https://mediacenter.ibm.com/playlist/dedicated/1_ykaqj9pe/1_ldh1byk5

z/OS Connect Server Architecture



Native Server



Containerized Server

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

API Creation – Open API 2.0 vs 3.0

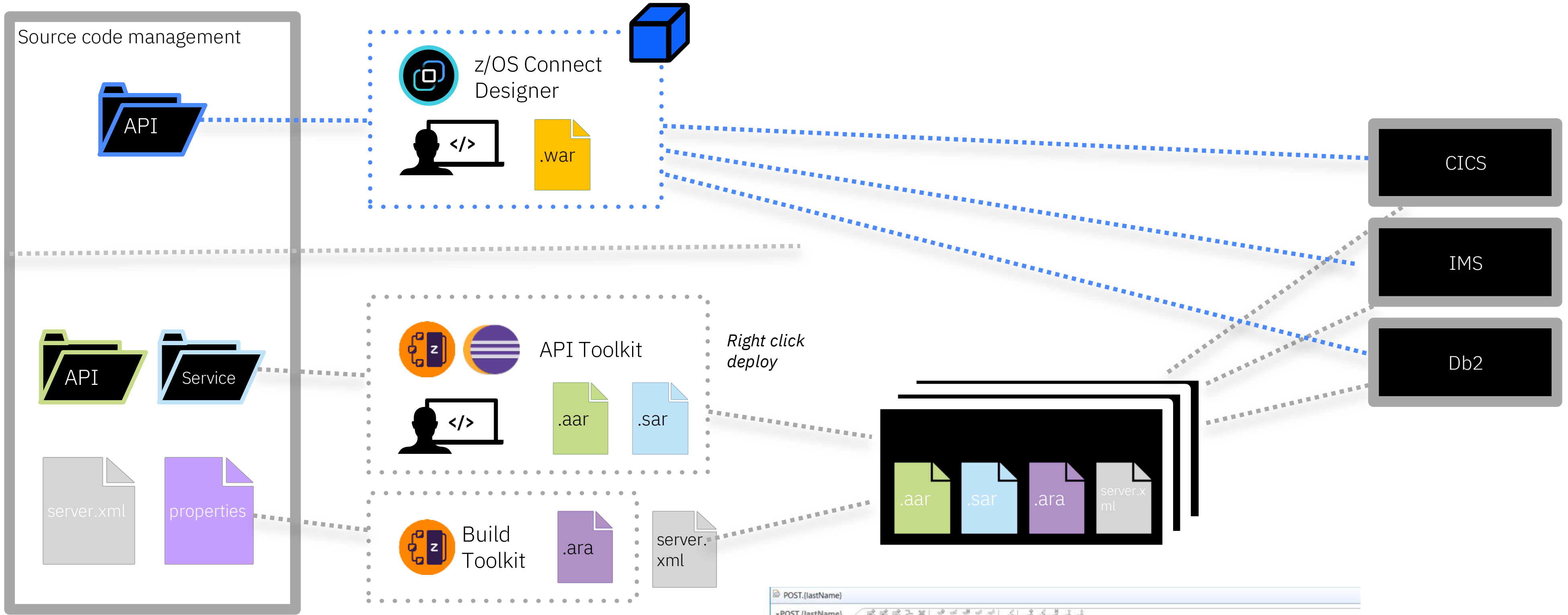
<u>OpenAPI 3.0</u>

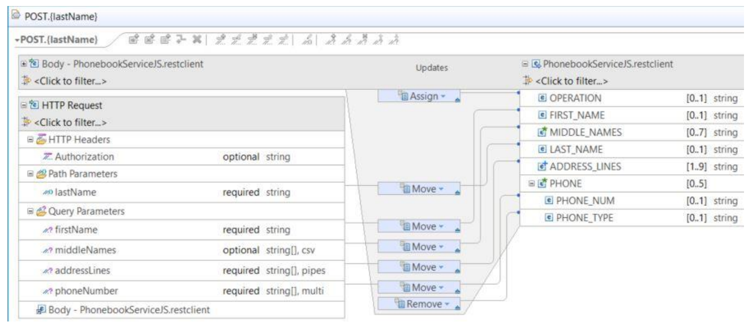
- Use the web-based designer
- Designer runs in a container, so no need for a development server to test
- As of today, only support for Db2 and CICS in bound

<u>OpenAPI 2.0</u>

- Use Eclipse based API toolkit

z/OS Connect 2.0 APIs must run in separate servers from the z/OS Connect 3.0 APIs.





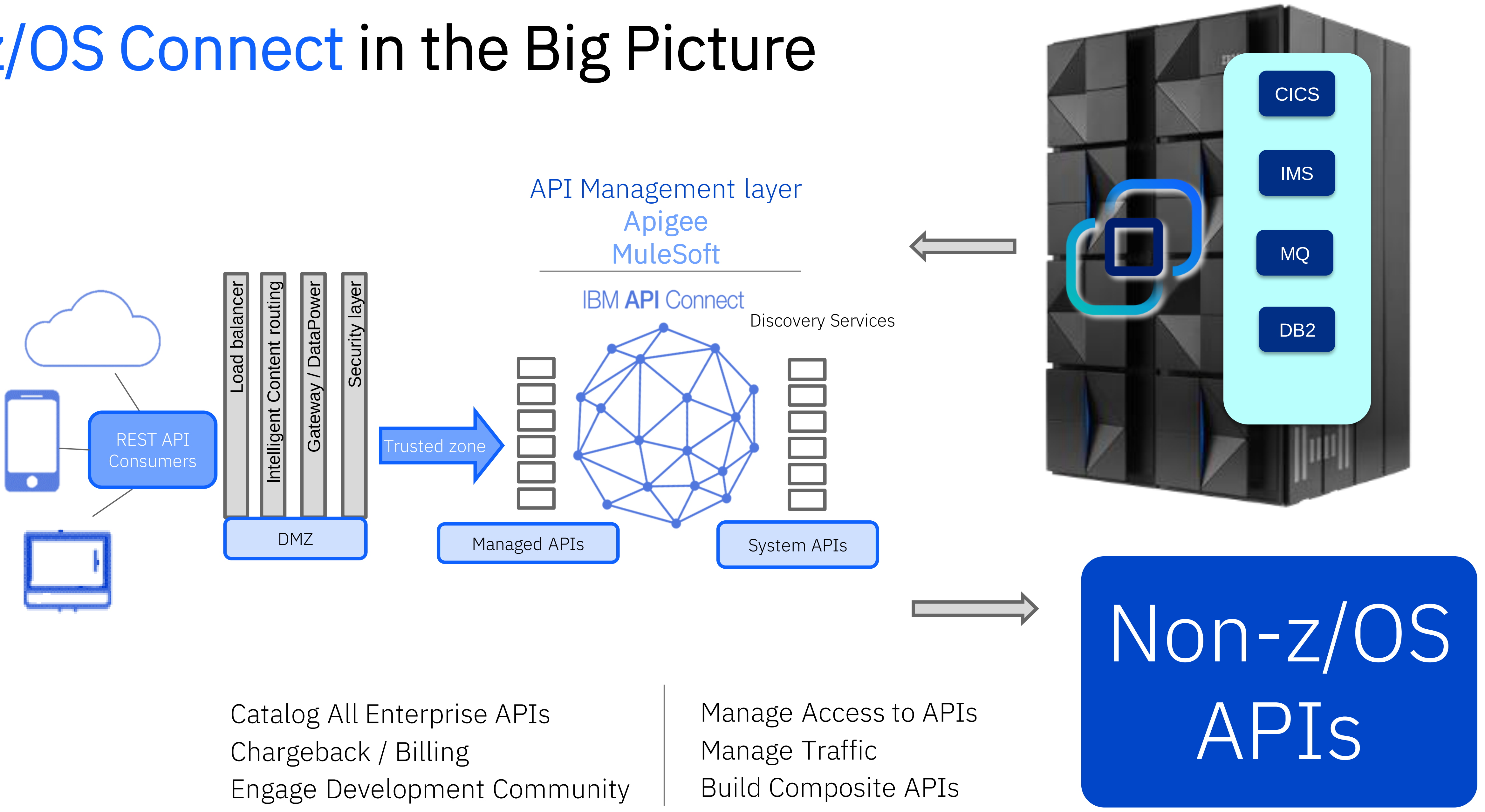
Body - PhonebookServiceJS.restclient
<Click to filter...>

HTTP Request		
<Click to filter...>		
HTTP Headers		
Authorization	optional	string
Path Parameters		
lastName	required	string
Query Parameters		
firstName	required	string
middleNames	optional	string[], csv
addressLines	required	string[], pipes
phoneNumber	required	string[], multi
Body - PhonebookServiceJS.restclient		

PhonebookServiceJS.restclient
<Click to filter...>

OPERATION	[0..1]	string
FIRST_NAME	[0..1]	string
MIDDLE_NAMES	[0..7]	string
LAST_NAME	[0..1]	string
ADDRESS_LINES	[1..9]	string
PHONE	[0..5]	
PHONE_NUM	[0..1]	string
PHONE_TYPE	[0..1]	string

z/OS Connect in the Big Picture

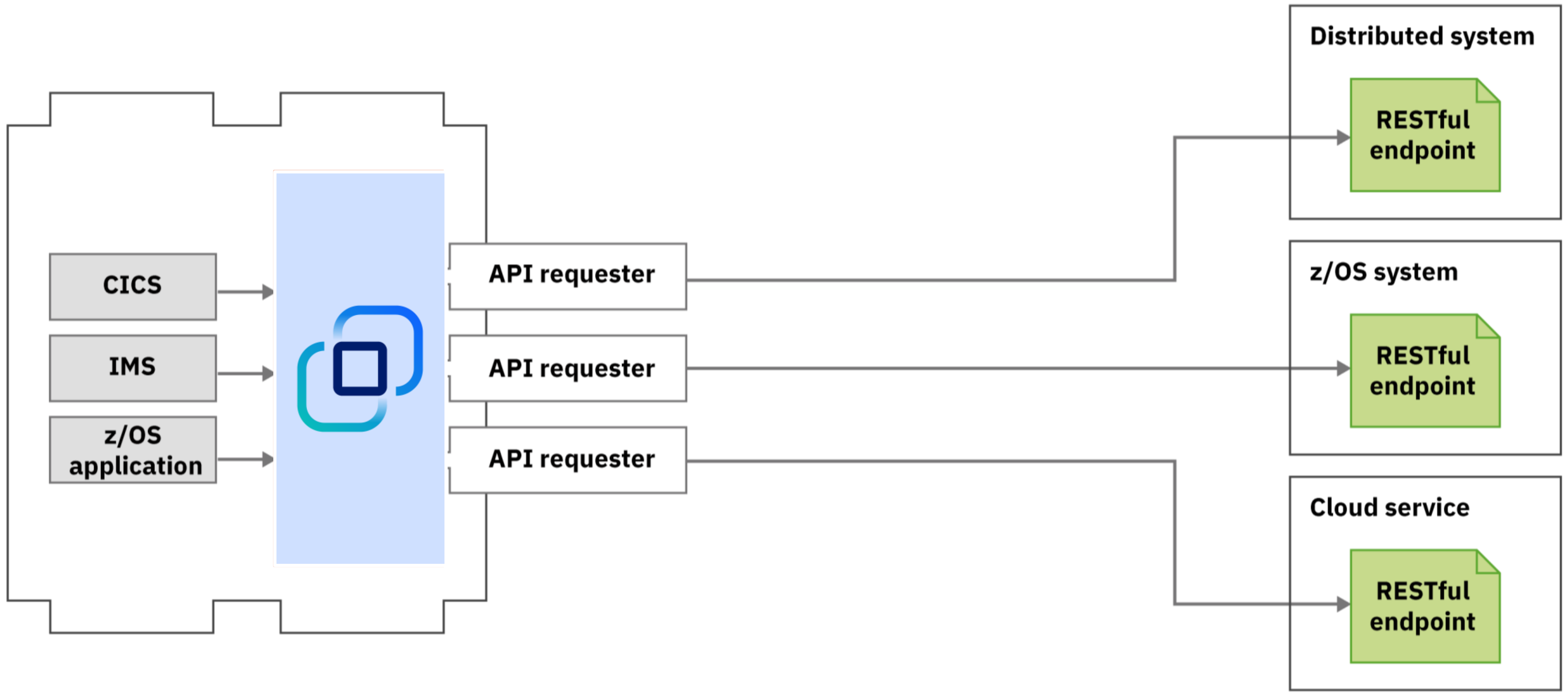


Catalog All Enterprise APIs
Chargeback / Billing
Engage Development Community

Manage Access to APIs
Manage Traffic
Build Composite APIs

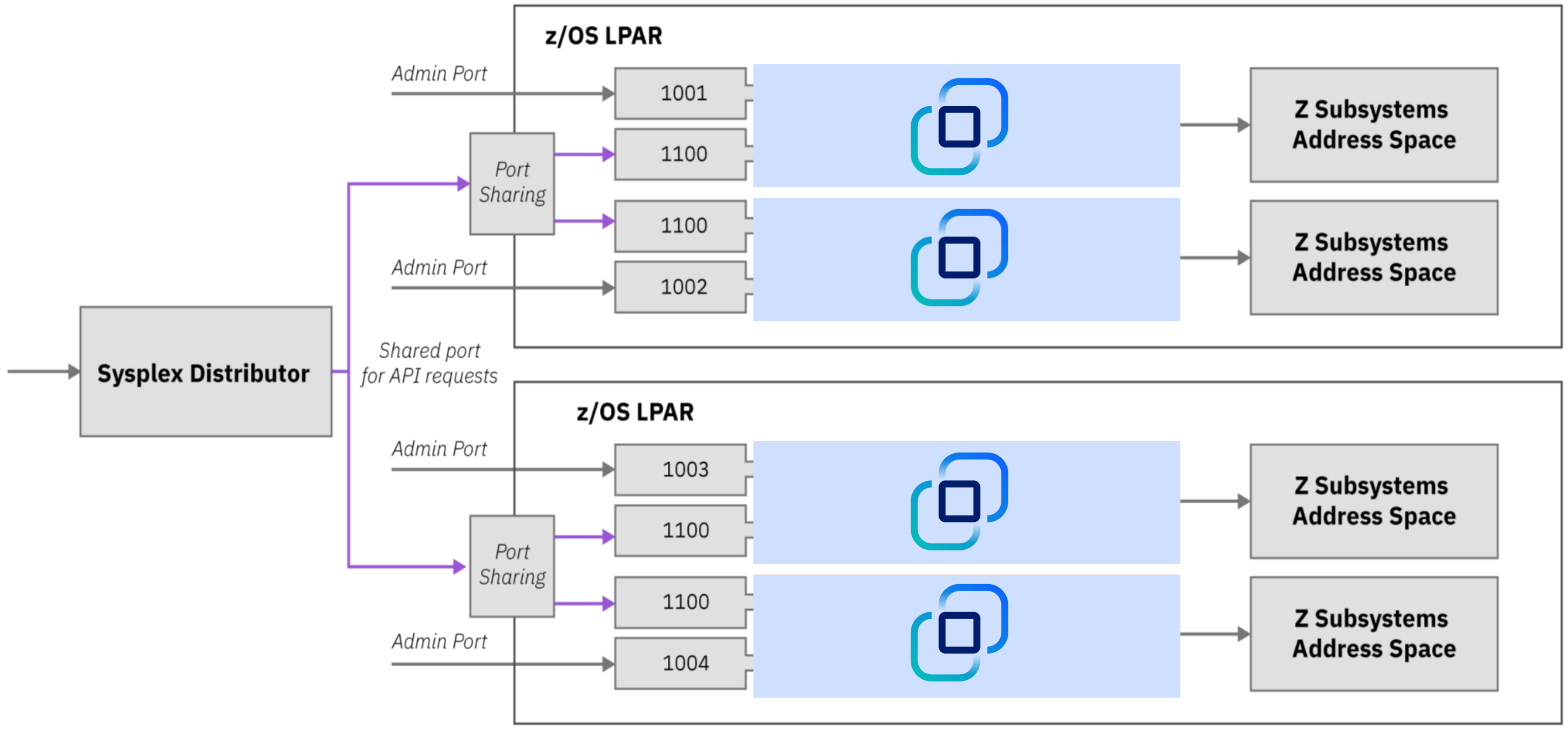
z/OS Connect API Requester

Mainframe applications can easily invoke RESTful APIs



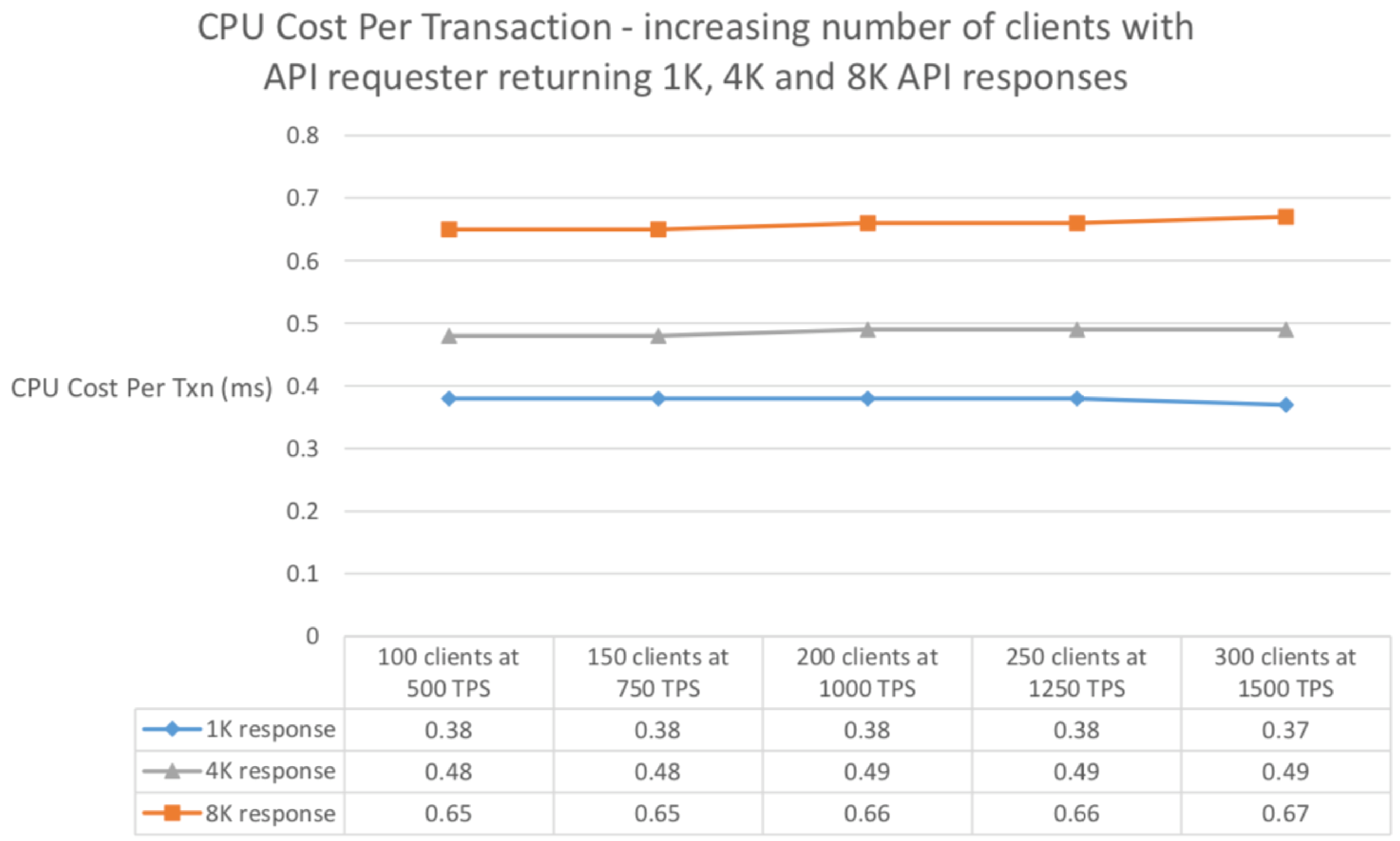
https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=gst-creating-cics-cobol-zos-connect-api-requester-application

z/OS Connect in High Availability Topology



ibm.biz/zosconnect-ha-concepts   ibm.biz/zosconnect-scenarios

Performance: z/OS Connect scales with increased volumes

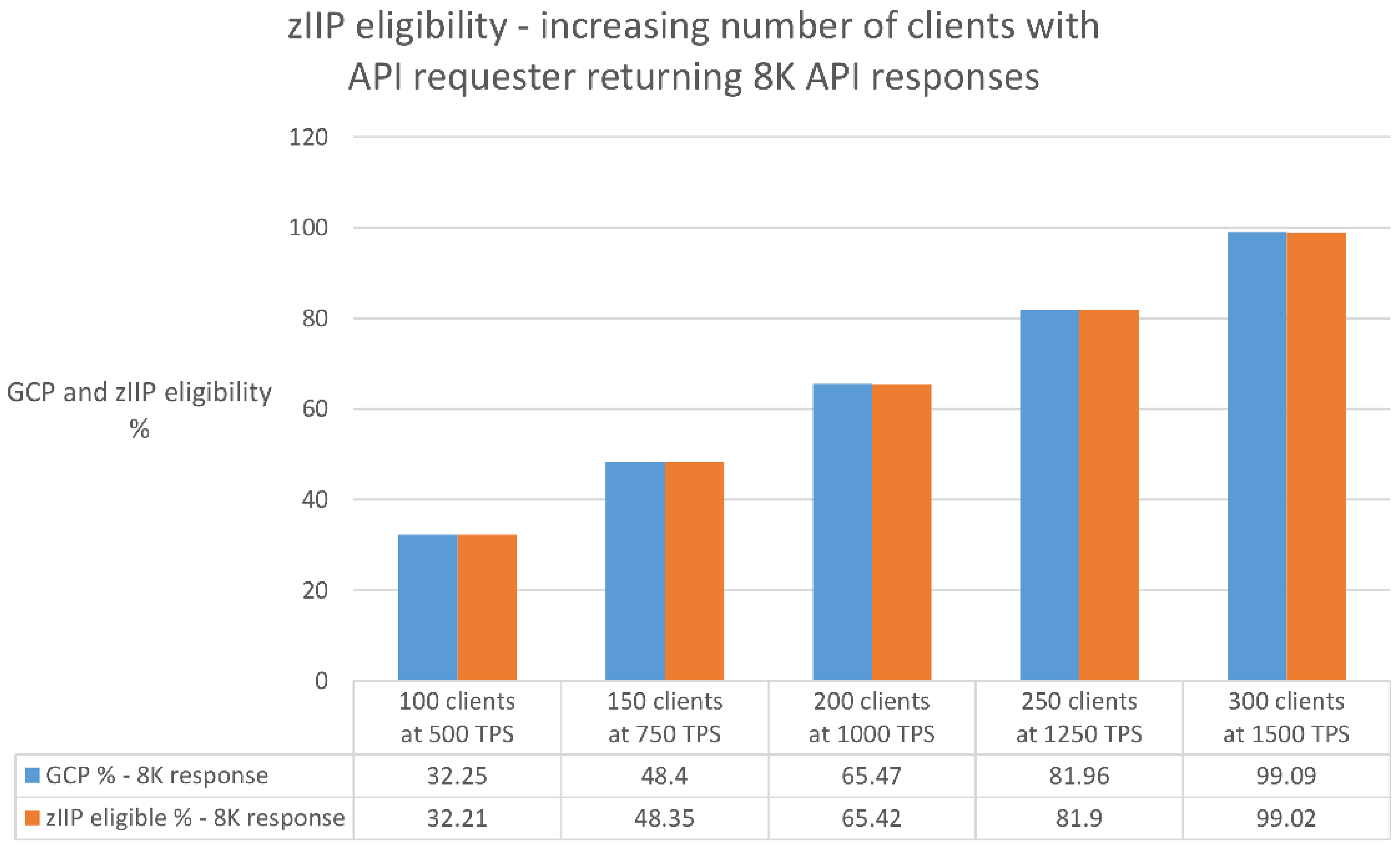


	100 clients at 500 TPS	150 clients at 750 TPS	200 clients at 1000 TPS	250 clients at 1250 TPS	300 clients at 1500 TPS
◆ 1K response	0.38	0.38	0.38	0.38	0.37
▲ 4K response	0.48	0.48	0.49	0.49	0.49
■ 8K response	0.65	0.65	0.66	0.66	0.67

ibm.biz/zosconnect-performance-report

Performance: zIIP Eligibility

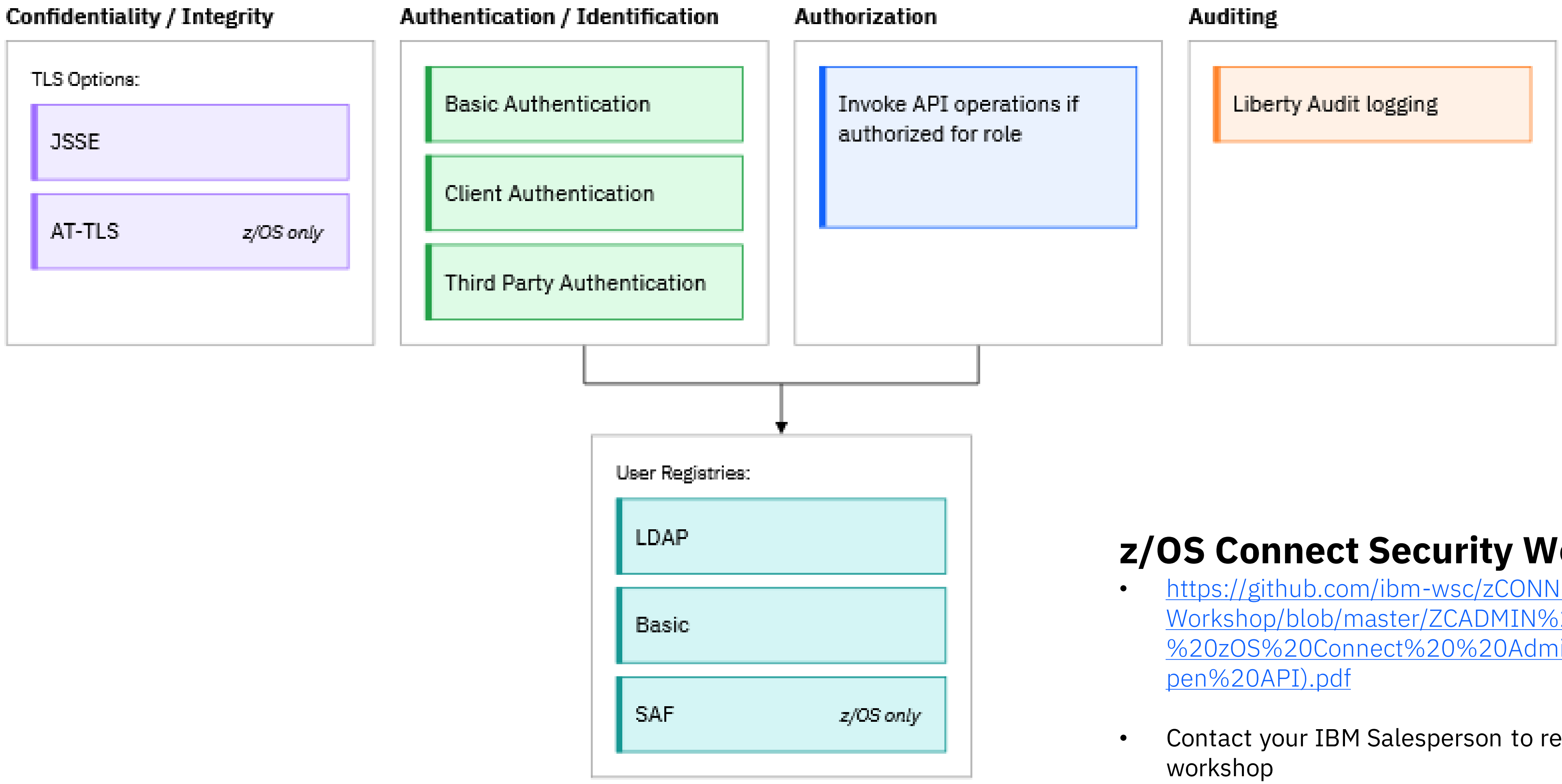
99% zIIP eligible



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

ibm.biz/zosconnect-performance-report

Security: High level options available in z/OS Connect get new screen shot from doc



z/OS Connect Security Workshop

- https://github.com/ibm-wsc/zCONNEE-Wildfire-Workshop/blob/master/ZCADMIN%20-%20zOS%20Connect%20%20Administration%20(Open%20API).pdf
- Contact your IBM Salesperson to request this workshop

https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=securing-zos-connect-resources

Db2 REST & z/OS Connect

Perfectly paired

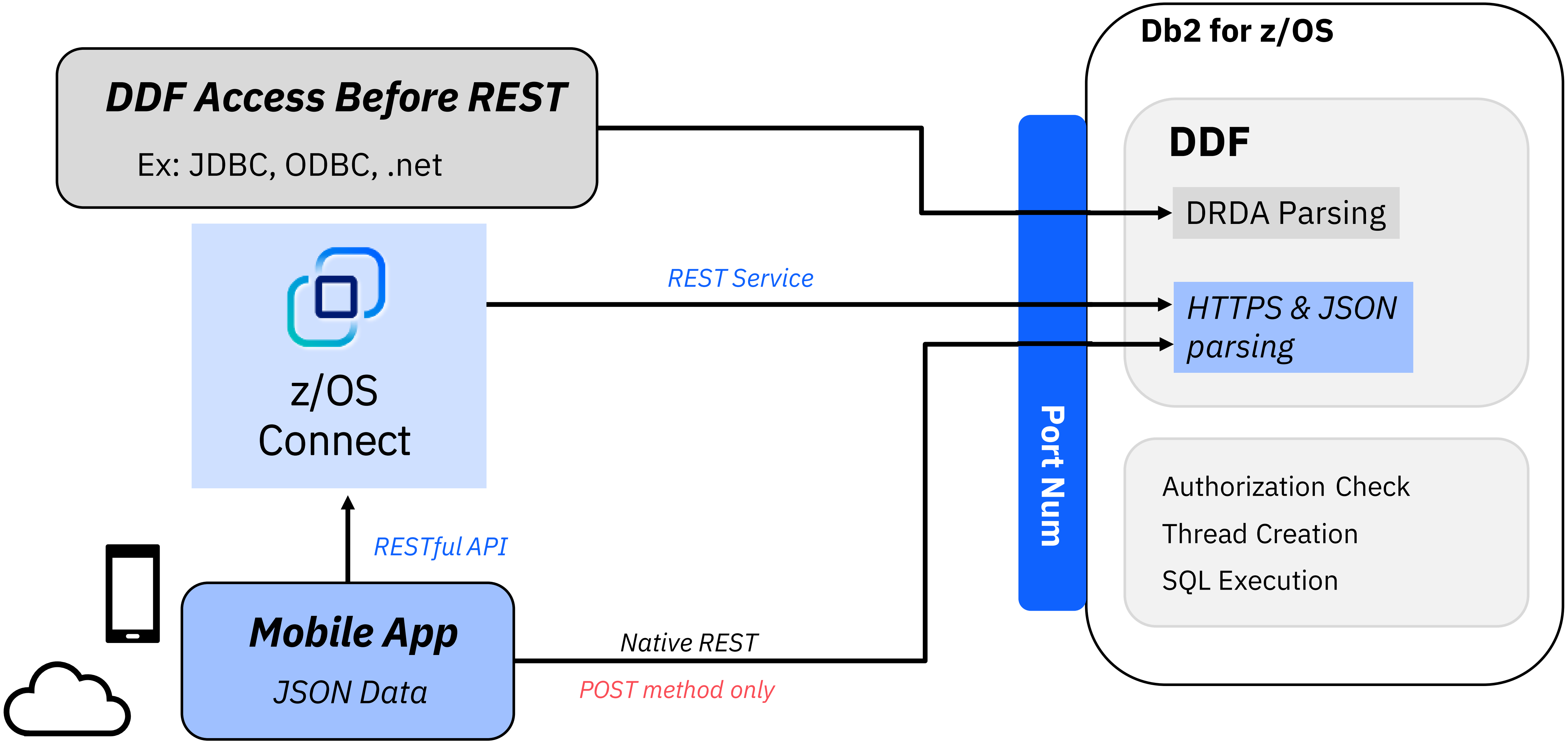
Db2 REST Services with z/OS Connect

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's "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 with 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

Let’s review!

Mobile Trends & the API Economy

RESTful APIs Overview

Db2 for z/OS REST Services

Versioning Db2 REST Services

---

z/OS Connect Overview
- Service & deployment process, data mapping, and performance

Db2 REST & z/OS Connect

z/OS Connect provides a single point of entry to z/OS resources (including Db2), allowing them to be exposed via RESTful APIs

z/OS Connect extends the value of Db2 Native REST, standardizing the interface for distributed developers, and adding additional security

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:

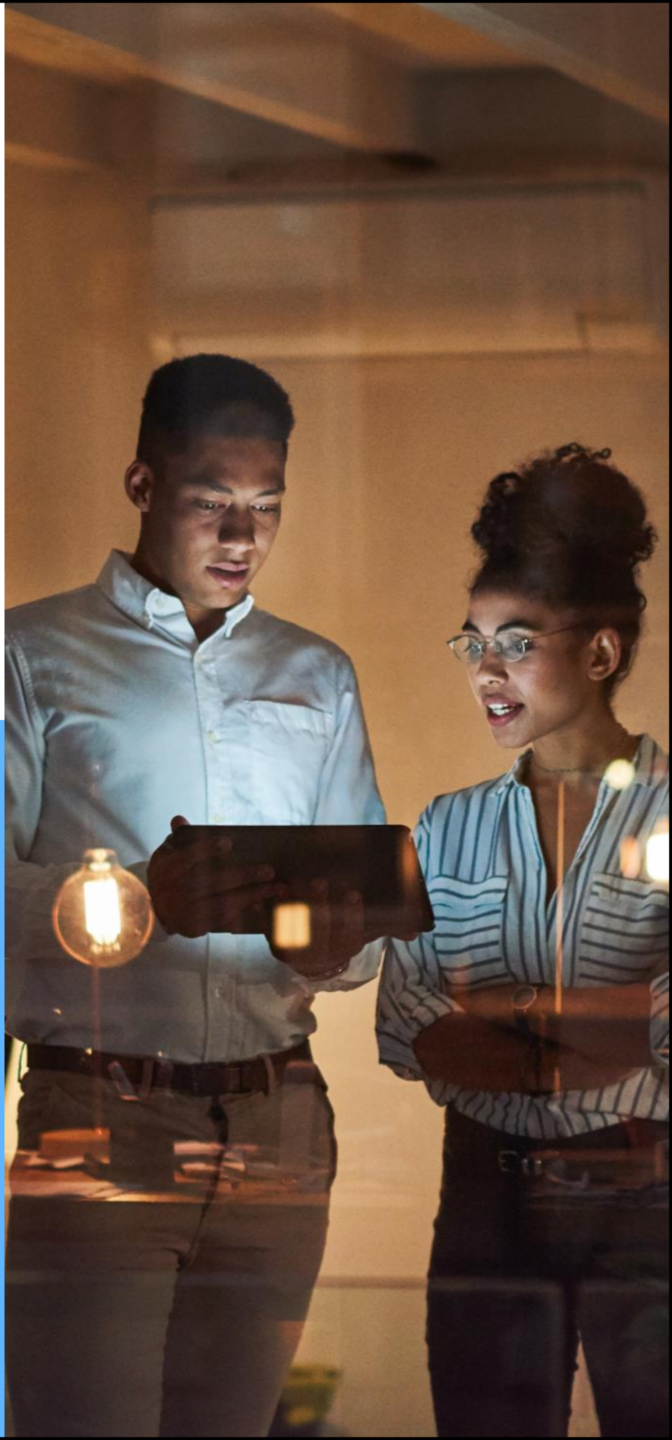
The manufacturer needed an easy access point to navigate around Db2 for z/OS.

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.

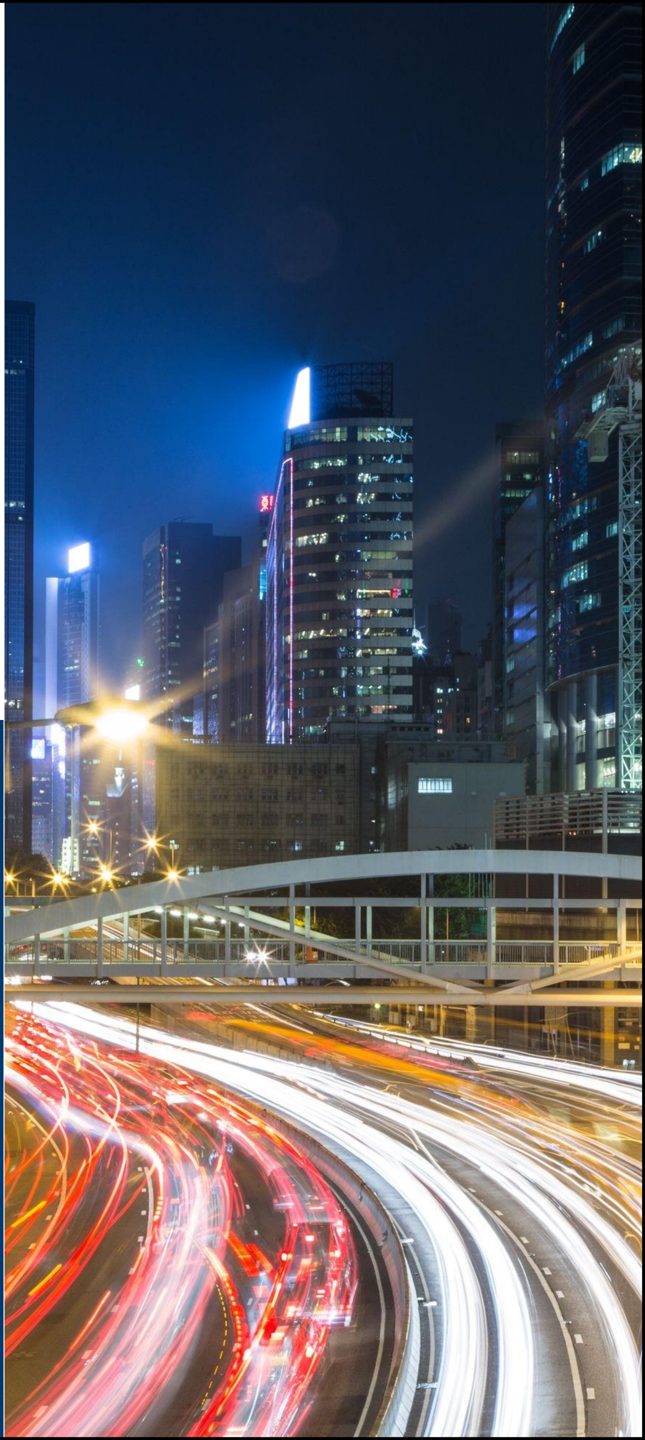
Our Solution:

IBM z/OS Connect generated REST APIs that could be easily called from applications on any platform.

Kubernetes®, microservices and z/OS Connect API enablement enabled unprecedented acceleration to create new user experiences owned by multiple groups within the enterprise.

Customer Benefit:

Leveraging on z/OS Connect'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 recourses 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 Security Wildfire Workshop**
- Db2 12 Technology Update Workshop
- Db2 13 for z/OS Technology Workshop for all Db2 13

➢ 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!

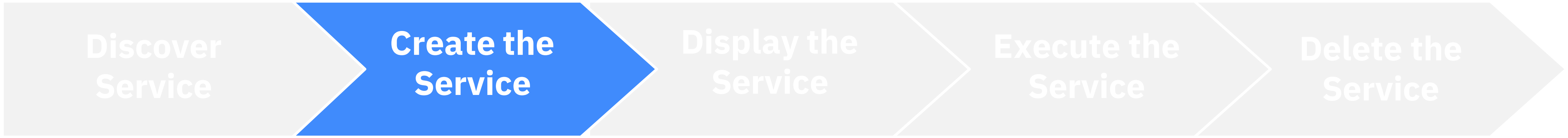
Before beginning, understand that everything you will be working with is mixed case sensitive.

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

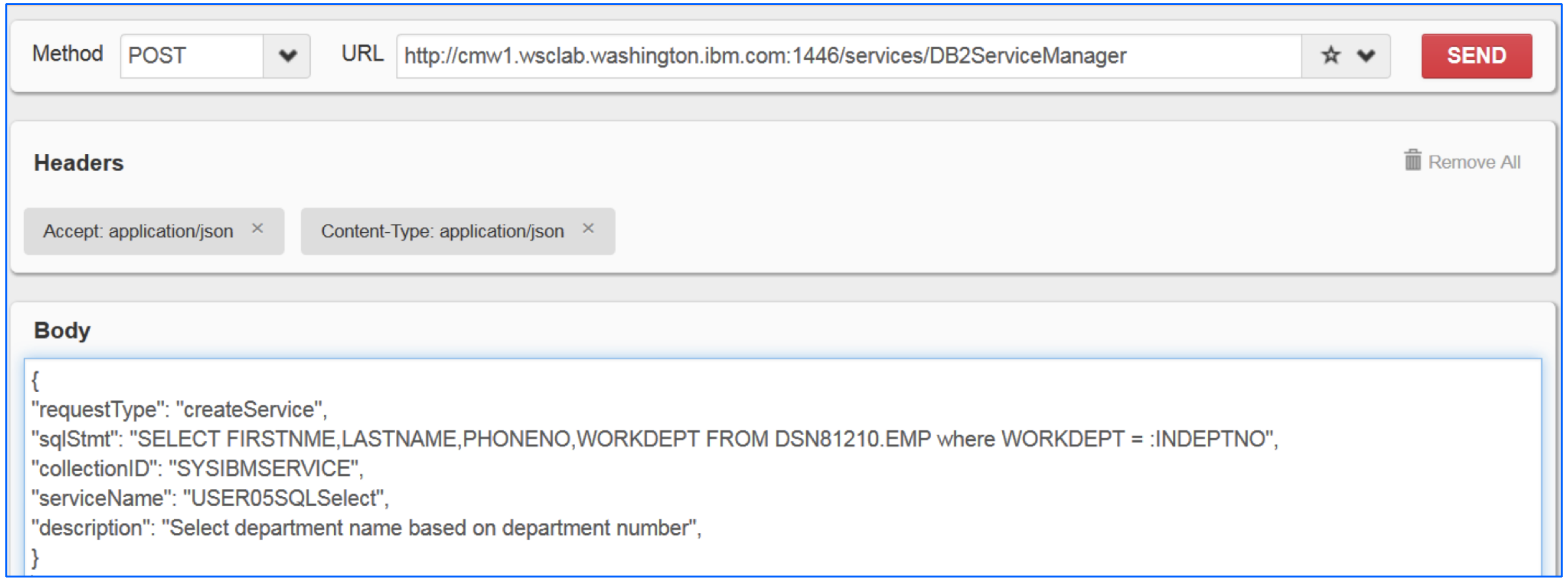
NativeREST <> NativeRESt <> NATIVEREST <> nativerest

Appendix

Db2 REST Service Progression



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



http://cmw1.wsclab.washington.ibm.com:1446/services/DB2ServiceManager

Accept: application/json

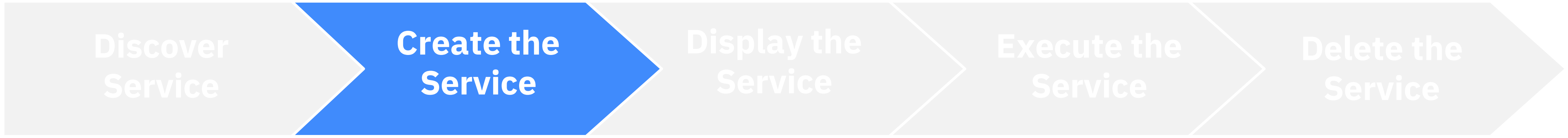
Content-Type: application/json

```
{
"requestType": "createService",
"sqlStmt": "SELECT FIRSTNME,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)**

<u>Db2 Stored Procedure CALL statement variables:</u>

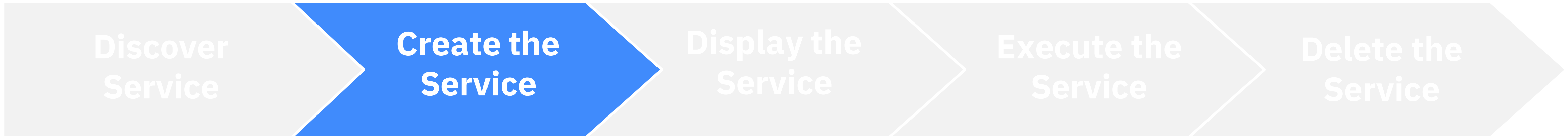
CALL USER01.USER01EMPL_DEPTS_NAT(?,?,?)

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

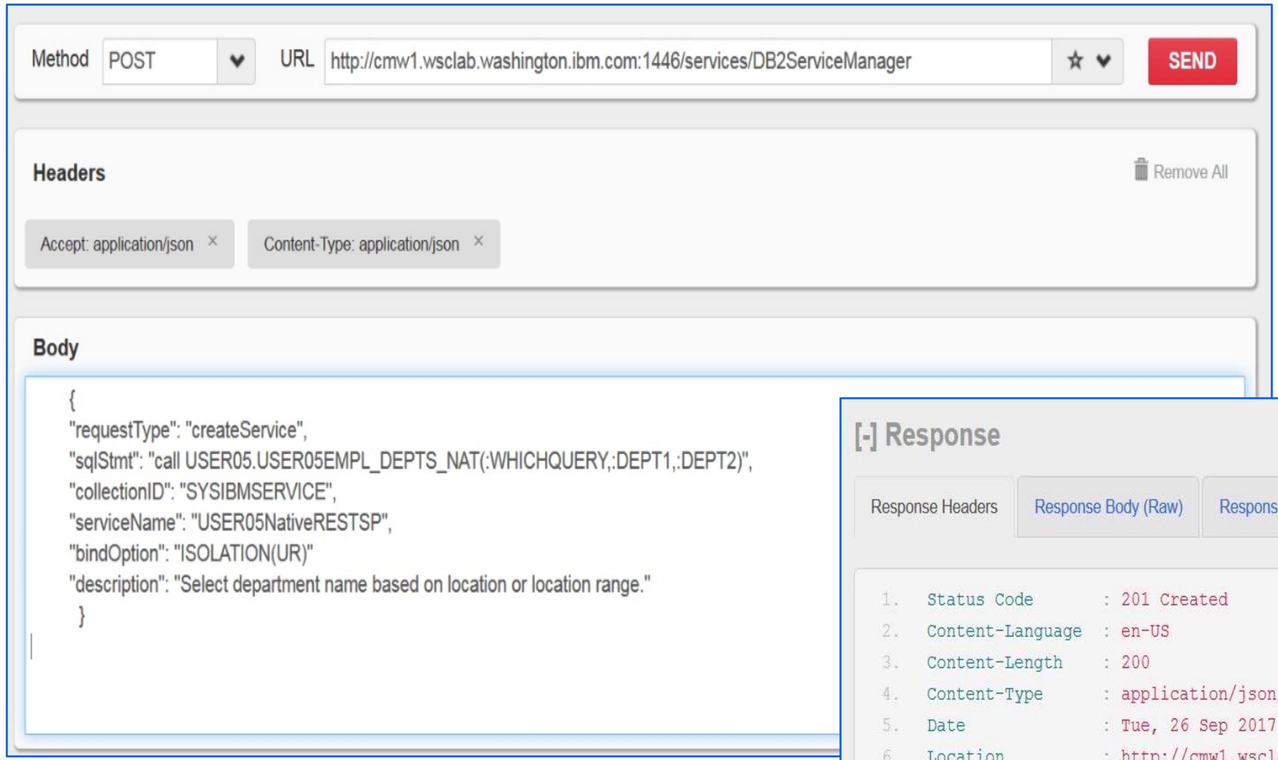
CALL USER01.USER01EMPL_DEPTS_NAT(:WHICHQUERY,:DEPT1,:DEPT2)

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

Db2 REST Service Progression



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



URL: http://cmw1.wsclab.washington.ibm.com:1446/services/DB2ServiceManager

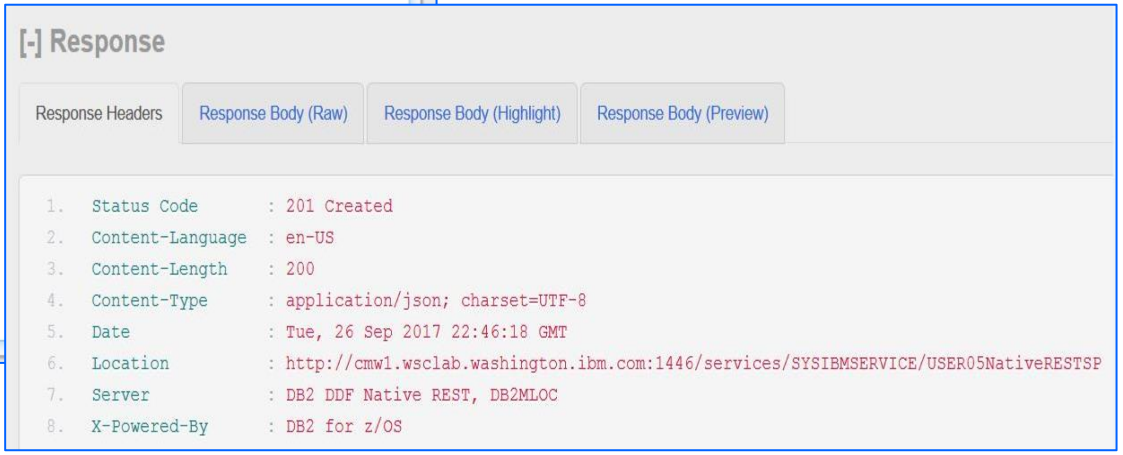
Accept: application/json

Content-Type: application/json

```
{
"requestType": "createService",
"sqlStmt": "call USER05.USER05EMPL_DEPTS_NAT(:WHICHQUERY,:DEPT1,:DEPT2)",
"collectionID": "SYSIBMSERVICE",
"serviceName": "USER05NativeRESTSP",
"bindOption": "ISOLATION(UR)"
"description": "Select department name based on location or location range."
 }
```

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

Default host variable name Px, where x = variable number

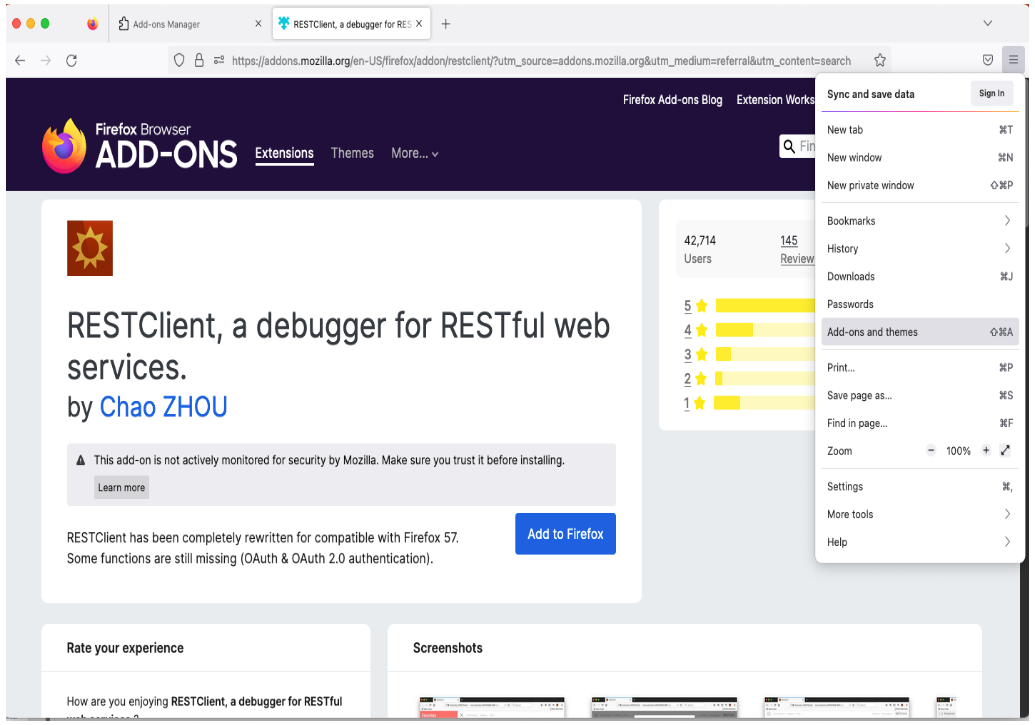


```
Status Code       : 201 Created
Content-Language  : en-US
Content-Length    : 200
Content-Type      : application/json; charset=UTF-8
Date              : Tue, 26 Sep 2017 22:46:18 GMT
Location          : http://cmw1.wsclab.washington.ibm.com:1446/services/SYSIBMSERVICE/USER05NativeRESTSP
Server            : DB2 DDF Native REST, DB2MLOC
X-Powered-By      : DB2 for z/OS
```

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:

Step 1



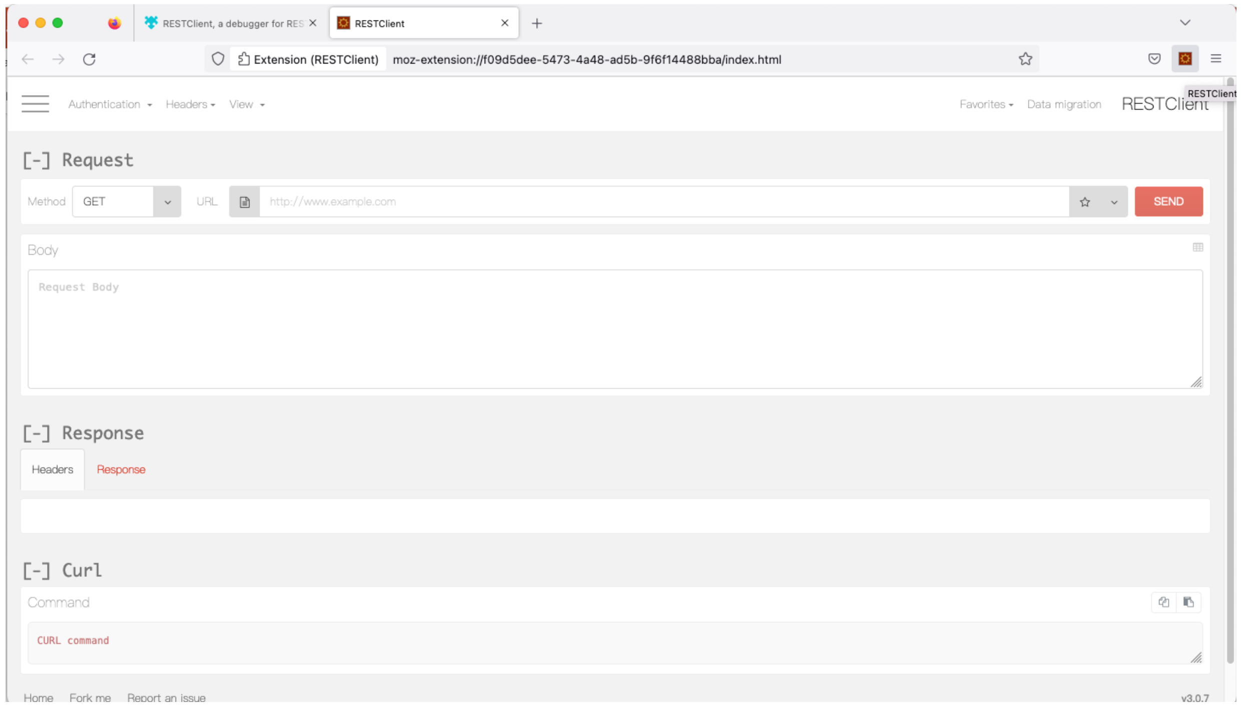
RESTClient, a debugger for RESTful web services.
by Chao ZHOU

This add-on is not actively monitored for security by Mozilla. Make sure you trust it before installing.

RESTClient has been completely rewritten for compatible with Firefox 57. Some functions are still missing (OAuth & OAuth 2.0 authentication).

How are you enjoying RESTClient, a debugger for RESTful web services?

Step 2



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#
```

If WHICHQUERY=1, SELECT one department only – DEPT1 is the department

If WHICHQUERY=2, SELECT multiple departments – from DEPT1 until DEPT2

Db2 REST - New catalog table created in installation job DSNTIJRS

The SYSIBM.DSNSERVICE table contains rows that describe Db2 REST services and their corresponding packages.
The following table describes the columns in table SYSIBM.DSNSERVICE:

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

Stateless

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.

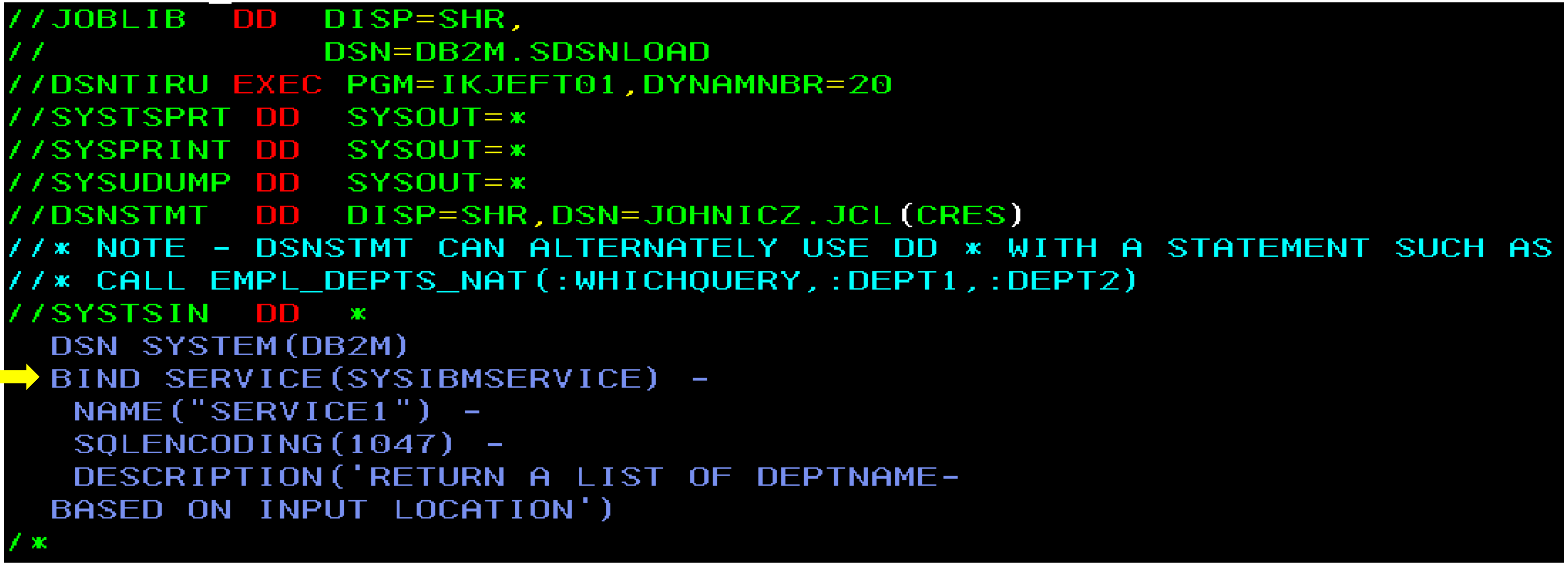
Types of Stored Procedures for Db2 REST

External stored procedures or native SQL procedures can be used.

- External stored procedures execute in a WLM-managed stored procedure address space
  - Under control of a TCB
  - Cross memory calls between stored procedure address space and DBM1
  - Languages include: Assembler, COBOL, PL/I, Java, C, C++, …

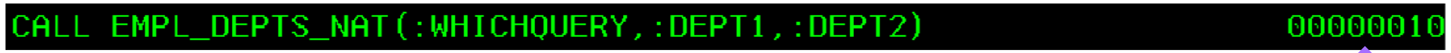
- Native SQL procedures execute in the DBM1 address space
  - Eligible to execute on a zIIP engine if distributed
  - No cross memory calls
  - Only SQL procedure language (SQLPL)

Traditional Db2 Interface Alternative for **CREATE**



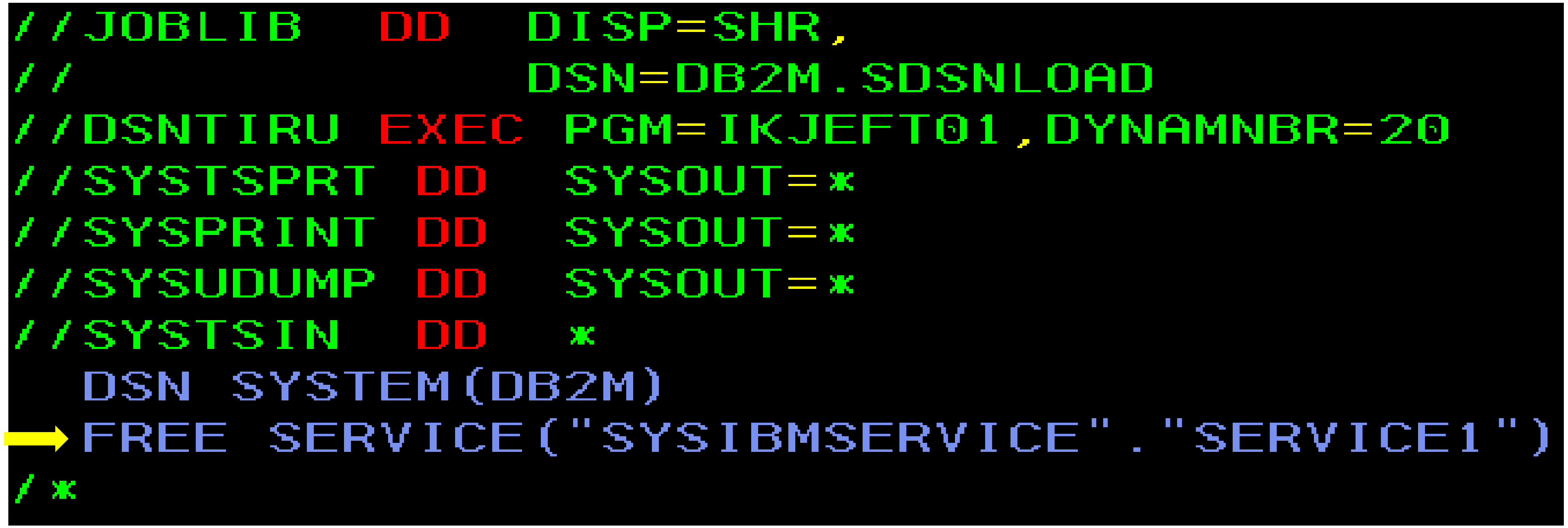
```
//JOBLIB   DD   DISP=SHR,
//              DSN=DB2M.SDSNLOAD
//DSNTIRU EXEC PGM=IKJEFT01,DYNAMNBR=20
//SYSTSPRT DD   SYSOUT=*
//SYSPRINT DD   SYSOUT=*
//SYSUDUMP DD   SYSOUT=*
//DSNSTMT  DD   DISP=SHR,DSN=JOHNICZ.JCL(CRES)
//* NOTE - DSNSTMT CAN ALTERNATELY USE DD * WITH A STATEMENT SUCH AS
//* CALL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

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



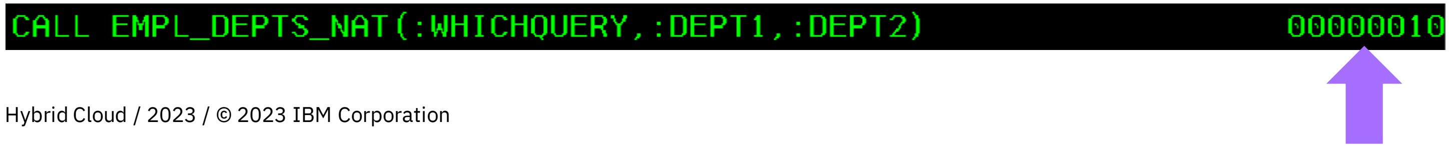
```
CALL EMPL_DEPTS_NAT(:WHICHQUERY,:DEPT1,:DEPT2)                  00000010
```

Traditional Db2 Interface Alternative for **FREE**



```
//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")
/*
```

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



```
CALL EMPL_DEPTS_NAT(:WHICHQUERY,:DEPT1,:DEPT2)                    00000010
```

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 zSystems APIs

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

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

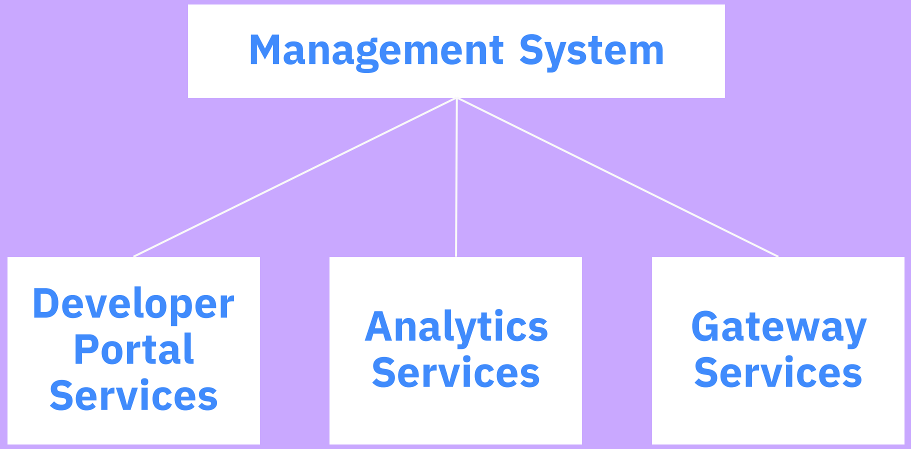
Delivers APIs as a discoverable resource using the OpenAPI specification (formerly Swagger)

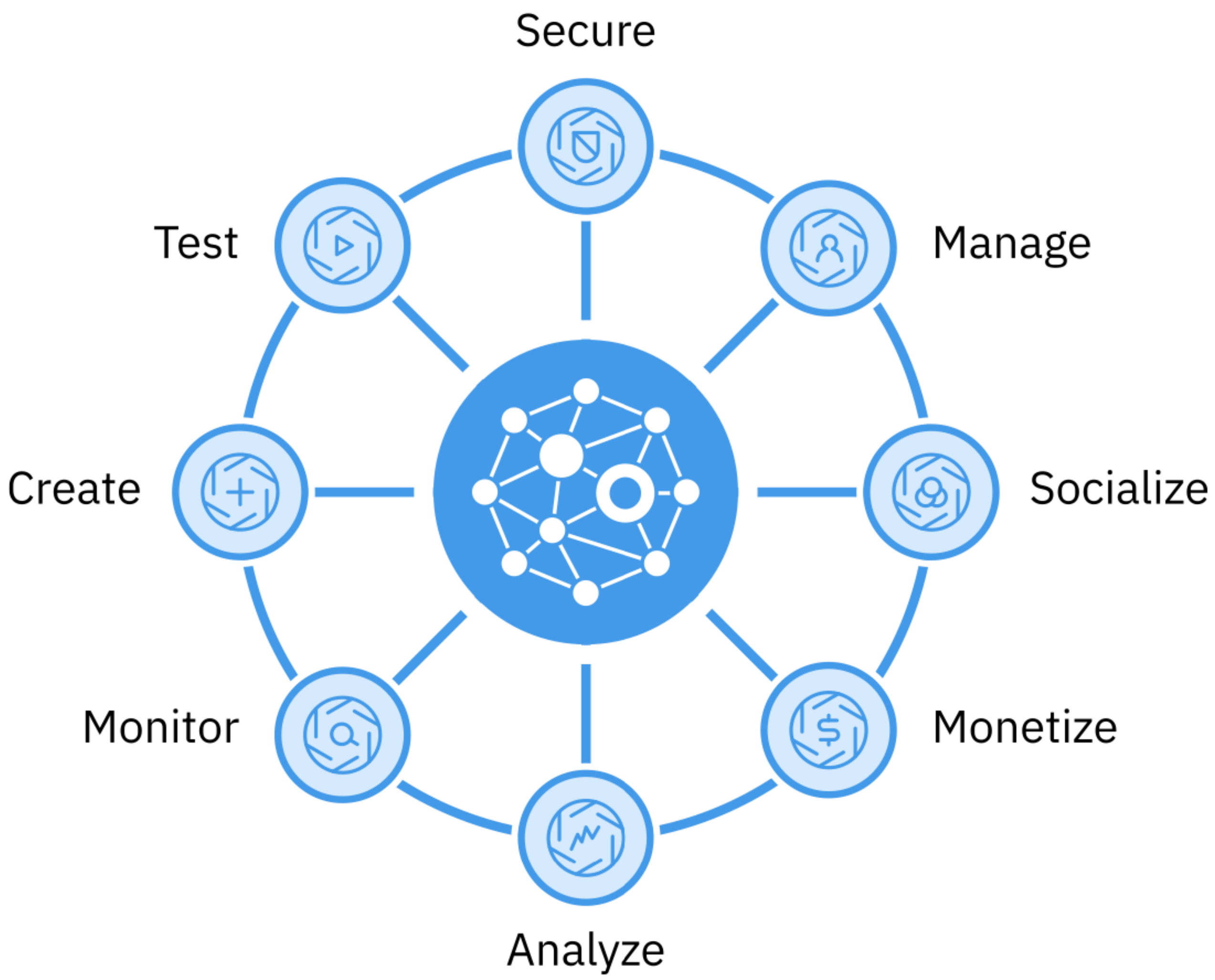
IBM API Connect

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 vs. Db2 Connect

z/OS Connect

- ✓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

- ✓Can contain 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 to support fintech startups

Speed
European Bank
Reduced API development time from 3 months to less than a day

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

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

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

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