Accessing REST APIs from z/OS using IBM z/OS Connect

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Agenda

- What is REST and what are REST APIs?
- Using an z/OS Connect API requester to access a REST API
- General API requester COBOL client programming considerations
- Developing API requesters for Swagger 2.0 2.0 REST APIs
- Developing API requesters for OpenAPI 3 REST APIs
- Configuration and Security considerations for API requesters

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Notes and Disclaimers

- There will be additional information on slides that will be designated as Tech/Tips. These contain information that hopefully will be useful to the reader.

- **IBM z/OS Connect (Swagger 2.0)** refers the z/OS Connect EE product prior to service level V3.0.55. **IBM z/OS Connect (OpenAPI 3)** refers to the additional functions and features added with service level V3.0.55. Important - servers configured for OpenAPI 2 can will continue to operate as is with service level V3.0.55 and later.

- A z/OS Connect Swagger 2.0, icon or a z/OS Connect OpenAPI icon will appear on slides where the information is specific to these products. Don't hesitate to ask questions as to why the icon does or does not appear on certain slides

- A Liberty icon will appear on slides where the information both products. Don't hesitate to ask questions as to why the icon does or does not appear on certain slides.

Note: For our purposes, the terms OpenAPI 2.0 and Swagger 2.0 are interchangeable.

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

Accessing z/OS resources with REST APIs using IBM z/OS Connect

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WebSphere Liberty Profile Administration

Managing WebSphere Liberty Profile servers for IBM z/OS Connect (OpenAPI 2 and OpenAPI 3), IBM MQ REST Console and zOSMF

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z/OS Connect OpenAPI 3

Designer and z/OS Native server Experiences and Observations

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

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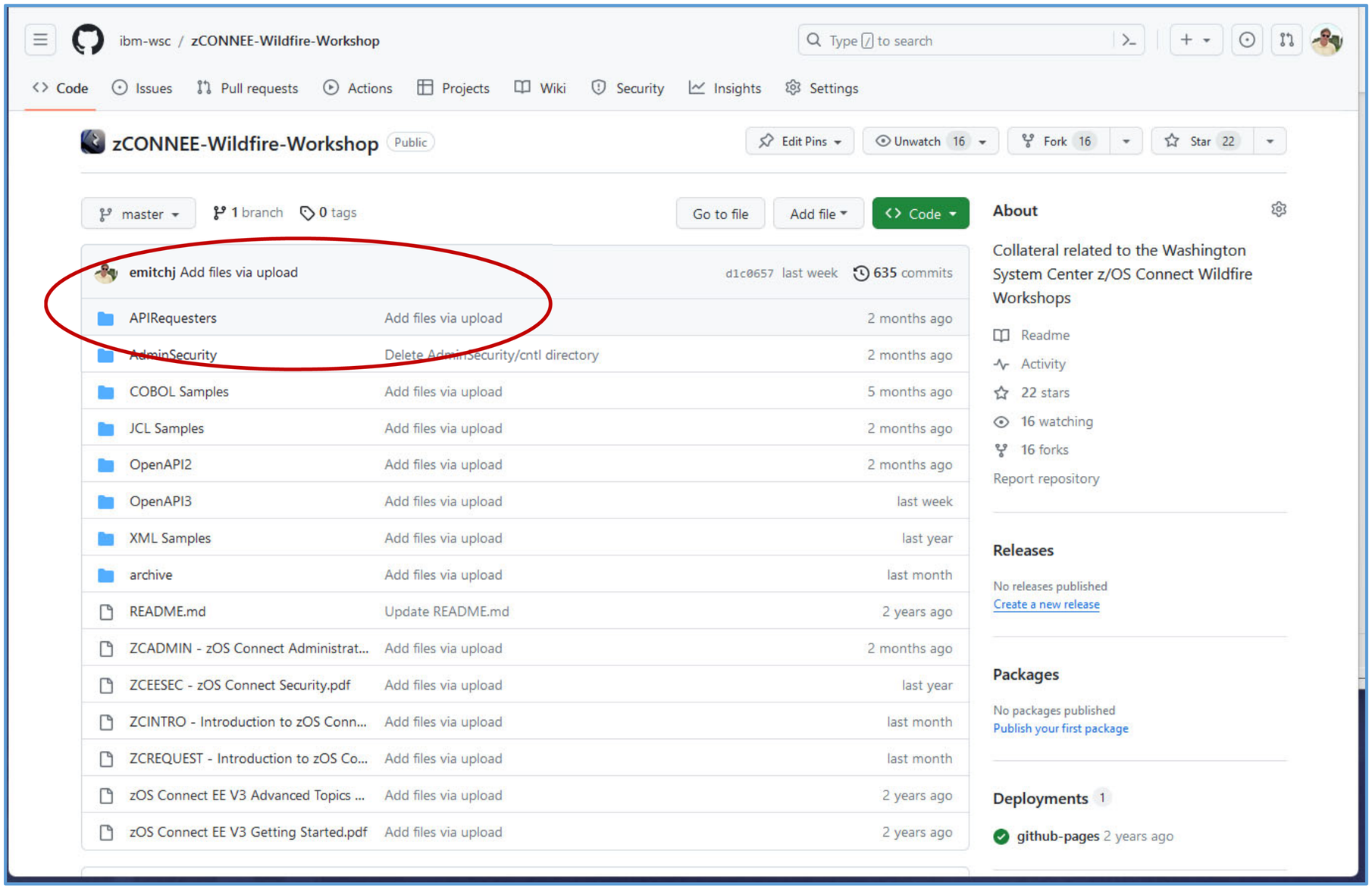
z/OS Connect Github Site

https://ibm.biz/zCEEWorkshopMaterial



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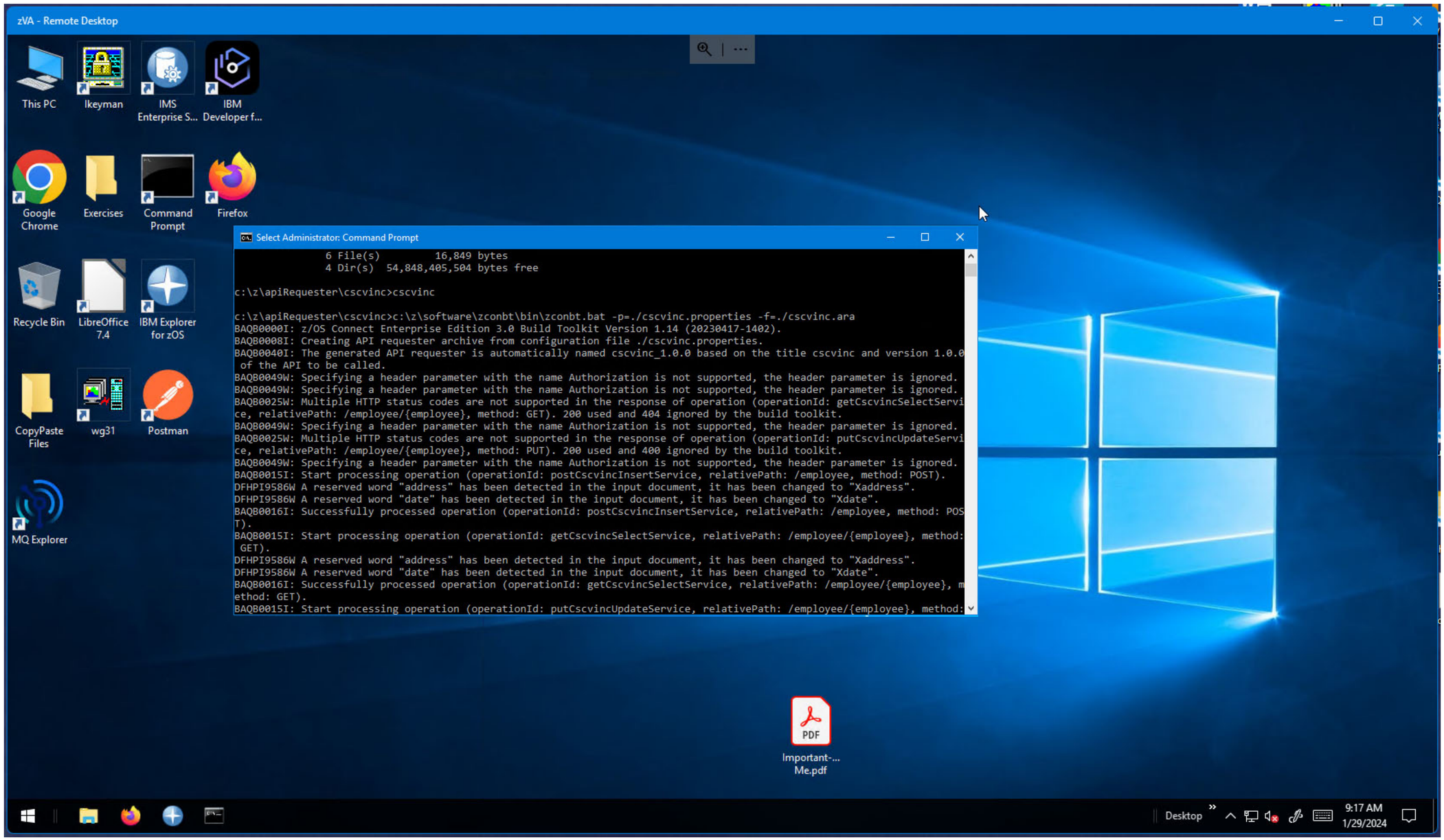
IBM’s Z Virtual Access (zVA) provides access to hand-on exercises



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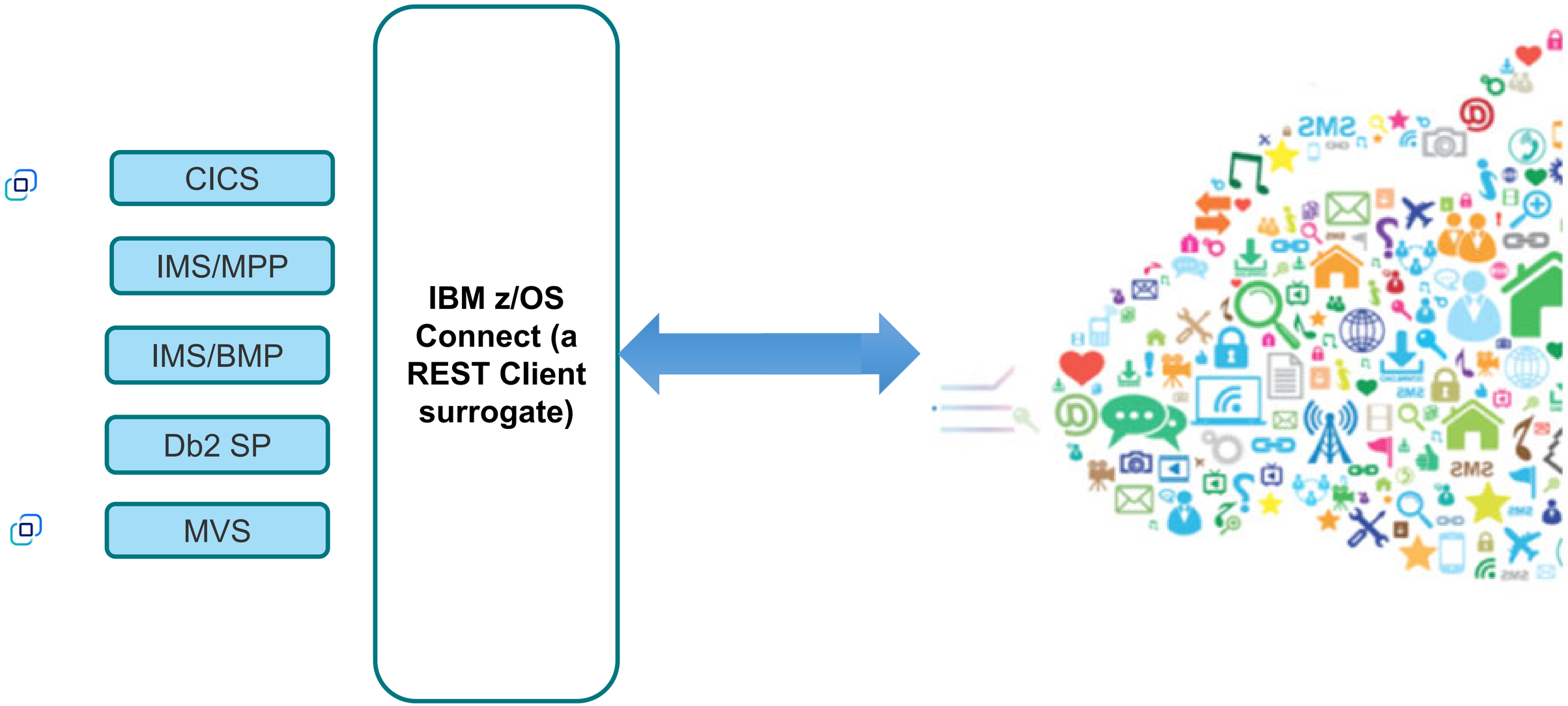
z/OS Connect “API requester support” exposes external REST APIs in the “cloud” to z/OS applications



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Note that z/OS Connect also supports accessing z/OS resources from clients in the “cloud” via RESTful APIs

IBM z/OS Connect (an API Gateway)

- CICS
- IMS/TM
- IMS/DB
- Db2
- MQ
- IBM File Manager+
- HATS(3270)
- IBM DVM+
- MVS
- WAS
- Custom*

+ HCL and Rocket Software
*Other Vendors or your own implementation

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Let’s start by defining REST

/what_is_REST?

And what makes an API “RESTful”?

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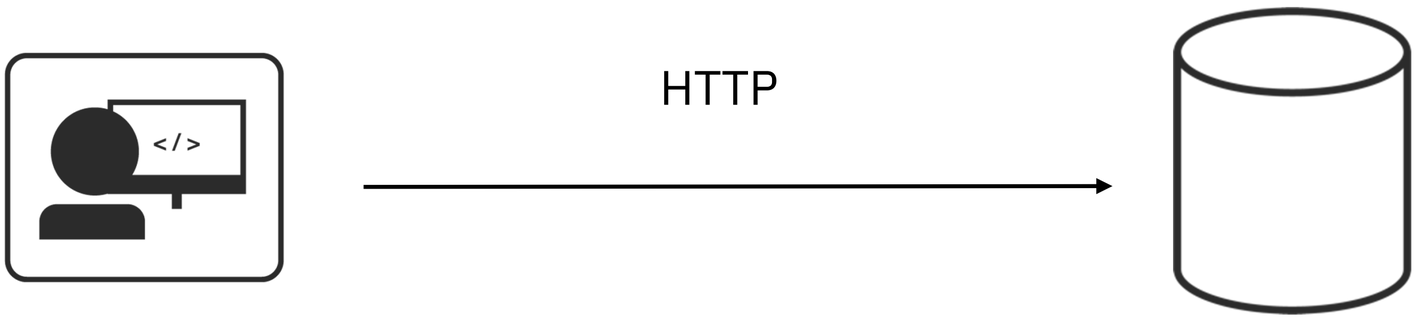
REST is architectural programming style

REST is an acronym standing for **Re**presentational **S**tate **T**ransfer*

An architectural programming style for **accessing** and **updating** data over the internet.

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

Providing a simple and intuitive programming style for the end consumer (**the developer**).



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

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REST APIs follow two key principles

REST APIs use a HTTP verb to specify the operations, e.g., **C**reate (POST), **R**ead(GET), **U**pdate(PUT), **D**elete(DELETE, for more information on *CURD*, see URL https://en.wikipedia.org/wiki/Create,_read,_update_and_delete

POST
GET
PUT
DELETE

Uniform Resource Identifier (URI) path identifies the resource (s)

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

Use Path and **Query** parameters to refine the request

Uniform Resource Locator (URL) identifies the protocol, host and port and includes the URI path

REST APIs use JSON (**J**ava **S**cript **O**bject **N**otation) to represent the data object in the Request/Response message bodies

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

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REST APIs that adhere to both principles are call RESTful APIs

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RESTful Examples

POST `/account/ +`  *(a JSON request message with Fred's information)*

GET `/account?number=1234`

PUT `/account/1234 +`  *(a JSON request message with dollar amount of deposit)*

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

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

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

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

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

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Let’s start with how are REST API described

By using an OpenAPI specification document

The industry standard framework for describing REST APIs

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

For more information see, https://en.wikipedia.org/wiki/OpenAPI_Specification

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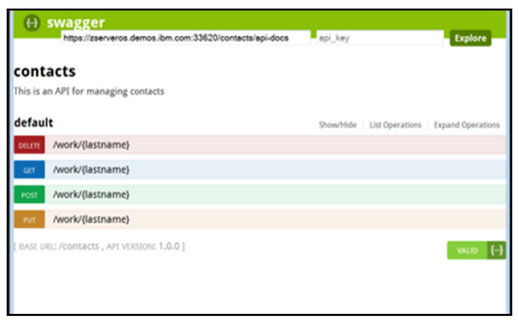
There are a number of tools available to aid in the creation and consumption of APIs

Code Generation* - create stub code, to consume APIs from various languages, *e.g., Java data beans, COBOL copy books that describe the request and response messages.*

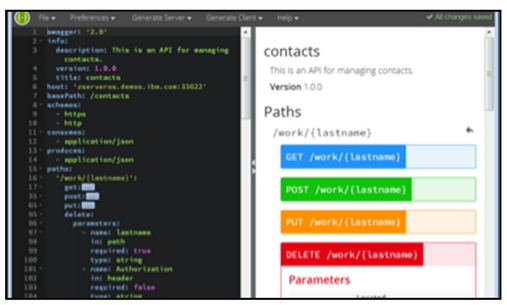
* z/OS Connect API Requester

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



+z/OS Connect, MQ REST support, Liberty, etc.

Editors - allows API developers to design their OpenAPI documents.



https://swagger.io/
https://jsonformatter.org/

Important - You may have used or heard of the term Swagger with the use of APIs. Swagger was the original name of the specification but in 2016 the Swagger specification was renamed the OpenAPI Specification (OAS).

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What is the significance of the OpenAPI Specification to z/OS Connect?

The OpenAPI Specification (OAS) is the industry standard framework for describing REST APIs

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

- **OpenAPI Specification 3 (OAS3), supported by z/OS Connect starting in March 2022, service V3.0.55**
  As companies mature their API strategy, they begin to introduce API governance boards to drive consistency in their API design. As more public APIs are created, government and industry standards bodies begin to regulate and drive for standardization. This drives the need for “API first” functional mapping capabilities within the integration platform. The external API design determined the layouts of the API request and response messages provided by the specification documents which was consumes by z/OS Connect to describe the z/OS resource interactions.
  - The API details of the methods and layouts of request and response messages are provided in advance and access to the z/OS resource is driven by the API design
  - **z/OS Connect consumes the specification document that describes the methods and request and response messages**

Note: For our purposes, the terms OpenAPI 2.0 and Swagger 2.0 are interchangeable.
Also, the term OAS3 is a recognized shortcut for OpenAPI3 while OAS2 is not for OpenAPI2.

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Contrast the Swagger 2.0 versus OpenAPI 3 specification

z/OS Connect OpenAPI2 tooling **produces** an Swagger 2.0 specification document (aka Swagger 2.0.0), where the details of the methods and request/response messages in the API specification are driven by the nature of the z/OS resource (JSON format).

cscvinc.json - Notepad

File Edit Format View Help

```
{
    "swagger": "2.0",
    "info" : {
        "description": "",
        "version": "1.0.0",
        "title": "cscvincapi"
    },
    "basePath": "/cscvincapi",
    "schemes": [
        "https",
        "http"
    ],
    "consumes": [
        "application/json"
    ],
    "produces": [
        "application/json"
    ],
    "paths": {
        "/employee/{employee}": {
            "get": {
                "tags": [
                    "cscvincapi"
                ],
                "operationId": "getCscvincSelectService",
                "parameters": [
                    {
                        "name": "Authorization",
                        "in": "header",
                        "required": false,
                        "type": "string"
                    },
                    {
                        "name": "employee",
                        "in": "path",
                        "required": true,
                        "type": "string",
                        "maxLength": 6
                    }
                ],
                "responses": {
                    "200": {
                        "description": "OK",
                        "schema": {
                            "$ref": "#/definitions/getCscvincSelectService_response_200"
                        }
                    },
                    "404": {
                        "description": "Not Found",
```

Ln 18, Col 7 100% Windows (CRLF) UTF-8

cscvinc.yaml - Notepad

File Edit Format View Help

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

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

z/OS Connect OpenAPI3 tooling **consumes** an OpenAPI3 specification document (aka OSA3) and the details of the methods and request/response messages are driven by the API specification (YAML format*) and not the nature of the z/OS resource. Also, JSONata can be used to augment the API response

*Yet Another Markup Language

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https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=migrating-openapi-2-openapi-3

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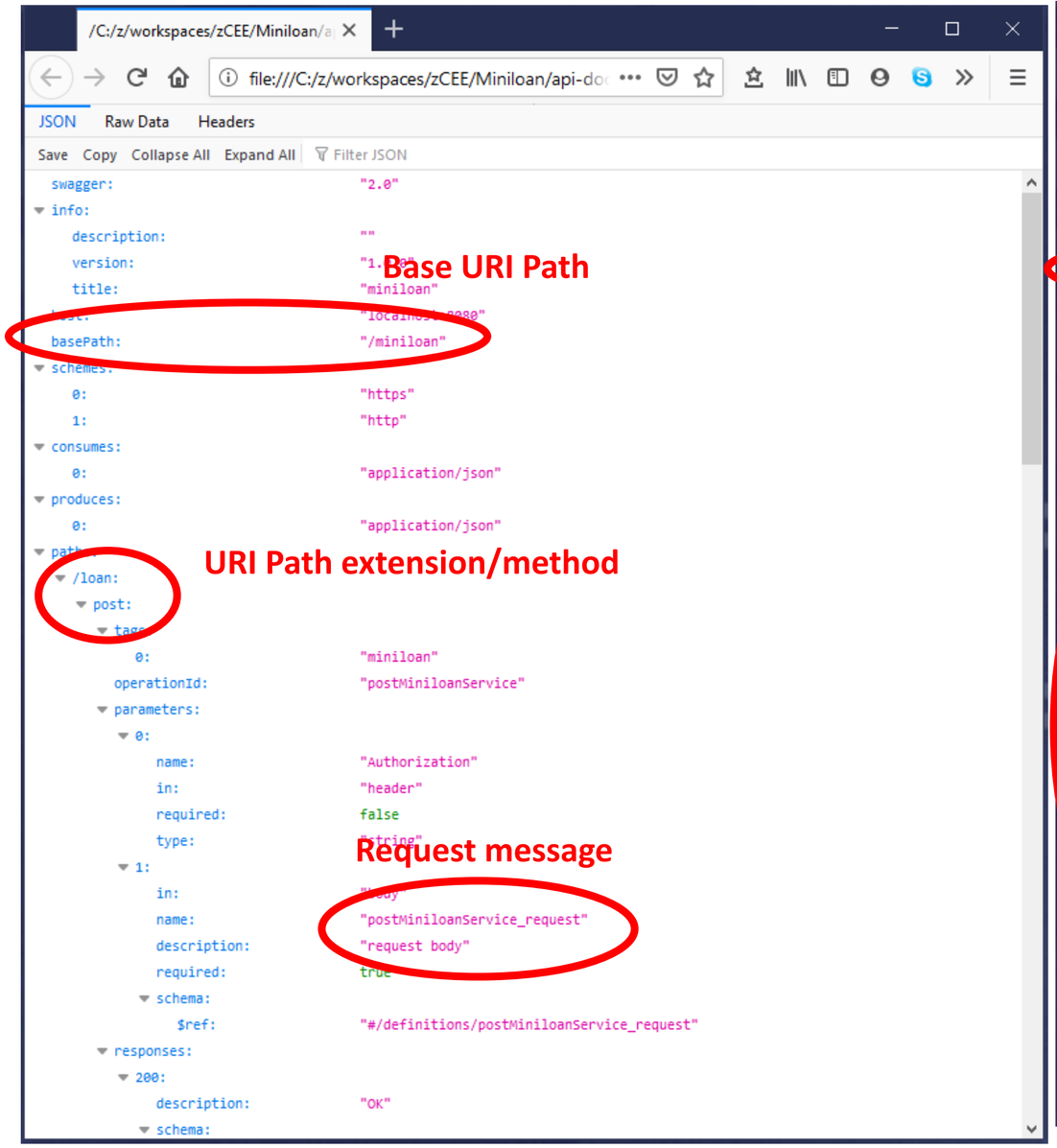
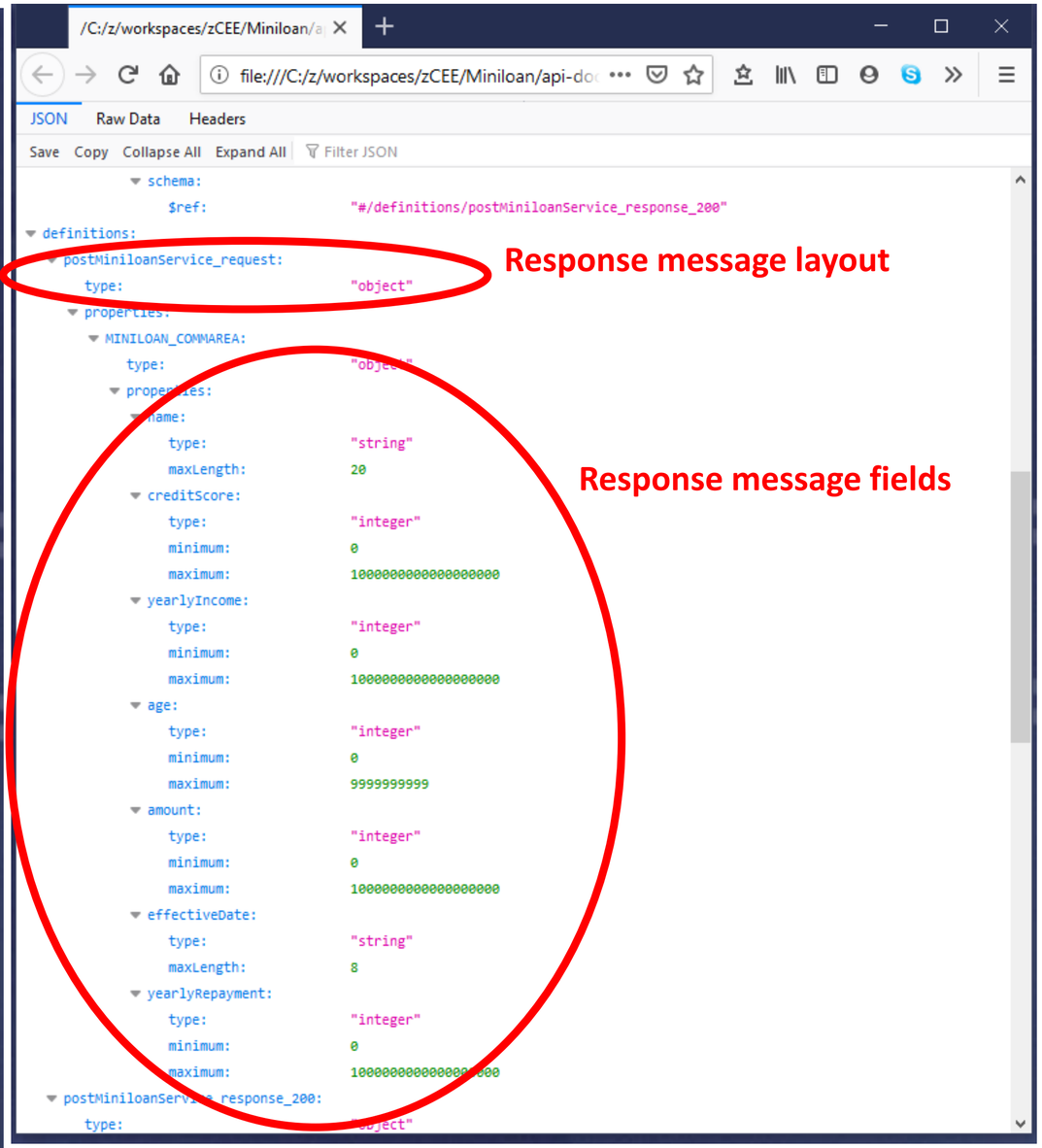
Tech-Tip: A detailed look at an OPENAPI specification documentation





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One of the goals of REST is to have code that is independent of the infrastructure

ZceeCICSGet.java

```
55          // Invoke the REST API using a GET method
56          URL url = new URL("https://wg31.washington.ibm.com:9453/cscvinc/employee/" + args[1]);
57          System.out.println("URL: " + url);
58          HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();
59          conn.setRequestMethod("GET");
60          conn.setRequestProperty("Content-Type", "application/json");
61          byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());
62          conn.addRequestProperty("Authorization", "Basic " + new String(bytesEncoded));
63          try {
64              if (conn.getResponseCode() != 200) {
65                  throw new RuntimeException("Failed : HTTP error code : " + conn.getResponseCode());
66              }
67              BufferedReader bufferReader = new BufferedReader(new InputStreamReader((conn.getInputStream())));
68              while ((output = bufferReader.readLine()) != null) {
```

ZceeDb2Get.java

```
52          // Invoke the REST API using a GET method
53          URL url = new URL("https://wg31.washington.ibm.com:9453/db2/employee/"+args[1]);
54          System.out.println("URL: " + url);
55          HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();
56          conn.setRequestMethod("GET");
57          conn.setRequestProperty("Content-Type", "application/json");
58          byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());
59          conn.addRequestProperty("Authorization", "Basic " + new String(bytesEncoded));
60          try {
61              if (conn.getResponseCode() != 200) {
62                  throw new RuntimeException("Failed : HTTP error code : " + conn.getResponseCode());
63              }
64              BufferedReader bufferReader = new BufferedReader(new InputStreamReader((conn.getInputStream())));
65              while ((output = bufferReader.readLine()) != null) {
```

In these examples, these Java clients have the same application programming pattern.

- They provide an URL, specify a method and provide a request message.
- Then use code to send a request to the API provider using HTTP.
- A response message is returned from a remote resource, e.g., a CICS program, a Db2 table, an IMS transaction or a MQ queue. The client application is unaware of the underlying infrastructure. No dependencies on knowing the infrastructure or coding for ECI, JDBC, OTMA, JMS, J2C, etc.

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Let’s look at what a COBOL equivalent program might look like

An example of using the COBOL JSON PARSE

An example of invoking a Java class from COBOL

mpz3

File Edit Settings View Communication Actions Window Help

```
  File  Edit  Edit_Settings  Menu  Utilities  Compiler
EDIT       USER1.ZCEE.SOURCE(TEST) - 01.01
Command ===>
000030     ******************************************
000100     * In this example, input to JSON PARSE star
000200     * 1047 and then be converted to UTF-8 (code
000300     * Convert to specific codepages using the d
000400     * The first argument to display-of should b
000500     * which the COBOL compiler represents in UT
000600     ******************************************
000700           Move function display-of(
000800            function national-of(
000900            jtxt-1047-client-data) 1208)
001000             to jtxt-1208(1:function length(jtx
001100           Json parse jtxt-1208 into client-dat
001200             with detail
001300             suppress transactions
001400             not on exception
001500               display "Successful JSON Parse"
001600           end-json.
001800           Move 2 to txnum.
001900           Initialize jtxt-1208 all value.
002000           Move function display-of(
002100            function national-of(
002200            jtxt-1047-transactions) 1208)
002300             to jtxt-1208(1:function length(jtx
002400           Json parse jtxt-1208 into transactio
002500             with detail
002600             name tx-price is 'tx-priceinUS$'
002700             not on exception
002800               display "Successful JSON Parse"
MA    B
```

Connected to remote server/host mpz3 using lu/pool MPZ30021 and port 23

WG31 - 3270

File Edit Settings View Communication Actions Window Help

```
  File  Edit  Edit_Settings  Menu  Utilities  Compilers  Test  Help
EDIT       JOHNSON.PASSTCKT.SOURCE(ATSPTKTJ) - 01.06        Columns 00001 00072
Command ===>                                                 Scroll ===> PAGE
000049           Procedure division.
000050               Set address of JNIEnv to JNIEnvPtr
000051               Set address of JNINativeInterface to JNIEnv
000052           *-------------------------------------------------------------
000053           * Redirect output to SYSOUT
000054           *-------------------------------------------------------------
000055               Invoke ZUtil "redirectStandardStreams"
000056               Perform JavaExceptionCheck.
000057           *-------------------------------------------------------------
000058           * Use JNI services to convert appl to jstring
000059           *-------------------------------------------------------------
000060               Call "NewStringPlatform"
000061                 using by value JNIEnvPtr
000062                       address of zAppl address of jAppl  0
000063                 returning rc
000064               If rc not = zero then
000065                 Display "Error occurred creating jAppl object"
000066                 Stop run
000067               End-if
000068           *-------------------------------------------------------------
000069           * Invoke method GetPassTicket in Java class
000070           *      com.ibm.ats.GetPassTicket
000071           *-------------------------------------------------------------
000072               Invoke PassTicketClass "getPassTicket"
000073                      using by value jIdentity jAppl returning jResponse.
000074               Perform JavaExceptionCheck
000075           *-------------------------------------------------------------
000076           * Use JNI services to obtain size of response returned
000077           *-------------------------------------------------------------
000078               Call "GetStringPlatformLength"
000079                      using by value JNIEnvPtr
000080                      jResponse address of jResponseLen 0 returning rc
000081               If rc not = zero then
000082                 Display "Error obtaining length of jResponse"
000083                 Stop run
000084               End-if
000085           *-------------------------------------------------------------
000086           * Use JNI services to convert jstring to string              *
000087           *-------------------------------------------------------------
MA    A                                                              13/00
```

Connected to remote server/host wg31 using lu/pool TCP00112 and port 23 | Adobe PDF on Documents*.pdf

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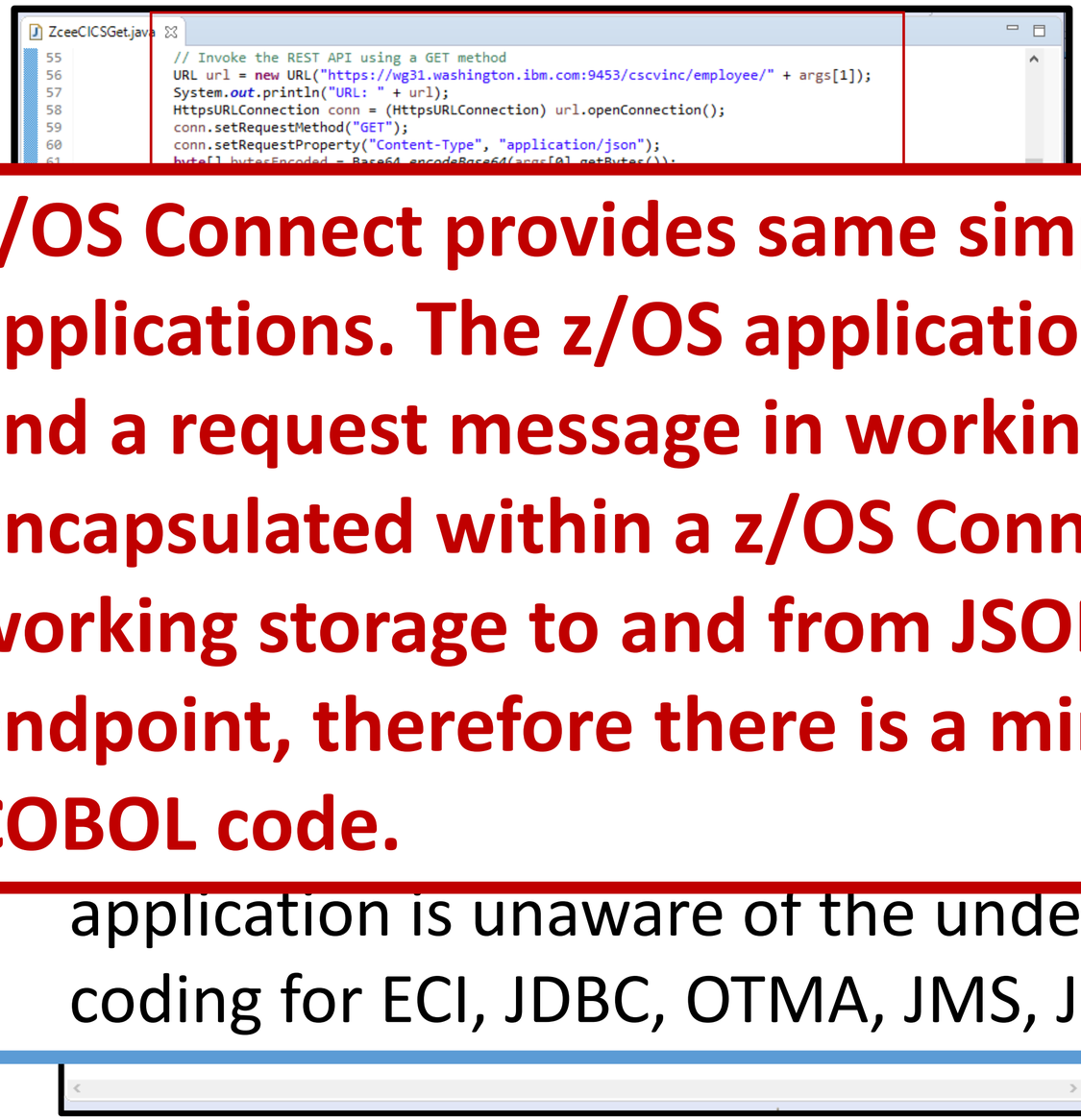
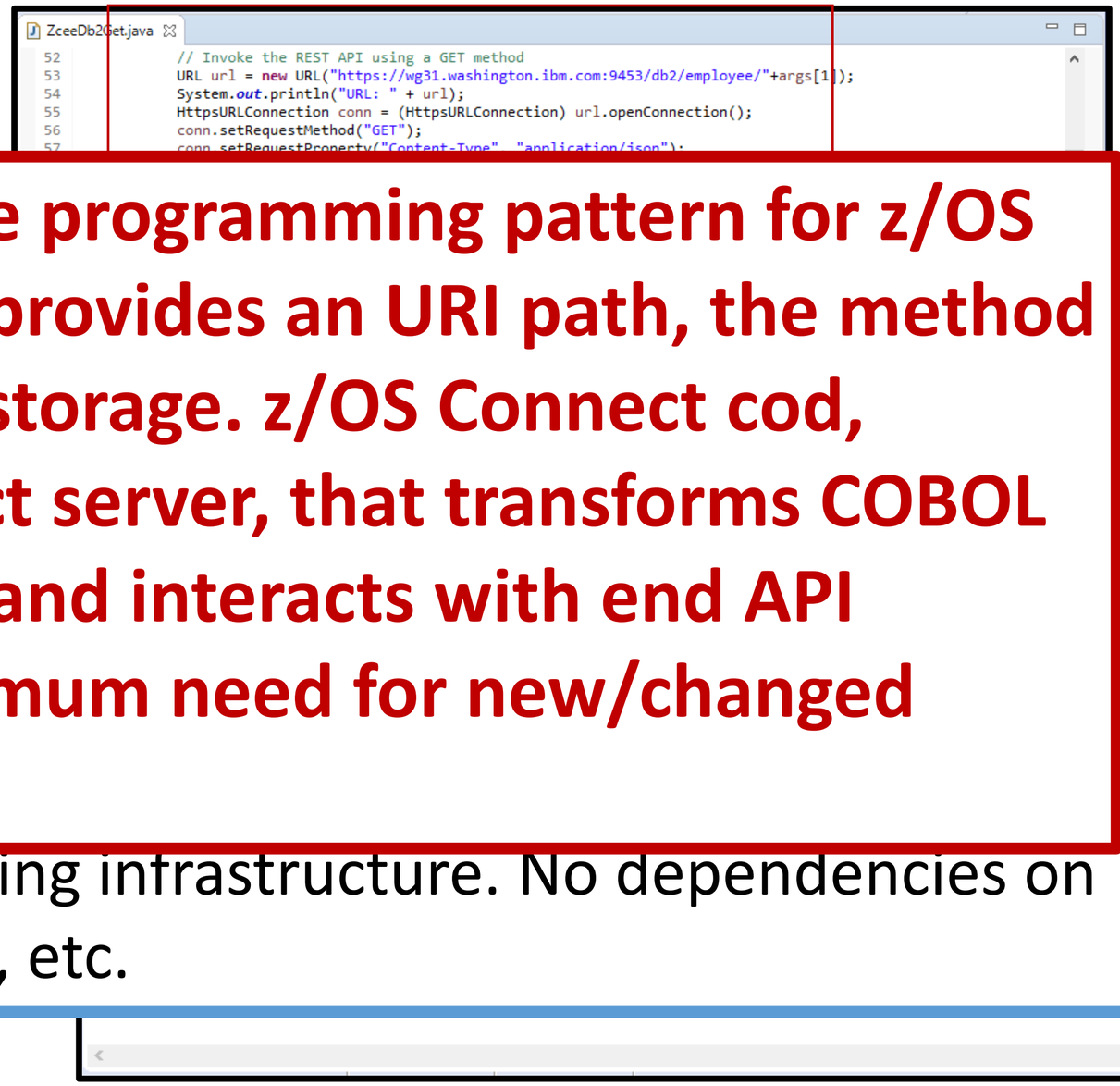
z/OS Connect performs the JSON transformations and the HTTP interactions





z/OS Connect provides same simple programming pattern for z/OS applications. The z/OS application provides an URI path, the method and a request message in working storage. z/OS Connect cod, encapsulated within a z/OS Connect server, that transforms COBOL working storage to and from JSON and interacts with end API endpoint, therefore there is a minimum need for new/changed COBOL code.

application is unaware of the underlying infrastructure. No dependencies on coding for ECI, JDBC, OTMA, JMS, J2C, etc.

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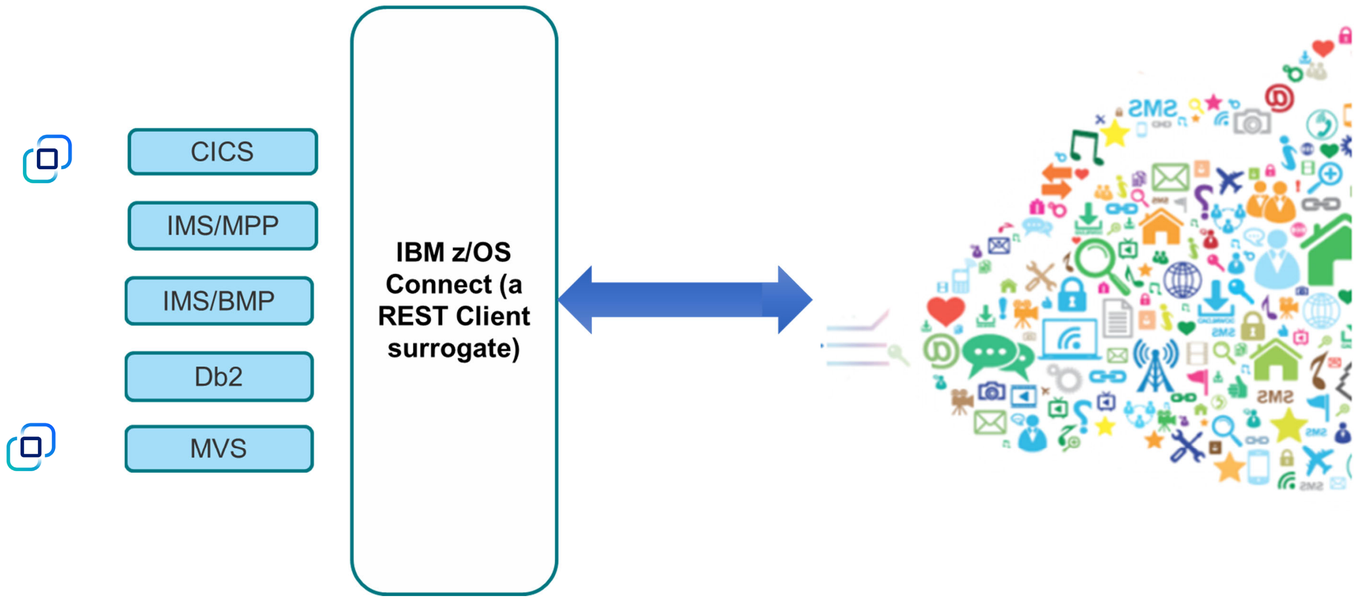
Using an z/OS Connect API requester to access a REST APIs

Developing COBOL API Requester applications



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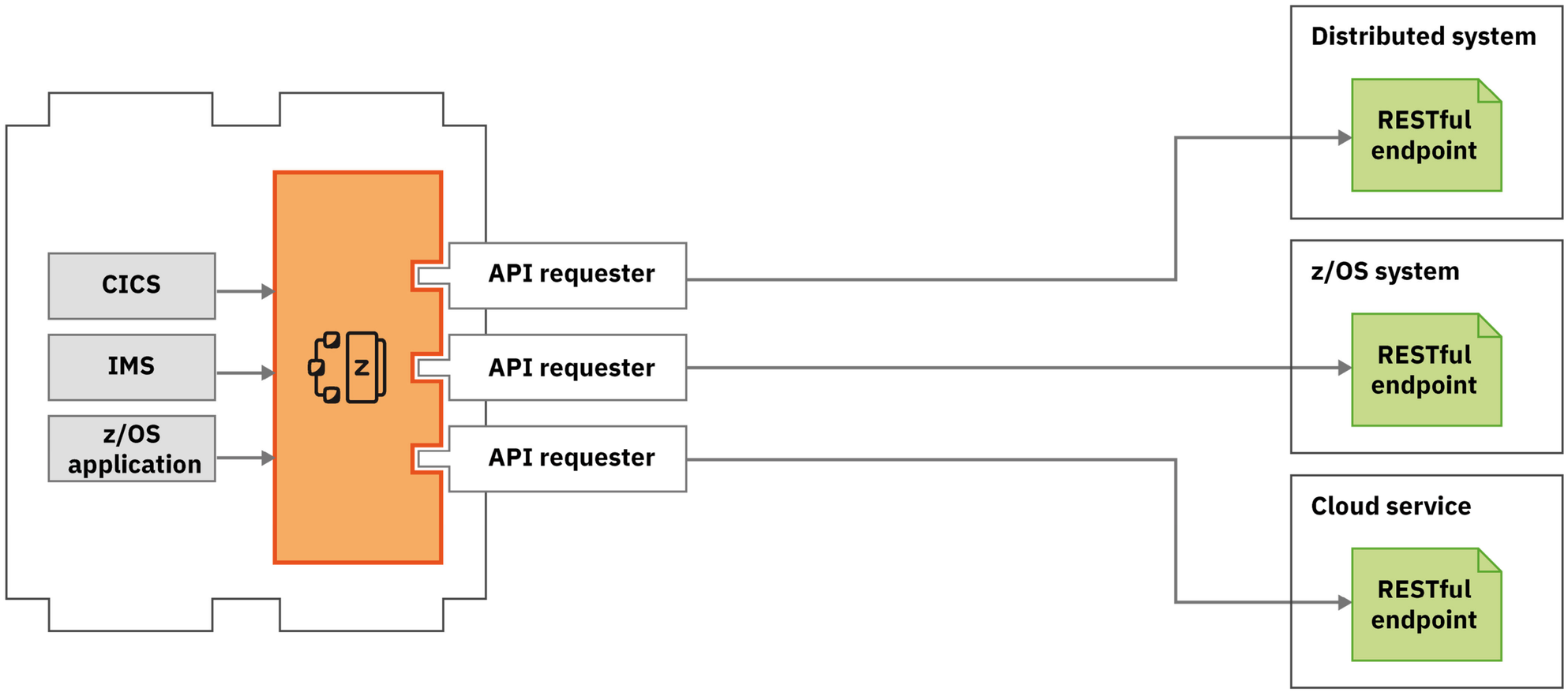
z/OS Connect tooling generates the artifacts used to invoke APIs from z/OS application



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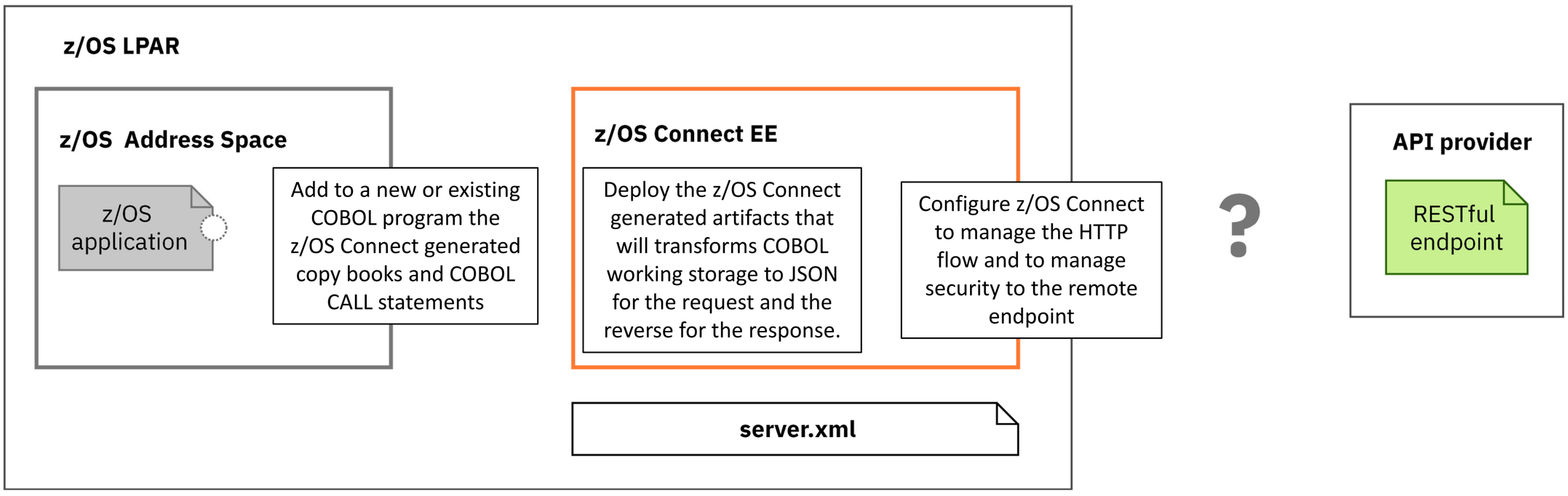
A detailed look at the steps required to invoke a remote API



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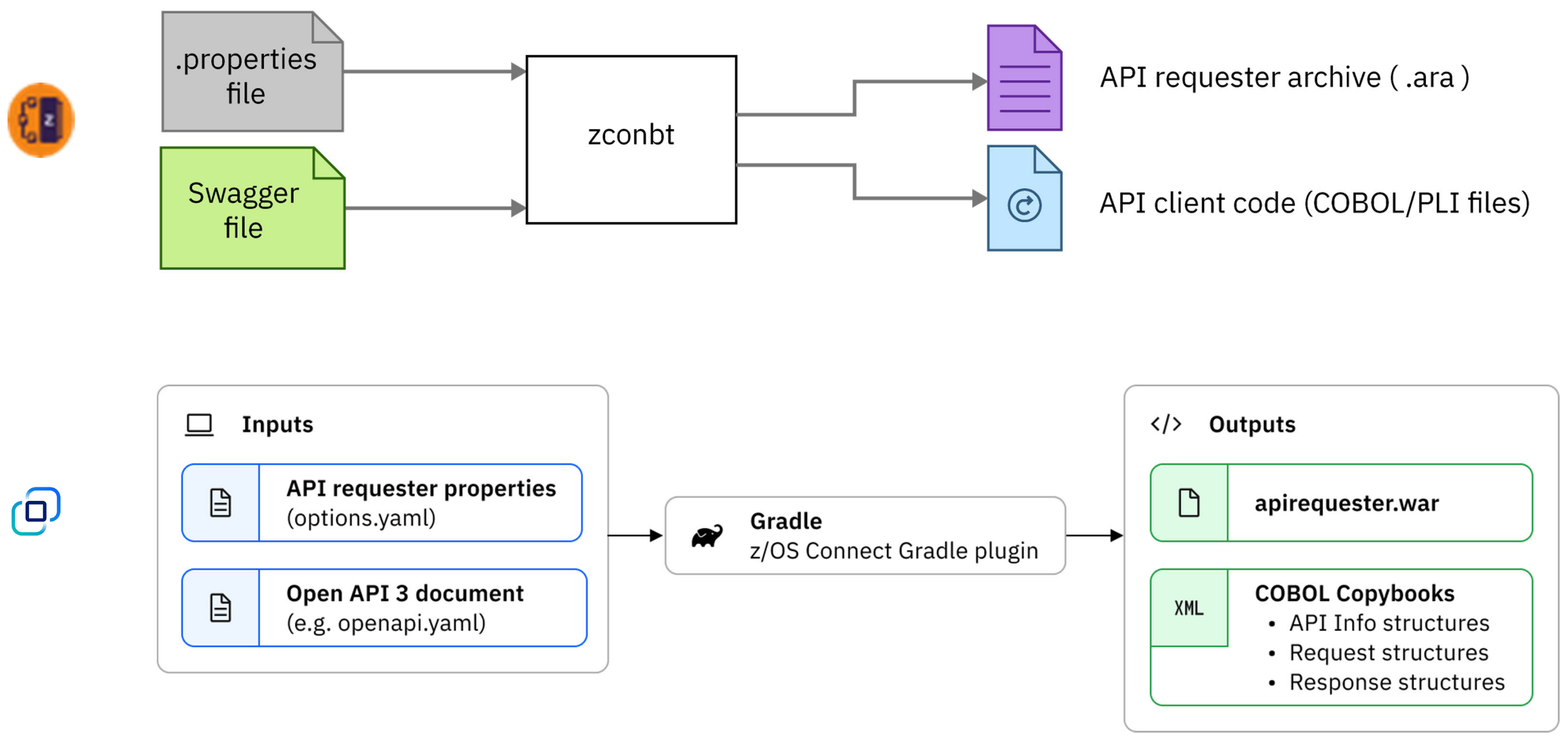
Development starts with the OAS specification document of the API

z/OS Connect tooling consuming the API's specification description to generate COBOL copy books and an API requester archive (ARA) file for an Swagger 2.0 API or a web archive (WAR) file for an OpenAPI 3 API.



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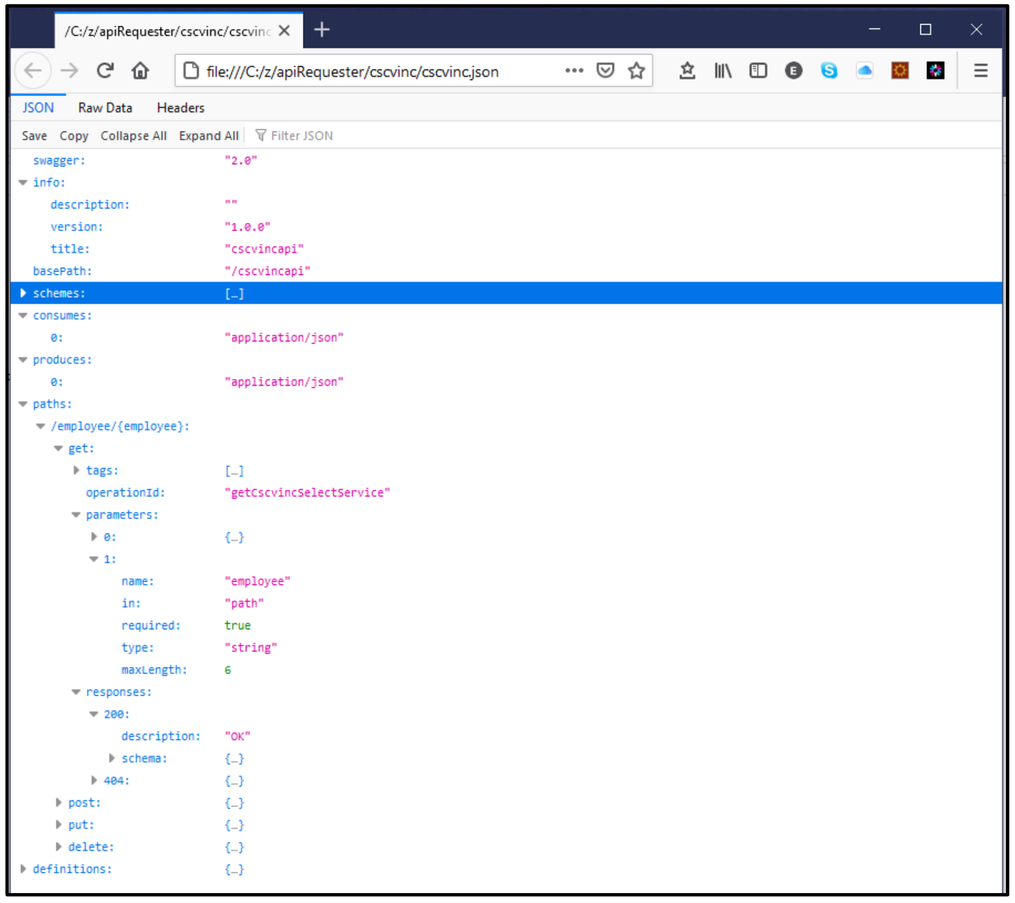
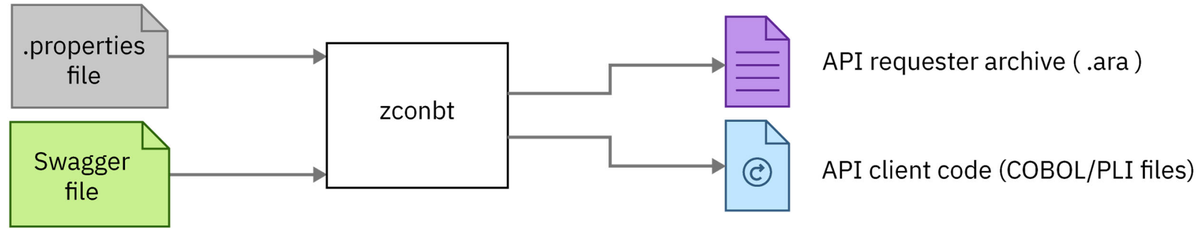
Use the z/OS Connect build toolkit (*zconbt)* for APIs described using Swagger 2.0





properties file#

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

#Additional property file attributes, e.g., *defaultCharacterMaxLength*, *defaultArrayMaxItems*, etc. are described at **The build toolkit properties file** article at URL https://www.ibm.com/docs/en/zosconnect/3.0?topic=toolkit-build-properties-file

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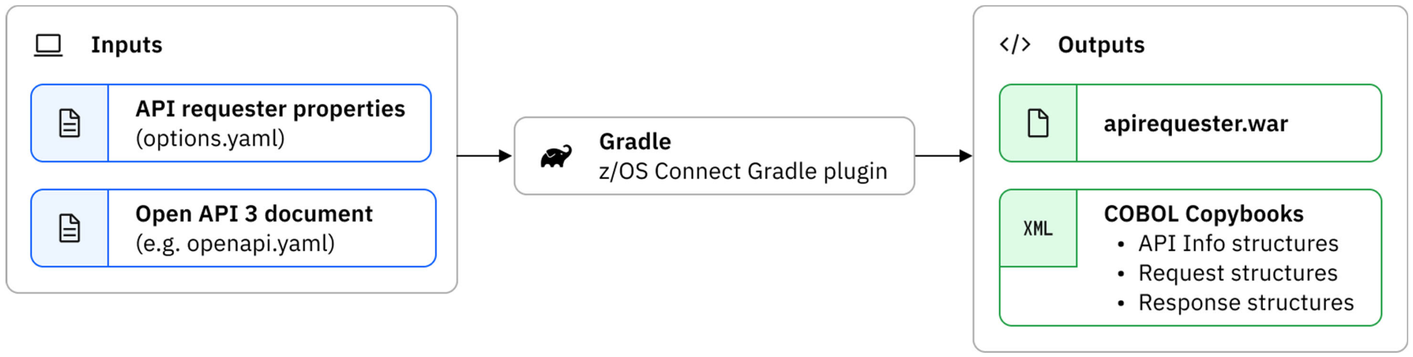
Use the z/OS Connect *Gradle plug-in* for APIs describe using OpenAPI 3

cscvinc.yaml

File Edit View

```
openapi: 3.0.0
info:
  description: "CICS Employee Sample VSAM Application"
  version: 1.0.0
  title: Employee
x-ibm-zcon-roles-allowed:
- Manager
paths:
  /employee:
    post:
      tags:
        - Employee
      operationId: postEmployeeInsertService
      parameters:
        - name: Authorization
          in: header
          required: false
          schema:
            type: string
      requestBody:
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/postEmployeeInsertService_request"
        description: request body
        required: true
      responses:
        "200":
          description: OK
```

Ln 12, Col 19 | 100% | Windows (CRLF) | UTF-8



Gradle plug-in properties and options#

```
apiKeyMaxLength=255
characterVarying=NO
Operations=getEmployeeSelectService
language=COBOL
connectionRef=cscvincAPI
requesterPrefix=csc
```

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

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Both z/OS Connect tools generate application artifacts

- The z/OS Connect build tooling, e.g., *zconbt* or the *Gradle plugin-in*, will generate at most, 3 copy books per method found in the specification document and either an **API requester archive file (ARA)** for an Swagger 2.0 APIs or a **web archive file (WAR)** for an OpenAPI 3 APIs.

```
zconbt.bat -p=./cscvinc.properties -f=./cscvinc.ara
BAQB0000I: z/OS Connect Enterprise Edition 3.0 Build Toolkit Version 1.5 (20210816-0926).
BAQB0008I: Creating API requester archive from configuration file ./cscvinc.properties.
BAQB0040I: The generated API requester is automatically named cscvincapi_1.0.0 based on the title cscvincapi and version 1.0.0 of the API to be
called.
. . . .  .
Total 4 operation(s) (success: 4, ignored: 0) defined in api description file: ./cscvinc.json
------ Successfully processed operation(s) ------
operationId: getCscvincSelectService, basePath: /cscvincapi, relativePath: /employee/{employee}, method: GET
- request data structure  : CSC00Q01
- response data structure : CSC00P01
- api info file           : CSC00I01

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

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

operationId: deleteCscvincDeleteService, basePath: /cscvincapi, relativePath: /employee/{employee}, method: DELETE
- request data structure  : CSC03Q01
- response data structure : CSC03P01
- api info file           : CSC03I01


BAQB0009I: Successfully created API requester archive file ./cscvinc.ara.
```


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Tech-Tip: The copy books naming convention

- The naming convention for the generated COBOL copy books is based on the *requesterPrefix* value specified in the properties file provided to the tools. That value was set to CSC in this case, e.g., CSC######. The next 2 characters in the name are assigned sequentially as each API and method is processed, e.g., CSC00### and CSC01###, and CSC02###.

- The next character will be either a Q, P or an I. A “Q” for a request copy book, the “P” for a response copy book and the “I” for the copy book which contains information, e.g., method, path name etc. derived from the specification document.

- Up to three copy books are generated for each method of each API found in the specification document.
  - In the previous example, there were 4 APIs with each having 1 method for a total of 12 copy books.
  - If there is no request message or no response message, then no copy book will be generated. But this null messages must be represented by addressable storage in the application's working area.

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

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Tech-Tip: BTW, the z/OS Connect Build Toolkit can be executed on z/OS

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

cscvinc.properties

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

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

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COBOL client programming considerations for both Swagger 2.0 and OpenAPI 3 APIs

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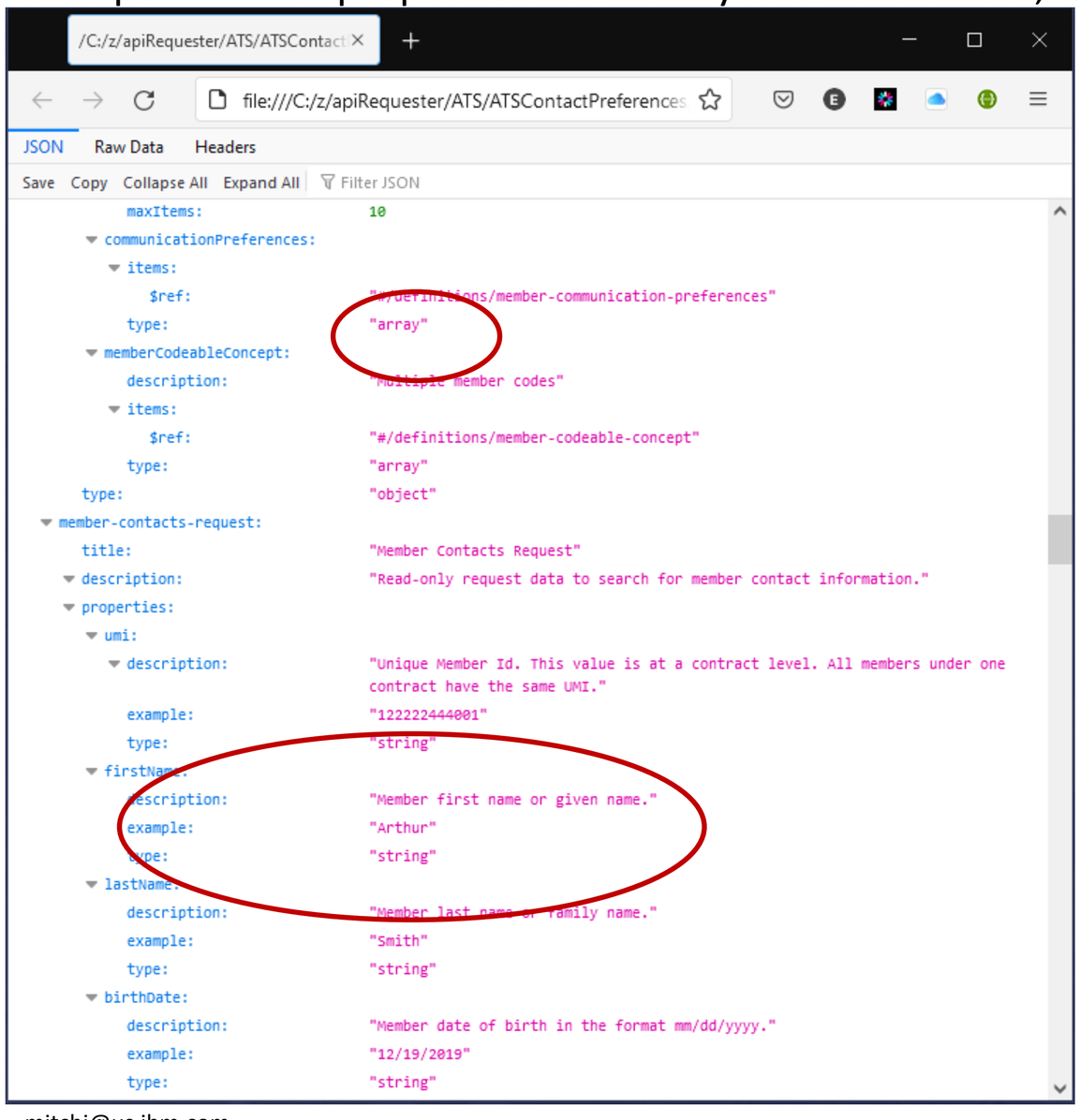
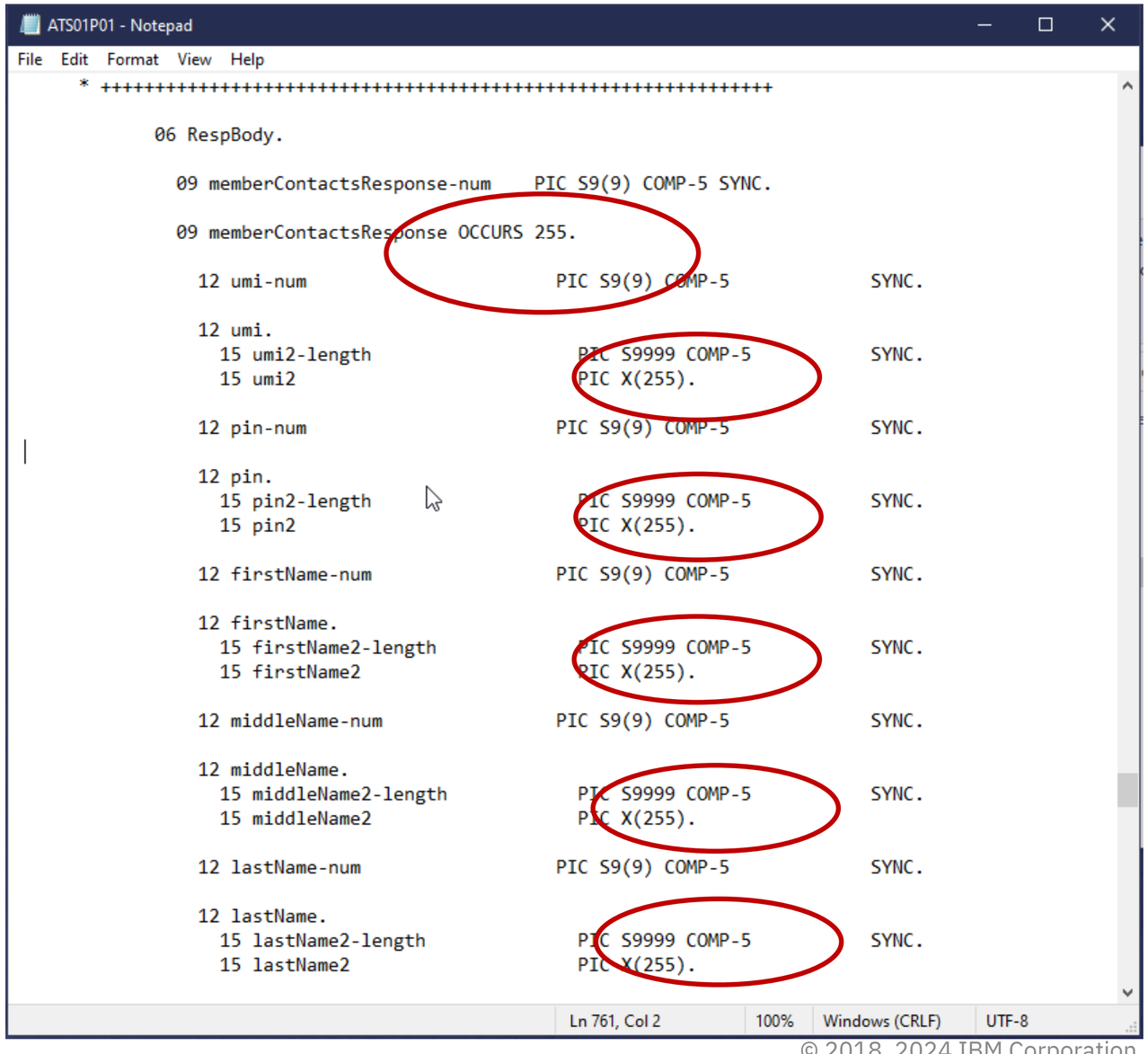
First, be aware of COBOL working storage implications

API specification properties are usually not constrained, this can lead to excessive working storage consumption[1]





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[1]Addressed in OpenAPI 3 tooling for response messages

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There are the API Requester generation properties available to help

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

- **defaultArrayMaxItems -** Specify the maximum array boundary to apply when no maximum occurrence information (maxItems) is implied in the API specification. The value of this parameter can be a positive integer in the range 1 - 32767. By default, **defaultArrayMaxItems** is set to **255.**
- **inlineMaxOccursLimit -** Specifies the size limit for an array before it is upgraded to a data area. If you specify inlineMaxOccursLimit=5, and the array has three elements, it remains an array. If the array has seven elements, it is transformed into a data area instead. See HOST API.

- **defaultCharacterMaxLength -** Specify the default array length of character data in characters for mappings where no length is implied in the JSON schema document. When **characterVarying** is set to YES, the value of this parameter can be a positive integer in the range of 1 to 32767. When **characterVarying** is set to NO or NULL the value of this parameter can be a positive integer in the range of 1 to 16777214 By default, **defaultCharacterMaxLength** is set to **255**.
- **characterVarying -** Specifies how variable-length character data is mapped to the language structure.
  - NO - Variable-length character data is mapped as fixed-length strings.
  - NULL - Variable-length character data is mapped to null-terminated strings (defaultCharacterMaxLength + 1)
  - YES - Variable-length character data is mapped to a CHAR VARYING data type in PL/I. In COBOL variable-length character data is mapped to an equivalent representation that consists of two related elements: the **data-length** and the **data**. By default, **characterVarying** is set to **YES**.

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

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

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

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

12 firstName                    PIC X(31).
```

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

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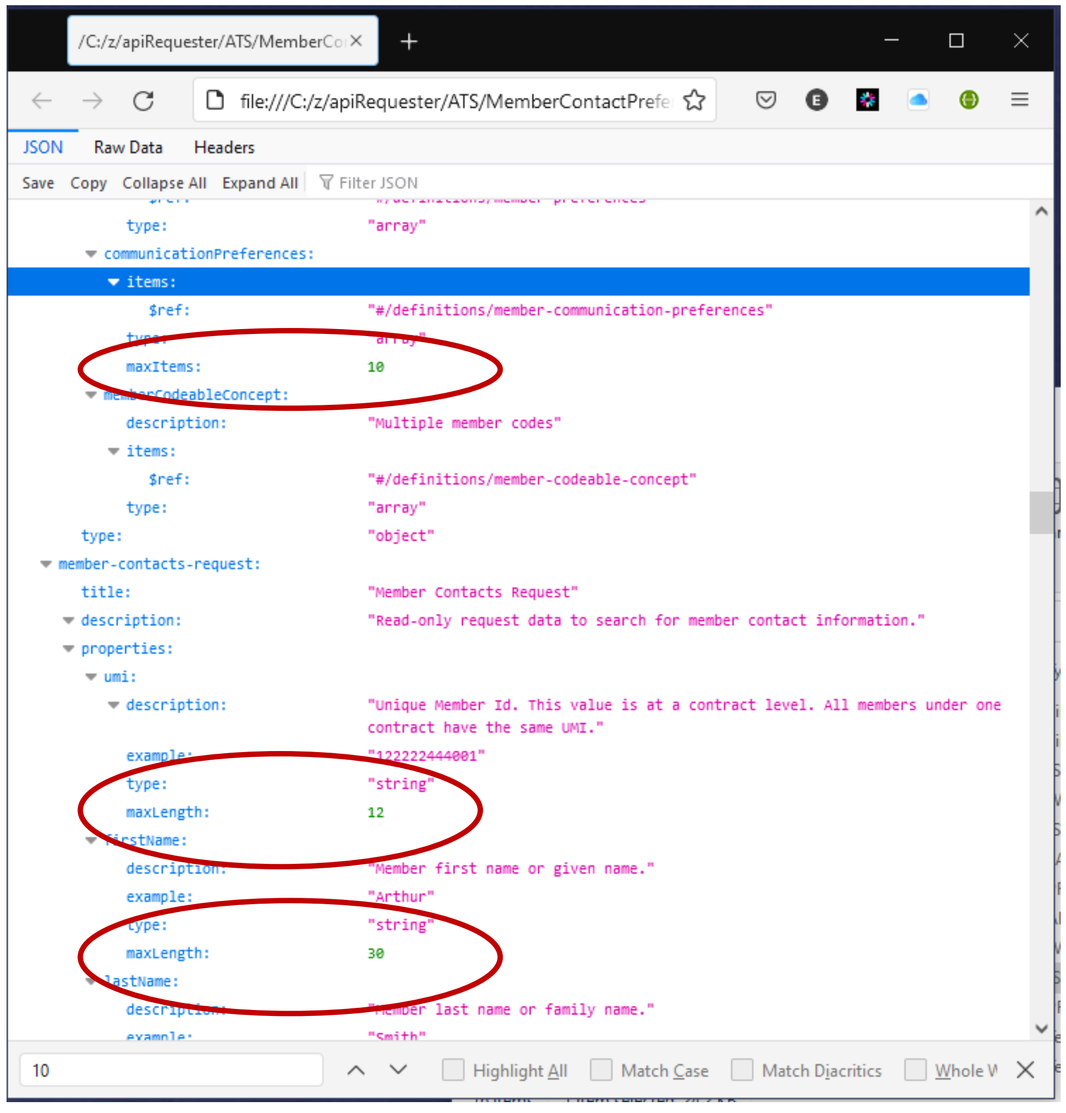
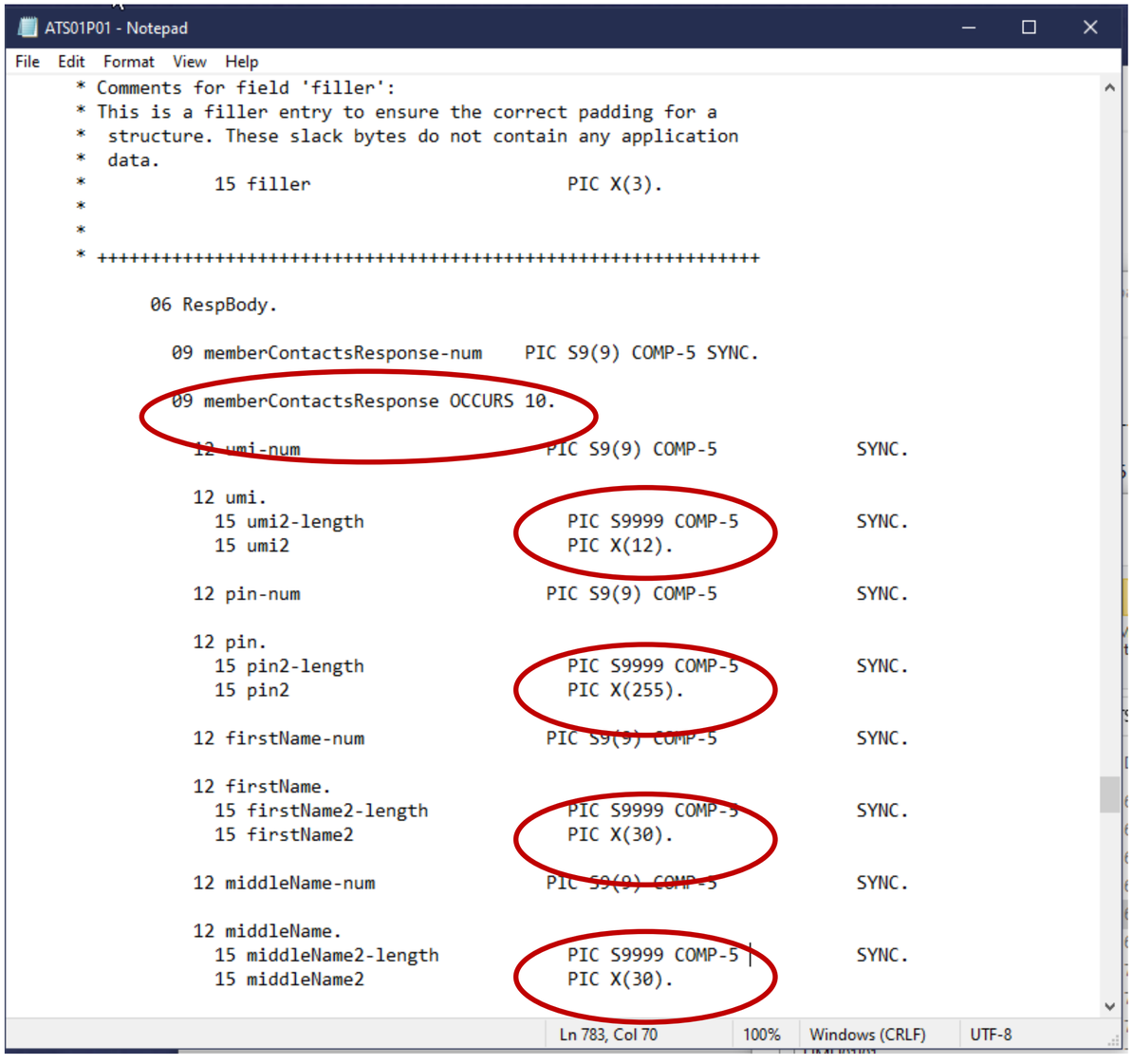
Tech-Tip: Consider adding explicit constraints to the properties

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





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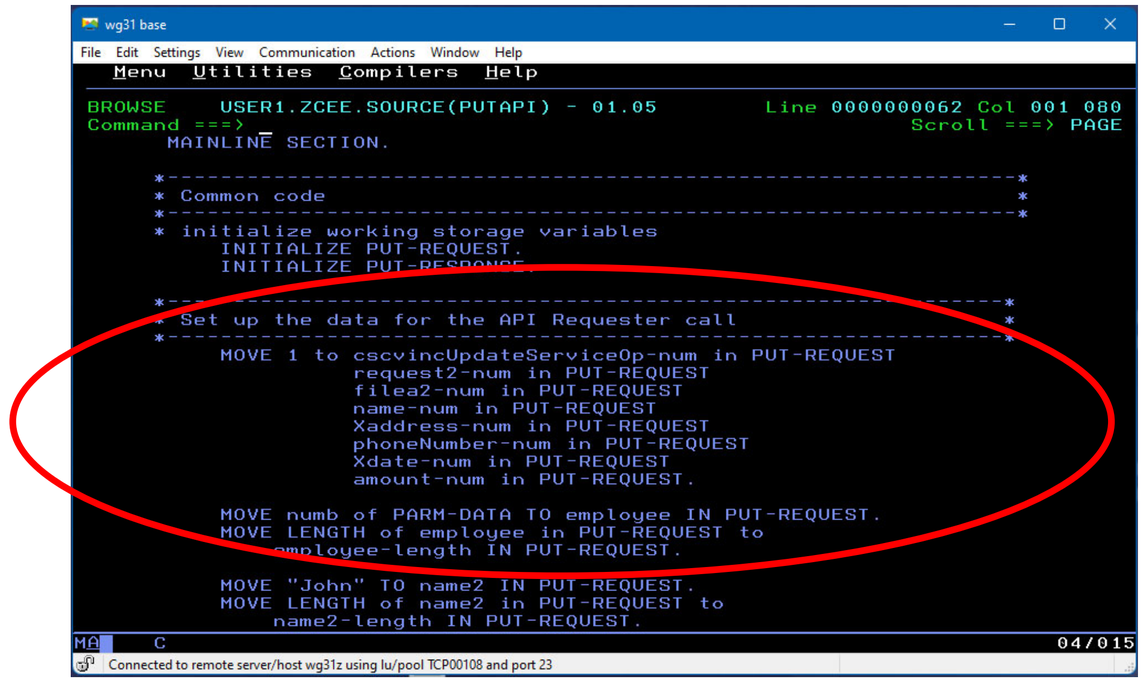
The number of occurrences of an entry can also be ambiguous

In this case the COBOL copy book will include a counter variable (***-num***) for each variable whose number of occurrences is ambiguously. Review the generated COBOL and provide the number of occurrences of these variables in a request message or use the value of this variable to know how many instances were returned.

If the JSON property is an *array,* then the variable name is appended with ***-num*** and the value of this variable provides the number of occurrences or array entries of this array, including 0. If the JSON variable was an *Object* type, then the variable name is appended with ***-existence*** and this variable contains either a 0 or 1 to specify whether an object was returned in the response.



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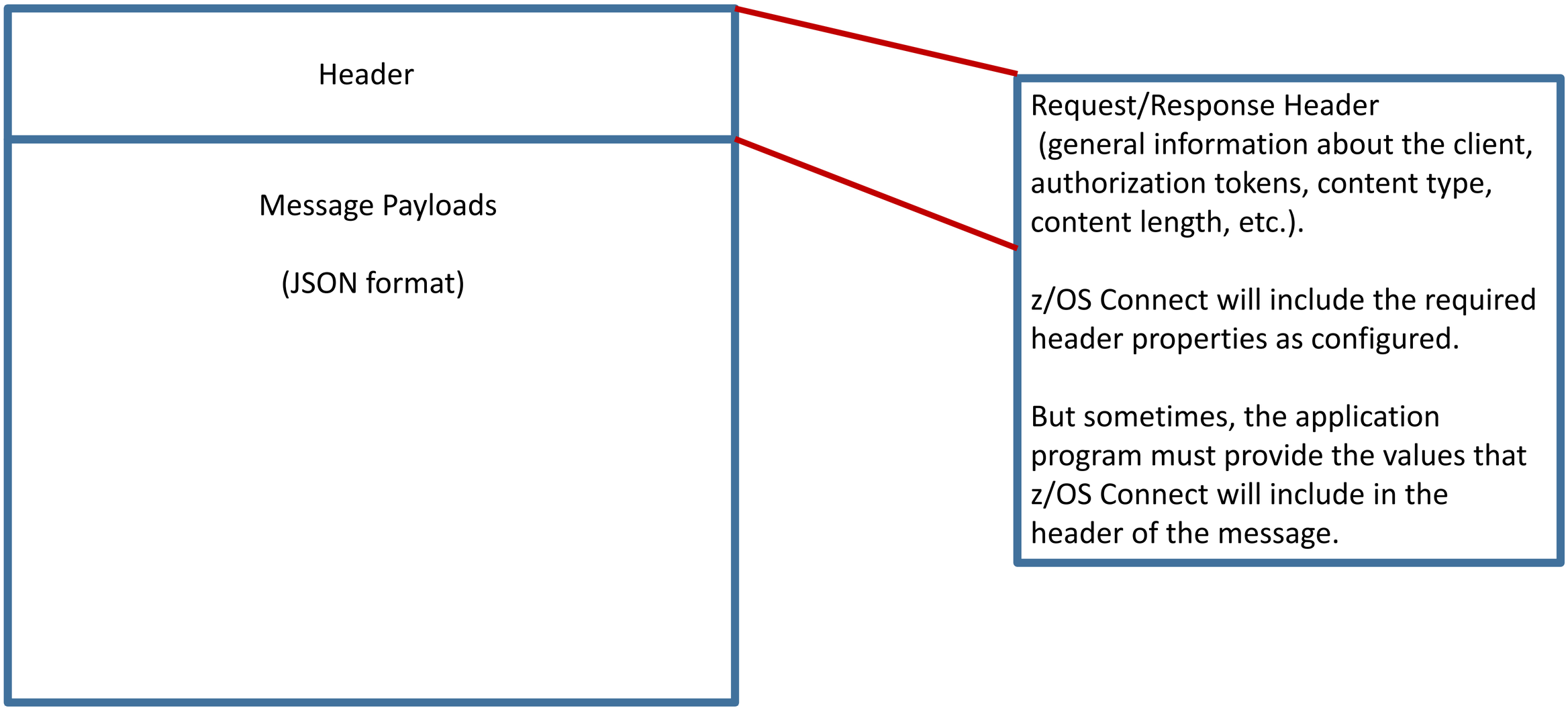
Let’s look at the anatomy of Request and Response Messages



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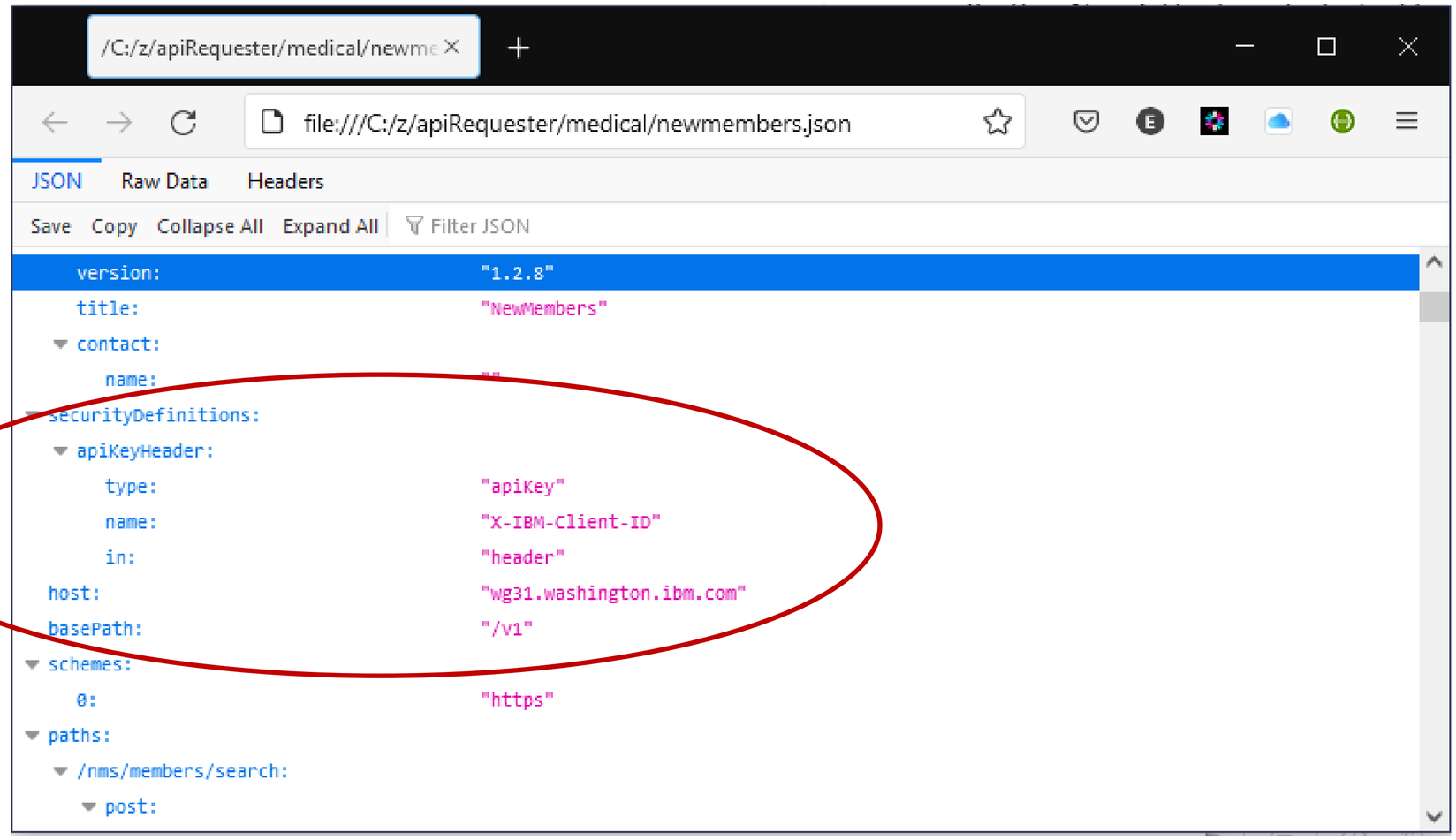
An API may require an API key (aka password)

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



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

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

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

Or if required and not in the specification, then generation properties must be used to have the required supported added to the request copybook ...

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

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

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

apiKeyParmNameInCookie - Specify the name of an API key that is sent as a cookie. The value of this parameter can be set in a comma separated list of a combination of client ID and client secret cookie names. The actual client ID and client secret values are set in the z/OS application. For example, you can set **apiKeyParmNameInCookie** =query-IBM-Client-ID,client-secret when a client ID and a client secret are used to protect an API.

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Either way, the application provides the value of the API key

The generated request copy book includes a ReqHeaders structure which can be used to provide values for the API key

request.cpy - Notepad

File Edit Format View Help

```
      *          12 dob2-length                  PIC S9999 COMP-5
      *  SYNC.
      *          12 dob2                         PIC X(255).
      *
      *
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

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

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

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

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

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

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

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

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

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

mpz3

File Edit Settings View Communication Actions Window Help

File Edit Edit_Settings Menu Utilities Compilers Test Help

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

Connected to remote server/host mpz3 using lu/pool MPZ30019 and port 23

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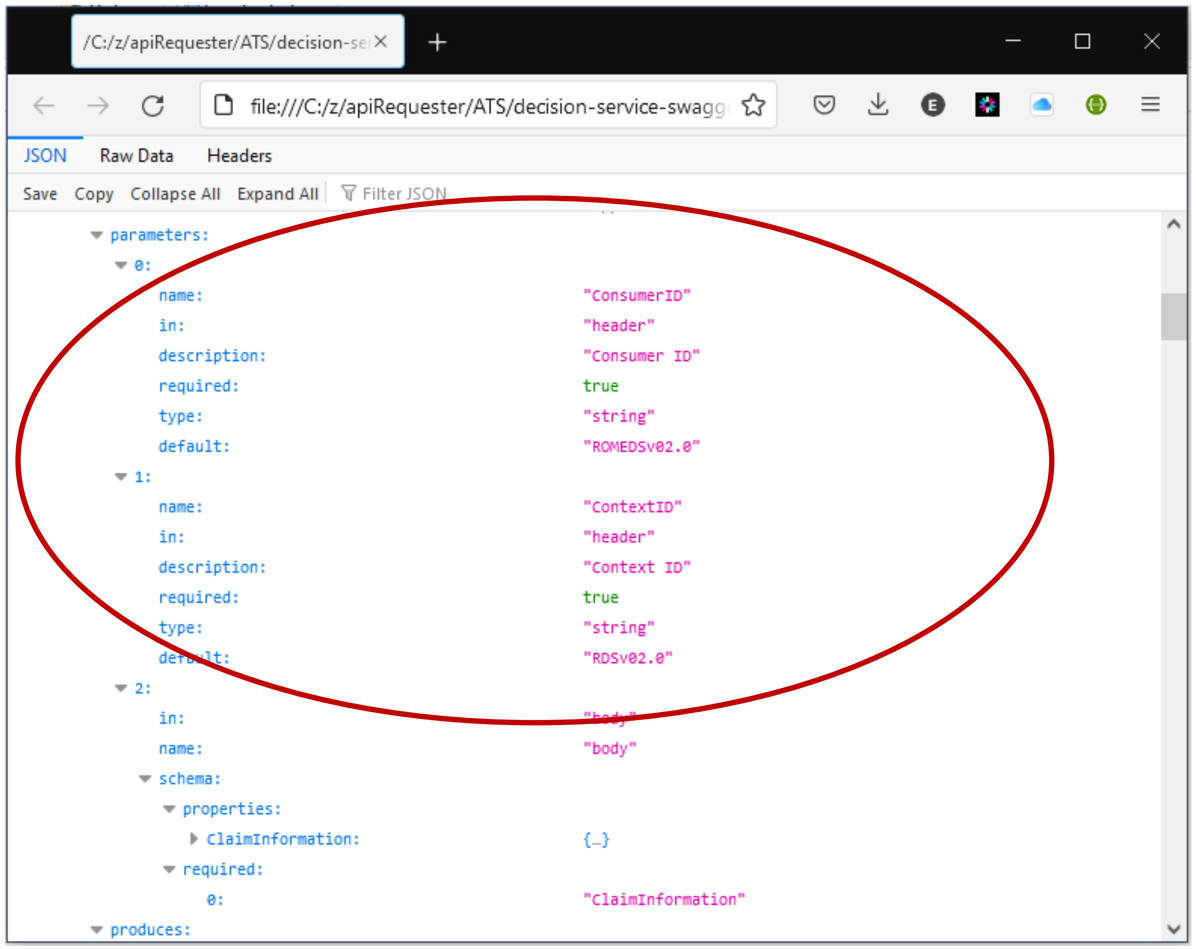
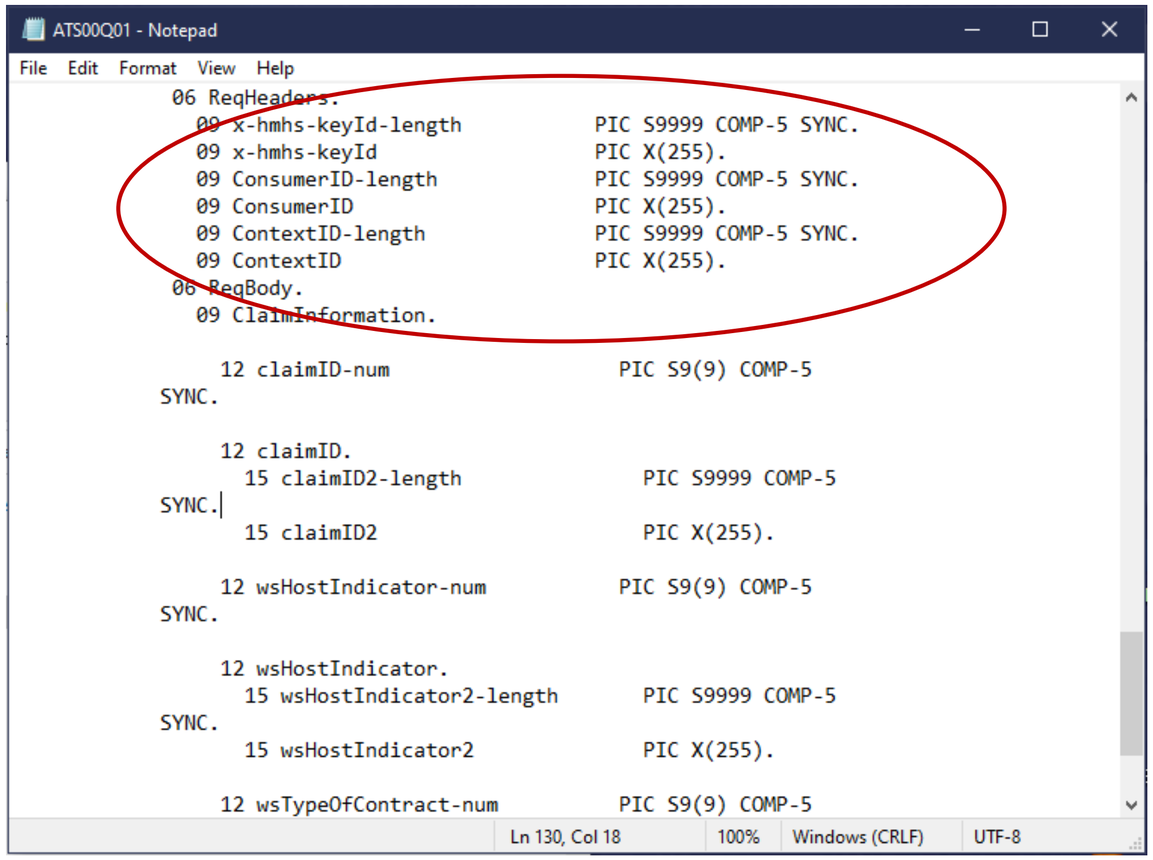
And there may be other required custom header properties

The application may also need to set the values for other header properties that may be required by the API and must be set by the application. These properties are defined in the specification document.





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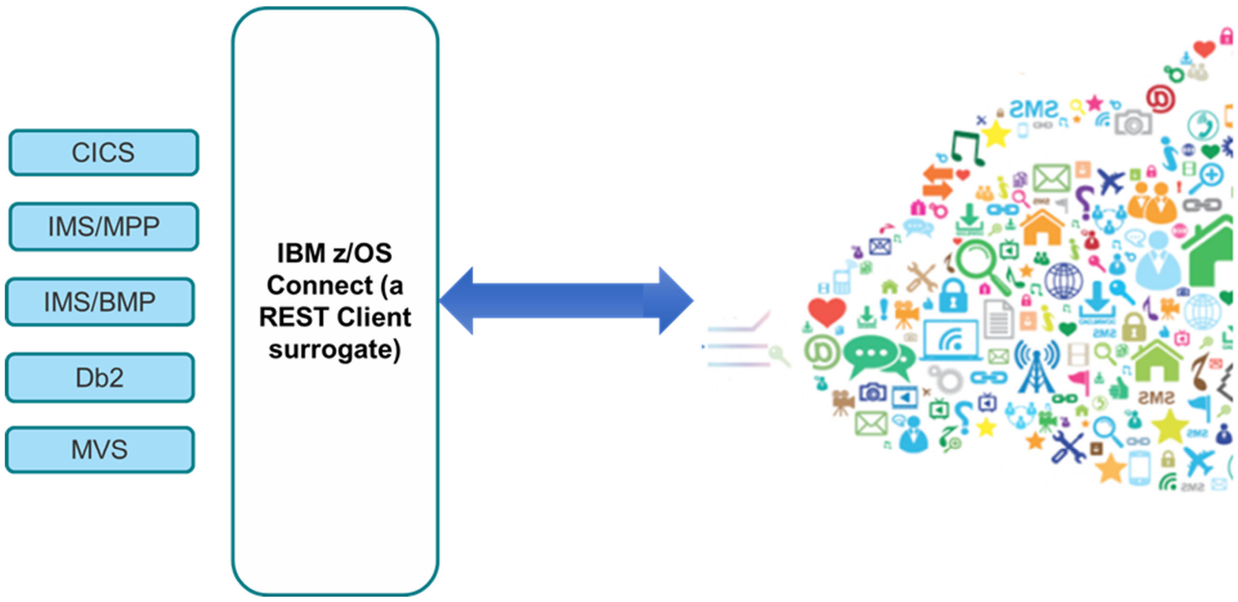
Developing API Requesters

For APIs defined using a Swagger 2.0 specification document



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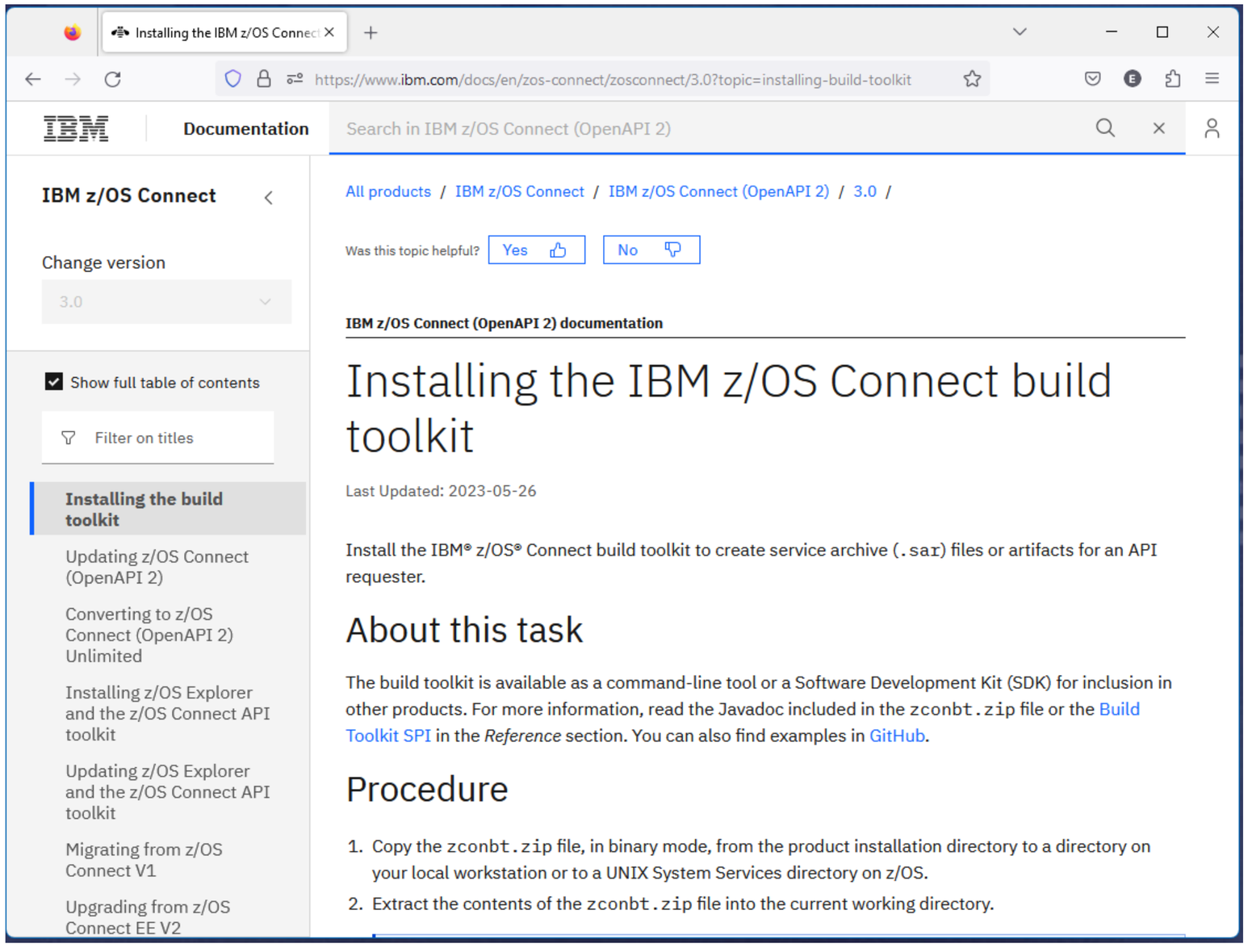
Installing the IBM z/OS Connect build toolkit - https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=installing-build-toolkit



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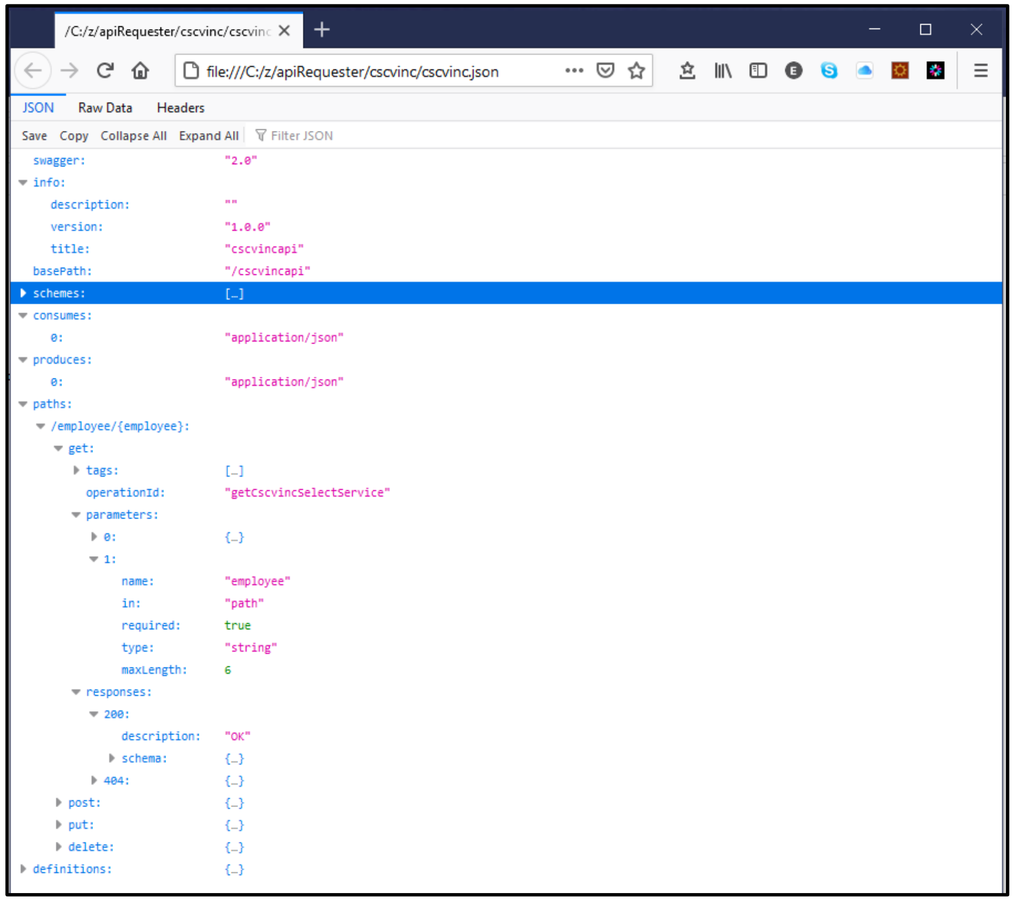
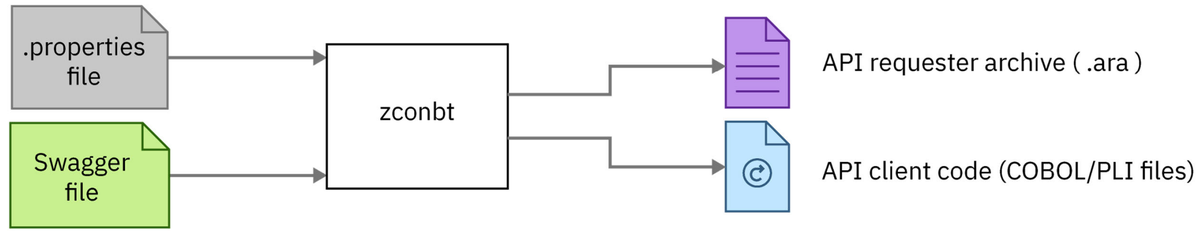
Use the z/OS Connect build toolkit (*zconbt)* for APIs described using Swagger 2.0






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

#Additional property file attributes, e.g., *defaultCharacterMaxLength*, *defaultArrayMaxItems*, etc. are described at **The build toolkit properties file** article at URL https://www.ibm.com/docs/en/zosconnect/3.0?topic=toolkit-build-properties-file

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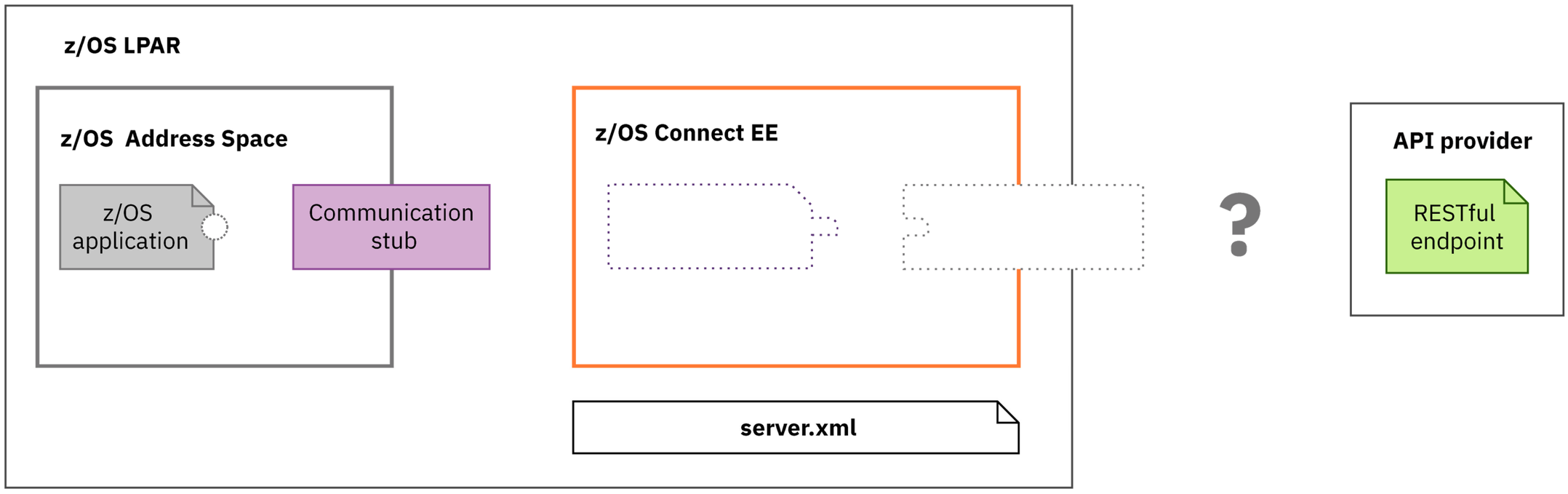
How to access an API from a COBOL program (Swagger 2.0)

Update the application by adding the generated copy books, a common BAQRINFO copy book and a call to communication stub



Configure a communication stub.

- For CICS region systems using URIMAP resources
- For non CICS client the configuration is done via environment variables

```
      *----------------------------------------------------------------*
      * Call the communication stub                                    *
      *----------------------------------------------------------------*
      * Call the subsystem-supplied stub code to send
      * API request to zCEE
           CALL COMM-STUB-PGM-NAME USING
                BY REFERENCE   GET-INFO-OPER1
                BY REFERENCE   BAQ-REQUEST-INFO
                BY REFERENCE   BAQ-REQUEST-PTR
                BY REFERENCE   BAQ-REQUEST-LEN
                BY REFERENCE   BAQ-RESPONSE-INFO
                BY REFERENCE   BAQ-RESPONSE-PTR
                BY REFERENCE   BAQ-RESPONSE-LEN.
```

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ibm.biz/zosconnect-configure-comms-stub

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Steps to calling a remote API

Include the generated copy books in the COBOL program

GETAPI

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

* Copy API Requester required copybook
 COPY BAQRINFO.

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

* Request and Response segment  used to store request and
```

API-REQUEST

CSC00I01 | CSC00Q01

```
* JSON schema keyword 'minLength' value: '0'.
* JSON schema keyword 'maxLength' value: '6'.
* This field contains a varying length array of characters or
*  binary data.
*       09 employee-length              PIC S9999 COMP-5 SYNC.
*       09 employee                     PIC X(6).
*
*
* ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      06 ReqPathParameters.
        09 employee-length              PIC S9999 COMP-5 SYNC.
        09 employee                     PIC X(6).
```

API-RESPONSE

CSC00I01 | CSC00Q01 | CSC00P01

```
*
* ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      06 RespBody.

        09 cscvincSelectServiceOp-num    PIC S9(9) COMP-5 SYNC.

        09 cscvincSelectServiceOperatio.
          12 Container1.

            15 RESPONSE-CONTAINER2-num       PIC S9(9) COMP-5
SYNC.
```

API-INFO-OPER1

CSC00I01

```
        03 BAQ-APINAME                PIC X(255)
           VALUE 'cscvincapi_1.0.0'.
        03 BAQ-APINAME-LEN            PIC S9(9) COMP-5 SYNC
           VALUE 16.
        03 BAQ-APIPATH                PIC X(255)
           VALUE '%2Fcscvincapi%2Femployee%2F%7Bemployee%7D'.
        03 BAQ-APIPATH-LEN            PIC S9(9) COMP-5 SYNC
           VALUE 41.
        03 BAQ-APIMETHOD              PIC X(255)
           VALUE 'GET'.
        03 BAQ-APIMETHOD-LEN          PIC S9(9) COMP-5 SYNC
           VALUE 3.
```

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Steps to calling a remote API

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

GETAPI

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

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

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

CSC00I01

```
03 BAQ-APINAME                 PIC X(255)
   VALUE 'cscvincapi_1.0.0'.
03 BAQ-APINAME-LEN             PIC S9(9) COMP-5 SYNC
   VALUE 16.
03 BAQ-APIPATH                 PIC X(255)
   VALUE '%2Fcscvincapi%2Femployee%2F%7Bemployee%7D'.
03 BAQ-APIPATH-LEN             PIC S9(9) COMP-5 SYNC
   VALUE 41.
03 BAQ-APIMETHOD               PIC X(255)
   VALUE 'GET'.
03 BAQ-APIMETHOD-LEN           PIC S9(9) COMP-5 SYNC
   VALUE 3.
```

CSC00I01 CSC00Q01

```
* JSON schema keyword 'minLength' value: '0'.
* JSON schema keyword 'maxLength' value: '6'.
* This field contains a varying length array of characters or
*  binary data.
*       09 employee-length              PIC S9999 COMP-5 SYNC.
*       09 employee                     PIC X(6).
*
*
* ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      06 ReqPathParameters.
        09 employee-length              PIC S9999 COMP-5 SYNC.
        09 employee                     PIC X(6).
```

CSC00I01 CSC00Q01 CSC00P01

```
*
* ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      06 RespBody.

        09 cscvincSelectServiceOp-num    PIC S9(9) COMP-5 SYNC.

        09 cscvincSelectServiceOperatio.
          12 Container1.

            15 RESPONSE-CONTAINER2-num       PIC S9(9) COMP-5
SYNC.
```

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Steps to calling a remote API

Access the results that have been placed in working storage

GETAPI

```
           BY REFERENCE   BAQ-RESPONSE-LEN.
* The BAQ-RETURN-CODE field in 'BAQRINFO' indicates whether this
* API call is successful.

* When BAQ-RETURN-CODE is 'BAQ-SUCCESS', response is
* successfully returned and fields in RESPONSE copybook
* can be obtained. Display the translation result.
    IF BAQ-SUCCESS THEN
       DISPLAY "NUMB:    " numb2   of API_RESPONSE
       DISPLAY "NAME:    " name2   of API_RESPONSE
       DISPLAY "ADDRX:   " addrx2  of API_RESPONSE
       DISPLAY "PHONE:   " phone2  of API_RESPONSE
       DISPLAY "DATEX:   " datex2  of API_RESPONSE
       DISPLAY "AMOUNT:  " amount2 of API_RESPONSE
       MOVE CEIBRESP of API_RESPONSE to EIBRESP
       MOVE CEIBRESP2 of API_RESPONSE to EIBRESP2
       DISPLAY "EIBRESP:     " EIBRESP
       DISPLAY "EIBRESP2:    " EIBRESP2
       DISPLAY "HTTP CODE:   " BAQ-STATUS-CODE

* Otherwise, some error happened in API, z/OS Connect EE server
* or communication stub. 'BAQ-STATUS-CODE' and
* 'BAQ-STATUS-MESSAGE' contain the detailed information
*  of this error.
    ELSE
       DISPLAY "Error code: " BAQ-STATUS-CODE
       DISPLAY "Error msg:" BAQ-STATUS-MESSAGE
       MOVE BAQ-STATUS-CODE TO EM-CODE
       MOVE BAQ-STATUS-MESSAGE TO EM-DETAIL
       EVALUATE TRUE
* When error happens in API, BAQ-RETURN-CODE is BAQ-ERROR-IN-API.
* BAQ-STATUS-CODE is the HTTP response code of API.
```

mpz3

File Edit Settings View Communication Actions Window Help

Menu Utilities Compilers Help

```
BROWSE     ZCEE30.SBAQCOB(BAQRINFO)                    Line 0000000066 Col 001 080
Command ===>                                                  Scroll ===> PAGE

       01  BAQ-RESPONSE-INFO.
         03 BAQ-RESPONSE-INFO-COMP-LEVEL PIC S9(9) COMP-5 SYNC VALUE 0.
         03 BAQ-STUB-NAME                PIC X(8).
         03 BAQ-RETURN-CODE              PIC S9(9) COMP-5 SYNC.
            88 BAQ-SUCCESS                 VALUE 0.
            88 BAQ-ERROR-IN-API            VALUE 1.
            88 BAQ-ERROR-IN-ZCEE           VALUE 2.
            88 BAQ-ERROR-IN-STUB           VALUE 3.
            88 BAQ-ERROR-NO-RESPONSE       VALUE 4.
         03 BAQ-STATUS-CODE              PIC S9(9) COMP-5 SYNC.
         03 BAQ-STATUS-MESSAGE           PIC X(1024).
         03 BAQ-STATUS-MESSAGE-LEN       PIC S9(9) COMP-5 SYNC.
****************************** Bottom of Data ********************************
```

MA B 18/058

Connected to remote server/host mpz3 using lu/pool MPZ30021 and port 23

Note that the return code only addresses the z/OS Connect related status, not the underlying HTTP status code.

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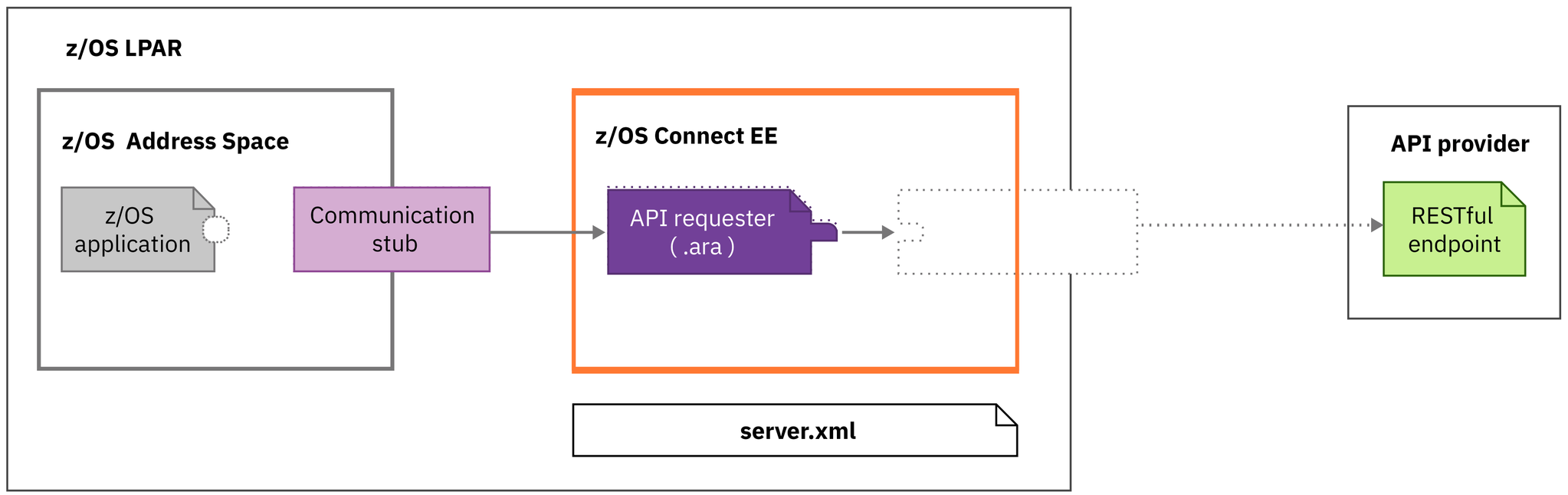
Deploy the API requester (.ara) archive



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

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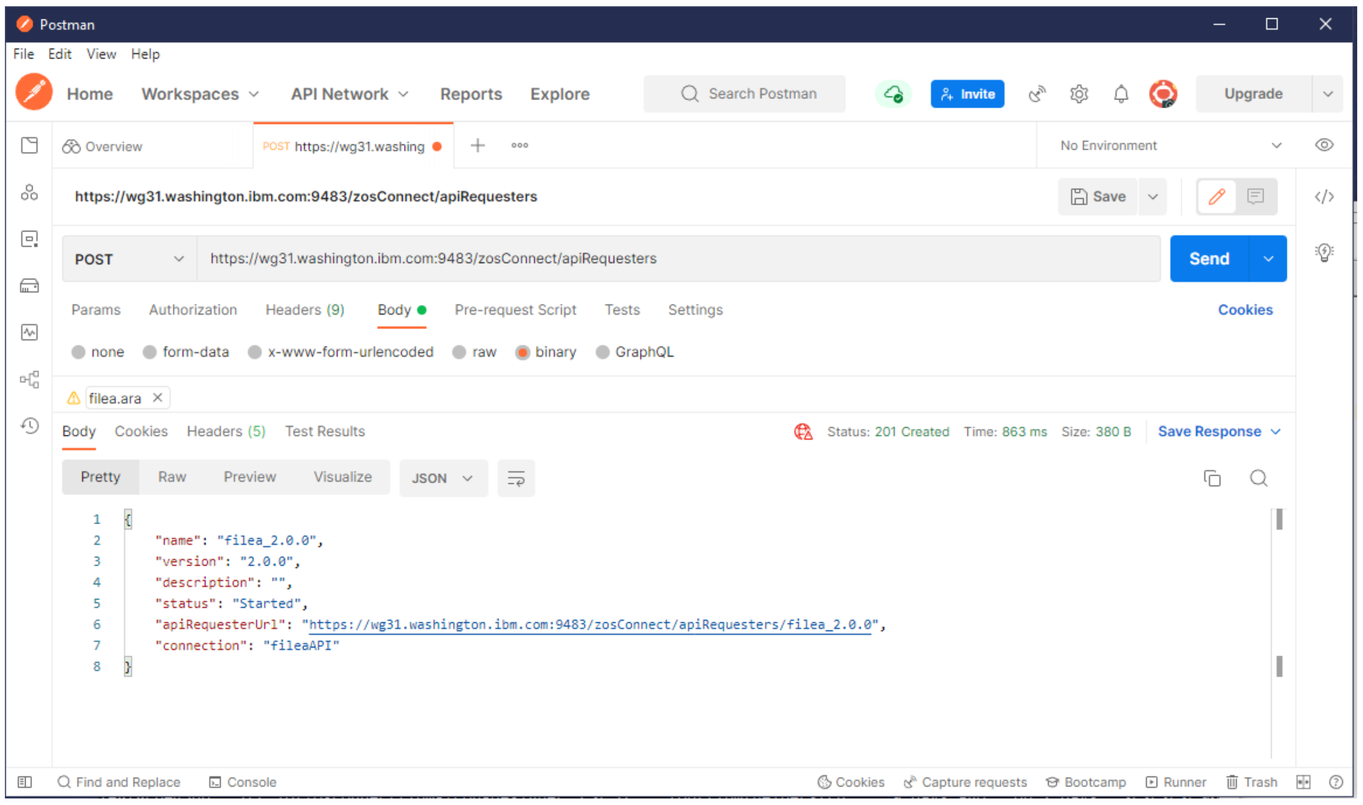
Tech-Tip: Deploy API requester archive file using Postman or cURL

- Use API requester archive as request message and use HTTP POST
- Use URI path /zosConnect/apiRequesters
- Postman or cURL



Command:
curl --data-binary @filea.ara
--header "Content-Type: application/zip"
https://mpxm:9453/zosConnect/apiRequesters

Results:
{"name":"filea_2.0.0","version":"2.0.0","description":"",
"status":"Started","apiRequesterUrl":"https:\/\/wg31.wash
ington.ibm.com:9483\/zosConnect\/apiRequesters\/filea_2.0
.0","connection":"fileaAPI"}

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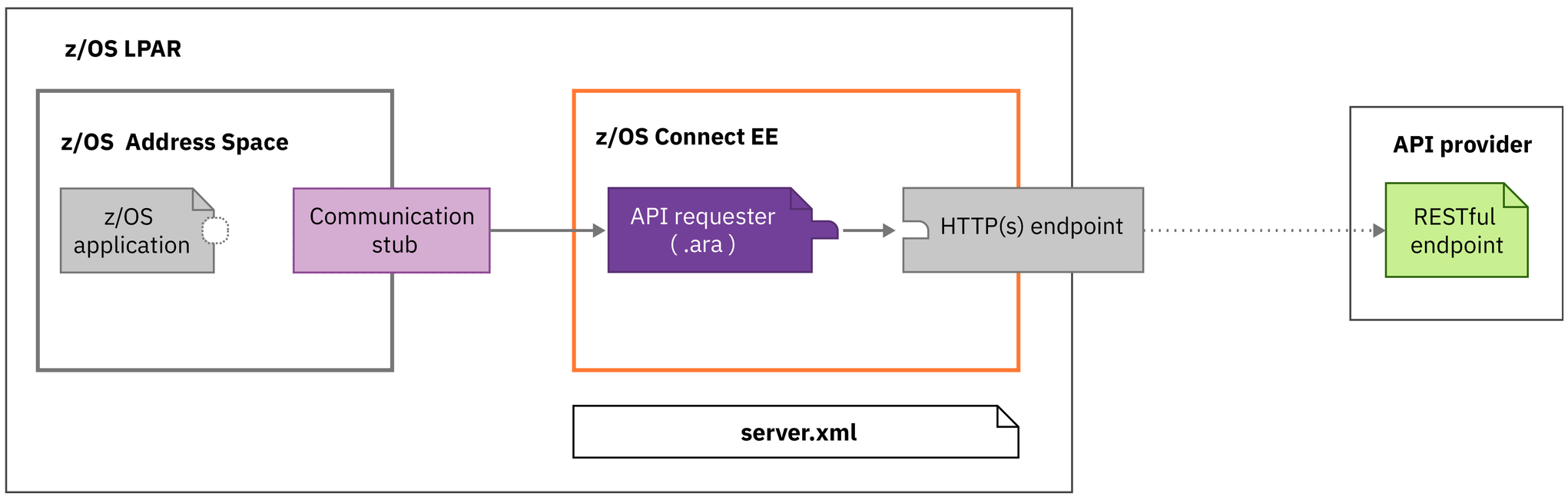
Steps to calling a remote API

Configure HTTP(S) endpoint configuration element



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

ibm.biz/zosconnect-configure-endpoint-connection

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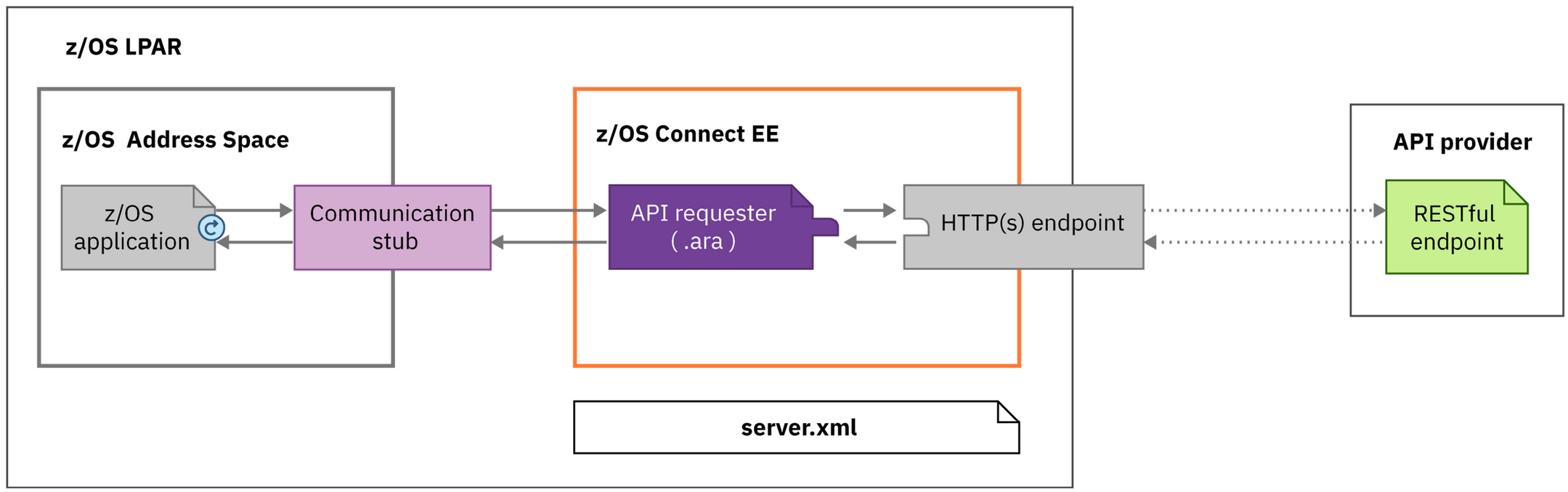
Results - A complete solution for calling a remote Swagger 2.0 API



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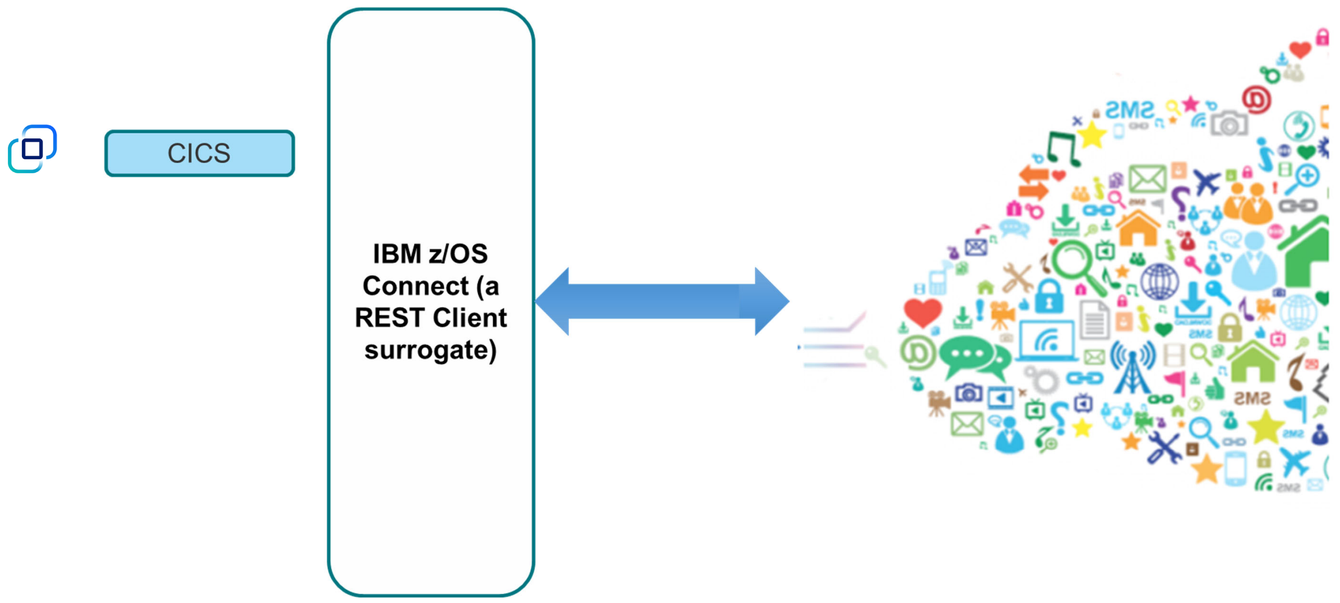
Developing z/OS Connect API Requesters

For APIs defined using an OpenAPI 3 specification



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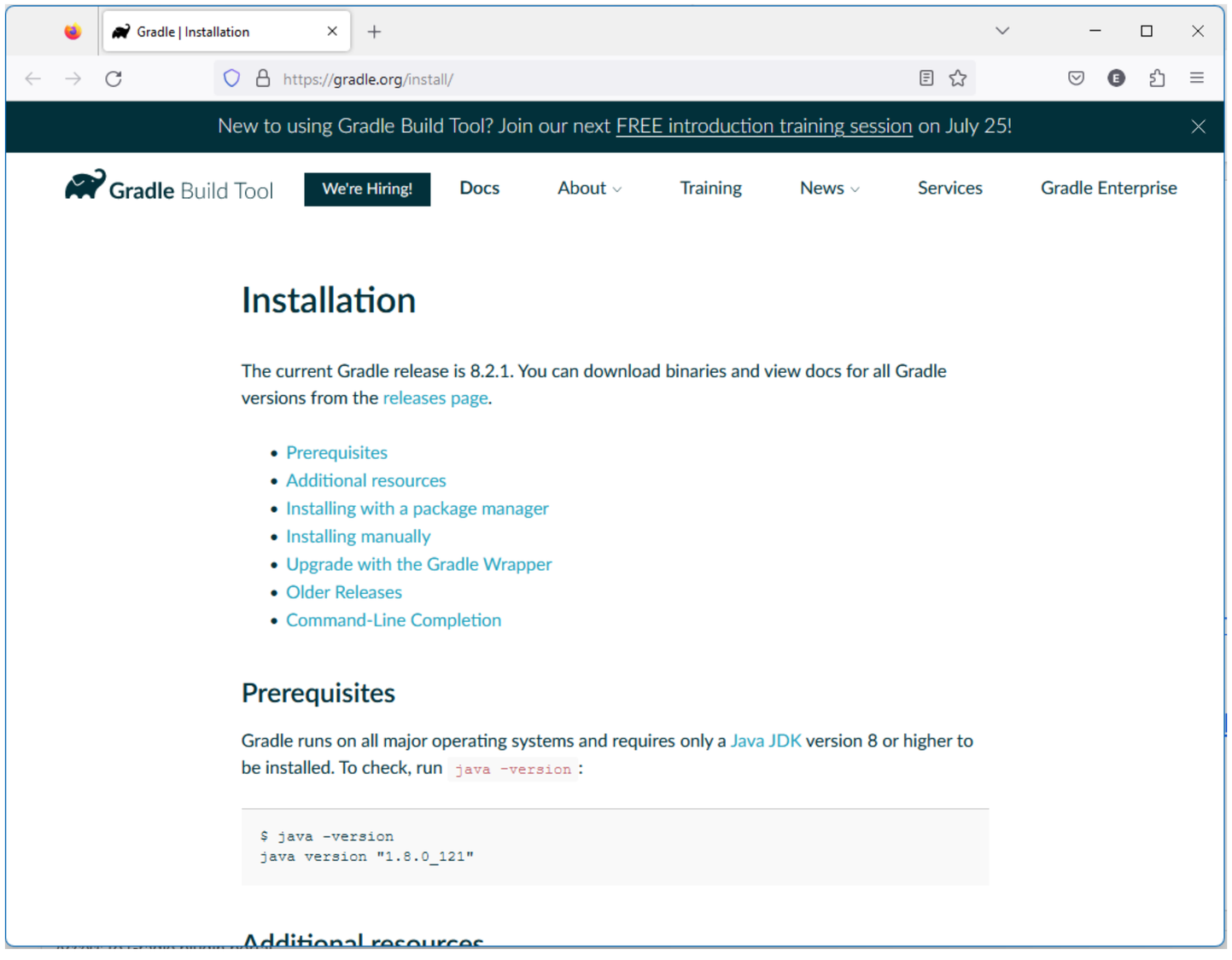
Gradle Build Tool – Installation -
https://gradle.org/install/



- Command line tool that builds the API requester deployable runtime artifact and the COBOL copybooks to invoke it
- It is the OpenAPI 3 equivalent of the z/OS Connect build toolkit for Swagger 2.0
- Not shipped as part of the SMP/E product
  - Hosted on Maven Central and Gradle Plugin Portal
  - Anyone can use it without purchasing z/OS Connect Unlimited
    - Uses “IBM International License Agreement for Non-Warranted Programs” IBM Terms

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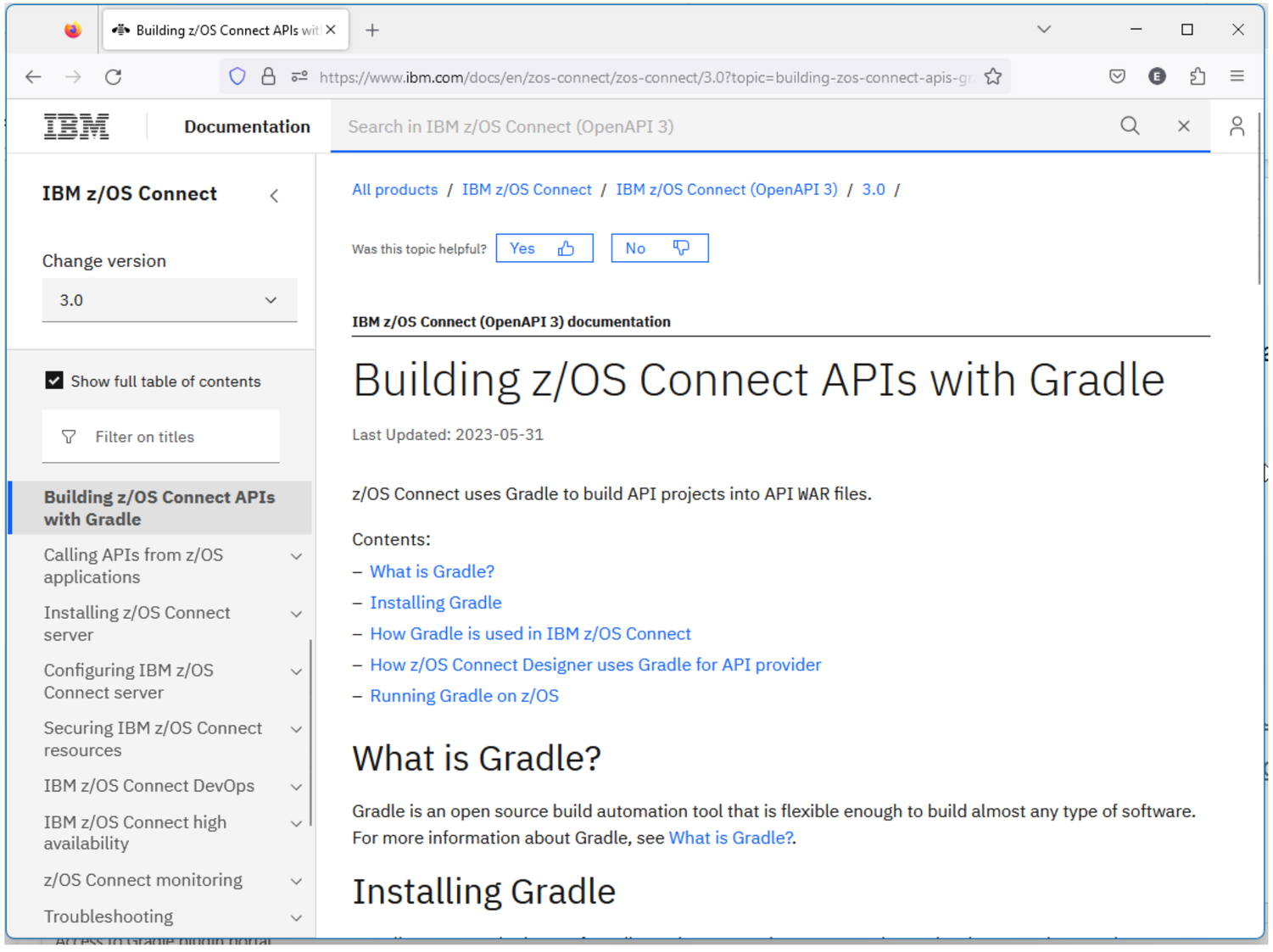
Building z/OS Connect APIs with Gradle - https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=building-zos-connect-apis-gradle



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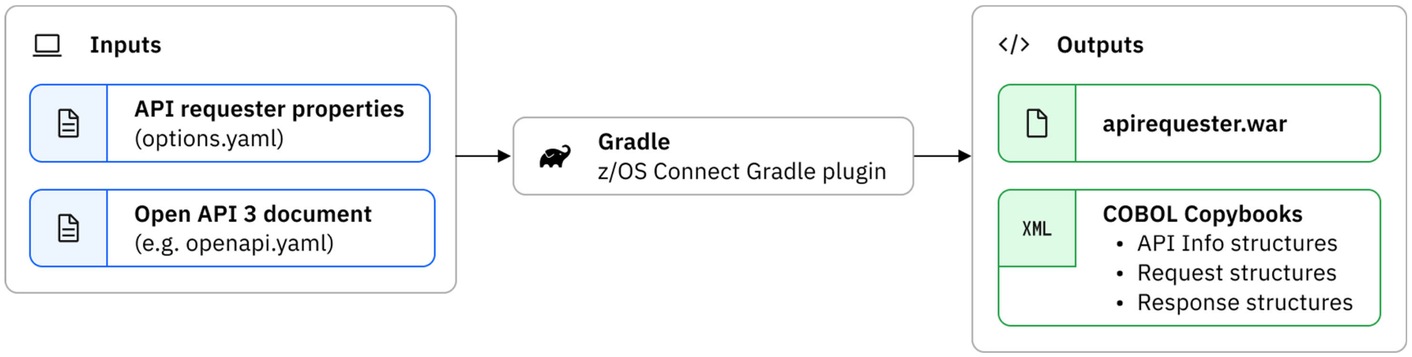
Use the Gradle plug-in to generate the artifacts

cscvinc.yaml

File Edit View

```
openapi: 3.0.0
info:
  description: "CICS Employee Sample VSAM Application"
  version: 1.0.0
  title: Employee
x-ibm-zcon-roles-allowed:
- Manager
paths:
  /employee:
    post:
      tags:
        - Employee
      operationId: postEmployeeInsertService
      parameters:
        - name: Authorization
          in: header
          required: false
          schema:
            type: string
      requestBody:
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/postEmployeeInsertService_request"
        description: request body
        required: true
      responses:
        "200":
          description: OK
```

Ln 12, Col 19 | 100% | Windows (CRLF) | UTF-8



Gradle plug-in properties and options#

```
apiKeyMaxLength=255
characterVarying=NO
Operations=getEmployeeSelectService
language=COBOL
connectionRef=cscvincAPI
requesterPrefix=csc
```

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

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Gradle plug-in options

options.yaml contains preferences for how

- The copybooks will be generated
- The API requester runtime will behave

language: **cobol**

- Only required property
- **apiRequesterLayout** task adds by default

Override context root and war filename

API endpoint connection

Only **required** property

Filter out the desired operations from the OpenAPI 3 document

New for OpenAPI 3

At what point to use data areas

When there is >1 media type, specify which to use

```
dgglwlrqdoSurshuwlhvVl}h
dslQdph
dslNh|Pd{Ohqjwk
dslNh|SdupQdphLqFrrnlh
dslNh|SdupQdphLqKhdghu
dslNh|SdupQdphLqTxhu|
fkdudfwhuPxowlsolhu
fkdudfwhuYdu|lqj
fkdudfwhuYdu|lqjOlplw
fkdudfwhuZklwhVsdfh
frqqhfwlrqUhi
gdwdWuxqfdwlrq
gdwhWlphIrupdw
ghidxowFkdudfwhuPd{Ohqjwk
ghidxowUhtxhvwPhgldW|sh
ghidxowUhvsrqvhPhgldW|sh
ghidxowIudfwlrqGljlwv
jhqhudwhgFrghSdjh
lqolqhPd{RffxuvOlplw
odqjxdjh
qdphWuxqfdwlrq
rshudwlrqv
uhtxhvwPhgldW|sh
uhtxhvwhuSuhil{
uhvsrqvhPhgldW|sh
uxqwlphFrghSdjh
zlghFrps6
```

[The API requester Gradle plug-in properties and options - IBM Documentation]

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Summary of API requester enhancements for OpenAPI 3

- **Data Areas** - When the OpenAPI 3 document has large unbounded arrays, Data Areas can be used to dynamically allocate the working storage that is required to access them. This reduces the memory requirements for the COBOL program and prevents large amounts of null data being transferred between the COBOL program and z/OS Connect.
- **Multiple Response Codes** - Operations defined in the OpenAPI 3 document that return multiple response codes are now supported. At runtime, the COBOL program can detect which HTTP response code was returned by the API endpoint and then access the Data Area that is associated with the response code.
- **SAF-based security** - API requester authorization is configured by using SAF EJBROLE profiles to define the SAF users and groups that have the authority to invoke the API requester.
- **Operation Filtering** - The API requester Gradle plug-in allows operation filtering so that only a subset of the operations in an OpenAPI 3 document is exposed to the calling COBOL program.
- **API endpoint response message change toleration** - An API requester WAR file does not need to be rebuilt if the remote API is updated to return more data fields. If fields are removed, the API requester WAR file must be rebuilt.
- **Multiple API requesters for an endpoint** - Multiple API requesters can be deployed to a single z/OS Connect server for a single API endpoint.

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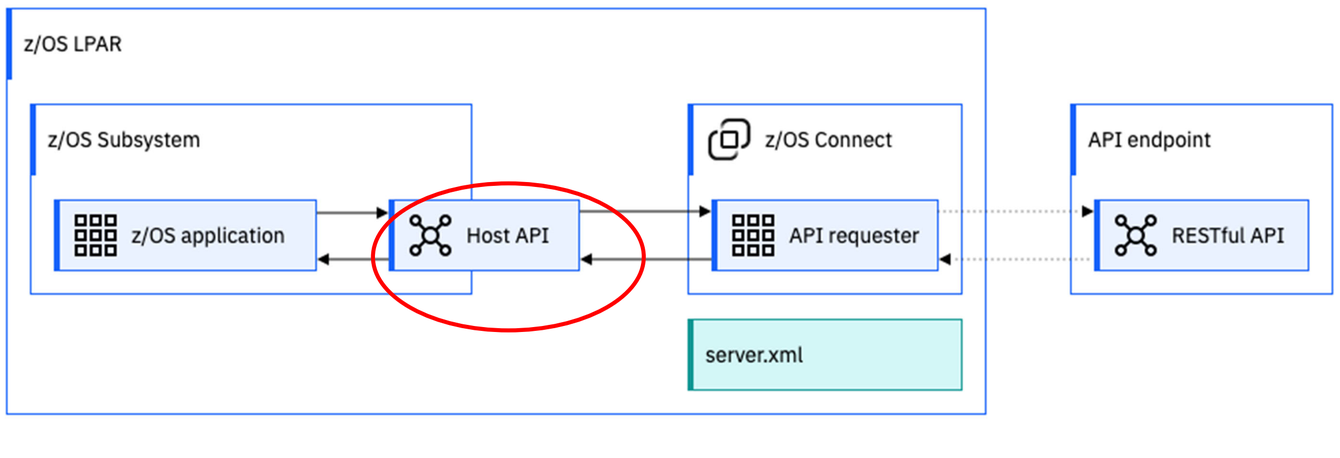
What are the major enhancements with OpenAPI 3 API requester support?

The major changes is that the applications uses multiple calls to a z/OS Connect server rather than a single call to a Swagger 2.0 communication stub. This change was implemented to address storage issues encountered with the Swagger 2.0 solution, to add the ability to handle multiple response messages and to add extended support for new OpenAP3 features. The APIs added for OpenAPI 3 support are collectively known as the **Host API** callable interface.



The Host API has an extended set of callable verbs to support the richer set of features available in the OpenAPI 3.0 specification. For example, the Host API supports receiving **multiple mapped HTTP response codes** and ***dynamically* sized arrays**.

- New function added support for an application to program to be able to handle different response message payloads depending on whether the HTTP status code is 200 (OK), 201 (CREATED), or 404 (NOTFOUND) for example. Each of the response payloads documented in the API's OpenAPI 3.0 definition are mapped to a different COBOL language structure.
- Also, the storage required for arrays in a response messages is no longer is contained in the application's program working storage section. Rather than reserving static storage to hold the entire contents of all arrays, the storage for a single entry of an array is defined in the application program's LINKAGE SECTION. Now the program processes individual array entries sequentially one at a time.
- To support these new features, a ***data area*** is used. Each dynamic array and each return response code message has its own data area. The data areas in the LINKAGE SECTION of program are updated by the HOST APIs and this provides access to the contents of response message and individual elements of an array.

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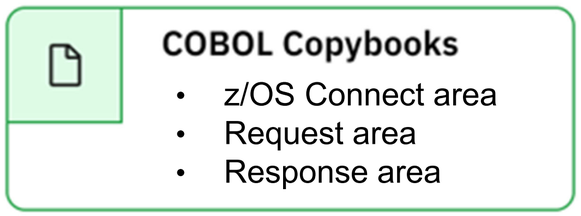
The OpenAPI3 COBOL copybooks

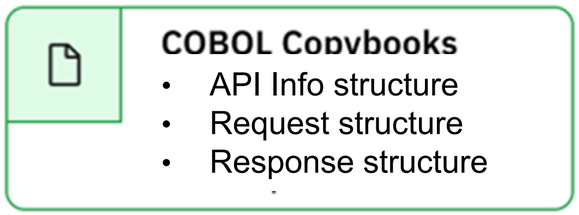
z/OS Connect provides two types of copybooks that are required to interface with the Host API and tooling to generate application specific copybooks

1. z/OS Connect provided static structures



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

2. Generated dynamic structures



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

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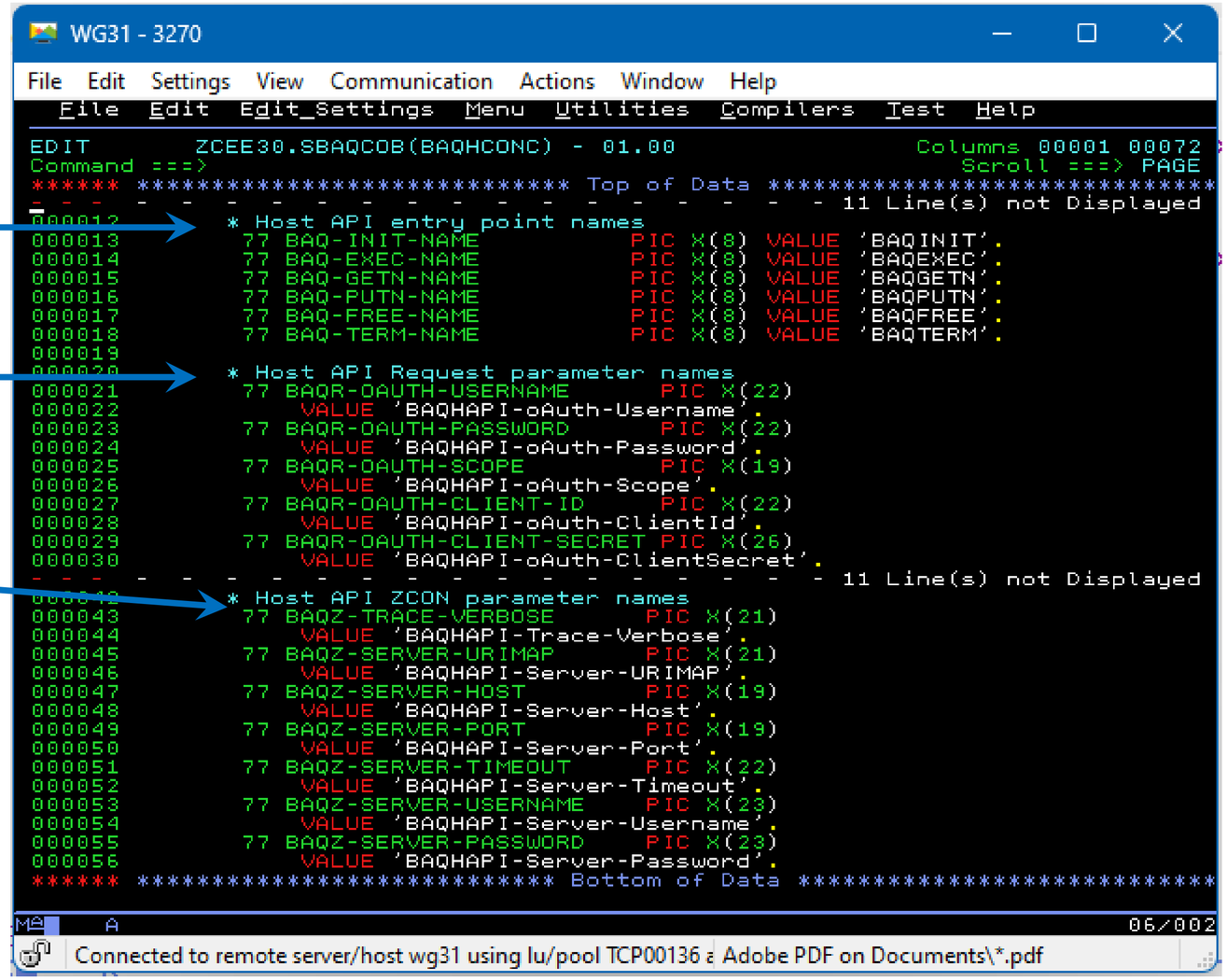
BAQHCONC copy book

Product provided constants for convenience

- Host API entry point names for dynamic calling
- Host API Request specific parameters – are relevant to invoking the API
- Host API z/OS Connect parameters – are relevant to the connection to the z/OS API requester server.



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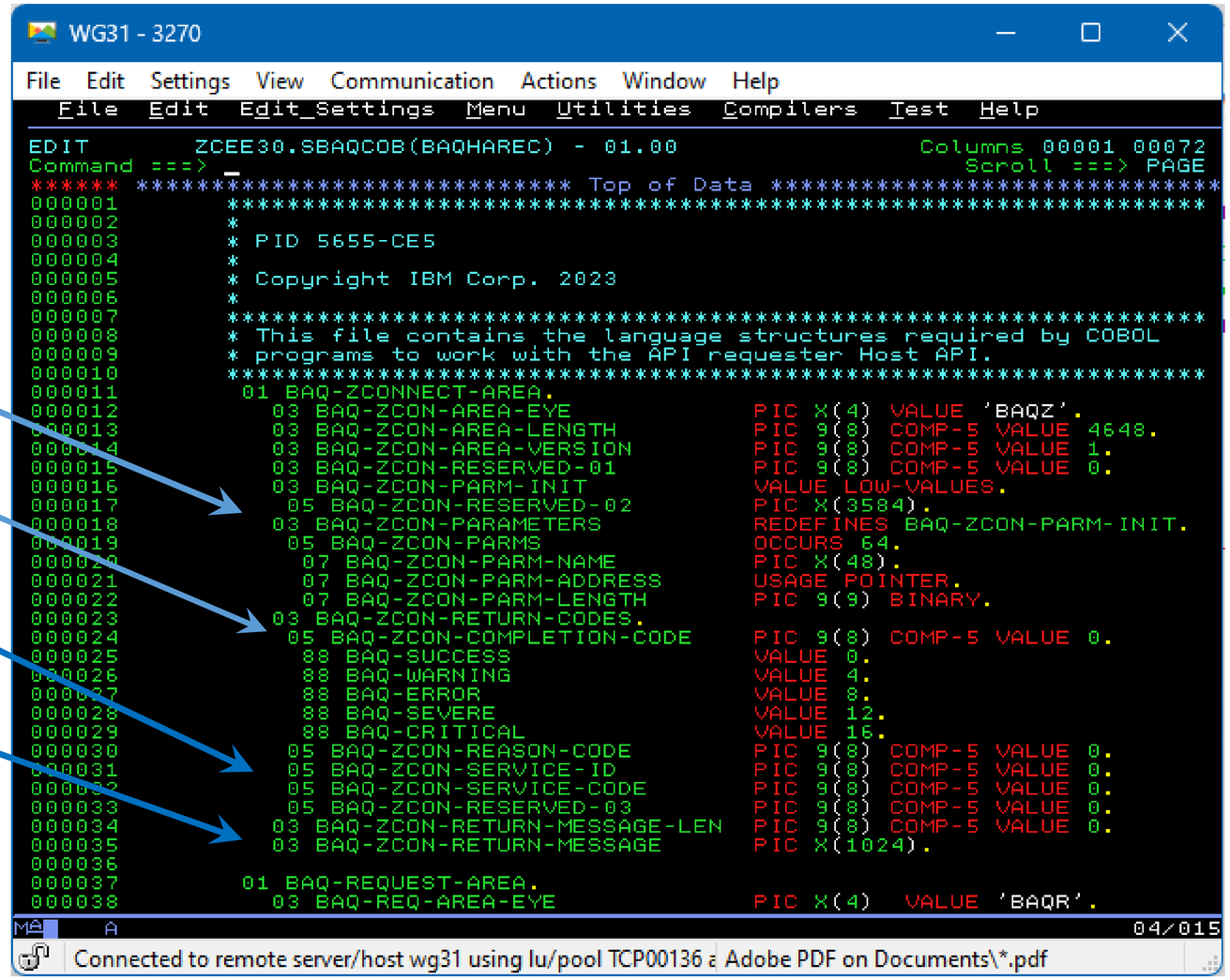
BAQHAREC copy book

BAQ-ZCONNECT-AREA

Input & Output interface for all Host API verbs

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



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BAQHAREC - BAQ-ZCONNECT_AREA

The BAQ-ZCON-PARMS array

```
EDIT       ZCEE30.SBAQCOB(BAQHAREC) - 01.00            Columns 00001 00072
Command ===> _                                          Scroll ===> PAGE
****** ***************************** Top of Data ********************************
000001         ******************************************************************
000002         *
000003         * PID 5655-CE5
000004         *
000005         * Copyright IBM Corp. 2023
000006         *
000007         ******************************************************************
000008         * This file contains the language structures required by COBOL
000009         * programs to work with the API requester Host API.
000010         ******************************************************************
000011          01 BAQ-ZCONNECT-AREA.
000012            03 BAQ-ZCON-AREA-EYE          PIC X(4)  VALUE 'BAQZ'.
000013            03 BAQ-ZCON-AREA-LENGTH       PIC 9(8)  COMP-5 VALUE 4648.
000014            03 BAQ-ZCON-AREA-VERSION      PIC 9(8)  COMP-5 VALUE 1.
000015            03 BAQ-ZCON-RESERVED-01       PIC 9(8)  COMP-5 VALUE 0.
000016            03 BAQ-ZCON-PARM-INIT         VALUE LOW-VALUES.
000017             05 BAQ-ZCON-RESERVED-02      PIC X(3584).
000018            03 BAQ-ZCON-PARAMETERS        REDEFINES BAQ-ZCON-PARM-INIT.
000019             05 BAQ-ZCON-PARMS            OCCURS 64.
000020              07 BAQ-ZCON-PARM-NAME       PIC X(48).
000021              07 BAQ-ZCON-PARM-ADDRESS    USAGE POINTER.
000022              07 BAQ-ZCON-PARM-LENGTH     PIC 9(9) BINARY.
000023            03 BAQ-ZCON-RETURN-CODES.
000024             05 BAQ-ZCON-COMPLETION-CODE  PIC 9(8) COMP-5 VALUE 0.
000025              88 BAQ-SUCCESS              VALUE 0.
000026              88 BAQ-WARNING              VALUE 4.
000027              88 BAQ-ERROR                VALUE 8.
000028              88 BAQ-SEVERE               VALUE 12.
000029              88 BAQ-CRITICAL             VALUE 16.
000030             05 BAQ-ZCON-REASON-CODE      PIC 9(8) COMP-5 VALUE 0.
000031             05 BAQ-ZCON-SERVICE-ID       PIC 9(8) COMP-5 VALUE 0.
000032             05 BAQ-ZCON-SERVICE-CODE     PIC 9(8) COMP-5 VALUE 0.
000033             05 BAQ-ZCON-RESERVED-03      PIC 9(8) COMP-5 VALUE 0.
000034            03 BAQ-ZCON-RETURN-MESSAGE-LEN PIC 9(8) COMP-5 VALUE 0.
000035            03 BAQ-ZCON-RETURN-MESSAGE    PIC X(1024).
000036
000037          01 BAQ-REQUEST-AREA.
000038            03 BAQ-REQ-AREA-EYE           PIC X(4)  VALUE 'BAQR'.
MA    A                                                          04/015
```

Connected to remote server/host wg31 using lu/pool TCP00136 a Adobe PDF on Documents*.pdf

Providing credentials for basic authentication

```
EDIT       JOHNSON.ZCEE.SOURCE(BAQZUSER) - 01.00          Columns 00001 00072
Command ===>                                              Scroll ===> PAGE
****** ***************************** Top of Data ********************************
000001          * User credentials for basic authentication
000002           01 MY-USER PIC X(10) VALUE 'myUsername'.
000003           01 MY-PSWD PIC X(10) VALUE 'myPassword'.
000004           PROCEDURE DIVISION.
000005         ...
000006          * Set user credentials
000007                MOVE BAQZ-SERVER-USERNAME
000008                  TO BAQ-ZCON-PARM-NAME OF BAQ-ZCON-PARMS(1)
000009                SET BAQ-ZCON-PARM-ADDRESS OF BAQ-ZCON-PARMS(1)
000010                  TO ADDRESS OF MY-USER
000011                MOVE LENGTH OF MY-USER
000012                  TO BAQ-ZCON-PARM-LENGTH OF BAQ-ZCON-PARMS(1)
000013                MOVE BAQZ-SERVER-PASSWORD
000014                  TO BAQ-ZCON-PARM-NAME OF BAQ-ZCON-PARMS(2)
000015                SET BAQ-ZCON-PARM-ADDRESS OF BAQ-ZCON-PARMS(2)
000016                  TO ADDRESS OF MY-PSWD
000017                MOVE LENGTH OF MY-PSWD
000018                  TO BAQ-ZCON-PARM-LENGTH OF BAQ-ZCON-PARMS(2).
000019          * Make the BAQINIT call
****** ***************************** Bottom of Data *****************************
```

Overriding the URIMAP value

```
EDIT       JOHNSON.ZCEE.SOURCE(BAQZUSER) - 01.01          Columns 00001 00072
Command ===>                                              Scroll ===> PAGE
****** ***************************** Top of Data ********************************
000001          IDENTIFICATION DIVISION.
000002          WORKING-STORAGE SECTION.
000003          01 WS-DYNAMIC-URIMAP PIC X(8) VALUE 'MYURIMAP'.
000004          PROCEDURE DIVISION.
000005 ...
000006 ...
000007        ***
000008              MOVE BAQZ-SERVER-URIMAP TO
000009                BAQ-ZCON-PARM-NAME OF BAQ-ZCON-PARMS(1).
000010              SET BAQ-ZCON-PARM-ADDRESS OF BAQ-ZCON-PARMS(1) TO
000011                ADDRESS OF WS-DYNAMIC-URIMAP.
000012              MOVE LENGTH OF WS-DYNAMIC-URIMAP TO
000013                BAQ-ZCON-PARM-LENGTH OF BAQ-ZCON-PARMS(1).
000014 ...
****** ***************************** Bottom of Data *****************************
```

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BAQHAREC – BAQ-REQUEST-AREA/BAQ-RESPONSE-AREA

BAQ-REQUEST-AREA

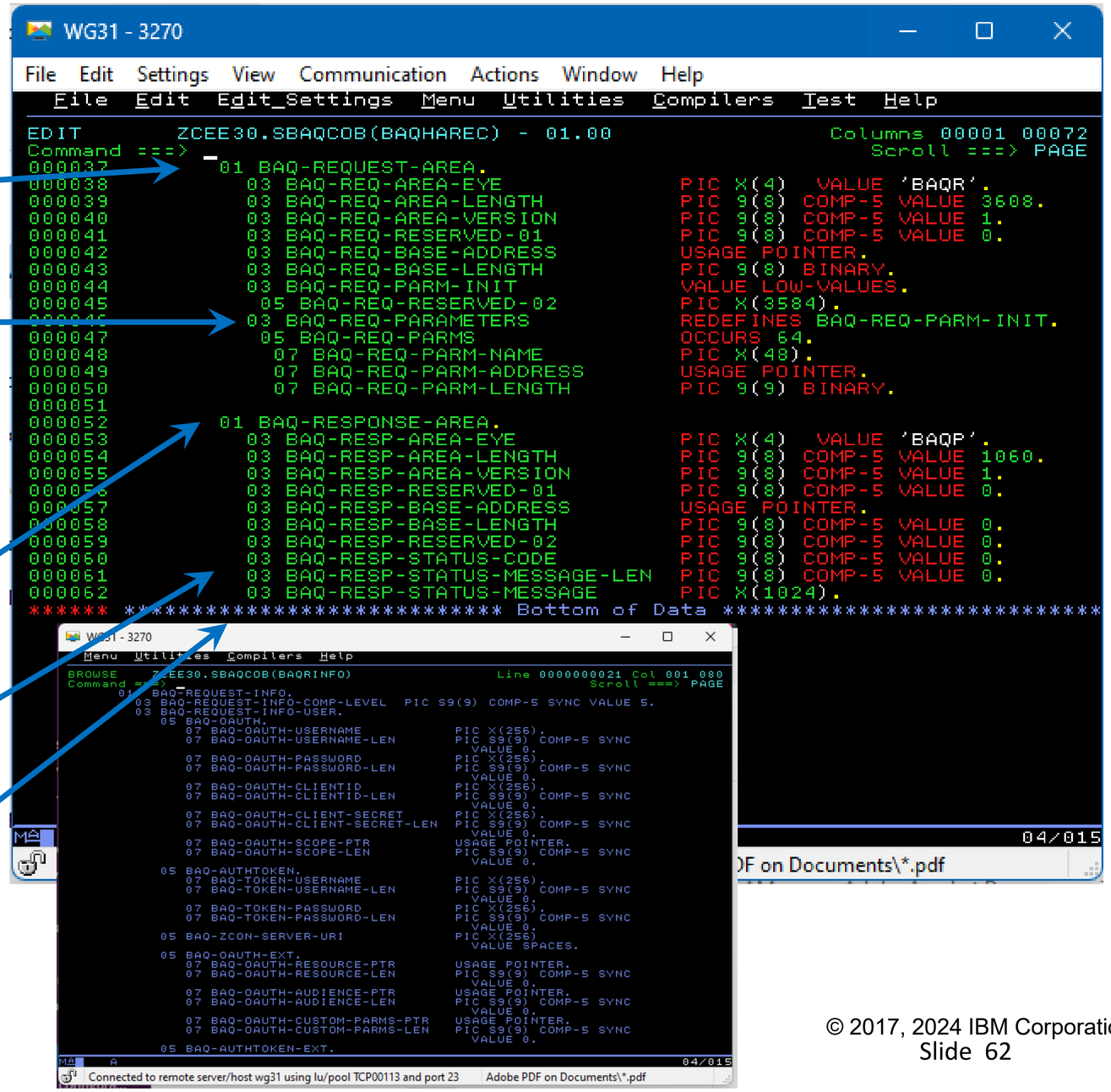
Input to the BAQEXEC for an API call

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

BAQ-RESPONSE-AREA

Output from the BAQEXEC call

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



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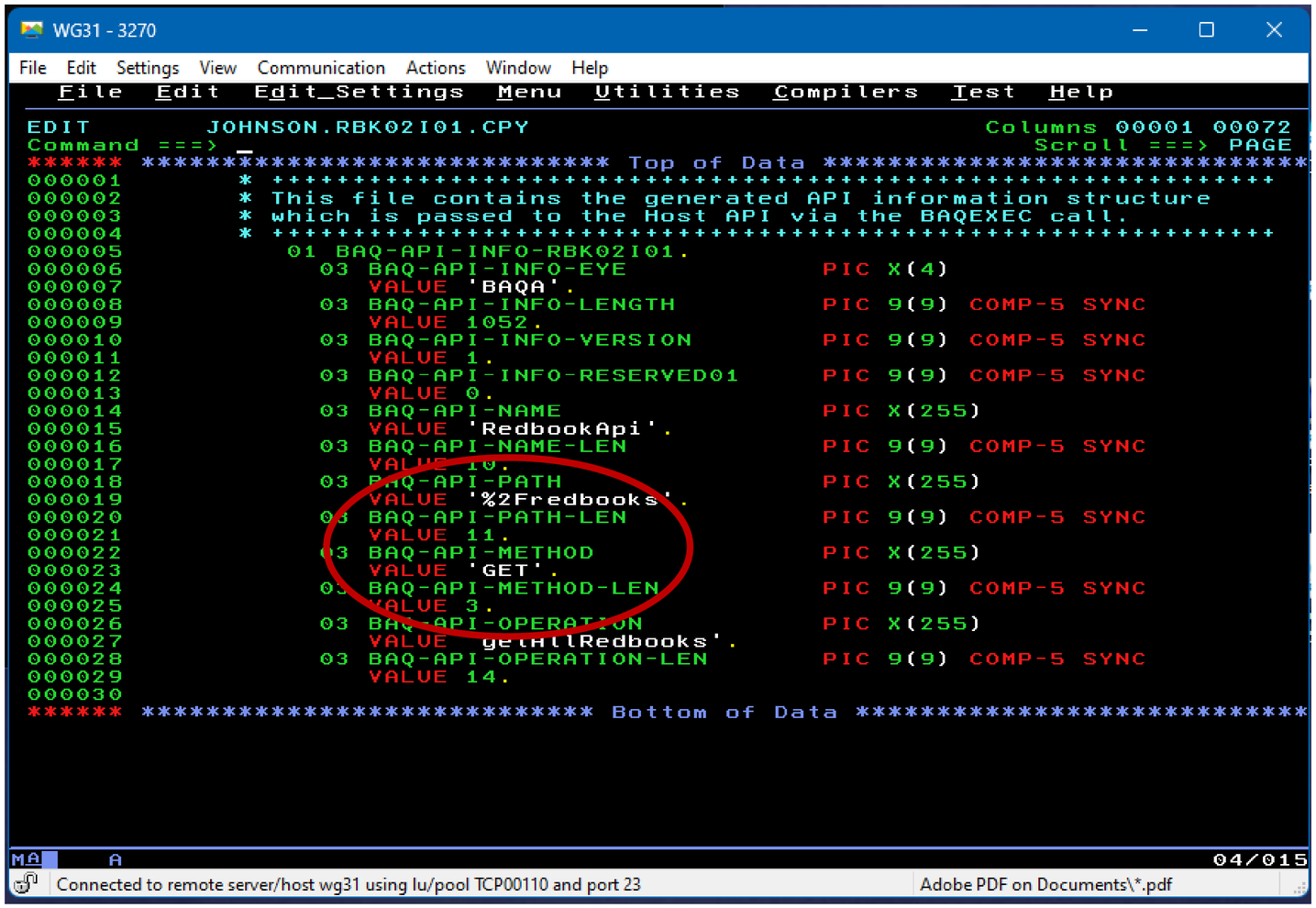
The generated API information (“I”) copybook

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



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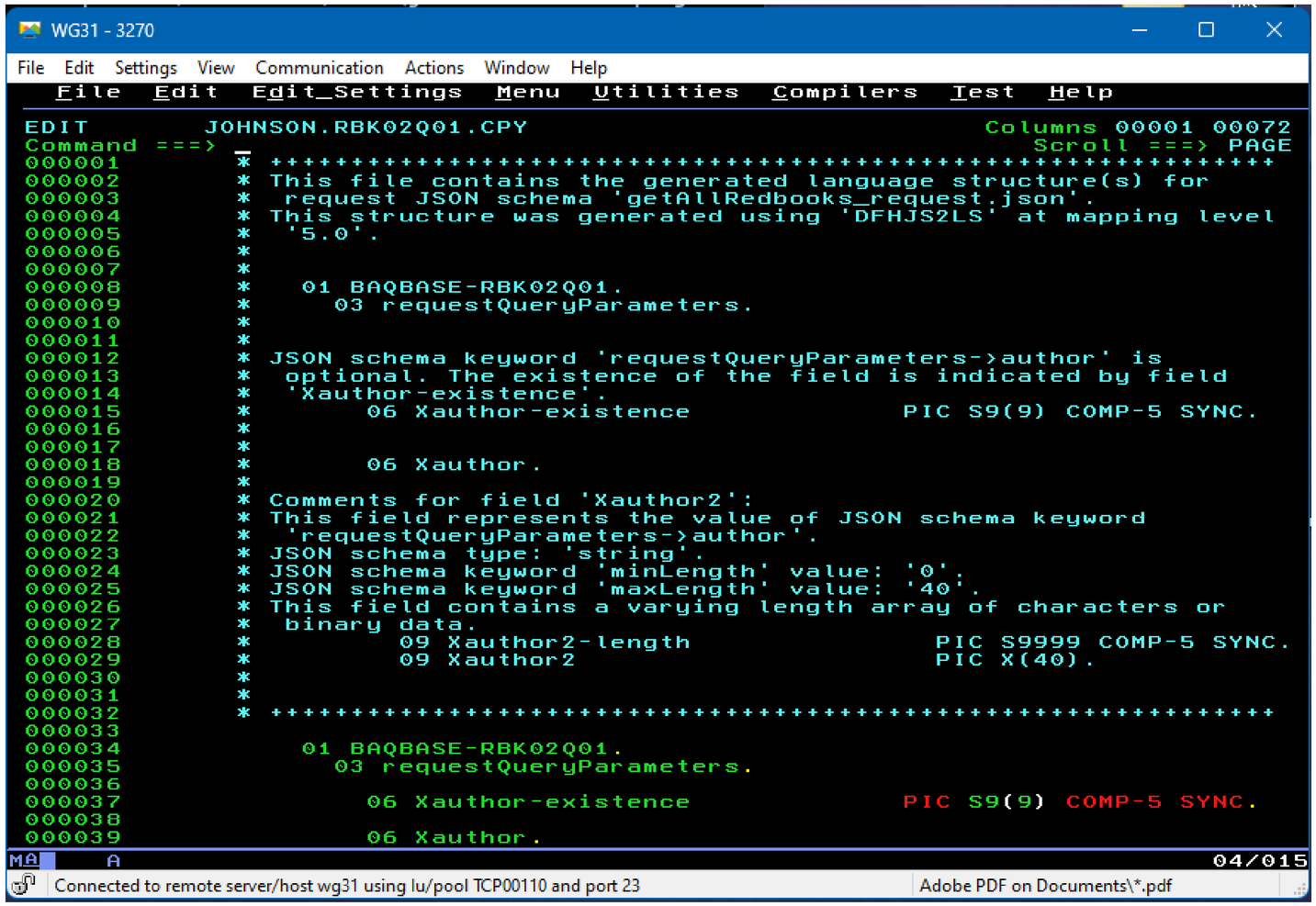
Generated Request message (“Q”) copybook

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

```
INITIALIZE BAQBASE-RBK02Q01.
```



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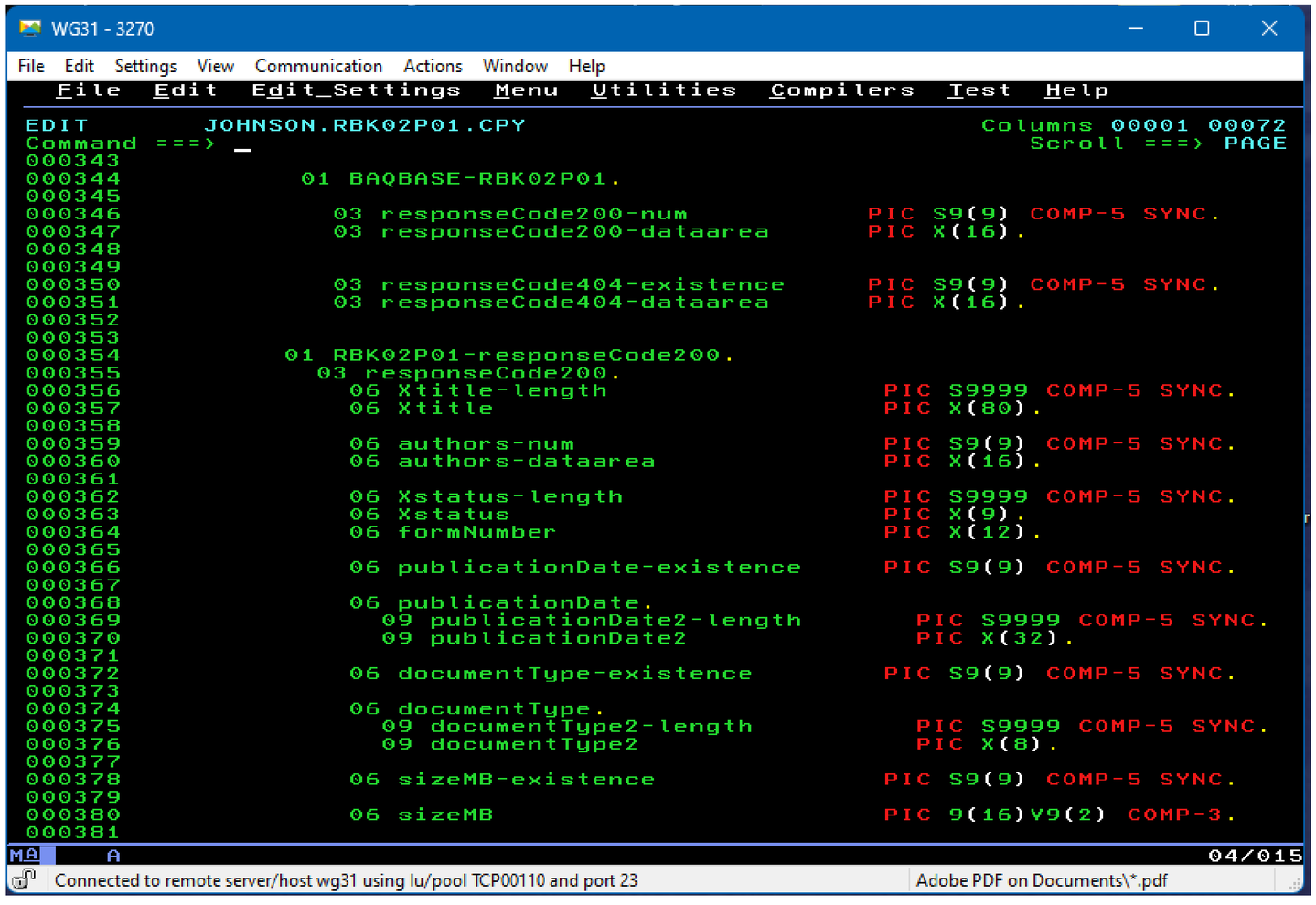
Generated Response message (“P”) copybook

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



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The generated response(“R”) copy book

- The Gradle build process creates a response message copybook for each of the API’s operations. In each response message copybook, there is a level 01 COBOL structures for each operation’s potential types of response status codes. The names of these structures are in the format ***copybookName*-reponseCode###** where ### is the API’s defined response code, e.g., 200, 4XX, or Def (default).

- Also in each response message copybook is a level 01 COBOL structure named **BAQBASE-*copybookName*.** In this structure, there are two 03 level variables for each of the possible response messages, the names of these variables are in the format ***responseCode###*-dataarea** and ***responseCode###*-num** *or* ***responseCode###*-dataarea** and **responseCode###-existence.**
  - The **responseCode###-dataarea** variable contains a token that is used by the runtime to track and/or manage of the data areas holding the response results. The returned data areas are not in the program’s working storage area but are addressable from the LINKAGE section.
  - If the JSON property was an *array,* then the variable name is appended with ***-num*** and the value of this variable provides the number of occurrences or array entries of this array, including 0. If the JSON variable was an *Object* type, then the variable name is appended with ***-existence*** and this variable contains either 0 or 1 to specify whether an object was returned in the response.

- Each ***copybookName*-reponseCode###** 01 level COBOL structure contains a variable for each JSON response property in the API’s specification.
  - Some of the variables in these structure are the format ***variableName*-dataarea** and ***variableName*-num** or ***variableName*-existence.** The variable names with these extensions have the same usage as describe above.
  - String JSON properties that are not constrained by their minimum length equal to their maximum length are preceded by variables that contain the value that contain the actual length of the string. These variable names are in the format ***variableName*-length**.
  - Numeric fields appear as expected.

- Other 01 level COBOL structures are generated in the response copybook for each for each array that occurs in the response.

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The z/OS Connect Host API Verbs

BAQINIT

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

BAQEXEC

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

BAQGETN

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

BAQFREE

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

BAQTERM

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

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Host API Verbs – initialize(BAQINIT) & execute (BAQEXEC)

BAQ base structure in the response copy book

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

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

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

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

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

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

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

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

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

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

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Host API Verbs – get next array entry(BAQGETN)

Structure for HTTP 200 response

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

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

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

4. Prepare the length and get the address of the next element from the Data Area
5. Use this address to access the Data Area element

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

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

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

6. Process the data in the Data Area element

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

  PERFORM WRITE-RESPONSE-MSG.
```

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Host API Verbs – free storage(BAQFREE) & terminate(BAQTERM)

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

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

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

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

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Host API Completion Codes

0000 - 1999

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

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

2000 - 2999

- Host API messages
  - More details on the next slide

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

3000 - 3999

- Host API running in CICS
  - CICS specific messages

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

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Host API Completion and Reason Codes

- 2000 - 2999

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

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

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

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

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

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

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Configuration and Security Considerations

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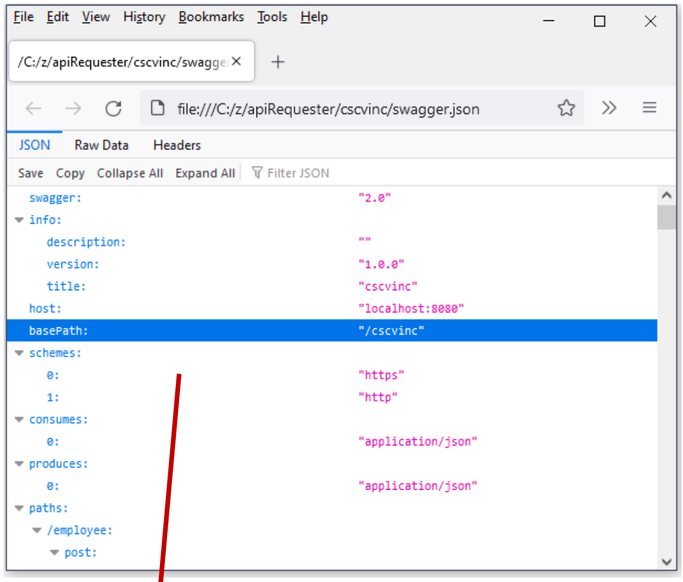
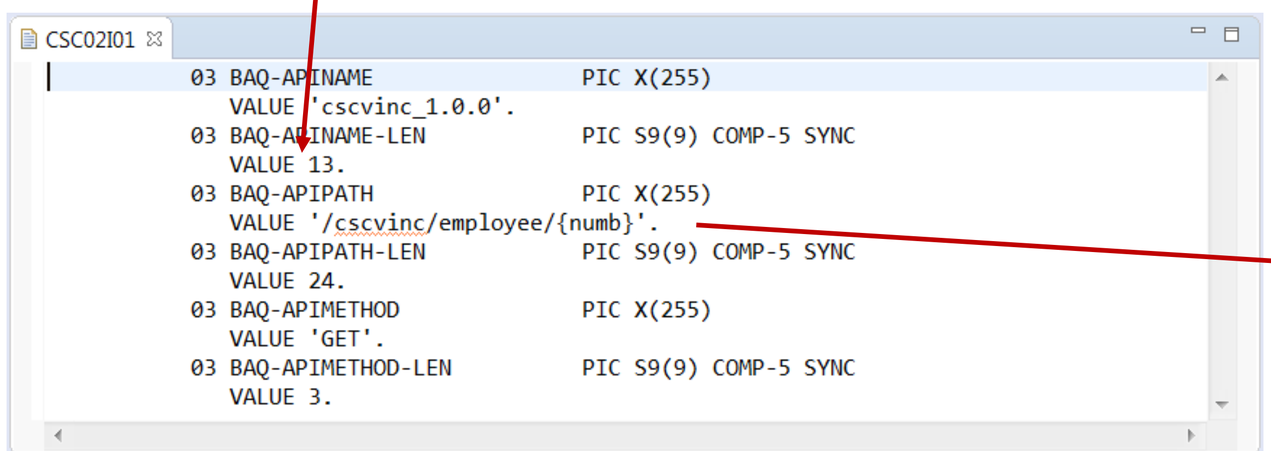
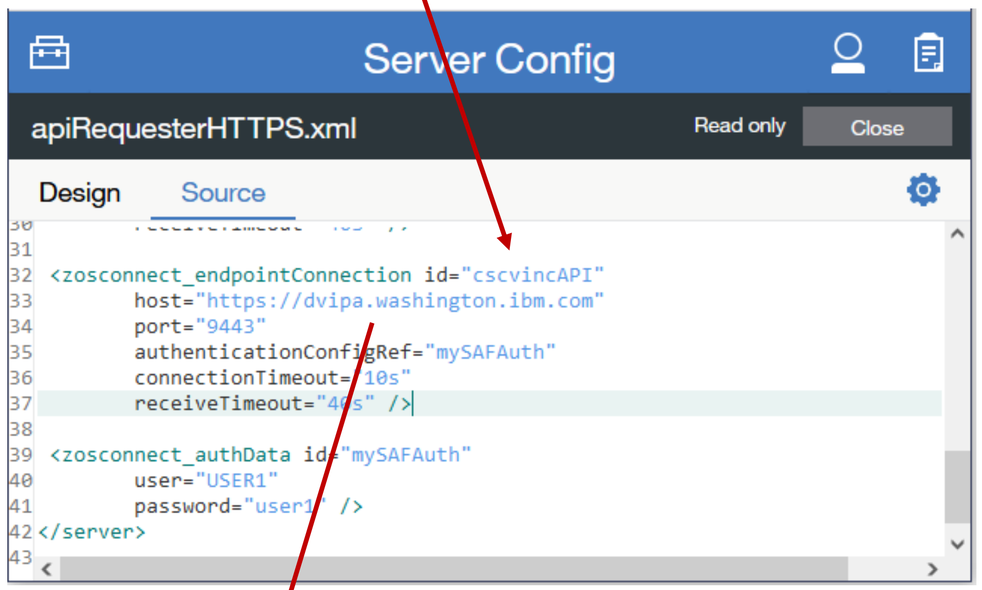
Resolving the endpoint's URL

An administrator configures the *endpointConnection* providing the host and port of the URL and required security details.





cscvinc.properties
`connectionRef=cscvincAPI`



http://dvipa.washington.ibm.com:9443/cscvincapi/employee/{numb}

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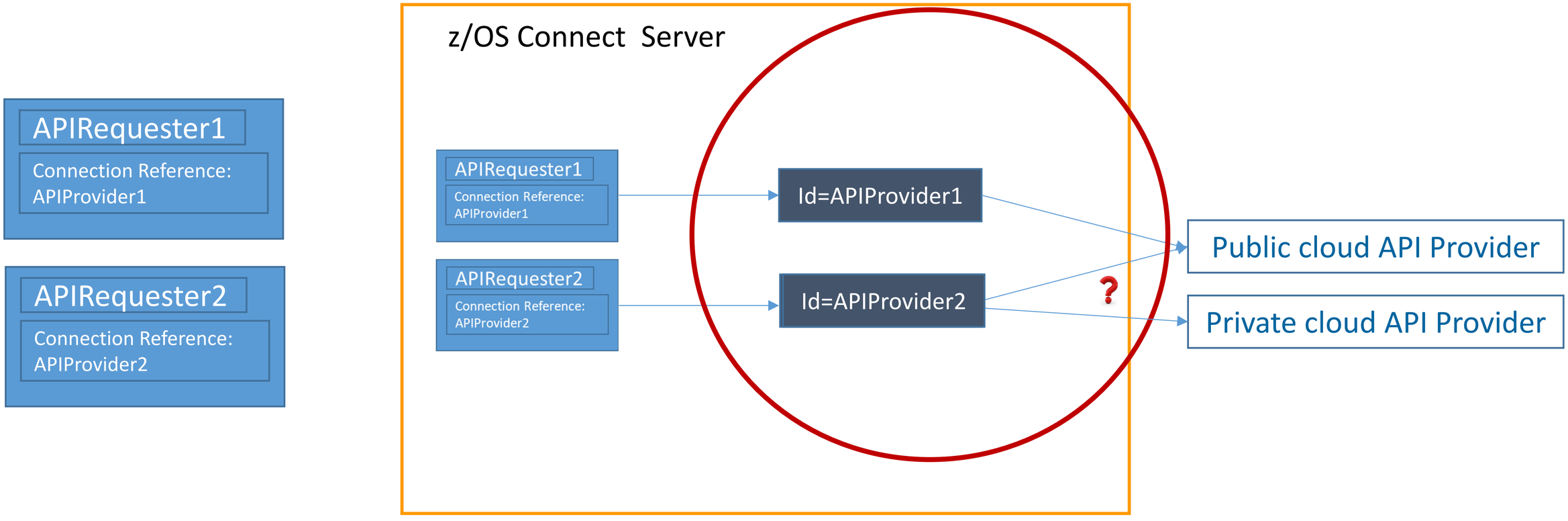
Tech-Tip: Use naming conventions for connection references

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




```
 <zosconnect_apiRequesters>
     requireAuth="true|false"
     <apiRequester name="cscvincapi_1.0.0"
         connectionRef="APIProvider2"
</zosconnect_apiRequesters>
```

```
<webApplication location="${server.config.dir}/apps/cscvincapi-1.0.0.war">
   <appProperties> <property name="connectionRef" value="APIProvider2"/>
   </appProperties>
</webApplication>
```

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Now let’s explore the security options for outbound API Requester connections and accessing remote resources

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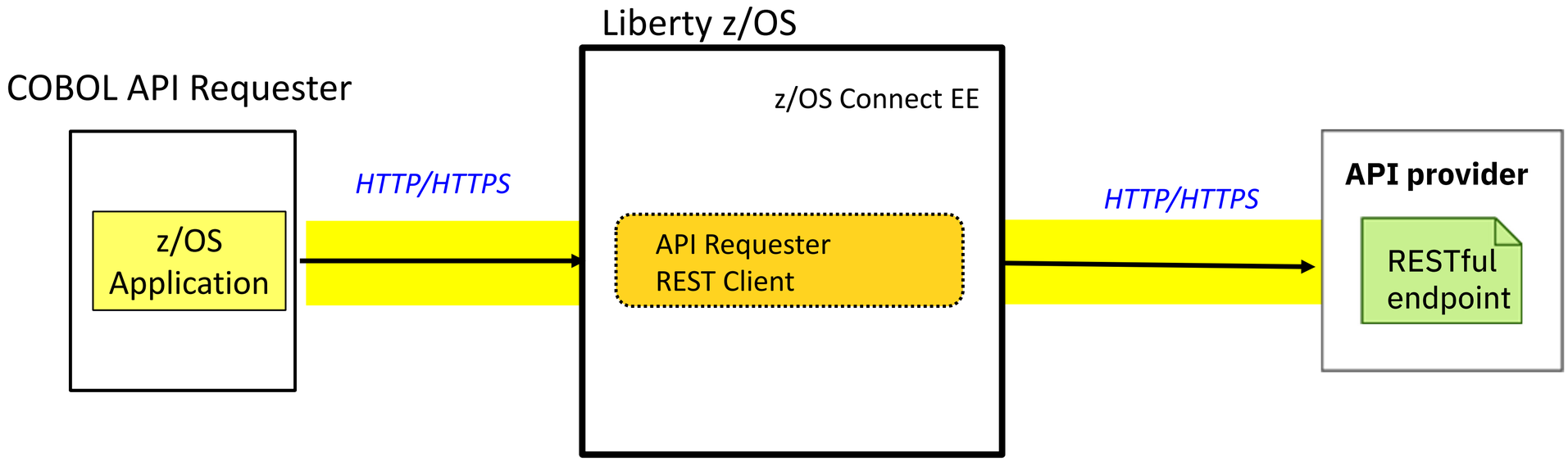
End to end API requester to API Provider connection overview



MVS Batch, IMS HTTP and Db2 stored procedure connection details provided by:

- Environment Variables (BAQURI, BAQPORT)
  - Via JCL
  - LE Options (CEEROPTS)
  - Programmatically (CEEENV)
- HTTP or HTTPS

CICS HTTP connection details provided by:

- CICS URIMAP resource (default BAQURIMP)
  - HOST
  - PORT
  - SCHEME (HTTP/HTTPS)

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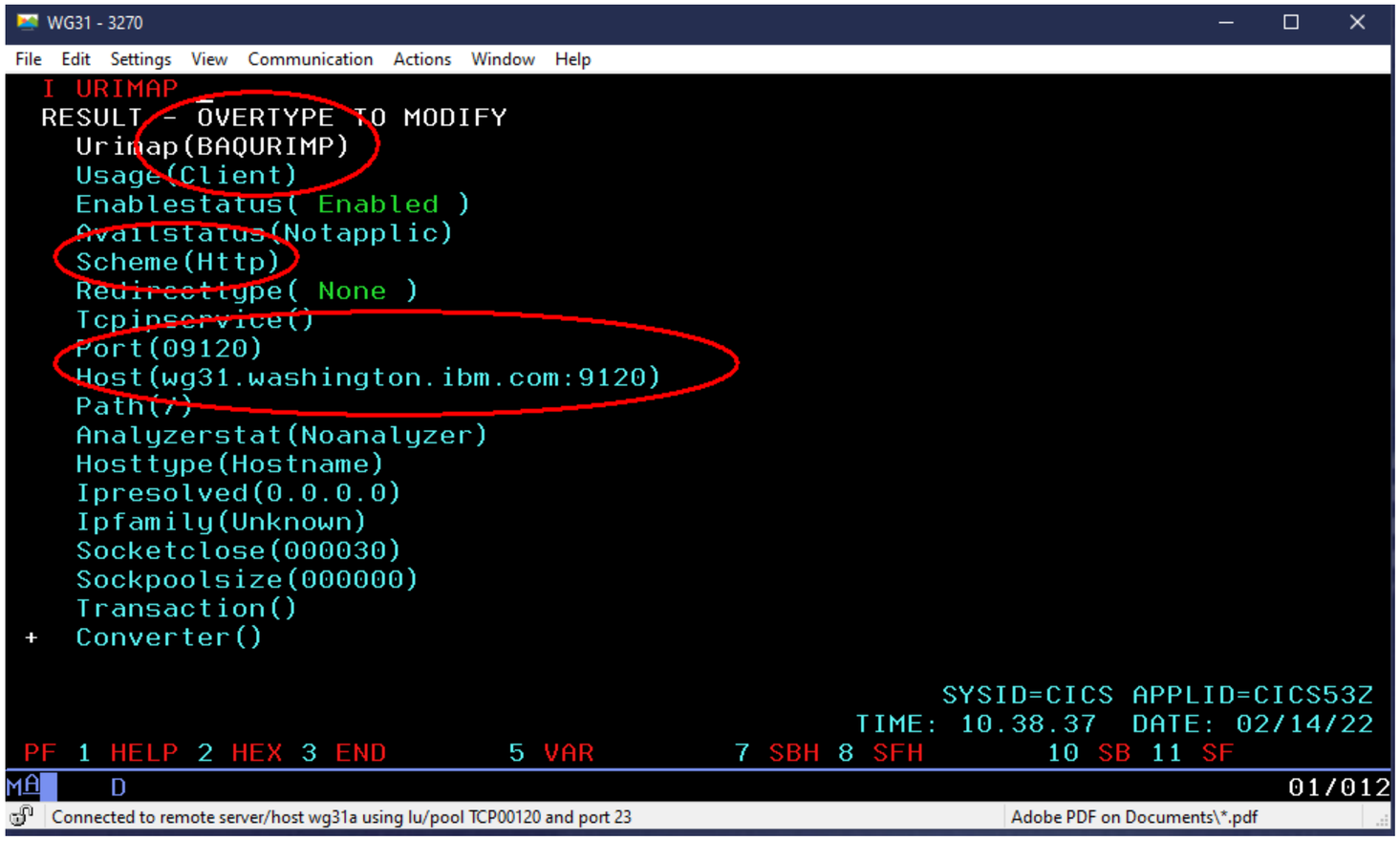
Configuring connections to the z/OS API requester server

Default CICS URI MAP*



LE Environment Variables

```
//DELTAPI EXEC PGM=DELTAPI,PARM='323232'
//STEPLIB  DD DISP=SHR,DSN=USER1.ZCEE.LOADLIB
//         DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//SYSOUT   DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//CEEOPTS  DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9120")
```

* V3.0.37 added support for a CICS application to specify or request a specific URIMAP resource the using BAQ-ZCON-SERVER-URI variable in BAQRINFO

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Environment variables for non-CICS clients

Use these runtime environment variables when connecting to a z/OS Connect server

BAQPASSWORD - Specifies the password, in clear text, for the specified BAQUSERNAME to be authenticated with the z/OS Connect server. The username and password that are used for basic authentication, when SSL mutual authentication is not enabled.

BAQPORT - Specifies the port number for the z/OS Connect server.

BAQTIMEOUT - An optional 4-byte integer to set a timeout value in seconds for waiting for an API response. Valid range is 1 - 2,678,400 seconds. The default timeout value is 10 seconds.

BAQURI - Specifies either an IPv4 or IPV6 address, or a hostname of the host where the z/OS Connect server resides.

BAQUSERNAME - Specifies the username for connections if basic authentication is used.

BAQVERBOSE - An optional value to turn on verbose messages to assist debugging of runtime and configuration issues. Valid values are **OFF**, **ON**, **ERROR**, **AUDIT** and **ALL**. See URL https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=car-configuring-other-zos-applications-access-zos-connect-api-calls for more information.

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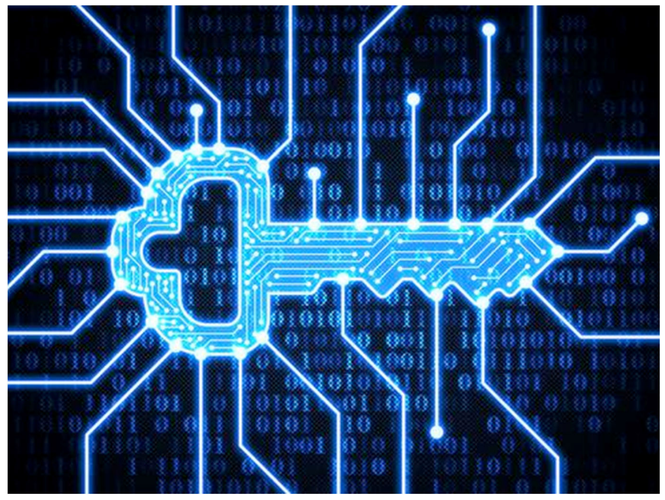
General security terms or considerations

Security involves

- Identifying who or what is requesting access (**Authentication)**
  - Basic Authentication
  - Mutual Authentication using Transport Layer Security (TLS), formerly known as SSL
  - Third Party Tokens

- Ensuring that the message has not been altered in transit (**Data Integrity)** and ensuring the confidentiality of the message in transit (**Encryption)**
  - TLS (encrypting messages and using a digital signature)

- Controlling access (**Authorization)**
  - Is the authenticated identity authorized to access to z/OS Connect
  - Is the authenticated identity authorized to access a specific API, Services, etc.



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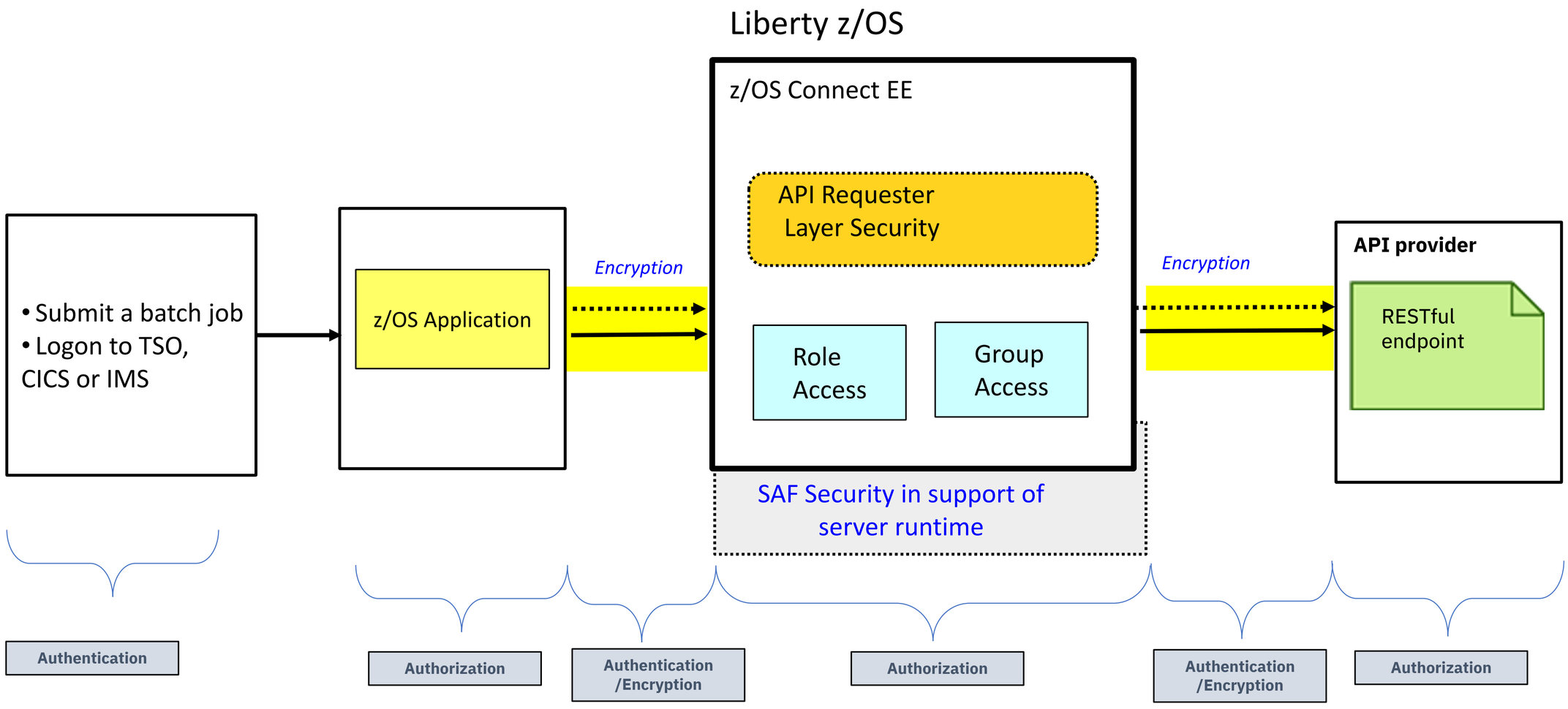
Outbound Authentication versus Authorization (Swagger 2.0)



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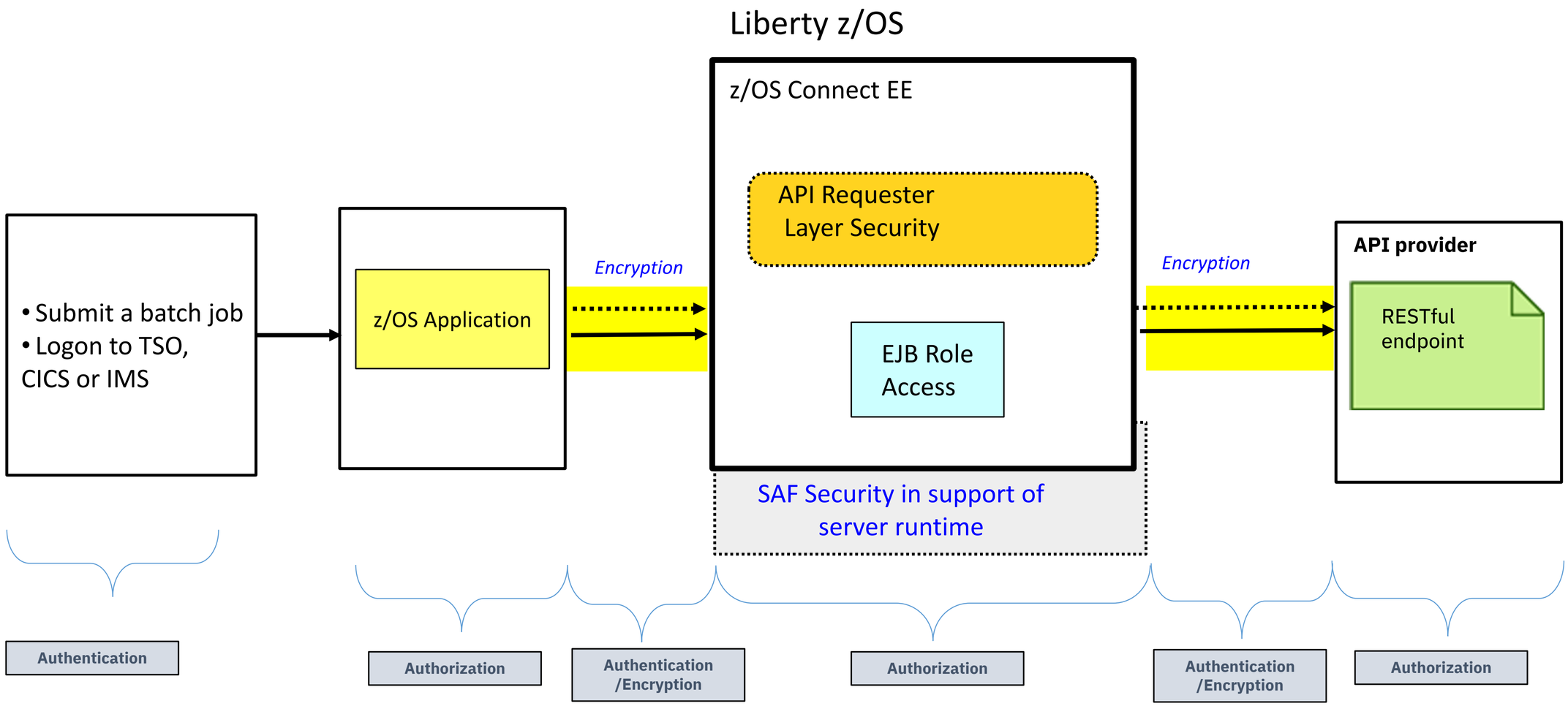
Outbound Authentication versus Authorization (OpenAPI 3)



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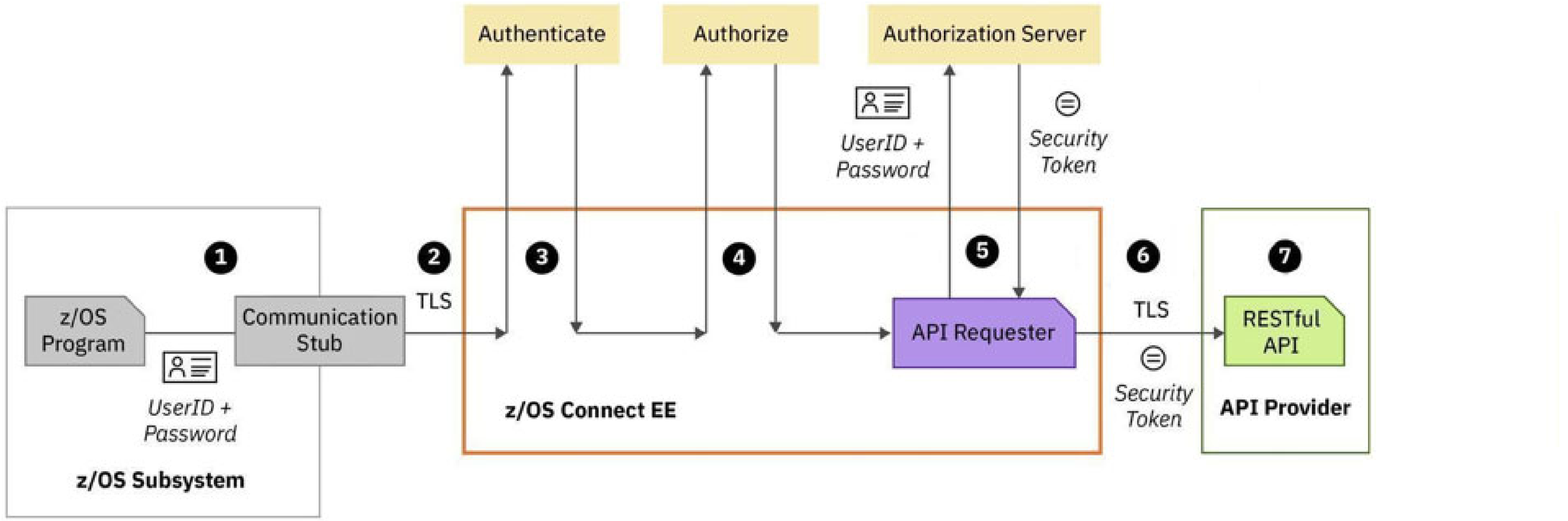
Typical z/OS Connect EE API Requester security flow



1. A user ID and password can be used for basic authentication by the z/OS Connect EE server
2. Connection between the CICS, IMS, or z/OS application and the z/OS Connect EE server can use TLS
3. Authenticate the CICS, IMS, or z/OS application.
4. Authorize the authenticated user ID to connect to z/OS Connect EE and to perform specific actions on z/OS Connect EE API requesters
5. Pass the user ID and password credentials to an authorization server to obtain a security token.
6. Secure the connection to the remote API provider, and provide security credentials such as a security token to be used to invoke the RESTful API
7. The RESTful API runs in the remote API provider

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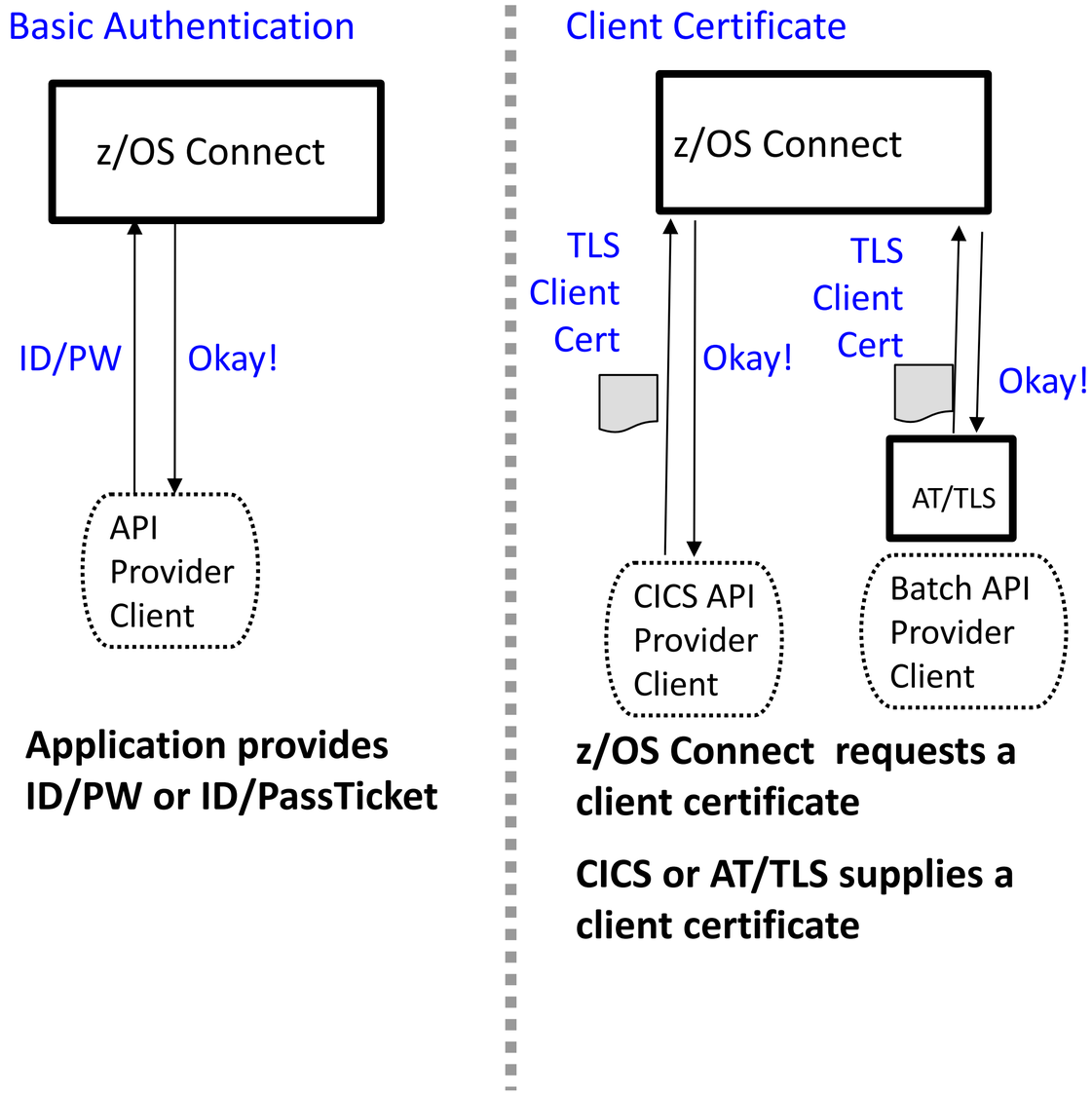
API Requester – Security from the application to the z/OS Connect server

Two options for providing credentials for authentication



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Basic authentication – non-CICS COBOL API Requester

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

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

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

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

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

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

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Tech/Tip: A PassTicket provides an alternative to a password

- A PassTicket is generated by or for a client by using a secured sign-on key (whose value is masked or encrypted) to encrypt a valid *RACF identity* combined with the *application name* of the targeted resource. Also embedded in the PassTicket is a time stamp (based on the current Universal Coordinated Time (UCT)) which sets the time when the PassTicket will expire (usually 10 minutes).

- Access to PassTickets is managed using the RACF PTKTDATA class.

- For z/OS Connect, a RACF PassTicket can be used for basic authentication when connecting from any REST client on any platform to a z/OS Liberty server and for requests from a z/OS Connect server accessing IMS and Db2.

- ***PassTickets do not have to be generated on z/OS using RACF services.*** IBM has published the algorithm used to generate a PassTickets, see manual *z/OS Security Server RACF Macros and Interfaces, SA23-2288-40. Github has examples using Java, Python and other example are available on other sites*.

```
<safRegistry id="saf" />
   <safAuthorization racRouteLog="ASIS" />
   <safCredentials unauthenticatedUser="WSGUEST"
      profilePrefix="BBGZDFLT" />
```

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Tech/Tip: Generating PassTickets on z/OS

- On z/OS, a COBOL user application can generate a pass tickets by calling RACF service IRRSPK00:

```
 77 COMM-STUB-PGM-NAME          PIC X(8) VALUE 'BAQCSTUB'.
 77 PTKT-STUB-PGM-NAME          PIC X(8) VALUE 'ATSPTKTC'.

*-----------------------------------------------------------------*

*****************************************************************
*    L I N K A G E   S E C T I O N
*****************************************************************
 LINKAGE SECTION.
*****************************************************************
*    P R O C E D U R E S
*****************************************************************
 PROCEDURE DIVISION using PARM-BUFFER.

*-----------------------------------------------------------------*
 MAINLINE SECTION.

*-----------------------------------------------------------------*
* Common code                                                     *
*-----------------------------------------------------------------*
* initialize working storage variables
     INITIALIZE GET-REQUEST.
     INITIALIZE GET-RESPONSE.
     CALL PTKT-STUB-PGM-NAME.
```

JOHNSON.PASSTCKT.SOURCE(ATSPTKTC)

```
      *-----------------------------------------------------------------*
      * Build IRRSPK00 parameters                                       *
      *-----------------------------------------------------------------*
           MOVE 0 to ws-length
           MOVE LENGTH OF identity to identity-length.
           INSPECT FUNCTION REVERSE (identity)
                  TALLYING ws-length FOR ALL SPACES.
           SUBTRACT ws-length FROM identity-length.
           MOVE 0 to ws-length
           MOVE LENGTH OF applid to applid-length.
           INSPECT FUNCTION REVERSE (applid)
                  TALLYING ws-length FOR ALL SPACES.
           SUBTRACT ws-length FROM applid-length.
           MOVE 8 to passTicket-length.
           MOVE 'NOTICKET' to passTicket.
           MOVE X'0003' to irr-functionCode.
           MOVE X'00000001' to irr-ticketOptions.
           SET irr-ticketOptions-ptr to ADDRESS OF irr-ticketOptions.
      *-----------------------------------------------------------------*
      * Call RACF service IRRSPK00 to obtain a pass ticket based        *
      *      on identity and applid                                     *
      *-----------------------------------------------------------------*
           PERFORM CALL-RACF.
           IF irr-safrc NOT = zero then
              DISPLAY "SAF_return_code:     " irr-safrc
              DISPLAY "RACF_return_code:    " irr-racfrc
              DISPLAY "RACF_reason_code:    " irr-racfrsn
           End-if
. . . .
      *-----------------------------------------------------------------*
      * Call IRRSPK00 requesting a pass ticket                          *
      *-----------------------------------------------------------------*
       CALL-RACF.
            CALL W-IRRSPK00 USING irr-workarea,
                  IRR-ALET, irr-safrc,
                  IRR-ALET, irr-racfrc,
                  IRR-ALET, irr-racfrsn,
                  IRR-ALET, irr-functionCode,
                  irr-optionWord,
                  IRR-PASSTICKET,
                  irr-ticketOptions-ptr,
                  IRR-IDENTITY,
                  IRR-APPLID
```

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See the full source of the program at URL https://ibm.biz/BdPXny

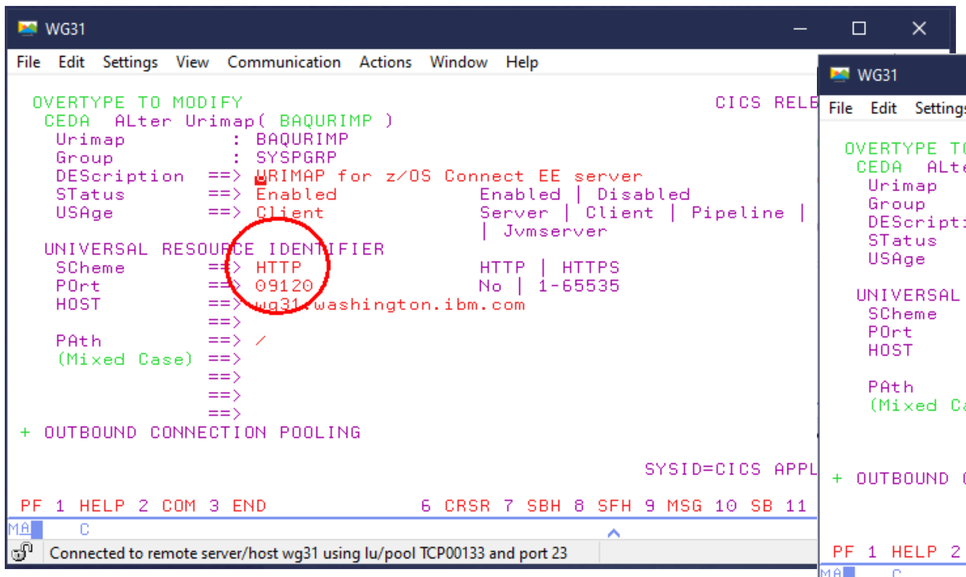
Tech/Tip: API Requester - HTTP v HTTPS

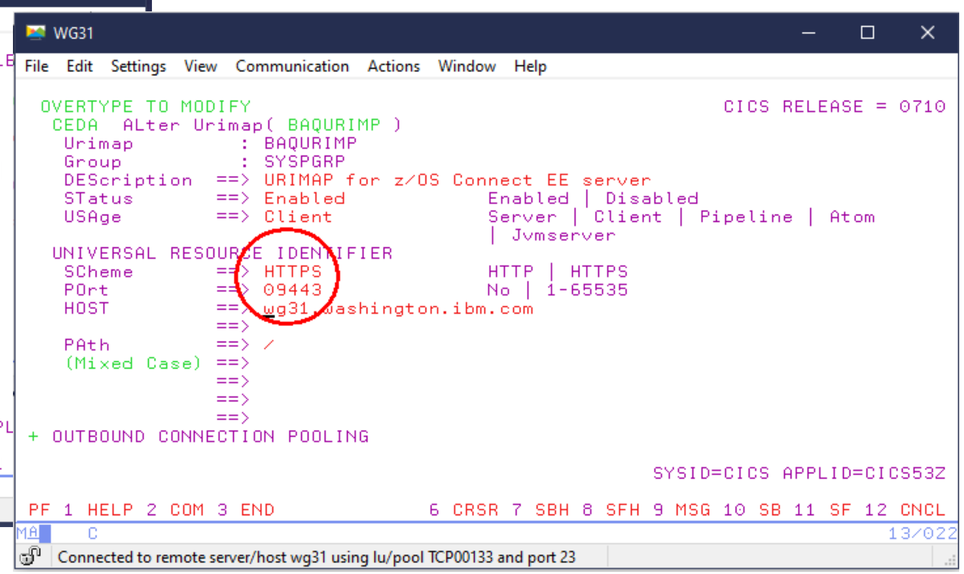
MVS Batch and IMS with and without an outbound AT-TLS policy

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

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

CICS URIMAPs





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

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

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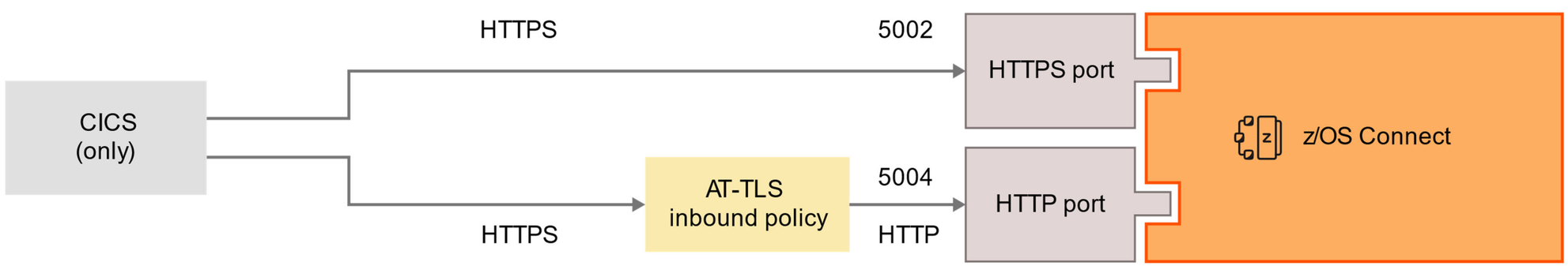
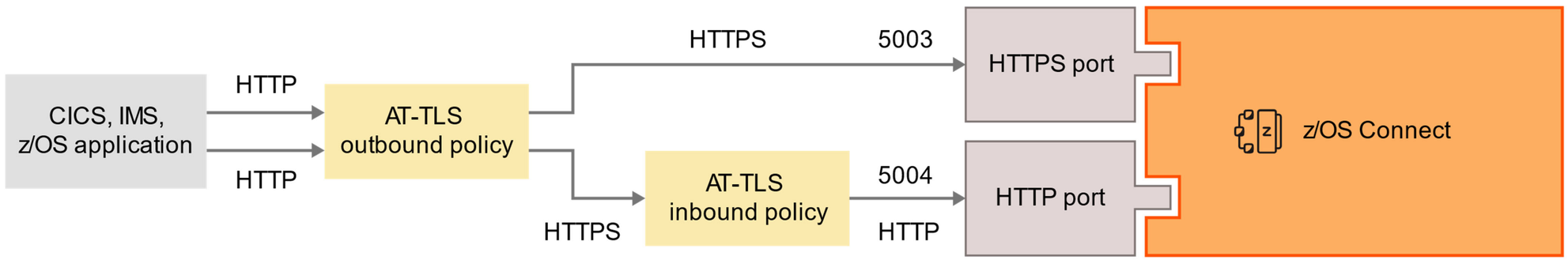
TLS Connection options from an application to the z/OS Connect server





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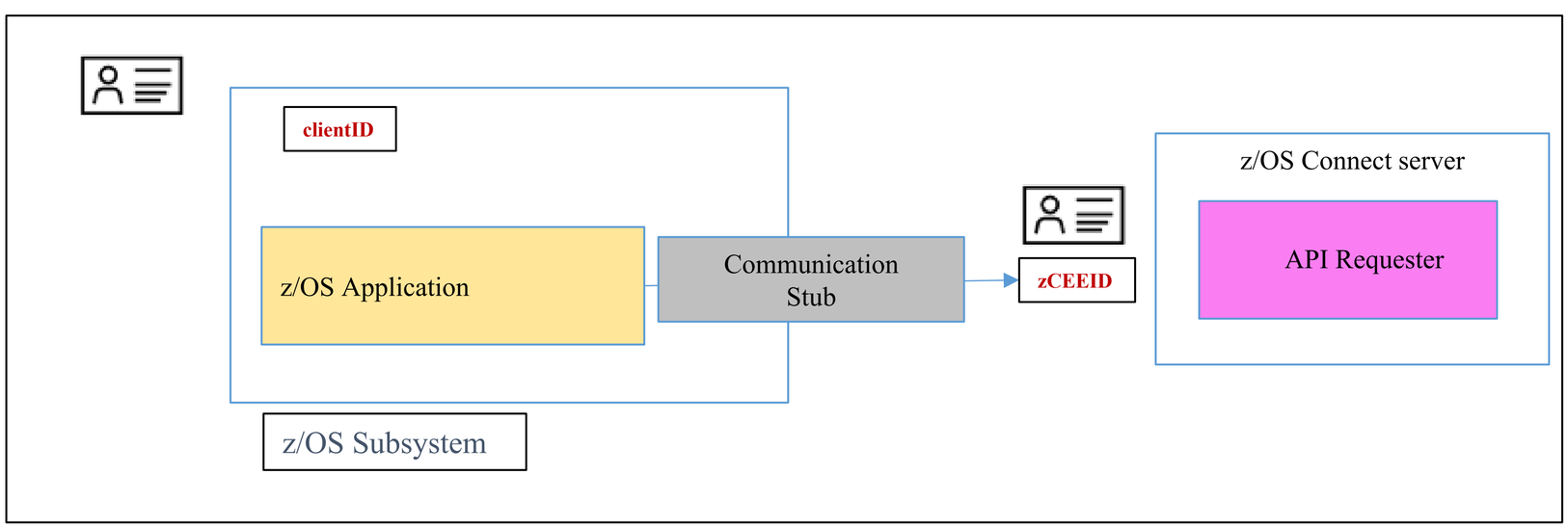
API Requester - basic authentication and identity assertion (Swagger 2.0 only)



clientID – the identity under which the z/OS application is executing.

- For CICS, the CICS task identity
- For IMS, the transaction owner
- For batch, the job card's USERID

zCEEID – The identity that is used for authenticating connectivity the z/OS subsystem to the zCEE server. It is configured using basic authentication or for CICS, TLS client authentication. For MVS batch, IMS and Db2 stored procedures, the *zCEEID* is provided by the environment variable ***BAQUSERNAME***. For CICS, the value for *zCEEID* is usually provided by the identity mapped to the CICS client certificate.

requireAuth	idAssertion	Actions performed by z/OS Connect
true	OFF	Identity assertion is disabled. The zCEE server authenticates *zCEEID* and checks whether *zCEEID* has the authority to invoke an API requester.
	ASSERT_SURROGATE	Identity assertion is enabled. The zCEE server authenticates *zCEEID* and checks whether *zCEEID* is a surrogate of *clientID*. If *zCEEID* is a surrogate of *clientID*, the server further checks whether *clientID* has the authority to invoke an API requester; otherwise, a BAQR7114E message occurs.
	ASSERT_ONLY	Identity assertion is enabled. The zCEE server authenticates *zCEEID* and directly checks whether *clientID* has the authority to invoke an API requester
false	OFF	Identity assertion is disabled. A BAQR0407W message occurs.
	ASSERT_SURROGATE	Identity assertion is enabled. The zCEE server checks whether *clientID* has the authority to invoke an API requester, and a warning message occurs to indicate that the ASSERT_ONLY value is used instead of the ASSERT_SURROGATE value.
	ASSERT_ONLY	Identity assertion is enabled. The zCEE server checks whether *clientID* has the authority to invoke an API requester

```
<zosconnect_zosConnectManager
           requireAuth="true|false"
           requireSecure="true|false"/>

<zosconnect_apiRequesters idAssertion="OFF">

<zosconnect_apiRequester name="cscvinc_1.0.0"
           requireAuth="true|false"
           requireSecure="true|false"/>
           idAssertion="ASSERT_ONLY"> *

<zosconnect_apiRequester name="db2employee_1.0.0"
           requireAuth="true|false"
           requireSecure="true|false"/>
           idAssertion="ASSERT_SURROGATE"> *

</zosconnect_apiRequesters>
```

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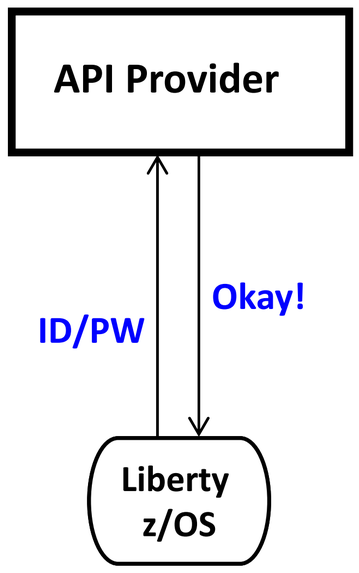
* Added in V3.0.45

API Requester - API Provider Authentication

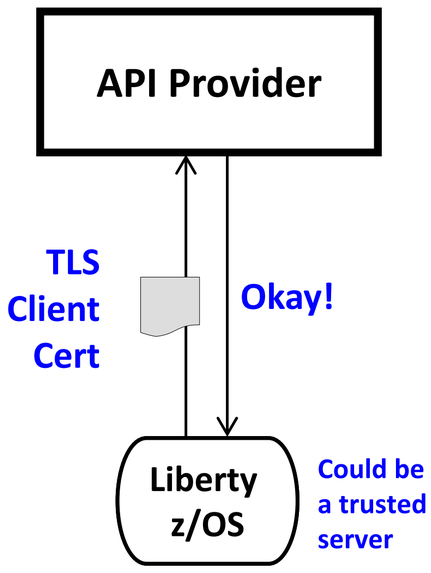
Several different ways this can be accomplished:

Basic Authentication



zCEE supplies ID/PW or ID/Passticket

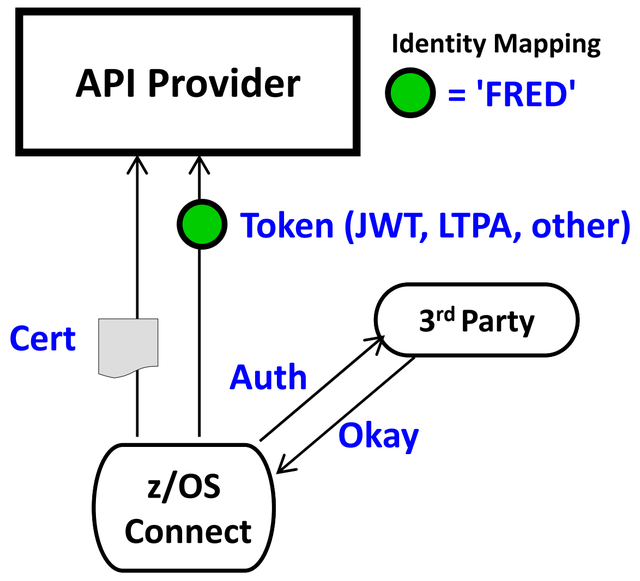
Client Certificate



Server prompts for certificate

zCEE supplies certificate

Third Party Authentication



zCEE authenticates to 3rd party sever

zCEE receives a trusted 3rd party token

Token flows to API Provider

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Identity assertion requires setting a program control extended attribute

As root or superuser, set the *libifaedjreg64.so* program control extended attribute bit

- ***Permit the server's identity to the required FACILITY resource***

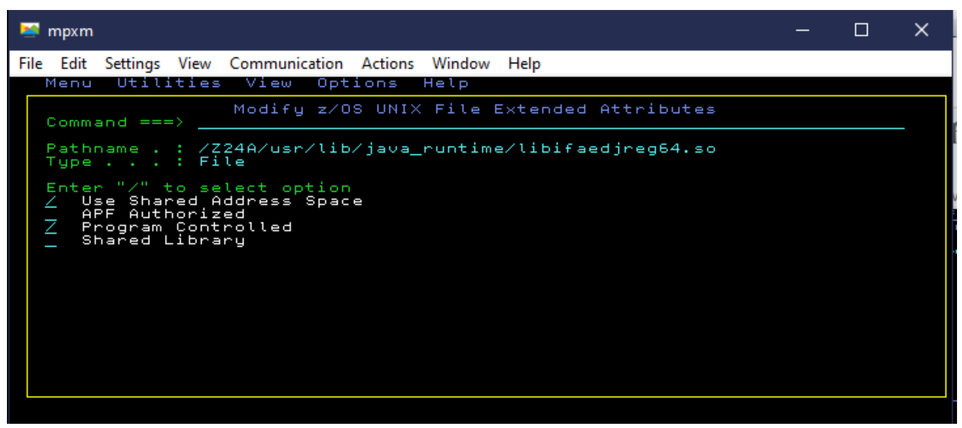
  PERMIT BPX.SERVER CLASS(FACILITY) ID(LIBSERV) ACCESS(READ)
  SETROPTS RACLIST(FACILITY) REFRESH

- ***Define a SURROGAT profile for the asserted identity and permit access to connection identity***

  RDEFINE SURROGAT clientID.BAQASSRT UACC(NONE) OWNER(SYS1)
  PERMIT clientID.BAQASSRT CLASS(SURROGAT) ACCESS(READ) ID(zCEEID)
  OR
  RDEFINE SURROGAT *.BAQASSRT UACC(NONE) OWNER(SYS1)
  PERMIT *.BAQASSRT CLASS(SURROGAT) ACCESS(READ) ID(zCEEID)
  SETROPTS RACLIST(SURROGAT) REFRESH

- ***Enable the program control bit for Java shared object ifaedjreg64***

  su
  cd /usr/lib/java_runtime
  extattr +p libifaedjreg64.so



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API Requester – authorization (OpenAPI 3 only)

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

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

<webApplication location="${server.config.dir}/apps/cscvinc.war">
   <appProperties> <property name="connectionRef" value="cscvincConnection"/> </appProperties>
   <application-bnd> <security-role name="invoke"> <group name="staffGroup" /> <user name="fred" /> </security-role>
   </application-bnd
</webApplication>
<webApplication name="catalogManager" location="${server.config.dir}/apps/catalog.war">
   <appProperties> <property name="connectionRef" value="catalogConnection"/> </appProperties>
   <application-bnd> <security-role name="invoke"> <group name="staffGroup" /> <user name="fred" /> </security-role>
   </application-bnd
</webApplication>
```

The *resourceName* defaults to the name of the WAR file if no name attribute is provided, otherwise the ***resourceName*** is value of the *name* attribute.

So, the required SAF EJB roles to be defined would be (*invoke* is the only role).

- *BBGZDFLT.**cscvinc**.**invoke***
- *BBGZDFLT.**catalogManager**.**invoke***

Authorization to invoke the API requester would require that the authenticated identity be a member of the STAFFGROUP or identity FRED.

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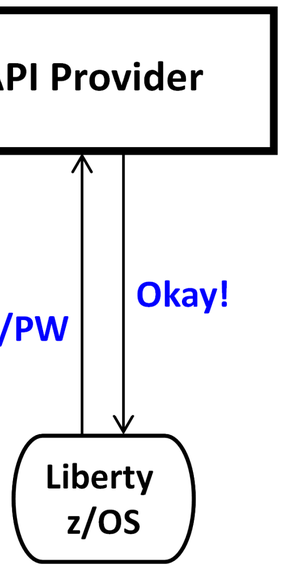
API Requester – Security from the z/OS Connect server to the API provider

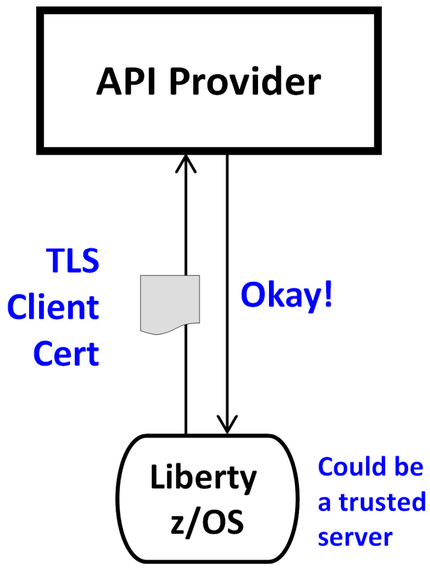
Several different ways this can be accomplished:

Basic Authentication



zCEE supplies ID/PW or ID/Passticket

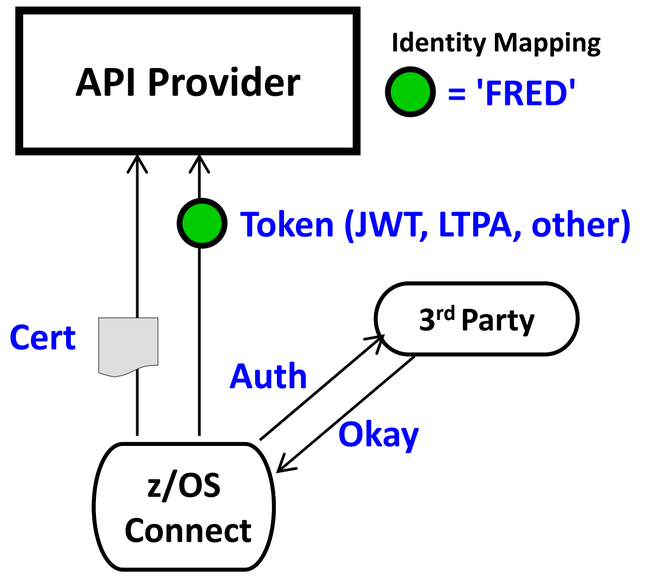
Client Certificate



Server prompts for certificate

zCEE supplies certificate

Third Party Authentication



zCEE authenticates to 3rd party sever

zCEE receives a trusted 3rd party token

Token flows to API Provider

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Configuring Basic and/or TSL support – z/OS Connect API Requester

Basic authentication with HTTP protocol

```
<zosconnect_endpointConnection id="cscvincAPI"
       host="http://wg31.washington.ibm.com" port="9080"
       authenticationConfigRef="myAuthData" />

<zosconnect_authData id="myAuthData"
  user="zCEEClient" password="secret"/>
```

TLS with HTTPS protocol

```
<zosconnect_endpointConnection id="cscvincAPI"
       host="https://wg31.washington.ibm.com" port="9443"
       authenticationConfigRef="myAuthData"  1
       sslCertsRef="OutboundSSLSettings" />

<zosconnect_authData id="myAuthData"   1
  user="zCEEClient" password="secret"/>
```

[1] Optional, if mutual authentication is enabled by the server endpoint

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Sample JCL - Executing the Liberty *securityUtility* command

```
//*************************************************************
//* Use securityUtility to encrypt a password using an
//* encryption key stored in a certificate
//*************************************************************
//IKJEFT01 EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *
BPXBATCH SH +
/usr/lpp/IBM/zosconnect/v3r0/wlp/bin/securityUtility encode +
--encoding=aes +
--keyring=safkeyring://JOHNSON/Liberty.KeyRing +
--keyringType=JCERACFKS --keyLabel="Johnson Client Cert" +
passwordToEncrypt
```

```
<featureManager>
 <feature>zosPasswordEncryptionKey-1.0</feature>
</featureManager>

<zosPasswordEncryptionKey
keyring="safkeyring://JOHNSON/Liberty.KeyRing"
label="Johnson Client Cert" type="JCERACFKS"/>
```

```
//*************************************************************
//* Use securityUtility to encrypt a password using an
//* encryption key string
//*************************************************************
//IKJEFT01 EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *
BPXBATCH SH +
/usr/lpp/IBM/zosconnect/v3r0/wlp/bin/securityUtility encode +
--encoding=aes -key myEncryptionKey +
passwordToEncrypt
```

```
wlp.password.encryption.key=myEncryptionKey
```

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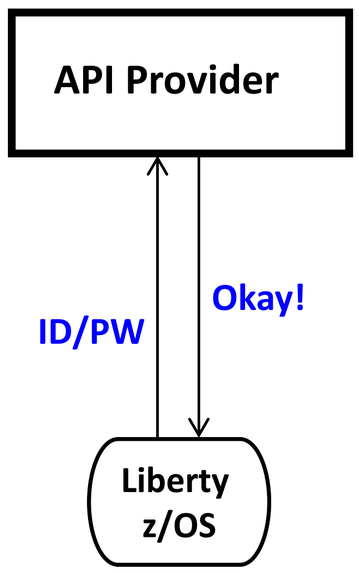
API Requester – Security from the z/OS Connect server to the API provider

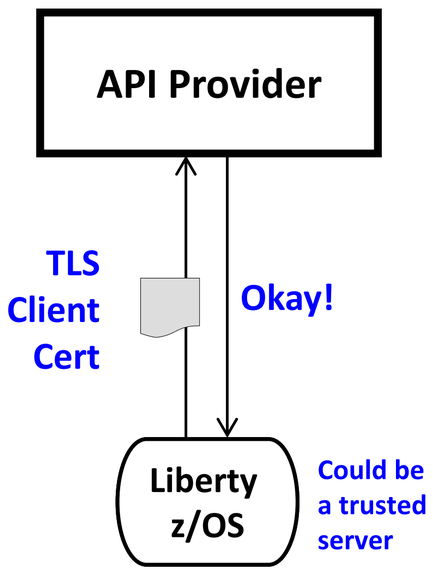
Several different ways this can be accomplished:

Basic Authentication



zCEE supplies ID/PW or ID/Passticket

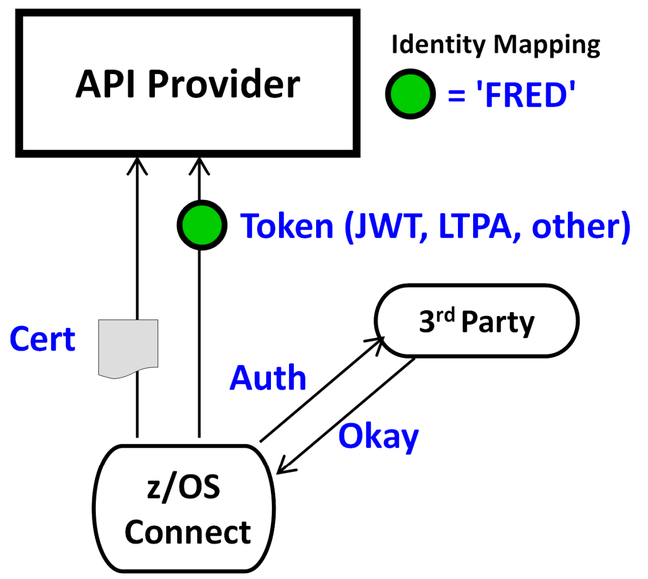
Client Certificate



Server prompts for certificate

zCEE supplies certificate

Third Party Authentication



zCEE authenticates to 3rd party sever

zCEE receives a trusted 3rd party token

Token flows to API Provider

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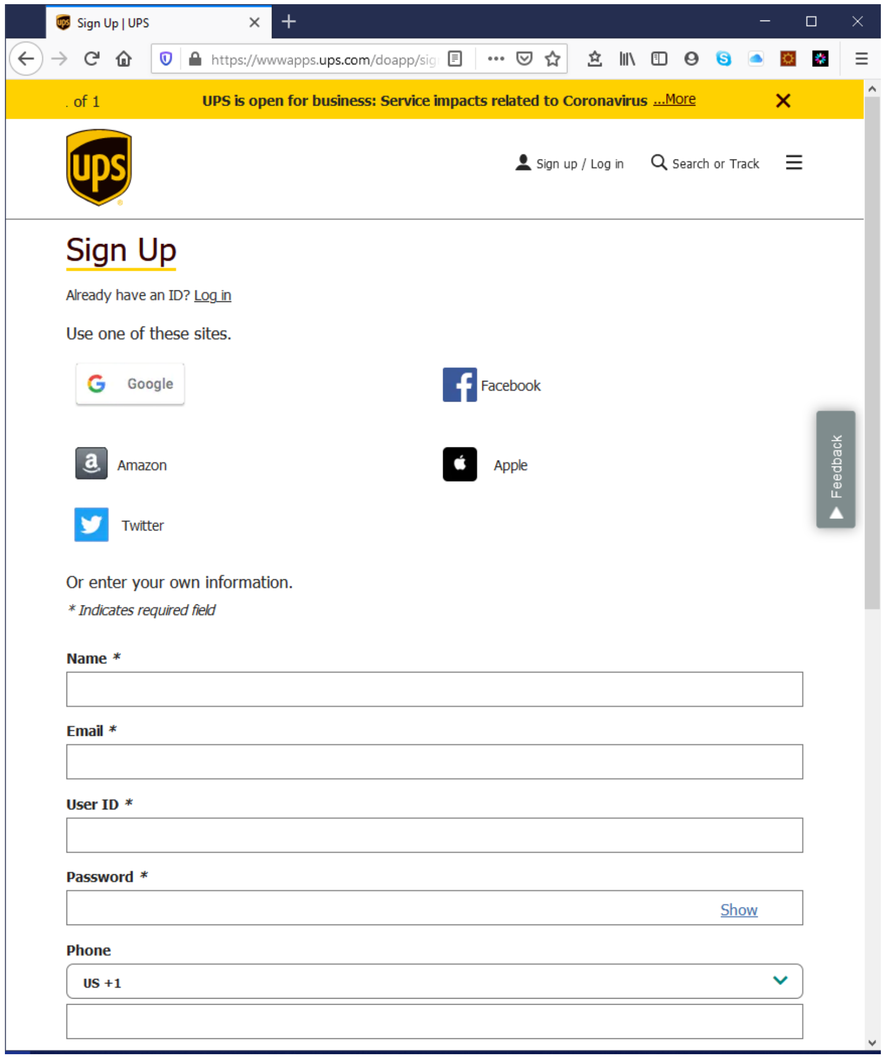
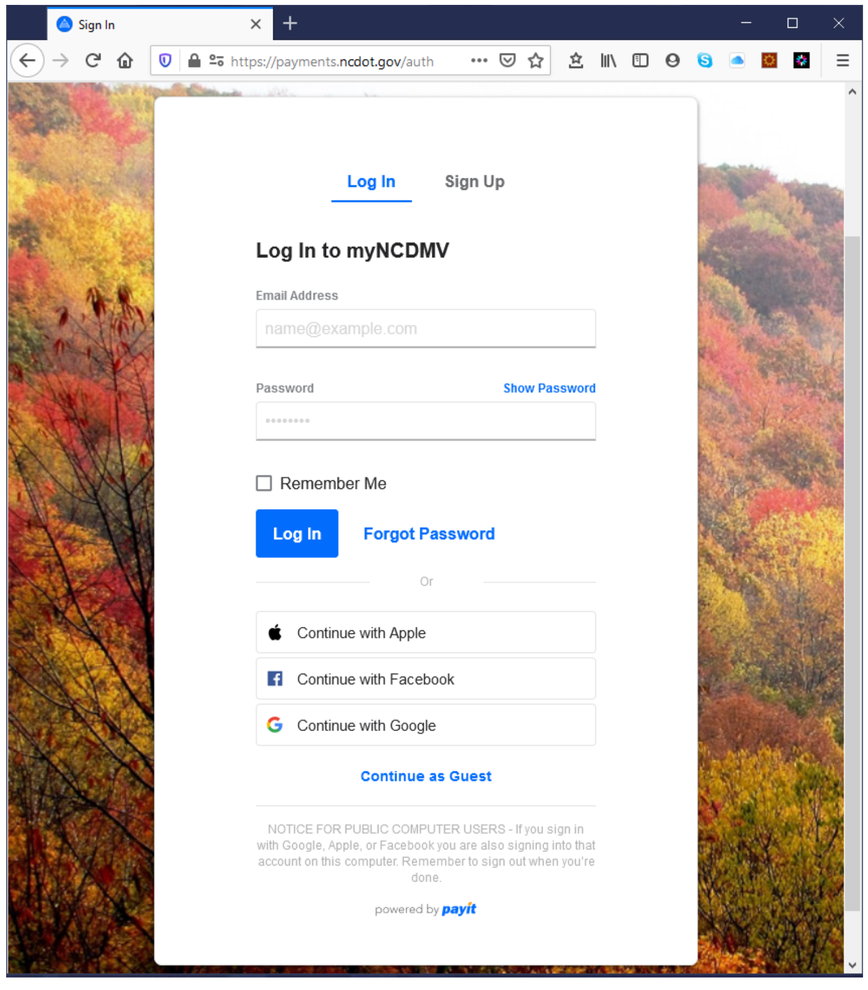
Third Party Authentication Examples





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Open security standards

- **OAuth** is an open standard for access delegation, used as a way to grant websites or applications access to their information without requiring a password.
- **OpenID Connect** is an authentication layer on top of Oauth. It allows the verification of the identity of an end-user based on authentication performed by an authorization server.
- **JWT** (JSON Web token) defines a compact and self-contained way for securely transmitting information between parties as a JSON object

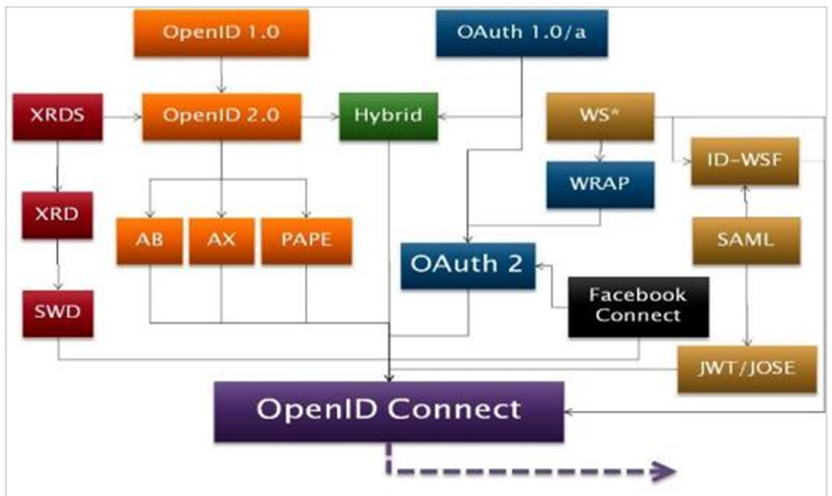
See the YouTube videos:

OAuth 2.0 and OpenID Connect (in plain English)

https://www.youtube.com/watch?v=996OiexHze0

OpenID Connect on Liberty

https://www.youtube.com/watch?v=fuajCS5bG4c



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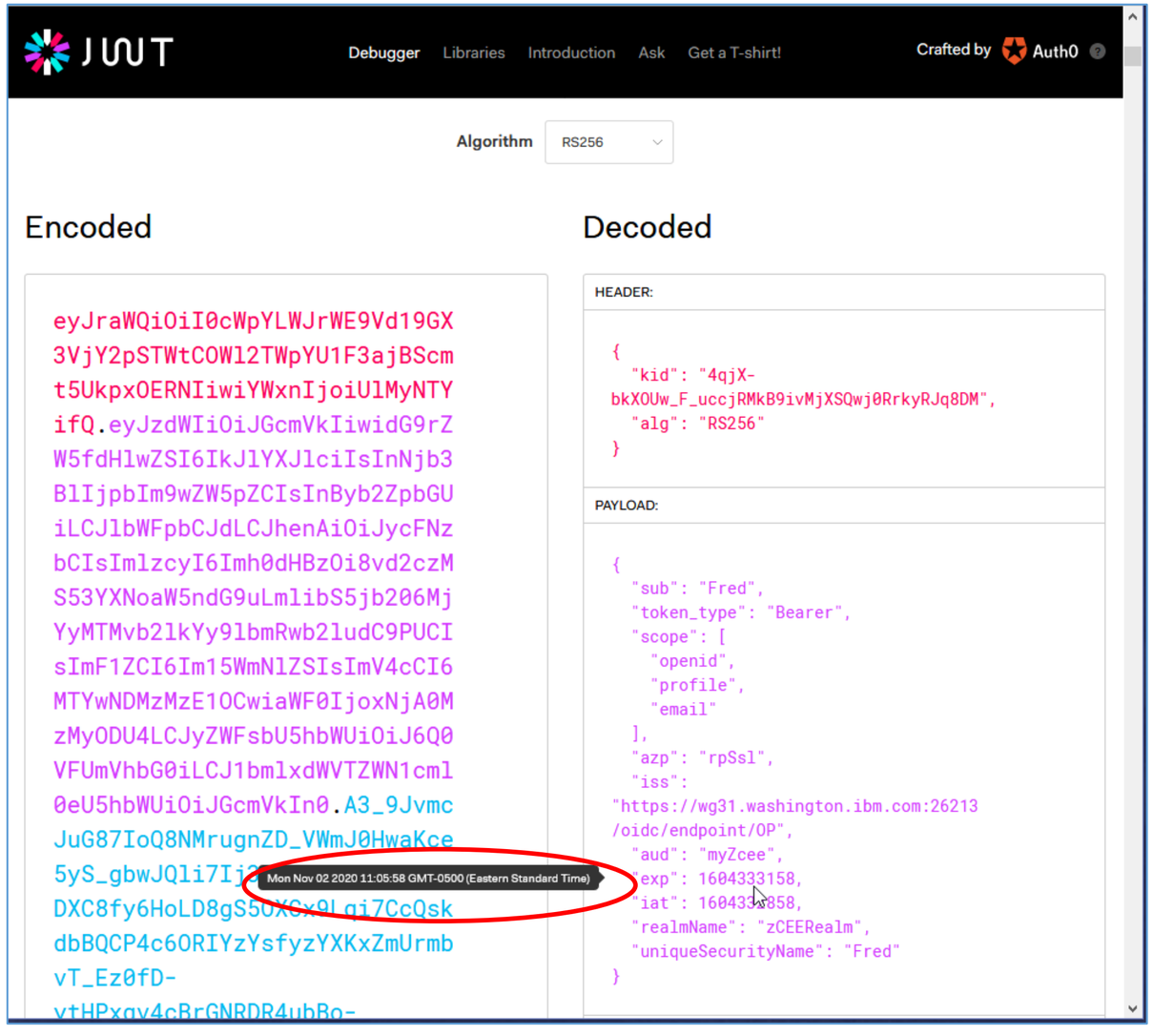
What is a JWT (JSON Web Token) ?

- JWT is a compact way of representing claims that are to be transferred between two parties

- Normally transmitted via HTTP header

- Consists of three parts
  - Header
  - Payload
  - Signature



Values derived from the OAUTH configuration:

- signatureAlgorithm="**RS256**“
- accessTokenLifetime="**300**"
- resourceIds="**myZcee**"

https://jwt.io

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z/OS Connect API Requester - Token Support

z/OS Connect EE provides ***three*** ways of calling an API secured with a token

1. Use the OAuth 2.0 support when the request is part of an OAuth 2.0 flow. With OAUTH configured, the token can be an opaque token or a JWT token.

1. In a non-OAuth 2.0 scenario, a JWT token is used in a custom flow, for example: when you need to specify the HTTP verb that is used in the request to the authentication server.
   - When you need to specify the HTTP verb that is used in the request to the authentication server
   - When you need to specify how the JWT is returned from the authentication server (for example, in an HTTP header or in a custom field in a JSON response message).
   - When you need to use a custom header name for sending the JWT to the request endpoint.

3. Use the locally generated JWT support when you need to send a JWT that is generated by the z/OS Connect EE server.

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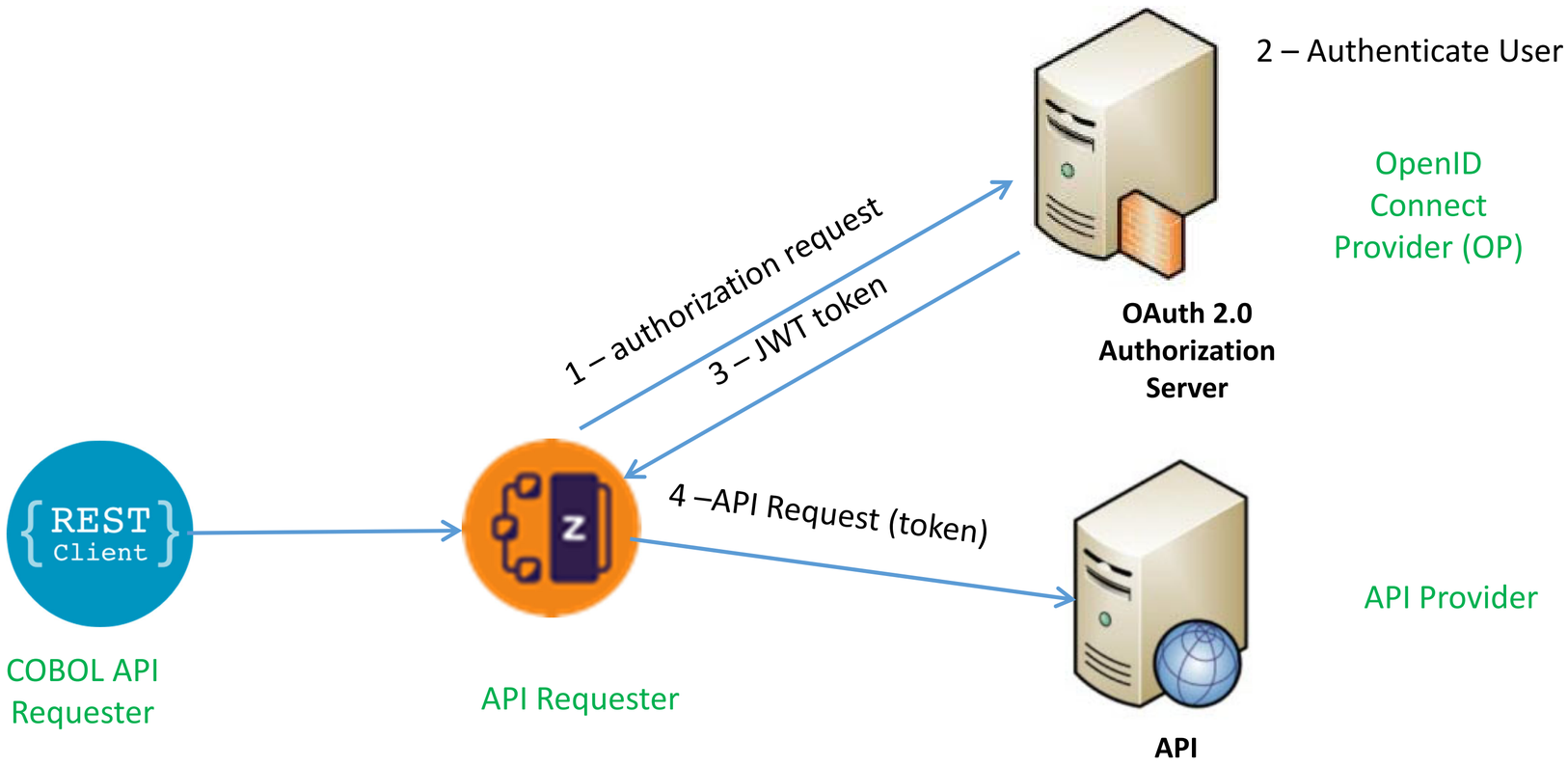
z/OS Connect OAuth Flow for API requester



Grant Types:

- client_credentials
- password

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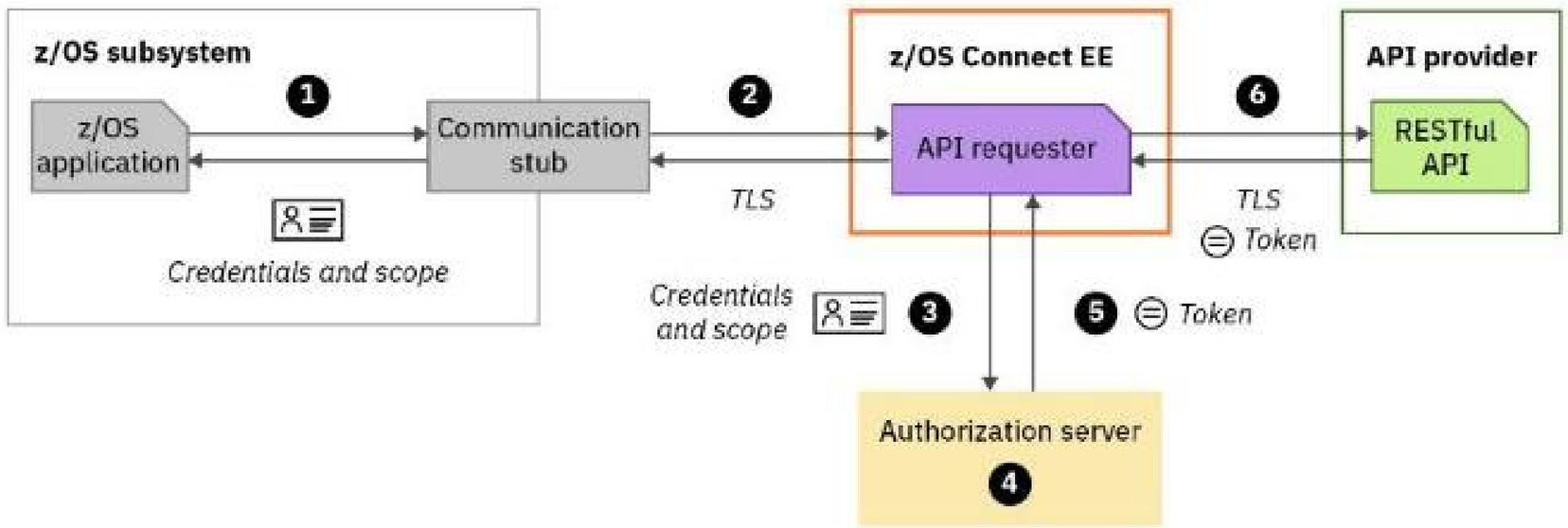
Calling an API with OAuth 2.0 support



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OAuth Grant Types Supported by z/OS Connect

client_credentials - *the identity associated with the combination of the CICS, IMS,* ***or*** *z/OS region* ***and*** *the z/OS Connect EE server that calls the RESTful API on behalf of the CICS, IMS, or z/OS application When this grant type is used, the z/OS Connect EE server sends the client credentials and the access scope to the authorization server.*

```
<zosconnect_oAuthConfig id="myoAuthConfig"
      grantType="client_credentials"
      authServerRef="myoAuthServer"/>
```

password - *The identity of the specific identity provided by the CICS, IMS, or z/OS application, or it might be another entity. When this grant type is used, the z/OS Connect EE server sends the resource owner's credentials, the client credentials, and the access scope to the authorization server.*

```
<zosconnect_oAuthConfig id="myoAuthConfig"
      grantType="password"
      authServerRef="myoAuthServer"/>
```

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OpenID Connect/OAuth and z/OS Connect

- ***From the z/OS Connect Knowledge Center:*** *z/OS Connect EE security can operate with traditional z/OS security, for example, System Authorization Facility (SAF) and also with open standards such as Transport Layer Security (TLS), JSON Web Token (JWT), and* ***OpenID Connect.***

- ***From the OpenID Core specification:*** *OpenID Connect 1.0 is a simple identity layer on top of the OAuth 2.0 protocol. It enables Clients to verify the identity of the End-User based on the authentication performed by an Authorization Server, as well as to obtain basic profile information about the End-User in an interoperable and REST-like manner.*

- ***OAuth 2.0 Core (RFC 6749) Specifications:*** https://tools.ietf.org/html/rfc6749

- ***OpenID Connect Core Specifications***: https://openid.net/specs/openid-connect-core-1_0.html

- ***Again, for a very good explanation of this topic see YouTube video*** *OAuth 2.0 and OpenID Connect (in plain English)* https://www.youtube.com/watch?v=996OiexHze0

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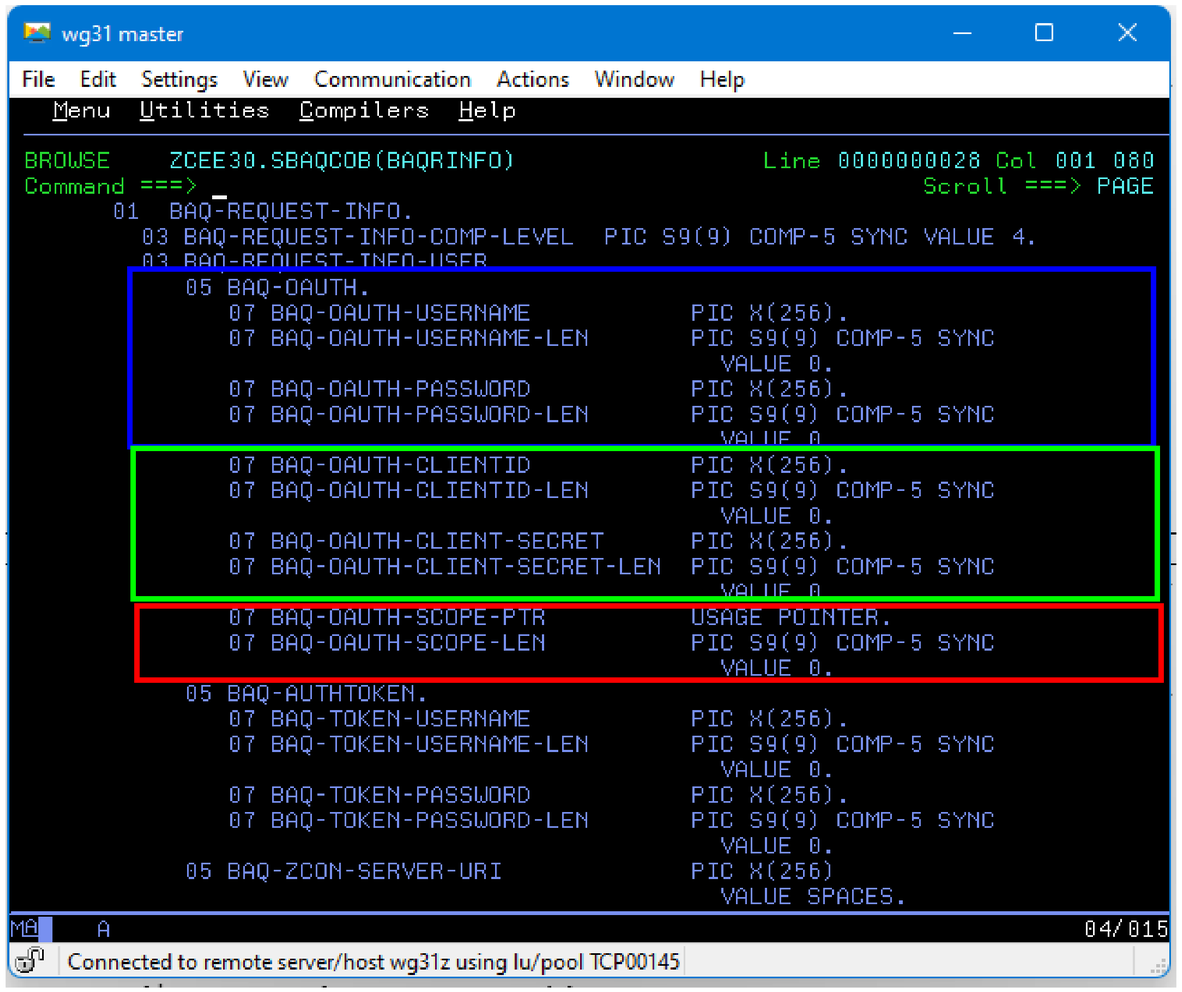
Configuring OAuth support – BAQRINFO copy book



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

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

Scope is always required.

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

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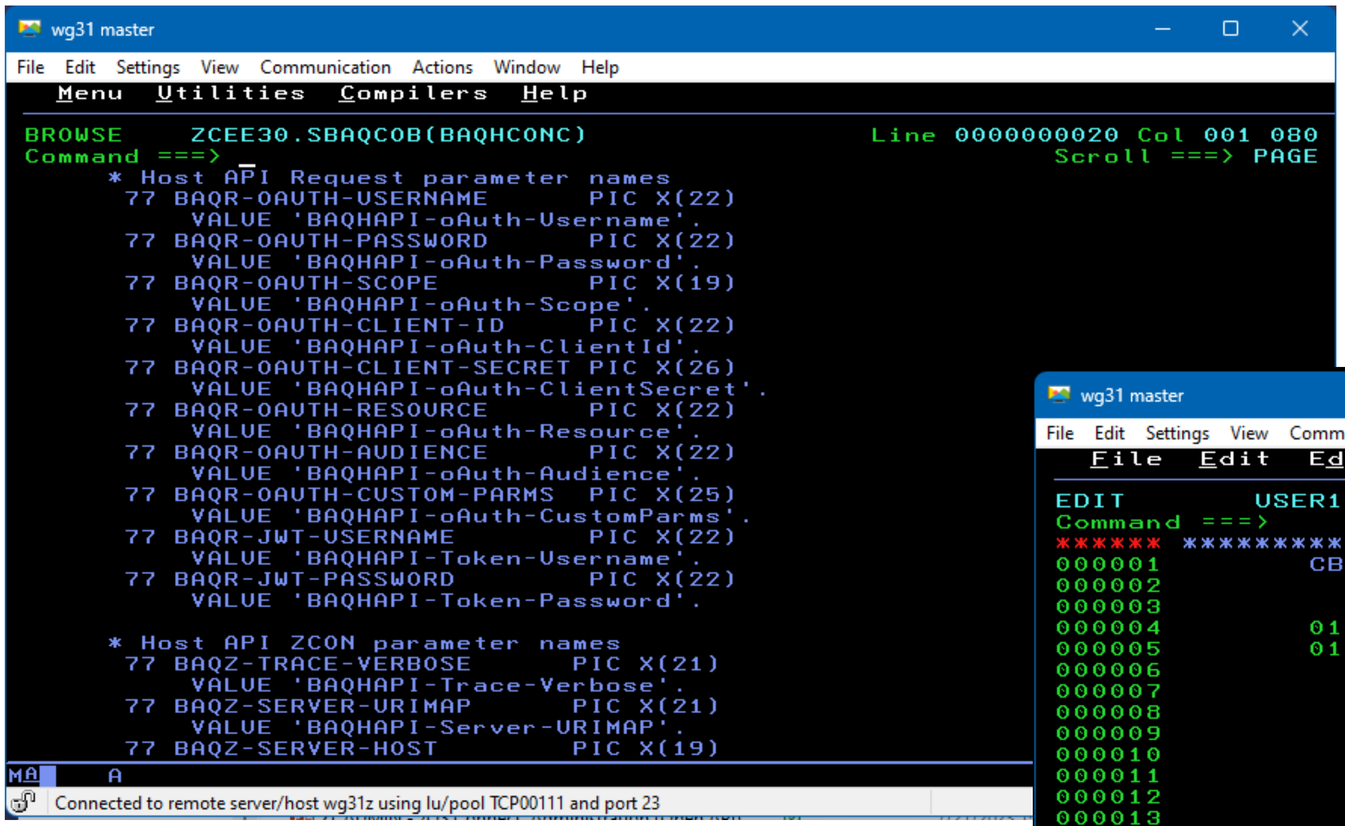
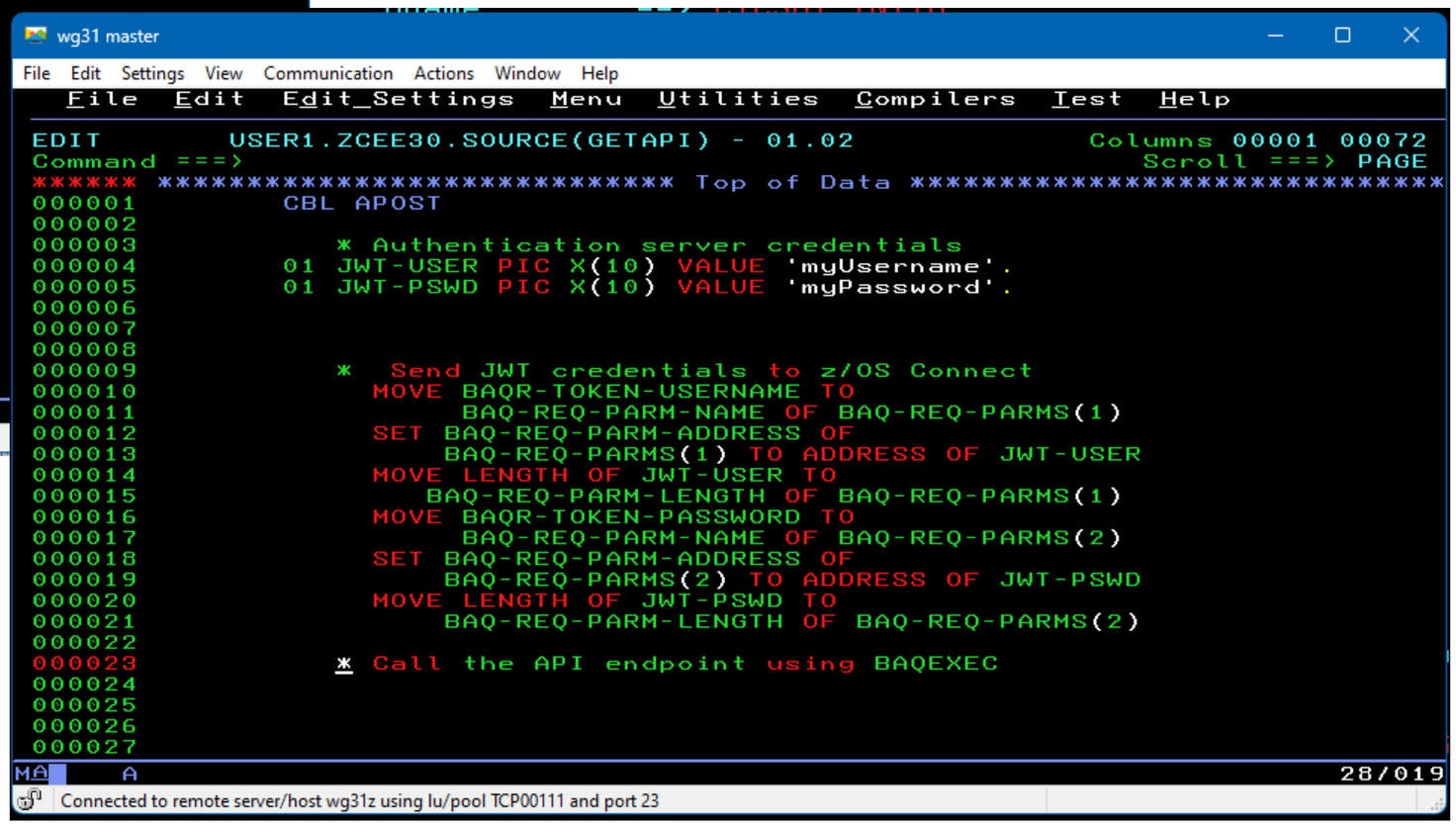
Obtaining a JWT using request parameters





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Sample program and JCL

COBOL Application

```
MOVE “ATSOAUTHUSERNAME" to envVariableName.
PERFORM CALL-CEEENV THRU CALL-CEEENV-END
MOVE VAR(1:valueLength) to BAQ-OAUTH-USERNAME
MOVE valueLength TO BAQ-OAUTH-USERNAME-LEN
MOVE “ATSOAUTHPASSWORD" to envVariableName.
PERFORM CALL-CEEENV THRU CALL-CEEENV-END
MOVE VAR(1:valueLength) to BAQ-OAUTH-PASSWORD
MOVE valueLength to BAQ-OAUTH-PASSWORD-LEN
MOVE SPACES      to BAQ-OAUTH-CLIENTID.
MOVE 0           to BAQ-OAUTH-CLIENTID-LEN.
MOVE SPACES      to BAQ-OAUTH-CLIENT-SECRET.
MOVE 0           to BAQ-OAUTH-CLIENT-SECRET-LEN.
MOVE "openid"    to BAQ-OAUTH-SCOPE.
MOVE 6           to BAQ-OAUTH-SCOPE-LEN.
SET BAQ-OAUTH-SCOPE-PTR TO ADDRESS OF BAQ-OAUTH-SCOPE.
```

Note that this is example is using environment variables to provide OAuth credentials, as documented in the z/OS Connect Advanced Topics Guide.

Execution JCL

```
//GETAPI  EXEC PGM=GETAPIPT,PARM='111111'
//STEPLIB  DD DISP=SHR,DSN=USER1.ZCEE30.LOADLIB
//         DD DISP=SHR,DSN=ZCEE30.SBAQLIB
//         DD DISP=SHR,DSN=JOHNSON.ZCEE.SDFHLOAD
//SYSOUT   DD SYSOUT=*
//SYSPRINT DD SYSOUT=*
//CEEOPTS  DD *
 POSIX(ON),
 ENVAR("BAQURI=wg31.washington.ibm.com",
 "BAQPORT=9080",
 "BAQUSERNAME=USER1",
 “ATSAPPL=BBGZDFLT",
 “ATSOAUTHUSERNAME=distuser1",
 “ATSOAUTHPASSWORD=pwd“)
```

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Tech/Tip: Accessing environment variables from COBOL application

```
      *-----------------------------------------------------------------*
      * Get the BAQUSERNAME environment variable                        *
      *-----------------------------------------------------------------*
           MOVE "BAQUSERNAME" to envVariableName.
           PERFORM CALL-GET-CEEENV THRU CALL-GET-CEEENV-END
           IF envVariableValueLength NOT = 0 THEN
              MOVE envVariable(1:envVariableValueLength) to identity
           ELSE
              DISPLAY envVariableName(1:envVariableNameLength)
               " NOT FOUND " envVariableNameLength
           END-IF.
      *-----------------------------------------------------------------*
      * Get the ATSAPPLID environment variable                          *
      *-----------------------------------------------------------------*
           MOVE "ATSAPPLID" to envVariableName.
           PERFORM CALL-GET-CEEENV THRU CALL-GET-CEEENV-END
           IF envVariableValueLength NOT = 0 THEN
              MOVE envVariable(1:envVariableValueLength) to applid
           ELSE
              DISPLAY envVariableName(1:envVariableNameLength)
               " NOT FOUND " envVariableNameLength
           END-IF.
```

```
      *-----------------------------------------------------------------*
           * Get environment variable                                    *
           *-----------------------------------------------------------------*
            CALL-GET-CEEENV.
                 SET getVariable to true.
                 MOVE SPACES to envVariableValue.
                 MOVE ZERO to envVariableNameLength, envVariableValueLength
           *-----------------------------------------------------------------*
           *      Calculate length of environment variable name              *
           *-----------------------------------------------------------------*
                 Inspect envVariableName tallying
                  envVariableNameLength for Characters Before Initial ' '
           *-----------------------------------------------------------------*
           *      Call CEEENV to obtain value of environment variable        *
           *-----------------------------------------------------------------*
                 CALL "CEEENV" USING functionCode,
                                     envVariableNameLength,
                                     envVariableName,
                                     envVariableValueLength,
                                     envVariablePointer,
                                     feedbackCode.
           CALL-SET-CEEENV-END.
```

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See the full source of the program at URL https://ibm.biz/BdPXny

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Configuring OAuth support – z/OS Connect API Requester

```
<zosconnect_endpointConnection id="cscvincAPI"
       host="http://wg31.washington.ibm.com" port="9080"
       authenticationConfigRef="myoAuthConfig"/>

<zosconnect_oAuthConfig id="myoAuthConfig"
      grantType="client_credentials|password"
      authServerRef="myoAuthServer"/>

<zosconnect_authorizationServer id="myoAuthServer"
      tokenEndpoint=https://wg31.washington.ibm.com:59443/oidc/endpoint/OP/token[1]
      basicAuthRef="tokenCredential"  [2]
      sslCertsRef="OutboundSSLSettings" />

<zosconnect_authData id="tokenCredential" [2]
  user="zCEEClient" password="secret"/>
```

```
openidConnectProvider id="OP"
   signatureAlgorithm="RS256"
   keyStoreRef="jwtStore"
  oauthProviderRef="OIDCssl" >
</openidConnectProvider>
```

[1] See URL https://www.ibm.com/support/knowledgecenter/SS7K4U_liberty/com.ibm.websphere.wlp.zseries.doc/ae/twlp_oidc_token_endpoint.html

[2] These credentials can be specified by the application

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Security Scenarios

```
BAQ-OAUTH-USERNAME:  distuser1
BAQ-OAUTH-PASSWORD:  pwd
EmployeeNumber: 111111
EmployeeName:   C. BAKER
USERID:         USER1
```

distuser1 is mapped to RACF identity USER1 who has full access

```
BAQ-OAUTH-USERNAME:  distuserx
BAQ-OAUTH-PASSWORD:  pwd
Error code: 00000500
Error msg:{"errorMessage":"BAQR1092E: Authentication or authorization failed for the z/OS Connect EE server."}
```

distuserx is unknown by the OAuth Provider

```
BAQ-OAUTH-USERNAME:  auser
BAQ-OAUTH-PASSWORD:  pwd
Error code: 0000000403
rror msg:{"errorMessage":"BAQR1144E: Authentication or authorization failed for the z/OS Connect EE server."}
Syslog:
ICH408I USER(ATSSERV ) GROUP(ATSGRP  ) NAME(LIBERTY SERVER
  DISTRIBUTED IDENTITY IS NOT DEFINED:
  auser zCEERealm
```

auser is not mapped to a valid RACF identity

```
BAQ-OAUTH-USERNAME:  distuser2
BAQ-OAUTH-PASSWORD:  pwd
Error code: 0000000403
Error msg:{"errorMessage":"BAQR1144E: Authentication or authorization failed for the z/OS Connect EE server."}
Syslog:
ICH408I USER(USER2   ) GROUP(SYS1    ) NAME(WORKSHOP USER2
  ATSZDFLT.zos.connect.access.roles.zosConnectAccess
  CL(EJBROLE )
  INSUFFICIENT ACCESS AUTHORITY
  ACCESS INTENT(READ   )  ACCESS ALLOWED(NONE   )
```

distuser2 is mapped to RACF identity USER2 which has no access to the EJBRole protecting z/OS Connect

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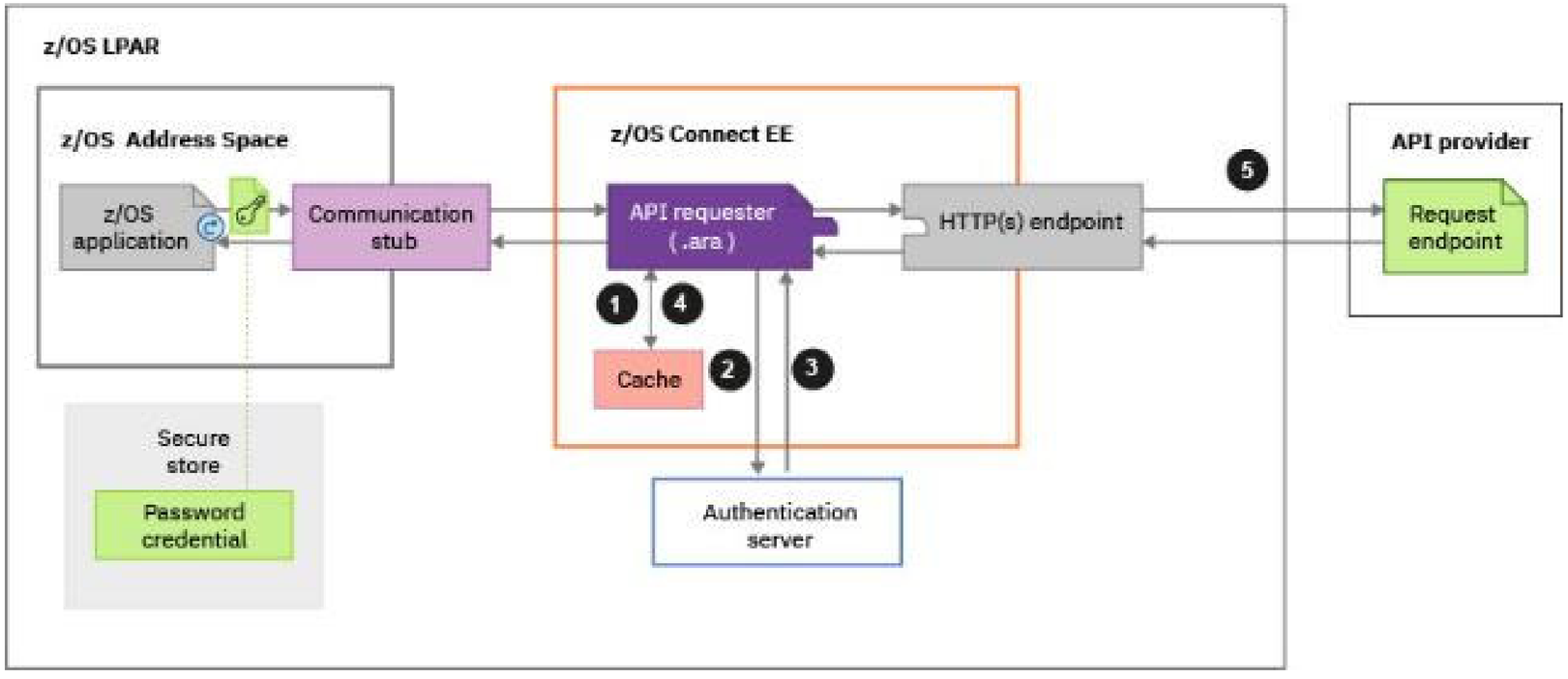
Calling an API with using a JWT custom flow

- In a non-OAuth 2.0 scenario, a JWT token is used in a custom flow, for example:
  - When you need to specify the HTTP verb that is used in the request to the authentication server.
  - When you need to specify how the JWT is returned from the authentication server (for example, in an HTTP header or in a custom field in a JSON response message).
  - When you need to use a custom header name for sending the JWT to the request endpoint.



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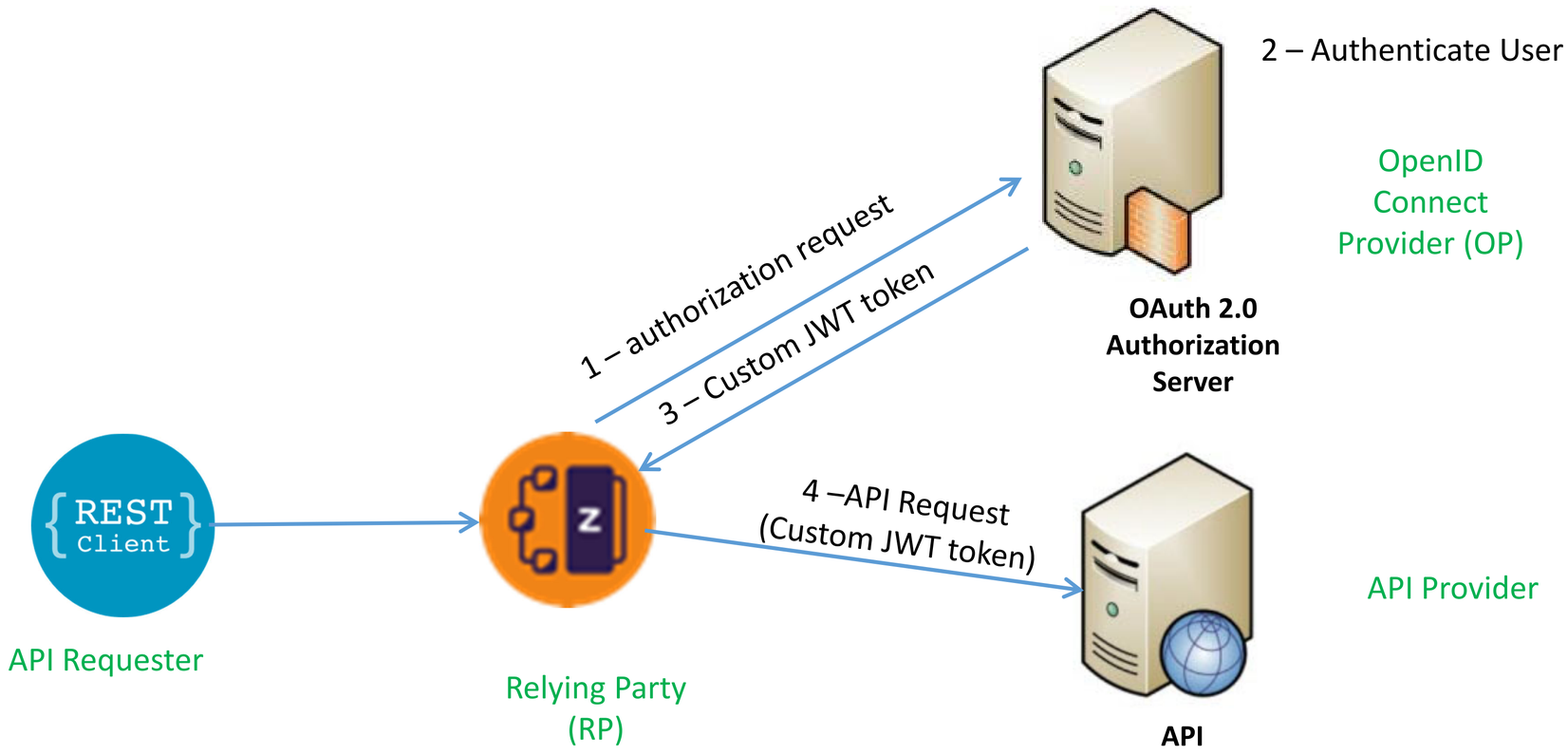
z/OS Connect OAuth Custom Flow



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API Requester – JWT Custom flow

BAQRINFO copy book

wg31 master

File Edit Settings View Communication Actions Window Help

Menu Utilities Compilers Help

```
BROWSE    ZCEE30.SBAQCOB(BAQRINFO)                  Line 0000000028 Col 001 080
Command ===>                                          Scroll ===> PAGE
       01  BAQ-REQUEST-INFO.
         03 BAQ-REQUEST-INFO-COMP-LEVEL  PIC S9(9) COMP-5 SYNC VALUE 4.
         03 BAQ-REQUEST-INFO-USER.
            05 BAQ-OAUTH.
               07 BAQ-OAUTH-USERNAME           PIC X(256).
               07 BAQ-OAUTH-USERNAME-LEN       PIC S9(9) COMP-5 SYNC
                                                 VALUE 0.
               07 BAQ-OAUTH-PASSWORD           PIC X(256).
               07 BAQ-OAUTH-PASSWORD-LEN       PIC S9(9) COMP-5 SYNC
                                                 VALUE 0.
               07 BAQ-OAUTH-CLIENTID           PIC X(256).
               07 BAQ-OAUTH-CLIENTID-LEN       PIC S9(9) COMP-5 SYNC
                                                 VALUE 0.
               07 BAQ-OAUTH-CLIENT-SECRET      PIC X(256).
               07 BAQ-OAUTH-CLIENT-SECRET-LEN  PIC S9(9) COMP-5 SYNC
                                                 VALUE 0.
               07 BAQ-OAUTH-SCOPE-PTR          USAGE POINTER.
               07 BAQ-OAUTH-SCOPE-LEN          PIC S9(9) COMP-5 SYNC
                                                 VALUE 0.
            05 BAQ-AUTHTOKEN.
               07 BAQ-TOKEN-USERNAME           PIC X(256).
               07 BAQ-TOKEN-USERNAME-LEN       PIC S9(9) COMP-5 SYNC
                                                 VALUE 0.
               07 BAQ-TOKEN-PASSWORD           PIC X(256).
               07 BAQ-TOKEN-PASSWORD-LEN       PIC S9(9) COMP-5 SYNC
                                                 VALUE 0.
            05 BAQ-ZCON-SERVER-URI             PIC X(256)
                                                 VALUE SPACES.
MA    A                                                          04/015
```

Connected to remote server/host wg31z using lu/pool TCP00145

COBOL application

```
MOVE "ATSTOKENUSERNAME" to envVariableName.
PERFORM CALL-CEEENV THRU CALL-CEEENV-END
MOVE VAR(1:valueLength) to BAQ-TOKEN-USERNAME
MOVE valueLength TO BAQ-TOKEN-USERNAME-LEN
MOVE "ATSTOKENPASSWORD" to envVariableName.
PERFORM CALL-CEEENV THRU CALL-CEEENV-END
MOVE VAR(1:valueLength) to BAQ-TOKEN-PASSWORD
MOVE valueLength to BAQ-TOKEN-PASSWORD-LEN
```

Note that this example is using environment variables to provide token credentials, as documented in the z/OS Connect Advanced Topics Guide.

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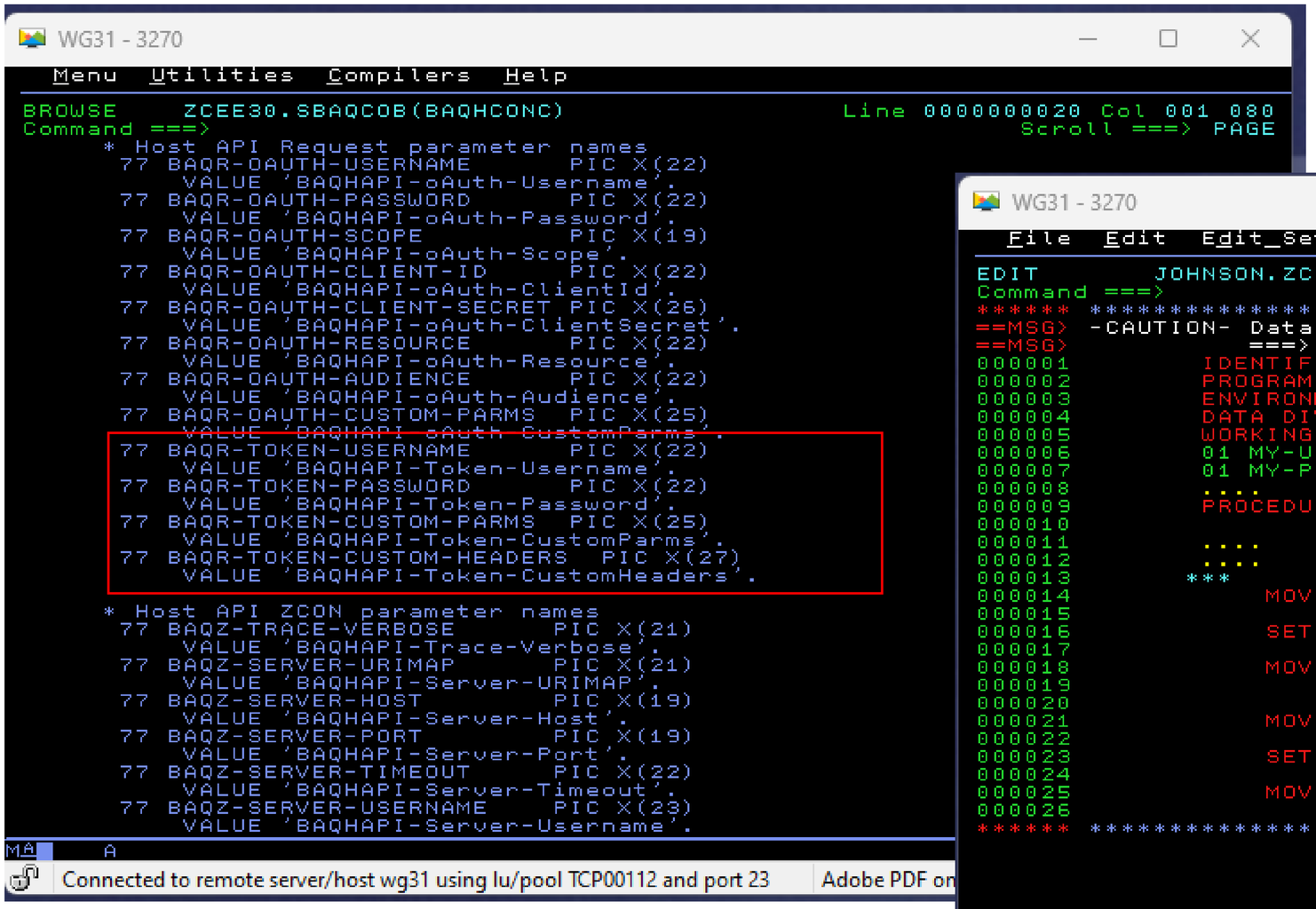
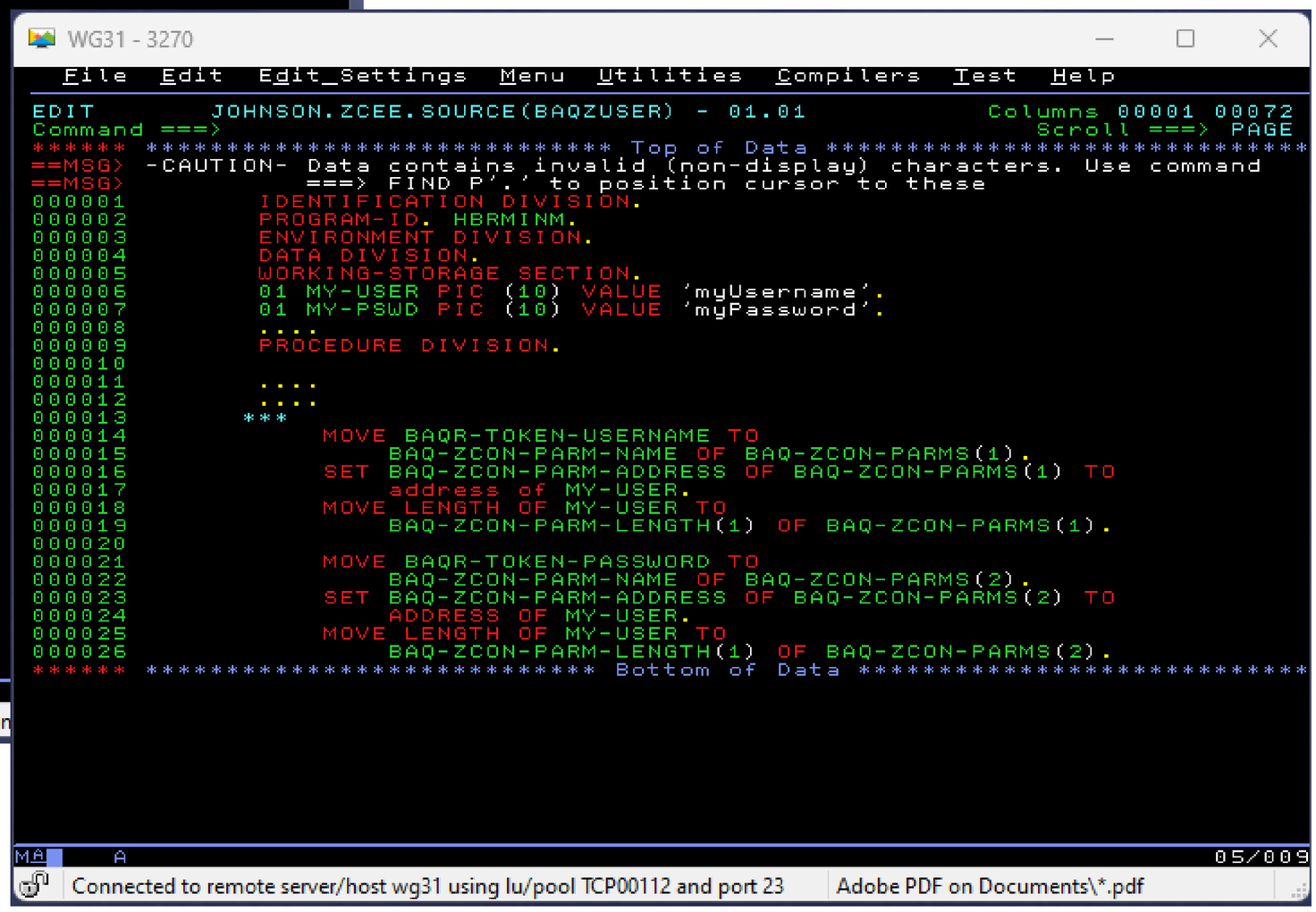
API Requester – JWT Custom flow





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Configuring JWT Custom flow

```
<zosconnect_endpointConnection id="cscvincAPI"
       host="http://wg31.washington.ibm.com" port="9080"
       authenticationConfigRef="myJWTConfig"/>

<zosconnect_authToken id="myJWTConfig" authServerRef="myJWTServer"
        header="myJWT-header-name"
      <tokenRequest/>     See next slide
      <tokenReponse/>     See next slide
</zosconnect_authToken>

<zosconnect_authorizationServer id="myJWTServer"
      tokenEndpoint=https://wg31.washington.ibm.com:59443/oidc/endpoint/OP/token[1]
      basicAuthRef="tokenCredential"  [2]
      sslCertsRef="OutboundSSLSettings" />

<zosconnect_authData id="tokenCredential" [2]
  user="zCEEClient" password="secret"/>
```

[1] See URL https://www.ibm.com/support/knowledgecenter/SS7K4U_liberty/com.ibm.websphere.wlp.zseries.doc/ae/twlp_oidc_token_endpoint.html

[2] These credentials can be specified by the application

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Configuring Custom JWT flow

Request Token Example 1

```
<tokenRequest
    credentialLocation="header"
    header="Authorization"
    requestMethod="GET" />
```

Response Token

```
<tokenResponse
   tokenLocation="header"
   header="JWTAuthorization" />
```

Response Token Example 2

```
<tokenRequest credentialLocation="body"
    requestMethod="POST"
   // Use XML escaped characters in requestBody
   requestBody="{&amp;quot;apiuser&amp;quot;:&amp;quot;${userid}&amp;quot;,&amp;quot;apipassword&amp;quot;:&amp;quot;${password}&amp;quot;}" />
```

Response Token

```
<tokenResponse
    tokenLocation="body"
  responseFormat="JSON"
  tokenPath="$.tokenname" />
```

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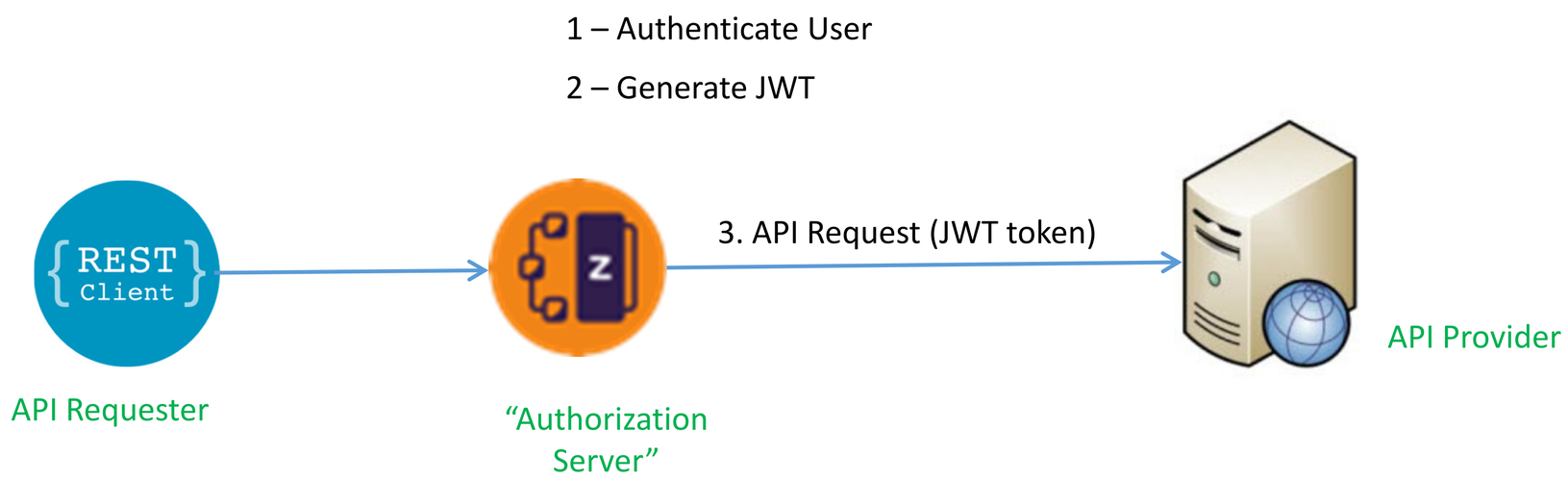
z/OS Connect JWT Generation – V3.0.43



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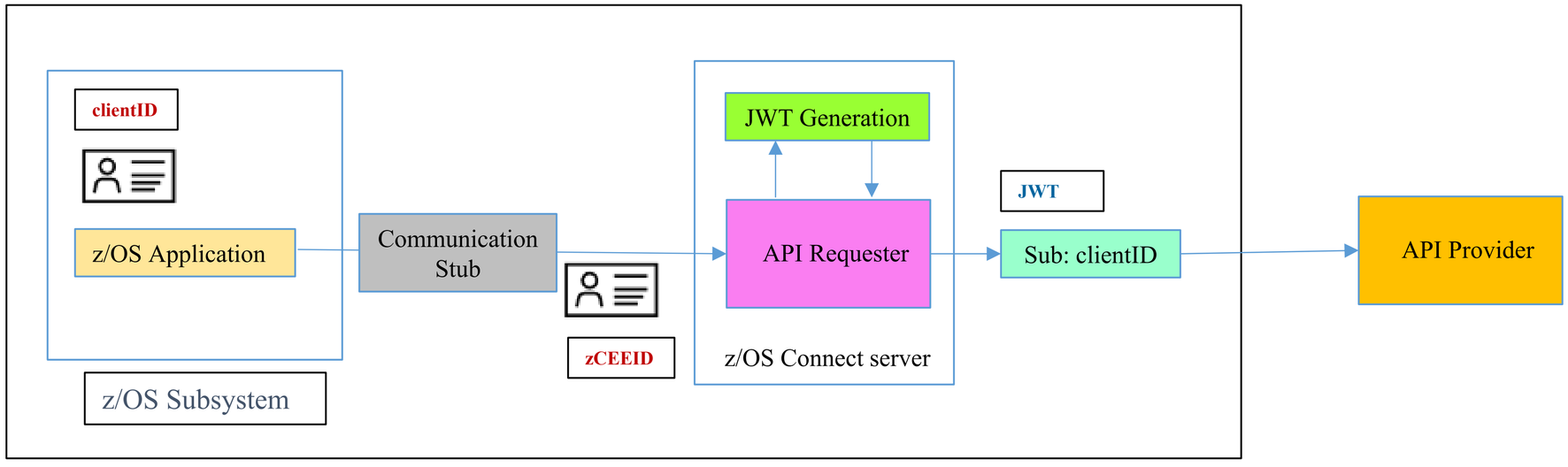
API Requester – JWT Generation



zCEEID – The identity that is used for authenticating connectivity the z/OS subsystem to the zCEE server. It is configured using basic authentication or for CICS, TLS client authentication.
clientID – the identity under which the z/OS application is executing.

- For CICS, the task owner
- For IMS, the transaction owner
- For batch, the job owner

requireAuth	idAssertion	Actions performed by z/OS Connect
true	ASSERT_SURROGATE	Identity assertion is enabled. The zCEE server authenticates *zCEEID* and checks whether *zCEEID* is a surrogate of *clientID*. If *zCEEID* is a surrogate of *clientID*, the server further checks whether *clientID* has the authority to invoke an API requester; otherwise, a BAQR7114E message occurs.
	ASSERT_ONLY	Identity assertion is enabled. The zCEE server authenticates *zCEEID* and directly checks whether *clientID* has the authority to invoke an API requester
false	ASSERT_SURROGATE	Identity assertion is enabled. The zCEE server checks whether *clientID* has the authority to invoke an API requester, and a warning message occurs to indicate that the ASSERT_ONLY value is used instead of the ASSERT_SURROGATE value.
	ASSERT_ONLY	Identity assertion is enabled. The zCEE server checks whether *clientID* has the authority to invoke an API requester

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JWT generation requires setting a program control extended attribute

As root or superuser, set the *libifaedjreg64.so* program control extended attribute bit

- ***Permit the server's identity to the required FACILITY resource***

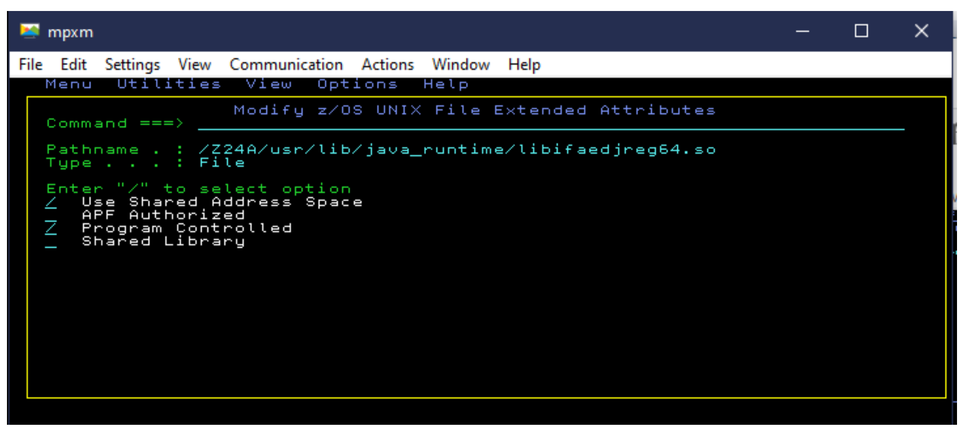
  PERMIT BPX.SERVER CLASS(FACILITY) ID(LIBSERV) ACCESS(READ)
  SETROPTS RACLIST(FACILITY) REFRESH

- ***Define a SURROGAT profile for the asserted identity and permit access to connection identity***

  RDEFINE SURROGAT clientID.BAQASSRT UACC(NONE) OWNER(SYS1)
  PERMIT clientID.BAQASSRT CLASS(SURROGAT) ACCESS(READ) ID(zCEEID)
  OR
  RDEFINE SURROGAT *.BAQASSRT UACC(NONE) OWNER(SYS1)
  PERMIT *.BAQASSRT CLASS(SURROGAT) ACCESS(READ) ID(zCEEID)
  SETROPTS RACLIST(SURROGAT) REFRESH

- ***Enable the program control bit for Java shared object ifaedjreg64***

  su
  cd /usr/lib/java_runtime
  extattr +p libifaedjreg64.so



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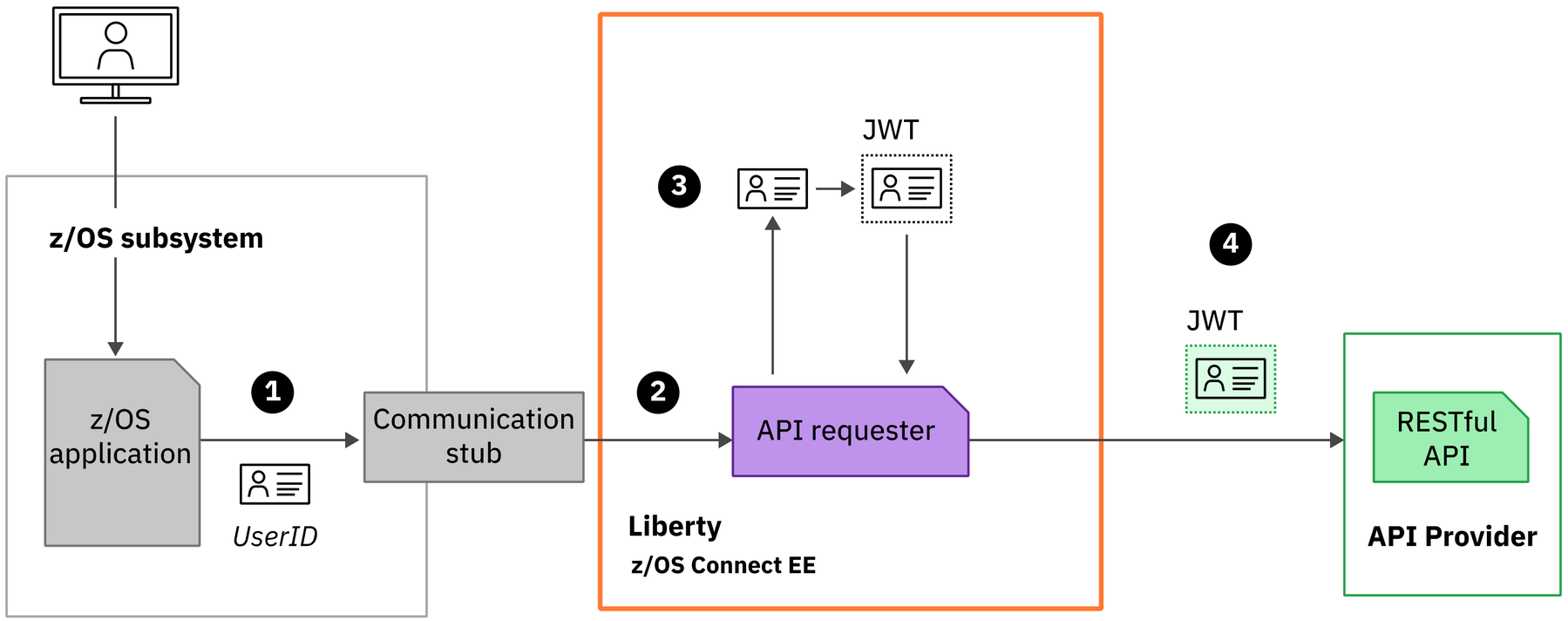
JWT Generation



1. Communication stub extracts the ID from the application environment
2. z/OS Connect generates a JWT token containing the z/OS application asserted user ID
3. The JWT is used to authorise the request to the API endpoint

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Configuring JWT Generation support

```
<zosconnect_endpointConnection id="conn"
    host="http://api.server.com" port="8080"
    authenticationConfigRef="jwtConfig" />

<zosconnect_authTokenLocal id="jwtConfig"
   tokenGeneratorRef="jwtBuilder"
   header="Authorization" >
   <claims>{"name":"JohnSmith,
             "ID":"1234567890"}
   </claims>

<jwtBuilder id="jwtBuilder"
    scope="scope1"
    audiences="myApp1"
    jti="true"
    signatureAlgorithm="RS256"
    keyStoreRef="myKeyStore"
    keyAlias="jwtsigner"
    issuer="z/OS Connect EE Default"/>
```

One or more Public claim (e.g., *aud,exp,nbf,iat,jti*) or one or more private claims

The "sub" claim value will be application asserted user ID.

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Configuring JWT Generation support

```
 <zosconnect_endpointConnection id="conn1"
    host="http://api.server.com" port="8080"
    authenticationConfigRef="jwtConfig" />
<zosconnect_endpointConnection id="conn2"
    host="http://api.server.com" port="8080"
    authenticationConfigRef="jwtConfig" />
<zosconnect_authTokenLocal id="jwtConfig"
   tokenGeneratorRef="jwtBuilder"
   header="Authorization" >
   <claims>{"scope":"Scope1"}</claims>
<zosconnect_authTokenLocal id="jwtConfig"
   tokenGeneratorRef="jwtBuilder"
   header="Authorization" >
   <claims>{"scope":"Scope2"}</claims>
<jwtBuilder id="jwtBuilder"
    scope="scope"
    audiences="myApp1"
    jti="true"
    signatureAlgorithm="RS256"
    keyStoreRef="myKeyStore"
    keyAlias="jwtsigner"
    issuer="z/OS Connect EE Default"/>
```

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server XML Configuration

```
<jwtBuilder id=”jwtBuilder”
    scope=“scope1”
    audiences=“myApp1”
    jti=“true”
    signatureAlgorithm=“RS256”
    keyStoreRef=”myKeyStore"
    keyAlias="jwtsigner"
    issuer="z/OS Connect EE Default”/>

<zosconnect_authTokenLocal id=”jwtConfig”
    tokenGeneratorRef=“jwtBuilder”
    header=“JWTAuthorization” >
    <claims>{"name":"JohnSmith,
              "ID":"1234567890"}</claims>
</ zosconnect_authTokenLocal >
<zosconnect_endpointConnection id="conn"
    host="http://api.server.com" port="8080"
    authenticationConfigRef=”jwtConfig" />
```

Configure the Liberty jwtBuilder element in server.xml.

Configure the zosconnect_authTokenLocal element, specifying any additional private claims required and the name of the header used to send the JWT to the endpoint.

header default value is Authorization

Finally, reference the JWT configuration from the zosconnect_endpointConnection element.

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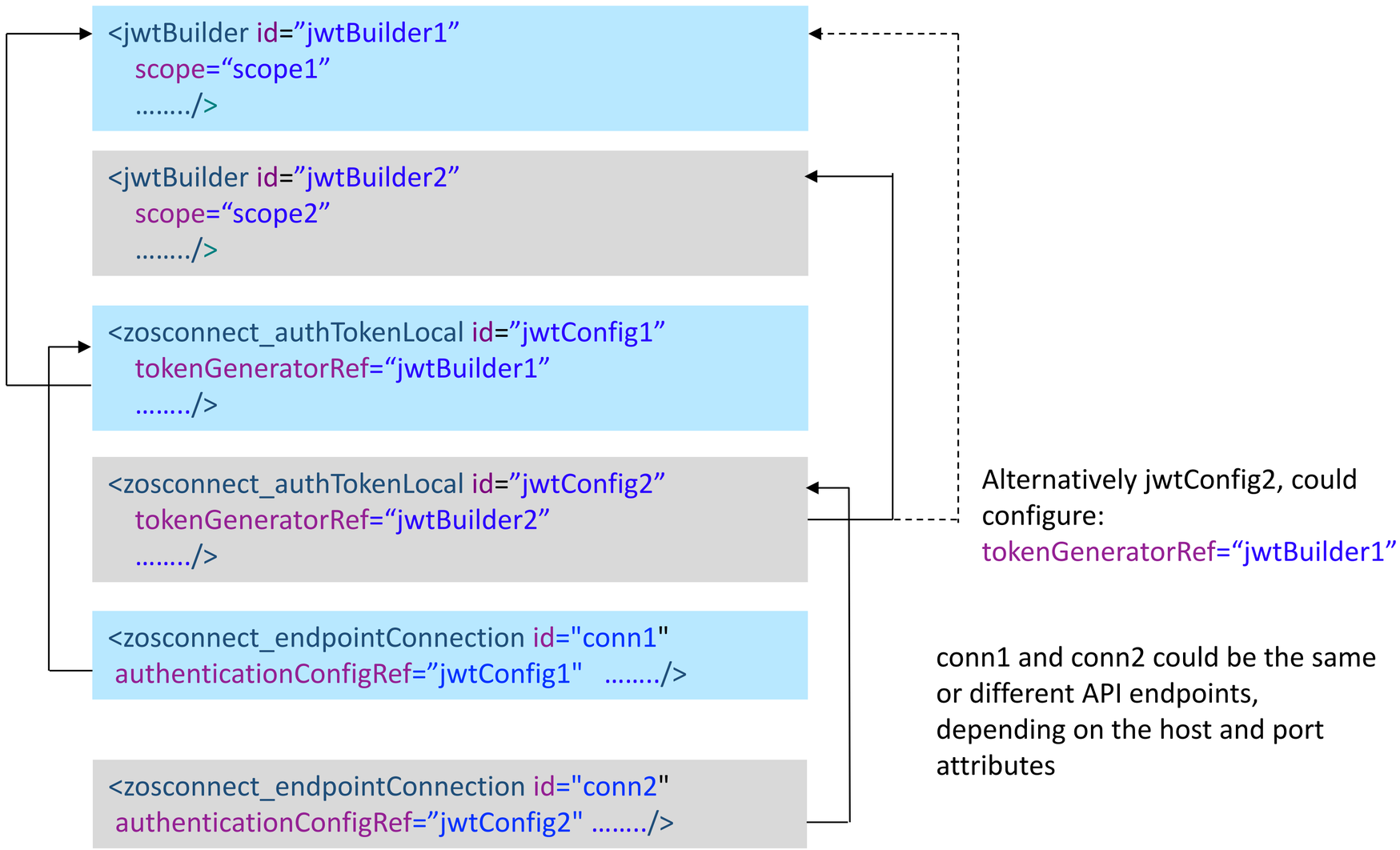
Using different claims for different API endpoints



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Agenda

- What is REST and what are REST APIs?
- Using an z/OS Connect API requester to access a REST API
- General API requester COBOL client programming considerations
- Developing API requesters for Swagger 2.0 REST APIs
- Developing API requesters for OpenAPI 3 REST APIs
- Configuration and Security considerations for API requesters

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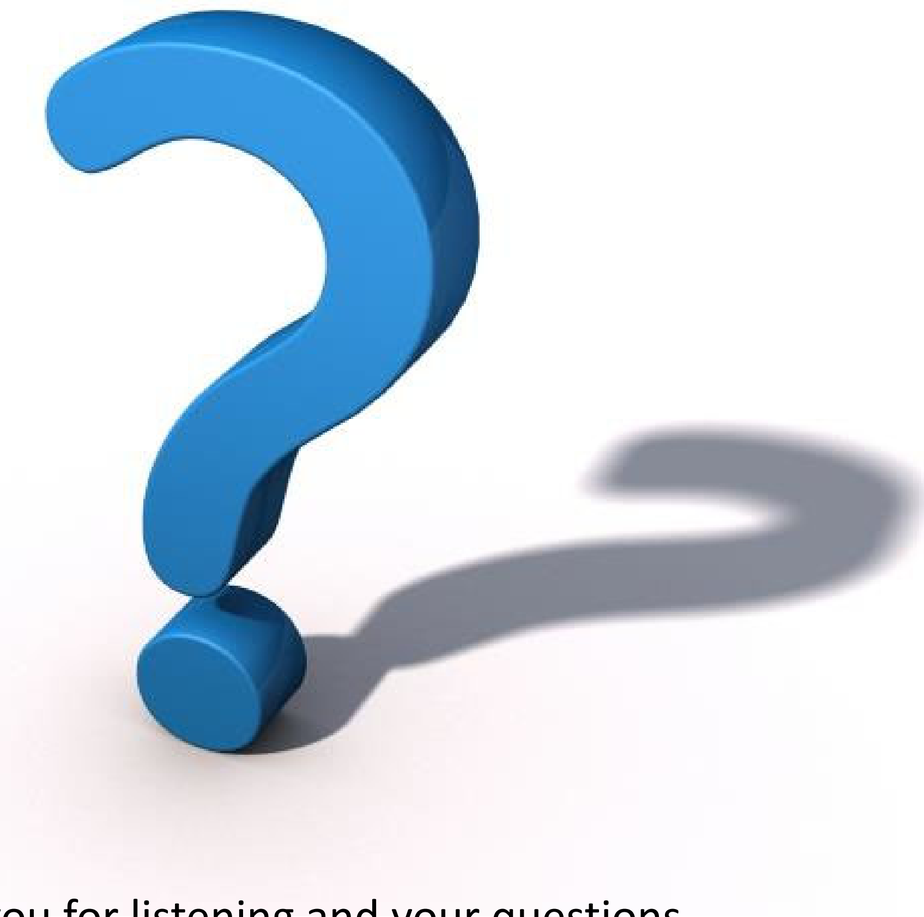

Thank you for listening and your questions.

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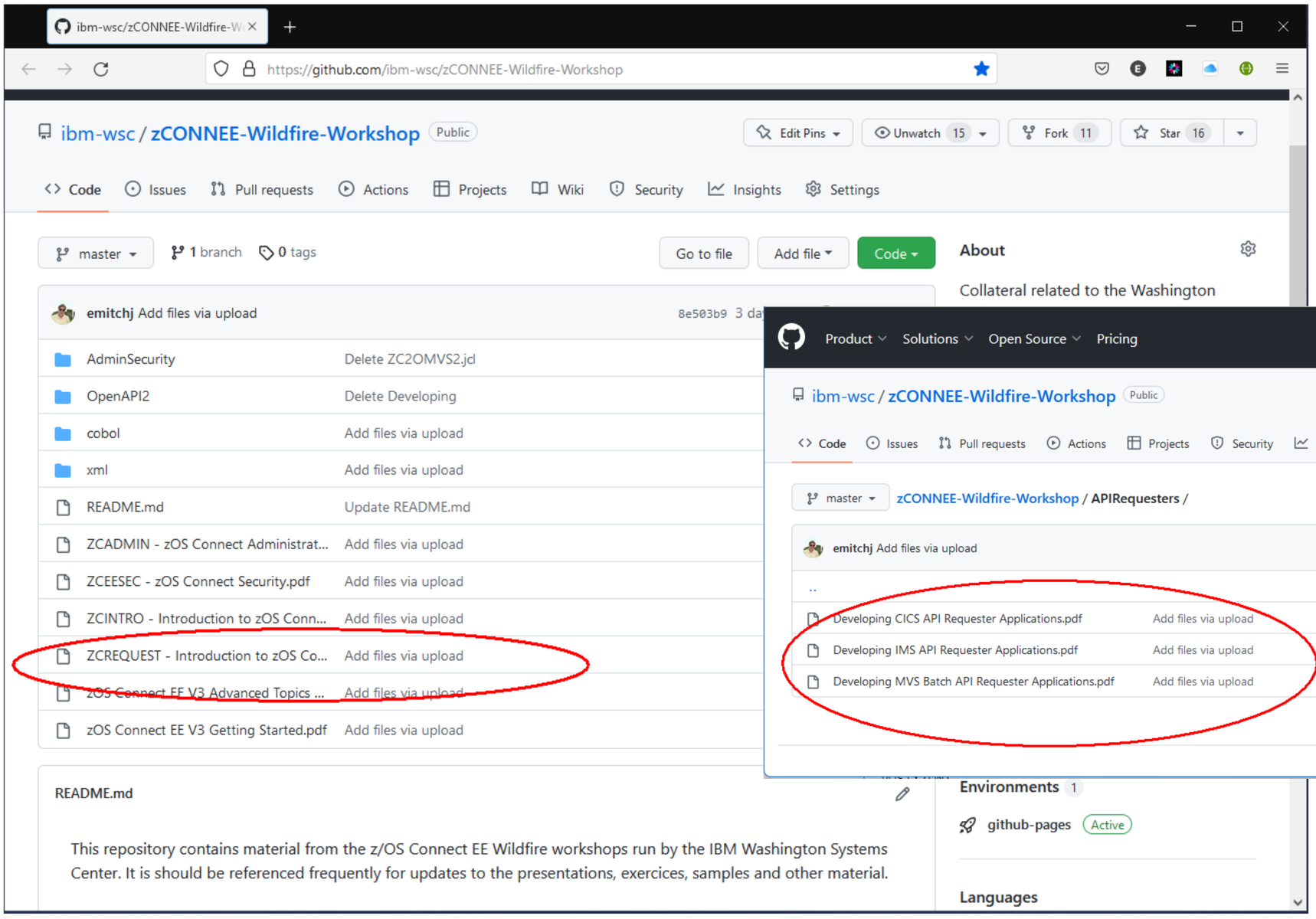
z/OS Connect Wildfire Github Site

https://ibm.biz/BdPRGD



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

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