



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 a 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

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 3 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.



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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Slide 1



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>



Screenshot of the GitHub repository page for [zCONNEE-Wildfire-Workshop](#).

The repository is public and contains 1 branch and 0 tags. The master branch has 635 commits from user [emitchj](#). A red oval highlights the first commit, which is an upload of files.

Commit	Message	Date
emitchj Add files via upload		d1c0657 last week
APIRequesters	Add files via upload	2 months ago
AdminSecurity	Delete AdminSecurity/ctl directory	2 months ago
COBOL Samples	Add files via upload	5 months ago
JCL Samples	Add files via upload	2 months ago
OpenAPI2	Add files via upload	2 months ago
OpenAPI3	Add files via upload	last week
XML Samples	Add files via upload	last year
archive	Add files via upload	last month
README.md	Update README.md	2 years ago
ZCADMIN - zOS Connect Administrat...	Add files via upload	2 months ago
ZCEESEC - zOS Connect Security.pdf	Add files via upload	last year
ZCINTRO - Introduction to zOS Conn...	Add files via upload	last month
ZCREQUEST - Introduction to zOS Co...	Add files via upload	last month
zOS Connect EE V3 Advanced Topics ...	Add files via upload	2 years ago
zOS Connect EE V3 Getting Started.pdf	Add files via upload	2 years ago

About
Collateral related to the Washington System Center z/OS Connect Wildfire Workshops

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

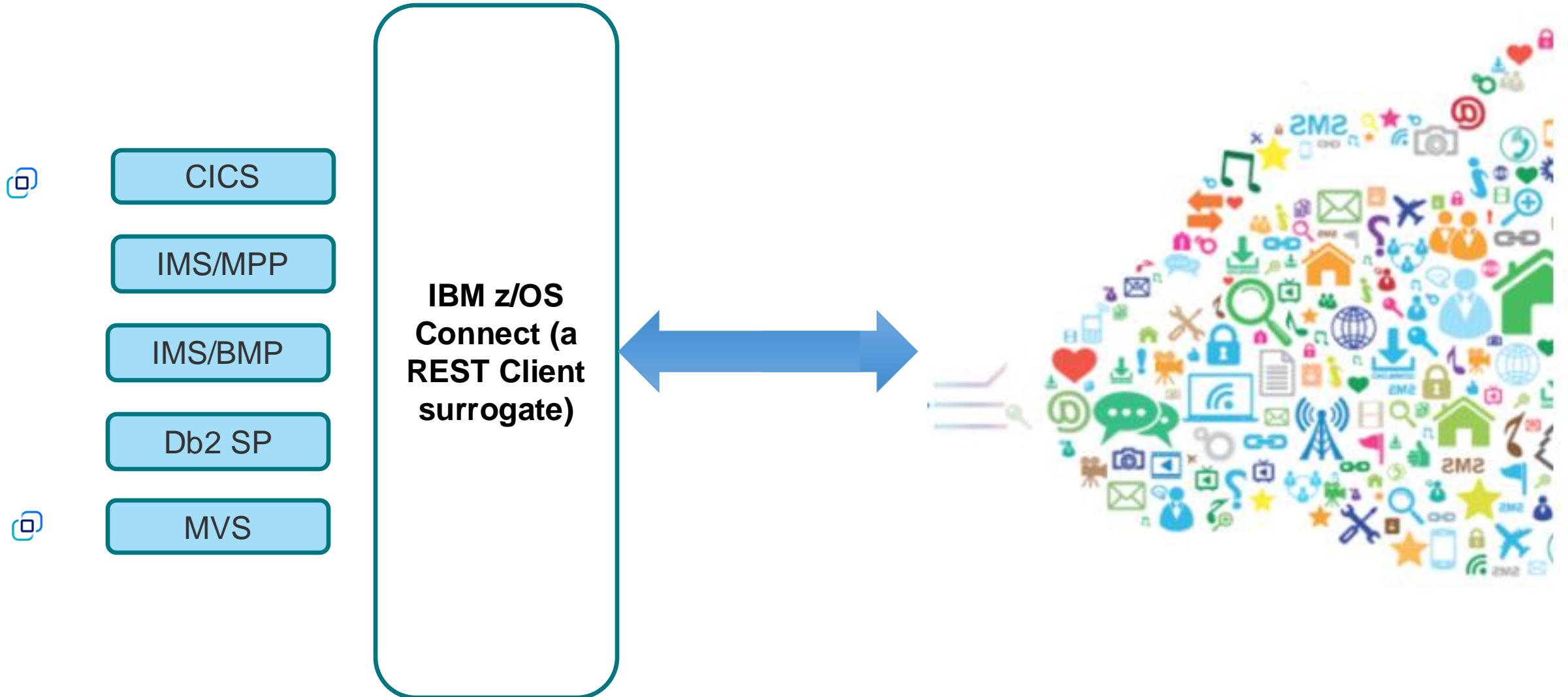


The screenshot shows a Windows desktop environment running on IBM's Z Virtual Access (zVA). The desktop background is the standard Windows 10 blue gradient. A 'zVA - Remote Desktop' window is open at the top, displaying a file explorer window titled 'Select Administrator: Command Prompt'. The file explorer shows a directory structure with 6 files and 4 dirs. The command prompt window displays a series of log messages related to API requester creation and processing operations. The taskbar at the bottom includes icons for the Start button, File Explorer, Firefox, Task View, Task Manager, and a search bar. A PDF file icon with the text 'Important... Me.pdf' is pinned to the taskbar.

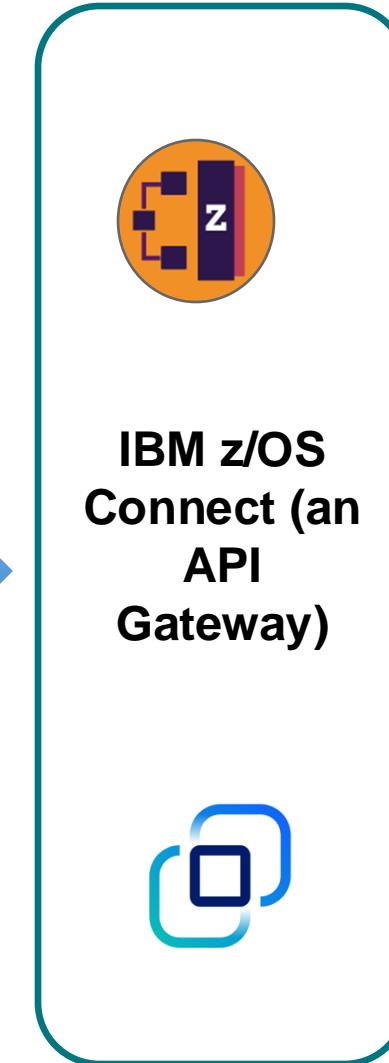
```
c:\ Select Administrator: Command Prompt
6 File(s) 16,849 bytes
4 Dir(s) 54,848,405,504 bytes free

c:\z\apiRequester\cscvinc>cscvinc
c:\z\apiRequester\cscvinc>c:\software\zconbt\bin\zconbt.bat -p= ./cscvinc.properties -f= ./cscvinc.ara
BAQ0000I: z/OS Connect Enterprise Edition 3.0 Build Toolkit Version 1.14 (20230417-1402).
BAQ00008I: Creating API requester archive from configuration file ./cscvinc.properties.
BAQ0040I: The generated API requester is automatically named cscvinc_1.0.0 based on the title cscvinc and version 1.0.0
of the API to be called.
BAQ0049W: Specifying a header parameter with the name Authorization is not supported, the header parameter is ignored.
BAQ0049W: Specifying a header parameter with the name Authorization is not supported, the header parameter is ignored.
BAQ0025W: Multiple HTTP status codes are not supported in the response of operation (operationId: getCscvincSelectService, relativePath: /employee/{employee}, method: GET). 200 used and 404 ignored by the build toolkit.
BAQ0049W: Specifying a header parameter with the name Authorization is not supported, the header parameter is ignored.
BAQ0025W: Multiple HTTP status codes are not supported in the response of operation (operationId: putCscvincUpdateService, relativePath: /employee/{employee}, method: PUT). 200 used and 400 ignored by the build toolkit.
BAQ0049W: Specifying a header parameter with the name Authorization is not supported, the header parameter is ignored.
BAQ0015I: Start processing operation (operationId: postCscvincInsertService, relativePath: /employee, method: POST).
DFHPI9586W A reserved word "address" has been detected in the input document, it has been changed to "Xaddress".
DFHPI9586W A reserved word "date" has been detected in the input document, it has been changed to "Xdate".
BAQ0016I: Successfully processed operation (operationId: postCscvincInsertService, relativePath: /employee, method: POST).
BAQ0015I: Start processing operation (operationId: getCscvincSelectService, relativePath: /employee/{employee}, method: GET).
DFHPI9586W A reserved word "address" has been detected in the input document, it has been changed to "Xaddress".
DFHPI9586W A reserved word "date" has been detected in the input document, it has been changed to "Xdate".
BAQ0016I: Successfully processed operation (operationId: getCscvincSelectService, relativePath: /employee/{employee}, method: GET).
BAQ0015I: Start processing operation (operationId: putCscvincUpdateService, relativePath: /employee/{employee}, method: PUT).
```

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



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



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

Let's start by defining REST

/what_is_REST?

And what makes an API “RESTful”?



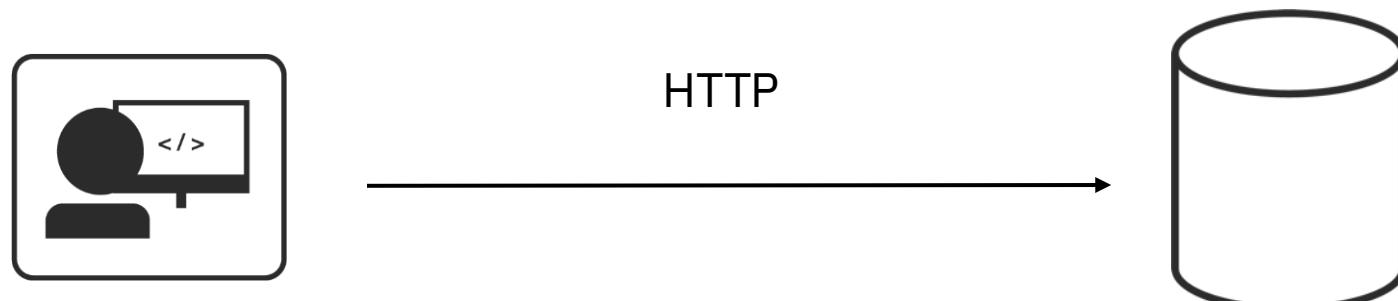
REST is architectural programming style

REST is an acronym standing for **R**epresentational **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.



REST APIs follow two key principles

REST APIs use a HTTP verb to specify the operations, e.g., **Create** (POST), **Read**(GET), **Update**(PUT), **Delete**(DELETE), for more information on **CRUD**, 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 (**Java Script Object Notation**) 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" }



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>



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

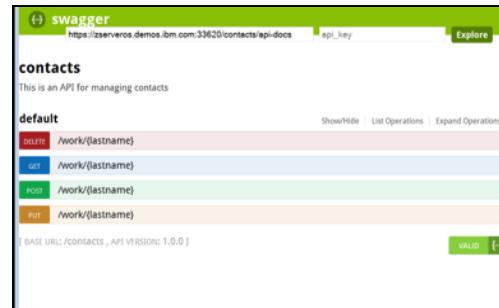


There are a number of tools available to aid in the creation and consumption of APIs

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.*

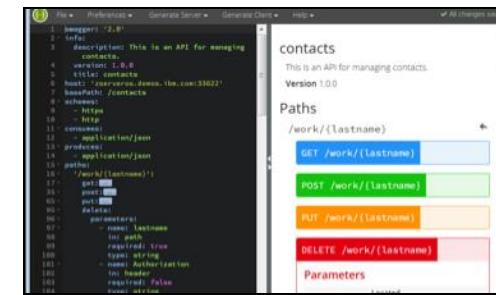


Test UIs - allows API consumers to easily browse and try APIs based on an OpenAPI document.



The screenshot shows the Swagger UI for a 'contacts' API. It lists four operations under the 'default' path: DELETE /work/{lastname}, GET /work/{lastname}, POST /work/{lastname}, and PUT /work/{lastname}. The 'DELETE' operation is highlighted in red. Below the operations, there is a 'VALID' button.

Editors - allows API developers to design their OpenAPI documents.



The screenshot shows the JSON Formatter interface displaying an OpenAPI specification for a 'contacts' API. The specification includes information about the API version (1.0.0), contact management, and various HTTP methods and paths. On the right side, there is a preview of the API operations.

* z/OS Connect API Requester

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

<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).



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 consumed 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.



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": "getCsvincSelectService",
        "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"
          }
        }
      }
    }
  }
}

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: getCsvincSelectService
          x-ibm-zcon-roles-allowed:
            - Staff
          parameters:
            - name: Authorization
              in: header
              schema:
                type: string
Ln 18, Col 7 100% Windows (CRLF) UTF-8
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

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



```
File Edit View
cscvinc.yaml
"/employee/{employee}":
  get:
    tags:
      - Employee
    operationId: getEmployeeSelectService
    x-ibm-zcon-roles-allowed:
      - Staff
    parameters:
      - name: Authorization
        in: header
        required: false
        schema:
          type: string
      - name: employee
        in: path
        required: true
        schema:
          type: string
          maxLength: 6
    responses:
      "200":
        description: OK
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getEmployeeSelectService_response_200"
      "404":
        description: Not Found
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getEmployeeSelectService_response_404"
      "500":
        description: Severe Error
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/getEmployeeSelectService_response_500"
  put:
    tags:
      - Employee
Ln 1, Col 1 | 100% | Windows (CRLF) | UTF-8
```

```
File Edit View
cscvinc.yaml
getEmployeeSelectService_response_200:
  type: object
  properties:
    summary:
      $ref: '#/components/schemas/getEmployeeSelectService_response_200_message'
    detail:
      $ref: '#/components/schemas/getEmployeeSelectService_response_200_detail'
  getEmployeeSelectService_response_200_message:
    type: object
    properties:
      message:
        type: string
      example:
        message: record retrieved
  getEmployeeSelectService_response_200_detail:
    type: object
    properties:
      EmployeeSelectServiceOperationResponse:
        type: object
        properties:
          employeeData:
            type: object
            properties:
              response:
                type: object
                properties:
                  employeeDetails:
                    type: object
                    properties:
                      employeeNumber:
                        type: string
                        maxLength: 6
                      name:
                        type: string
                        maxLength: 20
                      address:
                        type: string
                        maxLength: 20
                      phoneNumber:
                        type: string
                        maxLength: 8
Ln 1, Col 1 | 100% | Windows (CRLF) | UTF-8
```



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

```
55  
56  
57 // Invoke the REST API using a GET method  
58 URL url = new URL("https://wg31.washington.ibm.com:9453/cscvinc/employee/" + args[1]);  
59 System.out.println("URL: " + url);  
60 HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();  
61 conn.setRequestMethod("GET");  
62 conn.setRequestProperty("Content-Type", "application/json");  
63 byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());  
64 conn.addRequestProperty("Authorization", "Basic " + new String(bytesEncoded));  
65 try {  
66     if (conn.getResponseCode() != 200) {  
67         throw new RuntimeException("Failed : HTTP error code : " + conn.getResponseCode());  
68     }  
69     BufferedReader bufferReader = new BufferedReader(new InputStreamReader((conn.getInputStream())));  
70     while ((output = bufferReader.readLine()) != null) {  
71         System.out.println(output);  
72     }  
73 } catch (Exception e) {  
74     e.printStackTrace();  
75 }
```

```
52  
53  
54 // Invoke the REST API using a GET method  
55 URL url = new URL("https://wg31.washington.ibm.com:9453/db2/employee/" + args[1]);  
56 System.out.println("URL: " + url);  
57 HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();  
58 conn.setRequestMethod("GET");  
59 conn.setRequestProperty("Content-Type", "application/json");  
60 byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());  
61 conn.addRequestProperty("Authorization", "Basic " + new String(bytesEncoded));  
62 try {  
63     if (conn.getResponseCode() != 200) {  
64         throw new RuntimeException("Failed : HTTP error code : " + conn.getResponseCode());  
65     }  
66     BufferedReader bufferReader = new BufferedReader(new InputStreamReader((conn.getInputStream())));  
67     while ((output = bufferReader.readLine()) != null) {  
68         System.out.println(output);  
69     }  
70 } catch (Exception e) {  
71     e.printStackTrace();  
72 }
```

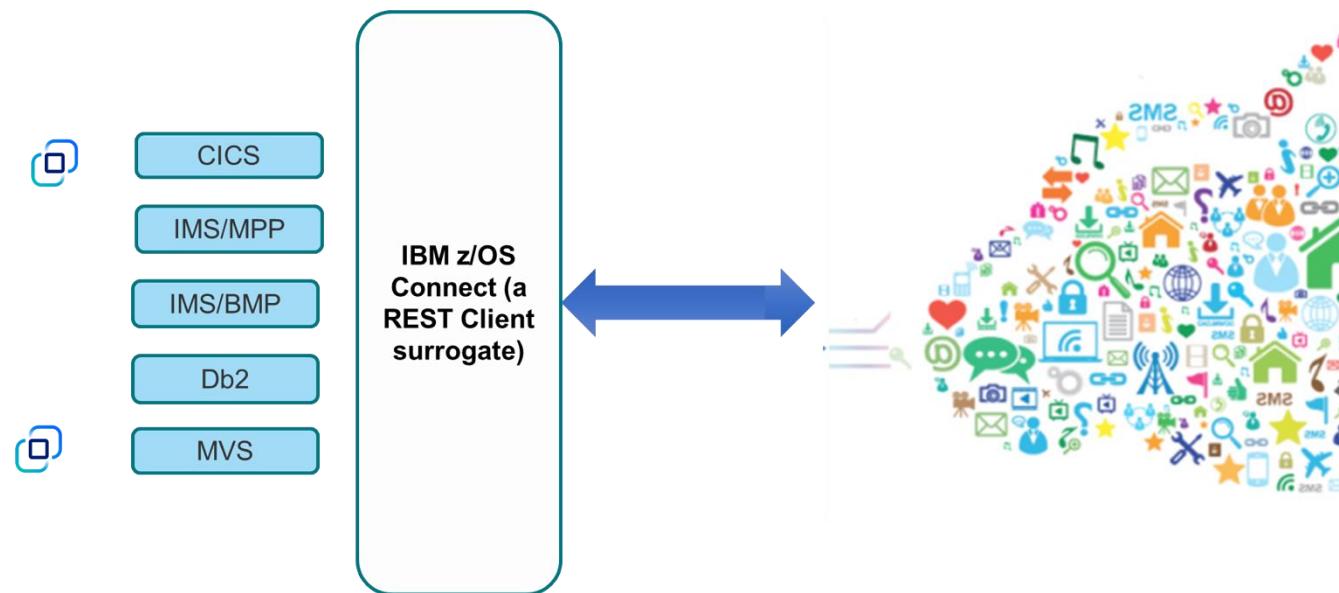
In these examples, these Java clients have the same application programming pattern.

- 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.



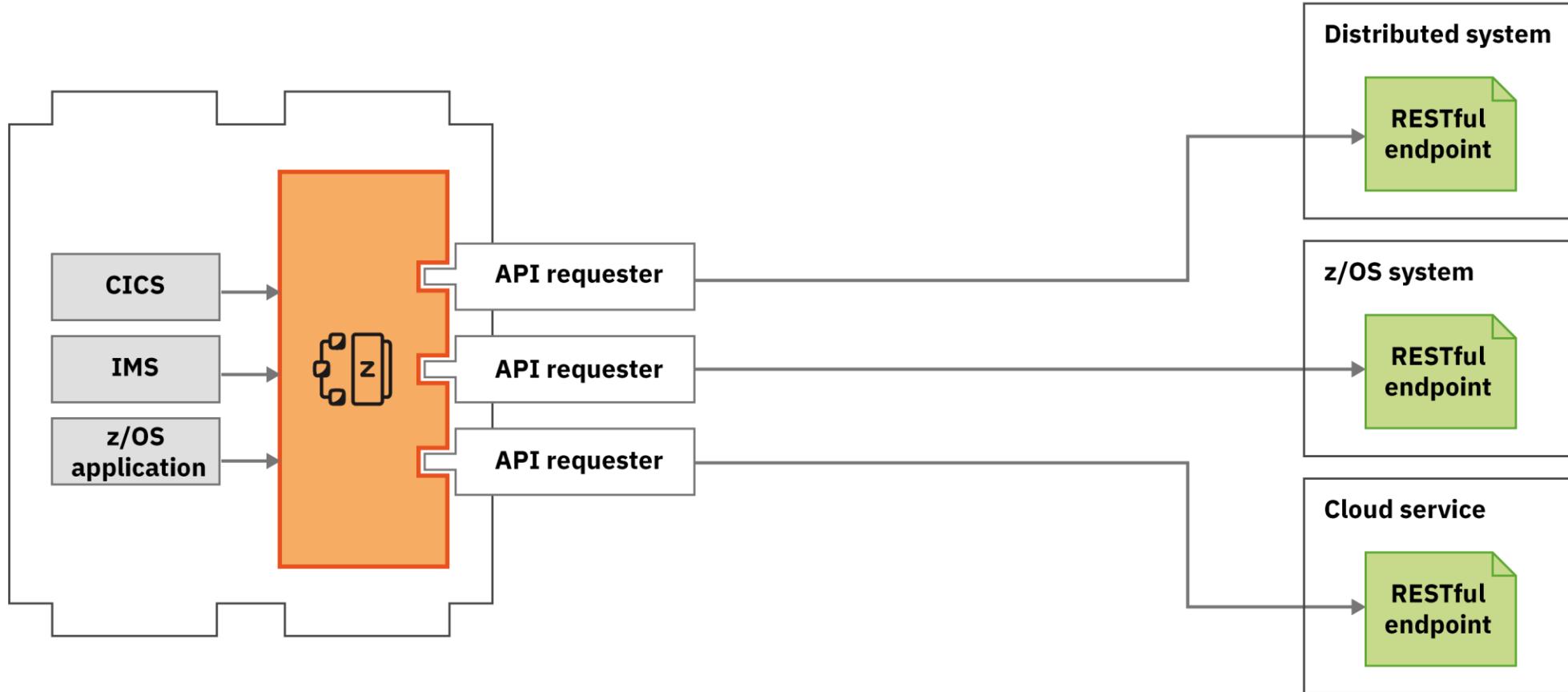
Using an z/OS Connect API requester to access a REST APIs

Developing COBOL API Requester applications

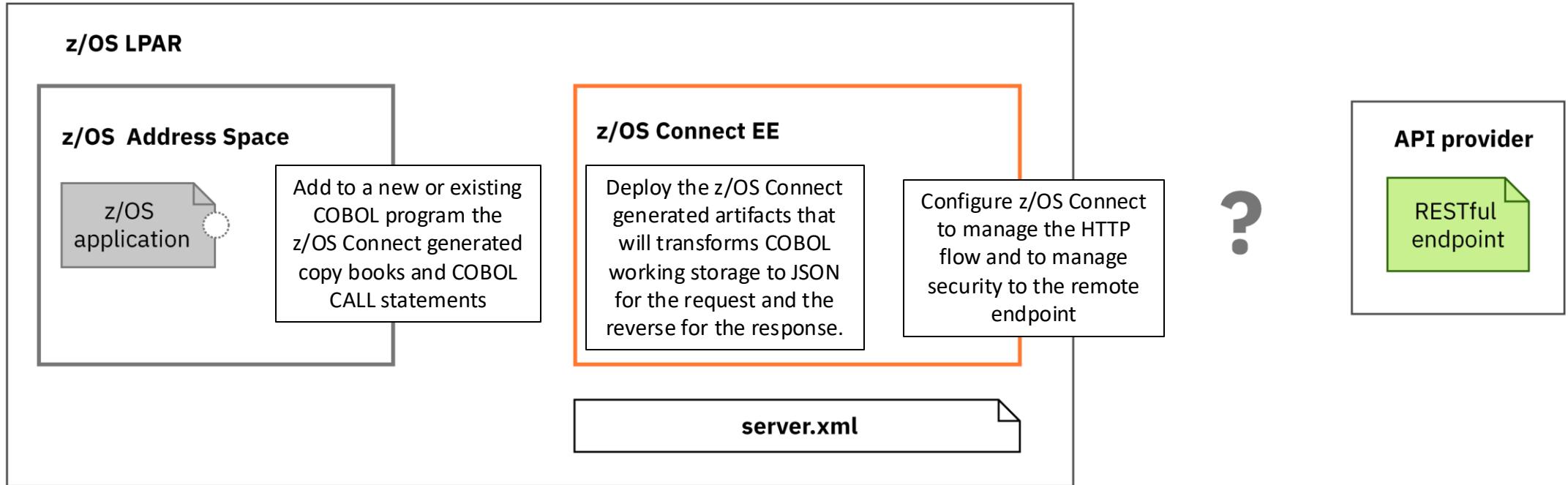




z/OS Connect tooling generates the artifacts used to invoke APIs from z/OS application



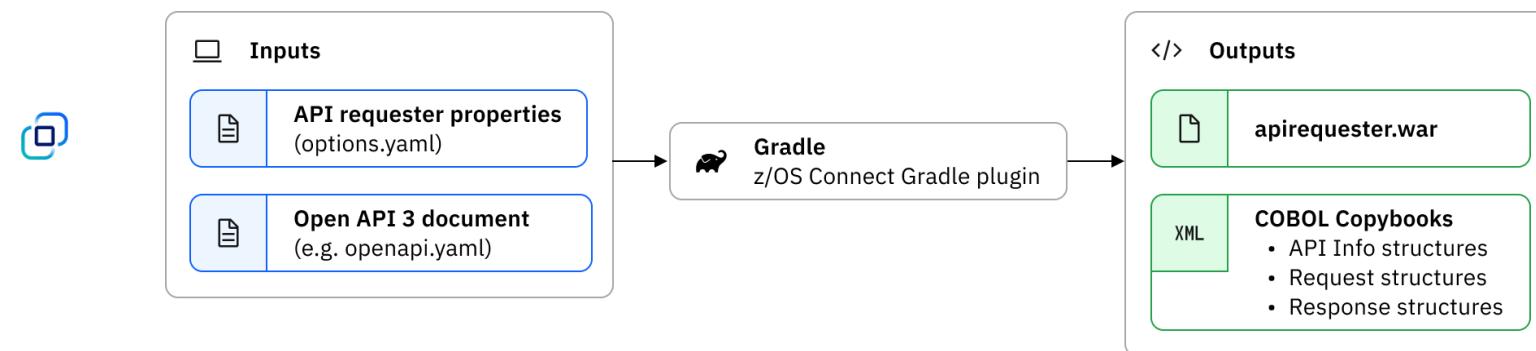
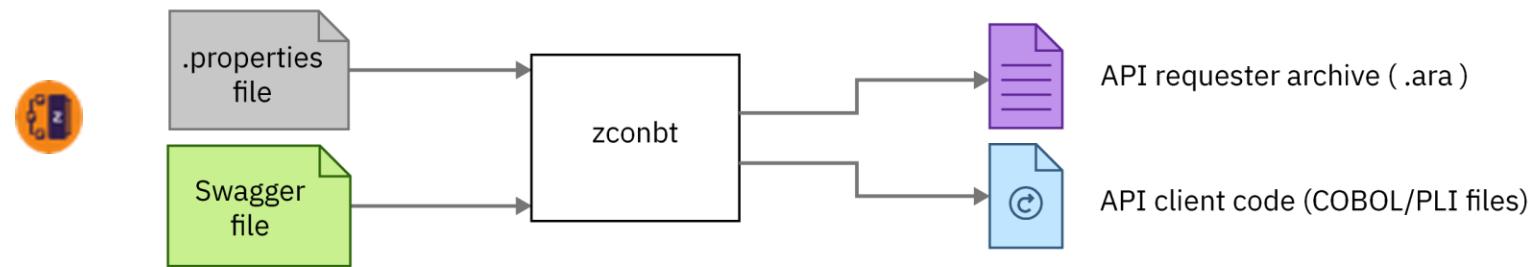
A detailed look at the steps required to invoke a remote API



Development starts with the OAS specification document of the API



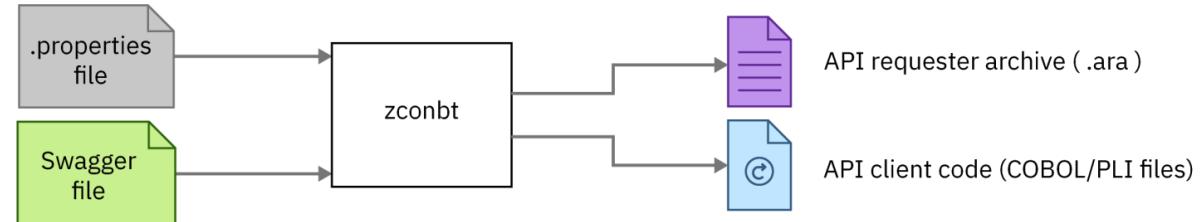
z/OS Connect tooling consuming the API's specification description to generate COBOL copy books and an API requester archive (ARA) file for an Swagger 2.0 API or a web archive (WAR) file for an OpenAPI 3 API.



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



The screenshot shows a browser window displaying a Swagger 2.0 JSON API definition. The URL is file:///C:/apiRequester/cscvinc/cscvinc.json. The JSON structure includes fields like swagger version (2.0), info (title: cscvincapi, version: 1.0.0), paths (including /employee/{employee}), and responses (200 OK). The 'schemes' field is highlighted in blue.



properties file#

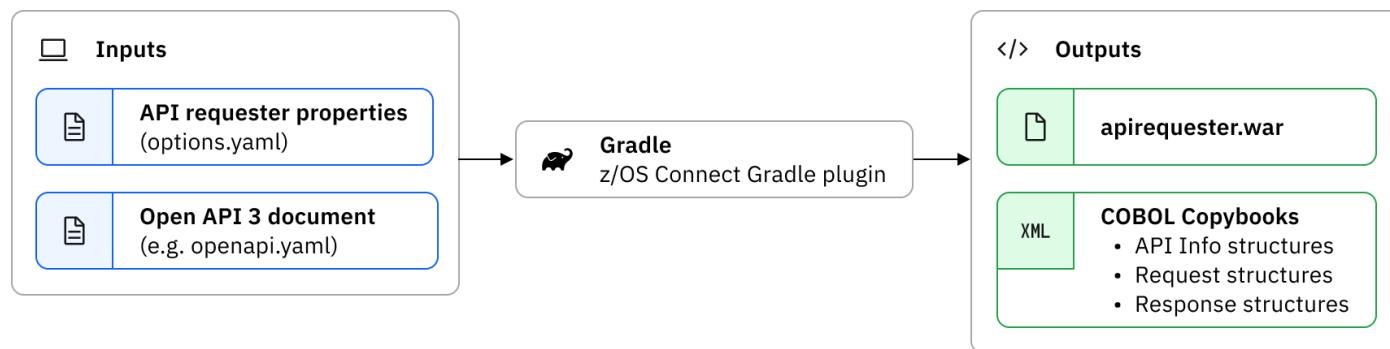
```
apiDescriptionFile=./cscvinc.json
dataStructuresLocation=./syslib
apiInfoFileLocation=./syslib
logFileDirectory=./logs
language=COBOL
connectionRef=cscvincAPI
requesterPrefix=csc
```

#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>

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



```
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>



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.
```



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
    01 GET-RESPONSE.
        COPY MQ000R01 SUPPRESS.
* Structure with the API information
01 GET-INFO-OPER1.
    COPY MQ000I01 SUPPRESS.
```

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.

Tech-Tip: BTW, the Gradle toolkit can be executed on z/OS

```
//*****  
/* SET SYMBOLS  
//*****  
//EXPORT EXPORT SYMLIST=(*)  
// SET JAVAHOME='/usr/lpp/java/J8.0_64'  
//*****  
/* Step ZCEEGRDL - Use Gradle command to create artifacts  
//*****  
//ZCEESRVR EXEC PGM=IKJEFT01,REGION=0M  
//SYSTSPRT DD SYSOUT=*  
//SYSERR DD SYSOUT=*  
//STDOUT DD SYSOUT=*  
//SYSTSIN DD *,SYMBOLS=EXECSYS  
BPXBATCH SH +  
export JAVA_HOME=&JAVAHOME; +  
cd gradle/cscvinc; +  
gradle build
```



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

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



An example of using the COBOL JSON PARSE

```
mpz3
File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
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.
001700      Move 2 to txnum.
001800      Initialize jtxt-1208 all value.
001900      Move function display-of(
002000          function national-of(
002100              jtxt-1047-transactions) 1208)
002200          to jtxt-1208(1:function length(jtx
002300      Json parse jtxt-1208 into transaction
002400      with detail
002500          name tx-price is 'tx-priceinUS$'
002600          not on exception
002700          display "Successful JSON Parse"
002800
MA       B
Connected to remote server/host mpz3 using lu/pool MPZ30021 and port 23
```

An example of invoking a Java class from COBOL

```
WG31 - 3270
File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
EDIT          JOHNSON.PASSTCKT.SOURCE(ATSPKTJ) - 01.06
Command ==>
000049      Procedure division.
000050          Set address of JNIEnv to JNIEnvPtr
000051          Set address of JNICALLInterface 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
Connected to remote server/host wg31 using lu/pool TCP00112 and port 23
Adobe PDF on Documents\*.pdf
13/00
```



```
// Invoke the REST API using a GET method
URL url = new URL("https://wg31.washington.ibm.com:9453/cscvinc/employee/" + args[1]);
System.out.println("URL: " + url);
HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();
conn.setRequestMethod("GET");
conn.setRequestProperty("Content-Type", "application/json");
byte[] bytesEncoded = Base64.encodeBase64(args[0].getBytes());
```

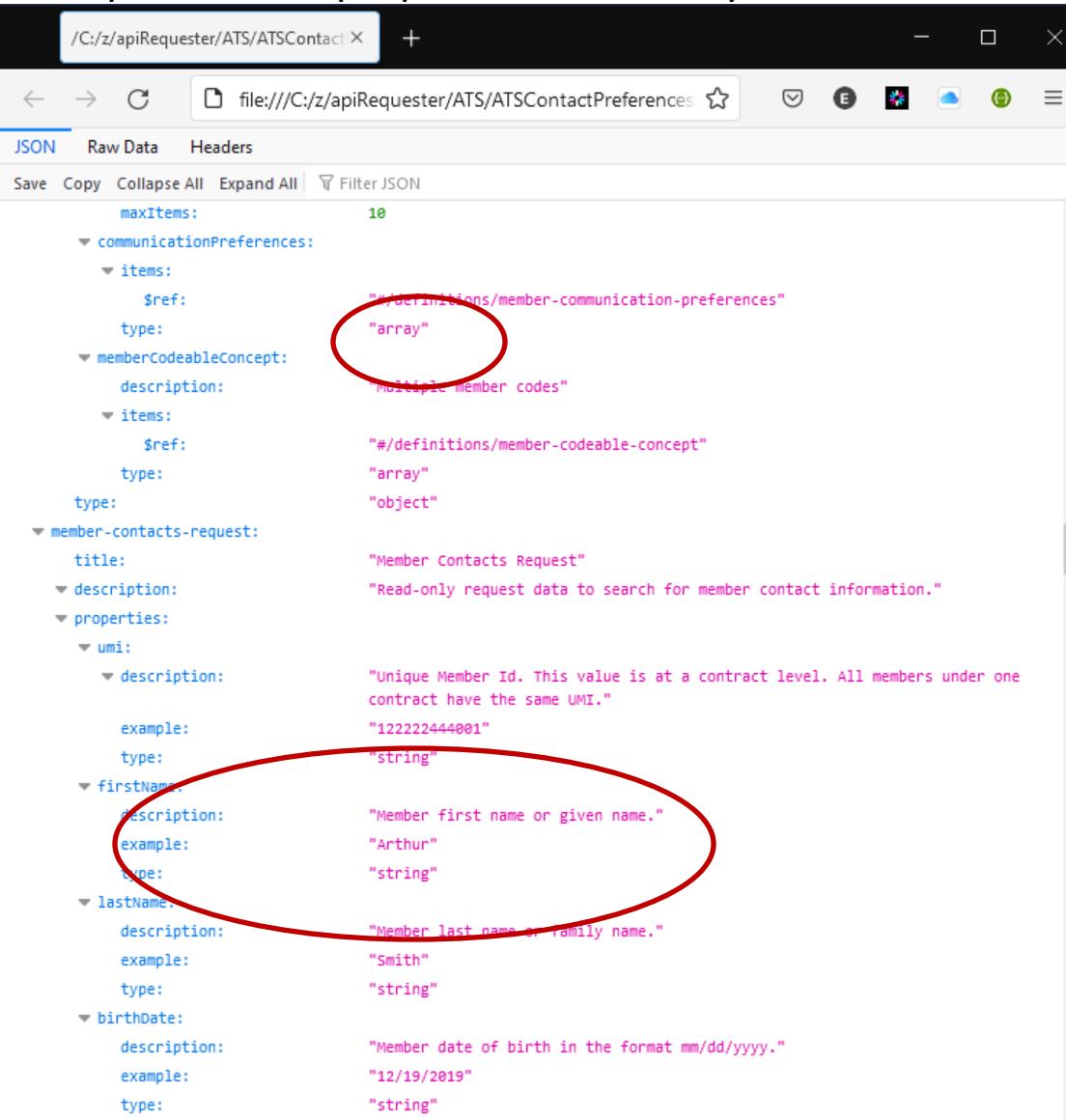
```
// Invoke the REST API using a GET method
URL url = new URL("https://wg31.washington.ibm.com:9453/db2/employee/" + args[1]);
System.out.println("URL: " + url);
HttpsURLConnection conn = (HttpsURLConnection) url.openConnection();
conn.setRequestMethod("GET");
conn.setRequestProperty("Content-Type", "application/json");
```

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.

First, be aware of COBOL working storage implications

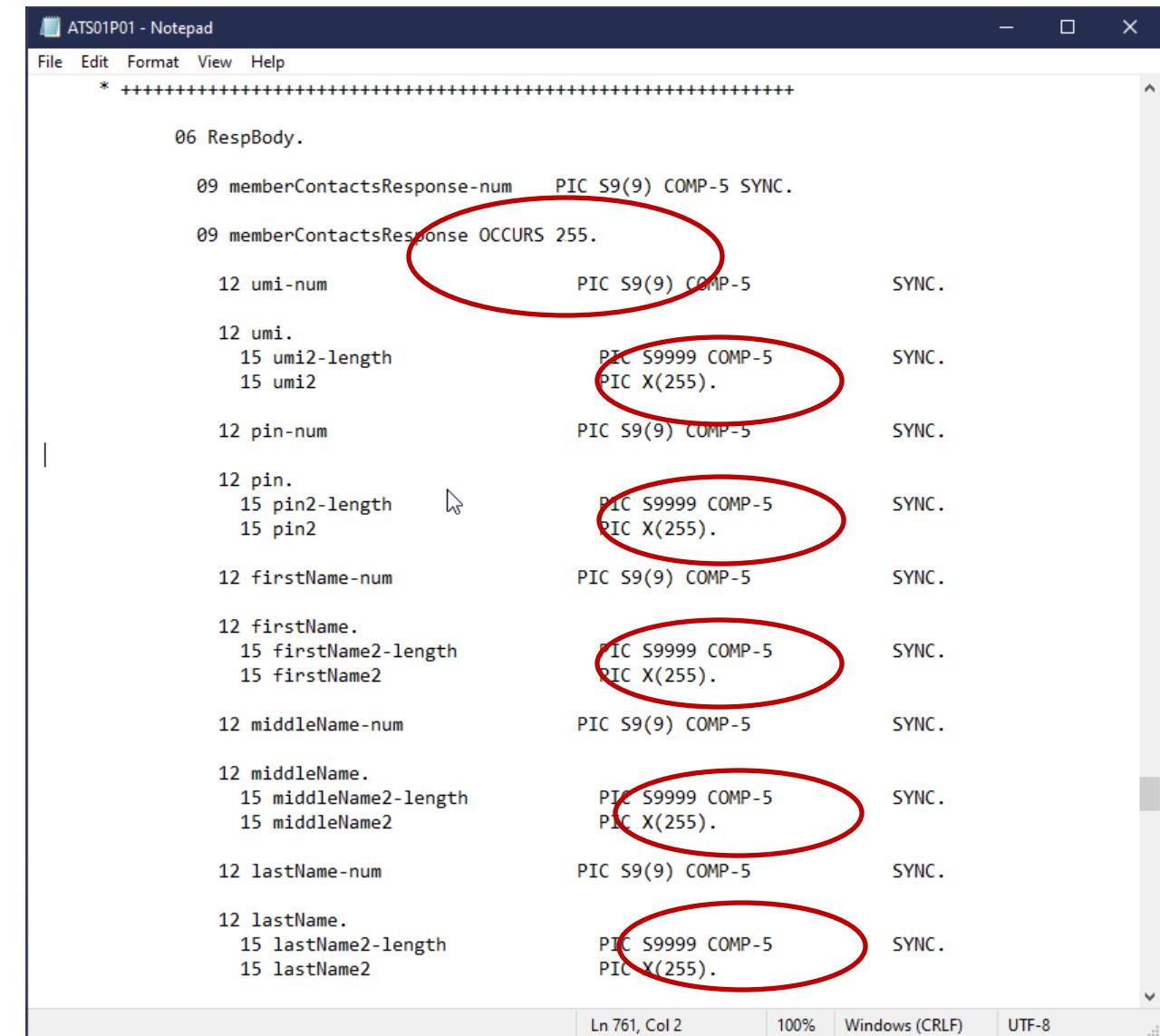
API specification properties are usually not constrained, this can lead to excessive working storage consumption¹



```

/C:/apiRequester/ATS/ATSContactX
+ - X
file:///C:/apiRequester/ATS/ATSContactPreferences
JSON Raw Data Headers
Save Copy Collapse All Expand All Filter JSON
maxItems: 10
communicationPreferences:
  items:
    $ref: "#/definitions/member-communication-preferences"
    type: "array"
  description: "Multiple member codes"
memberCodeableConcept:
  description: "Multiple member codes"
  items:
    $ref: "#/definitions/member-codeable-concept"
    type: "array"
    type: "object"
member-contacts-request:
  title: "Member Contacts Request"
  description: "Read-only request data to search for member contact information."
  properties:
    umi:
      description: "Unique Member Id. This value is at a contract level. All members under one contract have the same UMI."
      example: "12222444001"
      type: "string"
    firstName:
      description: "Member first name or given name."
      example: "Arthur"
      type: "string"
    lastName:
      description: "Member last name or family name."
      example: "Smith"
      type: "string"
    birthDate:
      description: "Member date of birth in the format mm/dd/yyyy."
      example: "12/19/2019"
      type: "string"

```



```

ATS01P01 - Notepad
File Edit Format View Help
* ++++++
06 RespBody.

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

09 memberContactsResponse OCCURS 255.

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

12 umi.
  15 umi2-length
  15 umi2
PIC S9(9) COMP-5
PIC X(255).

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

12 pin.
  15 pin2-length
  15 pin2
PIC S9(9) COMP-5
PIC X(255).

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

12 firstName.
  15 firstName2-length
  15 firstName2
PIC S9(9) COMP-5
PIC X(255).

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

12 middleName.
  15 middleName2-length
  15 middleName2
PIC S9(9) COMP-5
PIC X(255).

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

12 lastName.
  15 lastName2-length
  15 lastName2
PIC S9(9) COMP-5
PIC X(255).

```



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	

```
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.
STRING ws-length delimited by size
```



Tech-Tip: Consider adding explicit constraints to the properties

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

A screenshot of a JSON editor window titled "C:/z/apiRequester/ATS/MemberCo...". The JSON structure shows a "communicationPreferences" object with an "items" array. One item in this array has a "maxItems" constraint circled in red. Below it, the "umi" property has a "type" of "string" and a "maxLength" constraint circled in red.

```
JSON Raw Data Headers
Save Copy Collapse All Expand All Filter JSON
{
    "type": "array",
    "items": [
        {
            "$ref": "#/definitions/member-communication-preferences",
            "type": "array",
            "maxItems": 10
        }
    ],
    "memberCodeableConcept": {
        "description": "Multiple member codes"
    },
    "items": [
        {
            "$ref": "#/definitions/member-codeable-concept",
            "type": "array"
        }
    ],
    "type": "object"
}
```

Member-contacts-request:

```
title: "Member Contacts Request"
description: "Read-only request data to search for member contact information."
properties:
    umi:
        description: "Unique Member Id. This value is at a contract level. All members under one contract have the same UMI."
        example: "12222444001"
        type: string
        maxLength: 12
```

First Name and Last Name properties also have their "maxLength" constraints circled in red.

```
firstName:
    description: "Member first name or given name."
    example: "Arthur"
    type: string
    maxLength: 30
```

```
lastName:
    description: "Member last name or family name."
    example: "Smith"
```

A screenshot of a Notepad window titled "ATS01P01 - Notepad". It contains a series of COBOL-like definitions for fields in a memberContactsResponse structure. Several fields have their lengths circled in red: "filler" (length 15), "umi-num" (length 12), "umi2-length" (length 15), "pin-num" (length 12), "pin-length" (length 15), "firstName-num" (length 12), "firstName2-length" (length 15), "middleName-num" (length 12), and "middleName2-length" (length 15). Each circled length is followed by a "PIC" definition (e.g., PIC S9(9) COMP-5) and a "SYNC." indicator.

```
* Comments for field 'filler':
* This is a filler entry to ensure the correct padding for a
* structure. These slack bytes do not contain any application
* data.
*      15 filler          PIC X(3).
*
*
* ++++++
06 RespBody.

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

09 memberContactsResponse OCCURS 10.

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

12 umi.
    15 umi2-length
    15 umi2          PIC S9999 COMP-5
                    PIC X(12).

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

12 pin.
    15 pin2-length
    15 pin2          PIC S9999 COMP-5
                    PIC X(255).

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

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

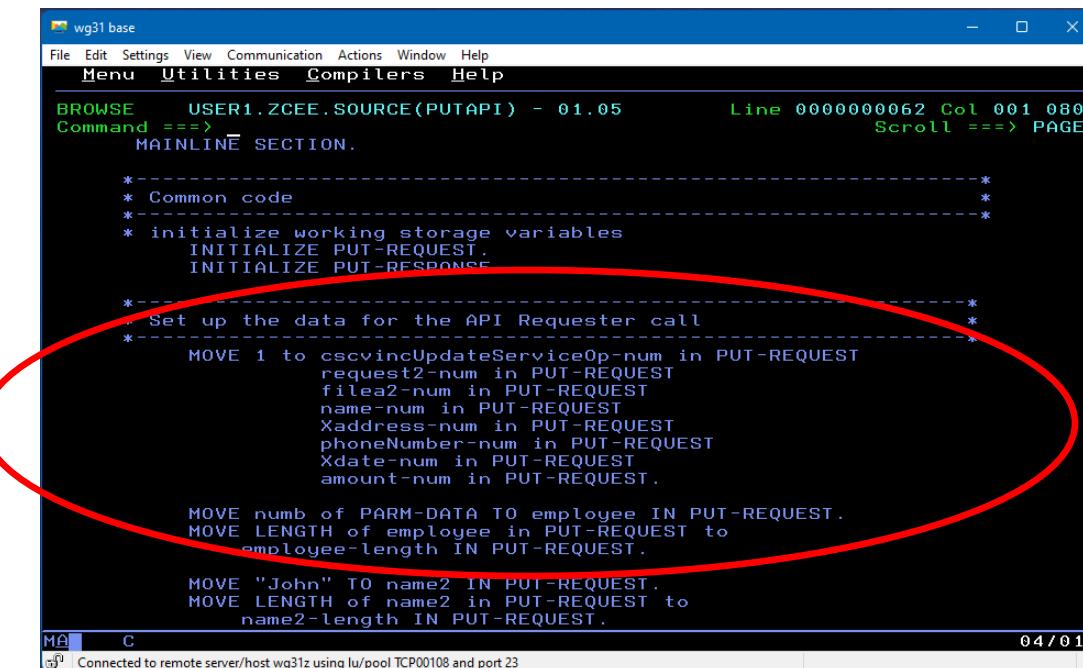
12 middleName-num               PIC S9(9) COMP-5 SYNC.

12 middleName.
    15 middleName2-length
    15 middleName2   PIC S9999 COMP-5
                    PIC X(30).
```

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.



```
wg31 base
File Edit Settings View Communication Actions Window Help
Menu Utilities Compilers Help
BROWSE USER1.ZCEE.SOURCE(PUTAPI) - 01.05      Line 0000000062 Col 001 080
Command ==>                                     Scroll ==> PAGE
MAINLINE SECTION.

*-----*
* Common code
*-----*
* initialize working storage variables
  INITIALIZE PUT-REQUEST.
  INITIALIZE PUT-RESPONSE.

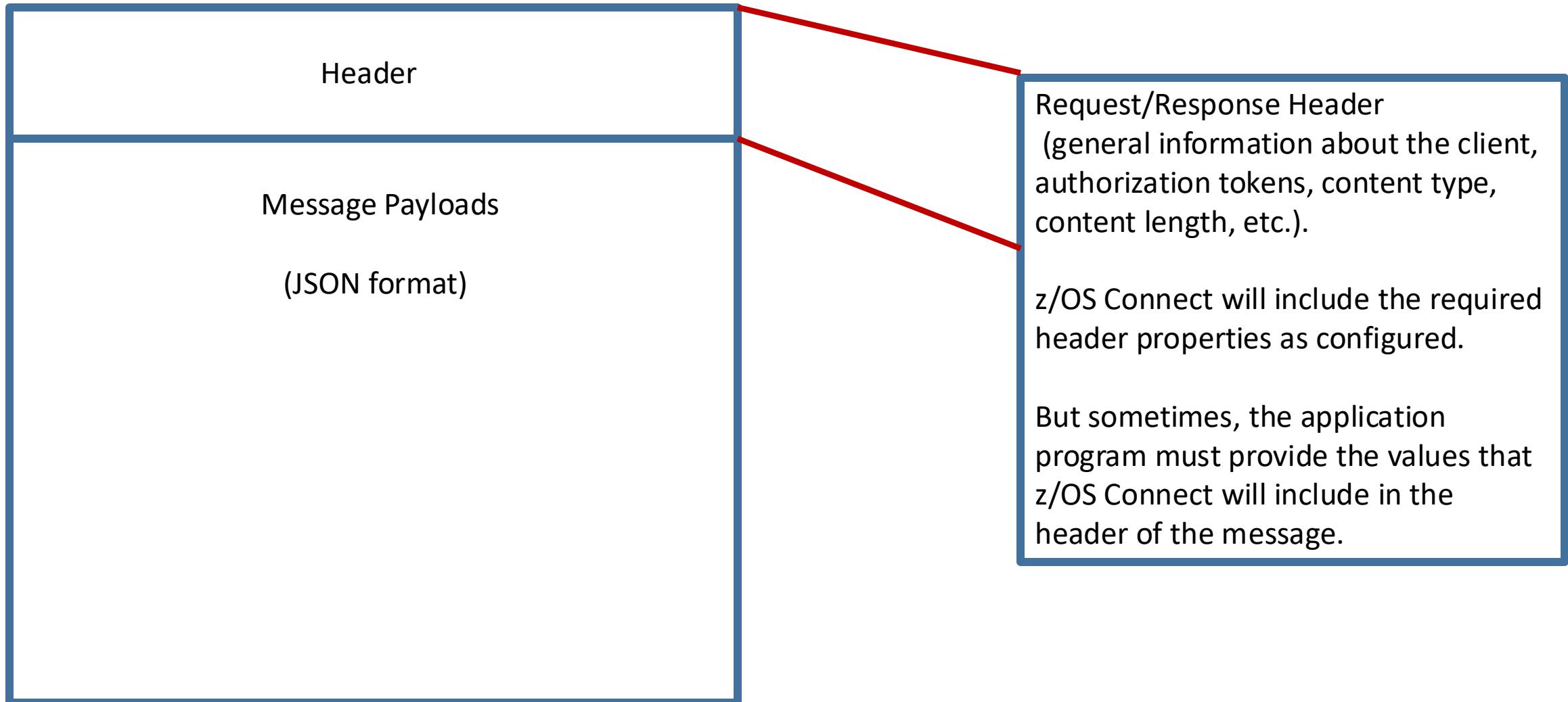
*-----*
* Set up the data for the API Requester call
*-----*
  MOVE 1 to csvincUpdateServiceOp-num in PUT-REQUEST
  request2-num in PUT-REQUEST
  filea2-num in PUT-REQUEST
  name-num in PUT-REQUEST
  Xaddress-num in PUT-REQUEST
  phoneNumber-num in PUT-REQUEST
  Xdate-num in PUT-REQUEST
  amount-num in PUT-REQUEST.

  MOVE numb of PARM-DATA TO employee IN PUT-REQUEST.
  MOVE LENGTH of employee in PUT-REQUEST to
        employee-length IN PUT-REQUEST.

  MOVE "John" TO name2 IN PUT-REQUEST.
  MOVE LENGTH of name2 in PUT-REQUEST to
        name2-length IN PUT-REQUEST.

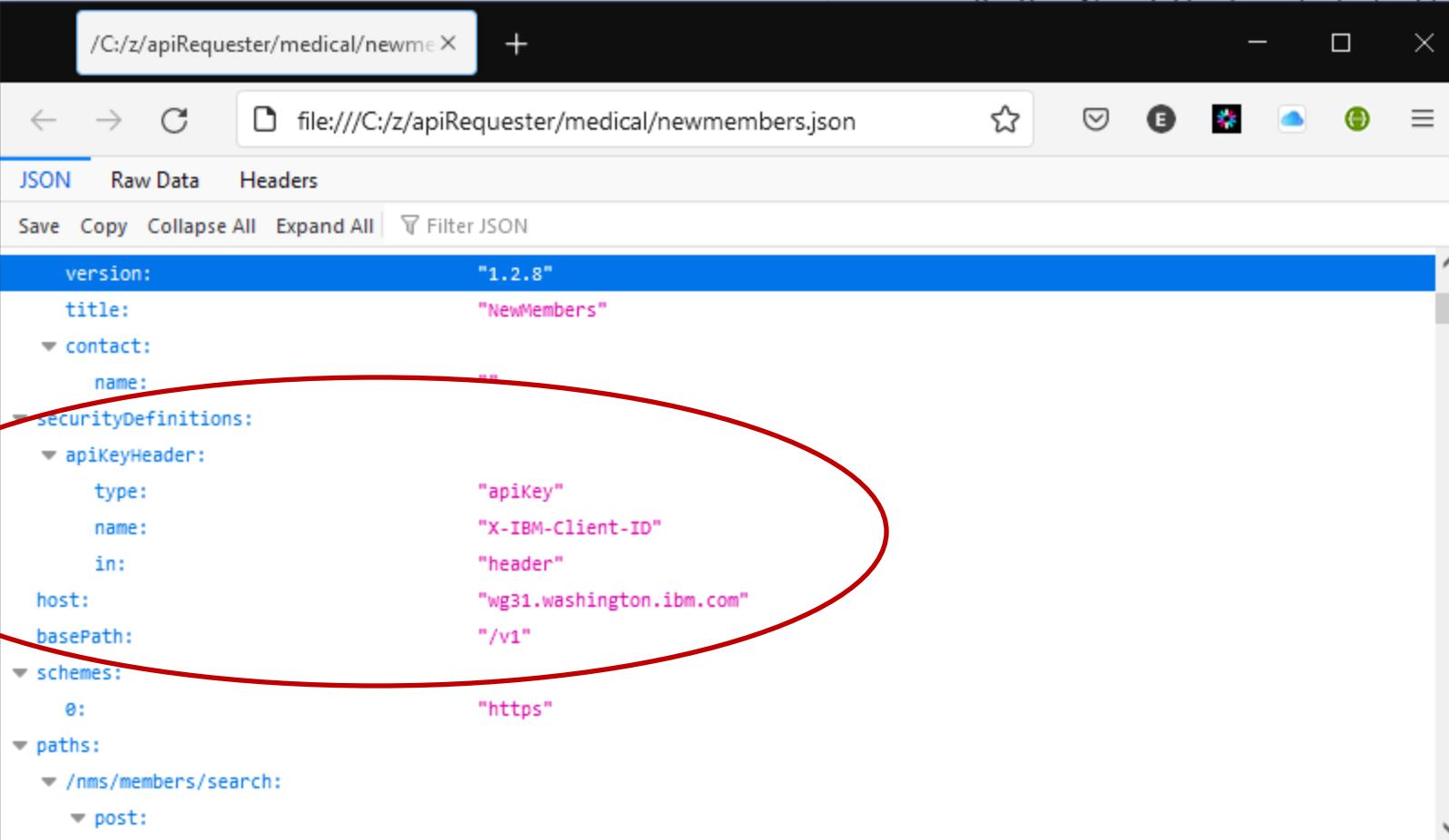
MA C 04/015
Connected to remote server/host wg31z using lu/pool TCP00108 and port 23
```

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



An API may require an API key (aka password)

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



A screenshot of a JSON editor window titled "file:///C:/z/apiRequester/medical/newmembers.json". The editor shows a JSON object with several fields. A red oval highlights the "securityDefinitions" field, which contains a "apiKeyHeader" object. This object specifies the header name "X-IBM-Client-ID" and its value "header". Other fields in the JSON include "version" (1.2.8), "title" (NewMembers), "contact" (name), and "paths" for "/nms/members/search" with a "post" method.

```
version: "1.2.8"
title: "NewMembers"
contact:
  name:
securityDefinitions:
  apiKeyHeader:
    type: "apiKey"
    name: "X-IBM-Client-ID"
    in: "header"
  host: "wg31.washington.ibm.com"
  basePath: "/v1"
schemes:
  0: "https"
paths:
  /nms/members/search:
    post:
```

Via a HTTP header

GET /something HTTP/1.1

X-API-Key: abcdef12345

Or via a query parameter

GET /something?api_key=abcdef12345



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.

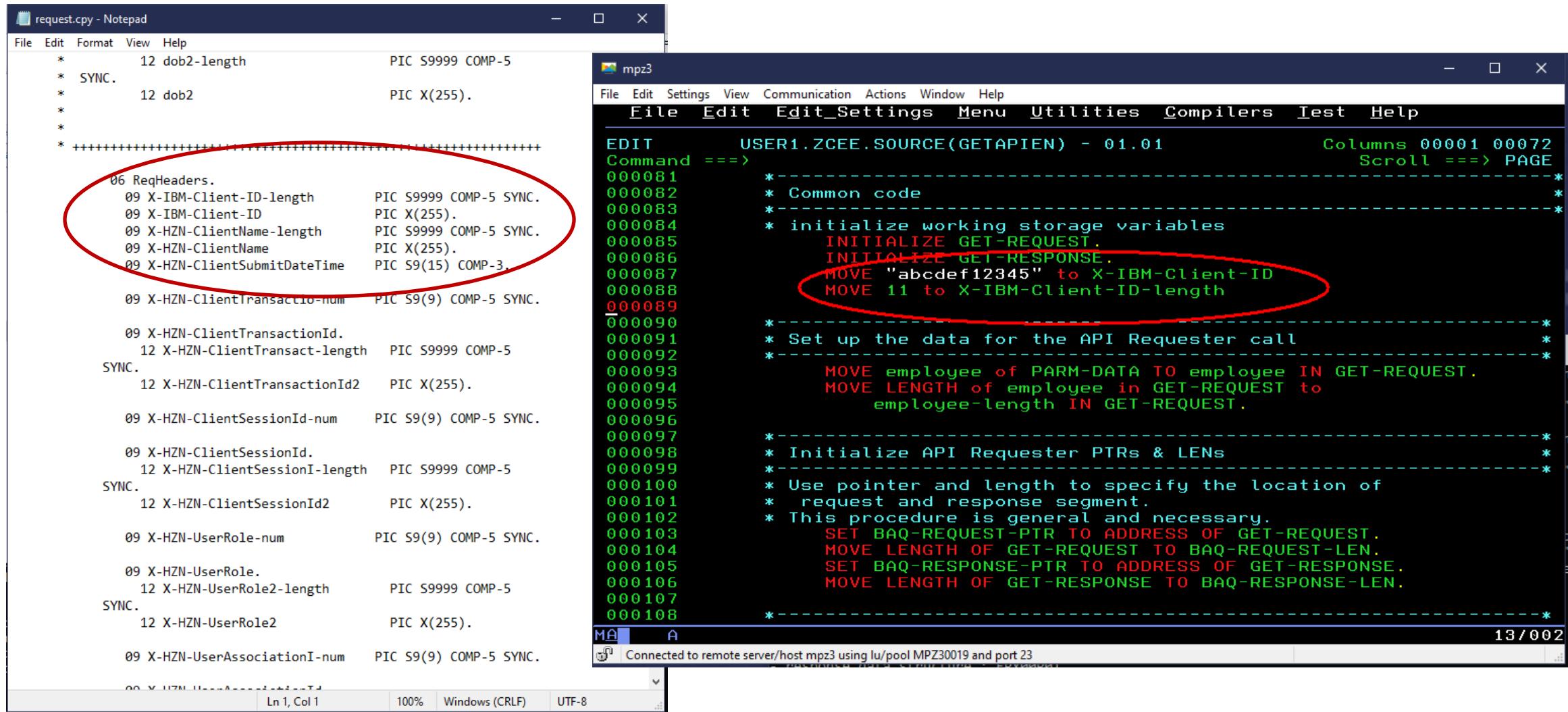
apiKeyParmNameInQuery - Specify the name of an API key that is sent in a query string. The value of this parameter can be set in a comma separated list of a combination of client ID and client secret. For example, you can set **apiKeyParmNameInQuery**=query-IBM-Client-ID, query-IBM-Client-secret when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

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-ClientTransaction-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-ClientSessionId-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.

```

mpz3

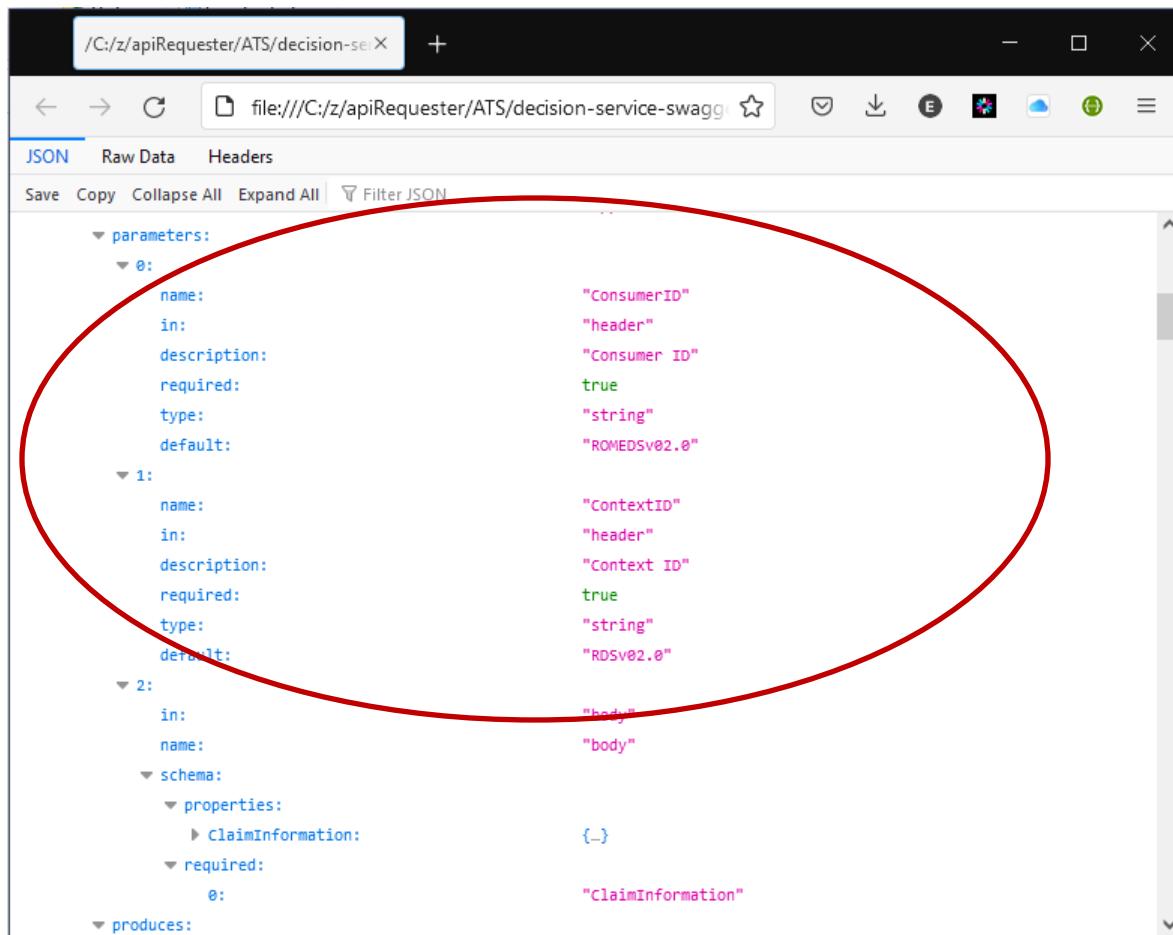
```

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
000099
000100      * Initialize API Requester PTRs & LENs
000101      *
000102      * Use pointer and length to specify the location of
000103      * request and response segment.
000104      * This procedure is general and necessary.
000105      SET BAQ-REQUEST-PTR TO ADDRESS OF GET-REQUEST.
000106      MOVE LENGTH OF GET-REQUEST TO BAQ-REQUEST-LEN.
000107      SET BAQ-RESPONSE-PTR TO ADDRESS OF GET-RESPONSE.
000108      MOVE LENGTH OF GET-RESPONSE TO BAQ-RESPONSE-LEN.
000109
000110
MA A
Connected to remote server/host mpz3 using lu/pool MPZ30019 and port 23
13 / 002

```

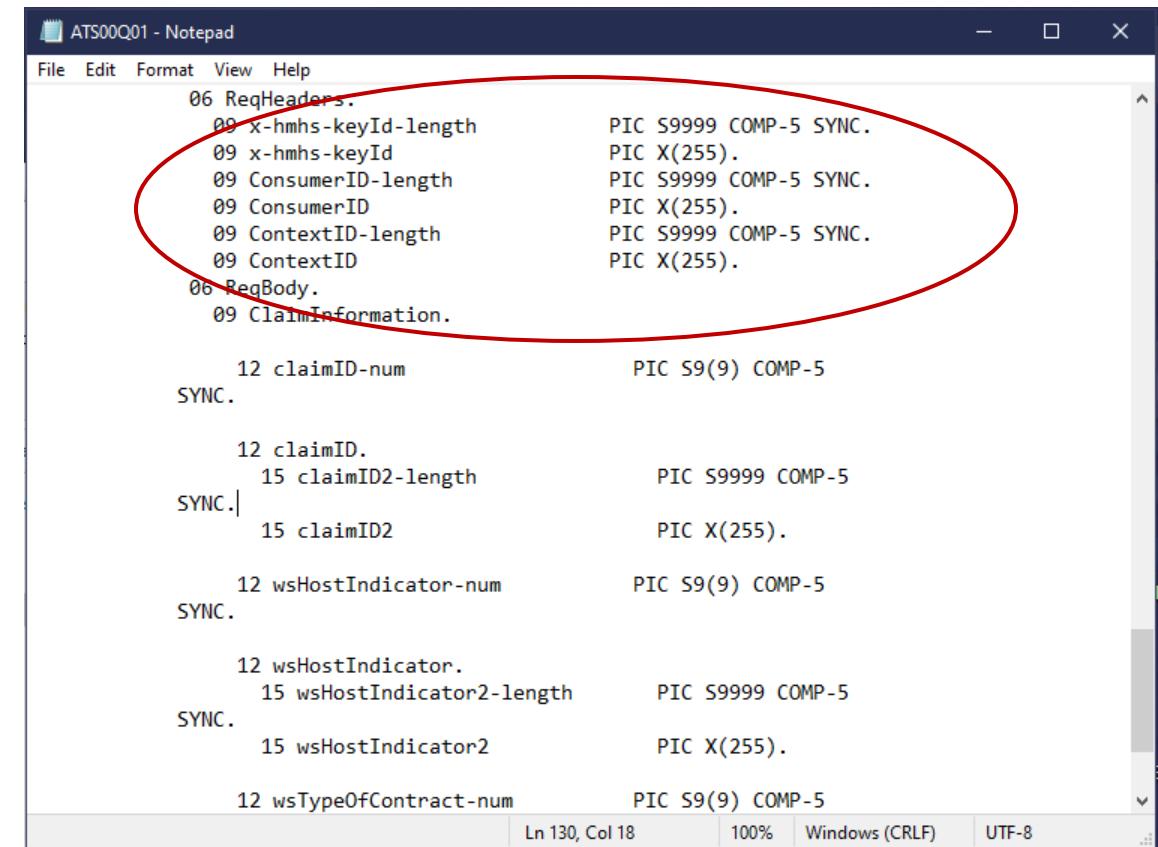
And there may be other required custom header properties

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.



```

{
  "parameters": [
    {
      "name": "ConsumerID",
      "in": "header",
      "description": "Consumer ID",
      "required": true,
      "type": "string",
      "default": "ROMEDSV02.0"
    },
    {
      "name": "ContextID",
      "in": "header",
      "description": "Context ID",
      "required": true,
      "type": "string",
      "default": "RDSV02.0"
    }
  ],
  "schema": {
    "properties": {
      "ClaimInformation": {}
    }
  }
}
  
```

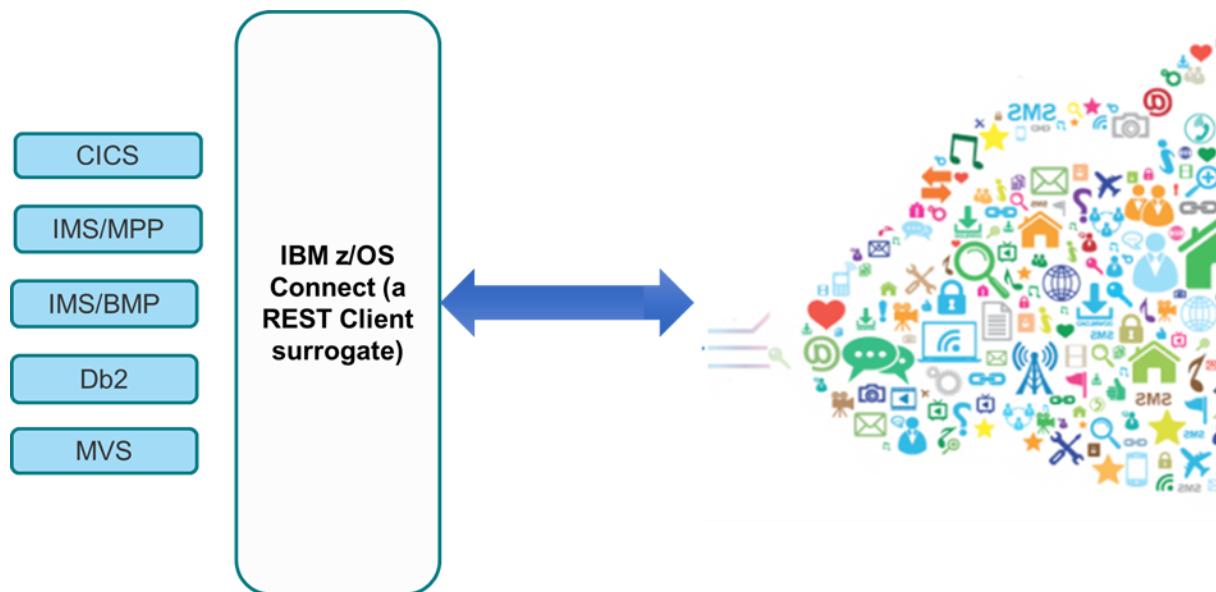


06 ReqHeaders.		PIC S9999 COMP-5 SYNC.
09 x-hmhs-keyId-length		PIC X(255).
09 x-hmhs-keyId		PIC S9999 COMP-5 SYNC.
09 ConsumerID-length		PIC X(255).
09 ConsumerID		PIC S9999 COMP-5 SYNC.
09 ContextID-length		PIC X(255).
09 ContextID		PIC S9999 COMP-5 SYNC.
06 ReqBody.		
09 ClaimInformation.		
12 claimID-num		PIC S9(9) COMP-5
SYNC.		
12 claimID.		PIC S9999 COMP-5
15 claimID2-length		
SYNC.		
15 claimID2		PIC X(255).
12 wsHostIndicator-num		PIC S9(9) COMP-5
SYNC.		
12 wsHostIndicator.		PIC S9999 COMP-5
15 wsHostIndicator2-length		
SYNC.		
15 wsHostIndicator2		PIC X(255).
12 wsTypeOfContract-num		PIC S9(9) COMP-5



Developing API Requesters

For APIs defined using a Swagger 2.0 specification document



Installing the IBM z/OS Connect build toolkit -

<https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=installing-build-toolkit>



The screenshot shows a web browser window displaying the IBM z/OS Connect documentation. The URL in the address bar is <https://www.ibm.com/docs/en/zos-connect/zosconnect/3.0?topic=installing-build-toolkit>. The page title is "Installing the IBM z/OS Connect build toolkit". The left sidebar lists several topics under "IBM z/OS Connect": "Change version" (set to 3.0), "Show full table of contents" (checked), "Filter on titles", "Installing the build toolkit" (selected), "Updating z/OS Connect (OpenAPI 2)", "Converting to z/OS Connect (OpenAPI 2) Unlimited", "Installing z/OS Explorer and the z/OS Connect API toolkit", "Updating z/OS Explorer and the z/OS Connect API toolkit", "Migrating from z/OS Connect V1", and "Upgrading from z/OS Connect EE V2". The main content area starts with the heading "Installing the IBM z/OS Connect build toolkit" and includes a "Last Updated: 2023-05-26" timestamp, a brief description of the toolkit's purpose, an "About this task" section, and a "Procedure" section with two numbered steps.

Installing the IBM z/OS Connect build toolkit

Last Updated: 2023-05-26

Install the IBM® z/OS® Connect build toolkit to create service archive (.sar) files or artifacts for an API requester.

About this task

The build toolkit is available as a command-line tool or a Software Development Kit (SDK) for inclusion in other products. For more information, read the Javadoc included in the `zconbt.zip` file or the [Build Toolkit SPI](#) in the [Reference](#) section. You can also find examples in [GitHub](#).

Procedure

1. Copy the `zconbt.zip` file, in binary mode, from the product installation directory to a directory on your local workstation or to a UNIX System Services directory on z/OS.
2. Extract the contents of the `zconbt.zip` file into the current working directory.

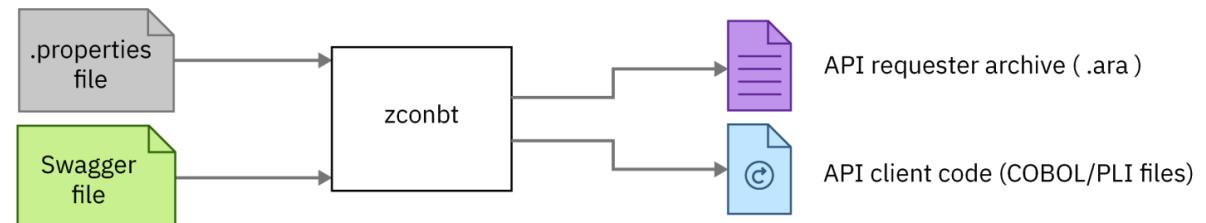


Use the z/OS Connect build toolkit (zconbt) for APIs described using Swagger 2.0

The screenshot shows a browser window displaying a Swagger 2.0 JSON API definition. The URL is `/C:/apiRequester/cscvinc/cscvinc.json`. The JSON structure includes fields like `swagger: "2.0"`, `info: { description: "", version: "1.0.0", title: "cscvincapi", basePath: "/cscvincapi" }`, and a detailed `paths` section for the `/employee/{employee}` endpoint, including methods `get`, `post`, `put`, and `delete`.

```

{
  "swagger": "2.0",
  "info": {
    "description": "",
    "version": "1.0.0",
    "title": "cscvincapi",
    "basePath": "/cscvincapi"
  },
  "schemes": [...],
  "consumes": [
    {
      "o": "application/json"
    }
  ],
  "produces": [
    {
      "o": "application/json"
    }
  ],
  "paths": {
    "/employee/{employee}": {
      "get": {
        "tags": [...],
        "operationId": "getcscvincSelectService",
        "parameters": [
          {
            "o": {...}
          },
          {
            "name": "employee",
            "in": "path",
            "required": true,
            "type": "string",
            "maxLength": 6
          }
        ],
        "responses": {
          "200": {
            "description": "OK",
            "schema": {...}
          },
          "404": {...}
        }
      },
      "post": {...},
      "put": {...},
      "delete": {...}
    }
  }
}
  
```



properties file#

```

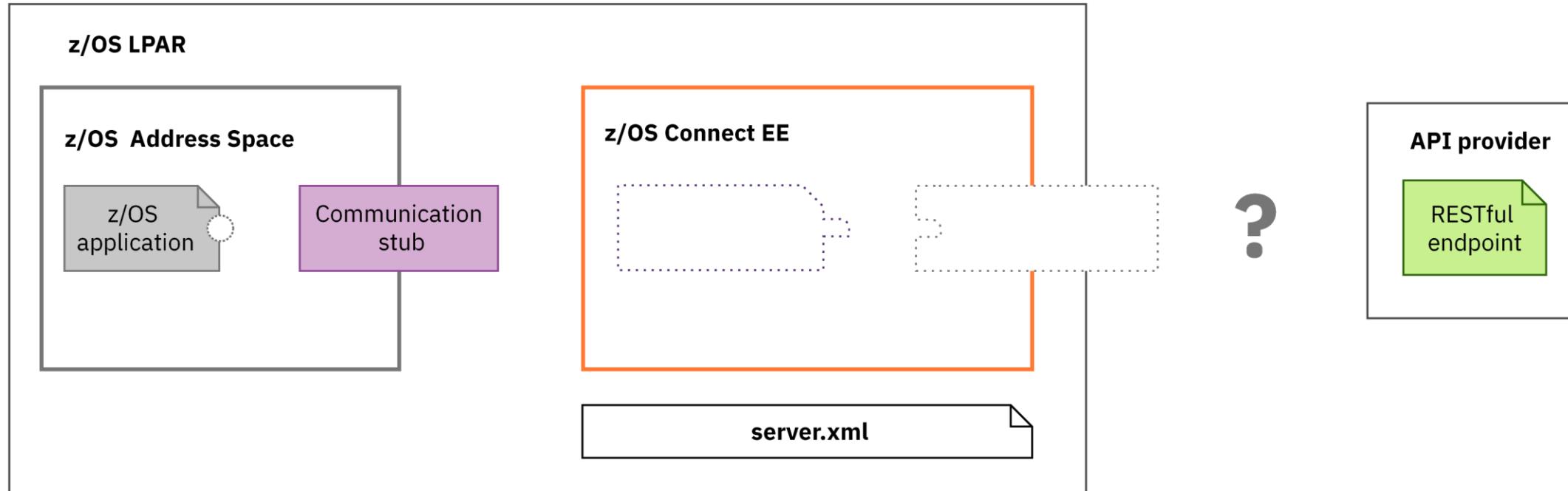
apiDescriptionFile=./cscvinc.json
dataStructuresLocation=./syslib
apiInfoFileLocation=./syslib
logFileDirectory=./logs
language=COBOL
connectionRef=cscvincAPI
requesterPrefix=csc
  
```

#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>

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.  
      BY REFERENCE    BAQ-RETURN-CODE-1  
      BY REFERENCE    BAQ-RETURN-INFO-1
```





Steps to calling a remote API

Include the generated copy books in the COBOL program

```
GETAPI X
  * 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 X
  * JSON schema type: string.
  * 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 X
  * ++++++
  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 X
  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 '%2Fscvincapi%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.
```



Steps to calling a remote API

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

The diagram illustrates the steps to calling a remote API, specifically focusing on the use of pointers to pass working storage addresses of copy books.

Main Window (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
```

Copy Book 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.
```

Copy Book 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).
```

Copy Book 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
SYN.
```

Steps to calling a remote API



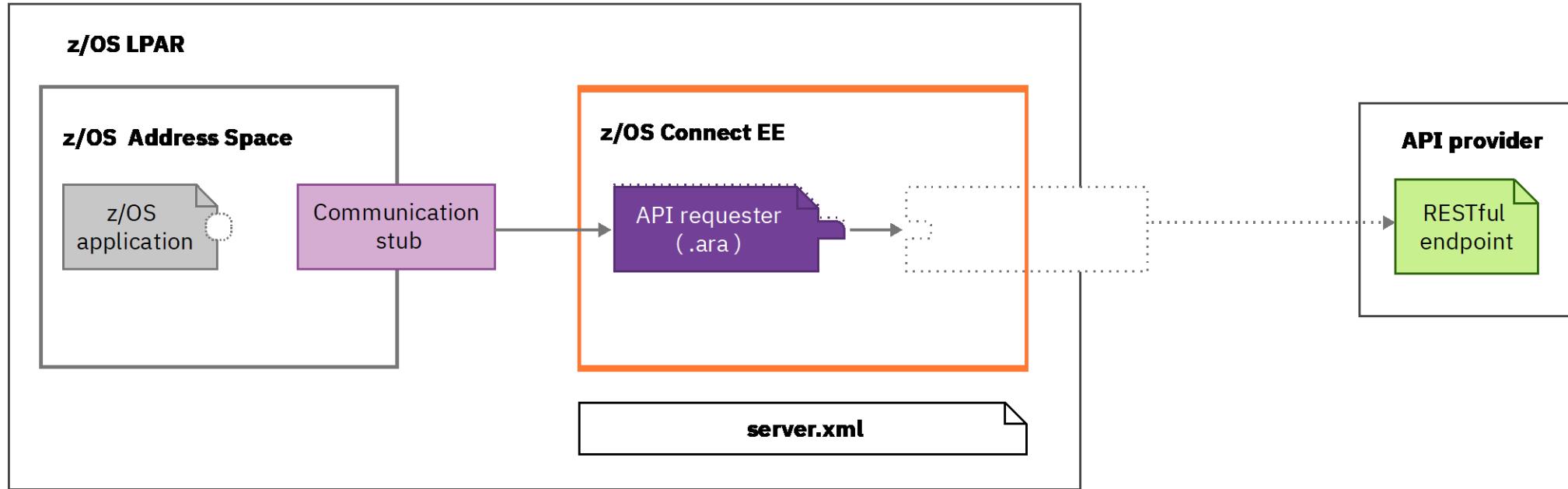
Access the results that have been placed in working storage

```
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.  
    WHEN BAQ-ERROR-IN-API
```

```
File Edit Settings View Communication Actions Window Help  
Menu Utilities Compilers Help  
BROWSE ZCEE30.SBAQC0B(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  
Connected to remote server/host mpz3 using lu/pool MPZ30021 and port 23 18/05/8
```

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

Deploy the API requester (.ara) archive



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



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

The screenshot shows the Postman application interface. The top navigation bar includes File, Edit, View, Help, Home, Workspaces, API Network, Reports, Explore, Search Postman, Invite, and Upgrade. The main workspace shows an overview of a POST request to <https://wg31.washington.ibm.com:9483/zosConnect/apiRequesters>. The request method is set to POST. In the Body tab, the file `filea.ara` is selected as the file to upload. The response status is 201 Created with a time of 863 ms and a size of 380 B. The response body is displayed in JSON format:

```
1 "name": "filea_2.0.0",
2 "version": "2.0.0",
3 "description": "",
4 "status": "Started",
5 "apiRequesterUrl": "https://wg31.washington.ibm.com:9483/zosConnect/apiRequesters/filea\_2.0.0",
6 "connection": "fileaAPI"
```

Command:

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

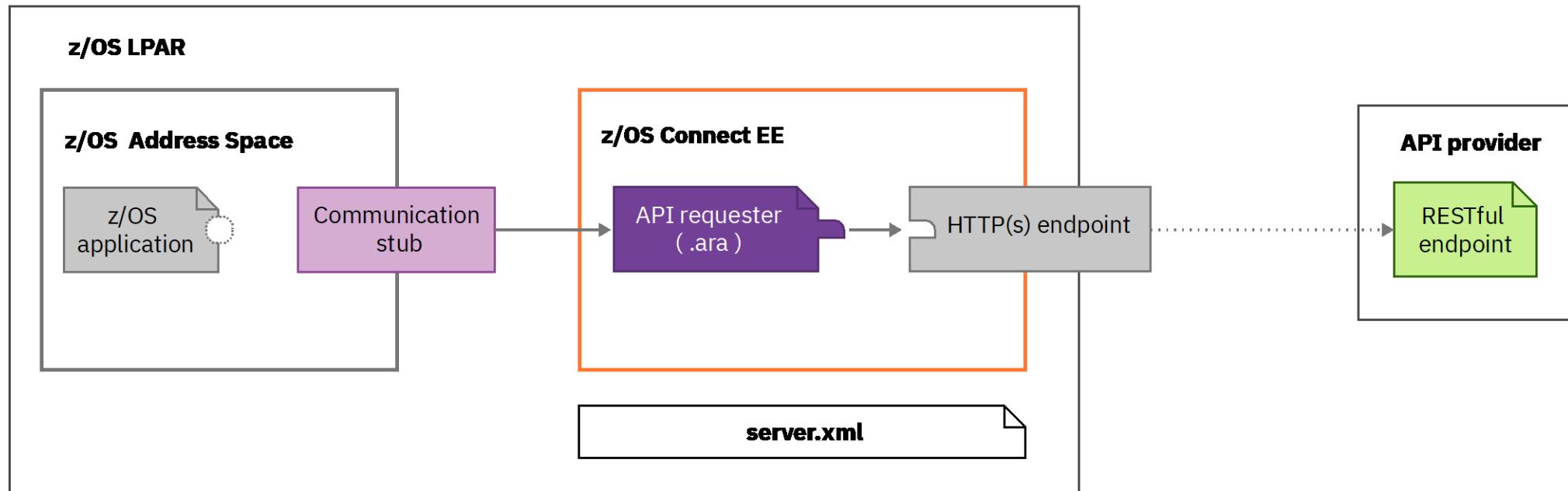
Results:

```
{"name": "filea_2.0.0", "version": "2.0.0", "description": "", "status": "Started", "apiRequesterUrl": "https://wg31.washington.ibm.com:9483/zosConnect/apiRequesters/filea_2.0.0", "connection": "fileaAPI"}
```



Steps to calling a remote API

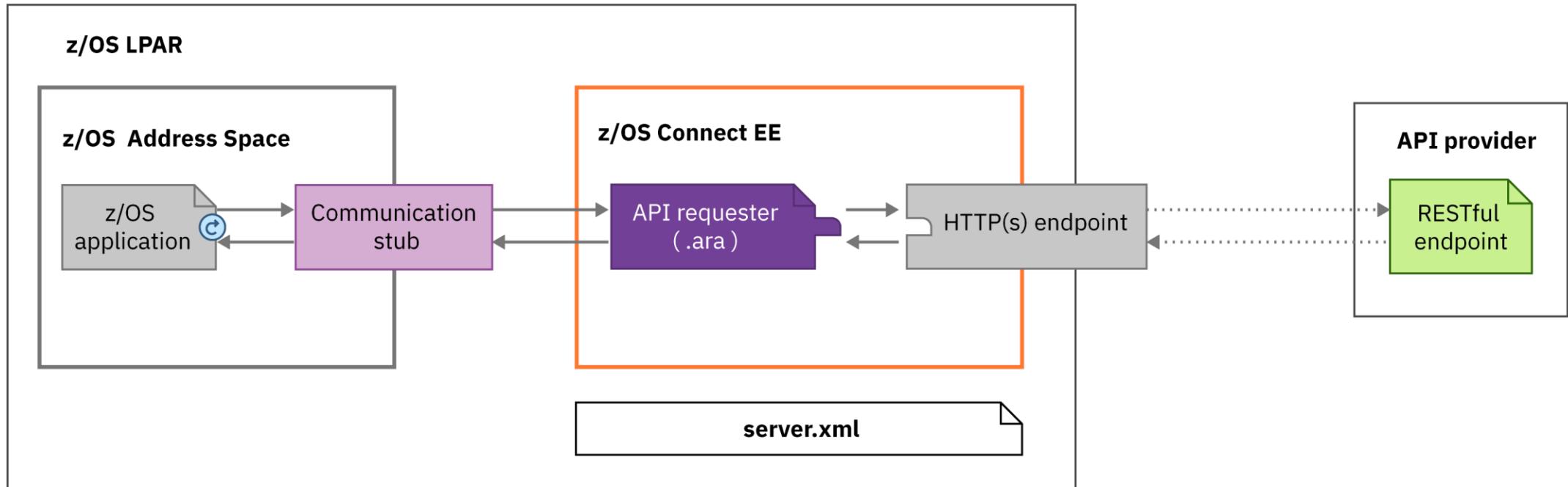
Configure HTTP(S) endpoint configuration element



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

i ibm.biz/zosconnect-configure-endpoint-connection

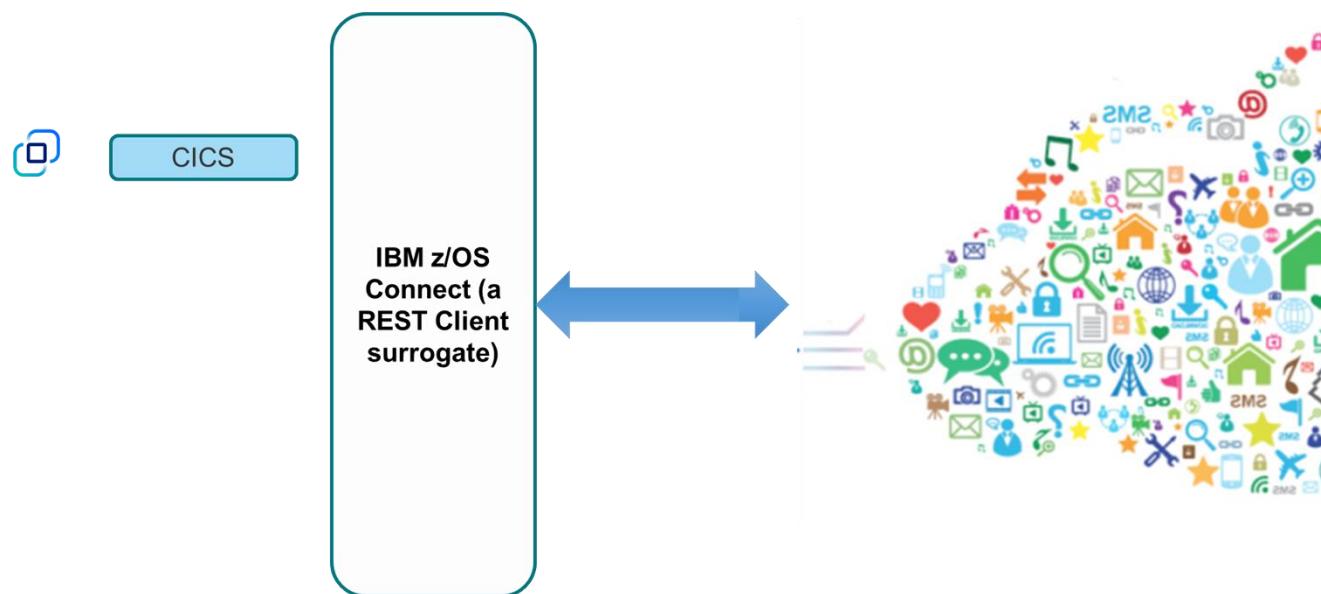
Results - A complete solution for calling a remote Swagger 2.0 API





Developing z/OS Connect API Requesters

For APIs defined using an OpenAPI 3 specification

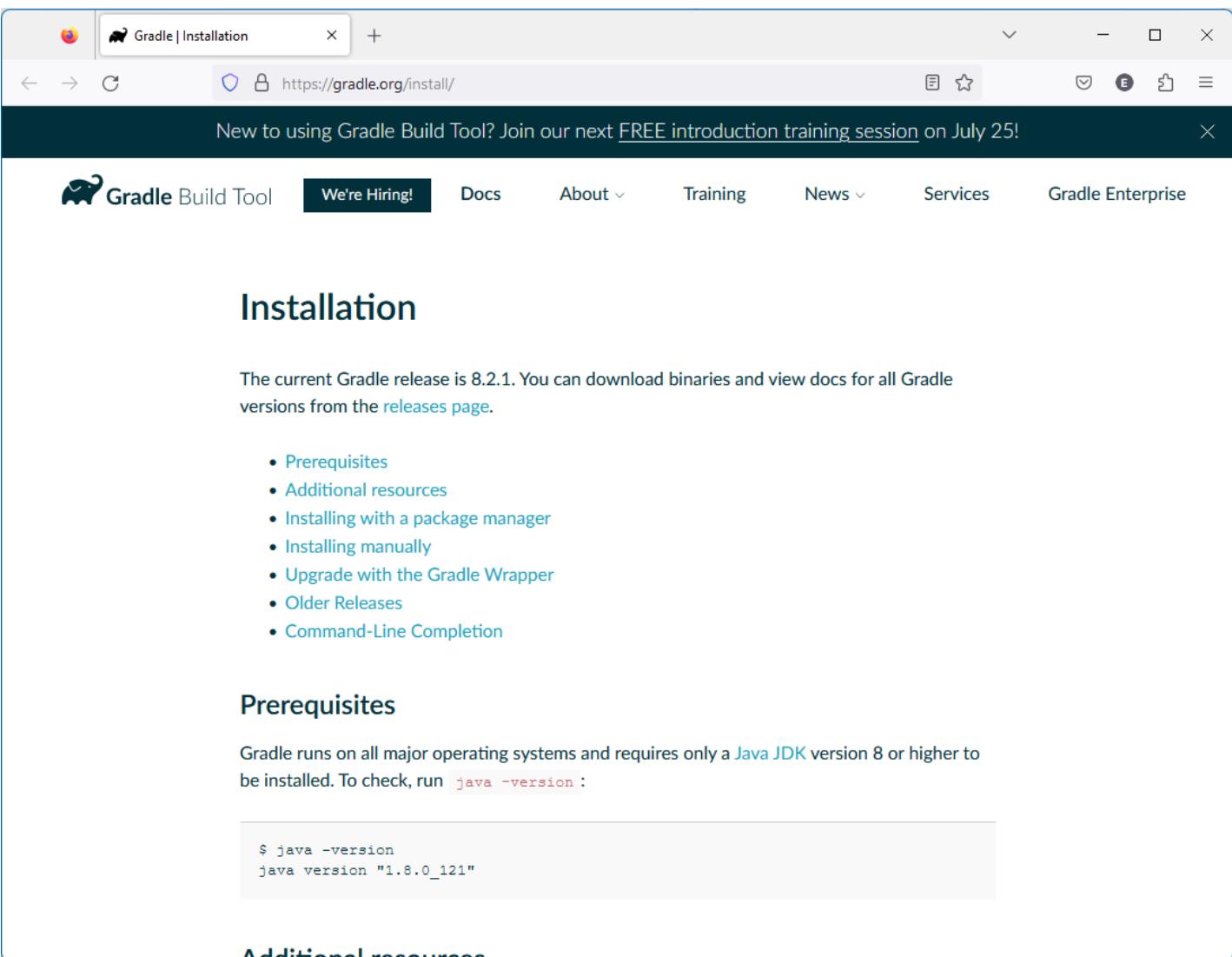


Gradle Build Tool – Installation -



<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](#)



The screenshot shows the "Installation" section of the Gradle website. At the top, there's a navigation bar with links for "We're Hiring!", "Docs", "About", "Training", "News", "Services", and "Gradle Enterprise". A banner at the top of the page encourages users to join a free introduction training session on July 25. Below the banner, the "Installation" section title is centered. A paragraph below the title states that the current Gradle release is 8.2.1 and provides links to download binaries and view documentation for all versions. A list of installation methods is provided, including "Prerequisites", "Additional resources", "Installing with a package manager", "Installing manually", "Upgrade with the Gradle Wrapper", "Older Releases", and "Command-Line Completion". A "Prerequisites" section follows, stating that Gradle runs on all major operating systems and requires Java JDK version 8 or higher. It includes a command-line example: `$ java -version` followed by the output `java version "1.8.0_121"`. An "Additional resources" section is also present.

For details on the level Gradle required for the z/OS Connect Gradle plug-in, see URL
<https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=introduction-system-requirements>



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>

The screenshot shows a web browser window displaying the IBM z/OS Connect documentation. The URL in the address bar is <https://www.ibm.com/docs/en/zos-connect/zos-connect/3.0?topic=building-zos-connect-apis-gradle>. The page title is "Building z/OS Connect APIs with Gradle". The left sidebar contains a navigation menu for "IBM z/OS Connect" version 3.0, with a specific section "Building z/OS Connect APIs with Gradle" highlighted. The main content area includes a breadcrumb trail: "All products / IBM z/OS Connect / IBM z/OS Connect (OpenAPI 3) / 3.0 /". Below the breadcrumb is a feedback section asking "Was this topic helpful?" with "Yes" and "No" buttons. The main content starts with the heading "Building z/OS Connect APIs with Gradle" and a note that "z/OS Connect uses Gradle to build API projects into API WAR files." It then lists several sub-topics under "Contents": "What is Gradle?", "Installing Gradle", "How Gradle is used in IBM z/OS Connect", "How z/OS Connect Designer uses Gradle for API provider", and "Running Gradle on z/OS". At the bottom of the page, there are two sections: "What is Gradle?" and "Installing Gradle".



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>



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

additionalPropertiesSize
apiName
apiKeyMaxLength
apiKeyParamNameInCookie
apiKeyParamNameInHeader
apiKeyParamNameInQuery
characterMultiplier
characterVarying
characterVaryingLimit
characterWhiteSpace
connectionRef
dataTruncation
dateTimeFormat
defaultCharacterMaxLength
defaultRequestMediaType
defaultResponseMediaType
defaultFractionDigits
generatedCodePage
inlineMaxOccursLimit
language
nameTruncation
operations
requestMediaType]
requesterPrefix
responseMediaType]
runtimeCodePage
wideComp3

New for OpenAPI 3

At what point to use data areas

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

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



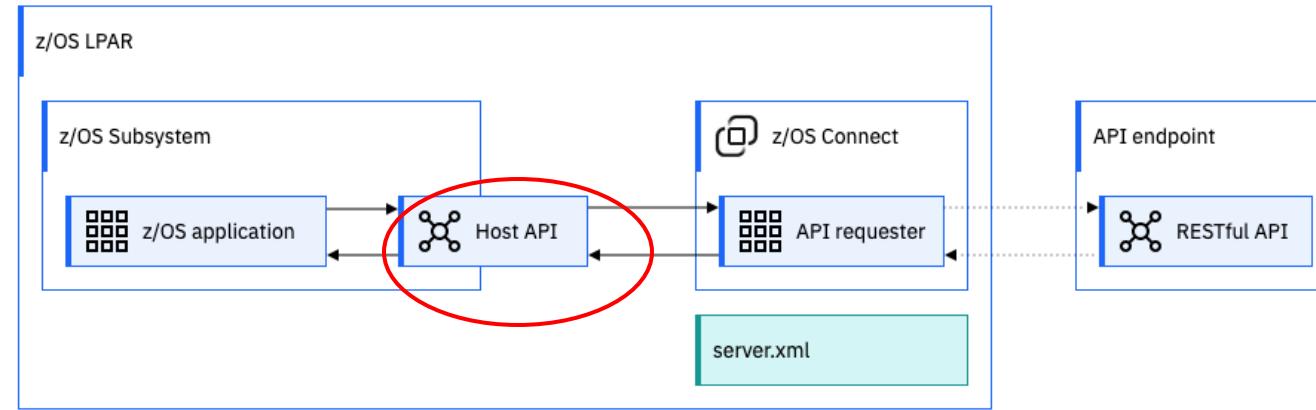
Summary of API requester enhancements for OpenAPI 3

- **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.



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**.

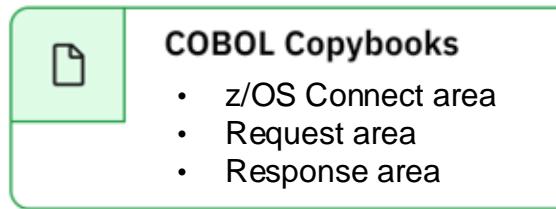
- New function added support for an application to program to be able to handle different response message payloads depending on whether the HTTP status code is 200 (OK), 201 (CREATED), or 404 (NOTFOUND) for example. Each of the response payloads documented in the API's OpenAPI 3.0 definition are mapped 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.



The OpenAPI3 COBOL copybooks

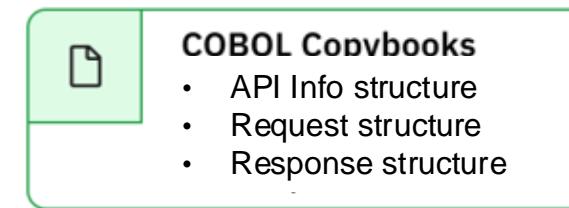
z/OS Connect provides two types of copybooks that are required to interface with the Host API and tooling to generate application specific copybooks

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



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.

```
File Edit Settings View Communication Actions Window Help  
File Edit Edit_Settings Menu Utilities Compilers Test Help  
EDIT ZCEE30.SBAQC0B(BAQHCONC) - 01.00 Columns 00001 00072  
Command ==> ***** **** Top_of_Data ***** 11 Line(s) not Displayed  
000012 * Host API entry point names  
000013 77 BAQ-INIT-NAME PIC X(8) VALUE 'BAQINIT'.  
000014 77 BAQ-EXEC-NAME PIC X(8) VALUE 'BAQEXEC'.  
000015 77 BAQ-GETN-NAME PIC X(8) VALUE 'BAQGETN'.  
000016 77 BAQ-PUTN-NAME PIC X(8) VALUE 'BAQPUTN'.  
000017 77 BAQ-FREE-NAME PIC X(8) VALUE 'BAQFREE'.  
000018 77 BAQ-TERM-NAME PIC X(8) VALUE 'BAQTERM'.  
000019  
000020 * Host API Request parameter names  
000021 77 BAQR-OAUTH-USERNAME PIC X(22)  
000022 VALUE 'BAQHAPI-oAuth-Username'.  
000023 77 BAQR-OAUTH-PASSWORD PIC X(22)  
000024 VALUE 'BAQHAPI-oAuth-Password'.  
000025 77 BAQR-OAUTH-SCOPE PIC X(19)  
000026 VALUE 'BAQHAPI-oAuth-Scope'.  
000027 77 BAQR-OAUTH-CLIENT-ID PIC X(22)  
000028 VALUE 'BAQHAPI-oAuth-ClientId'.  
000029 77 BAQR-OAUTH-CLIENT-SECRET PIC X(26)  
000030 VALUE 'BAQHAPI-oAuth-ClientSecret'.  
000031 * Host API ZCON parameter names  
000043 77 BAQZ-TRACE-VERBOSE PIC X(21)  
000044 VALUE 'BAQHAPI-Trace-Verbose'.  
000045 77 BAQZ-SERVER-URIMAP PIC X(21)  
000046 VALUE 'BAQHAPI-Server-URIMAP'.  
000047 77 BAQZ-SERVER-HOST PIC X(19)  
000048 VALUE 'BAQHAPI-Server-Host'.  
000049 77 BAQZ-SERVER-PORT PIC X(19)  
000050 VALUE 'BAQHAPI-Server-Port'.  
000051 77 BAQZ-SERVER-TIMEOUT PIC X(22)  
000052 VALUE 'BAQHAPI-Server-Timeout'.  
000053 77 BAQZ-SERVER-USERNAME PIC X(23)  
000054 VALUE 'BAQHAPI-Server-Username'.  
000055 77 BAQZ-SERVER-PASSWORD PIC X(23)  
000056 VALUE 'BAQHAPI-Server-Password'.  
***** Bottom_of_Data *****  
File Edit Settings View Communication Actions Window Help  
File Edit Edit_Settings Menu Utilities Compilers Test Help  
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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

```
EDIT      ZCEE30.SBAQC0B(BAQHAREC) - 01.00          Columns 00001 00072
Command ==> -                                     Scroll ==> PAGE
***** **** Top of Data ****
000001 *                                                 *
000002 * PID 5655-CE5
000003 * Copyright IBM Corp. 2023
000004 *
000005 * This file contains the language structures required by COBOL
000006 * programs to work with the API requester Host API.
000007 *
000008 * 01 BAQ-ZCONNECT-AREA.
000009   03 BAQ-ZCON-AREA-EYE
000010   03 BAQ-ZCON-AREA-LENGTH
000011   03 BAQ-ZCON-AREA-VERSION
000012   03 BAQ-ZCON-RESERVED-01
000013   03 BAQ-ZCON-PARM-INIT
000014   03 BAQ-ZCON-RESERVED-02
000015   03 BAQ-ZCON-PARAMETERS
000016   05 BAQ-ZCON-RESERVED-03
000017   05 BAQ-ZCON-RESERVED-04
000018   07 BAQ-ZCON-PARM-NAME
000019   07 BAQ-ZCON-PARM-ADDRESS
000020   07 BAQ-ZCON-PARM-LENGTH
000021   03 BAQ-ZCON-RETURN-CODES.
000022   05 BAQ-ZCON-COMPLETION-CODE
000023     88 BAQ-SUCCESS
000024     88 BAQ-WARNING
000025     88 BAQ-ERROR
000026     88 BAQ-SEVERE
000027     88 BAQ-CRITICAL
000028   05 BAQ-ZCON-REASON-CODE
000029   05 BAQ-ZCON-SERVICE-ID
000030   05 BAQ-ZCON-SERVICE-CODE
000031   03 BAQ-ZCON-RESERVED-05
000032   03 BAQ-ZCON-RETURN-MESSAGE-LEN
000033   03 BAQ-ZCON-RETURN-MESSAGE
000034     01 BAQ-REQUEST-AREA.
000035     03 BAQ-REQ-AREA-EYE
000036
000037
000038
PIC X(4) VALUE 'BAQZ'.
PIC 9(8) COMP-5 VALUE 4648.
PIC 9(8) COMP-5 VALUE 1.
PIC 9(8) COMP-5 VALUE 0.
VALUE LOW-VALUES.
PIC X(3584).
REDEFINES BAQ-ZCON-PARM-INIT.
OCCURS 64.
PIC X(48).
USAGE POINTER.
PIC 9(9) BINARY.
PIC 9(8) COMP-5 VALUE 0.
VALUE 0.
VALUE 4.
VALUE 8.
VALUE 12.
VALUE 16.
PIC 9(8) COMP-5 VALUE 0.
PIC X(1024).
PIC X(4) VALUE 'BAQR'.
```

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BAQHAREC - BAQ-ZCONNECT_AREA

The BAQ-ZCON-PARMS array

Providing credentials for basic authentication

```

File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
EDIT ZCEE30.SBAQCOB(BAQHAREC) - 01.00 Columns 00001 00072
Command ==> - Scroll ==> PAGE
***** **** Top of Data *****
000001 *
000002 * PID 5655-CES
000003 *
000004 * Copyright IBM Corp. 2023
000005 *
000006 **** This file contains the language structures required by COBOL
000007 * programs to work with the API requester Host API.
000008 ****
000009 01 BAQ-ZCONNECT-AREA.
000010    03 BAQ-ZCON-AREA-EYE
000011      PIC X(4) VALUE 'BAQR'.
000012    03 BAQ-ZCON-AREA-LENGTH
000013      PIC 9(8) COMP-5 VALUE 4648.
000014    03 BAQ-ZCON-AREA-VERSION
000015      PIC 9(8) COMP-5 VALUE 1.
000016    03 BAQ-ZCON-PARM-INIT
000017      PIC X(3584).
000018    03 BAQ-ZCON-RESERVED-02
000019      REDEFINES BAQ-ZCON-PARM-INIT.
000020    05 BAQ-ZCON-PARMS
000021      OCCURS 64.
000022      PIC X(48).
000023      USAGE POINTER.
000024      PIC 9(9) BINARY.
000025    03 BAQ-ZCON-RETURN-CODES.
000026      05 BAQ-ZCON-COMPLETION-CODE
000027        PIC 9(8) COMP-5 VALUE 0.
000028        88 BAQ-SUCCESS
000029        PIC 0.
000030        88 BAQ-WARNING
000031        PIC 4.
000032        88 BAQ-ERROR
000033        PIC 9.
000034        88 BAQ-SEVERE
000035        PIC 12.
000036        88 BAQ-CRITICAL
000037        PIC 16.
000038    05 BAQ-ZCON-REASON-CODE
000039      PIC 9(8) COMP-5 VALUE 0.
000040    05 BAQ-ZCON-SERVICE-ID
000041      PIC 9(8) COMP-5 VALUE 0.
000042    05 BAQ-ZCON-SERVICE-CODE
000043      PIC 9(8) COMP-5 VALUE 0.
000044    03 BAQ-ZCON-RESERVED-03
000045      PIC 9(8) COMP-5 VALUE 0.
000046    03 BAQ-ZCON-RETURN-MESSAGE-LEN
000047      PIC 9(8) COMP-5 VALUE 0.
000048    03 BAQ-ZCON-RETURN-MESSAGE
000049      PIC X(1024).

01 BAQ-REQUEST-AREA.
000050    03 BAQ-REQ-AREA-EYE
000051      PIC X(4) VALUE 'BAQR'.
04/015

```

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```

File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
EDIT JOHNSON.ZCEE.SOURCE(BAQZUSER) - 01.00 Columns 00001 00072
Command ==> -
***** **** 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

```

File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
EDIT JOHNSON.ZCEE.SOURCE(BAQZUSER) - 01.01 Columns 00001 00072
Command ==> -
***** **** 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 *****

```



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

The image shows two IBM i terminal windows. The top window is titled 'WG31 - 3270' and displays COBOL source code for the 'BAQ-REQUEST-AREA'. It includes fields like BAQ-REQ-AREA-EYE, BAQ-REQ-AREA-LENGTH, BAQ-REQ-AREA-VERSION, BAQ-REQ-RESERVED-01, BAQ-REQ-BASE-ADDRESS, BAQ-REQ-BASE-LENGTH, BAQ-REQ-PARM-INIT, BAQ-REQ-RESERVED-02, BAQ-REQ-PARAMETERS, BAQ-REQ-PARMS, BAQ-REQ-PARM-NAME, BAQ-REQ-PARM-ADDRESS, and BAQ-REQ-PARM-LENGTH. The bottom window is also titled 'WG31 - 3270' and displays COBOL source code for the 'BAQ-RESPONSE-AREA'. It includes fields like BAQ-RESP-AREA-EYE, BAQ-RESP-AREA-LENGTH, BAQ-RESP-AREA-VERSION, BAQ-RESP-RESERVED-01, BAQ-RESP-BASE-ADDRESS, BAQ-RESP-BASE-LENGTH, BAQ-RESP-RESERVED-02, BAQ-RESP-STATUS-CODE, BAQ-RESP-STATUS-MESSAGE-LEN, and BAQ-RESP-STATUS-MESSAGE.

```
ZCEE30.SBAQCOB(BAQHAREC) - 01.00
01 BAQ-REQUEST-AREA.
03 BAQ-REQ-AREA-EYE
03 BAQ-REQ-AREA-LENGTH
03 BAQ-REQ-AREA-VERSION
03 BAQ-REQ-RESERVED-01
03 BAQ-REQ-BASE-ADDRESS
03 BAQ-REQ-BASE-LENGTH
03 BAQ-REQ-PARM-INIT
05 BAQ-REQ-RESERVED-02
03 BAQ-REQ-PARAMETERS
05 BAQ-REQ-PARMS
07 BAQ-REQ-PARM-NAME
07 BAQ-REQ-PARM-ADDRESS
07 BAQ-REQ-PARM-LENGTH

01 BAQ-RESPONSE-AREA.
03 BAQ-RESP-AREA-EYE
03 BAQ-RESP-AREA-LENGTH
03 BAQ-RESP-AREA-VERSION
03 BAQ-RESP-RESERVED-01
03 BAQ-RESP-BASE-ADDRESS
03 BAQ-RESP-BASE-LENGTH
03 BAQ-RESP-RESERVED-02
03 BAQ-RESP-STATUS-CODE
03 BAQ-RESP-STATUS-MESSAGE-LEN
03 BAQ-RESP-STATUS-MESSAGE
```

Bottom of Data *****

```
ZCEE30.SBAQCOB(BAQRINFO)
01 BAQ-REQUEST-INFO.
03 BAQ-REQUEST-INFO-COMP-LEVEL PIC S9(9) COMP-5 SYNC VALUE 5.
03 BAQ-REQUEST-INFO-USER.
05 BAQ-DAUTH-INFO.
07 BAQ-DAUTH-USERNAME PIC X(256).
07 BAQ-DAUTH-USERNAME-LEN PIC S9(9) COMP-5 SYNC VALUE 0.
07 BAQ-DAUTH-PASSWORD PIC X(256).
07 BAQ-DAUTH-PASSWORD-LEN PIC S9(9) COMP-5 SYNC VALUE 0.
07 BAQ-DAUTH-CLIENTID PIC X(256).
07 BAQ-DAUTH-CLIENTID-LEN PIC S9(9) COMP-5 SYNC VALUE 0.
07 BAQ-DAUTH-CLIENT-SECRET PIC X(256).
07 BAQ-DAUTH-CLIENT-SECRET-LEN PIC S9(9) COMP-5 SYNC VALUE 0.
07 BAQ-DAUTH-SCOPE-PTR PIC X(256).
07 BAQ-DAUTH-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).
05 BAQ-DAUTH-EXT.
07 BAQ-DAUTH-RESOURCE-PTR PIC X(256).
07 BAQ-DAUTH-RESOURCE-LEN PIC S9(9) COMP-5 SYNC VALUE 0.
07 BAQ-DAUTH-AUDIENCE-PTR PIC X(256).
07 BAQ-DAUTH-AUDIENCE-LEN PIC S9(9) COMP-5 SYNC VALUE 0.
07 BAQ-DAUTH-CUSTOM-PARMS-PTR PIC X(256).
07 BAQ-DAUTH-CUSTOM-PARMS-LEN PIC S9(9) COMP-5 SYNC VALUE 0.
```

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



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!

```
WG31 - 3270
File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
EDIT          JOHNSON.RBK02I01.CPY
Command ==> -
*****
* ++++++*****+*****+*****+*****+*****+*****+*****+*****+*****+
* This file contains the generated API information structure
* which is passed to the Host API via the BAQEXEC call.
* ++++++*****+*****+*****+*****+*****+*****+*****+*****+*****+
000001      * ++++++*****+*****+*****+*****+*****+*****+*****+*****+*****+
000002      * ++++++*****+*****+*****+*****+*****+*****+*****+*****+*****+
000003      * ++++++*****+*****+*****+*****+*****+*****+*****+*****+*****+
000004      * ++++++*****+*****+*****+*****+*****+*****+*****+*****+*****+
000005      01 BAQ-API-INFO-RBK02I01.
000006      03 BAQ-API-INFO-EYE           PIC X(4)
000007      VALUE 'BAQA'.
000008      03 BAQ-API-INFO-LENGTH        PIC 9(9) COMP-5 SYNC
000009      VALUE 1052.
000010      03 BAQ-API-INFO-VERSION       PIC 9(9) COMP-5 SYNC
000011      VALUE 1.
000012      03 BAQ-API-INFO-RESERVED01   PIC 9(9) COMP-5 SYNC
000013      VALUE 0.
000014      03 BAQ-API-NAME            PIC X(255)
000015      VALUE 'RedbookApi'.
000016      03 BAQ-API-NAME-LEN         PIC 9(9) COMP-5 SYNC
000017      VALUE 10.
000018      03 BAQ-API-PATH             PIC X(255)
000019      VALUE '%2Fredbooks'.
000020      03 BAQ-API-PATH-LEN         PIC 9(9) COMP-5 SYNC
000021      VALUE 11.
000022      03 BAQ-API-METHOD          PIC X(255)
000023      VALUE 'GET'.
000024      03 BAQ-API-METHOD-LEN        PIC 9(9) COMP-5 SYNC
000025      VALUE 3.
000026      03 BAQ-API-OPERATION        PIC X(255)
000027      VALUE 'getallRedbooks'.
000028      03 BAQ-API-OPERATION-LEN     PIC 9(9) COMP-5 SYNC
000029      VALUE 14.
000030
*****
Bottom of Data *****
M A 04/015
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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.
```

```
WG31 - 3270
File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
EDIT JOHNSON.RBK02Q01.CPY Columns 00001 00072
Command ==> Scroll ==> PAGE
000001 * ++++++
000002 * This file contains the generated language structure(s) for
000003 * request JSON schema 'getAllRedbooks_request.json'.
000004 * This structure was generated using 'DFHJS2LS' at mapping level
000005 * '5.0'.
000006 *
000007 *
000008 * 01 BAQBASE-RBK02Q01.
000009 * 03 requestQueryParameters.
000010 *
000011 *
000012 * JSON schema keyword 'requestQueryParameters->author' is
000013 * optional. The existence of the field is indicated by field
000014 * 'Xauthor-existence'.
000015 * 06 Xauthor-existence PIC S9(9) COMP-5 SYNC.
000016 *
000017 *
000018 * 06 Xauthor.
000019 *
000020 * Comments for field 'Xauthor2':
000021 * This field represents the value of JSON schema keyword
000022 * 'requestQueryParameters->author'.
000023 * JSON schema type: 'string'.
000024 * JSON schema keyword 'minLength' value: '0'.
000025 * JSON schema keyword 'maxLength' value: '40'.
000026 * This field contains a varying length array of characters or
000027 * binary data.
000028 * 09 Xauthor2-length PIC S9999 COMP-5 SYNC.
000029 * 09 Xauthor2 PIC X(40).
000030 *
000031 *
000032 * ++++++
000033 *
000034 * 01 BAQBASE-RBK02Q01.
000035 * 03 requestQueryParameters.
000036 *
000037 * 06 Xauthor-existence PIC S9(9) COMP-5 SYNC.
000038 *
000039 * 06 Xauthor.
```

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Adobe PDF on Documents*.pdf



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

```
WG31 - 3270
File Edit Settings View Communication Actions Window Help
File Edit Edit_Settings Menu Utilities Compilers Test Help
EDIT          JOHNSON.RBK02P01.CPY
Command ===> -
000343
000344      01 BAQBASE-RBK02P01 .
000345
000346      03 responseCode200-num
000347      03 responseCode200-dataarea
000348
000349
000350      03 responseCode404-existence
000351      03 responseCode404-dataarea
000352
000353
000354      01 RBK02P01-responseCode200 .
000355      03 responseCode200
000356          06 Xtitle-length
000357          06 Xtitle
000358
000359          06 authors-num
000360          06 authors-dataarea
000361
000362          06 Xstatus-length
000363          06 Xstatus
000364          06 formNumber
000365
000366          06 publicationDate-existence
000367
000368          06 publicationDate
000369          09 publicationDate2-length
000370          09 publicationDate2
000371
000372          06 documentType-existence
000373
000374          06 documentType
000375          09 documentType2-length
000376          09 documentType2
000377
000378          06 sizeMB-existence
000379
000380          06 sizeMB
000381

MA A
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04/015
```



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.



The z/OS Connect Host API Verbs

BAQINIT

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

BAQEXEC

- EXECute the call to the desired API taking request data as input and providing response data as output

BAQGETN

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

BAQFREE

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

BAQTERM

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



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

```
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.
```

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

```
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.



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
6. Process the data in 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.
```

```
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.
```



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.
```



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)
```



Host API Completion and Reason Codes

- 2000 - 2999
- **Warning** – The COBOL program can continue to use the Host API.
- **Error** – The COBOL program must take an action to continue. Review the message for required action.
- **Severe** – The COBOL program must call the **BAQTERM** verb immediately. Contact IBM support if the problem persists.

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

```
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.
```

```
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.
```



Configuration and Security Considerations

Resolving the endpoint's URL

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

The screenshot shows a browser window displaying the Swagger JSON definition for the `/employee` endpoint. The JSON structure includes fields like `swagger: "2.0"`, `info`, `host: "localhost:8080"`, `basePath: "/cscvinc"`, `schemes: [https, http]`, `consumes: [application/json]`, `produces: [application/json]`, and a `paths` section containing a `/employee` path with a `post` method.

The screenshot shows an IBM i terminal window titled `CSC02101` displaying the DDS definition for the `/employee` endpoint. It lists fields such as `BAQ-APINAME` (PIC X(255), VALUE 'cscvinc_1.0.0.'), `BAQ-APINAME-LEN` (PIC S9(9) COMP-5 SYNC, VALUE 13), `BAQ-APIPATH` (PIC X(255), VALUE '/cscvinc/employee/{numb}'), `BAQ-APIPATH-LEN` (PIC S9(9) COMP-5 SYNC, VALUE 24), `BAQ-APIMETHOD` (PIC X(255), VALUE 'GET'), and `BAQ-APIMETHOD-LEN` (PIC S9(9) COMP-5 SYNC, VALUE 3).

The screenshot shows the `Server Config` interface with the `apiRequesterHTTPS.xml` configuration file open. The `Source` tab is selected, showing XML code for a `zosconnect_endpointConnection` named `cscvincAPI` with host `https://dvipa.washington.ibm.com`, port `9443`, and authentication configuration `mySAFAuth`. A red arrow points from the `connectionRef` value in the `cscvinc.properties` file to this connection definition.

```

<?xml version="1.0" encoding="UTF-8"?>
<server>
    <zosconnect_endpointConnection id="cscvincAPI">
        <host>https://dvipa.washington.ibm.com</host>
        <port>9443</port>
        <authenticationConfigRef>mySAFAuth</authenticationConfigRef>
        <connectionTimeout>10s</connectionTimeout>
        <receiveTimeout>40s</receiveTimeout>
    </zosconnect_endpointConnection>
    <zosconnect_authData id="mySAFAuth">
        <user>USER1</user>
        <password>user1</password>
    </zosconnect_authData>
</server>

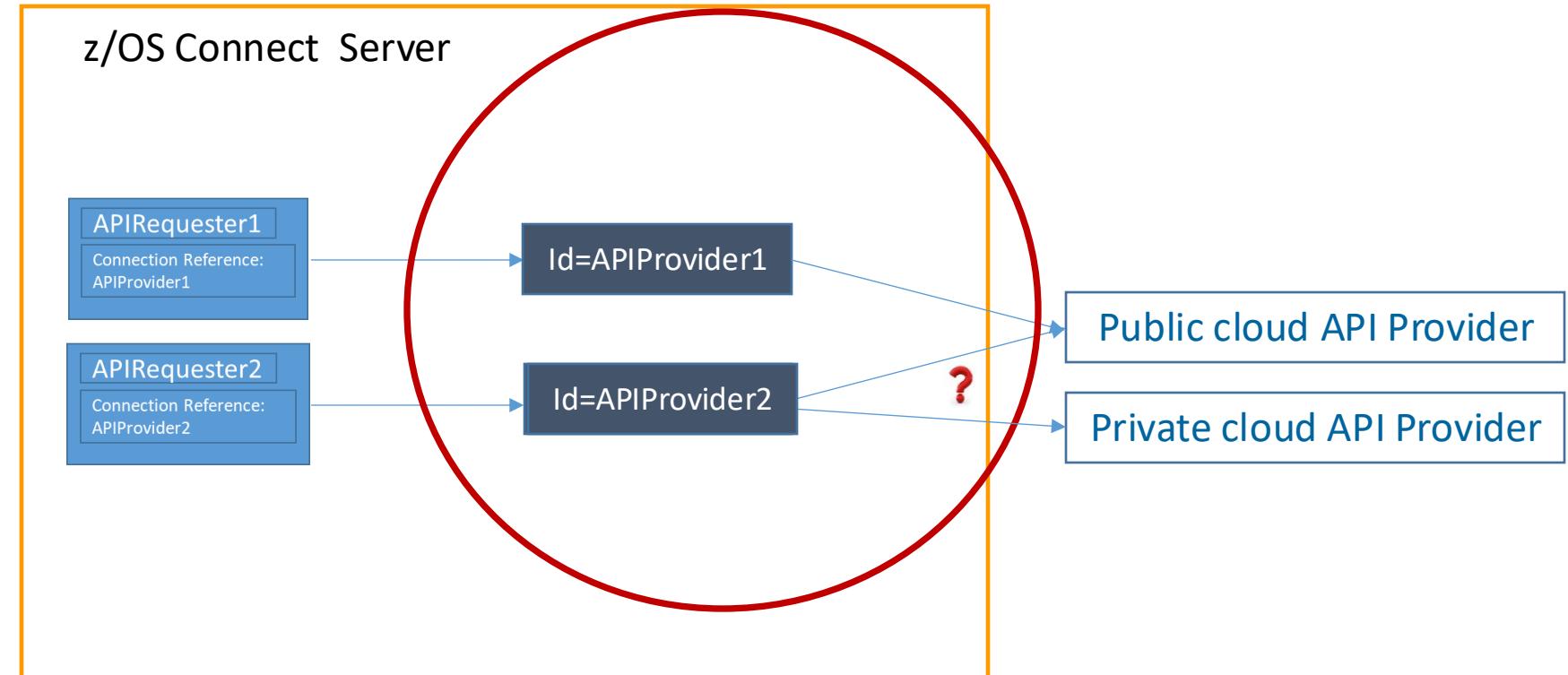
```

A red arrow also points from the resolved URL `http://dvipa.washington.ibm.com:9443/cscvincapi/employee/{numb}` back to the `BAQ-APIPATH` field in the DDS definition.

Tech-Tip: Use naming conventions for connection references



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



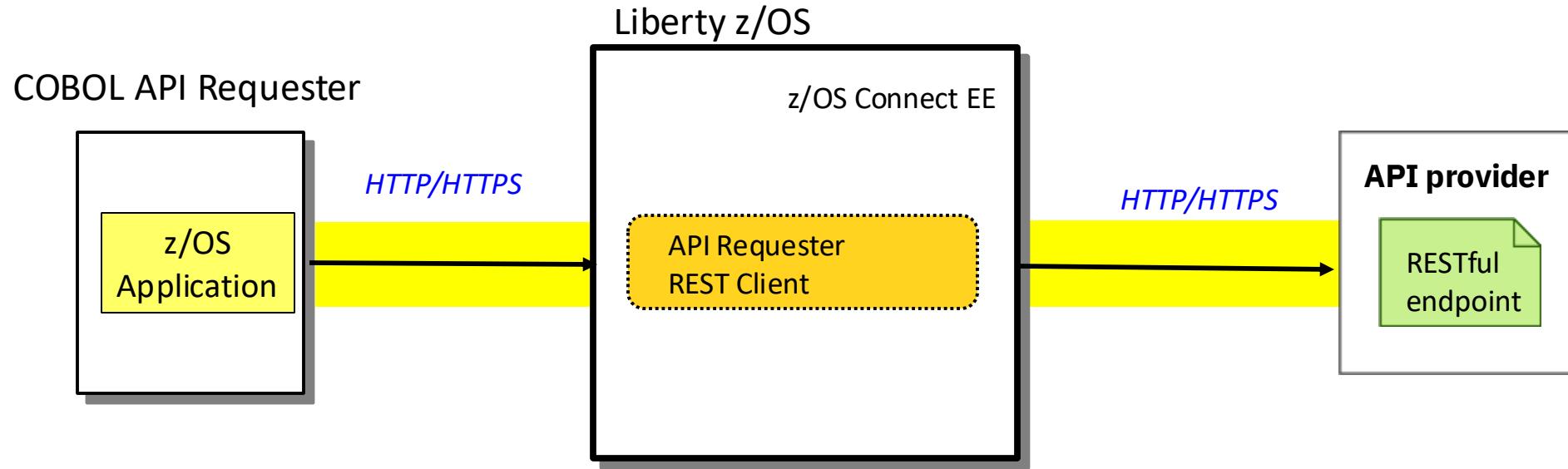
```
<zosconnect_apiRequesters>
  requireAuth="true|false"
  <apiRequester name="cscvincapi_1.0.0"
    connectionRef="APIProvider2"
  </zosconnect_apiRequesters>
```

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



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

End to end API requester to API Provider connection overview



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

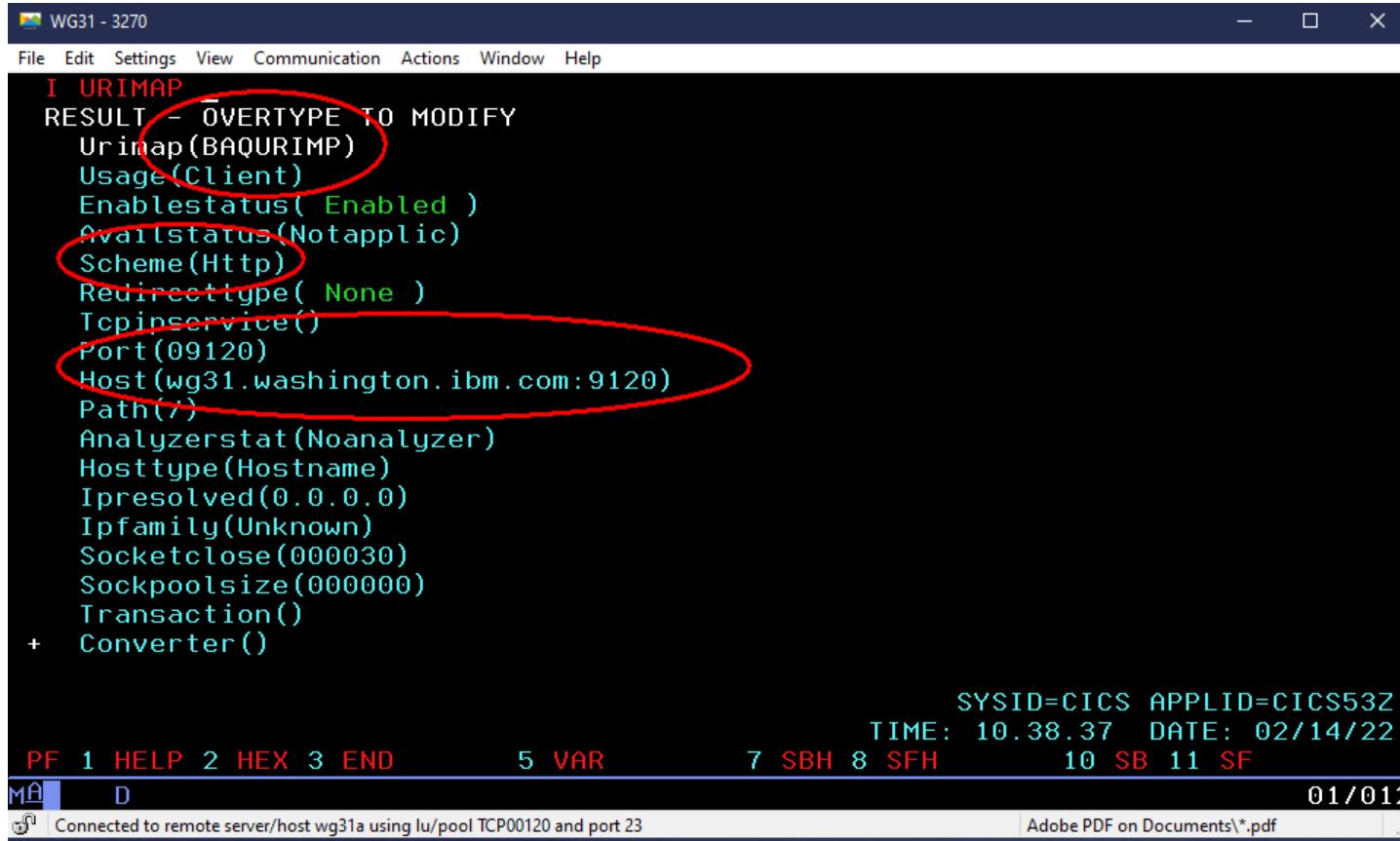
- Environment Variables (BAQURI, BAQPORT)
 - Via JCL
 - LE Options (CEEROPTS)
 - Programmatically (CEEENV)
- HTTP or HTTPS

CICS HTTP connection details provided by:

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

Configuring connections to the z/OS API requester server

Default CICS URI MAP*



```

WG31 - 3270
File Edit Settings View Communication Actions Window Help
I URIMAP
RESULT - OVERTYPE TO MODIFY
Urimap(BAQURIMP)
Usage(Client)
Enablestatus( Enabled )
Availstatus(Notapplic)
Scheme(Http)
Redirecttype( None )
TcpipService()
Port(09120)
Host(wg31.washington.ibm.com:9120)
Path(/)
Analyzerstat(Noanalyzer)
Hosttype(Hostname)
Ipresolved(0.0.0.0)
Ipfamily(Unknown)
Socketclose(000030)
Sockpoolsize(000000)
Transaction()
+ Converter()

PF 1 HELP 2 HEX 3 END      5 VAR      7 SBH 8 SFH      10 SB 11 SF
SYSID=CICS APPLID=CICS53Z
TIME: 10.38.37 DATE: 02/14/22
01/012
MA D
Connected to remote server/host wg31a using lu/pool TCP00120 and port 23
Adobe PDF on Documents\*.pdf

```

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



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.

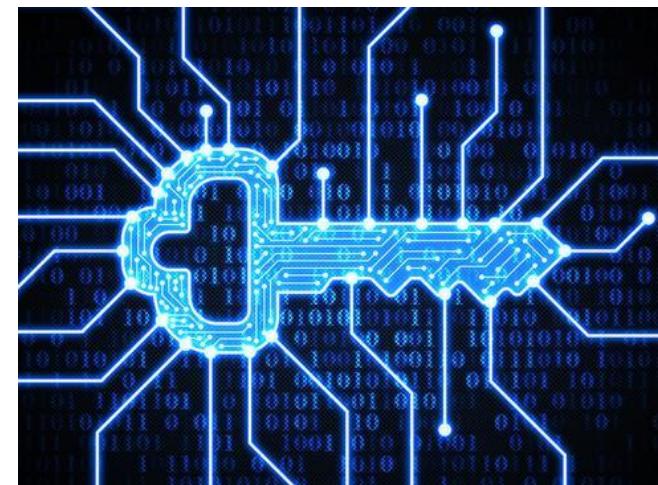
BAQUSERNAME - Specifies the username for connections if basic authentication is used.

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.

General security terms or considerations

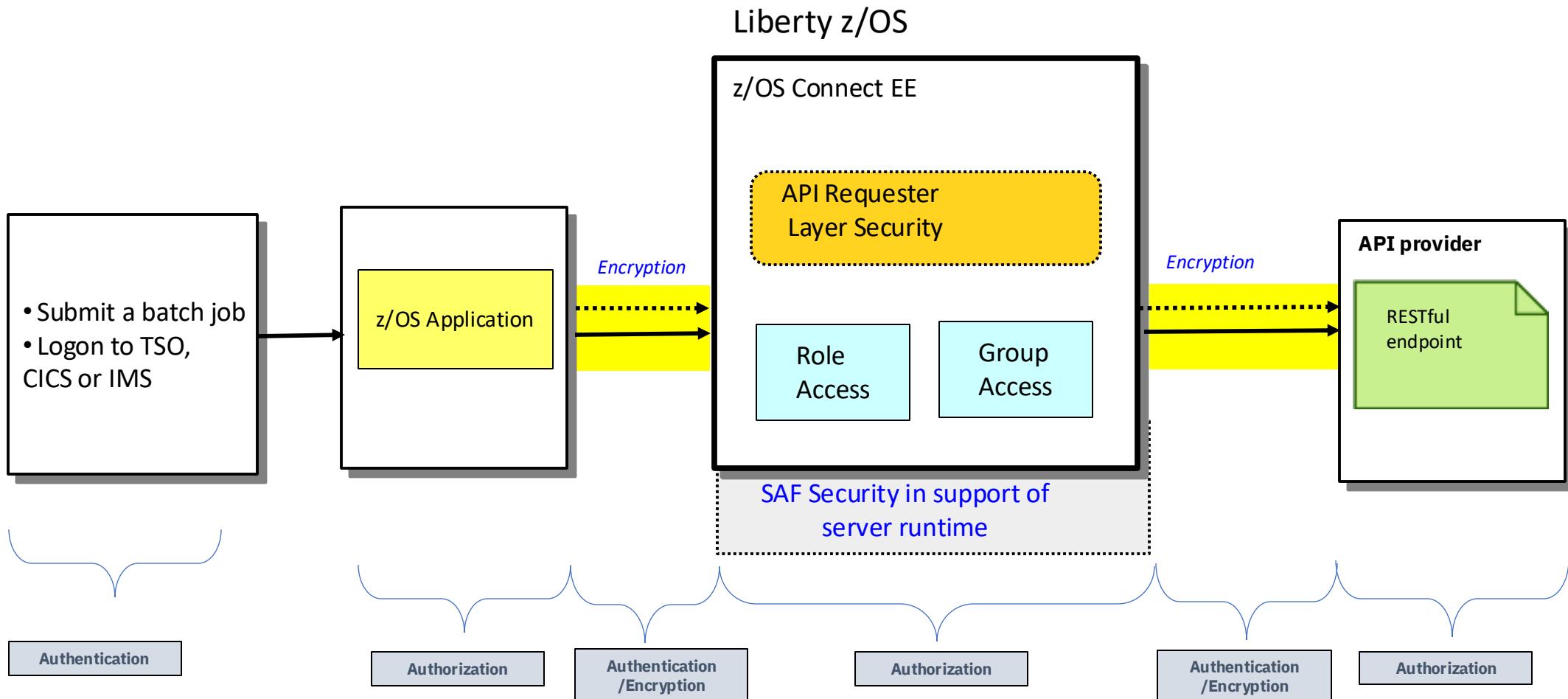
Security involves

- 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.



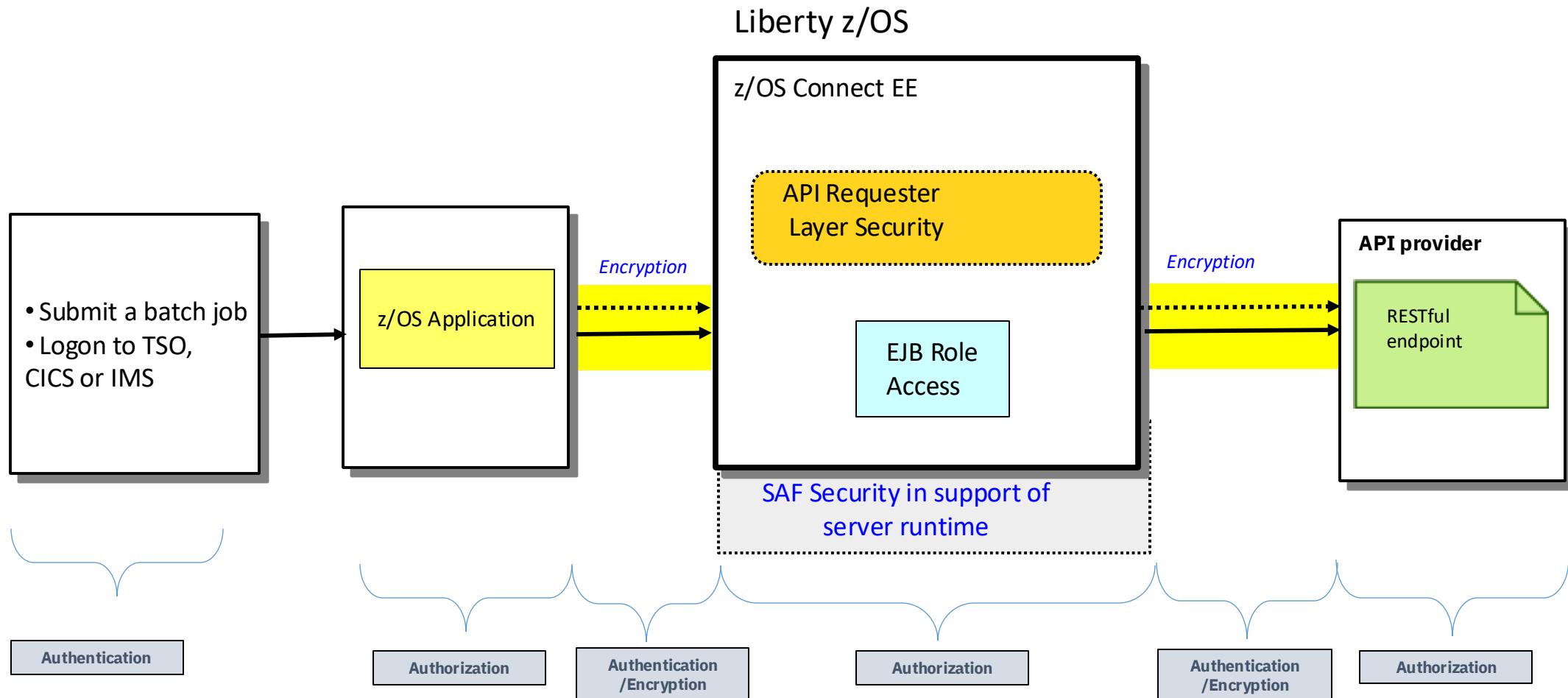


Outbound Authentication versus Authorization (Swagger 2.0)



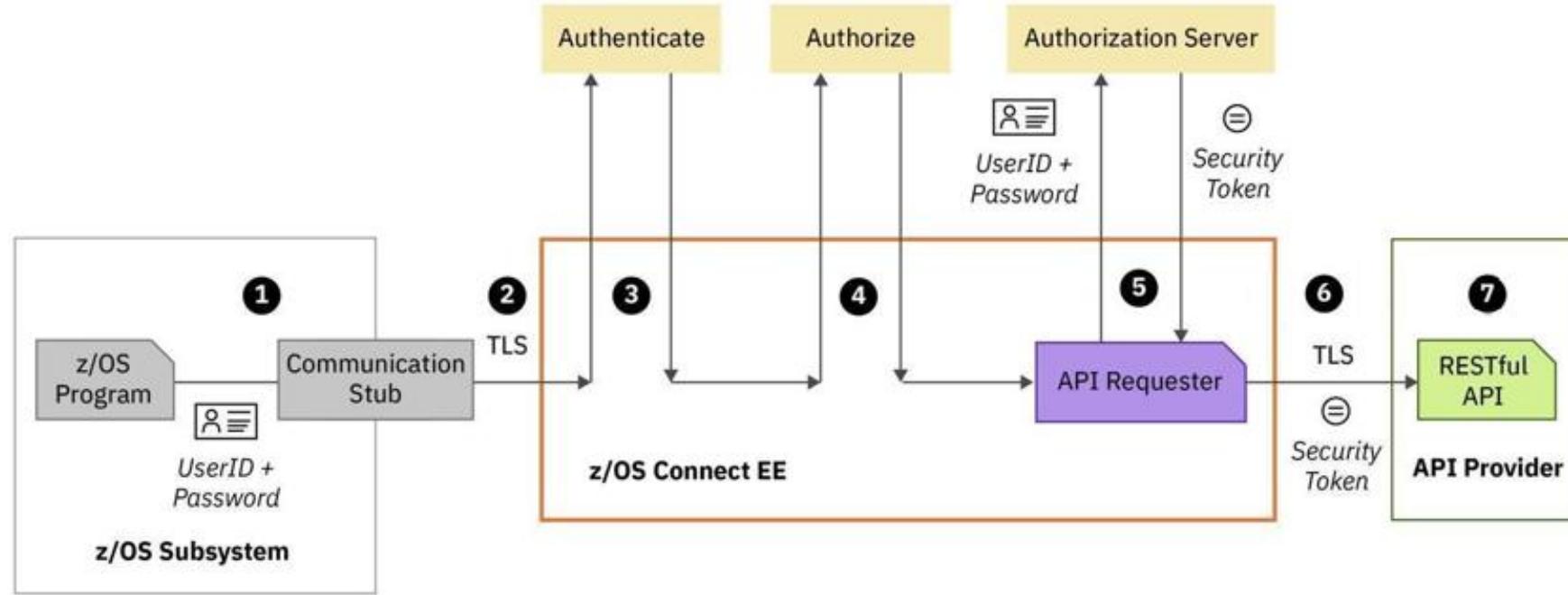


Outbound Authentication versus Authorization (OpenAPI 3)





Typical z/OS Connect EE API Requester security flow

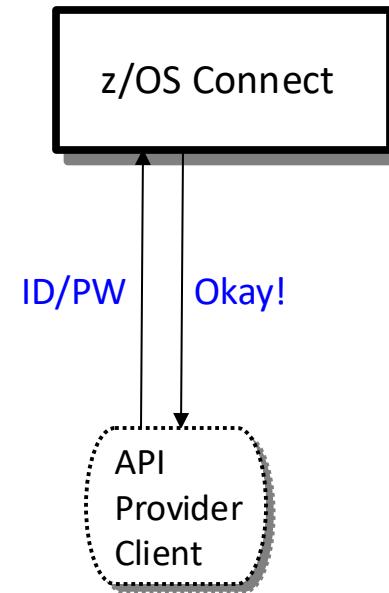


1. A user ID and password can be used for basic authentication by the z/OS Connect EE server
2. Connection between the CICS, IMS, or z/OS application and the z/OS Connect EE server can use TLS
3. Authenticate the CICS, IMS, or z/OS application.
4. Authorize the authenticated user ID to connect to z/OS 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

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

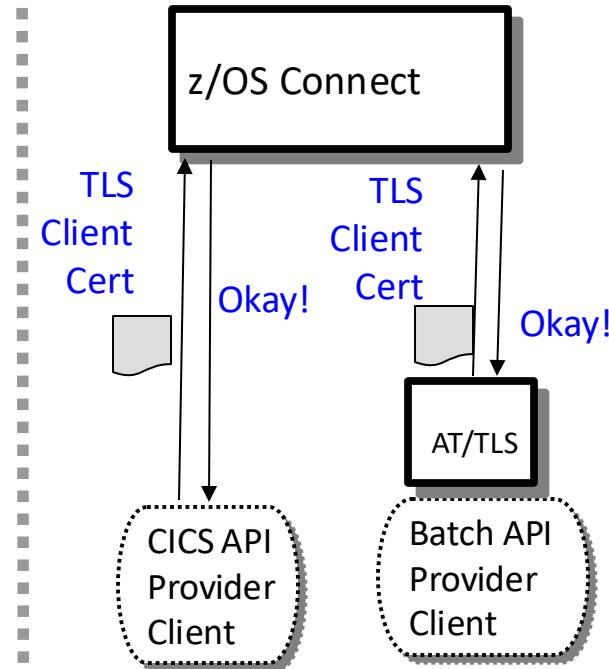
Two options for providing credentials for authentication

Basic Authentication



Application provides ID/PW or ID/PassTicket

Client Certificate



z/OS Connect requests a client certificate

CICS or AT/TLS supplies a client certificate



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:

```
//CEELOPTS 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



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" />
```



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 'ATSPKTTC'.

*-----*
***** 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(ATSPKTTC)

```
*-----*
* 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
```

Tech/Tip: API Requester - HTTP v HTTPS



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

```
CEE0PTS DD *
  POSIX(ON),
  ENVAR("BAQURI=wg31.washington.ibm.com",
  "BAQPORT=9080")
```

```
CEE0PTS DD *
  POSIX(ON),
  ENVAR("BAQURI=wg31.washington.ibm.com",
  "BAQPORT=9443")
```

CICS URIMAPs

```
WG31
File Edit Settings View Communication Actions Window Help
OVERTYPE TO MODIFY
CEDA ALter UriMap( BAQURIMP )
UriMap : BAQURIMP
Group : SYSGRP
DEscription ==> URIMAP for z/OS Connect EE server
Status ==> Enabled Enabled | Disabled
Usage ==> Client Server | Client | Pipeline |
          | Jvmserver
UNIVERSAL RESOURCE IDENTIFIER
SCHEME ==> HTTP HTTP | HTTPS
PORT ==> 09120 No | 1-65535
HOST ==> wg31.washington.ibm.com
==>
PATH ==> /
(Mixed Case) ==>
==>
==>
==>
+ OUTBOUND CONNECTION POOLING
SYSID=CICS APPL
PF 1 HELP 2 COM 3 END      6 CRSR 7 SBH 8 SFH 9 MSG 10 SB 11
MA C
Connected to remote server/host wg31 using lu/pool TCP00133 and port 23

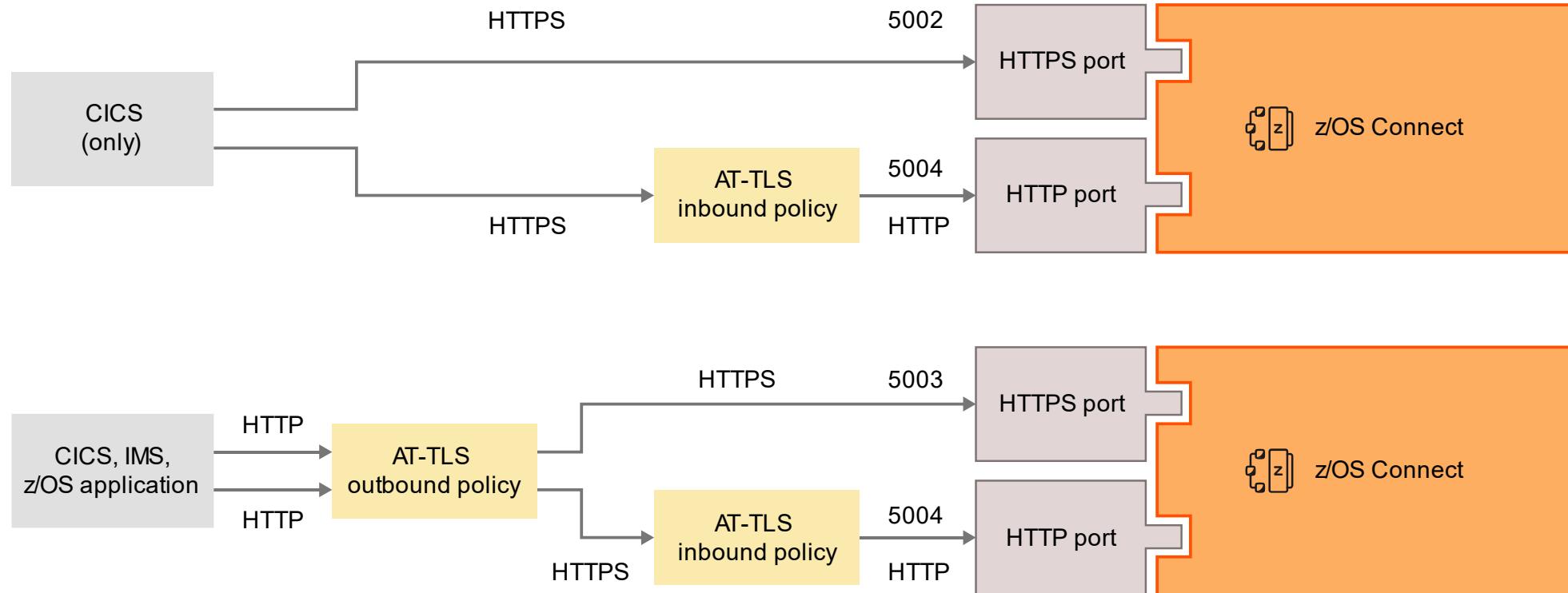
WG31
File Edit Settings View Communication Actions Window Help
OVERTYPE TO MODIFY
CICS RELEASE = 0710
CEDA ALter UriMap( BAQURIMP )
UriMap : BAQURIMP
Group : SYSGRP
DEscription ==> URIMAP for z/OS Connect EE server
Status ==> Enabled Enabled | Disabled
Usage ==> Client Server | Client | Pipeline | Atom |
          | Jvmserver
UNIVERSAL RESOURCE IDENTIFIER
SCHEME ==> HTTPS HTTP | HTTPS
PORT ==> 09443 No | 1-65535
HOST ==> wg31.washington.ibm.com
==>
PATH ==> /
(Mixed Case) ==>
==>
==>
==>
+ OUTBOUND CONNECTION POOLING
SYSID=CICS APPLID=CICS53Z
PF 1 HELP 2 COM 3 END      6 CRSR 7 SBH 8 SFH 9 MSG 10 SB 11 SF 12 CNCL
MA C
Connected to remote server/host wg31 using lu/pool TCP00133 and port 23
13/022
```

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

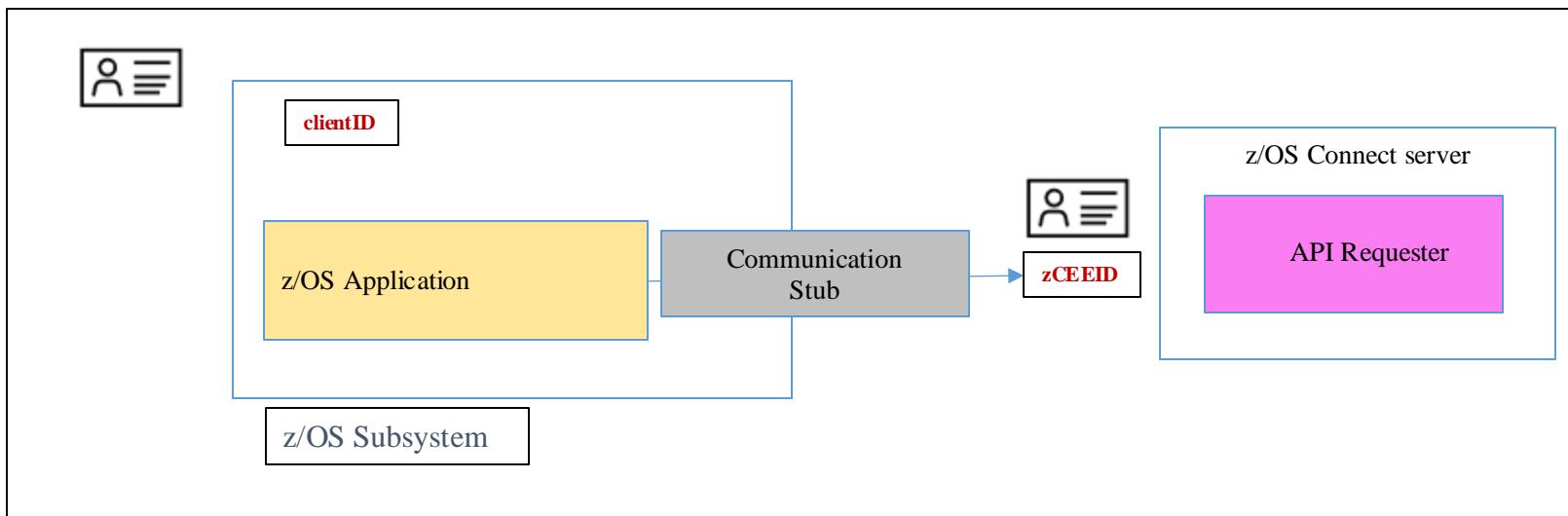
MOVE "URIMAP01" TO BAQ-ZCON-SERVER-URI.



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



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>
```

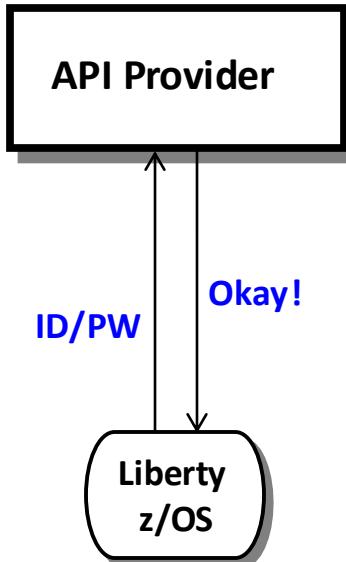
* Added in V3.0.45



API Requester - API Provider Authentication

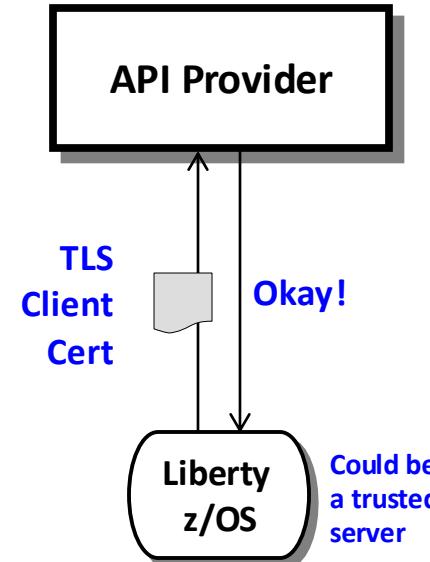
Several different ways this can be accomplished:

Basic Authentication



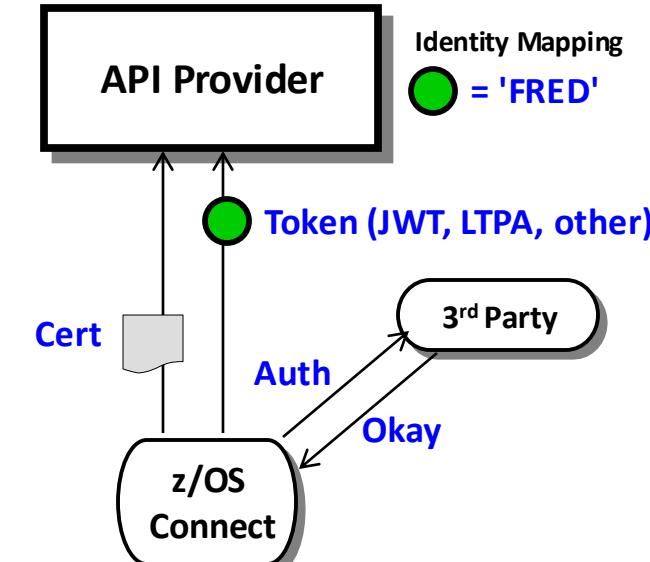
zCEE supplies ID/PW or
ID/Passticket

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



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

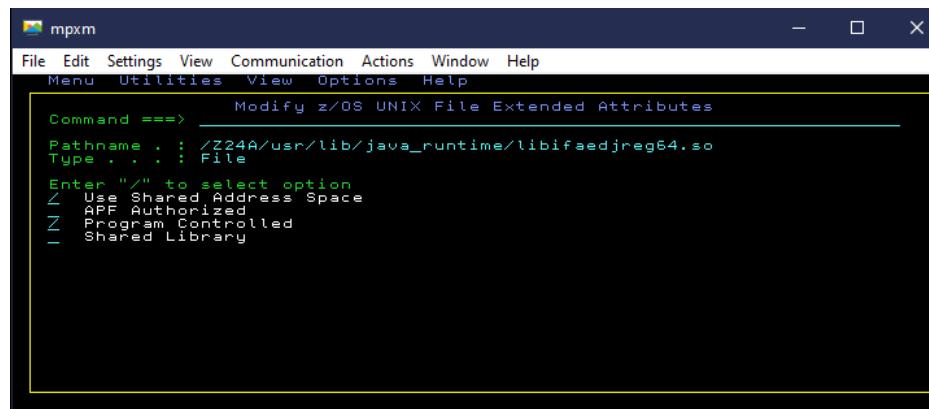
RDEFINE SURROGAT *.BAQASSRT UACC(NONE) OWNER(SYS1)

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
```





```
<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.

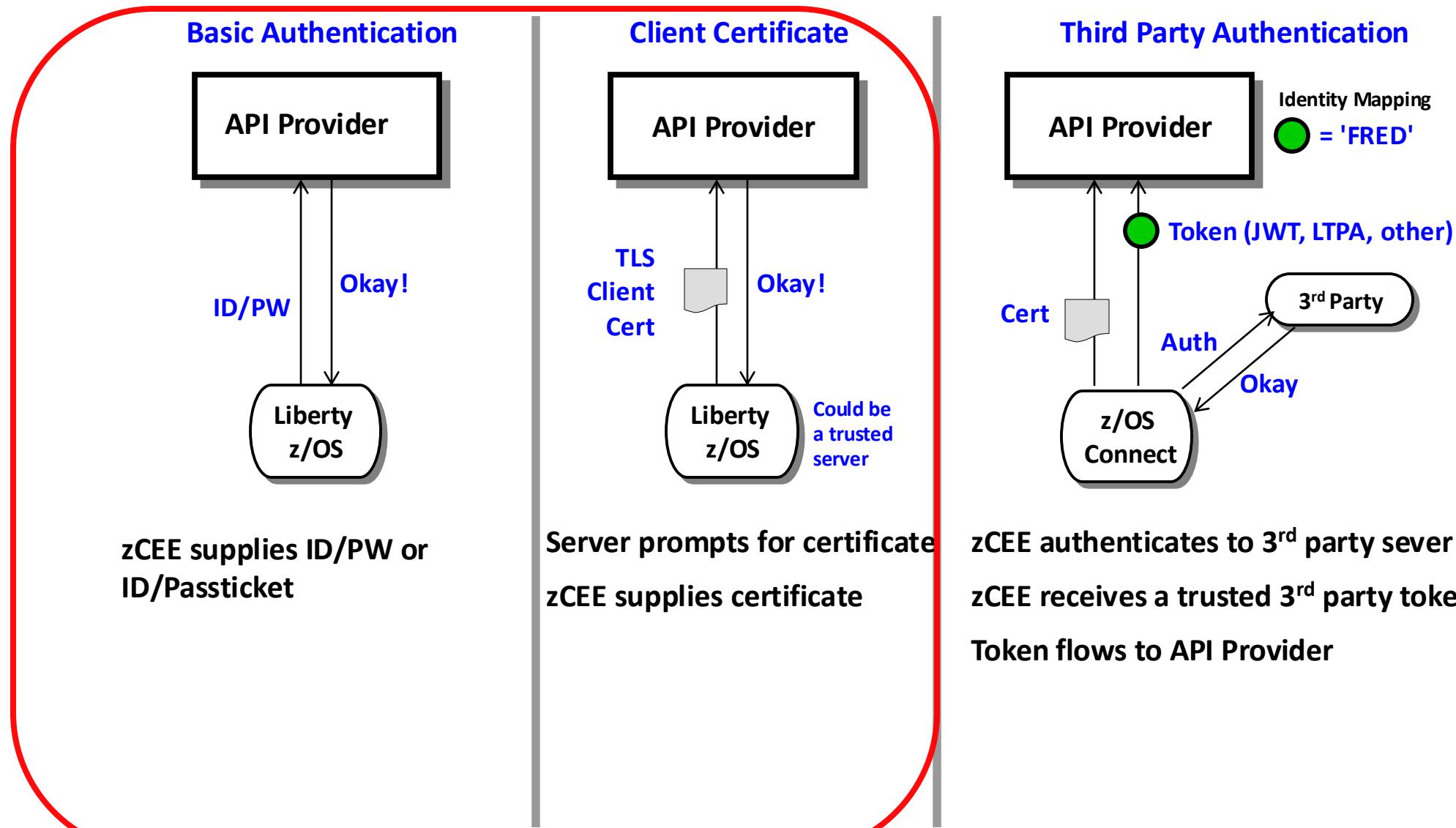
So, the required SAF EJB roles to be defined would be (*invoke* is the only role).

- *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.

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

Several different ways this can be accomplished:



Configuring Basic and/or TLS 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



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
```

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

Several different ways this can be accomplished:

Basic Authentication

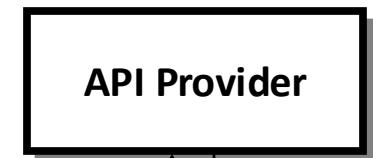


ID/PW

Liberty
z/OS

zCEE supplies ID/PW or
ID/Passticket

Client Certificate



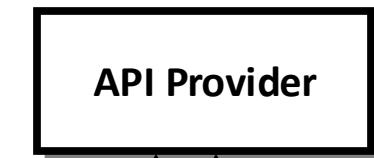
TLS
Client
Cert

Liberty
z/OS

Could be
a trusted
server

Server prompts for certificate
zCEE supplies certificate

Third Party Authentication



Cert

Token (JWT, LTPA, other)

z/OS
Connect

3rd Party

Identity Mapping
Green circle = 'FRED'

zCEE authenticates to 3rd party sever
zCEE receives a trusted 3rd party token
Token flows to API Provider



Third Party Authentication Examples

Screenshot of the UPS Sign Up page:

The page shows a yellow banner at the top stating "UPS is open for business: Service impacts related to Coronavirus ...More". Below the banner is the UPS logo and links for "Sign up / Log in" and "Search or Track".

Sign Up

Already have an ID? [Log in](#)

Use one of these sites.

[Google](#) [Facebook](#)
[Amazon](#) [Apple](#)
[Twitter](#)

Or enter your own information.

* Indicates required field

Name *

Email *

User ID *

Password * [Show](#)

Phone US +1

Screenshot of the myNCDMV Sign In page:

The page features a background image of autumn foliage. It has "Log In" and "Sign Up" tabs, with "Log In" selected.

Log In to myNCDMV

Email Address:

Password: [Show Password](#)

Remember Me

[Log In](#) [Forgot Password](#)

Or

[Continue with Apple](#)
[Continue with Facebook](#)
[Continue with Google](#)

[Continue as Guest](#)

NOTICE FOR PUBLIC COMPUTER USERS - If you sign in with Google, Apple, or Facebook you are also signing into that account on this computer. Remember to sign out when you're done.

powered by



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

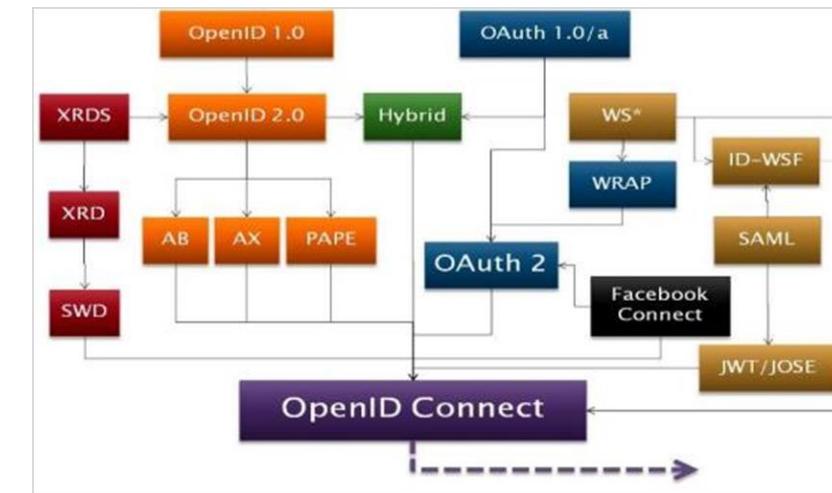
See the YouTube videos:

OAuth 2.0 and OpenID Connect (in plain English)

<https://www.youtube.com/watch?v=996OixerHze0>

OpenID Connect on Liberty

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





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

The screenshot shows the jwt.io debugger interface. At the top, it says "Encoded" and displays a long string of characters: eyJraWQiOiI0cWpYLWJrWE9Vd19GX... The bottom part of this string is circled in red and has a tooltip: "Mon Nov 02 2020 11:05:58 GMT-0500 (Eastern Standard Time)". To the right, under "Decoded", the token is split into "HEADER:" and "PAYLOAD:". The HEADER contains: { "kid": "4qjX-bkXOUw_F_uccjRMkB9ivMjXSQwj0RrkyRJq8DM", "alg": "RS256" }. The PAYLOAD contains: { "sub": "Fred", "token_type": "Bearer", "scope": ["openid", "profile", "email"], "azp": "rpSsl", "iss": "https://wg31.washington.ibm.com:26213/oidc/endpoint/OP", "aud": "myZcee", "exp": 1604333158, "iat": 1604333858, "realmName": "zCEERealm", "uniqueSecurityName": "Fred" }.

Values derived from the OAUTH configuration:

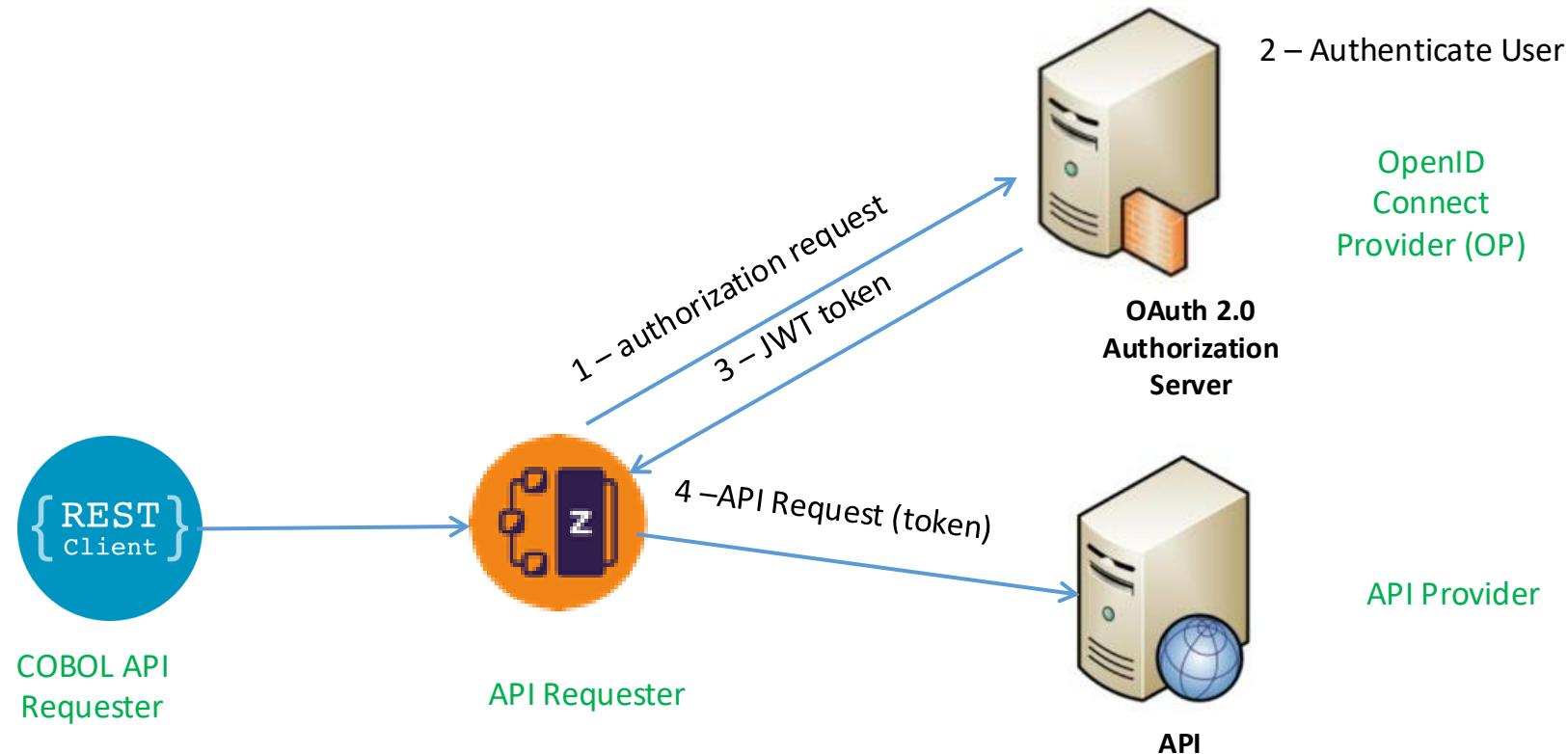
- signatureAlgorithm="RS256"
- accessTokenLifetime="300"
- resourceIds="myZcee"

<https://jwt.io>

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 OAAUTH 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.

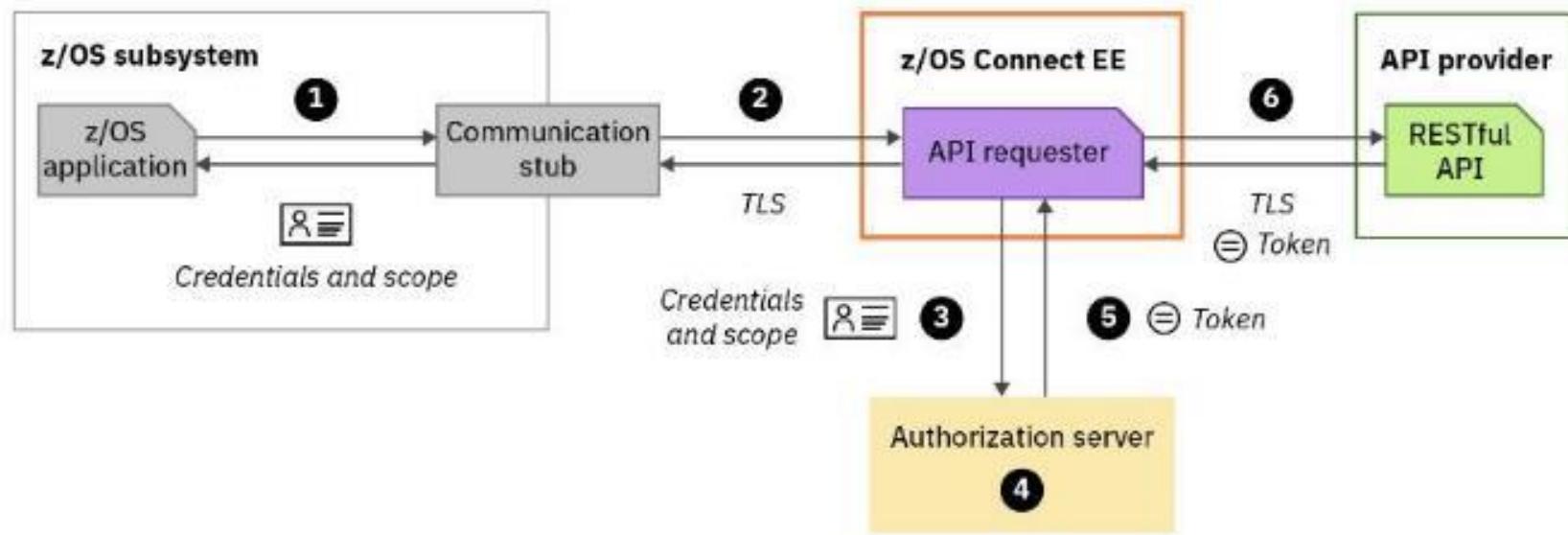
z/OS Connect OAuth Flow for API requester



Grant Types:

- client_credentials
- password

Calling an API with OAuth 2.0 support





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"/>
```

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=996OjexHze0>

Configuring OAuth support – BAQRINFO copy book



```
wg31 master
File Edit Settings View Communication Actions Window Help
Menu Utilities Compilers Help
BROWSE ZCEE30.SBAQC0B(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-TINFO-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
Connected to remote server/host wg31z using lu/pool TCP00145 04/015
```

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



Obtaining a JWT using request parameters

wg31 master

File Edit Settings View Communication Actions Window Help

Menu Utilities Compilers Help

BROWSE ZCEE30.SBAQCOB(BAQHCNC)

Line 0000000020 Col 001 080

Command ==> Scroll ==> PAGE

```
* Host API Request parameter names
77 BAQR-OAUTH-USERNAME      PIC X(22)
  VALUE 'BAQHAPI-oAuth-Username'.
77 BAQR-OAUTH-PASSWORD      PIC X(22)
  VALUE 'BAQHAPI-oAuth-Password'.
77 BAQR-OAUTH-SCOPE          PIC X(19)
  VALUE 'BAQHAPI-oAuth-Scope'.
77 BAQR-OAUTH-CLIENT-ID      PIC X(22)
  VALUE 'BAQHAPI-oAuth-ClientId'.
77 BAQR-OAUTH-CLIENT-SECRET PIC X(26)
  VALUE 'BAQHAPI-oAuth-ClientSecret'.
77 BAQR-OAUTH-RESOURCE       PIC X(22)
  VALUE 'BAQHAPI-oAuth-Resource'.
77 BAQR-OAUTH-AUDIENCE        PIC X(22)
  VALUE 'BAQHAPI-oAuth-Audience'.
77 BAQR-OAUTH-CUSTOM-PARMS   PIC X(25)
  VALUE 'BAQHAPI-oAuth-CustomParms'.
77 BAQR-JWT-USERNAME         PIC X(22)
  VALUE 'BAQHAPI-Token-Username'.
77 BAQR-JWT-PASSWORD         PIC X(22)
  VALUE 'BAQHAPI-Token-Password'.

* Host API ZCON parameter names
77 BAQZ-TRACE-VERBOSE        PIC X(21)
  VALUE 'BAQHAPI-Trace-Verbose'.
77 BAQZ-SERVER-URIMAP         PIC X(21)
  VALUE 'BAQHAPI-Server-URIMAP'.
77 BAQZ-SERVER-HOST           PIC X(19)
```

MA A

Connected to remote server/host wg31z using lu/pool TCP00111 and port 23

wg31 master

File Edit Settings View Communication Actions Window Help

File Edit Edit_Settings Menu Utilities Compilers Test Help

EDIT USER1.ZCEE30.SOURCE(GETAPI) - 01.02 Columns 00001 00072

Command ==> Scroll ==> PAGE

```
***** **** Top of Data *****
```

000001 CBL APOST

000002

000003 * Authentication server credentials

000004 01 JWT-USER PIC X(10) VALUE 'myUsername'.

000005 01 JWT-PSWD PIC X(10) VALUE 'myPassword'.

000006

000007

000008

000009 * Send JWT credentials to z/OS Connect

000010 MOVE BAQR-TOKEN-USERNAME TO

000011 BAQ-REQ-PARM-NAME OF BAQ-REQ-PARMS(1)

000012 SET BAQ-REQ-PARM-ADDRESS OF

000013 BAQ-REQ-PARMS(1) TO ADDRESS OF JWT-USER

000014 MOVE LENGTH OF JWT-USER TO

000015 BAQ-REQ-PARM-LENGTH OF BAQ-REQ-PARMS(1)

000016 MOVE BAQR-TOKEN-PASSWORD TO

000017 BAQ-REQ-PARM-NAME OF BAQ-REQ-PARMS(2)

000018 SET BAQ-REQ-PARM-ADDRESS OF

000019 BAQ-REQ-PARMS(2) TO ADDRESS OF JWT-PSWD

000020 MOVE LENGTH OF JWT-PSWD TO

000021 BAQ-REQ-PARM-LENGTH OF BAQ-REQ-PARMS(2)

000022

000023 * Call the API endpoint using BAQEXEC

000024

000025

000026

000027

MA A

Connected to remote server/host wg31z using lu/pool TCP00111 and port 23

28/019

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/token1
    basicAuthRef="tokenCredential" 2
    sslCertsRef="OutboundSSLSettings" />

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

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

¹See 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

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
```

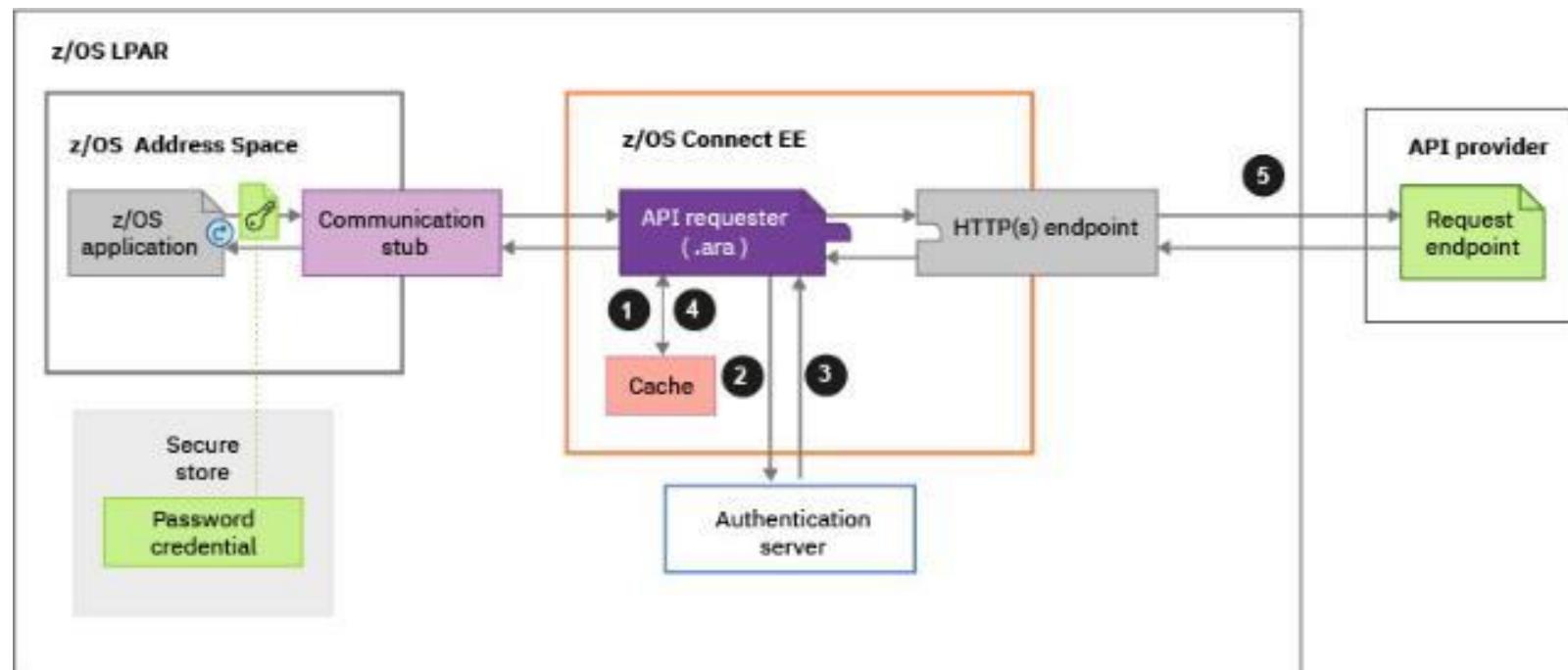
auser is not mapped to a valid RACF identity

```
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(EJBRROLE )  
INSUFFICIENT ACCESS AUTHORITY  
ACCESS INTENT(READ ) ACCESS ALLOWED(NONE )
```

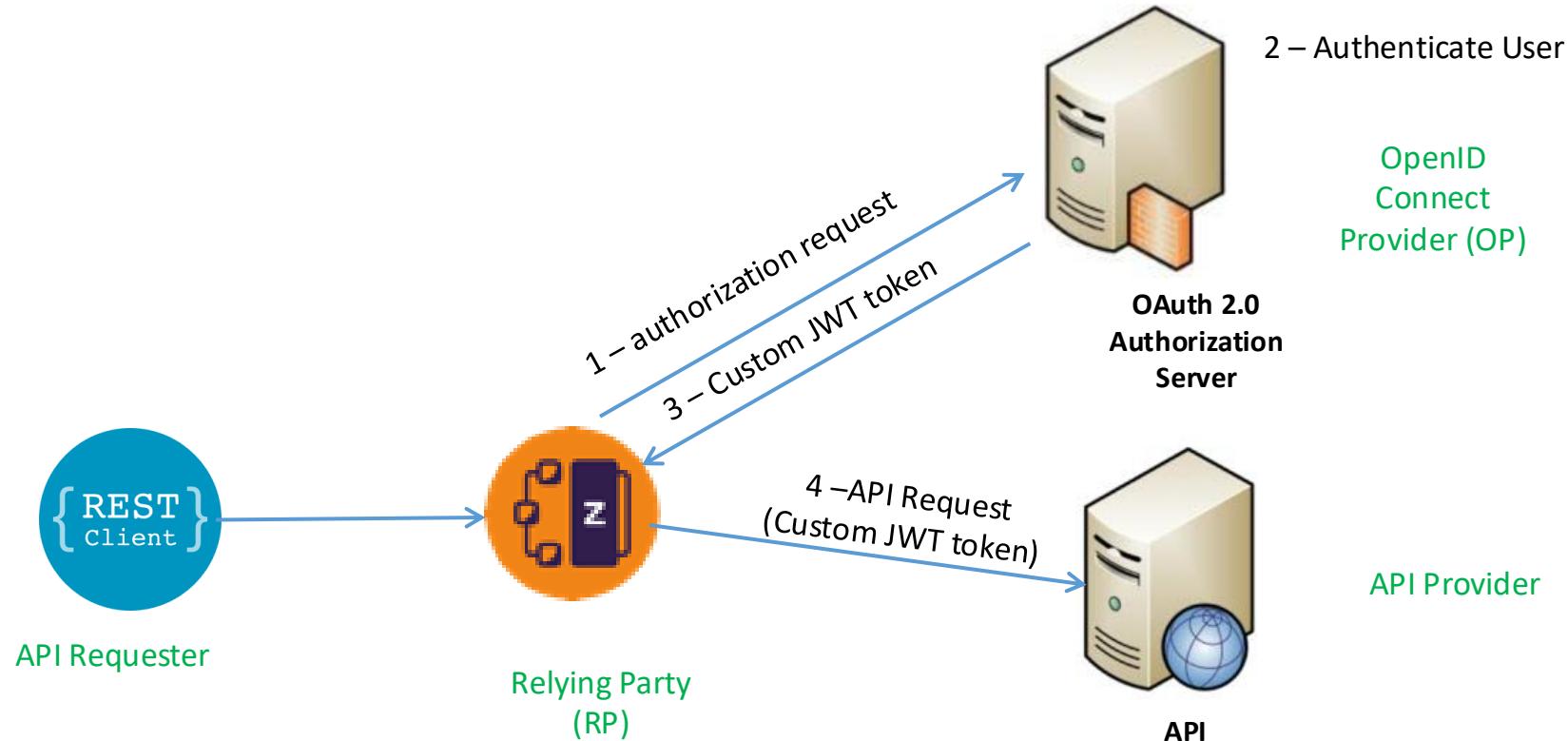
distuser2 is mapped to RACF identity USER2 which has no access to the EJBRole protecting z/OS Connect

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.



z/OS Connect OAuth Custom Flow





API Requester – JWT Custom flow

The screenshot shows the API Requester application window titled "wg31 master". The menu bar includes File, Edit, Settings, View, Communication, Actions, Window, Help, Menu, Utilities, Compilers, and Help. The main area displays the "BROWSE ZCEE30.SBAQCOB(BAQRINFO)" command. The code listing is as follows:

```
BROWSE ZCEE30.SBAQCOB(BAQRINFO)
Command ==> -
 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.
Line 0000000028 Col 001 080
Scroll ==> PAGE
```

The section from line 65 to 85, which defines the BAQ-AUTHTOKEN structure, is highlighted with a red box.

At the bottom of the window, the status bar shows "Connected to remote server/host wg31z using lu/pool TCP00145" and the date "04/015".

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.



API Requester – JWT Custom flow

WG31 - 3270

Menu Utilities Compilers Help

BROWSE ZCEE30.SBAQC0B(BAQHCONC) Line 000000020 Col 001 080
Command ==>

```
* Host API Request parameter names
 77 BAQR-DAUTH-USERNAME          PIC X(22)
   VALUE 'BAQHAPI-oAuth-Username'.
 77 BAQR-DAUTH-PASSWORD          PIC X(22)
   VALUE 'BAQHAPI-oAuth-Password'.
 77 BAQR-DAUTH-SCOPE             PIC X(19)
   VALUE 'BAQHAPI-oAuth-Scope'.
 77 BAQR-DAUTH-CLIENT-ID         PIC X(22)
   VALUE 'BAQHAPI-oAuth-ClientId'.
 77 BAQR-DAUTH-CLIENT-SECRET     PIC X(26)
   VALUE 'BAQHAPI-oAuth-ClientSecret'.
 77 BAQR-DAUTH-RESOURCE          PIC X(22)
   VALUE 'BAQHAPI-oAuth-Resource'.
 77 BAQR-DAUTH-AUDIENCE          PIC X(22)
   VALUE 'BAQHAPI-oAuth-Audience'.
 77 BAQR-DAUTH-CUSTOM-PARMS     PIC X(25)
   VALUE 'BAQHAPI-oAuth-CustomParms'.
 77 BAQR-TOKEN-USERNAME          PIC X(22)
   VALUE 'BAQHAPI-Token-Username'.
 77 BAQR-TOKEN-PASSWORD          PIC X(22)
   VALUE 'BAQHAPI-Token-Password'.
 77 BAQR-TOKEN-CUSTOM-PARMS     PIC X(25)
   VALUE 'BAQHAPI-Token-CustomParms'.
 77 BAQR-TOKEN-CUSTOM-HEADERS   PIC X(27)
   VALUE 'BAQHAPI-Token-CustomHeaders'.
```

* Host API ZCON parameter names
 77 BAQZ-TRACE-VERBOSE PIC X(21)
 VALUE 'BAQHAPI-Trace-Verbose'.
 77 BAQZ-SERVER-URIMAP PIC X(21)
 VALUE 'BAQHAPI-Server-URIMAP'.
 77 BAQZ-SERVER-HOST PIC X(19)
 VALUE 'BAQHAPI-Server-Host'.
 77 BAQZ-SERVER-PORT PIC X(19)
 VALUE 'BAQHAPI-Server-Port'.
 77 BAQZ-SERVER-TIMEOUT PIC X(22)
 VALUE 'BAQHAPI-Server-Timeout'.
 77 BAQZ-SERVER-USERNAME PIC X(23)
 VALUE 'BAQHAPI-Server-Username'.

MA A
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WG31 - 3270

File Edit Edit_Settings Menu Utilities Compilers Test Help

EDIT JOHNSON.ZCEE.SOURCE(BAQZUSER) - 01.01 Columns 00001 00072
Command ==> Scroll ==> PAGE

```
***** **** Top of Data ****
==MSG> -CAUTION- Data contains invalid (non-display) characters. Use command
==MSG>      == FIND P'. to position cursor to these
000001 IDENTIFICATION DIVISION.
000002 PROGRAM-ID. HBRMINM.
000003 ENVIRONMENT DIVISION.
000004 DATA DIVISION.
000005 WORKING-STORAGE SECTION.
000006 01 MY-USER PIC {10} VALUE 'myUsername'.
000007 01 MY-PSWD PIC {10} VALUE 'myPassword'.
000008 ....
000009 PROCEDURE DIVISION.
000010 ....
000011 ....
000012 ....
000013 ....
000014 MOVE BAQR-TOKEN-USERNAME TO
000015   BAQ-ZCON-PARM-NAME OF BAQ-ZCON-PARMS(1).
000016 SET BAQ-ZCON-PARM-ADDRESS OF BAQ-ZCON-PARMS(1) TO
000017   address of MY-USER.
000018 MOVE LENGTH OF MY-USER TO
000019   BAQ-ZCON-PARM-LENGTH(1) OF BAQ-ZCON-PARMS(1).
000020 ....
000021 MOVE BAQR-TOKEN-PASSWORD TO
000022   BAQ-ZCON-PARM-NAME OF BAQ-ZCON-PARMS(2).
000023 SET BAQ-ZCON-PARM-ADDRESS OF BAQ-ZCON-PARMS(2) TO
000024   ADDRESS OF MY-USER.
000025 MOVE LENGTH OF MY-USER TO
000026   BAQ-ZCON-PARM-LENGTH(1) OF BAQ-ZCON-PARMS(2).
***** **** Bottom of Data ****
```

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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/token1
    basicAuthRef="tokenCredential" 2
    sslCertsRef="OutboundSSLSettings" />

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

¹See 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



Configuring Custom JWT flow

Request Token Example 1

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

Response Token

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

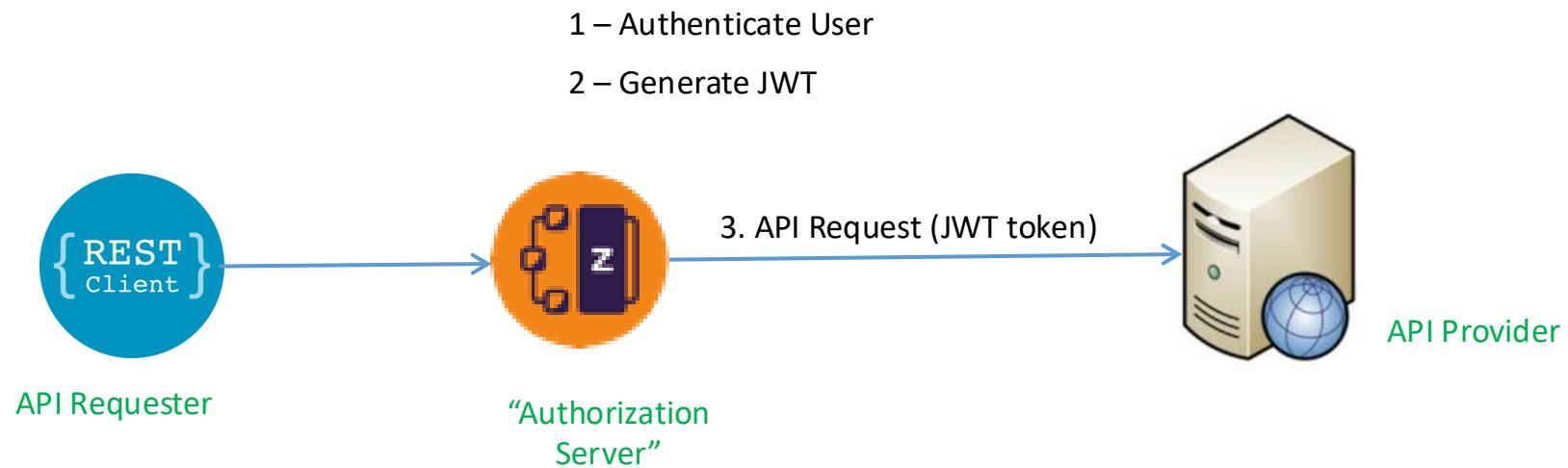
Response Token Example 2

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

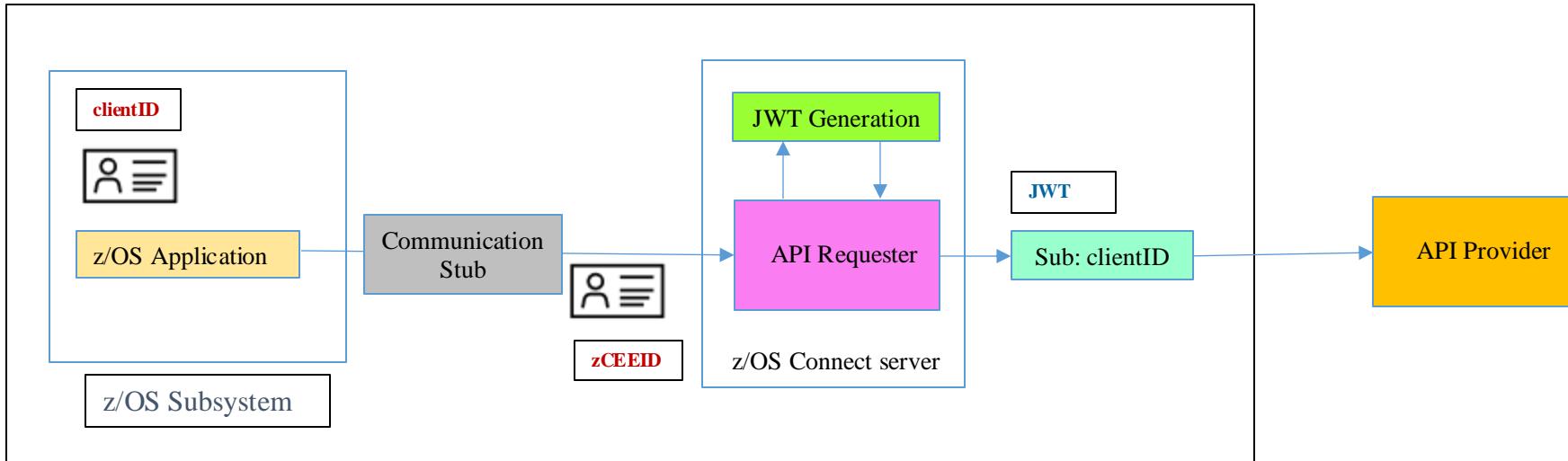
Response Token

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

z/OS Connect JWT Generation – V3.0.43



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 <i>zCEEID</i> and checks whether <i>zCEEID</i> is a surrogate of <i>clientID</i> . If <i>zCEEID</i> is a surrogate of <i>clientID</i> , the server further checks whether <i>clientID</i> has the authority to invoke an API requester; otherwise, a BAQR7114E message occurs.
	ASSERT_ONLY	Identity assertion is enabled. The zCEE server authenticates <i>zCEEID</i> and directly checks whether <i>clientID</i> has the authority to invoke an API requester
false	ASSERT_SURROGATE	Identity assertion is enabled. The zCEE server checks whether <i>clientID</i> 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 <i>clientID</i> has the authority to invoke an API requester

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**)**

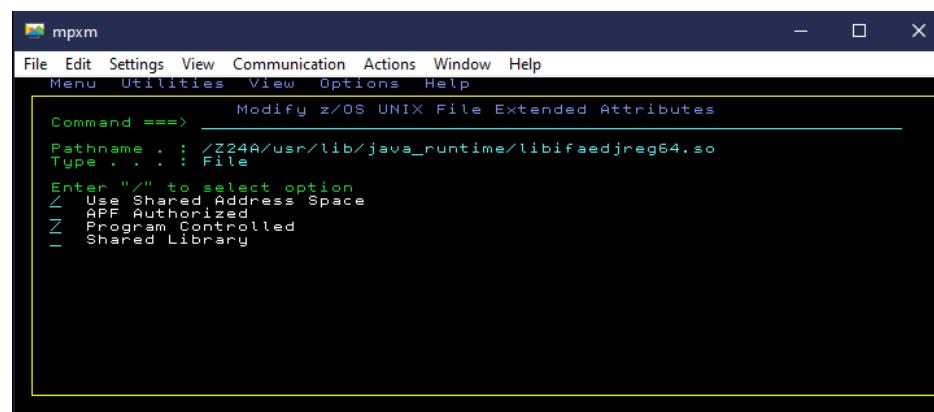
SETROPTS RACLIST(SURROGAT) REFRESH

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

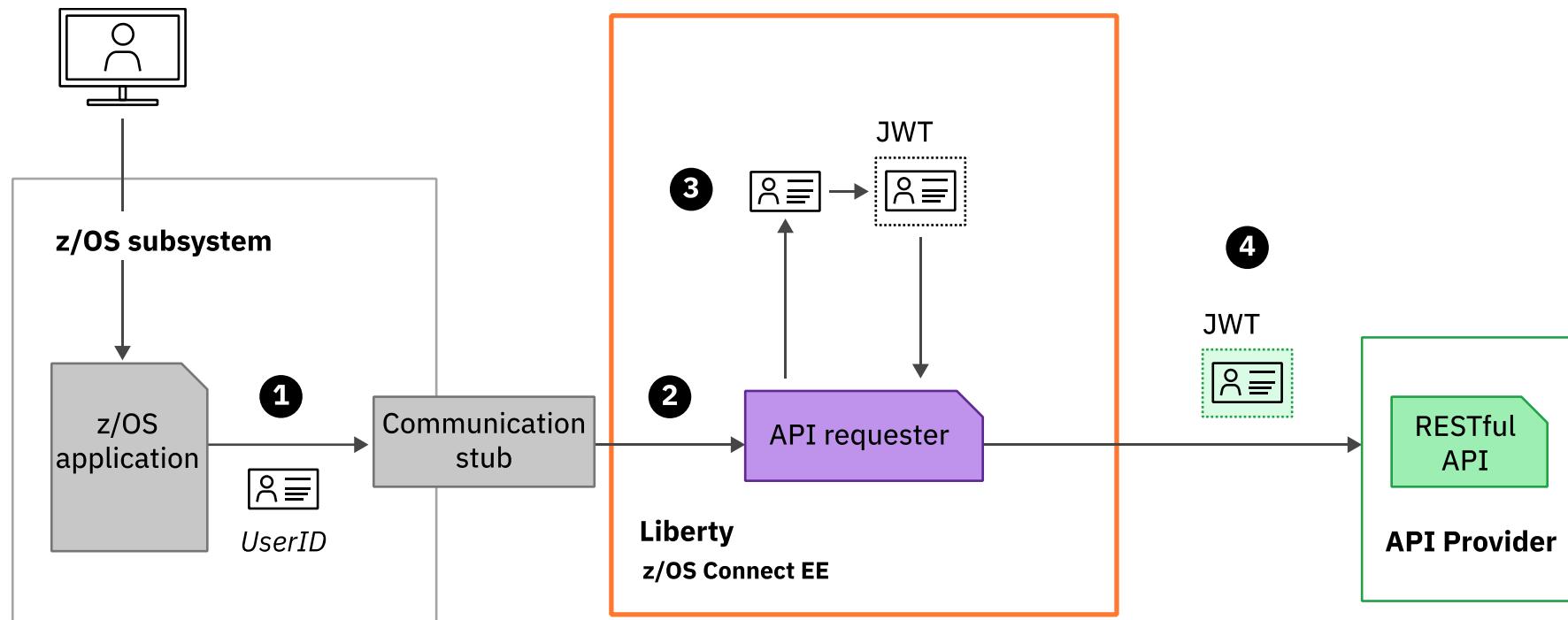
su

cd /usr/lib/java_runtime

extattr +p libifaedjreg64.so



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



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.

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"/>
```



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.

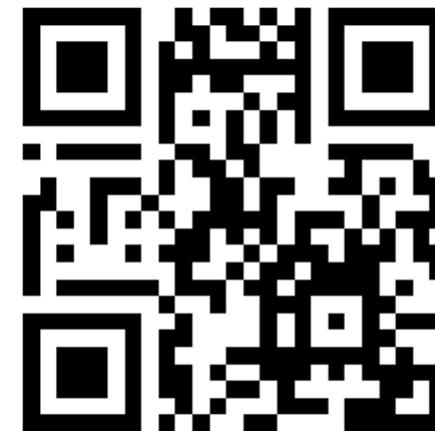
Configure the zosconnect_authTokenLocal element, specifying any additional private claims required and the name of the header used to send the JWT to the endpoint.

header default value is Authorization

Finally, reference the JWT configuration from the zosconnect_endpointConnection element.

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



The WSC Requests your Feedback!

Please scan the QR Code or go to this link:
<https://ibm.biz/wsc-survey>

For Event Code, Enter: **ZOSCON** + the current date
(DDMMYY)



z/OS Connect Wildfire Github Site

<https://ibm.biz/BdPRGD>

The screenshot displays two GitHub repository pages side-by-side.

Left Repository: <https://github.com/ibm-wsc/zCONNEE-Wildfire-Workshop> (Public)

- Commits:** 8e503b9 3 days ago by emitchj
- Files:**
 - Add files via upload (AdminSecurity, OpenAPI2, cobol, xml, README.md, ZCADMIN - zOS Connect Administrat..., ZCEESEC - zOS Connect Security.pdf, ZCINTRO - Introduction to zOS Conn..., ZREQUEST - Introduction to zOS Co..., zOS Connect FF V3 Advanced Topics ..., zOS Connect EE V3 Getting Started.pdf)
 - Delete ZC2OMVS2.jcl
 - Delete Developing
 - Add files via upload
 - Add files via upload
 - Update README.md

Right Repository: <https://github.com/ibm-wsc/zCONNEE-Wildfire-Workshop> (Public)

- Commits:** 428fc6c 5 days ago by emitchj
- Files:**
 - ..
 - Developing CICS API Requester Applications.pdf
 - Developing IMS API Requester Applications.pdf
 - Developing MVS Batch API Requester Applications.pdf

Common Elements:

- Header:** Product ▾ Solutions ▾ Open Source ▾ Pricing
- Top Right:** Search, Sign in, Sign up
- Bottom Left:** README.md
- Bottom Right:** Environments 1 (github-pages Active), Languages

A red oval highlights the list of PDF files in both repositories, indicating they are the focus of the workshop.

- Contact your IBM representative to schedule access to these exercises



Thank you for listening and your questions.