ZCREQUST - IBM z/OS Connect
An introduction to API Requesters

API Requester Code and Security Considerations

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Notes and Disclaimers

- The information in this presentation was derived from various product documentation web sites.
- Additional information included in this presentation was distilled from years of experience implementing security using RACF with z/OS products like CICS, IMS, Db2, MQ, etc. as well as Java runtimes environments like WebSphere Application Server and WebSphere Application Server Liberty which is commonly called Liberty.
- There will be additional information on slides that will designated as Tech/Tips. These contain information that at perhaps at least interesting and hopefully, useful to the reader.
- The examples, tips, etc. present in this material are based on firsthand experiences and are not necessarily sanctioned by Liberty or z/OS Connect product areas.

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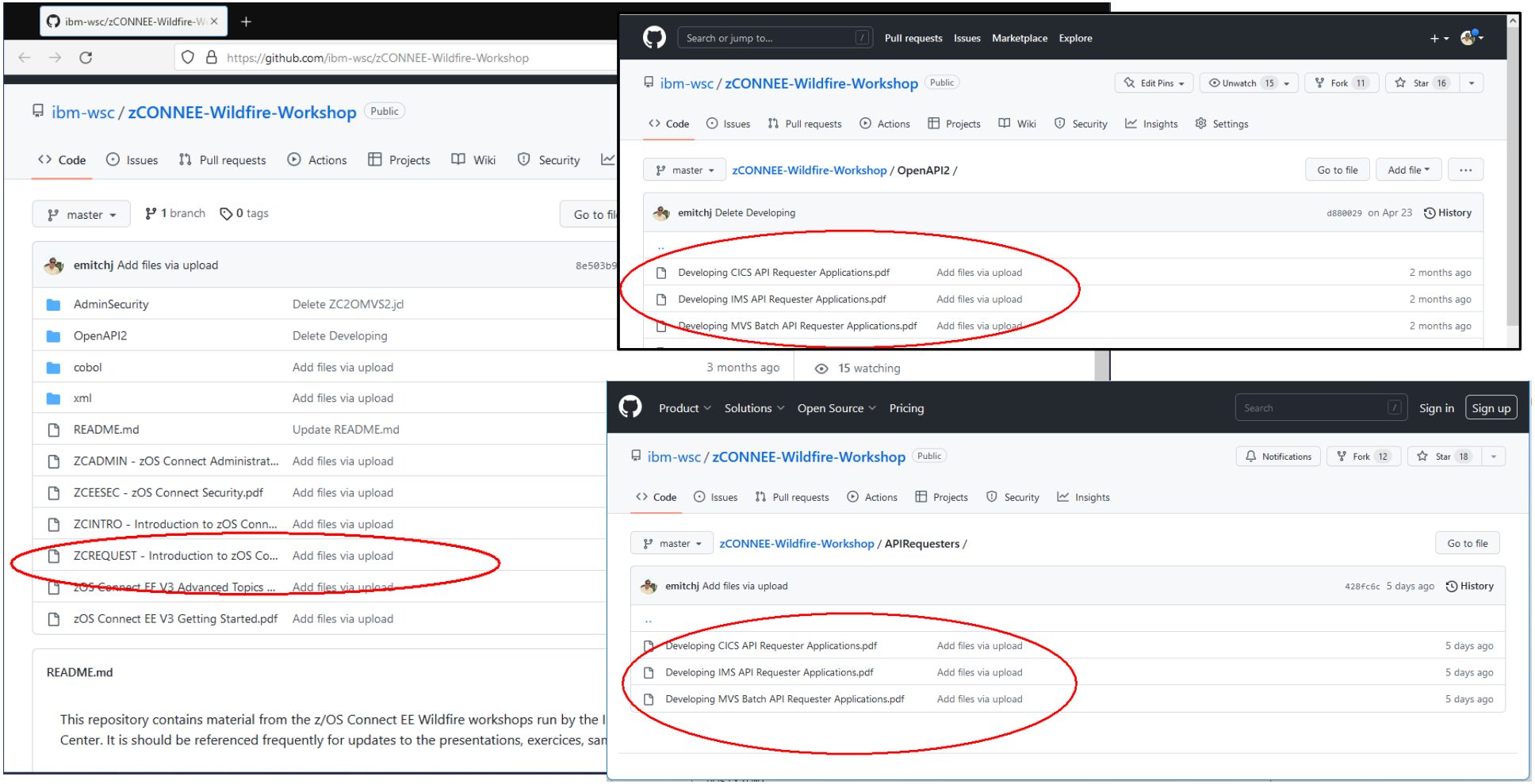
This session is part of a series of z/OS Connect workshops. . .

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

z/OS Connect Wildfire Github Site https://ibm.biz/BdPRGD



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

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

IBM z/OS Connect (an API Gateway)

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

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

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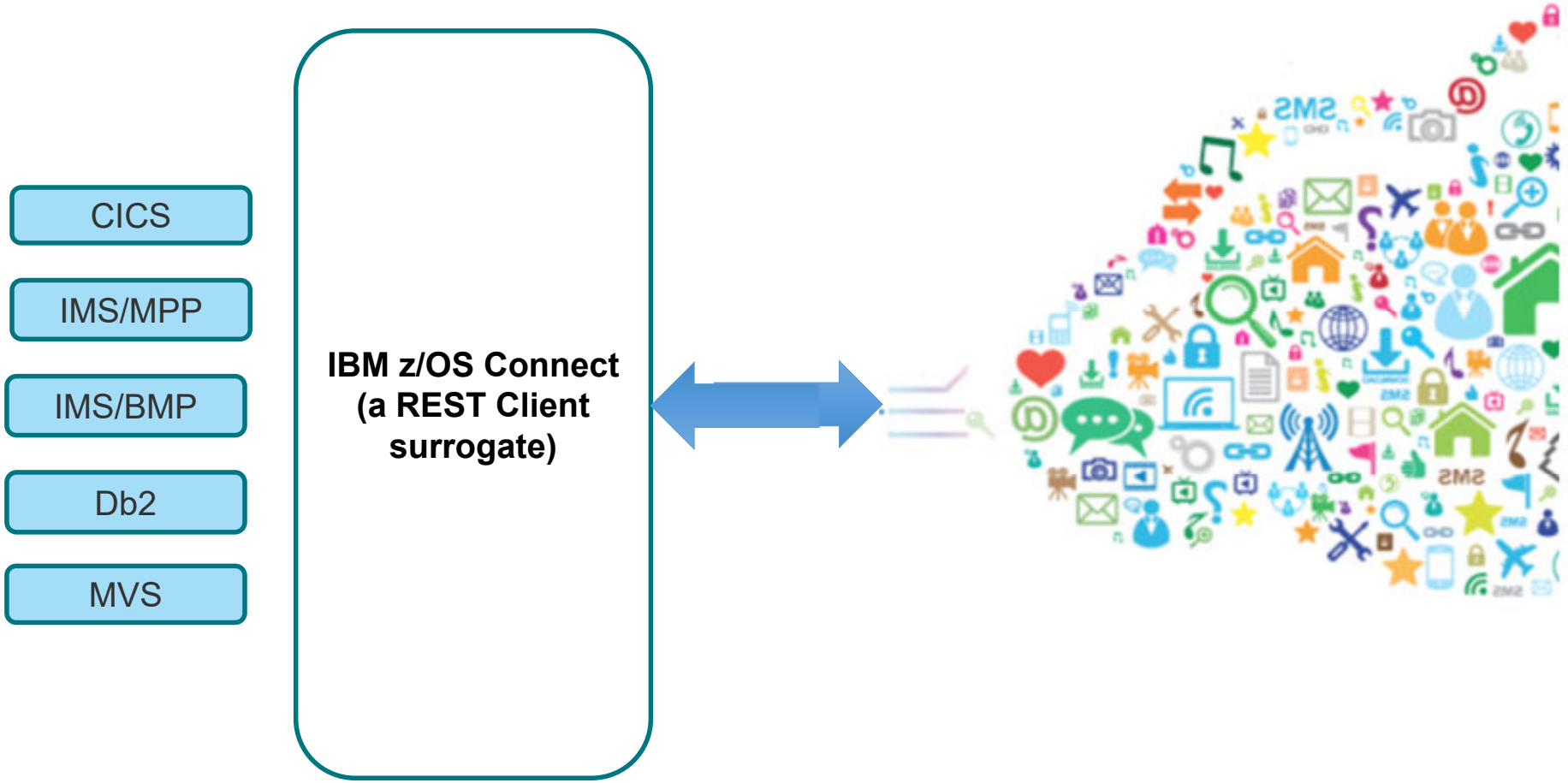
z/OS Connect EE exposes external REST APIs in the “cloud” to z/OS COBOL applications



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/but_first, what_is_REST?

What makes an API “RESTful”?

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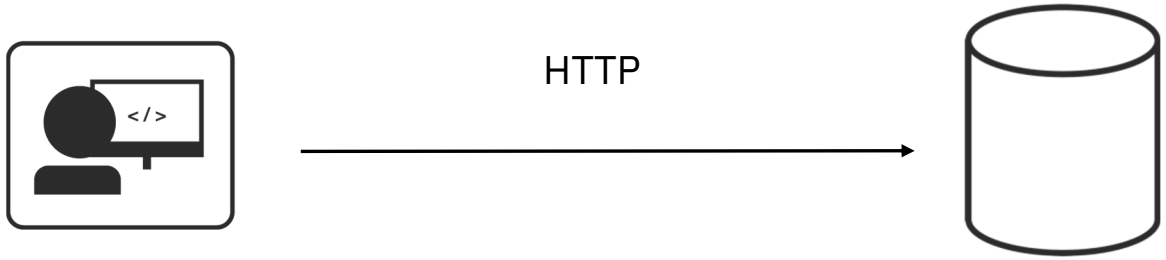
REST is architectural programming style

REST stands for **Re**presentational **S**tate **T**ransfer.

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

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

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



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

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Key Principles of REST

Use Path and Query parameters to refine the request

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

POST
GET
PUT
DELETE

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

URI path identifies a resource (or lists of resources)

URL identifies the protocol, host and port and includes the URI Path

Request/Response Body is used to represent the data object

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

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REST vs RESTful

REST is an architectural style of development having these principles plus..

- It should be stateless (transaction management should be managed by the client)
- It should access and/or identify all server resources using only a single URI
- For performing CRUD operations, it should use HTTP verbs such as get, post, put and delete
- It should return the result only in the form of consistent and simple JSON

When an API follows these basic principles, it is considered a RESTful API, whereas a REST API only follows some but not all the above principles

- Remember - Not all REST APIs are RESTful APIs
- The key is consistency, RESTful APIs are consistent with these basic principles, REST APIs are not

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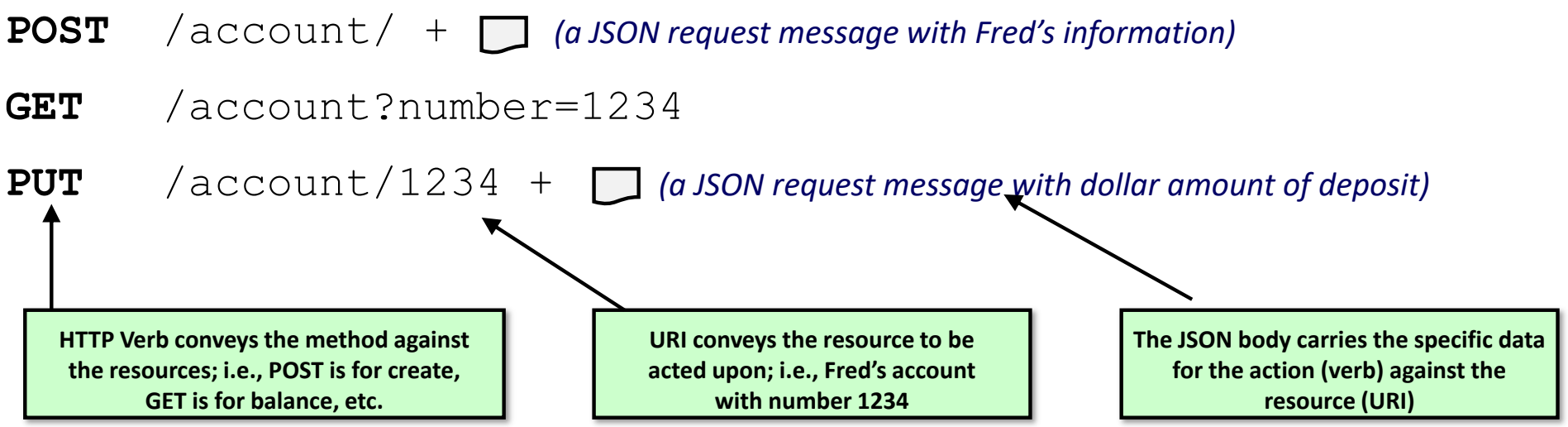
RESTful Examples



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

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

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Not every REST API is a RESTful API

- (How to know if an API is not RESTful)

1. Different URIs with the same method for operations on the same object

```
POST http://www.acme.com/customers/GetCustomerDetails/12345
POST http://www.acme.com/customers/UpdateCustomerAddress/12345?address=
```

2. Different representations of the same objects between request and response messages

```
POST http://www.acme.com/customers
BODY { "firstName": "Joe",
       "lastName" : "Bloggs",
       "addr"     : "10 Old Street",
       "phoneNo"  : "01234 0123456" }
```



```
RESPONSE HTTP 201 CREATED
BODY { "id"      : "12345",
       "name"    : "Joe Bloggs",
       "address": "10 New Street"
       "tel"     : "01234 0123456"}
```

3. Operational data (update, etc.) embedded in the request body

```
POST http://www.acme.com/customers/12345
BODY { "updateField": "address",
       "newValue"   : "10 New Street"}
```



```
RESPONSE HTTP 200 OK
BODY { "id"      : "12345",
       "name"    : "Joe Bloggs",
       "address": "10 New Street"
       "tel"     : "01234 123456" }
```

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Strive to design API to use RESTful properties

1. Use the same URIs for the same resource with the appropriate method for operations

```
GET  http://www.acme.com/customers/12345
PUT  http://www.acme.com/customers/12345?address=10%20New%20Street
```

2. Use the same JSON property names between request and response messages

```
POST http://www.acme.com/customers/12345
BODY { "name": "Joe Bloggs",
       "address": "10 Old Street",
       "phoneNo": "01234 0123456" }
```



```
RESPONSE HTTP 201
BODY { "id"      : "12345",
       "name"    : "Joe Bloggs",
       "address": "10 New Street"
       "phoneNo": "01234 0123456"}
```

3. Use JSON name/value pairs

```
PUT http://www.acme.com/customers/12345
BODY { "address"    : "10 New Street"}
```



```
RESPONSE HTTP 200 OK
```

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Why is REST popular?

Ubiquitous Foundation	It's based on HTTP, which operates on TCP/IP, which is a ubiquitous networking topology.
Relatively Lightweight	Compared to other technologies (for example, SOAP/WSDL), the REST/JSON pattern is relatively light protocol and data model, which maps well to resource-limited devices.
Relatively Easy Development	Since the REST interface is so simple, developing the client involves very few things: an understanding of the URI requirements (path, parameters) and any JSON data schema.
Increasingly Common	REST/JSON is becoming more and more a de facto "standard" for exposing APIs and Microservices. As more adopt the integration pattern, the more others become interested.
Stateless	REST is by definition a stateless protocol, which implies greater simplicity in topology design. There's no need to maintain, replicate or route based on state.

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How do we describe a REST API?

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/oai/open_api_initiative

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.

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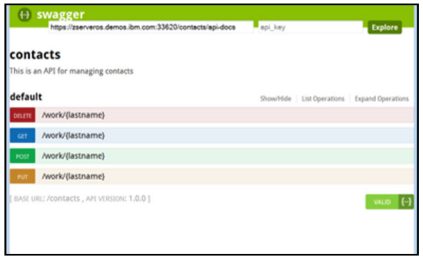
Why use OpenAPI?

- It is more than just an API framework

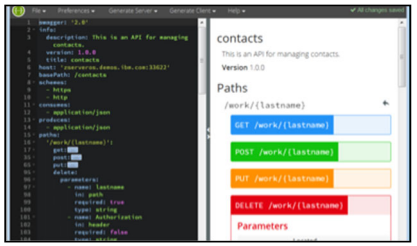
There are a number of tools available to aid consumption:

Code Generation* - create stub code to consume APIs from various languages

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



Editors - allows API developers to design their OpenAPI documents.



* z/OS Connect API Requester +z/OS Connect, MQ REST support, Zowe

Important - You may have used or heard of the term Swagger with the use of APIs. As the use of APIs has grown this term has become in some respects misleading. To be more precise, OpenAPI refers to the API specifications (OpenAPI 2 and OpenAPI3) where Swagger refers to the tooling used to implement the specifcations.

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An OpenAPI 2 versus an OpenAPI 3 specification document

JSON format

cscvinc.json - Notepad

File Edit Format View Help

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

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

cscvinc.yaml - Notepad

File Edit Format View Help

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

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YAML Format*

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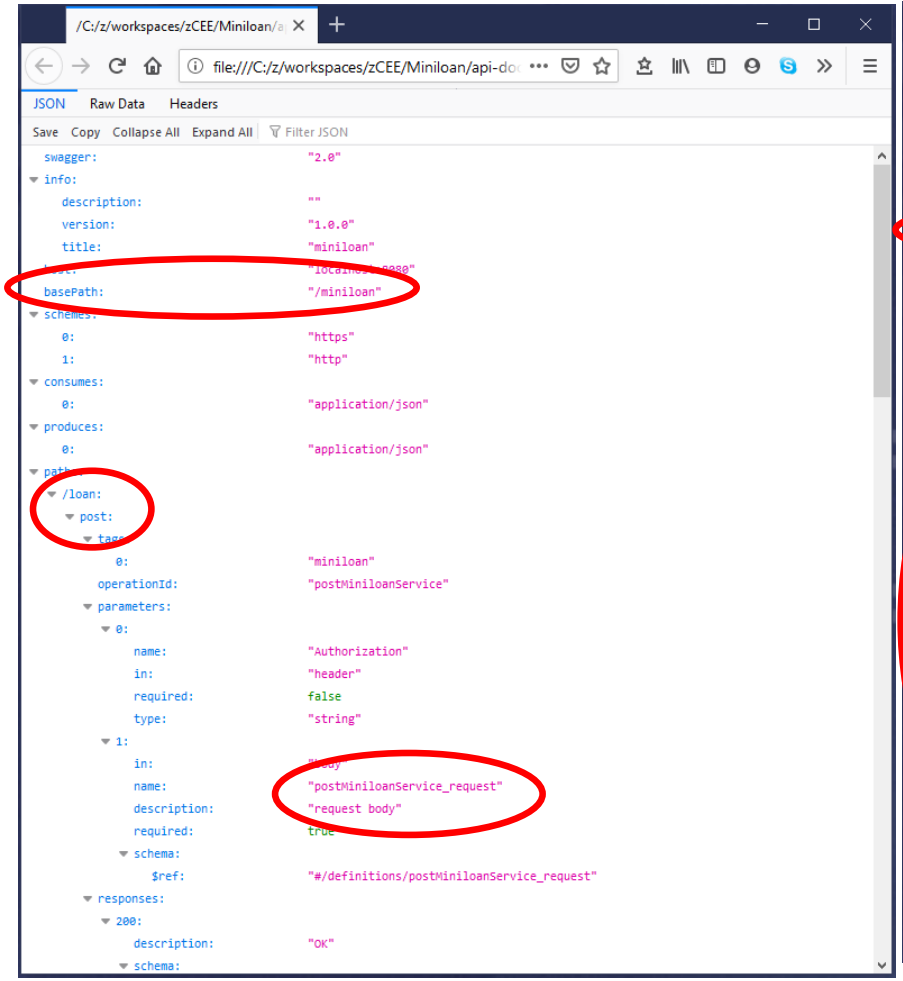
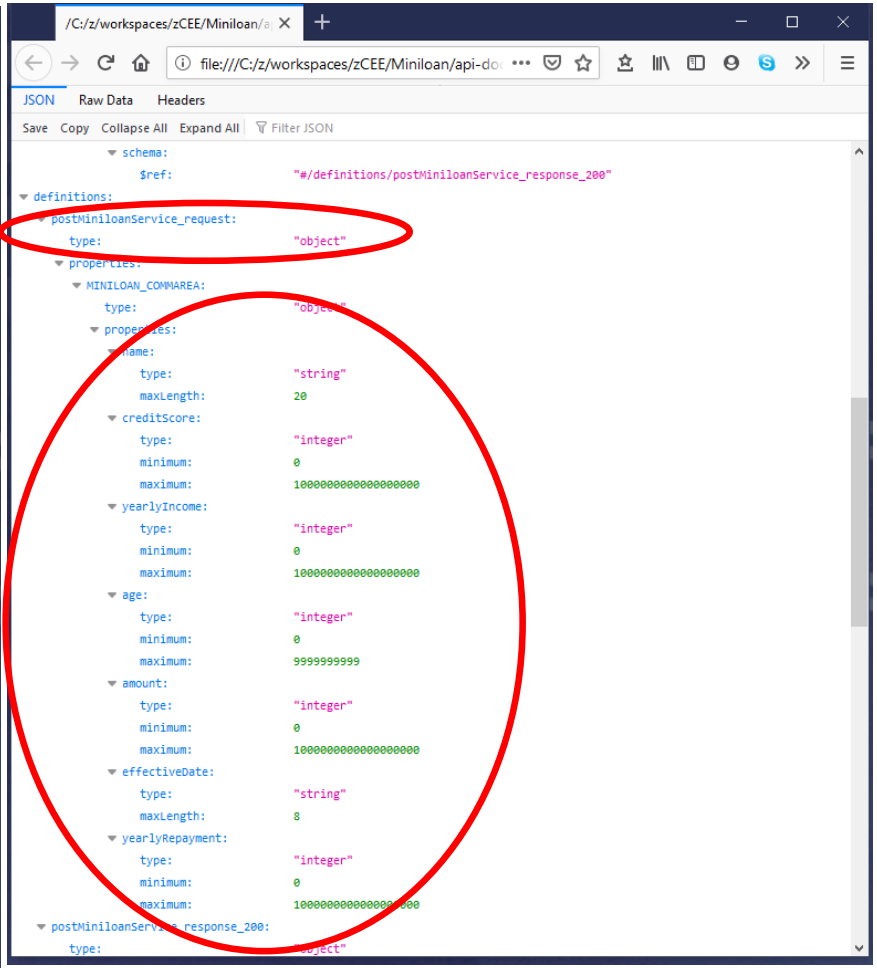
https://swagger.io/blog/api-strategy/difference-between-swagger-and-openapi/

*Yet Another Markup Language

Tech-Tip: Swagger (OpenAPI 2) Specification Example





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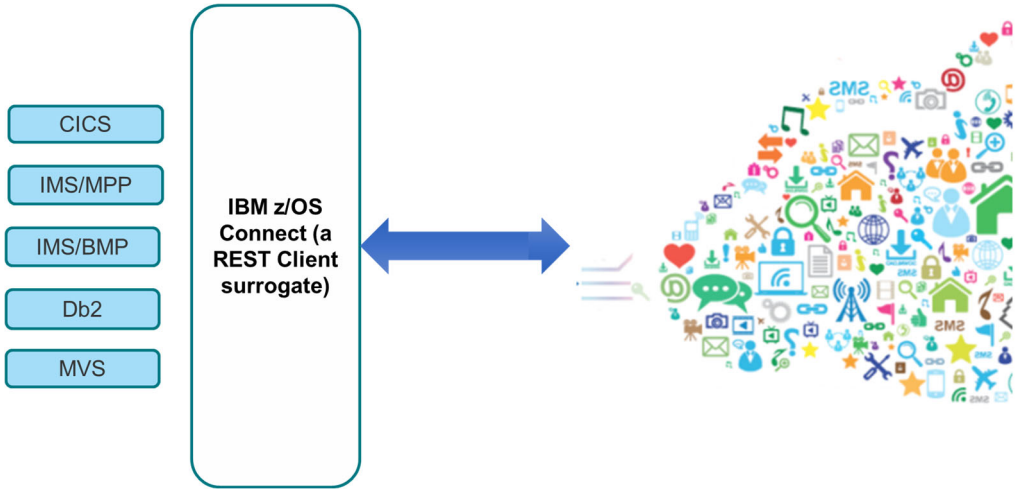
/api_toolkit/apiRequesters

Quick and easy **API mapping.**



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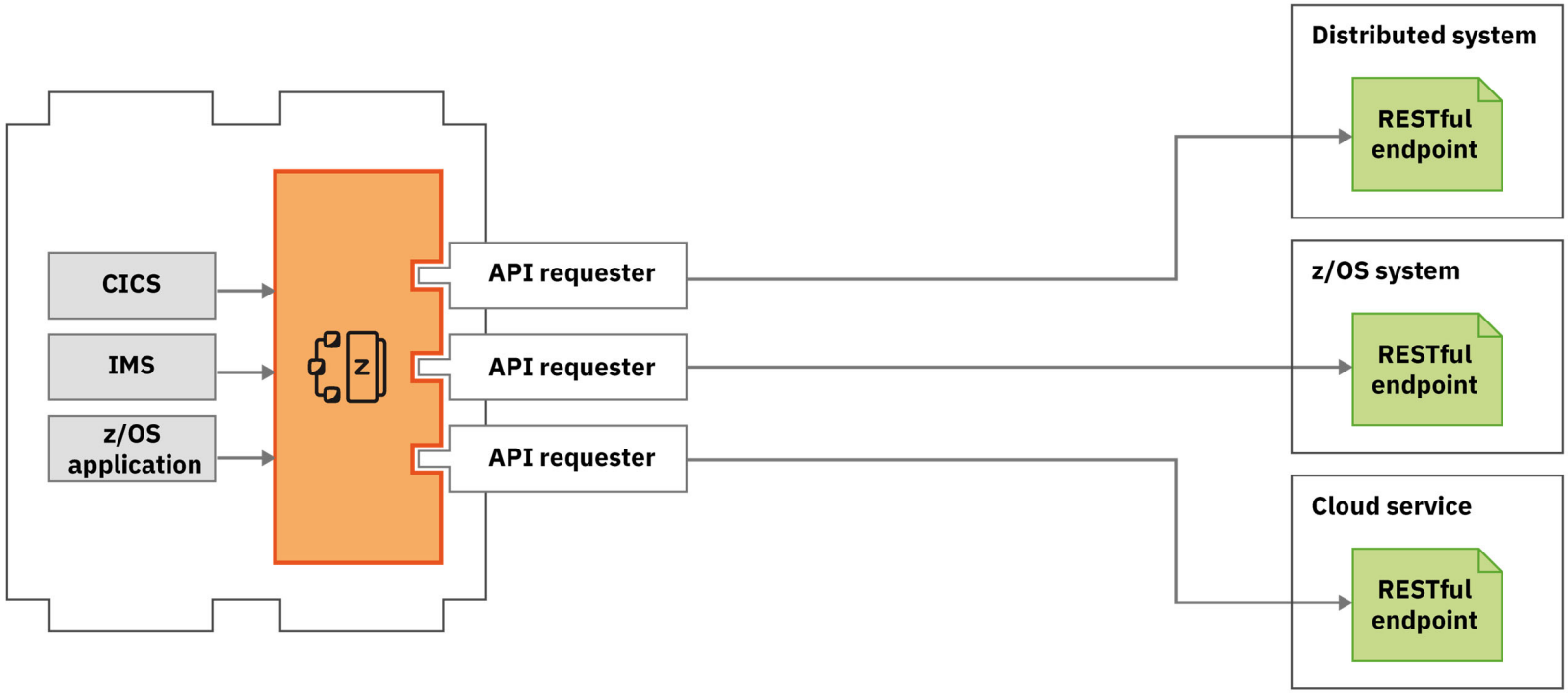
Use API requester to call external APIs from z/OS assets



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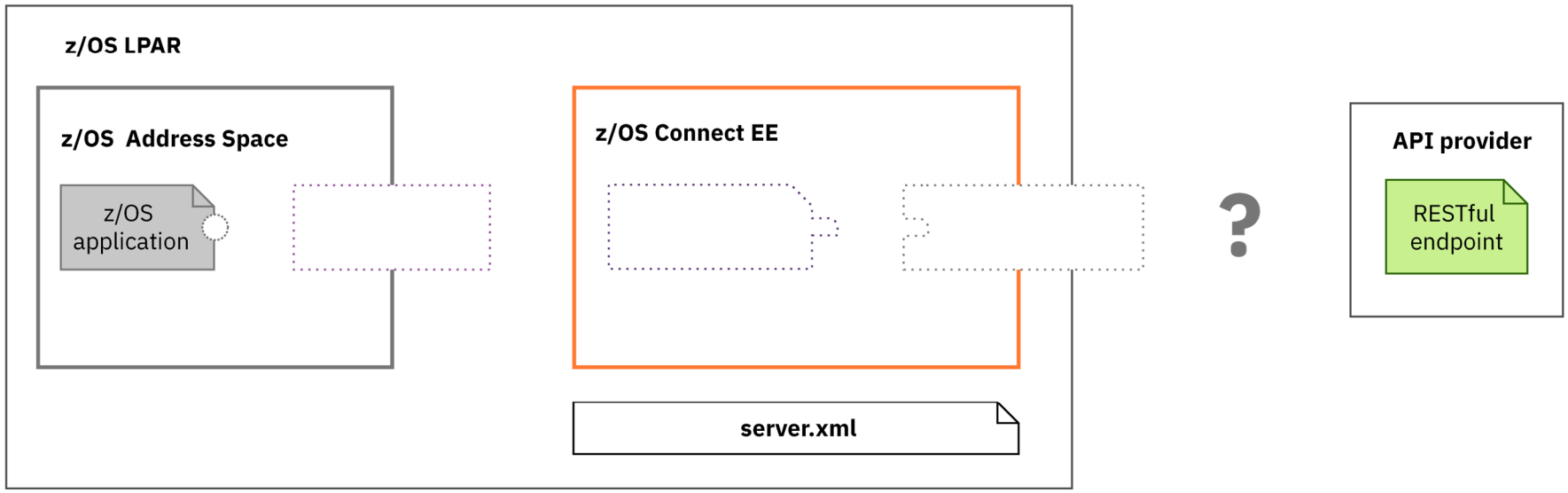
Steps to calling an external API

Starting point



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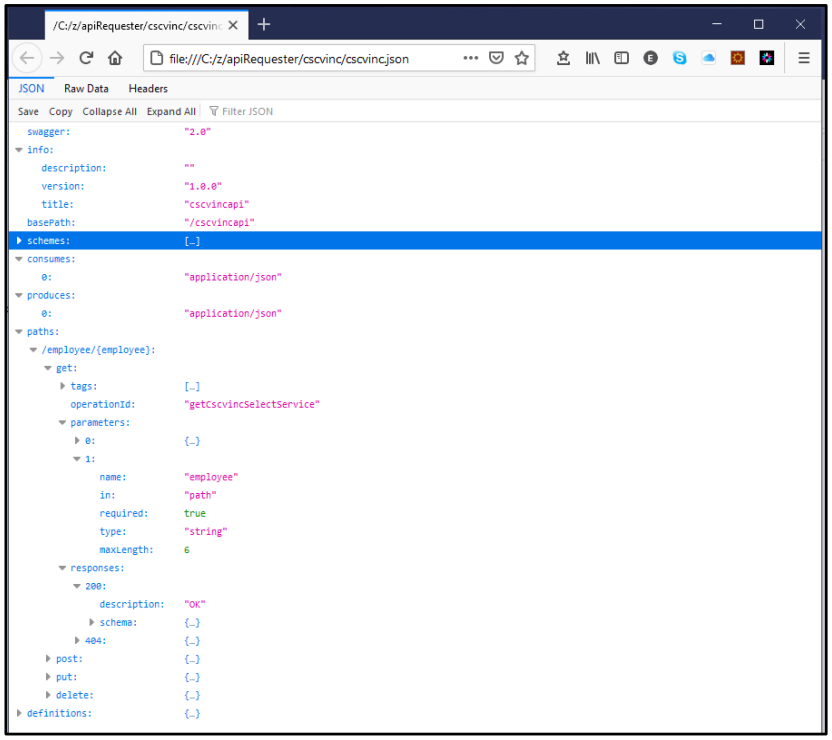
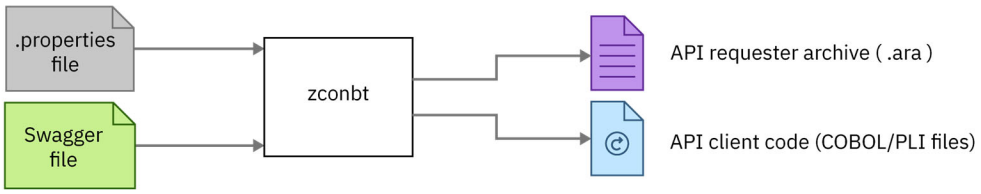
Calling an external API requires the API's specification document

Start with the API's specification and generate the API requester archive file and API client code





properties file[#]

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

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

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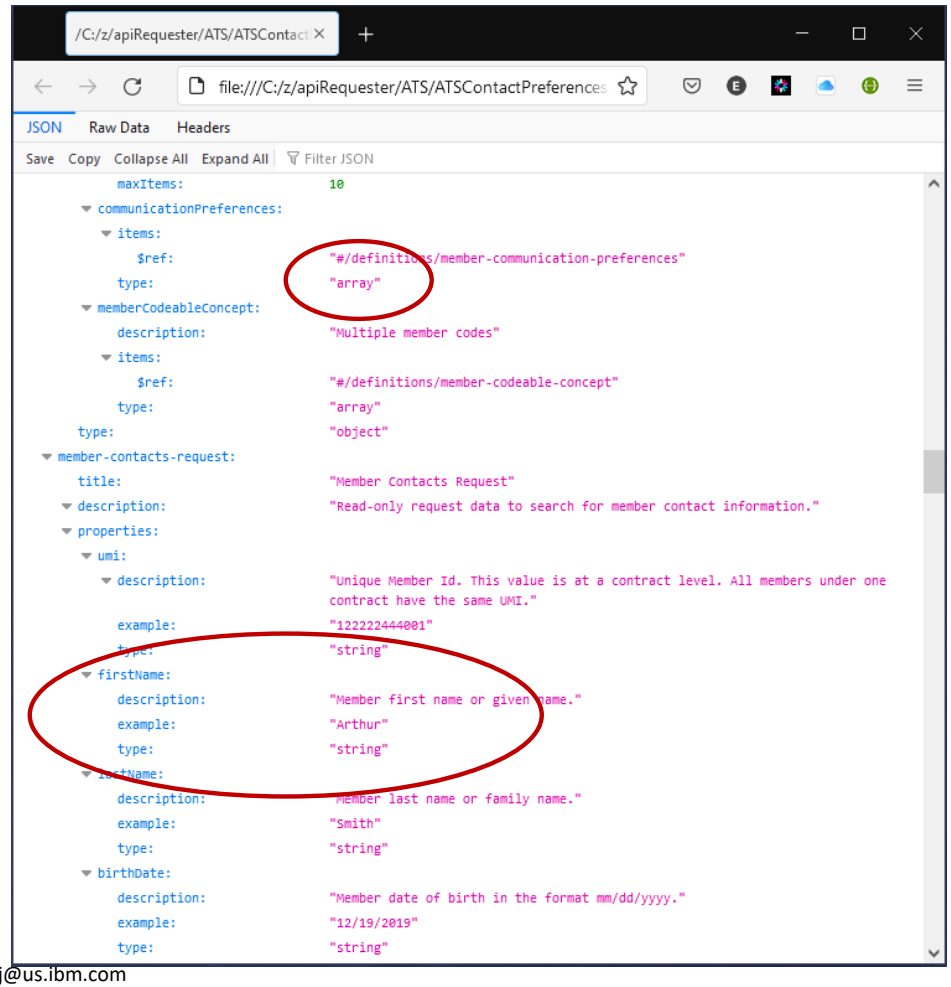
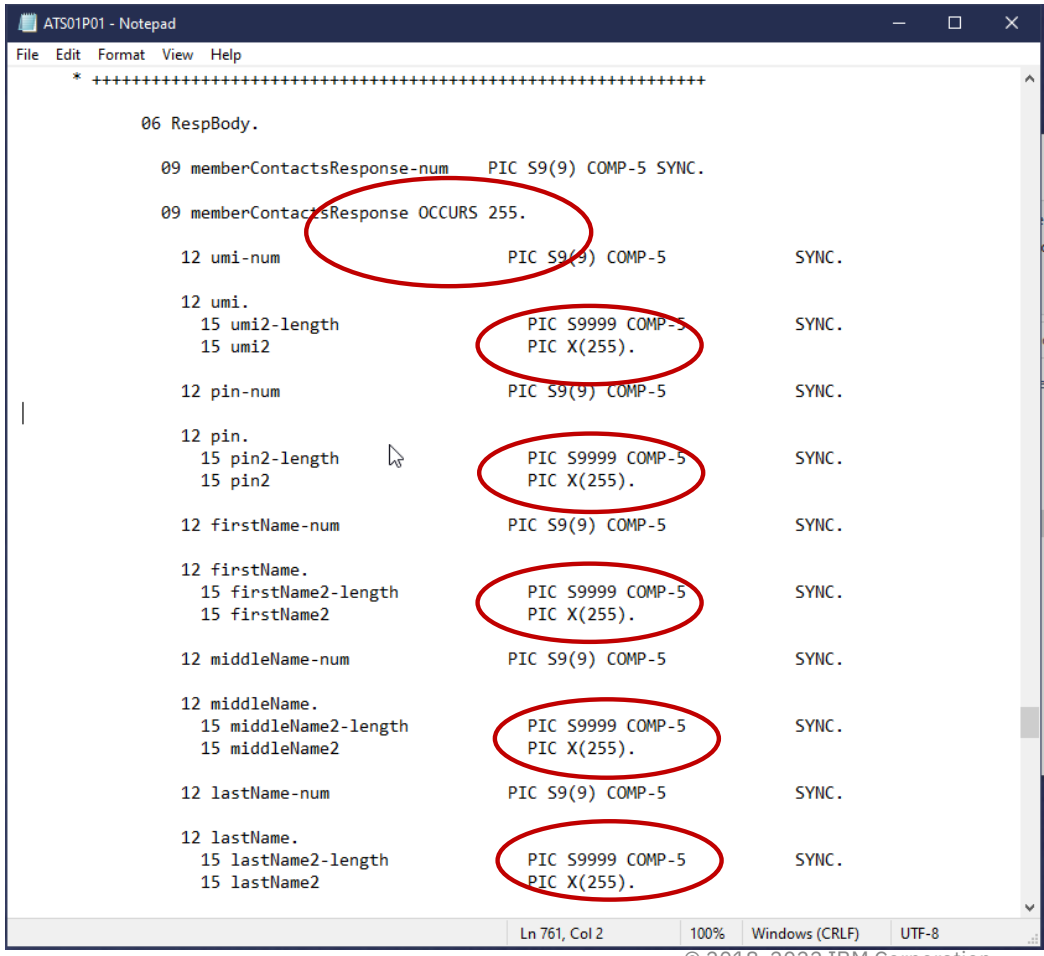
COBOL working storage implications

Specification properties are usually not constrained, this can lead to excessive working storage consumption





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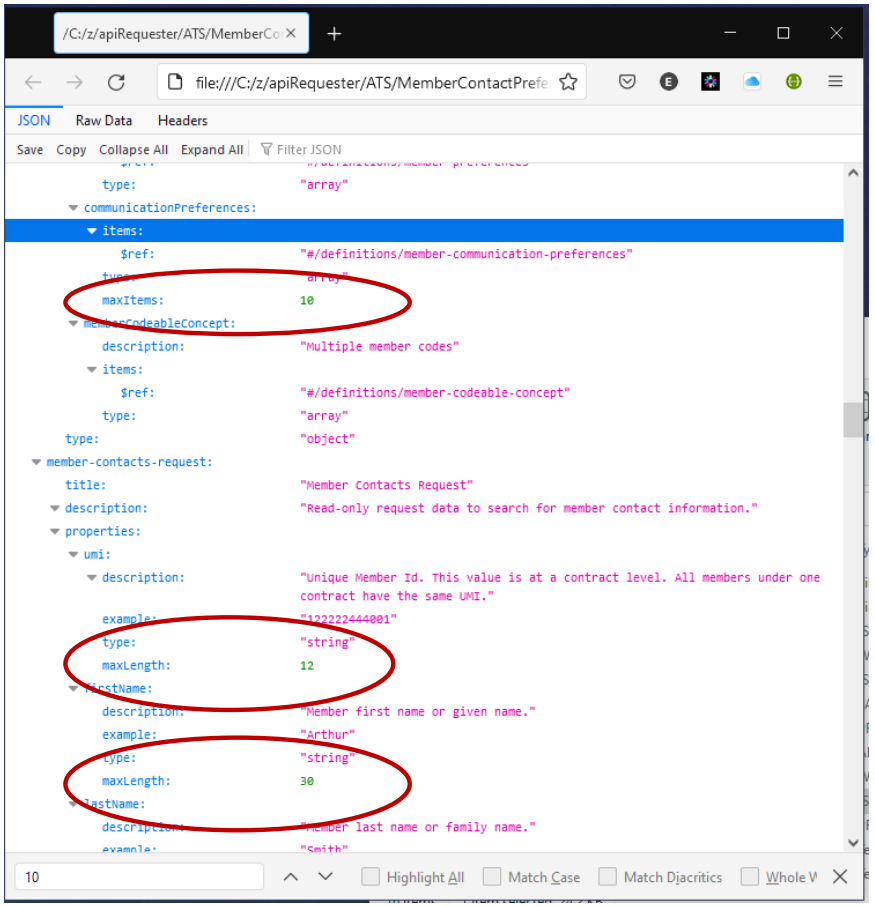
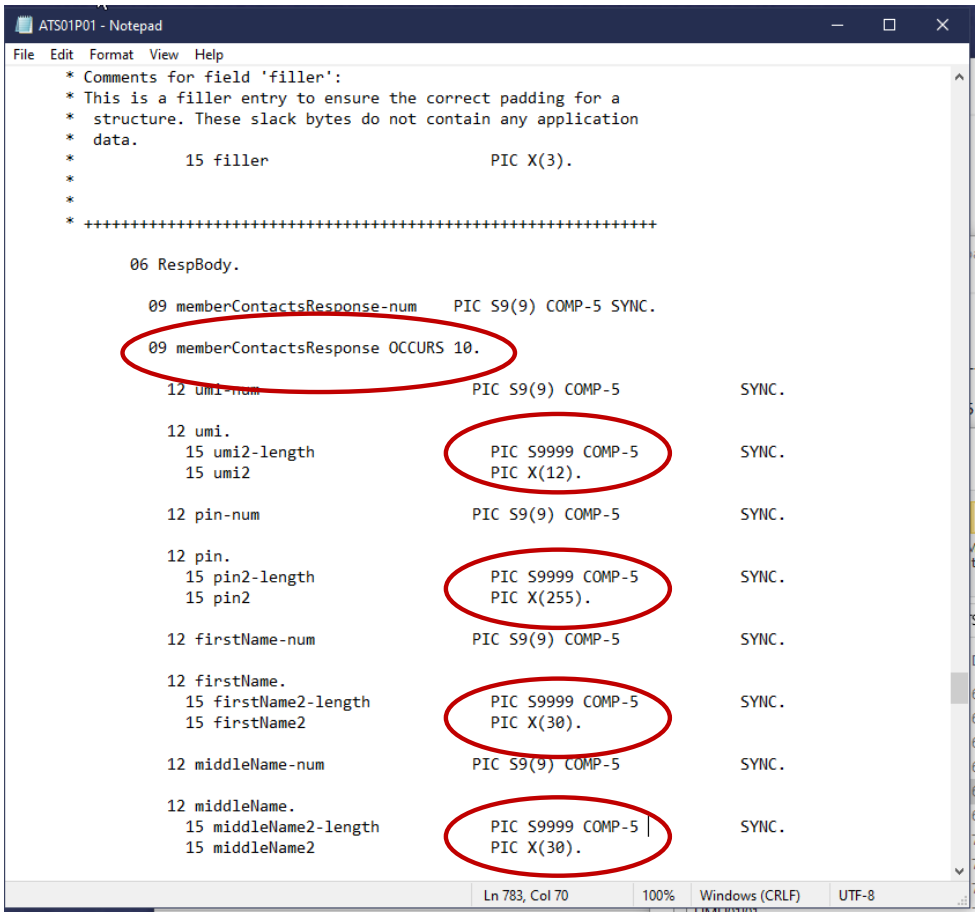
Consider adding constraints to the properties

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





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There are API Requester generation properties are 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 Swagger. The value of this parameter can be a positive integer in the range 1 - 32767. By default, **defaultArrayMaxItems** is set to **255.**

defaultCharacterMaxLength - Specify the default array length of character data in characters for mappings where no length is implied in the JSON schema document. When **characterVarying** is set to YES, the value of this parameter can be a positive integer in the range of 1 to 32767. When **characterVarying** is set to NO or NULL the value of this parameter can be a positive integer in the range of 1 to 16777214 By default, **defaultCharacterMaxLength** is set to **255**.

characterVarying - Specifies how variable-length character data is mapped to the language structure.

- NO - Variable-length character data is mapped as fixed-length strings.
- NULL - Variable-length character data is mapped to null-terminated strings (defaultCharacterMaxLength + 1)
- YES - Variable-length character data is mapped to a CHAR VARYING data type in PL/I. In COBOL variable-length character data is mapped to an equivalent representation that consists of two related elements: the **data-length** and the **data**. By default, **characterVarying** is set to **YES**.

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

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

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

12 firstName                    PIC X(31).
```

```
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.
```

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

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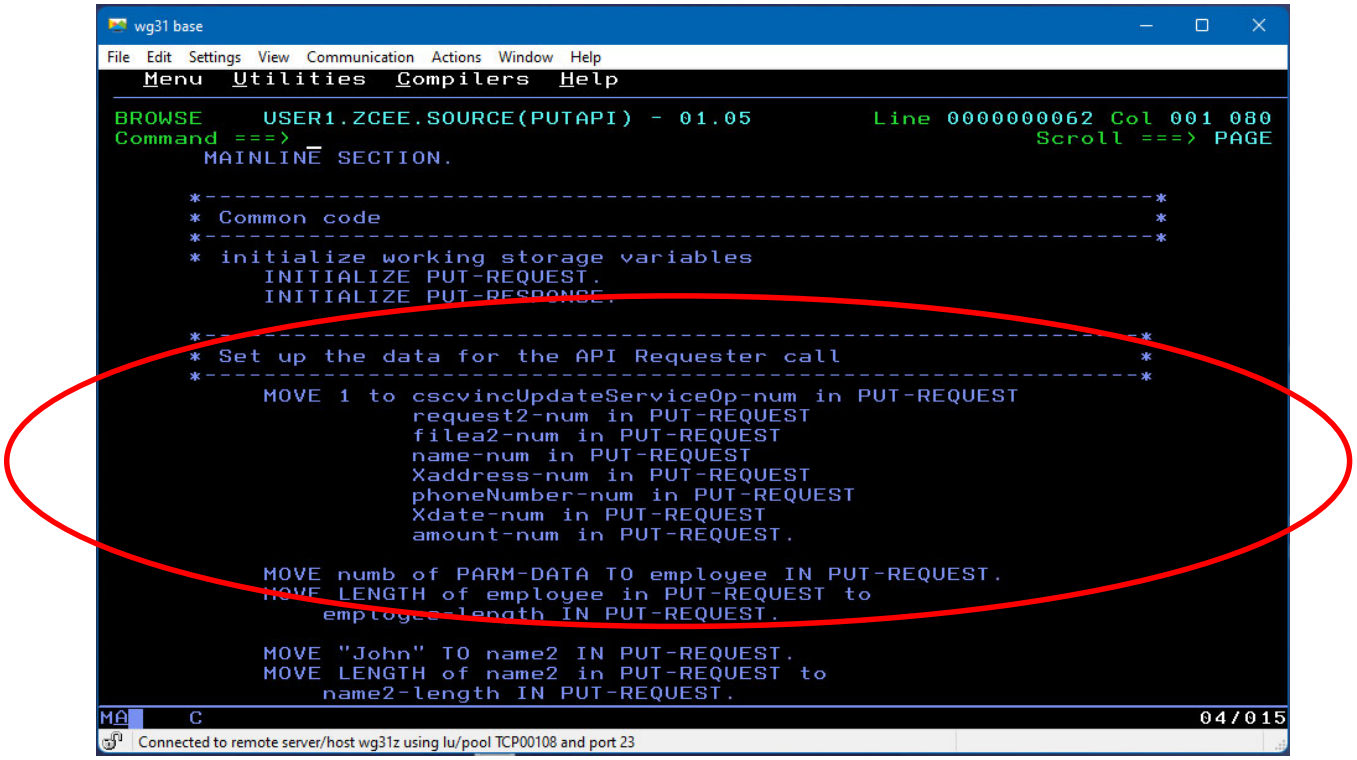
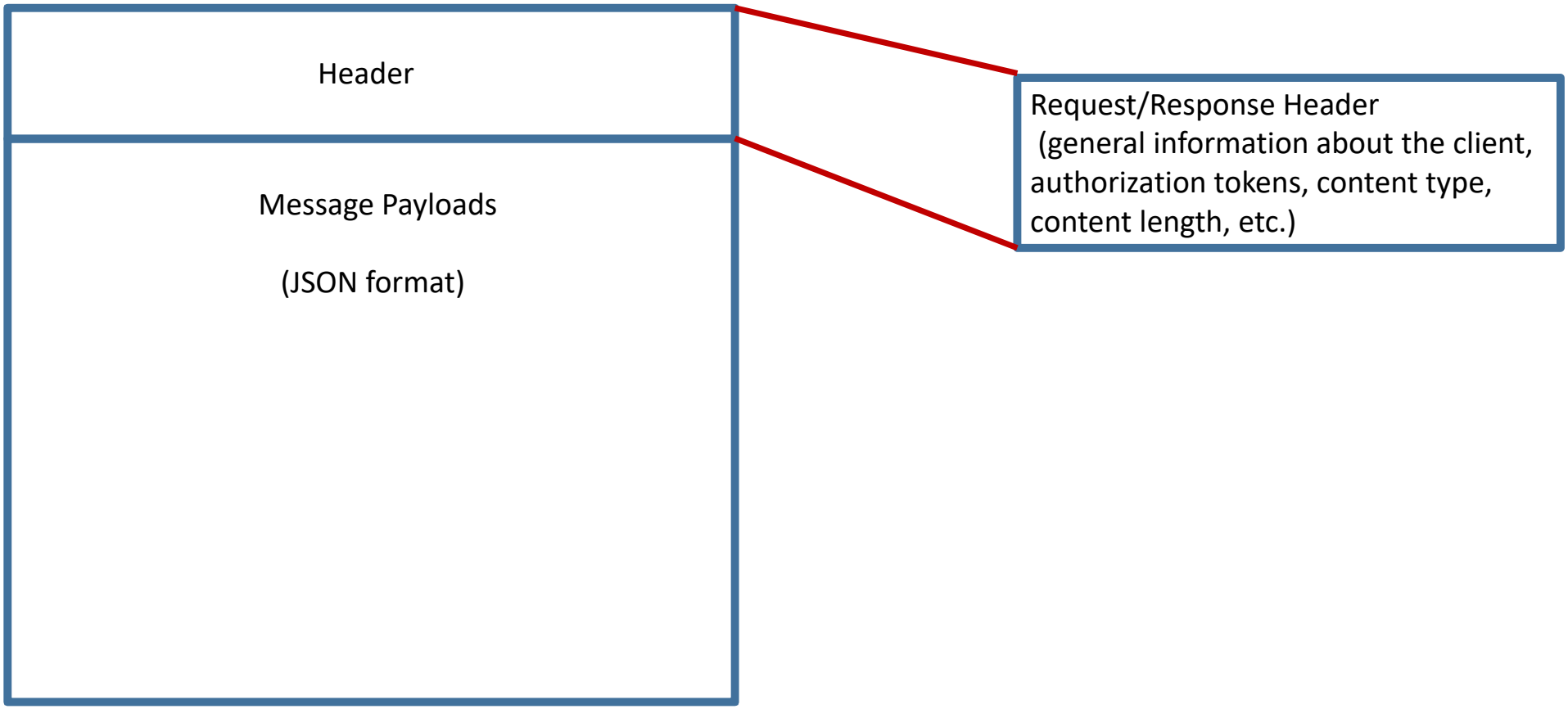
The number of specific entries can be ambiguous

The COBOL copy book will include a counter variable (*variable*-num) for each variable whose number of occurrences is ambiguously defined in the specification document. The number of occurrences of these variables must be provided.



Request and Response Message Layout



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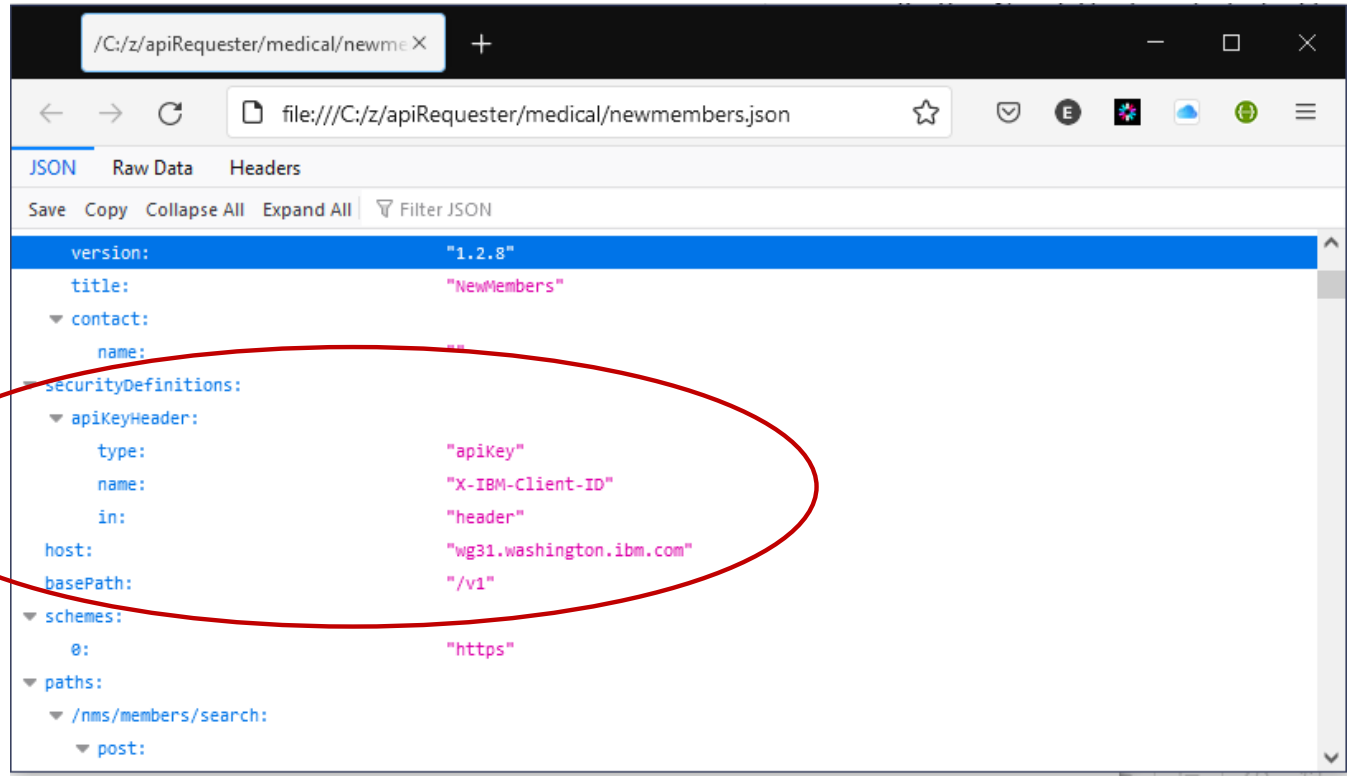
An API key(aka password) may be required for accessing an API

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



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

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

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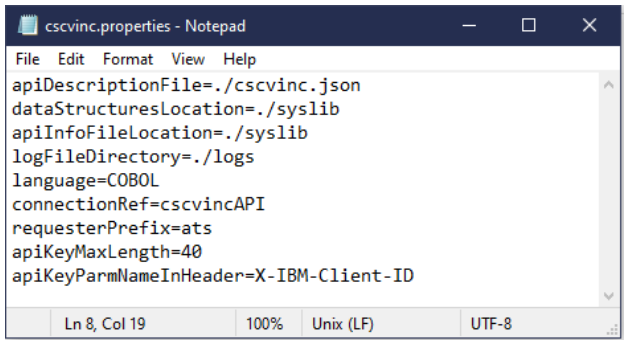
Or by including generation properties related to API keys

Use these generation properties to add API key information to the request message when not defined in specification document

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.



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An application provides th API key to the request header

Either way, the generated copy book includes a ReqHeaders structure which can be used to provide values for header properties

request.cpy - Notepad

```
File  Edit  Format  View  Help
      *          12 dob2-length                  PIC S9999 COMP-5
      *  SYNC.
      *          12 dob2                         PIC X(255).
      *
      *
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

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

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

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

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

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

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

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

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

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

mpz3

```
File  Edit  Settings  View  Communication  Actions  Window  Help
  File  Edit  Edit_Settings  Menu  Utilities  Compilers  Test  Help

EDIT       USER1.ZCEE.SOURCE(GETAPIEN) - 01.01            Columns 00001 00072
Command ===>                                                Scroll ===> PAGE
000081        *-------------------------------------------------------------*
000082        * Common code                                                 *
000083        *-------------------------------------------------------------*
000084        * initialize working storage variables
000085             INITIALIZE GET-REQUEST.
000086             INITIALIZE GET-RESPONSE.
000087             MOVE "abcdef12345" to X-IBM-Client-ID
000088             MOVE 11 to X-IBM-Client-ID-length
000089
000090        *-------------------------------------------------------------*
000091        * Set up the data for the API Requester call                  *
000092        *-------------------------------------------------------------*
000093             MOVE employee of PARM-DATA TO employee IN GET-REQUEST.
000094             MOVE LENGTH of employee in GET-REQUEST to
000095                 employee-length IN GET-REQUEST.
000096
000097        *-------------------------------------------------------------*
000098        * Initialize API Requester PTRs & LENs                        *
000099        *-------------------------------------------------------------*
000100        * Use pointer and length to specify the location of
000101        *  request and response segment.
000102        * This procedure is general and necessary.
000103             SET BAQ-REQUEST-PTR TO ADDRESS OF GET-REQUEST.
000104             MOVE LENGTH OF GET-REQUEST TO BAQ-REQUEST-LEN.
000105             SET BAQ-RESPONSE-PTR TO ADDRESS OF GET-RESPONSE.
000106             MOVE LENGTH OF GET-RESPONSE TO BAQ-RESPONSE-LEN.
000107
000108        *-------------------------------------------------------------*
MA    A                                                          13/002
Connected to remote server/host mpz3 using lu/pool MPZ30019 and port 23
```

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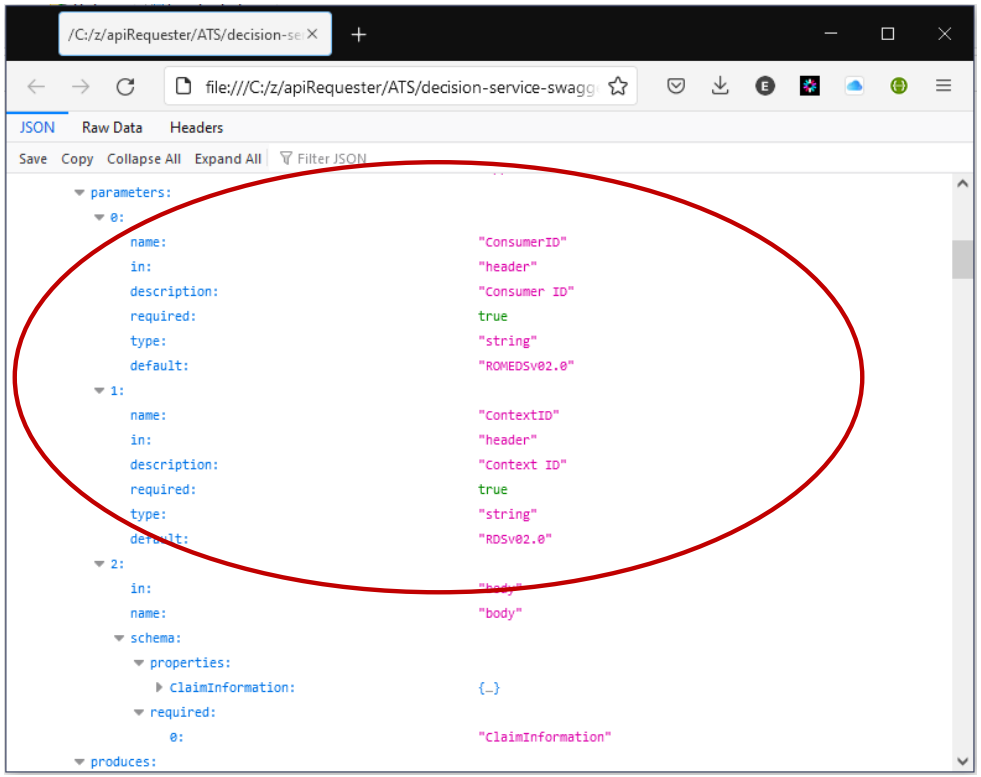
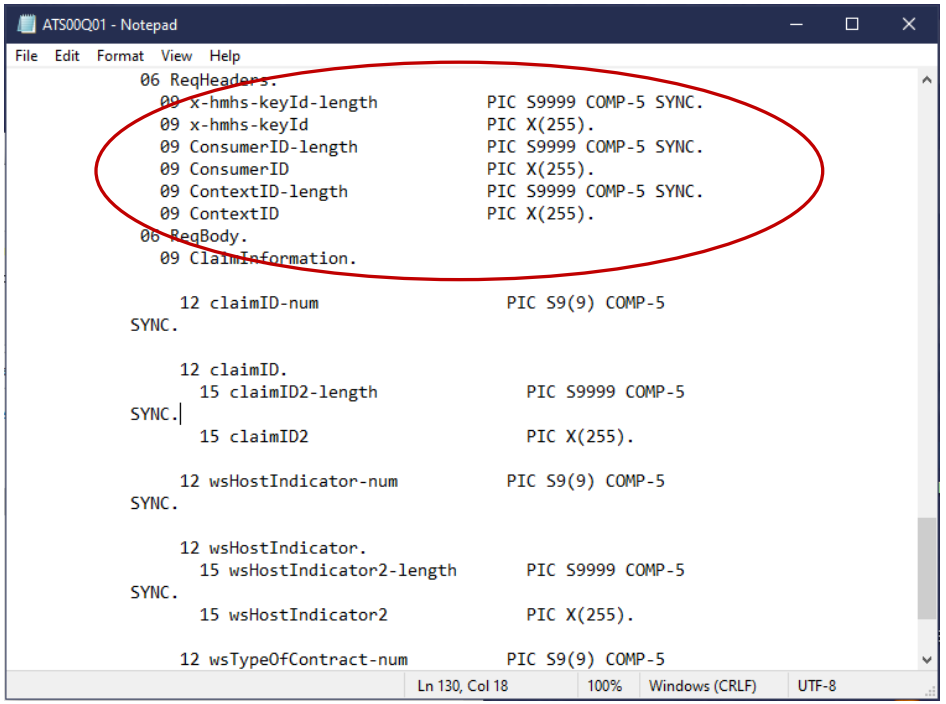
Other header properties can be required when accessing an API

The application can also set the values for other header properties that may be required by the API





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Steps to calling an external API

Use the z/OS Connect build toolkit, e.g., *zconbt*, to generate an API requester archive file and at most 3 copy books per method found in the Swagger

```
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.
```

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

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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: Copy books naming convention

- Up to three copy books are generated for each method of each API found in the Swagger 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 the messages stills need to have addressable storage in the application's working area.

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

- The naming convention for the generated COBOL copy books is based on the *requesterPrefix* value specified in the properties file. 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 Swagger document

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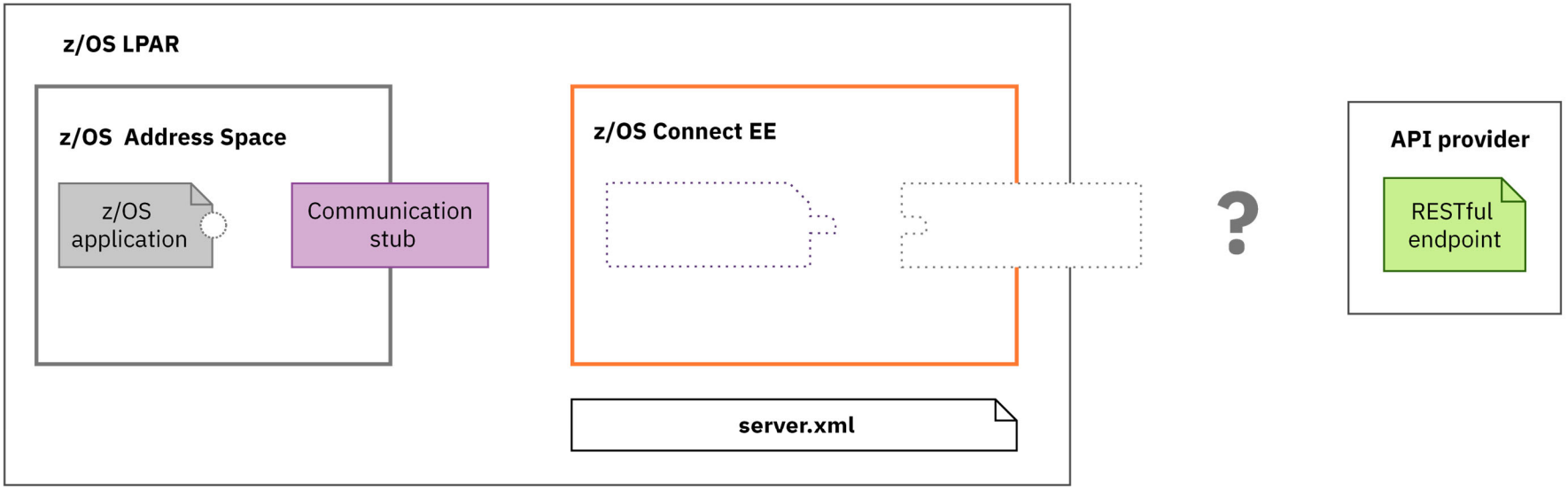
Steps for involving an external API from a COBOL progam

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



Configure a communication stub.

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

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

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ibm.biz/zosconnect-configure-comms-stub

Steps to calling an external API

Include the generated copy books in a COBOL program

GETAPI

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

      * Copy API Requester required copybook
       COPY BAQRINFO.

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

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

API-REQUEST

CSC00I01 | CSC00Q01

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

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

API-RESPONSE

CSC00I01 | CSC00Q01 | CSC00P01

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

           06 RespBody.

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

             09 cscvincSelectServiceOperatio.
               12 Container1.

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

API-INFO-OPER1

CSC00I01

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

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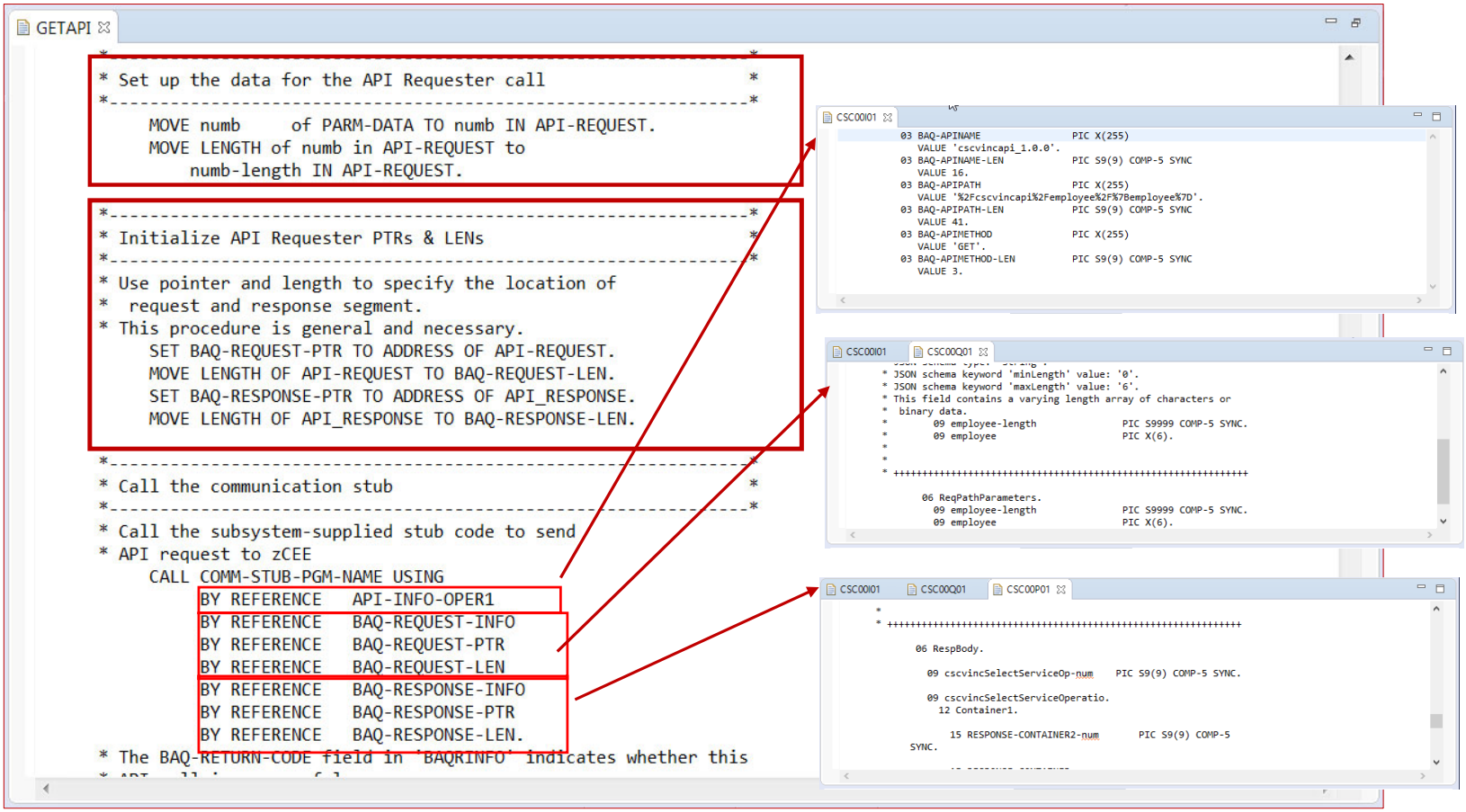
Steps to calling an external API

Add a call to the communication stub passing pointers to working storage of the copy books



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Steps to calling an external API

Access the results

GETAPI

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

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

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

mpz3

```
File  Edit  Settings  View  Communication  Actions  Window  Help
  Menu  Utilities  Compilers  Help
BROWSE    ZCEE30.SBAQCOB(BAQRINFO)                Line 0000000066 Col 001 080
Command ===>                                        Scroll ===> PAGE

      01  BAQ-RESPONSE-INFO.
        03 BAQ-RESPONSE-INFO-COMP-LEVEL PIC S9(9) COMP-5 SYNC VALUE 0.
        03 BAQ-STUB-NAME                PIC X(8).
        03 BAQ-RETURN-CODE              PIC S9(9) COMP-5 SYNC.
           88 BAQ-SUCCESS                 VALUE 0.
           88 BAQ-ERROR-IN-API            VALUE 1.
           88 BAQ-ERROR-IN-ZCEE           VALUE 2.
           88 BAQ-ERROR-IN-STUB           VALUE 3.
           88 BAQ-ERROR-NO-RESPONSE       VALUE 4.
        03 BAQ-STATUS-CODE              PIC S9(9) COMP-5 SYNC.
        03 BAQ-STATUS-MESSAGE           PIC X(1024).
        03 BAQ-STATUS-MESSAGE-LEN       PIC S9(9) COMP-5 SYNC.
******************************** Bottom of Data ********************************
MA    B                                                          18/058
Connected to remote server/host mpz3 using lu/pool MPZ30021 and port 23
```

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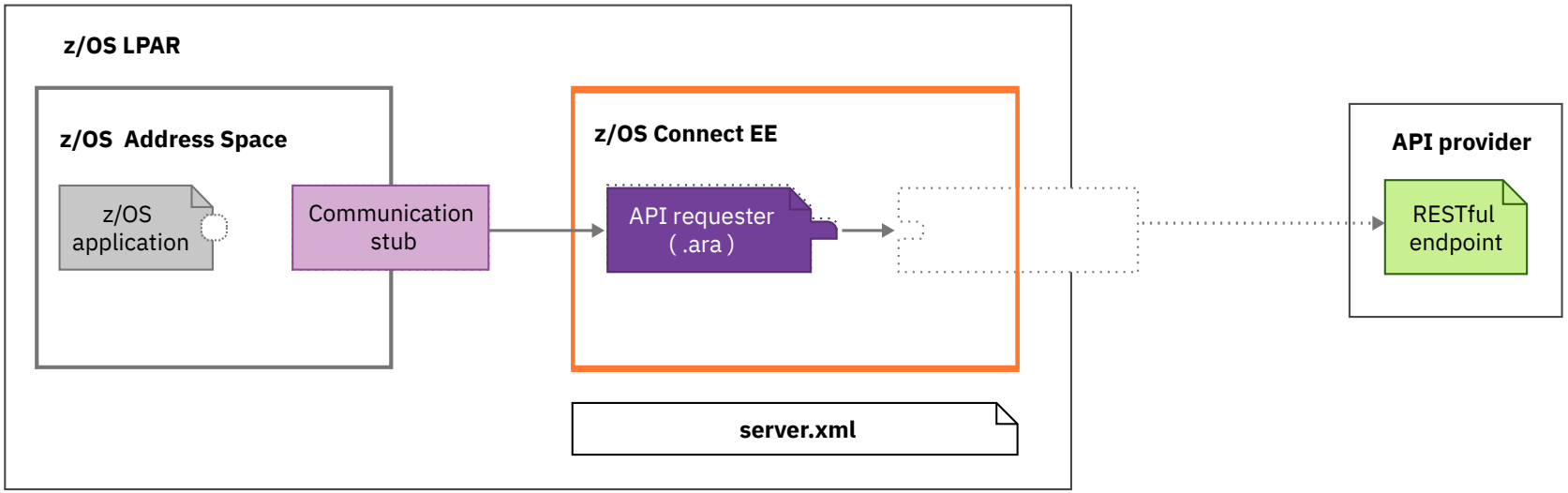
Steps to calling an external API

Deploy the API requester (.ara) archive



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

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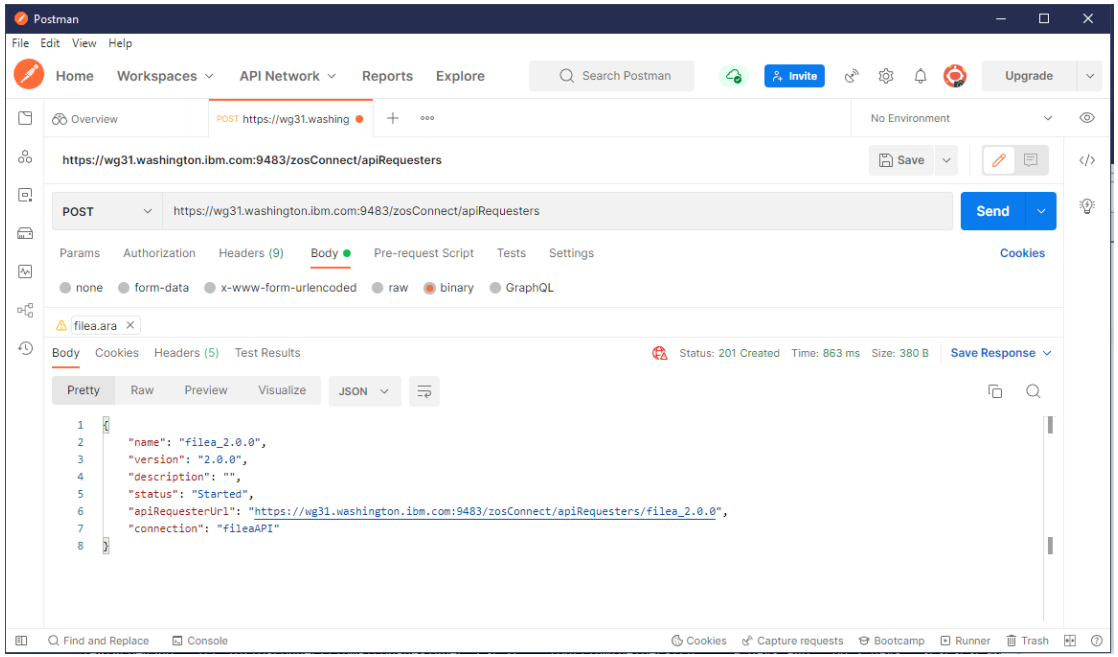
Tech-Tip-Deploying API requester archive files

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



Command:

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

Results:


```
{"name":"filea_2.0.0","version":"2.0.0","description":"",
"status":"Started","apiRequesterUrl":"https:\/\/wg31.wash
ington.ibm.com:9483\/zosConnect\/apiRequesters\/filea_2.0
.0","connection":"fileaAPI"}
```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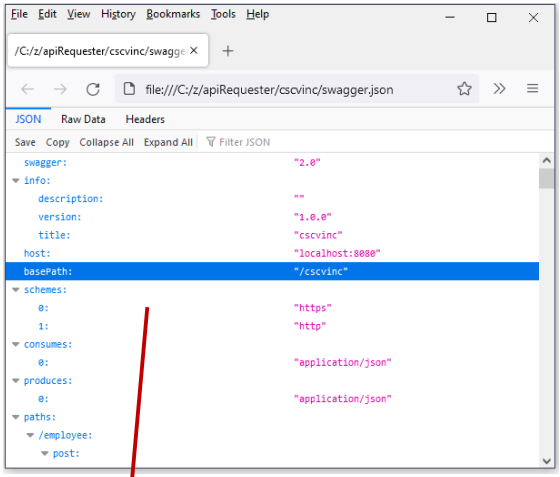
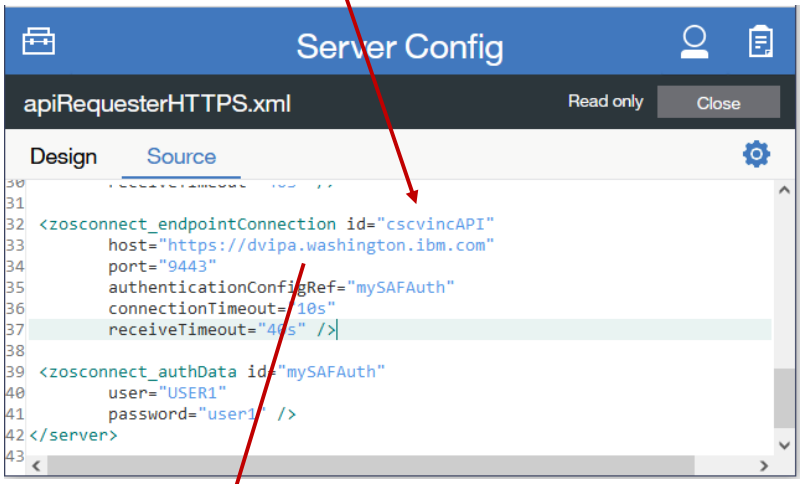
Steps to calling an external API

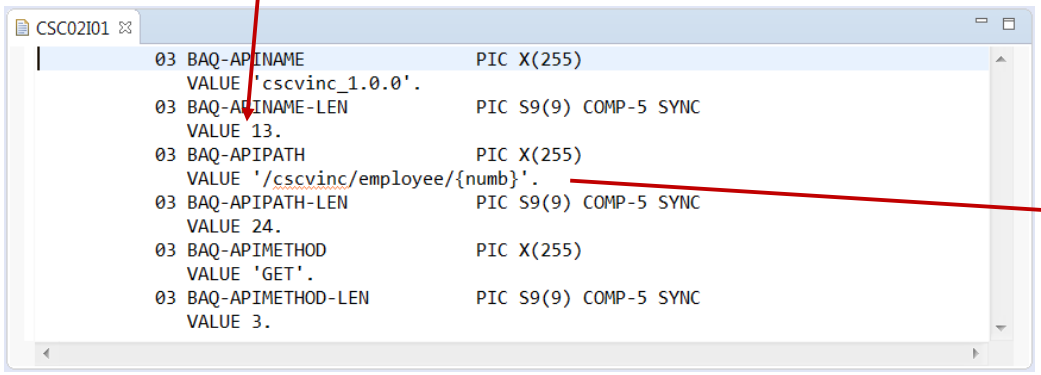
An administrator configures the endpointConnection providing the host and port of the URL



cscvinc.properties

```
connectionRef=cscvincAPI
```





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

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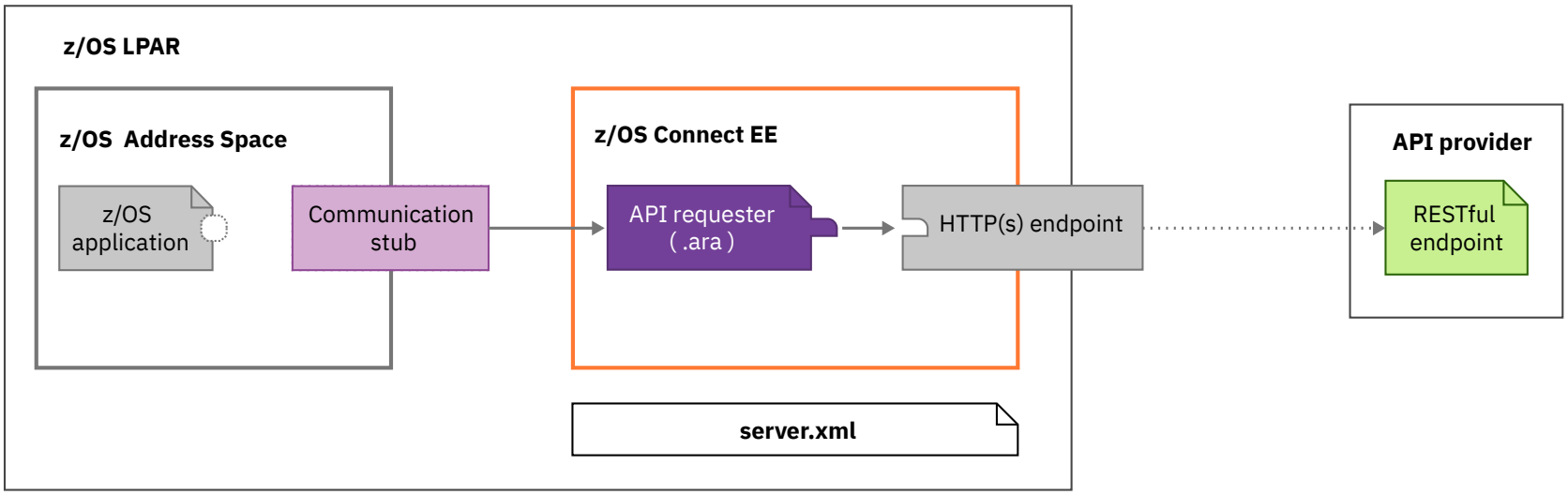
Steps to calling an external API

Configure HTTP(S) endpoint configuration element



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

ibm.biz/zosconnect-configure-endpoint-connection

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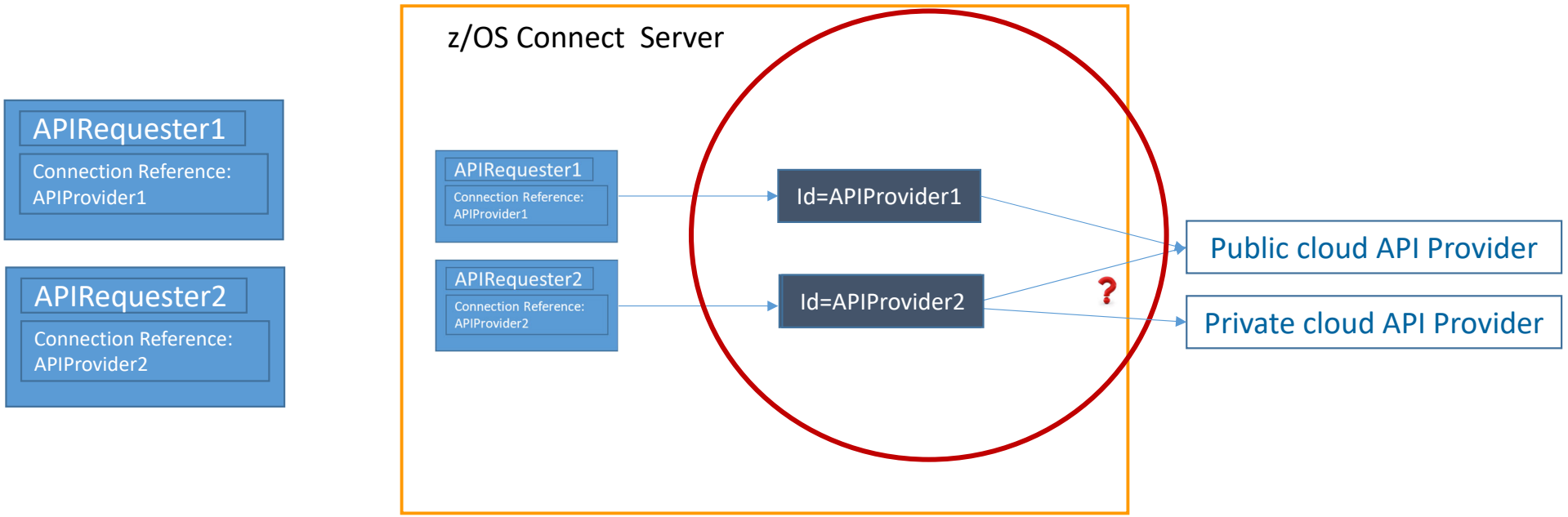
Use naming conventions for connection references

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>
```

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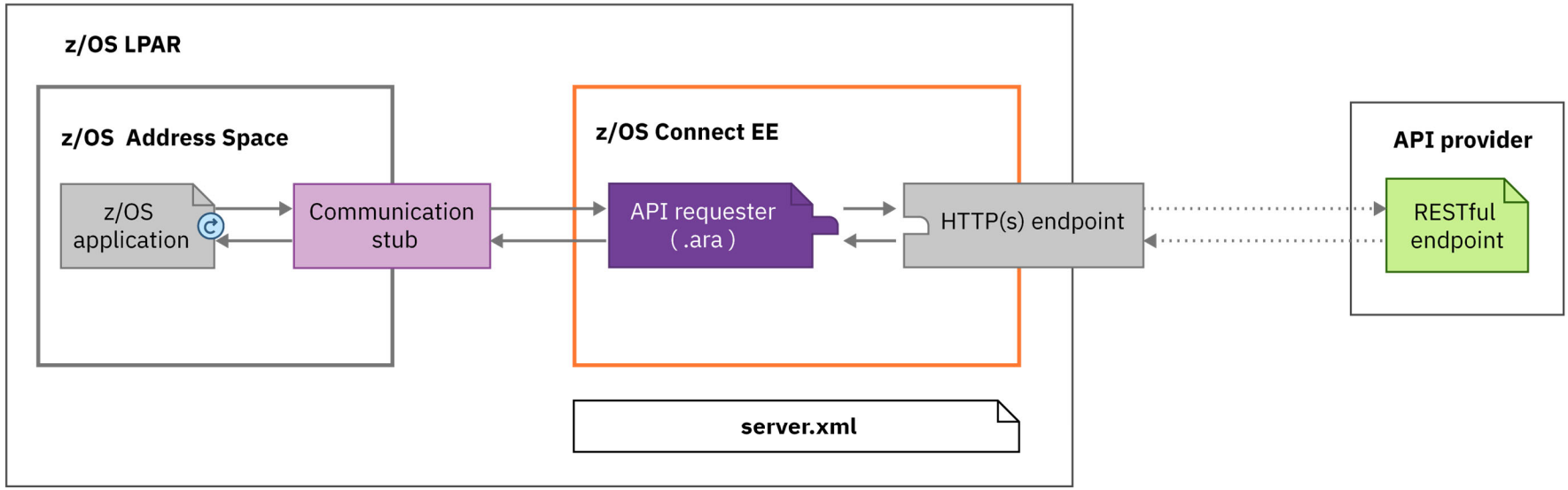
Steps to calling an external API

Done



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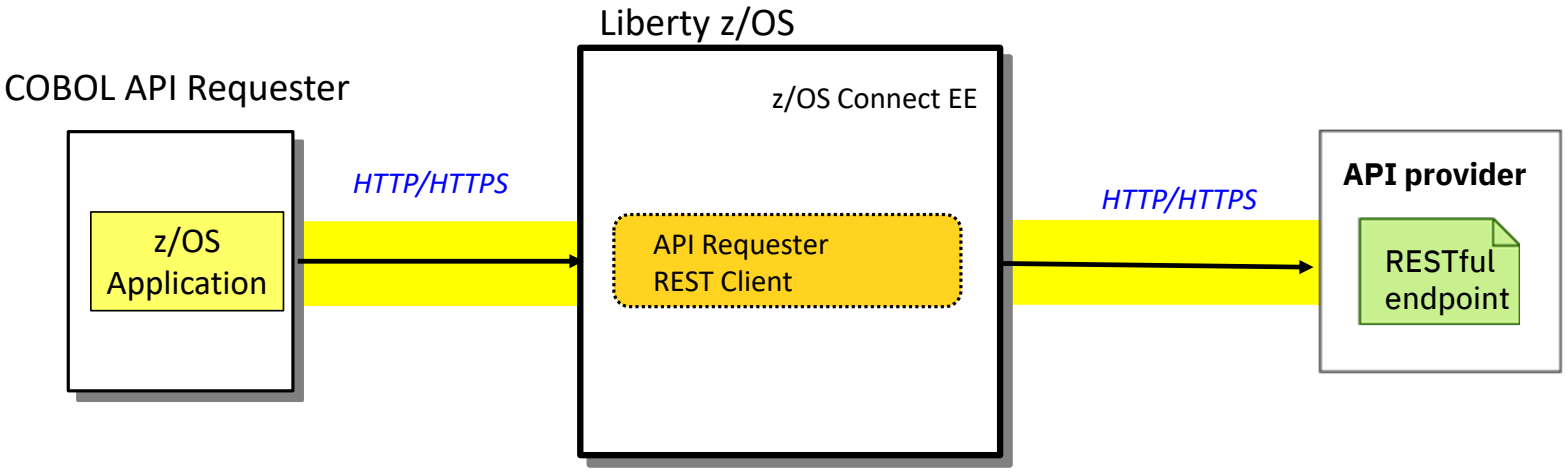
End to end API requester to API Provider connection overview



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

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

CICS HTTP connection details provided by:

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

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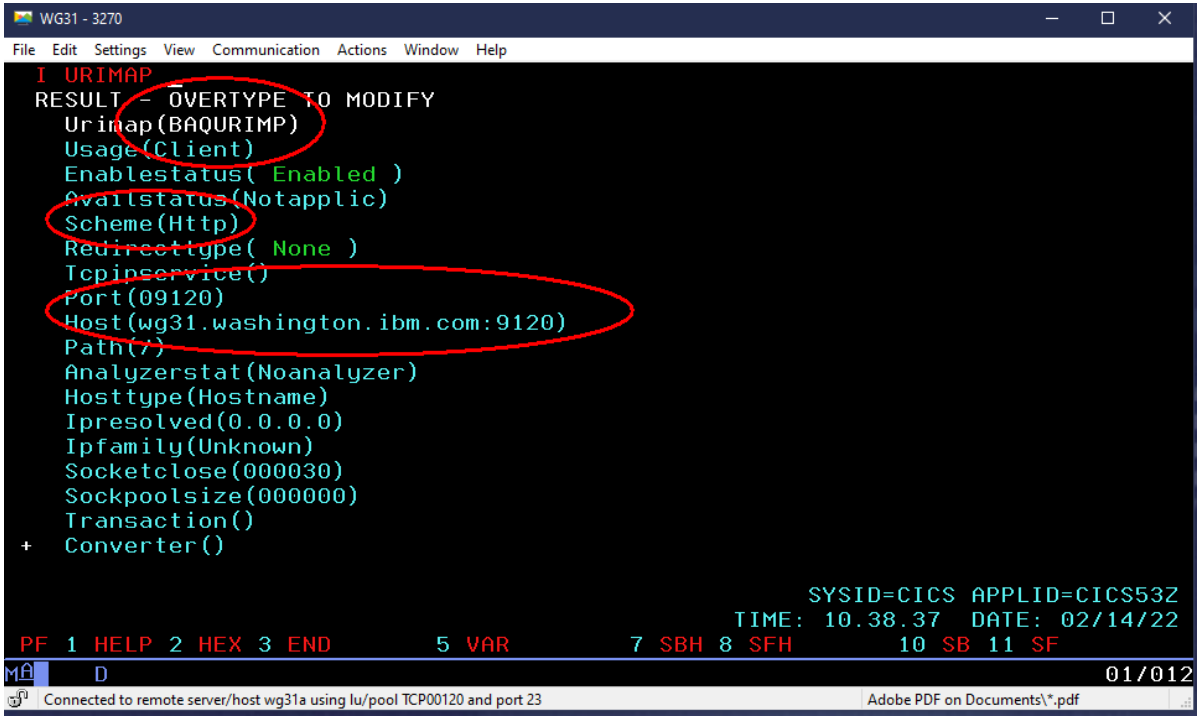
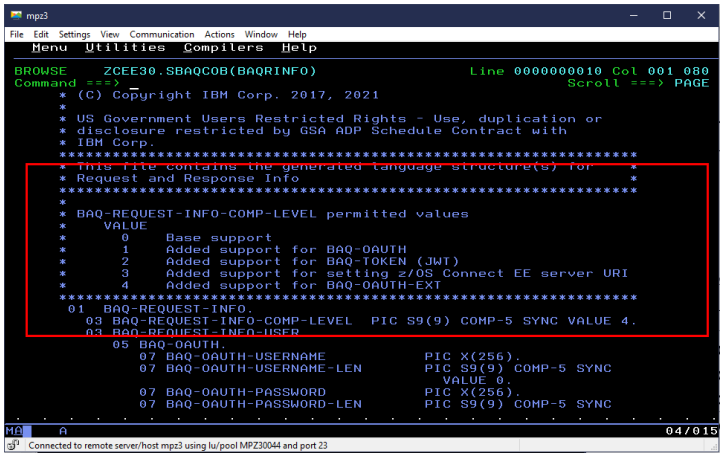
Configure connections to the z/OS API requester server

Default CICS URI MAP*



LE Environment Variables

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



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

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Environment variables for non-CICS clients

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

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

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

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

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

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

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

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/security

How is security implemented?

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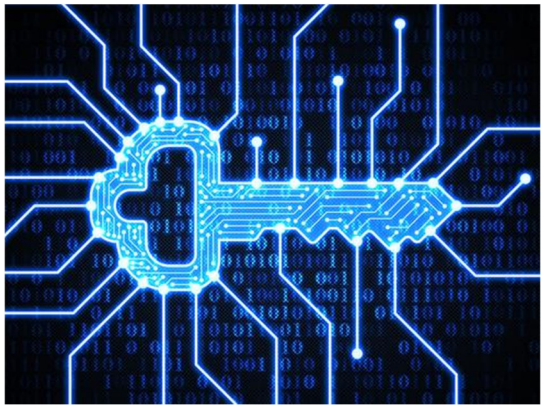
General security terms or considerations

Security involves

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

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

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



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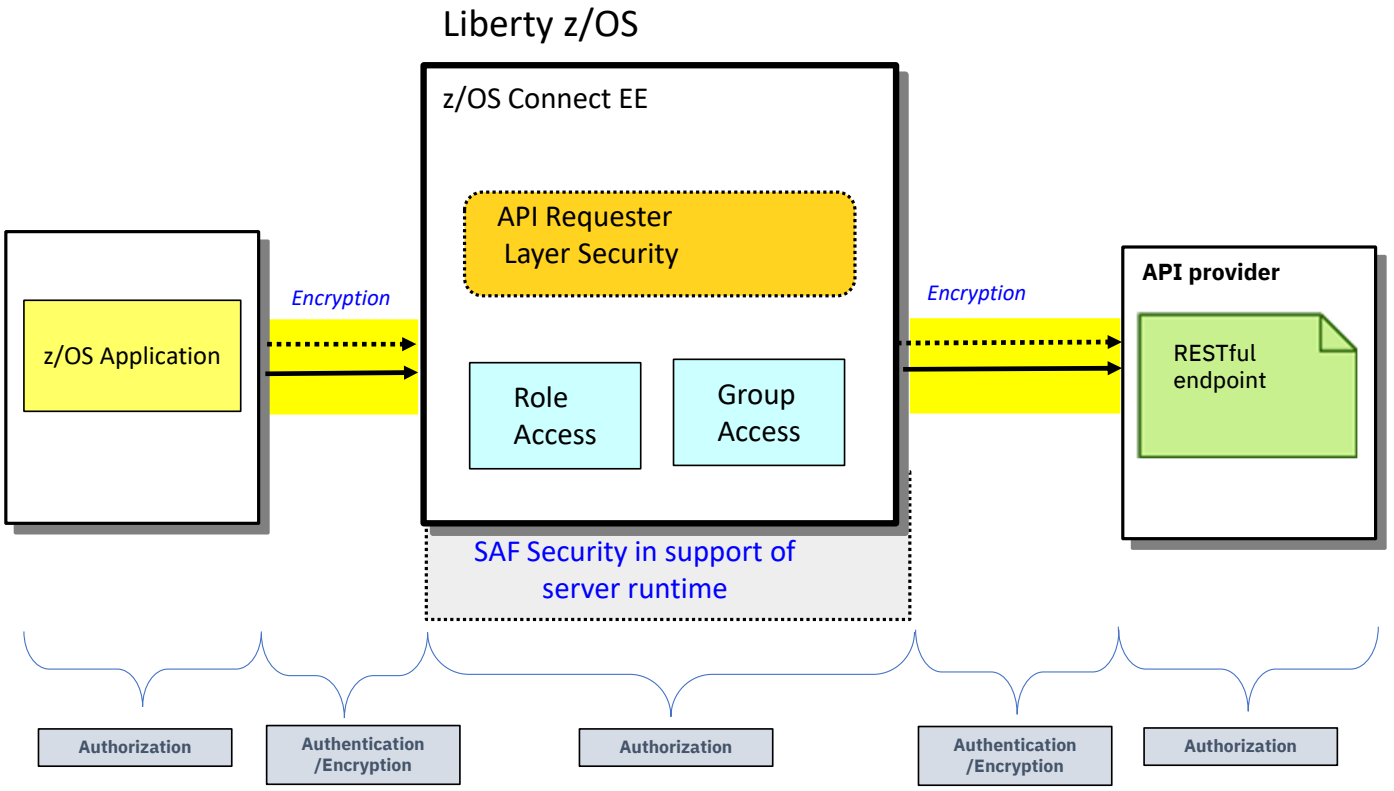
Outbound Authentication versus Authorization (OpenAPI 2)



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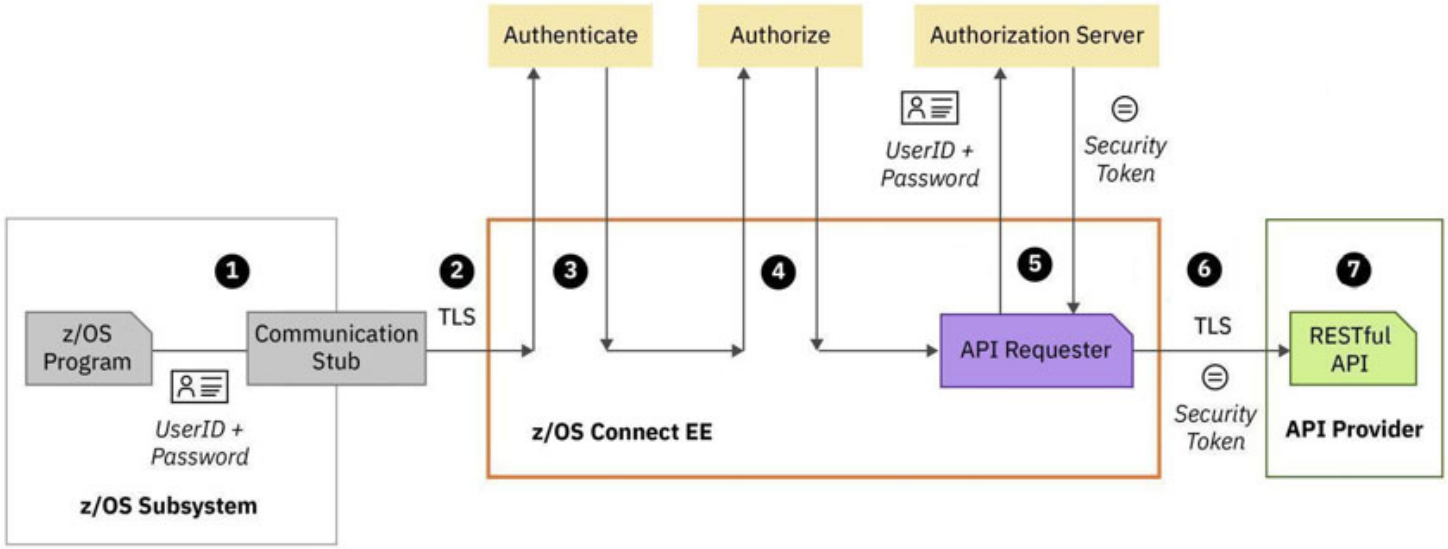
Typical z/OS Connect EE API Requester security flow



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

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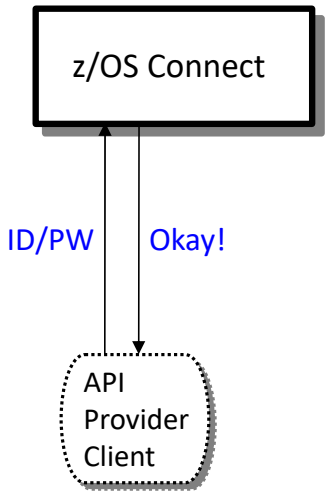
API Requester – Security from the application to the z/OS Connect server

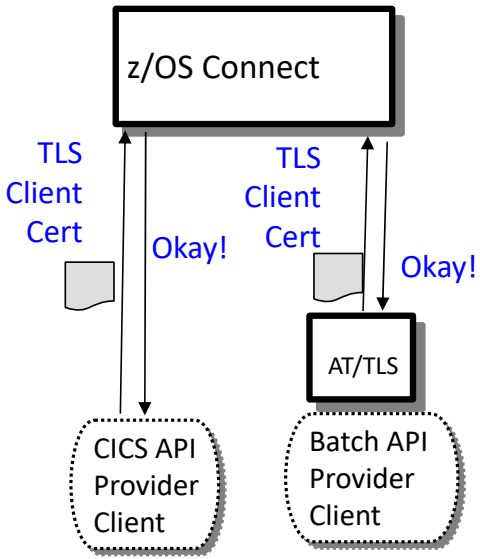
Two options for providing credentials for authentication

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

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Basic authentication – COBOL API Requester

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

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

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

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

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

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

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

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

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

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

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

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

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Tech/Tip: Generating PassTickets on z/OS

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

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

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

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

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

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

JOHNSON.PASSTCKT.SOURCE(ATSPTKTC)

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

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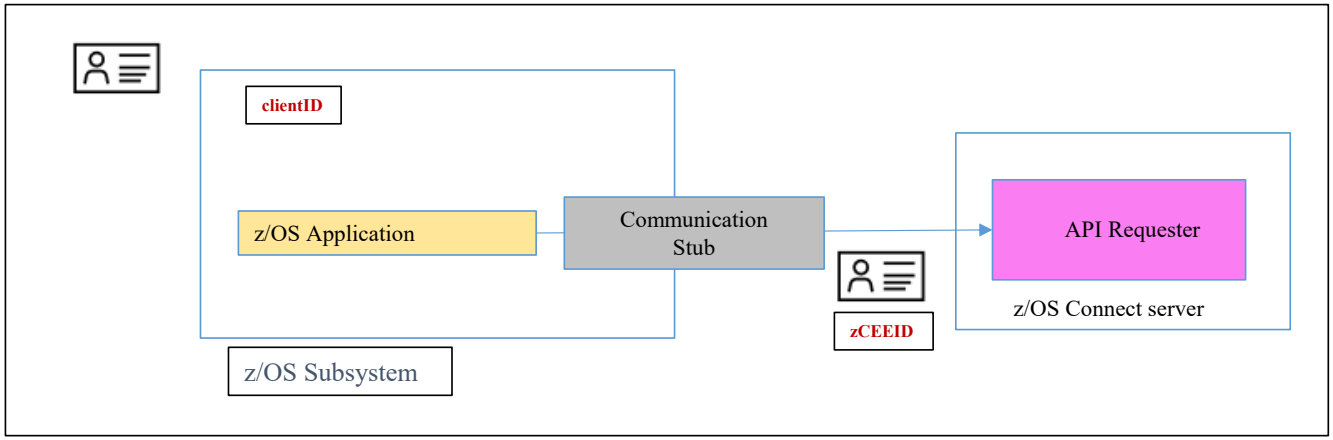
See the full source of the program at URL https://ibm.biz/BdPXny

API Requester - basic authentication and identity assertion



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 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 the 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

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Identity assertion requires setting a program control extended attribute

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

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

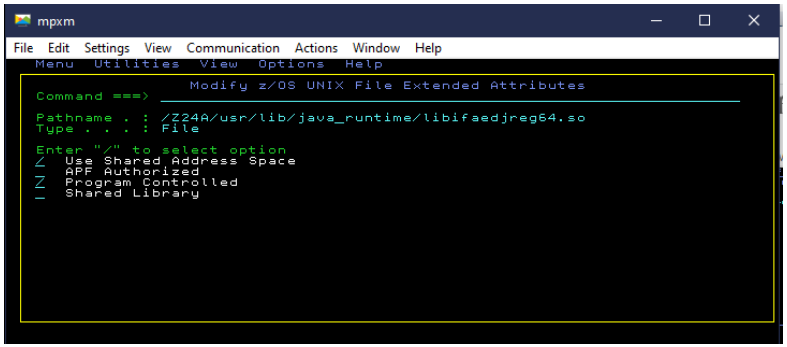
  PERMIT BPX.SERVER CLASS(FACILITY) ID(LIBSERV) ACCESS(READ)
  SETROPTS RACLIST(FACILITY) REFRESH

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

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

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

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



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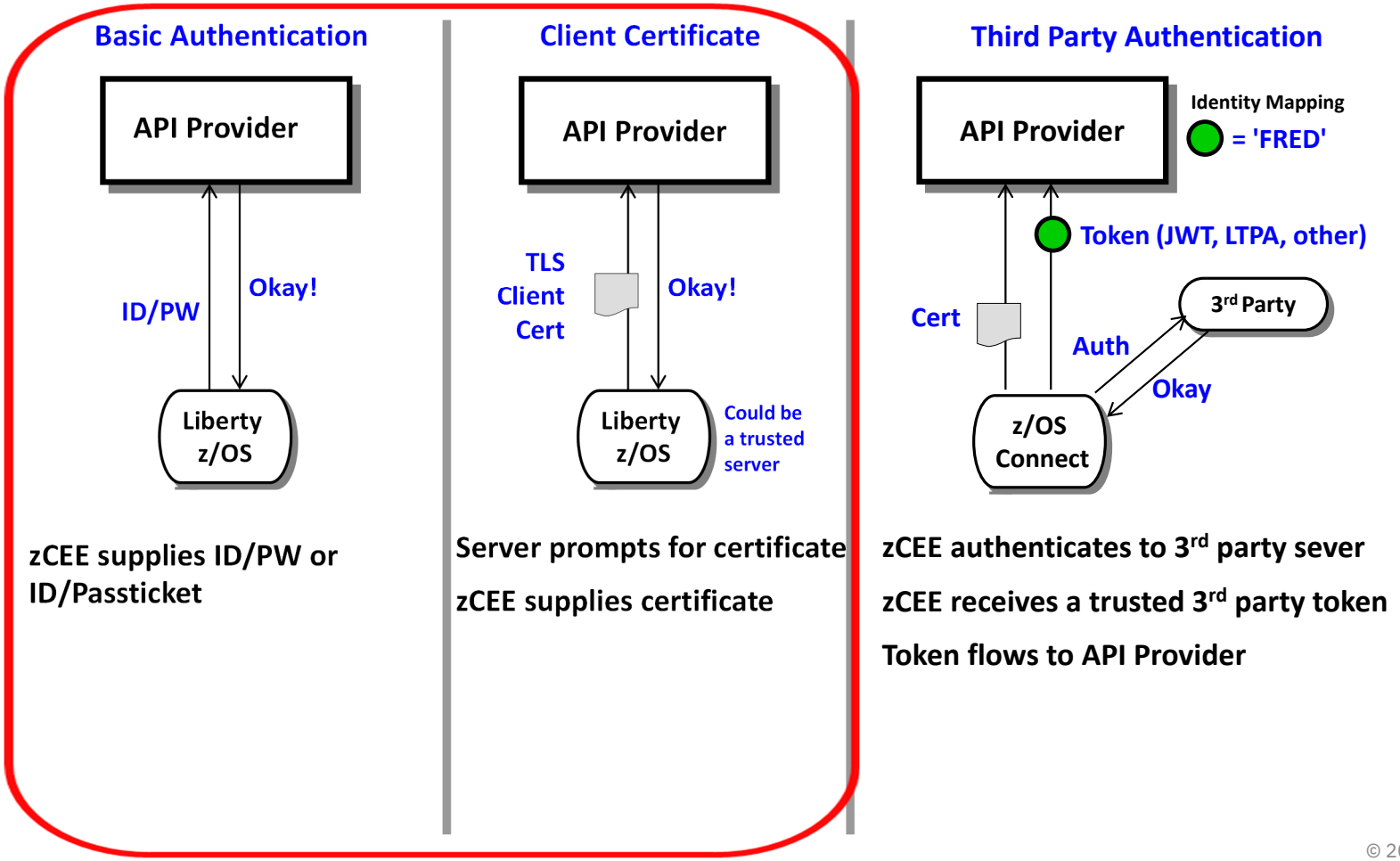
API Requester - API Provider Authentication

Several different ways this can be accomplished:



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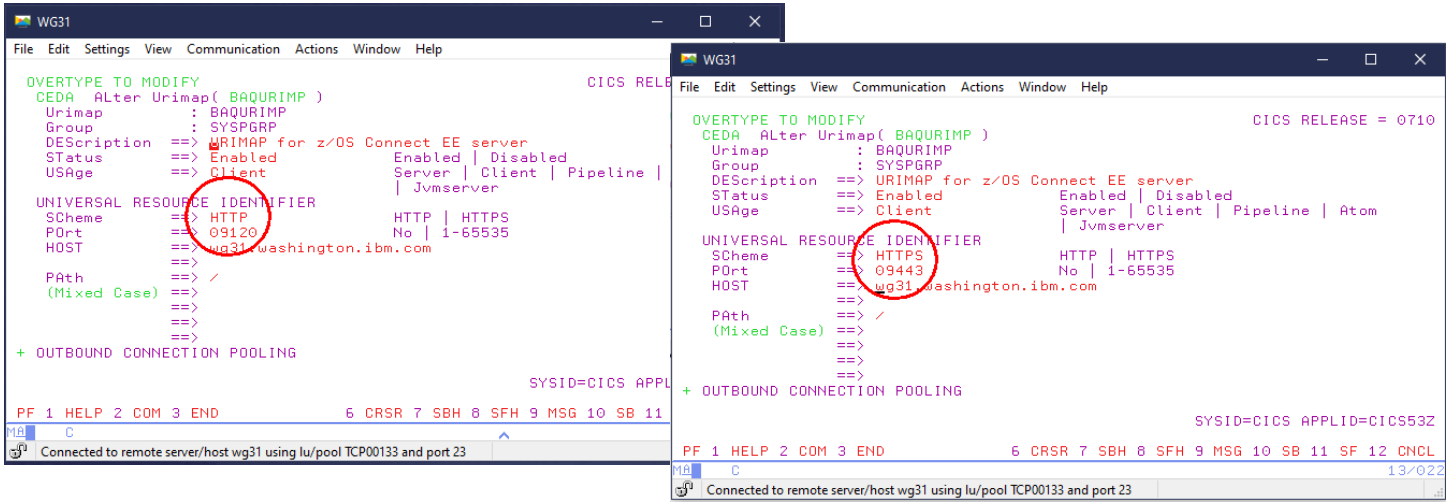
Tech/Tip: API Requester - HTTP v HTTPS

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

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

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

CICS URIMAPs



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

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

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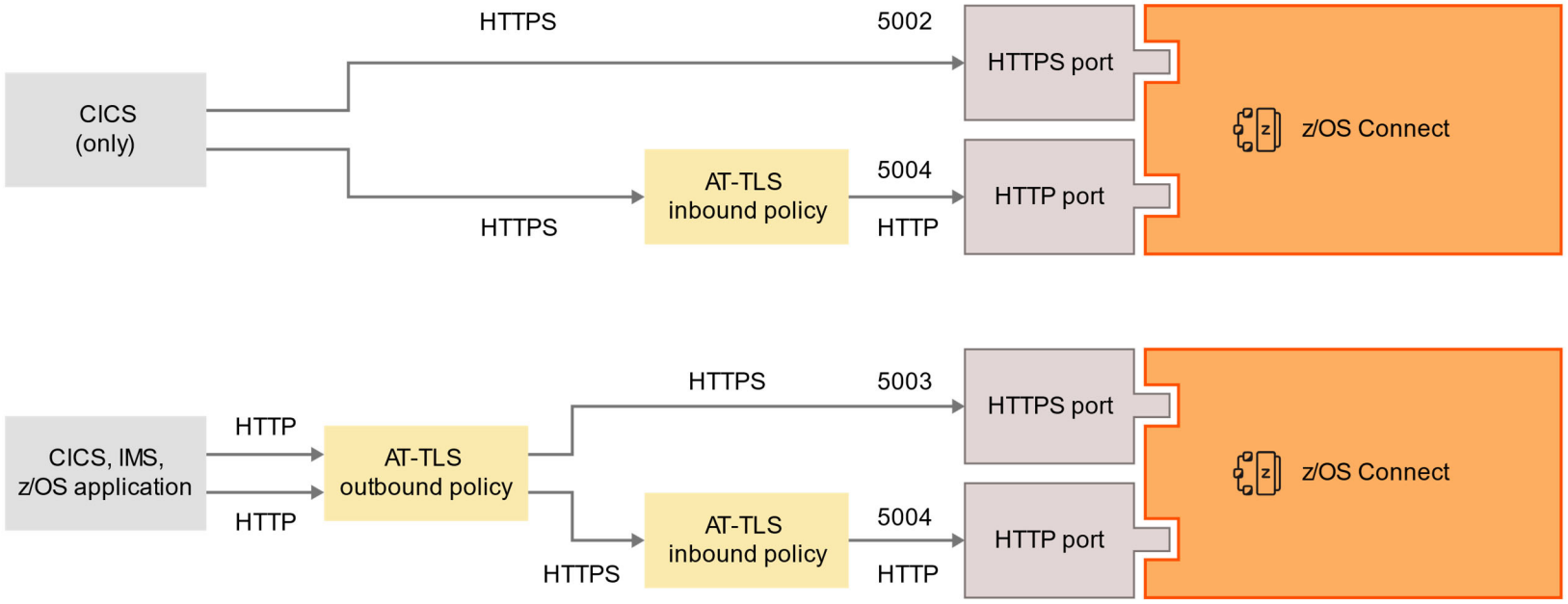
TLS Connection options from an application to the z/OS Connect server



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

Basic authentication with HTTP protocol

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

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

TLS with HTTPS protocol

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

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

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

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Sample JCL - Executing the Liberty *securityUtility* command

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

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

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

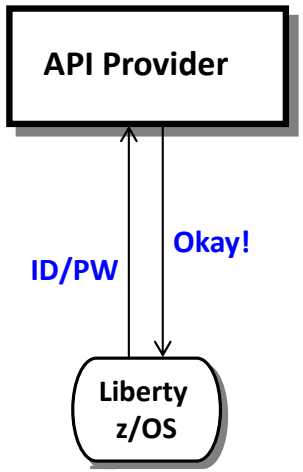
```
//*************************************************************
//* Use securityUtility to encrypt a password using an
//* encryption key string
//*************************************************************
//IKJEFT01 EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//STDOUT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

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

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

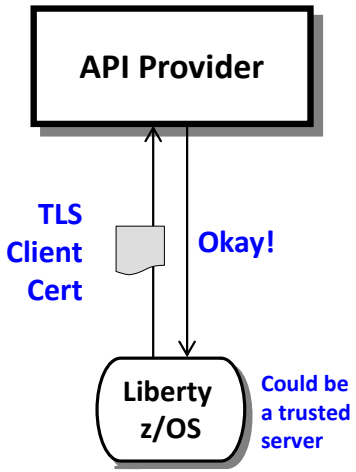
Several different ways this can be accomplished:

Basic Authentication



zCEE supplies ID/PW or ID/Passticket

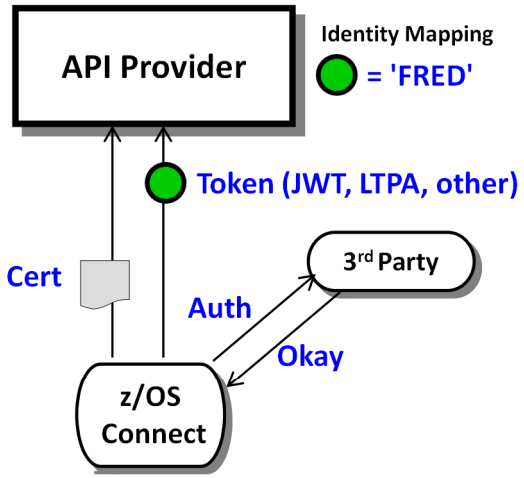
Client Certificate



Server prompts for certificate

zCEE supplies certificate

Third Party Authentication



zCEE authenticates to 3rd party sever

zCEE receives a trusted 3rd party token

Token flows to API Provider

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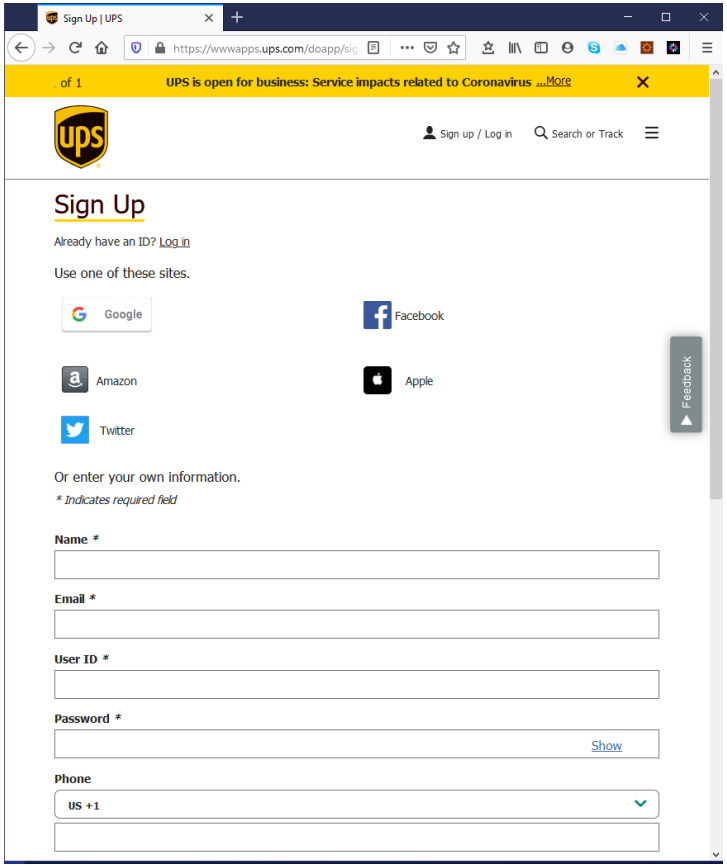
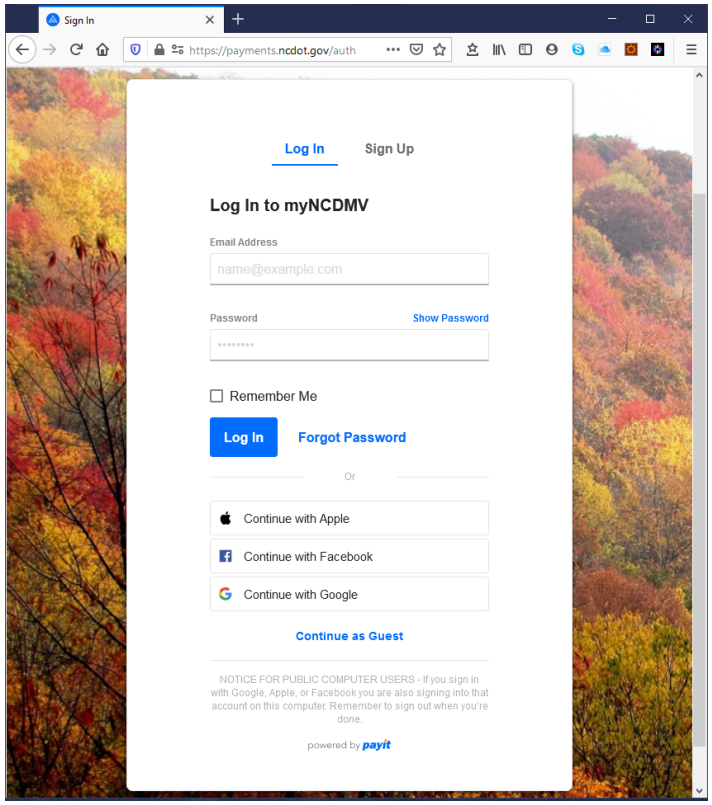
Third Party Authentication Examples





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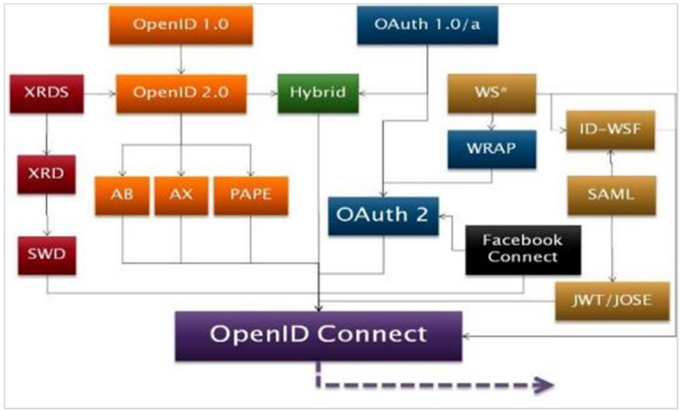
Open security standards

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

See the YouTube videos:

OAuth 2.0 and OpenID Connect (in plain English)
https://www.youtube.com/watch?v=996OiexHze0

OpenID Connect on Liberty
https://www.youtube.com/watch?v=fuajCS5bG4c



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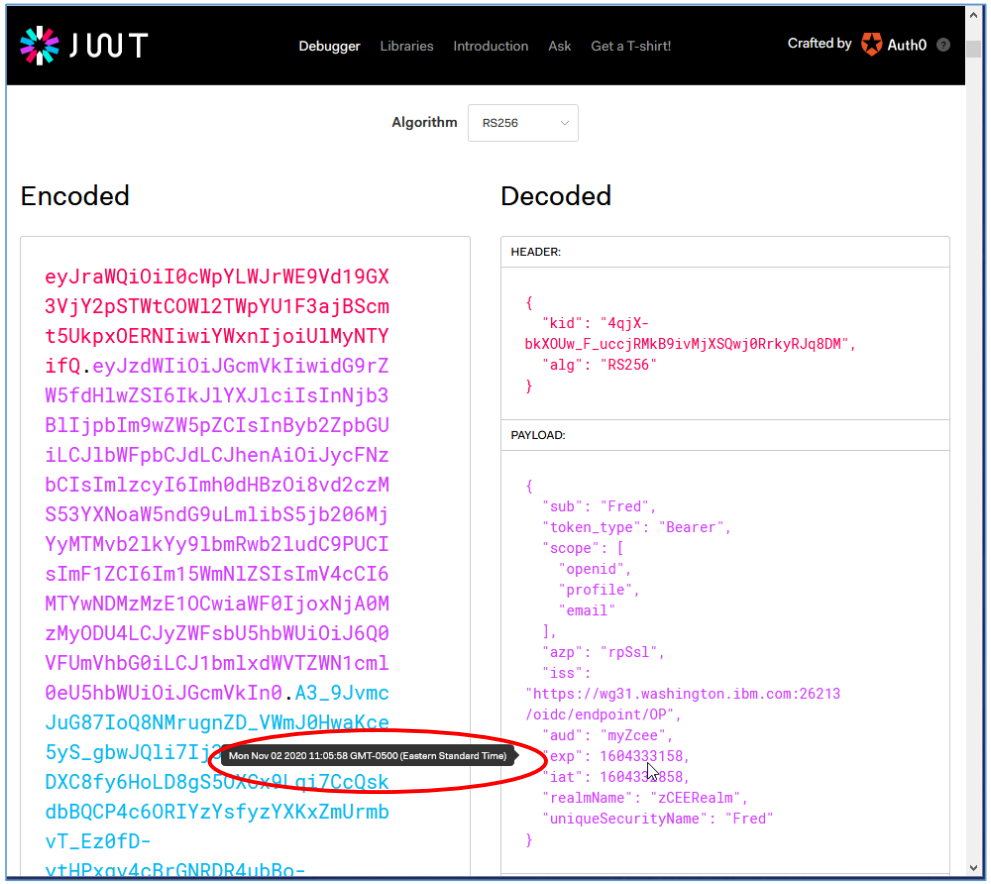
What is a JWT (JSON Web Token) ?

- JWT is a compact way of representing claims that are to be transferred between two parties
- Normally transmitted via HTTP header
- Consists of three parts
  - Header
  - Payload
  - Signature



Values derived from the OAUTH configuration:

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

https://jwt.io

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z/OS Connect API Requester - Token Support

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

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

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

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

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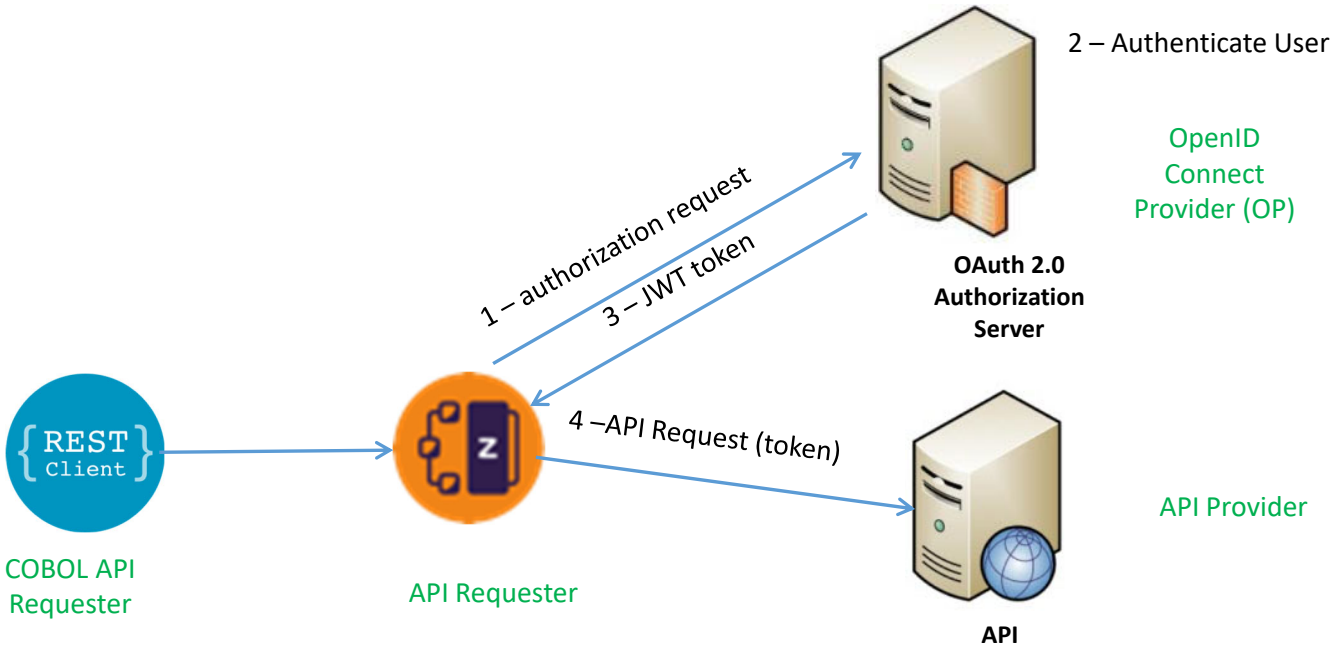
z/OS Connect OAuth Flow for API requester



Grant Types:

- client_credentials
- password

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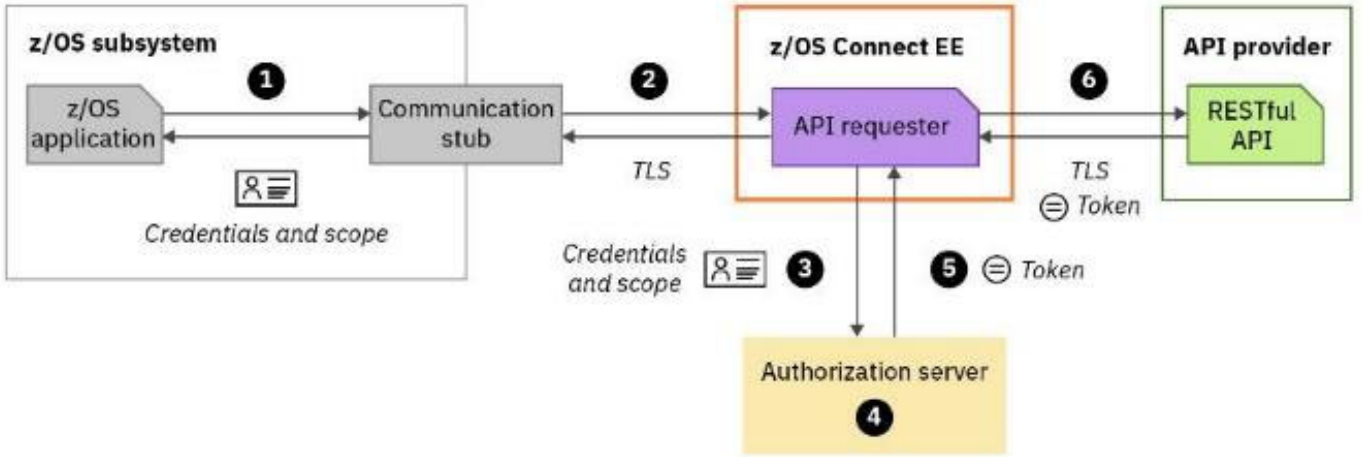
Calling an API with OAuth 2.0 support



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OAuth Grant Types Supported by z/OS Connect

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

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

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OpenID Connect/OAuth and z/OS Connect

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

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

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

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

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

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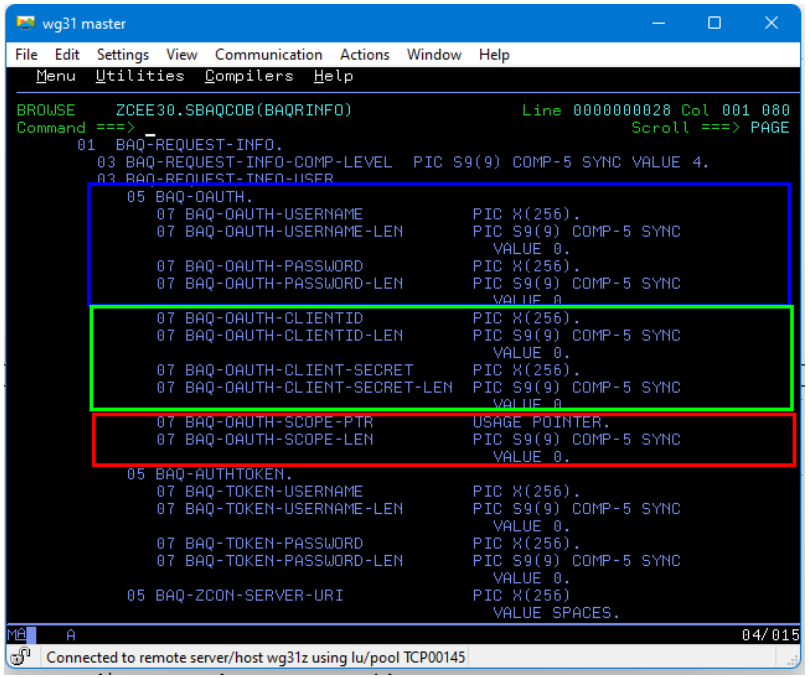
Configuring OAuth support – BAQRINFO copy book



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

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

Scope is always required.

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

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Sample program and JCL

COBOL Application

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

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

Execution JCL

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

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Tech/Tip: Accessing environment variables from COBOL application

```
      ************************************************
      **   Get the BAQ-OAUTH-USERNAME environment variable
      ************************************************
           MOVE "ATSOAUTHUSERNAME" TO envVariableName.
           PERFORM CALL-CEEENV THRU CALL-CEEENV-END
           IF valueLength NOT = 0 THEN
              MOVE VAR(1:valueLength) TO BAQ-OAUTH-USERNAME
              MOVE valueLength TO BAQ-OAUTH-USERNAME-LEN
              DISPLAY "BAQ-OAUTH-USERNAME:  "
                  BAQ-OAUTH-USERNAME(1:BAQ-OAUTH-USERNAME-LEN)
           ELSE
               DISPLAY "BAQ-OAUTH-USERNAME: Not found"
           END-IF.
      ************************************************
      **   Get the BAQ-OAUTH-PASSWORD environment variable
      ************************************************
           MOVE "ATSOAUTHPASSWORD" TO envVariableName.
           PERFORM CALL-CEEENV THRU CALL-CEEENV-END
           IF valueLength NOT = 0 THEN
              MOVE VAR(1:valueLength) TO BAQ-OAUTH-PASSWORD
              MOVE valueLength TO BAQ-OAUTH-PASSWORD-LEN
              DISPLAY "BAQ-OAUTH-PASSWORD:  "
                   BAQ-OAUTH-PASSWORD(1:BAQ-OAUTH-PASSWORD-LEN)
           ELSE
               DISPLAY "BAQ-OAUTH-PASSWORD: Not found"
```

```
       01  functionCode PIC 9(9) BINARY.
       01  envVariableNameLength PIC 9(9) BINARY.
       01  envVariableName PIC X(255).
       01  valueLength PIC 9(9) BINARY.
       01  valuePointer POINTER.
       01  ws-length PIC 9(3).

       01  feedbackCode.
           02  CONDITION-TOKEN-VALUE.
           COPY  CEEIGZCT.
               03  CASE-1-CONDITION-ID.
                  04  SEVERITY     PIC S9(4) BINARY.
                  04  MSG-NO       PIC S9(4) BINARY.
               03  CASE-SEV-CTL    PIC X.
               03  FACILITY-ID     PIC XXX.
           02  I-S-INFO            PIC S9(9) BINARY.
       01  VAL       PIC X(255).
```

```
CALL-CEEENV.
         MOVE 1 TO functionCode.
         MOVE ZERO TO ws-length.
         INSPECT FUNCTION REVERSE (envVariableName)
              TALLYING ws-length FOR LEADING SPACES.
         COMPUTE envVariableNameLength =
             LENGTH OF envVariableName - ws-length.
         MOVE " " TO VAL.
         MOVE 0 TO valueLength.
         CALL "CEEENV" USING functionCode,
                             envVariableNameLength,
                             envVariableName,
                             valueLength,
                             valuePointer,
                             feedbackCode.

         IF valueLength NOT = 0 THEN
             SET ADDRESS OF VAR TO valuePointer .

     CALL-CEEENV-END.,
```

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

Configuring OAuth support – z/OS Connect API Requester

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

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

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

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

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

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

[2] These credentials can be specified by the application

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Security Scenarios

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

distuser1 is mapped to RACF identity USER1 who has full access

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

distuserx is unknown by the OAuth Provider

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

auser is not mapped to a valid RACF identity

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

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

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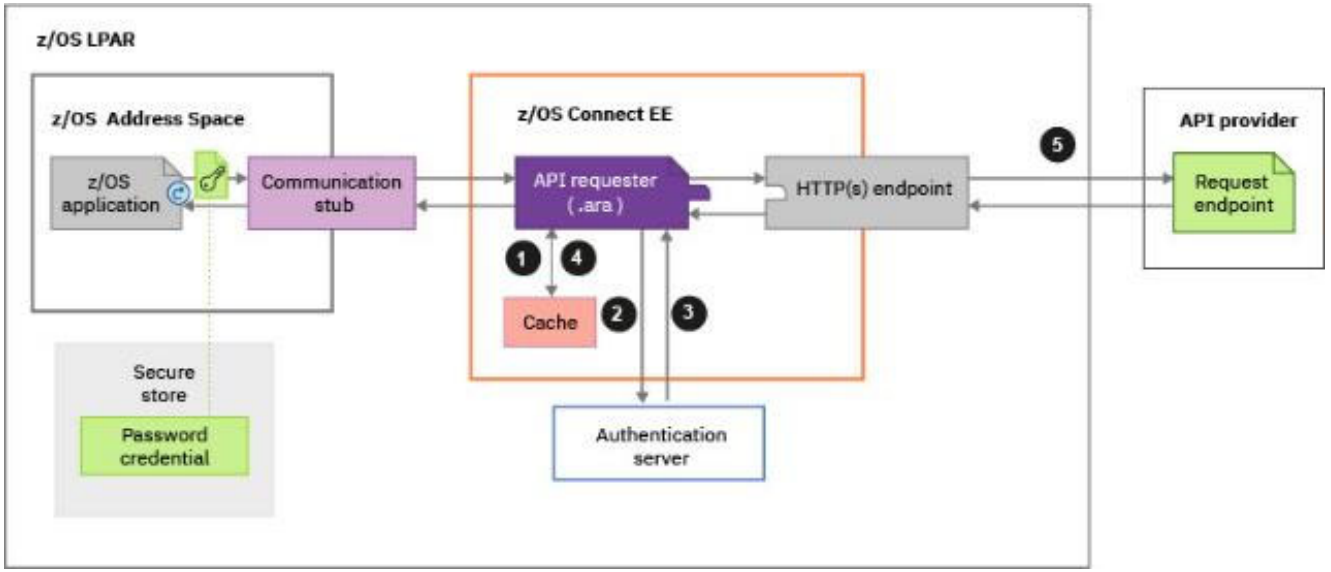
Calling an API with using a JWT custom flow

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



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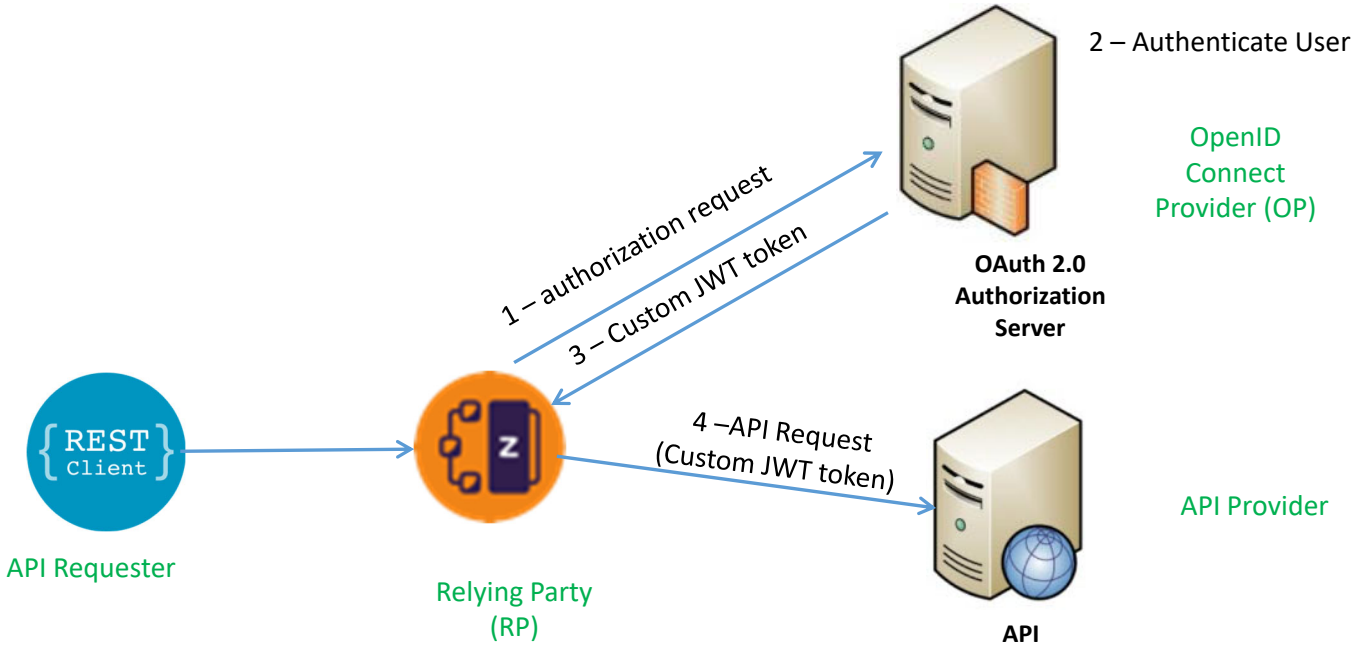
z/OS Connect OAuth Custom Flow



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API Requester – JWT Custom flow

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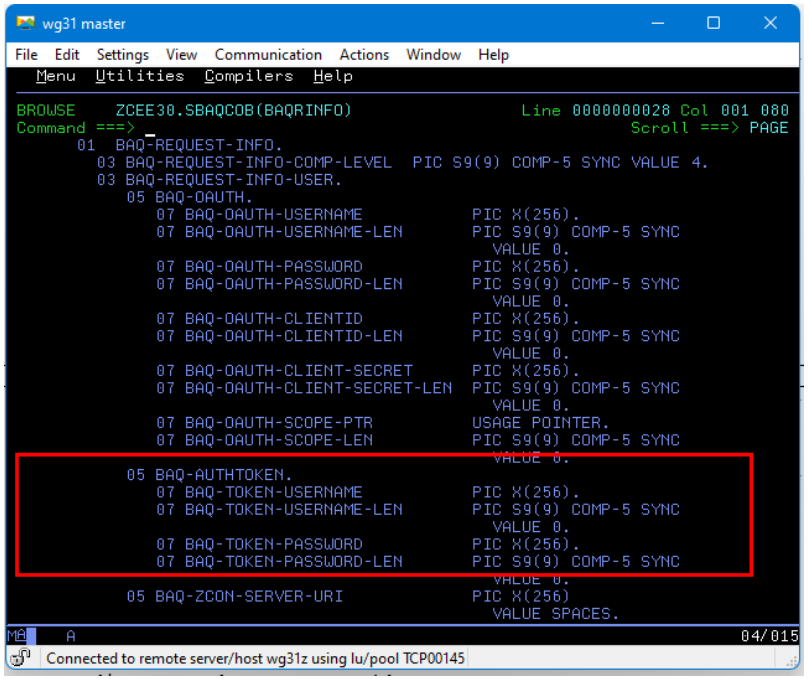

COBOL application

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

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

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Configuring JWT Custom flow

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

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

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

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

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

[2] These credentials can be specified by the application

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Configuring Custom JWT flow

Request Token Example 1

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

Response Token

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

Response Token Example 2

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

Response Token

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

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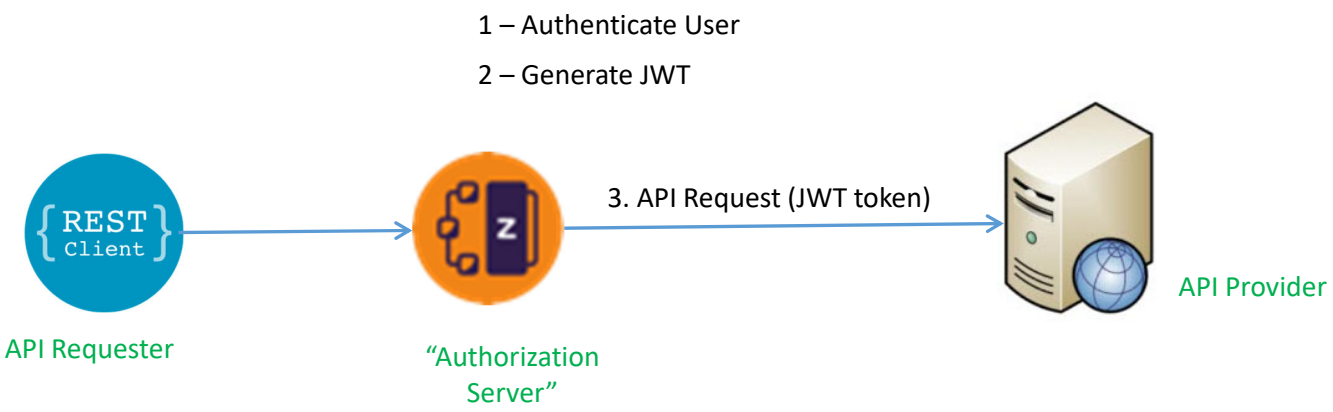
z/OS Connect JWT Generation – V3.0.43



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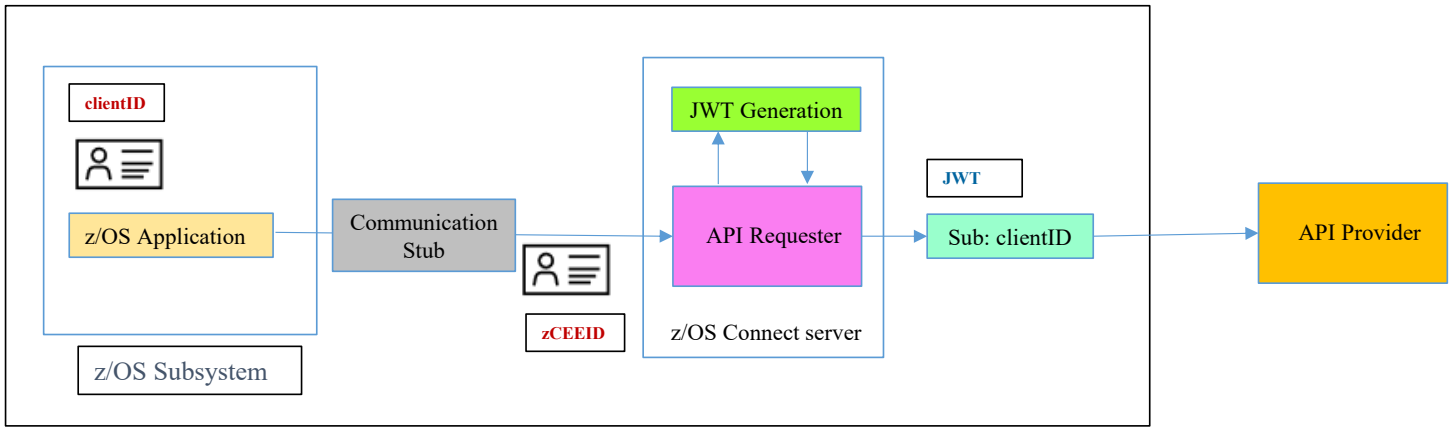
API Requester – JWT Generation



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

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

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

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JWT generation requires setting a program control extended attribute

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

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

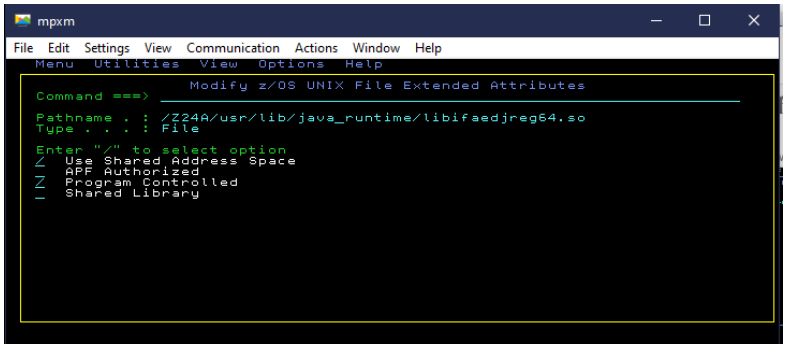
  PERMIT BPX.SERVER CLASS(FACILITY) ID(LIBSERV) ACCESS(READ)
  SETROPTS RACLIST(FACILITY) REFRESH

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

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

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

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



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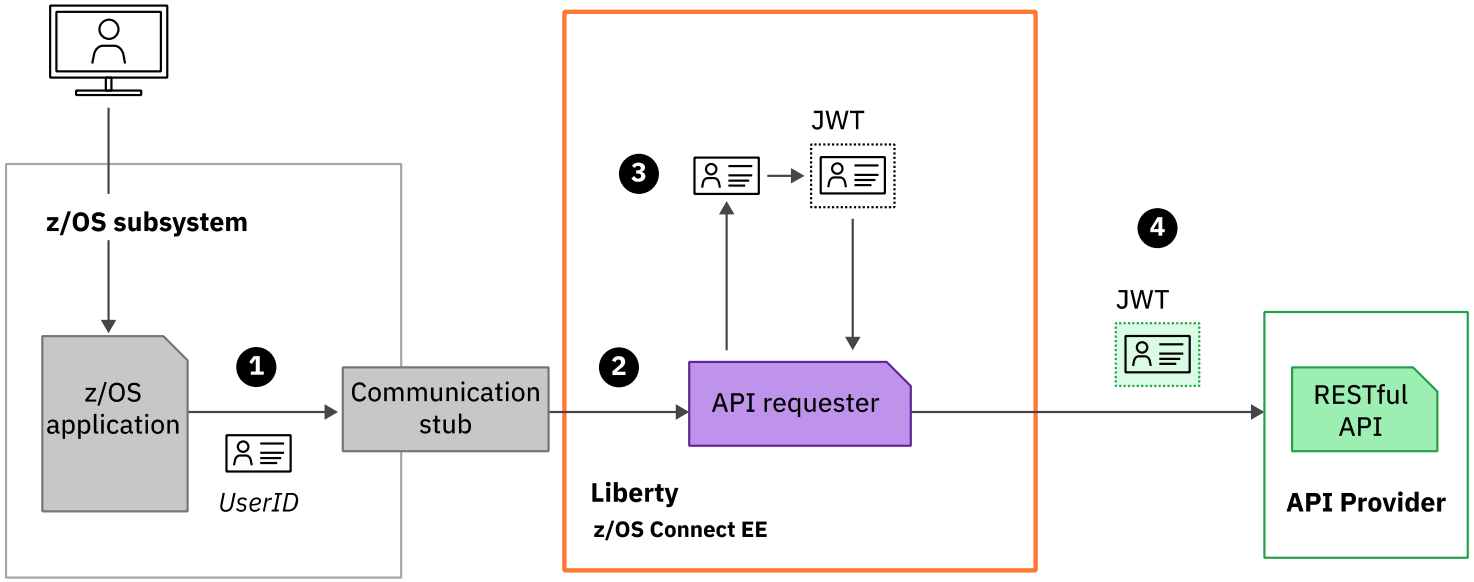
JWT Generation



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

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Configuring JWT Generation support

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

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

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

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

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

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Configuring JWT Generation support

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

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server XML Configuration

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

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

Configure the Liberty jwtBuilder element in server.xml.

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

header default value is Authorization

Finally, reference the JWT configuration from the zosconnect_endpointConnection element.

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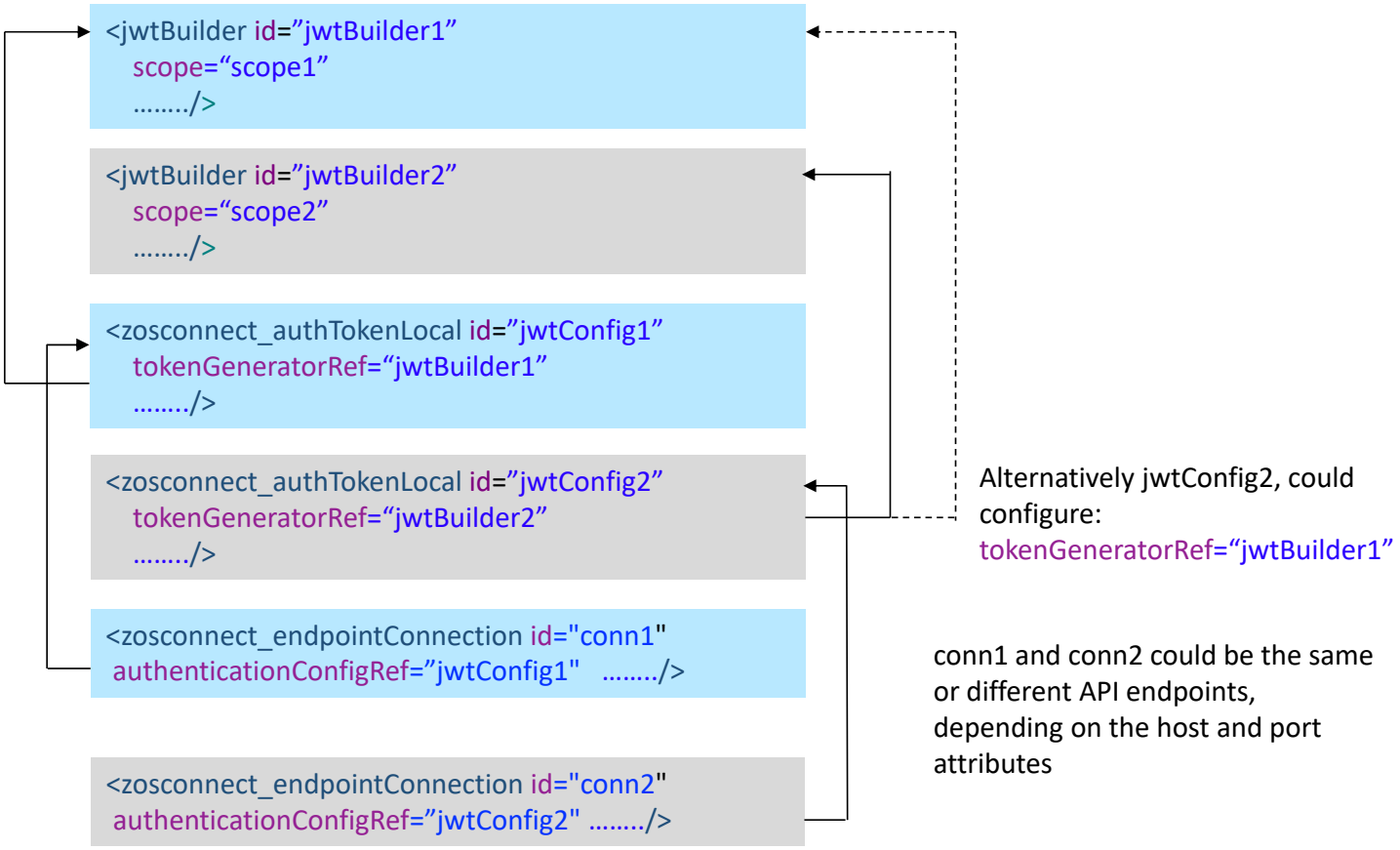
Using different claims for different API endpoints



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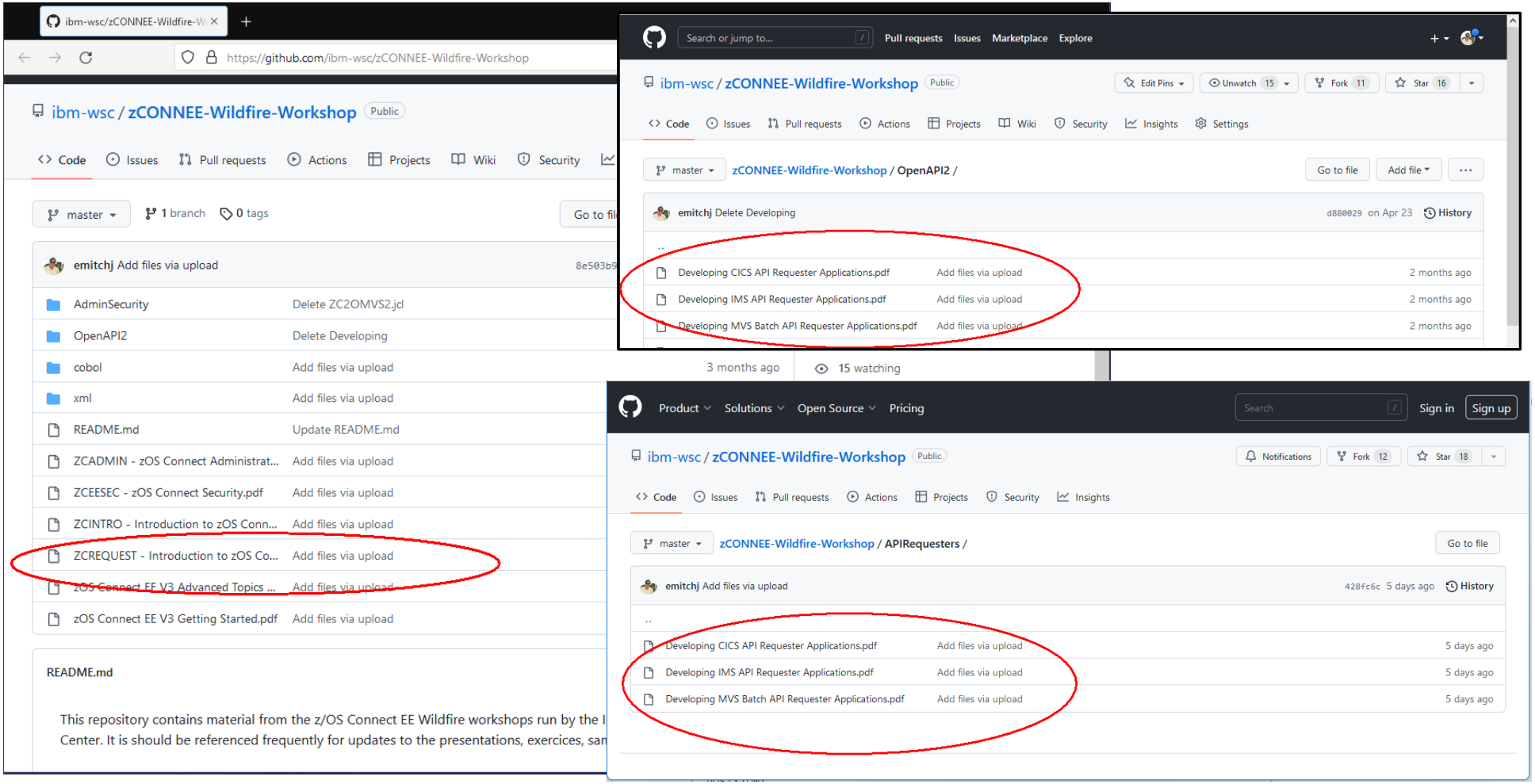
z/OS Connect Wildfire Github Site https://ibm.biz/BdPRGD



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

Thank you for listening and your questions.

And thank you for completing the Medallia survey

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