# A case study: The WSC experiences developing a CICS REST client from an OAS3 specification

IBM Washington Systems Center

*Mitch Johnson*
*John Brefach*
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Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

# Overview

This document was written by the Washington Systems Center to describe our experiences when developing a COBOL program that uses z/OS Connect API requester support to invoke a REST API. We started this project with two goals. The first goal was to describe how the details of the API as provided in an OpenAPI3 specification document impact the COBOL code in the API client requester application. And the second goal was to explore installing and using the Gradle build tool (see URL https://gradle.org) on z/OS. We know that using Gradle on z/OS is unlikely but we wanted to understand the steps required to install and enable Gradle on z/OS and show how the use of Gradle can be integrated with MVS utilities, MVS data sets, OMVS commands, etc. The lessons learned may be useful in other situations.

We chose to develop a CICS COBOL REST client to demonstrate the required COBOL coding since (1) we thought there are really no significance differences in the COBOL coding required for the other z/OS client environments and (2) because we thought CICS simply offered the more interesting execution environment. We know that there are differences between the environments, but the differences are primarily in the configuring the connection to the z/OS Connect server. For information about these connection differences, consult the z/OS Connect documentation.

For simplicity, we chose to use a BMS-enabled CICS application program. The BMS application interacts with a terminal user and for collecting and displaying information. But rather than developing a single program that included both CICS BMS code and the z/OS Connect related code, we chose a solution that followed the Model-View-Controller (MVC) architectural pattern. That is, the presentation logic (e.g., the View and Controller) would be in a BMS enabled program and the business logic,(e.g., the Model) would be a separate CICS linkable program. Separating the functions in a common program allows the exposure of the z/OS Connect HOST APIs to different clients interfaces. For example, the same CICS linkable program could also be accessed from clients using CICS Web Services support, or using ECI or EXCI protocols, or using JMS for sending and receiving request and response messages via the CICS MQ Bridge, or a Java client using the JCICS classes running in CICS Liberty servers or even other REST client by exposing the CICS linkable program using z/OS Connect API provider support.

An overview of the application used in this document is that once information was entered by the terminal user, the BMS program would do a CICS EXEC LINK to the CICS API requester application passing a channel with a request container. The CICS API requester application would use the information in the request container and the z/OS Connect Host API verbs to invoke the remote API, the results would be returned to the BMS application in a response container. A success container when the API returned an HTTP 200 (success) or an exception container if an HTTP 400 or HTTP 500 status code was returned.

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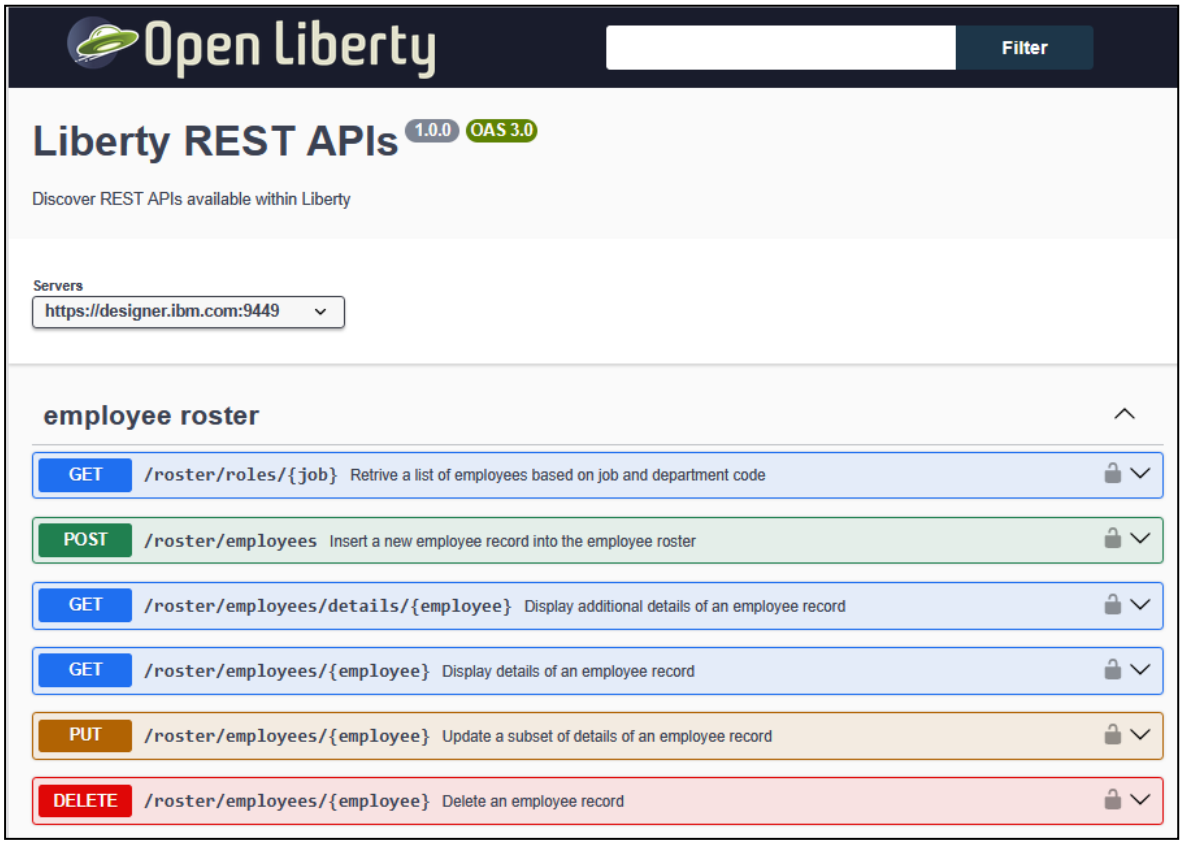
Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

# Reviewing the API specification's influence on the COBOL code

We started by reviewing the API's specification document. The details of the API's request and response messages and the details of the message payloads as defined in the API's specification directly impact key aspects of the COBOL code in a REST client application. The details of what we learn about these relationships are covered in this section..

Below is a screen shot from using the Liberty API Explorer (*/api/explorer*) to discuss the details of the API. This screen shows that the *Employee Roster* API can be accessed using six methods. Three *GET* methods for retrieving employee information (these methods are differentiated by their URI paths) and one *POST* method for adding a new employee, one *PUT* method for updating an employee's information and one *DELETE* method for removing or deleting an employee's information.

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We chose to use the *GET* method for URI path */roster/roles/{job}* as the subject for exploring. This method was chosen because it has the most interesting response because multiple individual items are returned in the response message. We also knew that the basic process used with this method could be applied to develop REST client applications for the other methods.

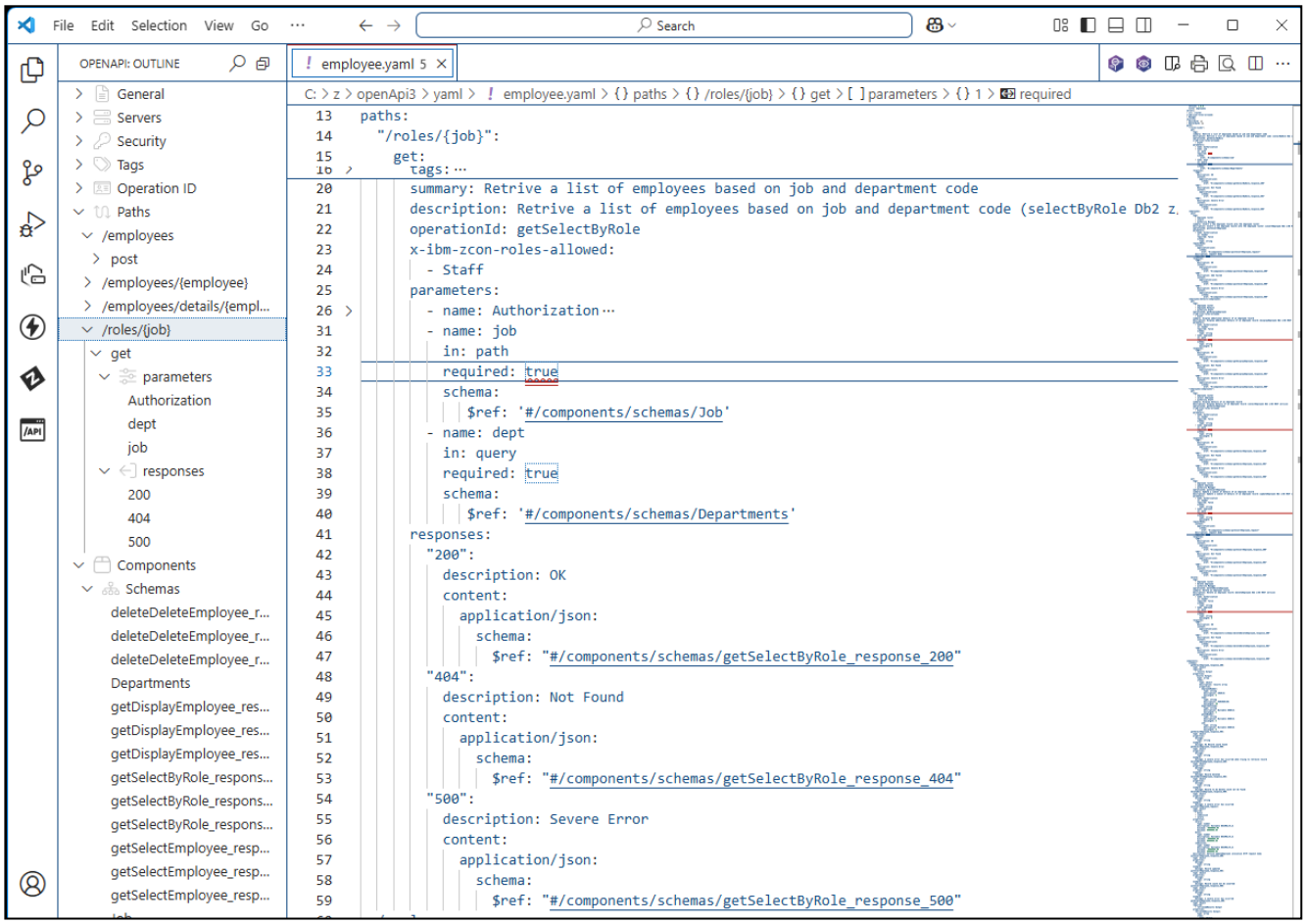


Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *Request and response messages*

The first part of the specification document we explored were the GET method's request and response messages. Normally the z/OS Connect API requester will parse the specification document and generate the correct COBOL code, but we wanted to understand the reasoning behind the details of the generation process..

The API specification document provided the basic details of this method in the section below. This tells us that the request message includes parameter *job* as a *path* parameter in the URI path and that parameter *dept* is a *query* parameter in the URI path, e.g., */roster/roles/PRES/?dept=A01.* Also, details of the different HTTP response codes (e.g., HTTP 200, HTTP 404, or HTTP 500) to be expected are provided.

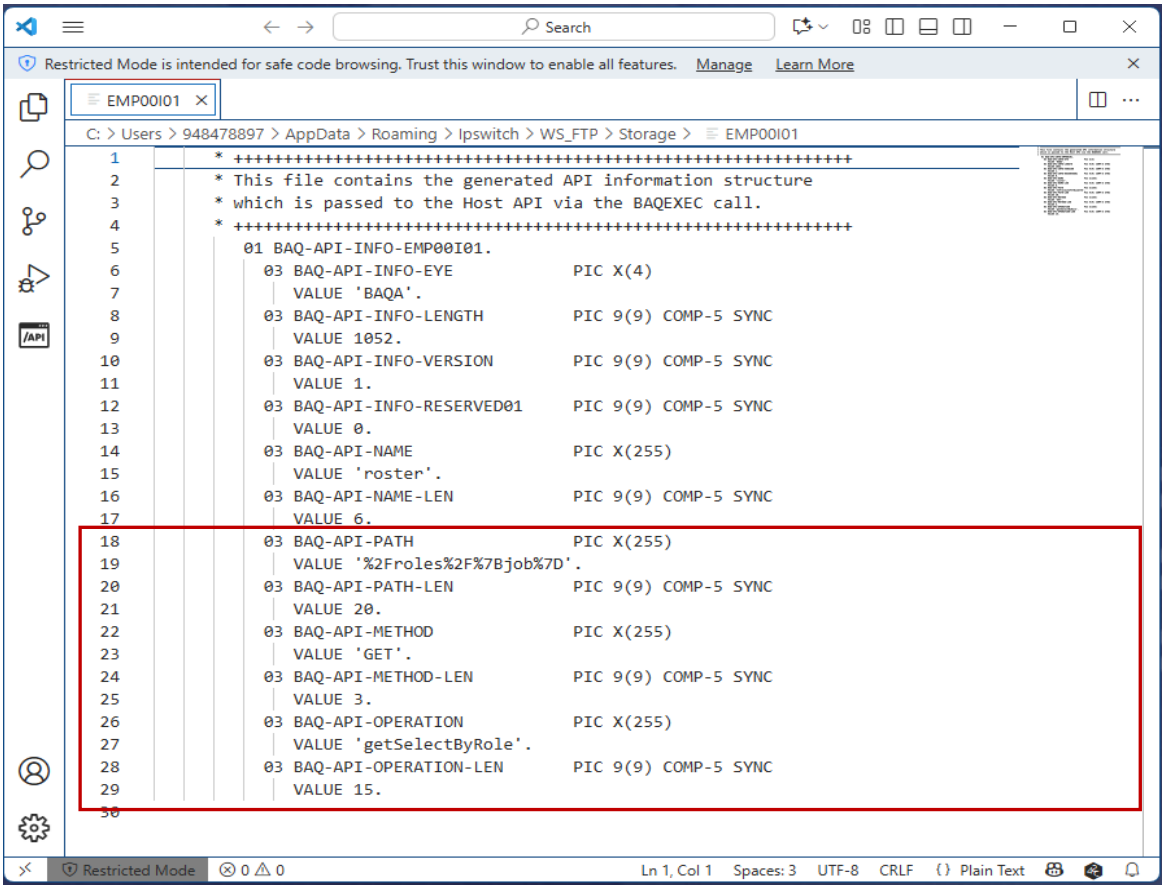



**N.B.:** *The screen shots of YAML files in this document were taken using the OpenAPI (Swagger) Editor extension in Visual Studio.*



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

Relevant information regarding the method of the API, e g., the URI path and method name is extracted from the specification document and saved in a generated copy book that needs to be included in the COBOL program. The COBOL program passes this information to z/OS Connect where it is used to build the URL for accessing the method and to identify which method is being invoked. Below is how these details are provided in a COBOL copy book. The application should not change the contents of any of these variables.

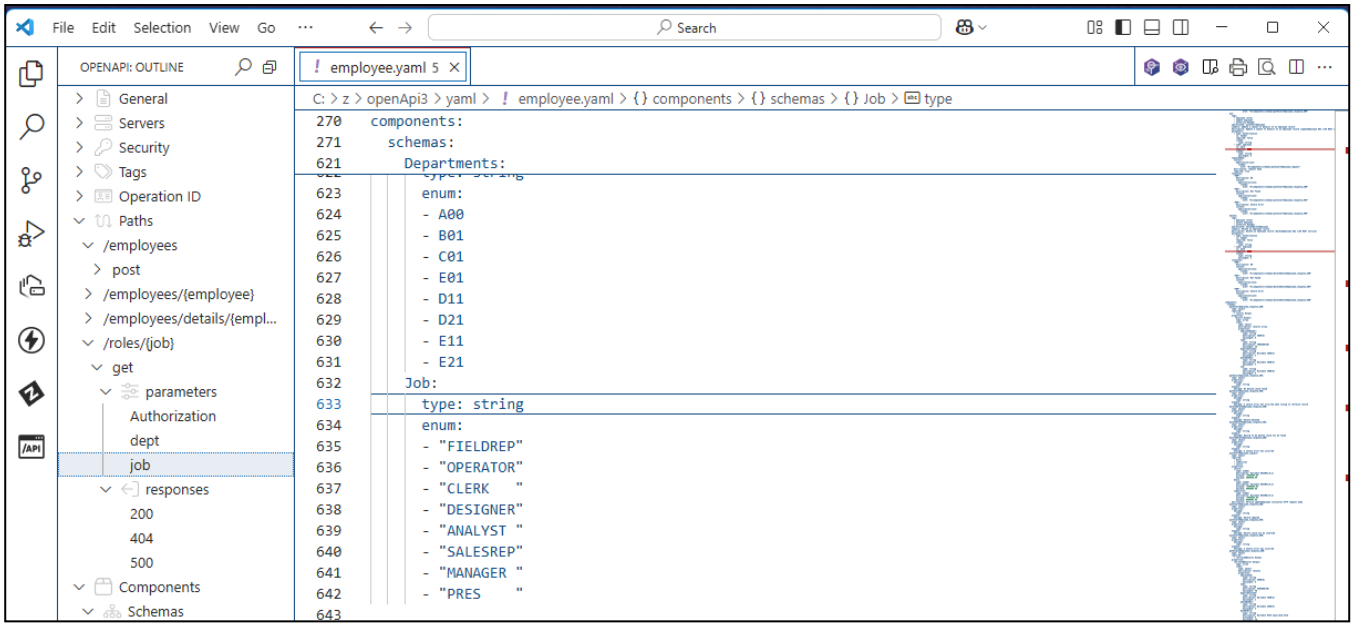



```
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      * This file contains the generated API information structure
      * which is passed to the Host API via the BAQEXEC call.
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
       01 BAQ-API-INFO-EMP00I01.
         03 BAQ-API-INFO-EYE            PIC X(4)
           VALUE 'BAQA'.
         03 BAQ-API-INFO-LENGTH         PIC 9(9) COMP-5 SYNC
           VALUE 1052.
         03 BAQ-API-INFO-VERSION        PIC 9(9) COMP-5 SYNC
           VALUE 1.
         03 BAQ-API-INFO-RESERVED01     PIC 9(9) COMP-5 SYNC
           VALUE 0.
         03 BAQ-API-NAME                PIC X(255)
           VALUE 'roster'.
         03 BAQ-API-NAME-LEN            PIC 9(9) COMP-5 SYNC
           VALUE 6.
         03 BAQ-API-PATH                PIC X(255)
           VALUE '%2Froles%2F%7Bjob%7D'.
         03 BAQ-API-PATH-LEN            PIC 9(9) COMP-5 SYNC
           VALUE 20.
         03 BAQ-API-METHOD              PIC X(255)
           VALUE 'GET'.
         03 BAQ-API-METHOD-LEN          PIC 9(9) COMP-5 SYNC
           VALUE 3.
         03 BAQ-API-OPERATION           PIC X(255)
           VALUE 'getSelectByRole'.
         03 BAQ-API-OPERATION-LEN       PIC 9(9) COMP-5 SYNC
           VALUE 15.
```

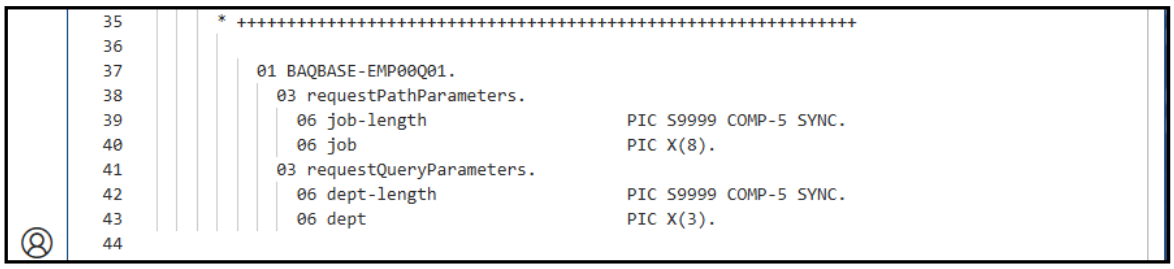


Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

Elsewhere in the specification document, the URI path fields (*job* and *dept*) are defined as unconstrainted strings (*type: string).* Unconstrainted in the respect that their respective lengths are not bounded by a *maxLength* attribute.




The maximum length of the *job* and *dept* variables can be deduced because the valid values for these fields are enumerated and their maximum lengths are constrained by the the lengths of the values in the enumerated lists. Note that if the size of a string can not be deduced, the length of the COBOL PIC X specification varaible will be set to a default value based on the API generation property *defaultCharacterMaxLength*, which has a default value of 255, e.g, a COBOL PIC X(255).





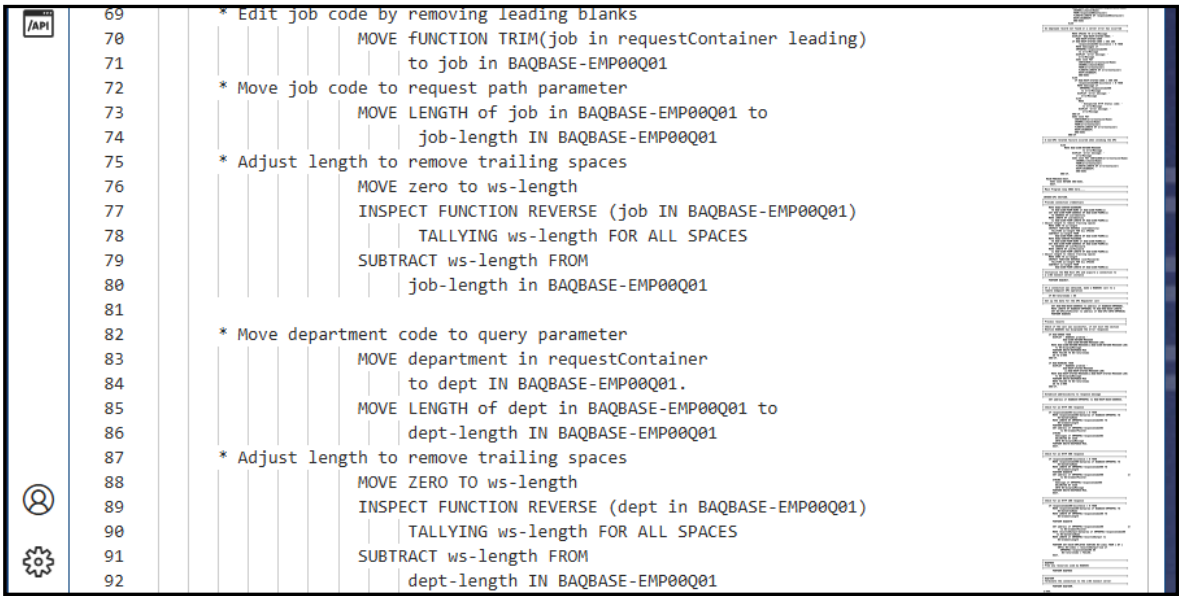

Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

**N.B.:** *The reason for these -length variables for containing the actual length of valid data at execution timer is because of how COBOL handles string variables versus how other programming languages manage string variables. Strings in COBOL are in continuous storage and are a finite maximum size as determined by the compiler based on the PIC attribute. The COBOL length function will always return the maximum length of a variable, not the actual length of the data in the variable. This works well for COBOL-to-COBOL calls but presents a problem for interlanguage calls.*

*Other languages such as Java maintain strings as simple objects and strings lengths are terminated by the presence of a null character, x'00'. So, the size of a string can vary and the length can easily be programmatically determined by Java by using the null character as the termination of a string.*

*So, if the COBOL program did not provide the length of the variable data, another programming language like Java would look for the first null character in storage and send the variable data plus the content of whatever else was in storage as the value of the variable (aka known as garbage).*

The actual length of the valid data in these variables is not apparent, and this could be a problem since a comparison for *job* with contents of "*PRES* " versus a comparison for "*PRES*" would provide different results. To address this, additional variables are generated in the COBOL source to hold the actual length of the data in the variables. These fields are identified in the COBOL source by the presence of the *-length* suffix added to the variable name, e.g., *job-length* and *dept-length*. It is the COBOL REST client application's responsibility to provide the actual length of the data using the corresponding *-length* variable, as shown in the example code as shown below.



```
69          * Edit job code by removing leading blanks
70                      MOVE fUNCTION TRIM(job in requestContainer leading)
71                          to job in BAQBASE-EMP00Q01
72          * Move job code to request path parameter
73                      MOVE LENGTH of job in BAQBASE-EMP00Q01 to
74                           job-length IN BAQBASE-EMP00Q01
75          * Adjust length to remove trailing spaces
76                      MOVE zero to ws-length
77                      INSPECT FUNCTION REVERSE (job IN BAQBASE-EMP00Q01)
78                           TALLYING ws-length FOR ALL SPACES
79                      SUBTRACT ws-length FROM
80                          job-length in BAQBASE-EMP00Q01
81
82          * Move department code to query parameter
83                      MOVE department in requestContainer
84                          to dept IN BAQBASE-EMP00Q01.
85                      MOVE LENGTH of dept in BAQBASE-EMP00Q01 to
86                          dept-length IN BAQBASE-EMP00Q01
87          * Adjust length to remove trailing spaces
88                      MOVE ZERO TO ws-length
89                      INSPECT FUNCTION REVERSE (dept in BAQBASE-EMP00Q01)
90                          TALLYING ws-length FOR ALL SPACES
91                      SUBTRACT ws-length FROM
92                          dept-length IN BAQBASE-EMP00Q01
```



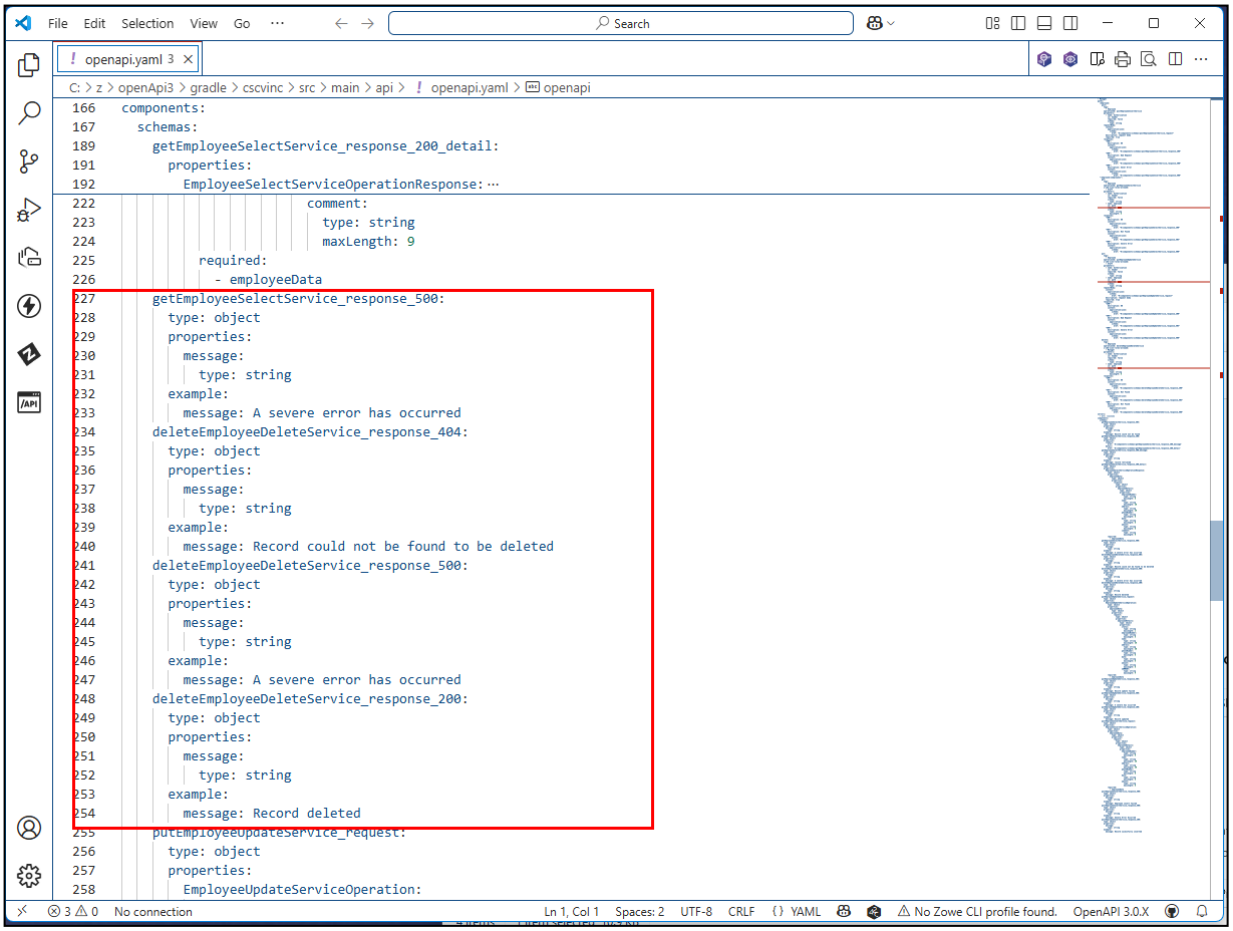
Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

The same applies for varaibles in the response message. In this case, z/OS Connect supplies the actual length of the data in the response's varaibles in the *-length* variables so the COBOL program would only work with valid data, see an example below.

```
450       *-------------------------------------------------------------*
451       * As each row is returned, save the results in a array
452       * This array will be used to populate the fields in the BMS map
453       *-------------------------------------------------------------*
454               ADD 1 to resultsIndex
455               MOVE  employeeNumber of
456                  resultsXOutput(1:employeeNumber-length)
457                  TO  employeeNumber of RESULTS(resultsIndex)
458               MOVE name of
459                  resultsXOutput(1:name-length)
460                  TO employeeName OF RESULTS(resultsIndex)
461               MOVE  phoneNumber of
462                  resultsXOutput(1:phoneNumber-length)
463                  TO employeePhone OF RESULTS(resultsIndex)
```

Remember, for both request and response message, using the *-length* variables prevents the sending and receiving of any unintentional or extraneous characters in these variables.

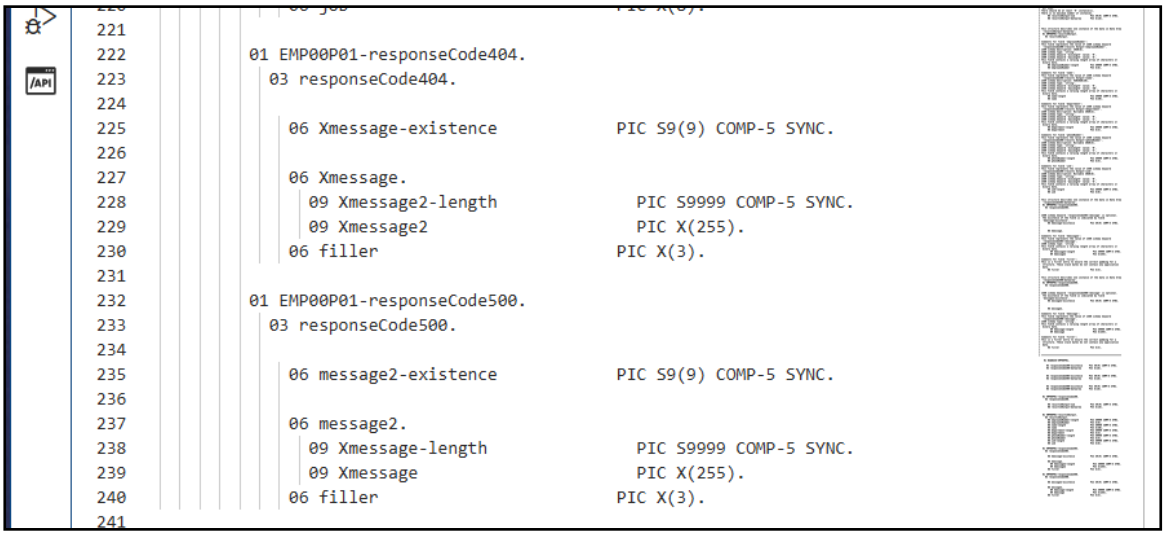
As stated above, if the length of a variable string is not contrainted or can not be deduced, the default maximum character property (*defaultCharacterMaxLength)* is used to control the COBOL being generated.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

As shown in the example below, the various *message* strings, will be genrerted as PIC X(255) variables.

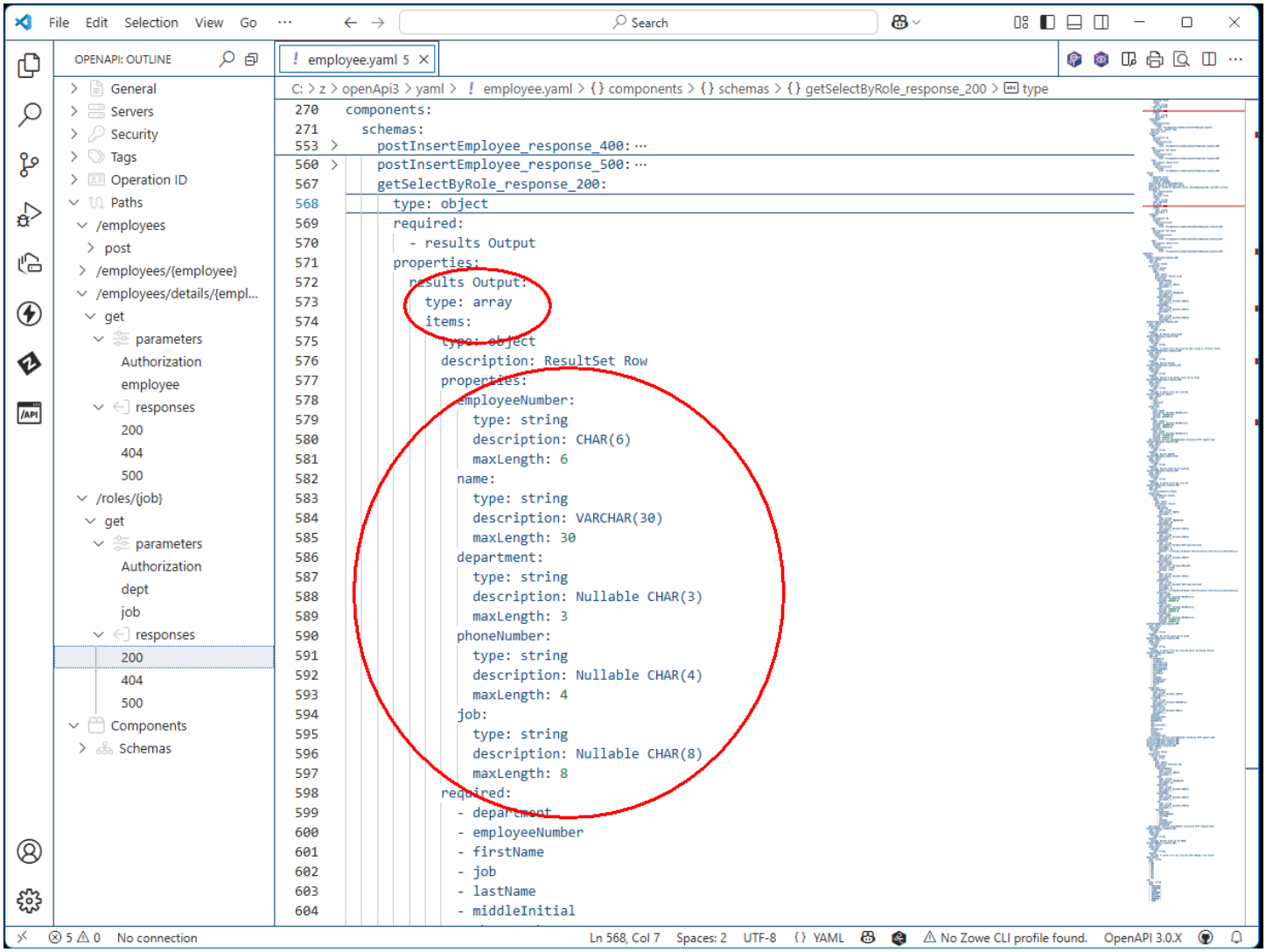


```
221
222          01 EMP00P01-responseCode404.
223            03 responseCode404.
224
225              06 Xmessage-existence           PIC S9(9) COMP-5 SYNC.
226
227              06 Xmessage.
228                09 Xmessage2-length             PIC S9999 COMP-5 SYNC.
229                09 Xmessage2                    PIC X(255).
230              06 filler                       PIC X(3).
231
232          01 EMP00P01-responseCode500.
233            03 responseCode500.
234
235              06 message2-existence           PIC S9(9) COMP-5 SYNC.
236
237              06 message2.
238                09 Xmessage-length             PIC S9999 COMP-5 SYNC.
239                09 Xmessage                    PIC X(255).
240              06 filler                       PIC X(3).
241
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

The response message for the GET method for URI path */roster/roles/{job}* is shown below:




Note that these variables are constrained with *maxLength* attributes. If this attribute were not present, the default lengths for strings would be set to the value of *defaultCharacterMaxLength.*



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

Notice that the response shown on the previous page will include an array of results (*type : array*). The number of elements in the array will be provided to the COBOL application in a variable with a ***-num*** suffix, see variable *resultsXOputput-num* in the example below:

```
202  01 EMP00P01-responseCode200.
203    03 responseCode200.
204
205      06 resultsXOutput-num            PIC S9(9) COMP-5 SYNC.
206      06 resultsXOutput-dataarea       PIC X(16).
207
```

The COBOL program will need to use the z/OS Connect BAQGETN Host API in a loop to process each entry in the array. The variable *resultsXOputput-num* will control how the number of times the loop needs to be repeated.

.

```
311      PERFORM GET-EACH-EMPLOYEE VARYING WS-index FROM 1 BY 1
312          UNTIL WS-index > resultsXOutput-num of
313            EMP00P01-responseCode200 OR
314             WS-returnCode = FAILED.
```

**N.B.:** *In this document we tried to be consistent with terminology. Some readers may use the term 'list' to refer to a set of multiple instance of an element; others may use the term 'table' for the same concept while others may use the term 'array'. In this document, they are equivalent.*



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *More about the response copy book*

The z/OS Connect Host APIs is a set of APIs that be called from a COBOL program to access z/OS Connection REST client functions. The APIs are documented in the section ***Understanding the HOST API*** at URL https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=apis-understanding-host-api

A COBOL REST client application using the Host APIs will usually make one BAQINIT (initialize the API storage and connect to the server) request, one or more BAQEXEC (execute an API) requests, one BAQFREE (free storage) request and one BAQTERM (terminate a connection) request. The number of BAQGETN (get next element) requests and their usage is based on the generated response message copy book. In this section we see how the contents of the generated response copybook determine when and how the BAQGETN requests are used in the COBOL code.

### The response copy book and the LINKAGE SECTION

The response copy book needs to be included in the LINKAGE SECTION of the COBOL program. This allows the COBOL structures defined in a LINKAGE SECTION to be used as templates for referencing data ini the storage used for inter-program communications. Overlaying the templates over the storage area allows the program to use the variables defined in these structure for referencing data in the storage area. Establishing addressability between the structure and the storage is done by using a SET ADDRESS statement to set the address of template structure to the address of the storage area as shown below.

```
251
252         *-----------------------------------------------------------------*
253         * Establish addressibilty to response message
254         *-----------------------------------------------------------------*
255             SET address of BAQBASE-EMP00P01 to BAQ-RESP-BASE-ADDRESS.
256
```

In the code above, BAQ-RESP-BASE-ADDRESs is a pointer variable that contains the address of the storage where the initial response message content resides.

The generated response copy book will begin with a *BAQBASE-**copybookName*** structure (where the string ***copybookName*** is the name of the generated copy book, e.g., *EMP00P01* as shown in the example below).

```
187
188     01 BAQBASE-EMP00P01.
189
190         03 responseCode200-existence     PIC S9(9) COMP-5 SYNC.
191         03 responseCode200-dataarea      PIC X(16).
192
193
194         03 responseCode404-existence     PIC S9(9) COMP-5 SYNC.
195         03 responseCode404-dataarea      PIC X(16).
196
197
198         03 responseCode500-existence     PIC S9(9) COMP-5 SYNC.
199         03 responseCode500-dataarea      PIC X(16).
200
201
202     01 EMP00P01-responseCode200.
203        03 responseCode200.
```

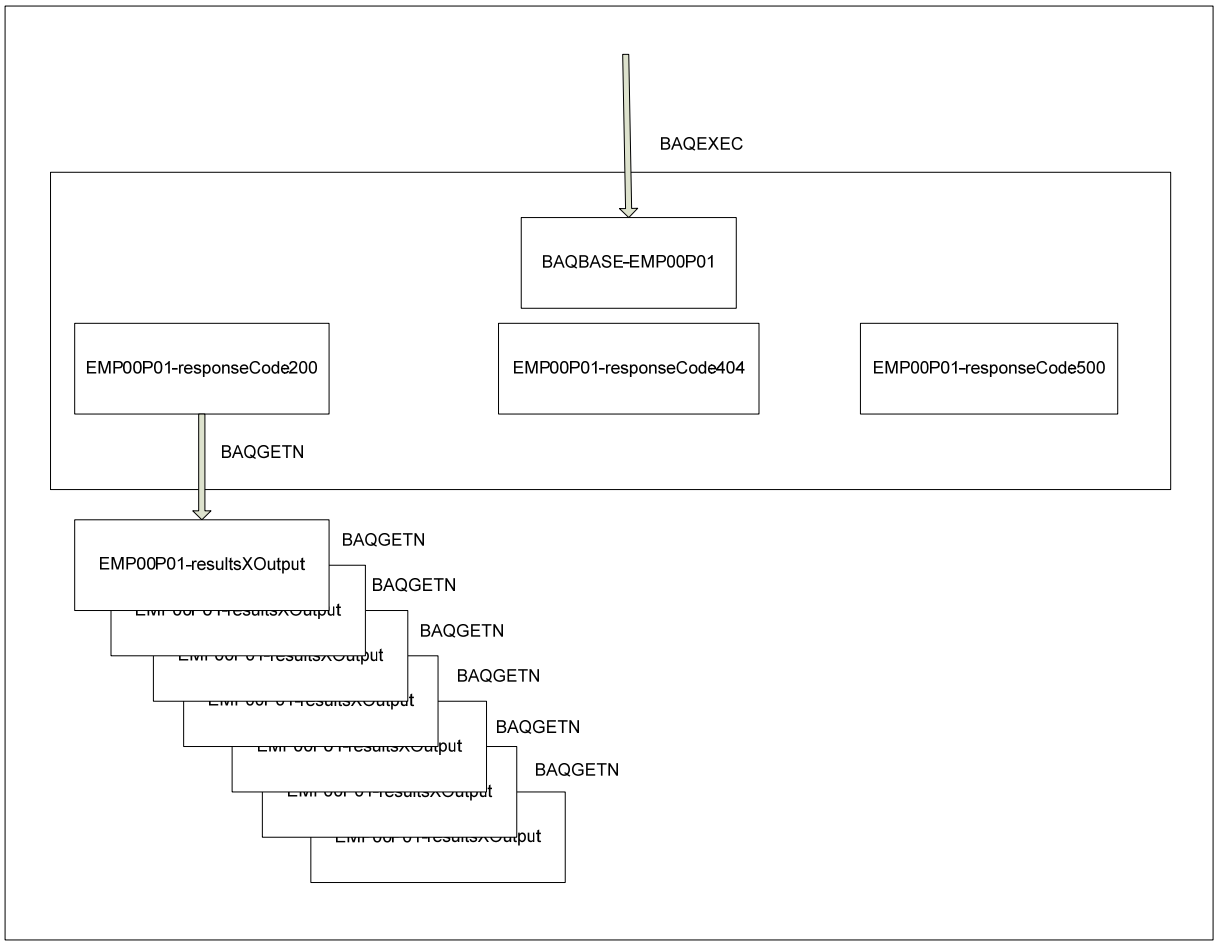


Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

In this example, the contents of the storage area represented by the BAQBASE-EMP00P01 structure are populated and a pointer address which was returned when the BAQEXEC host API is called.

```
216         *---------------------------------------------------------------*
217         * Set up the data for the API Requester call
218         *---------------------------------------------------------------*
219             SET BAQ-REQ-BASE-ADDRESS to address of BAQBASE-EMP00Q01.
220             MOVE LENGTH OF BAQBASE-EMP00Q01 TO BAQ-REQ-BASE-LENGTH.
221             SET WS-APIinfoPointer to address of BAQ-API-INFO-EMP00I01
222
223             CALL BAQ-EXEC-NAME USING
224                                  BY REFERENCE BAQ-ZCONNECT-AREA
225                                  BY VALUE WS-APIinfoPointer
226                                  BY REFERENCE BAQ-REQUEST-AREA
227                                  BY REFERENCE BAQ-RESPONSE-AREA
228                                  RETURNING WS-BAQreturnCode.
229
230             SET address of BAQBASE-EMP00P01 to BAQ-RESP-BASE-ADDRESS.
231
```

The diagram below shows the hierarchy or relationship of the structures in the Linkage section. The BAQEXEC requests populates the BAQBASE structures and the 3 response code structures. The application uses the BAQGETN request along with the -num and data area variables in the responseCode200 structure retrieve the individual resultsXOputput structures.

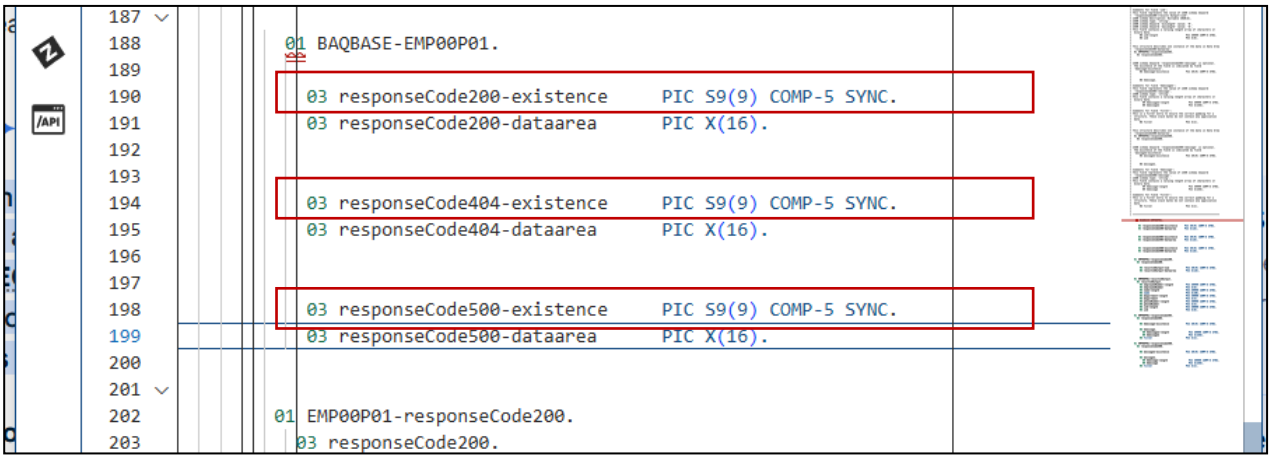





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## Determining the HTTP status code using the BAQBASE structure

The names and the number of variables in the BAQBASE-EMP00P01 structure is based on the number and occurrences of the HTTP response codes defined in the specification document. In our case there were three possible HTTP responses, e.g., 202, 404 and 500 so there were three sets of two variables for each of the possible response codes for our initial use.

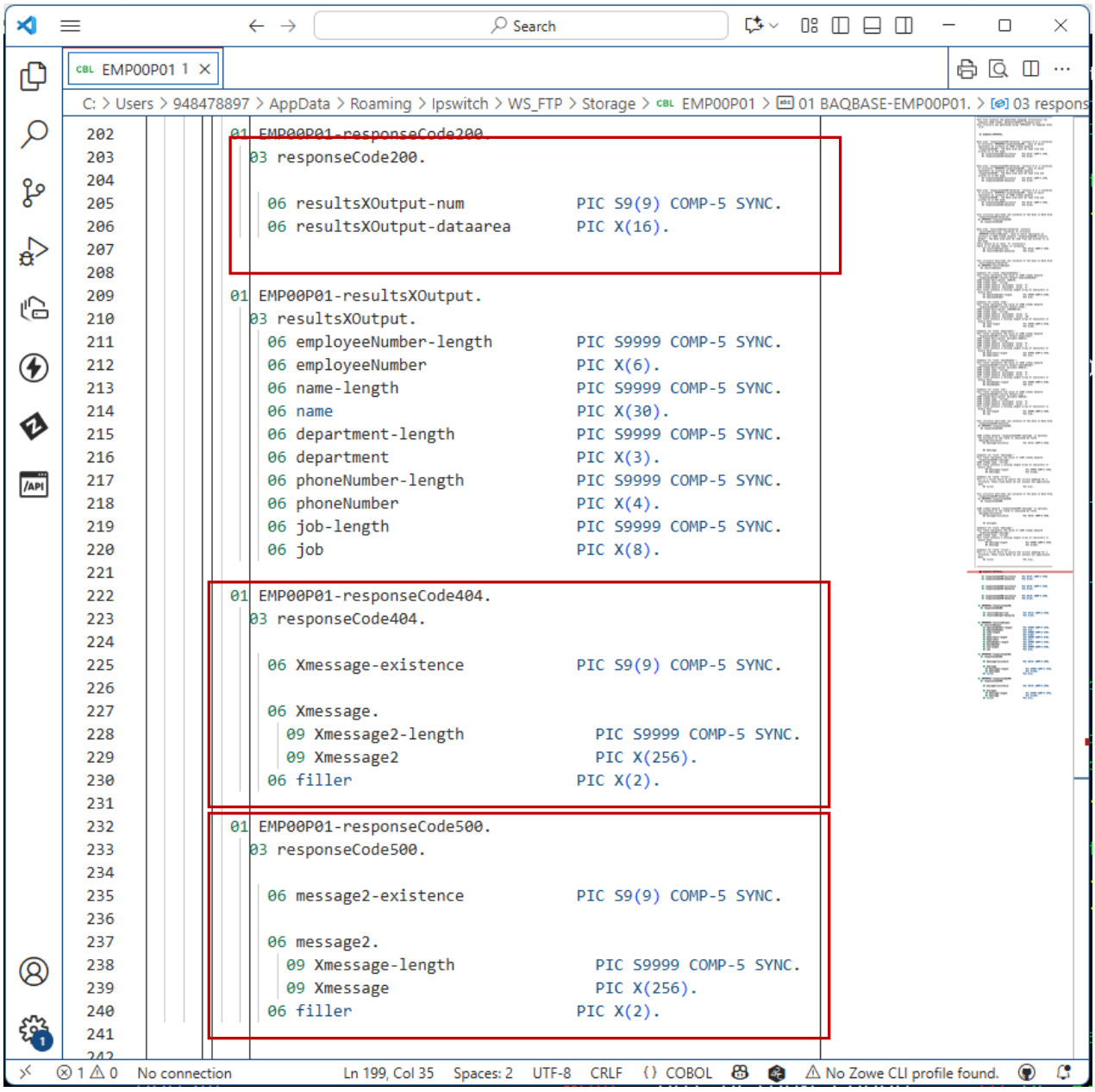



The variables with the *-existence* suffix(i.e., *responseCode200-existence*) are used by the application to determine which HTTP status code was returned when the API was executed. The client application checks to see if an existence variable associated with a specific HTTP status code has value of zero or 1. If the existence variable of a HTTP status code has a value of 1(or true), then that was the status code that was returned by BAQEXEC when the API was invoked. Otherwise, the value of the existence variable will be zero (or false). The variable with the *-dataarea* suffix(i.e., *responseCode200-dataarea*) provides a key or index that can be used to return or retrieve additional information with a BAQGETN request and we will see how it is used shortly.



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

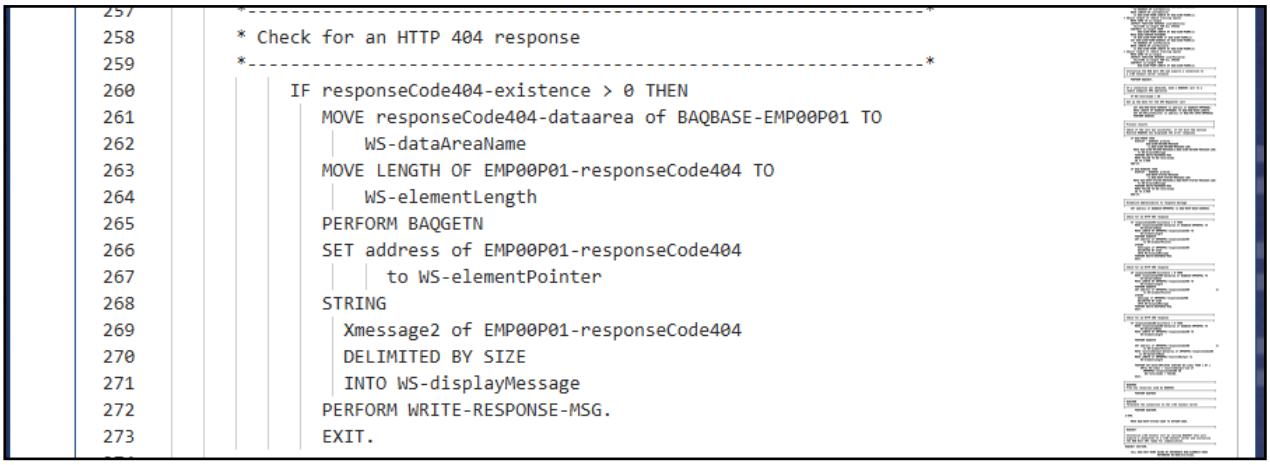
Knowing which HTTP status code was returned is not sufficient. The response message for each HTTP code will have a different layouts or mappings. Each of the HTTP status code response message mappings are also present in the response copybook. For this API the different response message mapping structures are shown below, these response structures have the string *responseCode* embedded in their structure name, e.g., *EMP00P01-responseCode-404*. Again, these structures are acting as templates representing the different possible response message layouts.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

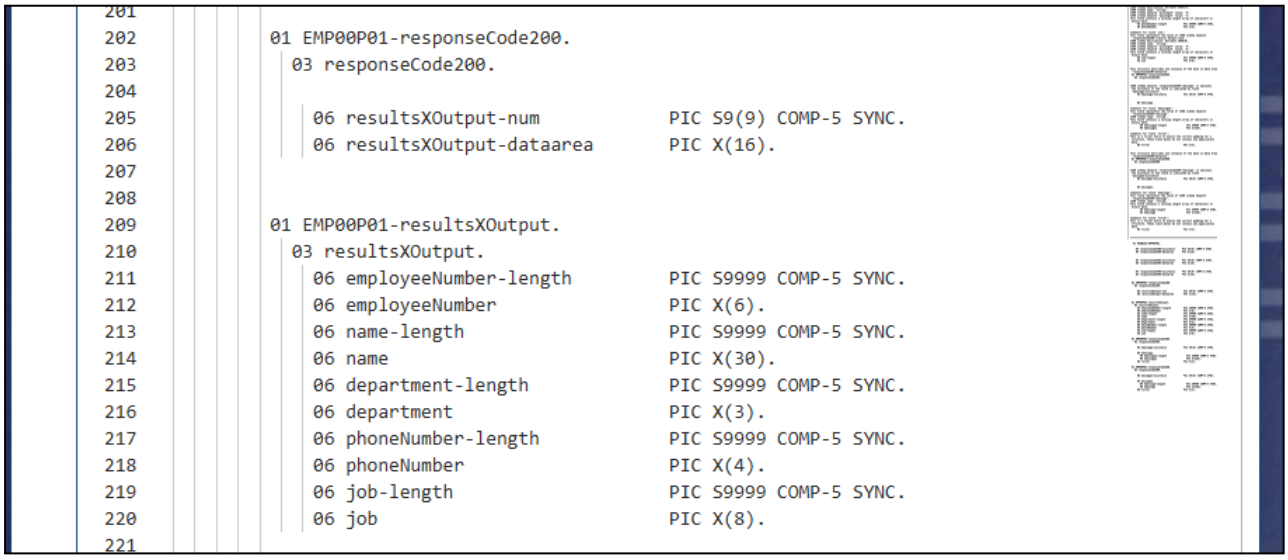
The application can determine which HTTP status was returned using the *-existence* variables. And now using the data area variable and information about the length of the response message, the application can call the BAQGETN request to retrieve the message specific to the HTTP status code and establish addressability to the response message storage area as shown below in an example below for an HTTP 404 response. Line 260 checks to see if the HTTP response was a 404 or not. Line 261 through 264 uses the index data area for retrieving the 404-response message and the length of the response message. Line 265 calls the BAQGETN API. Lines 266 through 267 establishes addressability to the 404-response message and sets up the COBOL mapping for this response.



```
257         *-----------------------------------------------------------------*
258         * Check for an HTTP 404 response
259         *-----------------------------------------------------------------*
260             IF responseCode404-existence > 0 THEN
261               MOVE responseCode404-dataarea of BAQBASE-EMP00P01 TO
262                  WS-dataAreaName
263               MOVE LENGTH OF EMP00P01-responseCode404 TO
264                  WS-elementLength
265               PERFORM BAQGETN
266               SET address of EMP00P01-responseCode404
267                   to WS-elementPointer
268               STRING
269                 Xmessage2 of EMP00P01-responseCode404
270                 DELIMITED BY SIZE
271                 INTO WS-displayMessage
272               PERFORM WRITE-RESPONSE-MSG.
273               EXIT.
```

## Handling Multiple occurrences (arrays)

Using these *existence* and *dataarea* variables, the coding is simple and straight-forward for the 404 and 500 HTTP response. Handling a HTTP 200 is little more complex. Notice that the *EMP00P01-responseCode200* structure has embedded data area (*resultsXOputput-dataarea)* and a variable with a *-num* suffix. This means that when HTTP 200 is returned for the HTTP status code, the response will contain an array of multiple elements.



```
201
202         01 EMP00P01-responseCode200.
203           03 responseCode200.
204
205             06 resultsXOutput-num           PIC S9(9) COMP-5 SYNC.
206             06 resultsXOutput-dataarea      PIC X(16).
207
208
209         01 EMP00P01-resultsXOutput.
210           03 resultsXOutput.
211             06 employeeNumber-length        PIC S9999 COMP-5 SYNC.
212             06 employeeNumber               PIC X(6).
213             06 name-length                  PIC S9999 COMP-5 SYNC.
214             06 name                         PIC X(30).
215             06 department-length            PIC S9999 COMP-5 SYNC.
216             06 department                   PIC X(3).
217             06 phoneNumber-length           PIC S9999 COMP-5 SYNC.
218             06 phoneNumber                  PIC X(4).
219             06 job-length                   PIC S9999 COMP-5 SYNC.
220             06 job                          PIC X(8).
221
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

And each element in the array must be mapped individually to *EMP00P01-resultsXOutput* using a BAQGETN API call. So, when an HTTP 200 is returned with an array of elements, there will be one BAQGETN invoked to obtain addressability to the *EMP00P01-responseCode200* storage area and *resultsXOputput-num* requests for BAQGETN to obtain addressability to each element in the array.

In the code below,

- Line 25 checks to see if an HTTP 200 status code was returned.
- Lines 26 through 29 sets up for the first BAGETN request to establish addressability for structure EMP00P01-responseCode200. This structure has the number of entries returned and the initial data area index. Lines 31 through 36 set up the parameters for the BAGETN request to retrieve the first element in the array of returned items.
- Lines 37 through 40 is loop for processing each element in the array until all have been processed.

```
1   LINKAGE SECTION.
2
3       01 BAQBASE-EMP00P01.
4         03 responseCode200-existence     PIC S9(9) COMP-5 SYNC.
5         03 responseCode200-dataarea      PIC X(16).
6       01 EMP00P01-responseCode200.
7         03 responseCode200.
8           06 resultsXOutput-num            PIC S9(9) COMP-5 SYNC.
9           06 resultsXOutput-dataarea       PIC X(16).
10      01 EMP00P01-resultsXOutput.
11        03 resultsXOutput.
12          06 employeeNumber-length         PIC S9999 COMP-5 SYNC.
13          06 employeeNumber                PIC X(6).
14          06 name-length                   PIC S9999 COMP-5 SYNC.
15          06 name                          PIC X(30).
16          06 department-length             PIC S9999 COMP-5 SYNC.
17          06 department                    PIC X(3).
18          06 phoneNumber-length            PIC S9999 COMP-5 SYNC.
19          06 phoneNumber                   PIC X(4).
20          06 job-length                    PIC S9999 COMP-5 SYNC.
21          06 job                           PIC X(8).
22
23      PROCEDURE DIVISION.
24
25        IF responseCode200-existence > 0 THEN
26          MOVE responseCode200-dataarea of BAQBASE-EMP00P01 TO
27             WS-dataAreaName
28          MOVE LENGTH OF EMP00P01-responseCode200 TO
29             WS-elementLength
30          PERFORM BAQGETN
31          SET address of EMP00P01-responseCode200
32            to WS-elementPointer
33          MOVE resultsXOutput-dataarea of EMP00P01-responseCode200
34            to WS-dataAreaName
35          MOVE LENGTH of EMP00P01-resultsXOutput to
36             WS-elementLength
37          PERFORM GET-EACH-EMPLOYEE VARYING WS-index FROM 1 BY 1
38             UNTIL WS-index > resultsXOutput-num of
39               EMP00P01-responseCode200 OR
40                WS-returnCode = FAILED.
41          EXIT.
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

- Lines 45 through 47 establishes addressability to an entry in the array.
- Lines 48 through 56 use the template variables to access specific data in the entry.
- Line 59 through 71  used the BAQGETN request to process the next element in the array, establish addressability to the storage where details of the elements and uses the mapped variables to access the element's information.

.

```
43          GET-EACH-EMPLOYEE SECTION.
44              PERFORM BAQGETN
45              SET address of EMP00P01-resultsXOutput
46                  to WS-elementPointer
47              ADD 1 to resultsIndex
48              MOVE employeeNumber of
49                resultsXOutput(1:employeeNumber-length)
50                TO employeeNumber of RESULTS(resultsIndex)
51              MOVE name of
52                resultsXOutput(1:name-length)
53                TO employeeName OF RESULTS(resultsIndex)
54              MOVE phoneNumber of
55                resultsXOutput(1:phoneNumber-length)
56                TO employeePhone OF RESULTS(resultsIndex)
57              EXIT.
58
59          BAQGETN SECTION.
60              CALL BAQ-GETN-NAME USING
61                BY REFERENCE BAQ-ZCONNECT-AREA
62                WS-dataAreaName
63                BY REFERENCE WS-elementPointer
64                BY REFERENCE WS-elementLength
65                RETURNING WS-BAQreturnCode.
66              MOVE BAQ-ZCON-COMPLETION-CODE TO WS-completionCode.
67              MOVE BAQ-ZCON-REASON-CODE TO WS-reasonCode.
68              IF NOT BAQ-SUCCESS THEN
69                 MOVE FAILED TO WS-returnCode
70              END-IF.
71              EXIT.
```

The purpose of this section was to show how the response copy book needs to be reviewed and understood before developing the COBOL request client application.



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

# Deploying the API Requester WAR file

Next the API requester ***w***eb application ***ar***chive (WAR) was deployed and made available to the z/OS Connect server.

Creating the API requester WAR and generating the associated COBOL copy books is done by running the Gradle build process. This build process is documented in section *Generating the artifacts for an API requester* at URL https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=30-generating-artifacts-api-requester. These instructions are fine but one of our goals was to do the build on z/OS. The details of our process are described in the *Gradle on z/OS* section of this document on page 40.

## *Server XML configuration Updates*

We updated the z/OS Connect server where the API requester will be installed with these configuration elements. The <*webApplication/*> configuration element defined the API requester application and provided the directory where the WAR file is located. An override is provided for the *connectionRef* attribute is provided just to show how it can be done.

```
<server description="API Requester">
   <!-- Enable features -->
   <featureManager>
       <feature>zosconnect:oasRequester-1.0</feature>
   </featureManager>

<webApplication id="Employee Roster API application"
  location="${server.config.dir}/apps/roster.war"
  name="roster">
  <appProperties>
      <property name="connectionRef" value="DB2SSID"/>
  </appProperties>
</webApplication>

!-- The location of the API being called -->
zosconnect_endpointConnection id="DB2SSID"
    host="http://wg31.washington.ibm.com"
    domainBasePath="/roster"
    port="9082"
    authenticationConfigRef="zosconnectBasicAuthConfig"/>

<zosconnect_authData id="zosconnectBasicAuthConfig"
     password="USER1"
     user="user1"/>

</server>
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *Make the WAR file available to the server*

The Gradle generated WAR file needs to be placed in the directory identified by the *location* attribute. We used two techniques to do this. The first was simply to copy the WAR file into a directory known by the z/O Connect API requester server. The second method was to use a Liberty managed bean (MBean) and the *curl* command to install the WAR file into the directory. The advantage of using the MBean with curl is that this technique is that it can be used regardless of the platform on which the WAR file was created, e.g., Windows, z/OS, Linux, etc.

### Using the OMVS copy (cp) command

A simple method was to copy the API requester WAR file to the API requester server's application directory using OMVS copy(cp) command.

```
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET WARDIR='/u/johnson/gradle/roster/build/libs'
// SET WARFILE='roster.war'
// SET WLPUSER='/var/ats/zosconnect'
// SET SERVER='OAS3ApiRequester'
//COPY EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
export WARDIR=&WARDIR; +
export WARFILE=&WARFILE; +
export WLPUSER=&WLPUSER; +
export SERVER=&SERVER; +
cp  $WARDIR/$WARFILE $WLPUSER/servers/$SERVER/apps
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

### Using the curl command

Another option we used was the cURL command to 'upload' the WAR file to the application directory using a Liberty provided Manage Bean (MBean).

```
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET WARDIR='/u/johnson/gradle/roster/build/libs'
// SET WARFILE='roster.war'
// SET WLPUSER='/var/ats/zosconnect'
// SET SERVER='OAS3ApiRequester'
//COPY EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
export WARDIR=&WARDIR; +
export WARFILE=&WARFILE; +
export WLPUSER=&WLPUSER; +
export SERVER=&SERVER; +
curl -X POST --user user1:user1 -insecure +
 --header "Content-Type: application/zip" +
 --data-binary @$WARDIR/$WARFILE -v -w " -HTTP CODE: %{http_code}" +
 https://wg31.washington.ibm.com:9465/IBMJMXConnectorREST/file/+
$WLPUSER/servers/$SERVER/apps/$WARFILE
```

The *curl* command used in the JCL above was provided by the installation of the IBM Open Enterprise Foundation for z/OS product, for more information see URL https://www.ibm.com/docs/en/oefzos

## *Security Updates*

The z/OS Connect server where the API requester will be installed had SAF security enabled which meant that an EJBRole SAF resource had to be defined and permission given to any identity who needed to access the API requester. This was done by using the RACF RDEFINE commands below:

- ***Define the EJBRole resource***

```
rdefine ejbrole BBGZDFLT.roster.invoke  uacc(read)
setropts raclist(ejbrole) refresh
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

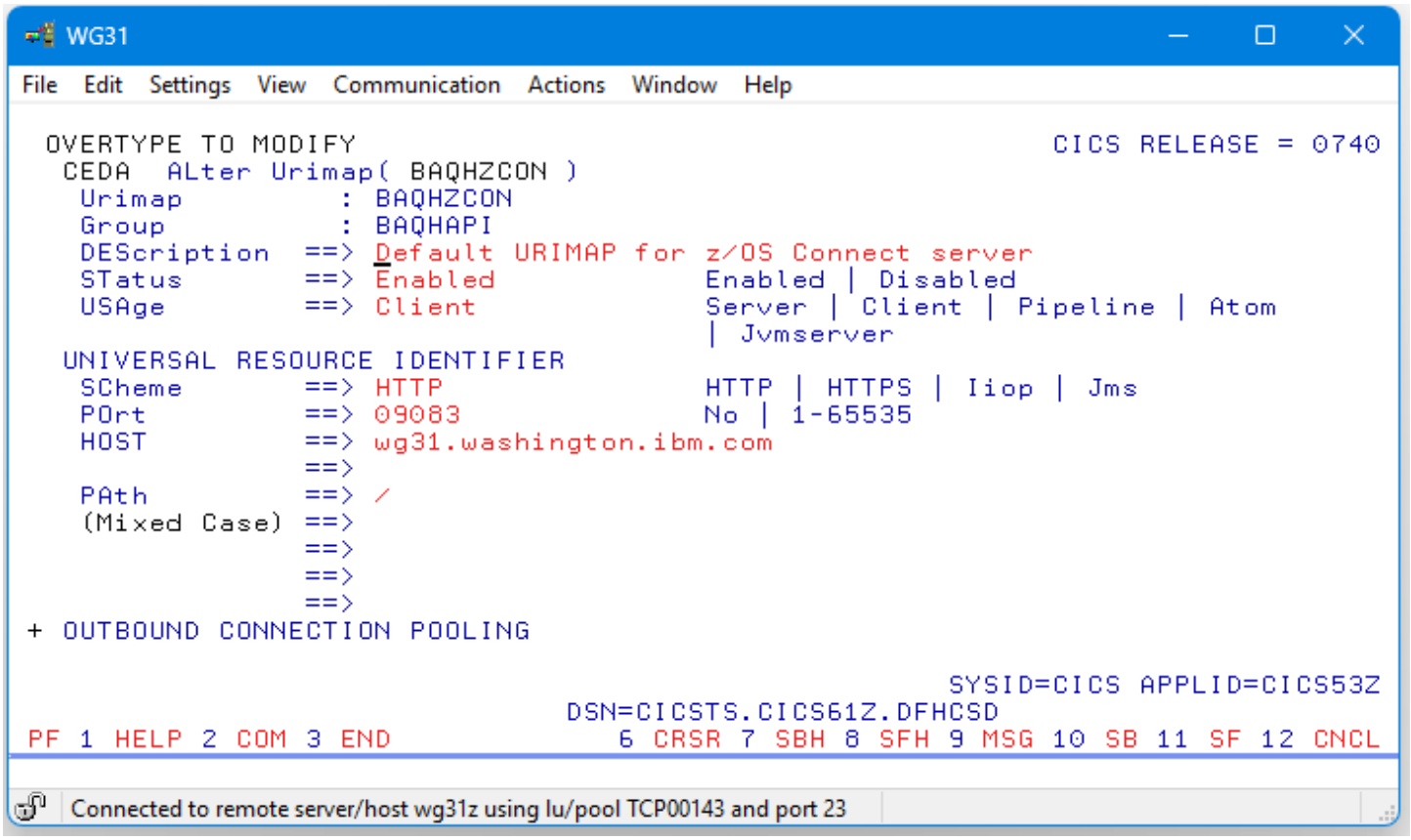
## *CICS Updates*

We added z/OS Connect API requester support to the CICS region by performing these tasks.

___1. The DFHCSDUP utility was used to add the CICS resource definitions in member BAQHCSD in data set SBAQSAMP to the CICS region's CSD file. The group BAQHAPI was then added to a group list entry in the CICS region's GRPLIST SIT parameter and then the group was installed using the CEDA transaction.

___2. The z/OS Connect SBAQLIB1 SMP/E target data set to added to the DFHRPL DD list in the region's startup JCL.

___3. The API HOST API by default uses the BAQHZCON resource defined to CICS to locate the z/OS Connect server where the request will be sent. The BAQHZCON URIMAP entry installed in Step 1 was modified to our local values for host and port. The Path was changed to be just a single slash, see below.





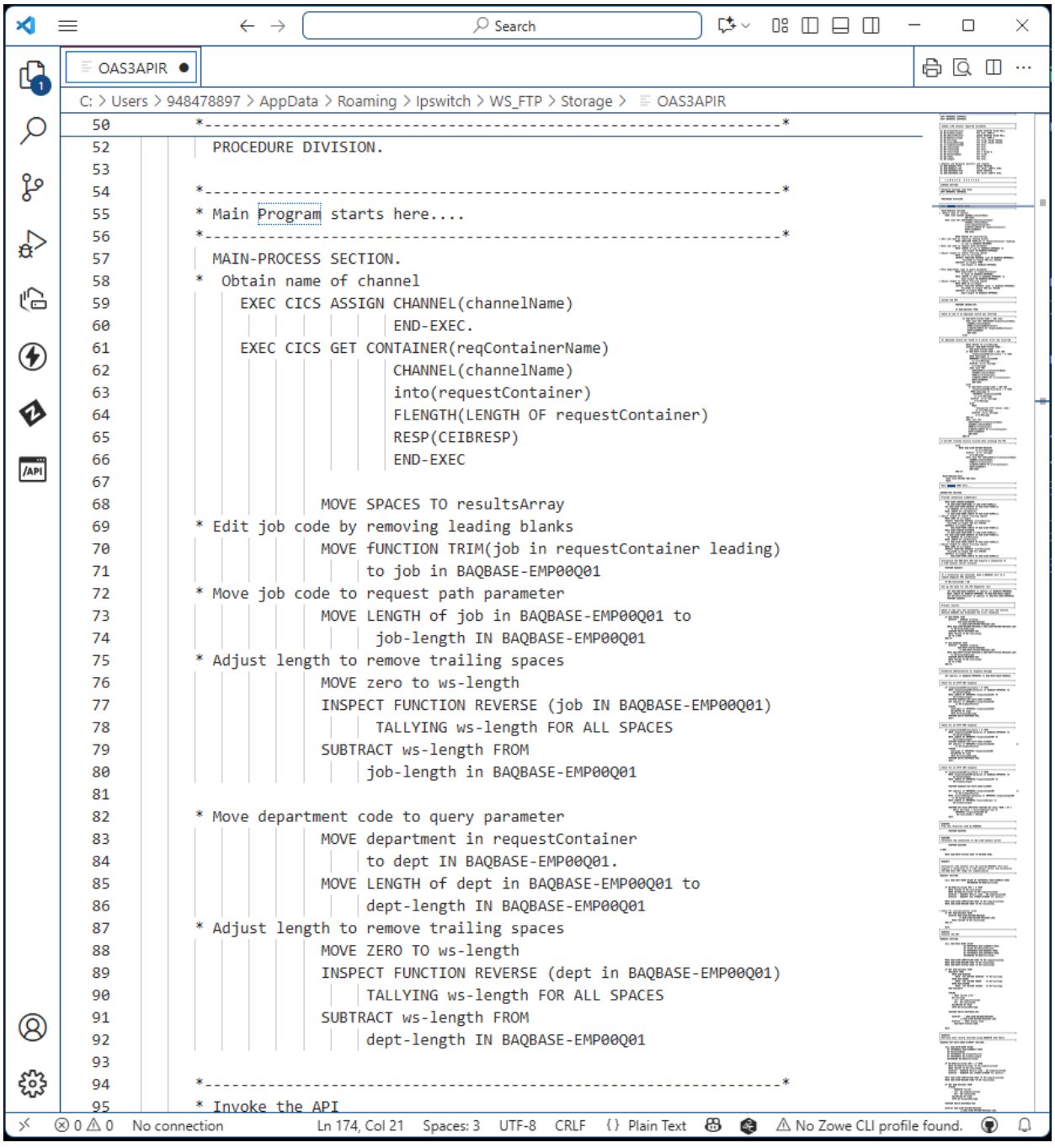

Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

# The CICS API requester client application

Let us review the CICS application as it was coded to use the z/OS Connect Host APIs.

## *MAIN-PROCESS SECTION*

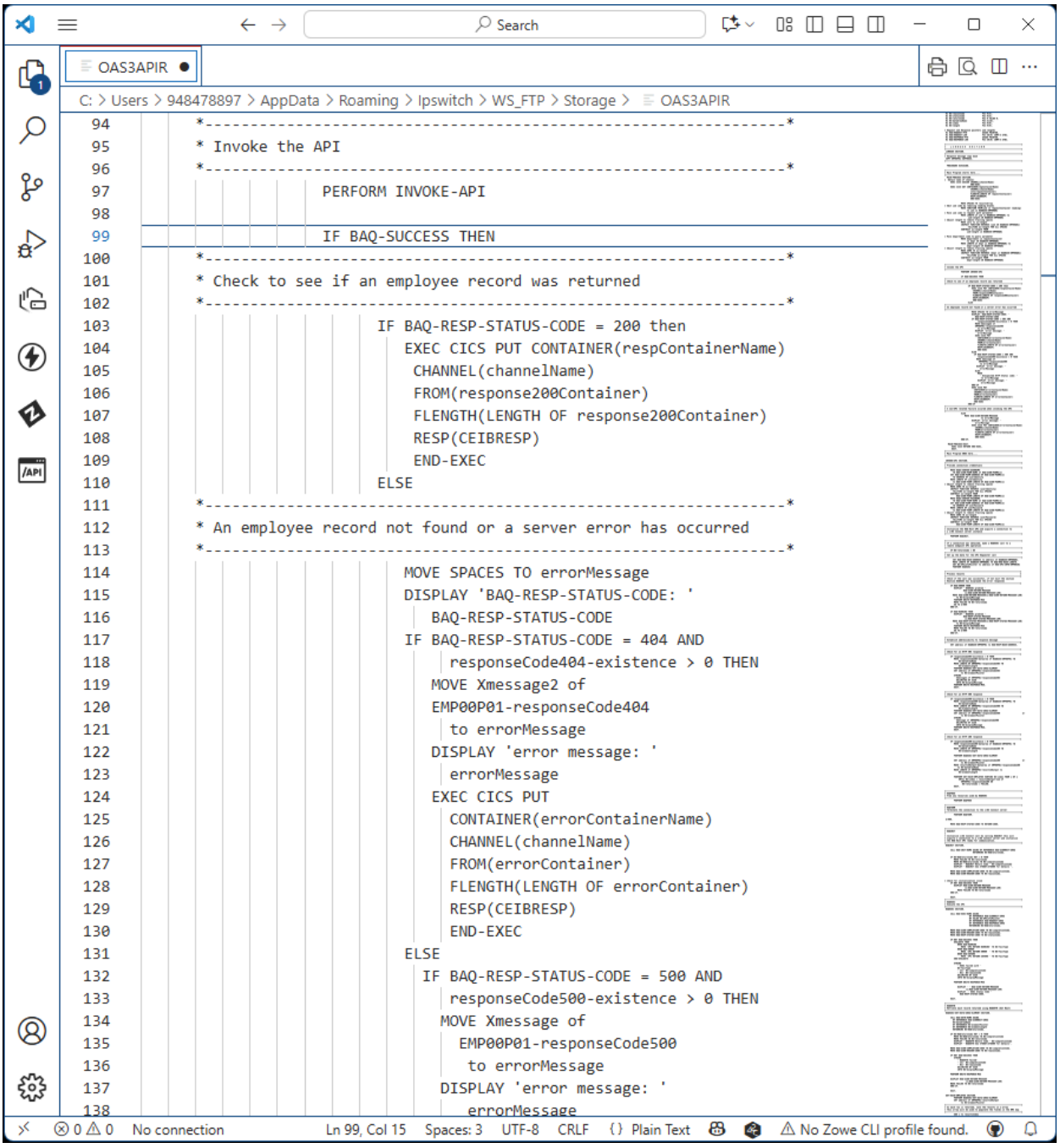
In the MAIN-PROCESS section of the application, the request container is retrieved from the channel (line 61). The request container contents are moved to the variables in API request message. Some minor editing of the contents of the fields is done and the length of each field is calculated and stored in the API request message (lines 69-92).






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

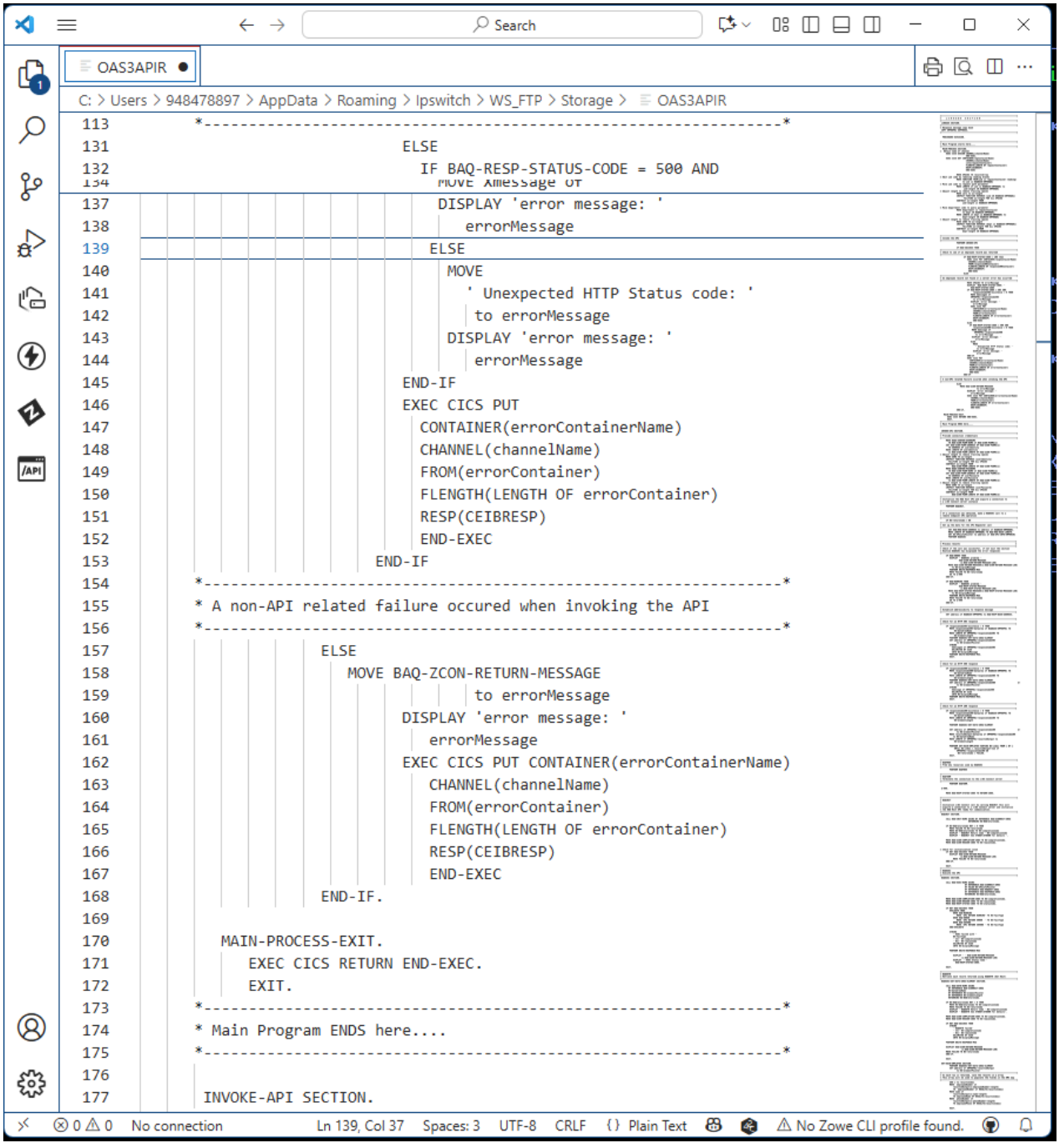
The execution of the Host APIs is performed in procedure INVOKE-API. Upon return, the results are checked for a HTTP 200 status code (line 103). If true, the results are placed in an “200” response container (line 104) and the container is returned in the channel. Otherwise, a check is made for a HTTP 404 (line 117) or a HTTP 500 (line 132) status codes. For either, the corresponding message from the status code’s response area is moved to a message variable in an error container and the container is returned in the channel  (lines 124 and 146).






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

Finally, checks for errors that are not caused by invoking the z/OS Connect API requester and are returned to the caller with as much information as possible (line 162).

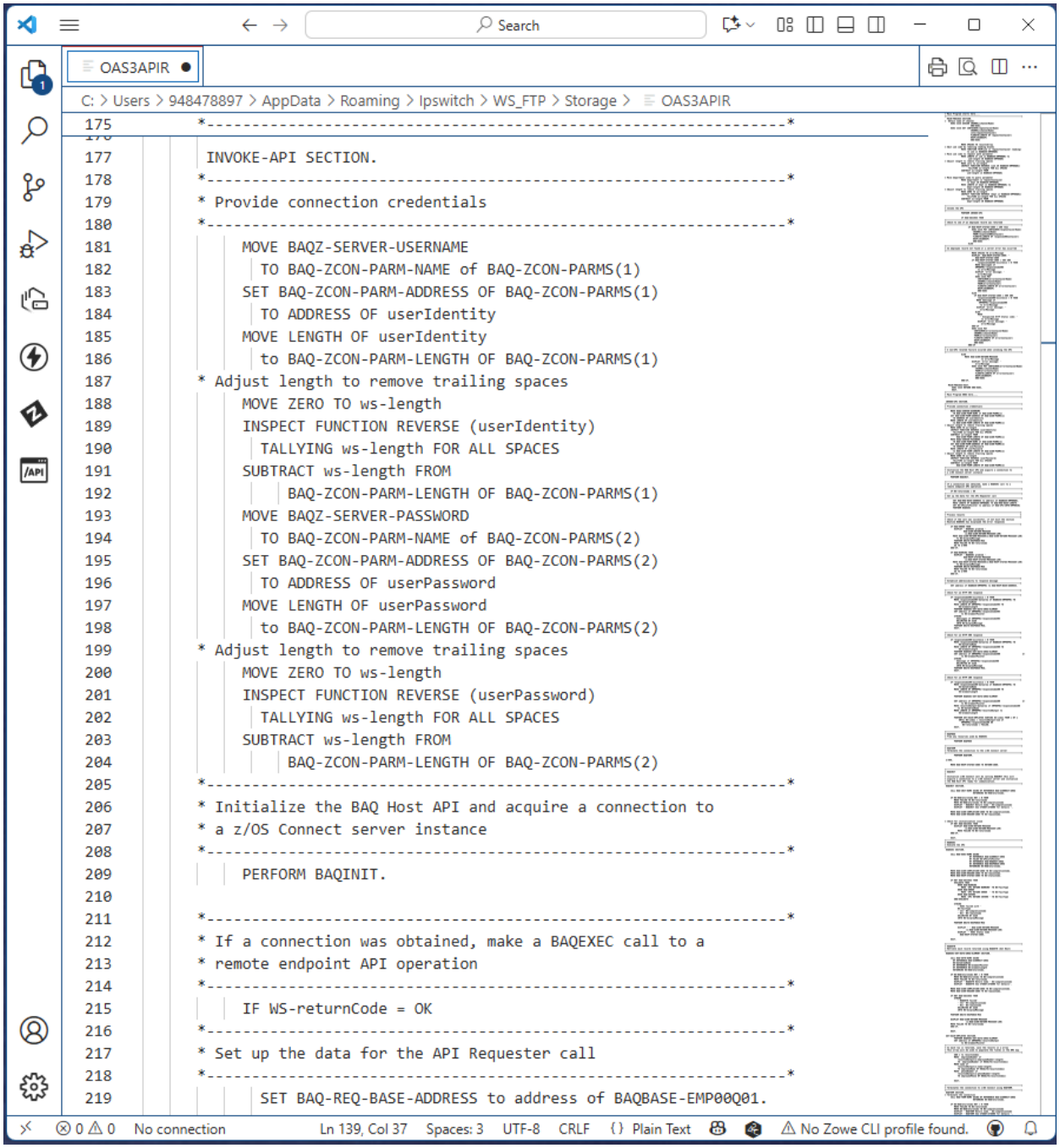





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *INVOKE-API SECTION*

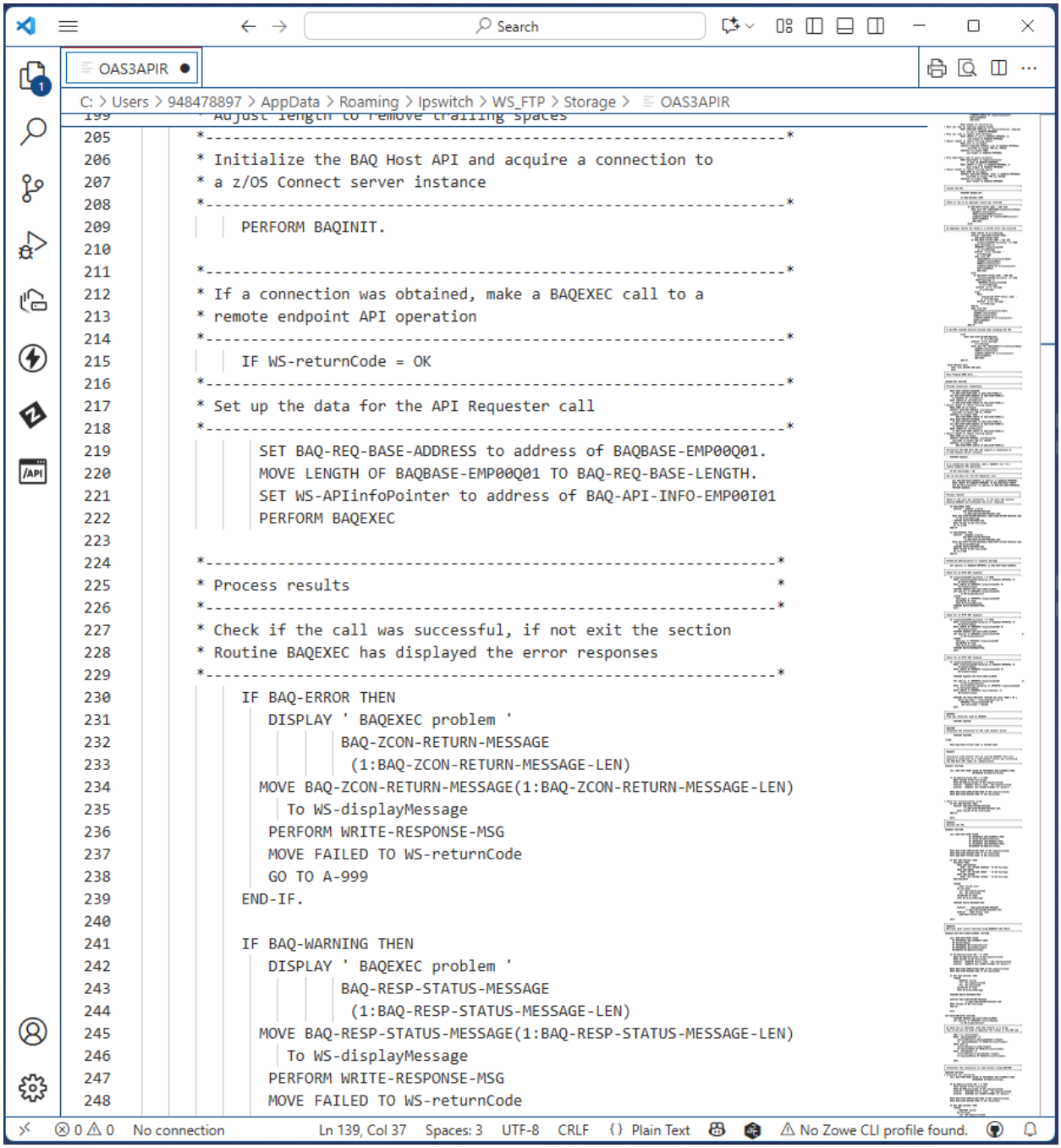
For clarity, each of the HOST APIs were coded in separate procedure sections and each section is driven by PERFORM statements in the INVOKE-API section. The INVOKE-API section starts by providing the connection properties to be used to establish the connection to the z/OS Connect server. In this application the identity(BAQZ-SERVER-USERNAME) (lines 181-192) and password(BAQZ-SERVER-PASSWORD) (lines 193-204) are provided. Other connection properties that can be provided are BAQZ-SERVER-URIMAP for CICS clients and BAQZ-SERVER-HOST and BAQZ-SERVER-PORT for other non-CICS clients. The full set of available properties are provided in the BAQHCONC copy book in the product's SBAQCOB data sets.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

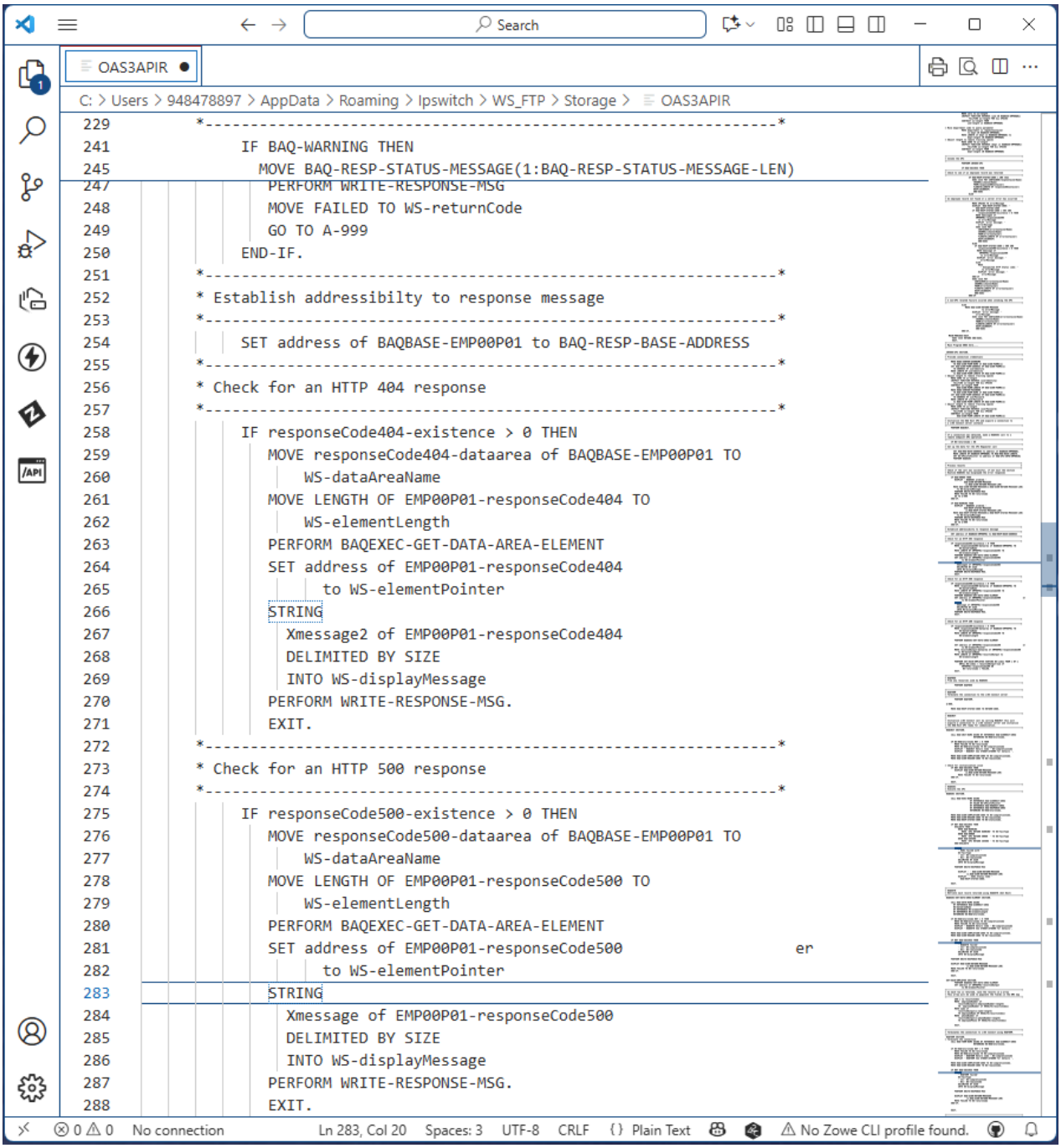
Once the connection properties are set,  perform the BAQINIT section (line 209) and upon return,  check the results (line 215). If no issues were encountered connecting to the server, set up the parameter for invoking the BAQEXEC API (lined 219-221) and then perform the BAQEXEC section and start checking its results (lines 230-248.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

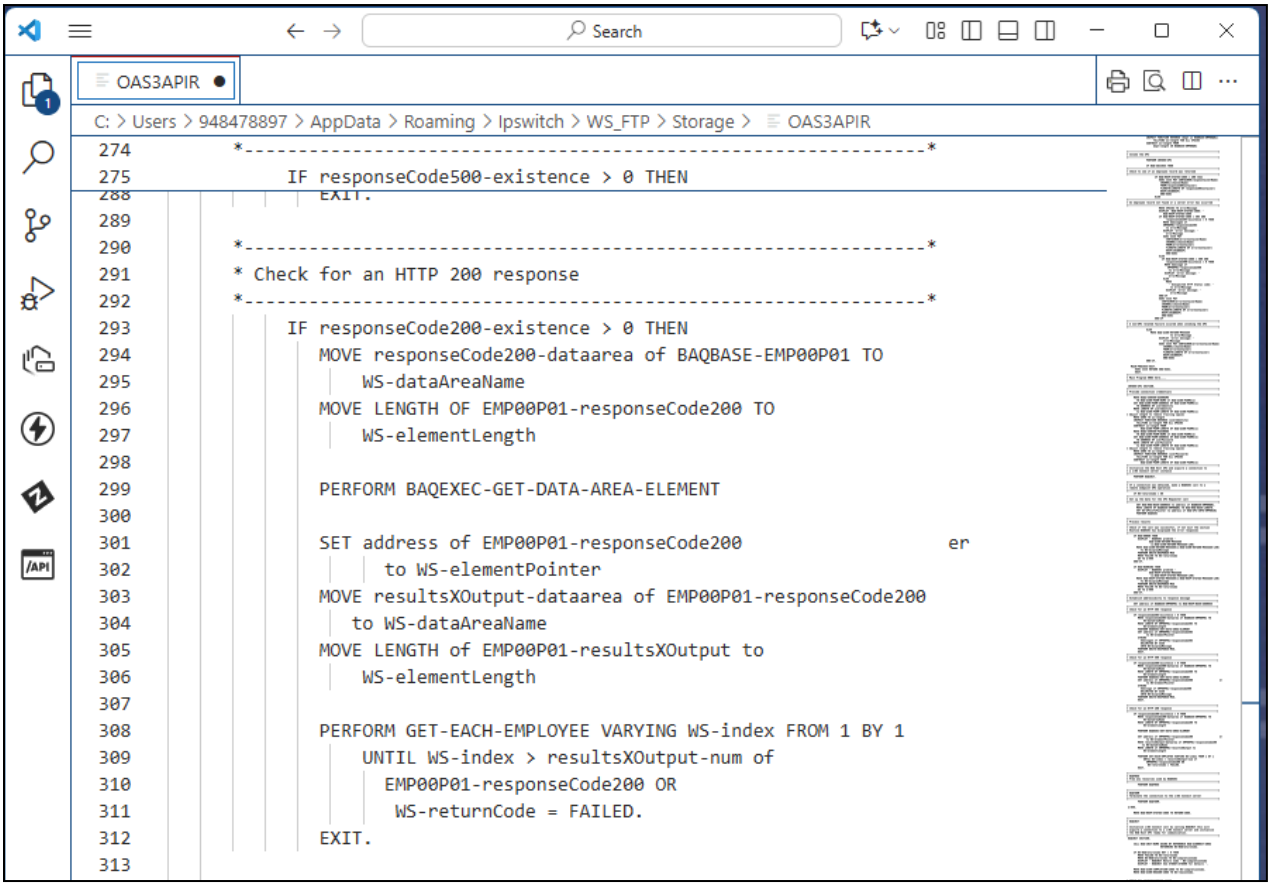
If the API was successfully executed, establish addressability from the linkage section structure in the COBOL application to the address where the initial results are located (line 254). Access the linkage area storage and see if an HTTP status code 404 (line 258) or an HTTP status code 500 (line 275) was returned. If either occurred, access the details of the results (line 259 or 276) and return to the main section.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

The INVOKIE-API continues by checking for a HTTP 200 response (line 293). If the response were a HTTP 200, an array with multiple entries could have been returned. First establish addressability to the HTTP 200 response area (line 294-297). Invoke a BAQGETN request in procedure BAQEXEC-GETUse the 200-response area to obtain addressability to the array (line 301-306).
Iterate for each item in the array performing section GET-EACH-EMPLOYEE starting with item 1 until the number of items have been processed(lines 308-311).

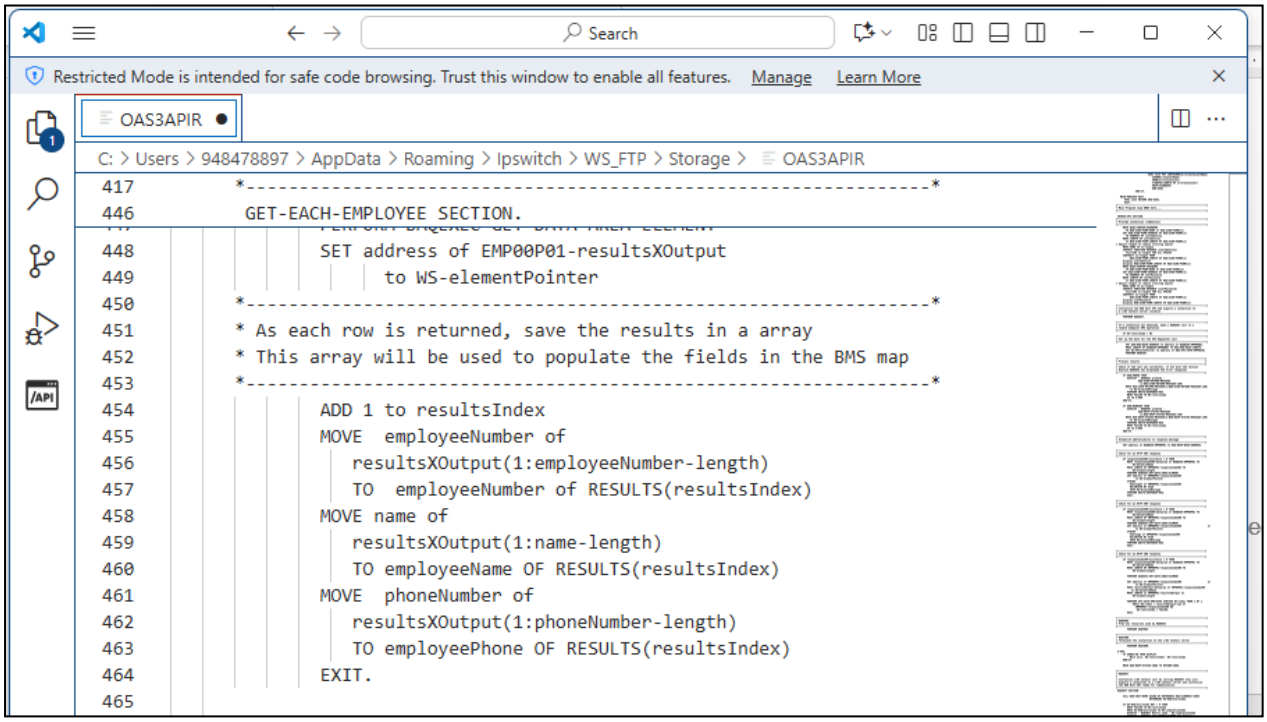





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *GET-EACH-EMPLOYEE SECTION*

This section processes each entry in the array returned by the BAQGETN Host API. Note that it sets the address of the EMP00P01-resultsXOutputet to the pointer returned by BAGETN(line 448). It then adds one to the counter index (line 454) and then uses the length of each returned file to move the data from the linkage area storage to a local array (line 455 to 463)

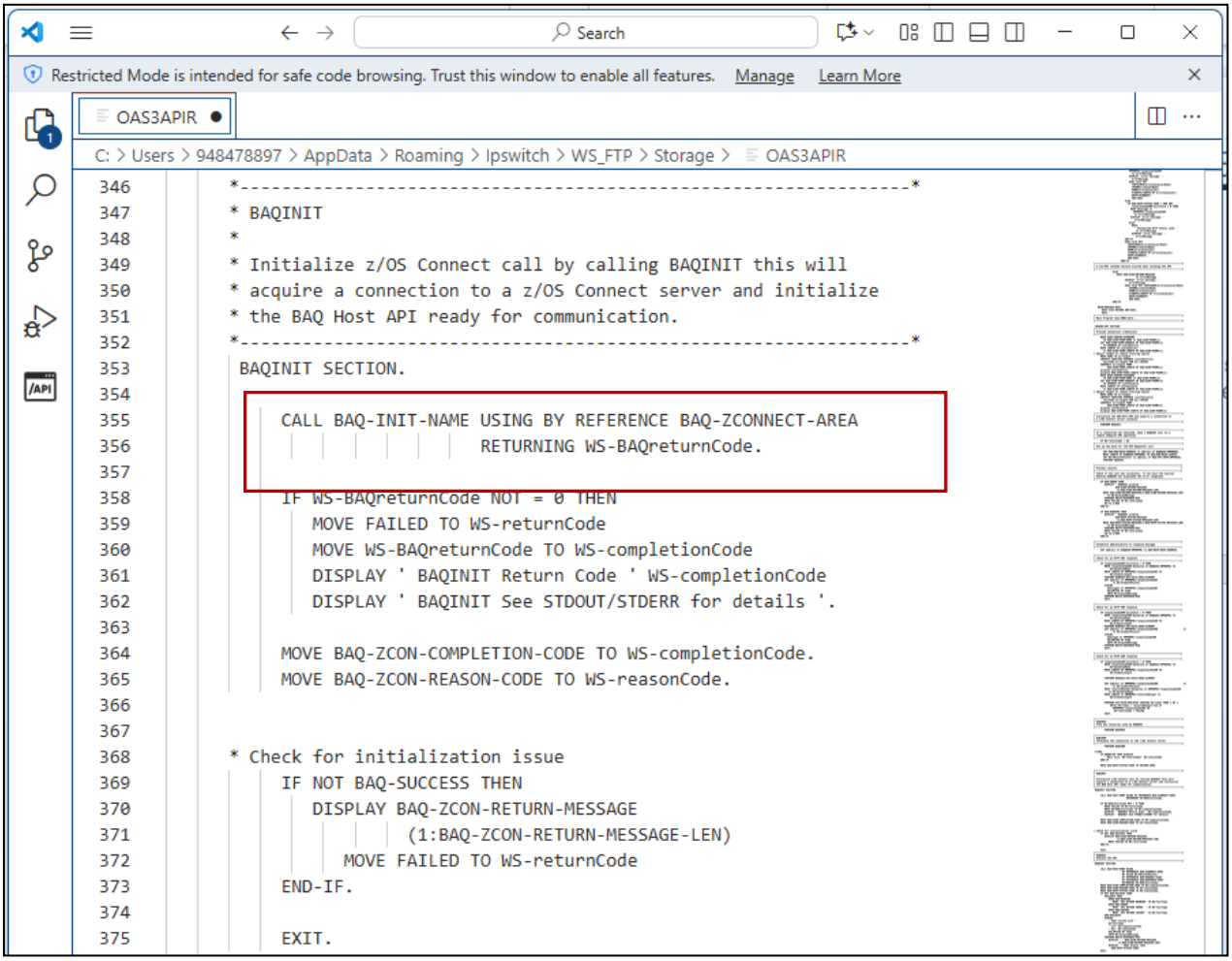





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *BAQINIT SECTION*

Invoke the Host API that connects to the z/OS Connect server.

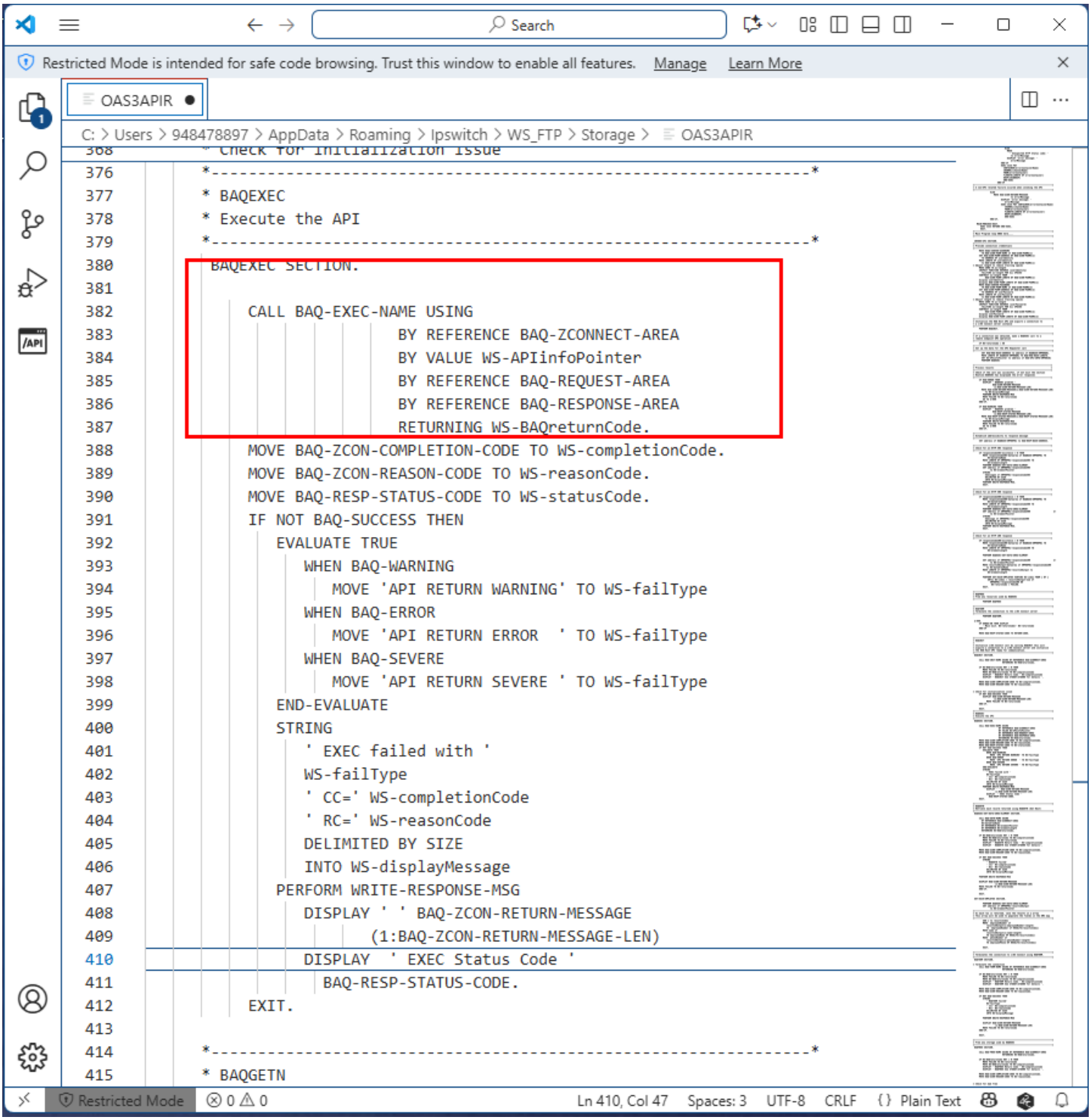





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *BAQEXEC SECTION*

Scroll down further and you will the call to the z/OS Connect API requester stub

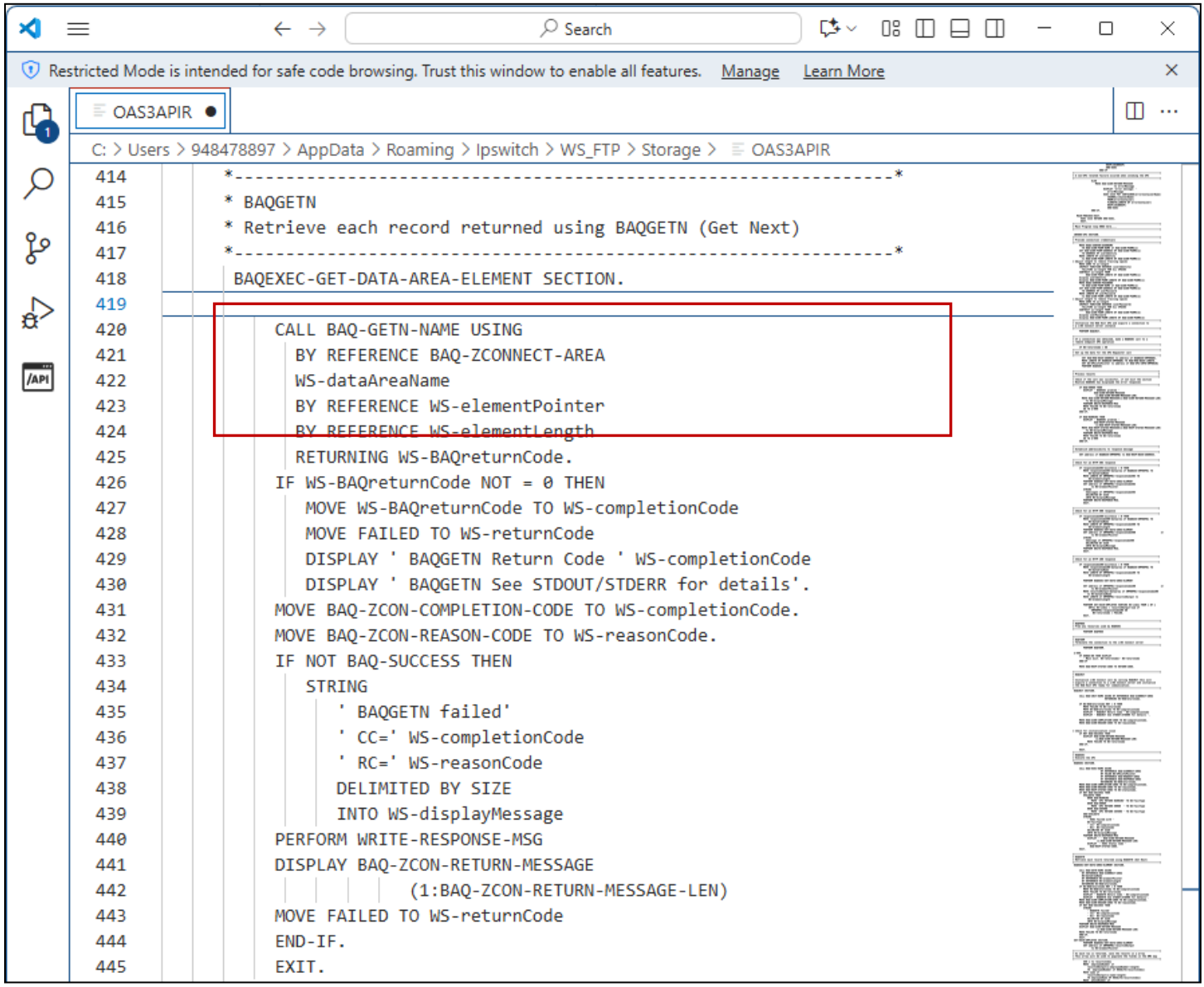





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *BAQEXEC-GET-DATA-NAME SECTION (BAQGETN)*

Section BAQEXEC-GET-DATA-NAME is invoked from various sections within the application.

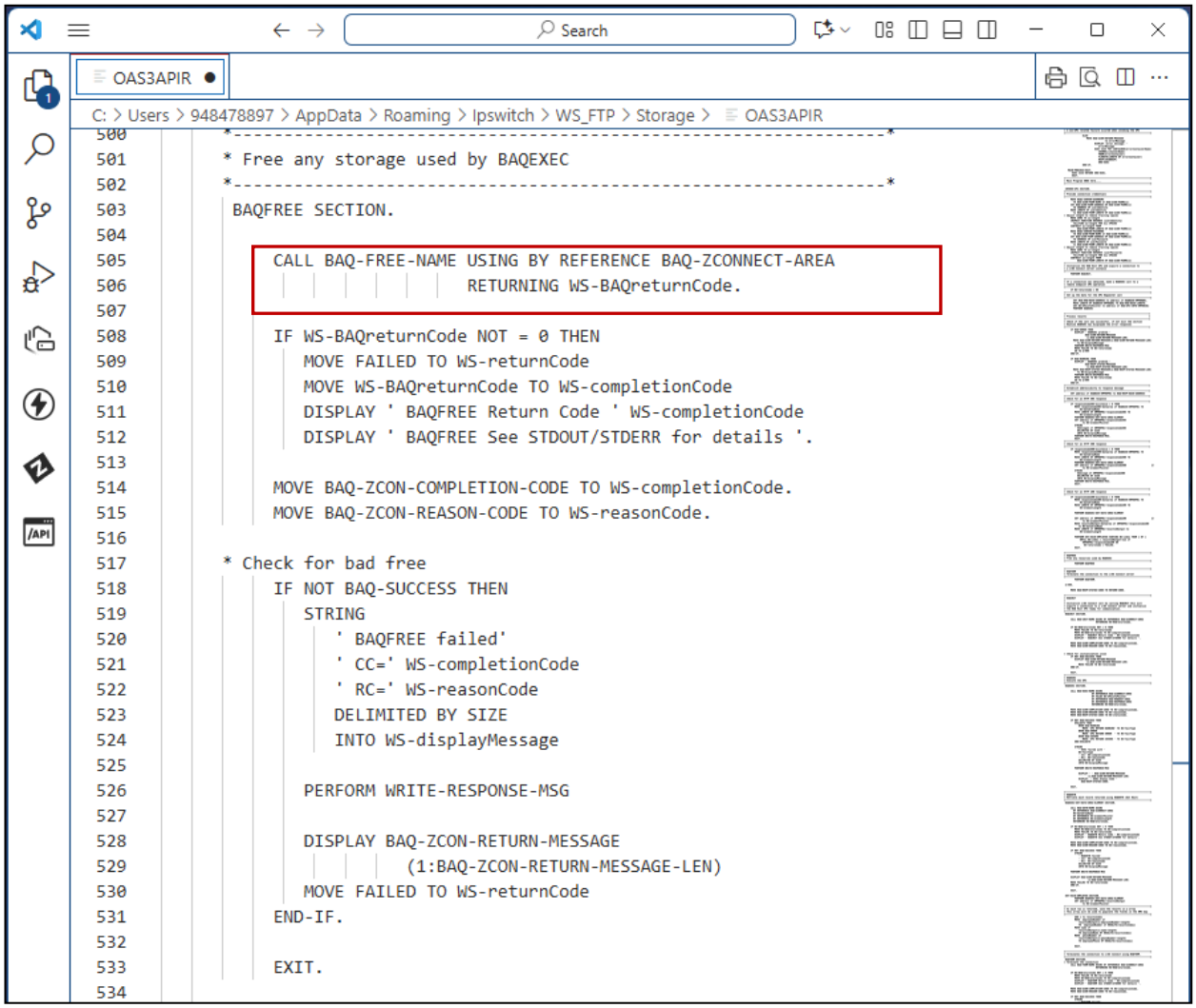





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *BAQFREE SECTION*

The BAQFREE section frees the storage acquired by the Host APIs  when processing.

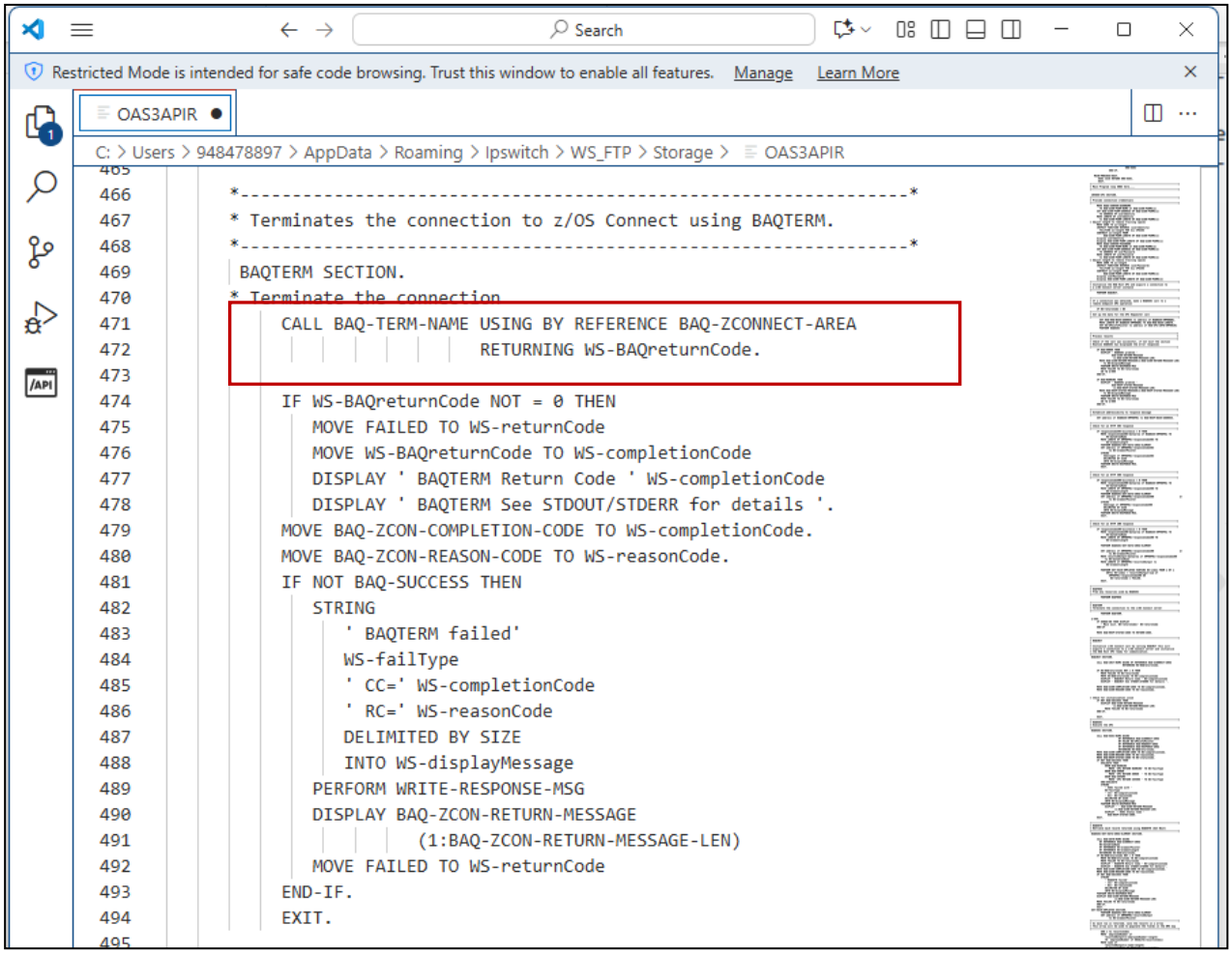





Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *BAQTERM SECTION*

The BAQTERM section terminates the connection to the z/OS Connect server using the BAQTERM Host API.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

Note that the parameters are being passed by reference. This means that the z/OS Connect API requester stub will have direct access to the program storage for both accessing data and making changes (i.e., the response message).

## *Compiling and link-editing the application program*

The applications programs were now ready to be compiled and link edited.

Note that the CALL statements in program OAS3APIR uses a variable for the names z/OS Connect HOST API modules. This means that these program will be dynamically loaded or linked at execution. The load module library containing the CICS version of the HOST API modules, SBAQLIB1 were made available in the CICS region's DFHRPL concatenation sequence. We used the JCL below to compile and link-edit the programs.

```
//COMPILE EXEC IGYWCL,LNGPRFX=SYS1.ECOBOL,
// PARM.COBOL='LIB,NODYNAM,CICS,SIZE(4000K)'
//COBOL.STEPLIB DD
//              DD DISP=SHR,DSN=CICSTS61.CICS.SDFHLOAD
//COBOL.SYSIN  DD DISP=SHR,DSN=JOHNSON.OAS3.SOURCE(OAS3APIR)
//COBOL.SYSLIB DD DISP=SHR,DSN=JOHNSON.OAS3.MAPLIB
//              DD DISP=SHR,DSN=JOHNSON.OAS3.COPYLIB
//              DD DISP=SHR,DSN=ZCEE30.SBAQCOB
//              DD DISP=SHR,DSN=CICSTS61.CICS.SDFHCOB
//LKED.SYSLMOD DD DISP=SHR,DSN=JOHNSON.ZCEE.SDFHLOAD(OAS3APIR)
//LKED.CICSLIB DD DISP=SHR,DSN=CICSTS61.CICS.SDFHLOAD
//LKED.SYSIN   DD *
 INCLUDE CICSLIB(DFHELII)
```

The jobs finished with zero return codes for all steps.

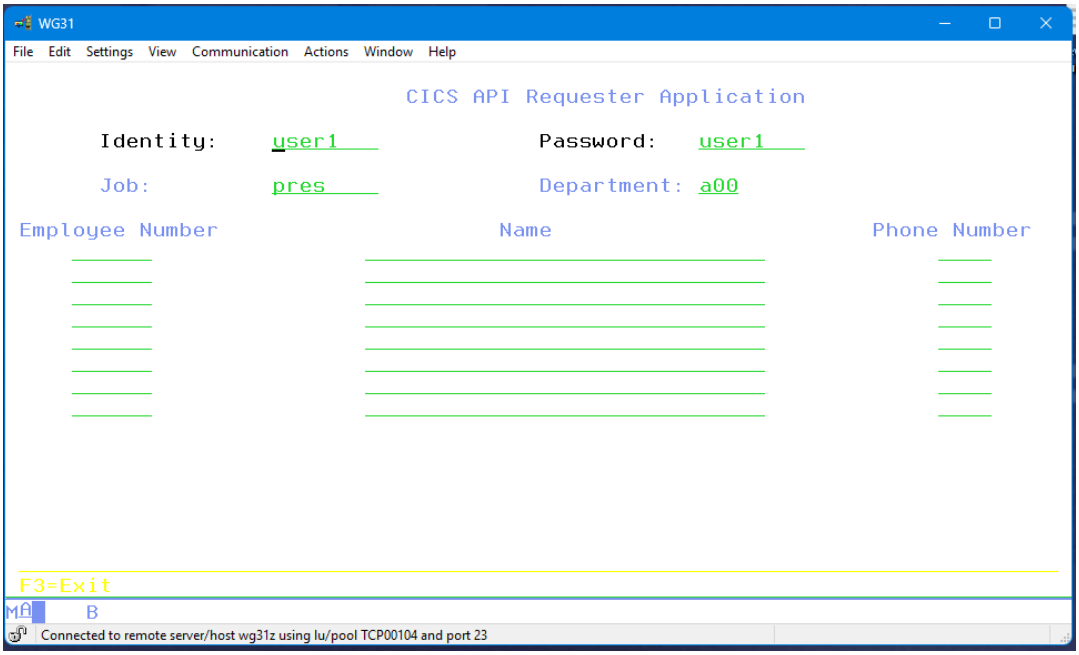


Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

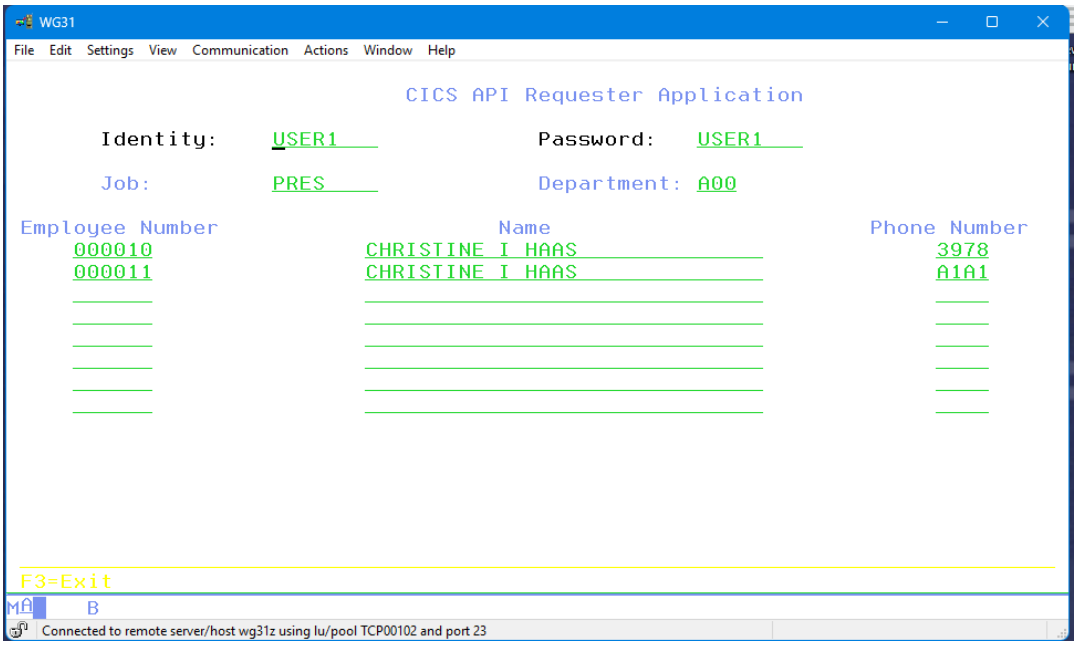
# Testing the CICS API requester application program

The CICS API requester application was then tested. This section shows our results.

___1. The transaction for the BMS application was entered and the screen below was displayed. The credentials for accessing the z/OS Connect server were entered (e.g., identity: *user1*, password: *user1*) and a value of *pres* was entered for the value of job and *a00* was entered for the value of department.



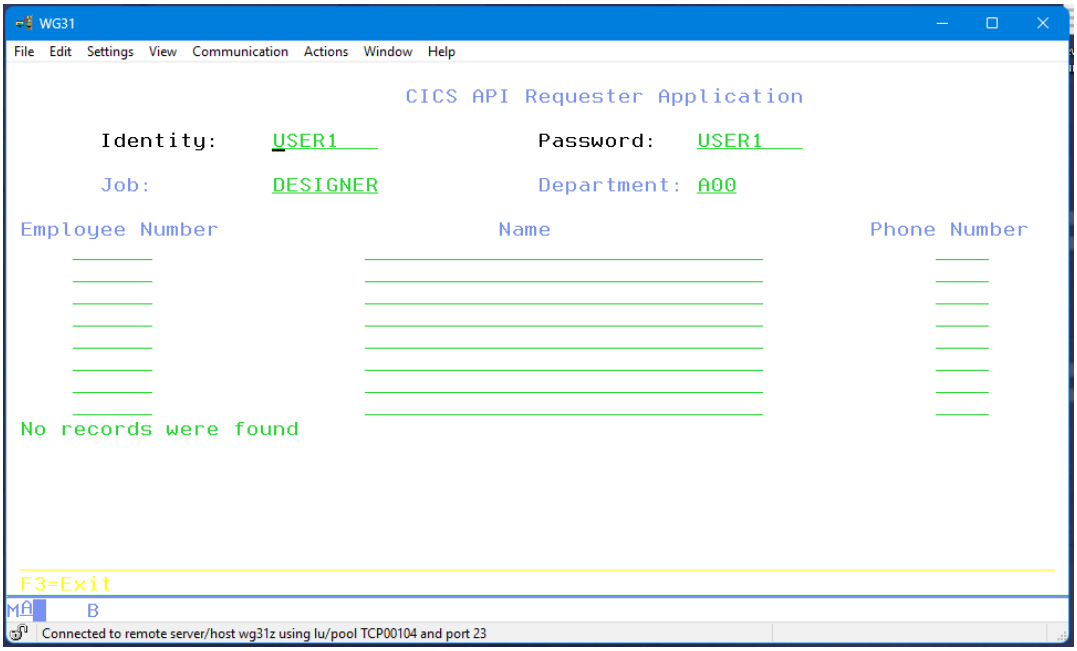

___1. Pressing the **Enter** key displayed the requests below. The API returned an HTTP response of 200 along with the rows that met the selection criteria.



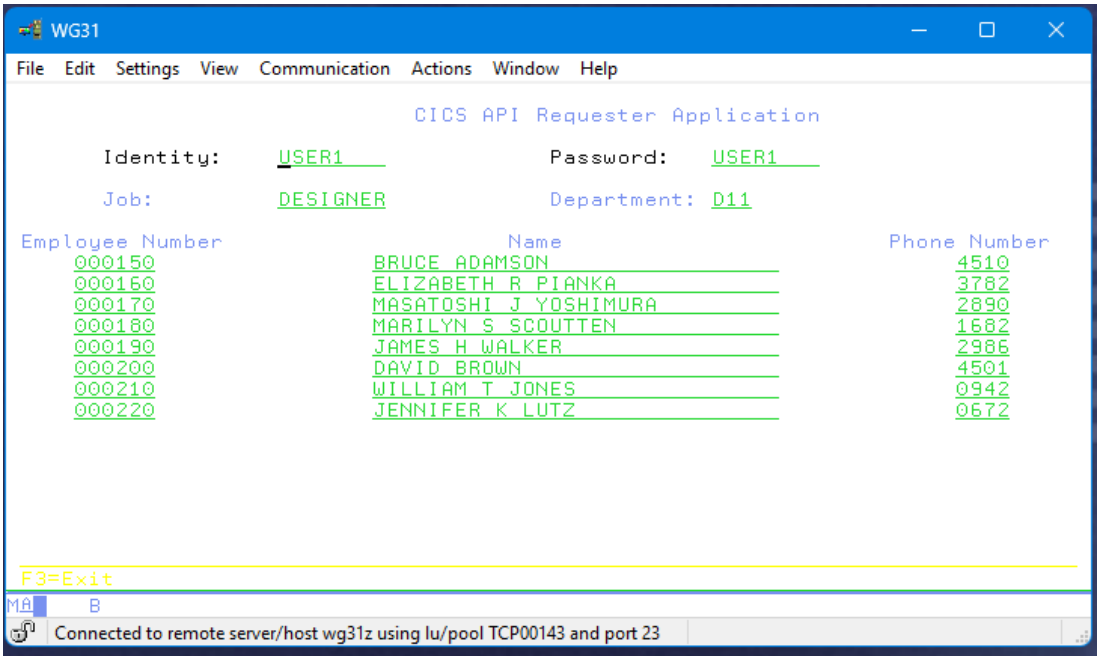



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

___2. The job value was changed to DESIGNER and when enter was pressed, the API returned an HTTP response of 404 along with the message that no records were found.



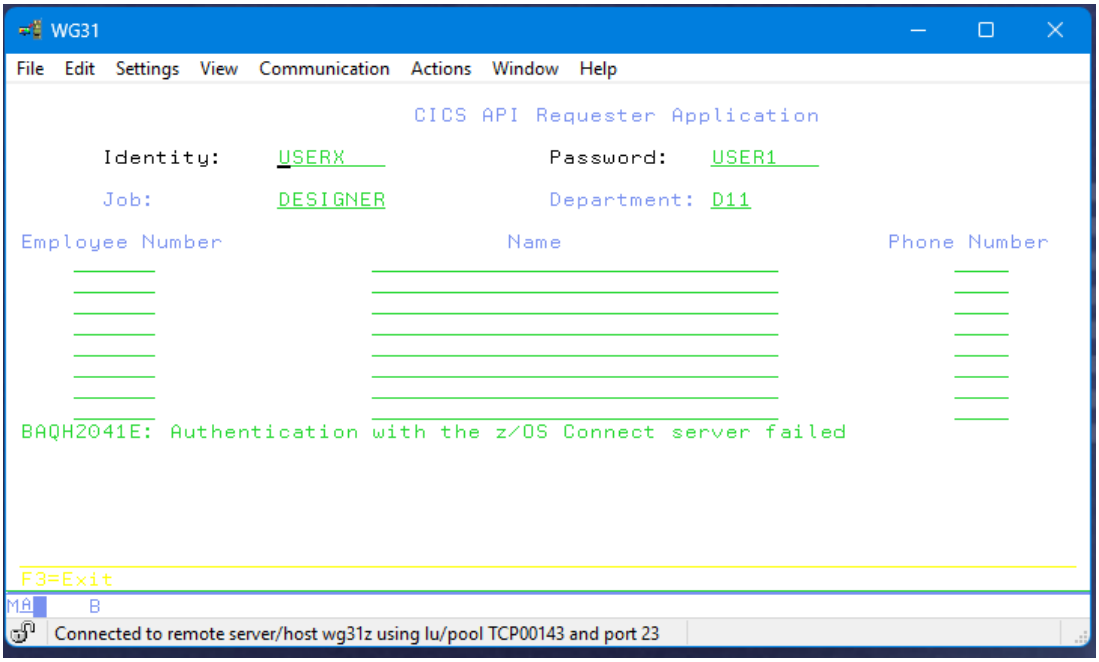

___3. Change the department to D11 and pressing entered returned the results below. The API returned an HTTP response of 200 along with the rows that met the selection criteria.



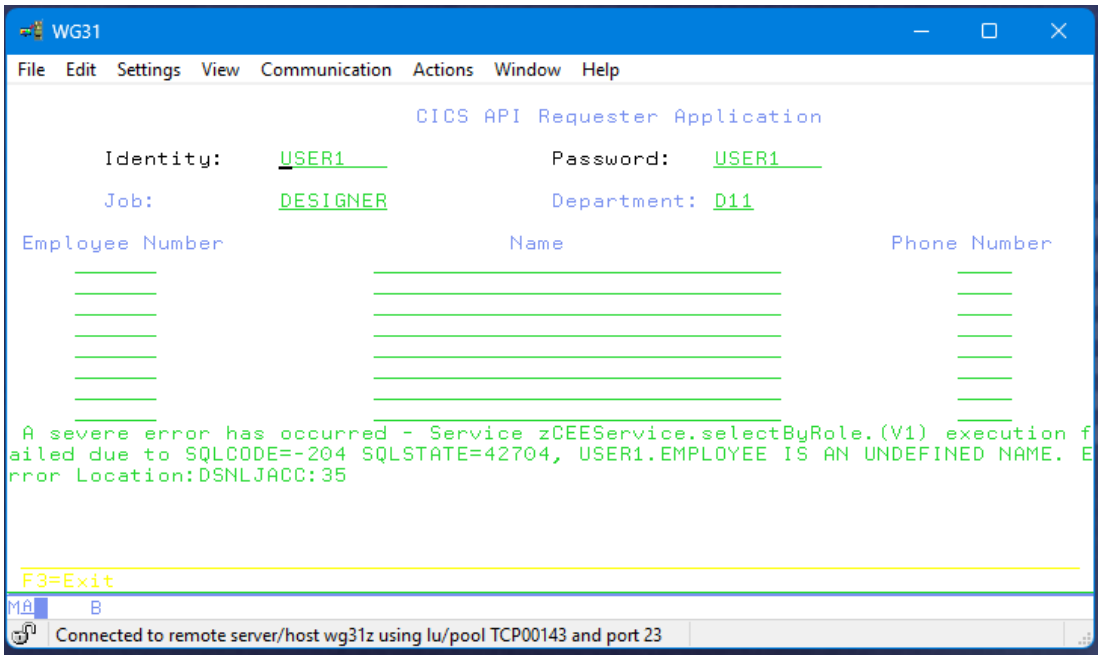



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

The value for identity was changed to USERX and when enter was pressed, the API request returned with the message authentication with the z/OS Connect server failed. Note that the message that was returned was from z/OS Connect (BAQG2041E). This failure occurred before the BAQEXEC host API could be invoked.




___5. The value for identity was changed back to USER1. But before enter was pressed, the table being accessed was dropped. When enter was pressed, the API returned an HTTP response of 500 along with the message that a SQL code of -204 had been encountered.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## Conclusion

In this document we tried to describe the process we used to develop a API requester application starting with the target API's specification document. The specification document was reviewed to understand the impact of how the details in the specification document have on the COBOL copy book details and how the z/OS Connect Host API is used.



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

# Gradle on z/OS

## *Installing and enabling the Gradle Build Tool on z/OS*

Building the API requester artifacts on any platform requires the use of the Gradle open-source automation tool. A Google search of "installing Grade on z/OS" provided the initial instructions on the steps required. We also followed the instructions in section *Using the API requester Gradle plug-in of the z/OS Connect documentation (*URL https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=requester-using-api-gradle-plug-in*)* to create the required directories and files in directory my API requester project directory */u/johnson/gradle/roster*.

Below are the steps we followed to install and enable the Gradle Build Tool on z/OS.

___1. We began by updating the PATH environment variable the *.profile* in the home directory *(/u/johnson*) with the contents below:

```
export PATH=$PATH:$JAVA_HOME/bin:
export PATH=$PATH:$JAVA_HOME/bin/classic:
```

These commands added access to the Java *jar* command to the PATH environment variable so it could be located for execution (equivalent to adding load modules to the STEPLIB DD statement). The Java *jar* will be useful for expanding or uncompacting compressed or zipped files.

**N.B.:** Updating the hidden file (*.profile*) made these changes effective for new shells in both batch and online processes. This environment variable can also be updated globally by updating the *profile* file in the */etc* directory

___2. We accessed OMVS and created a Gradle projects directory in the user's home directory, e.g., */u/johnson* using the *mkdir* command

*mkdir /u/johnson/gradle*

This directory is where we will be installing the Gradle code and where directories related to Gradle and the API requester projects will reside.

___3. To ensure there was sufficient space for Gradle and my API requester projects we created a new ZFS file system and mounted it over this new directory. A MOUNT command was also added to the appropriate BPXPRM## PARMLIB to ensure the filesystem was mounted at the next IPL.

___4. z/OS Connect ships the Grade code in its service stream (*gradle.zip* in */usr/lpp/IBM/zosconnect/v3r0*). So, the Gradle code was extracted the Gradle code by positioning in directory /u/johnson/gradle in an OMVS shell and use the Java **jar** command to extract the Gradle code as shown in the command below.

*jar -xf /usr/lpp/IBM/zosconnect/v3r0/gradle.zip*

This created a new directory whose name reflected the level of Gradle code in the *gradle.zip* file. This new directory now contains the Gradle Build Tool. For our service level of z/OS Connect the Gradle level was 8.11.1 and the new directory name reflected this level, e.g., /u/johnson/gradle/**gradle-8.11.1**.



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

___5. The *.profile* file in the home directory *(/u/johnson*) with the contents below:

```
export PATH=$PATH:/u/johnson/gradle/gradle-8.11.1/bin
export GRADLE_OPTS="-Dfile.encoding=UTF-8"
export _BPXK_AUTOCVT=ON
```

This added the Gradle executables to my PATH environment variable so the executables could be located for execution and they set the required Gradle and OMVS environment variables.

___6. Next a Gradle project directory */u/johnson/gradle/roster* was created using the *mkdir* command.

*mkdir /u/johnson/gradle/roster*

*The API requester project directory must be primed with two ASCII files, build.gradle and settings.gradle. The next steps show how the contents of these two files are determined.*

**N.B.:** *ASCII encoded files can be created using OMVS commands. First, use the touch command to create the file,* ***touch build.gradle,*** *then use the change tag command to change a file encoding to ASCII,* ***chtag -t -c ISO885901 build.gradle***

___7. The name and version of the z/OS Connect API requester plugin needs to be identified to Gradle using the contents of the *build.gradle* file and should have contents like this:

```
plugins {
    id 'com.ibm.zosconnect.requester' version '1.2.1'
 }
```

**N.B.:** *We were able to use the ISPF editor with ASCII files by using ISPF option 3.4. We simply enter /u/johnson/gradle beside the Dsname Level area on this screen and pressed Enter. Then by using the line command* ***L*** *, we were able to traverse into the /u/johnson/gradle/roster sub directories until the contents of directory /u/johnson/gradle/employee/src/main/api were displayed. Then by entering line command* ***EA*** *(edit ASCII or* ***VA*** *(view ASCII) we opened an ISPF edit or an ISPF browse session for the file.*

*Alternatively, if you are in an OMVS shell, the OEDIT command can be used to open an ISPF edit session or OBROWSE can be used to open an ISPF browse session.*



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

The version number (*1.2.1*) in the file was based on the service level of z/OS Connect installed. The relationship between the service level and the plug-in version can be determined from information available in *Table 2* at *IBM z/OS Connect capabilities compatibility* , see URL https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=reference-zos-connect-capabilities-compatibility. For example, we had service level 3.0.88 installed and using information from the table below, we set the API requester plug-in version to 1.2.1.

Table 2. z/OS Connect zosConnect-3.0 artifact compatibility

| z/OS Connect release version | API provider Gradle plug-in version | Gradle versions that are supported by the API provider Gradle plug-in | API requester Gradle plug-in version | Gradle versions that are supported by the API requester Gradle plug-in |
|---|---|---|---|---|
| 3.0.96 | 1.4.11 | 7.6.1 to 9.0.0 | 1.2.6 | 7.6.1 to 9.0.0 |
| 3.0.95 | 1.4.10 | 7.6.1 to 8.12.1 | 1.2.5 | 7.6.1 to 8.12.1 |
| 3.0.94 | 1.4.10 | 7.6.1 to 8.12.1 | 1.2.5 | 7.6.1 to 8.12.1 |
| 3.0.93 | 1.4.10 | 7.6.1 to 8.12.1 | 1.2.4 | 7.6.1 to 8.12.1 |
| 3.0.92 | 1.4.9 | 7.6.1 to 8.12.1 | 1.2.3 | 7.6.1 to 8.12.1 |
| 3.0.91 | 1.4.9 | 7.6.1 to 8.12.1 | 1.2.3 | 7.6.1 to 8.12.1 |
| 3.0.90 | 1.4.8 | 7.6.1 to 8.12.1 | 1.2.2 | 7.6.1 to 8.12.1 |
| 3.0.89 | 1.4.8 | 7.6.1 to 8.11.1 | 1.2.2 | 7.6.1 to 8.11.1 |
| 3.0.88 | 1.4.7 | 7.6.1 to 8.11.1 | 1.2.1 | 7.6.1 to 8.11.1 |
| 3.0.87 | 1.4.6 | 7.6.1 to 8.10 | 1.2.0 | 7.6.1 to 8.10 |
| 3.0.86 | 1.4.5 | 7.6.1 to 8.10 | 1.1.7 | 7.6.1 to 8.10 |
| 3.0.85 | 1.4.5 | 7.6.1 to 8.9 | 1.1.7 | 7.6.1 to 8.9 |
| 3.0.84 | 1.4.4 | 7.6.1 to 8.9 | 1.1.6 | 7.6.1 to 8.9 |
| 3.0.83 | 1.4.4 | 7.6.1 to 8.9 | 1.1.5 | 7.6.1 to 8.9 |

___8. According to information in section *Using the API requester Gradle plug-in* (see URL https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=requester-using-api-gradle-plug-in), Gradle will by default, try to retrieve plug-in from the repository hosted on the *Gradle Plug-in Portal*. Our z/OS image did not have access to the internet so we had to provide a local repository for Gradle to retrieve the necessary plug-ins. z/OS Connect provides a solution when the image is isolated from the internet (commonly called an *air gapped image*). Adding a *settings.gradle* file in the Gradle project directory provided a location from where additional code can be obtained locally. So, we added an ASCII file named *settings.gradle* in the API requester project directory with these contents.

```
pluginManagement {
    repositories {
        maven {
            url '/u/johnson/gradle/gradleLibs'
        }
    }
}
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

___9. The contents of */u/johnson/gradle/gradleLibs* directory were obtained by extracting the contents of the *dependencies.zip* file shipped with z/OS Connect while in the Gradle projects directory using the Java *jar* command again, as in.

*jar -xf /usr/lpp/IBM/zosconnect/v3r0/dependencies.zip*

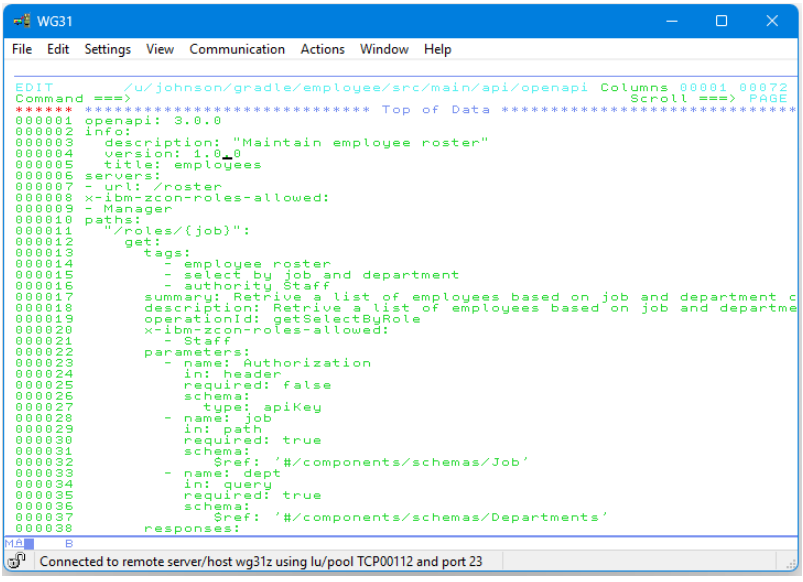
This created the directory *gradleLibs* in */u/johnson/gradle.*

___10. We next needed to create the required API requester directory structure along with a default z/OS Connection API requester generation options file. WE used the *cd* command to change to *roster* project directory. We then entered the command *gradle apiRequesterLayout* with the results shown below.

```
JOHNSON:/u/johnson/gradle/roster:> gradle apiRequesterLayout

> Task :apiRequesterLayout
BAQG1028I: Created the layout for a z/OS Connect API requester project.

Next:
1. Place the OpenAPI 3 document(s) in the src/main/api folder.
2. Configure the generation of the API requester in
file:///u/johnson/gradle/roster/src/main/config/options.yaml.
3. Run the build task of the project to create the API requester WAR and
copybooks.


BUILD SUCCESSFUL in 1s
1 actionable task: 1 executed
```

Later we will need a directory that will contain COBOL books that need to be included in the COBOL API requester programs. This was a good time to create this directory so we used a *mkdir* command to create a *SYSLIB* directory.

___11. We placed the API specification document in directory */u/johnson/gradle/employee/src/main/api* and as a file named *openapi.yaml.* The encoding for this file must be ASCII for the Gradle process to work correctly, so we ensured that if this file was uploaded to z/OS it is uploaded in binary mode so it is not converted to EBCDIC formatting.






Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

___12. Next we used the process described in the above note to edit ASCII file ***options.yaml*** in directory */u/johnson/gradle/roster/src/main/config*. In this file we entered the contents below:

```
apiName: roster                          1
characterVarying: YES                    2
connectionRef: DB2SSID                   3
defaultCharacterMaxLength: 255           4
inlineMaxOccursLimit: 1                  5
language: COBOL                          6
requesterExtension: cpy                  7
requesterPrefix: EMP                     8
```

1. Identifies the name of the API
2. Describes how strings (PIC X) files are to be generated.
3. Identifies the corresponding *zosconnect_endpointConnection* element that is defined in the z/OS Connect server's server.xml file.
4. Provides the default maximum string length for unbounded or unconstrained strings.
5. Controls when array is generated as an OCCURS Depending structure or as a dynamic area in the LINKAGE section.
6. Specifies that COBOL copy books should be generated.
7. Provides a 3-character file extension to be applied to all generated copybooks.
8. Provides a 3-character prefix to be used for all generated copybooks

**N.B.:** The copy books and WAR files for specific methods or operations can generated by using the *operations* Gradle plug-in generation property, as providing *operation=getSelectByRole* in the *options.yaml* file.
For the complete set of plug-in properties that can be used, see section *The API requester Gradle plug-in properties and options* section of the documentation at URL *https://www.ibm.com/docs/en/zos-connect/3.0.0?topic=requester-api-gradle-plug-in-properties-options*

When finished, the contents of the API requester project directory contain these directories and files.

```
JOHNSON:/u/johnson/gradle/roster:> ls -al
total 96
drwxr-xr-x   4 JOHNSON  SYS1        8192 Sep 11 18:18 .
drwxr-xr-x   7 JOHNSON  SYS1        8192 Sep 11 13:01 ..
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:08 SYSLIB
-rw-r--r--   1 JOHNSON  SYS1          66 Sep 10 14:59 build.gradle
-rw-r--r--   1 JOHNSON  SYS1         119 Sep 10 14:43 settings.gradle
drwxr-xr-x   3 JOHNSON  SYS1        8192 Sep 10 16:42 src
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *Building the API requester artifacts from an OpenAPI3 specification document*

Gradle builds can be performed on a variety platforms but because of the work done in the previous section, we now can run the JCL below to invoke the Gradle build process on z/OS.

The API's specification document is used to generate the COBOL copybooks required for the COBOL API client application and the API requester **w**eb application **ar**chive (WAR) file. The API requester WAR is accessed by the z/OS Connect API requester runtime to have the transformation of COBOL working storage to and from JSON request and response message as well as other API related actions.

```
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET JAVAHOME='/usr/lpp/java/J8.0_64'
// SET GRDLHOME='/u/johnson/gradle/roster'
//*************************************************************
//*  Step GRADLE - Use the gradle build command
//*************************************************************
//GRADLE EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//SYSERR   DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
 BPXBATCH SH +
 export JAVA_HOME=&JAVAHOME; +
 export GRADLE_HOME=&GRDLHOME; +
 cd $GRADLE_HOME; +
 gradle build --info
```

**N.B.:** Note that each HTTP method defined in the specification document will cause the generation of up to three copy books. One for the request message(Q01), one for the response message(P01) and one for the API details(I01). The copy book names are based on the *requesterPrefix* property (e.g., *EMP*) and use an ascending sequence number sequence to differentiate between methods. Also note that there may be fewer than three copy books generated. For example, if there is no response message or no request message for a specific method a copy book may not be generated.



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

13. The STDOUT output of the job will display numerous messages about the processing of the specification document. Some of the more important messages are shown below. These messages shown here identify the copy books that were generated for each method (or *operation*) selected or found in the API specification. It is important to note which copy books were generated for each method and use the corresponding copy book for each method.

```
> Task :generateApiRequester
Caching disabled for task ':generateApiRequester' because:
Total 6 operation(s) (success: 6, ignored: 0) defined in api : roster
------ Successfully processed operation(s) ------
operationId: deleteDeleteEmployee, path: /employees/{employee}, method: DELETE
- request data structure  : EMP05Q01.cpy
- response data structure : EMP05P01.cpy

operationId: getSelectByRole, path: /roles/{job}, method: GET
- request data structure  : EMP00Q01.cpy
- response data structure : EMP00P01.cpy

operationId: getDisplayEmployee, path: /employees/details/{employee}, method: GET
- request data structure  : EMP02Q01.cpy
- response data structure : EMP02P01.cpy

operationId: postInsertEmployee, path: /employees, method: POST
- request data structure  : EMP01Q01.cpy
- response data structure : EMP01P01.cpy

operationId: putInsertEmployee, path: /employees/{employee}, method: PUT
- request data structure  : EMP04Q01.cpy
- response data structure : EMP04P01.cpy

operationId: getSelectEmployee, path: /employees/{employee}, method: GET
- request data structure  : EMP03Q01.cpy
- response data structure : EMP03P01.cpy

BAQP0010I: Successfully processed the OpenAPI document.
BAQG1023W: Processing of the OpenAPI definition completed with warnings. See the log for more details:
file:///u/johnson/gradle/roster/build/logs/zosConnectRequester/
BAQG1012I: The following operations were parsed successfully:
deleteDeleteEmployee
getSelectByRole
getDisplayEmployee
postInsertEmployee
putInsertEmployee
getSelectEmployee
BAQG1022I: Parsing complete for OAS definition file: openapi.yaml.
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

___14. Below shows the directory structure created by the Gradle build process and the copy books associated with each operation, (method).

```
JOHNSON:/u/johnson/gradle/roster/build/generated/zosConnectRequester/structures/COBOL:> ls -Ral
.:
total 128
drwxr-xr-x   8 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   3 JOHNSON  SYS1        8192 Sep 11 09:07 ..
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 deleteDeleteEmployee
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 getDisplayEmployee
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 getSelectByRole
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 getSelectEmployee
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 postInsertEmployee
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 putInsertEmployee
./deleteDeleteEmployee:
total 80
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   8 JOHNSON  SYS1        8192 Sep 11 09:07 ..
-rw-r--r--   1 JOHNSON  SYS1        1361 Sep 11 09:07 API05I01.cpy
-rw-r--r--   1 JOHNSON  SYS1        6676 Sep 11 09:07 API05P01.cpy
-rw-r--r--   1 JOHNSON  SYS1        1181 Sep 11 09:07 API05Q01.cpy
./getDisplayEmployee:
total 112
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   8 JOHNSON  SYS1        8192 Sep 11 09:07 ..
-rw-r--r--   1 JOHNSON  SYS1        1366 Sep 11 09:07 API02I01.cpy
-rw-r--r--   1 JOHNSON  SYS1       19404 Sep 11 09:07 API02P01.cpy
-rw-r--r--   1 JOHNSON  SYS1        1179 Sep 11 09:07 API02Q01.cpy
./getSelectByRole:
total 96
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   8 JOHNSON  SYS1        8192 Sep 11 09:07 ..
-rw-r--r--   1 JOHNSON  SYS1        1344 Sep 11 09:07 API00I01.cpy
-rw-r--r--   1 JOHNSON  SYS1        9880 Sep 11 09:07 API00P01.cpy
-rw-r--r--   1 JOHNSON  SYS1        1912 Sep 11 09:07 API00Q01.cpy
./getSelectEmployee:
total 96
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   8 JOHNSON  SYS1        8192 Sep 11 09:07 ..
-rw-r--r--   1 JOHNSON  SYS1        1355 Sep 11 09:07 API03I01.cpy
-rw-r--r--   1 JOHNSON  SYS1       12298 Sep 11 09:07 API03P01.cpy
-rw-r--r--   1 JOHNSON  SYS1        1178 Sep 11 09:07 API03Q01.cpy
./postInsertEmployee:
total 96
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   8 JOHNSON  SYS1        8192 Sep 11 09:07 ..
-rw-r--r--   1 JOHNSON  SYS1        1340 Sep 11 09:07 API01I01.cpy
-rw-r--r--   1 JOHNSON  SYS1        6674 Sep 11 09:07 API01P01.cpy
-rw-r--r--   1 JOHNSON  SYS1        9703 Sep 11 09:07 API01Q01.cpy
./putInsertEmployee:
total 80
drwxr-xr-x   2 JOHNSON  SYS1        8192 Sep 11 09:07 .
drwxr-xr-x   8 JOHNSON  SYS1        8192 Sep 11 09:07 ..
-rw-r--r--   1 JOHNSON  SYS1        1355 Sep 11 09:07 API04I01.cpy
-rw-r--r--   1 JOHNSON  SYS1        6673 Sep 11 09:07 API04P01.cpy
-rw-r--r--   1 JOHNSON  SYS1        3022 Sep 11 09:07 API04Q01.cpy
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

15. The copy books were generated into OMVS directories and encoded in ASCII. To use them in a COBOL application they need to be converted to EBCDIC and then copied them into a partitioned datasets using the job below. Below is a snippet of the JCL used to perform these functions. Step ICONV invokes the OMVS *iconv* command. This command converts an ASCII file to EBCDIC and stores the results in the SYSLIB directory earlier. STEP COPY copies the contents of the SYSLIB directory into a PDS. The full job can be viewed in the Appendix of this document.

```
//*************************************************************
//*  SET SYMBOLS
//*************************************************************
//EXPORT EXPORT SYMLIST=(*)
// SET GRDLPROJ='/u/johnson/gradle/roster/'
// SET COBOL='build/generated/zosConnectRequester/structures/COBOL/'
// SET DSNAME='JOHNSON.OAS3.COPYLIB'
//ICONV EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
export GRADLE_PROJECT=&GRDLPROJ; +
export COBOL=&COBOL; +
cd $GRADLE_PROJECT; +
cd $COBOL; +
cd deleteDeleteEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP05I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP05I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP05P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP05P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP05Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP05Q01 ; +
cd ../getDisplayEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP02I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP02I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP02P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP02P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP02Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP02Q01 ; +
. . . .

cd ../putInsertEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP04I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP04I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP04P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP04P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP04Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP04Q01
//COPY EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
export GRADLE_PROJECT=&GRDLPROJ; +
export DSNAME=&DSNAME; +
cp  $GRADLE_PROJECT/SYSLIB/*  "//'$DSNAME'"
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)

## *Convert ASCII copy books to EBCDIC copy books*

JCL to convert the copy books from ASCII to EBCDIC encoding and then copy them to a partitioned data set.

```
//EXPORT EXPORT SYMLIST=(*)
// SET GRDLPROJ='/u/johnson/gradle/roster/'
// SET COBOL='build/generated/zosConnectRequester/structures/COBOL/'
// SET DSNAME='JOHNSON.OAS3.COPYLIB'
//ICONV EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
export GRADLE_PROJECT=&GRDLPROJ; +
export COBOL=&COBOL; +
cd $GRADLE_PROJECT; +
cd $COBOL; +
cd deleteDeleteEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP05I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP05I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP05P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP05P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP05Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP05Q01 ; +
cd ../getDisplayEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP02I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP02I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP02P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP02P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP02Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP02Q01 ; +
cd ../getSelectByRole   ; +
iconv -f ISO8859-1 -t IBM-1047 EMP00I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP00I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP00P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP00P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP00Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP00Q01 ; +
cd ../getSelectEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP03I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP03I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP03P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP03P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP03Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP03Q01 ; +
cd ../postInsertEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP01I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP01I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP01P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP01P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP01Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP01Q01 ; +
cd ../putInsertEmployee ; +
iconv -f ISO8859-1 -t IBM-1047 EMP04I01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP04I01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP04P01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP04P01 ; +
iconv -f ISO8859-1 -t IBM-1047 EMP04Q01.cpy > +
     $GRADLE_PROJECT/SYSLIB/EMP04Q01
//OGET EXEC PGM=IKJEFT01,REGION=0M
//SYSTSPRT DD SYSOUT=*
//STDOUT   DD SYSOUT=*
//SYSTSIN  DD *,SYMBOLS=EXECSYS
BPXBATCH SH +
export GRADLE_PROJECT=&GRDLPROJ; +
export DSNAME=&DSNAME; +
cp  $GRADLE_PROJECT/SYSLIB/*  "//'$DSNAME'"
```



Mitch Johnson (mitchj@us.ibm.com)
John Brefach (John.J.Brefach@ibm.com)