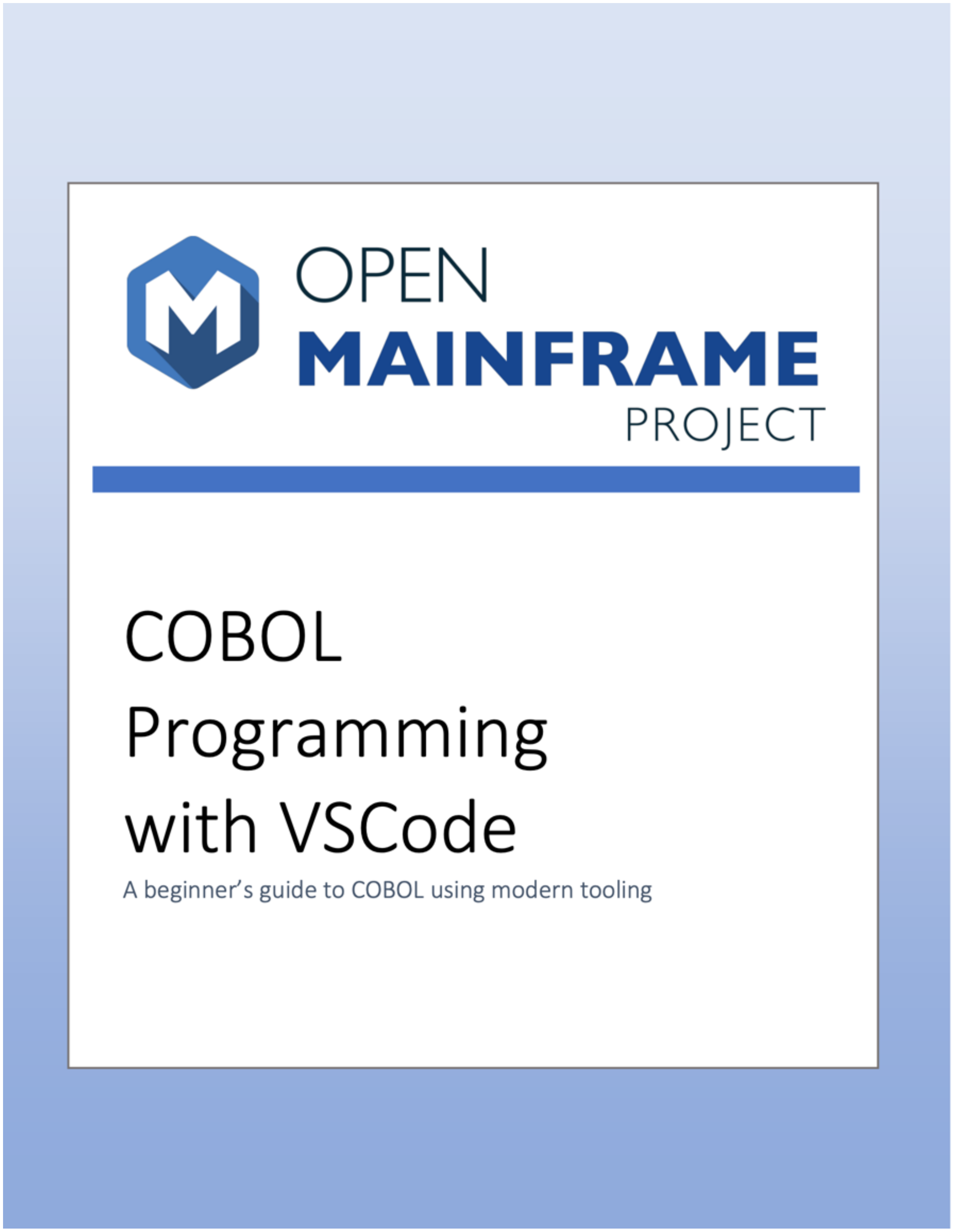
COBOL Programming with VSCode

A beginner's guide to COBOL using modern tooling



Preface

Abstract

One computer programming language was designed specifically for business, Common Business-Oriented Language, COBOL. Today COBOL remains as relevant as ever, handling $3 trillion in commerce every day.

This publication is aimed at beginners looking to build a working understanding of COBOL programming. It describes how to work with COBOL using modern tools including Visual Studio Code with Zowe and Z Open Editor extensions. It describes how to write, test, execute, and debug COBOL programs.

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-

Left-to-right: Ilicena, Suzy, Makenzie, Martin, Paul, and Tak

Contents

Part 1 - Getting started

1 Why COBOL?

This chapter introduces COBOL, specifically with reference to its use in enterprise systems.

- **What is COBOL?**
- **How is COBOL being used today?**
- **Why should I care about COBOL?**

1.1 What is COBOL?

One computer programming language was designed specifically for business, Common Business-Oriented Language, COBOL. COBOL has been transforming and supporting business globally since its invention in 1959. COBOL is responsible for the efficient, reliable, secure and unseen day-to-day operation of the world's economy. The day-to-day logic used to process our most critical data is frequently done using COBOL.

Many COBOL programs have decades of improvements which includes business logic, performance, programming paradigm, and application program interfaces to transaction processors, data sources, and the Internet.

Many hundreds of programming languages were developed during the past 60 years with expectations to transform the information technology landscape. Some of these languages, such as C, C++, Java, and JavaScript, have indeed transformed the ever-expanding information technology landscape. However, COBOL continues to distinguish itself from other programming languages due to its inherent ability to handle vast amounts of critical data stored in the largest servers such as the IBM Z mainframe.

Continuously updated to incorporate modernized and proven programming paradigms and best practices, COBOL will remain a critical programming language into the foreseeable future. Learning COBOL enables you to read and understand the day-to-day operation of critical systems. COBOL knowledge and proficiency is a required skill to be a "full stack developer" in large enterprises.

1.2 How is COBOL being used today?

COBOL is everywhere. You have probably used an application written in COBOL today. For example, consider the following statistics:

- About 95% of ATM swipes use COBOL code.
- COBOL powers 80% of in-person transactions.
- Every day, COBOL systems handle $3 trillion in commerce.

How pervasive is COBOL? Consider these mind-boggling facts:

- Every day there are 200 times more COBOL transactions executed than there are Google searches.
- There are over 220 billion lines of COBOL programs running today, which equates to around 80% of the world's actively used code.
- 1,500,000,000 lines of new COBOL code is written each year.

1.3 Why should I care about COBOL?

The COBOL programming language, COBOL compiler optimization, and COBOL run time performance have over 50 years of technology advancements that contribute to the foundation of world's economy. The core business logic of many large enterprises has decades of business improvement and tuning embedded in COBOL programs.

The point is - whatever you read or hear about COBOL, be very skeptical. If you have the opportunity to work directly with someone involved in writing or maintaining critical business logic using COBOL, you will learn about the operation of the core business. Business managers, business analysts, and decision makers come and go. The sum of all good business decisions can frequently be found in the decades of changes implemented in COBOL programs. The answer to “How does this business actually work?” can be found in COBOL programs.

Add the following to your awareness of COBOL. It is an absolute myth that you must be at least 50 years old to be good with COBOL. COBOL is incredibly easy to learn and understand. One of the many reasons financial institutions like COBOL, is the fact that it is not necessary to be a programmer to read and understand the logic. This is important because critical business logic code is subject to audit. Auditors are not programmers. However, auditors are responsible for ensuring the business financial statements are presented fairly. It is COBOL processing that frequently result in the business ledger updates and subsequent financial statements.

Now for a real-world lesson. A comment recently made in a well-known business journal by someone with a suspect agenda was quoted as saying, “COBOL is a computing language used in business and finance. It was first designed in 1959 and is pretty old and slow.” A highly experienced business technology person knows the only true part of that last sentence was that COBOL was first designed in 1959.

It’s no secret that lots of banks still run millions of lines of COBOL on mainframes. They probably want to replace that at some point. So why haven’t they? Most banks have been around long enough to still feel the pain from the ~1960’s software crisis. After spending enormous amounts of money, and time, on developing their computer systems, they finally ended up with a fully functional, well-tested, stable COBOL core system.

Speaking with people that have worked on such systems, nowadays they have Java front ends and wrappers which add functionality or more modern interfaces, they run the application on virtualized replicated servers, but in the end, everything runs through that single core logic. And that core logic is rarely touched or changed, unless necessary.

From a software engineering perspective, that even makes sense. Rewrites are always more expensive than planned, and always take longer than planned (OK, probably not always. But often.). Never change a running system etc., unless very good technical and business reasons exist.

2 VSCode with Zowe Explorer

Zowe Explorer is an open-source extension for VS Code that lets developers and system administrators interact with z/OS mainframes.

- **Introduction to Zowe Explorer**
- **Using Zowe Explorer**
- **Profiles in Zowe Explorer**
  - **Secure Credentials**
  - **Creating a New Profile**
  - **Editing Profiles**
  - **Deleting Profiles**
- **Summary**

2.1 Introduction to Zowe Explorer

The Zowe Explorer extension modernizes the way developers and system administrators interact with z/OS mainframes. Working with data sets and USS files from VS Code can be more convenient than using 3270 emulators. The extension provides the following benefits:

- Create, modify, rename, copy and upload data sets directly to a z/OS mainframe.
- Create, modify, rename and upload USS files directly to a z/OS mainframe.
- Streamlined process to access data sets, USS files and jobs.
- Easy interact with multiple z/OS systems

The Zowe Explorer can be installed into VS Code by searching the Extensions Marketplace inside VS Code for "Zowe Explorer" and selecting install. To see more detailed instructions on installing this extension, refer to "Installation of VSCode and Extensions".

2.2 Using Zowe Explorer

Zowe Explorer allows you to work with data sets, Unix System Service (USS) files, and jobs.

Zowe Explorer offers the following functions:

Data sets

- Search for data sets matching desired filters and view their contents
- Download, edit, and upload existing PDS members
- Create and delete both data sets and data set members
- Interact with data sets from multiple systems simultaneously
- Rename data sets
- Copy data sets
- Submit JCL from a chosen data set member

USS Files

- View multiple Unix System Services (USS) files simultaneously
- Download, edit, and upload existing USS files
- Create and delete USS files and directories
- Interact with USS files from multiple systems simultaneously
- Rename USS files

Jobs

- View multiple jobs simultaneously
- Download spool content
- Interact with jobs from multiple systems simultaneously

For more information about Zowe Explorer and the different use cases, visit the marketplace

2.3 Profiles in Zowe Explorer

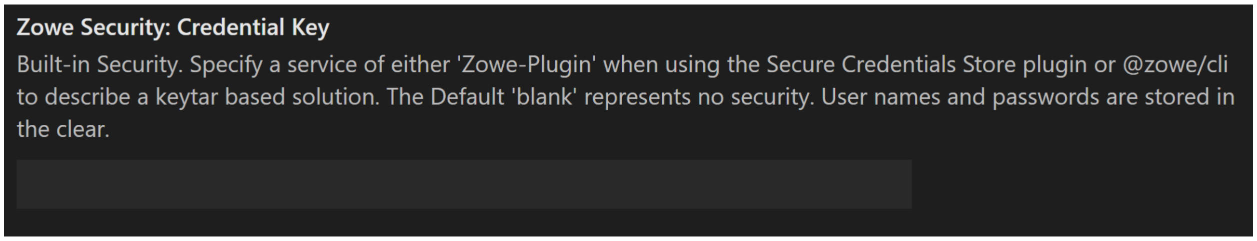
Profiles serve as a point-of-contact for Zowe Explorer and the Mainframe. Profiles contain the URL for the API services that you want to connect to, and your credentials. The main profile information that you need for Zowe Explorer is the z/OSMF Connection. If you have the Zowe Explorer installed, you can follow the steps in this section to connect to the mainframe.

2.3.1 Secure Credentials

Zowe Explorer has a built in Secure Credential Store. This enables you to encrypt the credentials that are stored in your machine, and as a result secure your connection to the Mainframe.

To enable this feature, follow these steps:

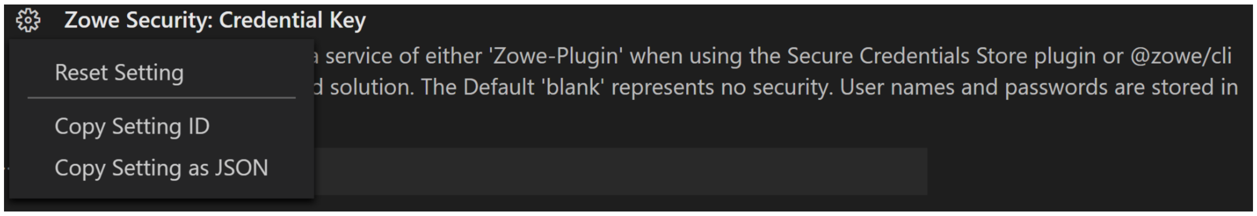
1. Click the **Gear Icon** at the bottom left and select **Settings**
2. Click **User Settings** > **Extensions** > **Zowe Explorer Settings** Look for the **Zowe Security: Credential Key** field


Zowe Security: Credential Key

Built-in Security. Specify a service of either 'Zowe-Plugin' when using the Secure Credentials Store plugin or @zowe/cli to describe a keytar based solution. The Default 'blank' represents no security. User names and passwords are stored in the clear.

3. Type **Zowe-Plugin** in the text box. This will trigger the Built-in Secure Credential Store.

Alternatively, to enable this feature by editing settings.json, hover over the gear icon and click “Copy Setting as JSON”. You can then paste that to settings.json and update the value to Zowe Plugin.


Zowe Security: Credential Key

service of either 'Zowe-Plugin' when using the Secure Credentials Store plugin or @zowe/cli

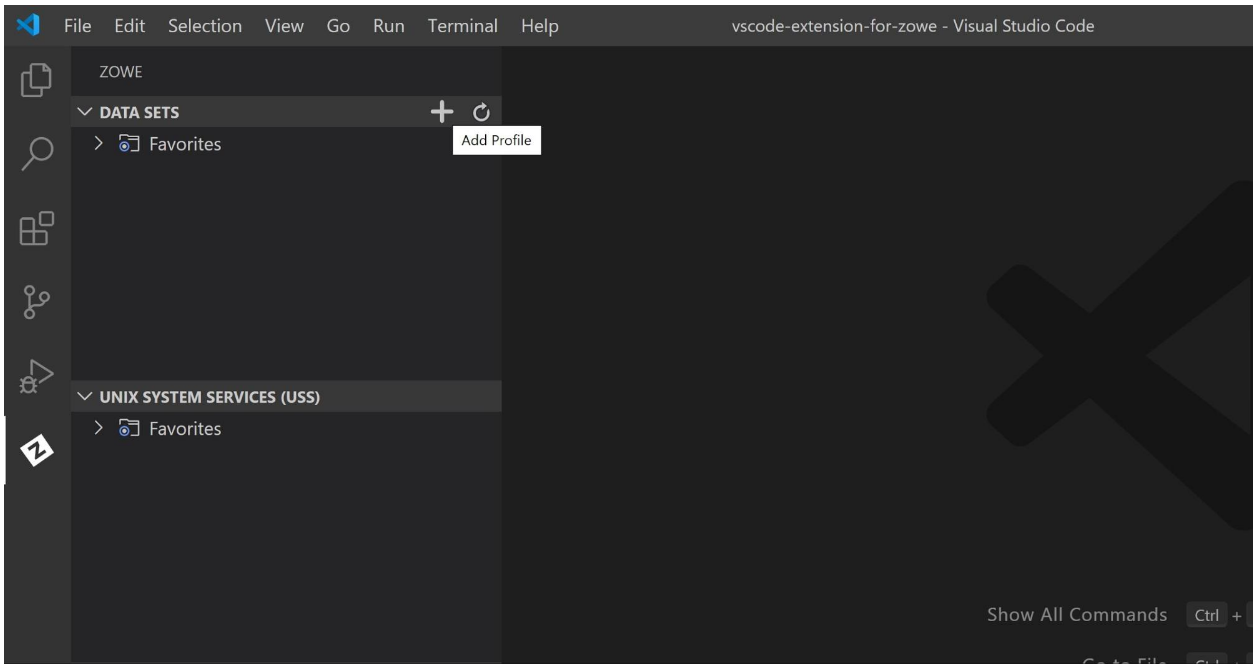
solution. The Default 'blank' represents no security. User names and passwords are stored in

Note: If you are using Zowe CLI and you’ve installed the Secure-Credential-Store Plugin, the steps to activate it will still be the same.

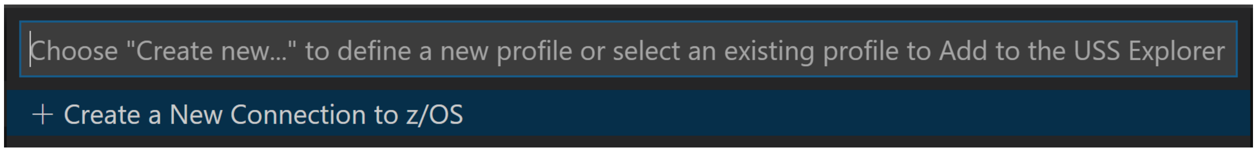
2.3.2 Creating a New Profile

Follow these steps:

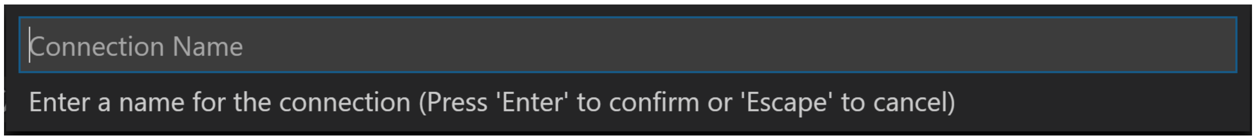
1. Navigate to the Zowe Explorer tree on the right side and look for the + sign.


File Edit Selection View Go Run Terminal Help
vscode-extension-for-zowe - Visual Studio Code
ZOWE
DATA SETS
Favorites
Add Profile
UNIX SYSTEM SERVICES (USS)
Favorites
Show All Commands Ctrl +

2. Click on the + sign. A dialog box will appear and ask if you want to "Create a New Connection to z/OS".
3. Press enter or click on that selection.

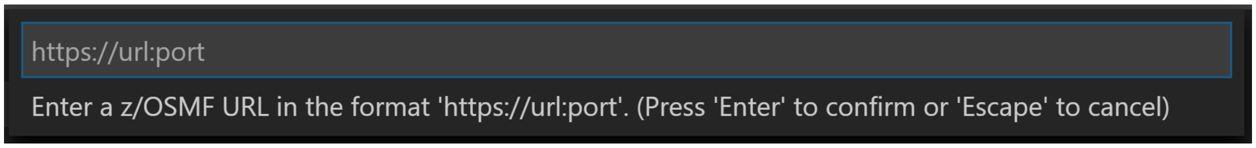

Choose "Create new..." to define a new profile or select an existing profile to Add to the USS Explorer
+ Create a New Connection to z/OS

4. Enter a Profile name in the "Connection Name" field.



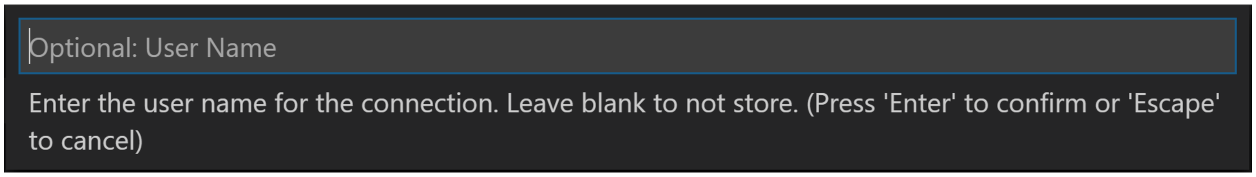
Enter a name for the connection (Press 'Enter' to confirm or 'Escape' to cancel)

5. Enter the URL and Port that you received by email when you registered for the COBOL Course. The connection information that you need has a title of "IP address for VSCode extension".



Enter a z/OSMF URL in the format 'https://url:port'. (Press 'Enter' to confirm or 'Escape' to cancel)

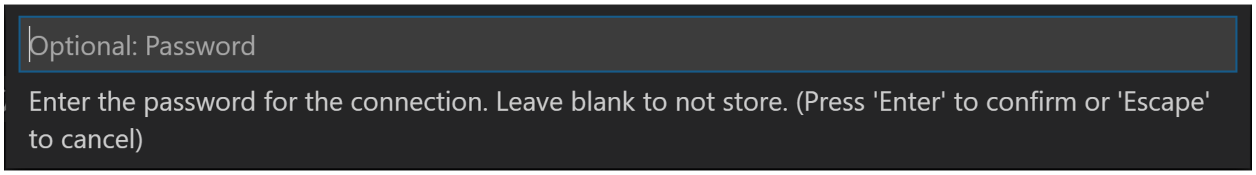
6. Enter your Username. This is also included in the email.



Enter the user name for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Note: You can leave this blank if you do not want to save your credentials in your machine. You will be prompted for your username once you start using Zowe Explorer.

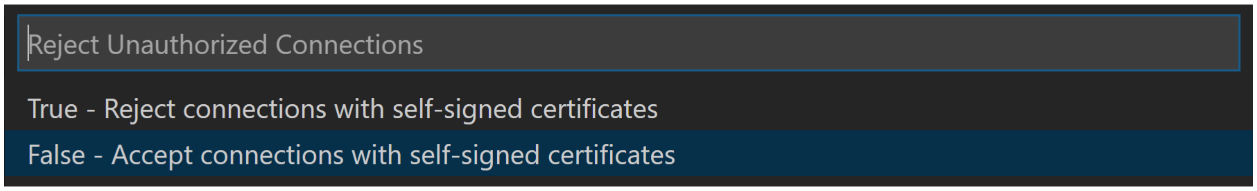
7. Enter your Password.


Optional: Password

Enter the password for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Note: You can leave this blank if you do not want to save your credentials in your machine. You will be prompted for your username once you start using Zowe Explorer.

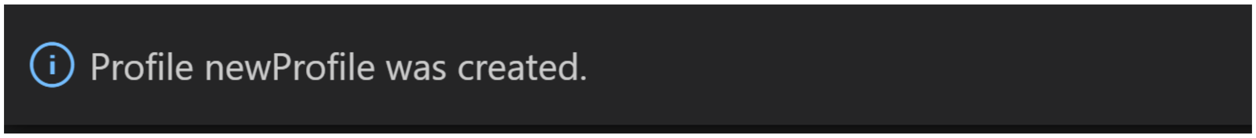
8. Select True/False if you want to accept or reject Self-Signed Certificates. For this course, please select false.


Reject Unauthorized Connections

True - Reject connections with self-signed certificates

False - Accept connections with self-signed certificates

If you are successful, you will receive this informational message:

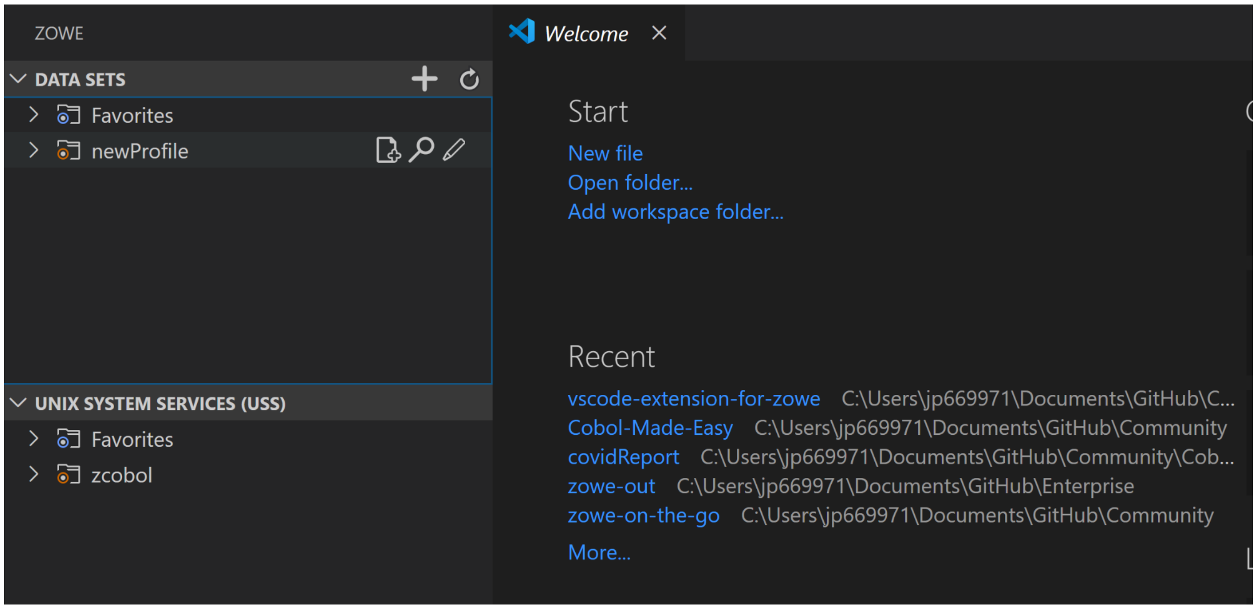

Profile newProfile was created.

2.3.3 Editing Profiles

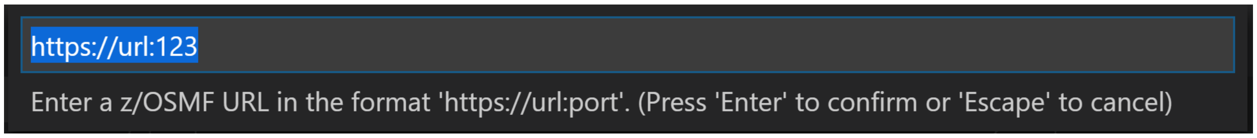
The Zowe Explorer v1.5.0 release introduces profile editing. This allows you to revise your existing profile information and continue using Zowe Explorer.

Follow these steps:

1. Add your profile to any of the Zowe Explorer Trees.
2. Click on the pencil icon to edit your profile. A dialog box opens displaying the current information in your profile, which you can edit as required.


ZOWE
DATA SETS
Favorites
newProfile
UNIX SYSTEM SERVICES (USS)
Favorites
zcobol
Welcome
Start
New file
Open folder...
Add workspace folder...
Recent
vscode-extension-for-zowe C:\Users\jp669971\Documents\GitHub\C...
Cobol-Made-Easy C:\Users\jp669971\Documents\GitHub\Community
covidReport C:\Users\jp669971\Documents\GitHub\Community\Cob...
zowe-out C:\Users\jp669971\Documents\GitHub\Enterprise
zowe-on-the-go C:\Users\jp669971\Documents\GitHub\Community
More...

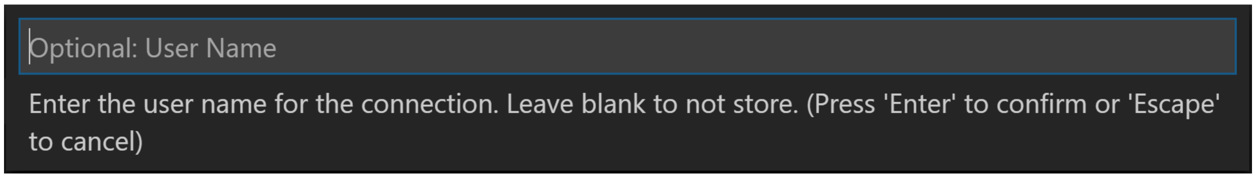
3. Edit the URL information if changes are required, or enter to confirm the information is still correct.



https://url:123

Enter a z/OSMF URL in the format 'https://url:port'. (Press 'Enter' to confirm or 'Escape' to cancel)

4. Edit your Username.

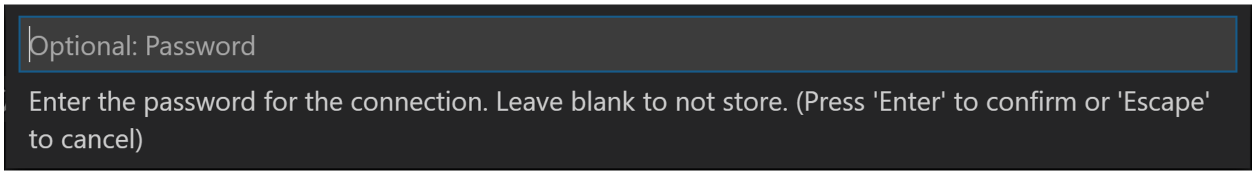


Optional: User Name

Enter the user name for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Note: You can leave this blank if you do not want to save your credentials in your machine. You will be prompted for your username once you start using Zowe Explorer.

5. Edit your Password.

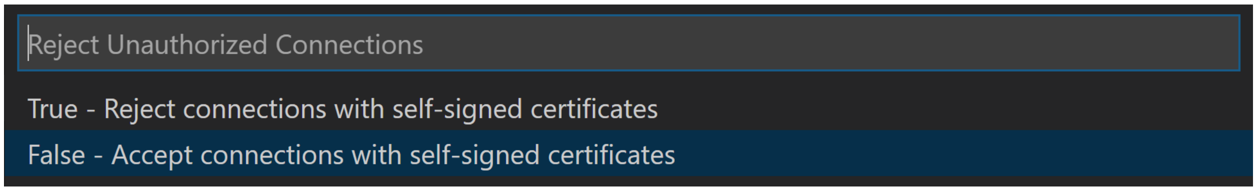


Optional: Password

Enter the password for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Note: You can leave this blank if you do not want to save your credentials in your machine. You will be prompted for your username once you start using Zowe Explorer.

6. Edit your authorized connections

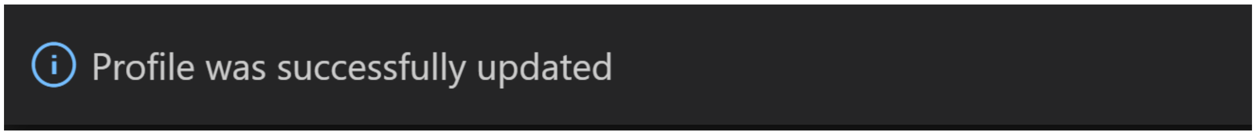


Reject Unauthorized Connections

True - Reject connections with self-signed certificates

False - Accept connections with self-signed certificates

If you are successful, an information message will appear:



Profile was successfully updated

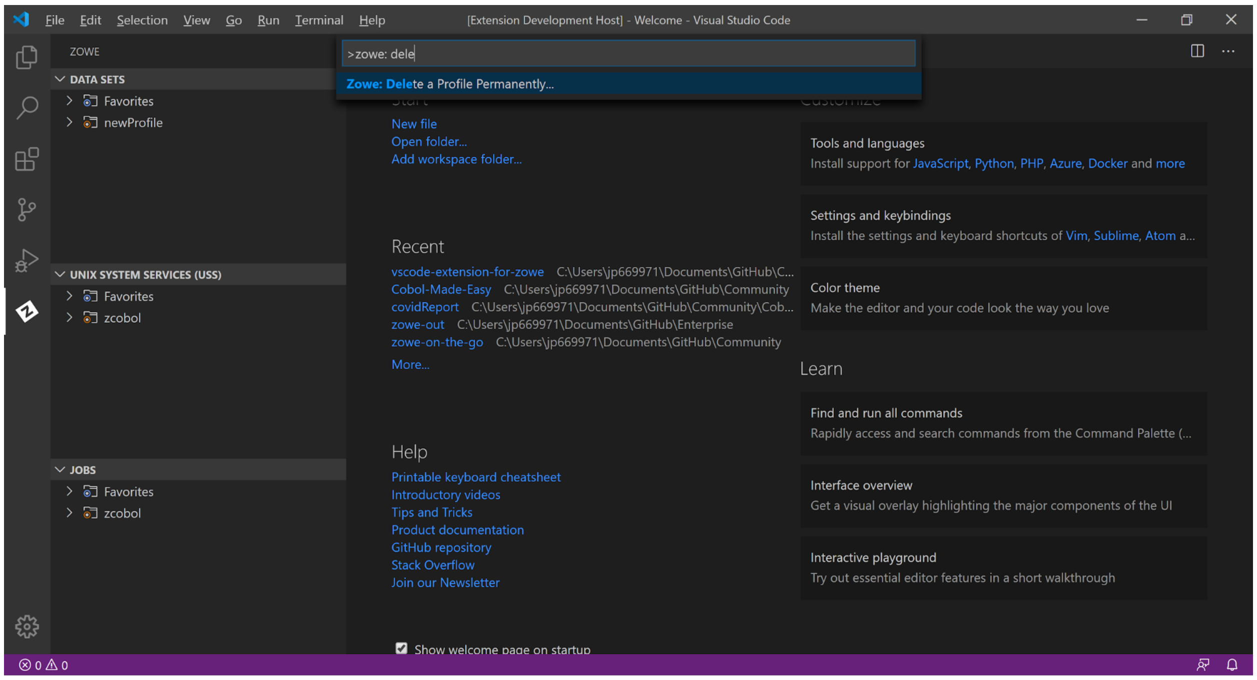
2.3.4 Deleting Profiles

The Zowe Explorer v1.5.0 release introduces the option to delete profiles. This allows you to permanently delete unwanted profiles and clean up your files. You can delete profiles either using the command palette or in the tree.

Follow these steps:

Command Palette:

1. Press **CTRL+SHIFT+P** or Click **View** > **Command Palette** to open the Command Palette
2. Type "Zowe: Delete". This command allows you to permanently delete a profile.


File Edit Selection View Go Run Terminal Help
[Extension Development Host] - Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites
newProfile
UNIX SYSTEM SERVICES (USS)
Favorites
zcobol
JOBS
Favorites
zcobol

>zowe: dele

Zowe: Delete a Profile Permanently...

New file
Open folder...
Add workspace folder...

Recent
vscode-extension-for-zowe C:\Users\jp669971\Documents\GitHub\C...
Cobol-Made-Easy C:\Users\jp669971\Documents\GitHub\Community
covidReport C:\Users\jp669971\Documents\GitHub\Community\Cob...
zowe-out C:\Users\jp669971\Documents\GitHub\Enterprise
zowe-on-the-go C:\Users\jp669971\Documents\GitHub\Community
More...

Help
Printable keyboard cheatsheet
Introductory videos
Tips and Tricks
Product documentation
GitHub repository
Stack Overflow
Join our Newsletter

Tools and languages
Install support for JavaScript, Python, PHP, Azure, Docker and more

Settings and keybindings
Install the settings and keyboard shortcuts of Vim, Sublime, Atom a...

Color theme
Make the editor and your code look the way you love

Learn

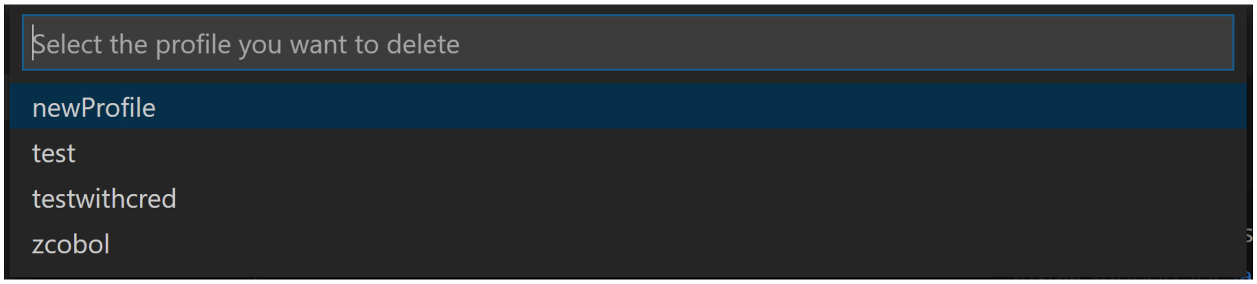
Find and run all commands
Rapidly access and search commands from the Command Palette (...

Interface overview
Get a visual overlay highlighting the major components of the UI

Interactive playground
Try out essential editor features in a short walkthrough

Show welcome page on startup

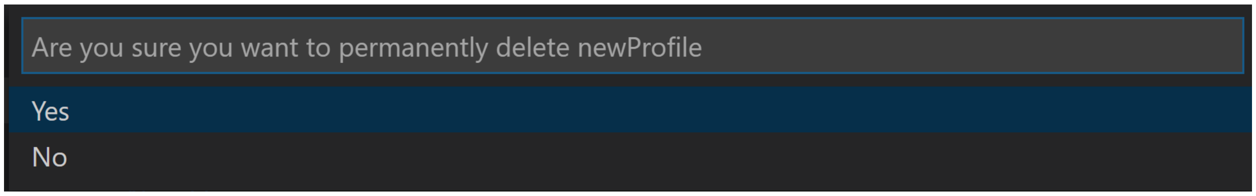
3. Select the Profile that you want to delete.



Select the profile you want to delete

newProfile
test
testwithcred
zcobol

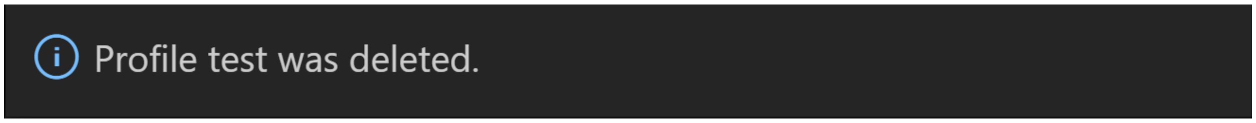
4. Confirm that you want to delete your profile.



Are you sure you want to permanently delete newProfile

Yes
No

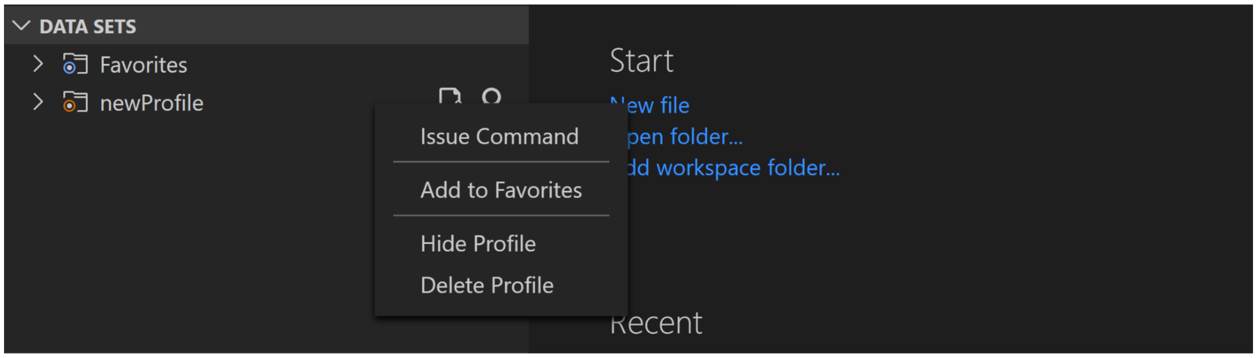
Once confirmed, the following message is displayed:



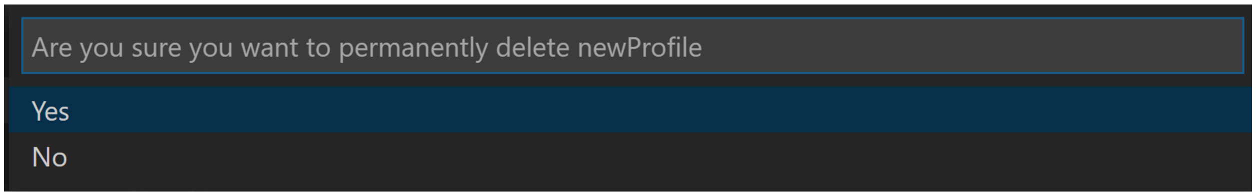
Profile test was deleted.

Zowe Explorer Tree:

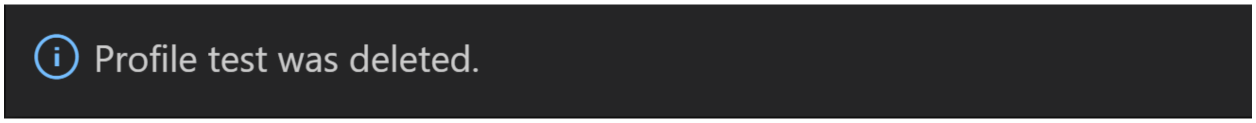
1. Right click on the profile and select **Delete Profile**.



2. Confirm that you want to delete your profile.


Are you sure you want to permanently delete newProfile

3. Once confirmed, the following message is displayed:


Profile test was deleted.

2.4 Summary

In this section you have learned the basic features of the Zowe Explorer extension and how to create and work with Zowe compatible `zosmf` profiles.

3 VSCode with Z Open Editor

In this chapter we will explain how to use the IBM Z Open Editor extension for VSCode and how using it can help you develop COBOL source code in a feature rich environment.

- **Introduction to the IBM Z Open Editor**
  - **What is the IBM Z Open Editor?**
  - **The role of the Language Server Protocol**
  - **Installing the IBM Z Open Editor for VS Code**
- **Basic editing**
  - **Known file extensions**
  - **Margins**
  - **Variable expansion**
  - **Syntax highlighting**
- **Navigation of code**
  - **Outline view**
  - **Breadcrumb view**
  - **Jump to declaration / reference**
- **Code-completion**
  - **COBOL reserved word completion**
  - **Variable completion**
  - **CICS, MQ, DB2 API completion**
- **Refactoring code**
  - **Renaming variables**
  - **Handling errors**
- **Summary**

3.1 Introduction to the IBM Z Open Editor

This section introduces the IBM Z Open Editor.

3.1.1 What is the IBM Z Open Editor?

The IBM Z Open Editor is a free extension for Visual Studio Code (VSCode) that provides language support for COBOL, PL/I and JCL languages. Along with this language support it also provides content assistance for applications that call CICS, MQ, IMS and DB2 APIs. The source code doesn't even need to reside on z/OS, it could be in a source code repository, locally in a file or on z/OS. Although this course focuses on COBOL as a source language, a lot of the functions we will discuss will also apply to PL/I and JCL.

3.1.2 The role of the Language Server Protocol

Integrated development environments always want to provide a rich platform for all supported programming languages, however, the proliferation of programming languages and the speed at which new editors reach the market makes keeping pace difficult. Each editor would need to provide an editor specific plugin for each language they wished to support, thus support for a certain language would differ between different editors.

Microsoft designed the Language Server Protocol (LSP) to act as a common description of how features like auto-complete should be implemented for a specific language. Languages which have an implemented LSP server can therefore be used within any editor that supports LSP. Many companies and the open source community have collaborated to provide LSP servers for an array of different languages.

The language server protocol defines six broad capabilities that should be implemented for a language server to be LSP compliant. These capabilities include code completion, hover, jump to definition, workspace symbols, find references and diagnostics. The IBM Z Open Editor provides compliant language servers for both the Enterprise Cobol and Enterprise PL/I for z/OS languages. In addition to being compliant, they also provide additional capabilities that we will discuss further on.

Note: More information on Language Server Protocol implementations can be found at: `https://langserver.org`

3.1.3 Installing the IBM Z Open Editor for VS Code

The IBM Z Open Editor can be installed into VS code by searching the Extensions Marketplace inside VSCode for "IBM Z Open Editor" and selecting install. Once installed, the default editor will be enabled to provide a rich editing experience for COBOL, PL/I and JCL. There is no need to use a specific editor for these languages. To see a more detailed instruction on installing this extension, refer to "Installation of VSCode and extensions".

3.2 Basic editing

For the rest of this chapter we will use the CBL0001 sample program to demonstrate how rich of an experience editing COBOL in VSCode can be. So, let's fire up VSCode, install IBM Z Open Editor (if it's not already) open up CBL0001 and get started.

3.2.1 Known file extensions

For VSCode to use the capabilities of the IBM Z Open Editor, it needs to know that the file we are editing is in fact COBOL type. VSCode accomplishes this by comparing the location and name of the file being opened against a list of known extensions to map the file to a known language. For COBOL the following associations are used:

- *.COBOL*
- *.CBL*
- *.COB*
- *.COBCOPY*
- *.COPYBOOK*
- *.COPY*

These are applied to both local files and files held in a Partitioned Data Set or PDS on the mainframe, which for simplicity you can think of as a folder. Thus, a PDS called:

```
Z99994.COBOL
```

Or a file on the local file system called:

```
PROGA1.COBOL
```

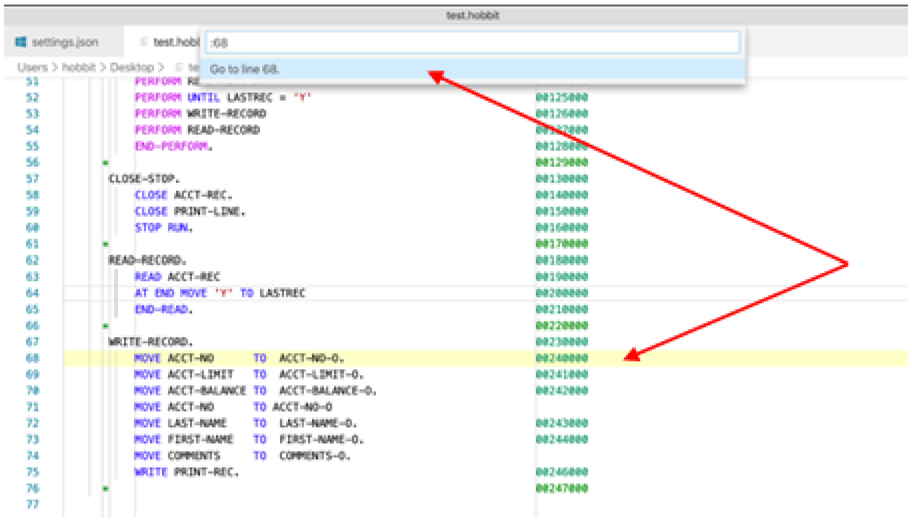
Will be assumed to be COBOL code. This information is stored in the global VSCode settings.json file that can be accessed through VSCode preferences. This allows for a user to tailor VSCode's known extensions to a particular site naming convention.

3.2.2 Margins

The first thing you will notice when editing COBOL source code is that VSCode will have inserted five vertical lines down the file. These lines segment each line of code into the areas reserved for sequence numbers, comment / continuation characters, area A and area B. When coding without this basic aid I cannot recount the number of times I have made a compilation error because I started coding in the wrong column. This alone is a very useful aid to a new COBOL programmer. Move information about COBOL syntax, and in particular the columns, will be discussed later

3.2.3 Variable expansion

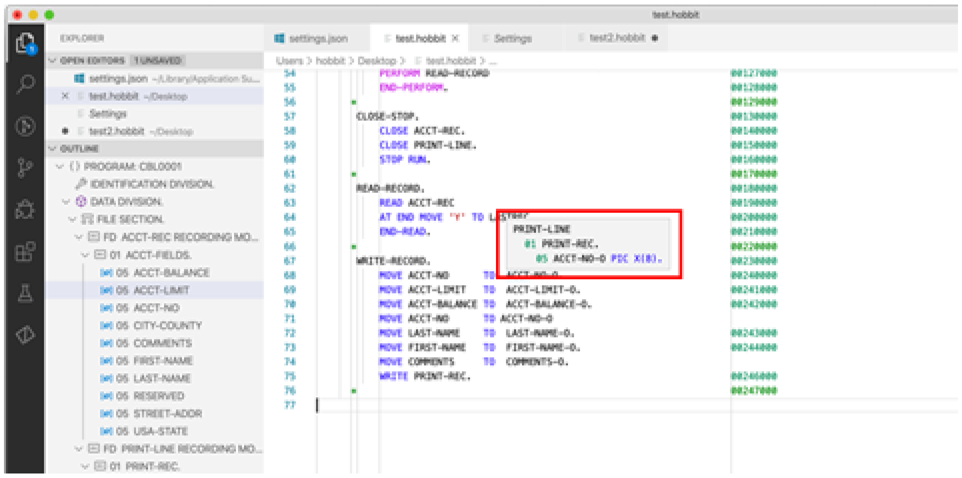
As you browse through CBL0001 type `CTRL + G` to jump to a specific line of code. A small dialog will open asking you for the line you wish to jump to, type `68` and press the enter key. VSCode will highlight that line of code and navigate you directly to it, as shown in Figure 1.



```
51             PERFORM RE
52             PERFORM UNTIL LASTREC = 'Y'                        00125000
53             PERFORM WRITE-RECORD                               00126000
54             PERFORM READ-RECORD                                00127000
55             END-PERFORM.                                       00128000
56                                                                00129000
57         CLOSE-STOP.                                            00130000
58             CLOSE ACCT-REC.                                    00140000
59             CLOSE PRINT-LINE.                                  00150000
60             STOP RUN.                                          00160000
61                                                                00170000
62         READ-RECORD.                                           00180000
63             READ ACCT-REC                                      00190000
64             AT END MOVE 'Y' TO LASTREC                         00200000
65             END-READ.                                          00210000
66                                                                00220000
67         WRITE-RECORD.                                          00230000
68             MOVE ACCT-NO       TO  ACCT-NO-O.                  00240000
69             MOVE ACCT-LIMIT    TO  ACCT-LIMIT-O.               00241000
70             MOVE ACCT-BALANCE  TO  ACCT-BALANCE-O.             00242000
71             MOVE ACCT-NO       TO ACCT-NO-O
72             MOVE LAST-NAME     TO  LAST-NAME-O.                00243000
73             MOVE FIRST-NAME    TO  FIRST-NAME-O.               00244000
74             MOVE COMMENTS      TO  COMMENTS-O.
75             WRITE PRINT-REC.                                   00246000
76                                                                00247000
77
```

Figure 1. Navigating to a specific line of code

If you hover your mouse over the 'ACCT-NO-O' field a pop up will appear displaying the declaration of that variable, shown in Figure 2.



```
{} PROGRAM: CBL0001
   IDENTIFICATION DIVISION.
   DATA DIVISION.
     FILE SECTION.
       FD ACCT-REC RECORDING MO...
         01 ACCT-FIELDS.
           05 ACCT-BALANCE
           05 ACCT-LIMIT
           05 ACCT-NO
           05 CITY-COUNTY
           05 COMMENTS
           05 FIRST-NAME
           05 LAST-NAME
           05 RESERVED
           05 STREET-ADDR
           05 USA-STATE
       FD PRINT-LINE RECORDING MO...
         01 PRINT-REC.
```

```
54             PERFORM READ-RECORD                                00127000
55             END-PERFORM.                                       00128000
56                                                                00129000
57         CLOSE-STOP.                                            00130000
58             CLOSE ACCT-REC.                                    00140000
59             CLOSE PRINT-LINE.                                  00150000
60             STOP RUN.                                          00160000
61                                                                00170000
62         READ-RECORD.                                           00180000
63             READ ACCT-REC                                      00190000
64             AT END MOVE 'Y' TO LASTREC                         00200000
65             END-READ.                                          00210000
66                                                                00220000
67         WRITE-RECORD.                                          00230000
68             MOVE ACCT-NO       TO  ACCT-NO-O.                  00240000
69             MOVE ACCT-LIMIT    TO  ACCT-LIMIT-O.               00241000
70             MOVE ACCT-BALANCE  TO  ACCT-BALANCE-O.             00242000
71             MOVE ACCT-NO       TO ACCT-NO-O
72             MOVE LAST-NAME     TO  LAST-NAME-O.                00243000
73             MOVE FIRST-NAME    TO  FIRST-NAME-O.               00244000
74             MOVE COMMENTS      TO  COMMENTS-O.
75             WRITE PRINT-REC.                                   00246000
76                                                                00247000
77
```

```
PRINT-LINE
  01 PRINT-REC.
    05 ACCT-NO-O PIC X(8).
```

Figure 2. View declaration of variable

Since this field is a 05-level variable nested within a 01-level variable, the pop up shows the declaration of the field as an eight-byte picture variable, the name of the parent structure and the file definition that it is within. If you hold the CMD/Ctrl key while hovering over the field, then the pop up will additionally contain the line of code where the variable is defined as well as the following three lines of code. These features can be extremely helpful when analyzing existing code.

3.2.4 Syntax highlighting

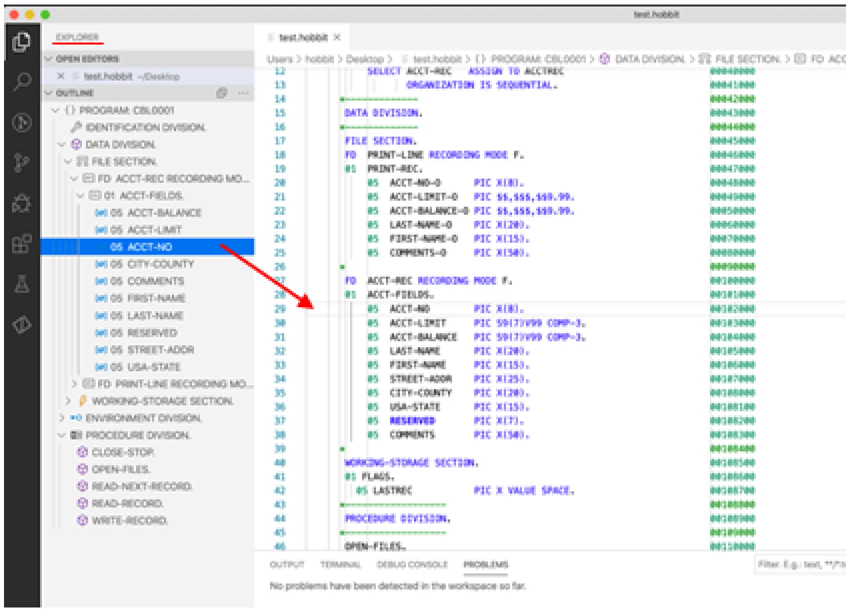
The COBOL code that you are editing will also be highlighted to help you understand the different elements of the COBOL language. Depending on the color theme that you have selected in VSCode, comments, COBOL reserved words, literal values and variables will be colored differently allowing you to spot obvious syntax issues early on before even submitting the code to a build.

3.3 Navigation of code

Although the code examples we are using in this section are fairly small, the code that you could be writing could have hundreds or thousands of lines. Being able to understand the general structure of the source code and being able to find your way around it without getting lost is a big advantage when editing COBOL. Fortunately, there are some great features to help you out, which we will discuss next.

3.3.1 Outline view

Within the explorer side bar of VSCode, there is an outline view that will be populated whenever you are editing a COBOL file. This view contains a collapsible look at each division, data structure and paragraph within your code. This allows you to easily view the structure of the source code. Clicking on a particular paragraph, division or data element will simultaneously move the editor to show that section of the code and highlight it, depicted in Figure 3. This makes jumping to a specific part of the code very easy.



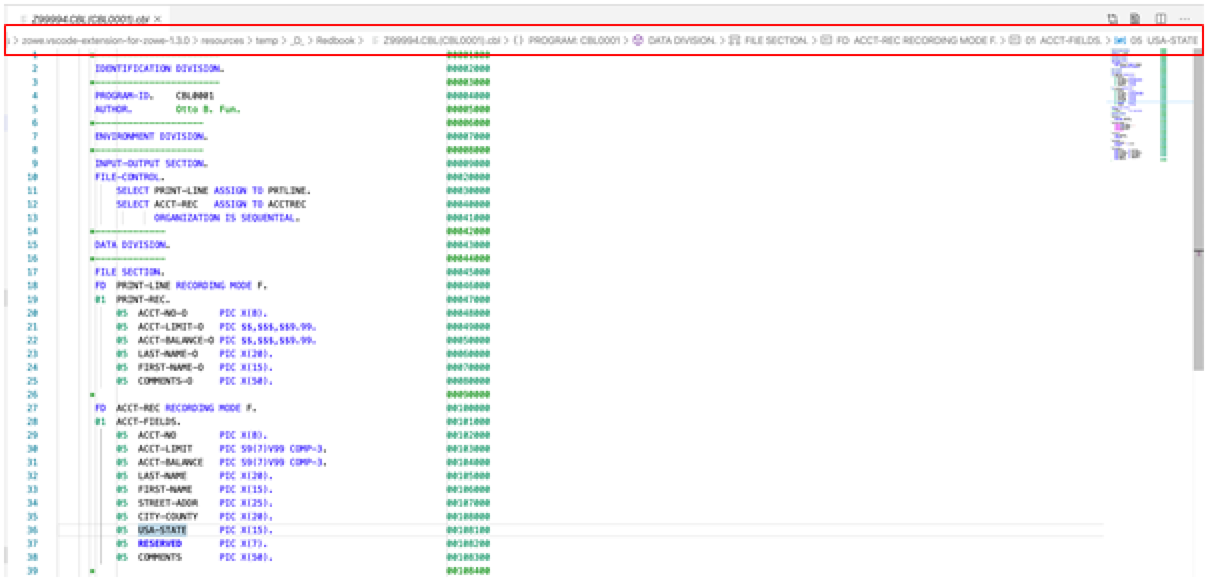
```
12            SELECT ACCT-REC   ASSIGN TO ACCTREC                      00040000
13                 ORGANIZATION IS SEQUENTIAL.                         00041000
14        *-------------                                               00042000
15         DATA DIVISION.                                              00043000
16        *-------------                                               00044000
17         FILE SECTION.                                               00045000
18         FD  PRINT-LINE RECORDING MODE F.                            00046000
19         01  PRINT-REC.                                              00047000
20             05  ACCT-NO-O      PIC X(8).                            00048000
21             05  ACCT-LIMIT-O   PIC $$,$$$,$$9.99.                   00049000
22             05  ACCT-BALANCE-O PIC $$,$$$,$$9.99.                   00050000
23             05  LAST-NAME-O    PIC X(20).                           00060000
24             05  FIRST-NAME-O   PIC X(15).                           00070000
25             05  COMMENTS-O     PIC X(50).                           00080000
26        *                                                            00090000
27         FD  ACCT-REC RECORDING MODE F.                              00100000
28         01  ACCT-FIELDS.                                            00101000
29             05  ACCT-NO            PIC X(8).                        00102000
30             05  ACCT-LIMIT         PIC S9(7)V99 COMP-3.             00103000
31             05  ACCT-BALANCE       PIC S9(7)V99 COMP-3.             00104000
32             05  LAST-NAME          PIC X(20).                       00105000
33             05  FIRST-NAME         PIC X(15).                       00106000
34             05  STREET-ADDR        PIC X(25).                       00107000
35             05  CITY-COUNTY        PIC X(20).                       00108000
36             05  USA-STATE          PIC X(15).                       00108100
37             05  RESERVED           PIC X(7).                        00108200
38             05  COMMENTS           PIC X(50).                       00108300
39        *                                                            00108400
40         WORKING-STORAGE SECTION.                                    00108500
41         01 FLAGS.                                                   00108600
42           05 LASTREC           PIC X VALUE SPACE.                   00108700
43        *-------------------                                         00108800
44         PROCEDURE DIVISION.                                         00108900
45        *-------------------                                         00109000
46         OPEN-FILES.                                                 00110000
```

No problems have been detected in the workspace so far.

Figure 3. Outline view in VSCode

3.3.2 Breadcrumb view

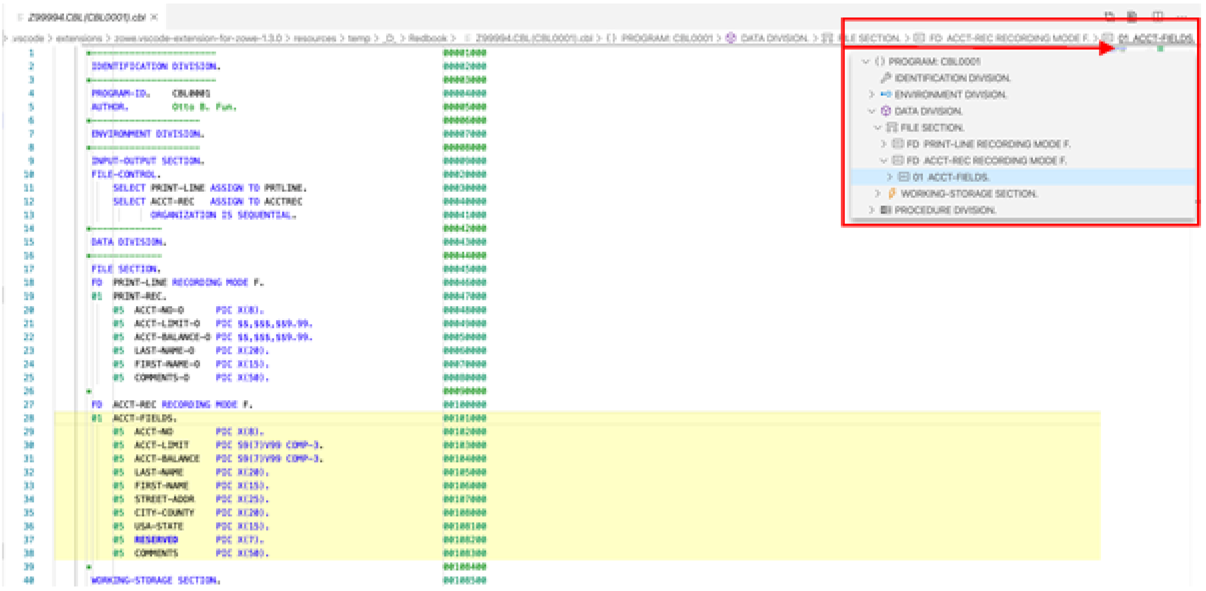
Similarly, the breadcrumb view across the top of the editor can show where the current line of code exists within the structure of the COBOL source code. As you navigate the source code in the editor, the breadcrumb trail will automatically update to reflect where you are in the structure of the program and provides you a mechanism to move to a different element of the code. Again, if you open CBL0001 in VSCode and jump to line 36, this line is a declaration of the field USA-STATE within the structure ACCT-FIELDS, in the FILE-SECTION of the DATA-DIVISION. Across the top of the editor the breadcrumb trail will show the information displayed in Figure 4.



```
Z99994.CBL(CBL0001).cbl ×
› zowe.vscode-extension-for-zowe-1.3.0 › resources › temp › _D_ › Redbook › Z99994.CBL(CBL0001).cbl › {} PROGRAM: CBL0001 › DATA DIVISION. › FILE SECTION. › FD ACCT-REC RECORDING MODE F. › 01 ACCT-FIELDS. › 05 USA-STATE
      *-----------------------                                          00001000
       IDENTIFICATION DIVISION.                                         00002000
      *-----------------------                                          00003000
       PROGRAM-ID.    CBL0001                                           00004000
       AUTHOR.        Otto B. Fun.                                      00005000
      *--------------------                                             00006000
       ENVIRONMENT DIVISION.                                            00007000
      *--------------------                                             00008000
       INPUT-OUTPUT SECTION.                                            00009000
       FILE-CONTROL.                                                    00020000
           SELECT PRINT-LINE ASSIGN TO PRTLINE.                         00030000
           SELECT ACCT-REC   ASSIGN TO ACCTREC                          00040000
                  ORGANIZATION IS SEQUENTIAL.                           00041000
      *-------------                                                    00042000
       DATA DIVISION.                                                   00043000
      *-------------                                                    00044000
       FILE SECTION.                                                    00045000
       FD  PRINT-LINE RECORDING MODE F.                                 00046000
       01  PRINT-REC.                                                   00047000
           05  ACCT-NO-O      PIC X(8).                                 00048000
           05  ACCT-LIMIT-O   PIC $$,$$$,$$9.99.                        00049000
           05  ACCT-BALANCE-O PIC $$,$$$,$$9.99.                        00050000
           05  LAST-NAME-O    PIC X(20).                                00060000
           05  FIRST-NAME-O   PIC X(15).                                00070000
           05  COMMENTS-O     PIC X(50).                                00080000
      *                                                                 00090000
       FD  ACCT-REC RECORDING MODE F.                                   00100000
       01  ACCT-FIELDS.                                                 00101000
           05  ACCT-NO            PIC X(8).                             00102000
           05  ACCT-LIMIT         PIC S9(7)V99 COMP-3.                  00103000
           05  ACCT-BALANCE       PIC S9(7)V99 COMP-3.                  00104000
           05  LAST-NAME          PIC X(20).                            00105000
           05  FIRST-NAME         PIC X(15).                            00106000
           05  STREET-ADDR        PIC X(25).                            00107000
           05  CITY-COUNTY        PIC X(20).                            00108000
           05  USA-STATE          PIC X(15).                            00108100
           05  RESERVED           PIC X(7).                             00108200
           05  COMMENTS           PIC X(50).                            00108300
      *                                                                 00108400
```

Figure 4. Breadcrumb trail in VSCode

Clicking on any of the items in the breadcrumb trail will highlight that element of the code in the editor, quickly showing you the location of that element within the code. It will also show a view of the code in a pop-up window, shown in Figure 5. , similar to the outline view previously discussed.



```
Z99994.CBL(CBL0001).cbl ×
› .vscode › extensions › zowe.vscode-extension-for-zowe-1.3.0 › resources › temp › _D_ › Redbook › Z99994.CBL(CBL0001).cbl › {} PROGRAM: CBL0001 › DATA DIVISION. › FILE SECTION. › FD ACCT-REC RECORDING MODE F. › 01 ACCT-FIELDS.
      *-----------------------                                          00001000
       IDENTIFICATION DIVISION.                                         00002000
      *-----------------------                                          00003000
       PROGRAM-ID.    CBL0001                                           00004000
       AUTHOR.        Otto B. Fun.                                      00005000
      *--------------------                                             00006000
       ENVIRONMENT DIVISION.                                            00007000
      *--------------------                                             00008000
       INPUT-OUTPUT SECTION.                                            00009000
       FILE-CONTROL.                                                    00020000
           SELECT PRINT-LINE ASSIGN TO PRTLINE.                         00030000
           SELECT ACCT-REC   ASSIGN TO ACCTREC                          00040000
                  ORGANIZATION IS SEQUENTIAL.                           00041000
      *-------------                                                    00042000
       DATA DIVISION.                                                   00043000
      *-------------                                                    00044000
       FILE SECTION.                                                    00045000
       FD  PRINT-LINE RECORDING MODE F.                                 00046000
       01  PRINT-REC.                                                   00047000
           05  ACCT-NO-O      PIC X(8).                                 00048000
           05  ACCT-LIMIT-O   PIC $$,$$$,$$9.99.                        00049000
           05  ACCT-BALANCE-O PIC $$,$$$,$$9.99.                        00050000
           05  LAST-NAME-O    PIC X(20).                                00060000
           05  FIRST-NAME-O   PIC X(15).                                00070000
           05  COMMENTS-O     PIC X(50).                                00080000
      *                                                                 00090000
       FD  ACCT-REC RECORDING MODE F.                                   00100000
       01  ACCT-FIELDS.                                                 00101000
           05  ACCT-NO            PIC X(8).                             00102000
           05  ACCT-LIMIT         PIC S9(7)V99 COMP-3.                  00103000
           05  ACCT-BALANCE       PIC S9(7)V99 COMP-3.                  00104000
           05  LAST-NAME          PIC X(20).                            00105000
           05  FIRST-NAME         PIC X(15).                            00106000
           05  STREET-ADDR        PIC X(25).                            00107000
           05  CITY-COUNTY        PIC X(20).                            00108000
           05  USA-STATE          PIC X(15).                            00108100
           05  RESERVED           PIC X(7).                             00108200
           05  COMMENTS           PIC X(50).                            00108300
      *                                                                 00108400
       WORKING-STORAGE SECTION.                                         00108500
```

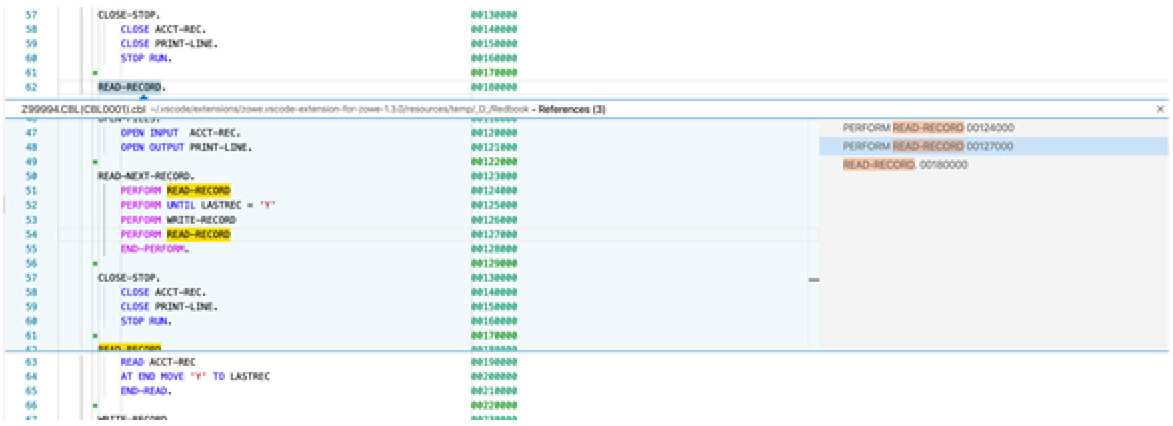
Figure 5. Pop-up view of code via breadcrumb selection

3.3.3 Jump to declaration / reference

As you browse through code you will come across COBOL PERFORM statements or variable references. Often you will need to navigate to the definition of that paragraph or variable to follow the execution of the code. At line 50 of CBL0001 we see a set of perform statements. Place the cursor within the name, READ-RECORD, on line 51, right click and select **Go to Definition** . The editor then navigates to the READ-RECORD paragraph on line 62. Instead of the right click, the same function can be reached by using the F12 key.

"Go to References" does the reverse of this operation and allows you to navigate from the definition of a paragraph or variable to all the places within the application that reference that paragraph or variable. To demonstrate this, navigate to line 62 of CBL0001, which again is the declaration of the READ-RECORD paragraph. To see all of the places where this paragraph is called, right click and select **Go to References** , or hit the key combination **SHIFT+F12** . This will summon a new pop up dialog which shows all the references to this paragraph in the code, shown in Figure 6.

Note: If **SHIFT+F12** does not work for your machine, you may need to use the key combination, **Fn+F12 instead.**



```
57      CLOSE-STOP.                                       00130000
58          CLOSE ACCT-REC.                               00140000
59          CLOSE PRINT-LINE.                             00150000
60          STOP RUN.                                     00160000
61                                                        00170000
62      READ-RECORD.                                      00180000
```

Z99994.CBL(CBL0001).cbl ~/.vscode/extensions/zowe.vscode-extension-for-zowe-1.3.0/resources/temp/_D_/Redbook - References (3)

```
47          OPEN INPUT  ACCT-REC.                         00120000
48          OPEN OUTPUT PRINT-LINE.                       00121000
49                                                        00122000
50      READ-NEXT-RECORD.                                 00123000
51          PERFORM READ-RECORD                           00124000
52          PERFORM UNTIL LASTREC = 'Y'                   00125000
53          PERFORM WRITE-RECORD                          00126000
54          PERFORM READ-RECORD                           00127000
55          END-PERFORM.                                  00128000
56                                                        00129000
57      CLOSE-STOP.                                       00130000
58          CLOSE ACCT-REC.                               00140000
59          CLOSE PRINT-LINE.                             00150000
60          STOP RUN.                                     00160000
61                                                        00170000
```

```
PERFORM READ-RECORD 00124000
PERFORM READ-RECORD 00127000
READ-RECORD. 00180000
```

```
63          READ ACCT-REC                                 00190000
64          AT END MOVE 'Y' TO LASTREC                    00200000
65          END-READ.                                     00210000
66                                                        00220000
```

Figure 6. Finding paragraph/variable references in VSCode

3.4 Code-completion

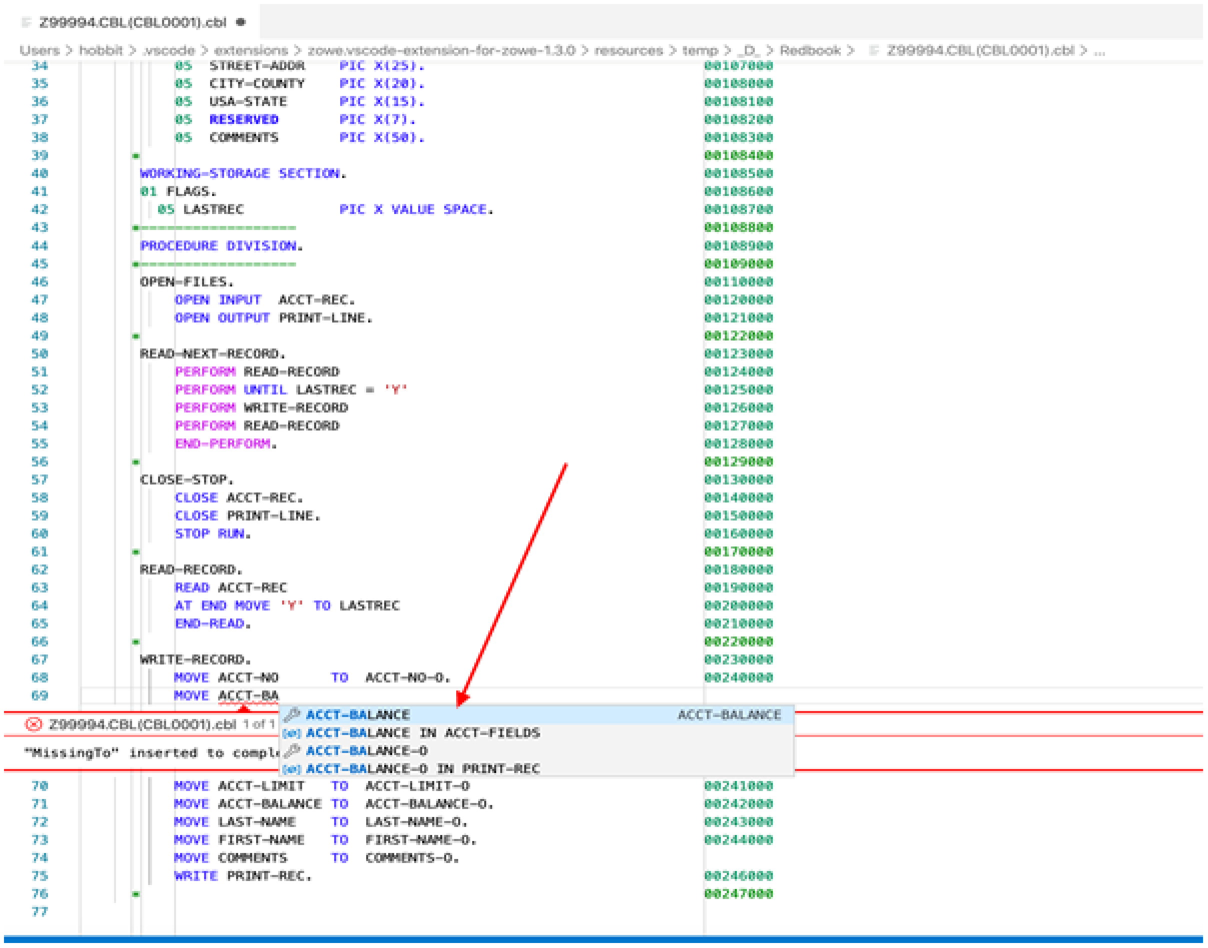
Code completion isn't exactly a new concept in most IDEs. For example, the Eclipse editor has provided auto-completion for Java APIs for a long time. The same key combination, **CTRL+SPACE** , triggers this auto-completion function while you are coding and can be used to help guide you through COBOL syntax and CICS, IMS API calls.

3.4.1 COBOL reserved word completion

As you are typing a COBOL reserved word, you can type `CTRL+SPACE` and the IBM Z Open Editor will present, in a pop-up, a list of possible COBOL reserved words that you might be trying to use. Using the cursor keys or the mouse allows you to select the correct recommended keyword and press enter to select it and the rest of the reserved word will be entered for you, aka auto-completed!

3.4.2 Variable completion

The same technique can be applied to variable completion. This can be particularly useful when you are referencing a variable that exists multiple times within different structures. In these cases, auto-completion can help you identify the variable you want to use. As an example, create a new line within the WRITE-RECORD paragraph. On the new line, enter the code `MOVE ACCT-BA` and then press **CTRL+SPACE** to invoke code auto-completion. You should see a pop up similar to the one shown in Figure 7. below.



Z99994.CBL(CBL0001).cbl

Users > hobbit > .vscode > extensions > zowe.vscode-extension-for-zowe-1.3.0 > resources > temp > _D_ > Redbook > Z99994.CBL(CBL0001).cbl > ...

```
34           05  STREET-ADDR     PIC X(25).                      00107000
35           05  CITY-COUNTY     PIC X(20).                      00108000
36           05  USA-STATE       PIC X(15).                      00108100
37           05  RESERVED        PIC X(7).                       00108200
38           05  COMMENTS        PIC X(50).                      00108300
39      *                                                        00108400
40       WORKING-STORAGE SECTION.                                00108500
41       01 FLAGS.                                               00108600
42         05 LASTREC            PIC X VALUE SPACE.              00108700
43      *------------------                                      00108800
44       PROCEDURE DIVISION.                                     00108900
45      *------------------                                      00109000
46       OPEN-FILES.                                             00110000
47           OPEN INPUT  ACCT-REC.                               00120000
48           OPEN OUTPUT PRINT-LINE.                             00121000
49      *                                                        00122000
50       READ-NEXT-RECORD.                                       00123000
51           PERFORM READ-RECORD                                 00124000
52           PERFORM UNTIL LASTREC = 'Y'                         00125000
53           PERFORM WRITE-RECORD                                00126000
54           PERFORM READ-RECORD                                 00127000
55           END-PERFORM.                                        00128000
56      *                                                        00129000
57       CLOSE-STOP.                                             00130000
58           CLOSE ACCT-REC.                                     00140000
59           CLOSE PRINT-LINE.                                   00150000
60           STOP RUN.                                           00160000
61      *                                                        00170000
62       READ-RECORD.                                            00180000
63           READ ACCT-REC                                       00190000
64           AT END MOVE 'Y' TO LASTREC                          00200000
65           END-READ.                                           00210000
66      *                                                        00220000
67       WRITE-RECORD.                                           00230000
68           MOVE ACCT-NO      TO  ACCT-NO-O.                    00240000
69           MOVE ACCT-BA
```

```
ACCT-BALANCE                                    ACCT-BALANCE
ACCT-BALANCE IN ACCT-FIELDS
ACCT-BALANCE-O
ACCT-BALANCE-O IN PRINT-REC
```

Z99994.CBL(CBL0001).cbl 1 of 1

"MissingTo" inserted to compl

```
70           MOVE ACCT-LIMIT   TO  ACCT-LIMIT-O                  00241000
71           MOVE ACCT-BALANCE TO  ACCT-BALANCE-O.               00242000
72           MOVE LAST-NAME    TO  LAST-NAME-O.                  00243000
73           MOVE FIRST-NAME   TO  FIRST-NAME-O.                 00244000
74           MOVE COMMENTS     TO  COMMENTS-O.
75           WRITE PRINT-REC.                                    00246000
76      *                                                        00247000
77
```

Figure 7. Auto-completion in VSCode

You can see that not only is the variable ACCT-BALANCE prompted as a potential candidate, but it also presents ACCT_BALANCE IN ACCT-FIELDS.

3.4.3 CICS, MQ, DB2 API completion

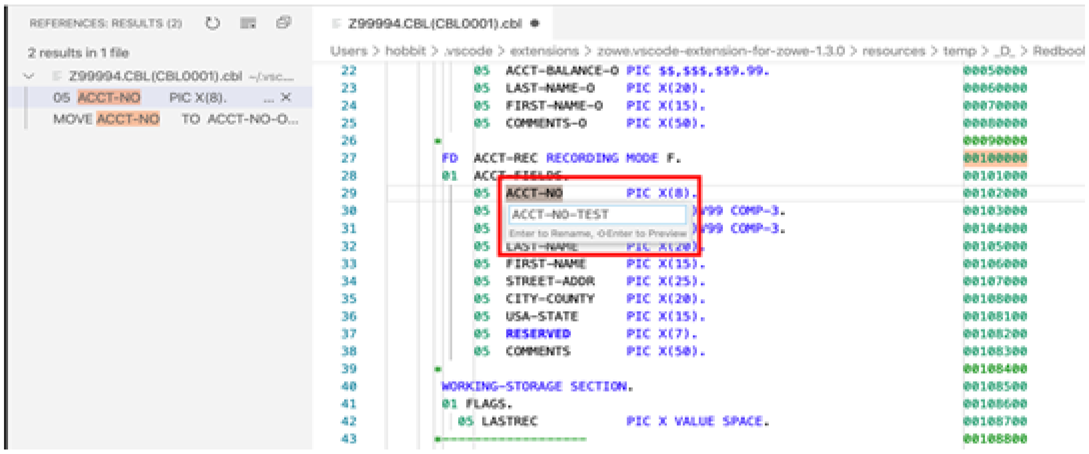
The auto-completion of variables also extends to the CICS and DB2 APIs, known as EXEC CICS and EXEC SQL statements. Although COBOL programming for DB2 and CICS is not a primary focus here, note that if you find yourself programming for either of these APIs that the capability is available.

3.5 Refactoring code

Working with source code is seldom just about the initial creation, during a programs life cycle it will be changed and re-worked we often call this work refactoring. This section explores renaming variables and handling errors.

3.5.1 Renaming variables

During maintenance of existing code, you might need to refactor variable names or paragraph names. Doing this manually can be a painful process, as you probably need to update both the original declaration and all the references within the source code. Fortunately, there is a function for that, let's work through an example. Back in CBL0001 hit **CTRL+G** to bring up the go to line function and go to line 29. This is the declaration of the variable ACCT-NO. Right click on the variable and select "**Find All References**". From this we can see that apart from the declaration, the variable is also referenced on line 68. So, if we rename the variable, we probably need to update this reference as well. To perform the rename, ensure that the cursor is on the variable and then press **SHIFT/Fn+F2** . This will bring up a small pop-up asking you to provide a new variable name, as shown in Figure 8. Enter `ACCT-NO-TEST` and press **enter** .


REFERENCES: RESULTS (2)
2 results in 1 file
Z99994.CBL(CBL0001).cbl ~/.vsc...
Z99994.CBL(CBL0001).cbl
Users > hobbit > .vscode > extensions > zowe.vscode-extension-for-zowe-1.3.0 > resources > temp > _D_ > Redbool

```
05 ACCT-NO      PIC X(8).      ...
MOVE ACCT-NO    TO  ACCT-NO-O...
```

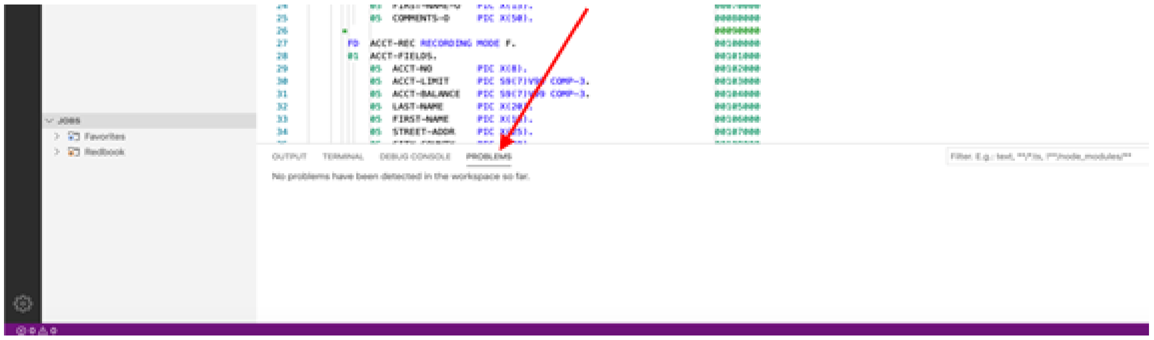
```
           05  ACCT-BALANCE-O PIC $$,$$$,$$9.99.                         00050000
           05  LAST-NAME-O    PIC X(20).                                 00060000
           05  FIRST-NAME-O   PIC X(15).                                 00070000
           05  COMMENTS-O     PIC X(50).                                 00080000
      *                                                                  00090000
       FD  ACCT-REC RECORDING MODE F.                                    00100000
       01  ACCT-FIELDS.                                                  00101000
           05  ACCT-NO        PIC X(8).                                  00102000
           05  ACCT-NO-TEST           V99 COMP-3.                        00103000
           05  Enter to Rename, ⇧Enter to Preview V99 COMP-3.            00104000
           05  LAST-NAME      PIC X(20).                                 00105000
           05  FIRST-NAME     PIC X(15).                                 00106000
           05  STREET-ADDR    PIC X(25).                                 00107000
           05  CITY-COUNTY    PIC X(20).                                 00108000
           05  USA-STATE      PIC X(15).                                 00108100
           05  RESERVED       PIC X(7).                                  00108200
           05  COMMENTS       PIC X(50).                                 00108300
      *                                                                  00108400
       WORKING-STORAGE SECTION.                                          00108500
       01 FLAGS.                                                         00108600
         05 LASTREC           PIC X VALUE SPACE.                         00108700
      *-------------------                                               00108800
```

Figure 8. Renaming variables

You will note that both the declaration of the variable and the reference on line 68 have been updated to the new value. As stated previously, the same process also works for paragraph names. For example, go ahead and refactor the name of the paragraph READ-RECORD to be READ-NEW-RECORD.

3.5.2 Handling errors

The IBM Z Open Editor plugin also provides a level of syntax checking for local source code. Although not as thorough as the compiler, it is a method of quickly identifying basic errors in your code before submitting it for compilation. To demonstrate, let's create an error and then see how the editor shows it to us. First, open the problems view by selecting **View** and then **Problems** from the editor menu. The problems view should open at the bottom of the window, as depicted in Figure 9.



```
           05  COMMENTS-O     PIC X(50).                                 00080000
      *                                                                  00090000
       FD  ACCT-REC RECORDING MODE F.                                    00100000
       01  ACCT-FIELDS.                                                  00101000
           05  ACCT-NO        PIC X(8).                                  00102000
           05  ACCT-LIMIT     PIC S9(7)V99 COMP-3.                       00103000
           05  ACCT-BALANCE   PIC S9(7)V99 COMP-3.                       00104000
           05  LAST-NAME      PIC X(20).                                 00105000
           05  FIRST-NAME     PIC X(15).                                 00106000
           05  STREET-ADDR    PIC X(25).                                 00107000
```

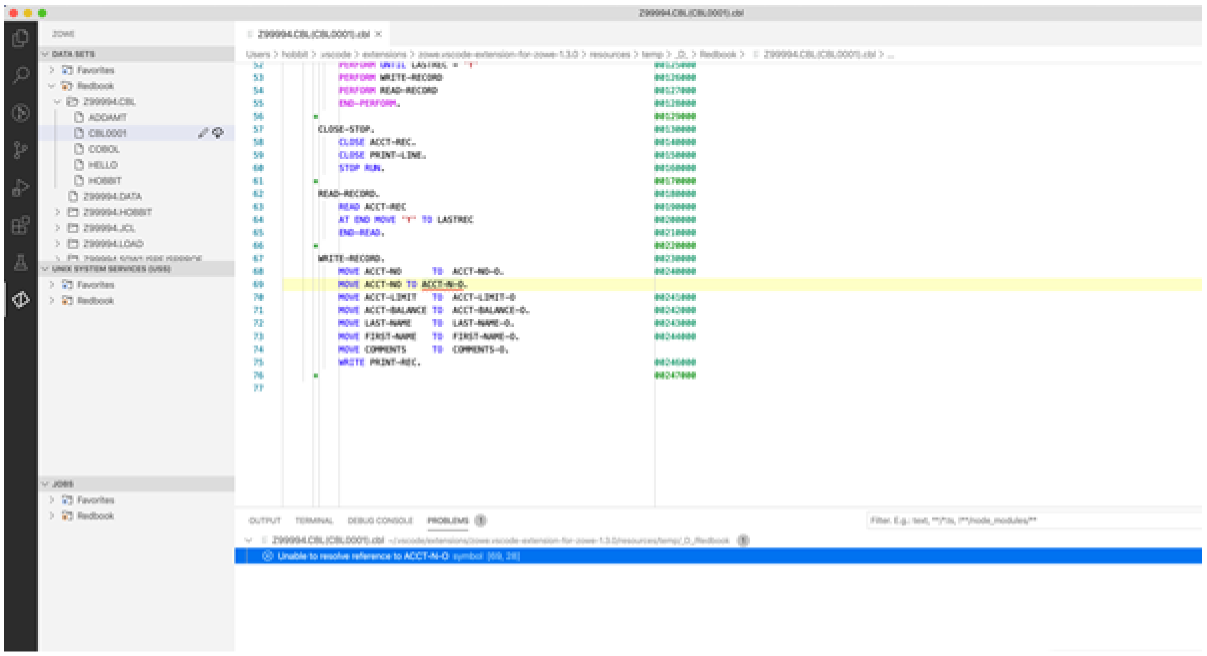
No problems have been detected in the workspace so far.

Figure 9. Problems view

Now we need to introduce an error into the code. After line 68, add the line:

```
MOVE ACCT-NO TO ACCT-N-O.
```

Note that this line incorrectly identifies the second variable, which doesn't exist. Once entering that line, you will notice that the invalid variable has been underlined in red to highlight it as an error. Also, the problems view has a new error. Clicking on the error will highlight the line of code at fault in the editor, shown in Figure 10. , allowing you to view the error directly.



```
           PERFORM UNTIL LASTREC = 'Y'                                  00125000
           PERFORM WRITE-RECORD                                         00126000
           PERFORM READ-RECORD                                          00127000
           END-PERFORM.                                                 00128000
      *                                                                 00129000
       CLOSE-STOP.                                                      00130000
           CLOSE ACCT-REC.                                              00140000
           CLOSE PRINT-LINE.                                            00150000
           STOP RUN.                                                    00160000
      *                                                                 00170000
       READ-RECORD.                                                     00180000
           READ ACCT-REC                                                00190000
           AT END MOVE 'Y' TO LASTREC                                   00200000
           END-READ.                                                    00210000
      *                                                                 00220000
       WRITE-RECORD.                                                    00230000
           MOVE ACCT-NO      TO  ACCT-NO-O.                             00240000
           MOVE ACCT-NO TO ACCT-N-O.
           MOVE ACCT-LIMIT   TO  ACCT-LIMIT-O                           00241000
           MOVE ACCT-BALANCE TO  ACCT-BALANCE-O.                        00242000
           MOVE LAST-NAME    TO  LAST-NAME-O.                           00243000
           MOVE FIRST-NAME   TO  FIRST-NAME-O.                          00244000
           MOVE COMMENTS     TO  COMMENTS-O.
           WRITE PRINT-REC.                                             00246000
      *                                                                 00247000
```

Z99994.CBL(CBL0001).cbl ~/.vscode/extensions/zowe.vscode-extension-for-zowe-1.3.0/resources/temp/_D_/Redbook 1

Unable to resolve reference to ACCT-N-O symbol [69, 28]

Figure 10. Highlighting error in source code

Now that you see where the error is located, it can now be corrected. As soon as the error has been rectified, the problem disappears from the problem view.

3.6 Summary

In this chapter you have been able to go through some of the editing features of the Z Open Editor for VSCode. These capabilities make editing COBOL, PL/Iand JCL a lot friendlier and easier than some of the other editors in the market.

4 VS Code with Code4z Open-Source Extension Package

This section introduces the Code4z extension package, in particular the COBOL Language Support extension.

- **What is Code4z?**
- **Known File Extensions**
- **Syntax Highlighting and Coloring**
- **Syntax and Semantic Check**
- **Navigation of Code**
  - **Go To Definition**
  - **Find All References**
- **Copybook Support**
- **Autocomplete**
- **Summary**

4.1 What is Code4z?

Code4z is an all-in-one, open-source mainframe extension package for Visual Studio Code. The Code4z package contains extensions which provide language support for COBOL and High Level Assembler language, a debugger for COBOL programs, as well as tools which enable developers to access mainframe data sets and CA Endevor code repositories using the Visual Studio Code interface. This guide focuses on the COBOL Language Support extension. The Zowe Explorer extension is also included in the Code4z package.

The COBOL Language Support extension leverages the Language Server Protocol to provide autocomplete, highlighting, and diagnostic features for COBOL code. Together with Zowe Explorer, you can load COBOL code from a mainframe data set, and edit it leveraging the LSP features of the extension. Once you finish editing, you can save the file back on the mainframe, and store a copy locally.

The Code4z Extension Pack can be installed into VS Code by searching the Extensions Marketplace inside VS Code for “Code4z” and selecting install. The extension pack contains a number of extensions that can be leveraged when working with the mainframe, including the COBOL Language Support extension which provides similar functionality to the Z Open Editor extension discussed earlier. Therefore, ensure only one of these two extensions is enabled. Other extensions included in the pack will work with either COBOL Language Support or Z Open Editor. To see more detailed instructions on installing this extension, refer to “Installation of VSCode and Extensions”.

4.2 Known File Extensions

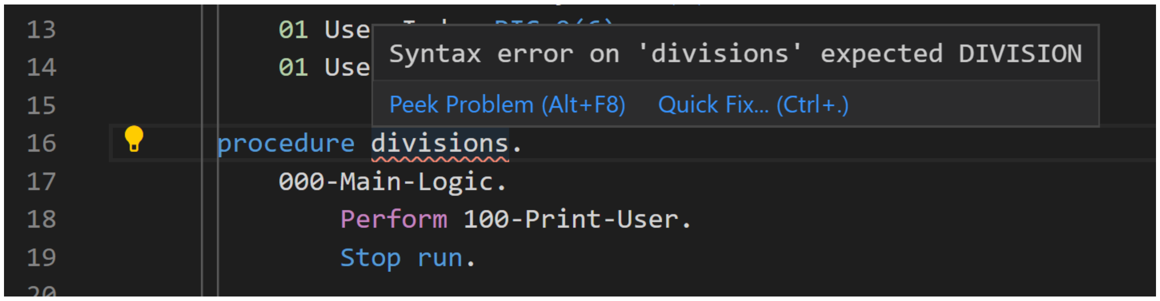
Code4z recognizes files with the extensions .COB and .CBL as COBOL files. This applies to both local files and files held in a PDS on the mainframe. COBOL Language Support features are automatically enabled when you open any file with an extension identifying it as a COBOL file.

4.3 Syntax Highlighting and Coloring

The COBOL Language Support extension enables coloring of keywords, paragraphs, and variables in different colors to make the code easier to navigate.

4.4 Syntax and Semantic Check

The COBOL Language Support extension checks for mistakes and errors in COBOL code. The syntax check feature reviews the whole content of the code, highlights errors and suggests fixes.



```
        01 Use
        01 Use
    procedure divisions.
        000-Main-Logic.
            Perform 100-Print-User.
            Stop run.
```

```
Syntax error on 'divisions' expected DIVISION
```

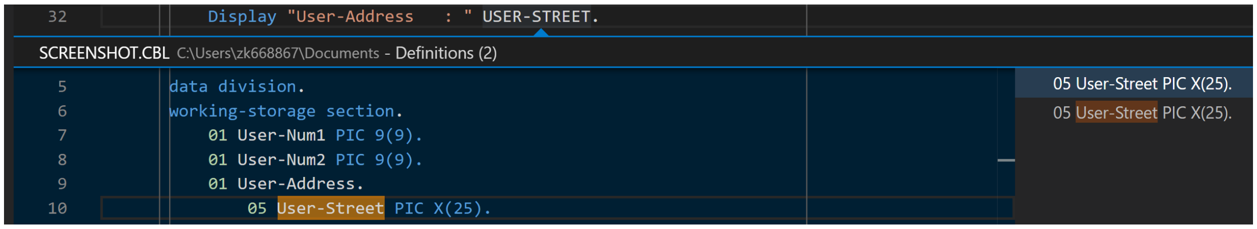
Figure 1. The syntax and semantic check feature highlights an error.

4.5 Navigation of Code

The COBOL Language Support extension enables several features for ease of navigation through code.

4.5.1 Go To Definition

While your cursor is placed on a variable or paragraph name, you can press **F12** or **CTRL+click** to use the **Go To Definition** functionality to display the point in the code where the variable or paragraph is defined.



```
        Display "User-Address    : " USER-STREET.
```

SCREENSHOT.CBL C:\Users\zk668867\Documents - Definitions (2)

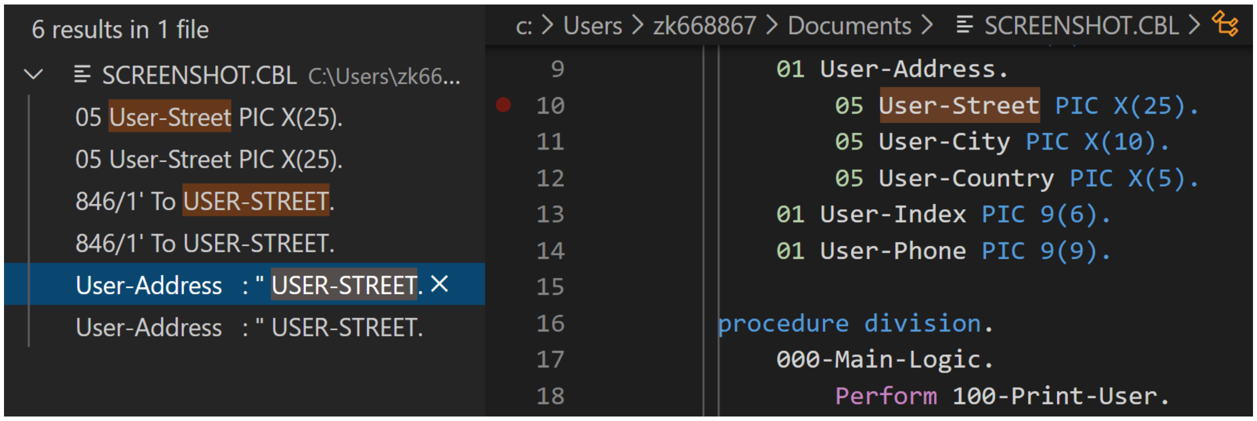
```
data division.
working-storage section.
    01 User-Num1 PIC 9(9).
    01 User-Num2 PIC 9(9).
    01 User-Address.
        05 User-Street PIC X(25).
```

05 User-Street PIC X(25).
05 User-Street PIC X(25).

Figure 2. Go To Definition shows the point at which the USER-STREET variable is first defined.

4.5.2 Find All References

The **Find All References** functionality (**SHIFT+ALT+F12**) highlights all references to a variable or paragraph and displays them in a list in the sidebar, so that you can easily navigate between them.



6 results in 1 file

SCREENSHOT.CBL C:\Users\zk66...
05 User-Street PIC X(25).
05 User-Street PIC X(25).
846/1' To USER-STREET.
846/1' To USER-STREET.
User-Address : " USER-STREET.
User-Address : " USER-STREET.

c: > Users > zk668867 > Documents > SCREENSHOT.CBL >

```
    01 User-Address.
        05 User-Street PIC X(25).
        05 User-City PIC X(10).
        05 User-Country PIC X(5).
    01 User-Index PIC 9(6).
    01 User-Phone PIC 9(9).

procedure division.
    000-Main-Logic.
        Perform 100-Print-User.
```

Figure 3. Find All References lists all references to the USER-STREET variable in the code.

4.6 Copybook Support

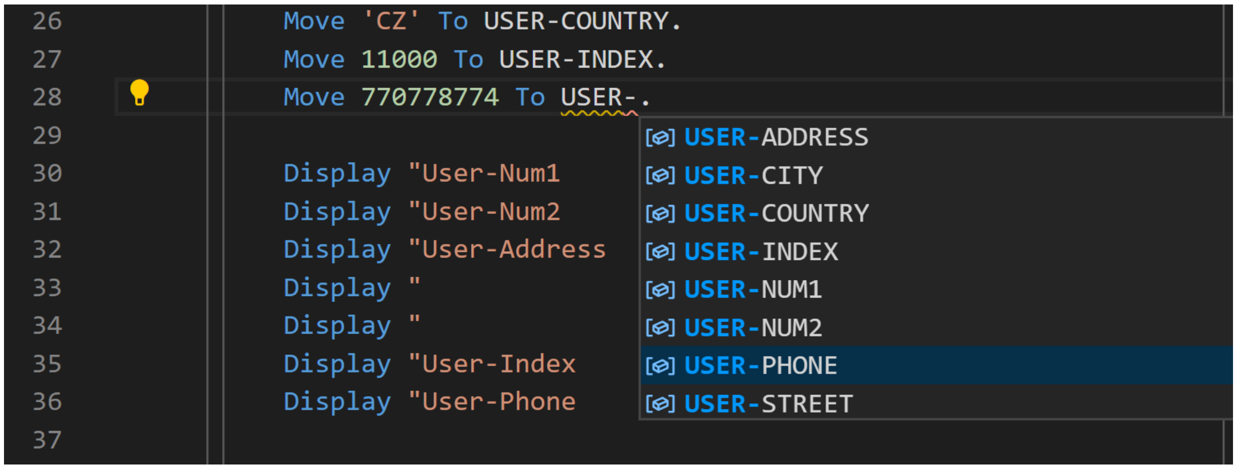
Copybooks are pieces of source code stored in separate data sets which are referenced in a program. The COBOL Language Support extension enables you to download all copybooks referenced in your program from the mainframe to a folder in your workspace. In order for this feature to work, you need to set up and configure a Zowe CLI `zosmf` profile. You can also enable support for copybooks stored locally in folders in your workspace. This is useful when working with a COBOL project stored in a Github repository.

The COBOL Language Support extension helps to ensure that copybooks called in the code remain compatible through semantic analysis of keywords, variables, and paragraphs within copybooks, and ensures the consistency of code by defining variables and paragraphs across copybooks. The extension also helps to protect against unwanted errors caused by recursive or missing copybooks.

The **Go To Definition** and **Find All References** functionalities are extended to work for occurrences of variables and paragraphs from copybooks called in the program as well as from the program itself. You can also use the **Go To Definition** feature on a copybook name in order to open it.

4.7 Autocomplete

The COBOL Language Support extension provides live suggestions while you type for COBOL keywords, as well as variables and paragraphs which are already referenced in the code or in copybooks used by the program.



```
           Move 'CZ' To USER-COUNTRY.
           Move 11000 To USER-INDEX.
           Move 770778774 To USER-.

           Display "User-Num1
           Display "User-Num2
           Display "User-Address
           Display "
           Display "
           Display "User-Index
           Display "User-Phone
```

Figure 4. Autocomplete lists possible variables and keywords beginning with the typed string in a list.

4.8 Summary

In this chapter you have been introduced to all the COBOL language support features of the Code4z package of open-source extensions for VS Code.

5 Zowe CLI and Zowe CLI Plug-ins

In this chapter we will explain what a CLI is and why you would use it, how to use Zowe CLI interactively, how to abstract CLI commands into useful scripts, and how Zowe CLI enables the use of familiar open source tooling while developing COBOL applications on the mainframe.

- **What is a CLI and why would you use it?**
- **What is Zowe CLI?**
- **Zowe CLI interactive use**
  - **Installing Zowe CLI**
  - **Interactive Help**
  - **Zowe Profiles**
  - **Interacting with z/OS Data Sets**
  - **Interacting with z/OS Jobs**
- **Automating tasks using Zowe CLI**
  - **Automated Job Submission**
  - **Using Other Programming Languages and Continuous Integration**
  - **Additional Examples**
- **The world of modern open source tooling**
- **Summary**

5.1 What is a CLI and why would you use it?

CLI stands for Command Line Interface. It is a program that allows for user interaction through text based input. In the early days of computing, command line interfaces were the only means to interact with operating systems. The invention of the mouse and development of graphical user interfaces led to the experience we are familiar with today. Well-designed GUIs certainly yield an improved interactive experience. However, CLIs are still heavily used today and are very powerful. Windows shell and bash are common examples of terminals where command line tools are run interactively.

If well-designed GUIs yield an improved interactive experience, why would you use a CLI? Simply put, automation. Command line interfaces can be used interactively allowing for quick exploration of available commands. They are also usually self-guided and some even offer modern help displays by launching content in a browser. But, they are also programmatic interfaces where command sequences and tasks can be easily abstracted into scripts.

5.2 What is Zowe CLI?

Zowe CLI is an open source CLI for the mainframe. It is a tool that can be run on Windows, Linux, and Mac offering a means to interact with the mainframe from an environment where modern open source tooling is available. Cloud platforms like Amazon Web Services, Azure, and Google Cloud Platform all provide heavily used CLIs. The Zowe CLI helps make interacting with the mainframe like interacting with other cloud services.

At its core, Zowe CLI provides remote interaction with z/OS data sets & jobs, Unix System Services files, TSO and Console commands, and provisioning services. Zowe CLI is also an extensible technology and numerous plug-ins exist that extend its reach to z/OS subsystems and vendor software.

Zowe CLI is a bridge tool between distributed systems and the mainframe. Pick your favorite language or open source tool and leverage it for mainframe development with the assistance of the Zowe CLI. Want to develop automation in Python? Want to write tests in Node? Want to run Jenkins pipelines for continuous integration? Want to use open source testing frameworks like Mocha or Facebook's Jest? Want to leverage code quality tools like SonarQube? Go for it!

CLIs are useful for automating repeated tasks. For mainframe COBOL apps, Zowe CLI can help you automate your build, deployment, and testing processes. Check out this blog for more info and the sample code that made it possible! Zowe CLI can also help you to automate administrative tasks.

Most IDEs have integrated terminals as well so the CLI can be leveraged from your favorite distributed development environment, including VS Code!

5.3 Zowe CLI interactive use

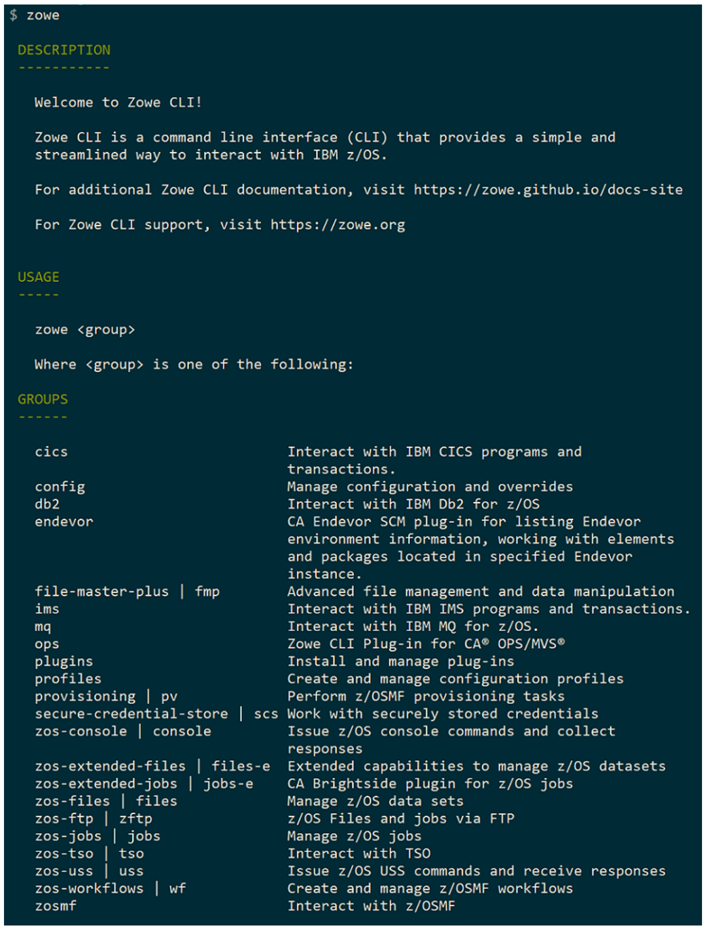
The Zowe CLI can be leveraged for quick exploration of z/OS services as well as issuing commands that are not yet available in your IDE of choice. Before developing automation, it is common to first accomplish a commonly repeated task from the CLI interactively.

5.3.1 Installing Zowe CLI

The Zowe CLI is a node package and is one of over 1.2 million node packages available on the public npm registry. After Node.js and npm are installed on the client machine, the core CLI can be installed by simply issuing `npm install -g @zowe/cli@zowe-v1-lts`. There is an alternative installation method if your workstation does not have access to the public registry. More details on installing Zowe CLI and Zowe CLI plug-ins are provided in a future section titled "Installation of Zowe CLI and plug-ins".

5.3.2 Interactive Help

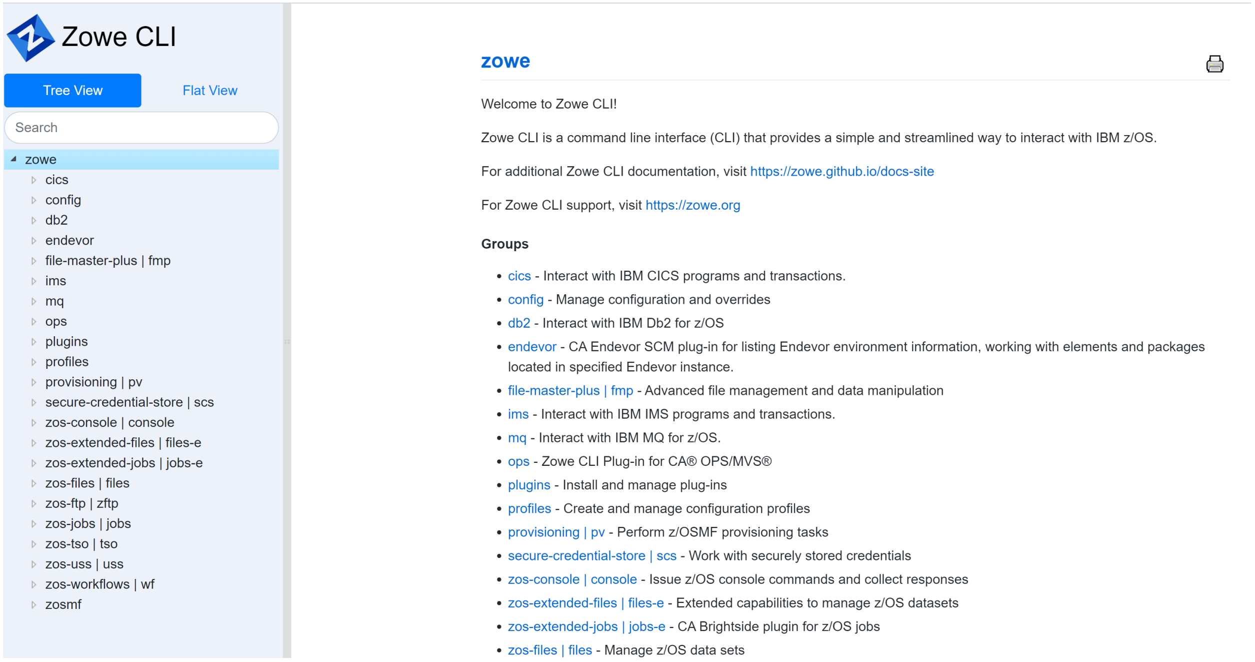
To get started, you can simply open a terminal and issue zowe. This will yield the top level help.



```
$ zowe

 DESCRIPTION
 -----------

   Welcome to Zowe CLI!

   Zowe CLI is a command line interface (CLI) that provides a simple and
   streamlined way to interact with IBM z/OS.

   For additional Zowe CLI documentation, visit https://zowe.github.io/docs-site

   For Zowe CLI support, visit https://zowe.org


 USAGE
 -----

   zowe <group>

   Where <group> is one of the following:

 GROUPS
 ------

   cics                             Interact with IBM CICS programs and
                                    transactions.
   config                           Manage configuration and overrides
   db2                              Interact with IBM Db2 for z/OS
   endevor                          CA Endevor SCM plug-in for listing Endevor
                                    environment information, working with elements
                                    and packages located in specified Endevor
                                    instance.
   file-master-plus | fmp           Advanced file management and data manipulation
   ims                              Interact with IBM IMS programs and transactions.
   mq                               Interact with IBM MQ for z/OS.
   ops                              Zowe CLI Plug-in for CA® OPS/MVS®
   plugins                          Install and manage plug-ins
   profiles                         Create and manage configuration profiles
   provisioning | pv                Perform z/OSMF provisioning tasks
   secure-credential-store | scs    Work with securely stored credentials
   zos-console | console            Issue z/OS console commands and collect
                                    responses
   zos-extended-files | files-e     Extended capabilities to manage z/OS datasets
   zos-extended-jobs | jobs-e       CA Brightside plugin for z/OS jobs
   zos-files | files                Manage z/OS data sets
   zos-ftp | zftp                   z/OS Files and jobs via FTP
   zos-jobs | jobs                  Manage z/OS jobs
   zos-tso | tso                    Interact with TSO
   zos-uss | uss                    Issue z/OS USS commands and receive responses
   zos-workflows | wf               Create and manage z/OSMF workflows
   zosmf                            Interact with z/OSMF
```

Figure 1. Zowe CLI Help

In the example above, multiple extensions are installed. The structure of commands is `zowe <group> <action> <object>` followed by various parameters and options specific to the command. For example, a valid command is `zowe files list data-set "HLQ.*"`. This command will list data-sets matching a pattern of "HLQ.*". You can append `-h` to any command to find out more information. Frequently referring to the help can be difficult and time consuming so if your environment has access to a web browser, simply append `--help-web` or `--hw` to any command to launch interactive web help.



zowe

Welcome to Zowe CLI!

Zowe CLI is a command line interface (CLI) that provides a simple and streamlined way to interact with IBM z/OS.

For additional Zowe CLI documentation, visit https://zowe.github.io/docs-site

For Zowe CLI support, visit https://zowe.org

Groups

- cics - Interact with IBM CICS programs and transactions.
- config - Manage configuration and overrides
- db2 - Interact with IBM Db2 for z/OS
- endevor - CA Endevor SCM plug-in for listing Endevor environment information, working with elements and packages located in specified Endevor instance.
- file-master-plus | fmp - Advanced file management and data manipulation
- ims - Interact with IBM IMS programs and transactions.
- mq - Interact with IBM MQ for z/OS.
- ops - Zowe CLI Plug-in for CA® OPS/MVS®
- plugins - Install and manage plug-ins
- profiles - Create and manage configuration profiles
- provisioning | pv - Perform z/OSMF provisioning tasks
- secure-credential-store | scs - Work with securely stored credentials
- zos-console | console - Issue z/OS console commands and collect responses
- zos-extended-files | files-e - Extended capabilities to manage z/OS datasets
- zos-extended-jobs | jobs-e - CA Brightside plugin for z/OS jobs
- zos-files | files - Manage z/OS data sets

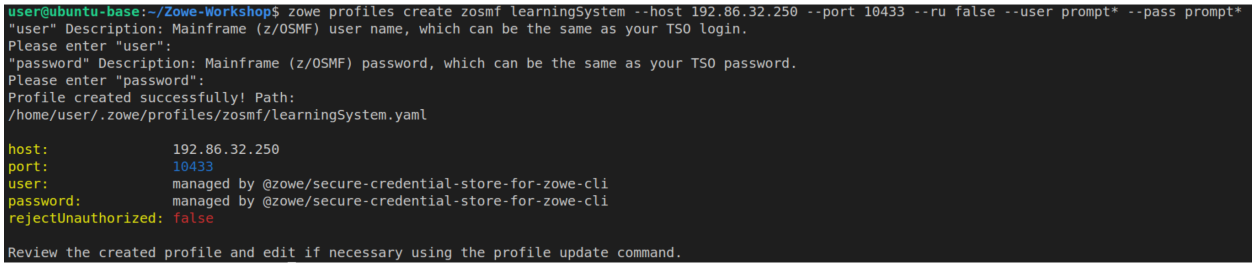
Figure 2. Zowe CLI Web Help

Don't have the CLI installed yet? You can also check out a copy of the web help for the core Zowe CLI and Zowe plug-ins here.

5.3.3 Zowe Profiles

Zowe client technologies like Zowe CLI and the Zowe Explorer VS Code Extension store connection information in files commonly known as profiles. This provides convenience as after profiles for services are created, users do not have to constantly provide this information. For the secure storage of credentials, there is the Secure Credential Store plug-in which is discussed more in a later section titled "Installation of Zowe CLI and plug-ins". The Secure Credential Store provides a means to store creds in the operating system's secure credential vault.

When creating profiles you can also specify the `prompt*` keyword to be prompted for your username and password so they will be masked on the command line. Figure 3 shows a sample command to create a zosmf profile. This will eliminate the need to provide these details on future commands.

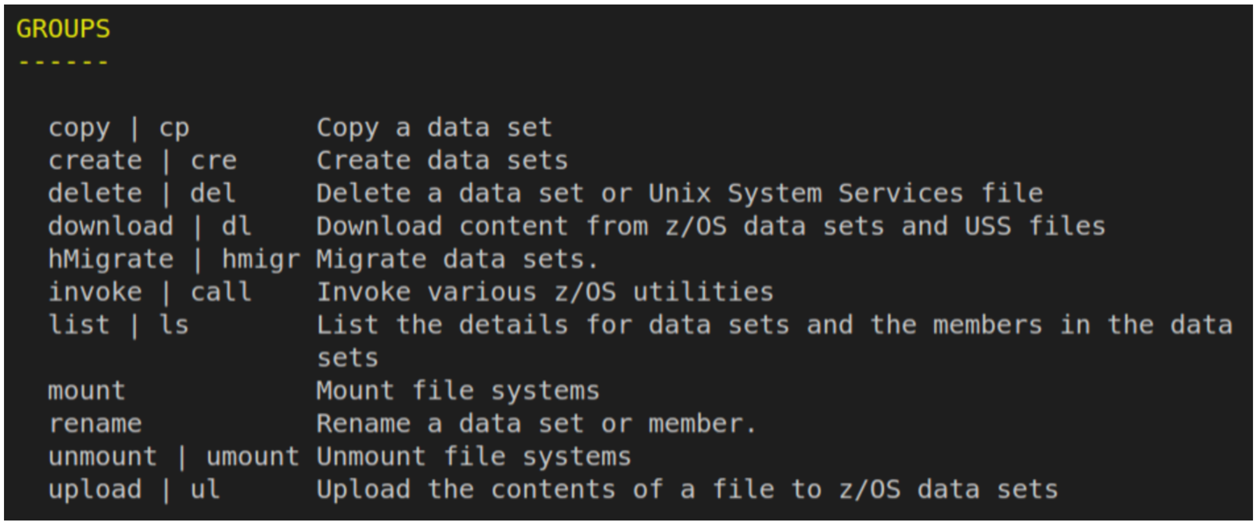


```
user@ubuntu-base:~/Zowe-Workshop$ zowe profiles create zosmf learningSystem --host 192.86.32.250 --port 10433 --ru false --user prompt* --pass prompt*
"user" Description: Mainframe (z/OSMF) user name, which can be the same as your TSO login.
Please enter "user":
"password" Description: Mainframe (z/OSMF) password, which can be the same as your TSO password.
Please enter "password":
Profile created successfully! Path:
/home/user/.zowe/profiles/zosmf/learningSystem.yaml

host:                192.86.32.250
port:                10433
user:                managed by @zowe/secure-credential-store-for-zowe-cli
password:            managed by @zowe/secure-credential-store-for-zowe-cli
rejectUnauthorized: false

Review the created profile and edit if necessary using the profile update command.
```

Figure 3. Zowe CLI z/OSMF Profile Creation Command

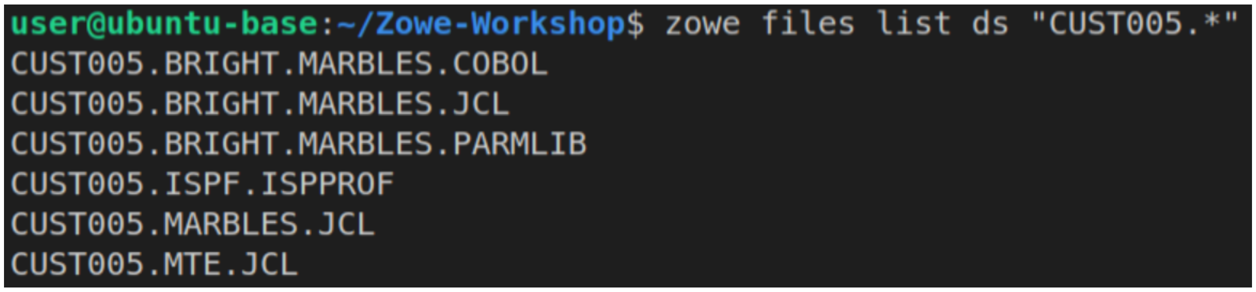
5.3.4 Interacting with z/OS Data Sets

Zowe CLI provides a significant suite of z/OS data set interaction functionality. See the following figures for details on available actions and a sample list command.



```
GROUPS
------

  copy | cp          Copy a data set
  create | cre       Create data sets
  delete | del       Delete a data set or Unix System Services file
  download | dl      Download content from z/OS data sets and USS files
  hMigrate | hmigr Migrate data sets.
  invoke | call      Invoke various z/OS utilities
  list | ls          List the details for data sets and the members in the data
                     sets
  mount              Mount file systems
  rename             Rename a data set or member.
  unmount | umount Unmount file systems
  upload | ul        Upload the contents of a file to z/OS data sets
```

Figure 4. Zowe CLI zos-files actions

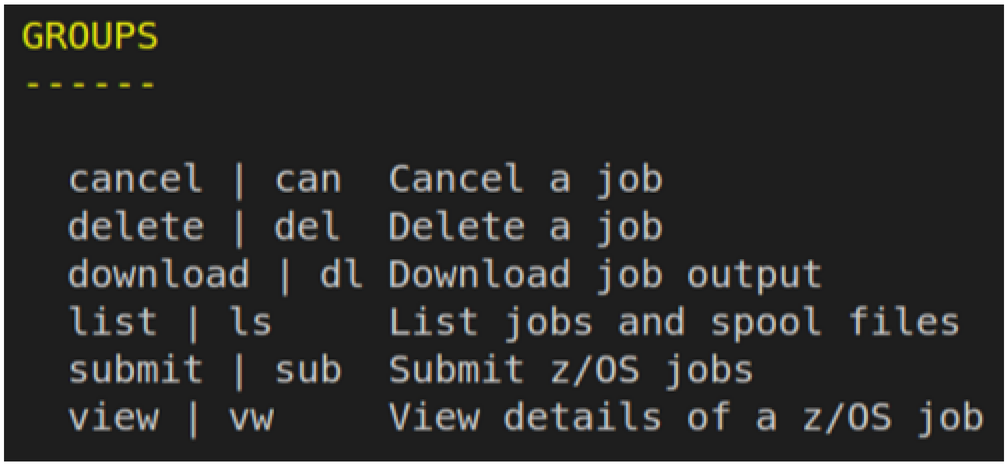


```
user@ubuntu-base:~/Zowe-Workshop$ zowe files list ds "CUST005.*"
CUST005.BRIGHT.MARBLES.COBOL
CUST005.BRIGHT.MARBLES.JCL
CUST005.BRIGHT.MARBLES.PARMLIB
CUST005.ISPF.ISPPROF
CUST005.MARBLES.JCL
CUST005.MTE.JCL
```

Figure 5. Sample Zowe CLI zos-files list ds command

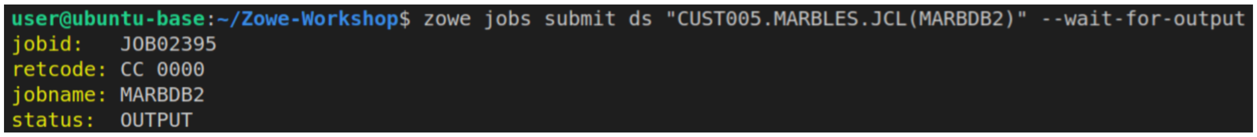
5.3.5 Interacting with z/OS Jobs

Zowe CLI provides a significant suite of z/OS jobs interaction functionality. See the following figures for details on available actions and a sample job submission command.



```
GROUPS
------

  cancel | can   Cancel a job
  delete | del   Delete a job
  download | dl  Download job output
  list | ls      List jobs and spool files
  submit | sub   Submit z/OS jobs
  view | vw      View details of a z/OS job
```

Figure 6. Zowe CLI zos-jobs actions



```
user@ubuntu-base:~/Zowe-Workshop$ zowe jobs submit ds "CUST005.MARBLES.JCL(MARBDB2)" --wait-for-output
jobid:   JOB02395
retcode: CC 0000
jobname: MARBDB2
status:  OUTPUT
```

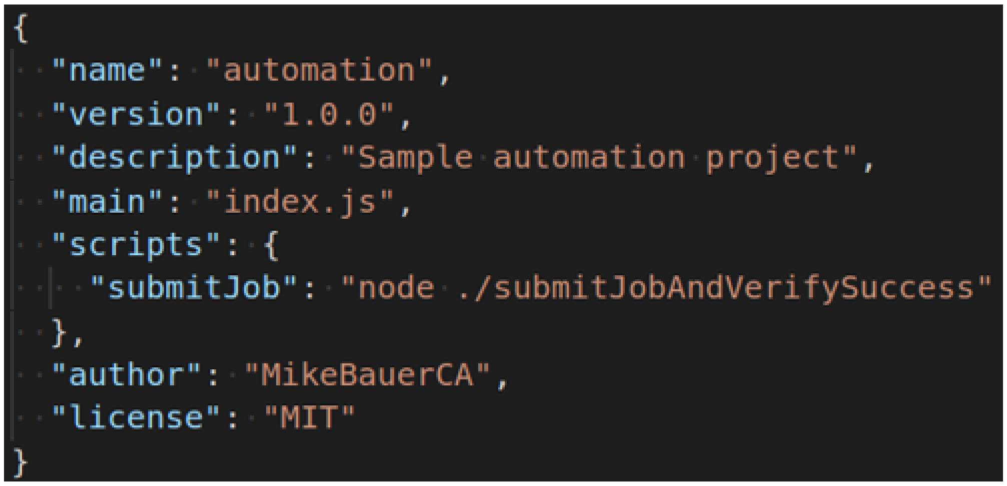
Figure 7. Sample Zowe CLI zos-jobs submit ds command

5.4 Automating tasks using Zowe CLI

Running commands interactively is a great way to learn the capabilities of the Zowe CLI. However, creating custom automation for your commonly repeated tasks and making use of valuable development tooling is where significant value lies. For COBOL development, significant time can be spent reviewing compiler output and testing programs. These repetitive tasks are excellent candidates for automation.

5.4.1 Automated Job Submission

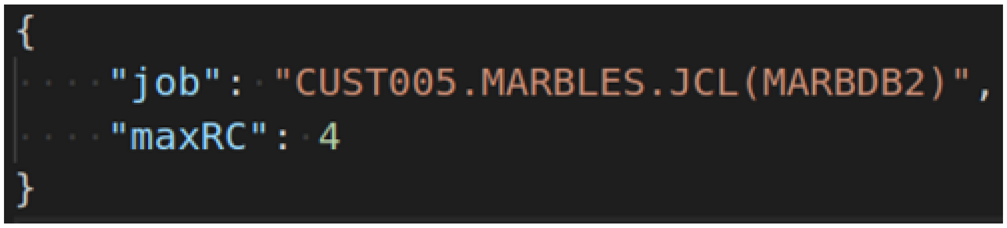
Let's investigate automating submitting a job and verifying the return code is 0. Of course, we could also parse the spool output for specific messages of interest but we will keep it simple for now. For this sample, we will leverage Node.js to develop a new automation suite. To start, I will create a package.json file to make it easy for others to manage and install the project. It will contain the list of dependencies for my project as well as the automation tasks I will develop. A quick way to create a package.json is to issue `npm init` and answer the prompts. Once created I will add a submitJob task. You can add whatever automation you want here. My final package.json is shown in the next figure. You can learn more about package.json files here.



```
{
  "name": "automation",
  "version": "1.0.0",
  "description": "Sample automation project",
  "main": "index.js",
  "scripts": {
    "submitJob": "node ./submitJobAndVerifySuccess"
  },
  "author": "MikeBauerCA",
  "license": "MIT"
}
```

Figure 8. Sample package.json

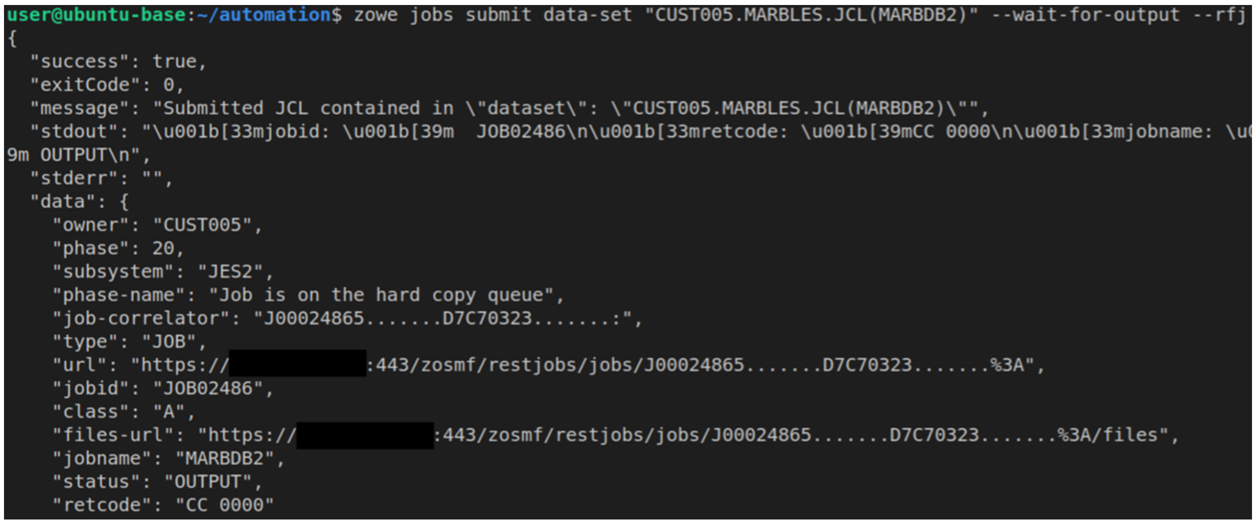
Then I will create a config.json file to store all the variables I may wish to change for my project. In this case, we will set the job to submit and the maximum allowable return code for that job.



```
{
    "job": "CUST005.MARBLES.JCL(MARBDB2)",
    "maxRC": 4
}
```

Figure 9. Sample config.json

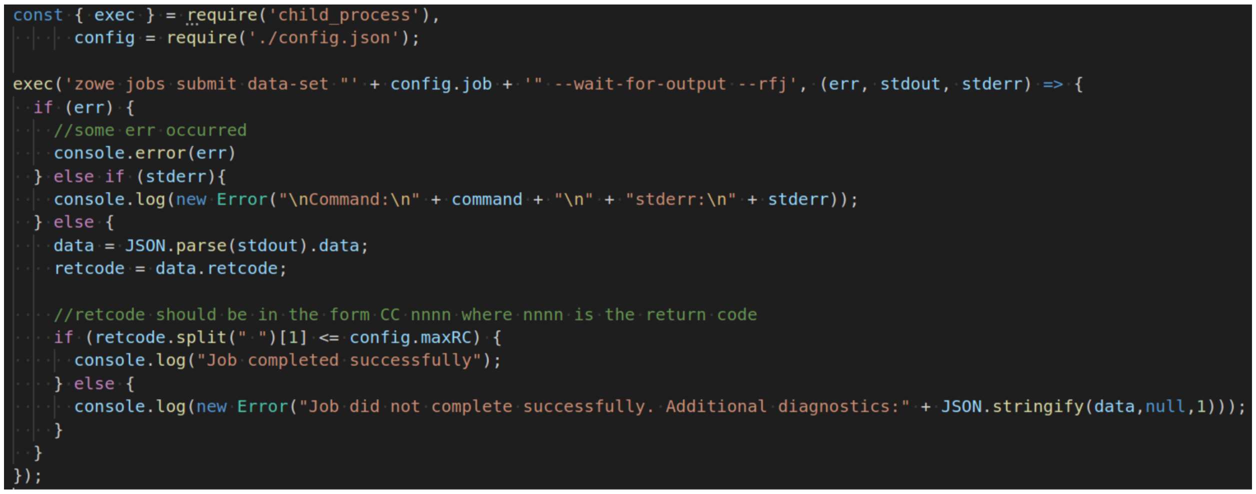
Next we will write our automation. The Zowe CLI was built with scripting in mind and can output responses in JSON format which can be easily parsed.



```
user@ubuntu-base:~/automation$ zowe jobs submit data-set "CUST005.MARBLES.JCL(MARBDB2)" --wait-for-output --rfj
{
  "success": true,
  "exitCode": 0,
  "message": "Submitted JCL contained in \"dataset\": \"CUST005.MARBLES.JCL(MARBDB2)\"",
  "stdout": "\u001b[33mjobid: \u001b[39m  JOB02486\n\u001b[33mretcode: \u001b[39mCC 0000\n\u001b[33mjobname: \u
9m OUTPUT\n",
  "stderr": "",
  "data": {
    "owner": "CUST005",
    "phase": 20,
    "subsystem": "JES2",
    "phase-name": "Job is on the hard copy queue",
    "job-correlator": "J00024865.......D7C70323.......:",
    "type": "JOB",
    "url": "https://[redacted]:443/zosmf/restjobs/jobs/J00024865.......D7C70323.......%3A",
    "jobid": "JOB02486",
    "class": "A",
    "files-url": "https://[redacted]:443/zosmf/restjobs/jobs/J00024865.......D7C70323.......%3A/files",
    "jobname": "MARBDB2",
    "status": "OUTPUT",
    "retcode": "CC 0000"
```

Figure 10. Sample Zowe CLI response format JSON output

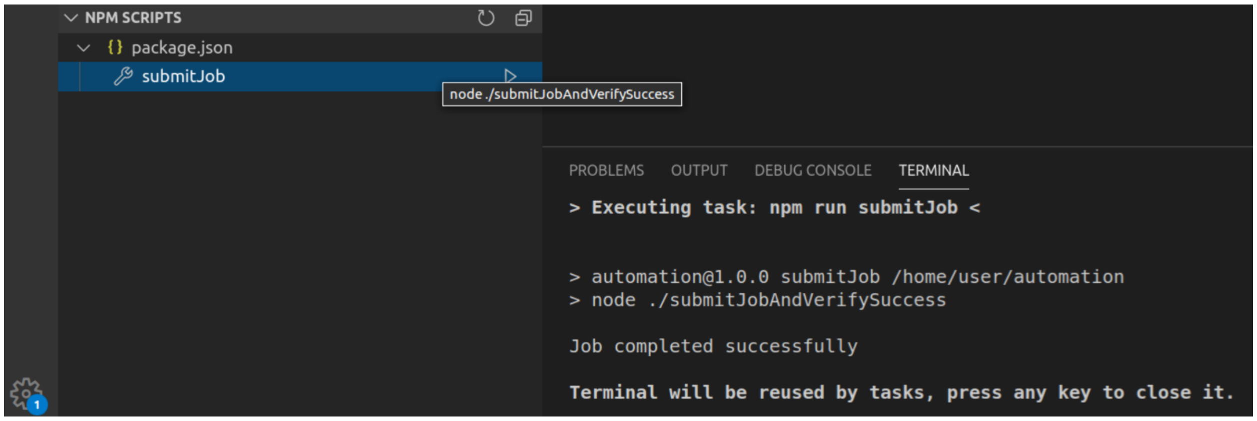
Now, instead of issuing this command and reviewing it to see if the retcode is less than or equal to 4, we want to automate it. See the implementation in a node script below.



```
const { exec } = require('child_process'),
      config = require('./config.json');

exec('zowe jobs submit data-set "' + config.job + '" --wait-for-output --rfj', (err, stdout, stderr) => {
  if (err) {
    //some err occurred
    console.error(err)
  } else if (stderr){
    console.log(new Error("\nCommand:\n" + command + "\n" + "stderr:\n" + stderr));
  } else {
    data = JSON.parse(stdout).data;
    retcode = data.retcode;

    //retcode should be in the form CC nnnn where nnnn is the return code
    if (retcode.split(" ")[1] <= config.maxRC) {
      console.log("Job completed successfully");
    } else {
      console.log(new Error("Job did not complete successfully. Additional diagnostics:" + JSON.stringify(data,null,1)));
    }
  }
});
```

Figure 11. Sample code to submit job and verify output is less than or equal to a maximum allowable RC

I had to make the investment to write this automation but for future job submissions I can simply issue `npm run submitJob`. IDEs like VS Code can visualize these tasks making my commonly repeated tasks as easy as clicking a button :). This job could compile, link, and/or run a COBOL program.



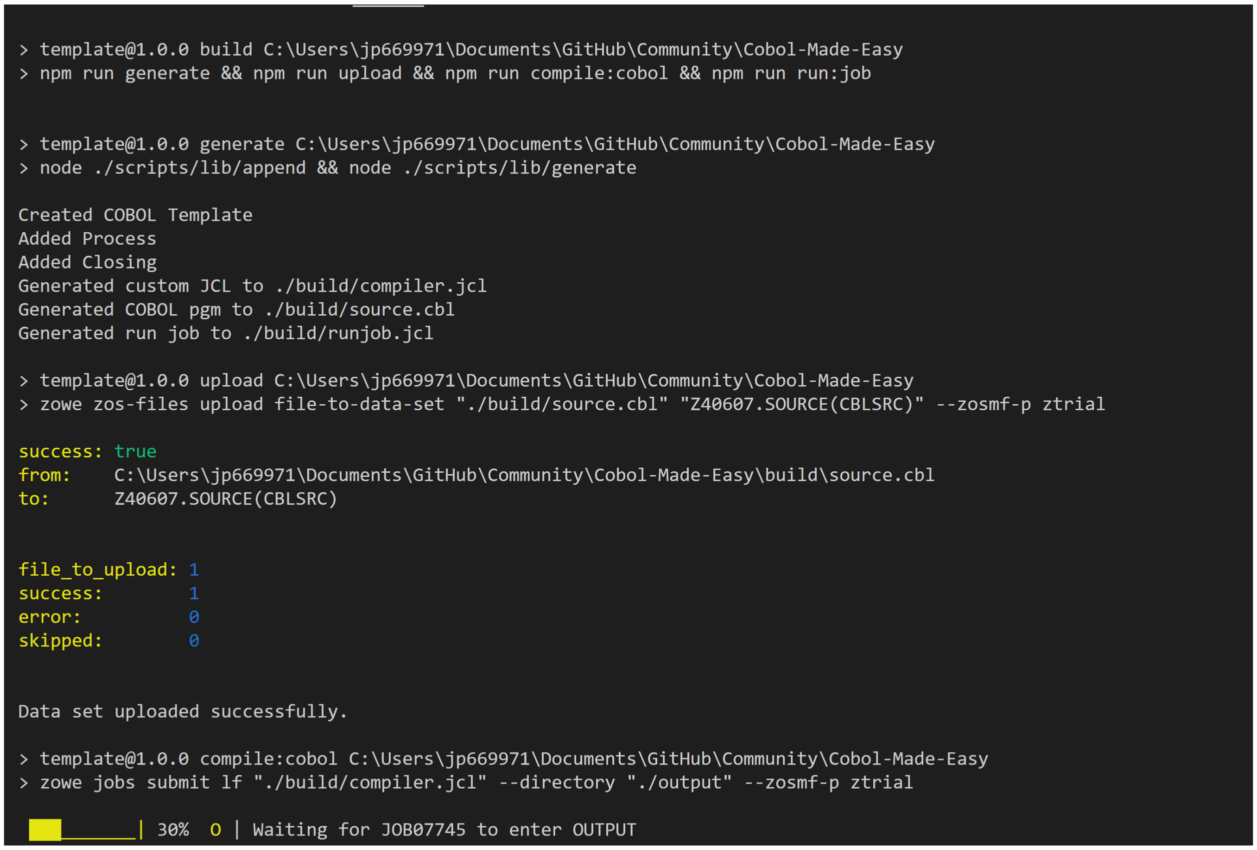
```
> Executing task: npm run submitJob <


> automation@1.0.0 submitJob /home/user/automation
> node ./submitJobAndVerifySuccess

Job completed successfully

Terminal will be reused by tasks, press any key to close it.
```

Figure 12. Vizualization of npm script and sample run

More advanced code automating the compilation, deployment to test environment, and testing of a COBOL CICS application is described in this blog.

5.4.2 Using Other Programming Languages and Continuous Integration

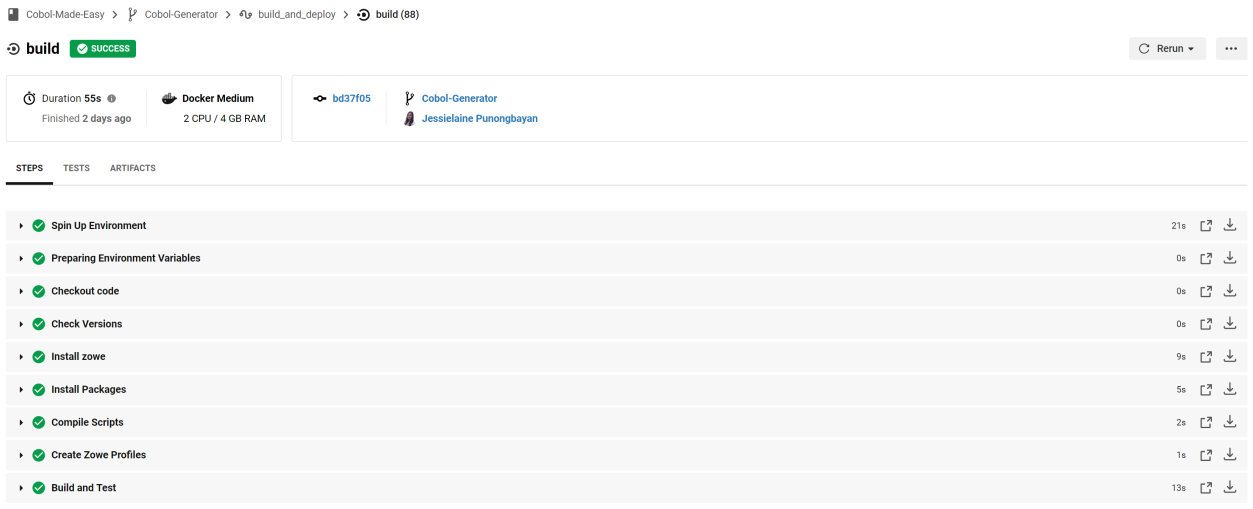
Another good example of automating tasks using Zowe CLI is when you want to integrate other programming languages into your COBOL development. Similar to 3.4.1, you can use other languages such as Typescript to write a COBOL program generator and use Zowe CLI to create a "one-click" process for creating your program. The figure below is a representation of that "one-click" automated process where several tasks are executed such as creating your COBOL program, uploading it in mainframe, compiling it and running your JCL to test it.



```
> template@1.0.0 build C:\Users\jp669971\Documents\GitHub\Community\Cobol-Made-Easy
> npm run generate && npm run upload && npm run compile:cobol && npm run run:job


> template@1.0.0 generate C:\Users\jp669971\Documents\GitHub\Community\Cobol-Made-Easy
> node ./scripts/lib/append && node ./scripts/lib/generate

Created COBOL Template
Added Process
Added Closing
Generated custom JCL to ./build/compiler.jcl
Generated COBOL pgm to ./build/source.cbl
Generated run job to ./build/runjob.jcl

> template@1.0.0 upload C:\Users\jp669971\Documents\GitHub\Community\Cobol-Made-Easy
> zowe zos-files upload file-to-data-set "./build/source.cbl" "Z40607.SOURCE(CBLSRC)" --zosmf-p ztrial

success: true
from:    C:\Users\jp669971\Documents\GitHub\Community\Cobol-Made-Easy\build\source.cbl
to:      Z40607.SOURCE(CBLSRC)


file_to_upload: 1
success:        1
error:          0
skipped:        0


Data set uploaded successfully.

> template@1.0.0 compile:cobol C:\Users\jp669971\Documents\GitHub\Community\Cobol-Made-Easy
> zowe jobs submit lf "./build/compiler.jcl" --directory "./output" --zosmf-p ztrial

 ███_______| 30%  O | Waiting for JOB07745 to enter OUTPUT
```

Figure 13. "One Click" COBOL build process

You can then level-up this process by leveraging a CI/CD pipeline. What is a CI/CD pipeline? It is an automated way of building, testing, and deploying your application and you can do the same with your COBOL development. The figure below shows the pipeline for the same automated tasks that we did earlier.


Cobol-Made-Easy > Cobol-Generator > build_and_deploy > build (88)

build SUCCESS

Duration 55s
Finished 2 days ago

Docker Medium
2 CPU / 4 GB RAM

bd37f05

Cobol-Generator
Jessielaine Punongbayan

STEPS TESTS ARTIFACTS

Spin Up Environment	21s
Preparing Environment Variables	0s
Checkout code	0s
Check Versions	0s
Install zowe	9s
Install Packages	5s
Compile Scripts	2s
Create Zowe Profiles	1s
Build and Test	13s

Figure 14. CI/CD pipeline of the “one click” COBOL build process

To know more about this topic, check this out.

5.4.3 Additional Examples

If you are looking for an example on how to use Zowe Explorer and Zowe CLI with Db2 Stored Procedures, check out this blog.

If you are interested in using open source tools in your development, you can review this blog where it talks about using Zowe CLI to leverage static code analysis tools when developing COBOL applications.

For additional blogs and articles on leveraging Zowe technologies, check out https://medium.com/zowe/users/home.

5.5 The world of modern open source tooling

We have only scratched the surface of using modern tools and languages for mainframe development and incorporating mainframe applications into enterprise DevOps pipelines. As a bridge tool, the Zowe CLI enables the use of a plethora of tools being developed by an enormous community for mainframe development. If you are new to mainframe, hopefully this offers some familiarity as you transition into this space. If you are an experienced mainframer, hopefully you find time to give some of these available technologies a try to see if they can help you.

5.6 Summary

As both a user and programmatic interface, command line interfaces offer significant value in simplifying complex repeatable processes into single tasks. CLIs are commonly used when developing on popular cloud platforms like Amazon Web Services. The Zowe CLI is the CLI for the mainframe that has been extended via numerous plug-ins. Zowe CLI acts as a bridge tool enabling the use of distributed development tooling while working with mainframe applications. Numerous resources and articles are available for using Zowe CLI to create custom automation, build CI pipelines, and incorporate static analysis into your COBOL development processes. Development tooling created by the distributed open source community can now be effectively leveraged for mainframe development.

6 Installation of VSCode and extensions

This chapter covers all aspects of download and installation of Visual Studio (VS) Code and any prerequisites that are needed. It includes:

- **Install prerequisites**
  - **Install node.js**
  - **Install Java SDK**
- **Install VSCode**
- **Install VSCode extensions**
  - **Zowe Explorer**
  - **IBM Z Open Editor**
  - **Code4z**
- **Summary**

6.1 Install prerequisites

This section will cover the necessary steps and information to download and install the prerequisites needed for the subsequent labs within this book. This software is needed for one of more of the applications we will be utilizing in our labs throughout the book. The prerequisites include:

- Install node.js
- Install Java SDK

6.1.1 Install node.js

1. Check for node.js installation and verify that the version number is v8 or higher.

   Open your workstation's version of the command prompt (called Terminal on Mac OS X). Once the command prompt is open, use the command in Example 1. to check if your workstation currently has a version of node.js installed.

```
C:\Users\User> node -v

V12.16.1
```

Example 1. Node.js version

If you do not see a version number after you submit the command, you do not have node.js installed, or if it shows a version less than v8, you should continue following these instructions. If you do see a version number and it is v8 or higher, you can move on to section Install Java SDK.

2. If node.js version is less than v8, or node isn't installed at all.

   Updating node.js to the appropriate version number is a relatively simple process because the installer takes care of most of the "heavy lifting". All you will need to do is visit the Node.js download site, provided below and follow the download and installation instructions for your specific workstation platform. Do this same process if you do not already have node.js installed.

`https://nodejs.org/en/download/`

This process will install the latest versions of Node.js and the node package manager (npm) and overwrite any older version files in your system. This removes the step of needing to manually uninstall the previous versions beforehand.

3. Once completed, verify the installation and proper version number, as shown previously in Example 1.

Note : The version numbers in our examples are provided purely for reference and may not reflect the latest versions of the software.

6.1.2 Install Java SDK

1. Check for Java installation and verify that the version number is v8 or higher.

   Open your workstation's version of the command prompt, if not already open. Once the command prompt is open, use the command in Example 2. to check if your workstation currently has a version of Java installed. Java SDK 8 is the preferred version for these labs, however, any versions higher than that will suffice.

```
C:\Users\User> java -version

java version "1.8.0_241"

Java(TM) SE Runtime Environment (build 1.8.0_241-b07)

Java HotSpot(TM) 64-Bit Server VM (build 25.241-b07, mixed mode)
```

Example 2. Java version

If you do not see a version number after you submit the command, you do not have Java installed or if it shows a version less than v8, you should continue following these instructions. The display format of the version number for Java is slightly different than what is displayed for node.js. With Java, the second value in the displayed version number, i.e. the "8" in Example 2. , is the version number. So, our example is showing Java SDK version 8. If you do see a version number and it is v8 or higher, you can move on to section Install VSCode.

2. If your version of Java displayed is less than v8, you need to uninstall the current version on your workstation and reinstall the correct version. Follow the link below to uninstall instructions that represent your workstation operating system (OS).

-Linux:

https://www.java.com/en/download/help/linux_uninstall.xml

-Mac:

https://www.java.com/en/download/help/mac_uninstall_java.xml

-Windows:

https://www.java.com/en/download/help/uninstall_java.xml

3. Once Java is uninstalled from your workstation, you can click the Java JDK 8 download link below and follow the installation instructions for your specific OS.

https://www.oracle.com/java/technologies/javase-jdk8-downloads.html

4. Verify the installation and proper version number as shown in Example 2.

Note : You will be prompted to register a new Oracle account in order to download the installation file, please do so. If you have an existing account, you may use that to log in and continue.

6.2 Install VSCode

If you do not already have VSCode installed on your workstation, please do so now by following the download and installation instructions at the link below:

https://code.visualstudio.com/download

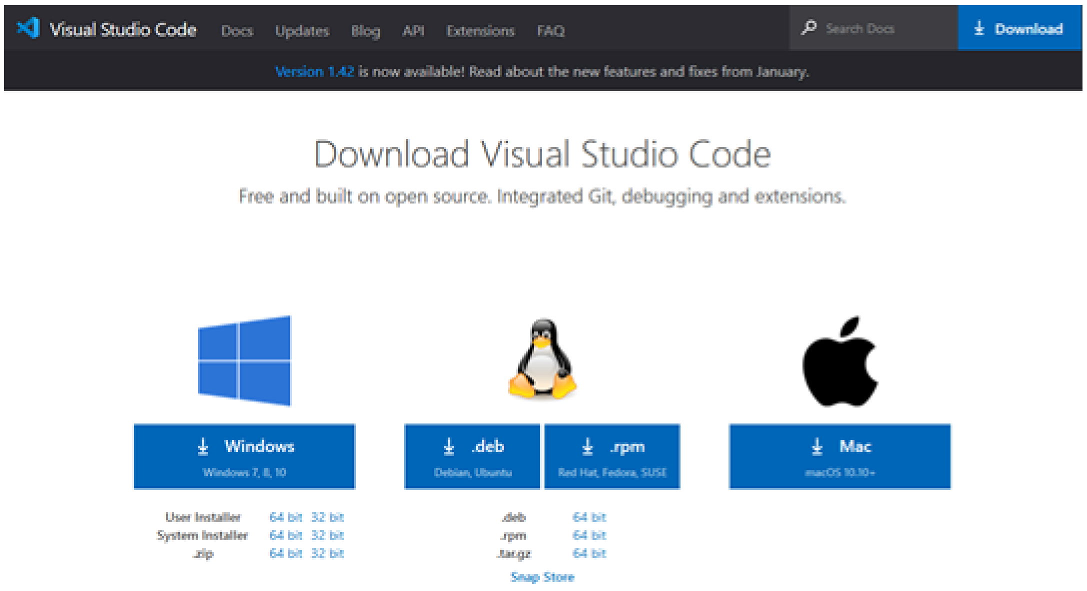

Visual Studio Code
Docs
Updates
Blog
API
Extensions
FAQ
Search Docs
Download
Version 1.42 is now available! Read about the new features and fixes from January.
Download Visual Studio Code
Free and built on open source. Integrated Git, debugging and extensions.
Windows
Windows 7, 8, 10
.deb
Debian, Ubuntu
.rpm
Red Hat, Fedora, SUSE
Mac
macOS 10.10+
User Installer 64 bit 32 bit
System Installer 64 bit 32 bit
.zip 64 bit 32 bit
.deb 64 bit
.rpm 64 bit
.tar.gz 64 bit
Snap Store

Figure 1. VSCode download site

Note : Be sure to select the correct installation file for your workstations respective OS, shown in Figure 1.

6.3 Install VSCode extensions

This section introduces two VSCode extensions, Zowe Explorer and IBM Z Open Editor listed in Figure 2. , and instructions on how to install them.

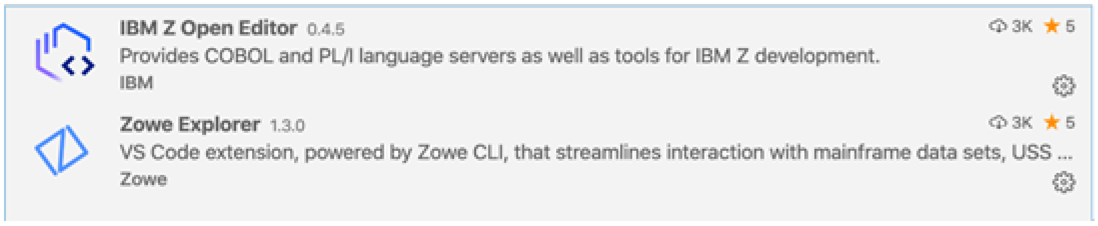

IBM Z Open Editor 0.4.5
3K 5
Provides COBOL and PL/I language servers as well as tools for IBM Z development.
IBM
Zowe Explorer 1.3.0
3K 5
VS Code extension, powered by Zowe CLI, that streamlines interaction with mainframe data sets, USS ...
Zowe

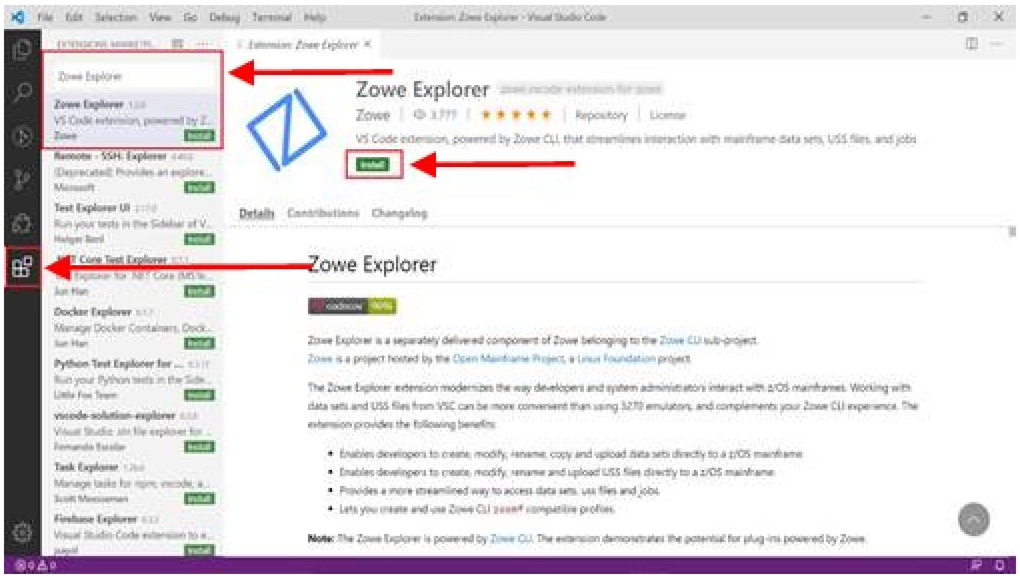
Figure 2. VSCode required extensions

6.3.1 Zowe Explorer

Zowe is a new, and the first open source framework for z/OS and provides solutions for development and operations teams to securely manage, control, script and develop on the mainframe like any other cloud platform. Out of the box, the Zowe Explorer provides a lot of functionality allowing z/OS developers access to jobs, datasets and (USS) files on a z/OS server. Backed by the Zowe CLI and z/OSMF, developers now have powerful features that makes it easy to work with z/OS within the familiar VSCode environment. This extension can be used to edit COBOL and PL/I files opened on z/OS MVS™ and USS using the Zowe extension's Data Sets and USS views. It can even run JCL and lets you browse job spool files. For more information on Zowe Explorer and its interaction with z/OS please visit:

https://ibm.github.io/zopeneditor-about/Docs/zowe_interactwithzos.html

6.3.1.1 Install Zowe Explorer Open VSCode and in the left side tool menu select **Extensions**. From there, in the "Search Extensions in Marketplace" search field, type `Zowe Explorer`. Search results will begin populating, select **"Zowe Explorer"** and click **install**, depicted in Figure 3.



VS Code extension, powered by Zowe CLI, that streamlines interaction with mainframe data sets, USS files, and jobs

Zowe Explorer

Zowe Explorer is a separately delivered component of Zowe belonging to the Zowe CLI sub-project.
Zowe is a project hosted by the Open Mainframe Project, a Linux Foundation project.

The Zowe Explorer extension modernizes the way developers and system administrators interact with z/OS mainframes. Working with data sets and USS files from VSC can be more convenient than using 3270 emulators, and complements your Zowe CLI experience. The extension provides the following benefits:

- Enables developers to create, modify, rename, copy and upload data sets directly to a z/OS mainframe.
- Enables developers to create, modify, rename and upload USS files directly to a z/OS mainframe.
- Provides a more streamlined way to access data sets, uss files and jobs.
- Lets you create and use Zowe CLI `zosmf` compatible profiles.

Note: The Zowe Explorer is powered by Zowe CLI. The extension demonstrates the potential for plug-ins powered by Zowe.

Figure 3. Install Zowe Explorer in VSCode

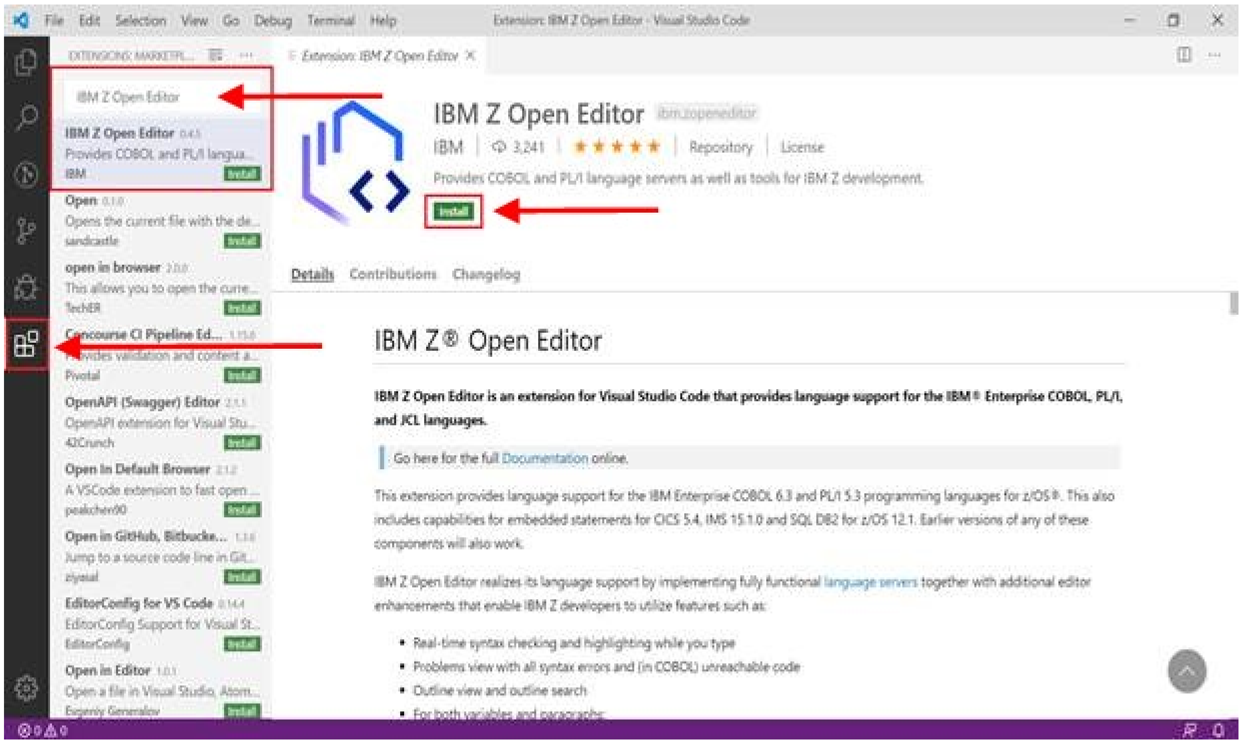
The Zowe communinity have a number of on-line video that walk through the steps required to install, configure and operate the Zowe Explorer, see Zowe Explorer VSC Extension (part 1).

6.3.2 IBM Z Open Editor

IBM Z Open Editor brings COBOL and PL/I language support to Microsoft VSCode. It is one of the several next generation capabilities for an open development experience for z/OS®. It also works in association with the Zowe Explorer plugin. For more information on IBM Z Open Editor, please visit:

https://ibm.github.io/zopeneditor-about/Docs/introduction.html#key-capabilities

6.3.2.1 Install IBM Z Open Editor Open VSCode and in the left side tool menu select **Extensions**. From there, in the "Search Extensions in Marketplace" search field, type `IBM Z Open Editor`. Search results will begin populating, select **" IBM Z Open Editor "** and click **install**, depicted in Figure 4.


File Edit Selection View Go Debug Terminal Help
Extension: IBM Z Open Editor - Visual Studio Code
EXTENSIONS: MARKETPL...
Extension: IBM Z Open Editor
IBM Z Open Editor
IBM Z Open Editor 0.4.5
Provides COBOL and PL/I langua...
IBM
Install
Open 0.1.0
Opens the current file with the de...
sandcastle
Install
open in browser 2.0.0
This allows you to open the curre...
TechER
Install
Concourse CI Pipeline Ed... 1.15.0
Provides validation and content a...
Pivotal
Install
OpenAPI (Swagger) Editor 2.1.1
OpenAPI extension for Visual Stu...
42Crunch
Install
Open In Default Browser 2.1.2
A VSCode extension to fast open ...
peakchen90
Install
Open in GitHub, Bitbucke... 1.3.6
Jump to a source code line in Git...
ziyasal
Install
EditorConfig for VS Code 0.14.4
EditorConfig Support for Visual St...
EditorConfig
Install
Open in Editor 1.0.1
Open a file in Visual Studio, Atom...
Evgeniy Generalov
Install
IBM Z Open Editor
ibm.zopeneditor
IBM
3,241
Repository
License
Install
Details
Contributions
Changelog

Provides COBOL and PL/I language servers as well as tools for IBM Z development.

IBM Z® Open Editor

IBM Z Open Editor is an extension for Visual Studio Code that provides language support for the IBM® Enterprise COBOL, PL/I, and JCL languages.

Go here for the full Documentation online.

This extension provides language support for the IBM Enterprise COBOL 6.3 and PL/I 5.3 programming languages for z/OS®. This also includes capabilities for embedded statements for CICS 5.4, IMS 15.1.0 and SQL DB2 for z/OS 12.1. Earlier versions of any of these components will also work.

IBM Z Open Editor realizes its language support by implementing fully functional language servers together with additional editor enhancements that enable IBM Z developers to utilize features such as:

- Real-time syntax checking and highlighting while you type
- Problems view with all syntax errors and (in COBOL) unreachable code
- Outline view and outline search
- For both variables and paragraphs:

Figure 4. Install IBM Z Open Editor in VSCode

Note : There may be some limitations with IBM Z Open Editor if running a 32-bit Java version on Windows.

6.3.3 Code4z

Code4z is an all-in-one, open-source mainframe extension package for developers working with z/OS applications, suitable for all levels of mainframe experience, even beginners. Mainframe application developers can use the Code4z package for a modern, familiar, and seamless experience, which helps to overcome some developers' reservations or concerns about the traditional mainframe user experience. To find out more about Code4z, please visit https://github.com/BroadcomMFD/code4z.

6.3.3.1 Install Code4z Open VSCode and in the left side tool menu select **Extensions**. From there, in the "Search Extensions in Marketplace" search field, type `Code4z`. Search results will begin populating, select **" Code4z "** and click **install**.

The extension pack contains a number of extensions that can be leveraged when working with the mainframe, including the COBOL Language Support extension which provides similar functionality to the Z Open Editor extension. Therefore, ensure only one of these extensions is enabled. Extensions can be disabled within VS Code by locating the extension in the Extensions menu, clicking the settings gear, and selecting `Disable`. Other extensions included in the Code4z pack will work with either COBOL Language Support or Z Open Editor.

6.4 Summary

In this chapter you have been introduced to VSCode and some of the extension tools available to it. We have walked through the process of installing the pre-requisite software, Node.js and Java SDK, as well as VSCode, Zowe Explorer, IBM Z Open Editor and Code4z. You have also been briefly introduced to the utility of these extensions in VSCode. In the subsequent chapters we will delve deeper into how and when to use them and get some practice through lab assignments.

7 Installation of Zowe CLI and Plug-ins

This chapter covers all aspects of the download and installation of Zowe CLI and Zowe CLI plug-ins.

- **Install prerequisites - Node.js**
- **Install Zowe CLI**
  - **Public npm Registry**
  - **Package from Zowe.org**
- **Install Zowe CLI Plug-ins**
  - **Public npm Registry**
  - **Package from Zowe.org**
- **Summary**

7.1 Install prerequisites - Node.js

Before installing Zowe CLI, please ensure an LTS version of Node v8.0 or higher is installed. Please refer back to the section titled "Install Node.js" if you have not already completed it. Please also verify that you have a version of Node Package Manager (npm) that is compatible with your version of Node.js. For a list of compatible versions, see https://nodejs.org/en/download/releases/. npm is included with the Node.js installation. Issue the command `npm --version` to view the version of npm that is installed.

7.2 Install Zowe CLI

There are two recommended methods for installing the Zowe CLI. If you have access to the public npm registry from your workstation, we recommend using that installation method as pulling updates is seamless. If you do not have access to this registry, we recommend downloading the package from zowe.org and installing from the bundled package.

7.2.1 Install from Public npm Registry

Issue the following command in your terminal (e.g. Command Prompt or if you are using VS Code, Terminal -> New Terminal):

```
npm install -g @zowe/cli@zowe-v1-lts
```

If the command returns an EACCESS error, refer to Resolving EACCESS permissions errors when installing packages globally in the npm documentation. If other issues are encountered in your environment, please review known Zowe CLI issues for solutions.

We also highly recommend installing the Secure Credential Store plug-in before using the CLI. The Secure Credential Store Plug-in for Zowe CLI lets you store your credentials securely in the default credential manager in your computer's operating system. On Linux, libsecret will need to be installed.

If running Linux, please run the following command for your Linux distribution:

- Debian/Ubuntu: `sudo apt-get install libsecret-1-dev`
- Red Hat-based: `sudo yum install libsecret-devel`
- Arch Linux: `sudo pacman -S libsecret`

To install the Secure Credential Store Plug-in for Zowe CLI, issue the following command:

```
zowe plugins install
   @zowe/secure-credential-store-for-zowe-cli@zowe-v1-lts
```

User profiles, which contain connection information for interacting with various z/OS services, created after installing the plug-in will automatically store your credentials securely.

To securely store credentials in existing user profiles (profiles that you created prior to installing the SCS plug-in), issue the following command:

```
zowe scs update
```

7.2.2 Install from Bundled Package

Navigate to Zowe.org Downloads and click the CLI Core button to download the core package which includes Zowe CLI and the Secure Credential Store plug-in. After accepting the EULA for Zowe, a package named `zowe-cli-package-v.r.m.zip` will be downloaded to your machine. Unzip the contents of `zowe-cli-package-v.r.m.zip` to a preferred location on your machine.

Open your terminal (e.g. Command Prompt or if you are using VS Code, Terminal -> New Terminal), change your working directory to wherever you unzipped the contents, and issue the following command:

```
npm install -g zowe-cli.tgz
```

If the command returns an EACCESS error, refer to Resolving EACCESS permissions errors when installing packages globally in the npm documentation. If other issues are encountered in your environment, please review known Zowe CLI issues for solutions.

The highly recommended Secure Credential Store Plug-in for Zowe CLI lets you store your credentials securely in the default credential manager in your computer's operating system. On Linux, libsecret will need to be installed.

If running Linux, please run the following command for your Linux distribution:

- Debian/Ubuntu: `sudo apt-get install libsecret-1-dev`
- Red Hat-based: `sudo yum install libsecret-devel`
- Arch Linux: `sudo pacman -S libsecret`

To install the Secure Credential Store Plug-in for Zowe CLI, issue the following command from where you unzipped the core CLI package contents:

```
zowe plugins install secure-credential-store-for-zowe-cli.tgz
```

User profiles, which contain connection information for interacting with various z/OS services, created after installing the plug-in will automatically store your credentials securely.

To securely store credentials in existing user profiles (profiles that you created prior to installing the SCS plug-in), issue the following command:

```
zowe scs update
```

7.3 Install Zowe CLI Plug-ins

Zowe CLI is an extendable technology that can be enhanced by installing plug-ins. Zowe offers a number of plug-ins. At the time of this writing, these include plug-ins for CICS, Db2, FTP, IMS, and MQ. There are also many vendor plug-ins, many of which are available on the public registry. At the time of this writing, these include plug-ins for CA Endevor, CA Endevor Bridge for Git, CA File Master Plus, CA OPS/MVS, CA View, IBM CICS Bundle Generation and Deployment, and IBM z/OS Connect EE.

7.3.1 Install from Public npm Registry

To install a Zowe CLI plug-in from the registry, simply locate the plug-in you wish to install, e.g. `@zowe/cics-for-zowe-cli`, find the distribution tag for the distribution you want to install, e.g. `zowe-v1-lts`, and issue the following command:

```
zowe plugins install <name>@<distTag>
```

For example,

```
zowe plugins install @zowe/cics-for-zowe-cli@zowe-v1-lts
```

Multiple plug-ins can be installed in a single command. For example, to install all Zowe CLI plug-ins available from the Zowe organization, you could issue:

```
zowe plugins install @zowe/cics-for-zowe-cli@zowe-v1-lts
   @zowe/ims-for-zowe-cli@zowe-v1-lts @zowe/mq-for-zowe-cli@zowe-v1-lts
   @zowe/zos-ftp-for-zowe-cli@zowe-v1-lts
   @zowe/db2-for-zowe-cli@zowe-v1-lts
```

Vendor plug-ins on the registry are installed in the same way. For example, to install the CA Endevor plug-in, you would issue

```
zowe plugins install @broadcom/endevor-for-zowe-cli@zowe-v1-lts
```

7.3.2 Install from Bundled Package

Navigate to Zowe.org Downloads and click the CLI Plugins button to download the package which includes all Zowe CLI plug-ins for the Zowe organization. After accepting the EULA for Zowe, a package named `zowe-cli-plugins-v.r.m.zip` will be downloaded to your machine. Unzip the contents of `zowe-cli-plugins-v.r.m.zip` to a preferred location on your machine. You can select which plug-ins you want to install. The IBM Db2 plug-in requires additional configuration when installing from a local package. To install all plug-ins you can issue:

```
zowe plugins install cics-for-zowe-cli.tgz zos-ftp-for-zowe-cli.tgz
   ims-for-zowe-cli.tgz mq-for-zowe-cli.tgz db2-for-zowe-cli.tgz
```

For offline installation of vendor plug-ins, please reach out to the specific vendor for details.

7.4 Summary

In this chapter we walked through the process of installing the prerequisite software, Node.js and npm, as well as Zowe CLI and various plug-ins.

Part 2 - Learning COBOL

8 Basic COBOL

This chapter introduces the basics of COBOL syntax. It then demonstrates how to view and run a basic COBOL program in VSCode.

8.1 COBOL characteristics

COBOL is an English-like computer language enabling COBOL source code to be easier to read, understand, and maintain. Learning to program in COBOL includes knowledge of COBOL source code rules, COBOL reserved words, COBOL structure, and the ability to locate and interpret professional COBOL documentation. These COBOL characteristics must be understood, to be proficient in reading, writing, and maintaining COBOL programs.

8.1.1 Enterprise COBOL

COBOL is a standard and not owned by any company or organization. “Enterprise COBOL” is the name for the COBOL programming language compiled and executed in the IBM Z Operating System, z/OS. COBOL details and explanations in the following chapters apply to Enterprise COBOL.

Enterprise COBOL has decades of advancements, including new functions, feature extensions, improved performance, application programming interfaces (APIs), etc. It works with modern infrastructure technologies with native support for JSON, XML, and Java®.

8.1.2 Chapter objectives

The object of the chapter is to expose the reader to COBOL terminology, coding rules, and syntax while the remaining chapters include greater detail with labs for practicing what is introduced in this chapter.

8.2 What must a novice COBOL programmer know to be an experienced COBOL programmer?

This section will provide the reader with the information needed to more thoroughly understand the questions and answers being asked in each subsequent heading.

8.2.1 What are the coding rules and the reference format?

COBOL source code is column dependent, meaning column rules are strictly enforced. Each COBOL source code line has five areas, where each of these areas has a beginning and ending column.

COBOL source text must be written in COBOL reference format. Reference format consists of the areas depicted in Figure 1. in a 72-character line.

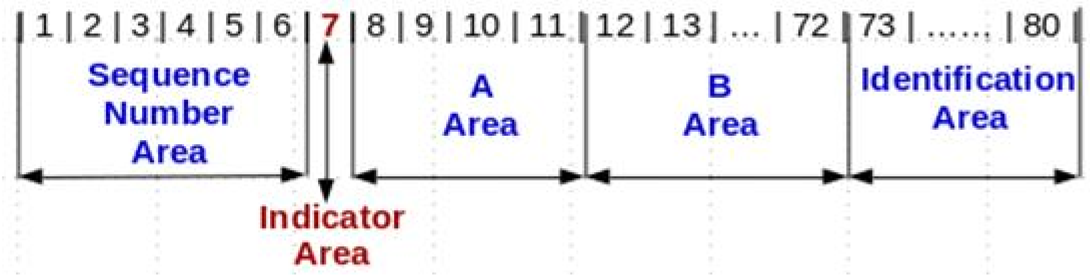


Figure 1. COBOL reference format

The COBOL reference format is formatted as follows:

8.2.1.1 Sequence Number Area (columns 1 - 6)

- Blank or reserved for line sequence numbers.

8.2.1.2 Indicator Area (column 7)

- A multi-purpose area:
  - Comment line (generally an asterisk symbol)
  - Continuation line (generally a hyphen symbol)
  - Debugging line (D or d)
  - Source listing formatting (a slash symbol)

8.2.1.3 Area A (columns 8 - 11)

- Certain items must begin in Area A, they are:
  - Level indicators
  - Declarative
  - Division, Section, Paragraph headers
  - Paragraph names
- Column 8 is referred to as the A Margin

8.2.1.4 Area B (columns 12 - 72)

- Certain items must begin in Area B, they are:
  - Entries, sentences, statements, and clauses
  - Continuation lines
- Column 12 is referred to as the B Margin

8.2.1.5 Identification Area (columns 73 - 80)

- Ignored by the compiler.
- Can be blank or optionally used by programmer for any purpose.

8.2.2 What is the structure of COBOL?

COBOL is a hierarchy structure consisting and in the top-down order of:

- Divisions
- Sections
- Paragraphs
- Sentences
- Statements

8.2.3 What are COBOL reserved words?

COBOL programming language has many words with specific meaning to the COBOL compiler, referred to as reserved words. These reserved words cannot be used as programmer chosen variable names or programmer chosen data type names.

A few COBOL reserved words pertinent to this book are: PERFORM, MOVE, COMPUTE, IF, THEN, ELSE, EVALUATE, PICTURE, etc.. You can find a table of all COBOL reserved words is located at:

https://www.ibm.com/support/knowledgecenter/zh/SSZJPZ_9.1.0/com.ibm.swg.im.iis.ds.mfjob.dev.doc/topics/r_dmnjbref_COBOL_Reserved_Words.html

8.2.4 What is a COBOL statement?

Specific COBOL reserved words are used to change the execution flow based upon current conditions. "Statements" only exist within the Procedure Division, the program processing logic. Examples of COBOL reserved words used to change the execution flow are:

- IF
- Evaluate
- Perform

8.2.5 What is the meaning of a scope terminator?

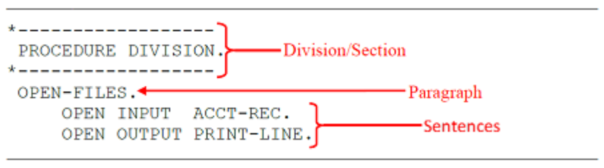
A scope terminator can be explicit or implicit. An explicit scope terminator marks the end of certain PROCEDURE DIVISION statements with the "END-" COBOL reserved word. Any COBOL verb that is either, always conditional (IF, EVALUATE), or has a conditional clause (COMPUTE, PERFORM, READ) will have a matching scope terminator. An implicit scope terminator is a period (.) that ends the scope of all previous statements that have not yet been ended.

8.2.6 What is a COBOL sentence?

A COBOL "Sentence" is one or more "Statements" followed by a period (.), where the period serves as a scope terminator.

8.2.7 What is a COBOL paragraph?

A COBOL "Paragraph" is a user-defined or predefined name followed by a period. A "Paragraph" consists of zero or more sentences and are the subdivision of a "Section" or "Division", see Example 1. below.



```
*-------------------
 PROCEDURE DIVISION.
*-------------------
 OPEN-FILES.
     OPEN INPUT  ACCT-REC.
     OPEN OUTPUT PRINT-LINE.
```

Example 1. Division -> paragraph -> sentences

8.2.8 What is a COBOL section?

A "Section" is either a user-defined or a predefined name followed by a period and consists of zero or more sentences. A "Section" is a collection of paragraphs.

8.3 COBOL Divisions

This section introduces the four COBOL Divisions and briefly describes their purpose and characteristics.

8.3.1 COBOL Divisions structure

Divisions are subdivided into Sections.

Sections are subdivided into Paragraphs.

Paragraphs are subdivided into Sentences.

Sentences consists of Statements.

Statements begin with COBOL reserved words and can be subdivided into "Phrases"

8.3.2 What are the four Divisions of COBOL?

8.3.2.1 IDENTIFICATION DIVISION The IDENTIFICATION DIVISION identifies the program with a name and, optionally, gives other identifying information, such as the Author name, program compiled date (last modified), etc.

8.3.2.2 ENVIRONMENT DIVISION The ENVIRONMENT DIVISION describes the aspects of your program that depend on the computing environment, such as the computer configuration and the computer inputs and outputs.

8.3.2.3 DATA DIVISION The DATA DIVISION is where characteristics of data are defined in one of the following sections:

- FILE SECTION:

  Defines data used in input-output operations.

- LINKAGE SECTION:

  Describes data from another program. When defining data developed for internal processing.

- WORKING-STORAGE SECTION:

  Storage allocated and remaining for the life of the program.

- LOCAL-STORAGE SECTION:

  Storage allocated each time a program is called and de-allocated when the program ends.

8.3.2.4 PROCEDURE DIVISION The PROCEDURE DIVISION contains instructions related to the manipulation of data and interfaces with other procedures are specified.

8.4 PROCEDURE DIVISION explained

The PROCEDURE DIVISION is where the work gets done in the program. Statements are in the PROCEDURE DIVISION where they are actions to be taken by the program. The PROCEDURE DIVISION is required for data to be processed by the program. PROCEDURE DIVISION of a program is divided into sections and paragraphs, which contain sentences and statements, as described here:

- **Section** - A logical subdivision of your processing logic. A section has a header and is optionally followed by one or more paragraphs. A section can be the subject of a PERFORM statement. One type of section is for declaratives. Declaratives are a set of one or more special purpose sections. Special purpose sections are exactly what they sound like, sections written for special purposes and may contain things like description of inputs and outputs. They are written at the beginning of the PROCEDURE DIVISION, the first of which is preceded by the key word DECLARATIVES and the last of which is followed by the key word END DECLARATIVES.
- **Paragraph** - A subdivision of a section, procedure, or program. A paragraph can be the subject of a statement.
- **Sentence** - A series of one or more COBOL statements ending with a period.
- **Statement** - An action to be taken by the program, such as adding two numbers.
- **Phrase** - A small part of a statement (i.e. subdivision), analogous to an English adjective or preposition

8.5 Additional information

This section provides useful resources in the form of manuals and videos to assist in learning more about the basics of COBOL.

8.5.1 Professional manuals

As Enterprise COBOL experience advances, the need for the professional documentation is greater. An internet search for Enterprise COBOL manuals includes: “Enterprise COBOL for z/OS documentation library - IBM”, link provided below. The site content has tabs for each COBOL release level. As of April 2020, the current release of Enterprise COBOL is V6.3. Highlight V6.3 tab, then select product documentation.

https://www.ibm.com/support/pages/enterprise-cobol-zos-documentation-library

Three ‘Enterprise COBOL for z/OS” manuals are referenced throughout the chapters as sources of additional information, for reference and to advance the level of knowledge. They are:

1. Language Reference - Describes the COBOL language such as program structure, reserved words, etc.

   http://publibfp.boulder.ibm.com/epubs/pdf/igy6lr30.pdf

2. Programming Guide - Describes advanced topics such as COBOL compiler options, program performance optimization, handling errors, etc.

   http://publibfp.boulder.ibm.com/epubs/pdf/igy6pg30.pdf

3. Messages and Codes - To better understand certain COBOL compiler messages and return codes to diagnose problems.

   http://publibfp.boulder.ibm.com/epubs/pdf/c2746481.pdf

8.5.2 Learn more about recent COBOL advancements

- What's New in Enterprise COBOL for z/OS V6.1:

  https://youtu.be/N_Zsd1W8hWc

- What's New in Enterprise COBOL for z/OS V6.2:

  https://youtu.be/H0iweEbVNFs

- What's New in Enterprise COBOL for z/OS V6.3:

  https://youtu.be/bRLKGeB6W2A

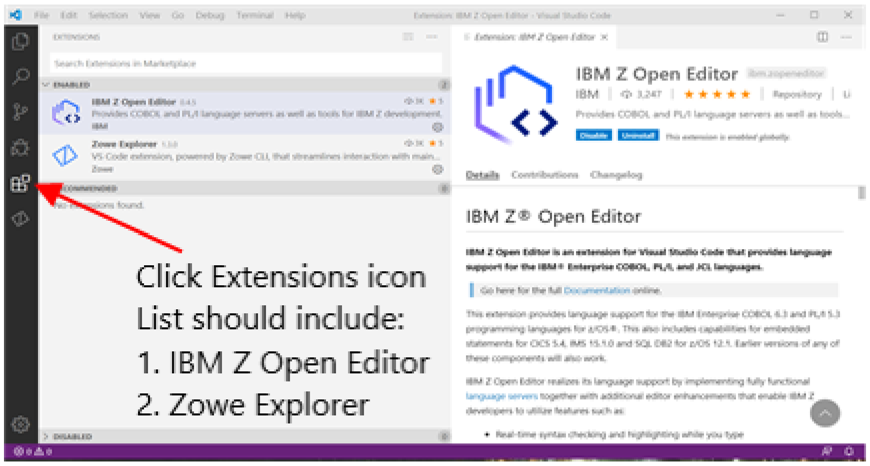
8.6 Lab

In this lab exercise you will connect to an IBM Z system, view a simple COBOL hello world program in VSCode, submit JCL to compile the COBOL program, and view the output. Refer to "Installation of VSCode and extensions" to configure VSCode if you have not already done so. You can either use Z Open Editor and Zowe Explorer, or Code4z.

1. The lab assumes installation of VSCode with either Z Open Editor and Zowe Explorer extensions, as shown in Figure 2a, or the Code4z extension pack, as shown in Figure 2b.

   Click the **Extensions** icon. If you installed Z Open Editor and Zowe Explorer, the list should include:

   1. IBM Z Open Editor
   2. Zowe Explorer



Provides COBOL and PL/I language servers as well as tools for IBM Z development.

VS Code extension, powered by Zowe CLI, that streamlines interaction with main...

This extension is enabled globally.

IBM Z® Open Editor

IBM Z Open Editor is an extension for Visual Studio Code that provides language support for the IBM® Enterprise COBOL, PL/I, and JCL languages.

Go here for the full Documentation online.

This extension provides language support for the IBM Enterprise COBOL 6.3 and PL/I 5.3 programming languages for z/OS®. This also includes capabilities for embedded statements for CICS 5.4, IMS 15.1.0 and SQL DB2 for z/OS 12.1. Earlier versions of any of these components will also work.

IBM Z Open Editor realizes its language support by implementing fully functional language servers together with additional editor enhancements that enable IBM Z developers to utilize features such as:

- Real-time syntax checking and highlighting while you type

Figure 2a. The Z Open Editor and Zowe Explorer VSCode extensions

If you installed Code4z, the list should include:

1. COBOL
2. COBOL Language Support
3. Code4z
4. Debugger for Mainframe
5. Explorer for Endevor
6. HLASM Language Support
7. Zowe Explorer

In these exercises, you will only use the COBOL Language Support and Zowe Explorer extensions.

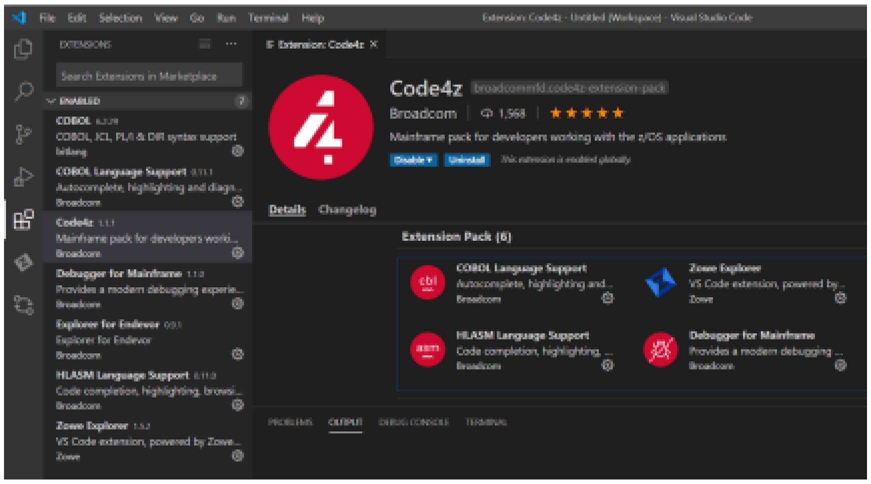


Figure 2b. The Code4z package of VS Code extensions.

Note: If your list contains both Z Open Editor and COBOL Language Support, disable one of them, by clicking on the **cog** icon next to the extension in the extensions list, and selecting **disable**.

2. Click the Zowe Explorer icon as shown in Figure 3.

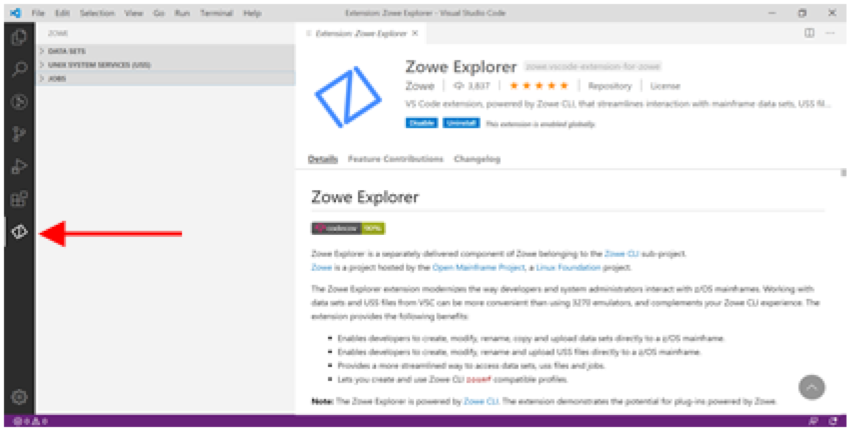
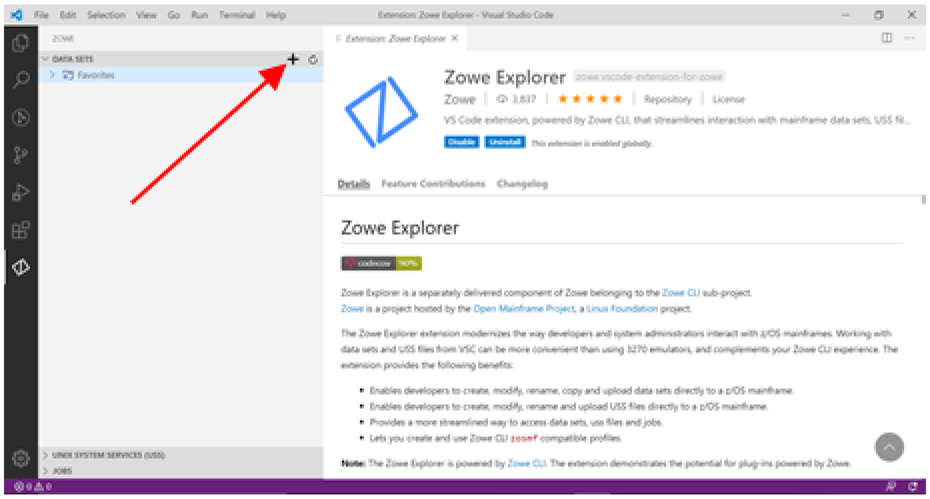


Figure 3. Zowe Explorer Zowe Explorer icon

3. Zowe Explorer can list Data Sets, Unix System Services (USS) files, and Jobs output as shown in Figure 4. + will appear when hovering to the far right on the DATA SETS line. Click the + to define a VSCode profile.


File Edit Selection View Go Run Terminal Help
Extension: Zowe Explorer - Visual Studio Code
ZOWE
DATA SETS
Favorites
UNIX SYSTEM SERVICES (USS)
JOBS
Extension: Zowe Explorer
Zowe | 3,837 | ★★★★★ | Repository | License
Disable
Uninstall
Details
Feature Contributions
Changelog
codecov 90%

Zowe Explorer zowe.vscode-extension-for-zowe

VS Code extension, powered by Zowe CLI, that streamlines interaction with mainframe data sets, USS fil...

This extension is enabled globally.

Zowe Explorer

Zowe Explorer is a separately delivered component of Zowe belonging to the Zowe CLI sub-project.
Zowe is a project hosted by the Open Mainframe Project, a Linux Foundation project.

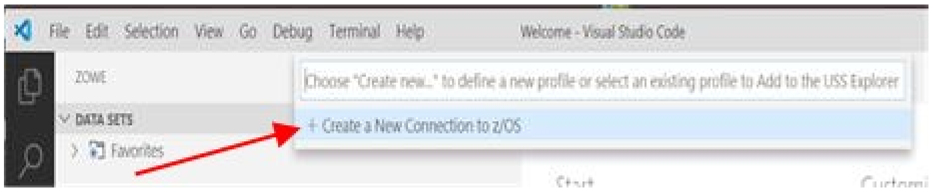
The Zowe Explorer extension modernizes the way developers and system administrators interact with z/OS mainframes. Working with data sets and USS files from VSC can be more convenient than using 3270 emulators, and complements your Zowe CLI experience. The extension provides the following benefits:

- Enables developers to create, modify, rename, copy and upload data sets directly to a z/OS mainframe.
- Enables developers to create, modify, rename and upload USS files directly to a z/OS mainframe.
- Provides a more streamlined way to access data sets, uss files and jobs.
- Lets you create and use Zowe CLI zosmf compatible profiles.

Note: The Zowe Explorer is powered by Zowe CLI. The extension demonstrates the potential for plug-ins powered by Zowe.

Figure 4. Zowe Explorer

4. A box appears to define a new profile. Click + to the left of Create a New Connection to z/OS as shown in Figure 5.

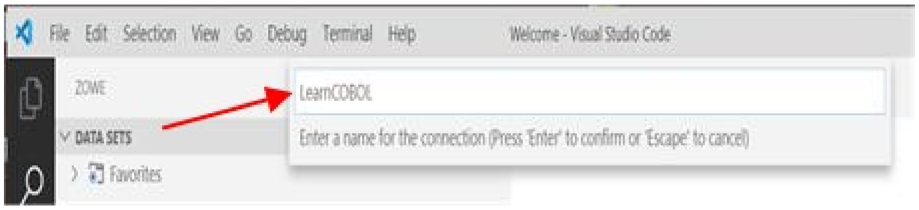

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites
Start
Customi

Choose "Create new..." to define a new profile or select an existing profile to Add to the USS Explorer

+ Create a New Connection to z/OS

Figure 5. Create a new connection to z/OS

5. Select a name to enter, then enter. Figure 6. used `LearnCOBOL` as the selected connection name.

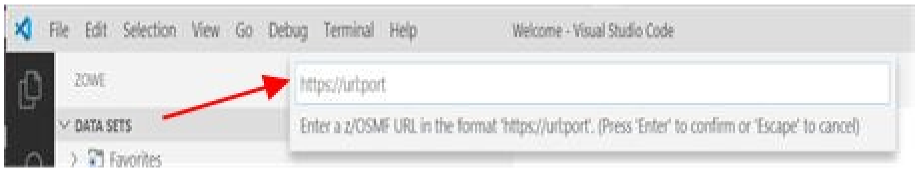

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

LearnCOBOL

Enter a name for the connection (Press 'Enter' to confirm or 'Escape' to cancel)

Figure 6. Set connection name

6. VSCode prompts for z/OSMF URL and port as shown in Figure 7. The z/OSMF URL and port will normally be provided by z/OS System Administrator.

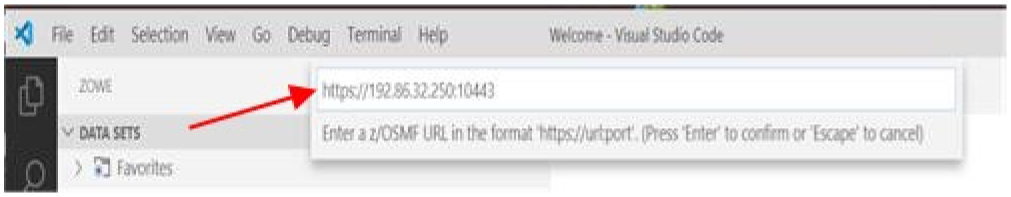

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

https://url:port

Enter a z/OSMF URL in the format 'https://url:port'. (Press 'Enter' to confirm or 'Escape' to cancel)

Figure 7. z/OSMF URL

7. A sample z/OSMF URL and port is entered as shown in Figure 8.

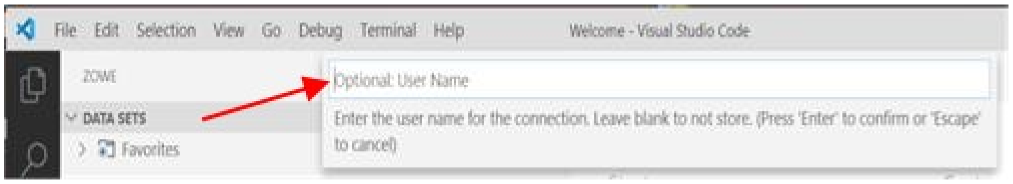

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

https://192.86.32.250:10443

Enter a z/OSMF URL in the format 'https://url:port'. (Press 'Enter' to confirm or 'Escape' to cancel)

Figure 8. Specified z/OSMF URL

8. The connection prompts for Username as shown in Figure 9.

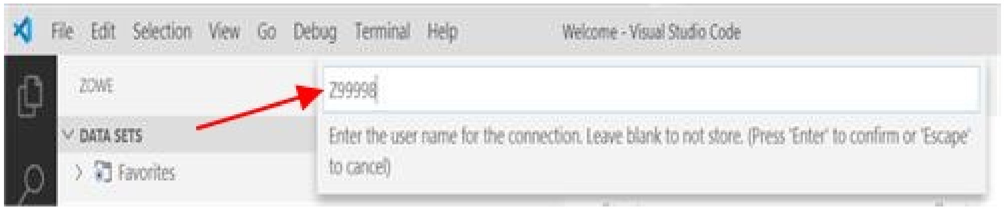

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

Optional: User Name

Enter the user name for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Figure 9. User name prompt

9. **Please enter the username assigned to you! Do not use the sample username of Z99998.** A sample username, is entered as shown in Figure 10. The ID is assigned by the System Administrator.

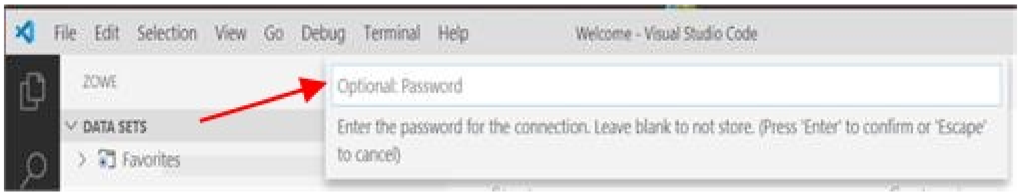

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

Z99998

Enter the user name for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Figure 10. Specified user name

10. The connection prompts for the password as shown in Figure 11.

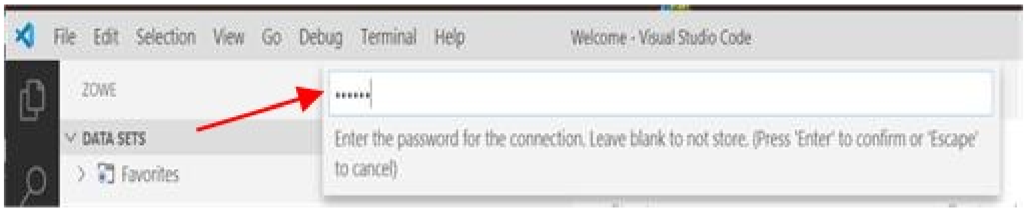

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

Optional: Password

Enter the password for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Figure 11. Password prompt

11. Enter the password as shown in Figure 12.

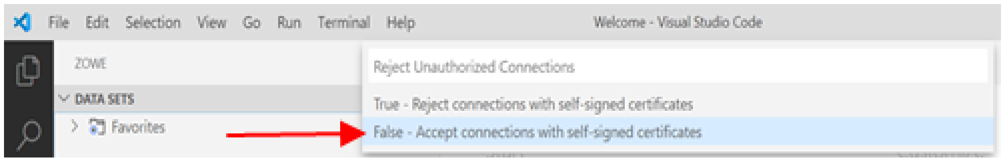

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

••••••

Enter the password for the connection. Leave blank to not store. (Press 'Enter' to confirm or 'Escape' to cancel)

Figure 12. Specified password

12. Select **False - Accept connections with self-signed certificates** to authorize workstation connection as shown in Figure 13.


File Edit Selection View Go Run Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

Reject Unauthorized Connections

True - Reject connections with self-signed certificates

False - Accept connections with self-signed certificates

Figure 13. Accept connections with self-signed certifications

13. Result is Favorites in the Data Sets, Unix System Services, and Jobs sections as shown in Figure 14.

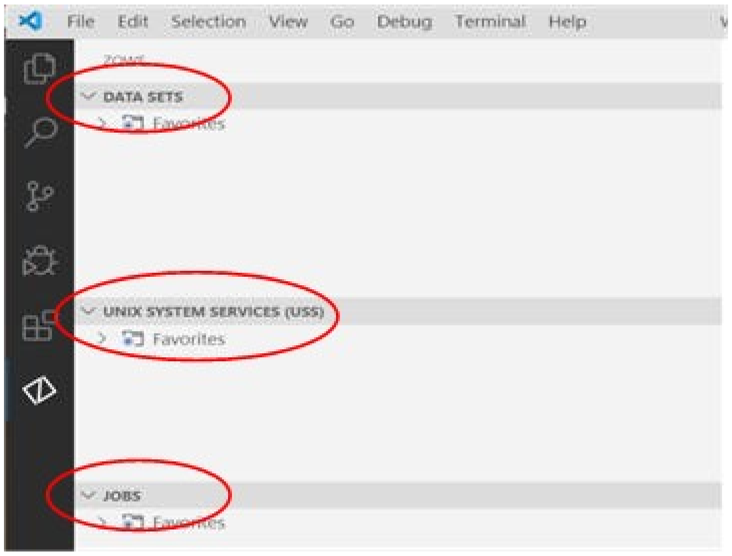
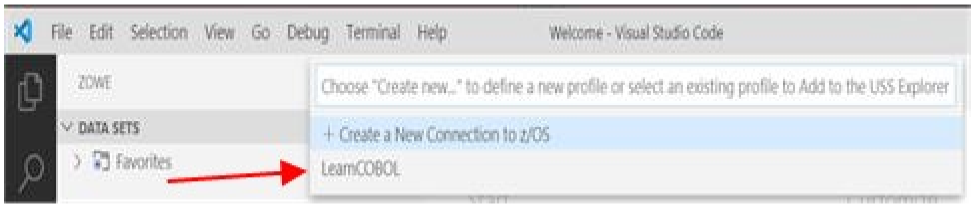

File Edit Selection View Go Debug Terminal Help
ZOWE
DATA SETS
Favorites
UNIX SYSTEM SERVICES (USS)
Favorites
JOBS
Favorites

Figure 14. Favorites

14. Again, click on the + to the far right on the Data Sets selection. Result is another prompt to Create a New Connection to z/OS. LearnCOBOL is in the connection list. Select **LearnCOBOL** for the Data Sets available to the previously defined LearnCOBOL connection to z/OS as shown in Figure 15.


File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites

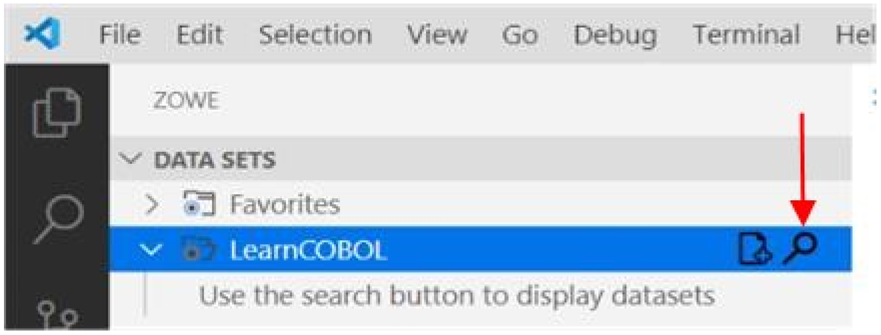
Choose "Create new..." to define a new profile or select an existing profile to Add to the USS Explorer

+ Create a New Connection to z/OS

LearnCOBOL

Figure 15. LearnCOBOL connection

15. Expansion of LearnCOBOL reads "Use the search button to display datasets". Click the search button as shown in Figure 16.



Use the search button to display datasets

Figure 16. Search button

16. A prompt to “Select a filter” appears for your username. Select the + to “Create a new filter” as shown in Figure 17.

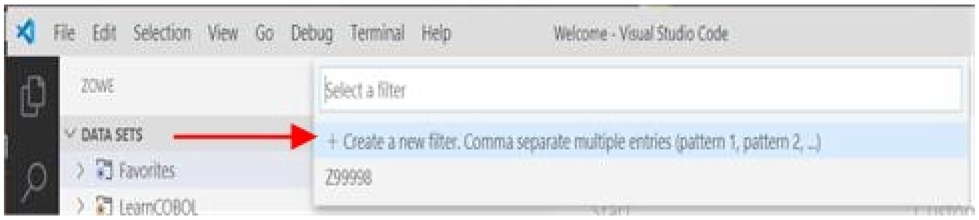

File Edit Selection View Go Debug Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites
LearnCOBOL
Select a filter
+ Create a new filter. Comma separate multiple entries (pattern 1, pattern 2, ...)
Z99998

Figure 17. Select a filter

17. A prompt appears to enter the filter name to be searched as shown in Figure 18.

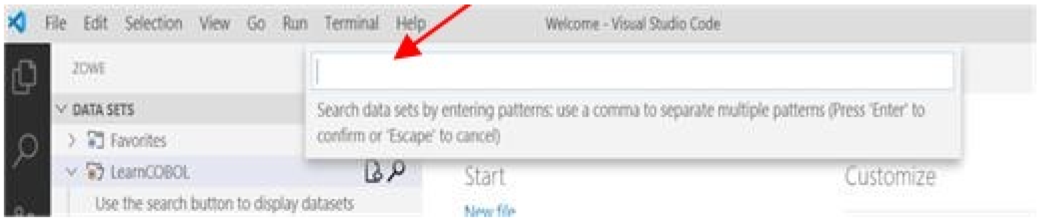

File Edit Selection View Go Run Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites
LearnCOBOL
Use the search button to display datasets
Search data sets by entering patterns: use a comma to separate multiple patterns (Press 'Enter' to confirm or 'Escape' to cancel)
Start
Customize
New file

Figure 18. Filter name to be searched

18. Each user has a high-level qualifier that is the same as their username. Therefore, enter your assigned username as the search criteria as shown in Figure 19. **Please use your username, not Z99998!**

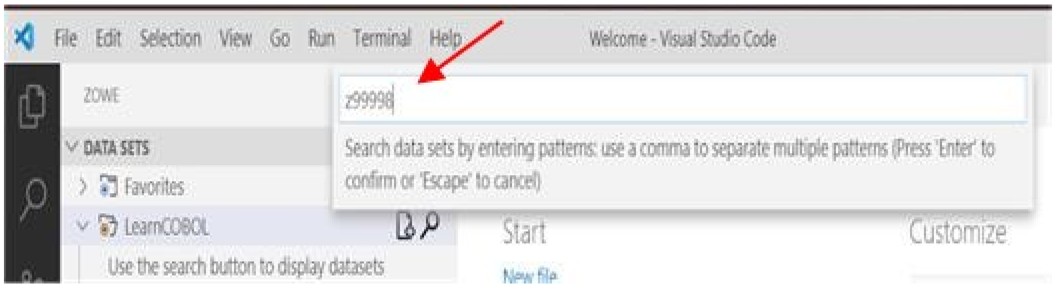

File Edit Selection View Go Run Terminal Help
Welcome - Visual Studio Code
ZOWE
DATA SETS
Favorites
LearnCOBOL
Use the search button to display datasets
z99998
Search data sets by entering patterns: use a comma to separate multiple patterns (Press 'Enter' to confirm or 'Escape' to cancel)
Start
Customize
New file

Figure 19. Entered filter name

19. A list of data set names beginning with your username from z/OS Connection LearnCOBOL appears as shown in Figure 20.

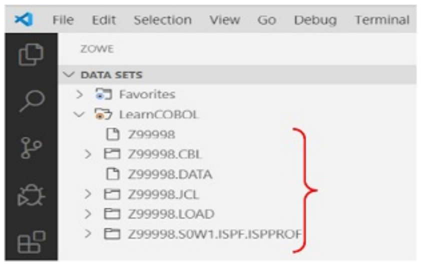
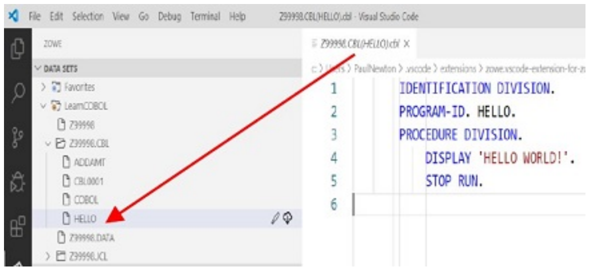


Figure 20. Filtered data set names

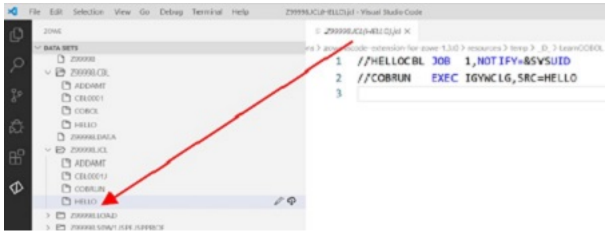
20. Expand **`<USERNAME>.CBL`** to view COBOL source members, then select member **HELLO** to see a simple COBOL ‘Hello World!’ program as shown in Figure 21.



```
IDENTIFICATION DIVISION.
PROGRAM-ID. HELLO.
PROCEDURE DIVISION.
    DISPLAY 'HELLO WORLD!'.
    STOP RUN.
```

Figure 21. <USERNAME>.CBL

21. Expand **<USERNAME>.JCL** to view JCL and select member HELLO which is the JCL to compile and execute simple 'Hello World!' COBOL source code as shown in Figure 22.



```
//HELLOCBL JOB  1,NOTIFY=&SYSUID
//COBRUN   EXEC IGYWCLG,SRC=HELLO
```

Figure 22. <USERNAME>.JCL

22. Right click on JCL member **HELLO** . A section box appears. Select **Submit Job** for system to process HELLO JCL as shown in Figure 23. The submitted JCL job compiles the COBOL HELLO source code, then executes the COBOL HELLO program.

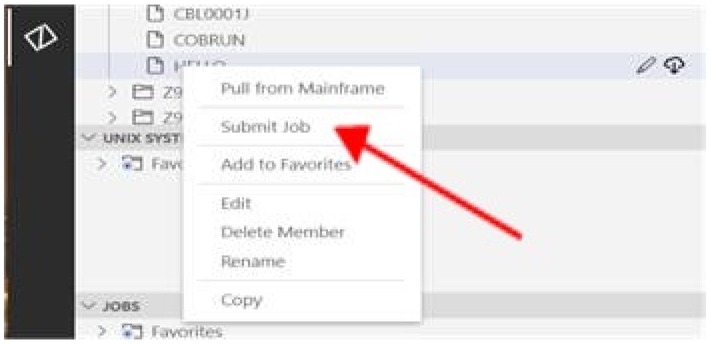


Figure 23. Submit Job

23. Observe the 'Jobs' section in Zowe Explorer as shown in Figure 24.

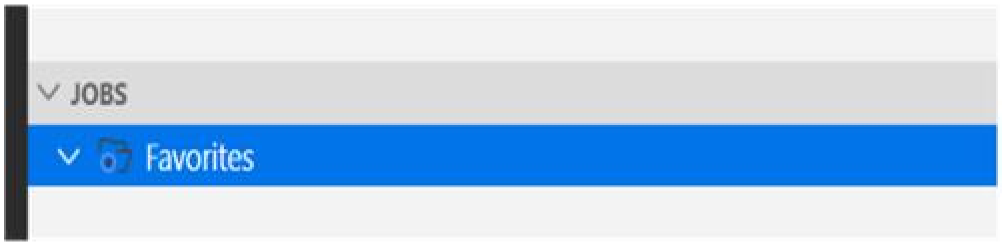
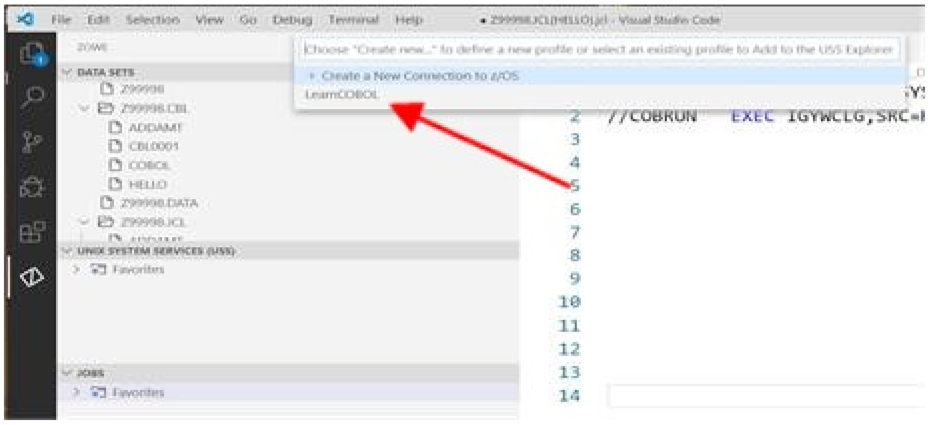


Figure 24. JOBS section

24. Again, click on the + to the far right on the Jobs selection. Result is another prompt to 'Create new'. Select **LearnCOBOL** from the list as shown in Figure 25.


File Edit Selection View Go Debug Terminal Help
• Z99998.JCL(HELLO).jcl - Visual Studio Code
ZOWE
DATA SETS
Z99998
Z99998.CBL
ADDAMT
CBL0001
COBOL
HELLO
Z99998.DATA
Z99998.JCL
UNIX SYSTEM SERVICES (USS)
Favorites
JOBS
Favorites
+ Create a New Connection to z/OS
LearnCOBOL

Choose "Create new..." to define a new profile or select an existing profile to Add to the USS Explorer

```
//COBRUN   EXEC IGYWCLG,SRC=
```

Figure 25. + Select LearnCOBOL connection

25. As a result, the JCL jobs owned by your username appears. HELLOCBL is the JCL job name previously submitted. Expand **HELLOCBL** output to view sections of the output as shown in Figure 26.

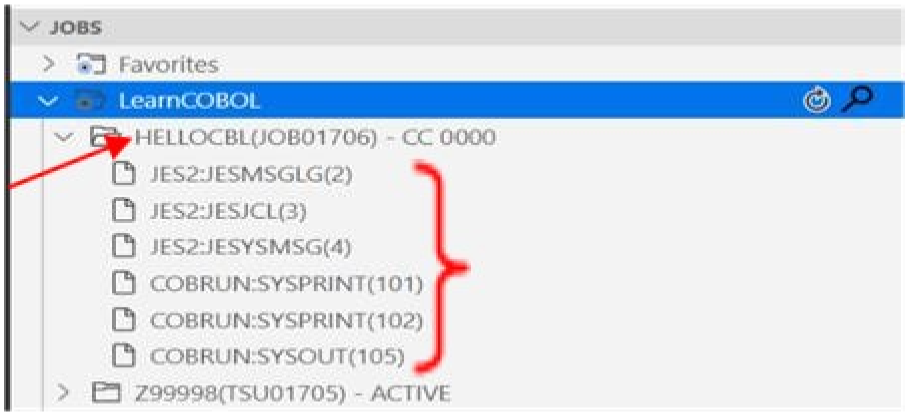
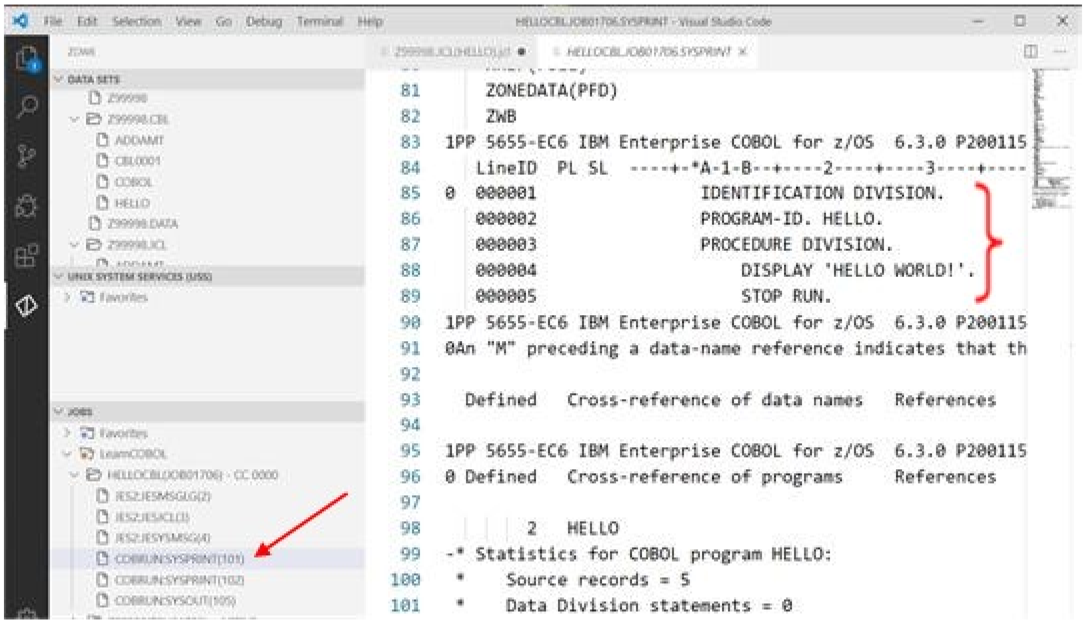


Figure 26. HELLOCBL output

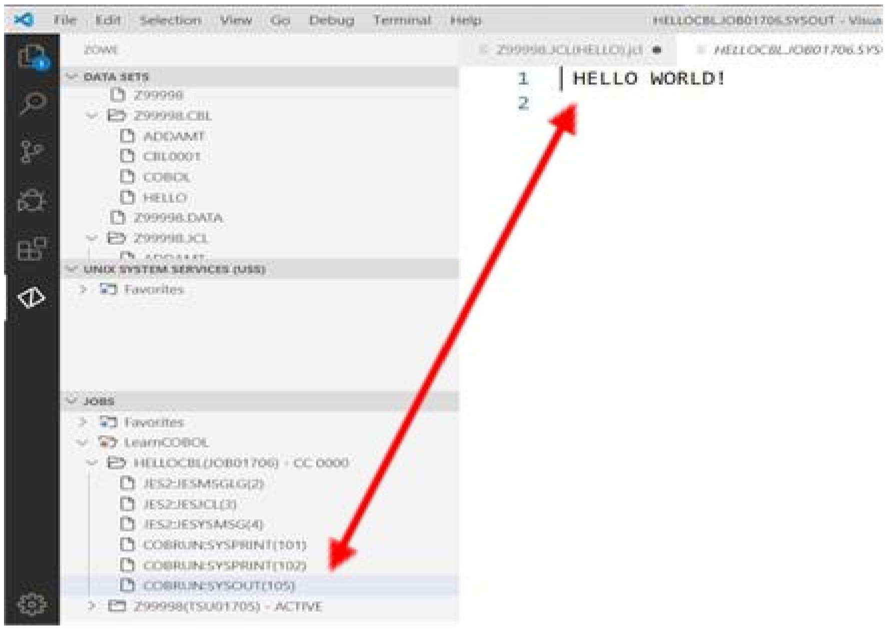
26. Select **COBRUN:SYSPRINT(101)** to view the COBOL compiler output. Scroll forward in the COBOL compile to locate the COBOL source code compiled into an executable module as shown in Figure 27. Observe the Indicator Area in column 7, A Area beginning in column 8, and B Area beginning in column 12. Also, observe the period (.) scope terminators in the COBOL source.



```
      ZONEDATA(PFD)
      ZWB
1PP 5655-EC6 IBM Enterprise COBOL for z/OS  6.3.0 P200115
    LineID  PL SL  ----+-*A-1-B--+----2----+----3----+----
0   000001                IDENTIFICATION DIVISION.
    000002                PROGRAM-ID. HELLO.
    000003                PROCEDURE DIVISION.
    000004                    DISPLAY 'HELLO WORLD!'.
    000005                    STOP RUN.
1PP 5655-EC6 IBM Enterprise COBOL for z/OS  6.3.0 P200115
0An "M" preceding a data-name reference indicates that th

  Defined   Cross-reference of data names   References

1PP 5655-EC6 IBM Enterprise COBOL for z/OS  6.3.0 P200115
0 Defined   Cross-reference of programs     References

         2   HELLO
-* Statistics for COBOL program HELLO:
 *    Source records = 5
 *    Data Division statements = 0
```

Figure 27. COBOL compiler output

27. View the COBOL program execution by selecting **COBRUN:SYSOUT(105)** from the LearnCOBOL in the Jobs section of Zowe Explorer as shown in Figure 28.



```
HELLO WORLD!
```

Figure 28. COBOL program execution

28. The following URL is another excellent document describing the above VSCode and Zowe Explore details with examples: https://marketplace.visualstudio.com/items?itemName=Zowe.vscode-extension-for-zowe

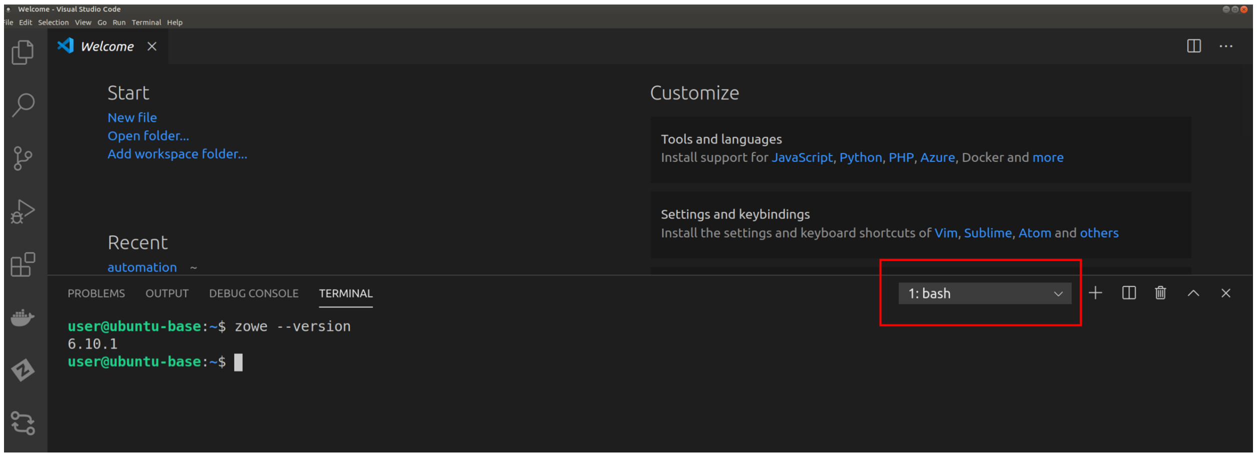
8.7 Lab - Zowe CLI & Automation

In this lab exercise you will use the Zowe CLI to automate submitting the JCL to compile, link, and run the COBOL program and downloading the spool output. Refer to the section on the "Installation of Zowe CLI and Plug-ins" to install Zowe CLI if you have not already done so. Before developing the automation, we will first leverage the Zowe CLI interactively.

8.7.1 Zowe CLI - Interactive Usage

In this section, we will use the Zowe CLI interactively to view data set members, submit jobs, and review spool output.

1. Within VS Code, open the integrated terminal (Terminal -> New Terminal). In the terminal, issue `zowe --version` to confirm the Zowe CLI is installed as depicted in the following figure. If it is not installed, please refer to to the section on the "Installation of Zowe CLI and Plug-ins." Also notice that the default shell selected (outlined in red) is `bash`. I would recommend selecting the default shell as either `bash` or `cmd` for this lab.


Welcome - Visual Studio Code
File Edit Selection View Go Run Terminal Help
Welcome
Start
New file
Open folder...
Add workspace folder...
Recent
automation ~
Customize
Tools and languages
Install support for JavaScript, Python, PHP, Azure, Docker and more
Settings and keybindings
Install the settings and keyboard shortcuts of Vim, Sublime, Atom and others
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
1: bash

```
user@ubuntu-base:~$ zowe --version
6.10.1
user@ubuntu-base:~$ 
```

Figure 29. `zowe --version` *command in VS Code Integrated Terminal (Shell selection outlined in red)*

2. In order for Zowe CLI to interact with z/OSMF the CLI must know the connection details such as host, port, username, password, etc. While you could enter this information on each command, Zowe provides the ability to store this information in configurations commonly known as profiles. Zowe CLI and the Zowe VS Code Extension share profiles. So if you created a connection profile in the first lab, you could naturally leverage it here.

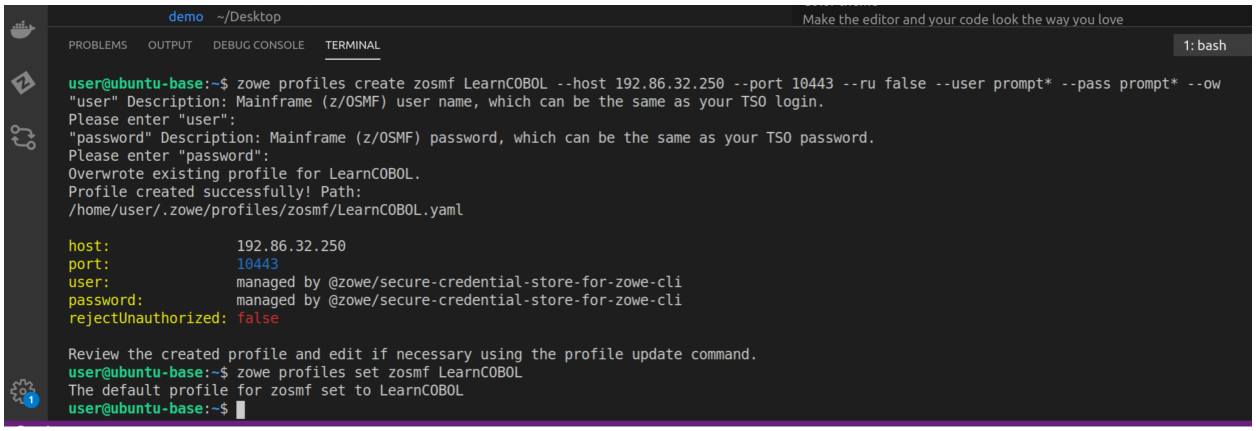
To create a LearnCOBOL profile (and overwrite it if it already exists), issue the following command with your system details (using `prompt*` will prompt you for certain fields and not show input):

```
zowe profiles create zosmf LearnCOBOL --host 192.86.32.250 --port 10443
   --ru false --user prompt* --pass prompt* --ow
```

Many profiles can be created for interacting with different z/OSMF instances. If this was not your first profile, you will want to set it as the default for the following lab exercises. Issue the following command:

```
zowe profiles set zosmf LearnCOBOL
```

The following figure demonstrates this sequence of commands.



```
user@ubuntu-base:~$ zowe profiles create zosmf LearnCOBOL --host 192.86.32.250 --port 10443 --ru false --user prompt* --pass prompt* --ow
"user" Description: Mainframe (z/OSMF) user name, which can be the same as your TSO login.
Please enter "user":
"password" Description: Mainframe (z/OSMF) password, which can be the same as your TSO password.
Please enter "password":
Overwrote existing profile for LearnCOBOL.
Profile created successfully! Path:
/home/user/.zowe/profiles/zosmf/LearnCOBOL.yaml

host:               192.86.32.250
port:               10443
user:               managed by @zowe/secure-credential-store-for-zowe-cli
password:           managed by @zowe/secure-credential-store-for-zowe-cli
rejectUnauthorized: false

Review the created profile and edit if necessary using the profile update command.
user@ubuntu-base:~$ zowe profiles set zosmf LearnCOBOL
The default profile for zosmf set to LearnCOBOL
user@ubuntu-base:~$
```

Figure 30. Create and set z/OSMF profile (secure credential store plug-in is in use)

3. Confirm you can connect to z/OSMF by issuing the following command:

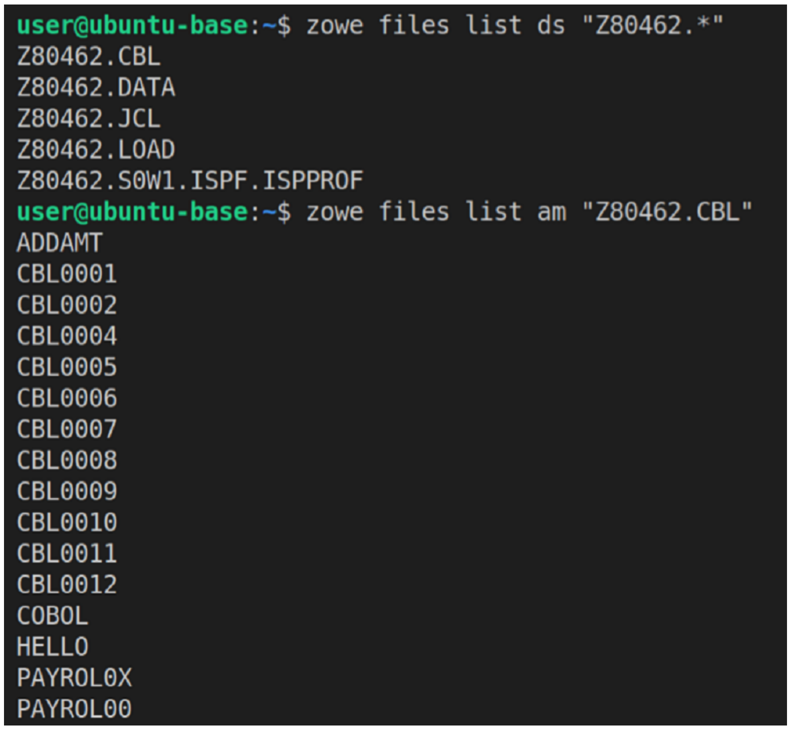
```
zowe zosmf check status
```

4. List data sets under your ID by issuing a command similar to (see sample output in the following figure):

```
zowe files list ds "Z80462.*"
```

You can also list all members in a partitioned data set by issuing a command similar to (see sample output in the following figure):

```
zowe files list am "Z80462.CBL"
```



```
user@ubuntu-base:~$ zowe files list ds "Z80462.*"
Z80462.CBL
Z80462.DATA
Z80462.JCL
Z80462.LOAD
Z80462.S0W1.ISPF.ISPPROF
user@ubuntu-base:~$ zowe files list am "Z80462.CBL"
ADDAMT
CBL0001
CBL0002
CBL0004
CBL0005
CBL0006
CBL0007
CBL0008
CBL0009
CBL0010
CBL0011
CBL0012
COBOL
HELLO
PAYROL0X
PAYROL00
```

Figure 31. zowe files list ds and am commands

5. Next, we will download our COBOL and JCL data set members to our local machine. First, create and open a new folder in your file explorer. Note that you could also create a workspace to manage multiple projects. See the following figure for help:

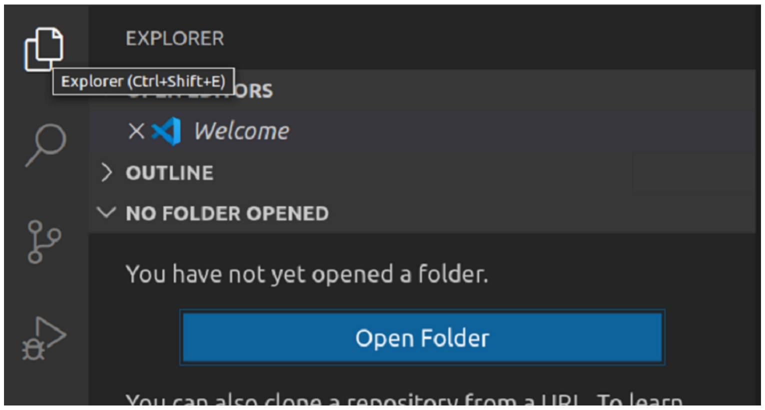
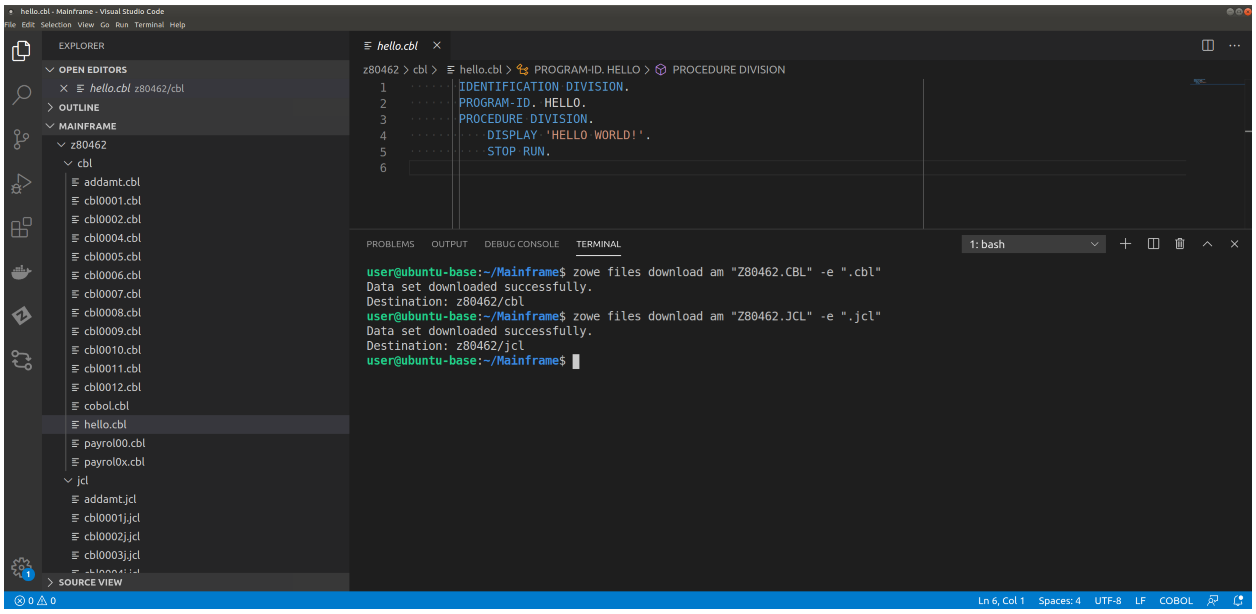

EXPLORER
Explorer (Ctrl+Shift+E)
OPEN EDITORS
Welcome
OUTLINE
NO FOLDER OPENED
You have not yet opened a folder.
Open Folder
You can also clone a repository from a URL. To learn

Figure 32. File explorer view to demonstrate opening a new folder

Once you have an empty folder opened, return to the integrated terminal, ensure you are in your folder, and issue commands similar to:

```
zowe files download am "Z80462.CBL" -e ".cbl"
zowe files download am "Z80462.JCL" -e ".jcl"
```

Then open `hello.cbl` in your file explorer. A completed example is shown in the following figure:



```
       IDENTIFICATION DIVISION.
       PROGRAM-ID. HELLO.
       PROCEDURE DIVISION.
           DISPLAY 'HELLO WORLD!'.
           STOP RUN.
```

```
user@ubuntu-base:~/Mainframe$ zowe files download am "Z80462.CBL" -e ".cbl"
Data set downloaded successfully.
Destination: z80462/cbl
user@ubuntu-base:~/Mainframe$ zowe files download am "Z80462.JCL" -e ".jcl"
Data set downloaded successfully.
Destination: z80462/jcl
user@ubuntu-base:~/Mainframe$
```

Figure 33. Download and view data set members using the CLI

6. Next, we will submit the job in member `Z80462.JCL(HELLO)`. To submit the job, wait for it to complete, and view all spool content, issue:

```
zowe jobs submit ds "Z80462.JCL(HELLO)" --vasc
```

We could also perform this step in piecemeal to get the output from a specific spool file. See the next figure for an example of the upcoming commands. To submit the job and wait for it to enter OUTPUT status, issue:

```
zowe jobs submit ds "Z80462.JCL(HELLO)" --wfo
```

To list spool files associated with this job id, issue:

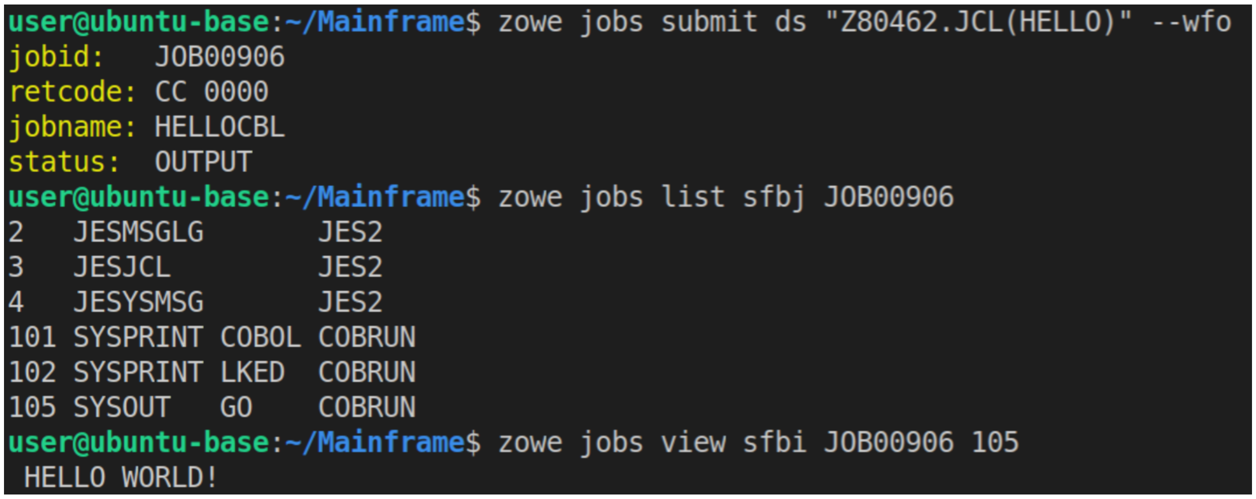
```
zowe jobs list sfbj JOB00906
```

where `JOB00906` was returned from the previous command.

To view a specific spool file (COBRUN:SYSOUT), issue:

```
zowe jobs view sfbi JOB00906 105
```

where `JOB00906` and `105` are obtained from the previous commands.

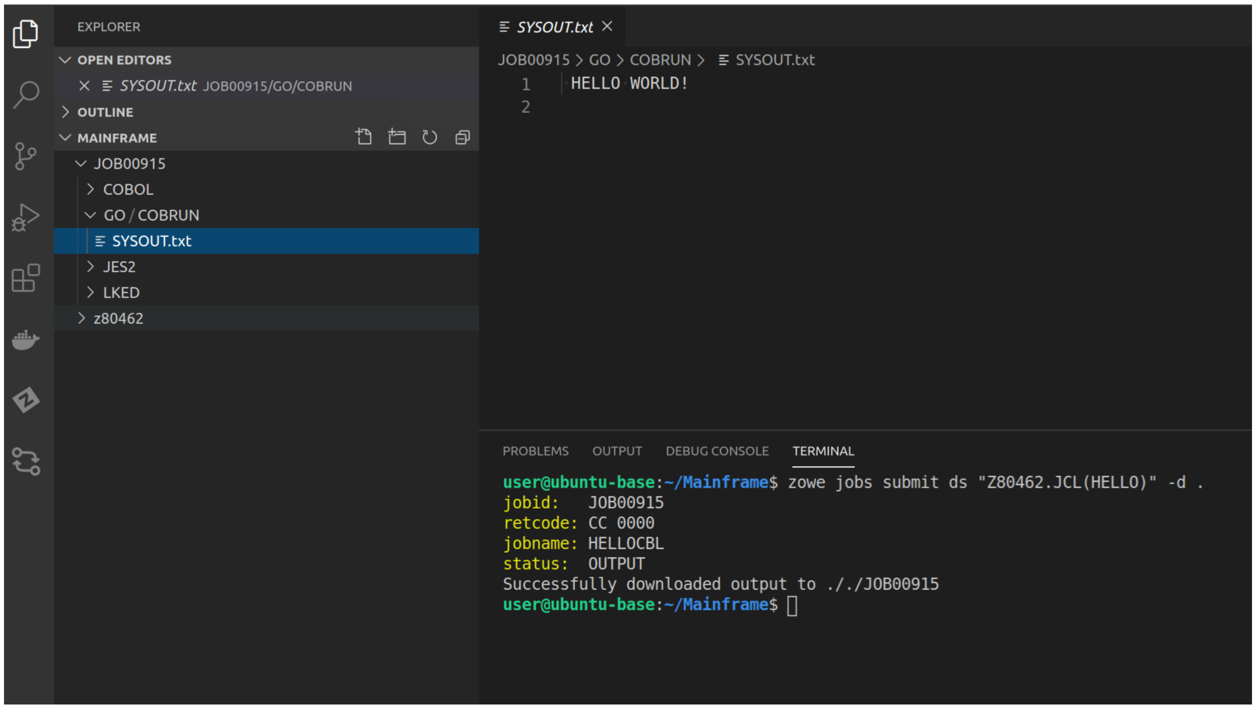


```
user@ubuntu-base:~/Mainframe$ zowe jobs submit ds "Z80462.JCL(HELLO)" --wfo
jobid:   JOB00906
retcode: CC 0000
jobname: HELLOCBL
status:  OUTPUT
user@ubuntu-base:~/Mainframe$ zowe jobs list sfbj JOB00906
2   JESMSGLG       JES2
3   JESJCL         JES2
4   JESYSMSG       JES2
101 SYSPRINT COBOL COBRUN
102 SYSPRINT LKED  COBRUN
105 SYSOUT   GO    COBRUN
user@ubuntu-base:~/Mainframe$ zowe jobs view sfbi JOB00906 105
 HELLO WORLD!
```

Figure 34. Submit a job, wait for it to complete, then list spool files for the job, and view a specific spool file

If desired, you can also easily submit a job, wait for it to complete, and download the spool content using the following command (see the following figure for the completed state):

```
zowe jobs submit ds "Z80462.JCL(HELLO)" -d .
```

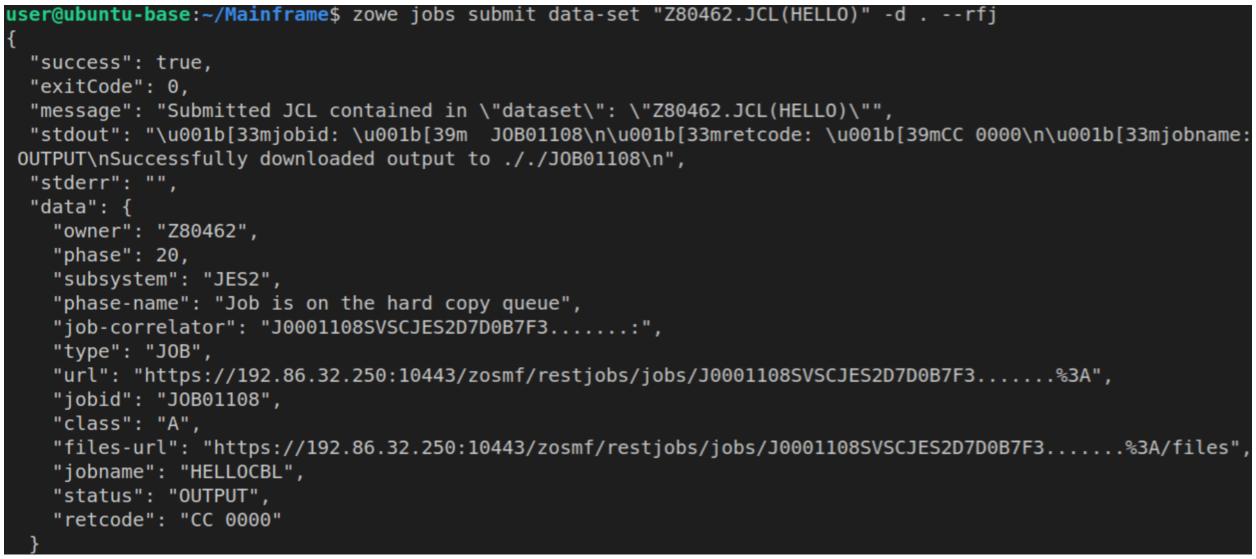


```
HELLO WORLD!
```

```
user@ubuntu-base:~/Mainframe$ zowe jobs submit ds "Z80462.JCL(HELLO)" -d .
jobid:    JOB00915
retcode:  CC 0000
jobname:  HELLOCBL
status:   OUTPUT
Successfully downloaded output to ././JOB00915
user@ubuntu-base:~/Mainframe$
```

Figure 35. Submit a job, wait for it to complete, download and view spool files

The Zowe CLI was built with scripting in mind. For example, you can use the `--rfj` flag to receive output in JSON format for easy parsing. See the next figure for an example.



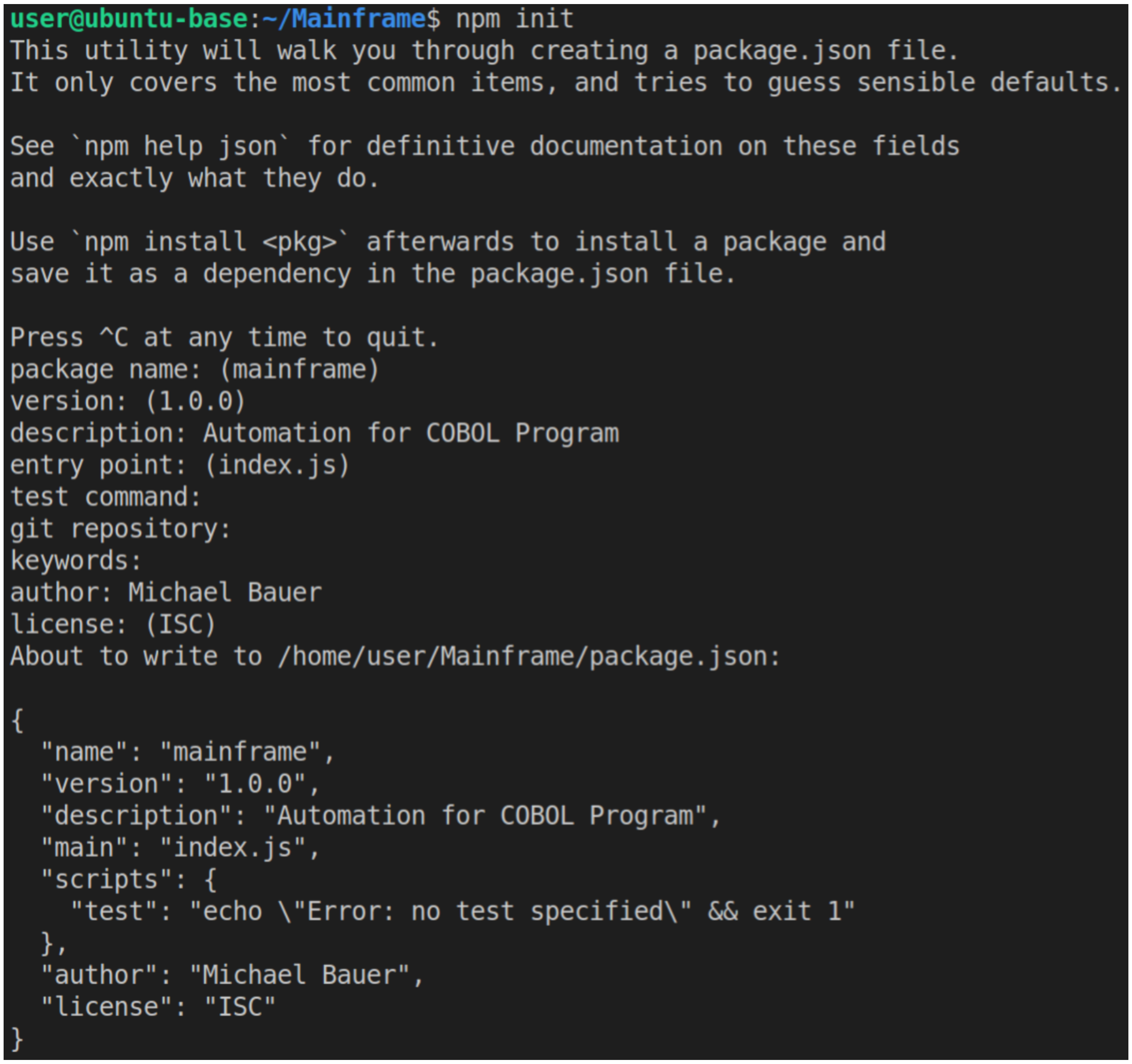
```
user@ubuntu-base:~/Mainframe$ zowe jobs submit data-set "Z80462.JCL(HELLO)" -d . --rfj
{
  "success": true,
  "exitCode": 0,
  "message": "Submitted JCL contained in \"dataset\": \"Z80462.JCL(HELLO)\"",
  "stdout": "\u001b[33mjobid: \u001b[39m  JOB01108\n\u001b[33mretcode: \u001b[39mCC 0000\n\u001b[33mjobname:
 OUTPUT\nSuccessfully downloaded output to ././JOB01108\n",
  "stderr": "",
  "data": {
    "owner": "Z80462",
    "phase": 20,
    "subsystem": "JES2",
    "phase-name": "Job is on the hard copy queue",
    "job-correlator": "J0001108SVSCJES2D7D0B7F3.......:",
    "type": "JOB",
    "url": "https://192.86.32.250:10443/zosmf/restjobs/jobs/J0001108SVSCJES2D7D0B7F3.......%3A",
    "jobid": "JOB01108",
    "class": "A",
    "files-url": "https://192.86.32.250:10443/zosmf/restjobs/jobs/J0001108SVSCJES2D7D0B7F3.......%3A/files",
    "jobname": "HELLOCBL",
    "status": "OUTPUT",
    "retcode": "CC 0000"
  }
```

Figure 36. The `--rfj` flag allows for easy programmatic usage

8.7.2 Zowe CLI - Programmatic Usage

In this section, we will leverage the Zowe CLI programmatically to automate submitting the JCL to compile, link, and run the COBOL program and downloading the spool output. Once you have the content locally you could use any number of distributed scripting and testing tools to eliminate the need to manually review the spool content itself. Historically, in Mainframe we use REXX EXEC etc. for automation, but today we are going to use CLI and distributed tooling.

1. Since we already have Node and npm installed, let's just create a node project for our automation. To initialize a project, issue `npm init` in your project's folder and follow the prompts. You can accept the defaults by just pressing enter. Only the description and author fields should be changed. See the following figure.



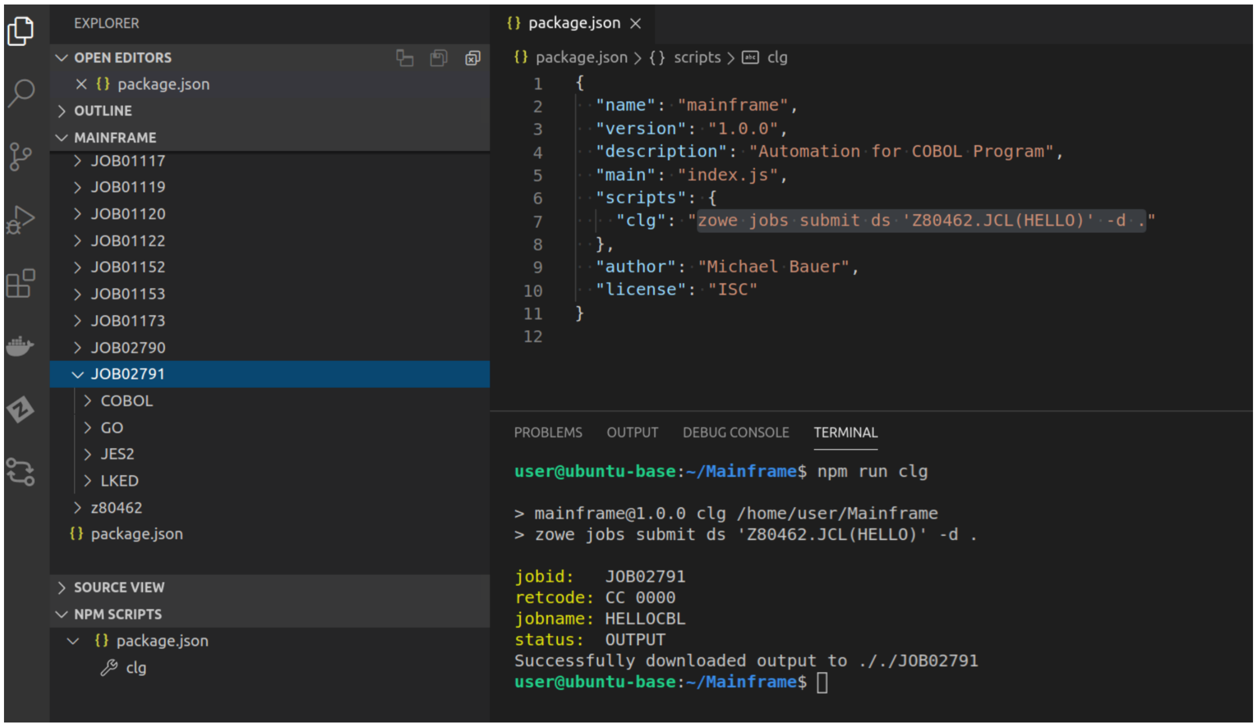
```
user@ubuntu-base:~/Mainframe$ npm init
This utility will walk you through creating a package.json file.
It only covers the most common items, and tries to guess sensible defaults.

See `npm help json` for definitive documentation on these fields
and exactly what they do.

Use `npm install <pkg>` afterwards to install a package and
save it as a dependency in the package.json file.

Press ^C at any time to quit.
package name: (mainframe)
version: (1.0.0)
description: Automation for COBOL Program
entry point: (index.js)
test command:
git repository:
keywords:
author: Michael Bauer
license: (ISC)
About to write to /home/user/Mainframe/package.json:

{
  "name": "mainframe",
  "version": "1.0.0",
  "description": "Automation for COBOL Program",
  "main": "index.js",
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
  },
  "author": "Michael Bauer",
  "license": "ISC"
}
```

Figure 37. Use of `npm init` to create `package.json` for the project

2. Now that we have our `package.json` simply replace the `test` script with a `clg` script that runs the following zowe command (replace `Z80462` with your high level qualifier):

```
zowe jobs submit ds 'Z80462.JCL(HELLO)' -d .
```

You can name the script whatever you want. I only suggested `clg` because the `CLG` in the `IGYWCLG` proc (which is what the JCL leverages) stands for compile, link, go. Now, simply issue `npm run clg` in your terminal to leverage the automation to compile, link and run the COBOL program and download the output for review. An example of the completed `package.json` and command execution are shown in the following figure.

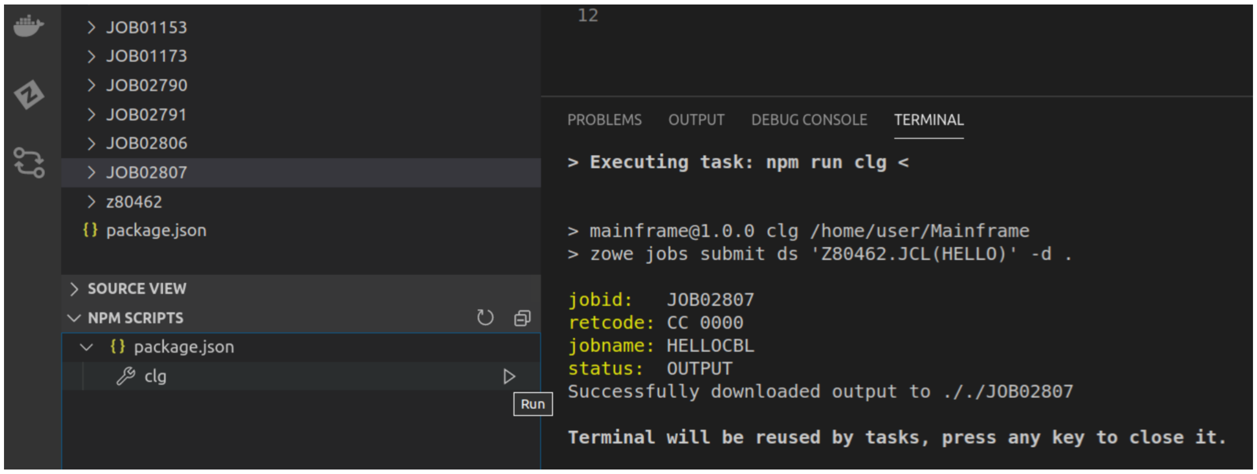


```
{
  "name": "mainframe",
  "version": "1.0.0",
  "description": "Automation for COBOL Program",
  "main": "index.js",
  "scripts": {
    "clg": "zowe jobs submit ds 'Z80462.JCL(HELLO)' -d ."
  },
  "author": "Michael Bauer",
  "license": "ISC"
}
```

```
user@ubuntu-base:~/Mainframe$ npm run clg

> mainframe@1.0.0 clg /home/user/Mainframe
> zowe jobs submit ds 'Z80462.JCL(HELLO)' -d .

jobid:   JOB02791
retcode: CC 0000
jobname: HELLOCBL
status:  OUTPUT
Successfully downloaded output to ././JOB02791
user@ubuntu-base:~/Mainframe$
```

Figure 38. Final `package.json` *and* `npm run clg` *execution*

3. If you prefer a graphical trigger, you can leverage VS Code as shown in the following figure. Essentially, the CLI enables you to quickly build your own buttons for your custom z/OS tasks. You could also invoke a script rather than a single command to accomodate more complex scenarios.



```
> Executing task: npm run clg <


> mainframe@1.0.0 clg /home/user/Mainframe
> zowe jobs submit ds 'Z80462.JCL(HELLO)' -d .

jobid:   JOB02807
retcode: CC 0000
jobname: HELLOCBL
status:  OUTPUT
Successfully downloaded output to ././JOB02807

Terminal will be reused by tasks, press any key to close it.
```

Figure 39. `clg` *task triggered via button*

9 Data division

Understanding COBOL variables and program processing of variables are essential to effectively learning the COBOL language. An experienced COBOL programmer must master characteristics of COBOL variables and the program processing using the variables introduced in this chapter. The objective is to introduce the reader to the basics of COBOL variables while exposing the reader to the many advanced COBOL variable options.

Following this chapter is a lab available to compile and execute the COBOL source code provided later in the chapter. Following the successful compile and execution of one provided program, a second provided COBOL program with a minor change is available to compile. The second program has an embedded error and on compile will fail. The failed compilation is an opportunity to identify the error associated with the significance of PICTURE clause data types associated with the operation of the COMPUTE statement (discussed in this chapter) and how to solve the error.

- **Variables / Data-items**
  - **Variable / Data-item name restrictions and data types**
- **PICTURE clause**
  - **PIC clause symbols and data types**
  - **Coding COBOL variable / data-item names**
  - **PICTURE clause character-string representation**
- **Literals**
  - **Figurative constants**
  - **Data relationships**
  - **Levels of data**
- **MOVE and COMPUTE**
- **Lab**

9.1 Variables / Data-items

A COBOL variable, also known as a data-item, is a name and is chosen by the COBOL programmer. The named variable is coded to hold data where the data value can vary, hence the generic term ‘variable’. A COBOL variable name is also known as ‘Data Name’. A COBOL variable name has restrictions.

9.1.1 Variable / Data-item name restrictions and data types

A list of COBOL variable name restrictions or rules are:

- Must not be a COBOL reserved word.
- Must not contain a space as a part of the name.
- Name contains letters (A-Z), digits (0-9), underscores (_) and hyphens (-).
- Maximum length of 30 characters.
- A hyphen cannot appear as the first or last character.
- An underscore cannot appear as the first character.

Note : A full list of COBOL reserved words can be found in the Enterprise COBOL Language Reference, Appendix E.

When COBOL source code is compiled into an executable program, the COBOL compiler is expecting a named COBOL variable to possess attributes such as a length and data type. During program execution, the variable represents a defined area of processing memory where the memory location has a maximum length and designated data type.

A list of the most common COBOL data types are:

- Numeric (0-9)
- Alphabetic (A-Z), (a-z), or a space
- Alphanumeric Numeric and Alphabetic Combination

9.2 PICTURE clause

The COBOL reserved word, PICTURE (PIC), determines the length and data type of a programmer selected variable name. Data types described by PIC are commonly referred to as a picture clause or pic clause. Some simple pic clauses are:

- PIC 9 - single numeric value where length is one
- PIC 9(4) - four numeric values where length is four
- PIC X - single alphanumeric (character) value where length is one
- PIC X(4) - four alphanumeric values where length is four

9.2.1 PIC clause symbols and data types

The maximum length of a picture clause is dependent upon the data type and compiler options. The PIC reserved word has many more data types beyond numeric (PIC 9) and alphanumeric (PIC X). As an example, an alphabetic only data type is defined as PIC A. Other PIC clause symbols are:

```
B E G N P S U V Z 0 / + - , . * CR DB cs
```

Where cs is any valid currency symbols such as the dollar sign ($).

All PIC clause symbols are described in the Enterprise COBOL for z/OS Language Reference manual.

9.2.2 Coding COBOL variable / data-item names

A PIC clause describes the data type of a variable/data-item name. Coding a variable/data-item is done in the DATA DIVISION. The COBOL code describing a variable/data-item name is accomplished using a level number and a picture clause.

- Level number - A hierarchy of fields in a record.
- Variable name / Data-item name - Assigns a name to each field to be referenced in the program and must be unique within the program.
- Picture clause - For data type checking.

Figure 1. below is an example of COBOL level numbers with respective variable/data-item names and picture clause.

9.2.3 PICTURE clause character-string representation

Some PIC clause symbols can appear only once in a PIC clause character-string, while other can appear more than once. For example:

- PIC clause to hold value 1123.45 is coded as follows, where the V represents the decimal position.

  ```
  PIC 9(4)V99
  ```

- PIC clause for a value such as $1,123.45 is coded as follows:

  `PIC $9,999V99`

9.3 Literals

A COBOL literal is constant data value, meaning the value will not change like a variable can. The COBOL statement, `DISPLAY "HELLO WORLD!",` is a COBOL reserved word, `DISPLAY` , followed by a literal, `HELLO WORLD!`

9.3.1 Figurative constants

Figurative constants are reserved words that name and refer to specific constant values. Examples of figurative constants are:

- ZERO, ZEROS, ZEROES
- SPACE, SPACES
- HIGH-VALUE, HIGH-VALUES
- LOW-VALUE, LOW-VALUES
- QUOTE, QUOTES
- NULL, NULLS

9.3.2 Data relationships

The relationships among all data to be used in a program is defined in the DATA DIVISION, through a system of level indicators and level-numbers. A level indicator, with its descriptive entry, identifies each file in a program. Level indicators represent the highest level of any data hierarchy with which they are associated. A level-number, with its descriptive entry, indicates the properties of specific data. Level-numbers can be used to describe a data hierarchy; they can indicate that this data has a special purpose.

9.3.2.1 Level numbers A structured level number hierarchic relationship is available to all DATA DIVISION sections. Figure 1. shows the level number hierarchic relationship with programmer chosen level numbers, variable names and PIC clauses in the File Section where “01 PRINT-REC” references the following “05”-level group of variables and the “01 ACCT-FIELDS” references the following “05”-level group of variables. Observe 05-level CLIENT-ADDR is further subdivided into several 10-level names. COBOL code referencing the name CLIENT-ADDR includes the 10-level names.

```
*--------------
 DATA DIVISION.
*--------------
 FILE SECTION.
 FD  PRINT-LINE RECORDING MODE F.
 01  PRINT-REC.
     05  ACCT-NO-O      PIC X(8).
     05  ACCT-LIMIT-O   PIC $$,$$$,$$9.99.
     05  ACCT-BALANCE-O PIC $$,$$$,$$9.99.
* PIC $$,$$$,$$9.99 -- Alternative for PIC on chapter 7.2.3,
* using $ to allow values of different amounts of digits
* and .99 instead of v99 to allow period display on output
     05  LAST-NAME-O    PIC X(20).
     05  FIRST-NAME-O   PIC X(15).
     05  COMMENTS-O     PIC X(50).
* since the level 05 is higher than level 01,
* all variables belong to PRINT-REC (see chapter 7.3.3)
*
 FD  ACCT-REC RECORDING MODE F.
 01  ACCT-FIELDS.
     05  ACCT-NO            PIC X(8).
     05  ACCT-LIMIT         PIC S9(7)V99 COMP-3.
     05  ACCT-BALANCE       PIC S9(7)V99 COMP-3.
* PIC S9(7)v99 -- seven-digit plus a sign digit value
* COMP-3 -- packed BCD (binary coded decimal) representation
     05  LAST-NAME          PIC X(20).
     05  FIRST-NAME         PIC X(15).
     05  CLIENT-ADDR.
         10  STREET-ADDR    PIC X(25).
         10  CITY-COUNTY    PIC X(20).
         10  USA-STATE      PIC X(15).
     05  RESERVED           PIC X(7).
     05  COMMENTS           PIC X(50).
*
 WORKING-STORAGE SECTION.
 01 FLAGS.
```

Figure 1. Level number hierarchic relationship

9.3.3 Levels of data

After a record is defined, it can be subdivided to provide more detailed data references as seen in Figure 1. A level number is a one-digit or two-digit integer between 01 and 49, or one of three special level numbers: 66, 77, or 88 where the variable names are assigned attributes different from the 01-49-level numbers. The relationship between level numbers within a group item defines the hierarchy of data within that group. A group item includes all group and elementary items that follow it until a level number less than or equal to the level number of that group is encountered.

9.4 MOVE and COMPUTE

MOVE and COMPUTE reserved word statements alter the value of variable names. Each MOVE shown in Figure 2. results in a literal stored in a 77-level variable name. The COMPUTE statement, also shown in Figure 2. , stores the value of `HOURS * RATE` in `GROSS-PAY.` All three variable names are assigned a numeric value data type using PIC 9, which is necessary for the operation of the COMPUTE statement.

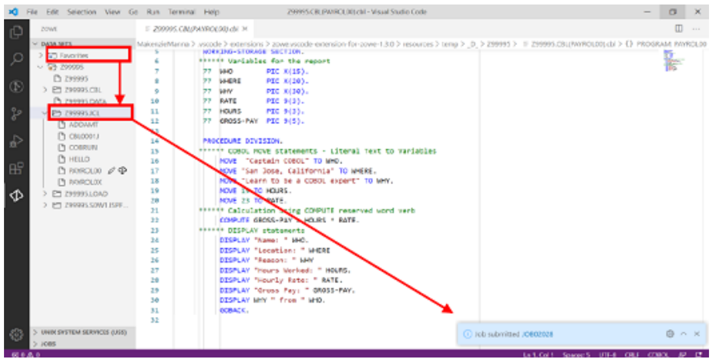
```
*         COBOL reference format (Figure 1., page 32)
*Columns:
*  1         2         3         4         5         6         7
*8901234567890123456789012345678901234567890123456789012345678901
*<A-><-------------------------B--------------------------------->
*Area                          Area
*<---Sequence Number Area          Identification Area---->
*-----------------------
 IDENTIFICATION DIVISION.
*-----------------------
 PROGRAM-ID. PAYROL00.
*-------------
 DATA DIVISION.
*-------------
 WORKING-STORAGE SECTION.
****** Variables for the report
* level number
* |  variable name
* |  |          picture clause
* |  |          |
* V  V          V
 77  WHO        PIC X(15).
 77  WHERE      PIC X(20).
 77  WHY        PIC X(30).
 77  RATE       PIC 9(3).
 77  HOURS      PIC 9(3).
 77  GROSS-PAY  PIC 9(5).

* PIC X(15) -- fiftheen alphanumeric characters
* PIC 9(3)  -- three-digit value
*------------------
 PROCEDURE DIVISION.
*------------------
****** COBOL MOVE statements - Literal Text to Variables
     MOVE  "Captain COBOL" TO WHO.
     MOVE "San Jose, California" TO WHERE.
     MOVE "Learn to be a COBOL expert" TO WHY.
     MOVE 19 TO HOURS.
     MOVE 23 TO RATE.
* The string "Captain COBOL" only contains 13 characters,
* the remaining positions of variable WHO are filled with spaces
* The value 19 only needs 2 digits,
* the leftmost position of variable HOURS is filled with zero
****** Calculation using COMPUTE reserved word verb
     COMPUTE GROSS-PAY = HOURS * RATE.
* The result of the multiplication only needs 3 digits,
* the remaining leftmost positions are filled with zeroes
****** DISPLAY statements
     DISPLAY "Name: " WHO.
     DISPLAY "Location: " WHERE
     DISPLAY "Reason: " WHY
     DISPLAY "Hours Worked: " HOURS.
     DISPLAY "Hourly Rate: " RATE.
     DISPLAY "Gross Pay: " GROSS-PAY.
     DISPLAY WHY " from " WHO.
     GOBACK.
```

Figure 2. MOVE and COMPUTE example

9.5 Lab

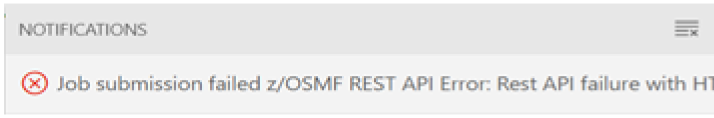
Note : It may take a few seconds to load in all segments of this lab. If files are not loading, hit the refresh button on the list that appears when hovering over the section bar.

1. View the PAYROL00 COBOL source code member in the 'id'.CBL data set.
2. Submit the JCL member, PAYROL00, from the id.JCL, where id is your id,dropdown. This is where id.JCL(PAYROL00) compiles and successfully executes the PAYROL00. program.



```
       WORKING-STORAGE SECTION.
      ****** Variables for the report
       77  WHO          PIC X(15).
       77  WHERE        PIC X(20).
       77  WHY          PIC X(30).
       77  RATE         PIC 9(3).
       77  HOURS        PIC 9(3).
       77  GROSS-PAY    PIC 9(5).

       PROCEDURE DIVISION.
      ****** COBOL MOVE statements - Literal Text to Variables
           MOVE  "Captain COBOL" TO WHO.
           MOVE "San Jose, California" TO WHERE.
           MOVE "Learn to be a COBOL expert" TO WHY.
           MOVE 19 TO HOURS.
           MOVE 23 TO RATE.
      ****** Calculation using COMPUTE reserved word verb
           COMPUTE GROSS-PAY = HOURS * RATE.
      ****** DISPLAY statements
           DISPLAY "Name: " WHO.
           DISPLAY "Location: " WHERE
           DISPLAY "Reason: " WHY
           DISPLAY "Hours Worked: " HOURS.
           DISPLAY "Hourly Rate: " RATE.
           DISPLAY "Gross Pay: " GROSS-PAY.
           DISPLAY WHY " from " WHO.
           GOBACK.
```

Figure 3. Submit PAYROL00 job

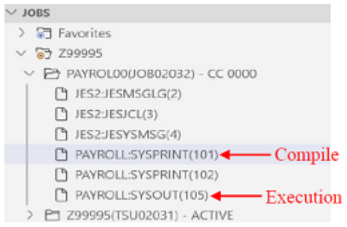


NOTIFICATIONS

Job submission failed z/OSMF REST API Error: Rest API failure with HT

Note : If you receive this error message after submitting the job: That is because you submitted the job from the .CBL data set and not the .JCL data set.

3. View both compile and execution of PAYROL00 job output, referenced in Figure 4.

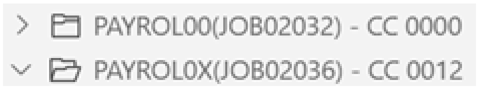


```
JOBS
  Favorites
  Z99995
    PAYROL00(JOB02032) - CC 0000
      JES2:JESMSGLG(2)
      JES2:JESJCL(3)
      JES2:JESYSMSG(4)
      PAYROLL:SYSPRINT(101)
      PAYROLL:SYSPRINT(102)
      PAYROLL:SYSOUT(105)
    Z99995(TSU02031) - ACTIVE
```

Figure 4. PAYROL00 output

4. Next, view PAYROL0X COBOL source code member in id.CBL data set.
5. View and submit the JCL member, PAYROL0X, from the id.JCL dropdown. This is where id.JCL(PAYROL0X) compiles and executes the PAYROL0X program.
6. View the compile of PAYROLL0X job output, notice there is no execution output.

   Do you notice a difference between this compile and the previous job compile shown in Figure 5. ?



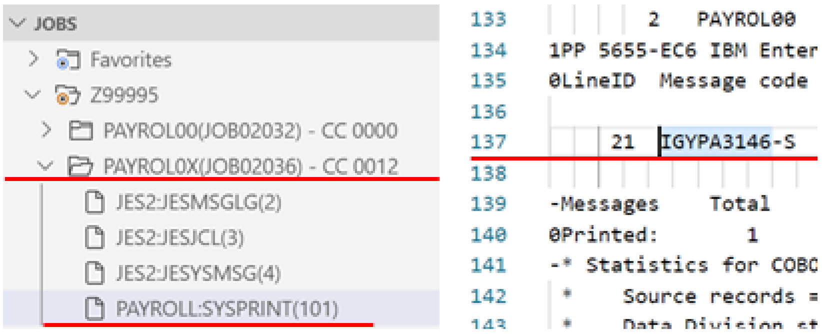
```
> PAYROL00(JOB02032) - CC 0000
v PAYROL0X(JOB02036) - CC 0012
```

Figure 5. Compare job compiles

The difference is the return/completion code associated with each job output, located both next to the job output name within the JOBS section as shown above, or at the end of the compile output as, 0Return code

##. A return code of 12 means there was an error, but how do we know what that error was? Continue to find out!

7. Observe the text associated with IGYPA3146-S on line 137 within the job output (compile), illustrated in Figure 6.



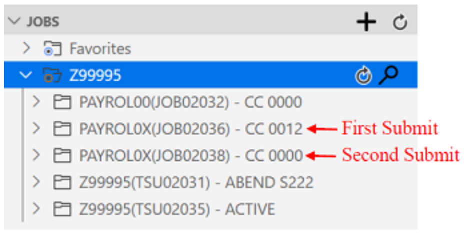
```
JOBS
> Favorites
v Z99995
  > PAYROL00(JOB02032) - CC 0000
  v PAYROL0X(JOB02036) - CC 0012
      JES2:JESMSGLG(2)
      JES2:JESJCL(3)
      JES2:JESYSMSG(4)
      PAYROLL:SYSPRINT(101)
```

```
133          2    PAYROL00
134   1PP 5655-EC6 IBM Enter
135   0LineID  Message code
136
137         21  IGYPA3146-S
138
139   -Messages    Total
140   0Printed:        1
141   -* Statistics for COBO
142    *     Source records =
143    *     Data Division st
```

Figure 6. IGYPA3146-S message

Notice that this line tells you to focus on the GROSS-PAY picture clause in order to identify the problem. Use this information, modify the PAYROL0X COBOL source code to fix the error. Be sure you are editing the correct code.

8. After modifying, re-submit the PAYROL0X JCL to verify the problem has been identified and corrected, resulting in a successful compile and execution with a return code of zero, shown in Figure 7.



```
JOBS
> Favorites
v Z99995
  > PAYROL00(JOB02032) - CC 0000
  > PAYROL0X(JOB02036) - CC 0012 <-- First Submit
  > PAYROL0X(JOB02038) - CC 0000 <-- Second Submit
  > Z99995(TSU02031) - ABEND S222
  > Z99995(TSU02035) - ACTIVE
```

Figure 7. Compare return codes

10 File handling

The previous chapter and lab focused on variables and moving literals into variables, then writing variable content using the COBOL DISPLAY statement. This section introduces reading records from files into variables, moving the variables to output variables, and writing the output variables to a different file. A simple COBOL program to read each record from a file and write each record to a different file is used to illustrate COBOL code necessary to read records from an input external data source and write records to an output external data source.

An experienced COBOL programmer can answer the question, "How does an Enterprise COBOL program read data from an input external data source and write data to an output external data source?" The objective of this chapter is to provide enough comprehensive information for the reader to be able to answer that question.

- **COBOL code used for sequential file handling**
  - **COBOL inputs and outputs**
  - **FILE-CONTROL paragraph**
  - **COBOL external data source**
  - **Data sets, records, and fields**
  - **Blocks**
  - **ASSIGN clause**
- **PROCEDURE DIVISION sequential file handling**
  - **Open input and output for read and write**
  - **Close input and output**
- **COBOL programming techniques to read and write records sequentially**
  - **READ-NEXT-RECORD paragraph execution**
  - **READ-RECORD paragraph**
  - **WRITE-RECORD paragraph**
  - **Iterative processing of READ-NEXT-RECORD paragraph**
- **Lab**

10.1 COBOL code used for sequential file handling

COBOL code used for sequential file handling involves:

- ENVIRONMENT DIVISION.
  - SELECT clauses
  - ASSIGN clauses
- DATA DIVISION.
  - FD statements
- PROCEDURE DIVISION.
  - OPEN statements
  - CLOSE statements
  - READ INTO statement

– WRITE FROM statement

10.1.1 COBOL inputs and outputs

The ENVIRONMENT DIVISION and DATA DIVISION describes the inputs and outputs used in the PROCEDURE DIVISION program logic. Previous chapters introduced variable descriptions in the DATA DIVISION and literals were moved into the defined variables. The role of the ENVIRONMENT DIVISION and more specifically, the INPUT-OUTPUT SECTION, FILE-CONTROL paragraph introduces accessing external data sources where the data from external sources are moved into defined variables.

10.1.2 FILE-CONTROL paragraph

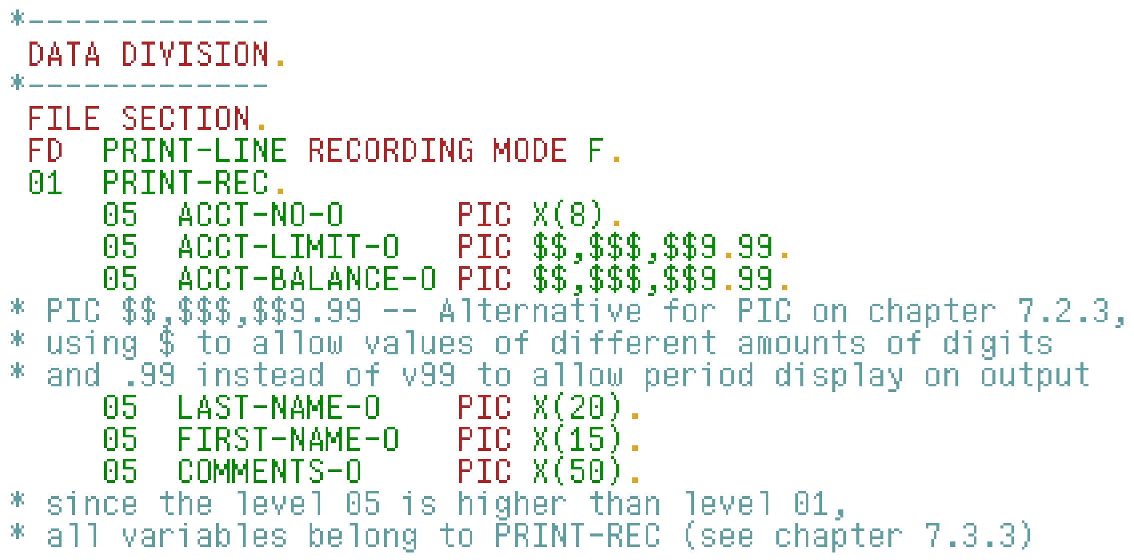
The FILE-CONTROL paragraph associates each COBOL internal file name with an external dataset name. Within the FILE-CONTROL paragraph, the SELECT clause creates an internal file name and the ASSIGN clause creates an external dataset name. Figure 1. shows the PRINT-LINE internal file name associated with the PRTLINE external dataset name and the ACCT-REC internal file name associated with the ACCTREC external dataset name. Section titled Assign Clause further explains the SELECT ASSIGN TO relationship.

```
*--------------------
 ENVIRONMENT DIVISION.
*--------------------
 INPUT-OUTPUT SECTION.
 FILE-CONTROL.
     SELECT PRINT-LINE ASSIGN TO PRTLINE.
     SELECT ACCT-REC   ASSIGN TO ACCTREC.
*SELECT clause creates an internal file name
*ASSIGN clause creates a name for an external data source,
*which is associated with the JCL DDNAME used by the z/OS
*e.g. ACCTREC is linked in JCL file CBL0001J to &SYSUID..DATA
*where &SYSUID. stands for Your z/OS user id
*e.g. if Your user id is Z54321,
*the data set used for ACCTREC is Z54321.DATA
```

Figure 1. FILE-CONTROL

While SELECT gives a name to an internal file and ASSIGN gives a name to the external dataset name, a COBOL program needs more information about both. The COBOL compiler is given more information about both in the DATA DIVISION, FILE SECTION.

The COBOL reserved word ‘FD’ is used to give the COBOL compiler more information about internal file names in the FILE-SECTION. The code below the FD statement is the record layout. The record layout consists of level numbers, variable names, data types, and lengths as shown in Figure 2.



```
*--------------
 DATA DIVISION.
*--------------
 FILE SECTION.
 FD  PRINT-LINE RECORDING MODE F.
 01  PRINT-REC.
     05  ACCT-NO-O      PIC X(8).
     05  ACCT-LIMIT-O   PIC $$,$$$,$$9.99.
     05  ACCT-BALANCE-O PIC $$,$$$,$$9.99.
* PIC $$,$$$,$$9.99 -- Alternative for PIC on chapter 7.2.3,
* using $ to allow values of different amounts of digits
* and .99 instead of v99 to allow period display on output
     05  LAST-NAME-O    PIC X(20).
     05  FIRST-NAME-O   PIC X(15).
     05  COMMENTS-O     PIC X(50).
* since the level 05 is higher than level 01,
* all variables belong to PRINT-REC (see chapter 7.3.3)
```

Figure 2. FILE-SECTION

10.1.3 COBOL external data source

Enterprise COBOL source code compiles and executes on IBM Z Mainframe hardware where z/OS is the operating system software. z/OS stores data in both data sets and Unix files. z/OS includes many data storage methods. This chapter will focus on the z/OS sequential data storage method. A sequential dataset is a collection of records.

10.1.4 Data sets, records, and fields

A dataset has many records. A record is a single line in the dataset and has a defined length. Each record can be subdivided into fields where each field has a defined length. Therefore, the sum of all field lengths would equal the length of the record. Observe Figure 3.

10.1.5 Blocks

Each record read by the program can result in disk storage access. A program typically reads 1 record at a time in sequential order until all records are read. When a record is read, the record retrieved from disk is stored in memory for program access. When each next record read requires the need to retrieve the record from disk, system performance is impacted negatively. Records can be blocked where a block is a group of records. The result is when the first record is read, then an entire block of records is read into memory assuming the program will be reading the second, third, etc. records avoiding unnecessary disk retrievals and negative system performance. The memory holding a record or block of records to be read by the program is known as a buffer. COBOL BLOCK CONTAINS clause is available to specify the size of the block in the buffer. Observe Figure 3.

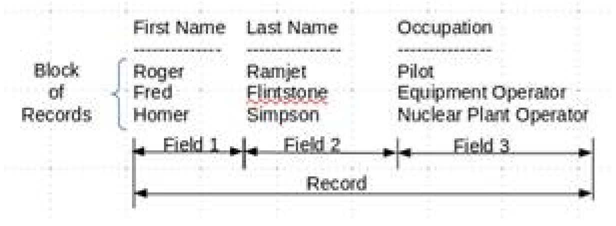


Figure 3. Records, fields, and blocks

10.1.6 ASSIGN clause

While the SELECT clause name is an internal file name, the ASSIGN clause name is describing a data source external to the program. z/OS uses Job Control Language, JCL, operations to tell the system what program to load and execute followed by input and output names needed by the program. The JCL input and output names are call DDNAMEs. The JCL DDNAME statement includes a JCL DD operation where DD is an abbreviation for Data Definition. On the same DDNAME statement is the system-controlled data set name.

COBOL code “SELECT ACCT-REC ASSIGN TO ACCTREC” requires a JCL DDNAME ACCTREC with a DD redirecting ACCTREC to a z/OS controlled dataset name, MY.DATA. The COBOL program is shown in Example 1.

The purpose of the redirection of ACCT-REC, via ASSIGN TO, to JCL DDNAME, ACCTREC is flexibility. ACCT-REC is used in the program itself, ACCTREC is a bridge to JCL, shown in Example 1. , and a DD JCL statement links ACCTREC to an actual dataset, shown in Example 2. This flexibility allows the same COBOL program to access a different data source with a simple JCL modification avoiding requirement to change the source code to reference the alternate data source.

```
SELECT ACCT-REC ASSIGN TO **ACCTREC**
```

Example 1. COBOL program

The JCL statement required by the compiled COBOL program during execution to redirect ACCTREC to the MY.DATA z/OS controlled dataset is shown in Example 2.

```
//**ACCTREC**   DD  DSN=MY.DATA,DISP=SHR
```

Example 2. JCL statement

In summary, ACCT-REC is the internal file name. ACCTREC is the external name where a JCL DDNAME must match the COBOL ASSIGN TO ACCTREC name. At program execution the JCL ACCTREC DDNAME statement is redirected to the dataset name identified immediately after the JCL DD operation.

```
ACCT-REC >>> ACCTREC >>> //ACCTREC >>> DD >>> MY.DATA
```

As a result, the COBOL internal ACCT-REC file name reads data records from sequential dataset named MY.DATA.

JCL is a separate z/OS technical skill. The introduction to COBOL explains just enough about JCL to understand how the COBOL internal file name locates the external sequential dataset name. To read more on JCL, visit the IBM Knowledge Center:

https://www.ibm.com/support/knowledgecenter/zosbasics/com.ibm.zos.zjcl/zjclc_basicjclconcepts.htm

10.2 PROCEDURE DIVISION sequential file handling

During COBOL program runtime, SELECT ASSIGN TO a JCL DDNAME is mandatory. If the ASSIGN TO name fails to associate with a JCL DDNAME of the same spelling, at runtime, then a program runtime error occurs when the OPEN operation is attempted. A message appears in the runtime output indicating the DDNAME was not found. READ and WRITE are dependent upon successful completion of the OPEN operation. The compiler cannot detect the runtime error because the compiler is unaware of the actual runtime JCL DDNAME dataset name subject to OPEN, READ, or WRITE. The FD, File Descriptor, mapping of the data record fields requires a successful OPEN to be populated by subsequent READ or WRITE operations.

10.2.1 Open input and output for read and write

COBOL inputs and outputs must be opened to connect the selected internal name to the assigned external name. Figure 4. opens the file name ACCT-REC as program input and file name PRINT-LINE as program output.

```
*-------------------
 PROCEDURE DIVISION.
*-------------------
 OPEN-FILES.
     OPEN INPUT  ACCT-REC.
     OPEN OUTPUT PRINT-LINE.
 OPEN-FILES-END.
*OPEN-FILES-END -- consists of an empty paragraph suffixed by
*-END that ends the past one and serves as a visual delimiter
*
```

Figure 4. OPEN-FILES

10.2.2 Close input and output

COBOL inputs and outputs should be closed at program completion or better yet when the program is done reading from or writing to the internal file name. Figure 5. closes the internal file name ACCT-REC and internal file name PRINT-LINE, then stops processing, STOP RUN.

```
*
 CLOSE-STOP.
     CLOSE ACCT-REC.
     CLOSE PRINT-LINE.
     STOP RUN.
*
```

Figure 5. CLOSE-STOP

10.3 COBOL programming techniques to read and write records sequentially

When reading records, the program needs to first check for no records to be read or check for no more records to be read. If a record exists, then the fields in the read record populate variable names defined by the FD clause. COBOL uses a PERFORM statement for iteration. In computer programming, iterative is used to describe a situation in which a sequence of instructions or statements can be executed multiple times. One pass through the sequence is called an iteration. Iterative execution is also called a loop. In other programming languages, 'DO' or 'FOR' statements are used for iterative execution. COBOL uses a PERFORM statement for iterative execution. Figure 6. shows four programmer chosen paragraph names in the PROCEDURE DIVISION.

- READ-NEXT-RECORD
- CLOSE-STOP
- READ-RECORD
- WRITE-RECORD

READ-NEXT-RECORD repeatedly executes READ-RECORD and WRITE-RECORD until a last record is encountered. When the last record is encountered, then CLOSE-STOP is executed stopping the program.

```
 READ-NEXT-RECORD.
     PERFORM READ-RECORD
*     The previous statement is needed before entering the loop.
*     Both the loop condition LASTREC = 'Y'
*     and the call to WRITE-RECORD depend on READ-RECORD having
*     been executed before.
*     The loop starts at the next line with PERFORM UNTIL
      PERFORM UNTIL LASTREC = 'Y'
      PERFORM WRITE-RECORD
      PERFORM READ-RECORD
      END-PERFORM
     .
*
 CLOSE-STOP.
     CLOSE ACCT-REC.
     CLOSE PRINT-LINE.
     STOP RUN.
*
 READ-RECORD.
     READ ACCT-REC
     AT END MOVE 'Y' TO LASTREC
     END-READ.
*
 WRITE-RECORD.
     MOVE ACCT-NO      TO  ACCT-NO-O.
     MOVE ACCT-LIMIT   TO  ACCT-LIMIT-O.
     MOVE ACCT-BALANCE TO  ACCT-BALANCE-O.
     MOVE LAST-NAME    TO  LAST-NAME-O.
     MOVE FIRST-NAME   TO  FIRST-NAME-O.
     MOVE COMMENTS     TO  COMMENTS-O.
     WRITE PRINT-REC.
```

Figure 6. Reading and writing records

Note: COBOL is English-like and COBOL reserved words are English-like. The programmer is free to use English-like variable names to help remember the purpose of the variable names. The PROCEDURE DIVISION structure is English-like. A paragraph contains one or more sentences. A sentence contains one or more statements. The implicit scope terminator, a period (.), terminates a sentence or terminates several consecutive statements which would be analogous to a compounded sentence where 'and' joins potentially independent sentences together. ###

10.3.1 READ-NEXT-RECORD paragraph execution

The READ-NEXT-RECORD paragraph is a COBOL programming technique used to read all records from a sequential file UNTIL the last record is read. The paragraph contains a compounded sentence terminated by an implicit scope terminator, (.) period, on a separate line following the END-PERFORM statement. The PERFORM UNTIL through END-PERFORM, explicit scope terminator, is repeatedly executed until LASTREC variable contains Y. The first PERFORM READ-RECORD results in a branch to the READ-RECORD paragraph. Observe #1 in Figure 7.

10.3.2 READ-RECORD paragraph

The READ-RECORD paragraph executes the COBOL READ statement resulting in the external sequential file populating the variables associated with ACCT-REC internal file name. If 'AT END' of records read, then Y is moved into the LASTREC variable. The READ statement is terminated by an explicit scope terminator, END-READ. The paragraph is terminated by an implicit scope terminator, (.) period. Control is returned to READ-NEXT-RECORD paragraph to execute the next statement, PERFORM WRITE-RECORD.

10.3.3 WRITE-RECORD paragraph

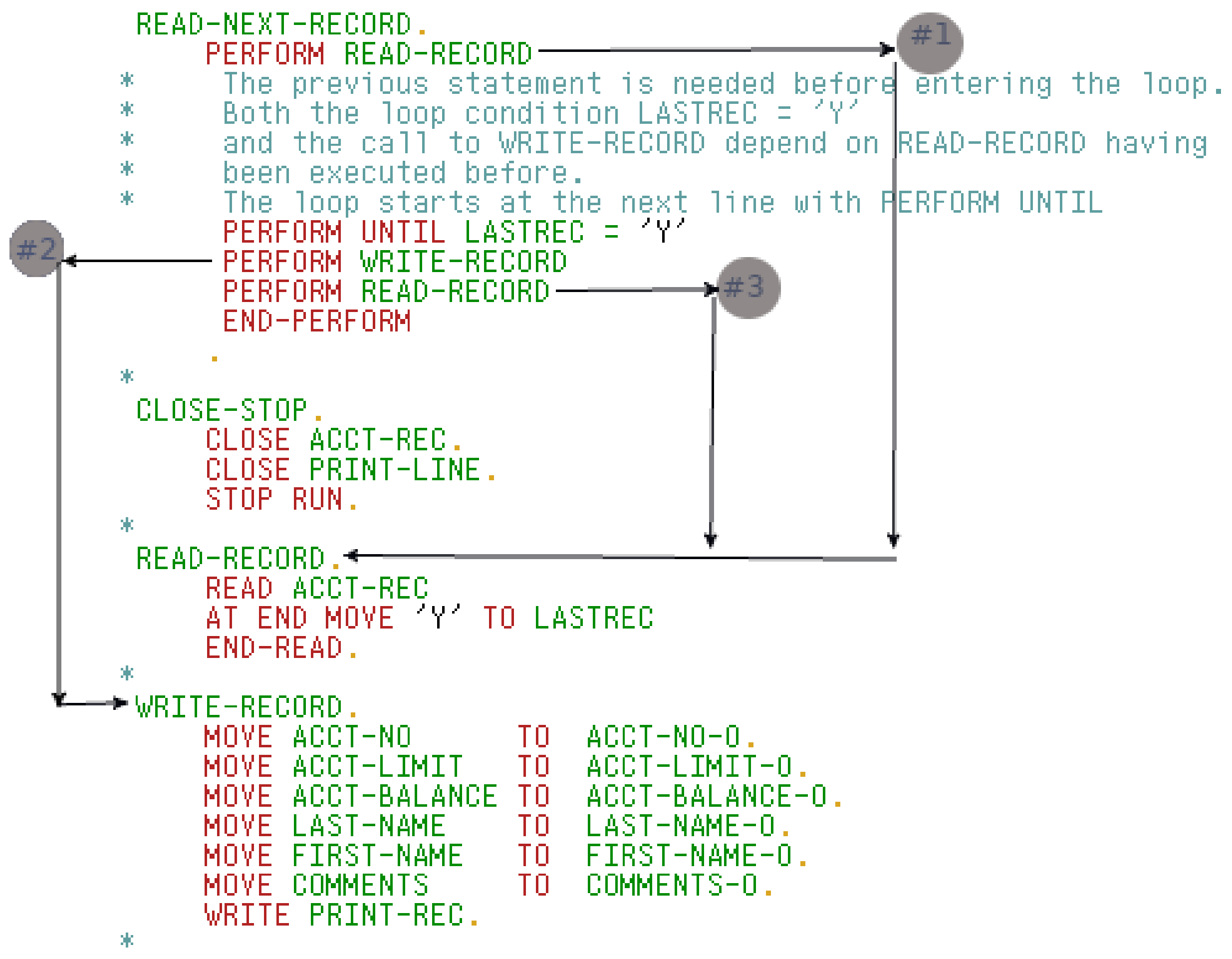
The WRITE-RECORD paragraph contains several sentences terminated by an implicit scope terminator, (.) period. The MOVE statements result in each input file variable name moved to an output file variable name. The last sentence in the paragraph writes the collection of output file variable names, PRINT-REC.

PRINT-REC is assigned to PRTREC. JCL is used to execute the COBOL program. An associated JCL PRTREC DDNAME redirects the written output to a z/OS controlled data set name, etc. using JCL DD operation on the JCL DDNAME statement. Observe #2 in Figure 7.

10.3.4 Iterative processing of READ-NEXT-RECORD paragraph

Once all statements in the WRITE-RECORD paragraph are executed, then control is returned to the READ-NEXT-RECORD paragraph where the next sentence to be executed is the second PERFORM READ-RECORD statement.

Again, the READ-RECORD paragraph executes the COBOL READ statement, resulting in the external sequential file populating the variables associated with ACCT-REC internal file name. If 'AT END' of records read, Y is moved into the LASTREC variable, then returns control to READ-NEXT-RECORD paragraph. The READ-NEXT-RECORD paragraph would continue the iterative process UNTIL Y is found in the LASTREC variable. Observe #3 in Figure 7.



```
 READ-NEXT-RECORD.
     PERFORM READ-RECORD
*     The previous statement is needed before entering the loop.
*     Both the loop condition LASTREC = 'Y'
*     and the call to WRITE-RECORD depend on READ-RECORD having
*     been executed before.
*     The loop starts at the next line with PERFORM UNTIL
      PERFORM UNTIL LASTREC = 'Y'
      PERFORM WRITE-RECORD
      PERFORM READ-RECORD
      END-PERFORM
     .
*
 CLOSE-STOP.
     CLOSE ACCT-REC.
     CLOSE PRINT-LINE.
     STOP RUN.
*
 READ-RECORD.
     READ ACCT-REC
     AT END MOVE 'Y' TO LASTREC
     END-READ.
*
 WRITE-RECORD.
     MOVE ACCT-NO      TO  ACCT-NO-O.
     MOVE ACCT-LIMIT   TO  ACCT-LIMIT-O.
     MOVE ACCT-BALANCE TO  ACCT-BALANCE-O.
     MOVE LAST-NAME    TO  LAST-NAME-O.
     MOVE FIRST-NAME   TO  FIRST-NAME-O.
     MOVE COMMENTS     TO  COMMENTS-O.
     WRITE PRINT-REC.
*
```

Figure 7. Iterative processing

10.4 Lab

The lab associated with this chapter demonstrates the 'end-of-file' COBOL coding technique for reading all data records from a sequential file. If a step has an asterisk (*) next to it, it will have a hint associated at the end of the lab content.

1. If not already, open VSCode and select Zowe Explorer from the left sidebar.

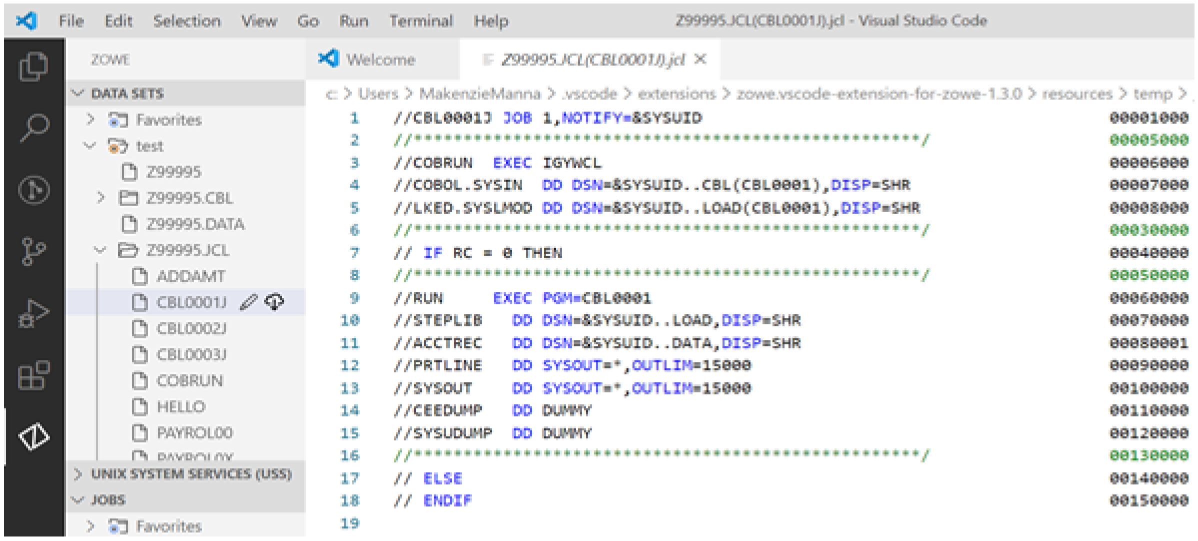
Note : If you are opening a new instance of VSCode (i.e. you closed out of it after the previous usage), you may need to 'Select a filter' again. You can do so by selecting the search icon 🔍 next to your named connection in the DATA SETS section and then reselecting the filter previously used. It should be in the listed filters after you have selected the search symbol.

2. View these COBOL source code members listed in the id.CBL data set:

- CBL0001
- CBL0002

3. View these three JCL members in the id.JCL data set:

- CBL0001J
- CBL0002J
- CBL0033J

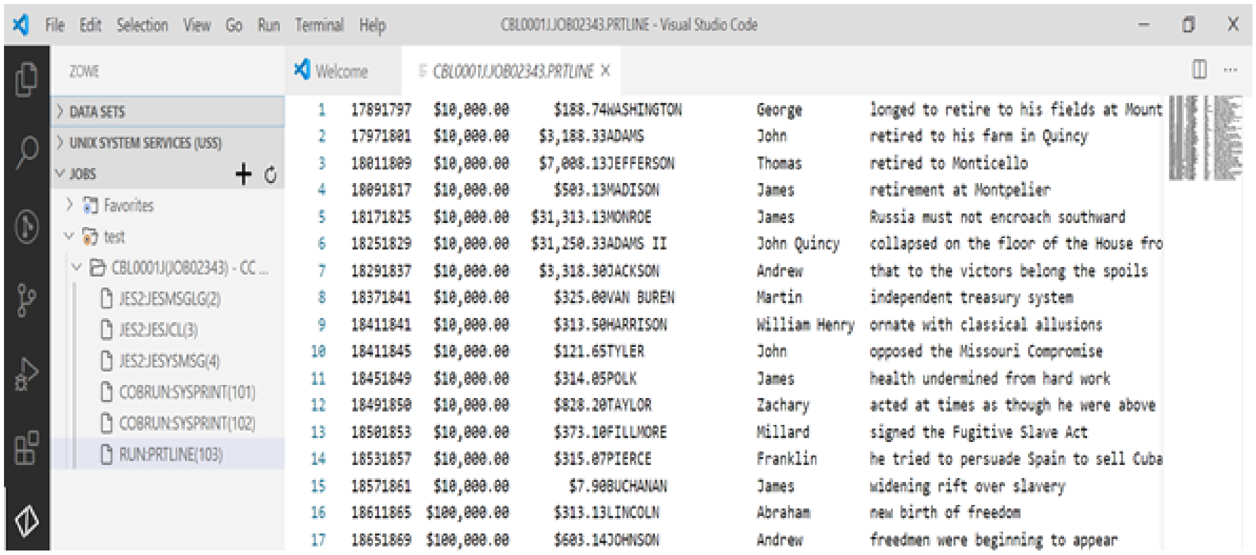


```
//CBL0001J JOB 1,NOTIFY=&SYSUID                                         00001000
//***************************************************/                  00005000
//COBRUN  EXEC IGYWCL                                                   00006000
//COBOL.SYSIN  DD DSN=&SYSUID..CBL(CBL0001),DISP=SHR                    00007000
//LKED.SYSLMOD DD DSN=&SYSUID..LOAD(CBL0001),DISP=SHR                   00008000
//***************************************************/                  00030000
// IF RC = 0 THEN                                                       00040000
//***************************************************/                  00050000
//RUN     EXEC PGM=CBL0001                                              00060000
//STEPLIB   DD DSN=&SYSUID..LOAD,DISP=SHR                               00070000
//ACCTREC   DD DSN=&SYSUID..DATA,DISP=SHR                               00080001
//PRTLINE   DD SYSOUT=*,OUTLIM=15000                                    00090000
//SYSOUT    DD SYSOUT=*,OUTLIM=15000                                    00100000
//CEEDUMP   DD DUMMY                                                    00110000
//SYSUDUMP  DD DUMMY                                                    00120000
//***************************************************/                  00130000
// ELSE                                                                 00140000
// ENDIF                                                                00150000
```

Figure 8. Id.JCL(CBL0001J).jcl

4. Submit job, JCL(CBL0001J), within the DATA SET section.
5. View that job output using the JOBS section.

- COBRUN:SYSPRINT(101) - COBOL program compiler output
- RUN:PRTLINE(103) - COBOL program execution output, shown in Figure 9.

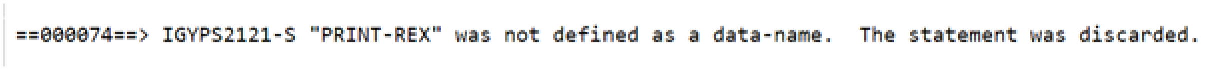

File Edit Selection View Go Run Terminal Help
CBL0001J.JOB02343.PRTLINE - Visual Studio Code
ZOWE
DATA SETS
UNIX SYSTEM SERVICES (USS)
JOBS
Favorites
test
CBL0001J(JOB02343) - CC ...
JES2:JESMSGLG(2)
JES2:JESJCL(3)
JES2:JESYSMSG(4)
COBRUN:SYSPRINT(101)
COBRUN:SYSPRINT(102)
RUN:PRTLINE(103)
Welcome
CBL0001J.JOB02343.PRTLINE

```
17891797  $10,000.00     $188.74WASHINGTON          George         longed to retire to his fields at Mount
17971801  $10,000.00   $3,188.33ADAMS               John           retired to his farm in Quincy
18011809  $10,000.00   $7,008.13JEFFERSON           Thomas         retired to Monticello
18091817  $10,000.00     $503.13MADISON             James          retirement at Montpelier
18171825  $10,000.00  $31,313.13MONROE              James          Russia must not encroach southward
18251829  $10,000.00  $31,250.33ADAMS II            John Quincy    collapsed on the floor of the House fro
18291837  $10,000.00   $3,318.30JACKSON             Andrew         that to the victors belong the spoils
18371841  $10,000.00     $325.00VAN BUREN           Martin         independent treasury system
18411841  $10,000.00     $313.50HARRISON            William Henry  ornate with classical allusions
18411845  $10,000.00     $121.65TYLER               John           opposed the Missouri Compromise
18451849  $10,000.00     $314.05POLK                James          health undermined from hard work
18491850  $10,000.00     $828.20TAYLOR              Zachary        acted at times as though he were above
18501853  $10,000.00     $373.10FILLMORE            Millard        signed the Fugitive Slave Act
18531857  $10,000.00     $315.07PIERCE              Franklin       he tried to persuade Spain to sell Cuba
18571861  $10,000.00       $7.90BUCHANAN            James          widening rift over slavery
18611865 $100,000.00     $313.13LINCOLN             Abraham        new birth of freedom
18651869 $100,000.00     $603.14JOHNSON             Andrew         freedmen were beginning to appear
```

Figure 9. RUN:PRTLINE(103) for JCL(CBL0001J)

6. Submit job, JCL(CBL0002J), within the DATA SET section.
7. View that job output using the JOBS section.
   - COBRUN:SYSPRINT(101) - COBOL program compiler output

   Locate COBOL compiler severe message IGYPS2121-S within the output file referred to in step 7, shown in Figure 10.

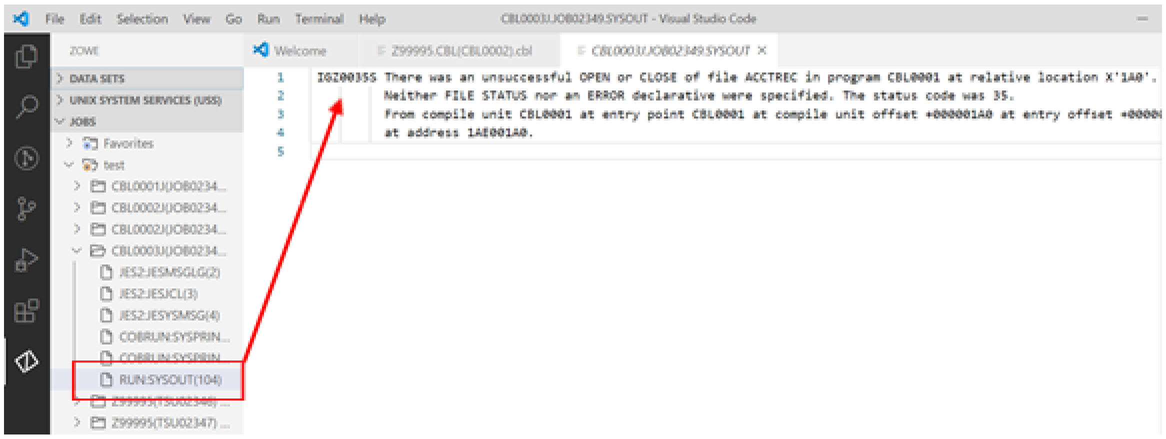


```
==000074==> IGYPS2121-S "PRINT-REX" was not defined as a data-name.  The statement was discarded.
```

Figure 10. IGYPS2121-S message

8. Edit CBL(CBL0002):
   - Determine appropriate spelling of PRINT-REX, correct it within the source code and save the updated source code.
9. Re-submit job, JCL(CBL0002J), using the DATA SET section and view the output in the JOBS section.
   - COBRUN:SYSPRINT(101) COBOL program compiler output
   - RUN:PRTLINE(103) is the COBOL program execution output (if correction is successful)
10. Submit job, JCL(CBL0033J), using the DATA SET section.
11. View CBL0033J ABENDU4038 output, using the JOBS section:
    - View the IGZ00355 abend message in RUN:SYSOUT(104) from the COBOL program execution output.

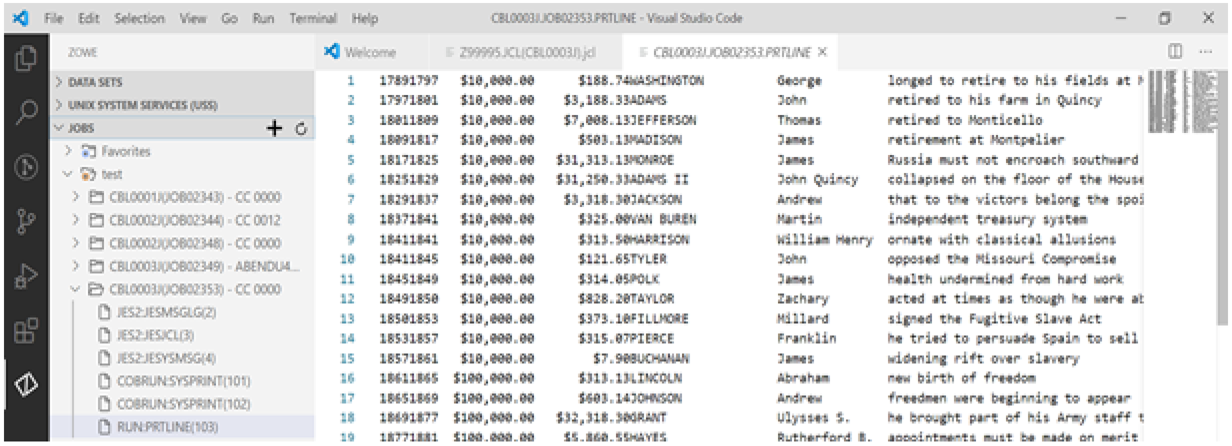
- IGZ00355 reads, program is unable to open or close ACCTREC file name, shown in Figure 11. guiding you to the root of the error.



```
IGZ0035S There was an unsuccessful OPEN or CLOSE of file ACCTREC in program CBL0001 at relative location X'1A0'.
         Neither FILE STATUS nor an ERROR declarative were specified. The status code was 35.
         From compile unit CBL0001 at entry point CBL0001 at compile unit offset +000001A0 at entry offset +0000
         at address 1AE001A0.
```

Figure 11. RUN:SYSOUT(104) message

12. Fix this error by editing JCL(CBL0033J):
    - Determine the DDNAME needed, but missing or misspelled.
    - Correct it within the code and save
13. Re-submit job, JCL(CBL0033J), using the DATA SET section.
14. View CBL0033J output using the JOBS section, your output should look like Figure 12.
    - RUN:PRTLINE - COBOL program execution output (if correction is successful)

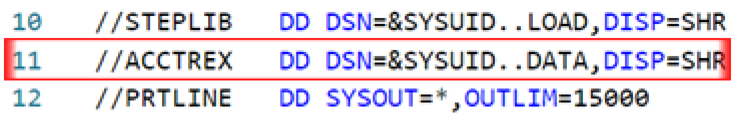


```
17891797   $10,000.00     $188.74WASHINGTON          George          longed to retire to his fields at M
17971801   $10,000.00   $3,188.33ADAMS               John            retired to his farm in Quincy
18011809   $10,000.00   $7,008.13JEFFERSON           Thomas          retired to Monticello
18091817   $10,000.00     $503.13MADISON             James           retirement at Montpelier
18171825   $10,000.00  $31,313.13MONROE              James           Russia must not encroach southward
18251829   $10,000.00  $31,250.33ADAMS II            John Quincy     collapsed on the floor of the House
18291837   $10,000.00   $3,318.30JACKSON             Andrew          that to the victors belong the spoi
18371841   $10,000.00     $325.00VAN BUREN           Martin          independent treasury system
18411841   $10,000.00     $313.50HARRISON            William Henry   ornate with classical allusions
18411845   $10,000.00     $121.65TYLER               John            opposed the Missouri Compromise
18451849   $10,000.00     $314.05POLK                James           health undermined from hard work
18491850   $10,000.00     $828.20TAYLOR              Zachary         acted at times as though he were at
18501853   $10,000.00     $373.10FILLMORE            Millard         signed the Fugitive Slave Act
18531857   $10,000.00     $315.07PIERCE              Franklin        he tried to persuade Spain to sell
18571861   $10,000.00       $7.90BUCHANAN            James           widening rift over slavery
18611865  $100,000.00     $313.13LINCOLN             Abraham         new birth of freedom
18651869  $100,000.00     $603.14JOHNSON             Andrew          freedmen were beginning to appear
18691877  $100,000.00  $32,318.30GRANT               Ulysses S.      he brought part of his Army staff t
18771881  $100,000.00   $5,860.55HAYES               Rutherford B.   appointments must be made on merit
```

Figure 12. RUN:PRTLINE(103) for JCL(CBL0033J)

Lab hints

13. The error is located on line 11, adjust 'ACCTREX' accordingly.



```
10    //STEPLIB    DD DSN=&SYSUID..LOAD,DISP=SHR
11    //ACCTREX    DD DSN=&SYSUID..DATA,DISP=SHR
12    //PRTLINE    DD SYSOUT=*,OUTLIM=15000
```

Figure 13. Error in id.JCL(CBL0033J).jcl

11 Program structure

In this chapter we discuss the concept of structured programming and how it relates to COBOL. We highlight the key techniques within the COBOL language that allow you to write good well-structured programs.

- **Styles of programming**
  - **What is structured programming**
  - **What is Object Orientated Programming**
  - **COBOL programming style**
- **Structure of the Procedure Division**
  - **Program control and flow through a basic program**
  - **Inline and out of line perform statements**
  - **Using performs to code a loop**
  - **Learning bad behavior using the GO TO keyword**
- **Paragraphs as blocks of code**
  - **Designing the content of a paragraph**
  - **Order and naming of paragraphs**
- **Program control with paragraphs**
  - **PERFORM TIMES**
  - **PERFORM THROUGH**
  - **PERFORM UNTIL**
  - **PERFORM VARYING**
- **Using subprograms**
  - **Specifying the target program**
  - **Specifying program variables**
  - **Specifying the return value**
- **Summary**
- **Lab**

11.1 Styles of programming

Before we discuss in more detail how to structure a program written in COBOL, it's important to understand the type of language COBOL is and how it's both different from other languages and how it affects the way you might structure your programs.

11.1.1 What is structured programming

Structured programming is the name given to a set of programming styles that could include functional, procedural amongst others. Structured programming technique results in program logic being easier to understand and maintain. Examples of structured programming languages are C, PL/I, Python and of course, COBOL. These languages, given specific control flow structures such as loops, functions and methods, allow a programmer to organize their code in a meaningful way.

Unstructured programming constructs, also known as spaghetti code, are concepts such as GOTO or JUMP which allow the flow of execution to branch wildly around the source code. Such code like this is hard to analyze and read. Although COBOL does contain these structures, it is important to use them sparingly and not as the backbone of well-structured code.

Well-structured code is both easy to understand and to maintain. It is highly likely that at some point in your career you will be required to read and work from someone else's code, often a decade after it was originally written. It would be extremely helpful to you if the original author structured their code well and likewise if it is your code someone else is reading.

11.1.2 What is Object Orientated Programming

Object Orientated programming, or OO programming, differs from structured programming, although it borrows a lot of the same concepts. In OO programming, code is split up into multiple classes, each representing an actor within the system. Each class is made up of variables and a sequence of methods. Instantiations of a class or objects can execute methods of another object. Each class within an OO program can be considered a structured program, as it will still contain methods and iteration constructs. However, it is the composition of the program from a set of individual classes that makes OO programming different. It is possible to write Object Orientated COBOL; however, it is not supported by some of the middleware products that provide COBOL APIs. It is not generally used within the market and so it is not covered in this course.

11.1.3 COBOL programming style

COBOL doesn't directly have some of the components of a structured programming language as you may know them if you have studied a language like C or Java. COBOL doesn't contain for or while loops, nor does it contain defined functions or methods. Because COBOL is meant to be a language that is easy to read these concepts are embodied through the use of the PERFORM keyword and the concept of paragraphs. This allows the programmer to still create these structures, but in a way that is easy to read and follow.

11.2 Structure of the Procedure Division

As you already know, a COBOL program is split into several divisions, including identification, environment and data. However, this chapter concerns itself with how you structure the content of the procedure division to be easy to read, understandable and maintainable in the future.

11.2.1 Program control and flow through a basic program

Typically, execution in a COBOL program begins at the first statement within the procedure division and progresses sequentially through each line until it reaches the end of the source code. For example, take a look at Example 1. Snippet from TOTEN1. This is a simple program that displays a simple message counting to ten.

```
OPEN OUTPUT PRINT-LINE.

MOVE 'THE NUMBER IS: ' TO MSG-HEADER OF PRINT-REC.

ADD 1 TO COUNTER GIVING COUNTER.
MOVE COUNTER TO MSG-TO-WRITE.
WRITE PRINT-REC.

ADD 1 TO COUNTER GIVING COUNTER.
MOVE COUNTER TO MSG-TO-WRITE.
WRITE PRINT-REC.

...

CLOSE PRINT-LINE.
```

```
STOP RUN.
```

Example 1. Snippet from TOTEN1

Although this code is very simple to read, it's not very elegant, there is a lot of code repetition as the number is increased. Obviously, we want to provide some structure to the program. There are three keywords that we can use to transfer control to a different section of the source code and provide the structure we need. These keywords are PERFORM, GO TO and CALL.

11.2.2 Inline and out of line perform statements

The PERFORM keyword is a very flexible element of the COBOL language, as it allows functions and loops to be entered. At the most basic level, a PERFORM allows control to be transferred to another section of the code. Once this section has executed, control returns to the following line of code. Take the following example:

```
    OPEN OUTPUT PRINT-LINE.

    MOVE 'THE NUMBER IS: ' TO MSG-HEADER OF PRINT-REC.

    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.
    PERFORM WRITE-NEW-RECORD.


    CLOSE PRINT-LINE.
    STOP RUN.



WRITE-NEW-RECORD.
    ADD 1 TO COUNTER GIVING COUNTER
    MOVE COUNTER TO MSG-TO-WRITE
    WRITE PRINT-REC.
```

Example 2. Snippet from TOTEN2

In this example, the three lines of code that constructed a new line of output and printed it has been extracted into a new paragraph called WRITE-NEW-RECORD. This paragraph is then performed ten times by use of the PERFORM keyword. Each time the PERFORM keyword is used, execution jumps to the paragraph WRITE-NEW-RECORD, executes the three lines contained within that paragraph before returning to the line following the PERFORM statement. The concept of a paragraph will be covered later in this chapter in more depth.

11.2.3 Using performs to code a loop

The code we have built so far is still not optimal, the repetition of the perform statement ten times is inelegant and can be optimized. Observe the following snippet of code:

```
MOVE 'THE NUMBER IS: ' TO MSG-HEADER OF PRINT-REC.

```

```
PERFORM VARYING COUNTER FROM 01 BY 1 UNTIL COUNTER EQUAL 11
MOVE COUNTER TO MSG-TO-WRITE
WRITE PRINT-REC
END-PERFORM.

CLOSE PRINT-LINE.
STOP RUN.
```

Example 3. Snippet from TOTEN2

In this example, we are using the PERFORM keyword in a way that is similar to a for loop in other languages. The loop runs from the PERFORM keyword to the END-PERFORM keyword. Each time execution iterates over the loop, the value of COUNTER is incremented and tested by one. For comparison, the same loop would be written in Java like so:

```
for(int counter =0; counter<11; counter++){
    //move counter to msg-to-write
    //write print-rec
}
```

Example 4. Java example

Although the COBOL version is perhaps more verbose than a for loop in other languages, it is easier to read, and remember you always have autocomplete (if you are using a good editor) to help you with the typing.

11.2.4 Learning bad behavior using the GO TO keyword

Programmers tend to have strong beliefs about choice of editor, tabs or spaces and many heated discussions have been had on such subjects. However, if there is one thing that we can agree on, it is that use of GO TO is usually a bad idea. To demonstrate why GO TO can be a poor idea, we will take a look at TOTEN2 again, and replace the second instance of the PERFORM keyword with a GO TO, shown in Example 5.

```
PERFORM WRITE-NEW-RECORD.
GO TO WRITE-NEW-RECORD.
PERFORM WRITE-NEW-RECORD.
```

Example 5. GO TO example

If we were to compile and run the program, you would see that although the job ABENDS (abnormally ends) with a 4038-abend code, it did execute some of the code and wrote the first two lines of the output. If you were to look at the output in more detail, you would see a message like the following:

```
IGZ0037S The flow of control in program TOTEN1 proceeded beyond the last
   line of the program.
```

Example 6. Abend from GO TO example

So, what went so terribly wrong when we used the GO TO command? To answer this, we need to understand the key difference between GO TO and PERFORM. On the first line we used the PERFORM keyword, that transferred control to the WRITE-NEW-RECORD paragraph. Once the execution reached the end of that paragraph, execution returned to the line following the PERFORM statement. The next line used the GOTO keyword to again transfer control to the WRITE-NEW-RECORD paragraph, which prints the second line of output. However, when that paragraph completed, execution continued to the next line following the WRITE-NEW-RECORD paragraph. Since there are no lines of code following that paragraph the processor tried to execute code beyond the program, z/OS caught this as a problem and abended the program.

As we can see, the use of GO TO causes a branch of execution that doesn't return to the line of code that issued it. Let's demonstrate how messy this code can get:

```
0 01  FLAG           PIC 9(1) VALUE 1.

1  OPEN OUTPUT PRINT-LINE.
2    GO TO SAY-HELLO-WORLD DEPENDING ON FLAG.
3
4 PRINT-NEW-MESSAGE.
5    MOVE 2 TO FLAG
6    GO TO SAY-HELLO-COBOL DEPENDING ON FLAG
7    GO TO END-RUN.
8
9 SAY-HELLO-WORLD.
10    MOVE "Hello World" TO MSG-TO-WRITE
11    WRITE PRINT-REC
12    GO TO PRINT-NEW-MESSAGE.
13
14 SAY-HELLO-COBOL.
15    MOVE "Hello COBOL" TO MSG-TO-WRITE
16    WRITE PRINT-REC
17    GO TO END-RUN.
18
19 END-RUN.
20    CLOSE PRINT-LINE
21    STOP RUN.
```

Example 7. Messy code using GO TO

This example is using a mix of conditional and non-conditional GO TO statements, and there are included line numbers to make following the code easier. Line 2 executes and will branch to SAY-HELLO-WORLD on line 9, if the flag variable is set to 1. In this case, it is, so we progress through lines 9-12 and branch to lines 4-6 where the value of the flag is updated and tested again to see if we should jump to SAY-HELLO-COBOL. Since the value of flag is no longer 1, execution just continues to line 7 before jumping to line 19 and finishing the run. Take this program and comment out line 5 and run the program again. Track the execution of the program. Messy right?

Note: Both the TO and ON parts of the conditional GO TO statement can be omitted, giving a statement that looks like GO SAY-HELLO-WORLD DEPENDING FLAG. Which although is less verbose, is no less easy to understand.

So why teach you something that we have said is messy and not advised? Well, by giving you some understanding of its behavior, you will be better equipped when looking through existing code and maintaining it.

11.3 Paragraphs as blocks of code

So far in this section we have used a few examples of paragraphs without really explaining what they are, how they work and what they can be used for. This section addresses that.

The most analogous way to think about a paragraph in COBOL is to think of a function or method in another language that accepts no parameters, returns no response and alters global variables. It is basically a block of code that performs a sequence of actions that could be used multiple times within the same program.

A paragraph is defined within the procedure division and starts at column eight and can have any name that the user likes, apart from a COBOL keyword, and the declaration of the paragraph is completed with a period (.). A paragraph can contain one to many COBOL sentences and is terminated either by the start of another paragraph or the physical end of the program.

Note: A paragraph can also be ended by END-PROGRAM, END-METHOD, END FACTORY OR END-OBJECT. Most of these are used within Object Orientated COBOL which is not discussed here.

Considering that a program can be made up of multiple paragraphs and that the PERFORM keyword can be used to call the paragraph, either conditionally or as part of a loop, it is easy to see that good paragraph design really helps makes your COBOL more structured and readable.

11.3.1 Designing the content of a paragraph

There are no restrictions as to what content can go inside a paragraph, however, there are two main reasons why you might want to refactor code to be inside a paragraph:

1. To group a sequence of COBOL sentences together that achieve a particular function or task, such as, open all the files that an application is using, calculate a particular function or perform some data validation. Grouping such sentences into a paragraph allows you to give them a name that explains the purpose of the lines of code.
2. The sequence of sentences will be used within a loop. Extracting these lines into a paragraph and then using the PERFORM keyword to create a loop can make for very comprehensible code.

Remember that you can also perform other paragraphs within existing paragraphs. This nested calling of paragraphs can again, help to structure your code.

11.3.2 Order and naming of paragraphs

There is no requirement about the order that paragraphs should appear within a COBOL program. A paragraph can be called from a point either before or after where it is declared. Although there are no restrictions enforced by the language, there are some techniques that you can follow that will make larger programs easier to follow and understand. Some of these techniques and best practices are:

- Name each paragraph to correspond with its function or behavior. A paragraph named OPEN-INPUT-FILES. is a lot more understandable than one named DO-FILE-STUFF.
- Order the paragraphs in the general order in which they will be executed at runtime. Doing this has two main advantages. Using the outline view in a modern IDE will allow you to 'read' the name of each paragraph from top to bottom, in doing so you will be able to establish the general structure of the program and its behavior.
- Some COBOL programmers prefix the name of paragraphs with a number that increases throughout the source code as per Example 8.
- Because the paragraphs are numbered and appear in the source code in that order, when a sentence references a paragraph it is easier to know where in the program that paragraph might appear. When initially structuring a program in this way, the numbers used would only increment the highest significant figure, allowing for new paragraphs to be inserted in between if needed. Although the rise of modern editors, which allow outlining and instant jumping to a reference or declaration, makes this technique of less necessity, it is still useful to understand.

```
           PERFORM 1000-OPEN-FILES.
           PERFORM 2000-READ-NEXT-RECORD.
           GO TO 3000-CLOSE-STOP.
       1000-OPEN-FILES.
           OPEN INPUT  ACCT-REC.
           OPEN OUTPUT PRINT-LINE.
      *
       2000-READ-NEXT-RECORD.
           PERFORM 4000-READ-RECORD
           PERFORM UNTIL LASTREC = 'Y'
           PERFORM 5000-WRITE-RECORD
```

```
     PERFORM 4000-READ-RECORD
     END-PERFORM.
*
 3000-CLOSE-STOP.
     CLOSE ACCT-REC.
     CLOSE PRINT-LINE.
     STOP RUN.
*
 4000-READ-RECORD.
     READ ACCT-REC
     AT END MOVE 'Y' TO LASTREC
     END-READ.
*
 5000-WRITE-RECORD.
     MOVE ACCT-N  -    TO  ACCT-NO-O.
     MOVE ACCT-LIMIT   TO  ACCT-LIMIT-O.
     MOVE ACCT-BALANCE TO  ACCT-BALANCE-O.
     MOVE LAST-NAME    TO  LAST-NAME-O.
     MOVE FIRST-NAME   TO  FIRST-NAME-O.
     MOVE COMMENTS     TO  COMMENTS-O.
     WRITE PRINT-REC.
```

Example 8. Numbered paragraphs

- Lastly, it is common to explicitly end a paragraph by coding an empty paragraph following each paragraph, see Example 9. This empty paragraph does not contain any code, has the same name as the paragraph it is closing, suffixed with -END and is in turn closed by the starting of a following paragraph. But it can be used as a visual delimiter and is useful when using the PERFORM THRU keyword, which is discussed further on in this chapter. Some Java programmers who have learned COBOL have commented that it is equivalent to the closing brace ("}") at the end of a block of code.

```
 1000-OPEN-FILES.
     OPEN INPUT  ACCT-REC.
     OPEN OUTPUT PRINT-LINE.
 1000-OPEN-FILES-END.
*
 2000-READ-NEXT-RECORD.
     PERFORM 4000-READ-RECORD
     PERFORM UNTIL LASTREC = 'Y'
     PERFORM 5000-WRITE-RECORD
     PERFORM 4000-READ-RECORD
     END-PERFORM.
 2000-READ-NEXT-RECORD-END.
```

Example 9. Explicitly closed paragraphs

11.4 Program control with paragraphs

So far in this chapter we have discussed the importance of using paragraphs to structure your code. In doing this, we have used the PERFORM keyword a few times to execute the paragraphs we had created. Specifically, we used the keyword by itself and used it with the VARYING keyword to construct a loop. In this section, we will discuss in more detail how the PERFORM keyword can be used.

11.4.1 PERFORM TIMES

Perhaps the simplest way of repeating a perform statement is to use the TIMES keyword to perform a paragraph or sections of code a static number of times, shown in Example 10.

```
PERFORM 10 TIMES
 MOVE FIELD-A TO FIELD-B
 WRITE RECORD
END-PERFORM.
```

Example 10. TIMES

The required number of times that the code should be executed can either be a literal, as above, or the value of a numeric variable as shown in Example 11. where the PERFORM keyword is being used to execute a paragraph.

```
PERFORM MY-NEW-PARAGRAPH COUNTER TIMES.
```

Example 11. TIMES 2

11.4.2 PERFORM THROUGH

You may require a sequential list of paragraphs to be executed in turn, instead of performing them individually. The THROUGH or THRU keyword can be used to list the start and end paragraphs of the list. Execution will progress through each of the paragraphs as they appear in the source code, from beginning to end, before returning to the line following the initial perform statement, observe Example 12.

```
 1000-PARAGRAPH-A.
     PERFORM 2000-PARAGRAPH-B THRU
             3000-PARAGRAPH-C.
*
 2000-PARAGRAPH-B.
     ...
*
 3000-PARAGRAPH-C.
     ...
*
 4000-PARAGRAPH-D.
     ...
```

Example 12. PEFORM THRU

Note: The use of the THRU keyword can also be used alongside the TIMES, UNTIL and VARYING keywords, to allow the list of paragraphs to be executed rather than just a single paragraph or blocks of code.

11.4.3 PERFORM UNTIL

Adding the UNTIL keyword to a perform sentence allows you to iterate over a group of sentences until the Boolean condition is met. Effectively allowing you to program while loops in COBOL, take this basic example:

```
MOVE 0 TO COUNTER.
PERFORM UNTIL COUNTER = 10
 ADD 1 TO COUNTER GIVING COUNTER
 MOVE COUNTER TO MSG-TO-WRITE
 WRITE PRINT-REC
END-PERFORM.
```

Example 13. PERFORM UNTIL

This would be equivalent to the Java code:

```
while(counter != 10){
    //counter++
    //move counter to msg-to-write
    //write print-rec
}
```

Example 14. Java while loop

In this case, the Boolean condition is evaluated before the loop is executed. However, if you wish for the loop to be executed at least once before the condition is evaluated, you can alter the sentence to read:

```
 PERFORM UNTIL COUNTER = 10 WITH TEST AFTER
  ADD 1 TO COUNTER GIVING COUNTER
  MOVE COUNTER TO MSG-TO-WRITE
  WRITE PRINT-REC
 END-PERFORM.
```

Example 15. PERFORM UNTIL WITH TEST AFTER

This would be similar to a "do while" loop in Java:

```
do{
    //counter++
    //move counter to msg-to-write
    //write print-rec
}
While(counter != 10);
```

Example 16. Java while loop

11.4.4 PERFORM VARYING

We've already used the VARYING keyword earlier in the section titled Using performs to code a loop, recall:

```
PERFORM VARYING COUNTER FROM 01 BY 1 UNTIL COUNTER EQUAL 11
...
END-PERFORM.
```

Example 17. Basic loop

In this example, the variable counter is tested to see if it equals 11, as long as it doesn't then it is incremented, and the sentences nested within the perform statement are executed. This construct can be extended, exemplified in Example 18.

```
PERFORM VARYING COUNTER FROM 01 BY 1 UNTIL COUNTER EQUAL 11
     AFTER COUNTER-2 FROM 01 BY 1 UNTIL COUNTER-2 EQUAL 5
...
END-PERFORM.
```

Example 18. Extended loop

This may seem complex, but compare it to this Java pseudo-code:

```
for(int counter = 0; counter < 11; counter++){
    for(int counter2 = 0; counter2 < 5; counter2++{
       //move counter to msg-to-write
```

```
        //write print-rec
    }
}
```

Example 19. Java extended loop

This is really, just two for loops nested within each other. This construct is very useful when iterating over tables or nested record structures. As for each loop of the outer varying loop, the inner loop will be executed five times. As mentioned previously, the test of the condition will be assumed by COBOL to be at the beginning of the loop, however, it can be specified to be evaluated at the end of the loop by adding the phrase WITH TEST AFTER to the initial perform sentence.

11.5 Using subprograms

So far, we have only examined the internal structure of a single COBOL program. As programs increase in function and number, it is common that a programmer might want certain aspects of a programs function to be made available to other programs within the system. Abstracting generic functions into their own program and allowing them to be called from other programs can reduce the amount of code duplication within a system and therefore decrease the cost of maintenance, as fixes to shared modules only need to be made once.

Note: Although here we will describe the COBOL native way of calling another program, note that some middleware products will provide APIs that might do this in an enhanced way.

When calling another program, we need to consider three main concerns: how we will reference the program we wish to call, the parameters we want to send to the target program and the parameter that we wish the target program to return.

11.5.1 Specifying the target program

To call a target program we will use the keyword CALL followed by a reference to the target program we wish to call. The two main ways to do this are by a literal value or by referencing a variable, shown in Example 20.

```
CALL 'PROGA1' ...
...
MOVE 'PROGA2' TO PROGRAM-NAME.
CALL PROGRAM-NAME ...
```

Example 20. Basic CALL

It is also possible to reference the target platform by passing a pointer reference to the target program. If you thought that passing a pointer reference to a function was only something that ultra-modern languages had, nope COBOL got there first!

11.5.2 Specifying program variables

Now that we have identified the name of the program we wish to call; we must identify the variables that the calling program might want to send. These are individually specified by the USING keyword. COBOL provides support to both pass by reference and pass by copy, as well as a pass by value concept. Each of the supported passing techniques can be applied to all the data-items being passed or used selectively against different items.

By default, COBOL will pass data items by reference. This means that both the calling and target program will be able to read and write to the same area of memory that is represented by the variable. This means that if the target program updates the content of the variable, that change will be visible to the calling program once execution has returned.

The BY CONTENT phrase allows a copy of the passed variable to be passed to the target program. Although the target program can update the variable, those updates will not be visible to the calling program.

Note: When passing variables either BY REFERENCE or BY CONTENT, note you can send data items of any level. Which means you can pass entire data structures, handy for dealing with common records.

You might also see the phrase, BY VALUE, being used in a CALL sentence. BY VALUE is similar to BY CONTENT, as a copy of the content of the variable is passed. The difference is that only a subset of COBOL datatypes are supported and you can only specify elementary data-items. This is because BY VALUE is primarily used when COBOL is calling a program of another language (such as C).

11.5.3 Specifying the return value

Finally, the RETURNING phrase is used to specify the variable that should be used to store the return value. This can be any elementary data-item declared within the data-division. Note that this is optional. Some programs might not return anything, or you might have passed values BY REFERENCE to the target program in which case updates to those variables will be visible once the target program returns.

11.6 Summary

In summary, this chapter should provide the necessary foundation to understand structured programming and how it relates to COBOL and its importance to understanding and maintaining code. Many examples of how, when and why to implement key techniques have been provided and explained for further understanding. You should be able to identify the basic differences between structured programming (COBOL) and OO programming (Java). You should also understand the general concept of the best practices in the structure of the Procedure Division with reference to the design and content of paragraphs, program control options and ways to call other programs within the same system.

11.7 Lab

This lab utilizes COBOL program CBL0003, located within your id.CBL data set, as well as JCL job CBL0003J, located within your id.JCL data set. The JCL jobs are used to compile and execute the COBOL programs, as discussed in previous chapters.

11.7.0.1 Using VSCode and Zowe Explorer

1. Take a moment and look over the source code of the COBOL program provided: CBL0003.
2. Compare CBL0003 with CBL0001 and CBL0002 from the previous lab. Do you notice the differences?
   a. Observe the new COUNTER line within the WORKING-STORAGE > DATA DIVISION.
   b. Observe the paragraphs are numerated and they are all explicitly ended by a -END sentence.
   c. Observe the new paragraphs READ-FIRST-RECORD, READ-TEN-RECORDS, READ-ANOTHER-RECORD, READ-NEXT-RECORDS and CALLING-SUBPROGRAM within the PRECEDURE DIVISION.
   d. These paragraphs perform the same loop as in CBL0001, but using the PERFORM statement in different ways. The CALLING-SUBPROGRAM calls the HELLO program, already presented in the second Lab of this course.
3. Submit job: CBL0003J. This JCL first compiles the program HELLO, then compiles CBL0003 and links the result of both compilations together.
4. View CBL0003J output using the JOBS section and open RUN:PRTLINE, observe the report is identical to CBL0001.
5. View output of target program HELLO using the JOBS section and open RUN:SYSOUT.

12 File output

Designing a structured layout that is easy to read and understand is required to format output. Designing a structured layout involves column headings and variable alignment using spaces, numeric format, currency format, etc. This chapter aims to explain this concept utilizing example COBOL code to design column headings and align data names under the such headings. At the end of the chapter you are asked to complete a lab that practices implementation of the components covered.

A capability of COBOL data output formatting that is worth noting but not covered in this chapter is that COBOL is a web enabled computer language. COBOL includes easy and quick transformation of existing COBOL code to write JSON (JavaScript Object Notation) where the output is subsequently formatted for a browser, a smartphone, etc. Frequently, the critical data accessed by a smart phone, such as a bank balance, is stored and controlled by z/OS where a COBOL program is responsible for retrieving and returning the bank balance to the smart phone.

- **Review of COBOL write output process**
  - **ENVIRONMENT DIVISION**
- **FILE DESCRIPTOR**
  - **FILLER**
- **Report and column headers**
  - **HEADER-2**
- **PROCEDURE DIVISION**
  - **MOVE sentence**
  - **PRINT-REC FROM sentences**
- **Lab**

12.1 Review of COBOL write output process

This section briefly reviews certain aspects of the ENVIRONMENT DIVISION for the purpose of understanding how it ties together with the content of this chapter.

12.1.1 ENVIRONMENT DIVISION

The "File handling" section covered the SELECT and respective ASSIGN programmer chosen names, whereas this chapter focuses on output. Figure 1. shows a coding example using PRINT-LINE as the programmer chosen COBOL internal file name for output.

```
*--------------------
 ENVIRONMENT DIVISION.
*--------------------
 INPUT-OUTPUT SECTION.
 FILE-CONTROL.
     SELECT PRINT-LINE ASSIGN TO PRTLINE.
     SELECT ACCT-REC   ASSIGN TO ACCTREC.
*SELECT clause creates an internal file name
*ASSIGN clause creates a name for an external data source,
*which is associated with the JCL DDNAME used by the z/OS
*e.g. ACCTREC is linked in JCL file CBL0001J to &SYSUID..DATA
*where &SYSUID. stands for Your z/OS user id
*e.g. if Your user id is Z54321,
*the data set used for ACCTREC is Z54321.DATA
```

Figure 1. SELECT and ASSIGN

12.2 FILE DESCRIPTOR

The File Description (FD), previously described under the FILE-CONTROL paragraph section, entry represents the highest level of organization in the FILE SECTION. The FD entry describes the layout of the file defined by a previous FILE-CONTROL SELECT statement. Therefore, the FD entry connects the SELECT file name with a defined layout of the file name. An example file descriptor, FD, for PRINT-LINE is shown in Figure 2. What follows the file descriptor is a defined layout of PRINT-LINE.

12.2.1 FILLER

Observe the data name FILLER. While most data fields have unique names, FILLER is a COBOL reserved word data name, that is useful for output formatting. This is in part because FILLER allocates memory space without the need for a name. Also, FILLER allocated memory has a defined length in the output line and may contain spaces or any literal. Figure 2. shows multiple VALUE SPACES for FILLER. SPACES create white space between data-items in the output which is valuable in keeping the code readable. More specifically in Figure 2. FILLER PIC X(02) VALUE SPACES, represents the output line containing two spaces.

```
*-------------
 DATA DIVISION.
*-------------
 FILE SECTION.
 FD  PRINT-LINE RECORDING MODE F.
*FD -- describes the layout of PRINT-LINE file,
*including level numbers, variable names, data types and lengths
*
 01  PRINT-REC.
     05  ACCT-NO-O      PIC X(8).
     05  FILLER         PIC X(02) VALUE SPACES.
*    FILLER -- COBOL reserved word used as data name to remove
*    the need of variable names only for inserting spaces
*
     05  LAST-NAME-O    PIC X(20).
     05  FILLER         PIC X(02) VALUE SPACES.
*    SPACES -- used for structured spacing data outputs rather
*    than using a higher PIC Clause length as in CBL0001.cobol,
*    which makes a good design practice and a legible output
*
 01 WS-CURRENT-DATE-DATA.
     05  ACCT-LIMIT-O   PIC $$,$$$,$$9.99.
*    The repeated $ characters revert to spaces and then one $
*    in front of the printed amount.
*
     05  FILLER         PIC X(02) VALUE SPACES.
     05  ACCT-BALANCE-O PIC $$,$$$,$$9.99.
     05  FILLER         PIC X(02) VALUE SPACES.
```

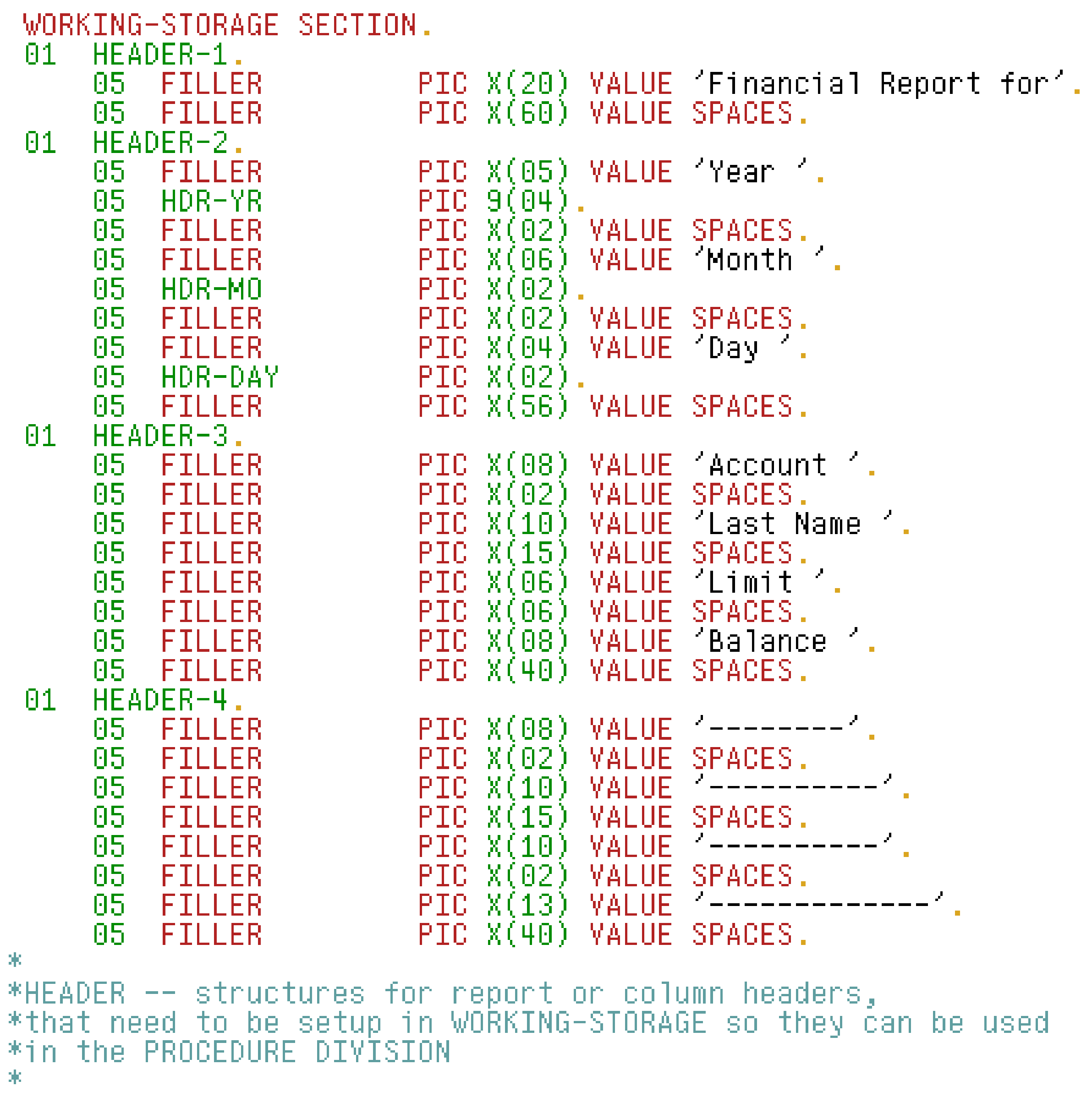
Figure 2. FILLER

12.3 Report and column headers

Writing report or column headers requires a structured output layout designed by the programmer. Figure 3. illustrates such a structure. The designed output structure layout is implemented within the DATA

DIVISION and includes the headers listed and defined below.

- **HEADER-1:**
  - Writes a literal
  - Example: ‘Financial Report for’
- **HEADER-2:**
  - Writes literals
  - Examples:
    - ‘Year’ followed by a variable name
    - ‘Month’ followed by a variable name
    - ‘Day’ followed by a variable name
- **HEADER-3:**
  - Writes literals
  - Examples:
    - ‘Account’ followed by FILLER spacing
    - ‘Last Name’ followed by FILLER spacing
    - ‘Limit’ followed by FILLER spacing
    - ‘Balance; followed by FILLER spacing
- **HEADER-4:**
  - Writes dashes followed by FILLER spacing



```
 WORKING-STORAGE SECTION.
 01  HEADER-1.
     05  FILLER         PIC X(20) VALUE 'Financial Report for'.
     05  FILLER         PIC X(60) VALUE SPACES.
 01  HEADER-2.
     05  FILLER         PIC X(05) VALUE 'Year '.
     05  HDR-YR         PIC 9(04).
     05  FILLER         PIC X(02) VALUE SPACES.
     05  FILLER         PIC X(06) VALUE 'Month '.
     05  HDR-MO         PIC X(02).
     05  FILLER         PIC X(02) VALUE SPACES.
     05  FILLER         PIC X(04) VALUE 'Day '.
     05  HDR-DAY        PIC X(02).
     05  FILLER         PIC X(56) VALUE SPACES.
 01  HEADER-3.
     05  FILLER         PIC X(08) VALUE 'Account '.
     05  FILLER         PIC X(02) VALUE SPACES.
     05  FILLER         PIC X(10) VALUE 'Last Name '.
     05  FILLER         PIC X(15) VALUE SPACES.
     05  FILLER         PIC X(06) VALUE 'Limit '.
     05  FILLER         PIC X(06) VALUE SPACES.
     05  FILLER         PIC X(08) VALUE 'Balance '.
     05  FILLER         PIC X(40) VALUE SPACES.
 01  HEADER-4.
     05  FILLER         PIC X(08) VALUE '--------'.
     05  FILLER         PIC X(02) VALUE SPACES.
     05  FILLER         PIC X(10) VALUE '----------'.
     05  FILLER         PIC X(15) VALUE SPACES.
     05  FILLER         PIC X(10) VALUE '----------'.
     05  FILLER         PIC X(02) VALUE SPACES.
     05  FILLER         PIC X(13) VALUE '-------------'.
     05  FILLER         PIC X(40) VALUE SPACES.
*
*HEADER -- structures for report or column headers,
*that need to be setup in WORKING-STORAGE so they can be used
*in the PROCEDURE DIVISION
*
```

Figure 3. Designed output structure layout

12.3.1 HEADER-2

HEADER-2 includes the year, month, day of the report together with FILLER area, creating blank spaces between the year, month, and day, as you can see in Figure 3. Figure 4. is an example of the data name layout used to store the values of CURRENT-DATE. The information COBOL provides in CURRENT-DATE is used to populate the output file in HEADER-2.

```
 01 WS-CURRENT-DATE-DATA.
     05  WS-CURRENT-DATE.
         10  WS-CURRENT-YEAR         PIC 9(04).
         10  WS-CURRENT-MONTH        PIC 9(02).
         10  WS-CURRENT-DAY          PIC 9(02).
     05  WS-CURRENT-TIME.
         10  WS-CURRENT-HOURS        PIC 9(02).
         10  WS-CURRENT-MINUTE       PIC 9(02).
         10  WS-CURRENT-SECOND       PIC 9(02).
         10  WS-CURRENT-MILLISECONDS PIC 9(02).
*    This data layout is organized according to the ouput
*    format of the FUNCTION CURRENT-DATE.
*
```

Figure 4. CURRENT-DATE intrinsic function

12.4 PROCEDURE DIVISION

Figures 1 through 4 are a designed data layout that includes a data line and report headers. Using the storage mapped by the data line and report headers, COBOL processing logic can write the headers followed by each data line. Figure 5. is an example of an execution logic resulting used to write the header layout structure in a COBOL program.

```
 WRITE-HEADERS.
     MOVE FUNCTION CURRENT-DATE TO WS-CURRENT-DATE-DATA.
*        The CURRENT-DATE function returns an alphanumeric value
*        that represents the calendar date and time of day
*        provided by the system on which the function is
*        evaluated.
     MOVE WS-CURRENT-YEAR  TO HDR-YR.
     MOVE WS-CURRENT-MONTH TO HDR-MO.
     MOVE WS-CURRENT-DAY   TO HDR-DAY.
     WRITE PRINT-REC FROM HEADER-1.
     WRITE PRINT-REC FROM HEADER-2.
     MOVE SPACES TO PRINT-REC.
     WRITE PRINT-REC AFTER ADVANCING 1 LINES.
     WRITE PRINT-REC FROM HEADER-3.
     WRITE PRINT-REC FROM HEADER-4.
     MOVE SPACES TO PRINT-REC.
```

Figure 5. Execution logic to write header layout structure

12.4.1 MOVE sentences

The COBOL MOVE sentence, on line 1, in the WRITE-HEADERS paragraph is collecting the current date information from the system and storing that information in a defined data name layout, WS-CURRENT-DATE-DATA. The use of the reserved word FUNCTION means whatever follows is a COBOL intrinsic function. The sentences on lines 2, 3, and 4 are storing the date information, year, month and day, in HEADER-2 defined data name areas, HDR-YR, HDR-MO and HDR-DAY. The sentence on line 11, the final sentence in the paragraph, writes spaces into the PRINT-REC area to clear out the line storage in preparation for writing the data lines.

12.4.2 PRINT-REC FROM sentences

PRINT-REC is opened for output resulting in PRINT-REC FROM following through with a write PRINT-REC FROM a different header or defined data name layout. The sentences on lines 5 and 6 write the

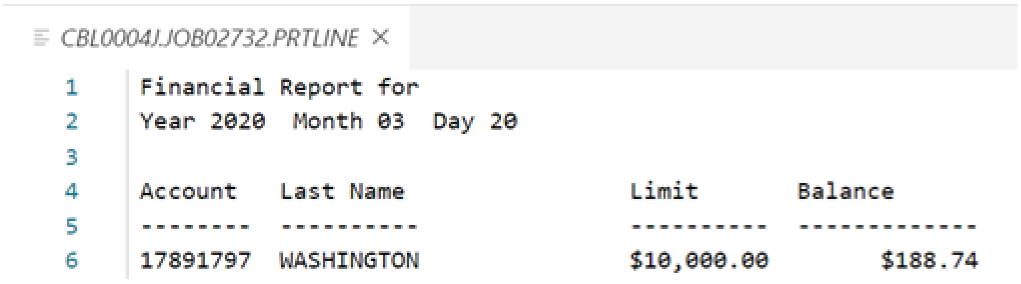
PRINT-REC FROM defined header data names, HEADER-1 and HEADER-2, from Figure 3. The PRINT-REC file descriptor data names in Figure 2. are effectively replaced with the content of the header data names in Figure 3. written to output. The sentences on lines 7 and 8 result in a blank line written between headers. The sentences on lines 9 and 10 write the PRINT-REC FROM defined HEADER-3 and HEADER-4 data names from Figure 3. The PRINT-REC file descriptor data names in Figure 2. are effectively replaced with the content of the header data names in Figure 3.

12.5 Lab

This lab utilizes two COBOL programs, CBL0004 and CBL0005, located within your id.CBL data set, as well as two JCL jobs, CBL0004J and CBL0005J, located within your id.JCL data set. The JCL jobs are used to compile and execute the COBOL programs, as discussed in previous chapters.

12.5.0.1 Using VSCode and Zowe Explorer

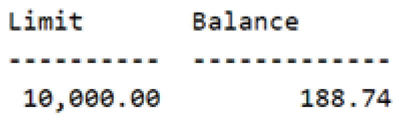
1. Submit job: CBL0004J
2. Observe the report written with headers like Figure 6. below.



```
Financial Report for
Year 2020  Month 03  Day 20

Account   Last Name                 Limit      Balance
--------  ----------                ----------  -------------
17891797  WASHINGTON                $10,000.00        $188.74
```

Figure 6. Report with headers

3. Submit job: CBL0005J
4. Observe the report data lines are written without dollar currency symbol, illustrated in Figure 7.



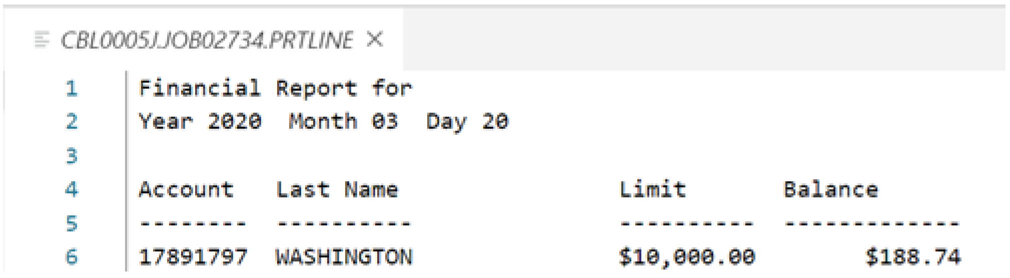
```
Limit        Balance
----------  -------------
 10,000.00         188.74
```

Figure 7. No currency symbol in output

5. Modify id.CBL(CBL0005) to include the dollar currency symbol in the report.

   Hint: Compare with CBL0004 line 25

6. Re-submit job: CBL0005J
7. Observe the report data lines should now include the dollar currency symbol.



```
Financial Report for
Year 2020  Month 03  Day 20

Account   Last Name                 Limit      Balance
--------  ----------                ----------  -------------
17891797  WASHINGTON                $10,000.00        $188.74
```

Figure 8. Currency symbol added to output

13 Conditional expressions

This chapter dives into how programs make decisions based upon the programmer written logic. Specifically, programs make these decisions within the PROCEDURE DIVISION of the source code. We will expand on several topics regarding conditional expressions written in COBOL through useful explanations, examples and eventually practicing implementation through a lab.

- **Boolean logic, operators, operands, and identifiers**
  - **COBOL conditional expressions and operators**
  - **Examples of conditional expressions using Boolean operators**
- **Conditional expression reserved words and terminology**
  - **IF, EVALUATE, PERFORM and SEARCH**
  - **Conditional states**
  - **Conditional names**
- **Conditional operators**
- **Conditional expressions**
  - **IF ELSE (THEN) statements**
  - **EVALUATE statements**
  - **PERFORM statements**
  - **SEARCH statements**
- **Conditions**
  - **Relation conditions**
  - **Class conditions**
  - **Sign conditions**
- **Lab**

13.1 Boolean logic, operators, operands, and identifiers

Programs make decisions based upon the programmer written logic. Program decisions are made using Boolean logic where a conditional expression is either true or false, yes or no. A simple example would be a variable named 'LANGUAGE'. Many programming languages exist; therefore, the value of variable LANGUAGE could be Java, COBOL, etc... Assume the value of LANGUAGE is COBOL. Boolean logic is, IF LANGUAGE = COBOL, THEN DISPLAY COBOL, ELSE DISPLAY NOT COBOL. IF triggers the Boolean logic to determine the condition of true/false, yes/no, applied to LANGUAGE = COBOL which is the conditional expression. The result of IF condition executes what follows THEN when the condition is true and executes what follows ELSE when the condition is false.

The Boolean IF verb operates on two operands or identifiers. In the example above, LANGUAGE is an operand and COBOL is an operand. A Boolean relational operator compares the values of each operand.

13.1.1 COBOL conditional expressions and operators

Three of the most common type of COBOL conditional expressions are:

1. General relation condition
2. Class condition
3. Sign condition

A list of COBOL Boolean relational operators for each of the common type of COBOL conditional expressions are represented in Figures 1, 2 and 3 below.

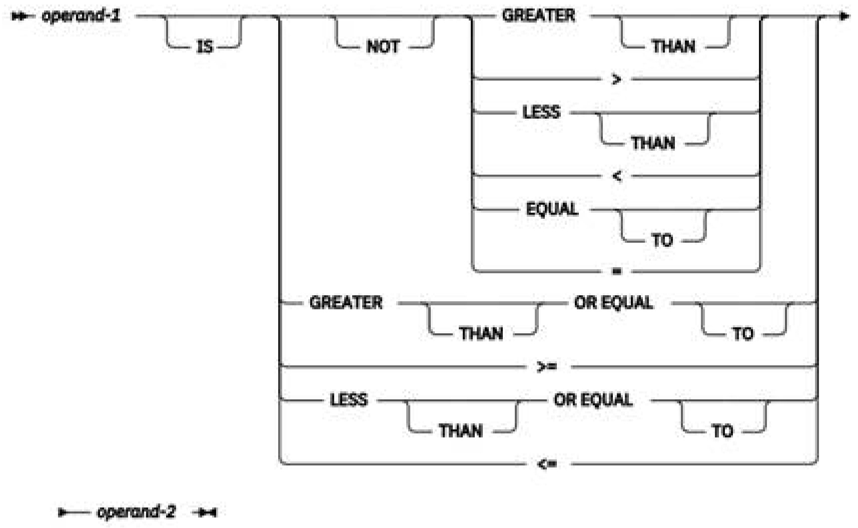


Figure 1. General relation condition operators

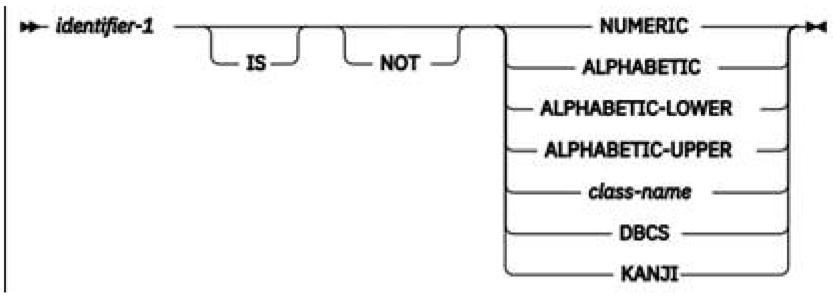


Figure 2. Class condition operators

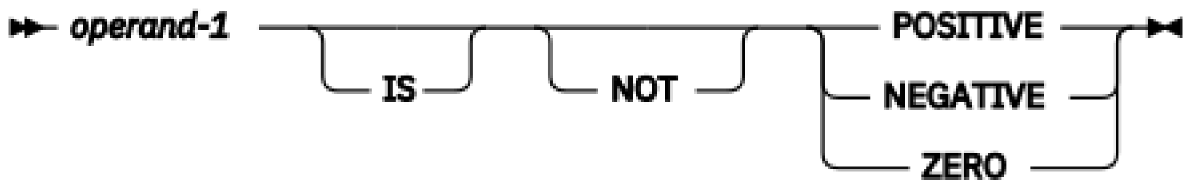


Figure 3. Sign condition operators

13.1.2 Examples of conditional expressions using Boolean operators

A simple conditional expression can be written as:

```
IF 5 > 1 THEN DISPLAY '5 is greater than 1' ELSE DISPLAY '1 is greater than 5'.
```

Compounded conditional expressions are enclosed in parenthesis and their Boolean operators are:

```
AND
```

```
OR
```

The code snippet below demonstrates a compounded conditional expression using the AND Boolean operator.

```
IF (5 > 1 AND 1 > 2)THEN .... ELSE ....
```

This conditional expression evaluates to false because while 5 > 1 is true, 1 > 2 is false. The AND operation requires both expressions to be true to return true for the compounded condition expression. Let's show another implementation, this time using the OR Boolean operator.

```
IF (5 > 1 OR 1 > 2)THEN .... ELSE ....
```

This conditional expression evaluates to true because while 1 > 2 is false, 5 > 1 is true. The OR operation requires only one of the expressions to be true to return true for the entire compounded condition expression. More conditional operators used for relation, class, and sign conditions are discussed further on in the chapter.

13.2 Conditional expression reserved words and terminology

Thus far in this book, we have touched upon the necessity and use of COBOL reserved words. This section aims to expand on the topic of reserved words, specifically ones that are used when processing conditional expressions.

13.2.1 IF, EVALUATE, PERFORM and SEARCH

These are COBOL reserved words available for the processing of conditional expressions, where a condition is a state that can be set or changed.

13.2.2 Conditional states

TRUE and FALSE are among the most common conditional states.

13.2.3 Conditional names

A conditional-name is a programmer defined variable name with the TRUE condition state. Conditional names are declared in the WORKING STORAGE SECTION with an 88-level number. The purpose of 88-level is to improve readability by simplifying IF and PERFORM UNTIL statements.

The 88-level conditional data-name is assigned a value at compile time. The program cannot change the 88-level data-name during program execution. However, the program can change the data name value in the level number above the 88-level conditional data-name. 01-level USA-STATE in Example 1. can be changed. A program expression referencing the 88-level data-name is only true when the current value of the preceding level data name, USA-STATE, is equal to the WORKING-STORAGE 88-level conditional data-name assigned value.

Observe in Example 1. 'The State is not Texas' is written as a result of the first IF STATE because the value of USA-STATE is AZ which is not equal to the 88-level conditional data-name, TX. The second IF STATE writes, 'The State is Texas' because the value of USA-STATE is equal to the assigned 88-level value of TX.

```
WORKING-STORAGE.
01 USA-STATE     PIC X(2) VALUE SPACES.
   88 STATE      VALUE 'TX'.
....
....
PROCEDURE DIVISION.
....
....
MOVE 'AZ' TO USA-STATE.
....
....
IF STATE DISPLAY 'The State is Texas'
   ELSE DISPLAY  'The State is not Texas'
END-IF.
....
....
```

```
MOVE 'TX' TO USA-STATE.
....
....
IF STATE DISPLAY 'The State is Texas'
   ELSE DISPLAY  'The State is not Texas'
END-IF.
```

Example 1. Using 88-level conditional name

Numerous 88-level conditional data-names can follow an 01-level data-name. As a result an IF reference to 01-level data-name expression can have numerous values that would return true.

Other level number data-names require the condition expression to include a Boolean operator as shown in Example 2. , where a value can be stored in the 05-level STATE data name to be compared with some other stored value. Therefore, a little bit of extra coding is needed.

```
WORKING-STORAGE.
01 USA-STATE.
   05 STATE      PIC X(2) VALUE SPACES.
....
....
PROCEDURE DIVISION.
....
....
MOVE 'AZ' TO STATE.
....
....
IF STATE = 'TX' DISPLAY 'The State is Texas'
   ELSE DISPLAY  'The State is not Texas'
END-IF.
....
....
MOVE 'TX' TO STATE.
....
....
IF STATE = 'TX' DISPLAY 'The State is Texas'
   ELSE DISPLAY  'The State is not Texas'
END-IF.
```

Example 2. Without 88-level conditional name

13.3 Conditional operators

Relational operators compare numeric, character string, or logical data. The result of the comparison, either true (1) or false (0), can be used to make a decision regarding program flow. Table 1 displays a list of relational operators, how they can be written and their meaning.

Relational operator	Can be written	Meaning
IS GREATER THAN	IS >	Greater than
IS NOT GREATER THAN	IS NOT >	Not greater than
IS LESS THAN	IS <	Less than
IS NOT LESS THAN	IS NOT <	Not less than
IS EQUAL TO	IS =	Equal to
IS NOT EQUAL TO	IS NOT =	Not equal to
IS GREATER THAN OR EQUAL TO	IS >=	Is greater than or equal to

Relational operator	Can be written	Meaning
IS LESS THAN OR EQUAL TO	IS <=	Is less than or equal to

Table 1. Relational operator

13.4 Conditional expressions

A conditional expression causes the object program to select alternative paths of control, depending on the truth value of a test. Conditional expressions are specified in EVALUATE, IF, PERFORM, and SEARCH statements.

13.4.1 IF ELSE (THEN) statements

IF statements are used to implement or evaluate relational operations. IF ELSE is used to code a choice between two processing actions and inclusion of the word THEN is optional. When an IF statement is present, the statements following the IF statement are processed based on the truth of the conditional expression. Statements are processed until an END-IF or an ELSE statement is encountered. The ELSE statement can appear on any line before the END-IF. IF statements, regardless of the number of lines, are explicitly terminated using END-IF.

Consider this, during program processing something occurs to change the value in the data-name, FACIAL-EXP. Subsequent statements, the conditional expression, needs to check the value of the data-name to decide on how to proceed in the program. Exemplified in Example 3. by the THEN DISPLAY and ELSE DISPLAY statements.

```
IF FACIAL-EXP = 'HAPPY' THEN
   DISPLAY 'I am glad you are happy'
ELSE DISPLAY 'What can I do to make you happy'
END-IF.
```

Example 3. IF, THEN, ELSE, END-IF statement

13.4.2 EVALUATE statements

EVALUATE statements are used to code a choice among three or more possible actions. The explicit terminator for an EVALUATE statement is END-EVALUATE. The EVALUATE statement is an expanded form of the IF statement that allows you to avoid nesting IF statements, a common source of logic errors and debugging issues. EVALUATE operates on both text string values and numerical variables. Using the FACIAL-EXP conditional-name, observe the COBOL code implementing an EVALUATE statement, shown in Example 4.

```
EVALUATE FACIAL-EXP
 WHEN 'HAPPY'
  DISPLAY 'I am glad you are happy'
 WHEN 'SAD'
  DISPLAY 'What can I do to make you happy'
 WHEN 'PERPLEXED'
  DISPLAY 'Can you tell me what you are confused about'
 WHEN 'EMOTIONLESS'
  DISPLAY 'Do you approve or disapprove'
END-EVALUATE
```

Example 4. EVALUATE statement

13.4.3 PERFORM statements

A PERFORM with UNTIL phrase is a conditional expression. In the UNTIL phrase format, the procedures referred to are performed until the condition specified by the UNTIL phrase evaluates to true. Using the FACIAL-EXP conditional-name, the SAY-SOMETHING-DIFFERENT paragraph is executed continuously UNTIL FACIAL-EXP contains 'HAPPY', observe Example 5.

```
PERFORM SAY-SOMETHING-DIFFERENT BY FACIAL-EXP UNTIL 'HAPPY'
END-PERFORM.
```

Example 5. PERFORM statement

13.4.4 SEARCH statements

The SEARCH statement searches a table for an element that satisfies the specified condition and adjusts the associated index to indicate that element. Tables, effectively an array of values, are created with an OCCURS clause applied to WORK-STORAGE data-names. A WHEN clause is utilized in SEARCH statements to verify if the element searched for satisfies the specified condition. Assuming FACIAL-EXP has many possible values, then SEARCH WHEN is an alternative conditional expression, observe Example 6.

```
SEARCH FACIAL-EXP
WHEN 'HAPPY' STOP RUN
END-SEARCH
```

Example 6. SEARCH WHEN statement

13.5 Conditions

A conditional expression can be specified in either simple conditions or complex conditions. Both simple and complex conditions can be enclosed within any number of paired parentheses; the parentheses, however, do not change whether the condition is simple or complex. This section will cover three of the five simple conditions:

- Relation
- Class
- Sign

13.5.1 Relation conditions

A relation condition specifies the comparison of two operands. The relational operator that joins the two operands specifies the type of comparison. The relation condition is true if the specified relation exists between the two operands; the relation condition is false if the specified relation does not exist. Provided, is a list of a few defined comparisons:

- Numeric comparisons - Two operands of class numeric
- Alphanumeric comparisons - Two operands of class alphanumeric
- DBCS (Double Byte Character Set) comparisons - Two operands of class DBCS
- National comparisons - Two operands of class national

13.5.2 Class conditions

The class condition determines whether the content of a data item is alphabetic, alphabetic-lower, alphabetic-upper, numeric, DBCS, KANJI, or contains only the characters in the set of characters specified by the CLASS clause, as defined in the SPECIAL-NAMES paragraph of the environment division. Provided below is a list of a few valid forms on the class condition for different types of data items.

- Numeric
  - IS NUMERIC or IS NOT NUMERIC
- Alphabetic
  - IS ALPHABETIC or IS NOT ALPHABETIC
  - IS ALPHABETIC-LOWER / ALPHABETIC-UPPER
  - IS NOT ALPHABETIC-LOWER / ALPHABETIC-UPPER
- DBCS
  - IS DBCS or IS NOT DBCS
  - IS KANJI or IS NOT KANJI

13.5.3 Sign conditions

The sign condition determines whether the algebraic value of a numeric operand is greater than, less than, or equal to zero. An unsigned operand is either POSITIVE or ZERO. When a numeric conditional variable is defined with a sign, the following are available:

- IS POSITIVE
- IS NEGATIVE
- IS ZERO

Note : To read more information about these conditions please visit the link:

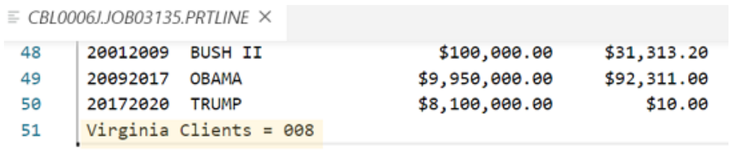
IBM Knowledge Center - Enterprise COBOL for z/OS 4.2.0

13.6 Lab

This lab requires two COBOL programs, CBL0006 and CBL0007 and two respective JCL Jobs, CBL0006J and CBL0007J, to compile and execute the COBOL programs. All of which are provided to you in your VSCode - Zowe Explorer.

13.6.0.1 Using VSCode and Zowe Explorer:

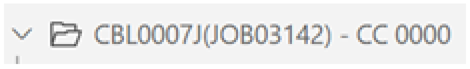
1. Take a moment and look over the source code of the two COBOL programs provided: CBL0006 and CBL0007.
2. Compare CBL0006 with CBL0005 from the previous lab. Do you notice the differences?
   a. Observe the new CLIENTS-PER-STATE line within the WORKING-STORAGE > PROCEDURE DIVISION.
   b. Observe the new paragraph IS-STATE-VIRGINIA within that same division.
   c. This paragraph checks whether the client is from Virginia. If that condition is met (true) then the program should add 1 to the clients from Virginia total.
   d. Program writes "Virginia Clients = ", in last line of report.
3. Submit CBL0006J
4. View the job output from the JOBS section and verify the steps mentioned above were executed.



```
20012009  BUSH II                $100,000.00     $31,313.20
20092017  OBAMA                $9,950,000.00     $92,311.00
20172020  TRUMP                $8,100,000.00         $10.00
Virginia Clients = 008
```

Figure 4. Id.JCL(CBL0006J) output

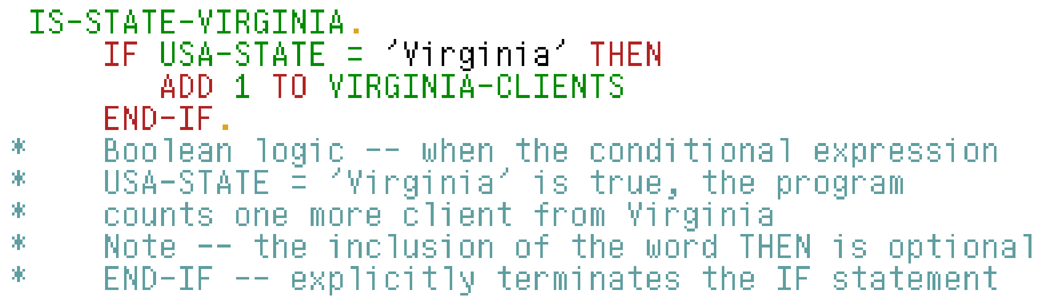
5. Submit CBL0007J
6. Find the compile error, IGYPS2113-E, in the job output.
7. Go ahead and modify id.CBL(CBL0007) to correct the syntax error outlined by the IGYPS2113-E message.*
8. Re-submit CBL0007J
9. Validate that the syntax error was corrected by getting an error free output file.



```
CBL0007J(JOB03142) - CC 0000
```

Figure 5. Successful compile

Lab Hints



```
  IS-STATE-VIRGINIA.
      IF USA-STATE = 'Virginia' THEN
         ADD 1 TO VIRGINIA-CLIENTS
      END-IF.
 *    Boolean logic -- when the conditional expression
 *    USA-STATE = 'Virginia' is true, the program
 *    counts one more client from Virginia
 *    Note -- the inclusion of the word THEN is optional
 *    END-IF -- explicitly terminates the IF statement
```

14 Arithmetic expressions

This chapter aims to introduce the concept of implementing arithmetic expressions in COBOL programs. We will review the basic concept of arithmetic expressions, operators, statements, limitations, statement operands, as well as precedence of operation within the expressions. You will be able to follow along with a comprehensive example exhibiting the usage of arithmetic expressions in a COBOL program that you have seen in previous chapters and labs. Following the chapter is a lab to practice the implementation of what you have learned.

14.1 What is an arithmetic expression?

Arithmetic expressions are used as operands of certain conditional and arithmetic statements. An arithmetic expression can consist of any of the following items:

1. An identifier described as a numeric elementary item (including numeric functions).
2. A numeric literal.
3. The figurative constant ZERO.
4. Identifiers and literals, as defined in items 1, 2, and 3, separated by arithmetic operators.
5. Two arithmetic expressions, as defined in items 1, 2, 3, or 4, separated by an arithmetic operator.
6. An arithmetic expression, as defined in items 1, 2, 3, 4, or 5, enclosed in parentheses.
7. Any arithmetic expression can be preceded by a unary operator.

Identifiers and literals that appear in arithmetic expressions must represent either numeric elementary items or numeric literals on which arithmetic can be performed. If the value of an expression to be raised to a power is zero, the exponent must have a value greater than zero. Otherwise, the size error condition exists. In any case where no real number exists as the result of an evaluation, the size error condition exists.

14.1.1 Arithmetic operators

Five binary arithmetic operators and two unary arithmetic operators can be used in arithmetic expressions. These operators are represented by specific characters that must be preceded and followed by a space. However, no space is required between a left parenthesis and unary operator. These binary and unary arithmetic operators are listed in Table 1.

Binary operator	Meaning	Unary operator	Meaning
+	Addition	+	Multiplication by +1

Binary operator	Meaning	Unary operator	Meaning
-	Subtraction	-	Multiplication by -1
	Multiplication		
/	Division		
	Exponentiation		

Table 1. Arithmetic operators

14.1.2 Arithmetic statements

Arithmetic statements are utilized for computations. Individual operations are specified by the ADD, SUBTRACT, MULTIPLY, and DIVIDE statements. These individual operations can be combined symbolically in a formula that uses the COMPUTE statement for ease of programming and performance. The COMPUTE statement assigns the value of an arithmetic expression to one or more data items. With the COMPUTE statement, arithmetic operations can be combined without the restrictions on receiving data items imposed by the rules for the ADD, SUBTRACT, MULTIPLY, and DIVIDE statements. When arithmetic operations are combined, the COMPUTE statement can be more efficient than the separate arithmetic statements written in a series. For these reasons, it is best practice to use the `COMPUTE` statement for most arithmetic evaluations rather than `ADD` , `SUBTRACT` , `MULTIPLY` , and `DIVIDE` statements. Often, you can code only one `COMPUTE` statement instead of several individual arithmetic statements. The `COMPUTE` statement assigns the result of an arithmetic expression to one or more data items, for example:

```
COMPUTE z = a + b / c \*\* d - e
```

```
COMPUTE x y z = a + b / c \*\* d - e
```

Some arithmetic calculations might be more intuitive using arithmetic statements other than `COMPUTE` . You might also prefer to use the `DIVIDE` statement (with its `REMAINDER` phrase) for division in which you want to process a remainder. The `REM` intrinsic function also provides the ability to process a remainder.

14.2 Arithmetic expression precedence rules

Order of operation rules have been hammered into your head throughout the years of learning mathematics, remember the classic PEMDAS (parentheses, exponents, multiply, divide, add, subtract)? Arithmetic expressions in COBOL are not exempt from these rules and often use parentheses to specify the order in which elements are to be evaluated.

14.2.1 Parentheses

Parentheses are used to denote modifications to normal order of operations (precedence rules). An arithmetic expression within the parentheses is evaluated first and result is used in the rest of the expression. When expressions are contained within nested parentheses, evaluation proceeds from the least inclusive to the most inclusive set. That means you work from the inner most expression within parentheses to the outer most. The precedence for how to solve an arithmetic expression in Enterprise COBOL with parentheses is:

1. Parentheses (simplify the expression inside them)
2. Unary operator
3. Exponents
4. Multiplication and division (from left to right)
5. Addition and subtraction (from left to right)

Parentheses either eliminate ambiguities in logic where consecutive operations appear at the same hierarchic level or modify the normal hierarchic sequence of execution when necessary. When the order of consecutive operations at the same hierarchic level is not completely specified by parentheses, the order is from left to right.

An arithmetic expression can begin only with a left parenthesis, a unary operator, or an operand (that is, an identifier or a literal). It can end only with a right parenthesis or an operand. An arithmetic expression must contain at least one reference to an identifier or a literal.

There must be a one-to-one correspondence between left and right parentheses in an arithmetic expression, with each left parenthesis placed to the left of its corresponding right parenthesis. If the first operator in an arithmetic expression is a unary operator, it must be immediately preceded by a left parenthesis if that arithmetic expression immediately follows an identifier or another arithmetic expression.

14.3 Arithmetic expression limitations

Exponents in fixed-point exponential expressions cannot contain more than nine digits. The compiler will truncate any exponent with more than nine digits. In the case of truncation, the compiler will issue a diagnostic message if the exponent is a literal or constant; if the exponent is a variable or data-name, a diagnostic message is issued at run time.

Detailed explanation of fixed-point exponential expressions is an advanced topic and beyond the scope of the chapter. However, reference is made to fixed-point exponential expressions for your awareness as you advance your experience level with COBOL programming and arithmetic applied to internal data representations.

14.4 Arithmetic statement operands

The data descriptions of operands in an arithmetic statement need not be the same. Throughout the calculation, the compiler performs any necessary data conversion and decimal point alignment.

14.4.1 Size of operands

If the ARITH(COMPAT) compiler option is in effect, the maximum size of each operand is 18 decimal digits. If the ARITH(EXTEND) compiler option is in effect, the maximum size of each operand is 31 decimal digits.

The composite of operands is a hypothetical data-item resulting from aligning the operands at the decimal point and then superimposing them on one another. How to determine the composite of operands for arithmetic statements is shown in Table 2.

If the ARITH(COMPAT) compiler option is in effect, the composite of operands can be a maximum of 30 digits. If the ARITH(EXTEND) compiler option is in effect, the composite of operands can be a maximum of 31 digits.

Statement	Determination of the composite of operands
SUBTRACT, ADD	Superimposing all operands in a given statement, except those following the word GIVING.
MULTIPLY	Superimposing all receiving data-items
DIVIDE	Superimposing all receiving data items except the REMAINDER data-item
COMPUTE	Restriction does not apply

Table 2. How the composite of operands is determined

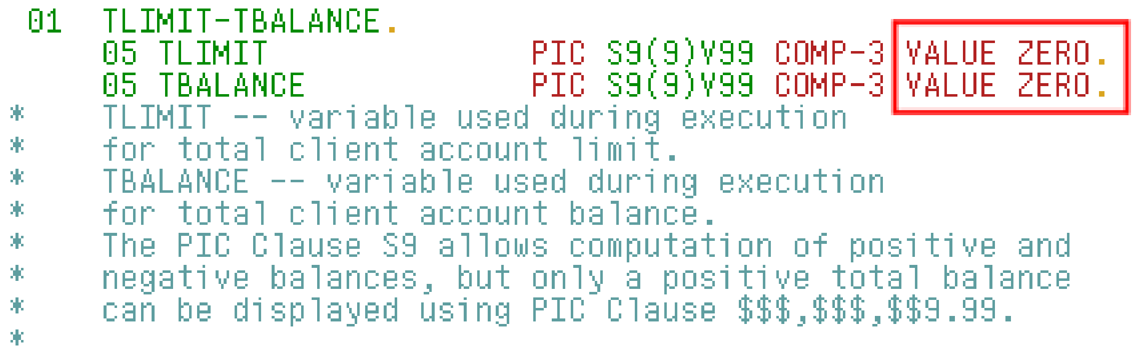
In all arithmetic statements, it is important to define data with enough digits and decimal places to ensure the required accuracy in the result. Arithmetic precision details are available in the IBM Enterprise COBOL Programming Guide Appendix A.

Additionally, in the IBM Enterprise COBOL Language Reference, Chapter 20. "PROCEDURE DIVISION Statements", includes a detailed explanation of DIVIDE and COMPUTE statement capabilities applied to

ROUNDING and ON SIZE ERROR handling.

14.5 Examples of COBOL arithmetic statements

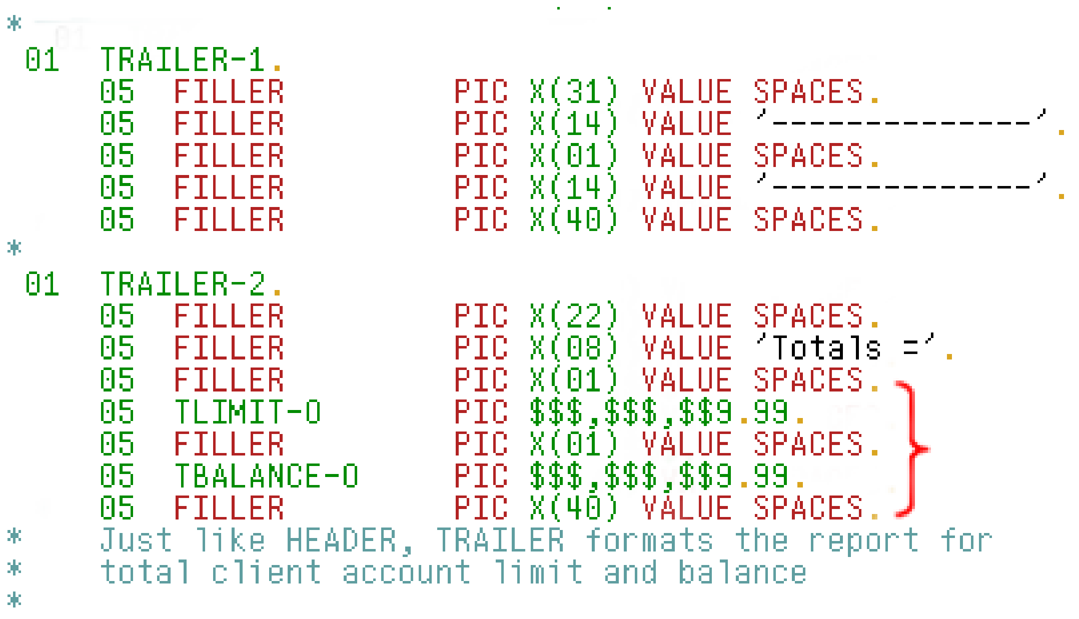
In this section, COBOL source code used in previous labs will be modified to demonstrate arithmetic processing. Figure 1. shows level number data-items in the WORKING-STORAGE section. The data-items will be used to total client account limit and client account balance. Observe that the initial value is ZERO.



```
 01  TLIMIT-TBALANCE.
     05 TLIMIT              PIC S9(9)V99 COMP-3 VALUE ZERO.
     05 TBALANCE            PIC S9(9)V99 COMP-3 VALUE ZERO.
*    TLIMIT -- variable used during execution
*    for total client account limit.
*    TBALANCE -- variable used during execution
*    for total client account balance.
*    The PIC Clause S9 allows computation of positive and
*    negative balances, but only a positive total balance
*    can be displayed using PIC Clause $$$,$$$,$$9.99.
*
```

Figure 1. Number level data-items (1)

Shown in Figure 2. is another example of number level data-items in the WORKING-STORAGE section. These data-items are report trailer lines that are used to write a formatted total account limit and total account balance for all clients in the report. Observe the TLIMIT and TBALANCE data-items with large currency number picture clauses.



```
*
 01  TRAILER-1.
     05  FILLER         PIC X(31) VALUE SPACES.
     05  FILLER         PIC X(14) VALUE '--------------'.
     05  FILLER         PIC X(01) VALUE SPACES.
     05  FILLER         PIC X(14) VALUE '--------------'.
     05  FILLER         PIC X(40) VALUE SPACES.
*
 01  TRAILER-2.
     05  FILLER         PIC X(22) VALUE SPACES.
     05  FILLER         PIC X(08) VALUE 'Totals ='.
     05  FILLER         PIC X(01) VALUE SPACES.
     05  TLIMIT-O       PIC $$$,$$$,$$9.99.
     05  FILLER         PIC X(01) VALUE SPACES.
     05  TBALANCE-O     PIC $$$,$$$,$$9.99.
     05  FILLER         PIC X(40) VALUE SPACES.
*    Just like HEADER, TRAILER formats the report for
*    total client account limit and balance
*
```

Figure 2. Number level data-items (2)

In Figure 3. the READ-NEXT-RECORD paragraph, located within the PROCEDURE DIVISION, includes a PERFORM LIMIT-BALANCE-TOTAL statement. The result of this statement is to transfer control to the LIMIT-BALANCE-TOTAL paragraph, located within the PROCEDURE DIVISION, to perform the COMPUTE statements.

```
*
 READ-NEXT-RECORD.
     PERFORM READ-RECORD
      PERFORM UNTIL LASTREC = 'Y'
      PERFORM LIMIT-BALANCE-TOTAL
      PERFORM WRITE-RECORD
      PERFORM READ-RECORD
      END-PERFORM
     .
*
```

Figure 3. READ-NEXT-RECORD.

Figure 4. is an example of two COMPUTE statements in the paragraph, LIMIT-BALANCE-TOTAL. Notice that the results of the COMPUTE statements are to add client ACCT-LIMIT to the current TLIMIT and add client ACCT-BALANCE to TBALANCE totals each time the paragraph is executed, which is one time for each client record read in our example.

```
*     The LIMIT-BALANCE-TOTAL paragraph performs an arithmetic
*     statement for each client through the loop,
*     in order to calculate the final limit and balance report.
*
 LIMIT-BALANCE-TOTAL.
     COMPUTE TLIMIT   = TLIMIT   + ACCT-LIMIT   END-COMPUTE
     COMPUTE TBALANCE = TBALANCE + ACCT-BALANCE END-COMPUTE
     .
*    The COMPUTE verb assigns the value of the arithmetic
*    expression to the TLIMIT and TBALANCE data items.
*    Since the expression only includes an addition operation,
*    the statements can also be written as:
*    ADD ACCT-LIMIT TO TLIMIT.
*    ADD ACCT-BALANCE TO TBALANCE.
*    Or, alternatively specifying the target variable:
*    ADD ACCT-LIMIT TO TLIMIT GIVING TLIMIT.
*    ADD ACCT-BALANCE TO TBALANCE GIVING TLIMIT.
*    A END-COMPUTE or END-ADD stetement is optional.
*
```

Figure 4. COMPUTE statements

The WRITE-TLIMIT-TBALANCE paragraph shown in Figure 5. is positioned within the PROCEDURE DIVISION to be executed immediately after all records are read and before the final paragraph that closes the files and terminates program execution.

```
*
 WRITE-TLIMIT-TBALANCE.
      MOVE TLIMIT   TO TLIMIT-O.
      MOVE TBALANCE TO TBALANCE-O.
      WRITE PRINT-REC FROM TRAILER-1.
      WRITE PRINT-REC FROM TRAILER-2.
*
```

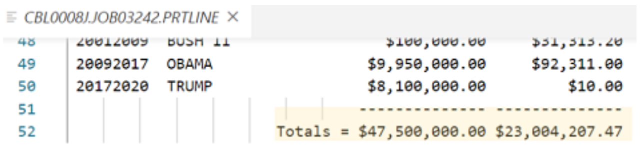
Figure 5. WRITE-TLIMIT-TBALANCE

14.6 Lab

This lab requires two COBOL programs, CBL0008 and CBL0009 and two respective JCL Jobs, CBL0008J and CBL0009J, to compile and execute the COBOL programs. All of which are provided to you in your VSCode - Zowe Explorer.

14.6.0.1 Using VSCode and Zowe Explorer

1. Take a moment and look over the source code of the two COBOL programs provided: CBL0008 and CBL0009.
2. Submit CBL0008J
3. Observe report written with trailers consisting of limit and balance totals at the bottom of the output.

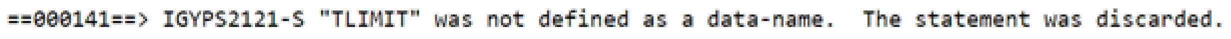


CBL0008J.JOB03242.PRTLINE

```
 20012009  BUSH II                $100,000.00     $31,313.20
 20092017  OBAMA                $9,950,000.00     $92,311.00
 20172020  TRUMP                $8,100,000.00         $10.00
                               -------------- --------------
                     Totals = $47,500,000.00 $23,004,207.47
```

Figure 6. Limit and balance totals

4. Submit CBL0009J
5. Was the job successful? If not, find the compile error message to understand why.
6. Modify id.CBL(CBL0009), correcting the compile error.*



```
==000141==> IGYPS2121-S "TLIMIT" was not defined as a data-name.  The statement was discarded.
```

Figure 7. IGYPS2121-S error message

7. Re-submit CBL0009J
8. Validate that the syntax error was corrected by getting an error free output file like in Figure 8. The correction should report written with trailers consisting of limit and balance totals, like Figure 6.

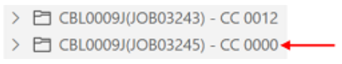
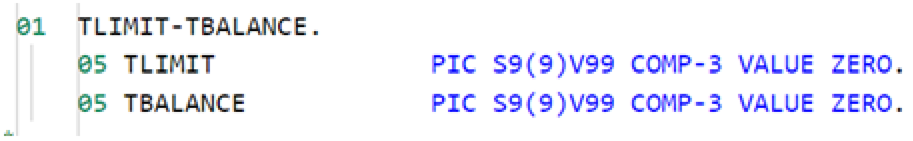


Figure 8. Successful compile

Lab Hints



```
01  TLIMIT-TBALANCE.
    05 TLIMIT             PIC S9(9)V99 COMP-3 VALUE ZERO.
    05 TBALANCE           PIC S9(9)V99 COMP-3 VALUE ZERO.
```

15 Data types

A COBOL programmer must be aware that the computer stored internal data representation and formatting can differ, where the difference must be defined in the COBOL source code. Understanding the computer's internal data representation requires familiarity with binary, hexadecimal, ASCII, and EBCDIC. Packed-Decimal is needed to explain COBOL Computational and Display data format. This chapter aims to familiarize the reader with these different "types" of data representation.

- **Data representation**
  - **Numerical value representation**
  - **Text representation**
- **COBOL DISPLAY vs COMPUTATIONAL**
- **Lab**

15.1 Data representation

Data such as numerical values and text are internally represented by zeros and ones in most computers, including mainframe computers used by enterprises. While data representation is a somewhat complex topic in computer science, a programmer does not always need to fully understand how various alternative representations work. It is important, however, to understand the differences and how to specify a specific representation when needed.

15.1.1 Numerical value representation

COBOL has five computational (numerical) value representations. The awareness of these representations is important due to two main reasons. The first reason being, when a COBOL program needs to read or write data, it needs to understand how data is represented in the dataset. The second reason is when there are specific requirements regarding the precision and range of values being processed. For additional details on binary and hexadecimal numbering systems as well as these numeric representations, consider reading the "Numerical Data Representation" chapter in the advanced topics course.

15.1.1.1 COMP-1 This is also known as a single-precision floating point number representation. Due to the floating-point nature, a COMP-1 value can be very small and close to zero, or it can be very large (about 10 to the power of 38). However, a COMP-1 value has limited precision. This means that even though a COMP-1 value can be up to 10 to the power of 38, it can only maintain about seven significant decimal digits. Any value that has more than seven significant digits are rounded. This means that a COMP-1 value cannot exactly represent a bank balance like $1,234,567.89 because this value has nine significant digits. Instead, the amount is rounded. The main application of COMP-1 is for scientific numerical value storage as well as computation.

15.1.1.2 COMP-2 This is also known as a double-precision floating point number representation. COMP-2 extends the range of value that can be represented compared to COMP-1. COMP-2 can represent values up to about 10 to the power of 307. Like COMP-1, COMP-2 values also have a limited precision. Due to the expanded format, COMP-2 has more significant digits, approximately 15 decimal digits. This means that once a value reaches certain quadrillions (with no decimal places), it can no longer be exactly represented in COMP-2.

COMP-2 supersedes COMP-1 for more precise scientific data storage as well as computation. Note that COMP-1 and COMP-2 have limited applications in financial data representation or computation.

15.1.1.3 COMP-3 This is also known as packed BCD (binary coded decimal) representation. This is, by far, the most utilized numerical value representation in COBOL programs. Packed BCD is also somewhat unique and native to mainframe computers such as the IBM z architecture.

Unlike COMP-1 or COMP-2, packed BCD has no inherent precision limitation that is independent to the range of values. This is because COMP-3 is a variable width format that depends on the actual value format. COMP-3 exactly represents values with decimal places. A COMP-3 value can have up to 31 decimal digits.

15.1.1.4 COMP-4

COMP-4 is only capable of representing integers. Compared to COMP-1 and COMP-2, COMP-4 can store and compute with integer values exactly (unless a division is involved). Although COMP-3 can also be used to represent integer values, COMP-4 is more compact.

15.1.1.5 COMP-5

COMP-5 is based on COMP-4, but with the flexibility of specifying the position of a decimal point. COMP-5 has the space efficiency of COMP-4, and the exactness of COMP-3. Unlike COMP-3, however, a COMP-5 value cannot exceed 18 decimal digits..

15.1.2 Text representation

COBOL programs often need to represent text data such as names and addresses.

15.1.2.1 EBCDIC

Extended Binary Coded Decimal Interchange Code (EBCDIC) is an eight binary digits character encoding standard, where the eight digital positions are divided into two pieces. EBCDIC was devised in the early 1960's for IBM computers. EBCDIC is used to encode text data so that text can be printed or displayed correctly on devices that also understand EBCDIC.

15.1.2.2 ASCII

American Standard Code for Information Interchange, ASCII, is another binary digit character encoding standard.

15.1.2.3 EBCDIC vs ASCII

Why are these two standards when they seemingly perform the same function?

EBCDIC is a standard that traces its root to punch cards designed in 1931. ASCII, on the other hand, is a standard that was created, unrelated to IBM punch cards, in 1967. A COBOL program natively understands EBCDIC, and it can comfortably process data originally captured in punch cards as early as 1931.

ASCII is mostly utilized by non-IBM computers.

COBOL can encode and process text data in EBCDIC or ASCII. This means a COBOL program can simultaneously process data captured in a census many decades ago while exporting data to a cloud service utilizing ASCII or Unicode. It is important to point out, however, that the programmer must have the awareness and choose the appropriate encoding.

15.2 COBOL DISPLAY vs COMPUTATIONAL

Enterprise COBOL for z/OS by default utilizes EBCDIC encoding. However, it is possible to read and write ASCII in z/OS. The EBCDIC format representation of alphabetic characters is in a DISPLAY format. Zoned decimal for numbers, without the sign, is in a DISPLAY format. Packed decimal, binary and floating point are NOT in a DISPLAY format. COBOL can describe packed decimal, binary and floating point fields using COMPUTATIONAL, COMP-1, COMP-2, COMP-3, COMP-4, and COMP-5 reserved words.

15.3 Lab

Many of the previous COBOL lab programs you have worked with thus far are reading records containing two packed decimal fields, the client account limit and the client account balance. In the Arithmetic expressions lab, the total of all client account limits and balances used a COMPUTE statement, where the COMP-3 fields contained the packed decimal internal data.

What happens when an internal packed decimal field is not described using COMP-3? Without using COMP-3 to describe the field, the COBOL program treats the data as DISPLAY data (EBCDIC format). This lab demonstrates what happens during program execution without using COMP-3.

15.3.0.1 Using VSCode and Zowe Explorer

1. Submit the job, id.JCL(CBL0010J)
2. Observe that the compile of the COBOL source was successful, however, also observe that the execution of the job failed. How can you tell?

   There's no CC code next to CBL0010J(JOB#), instead there is an ABENDU4038 message. U4038 is a common user code error typically involving a mismatch between the external data and the COBOL representation of the data.
3. Read the execution SYSOUT message carefully. The SYSOUT message mistakenly believes the records are 174 characters in length while the program believes the records are 170 characters in length.

   Explanation: Packed decimal (COMP-3) expands into two numbers where only one number would typically exist. If the program reads a packed decimal field without describing the field as COMP-3, then program execution becomes confused about the size of the record because the PIC clause, S9(7)V99, is expecting to store seven numbers plus a sign digit when only three word positions are read. Therefore, execution reports a four-record length position discrepancy.
4. Edit id.CBL(CBL0010) to identify and correct the source code problem.*
5. Submit id.JCL(CBL0010J) and verify correction is successful with a CC 0000 code.

Lab Hints:

The ACCT-LIMIT PIC clause in the ACCT-FIELDS paragraph should be the same as the PIC clause for ACCT-BALANCE.

16 Intrinsic functions

Today's COBOL is not your parents COBOL. Today's COBOL includes decades of feature/function rich advancements and performance improvements. Decades of industry specifications are applied to COBOL to address the growing needs of businesses. What Enterprise COBOL for z/OS promised and delivered, is decades of upward compatibility with new releases of hardware and operating system software. The original DNA of COBOL evolved into a powerful, maintainable, trusted, and time-tested computer language with no end in sight.

Among the new COBOL capabilities is JSON GENERATE and JSON PARSE, providing an easy to use coding mechanism to transform DATA DIVISION defined data-items into JSON for a browser, a smart phone, or any IoT (Internet of Things) device to format in addition to transforming JSON received from a browser, a smart phone, or any IoT device into DATA DIVISION defined data-items for processing. Frequently, the critical data accessed by a smart phone, such as a bank balance, is stored and controlled by z/OS where a COBOL program is responsible for retrieving and returning the bank balance to the smart phone. COBOL has become a web enabled computer language.

Previous COBOL industry specifications included intrinsic functions, which remain largely relevant today. An experienced COBOL programmer needs to be familiar with intrinsic functions and stay aware of any new intrinsic functions introduced. This chapter aims to cover the foundation of intrinsic functions and their usage in COBOL.

- **What is an intrinsic function?**
  - **Intrinsic function syntax**
  - **Categories of intrinsic functions**
- **Intrinsic functions in Enterprise COBOL for z/OS V6.3**
  - **Mathematical example**
  - **Statistical example**
  - **Date/time example**
  - **Financial example**
  - **Character-handling example**
- **Use of intrinsic functions with reference modifiers**
- **Lab**

16.1 What is an intrinsic function?

Intrinsic functions are effectively re-usable code with simple syntax implementation and are another powerful COBOL capability. Intrinsic functions enable desired logic processing with a single line of code. They also provide capabilities for manipulating strings and numbers. Because the value of an intrinsic function is derived automatically at the time of reference, you do not need to define these functions in the DATA DIVISION.

16.1.1 Intrinsic function syntax

Written as:

```
FUNCTION function-name (argument)
```

Where function-name must be one of the intrinsic function names. You can reference a function by specifying its name, along with any required arguments, in a PROCEDURE DIVISION statement. Functions are elementary data items, and return alphanumeric characters, national characters, numeric, or integer values.

```
01  Item-1   Pic x(30)  Value "Hello World!".
01  Item-2   Pic x(30).
. . .
    Display Item-1
    Display Function Upper-case(Item-1)
    Display Function Lower-case(Item-1)
    Move Function Upper-case(Item-1) to Item-2
    Display Item-2
```

Example 1. COBOL FUNCTION reserved word usage

The code shown in Example 1. above, displays the following messages on the system logical output device:

```
Hello World! HELLO WORLD! hello world! HELLO WORLD!
```

16.1.2 Categories of intrinsic functions

The intrinsic functions can be grouped into six categories, based on the type of service performed. They are as follows:

1. Mathematical
2. Statistical
3. Date/time
4. Financial
5. Character-handling
6. General

Intrinsic functions operate against alphanumeric, national, numeric, and integer data-items.

- **Alphanumeric** functions are of class and category alphanumeric. The value returned has an implicit usage of DISPLAY. The number of character positions in the value returned is determined by the function definition.
- **National** functions are of class and category national. The value returned has an implicit usage of NATIONAL and is represented in national characters (UTF-16). The number of character positions in the value returned is determined by the function definition.
- **Numeric** functions are of class and category numeric. The returned value is always considered to have an operational sign and is a numeric intermediate result.
- **Integer** functions are of class and category numeric. The returned value is always considered to have an operational sign and is an integer intermediate result. The number of digit positions in the value returned is determined by the function definition.

16.2 Intrinsic functions in Enterprise COBOL for z/OS V6.3

The current release of Enterprise COBOL for z/OS V6.3, includes 70 intrinsic functions. Each one of these functions falling into one of the aforementioned six categories. While an entire book could be written on intrinsic functions, a single example for each of the six categories are provided in this section.

16.2.1 Mathematical example

Example 2. is storing into X the total of A + B + value resulting from C divided by D. FUNCTION SUM enables the arithmetic operation.

```
Compute x = Function Sum(a b (c / d))
```

Example 2. Mathematical intrinsic function

16.2.2 Statistical example

Example 3. shows three COBOL functions, MEAN, MEDIAN, and RANGE where the arithmetic values are stored in Avg-Tax, Median-Tax, and Tax-Range using the data names with assigned pic clause values.

```
01  Tax-S           Pic 99v999 value .045.
01  Tax-T           Pic 99v999 value .02.
01  Tax-W           Pic 99v999 value .035.
01  Tax-B           Pic 99v999 value .03.
01  Ave-Tax         Pic 99v999.
01  Median-Tax      Pic 99v999.
01  Tax-Range       Pic 99v999.
. . .
    Compute Ave-Tax      = Function Mean   (Tax-S Tax-T Tax-W Tax-B)
    Compute Median-Tax   = Function Median (Tax-S Tax-T Tax-W Tax-B)
    Compute Tax-Range    = Function Range  (Tax-S Tax-T Tax-W Tax-B)
```

Example 3. Statistical intrinsic function

16.2.3 Date/time example

Example 4. shows usage of three COBOL functions, Current-Date, Integer-of-Date, and Date-of-Integer applied to MOVE, ADD, and COMPUTE statements.

```
01  YYYYMMDD        Pic 9(8).
01  Integer-Form    Pic S9(9).
. . .
    Move Function Current-Date(1:8) to YYYYMMDD
    Compute Integer-Form = Function Integer-of-Date(YYYYMMDD)
    Add 90 to Integer-Form
    Compute YYYYMMDD = Function Date-of-Integer(Integer-Form)
    Display 'Due Date: ' YYYYMMDD
```

Example 4. Date/time intrinsic function

16.2.4 Financial example

Example 5. shows application of COBOL function ANNUITY financial algorithm where values for loan amount, payments, interest, and number of periods are input to ANNUITY function.

```
01  Loan                 Pic 9(9)V99.
01  Payment              Pic 9(9)V99.
01  Interest             Pic 9(9)V99.
01  Number-Periods       Pic 99.
. . .
    Compute Loan = 15000
    Compute Interest = .12
    Compute Number-Periods = 36
    Compute Payment = Loan * Function Annuity((Interest / 12)
       Number-Periods)
```

Example 5. Financial intrinsic function

16.2.5 Character-handling example

Example 6. shows used of COBOL function UPPER-CASE where an string or alphabetic variable processed by UPPER-CASE will translate any lower case characters to upper case.

```
MOVE FUNCTION UPPER-CASE("This is shouting!") TO SOME-FIELD
DISPLAY SOME-FIELD
Output - THIS IS SHOUTING!
```

Example 6. Character-handling intrinsic function

16.3 Use of intrinsic functions with reference modifiers

A reference modification defines a data item by specifying the leftmost character position and an optional length for the data item, where a colon (:) is used to distinguish the leftmost character position from the optional length, as shown in Example 7.

```
05 LNAME    PIC X(20).

LNAME(1:1)
LNAME(4:2)
```

Example 7. Reference modification

Reference modification, LNAME(1:1), would return only the first character of data item LNAME, while reference modification, LNAME(4:2), would return the fourth and fifth characters of LNAME as the result of starting in the fourth character position with a length of two. If LNAME of value SMITH was the data item being referenced in the intrinsic function, the first reference would output, S. Considering those same specs, the second reference would output, TH.

16.4 Lab

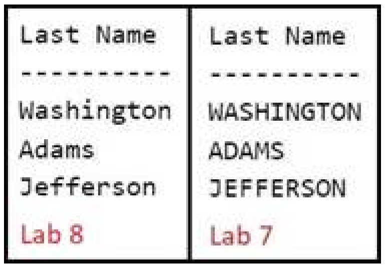
This lab contains data that includes a last name, where last name is all upper-case. It demonstrates the use of intrinsic functions together with reference modification to lower-case the last name characters, except the first character of the last name.

This lab requires two COBOL programs, CBL0011 and CBL0012 and two respective JCL Jobs, CBL0011J and CBL0012J, to compile and execute the COBOL programs. All of which are provided to you in your VSCode - Zowe Explorer.

16.4.0.1 Using VSCode and Zowe Explorer

1. Submit job, CBL0011J.
2. Observe the report output, last name, with first character upper-case and the remaining characters lower-case.

   Figure 1. , below, illustrates the difference in output from the Data types lab compared to this lab. Notice that in the previous lab, the last names were listed in all capitalized characters, whereas, as previously stated, this lab output has only the first character of the last name capitalized.



```
Last Name     Last Name
----------    ----------
Washington    WASHINGTON
Adams         ADAMS
Jefferson     JEFFERSON
Lab 8         Lab 7
```

Figure 1. Current lab vs. Data types lab output

3. Observe the PROCEDURE DIVISION intrinsic function, lower-case, within the WRITE-RECORD paragraph. This intrinsic function is paired with a reference modification resulting in output of last name with upper-case first character and the remainder in lower-case.
4. Submit CBL0012J
5. Observe the compile error.

Previous lab programs made use of a date/time intrinsic function. The date/time intrinsic function in this lab has a syntax error that needs to be identified and corrected.

6. Modify id.CBL(CBL0012) correcting compile error.*
7. Re-submit CBL0012J
8. Corrected CBL0012 source code should compile and execute the program successfully. A successful compile will result in the same output as CBL0011J.

Lab Hints

Refer to CBL0011 line 120 for the proper formatting of the function-name causing the compile error.