IBM **Z**

Rexx Language Coding Techniques
Part 1

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IBM

Agenda

➢ Part 1

- Rexx products

- External environments and interfaces

- Instructions, functions, and subroutines

- Variable visibility

- Parsing

➢ Part 2

- Rexx compound variables vs. data stack

- I/O

- Troubleshooting

- Programming style and techniques

- Other Rexx products and projects

➢ Additional material included in hand-out, not covered in session

Rexx Interpreter and Libraries

➢ A procedural language

➢ Indicator to operating system that it's Rexx - **first line** contains:

   `/* Comment (if any) */`

➢ The Interpreter executes (interprets) Rexx code "line by line"

 • Included in all z/OS and z/VM releases

➢ A Rexx library is required to execute compiled programs

 • Compiled Rexx is **not** an LE language

➢ Two Rexx library choices:

 • (Runtime) Library – a **priced** IBM product

 • Alternate library – a **free** IBM download

   • Uses the native system's Rexx **interpreter**

➢ At execution, compiled Rexx will use whichever library is available

The Rexx Products

➢ IBM **Compiler** for Rexx on zSeries Release 4

- z/VM, z/OS: product number 5695-013

➢ IBM **Library** for Rexx on zSeries Release 4

- z/VM, z/OS: product number 5695-014

➢ z/VSE

- Part of operating system

➢ IBM **Alternate Library** for Rexx on zSeries Release 4

- Included in z/OS base operating system
- Free download for z/VM (and z/OS)
  - http://www.ibm.com/software/awdtools/rexx/rexxzseries/altlibrary.html

➢ Rexx **Interpreter**

- Included in all z/OS and z/VM releases

Why Use a Rexx Compiler?

➢ Program **performance**
- Known value propagation
- Assign constants at compile time
- Common sub-expression elimination
- stem.i processing

➢ Source code **protection**
- Source code not in deliverables

➢ Improved **productivity and quality**
- Syntax checks all code statements
  - Trace S provides limited syntax checking
    - Flags missing END statements
    - Does not catch syntax errors in If Then statements regarding value comparisons
- Source and cross reference listings

➢ Compiler control directives
- %include, %page, %copyright, %stub, %sysdate, %systime, %testhalt

Rexx External Environments

External Environments

➢ ADDRESS instruction is used to define the external environment to receive host commands

- For example, to set TSO/E as the environment to receive commands

`Address TSO`

➢ Several host command environments available in z/OS

➢ A few host command environments available in z/VM

Host Command Environments in z/OS

- TSO
    - Used to run TSO/E commands like ALLOCATE and TRANSMIT
    - Only available to Rexx running in a TSO/E address space
    - The default environment in a TSO/E address space
    - Example:

      ```
      Address TSO "ALLOC FI(INDD) DA('USERID.SOURCE') SHR"
      ```

- MVS
    - Use to run a subset of TSO/E commands like EXECIO
    - The default environment in a non-TSO/E address space
    - Example:

      ```
      Address MVS "EXECIO * DISKR MYINDD (FINIS STEM MYVAR"
      ```
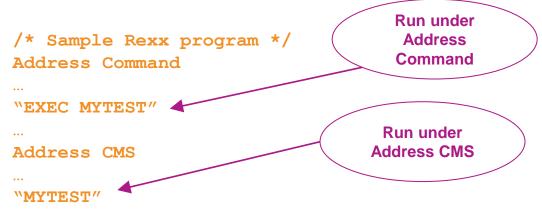
- **Many more**

Other z/OS Host Command Environments

- ISPF services
- ISPF edit macros
- CONSOLE
- LINK, LINKMVS, LINKPGM, ATTACH, ATTCHMVS, ATTCHPGM
- SYSCALL
- SDSF
- DSNREXX

Host Command Environments in z/VM

➢ CMS (default)
  • Commands treated as if entered on the CMS command line
    • Translation of parameter list
      ▪ **Uppercasing and tokenizing**
  • Same search order as CMS command line
➢ COMMAND
  • Basic CMS CMSCALL command resolution
    • No translation of parameter list
      ▪ **No uppercasing of tokenized parameter lists**
    • To call an EXEC, **prefix the command** with the word EXEC
    • To send a command to CP, use the prefix CP
➢ CPICOMM, CPIRR, OPENVM
➢ Generally, best practice is to use "Address Command" at the top of Rexx EXECs that will be run in CMS environment

Multiple Methods to Specify External Environment

- Initial value, later changed:
  - MYTEST is another Rexx EXEC I'm calling from this program:

```
/* Sample Rexx program */
Address Command
…
"EXEC MYTEST"
…
Address CMS
…
"MYTEST"
```

Run under Address Command

Run under Address CMS

- All future commands are treated as **Address CMS** unless specified otherwise

Multiple Methods to Specify External Environment

- Initial value used as default
    - All calls requiring a different value have **Address** statement
    - MYTEST is another Rexx EXEC I'm calling from this program:

```
/* Sample Rexx program */
Address Command
…
"EXEC MYTEST"
…
Address CMS "MYTEST"
…
"EXEC MYTEST"
```

Run under Address Command

Run under Address CMS

Instructions, Functions, and Subroutines

Instructions vs Functions vs Subroutines

➢ Keyword instruction

- • One or more clauses
- • First word is a keyword that identifies the instruction
  - **Arg, Do, If, Parse, …**

➢ Instruction

- • Statement that performs an assignment of a value to a variable
  - **counter = 1**

➢ Function

- • Must return a single result string (i.e. often on the **right side of equal sign**)
- • Built-in - provided as part of the Rexx language
- • Internal - create your own within the same program
- • External – create your own outside this program

➢ Subroutine

- • Called (similar to a function) but may not return data
- • Returns data in special variable: **Result**

Functions

➢ Must return a single result string

- Often on the **right side of an equal sign**

➢ Built-in functions – too many to list, so a few examples

- Absolute value of a number
```
total = -3
newtotal = Abs(total)
```
→ 3

- Left justify a string
```
fullname = Left('Tracy Dean',20)
```
→ 'Tracy Dean   '

- Determine the type of data
```
If Datatype(amtowed,'N')=1
   Then amtowed = amtowed * 1.1
   Else Say 'Amount owed is invalid'
```

- Today's date or day of the week
```
today = Date()
```
→ 25 October 2021

```
todaydow = Date('W')
```
→ Friday

- Find a string within another string
```
startcol = Pos('day','Tuesday')
```
→ 5
```
startcol = Pos('x','Tuesday')
```
→ 0

Subroutines

➢ **Multi-step task to execute multiple times**

- Write once, use multiple times

- Make code easier to read

➢ **Call a subroutine, pass and return variables**

```
…
Call CalcInterest amountborrowed
amountdue = Result
…
```

Value from Return instruction in special variable called "Result"

➢ **Define a subroutine**

- After Exit instruction of main program

- Start with name of subroutine followed by colon

- End with Return instruction

```
CalcInterest:
Parse Arg principal
…
total = principal + (principal * rate)
Return total
```

Declaration and Visibility of Variables

Variable Declaration

➢ Rexx is a procedural language

➢ Variables are **not** declared

- Initial value is same as **variable name** in uppercase

- Seen as a string unless perform mathematical operation

  - Requires the value **at the time** be valid for the operation
  - **Type** of data assigned to a variable can **change** within a program
  - Valid:
    ```
    total = 'Here is some text'
    Say 'Here is the original total:' total
    total = 5+3
    newtotal = 1.5 * total
    Say 'Here is the new total:' newtotal
    ```
  - Output:
    ```
    Here is the original total: Here is some text
    Here is the new total: 12.0
    ```

Visibility of Variables

➢ Variables can be visible throughout a program

- Visible within **Functions** and **Subroutines** you create within the program
  - No need to pass, declare or expose them
- Not visible in **Procedures** unless specifically exposed

➢ Programming practice

- Functions, Subroutines, and Procedures use **different** variable names for reusability
- Pass the value of variables on the call
- Function, Subroutine or Procedure will parse the value and assign to its own variables
- Pass values back to main program via Return statement
  - For subroutines and procedures, values are visible to calling routine via **Result** variable

Visibility of Variables in Functions and Subroutines

- Using existing variables
  - In a function

- Creating new variables
  - In a subroutine

```
principal = 100
interest = 0.10
totaldue = CalcTotalDue()

…
Exit
…
CalcTotalDue:
total = principal*(1 + interest)
Return total
```

```
loan = 100
rate = 0.10
Call CalcTotalDue(loan rate)
totaldue = Result
…
Exit
…
CalcTotalDue:
Parse Arg principal interest .
total = principal*(1 + interest)
Return total
```

Both are valid for functions and subroutines

More common to use separate variables in the function or subroutine

Visibility of Variables in Procedures

➢ **No visibility** of variables from main program unless specifically requested – **most common**

```
total = 855
…
loan = 100
rate = 0.10
Call CalcTotalDue(loan rate)
Say 'This is your total due:' Result
Say 'Principal & interest:' principal interest
…
Exit
…
CalcTotalDue: Procedure
Parse Arg principal interest .
total = principal*(1 + interest)
Return total
```

Variable used for something else in the program

Value from Return statement in Procedure

Does not effect variable of same name in main program

Indicates no exposure of variables from main program

Value of anything here becomes value of "Result" variable

Visibility of Variables in Procedures

➤ **No visibility** of variables from main program unless specifically requested

```
total = 855
```

Variable used for something else in the program

Output:

    This is your total due: 110.00

    Principal & interest: PRINCIPAL INTEREST

Doe... effect ... of same name in main program

```
...est
Exit
...
CalcTotalDue: Procedure
Parse Arg principal interest .
total = principal*(1 + interest)
Return total
```

Value of anything here becomes value of "Result" variable

Visibility of Variables in Procedures

➤ **Exposing** variables from main program to a Procedure

```
loan = 100
rate = 0.10
Call CalcTotalDue(loan rate)
Say 'This is your total due:' total
Say 'Principal & interest:' principal interest
…
Exit
…
CalcTotalDue: Procedure Expose total
Parse Arg principal interest .
total = principal*(1 + interest)
Return
```

Never set in main program, only set in Procedure

Brings in value of this variable from main program

BEWARE: Also changes value in main program

No need to Return "total" as "Result"

Visibility of Variables in Procedures

➤ **Exposing** variables from main program to a Procedure

```
loan = 100
rate = 0.10
```

> Note never set in
> main program,
> only set in
> Procedure

> BEWA...
> Als...
> chang...
> value i...
> progr...

> ...value
> ...able
> ...in
> ...m

```
total = principal*(1 + interest)
Return
```

> No need to
> Return "total"
> as "result"

Same output:
    This is your total due: 110.00
    Principal & interest: PRINCIPAL INTEREST

Returning Variables from Functions and Procedures

➢ **Returning** variables from a Procedure to the main program

```
loan = 100
rate = 0.10
Call CalcTotalDue(loan rate)
totaldue = Result
Say totaldue

…
Exit

…
CalcTotalDue: Procedure
Parse Arg principal interest .
total = principal*(1 + interest)
Return 'Total due:' total
```

All data from "Return" statement is assigned as a string to "Result" variable

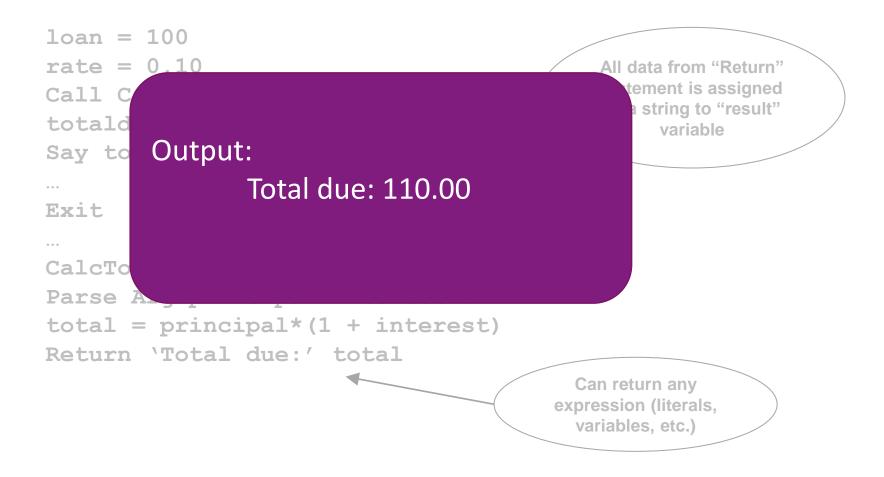*Can return any expression (literals, variables, etc.)*

Returning Variables from Functions and Procedures

➢ **Returning** variables from a Procedure to the main program

```
loan = 100
rate = 0.10
Call C
totald
Say to
…
Exit
…
CalcTo
Parse A
total = principal*(1 + interest)
Return 'Total due:' total
```

> Output:
>   Total due: 110.00

> All data from "Return"
> statement is assigned
> a string to "result"
> variable

> Can return any
> expression (literals,
> variables, etc.)

Calling a Subroutine vs External Routine

➤ From within a Rexx EXEC, call another Rexx EXEC

- As an external routine
```
'EXEC CALCINTEREST' amountborrowed
If rc=0 Then
    Parse Pull amountdue
```

Processed as a variable unless in quotes. Be aware of case sensitivity

- As an subroutine
```
Call CalcInterest amountborrowed
amountdue = Result
```

Calling a Subroutine vs External Routine

- External calls
  - Receive data
    - Parameters (aka arguments)
    - On the stack
  - Return data
    - In a return code (variable **rc**)
      - Must be a whole number
    - On the stack

- Subroutines
  - Receive data
    - Parameters (aka arguments)
    - Visible variables
    - On the stack
  - Return data in
    - Result variable
    - Other visible variables
    - On the stack

No variable visibility

Controlled variable visibility

Parsing

Keyword Instruction: Parse

➢ Parse
- • Allows the use of a template to split a source string into multiple components
- • Syntax:

```
>>-PARSE--+-------+--+-ARG--------------------------+-------------->
          '-UPPER-'  +-EXTERNAL------------------+
                     +-NUMERIC-------------------+
                     +-PULL----------------------+
                     +-SOURCE--------------------+
                     +-VALUE-+------------+-WITH-+
                     |        '-expression-'      |
                     +-VAR--name-----------------+
                     '-VERSION-------------------'


>--+---------------+--;-------------------------------------------><
   '-template_list-'
```

➢ **Short forms** to some of these instructions exist
- • **NOT RECOMMENDED**
- • But you may see them in another user's code you must maintain
  - • ARG
    - ▪ Short form for **Parse Upper Arg**
  - • PULL
    - ▪ Short form for **Parse Upper Pull**

Parse Templates

➢ Simple template

- Divides the source string into **blank-delimited** words and assigns them to the variables named in the template
  - The last variable gets the rest of the string exactly as entered

```
datastring = '  Write  the    blank-delimited   string  '
Parse Var datastring firstvar secondvar thirdvar fourthvar

firstvar  -> 'Write'
secondvar -> 'the'
thirdvar  -> 'blank-delimited'
fourthvar -> '   string  '
```

Parse Templates – Blank Delimiter

➤ Simple template

- A period (aka a dot) is a placeholder in a template
    - A "dummy" variable used to collect unwanted data
    - Notice the consecutive single quotes so the single quote is recognized as part of the string

    ```
    datastring = 'Last one gets what''s left'
    Parse Var datastring firstvar . secondvar

    firstvar -> "Last"
    secondvar -> "gets what's left"
    ```

  - Often used at the end of Parse statement to take "the rest of the data"

    ```
    datastring = 'Last one gets what''s left'
    Parse Var datastring firstvar secondvar .

    firstvar -> "Last"
    secondvar -> "one"
    ```

  - Causes the last variable to get the last word without leading and trailing blanks

    ```
    datastring = '  Write the    blank-delimited   string  '
    Parse Var datastring firstvar secondvar thirdvar fourthvar .
    firstvar -> 'Write'
    secondvar -> 'the'
    thirdvar -> 'blank-delimited'
    fourthvar -> 'string'
    ```

Parse Templates – Literal or Variable Delimiter

➢ String pattern template

- A **literal or variable string pattern** indicating where the source string should be split
- Assumes blank-delimited if no other pattern specified

```
datastring = '  Write the   blank-delimited  string  '
```

Literal:

```
Parse Var datastring firstvar '-' secondvar .
```

Literal delimited

Blank delimited

Variable:

```
delim = '-'
Parse Var datastring firstvar (delim) secondvar .
```

Outcome (the same in both cases):

```
firstvar -> '  Write the    blank'
secondvar -> 'delimited'
```

Parse Templates – Positional Delimiter

➢ Positional pattern template

- • Use numeric values to identify the **character positions** at which to split data in the source string

- • An <u>absolute</u> positional pattern is a number or a number preceded by an equal sign

```
                    ----+----1----+----2----+----3----+----4----+
datastring = 'Cowlishaw           Mike            UK          '
Parse Var datastring =1 surname =20 chrname =35 country =46 .

surname -> 'Cowlishaw          '
chrname -> 'Mike            '
country -> 'UK          '
```

- • A <u>relative</u> positional pattern is a number preceded by a plus or minus sign

  - • Plus or minus indicates movement right or left, respectively, from the last match

```
                    ----+----1----+----2----+----3----+----4----+
datastring = 'Cowlishaw           Mike            UK          '
Parse Var datastring =1 surname +19 chrname +15 country +11 .

surname -> 'Cowlishaw          '
chrname -> 'Mike            '
country -> 'UK          '
```

Parse Templates . . .

➤ Positional pattern template – removing blanks

- Specify an <u>absolute</u> positional pattern
- Insert periods to strip blanks

```
                ----+----1----+----2----+----3----+----4----+
datastring = 'Cowlishaw        Mike            UK          '
Parse Var datastring =1 surname . =20 chrname . =35 country .

surname -> 'Cowlishaw'
chrname -> 'Mike'
country -> 'UK'
```

If data starts in column 1 and is blank-delimited, this is the same as
```
Parse Var datastring surname chrname country
```

- **Warning –** won't work if any of the data has more than one "word"

```
                ----+----1----+----2----+----3----+----4----+
datastring = 'Cowlishaw, Jr.    Mike            UK          '
Parse Var datastring =1 surname . =20 chrname . =35 country .

surname -> 'Cowlishaw,'
chrname -> 'Mike'
country -> 'UK'
```

Blank delimited

Rexx Language Coding Techniques

Summary

➢ **Part 1**

- Rexx products

- External environments and interfaces

- Instructions, functions, and subroutines

- Variable visibility

- Parsing

➢ Part 2

- Rexx compound variables vs. data stack

- I/O

- Troubleshooting

- Programming style and techniques

- Other Rexx products and projects

➢ **Additional material included in hand-out, not covered in session**

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IBM

Rexx Language Coding Techniques

धन्यवाद
Hindi

多謝
Traditional Chinese

감사합니다
Korean

Спасибо
Russian

Ndzi khense ngopfu
Tsonga

Gracias
Spanish

Thank You
English

Obrigado
Brazilian Portuguese

شكراً
Arabic

Grazie
Italian

Danke
German

Ke a leboha
Tswana

多谢
Simplified Chinese

Merci
French

நன்றி
Tamil

ありがとうございました
Japanese

ขอบคุณ
Thai

Rexx Language Coding Techniques