REXX Language Coding Techniques

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Agenda

- **REXX Compiler**
- **External Environments and Interfaces**
- **Key Functions and Instructions – Power Tools**
- **REXX Data Stack Vs Compound Variables**
- **EXECIO and Stream I/O**
- **Troubleshooting**
- **Programming Style and Techniques**

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
  - Source and cross reference listings
- **Compiler control directives**
  - %include, %page, %copyright, %stub, %sysdate, %systime, %testhalt

REXX Compiler on z/OS and z/VM

- **IBM Compiler for REXX on zSeries Release 4**
  - z/VM, z/OS: PID 5695-013
- **IBM Run Time Library for REXX on zSeries Release 4**
  - z/VM, z/OS: PID 5695-014
- **VSE part of operating system**
- **IBM Alternate Library for REXX on zSeries Release 4**
  - Included in z/OS 1.9 base operating system
    - Free download
    - http://www-01.ibm.com/software/awdtools/rexx/rexxzseries/altlibrary.html

REXX Compiler Libraries

- **A REXX library is required to execute compiled programs**
- **Compiled REXX is not an LE language**
- **2 choices: Run-time library and Alternate library**
  - Run-time library. Program product.
  - Alternate library. Free. Uses the native system's REXX interpreter.
- **Compiled and library code runs in 31-bit mode**
  - base/displacement instead of relative addressing
  - BALR and other old opcodes. Can run on old hardware.
  - No z/Architecture in plan today.
- **Compiled REXX will use whichever library (run-time or alternate) is available at execution**

External Environments

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

```
Address TSO     - sets TSO/E as the environment to receive commands
```

- **A varied array of host command environments available 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
    - See: *TSO/E REXX Reference* - http://publibz.boulder.ibm.com/epubs/pdf/ikj4a380.pdf

```
Address TSO “ALLOC FI(INDD) DA(‘USERID.SOURCE’) SHR”
```

  - ISPEXEC
    - Used to invoke ISPF services like DISPLAY and SELECT
    - Only available to REXX running in ISPF
    - See: *ISPF Services Guide* - http://publibz.boulder.ibm.com/epubs/pdf/ispzsg80.pdf

```
Address ISPEXEC “DISPLAY PANEL(APANEL)”
```

External Environments. . .

  - ISREDIT
    - Used to invoke ISPF edit macro commands like FIND and DELETE
    - Only available to REXX running in an ISPF edit session
    - See: *ISPF Edit and Edit Macros* - http://publibz.boulder.ibm.com/epubs/pdf/ispzem80.pdf

```
Address ISREDIT "DELETE .ZFIRST .ZLAST"
```

  - MVS
    - Use to run a subset of TSO/E commands like EXECIO and MAKEBUF
    - The default environment in a non-TSO/E address space
    - See: *TSO/E REXX Reference*

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

External Environments. . .

- CONSOLE
  - Used to invoke MVS system and subsystem commands
  - Only available to REXX running in a TSO/E address space
  - Requires an extended MCS console session
  - Requires CONSOLE command authority
  - See: *TSO/E REXX Reference*

```
"CONSOLE ACTIVATE"
Address CONSOLE "D A"  /* Display system activity */
"CONSOLE DEACTIVATE"
```

Result:

```
 IEE114I 04.50.01 2011.173 ACTIVITY 602
  JOBS     M/S    TS USERS    SYSAS    INITS   ACTIVE/MAX VTAM     OAS
 00002    00014    00002      00032    00005    00001/00020       00010
```

External Environments. . .

- LINK, LINKMVS, LINKPGM, ATTACH, ATTCHMVS, ATTCHPGM
  - Host command environments for linking to and attaching unauthorized programs
  - Available to REXX running in any address space
  - LINK & ATTACH – can pass one character string to program
  - LINKMVS & ATTCHMVS – pass multiple parameters; half-word length field precedes each parameter value
  - LINKPGM & ATTCHPGM – pass multiple parameters; no half-word length field
  - See: *TSO/E REXX Reference*

```
"FREE FI(SYSOUT SORTIN SORTOUT SYSIN)"
"ALLOC FI(SYSOUT)   DA(*)"
"ALLOC FI(SORTIN)   DA('VANDYKE.SORTIN') REUSE"
"ALLOC FI(SORTOUT)  DA('VANDYKE.SORTOUT') REUSE"
"ALLOC FI(SYSIN)    DA('VANDYKE.SORT.STMTS') SHR REUSE"
sortparm = "EQUALS"
Address LINKMVS "SORT sortparm"
```

External Environments. . .

- SYSCALL
  - Used to invoke interfaces to z/OS UNIX callable services
  - The default environment for REXX run from the z/OS UNIX file system
  - Use syscalls('ON') function to establish the SYSCALL host environment for a REXX run from TSO/E or MVS batch
  - See: *Using REXX and z/OS UNIX System Services* - http://publibz.boulder.ibm.com/epubs/pdf/bpxzb690.pdf

```
call syscalls 'ON'
address syscall 'readdir / root.'
do i=1 to root.0
 say root.i
end
```

```
Result:
.
..
bin
dev
etc
 .
 .
```

External Environments. . .

- SDSF
  - Used to invoke interfaces to SDSF panels and panel actions
  - Use isfcalls('ON') function to establish the SDSF host environment
  - Use the ISFEXEC host command to access an SDSF panel
  - Panel fields returned in stem variables
  - Use the ISFACT host command to take an action or modify a job value
  - See: *SDSF Operation and Customization* - http://publibz.boulder.ibm.com/epubs/pdf/isf4cs91.pdf

```
rc=isfcalls("ON")
Address SDSF "ISFEXEC ST"
do ix = 1 to JNAME.0
  if pos("PVANDYK",JNAME.ix) = 1 then do
    say "Cancelling job ID" JOBID.ix "for PVANDYK"
    Address SDSF "ISFACT ST TOKEN('"TOKEN.ix"') PARM(NP P)"
  end
end
rc=isfcalls("OFF")
exit
```

External Environments. . .

- DSNREXX
  - Provides access to DB2 application programming interfaces from REXX
  - Any SQL command can be executed from REXX
    - Only dynamic SQL supported from REXX
  - Use RXSUBCOM to make DSNREXX host environment available
  - Must CONNECT to required DB2 subsystem
  - Can call SQL Stored Procedures
  - See: *DB2 Application Programming and SQL Guide* - *http://publib.boulder.ibm.com/epubs/pdf/dsnapm02.pdf*

```
RXSUBCOM('ADD','DSNREXX','DSNREXX')
SubSys = 'DB2PRD'
Address DSNREXX "CONNECT" SubSys
Owner = 'PRODTBL'
RecordKey = 'ROW2DEL'
SQL_stmt = "DELETE * FROM" owner".MYTABLE" ,
           "WHERE TBLKEY = '"RecordKey"'"
Address DSNREXX "EXECSQL EXECUTE IMMEDIATE" SQL_stmt
Address DSNREXX "DISCONNECT"
```

Other External Environments

- IPCS
  - Used to invoke IPCS subcommands from REXX
  - Only available when run from in an IPCS session
  - See: *MVS IPCS Commands*

- CPICOMM, LU62, and APPCMVS
  - Supports the writing of APPC/MVS transaction programs (TPs) in Rexx
  - Programs can communicate using SAA common programming interface (CPI) Communications calls and APPC/MVS calls
  - See: *TSO/E REXX Reference* - http://publibz.boulder.ibm.com/epubs/pdf/iea2c5a0.pdf

Other “Environments” and Interfaces

- System Rexx
  - A function package that allows REXX execs to be executed outside of conventional TSO/E and Batch environments
  - System REXX execs can be invoked using assembler macro interface AXREXX or through an operator command
  - Easy way for Web Based Servers to run commands/functions & get back pertinent details
  - Exec runs in problem state, key 8, in an APF authorized address space under the MASTER subsystem
  - 2 modes of execution

–TSO=NO	runs in MVS host environment address space shared with up to 64 other execs limited data set support
–TSO=YES	runs isolated in a single address space can safely allocate data sets does not support all TSO functionality

  - See: *MVS Programming Authorized Assembler Services Guide -* http://publibz.boulder.ibm.com/epubs/pdf/iea2a8a0.pdf

Other “Environments” and Interfaces. . .

- RACF Interfaces
  - IRRXUTIL
    - REXX interface to R_admin callable service (IRRSEQ00) extract request
    - Stores output from extract request in a set of stem variables

```
myrc=IRRXUTIL("EXTRACT","FACILITY","BPX.DAEMON","RACF","","FALSE")
say "Profile name: "||RACF.profile
do a=1 to RACF.BASE.ACLCNT.REPEATCOUNT
  Say " "||RACF.BASE.ACLID.a||":"||RACF.BASE.ACLACS.a
end
```

  - RACVAR function
    - Provides information from the ACEE about the running user
    - Arguments: USERID, GROUPID, SECLABEL, ACEESTAT

```
if  racvar('ACEESTAT') <> 'NO ACEE' then
  say "You are connected to group " racvar('GROUPID')"."
```

  - See: *Security Server RACF Macros and Interfaces -* http://publibz.boulder.ibm.com/epubs/pdf/ichza3a0.pdf

Other “Environments” and Interfaces. . .

- Other ISPF Interfaces
  - Panel REXX
    - Allows REXX to be run in a panel procedure
    - *REXX statement used to invoke the REXX
    - REXX can be coded directly in the procedure or taken from a SYSEXEC or SYSPROC DD member
    - REXX can modify the values of ISPF variables
  - File Tailoring Skeleton REXX
    - Allows REXX to be run in a skeleton
    -)REXX control statement used to invoke the REXX
    - REXX can be coded directly in the procedure or taken from a SYSEXEC or SYSPROC DD member
    - REXX can modify the values of ISPF variables
  - See: *ISPF Dialog Developer’s Guide and Reference -* http://publibz.boulder.ibm.com/epubs/pdf/ispzdg80.pdf

Key Instructions – ARG, PULL, and PARSE

- **ARG**
  - retrieves the argument strings provided to a program or internal routine and assigns them to variables
  - short form for PARSE UPPER ARG
- **PULL**
  - reads a string from the head of the external data queue
  - short form for PARSE UPPER PULL
- **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-'
```

PARSE Templates

- **Simple Template**
  - divides the source string into blank-delimited words and assigns them to the variables named in the template

```
string = ‘  Parse the    blank-delimited   string’
parse var string var1 var2 var3 var4 .
var1 -> ‘   Parse’
var2 -> ‘the’
var3 -> ‘blank-delimited’
var4 -> ‘string’
```

  - A period is a placeholder in a template – a “dummy” variable used to collect unwanted data

```
string = “Last one gets what's left”
parse var string var1 . var2
var1 -> “Last”
var2 -> “gets what’s left”
```

PARSE Templates. . .

- **String Pattern Template**
  - a literal or variable string pattern indicating where the source string should be split

```
string = ‘  Parse the    blank-delimited   string’

Literal:
parse var string var1 ‘-’ var2 .

Variable:
dlm = ‘-’
parse var string var1 (dlm) var2 .

Result:
var1 -> ‘   Parse the    blank’
var2 -> ‘delimited’
```

PARSE Templates. . .

- **Positional Pattern Template**
  - Use numeric values to identify the character positions at which to split data in the source string
  - An absolute positional pattern is a number or a number preceded with an equal sign

```
          ----+----1----+----2----+----3----+----4----+
string = ‘Van Dyke           Peter          Australia  ’
parse var string 1 surname 20 chrname 35 country 46 .
surname -> ‘Van Dyke           ’
chrname -> ‘Peter          ’
country -> ‘Australia  ’
```

  - A relative 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----+
string = ‘Van Dyke           Peter          Australia  ’
parse var string 1 surname +19 chrname +15 country +11 .
surname -> ‘Van Dyke           ’
chrname -> ‘Peter          ’
country -> ‘Australia  ’
```

INTERPRET Instruction

- **Expression specified with the INTERPRET instruction is evaluated and then the resulting value is processed (interpreted)**
  - Adds an extra level of interpretation

```
conf = ‘SHARE’
interpret conf "= 'Orlando';say 'Location is' share"
Result:
Location is Orlando
```

  - Provides powerful test and debugging capabilities

```
parse external debug_cmd    /* Receive command from user */
interpret debug_cmd         /* Run the user’s command    */
```

STORAGE Function

- **Syntax:**

```
>>-STORAGE(address-+------------------------+-)---------------><
                   '-,-+--------+-+-------+-'
                       '-length-' '-,data-'
```

- **Returns *length* bytes of data from the specified address in storage.**
  - *address* is a character string containing the hexadecimal representation of the storage address
  - *data* is a character string that overwrites the data at *address*

```
data = storage(00FDE309,3)  /* Get 3 bytes at addr FDE309 */
```

- **A TSO/E external function but can be used in any MVS address space (TSO/E and non-TSO/E)**

- **Not all storage is available to access or update**
  - Virtual storage addresses may be fetch protected, update protected, or may not be valid
  - Null string returned

STORAGE Function. . .

- **Use the C2D and D2X functions to process addresses obtained with the STORAGE function**
  - C2D - returns the decimal value of the binary representation of a string

```
C2D('81'X)     ->    129
```

  - D2X - returns a string, in character format, that represents a decimal number converted to hexadecimal

```
D2X(249)       ->    'F9'
```

  - Example – get the Address Space Vector Table address (CVTASVT) from the Communications Vector Table (CVT)

```
cvt = STORAGE(10,4)                    /* Get CVT address     */
cvtasvt  = STORAGE(D2X(C2D(cvt)+556),4)  /* Get CVTASVT         */
```

STORAGE Function. . .

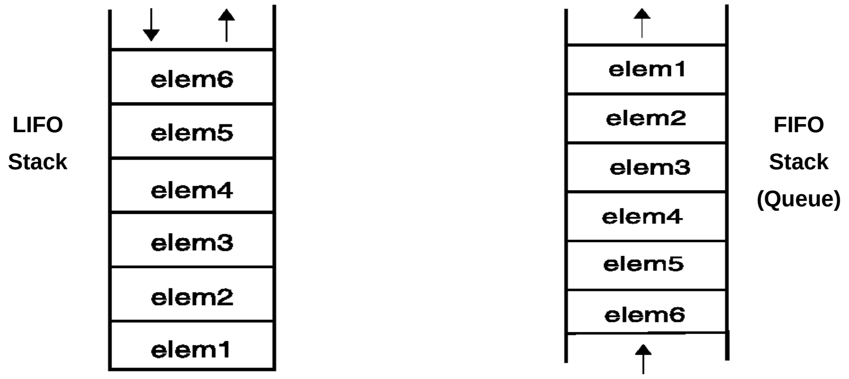
- **Use functions to simplify the job of retrieving pointers and other data**
  - PTR() - returns a 4 byte pointer as a decimal value
    - arg(1) is the decimal value of the address where the pointer is located
  - STG() - returns an EBCDIC string
    - arg(1) is the decimal value of the address where the data is located
    - arg(2) is the length of the data to be returned
  - Example – get the MVS release and FMID from the CVT prefix area

```
NUMERIC DIGITS 20              /* Set precision to 20 digits    */
cvt = PTR(16)                  /* Get CVT address               */
cvtfixa  = cvt-256             /* CVT prefix address            */
cvtprod  = STG(cvtfixa+216,16) /* MVS product level data        */
Say 'MVS release and FMID:' cvtprod
PTR: RETURN C2D(STORAGE(D2X(arg(1)),4))      /* Return pointer  */
STG:  RETURN STORAGE(D2X(Arg(1)),Arg(2))     /* Return storage  */
```

Result:
```
MVS release and FMID: SP7.1.0 HBB7750
```

What is a Data Stack?

- **An expandable data structure used to temporarily hold data items (elements) until needed**
- **When an element is needed it is ALWAYS removed from the TOP of the stack**
- **A new element can be added either to the top (LIFO) or the bottom (FIFO) of the stack**
  - FIFO stack is often called a queue



Manipulating the Data Stack

- **3 basic REXX instructions**
  - PUSH - put one element on the top of the stack

```
elem = ‘new top element’
PUSH elem
```

  - QUEUE - put one element on the bottom of the stack

```
 elem = ‘new bottom element’
QUEUE elem
```

  - PARSE PULL - remove an element from the stack (top)

```
PARSE PULL top_elem .
```

- **1 REXX function**
  - QUEUED() - returns the number of elements in the stack

```
num_elems = QUEUED()
```

Why Use the Data Stack?

- **To store a large number of data items of virtually unlimited size for later use**
- **Pass a large or unknown number of arguments between execs or routines**
- **Specify commands to be run when the exec ends**
  - Elements left on the data stack when an exec ends are treated as commands

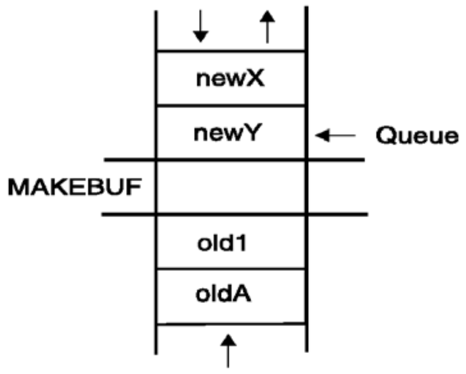
```
Queue “TSOLIB RESET QUIET”
Queue “ALLOC FI(ISPLLIB) DA(‘ISP.SISPLOAD’ 'SYS1.DFQLLIB‘) SHR REUSE”
Queue “TSOLIB ACTIVATE FILE(ISPLLIB) QUIET”
Queue “ISPF”
```

- **Pass responses to an interactive command that runs when the exec ends**

```
dest = SYSVAR('SYSNODE')"."USERID()
message = “Lunch time”
Queue “TRANSMIT”
Queue dest “LINE”
Queue message
Queue “ ”
```

Using Buffers in the Data Stack

- **An exec can create a buffer in a data stack using the MAKEBUF command**
- **All elements added after a MAKEBUF command are placed in the new buffer**
  - MAKEBUF basically changes the location the QUEUE instruction inserts new elements



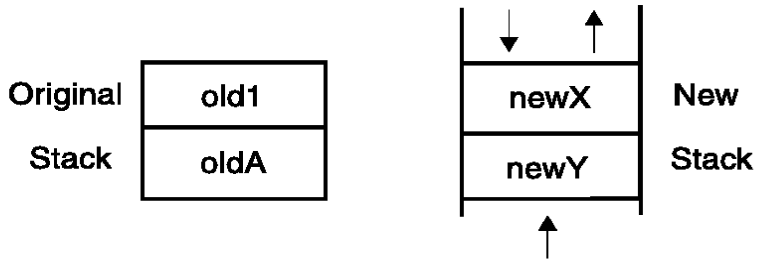
Using Buffers in the Data Stack. . .

- **An exec can use MAKEBUF to create multiple buffers in the data stack**
  - MAKEBUF returns in the RC variable the number identifying the newly created buffer
- **DROPBUF command is used to remove a buffer from the data stack**
  - Allows an exec to easily remove temporary storage assigned to the data stack
  - A buffer number can be specified with DROPBUF to identify the buffer to remove
    - Default is to remove the most recently created buffer
  - DROPBUF 0 creates an empty data stack (use with caution)
- **The QBUF command is used to find out how many buffers have been created**
- **The QELEM command is used to find out the number of elements in the most recently created buffer**
- **CAUTION: When an element is removed below a buffer the buffer disappears.**

Protecting Elements in the Data Stack

- **An exec can protect data stack elements from being inadvertently removed by creating a new private data stack using the NEWSTACK command**

- **All elements added after a NEWSTACK command are placed in the new data stack**
  - elements on the original data stack cannot be accessed by an exec or any called routines until the new stack is removed
  - When there are no more elements in the new data stack information is taken from the terminal



Protecting Elements in the Data Stack. . .

- **The DELSTACK command removes a data stack and all the remaining elements in the stack**
  - Removes the most recently created data stack

- **CAUTION: If no stack was previously created with the NEWSTACK command DELSTACK removes all the elements from the <u>original stack</u>**

- **The QSTACK command returns in the variable RC the number of data stacks (including the original stack)**

- **<u>NOTE</u>: The QUEUED() function returns the number of elements in the current data stack**

What is a Compound Variable?

- **A series of symbols (simple variable or constant) separated by periods.**
- **Made up of 2 parts – the *stem* and the *tail*.**
- **The *stem* is the first symbol <u>and</u> the first period. The symbol must be a name. Sometimes called the *stem variable*.**
- **The *tail* follows the stem and comprises one or more symbols separated by periods.**
  - **Variables take on previously assigned values**
  - **If no value assigned takes on the uppercase value of the variable name**

```
day.1                            stem:  day.
                                 tail:  1

array.i                          stem:  array.
                                 tail:  i

name = 'Smith';phone = 12345;
employee.name.phone              stem:  employee.
                                 tail:  Smith.12345
```

Compound Variable Values

- **Initializing a stem to some value automatically initializes every compound variable with the same stem to the same value**

```
say month.15   → MONTH.15
month. = 'Unknown'
month.6 = 'June'
month.3 = 'March'
say month.15   → Unknown
val = 3
say month.val  → March
```

- **Easy way to reset the values of compound variables**

```
month. = ''
say month.6   → ''
```

- **DROP instruction can be used to restore compound variables to their uninitialized state**

```
drop month.
say month.6   → MONTH.6
```

Processing Compound Variables

- **Compound variables provide the ability to process one-dimensional arrays in an exec**
  - Use a numeric value for the tail
  - Good practice to store the number of array entries in the compound variable with a tail of 0 (zero)
  - Often processed in a DO loop using the loop control variable as the tail

```
invitee.0 = 10
do i = 1 to invitee.0
  SAY ‘Enter the name for invitee’ i
  PARSE PULL invitee.i
end
```

- **Stems can be used with the EXECIO command to read data from and write data to a data set**

- **Stems can also be used with the OUTTRAP external function to capture output from commands**

Processing Compound Variables. . .

- **The tail for a compound variable can be used as an index to related data**

- **Given the following input data:**

```
Symbol  Atomic#   Name       Weight
H       1         Hydrogen   1.00794
HE      2         Helium     4.002602
LI      3         Lithium    6.941
. . .
```

- **The unique symbol value can be used as the tail of compound variables that hold the rest of the symbol’s values**

```
 "EXECIO * DISKR INDD (STEM rec. FINIS"
Do i = 2 To rec.0
  Parse Var rec.i symbol atomic#.symbol name.symbol weight.symbol
End i
Say "Which atomic symbol do you want to learn about?"
Parse Pull symbol
Say "The name of" symbol "is" name.symbol"."
Say "The atomic number for" symbol "is" atomic#.symbol"."
Say "The atomic weight of" symbol "is" weight.symbol"."
```

Data Stack Vs Compound Variables

- **Data Stack**
  - Advantages
    - –Can be used to pass data to external routines
    - –Able to specify commands to be run when an exec ends
    - –Can provide response to an interactive command that runs when the exec ends
  - Disadvantages
    - –Program logic required for stack management
    - –Processing needs 2 steps: take data from input source and store in stack, then read from stack into variables
    - –Stack attributes and commands are OS dependent

Data Stack Vs Compound Variables. . .

- **Compound Variables**
  - Advantages
    - –They are basically variables and REXX will manage them like other variables
    - –Only one step required to assign a value
    - –They provide opportunities for clever and imaginative processing
  - Disadvantages
    - –They cannot be used to pass data between external variables
- **Conclusion**
  - Try to use compound variables whenever appropriate. They are **<u>simpler</u>**.

EXECIO Command

- **Used to read and write records from and to a sequential data set or partitioned data set member**
- **Requires a DDNAME to be specified**
  - Use ALLOC command to allocate data set or member to a DD
- **Records can be read into or written from compound variables or the data stack**
- **Can also be used for the following functions:**
  - Open a data set without reading or writing any records
  - Empty a data set
  - Copy records from one data set to another
  - Add records to the end of a sequential data set
  - Update data in a data set one record at a time
- **EXECIO is a TSO/E REXX command that provides record-based processing**

REXX Stream I/O

- **Function package available as a free download from IBM**
  - ftp://ftp.software.ibm.com/s390/zos/tools/rexx/
  - Look for REXXFUNC files
- **Also shipped with the IBM Library for Rexx on zSeries (5695-014)**
- **Allows REXX execs to use stream I/O functions to process sequential data sets and partitioned data set members**
- **Why user stream I/O?**
  - Extends and enhances I/O capabilities of REXX for TSO/E
  - shields the complexity of z/OS data set I/O (to some degree)
  - A familiar I/O concept
  - Provides better portability of REXX between OS platforms

Troubleshooting – Condition Trapping

- **The CALL ON and SIGNAL ON instructions can be used to trap exception conditions**

- **Syntax:**

```
▶▶──SIGNAL ON ┬ERROR───┬ NAME labelname──▶◀
              ├FAILURE┤
              ├HALT───┤
              ├NOVALUE┤
              └SYNTAX─┘

▶▶──CALL ON ┬ERROR───┬ NAME trapname──▶◀
            ├FAILURE┤
            └HALT───┘
```

- **Condition types:**

• ERROR	- error upon return (positive return code)
• FAILURE	- failure upon return (negative return code)
• HALT	- an external attempt was made to interrupt and end execution
• NOVALUE	- attempt was made to use an uninitialized variable
• SYNTAX	- language processing error found during execution

Troubleshooting – Condition Trapping. . .

- **Good practice to enable condition handling to process unexpected errors**

- **Use REXX provided functions and variables to identify and report on exceptions**
  - CONDITION function – returns information on the current condition
    - Name and description of the current condition
    - Indication of whether the condition was trapped by SIGNAL or CALL
    - Status of the current trapped condition

  - RC variable – Return Code
    - Contains the command return code for ERROR and FAILURE
    - Contains the syntax error number for SYNTAX

  - SIGL variable – line number of the clause that caused the condition

  - ERRORTEXT function – returns REXX error message for a SYNTAX condition
    ```
    say ERRORTEXT(rc)
    ```

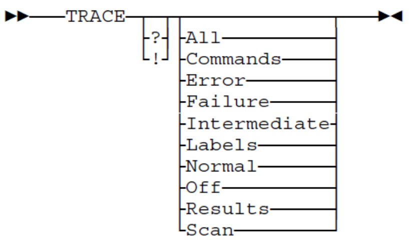
  - SOURCELINE function – returns a line of source from the REXX exec
    ```
    say SOURCELINE(sigl)
    ```

Troubleshooting – The Trace Facility

- **The Trace Facility provides powerful debugging capabilities**
  - Display the results of expression evaluations
  - Display the variable values
  - Follow the execution path
  - Interactively pause execution and run REXX statements

- **Activated using the TRACE instruction and function**

- **Syntax:**



Troubleshooting – The Trace Facility. . .

- **Trace example:**

```
A = 1
B = 2
C = 3
D = 4
Trace I
If (A > B) | (C < 2 * D) Then
  Say 'At least one expression was true.'
Else
  SAY 'Neither expression was true.'
```

- **Result:**

```
 6 *-* If (A > B) | (C < 2 * D)
       >V>   "1"
       >V>   "2"
       >O>   "0"
       >V>   "3"
       >L>   "2"
       >V>   "4"
       >O>   "8"
       >O>   "1"
       >O>   "1"
       *-*  Then
     7 *-*  Say 'At least one expression was true.'
       >L>    "At least one expression was true."
At least one expression was true.
```

Troubleshooting – The Trace Facility. . .

- **Interactive trace provides additional debugging power**
  - Pause execution at specified points
  - Insert instructions
  - Re-execute the previous instruction
  - Continue to the next traced instruction
  - Change or terminate interactive tracing
- **Starting interactive trace**
  - ? Option with the TRACE instruction
  - EXECUTIL TS command
    - Code in your REXX exec
    - Issue from the command line to debug next REXX exec run
  - Cause an attention interrupt and enter TS

Programming Style and Techniques

- **Be consistent with your style**
  - Helps others to read and maintain your code
  - Having style rules will make the job of coding easier
- **Indentation**
  - Improves readability
  - Helps identify unbalanced or incomplete structures (DO-END groups)
- **Comments**
  - Provide them!
  - Choices:
    - In blocks
    - To the right of the code
- **Capitalization**
  - Can improve readability
  - Suggestion – use all lowercase except for labels and calls to internal subroutines

Programming Style and Techniques. . .

- **Variable names**
  - Try to use meaningful names – helps understanding and readability
  - Avoid 1 character names – easy to type but difficult to manage and understand
- **Subroutines**
  - Try to avoid the over use of subroutines or functions
  - Subroutines are useful, but have performance impact
  - If it's only called once, does it need to be a subroutine?
- **Comparisons**
  - REXX supports *exact* (e.g. "==") and *inexact* (e.g. "=") operators
  - Only use *exact* operators when appropriate

```
arg a
if a == "SAVE" then …
```

  - Above comparison will fail if argument received is "SAVE "
  - Avoid using the NOT ("¬") character
    - Portability problem when transferring code to an ASCII platform
    - Use "<>", "/=", or "\="

Programming Style and Techniques. . .

- **Semicolons**
  - Can be used to combine multiple statements in one line
    - DON'T – detracts from readability
  - Languages like C and PL/I require a ";" to terminate a line
  - Can also be done in REXX
    - DON'T – doubles internal logic statement count for interpreted REXX
- **Conditions**
  - For complex statements REXX evaluates all Boolean expressions, even if first fails:

```
if 1 = 2 | 3 = 4 | 5 = 6 then say 'Impossible'
```

  - Nesting of IF statements sometimes required

```
if a \== 0 & b/a > 1 then ...
   –Divide-by-zero can still occur if a=0
```

  - Can be avoided by nesting IF statements:

```
if a \== 0 then
  if b/a > 1 then ...
```

Programming Style and Techniques. . .

- **Literals**
  - Important to use literals where appropriate such as for external commands
  - Lazy programming can lead to unfortunate results
    - For uninitialized variables: value=name

      ```
      control errors cancel
      ```
    - This usually works, but breaks if any of the 3 words is a variable that is already assigned a value
    - Also a performance cost for unnecessary variable lookups (20%+ more CPU)

Additional Information and Contacts

- **REXX Compiler User's Guide and Reference**
  http://publibfi.boulder.ibm.com/epubs/pdf/h1981605.pdf

- **IBM REXX Web Site**
  http://www-01.ibm.com/software/awdtools/rexx

- **IBM Contacts**

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