

REXX Language Coding Techniques



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Peter Van Dyke
IBM Australia
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pvandyke@au1.ibm.com

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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 "CONNECT"

```

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 in 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:

```
d1m = '-'
parse var string var1 (d1m) 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-+-----+)-+----->>X
                '-,+-----+-----+'
                '-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

```

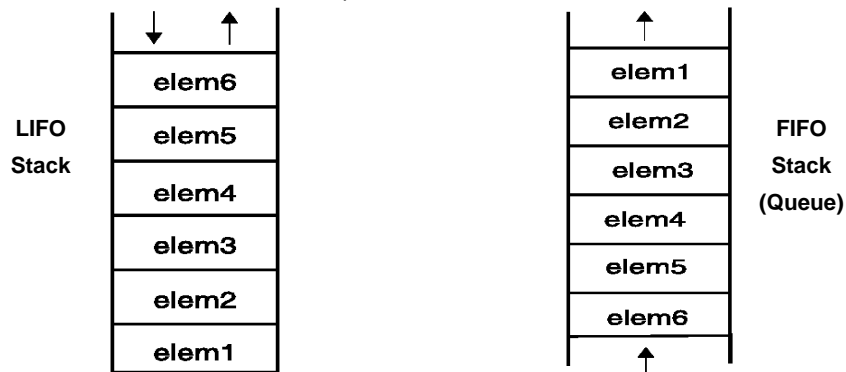
NUMERIC DIGITS 20          /* Set precision to 20 digits */
cvt = PTR(16)              /* Get CVT address */
cvtfixa = cvt-256         /* CVT prefix address */
cvtprod = STG(cvtfixa+216,16) /* MVS product level data */
Say 'MVS release and FMID:' cvtprod
PTR: RETURN C2D(STORAGE(D2X(arg(1)),4)) /* Return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

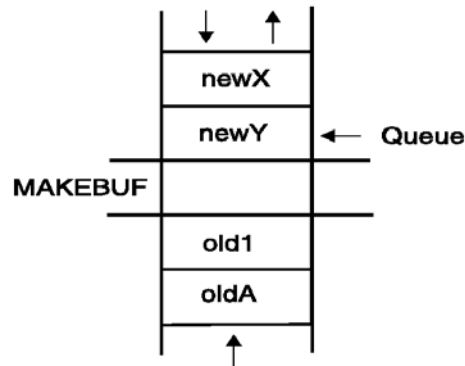
```
Queue "TSOLIB RESET QUIET"
Queue "ALLOC FI(ISPLLIB) DA('ISP.SISPLOAD' 'SYS1.DFQLLIB') SHR REUSE"
Queue "TSOLIB ACTIVATE FILE(ISPLLIB) QUIET"
Queue "ISPF"
```

- **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

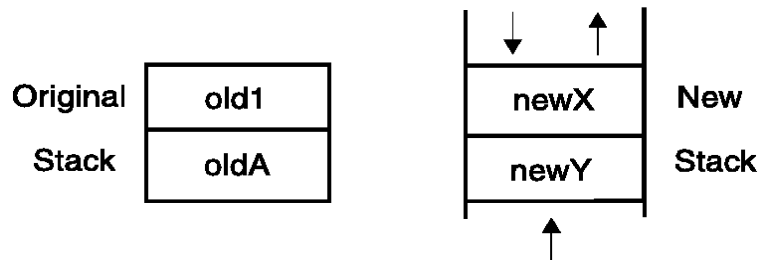


Using Buffers in the Data Stack. . .

- 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 original stack
- The **QSTACK** command returns in the variable **RC** the number of data stacks (including the original stack)
- **NOTE:** 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 and 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 **simpler**.

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
 - **ERRORTXT** function – returns REXX error message for a **SYNTAX** condition

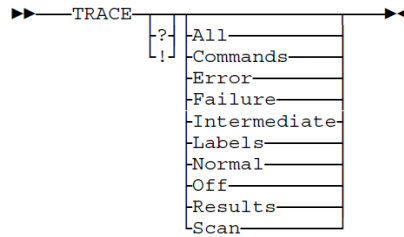

```
say ERRORTXT(rc)
```
 - **SOURCELINE** function – returns a line of source from the REXX exec


```
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**
Virgil Hein, vhein@us.ibm.com (REXX at IBM)
George Kochanowski, jjkoch@us.ibm.com (REXX Compiler)