REXX Language Coding Techniques

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Agenda

- **REXX products**
- **REXX Enhancements (z/OS)**
- **External environments and interfaces**
- **Key functions and instructions**
- **REXX data stack vs. compound variables**
- **I/O**
- **Troubleshooting**
- **Programming style and techniques**

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REXX Session at SHARE

- **I am site editor of Destinationz.org. Destination z is an online mainframe community of IBMers, those in mainframe related jobs, academics and business partners. Looking over your REXX Language Coding presentation you gave at SHARE, I was wondering if you might be interested in contributing an article to Destination z based off your presentation?**

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REXX Interpreter and Libraries

- **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:**
  - (Runtime) Library
  - Alternate Library

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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
- **VSE**
  - Part of operating system
- **IBM Alternate Library for REXX on zSeries Release 4**
  - Included in z/OS base operating system (V1.9 and later)
  - 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

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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

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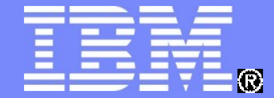

IBM Software

REXX Enhancements in z/OS V2.1

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REXX Enhancements in z/OS V2.1 and later

- **EXECIO enhanced to support I/O with RECFM=U, VS, VBS**
- **RECFM=U,VS,VBS support also added to callable I/O interface**
- **New TRAPMSG function allows IRX... messages, if issued from a command invoked by the EXEC, to be captured via OUTTRAP**
- **STORAGE function now supports 64-bit addresses for both reading from and writing to storage.**
- **Empty sequential data set can be part of a concatenation accessed by EXECIO, CLIST I/O, PRINTDS if it is SMS managed**
- **LISTDSI enhanced (REXX and CLIST)**
  - RACF/NORACF operand
  - Multi Volume Support
  - Handles data sets with extended attributes
- **Other smaller requirements**

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Overview

- Over the years many customers have asked for the capability to handle I/O to data sets containing records with Variable Spanned (VS, VBS) RECFM, and with data sets having undefined (U) RECFM. This includes the ability to handle spanned files generated by SMF, or to read load library type undefined files.
- Problem Statement / Need Addressed
  - Provide the capability to read or write RECFM=VS, VBS, U type data sets under REXX.

    Note: RECFM=VS/VBS files do not support update mode (DISKRU).
- Solution
  - EXECIO support extended
- Benefit / Value
  - The power of REXX and EXECIO can be used to process data sets with RECFM attributes that were formerly not supported.

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Usage & Invocation

- There is no change to the execio syntax. Just enhanced capabilities.
- **Example 1. Use EXECIO to read records from an input RECFM=VS file and write them to a new file having RECFM=VBS. (Assumes input LRECL <= 240).**

```
/* REXX */
"ALLOC FI(INVS) DA('userid.test.vs') SHR REUSE"
ALLOCRC = RC
"ALLOC FI(OUTVBS) DA('userid.test.newvbs') SPACE(1) TRACKS " ,
   " LRECL(240) BLKSIZE(80) RECFM(V B S) DSORG(PS) NEW REUSE"
ALLOCRC = MAX(RC,ALLOCRC)
execio_rc = 0                          /* Initialize              */
error = 0                              /* Initialize              */
IF ALLOCRC = 0 THEN
  do
    /***************************************************************/
    /* When spanned records are read, each logical record is the  */
    /* collection of all spanned segments of that record on DASD. */
    /***************************************************************/
    "execio * DISKR INVS (STEM inrec. FINIS"  /* Read all records */
    if rc /= 0 then
      error = 1                         /* Read Error occurred    */
  end
```


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Usage & Invocation

- Example 1 continued

```
ELSE
     do
       say 'File allocation error ...'
       error = 1                          /* Error occurred            */
     end
   IF error = 0 then                  /* If no d is ok               */
     DO
       "execio "inrec.0" DISKW OUTVBS (STEM inrec. FINIS"  /* Write all
                                         records read to the new file */
       if rc=0 then
         do
           say 'Output to new VBS file completed successfully'
           say 'Number of records copied ===> ' inrec.0
         end
       else
         do
           say 'Error writing to new VBS file '
           error = 1                      /* Error occurred            */
         end
     END
```


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Usage & Invocation

- **Example 2. Use EXECIO to read a member of a RECFM=U file and change the first occurrence of the word 'TSOREXX ' within each record to 'TSOEREXX' before rewriting the record. If a record is not changed, it need not be rewritten.**

```
/* REXX */
/* Alloc my Load Lib data set having RECFM=U BLKSIZE=32000 LRECL=0 */
"ALLOC FI(INOUTDD) DA('apar2.my.load(mymem)') SHR REUSE"
readcnt = 0                        /* Initialize rec read cntr    */
updtcnt = 0                        /* Initialize rec update cntr  */
error = 0                          /* Initialize flag             */
EoF = 0                            /* Initialize flag             */
do while (EoF=0 & error=0)         /* Loop while more recs/no err */
  "execio 1 DISKRU INOUTDD (STEM inrec." /* Read a rec for update  */
  if rc = 0 then                   /* If read ok                  */
    do  /* Replace 1st occurrence of 'TSOREXX' in record by 'TSOEREXX'
                                  and write it back               */
      readcnt = readcnt + 1      /* Records read                  */
      z = POS('TSOREXX ',inrec.1,1)    /* Find target within rec   */
      if z /= 0 then              /* If found, replace it          */
         do
           inrec.1 = SUBSTR(inrec.1,1,z-1)||'TSOEREXX'|| ,
                  SUBSTR(inrec.1,z+LENGTH('TSOEREXX'))  /*Replace it*/
           "execio 1 DISKW INOUTDD (STEM inrec." /* Rewrite the update
                                       made to the last record read*/
```

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Usage & Invocation

- **Example 2 continued**

```
        if rc > 0 then                  /* If error                    */
                error=1                 /* Indicate error              */
              else
                updtcnt = updtcnt + 1   /* Incr update count           */
            end
          else                          /* Else nothing changed, nothing
                                           to rewrite                  */
            NOP                         /* Continue with next record   */
        end
      else                              /* Else non-0 RC               */
        if rc=2 then                    /* if end-of-file              */
          EoF=1                         /* Indicate end-of-file        */
        else
          error=1                       /* Else read error             */
    end                                 /* End do while                */
    "execio 0 DISKW INOUTDD (FINIS"     /* Close the file              */
    if error = 1 then
      say '*** Error occurred while updating file '
    else
      say updtcnt' of 'readcnt' records were changed'
    "FREE FI(INOUTDD)"
    exit 0
```


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Overview

- TRAPMSG – a new TSO/E REXX function used in conjunction with OUTTRAP to permit REXX to trap REXX messages (i.e. IRX..... msgs) in some instances. Prior to this, no IRX.... msg could be trapped.
- Problem Statement / Need Addressed
  - REXX IRX..... messages should be trappable via OUTTRAP just as other output (e.g. such as say output from nested execs) is trappable.
- Solution
  - Use TRAPMSG('on') to tell REXX to treat REXX msg output in the same was as any other output, for purposes of trapping.
- Benefit / Value
  - REXX msgs issued by nested execs, and by host commands invoked by REXX (e.g. execio) can now be trapped into an OUTTRAP variable, rather than always being written to screen.
  - CLIST error msgs from CLISTs invoked by REXX also now trappable.

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Usage & Invocation

- TRAPMSG() - returns current setting. /* OFF perhaps   */

- TRAPMSG('ON' | 'OFF') - enables or disables output trapping for IRX.... msgs. Default is 'OFF'

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Usage & Invocation

- Example 1: A REXX exec invokes execio without allocating the indd file. EXECIO will return RC=20 and an error message. By trapping the message with OUTTRAP, the exec can decide what to do with the error.
  (This same technique can be used to trap the IRX0250E message if execio were to take an abend, like a space B37 abend.)

```
==============================================

msgtrapstat = TRAPMSG('ON')      /* Save current status and set
                   TRAPMSG ON to allow REXX msgs to be trapped  */
outtrap_stat = OUTTRAP('line.')   /* Enable outtrap             */
/****************************************************************/
/* Invoke TSO host cmd, execio, and trap any error msgs issued  */
/****************************************************************/
"execio 1 diskr indd (stem rec. finis"

if RC = 20 then                  /* If execio error  occurred    */
  do i=1 to line.0
    say '==> ' line.i            /* Write any error msgs         */
  end
outtrap_stat = OUTTRAP('OFF')    /* Disable outtrap              */
msgtrapstat = TRAPMSG('OFF')     /* Turn it off                  */
exit 0
```


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Usage & Invocation

- Example 2: A REXX exec turns on OUTTRAP and TRAPMSG and invokes a second REXX exec. The second REXX exec gets an IRX0040I message due to an invalid function call. Exec1 is able to trap the message issued from exec2.

Note that if exec1 had made the bad function call, it could not trap the error message because a function message is considered at the same level as the exec. This is similar to the fact that an exec can use OUTTRAP to trap SAY statements from an exec that it invokes, but it cannot trap its own SAY output.

```
=======================================================
    /* REXX - exec1 */
      trapit = OUTTRAP('line.')
      trapmsg_stat = TRAPMSG('ON')
      call exec2
      do i=1 to line.0   /* Display any output trapped from exec2 */
        say '==> ' line.
      end
      trapit = OUTTRAP('OFF')
      trapmsg_stat = TRAPMSG('OFF')
      exit 0

      /* REXX - exec2 */
      say 'In exec2 ...'
      time = TIME('P')    /* Invalid time operand, get msg IRX0040I*/
      return time
```


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Overview

- z/OS can use address 64-bit storage, providing vastly expanded addressable areas. REXX cannot read or write to these areas.
- Problem Statement / Need Addressed
  - REXX STORAGE needs ability to view or change storage within 64-bit addressable areas above the BAR.
- Solution
  - STORAGE extended to handle 64-bit addresses, in addition traditional 24-bit and 31-bit addresses.
- Benefit / Value
  - Clever programmers can make use of 64-bit storage to greatly expand the amount of data than can be maintained, in storage, by REXX.

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Usage & Invocation

- **STORAGE** function now supports 64-bit address represented by 9-17 hexidecimal chars, consisting of 8-16 hex chars and an optional underscore (“_”) separating high and low order half
- Retrieve 25-bytes from addr 000AAE35:

storet = STORAGE(000AAE35,25)

- Replace data at 0035D41F with 'TSO/E REXX'

storet = STORAGE(0035D41F,,'TSO/E REXX')

- The following ilustrate valid 64-bit addresses that can be used with storage .

storet = STORAGE(00000001EF_80000010,60) – read 60-bytes from 64-bit address 1EF_80000010

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Usage & Invocation

```
------------------------------------------------------------------
        The following illustrates some valid and invalid 64-bit addresses:
        ------------------------------------------------------------------
         Hex Address passed   Binary Address
         to STORAGE           used by STORAGE         Comment
         ================     ==================      ===================
                _00000010     '0000000000000010'x     - Valid 64-bit addr.
                                                        (Padded to left with
                                                        0's to 64-bits.)
                                                        Addresses same area as
                                                        31-bit '00000010'x addr.
               0_00000010     '0000000000000010'x     - Valid 64-bit addr.
                                                        Addresses same area
                                                        as _00000010.
               0_80000010     '0000000080000010'x     - Valid 64-bit addr.
                                                        Addr is 2GB beyond
                                                        the 0_00000010 addr.
               000001EF10     '000000000001EF10'x     - Valid 64-bit addr.
             1EF_80000010     '000001EF80000010'x     - Valid 64-bit addr.
              1EF80000010     '000001EF80000010'x     - Valid 64-bit addr
                                                        without "_" separator.
        000001EF_80000010     '000001EF80000000'x     - Valid 64-bit addr.
        000001EF_10            Invalid Addr           - Right half of 64-bit
                                                        addr <8 chars.
```


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Usage & Invocation

Hex Address passed to STORAGE	Binary Address used by STORAGE	Comment
00000001EF_000010	Invalid Addr	- Left half of addr >8 chars, right half <8 chars.
0000001EF_80000010 chars	Invalid Addr	- More than 16 hex Also, left half more than 8 chars.
00001EF8000001000 chars	Invalid Addr	- More than 16 hex

- As an example of what you might expect, consider STORAGE used to retrieve 25 bytes from a 64-bit addressable area:

```
say
'<'C2X(STORAGE(1EF_80000010,25))'>'
                /* Returns  ...
               <IARST64 COMM SIZE 000512 >  perhaps */
```


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Overview

- Keep LISTDSI REXX function/ CLIST statement current with new features added to z/OS, and improve current capabilities.
- Problem Statement / Need Addressed
  - As new features are introduces to data sets, LISTDSI should be improved to report on those. Also LISTDSI should be able to handle multi-volume data sets.
- Solution
  - New variables have been added to LISTDSI.
  - LISTDSI now provides information on all volumes of a multi-volume data set, not just the first.
  - RACF/NORACF operand added.
- Benefit / Value
  - New capabilities help keep LISTDSI current.

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Usage & Invocation

- LISTDSI 'dsname'... RACF/NORACF MULTIVOL/NOMULTIVOL
  - Specifying NORACF means LISTDSI will not determine the RACF status. This implies that LISTDSI will not attempt to open the data set to gather additional information, even if open is necessary based on another keyword. For example, for a PDS, if DIRECTORY is specified, LISTDSI would open the data set to get directory info, but will not if NORACF is specified.
  - Specify NORACF if you do not want LISTDSI to query RACF as to whether a data set is protected. (Default is RACF.)
  - Specify MULTIVOL if you want information on the totality of all volumes of a multi-volume data set. NOMULTIVOL provides information on just the first volume (as prior to this support).

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Usage & Invocation

- New LISTDSI variables set
  - SYSNUMVOLS - Number of volumes used, always returned
    - SYSVOLUMES - Volume names separated by blanks, up to number in SYSNUMVOLS. Returns 7-char per volume (6-char

      volume name plus 1 blank separator). Up to 412 chars (59 vols) .
    - SYSVOLUME – existing variable, returns name of first volume
  - SYSUSEDPERCENT - Percent pages used for PDSEs. Always returned for PDSEs along with previously existing SYSUSEDPAGES. One or all vols.

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Usage & Invocation

- For EAV volumes:
  - SYSCREATEJOB - Jobname that created data set, if available
    e.g. PAYROLL
  - SYSCREATESTEP- Stepname that created data set, if available
    e.g. IKJEFT01
  - SYSCREATETIME- Time that data set was created, if available in format hh:mm:ss. (e.g. 02:35:15)
  - SYSCREATE - Previously existing var, returns Create Date
    (e.g. 2012/193)
- Existing variables with modified meaning
  - SYSALLOC - one or all vols. Space allocated.
  - SYSUSED – one or all vols. Space used.
  - SYSEXTENTS – one or all vols. Number of extents.
  - SYSRACFA - blank if NORACF. **'NONE'/'GENERIC'/'DISCRETE'** if RACF was specified or defaulted.

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Enhancement Summary

New features of REXX now include

- Enhancements to EXECIO to support I/O to RECFM=VS,VBS, U data sets.
- New TRAPMSG function.
- Enhancements to REXX STORAGE function to support 64-bit addresses.
- Null SMS managed data sets allowed in a sequential concatenation for EXECIO, CLIST I/O, PRINTDS.
- Enhancements to LISTDSI

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More Details

- **SA22-7790-11, z/OS TSO/E REXX Reference**
- **SA22-7781-08, z/OS TSO/E CLISTs**
- **SA22-7786-12, z/OS TSO/E Messages**

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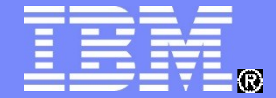

REXX External Environments

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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**

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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
  - TSO/E REXX Reference (SA22-7790)
  - Example:

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

– MVS
  - Use to run a subset of TSO/E commands like EXECIO and MAKEBUF
  - The default environment in a non-TSO/E address space
  - TSO/E REXX Reference (SA22-7790)
  - Example:

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

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Host Command Environments in z/OS

- ISPEXEC
  - Used to invoke ISPF services like DISPLAY and SELECT
  - Only available to REXX running in ISPF
  - ISPF Services Guide (SC19-3626, SC34-4819)
  - Example:

```
Address ISPEXEC "DISPLAY PANEL(APANEL)"
```

- ISREDIT
  - Used to invoke ISPF edit macro commands like FIND and DELETE
  - Only available to REXX running in an ISPF edit session
  - ISPF Edit and Edit Macros (SC19-3621, SC28-1312)
  - Example:

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


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Host Command Environments in z/OS …

- CONSOLE
- LINK, LINKMVS, LINKPGM, ATTACH, ATTCHMVS, ATTCHPGM
- SYSCALL
- SDSF
- DSNREXX

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Host Command Environments in z/OS …

– 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
- *TSO/E REXX Reference (SA22-7790)*
- Example:

```
    "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
```


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Host Command Environments in z/OS …

- **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
  - *TSO/E REXX Reference (SA22-7790)*
  - Example:

```
“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”
```


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Host Command Environments in z/OS …

- 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
  - *Using REXX and z/OS UNIX System Services (SA22-7806)*
  - Example:

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

Result:

```
…
bin
dev
etc
…
```


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Host Command Environments in z/OS …

– 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
  - *SDSF Operation and Customization (SA22-7670)*

  - Example:

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


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Host Command Environments in z/OS …

- 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
  - *DB2 Application Programming and SQL Guide (SC19-4051)*
  - Example:

```
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"
```


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Other External Environments in z/OS

- **IPCS**
  - Used to invoke IPCS subcommands from REXX
  - Only available when run from in an IPCS session
  - *MVS IPCS Commands (SA22-7594)*
- **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
  - *TSO/E REXX Reference (SA22-7790)*

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Other “Environments” and Interfaces in z/OS

- **System REXX**
  - A function package that allows REXX EXECs to be executed outside of conventional TSO/E and Batch environments
  - Can be invoked using assembler macro interface AXREXX or through an operator command
  - Easy way for Web Based Servers to run commands/functions and get back pertinent details
  - EXEC runs in problem state, key 8, in an APF authorized address space under the MASTER subsystem
  - Two 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
  - *MVS Programming Authorized Assembler Services Guide (SA22-7605)*

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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","","F
  ALSE")
  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')"."
```

  - *Security Server RACF Macros and Interfaces (SA22-7682)*

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Other “Environments” and Interfaces . . .

- **Other ISPF Interfaces**
  - Panel REXX
    - Allows REXX to be run in a panel procedure
    - *REXX statement used to invoke it
    - 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 it
    - 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
  - ISPF Dialog Developer’s Guide and Reference (SC19-3619, SC34-4821)

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Host Command Environments in z/VM

- **CMS (default)**
  - Commands treated as if entered on the CMS command line
  - 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**

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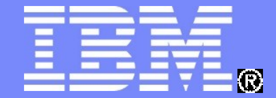

Key Instructions and Functions

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Instructions vs. Functions

- **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**
    - Built-in - provided as part of the REXX language
    - Internal - create your own
    - External – create your own or use platform unique functions
    - Must return a single result string (i.e. must be on the right side of an equal sign)
- **Subroutine**
  - Called like a function, but may not return data

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Key Instructions – PARSE, ARG, 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-'
```

- **ARG**
  - Retrieves th
    - 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
- **Good practice to use full commands vs short forms**

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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

```
string = '  Write the    blank-delimited
string  '
parse var string var1 var2 var3 var4

var1 -> 'Write'
var2 -> 'the'
var3 -> 'blank-delimited'
var4 -> '   string  '
```


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PARSE Templates

- **Simple template**
  - 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”
```

    - Often used at the end of PARSE statement to take “the rest of the data”

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

var1 -> “Last”
var2 -> “one”
```

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

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


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PARSE Templates . . .

- **String pattern template**
  - A literal or variable string pattern indicating where the source string should be split

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

Literal:

```
parse var string var1 '-' var2 .
```

Variable:

```
dlm = '-'
parse var string var1 (dlm) var2 .
```

Result (the same in both cases):

```
var1 -> '  Write the    blank'
var2 -> 'delimited'
```


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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 by an equal sign

```
          ----+----1----+----2----+----3----+----4----+
string = 'Cowlishaw          Mike           UK         '
parse var string =1 surname =20 chrname =35 country =46 .

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

  - 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 = 'Cowlishaw          Mike           UK         '
parse var string =1 surname +19 chrname +15 country +11 .

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


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PARSE Templates . . .

- **Positional pattern template – removing blanks**
  - Specify an absolute positional pattern
  - Insert periods to strip blanks

```
                    ----+----1----+----2----+----3----+----4----+
string = 'Cowlishaw          Mike           UK          '
parse var string =1 surname . =20 chrname . =35 country .

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

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

```
                ----+----1----+----2----+----3----+----4----+
string = 'Cowlishaw, Jr.     Mike           UK          '
parse var string =1 surname . =20 chrname . =35 country .

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


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Data Stack and Compound Variables

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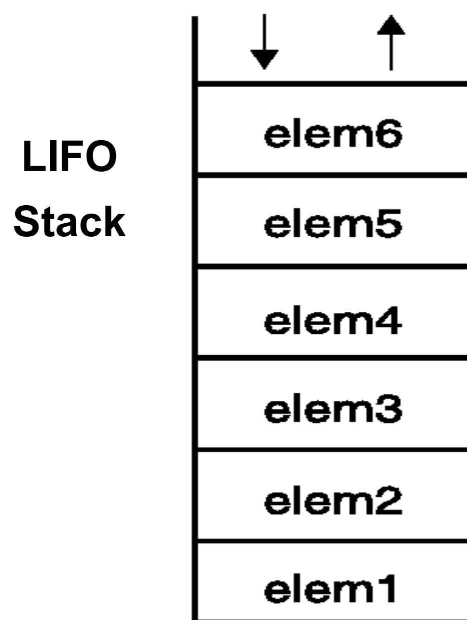
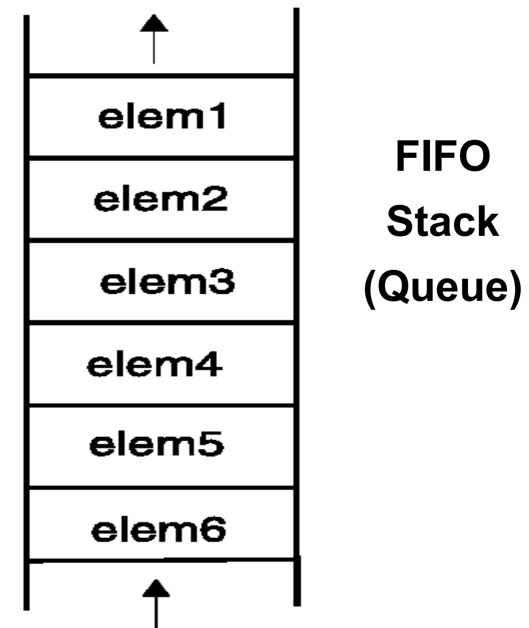
What is a Data Stack?

- **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





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Manipulating the Data Stack

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

```
elem1 = 'new top element'
PUSH elem1
```

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

```
elem2 = 'new bottom element'
QUEUE elem2
```

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

```
PARSE PULL elem3
```

  - Result:

```
elem3 → 'new top element'
```

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

```
num_elems = QUEUED()
```


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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 " "
```


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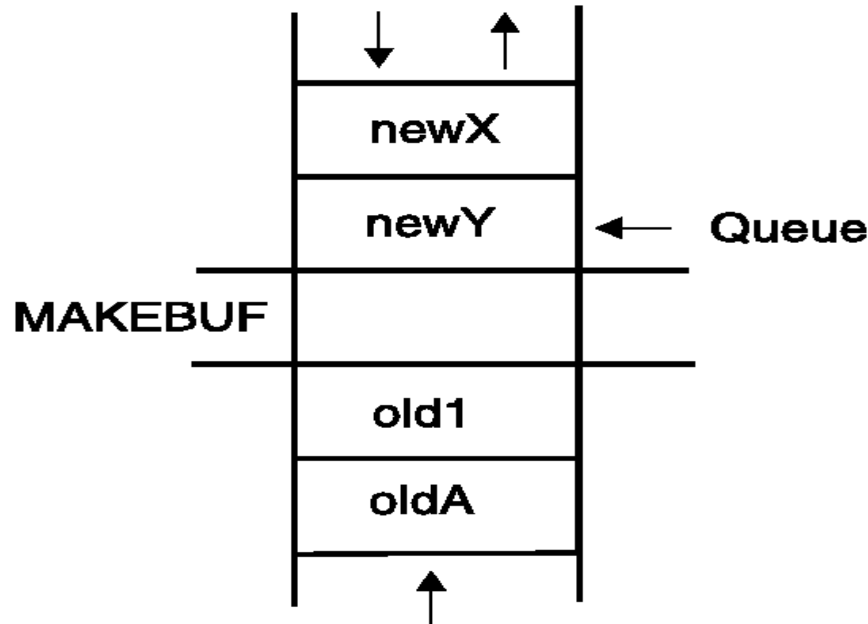
Using Buffers in the Data Stack

- **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 where the QUEUE instruction inserts new elements
    - Remember QUEUE inserts at the "bottom" of the stack (or buffer)



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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 results in an empty data stack (use with caution)
- **z/OS only**
  - 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

- **Notes**
  - When an element is removed from an empty buffer, the buffer disappears.
  - To remove a buffer
    - Issue DROPBUF, or
    - Remove an element (via PARSE PULL) when the buffer is already empty
  - The next request to remove an element will move to the next buffer (if there is one)

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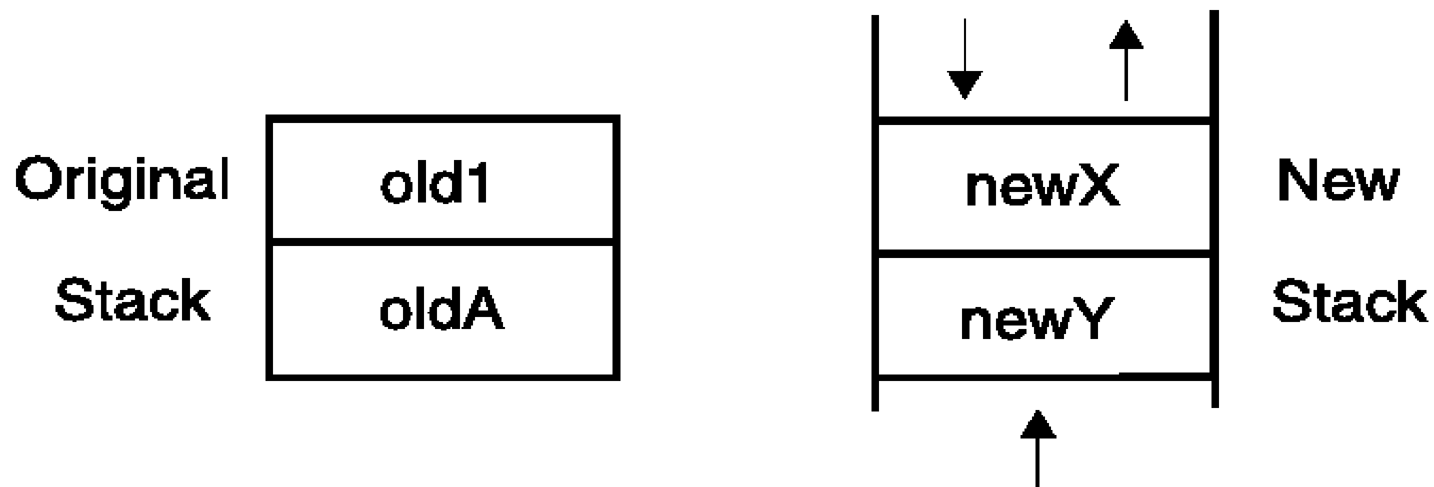
Protecting Elements in the Data Stack – z/OS Only

- **REXX code can use the stack, but protect itself from inadvertently removing someone else's data stack elements**
  - Create 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 (not just emptied)
  - When there are no more elements in the new data stack, information is taken from the terminal (not the original data stack)



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Protecting Elements in the Data Stack - z/OS Only

- **DELSTACK - removes a data stack**
  - Removes the most recently created data stack
    - Including all remaining elements in the stack
  - CAUTION
    - If no stack previously created with NEWSTACK, then DELSTACK removes all the elements from the original stack
- **QSTACK - returns the number of data stacks**
  - Including the original stack
  - Puts the value in the variable RC
- **NOTE: For z/OS, the QUEUED() function returns the number of elements in the current data stack.**

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Data Stack vs Buffers

- **Data Stack**
  - Advantages
    - Protects data in the original stack
      - Never defaults back to the “previous” stack in the chain
      - Must specifically delete current stack to move to previous stack
      - Can easily request terminal input if also have items in the stack
        - Just create a new stack with nothing on it and issue “Pull”
  - Disadvantages
    - Only available on z/OS
      - z/VM must issue “Parse External” to request terminal input if data is in the stack

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Data Stack vs Buffers

- **Buffers**
  - Advantages
    - Create a stack on top of the existing stack for new list of items
    - Use “QElem” to keep track of how many items in this buffer
  - Disadvantages
    - No guaranteed protection of previous stack in the chain
      - If current stack is empty, will proceed to next one automatically

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What is a Compound Variable?

- **A way to reference a collection of related values**
  - Also called a *stem variable* or *stem array*
- **Variable name is *stem* followed by zero or more *tail*s**
  - *stem* must be simple variable ending in a period
  - *tail* must be simple variable or decimal integer
  - Multiple *tail*s are separated by periods
- **Each *tail* variable is replaced by its value**
  - Default value of *stem* and *tail* is the variable names used for *stem* and *tail*
  - Each *tail* references a dimension of the collection
- **The resulting *derived name* is used to access a specific value from the collection**
- **Tails which are variables are replaced by their respective 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
```


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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
```

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Processing Compound Variables

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

```
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 I/O functions to read data from and write data to a file on z/VM or data set on z/OS**
  - Stream I/O
  - EXECIO
  - PIPE
- **Stems can also be used with the external function OUTTRAP (z/OS) or PIPE (z/VM) to capture output from commands**

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Processing Compound Variables . . .

- The tail for a compound variable can be used as an index to related data
- The tail (index) and data can contain blanks
- Given the following input data:

```
Employee# Name          Location
1         M Cowlishaw   United Kingdom
2         T Dean        Portland
3         V Hein        Austin
...
```

- The unique employee number value can be used as the tail of compound variables that hold the rest of the person's data

```
"EXECIO * DISKR EMPLOYEE INFO A (STEM REC. FINIS"
Do i = 2 To REC.0
  Parse Var REC.i =1 empnum +10 name.empnum +14 location.empnum
End i
Say "Which employee number do you want to learn about?"
Parse Upper Pull empnum
empnum=Left(empnum,10)
Say "The name of employee" Strip(empnum) "is" Strip(name.empnum)"."
Say "The location of employee" Strip(empnum) "is" Strip(location.empnum)"."
```


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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 the EXEC ends
    - Can provide response(s) 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
      - Read from stack into variables
    - Stack attributes and commands are OS dependent

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Data Stack vs Compound Variables . . .

- **Compound Variables**
  - Advantages
    - Basically variables - REXX will manage them like other variables
    - Only one step required to assign a value
    - Provide opportunities for clever and imaginative processing
  - Disadvantages
    - Can not be used to pass data between external routines

- **Conclusion**
  - Try to use compound variables whenever appropriate
    - They are **simpler**

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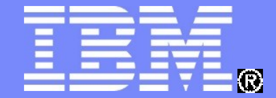

IBM Software

I/O and Troubleshooting

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EXECIO Command – z/OS

- **A TSO/E REXX command that provides record-based processing**
  - Used to read and write records from/to a z/OS sequential data set or z/OS 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 to:**
  - 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

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EXECIO Command – z/VM

- **CMS EXECIO command provides record-based processing**
  - Recommend using CMS Pipelines (PIPE command) instead
    - Simpler to use

```
    'EXECIO * DISKR EMPLOYEE INFO A (STEM REC. FINIS'
  vs
    'PIPE < EMPLOYEE INFO A | STEM rec.'
```

    - PIPEs has much more function

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REXX Stream I/O

- **Available natively in z/VM**
- **Function package shipped with z/OS**
  - Also shipped with the IBM Library for REXX on zSeries
  - Allows REXX EXECs to use stream I/O functions to process sequential data sets and partitioned data set members
- **Process data**
  - Character by character, or
  - Line by line
- **Why use stream I/O?**
  - Extends and enhances I/O capabilities of REXX for TSO/E
  - A familiar I/O concept
  - Provides better portability of REXX between OS platforms

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Troubleshooting – Condition Trapping

- **SIGNAL ON and CALL 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
  - NOTREADY - z/VM only. Error during input or output operation

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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)
    ```


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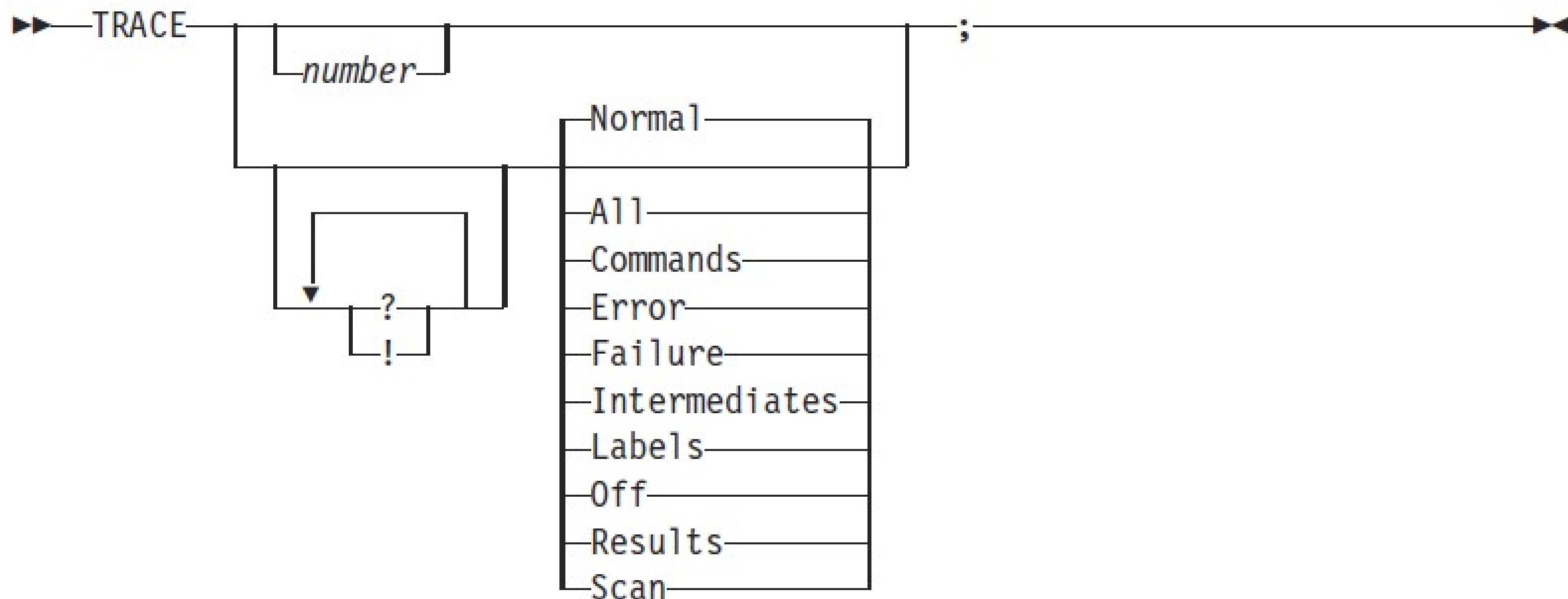
Troubleshooting – Trace Facility

- **Provides powerful debugging capabilities**
  - Displays the results of expression evaluations
  - Displays the variable values
  - Follows the execution path
  - Interactively pauses execution and runs REXX statements
- **Activated using the TRACE instruction and function**
- **Syntax:**



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Troubleshooting – Trace Facility . . .

- **Code 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.
```


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Troubleshooting – 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
  - In TSO, use EXECUTIL TS command (Trace Start)
    - Code in your REXX EXEC
    - Issue from the command line to debug next REXX EXEC run
  - Cause an attention interrupt and enter TS

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Programming Style and Techniques

- **Be consistent with your style**
  - Helps others 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 pairs)
- **Comments**
  - Provide them!
  - Choices:
    - In blocks
    - To the right of the code
- **Capitalization**
  - Can improve readability
  - Suggestions
    - Use all lowercase for variables
    - Use mixed case (captilize the first letter) for keywords, labels, calls to internal subroutines
    - Use upper case for calls to external routines (commands)

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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 called only 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

    ```
    if a == "SAVE" then …
    ```
  - Above comparison will fail if `a` is `"SAVE "`
  - Avoid using non-standard NOT characters: "¬" and "/"
    - Portability problem when transferring code to an ASCII platform
    - Use "\=", or less commonly used "\>" "\<=

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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 = 5 then say 'Impossible`
```

    - Divide-by-zero can still occur if a=0

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

    - Can be avoided by nesting IF statements:

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


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Programming Style and Techniques . . .

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

      `control errors cancel`
    - This usually works
      - Breaks if any of the 3 words is a variable with value already assigned
    - Also a performance cost for unnecessary variable lookups (20%+ more CPU)
    - Instead enclose literals in quotation marks

      `"CONTROL ERRORS CANCEL"`

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Programming Style and Techniques . . .

- **External commands**
  - Best practices
    - Enclose in quotation marks
    - Use uppercase
    - Fully spell out the command
      - Don't assume any abbreviations that may not be present if the EXEC is moved to another system
      - Preface with the external environment as needed

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Related Programs

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CMS and TSO Pipelines

- **A powerful method of processing or manipulating data**
- **Can be called within REXX programs**
- **A collection of data processing elements connected in a series**
  - Output of one element becomes the input to the next element
  - For example, on z/VM

    ```
    'PIPE cp query dasd | stem dasd.'
    ```

    - Issues the CP command QUERY DASD and response is written into the pipeline
    - The next stage (STEM) receives the input and places it into the stem variable DASD, setting DASD.0 to the number of lines of data
- Included in all current releases of z/VM
- Available as a separate product for TSO
  - **Batchpipes (5655-D45)**

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Open Object REXX

- **Open Object REXX is available via open source community**
  - Runs on Linux on System z
  - Many other platforms
- **www.oorexx.org**
  - Managed by REXX Language Association
- **99% compatible with other System z REXX programs**
- **Informal testing with SLES on memory and CPU constrained system**
  - Compare PERL and OOREXX – OOREXX is much faster!
  - Memory footprint of OOREXX is similar to PERL with several modules loaded

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(Open Source) NetRexx

- **An object oriented Rexx for the Java virtual machine (JVM)**
  - Write in REXX (or REXX-like)
  - Compiler converts to Java source statements and bytecode
- **Available via open source community since 2011**
- **netrexx.org**
  - Managed by REXX Language Association

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Additional Information and Contacts

- **REXX Compiler User's Guide and Reference**
  http://publibfi.boulder.ibm.com/epubs/pdf/h1981605.pdf
- **IBM REXX Website**
  http://www.ibm.com/software/awdtools/rexx
- **Additional IBM Contacts**
  - Virgil Hein, vhein@us.ibm.com
    - Compiler and Library for REXX on zSeries
  - John Ehrman, ehrman@us.ibm.com
    - REXX Compiler

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धन्यवाद

Hindi

多謝

Traditional Chinese

감사합니다

Korean

Спасибо

Russian

Gracias

Spanish

Thank You

English

Obrigado

Brazilian Portuguese

شكرا

Arabic

Danke

German

Grazie

Italian

多谢

Simplified Chinese

Merci

French

நன்றி

Tamil

ありがとうございました

Japanese

ขอบคุณ

Thai

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