Using REXX for IBM Mainframe Application Development

Liam Doherty
IBM Corporation

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Agenda

- What use REXX?
- The Product
- The REXX compiler
- REXX External environments
- Common code constructs used
- Less Common code constructs

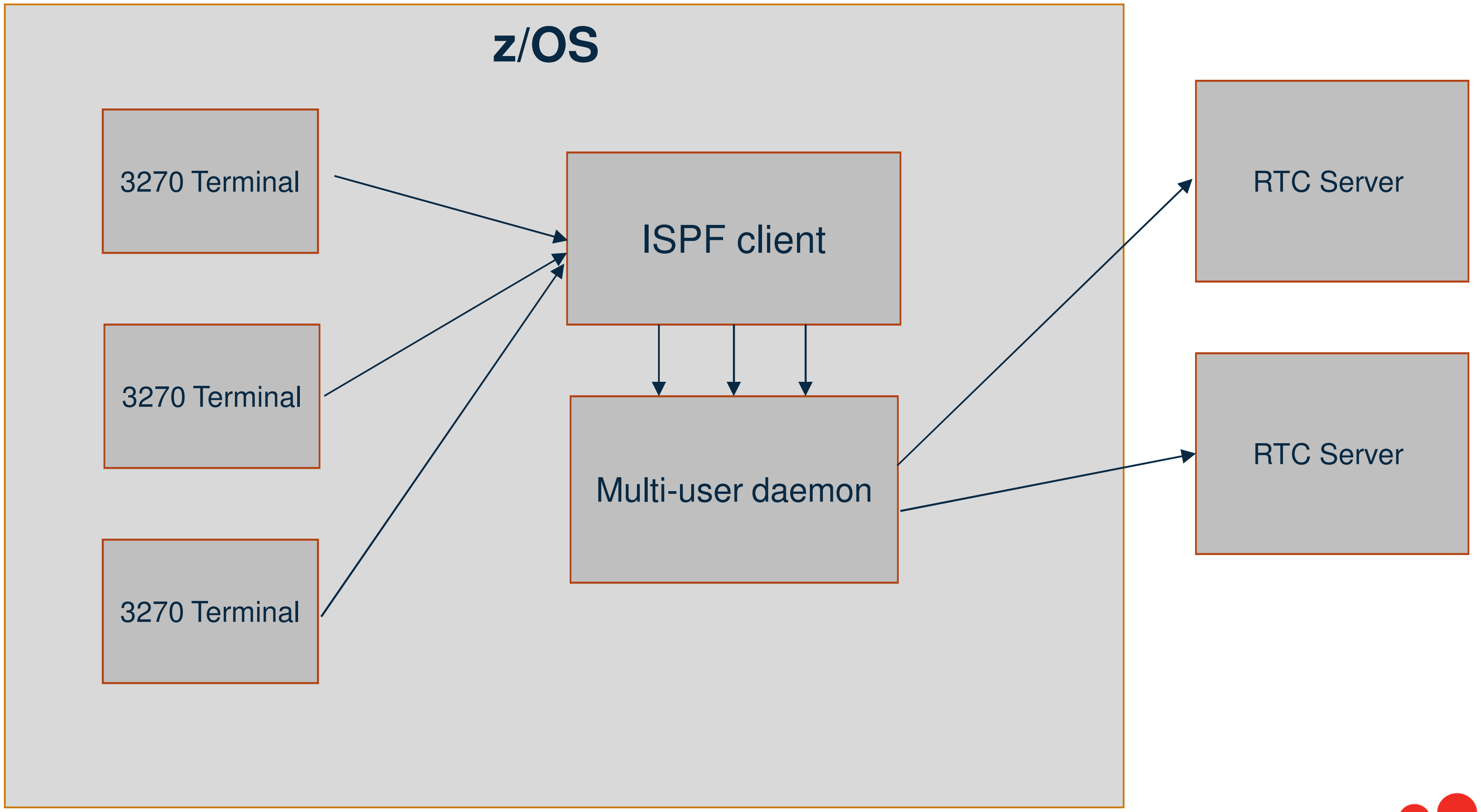
Why use REXX?

- Easy to pick up if you are unfamiliar with mainframe languages
- Easy to "get runs on the board".
  - In an Agile environment with short sprints we could prototype and show progress very quickly
- Interfaces with other environments very well
  - In particular z/OS Unix
- Is the perfect language when paired with ISPF Dialog development
- Ideal for parsing data
- Because I love it…

The Product

- Rational Team Concert was originally offered as an Eclipse Client and a Web Client
  - However a number of customers expressed an interest in there being an ISPF Client
- The ISPF Client would need to send requests to a Java Daemon. The daemon would send/receive the data to the RTC Server. Then send a response in the form of a JSON string back to the ISPF client.
- In a later release a Configuration Utility and IVP were also provided

Architecture



The REXX Compiler

- **Why use the REXX compiler?**
  - Source Code Protection
    - *Protects your intellectual property*
    - *Protects your code from manipulation*
    - *Keeps your code maintainable*
  - Meet IBM packaging rules to include a copyright in the load
  - Program performance
    - *Approximately 30% performance gain unless you are using the REXX Alternate library*
  - Compiler syntax checks the code without the need for execution
    - *Lists all errors, rather than stopping at the first error when run interactively*

The REXX Compiler

- The REXX library is required to run compiled programs
- Compiled REXX is not an LE Language
- Compiled with run one of 2 ways
  - Run-Time Library : Purchased Program Product
  - REXX Alternate : Installed on z/OS
    - *Will use the native systems REXX interpreter*
  - Compiled REXX will use whichever library is available at execution time
- Compiled code runs in 31-bit mode
  - Uses old opcodes such as BALR. Can run on old hardware
  - No z/Architecture in plan today.

The REXX Compiler - %STUB

- The %STUB compiler directive provides interfaces with various parameter-passing conventions
- The only two we use are:
  - CALLCMD
    - *When the CALL program_name command is issued from the TSO/E command line, or when the CALL program_name host command is issued from within an EXEC executing under TSO/E.*
    - *In simple terms, any "Main" program invoked by:*
      - *SELECT CMD(program_name)*
    - *First parm will be the module name*
  - *CPPLEFPL*
    - *It contains the logic to determine if the REXX program is being invoked as a TSO/E command or as a REXX external routine. Once this has been determined, the compiled REXX program is given control with the appropriate parameters.*
    - *In simple terms, subroutines called using the CALL statement or invoked as a function call*
- See IBM Compiler and Library for REXX on System z: User's Guide and Reference

  http://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.rexa100/toc.htm?lang=en

REXX external environments

- One of the main reasons REXX is so powerful as a development language
- ADDRESS instruction is used to define the external environment to receive host commands
  - Address <environment name>
- There are many different environments that provide many different functions
  - TSO
  - ISPEXEC
  - ISREDIT
  - CONSOLE
  - LINK, LINKMVS, LINKPGM, ATTACH, ATTCHMVS, ATTCHPGM
  - SYSCALL
  - SDSF
  - DSNREXX
  - …and more

Address TSO

- One of the most common environments, and the default if running in a TSO/E address space
- Used to run TSO/E commands like ALLOCATE and TRANSMIT
- See: *TSO/E REXX Reference* –

  http://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.ikja300/toc.htm
- Examples:

```
Address TSO "ALLOC F(SYSIN) NEW RECFM(F B) LRECL(80) SP(1 1) TRACKS"
Address TSO "EXECIO * DISKR SYSPRINT (STEM cmdout. FINIS "
Address TSO "TSOEXEC CALL *(BLZPASTK) '"USER APPLID PASSTCKT"''
Address TSO "DELETE 'DOHERTL.MY.DATASET'"
```

Address ISPEXEC

- Used to invoke ISPF services like DISPLAY and SELECT
- Only available to REXX running in ISPF
- See: *ISPF Services Guide* –

  http://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.f54sg00/toc.htm

Examples:

```
Address ISPEXEC
"ADDPOP ROW(2) COLUMN(4)"
"DISPLAY PANEL(BLZ@ABOU)"
"REMPOP"
```

REXX external environments

- Environment can be set for a single command, or for all non-REXX commands from a certain point
- Last set environment will be used if REXX does not recognise a command
- Example

```
Address ISPEXEC
“VGET (BLZTRACE) SHARED”

Address TSO "ALLOC F(INDD) DA(‘DOHERTL.EXEC(COND)’) SHR“
Address TSO "EXECIO * DISKR INDD (STEM cmdout. FINIS “

"DSINFO DATASET(‘DOHERTL.EXEC')“

Address TSO
"ALLOC F(OUTDD) DA(‘DOHERTL.EXEC(OUTPUT)’) SHR“
"EXECIO * DISKW OUTDD (STEM cmdout. FINIS “
“ISPEXEC VPUT (BLZVAR) PROFILE”
```

Address 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://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.bpxb600/toc.htm

  Examples:

```
xx = syscalls('ON')
Address Syscall 'readdir /tmp tmp. tmpst.`
Do sb = 1 to tmp.0
  If Substr(tmp.sb,1,1) = '.' then
  Do
    If Pos(substr(tmpst.sb.ST_MODE,1,1),'2467') = 0 |,
       Pos(substr(tmpst.sb.ST_MODE,2,1),'2467') = 0 |,
       Pos(substr(tmpst.sb.ST_MODE,3,1),'2467') = 0 then
    Do
      Say ‘/tmp is not writable’
```

Address 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://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.f54em00/toc.htm

  Examples:

```
Address ISREDIT "MACRO (PARMSTR)"
Do while (PARMSTR /= '')
  Parse var PARMSTR cmd ';' PARMSTR
  Address ISREDIT cmd
End
Address ISREDIT 'END'


Address ISREDIT "MACRO"
Address ISPEXEC "VGET (CONFLICT) SHARED"
Address ISPEXEC "VGET (BLZMOD) SHARED"
Address ISREDIT "COMPARE '"CONFLICT"' X"
```

Address 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 –*
  http://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.ikja300/toc.htm
- Examples:

```
Address TSO "ALLOC F(NEWDD) DA('DOHERTL.V6DEV.SOURCE') SHR"
Address TSO "ALLOC F(OUTDD) NEW SP(1 1) CYL"
Address TSO "ALLOC F(SYSIN) NEW SP(1 1) CYL"

Sysin.0 = 2
Sysin.1 = "SRCHFOR  'BLZDEMON'"
Sysin.2 = "SELECT BLZBKPZP,BLZBUILD,BLZCIVP,BLZCKHIS,BLZCLMM,BLZCNVRT"
Address TSO "EXECIO * DISKW SYSIN (STEM SYSIN. FINIS)"

PARMS = "SRCHCMP,ANYC"

Address LINKMVS 'ISRSUPC PARMS'

"EXECIO * DISKR OUTDD (FINIS STEM outdd."
```

Address 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://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.isfa500/toc.htm
- And: **Implementing REXX Support in SDSF**
  http://www.redbooks.ibm.com/abstracts/sg247419.html?Open
- Examples:

```
rc=isfcalls('ON')
mycmd.0=1
mycmd.1="D IKJTSO,AUTHPGM"
Address SDSF ISFSLASH "("mycmd.") (WAIT)"
Say RC
/* List any error messages */
Say "isfmsg is:" isfmsg
Say "isfmsg2.0 is:" isfmsg2.0
if datatype(isfmsg2.0) = "NUM" then
  do ix=1 to isfmsg2.0
    Say "isfmsg2."ix "is:" isfmsg2.ix
  end
rc=isfcalls('OFF')
/* get output */
do i = 1 to ISFULOG.0
  say ISFULOG.i
end
```

Address SDSF (cont)

```
rc=isfcalls('ON')
/* Access the ST display */
isfprefix = 'BLZGO1'
Address SDSF "ISFEXEC ST"
/* Loop for all running BLZJMON jobs */
Do ix=1 to JNAME.0
  if JNAME.ix = "BLZGO1" & QUEUE.ix = "EXECUTION" & ACTSYS.ix <> "" then
  Do
    /* Issue the ? (JDS) action against the  */
    /* row to list the data sets in the job. */
    Address SDSF "ISFACT ST TOKEN('"TOKEN.ix"') PARM(NP ?)" ,
       "( prefix jds_"

    /* Find the SYSOUT data set and allocate it   */
    /* using the SA action character              */
    Do jx=1 to jds_DDNAME.0
      if jds_DDNAME.jx = "STDOUT" then
      Do
        Address SDSF "ISFACT ST TOKEN('"jds_TOKEN.jx"')" ,
          "PARM(NP SA)"

        /* Read the records from the data set and list them. */
        /* The ddname for each allocated data set will be in */
        /* the isfddname stem.  Since the SA action was done */
        /* from JDS, only one data set will be allocated.    */
        Do kx=1 to isfddname.0
          Say "Now reading" isfdsname.kx
          "EXECIO * DISKR" isfddname.kx "(STEM line. FINIS"
          Say "  Lines read:" line.0
          Do lx = 1 to line.0
            Say "  line."lx "is:" line.lx
          end
        end
      end
    end
  end
end
rc=isfcalls('OFF') "
```

Address 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://www-01.ibm.com/support/knowledgecenter/SSEPEK_11.0.0/com.ibm.db2z11.doc.apsg/src/apsg/db2z_apsg.dita
- Examples:

```
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

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

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

- 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

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*

See: *Security Server RACF Macros and Interfaces –*

http://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.icha300/toc.htm

```
class = 'STARTED'
profile = ‘BLZBFA.*'
rc=IRRXUTIL("EXTRACT",class,profile,"RACF","","FALSE")
racfUser  = RACF.STDATA.USER.1
racfGroup = RACF.STDATA.GROUP.1
```

Common code constructs used

- PARSE
- Compound variables

PARSE – Key Instructions : ARG

- ARG
  - Retrieves the argument strings provided to a program or internal routine and assigns them to variables
  - ARG by itself is a short form of PARSE UPPER ARG
  - Examples:

```
Arg HLQ TEAMHLQ LANG TR
```

```
Parse Arg WSUUID BLZZHUID BLZZLNME BLZZHNME
```

```
Parse Arg EditDsn '(' EditMem ')'
```

```
Parse arg Module '"'manifest'"' '"'ziploc'"' '"'pkgzip'"`,
                 '"'restore'"' '"'builddefVersion'"',
                 '"'runtimeVersion'"' '"'tstamp'"`,
                 '"'traceOption'"'.
```

PARSE – Key Instructions : PULL

- PULL
  - Reads a string from the head of the external data queue
  - PULL by itself is a short form of PARSE UPPER PULL
  - Example

```
Say 'Unable to determine HLQ for the SBLZEXEC installed dataset'
Say 'Please enter correct HLQ ? (eg: BLZ.V5)'
Pull hlq
If hlq = '' Then
Do
  Say 'No High Level Qualifier entered .. processing ends'
  Exit 8
End
```

PARSE – Key Instructions : Templates

- PARSE
  - Allows the use of a template to split a source string into multiple components
  - Full Syntax:

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

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

PARSE – Key Instructions : Templates

- Simple Templates
  - Divides the source string into blank-delimited words and assigns them to the variables named in the template
  - A period is a placeholder in a template – a “dummy” variable used to collect unwanted data

```
ex 'dohertl.v6dev.sblzexec(blzcinit)' 'dohertl.v6dev dohertl.v6conf enu'
```

```
Parse Upper Arg parms
Parse Var parms hlq usrhlq LANG .
If LANG = '' Then LANG = 'ENU'
```

parms	= ‘DOHERTL.V6DEV DOHERTL.V6CONF ENU’
hlq	= ‘DOHERTL.V6DEV’
usrhlq	= ‘DOHERTL.V6CONF’
LANG	= ‘ENU’

PARSE – Key Instructions : Templates

- String Pattern Template
  - A literal or variable string pattern indicating where the source string should be split
  - Literal example

```
string = `  Parse the    blank-delimited   string'
parse var string var1 `-' var2 .
```

  - Variable example

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

  - Result

var1 → '   Parse the   blank'
var2 → 'delimited'

PARSE – Key Instructions : Templates

- Positional Pattern Templates
  - 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 = ‘Doherty            Liam           Australia  ’
parse var string 1 surname 20 chrname 35 country 46 .
surname -> ‘Doherty            ’
chrname -> ‘Liam           ’
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 = ‘Doherty            Liam           Australia  ’
parse var string 1 surname +19 chrname +15 country +11 .
surname -> ‘Doherty            ’
chrname -> ‘Liam           ’
country -> ‘Australia  ’
```

PARSE – Key Instructions : Templates

- RTC ISPF Client usage
  - RTC used numerical positioning to pull the value of “special” characters out of a returned JSON string. Then use those characters as variable substitution in subsequent parsing instructions:

```
Parse Var Result junk 'returnValue' var2 +23 Specials +6
Specials = Substr(Specials,1,6)

BLZSQBOP = Substr(Specials,1,1)
BLZSQBCL = Substr(Specials,2,1)
BLZCUBOP = Substr(Specials,3,1)
BLZCUBCL = Substr(Specials,4,1)
BLZTSLAC = Substr(Specials,5,1)
BLZDBQTE = Substr(Specials,6,1)

Parms = ''
Result = BLZDEMON('BLZC010' 'getApplId' Parms)
Parse Var Result APPLI_RC . BLZDBQTE'returnValue'BLZDBQTE':',
                 Result
```

What is a Compound variables

- 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 variables 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               → 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
```

Processing Compound variables

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

```
sqlin.0 = 3
sqlin.1 = "  SELECT *"
sqlin.2 = "    FROM SYSIBM.SYSUSERAUTH"
sqlin.3 = "   WHERE GRANTEE = 'DOHERTL'"
"ALLOC F(SYSIN) NEW RECFM(F B) LRECL(80) SP(1 1) TRACKS"
"EXECIO * DISKW SYSIN (FINIS STEM sqlin."
```

```
"EXECIO * DISKR SYSPRINT (STEM cmdout. FINIS "
```

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

```
x = outtrap(profile.)
Address TSO "PROFILE"
x = outtrap('OFF')
Parse var profile.1 . 'PREFIX(' BLZTSOPR ')' .
```

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

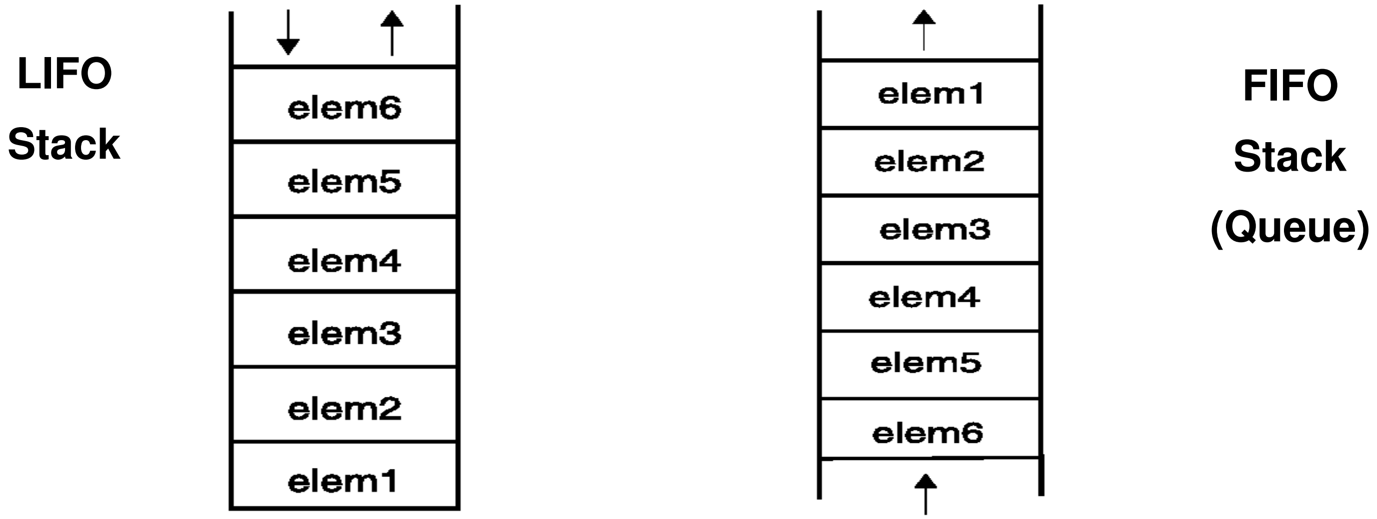
```
Address TSO "ALLOC F(INDD) DA('DOHERTL.EXEC(ATOMIC)') SHR"
"EXECIO * DISKR INDD (STEM rec. FINIS"
Do i = 2 To rec.0
  Parse Var rec.i symbol atomic#.symbol name.symbol weight.symbol
End
Say "Which atomic symbol do you want to learn about?"
Parse Pull symbol
symbol = Translate(symbol)
Say "The name of" symbol "is" name.symbol"."
Say "The atomic number for" symbol "is" atomic#.symbol"."
Say "The atomic weight of" symbol "is" weight.symbol"."
```

Less common code constructs used

- Data Stacks
- Interpret
- Sockets

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()
```

Data Stacks usage examples #1

- Running SQL and displaying output

```
subSys   = 'DSNA'
sqlin.0 = 3
sqlin.1 = "   SELECT NAME"
sqlin.2 = "     FROM SYSIBM.SYSPLAN"
sqlin.3 = "    WHERE NAME LIKE 'DSN%'"
"ALLOC F(SYSIN) NEW RECFM(F B) LRECL(80) SP(1 1) TRACKS"
"EXECIO * DISKW SYSIN (FINIS STEM sqlin."
"ALLOC F(SYSPRINT) TRACKS SPACE(5,5) UNIT(VIO) NEW"

/* Run DSNTEP2 to run SQL */
"NEWSTACK"
queue "RUN PROGRAM(DSNTEP2) PLAN(DSNTEP10) LIB('DBAWK1.RUNLIB.LOAD')"
queue "END"
"DSN SYSTEM ("subSys")"
db2_rc = rc
"DELSTACK"

"EXECIO * DISKR SYSPRINT (STEM cmdout. FINIS "
Do co = 1 to cmdout.0
  say cmdout.co
End
"FREE F(SYSPRINT)"
"FREE F(SYSIN)"
```

Data Stacks usage examples #2

- Running DB2 commands and displaying output

```
Command = '-DIS DDF'

X = OUTTRAP('db2out.')
queue Command
queue "End"
Address TSO "DSN SYSTEM(DSNA)"
If rc /= 0 Then
Do
  /* Clear the command queue so we don't exit with an error */
  Do x = 1 to Queued()
    Pull oldStuff
  End
End
X = OUTTRAP('OFF')
Do i = 1 to db2out.0
  Say db2out.i
End
```

Data Stacks usage examples #3

- Reading a file, uppercase certain words, rewrite file

```
Address TSO "ALLOC F(GMLUP) DA('"ToDataset"("Member")') SHR"
Do queued();Pull;End       /*Insure a clean stack */
'EXECIO * DISKR GMLUP (STEM INPUT. FINIS'
Do i = 1 to input.0
   If Pos('<:ENTITY',input.i) <> 0 Then
   Do
      Parse var input.i '<:ENTITY' entity sysstr transtg
      If strip(sysstr) = 'system' | strip(entity) = '%' Then
         Upper input.i
      Else
      Do
         transtg = sysstr transtg
         Upper transtg
         input.i = '<:ENTITY' entity transtg
      End
      Queue input.i
   End
   Else
   Do
      Upper input.i
      Queue input.i
   End
End
'EXECIO' queued() 'DISKW GMLUP (FINIS'
```

Other Data Stack functions

- **MAKEBUF**
  - All elements added after a MAKEBUF command are placed in the new buffer
  - MAKEBUF basically changes the location the QUEUE instruction inserts new elements
- **DROPBUF**
  - Removes a buffer from 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
- **QBUF**
  - The QBUF command is used to find out how many buffers have been created
- **QELEM**
  - The QELEM command is used to find out the number of elements in the most recently created buffer
- **NEWSTACK**
  - protect data stack elements from being inadvertently removed by creating a new private data stack
- **DELSTACK**
  - Removes the most recently created data stack
- **QSTACK**
  - returns in the variable RC the number of data stacks (including the original stack)

Data Stacks

- **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

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

Interpret

- Expression specified with the INTERPRET instruction is evaluated and then the resulting value is processed (interpreted)
- Given the following input data read from a file:
  `<cfg:InclCond>SHARE = "Seattle"</cfg:InclCond>`

```
Share = 'Seattle'

Address TSO "ALLOC F(INDD) DA('DOHERTL.EXEC(COND)') SHR"
"EXECIO * DISKR INDD (STEM rec. FINIS"
Address TSO "FREE  F(INDD)"

Parse var rec.1 "<cfg:InclCond>"cond"</cfg:InclCond>"

continue = 'N'
Cond = 'If 'Cond 'then continue = "Y"'

/* Execute the statement just created */
Interpret Cond

If continue /= 'Y' Then
  Exit 0
Else
  Say 'Running at SHARE Seattle'
```

Interpret

- Interpret Can provide powerful test and debugging capabilities

```
Address ISPEXEC
'VGET (BLZTRACE) SHARED'

Parse var BLZTRACE TraceOn '(' TraceMod ')'
TraceCmd = ''
If Substr(TraceOn,1,5) = 'TRACE' Then
Do
  modname = 'BLZAWI'
  If TraceMod = 'ALL' | TraceMod = modname Then
  Do
    Say "*** Tracing activated for "modname "on "Date('N') ||,
        " at "Time()" ***"
    Select
      When (TraceOn = 'TRACE?I') Then TraceCmd = 'Trace ?i'
      When (TraceOn = 'TRACEI')  Then TraceCmd = 'Trace i'
      Otherwise NOP
    End
  End
End
Interpret TraceCmd
```

REXX Sockets

- **Requirement for Socket protocol**
  - RTC needed to remove it's dependency on cURL
  - We used a Java daemon, running on a Port, to serve requests to an RTC server using the cURL request
  - In replacing cURL, Sockets were the obvious candidate
  - There are already plenty of materials, also from SHARE, on REXX sockets, just google "REXX Sockets".
  - See the z/OS Communications Server: IP Sockets Programming interface Guide and Reference:

    http://www-01.ibm.com/support/knowledgecenter/SSLTBW_2.1.0/com.ibm.zos.v2r1.hala001/toc.htm

  - The ISPF Client would build a request for an internal API and send it to the daemon running on a port, via the socket.
  - The daemon would return the result in a JSON string read from the socket

REXX Sockets

- Open Socket

```
Host = '127.0.0.1'
Port = '7333'
/*--------------------------------------------------------------*/
/* Initialize the socket                                        */
/*--------------------------------------------------------------*/
Result = Socket('Initialize',USER)

/*--------------------------------------------------------------*/
/* Establish the socket                                         */
/*--------------------------------------------------------------*/
Result = Socket('Socket', 'AF_INET', 'STREAM', 'TCP')

/*--------------------------------------------------------------*/
/* Set Socket descriptor                                        */
/*--------------------------------------------------------------*/
Sdesc = sres

/*--------------------------------------------------------------*/
/* Enable EBCDIC-ASCII conversion                               */
/*--------------------------------------------------------------*/
Result = Socket('SetSockOpt',sdesc,'SOL_SOCKET','SO_ASCII','On')

/*--------------------------------------------------------------*/
/* Connect the socket                                           */
/*--------------------------------------------------------------*/
Result = Socket('Connect', sdesc, 'AF_INET' Port Host)
```

REXX Sockets

- Send Request

```
Command = Method Service "HTTP/1.1" ||CRLF
Command = Command"User-Agent: ISPF" ||CRLF
Command = Command"Host: "BLZLPBAK":"Port ||CRLF
Command = Command"Accept: */*"||CRLF
Command = Command"X-Secret-Key:"Key||CRLF

if (Method = "POST") Then
Do
  Command = Command"Content-Type:application"
  Command = Command"/x-www-form-urlencoded"||CRLF
  Command = Command"Content-Length:"lgParameters||CRLF||CRLF
  Command = Command||Parameters
End
Command = Command||CRLF
Result = Socket('Send', sdesc, Command,'')
```

REXX Sockets

- Receive response

```
/*-------------------------------------------------------------*/
/* Receive response in a non-blocking socket                   */
/*-------------------------------------------------------------*/
Result = Socket('Fcntl',sdesc,'F_SETFL','NON-BLOCKING')
mask = 'READ 'sdesc
Result = Socket('SELECT',mask, Timeout)
numTotal = 0;receivedTotal = '`;messagelength = -1
Do forever
  fc = SOCKET('READ',sdesc,'8000')
  parse var fc read_rc num_read_bytes received_string
  /* Complete message involved */
  if read_rc <> 0 | numTotal = messagelength then leave
  else
  do
    numTotal = numTotal + num_read_bytes
    receivedTotal = receivedTotal||received_string
    if messagelength = -1 Then
    do
      parse var received_string . "Content-Length: "contentlength (CRLF) .
      headerlength = Length(received_string)
      Do While received_string <> ''
        Parse Var received_string Line (LF) received_string
        if length(Line) <= 1 Then Leave
      End
      headerlength = headerlength - Length(received_string)
      messagelength = headerlength + contentlength
    end
  End
End
```

REXX Sockets

- Close Socket

```
Result = Socket('CLOSE', sdesc)
parse var Result src sres
If src <> 0 then
  return

Result = Socket('Terminate',USER)
```