Language Environment for Dummies

Thomas Petrolino
IBM Poughkeepsie
tapetro@us.ibm.com

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Agenda

- What is a Run-time Library?
- Why LE?
- LE Terminology
- LE CEL Functions
- Setting Run-time Options
- Appendix
What is a Run-Time Library?

- A Run-time Library works together with the code produced by a compiler to provide functionality for an application
  - Obtain and manage storage
  - Read and write data
  - Perform math calculations

- There are advantages to providing function in a Run-time Library
  - Greatly reduces need for the compilers to generate the code
  - Shields the languages from needing detailed knowledge of the underlying operating system and hardware
  - Greatly reduces the need to recompile and re-link when fixes are required to run-time functions
So, Why Language Environment?

Since their creation, customers were having trouble getting COBOL and PL/I to play nicely together

- COBOL and PL/I each designed to be stand-alone, unaware of each other
  - When leaving a COBOL program to return to a PL/I program, the COBOL library might free storage that PL/I still wanted
  - Language-specific Math Libraries produced different results

- Customers at GUIDE and SHARE worked with IBM to design a solution
  - The result: Language Environment
Time to make the doughnut…

- Pre-LE environment
  - 4 independent products
  - upward incompatibilities
  - loose adherence to standards
  - purely a customer application enabler

- LE environment
  - 1 product for z/OS (also z/VM and VSE)
  - 100% upward/downward compatibility
  - strict adherence to standards
  - part of the z/OS base
  - exploiters include USS, TCP/IP, BCPii, LOTUS Domino, WebSphere, etc…
Other Advantages

- Language Environment not only helped the languages to cooperate with each other, but also allowed member languages to share each other’s features. For example:

  - COBOL can use the C and PL/I condition handling infrastructure
  - Storage managed in a 'common' fashion
  - All languages now access the excellent Fortran library math routines
  - “hybrid” languages – Enterprise PL/I
Language Environment for z/VM, z/OS, VSE

Source Code
- PL/I
- COBOL
- C/C++
- Fortran
- Assembler

Compilers
- PL/I
- COBOL
- C/C++
- Fortran
- ASM

Operating Environments
- IMS
- TSO
- Batch
- CICS
- DB2
- UNIX System Services

Operating Systems
- z/OS
- VSE
- z/VM

no run-time required
LE Terminology - Program Management

- **main program** – the routine that causes the LE environment to be initialized
- **routine** either a procedure, function, or subroutine
  
  Equivalent HLL terms:
  - COBOL - program
  - C/C++ - function
  - PL/I - procedure, BEGIN block

- **ILC** – inter-language communication – application contains a mixture of languages, which introduces special issues
  - how the languages' data maps across load module boundaries
  - how conditions are handled
  - how data can be passed and received by each language
LE Terminology - Program Management

- **member language** – a high-level language that is compiled with an LE-supported compiler
- **member event handler** - member-supplied routine that is called at various times as a program runs when a significant event has occurred, or when the environment needs some information that is held by the member
- **LE-Enabled** - Routine that can run with LE run-time, and may also run with previous run-times. Cannot make use of Language Environment callable services.
- **LE-Conforming** - Routine that can run only with the LE run-time library. Can make use of LE callable services.
**LE Terminology – Callable Services**

- **LE Callable Services** – programmatic way of utilizing LE services
  - AWI - Application Writer Interface
  - CWI - Compiler Writer Interface
  - CEE prefixed – general to all platforms
  - CEE3 prefixed – specific to only z/OS
LE Terminology – Program Model

- **region** - the range of storage the application set runs in
- **process** - set of applications that accomplish a task
- **enclave** - an application - set of modules that accomplish some subtask
- **thread** - dispatchable unit of work that shares storage with others in the enclave
LE Terminology - Program Model

region

process

enclave

main

sub

Sub

enclave

main

sub

Sub
LE Terminology - MVS 'Model'

region - address space

process - application

enclave - pgm - enclave

main

sub

sub

sub
LE Terminology – Multi-threading 'Model'

- region
- process
- enclave
- thread
- main
- sub
- sub
- sub
- sub
CICS Terminology

- **region** - the range of storage the application set runs in
- **transaction** - set of applications that accomplish a task
- **run-unit** - an application - set of modules that accomplish some subtask
LE Terminology - CICS 'Model'

region - Region

process - Transaction (Thread)

enclave RunUnit enclave

main sub
sub sub
sub sub
LE CEL Functions

- CEL is a set of common functions and routines used by all member languages of LE
  - Initialization/Termination
  - Storage Management
  - Condition Handling
  - Message Services
  - Date/Time Services
  - Math Functions

- Behavior customizable by the use of Run-time Options
Common LE Functions – Initialization/Termination

- LE code linked with the module begins a bootstrap process to initialize LE
  - initial storage is obtained
  - LE Program Model levels are built
    - active member language specific run-time is initialized via event handler calls
- Control is given to the application code
- Once the application ends and 'returns' to LE
  - The LE environment is terminated via cleanup of Program Model levels
  - System resources obtained during initialization and throughout the execution of the application are cleaned up
Common LE Functions - Storage Management

LE manages two types of storage for use by the application (and itself):

- HEAP - used for COBOL WORKING-STORAGE, C malloc, and PL/I ALLOCATE requests
- STACK - module linkage (save areas), C and PL/I automatic variables, COBOL LOCAL-STORAGE

Initial storage is obtained with one GETMAIN and managed internal to LE
**Common LE Functions - Condition Handling**

- **Condition** - Any change to the normal flow of a program
  - a.k.a. exception, interruption
  - Could be detected by hardware or software (ours or yours)

- **Condition Handler** – A routine called by LE to respond to a condition
  - Registered by application using CEEHDLR, or part of a member language semantics, such as PL/I ON statements

- **Condition Handler Response**
  - **Resume** – after corrective action taken, control returns to a ‘resume cursor’
    - Either back to point of failure, or to a new resume point set by the condition handler
  - **Percolate** - decline to handle the condition, LE calls next condition handler
  - **Promote** - change condition meaning and percolate
Common LE Functions - Condition Handling

- Diagnostic Documentation
  - Messages (same as module prefixes)
    - CEE  CEL
    - IGZ  COBOL
    - IBM  PL/I
    - AFH  FORTRAN
    - EDC  C/C++
  - ABEND Codes
    - User ABENDs U4000-4095 reserved by LE
    - Usually have reason codes to help isolate the problem
- CEEDUMP and/or system dump
- Run-time Options Report
- Run-time Storage Report
Common LE Functions - Message Services

- allows HLLs to 'issue' common messages
- messages written to a common place - LE's MSGFILE
- can be formatted in:
  - Mixed-case American English (ENU)
  - Uppercase American English (UEN)
  - Japanese (JPN)
Common LE Functions – Date/Time Services

- provides a consistent 'answer' when requesting date and time from the running system
- format date and time by country code
- parse date and time values
- convert between different formats (Gregorian, Julian, Asian, etc)
- calculate days between dates, elapsed time
- get local time
- handle 2 year dates as part of Y2K solution
Common LE Functions – Math Services

- derived from FORTRAN math functions
- binary, single floating point, double floating point, IEEE support
- See the LE Programming Reference for a complete list
Run-Time Options

- Allows users to specify how Language Environment behaves when an application runs
  - Performance tuning
  - Error handling characteristics
  - Storage management
  - Production of debugging information
- May be set in many different locations with varying scopes
Setting Run-Time Options

- The default RTOs for applications across all systems
  - IBM-supplied defaults
    - Base set of values for Language Environment RTOs
    - Note: RTO ++USERMODs have been eliminated as of V2R1!
  - To set default RTOs for applications on one or more systems
    - System defaults
      - Options specified in a PARMLIB member (CEEPRMxx)
      - Options specified with an operator command (SETCEE)
  - To affect applications running within a region
    - Region Level Overrides (CEEROPT/CELQROPT)
      - CICS TS, LRR users (e.g. IMS), also Batch
      - Separate module loaded at run-time during region initialization
      - CLER transaction for CICS environment (RTO subset)
Setting Run-Time Options

To provide RTO settings for a specific application:

- **Application Level Overrides** (CEEUOPT/CELQUOPT)
  - CSECT linked with the application

- **Programmer Overrides**
  - #pragma runopts for C/C++
  - PLIXOPT for PL/I

To provide RTO settings for a given run of an application:

- **Program Invocation Overrides**
  - USS shell: export _CEE_RUNOPTS=‘run-time options’
  - In batch, on EXEC card: PARM=

- **DD:CEEEOPTS Overrides**
  - Optional data set in which run-time options may be specified
Setting Run-Time Options

- Options Merge (priority)
  - Program Invocation Overrides
  - DD:CEEOPTS Overrides
  - Programmer Overrides
  - Application Level Overrides
  - Region Level Overrides (where applicable)
  - System Defaults (CEEPRMxx and SETCEE)
  - IBM-Supplied Defaults

- For more information on setting run-time options, see Appendix
Key Run-Time Options

• Subtopics

• Tuning
  • Additional Information in SHARE sessions:
    • Look What I Found Under the Bar! (Tue 11:15AM)

• Diagnostics
  • Additional Information in SHARE sessions:
    • Finding Debugging Clues in LE Dumps (Wed 8:30AM)
    • Heap Damage, Get Into the Zone! (Fri 10:00AM)
Key Run-Time Options - Tuning

• ALL31 (option)
  • ON For AMODE 31 programs
  • OFF For AMODE 24 programs
    (can be determined dynamically)
Key Run-Time Options - Tuning

- ANYHEAP(initial, increment, location, disp)
- BELOWHEAP(initial, increment, disp)
- HEAP(initial, increment, location, disp, init24, incr24)
  - initial Minimum size of initial heap segment
  - increment Minimum size of additional segments
  - location BELOW (<16MB), ANYWHERE
  - disp KEEP, FREE (action when empty)

- Notes:
  - ANYHEAP/BELOWHEAP used internally by Language Environment
  - HEAP – used for application-related storage
    - COBOL WORKING-STORAGE (for RENT programs)
    - Dynamic storage (C malloc, C++ new, PL/I ALLOCATE)
Key Run-Time Options - Tuning

• STACK(init, incr, location, disp, dsinit, dsincr)
  • init Actual size of initial stack segment
  • incr Minimum size of additional segments
  • location BELOW, ANYWHERE
  • disp KEEP, FREE (action when empty)
  • dsinit XPLINK initial stack
  • dsincr XPLINK increment stack

• Notes:
  • Used for Dynamic Save Areas / Stack Frames
    • C/C++ and PL/I local variables, COBOL LOCAL-STORAGE
  • Must use STACK(,,BELOW) when running ALL31(OFF)
Key Run-Time Options - Tuning

• RPTSTG(option)
  • OFF  Storage report not requested
  • ON   Generates a report of stack/heap usage
    • including recommended settings

• Caution:
  • Use only for application tuning. Do not make RPTSTG(ON) system wide default due to significant performance impact.

Consider CICS TS dynamic storage tuning as an alternative.
Key Run-Time Options - Diagnostics

• TERMTTHDACT(option)
  • QUIET  Messages off, no dump
  • MSG  Messages only, no dump
  • TRACE  CEEDUMP with traceback only
  • DUMP  CEEDUMP
  • UADUMP  CEEDUMP, optional system dump
  • UAONLY  System dump only, no CEEDUMP
  • UATRACE  System dump and traceback

• Notes:
  • SYSMDUMP DD card required for system dump
    (unless DYNDUMP is being used)
Key Run-Time Options - Diagnostics

- **DYNDUMP**(hlq,U4039 Behavior,U40xx Behavior)
  - hlq – may be user-specified, or:
    - *USERID | *USERID.hlq
    - *TSOPREFIX | *TSOPREFIX.hlq
  - **U4039 Behavior** - with TERMTTHDACT(UADUMP/UAONLY/UARTRACE)
    - NODYNAMIC – Do not create IPCS-readable dump (default)
    - DYNAMIC – Create IPCS-readable dump if no other dump DD name
    - FORCE – Create IPCS-readable dump instead of other dumps
    - BOTH – Create IPCS-readable dump in addition to other dumps
  - **U40xx Behavior** – non-U4039 dumps
    - TDUMP – Create IPCS-readable dump (default)
    - NOTDUMP – Do not create IPCS-readable dump
Key Run-Time Options - Diagnostics

- **HEAPCHK**(ON|OFF, frequency, delay, level, call-depth, num-entries, pool-num)
  - **OFF** Normal processing
  - **ON** Checks HEAP structures on get/free
  - **frequency** How often the HEAP is checked
  - **delay** Number of get/free before starting
  - **level** Number of calls to be displayed in Heap Storage Diagnostic Report
  - **call-depth** Number of calls to be displayed for HEAPPOOLS Serviceability
  - **num-entries** Number of entries to be recorded in the heap pool trace table for the main user heap
  - **pool-num** ID of the heap pool to be traced
Key Run-Time Options - Diagnostics

• HEAPCHK(ON|OFF, frequency, delay, level, call-depth, num-entries, pool-num) (continued)
  • Caution:
    • Use only for application tuning/diagnostics. Do not make HEAPCHK(ON) system wide default due to serious performance impact.
  • Notes:
    • To generate only Heap Storage Diagnostic Report use, e.g.
      • HEAPCHK(ON,0,0,10,0)
    • To activate only HEAPPOOLS Serviceability use, e.g.
      • HEAPCHK(ON,0,0,0,5)
Key Run-Time Options - Diagnostics

- STORAGE(getheap, freeheap, stack, reserve)
  - getheap: One byte value used to initialize every heap allocation
  - freeheap: One byte value used to initialize every heap free
  - stack: One byte value used to initialize every stack allocation
  - reserve: Amount of space to reserve for out of storage condition processing
Key Run-Time Options - Diagnostics

• STORAGE(getheap, freeheap, stack, reserve) *(continued)*

Notes:
  • STORAGE(AA,EE,,) useful for debugging
    • When HEAPCHK(ON), free elements are checked to ensure they contain the freeheap value
  • STORAGE(00,,,) is equivalent to COBOL WSCLEAR
  • STORAGE(,,00,) vs. STORAGE(,,CLEAR,)
    • 00 is very expensive (especially for C/C++)
    • CLEAR sets to binary zeros the unused portion of the initial stack segment just prior to the “main” getting control
Key Run-Time Options - Diagnostics

• TRAP(option)
  • ON, SPIE  Condition handling enabled
  • ON, NOSPIE  Allows user applications to have their own SPIE routine, Language Environment condition handling will take place via the ESTAE
  • OFF  Condition handling disabled, some functionality not available (AVOID)

• Notes:
  • TRAP(ON, SPIE)  **highly** recommended for normal processing
Key Run-Time Options - Diagnostics

- **RPTOPTS**(option)
  - **OFF** Options report not requested
  - **ON** Generate a report of all current options (upon successful termination)

- **Notes:**
  - Automatically included in CEEDUMP
Other Good sessions

- COBOL V5.2 was Announced! What’s New? Mon 11:15AM
- What’s in the Just Announced Release of PL/I and C/C++ Mon 1:45PM
- Make Your PL/I&C/C++ Code Fly With The Right Compiler Options Mon 3:15PM
- An Introduction to IPCS for Application Programmers Tue 11:15AM
- High Level Assembler Bootcamp – Part 1 of 2 Tue 1:45PM
- How to Take Advantage of the COBOL V5 Compiler – Migration Tue 3:15PM
- RACF and REXX – A Marriage Made in Heaven! Tue 4:30PM
- Finding Debugging Clues in LE Dumps Wed 8:30AM
- Examples of Invoking HLAsm Exits and Why They Are Useful Wed 10:00AM
- High Level Assembler Bootcamp – Part 2 of 2 Wed 11:15AM
- Meet the Experts in LE and Languages! Wed 3:15PM
- REXX Language Coding Techniques Wed 4:30PM
- Dinner - LANG Project Rib Joint Expeditionary Force Wed 7:00PM
- Look What I Found Under The Bar! Thu 10:00AM
- An ISV’s Journey From AMODE 31 to 64 Assembler Thu 1:45PM
- Make SOA Possible in z/OS batch COBOL Thu 3:15PM
- Invoking REXX during High Level Assembly via SETCF Thu 4:30PM
- COBOL V5 Migration Strategies Fri 8:30AM
- Heap Damage, Get Into the Zone! Fri 11:15AM
Appendix

- Compilers Compatible With LE
- Compilers That Require LE
- The Life of a Module
- Setting Run-time Options
Compilers Compatible with LE

Object modules compiled with the following compilers will run with LE without having to be re-linked or if linked with LE do not need to be recompiled:

- C/370 Versions 1 and 2
- OS/VS COBOL Release 2
- VS COBOL II Release 3 or later
- OS PL/I Version 1 Release 3 (object modules), Version 1 Release 5.1 and Version 2, all releases (load modules)
- VS FORTRAN Versions 1 and 2 (MVS only)
- FORTRAN IV H Extended (MVS only)
- FORTRAN IV G1 (MVS only) for OS/390 VS FORTRAN and FORTRAN IV (in compatibility mode)
Compilers that Require LE

- z/OS XL C/C++
- OS/390 C/C++
- C/C++ Compiler for MVS/ESA(TM)
- AD/Cycle® C/370(TM) Compiler
- VisualAge for Java, Enterprise Edition for OS/390
- Enterprise COBOL for z/OS
- Enterprise COBOL for z/OS and OS/390
- COBOL for OS/390 & VM
- COBOL for MVS & VM (formerly COBOL/370)
- Enterprise PL/I for z/OS
- Enterprise PL/I for z/OS and OS/390
- VisualAge PL/I for OS/390
- PL/I for MVS & VM
- AD/Cycle PL/I for MVS & VM
- VS FORTRAN and FORTRAN IV (in compatibility mode)
The Life of a Module

LE libraries that may get involved:

SCEEMAC, SCEEH.*

SCEELKED, SCEELKEX, SCEEOBJ, SCEECPP, SCEELIB, SCEEBND2

SCEERUN, SCEERUN2, SCEELPA, SCEECICS
Setting Run-Time Options

- System defaults
  - Options may be specified in a PARMLIB member
    - CEEPRMxx
  - Options may be specified with an operator command
    - SETCEE
Setting Run-Time Options

- System defaults *(continued)*
- Specifying options in PARMLIB member
  - Member name CEEPRMxx
    - Member(s) specified at IPL time using CEE=xx via IEASYSxx or at the system parameters prompt
    - Can by dynamically changed via SET CEE=yy command
- Options specified in groups

```
CEEDOPT(ABPERC(NONE) ALL31(ON)
    rptopts(on) )   /* Options report */
CEEDOPT(ABPERC(NONE) ALL31(ON)
    CEEDOPT(anyheap(4k,4080,anywhere,free))
CEEDOPT(ALL31(OFF) ) /* Turn off this option */
```
Setting Run-Time Options

- System defaults (*continued*)
  - Using the SETCEE system command
    - Overrides the current system defaults
  - Usage
    - Specify one group per command
    - Up to 126 characters
    - Example:

      ```
      SETCEE ceedopt, rptstg(on), rptopts(on)
      ```
Setting Run-Time Options

- System defaults *(continued)*
  - Displaying the system defaults
    - D CEE displays the active members
      ```
      d cee
      CEE3744I 17.57.31 DISPLAY
      CEE=(JM)
      ```
    - D CEE,groupname displays the options for a particular group
      ```
      d cee,ceedopt
      CEE3745I 17.59.44 DISPLAY CEEDOPT
      CEE=(01)
      LAST WHERE SET OPTION
      -----------------------------------------------
      CEEPRM01       ENVAR("testing=roger","verify=1 2 3")
      CEEPRM01       HEAP(4194304,5242880,ANYWHERE,KEEP,
                      16384,16384)
      CEEPRM01       PROFILE(OFF,"XXX")
      CEEPRM01       RPTOPTS(ON)
      ```
Setting Run-Time Options

Region Level Overrides (CEEROPT)

- CICS TS and LRR users (e.g. IMS) only (pre-z/OS V1.10)
- Batch users (via CEEROPT/CELQROPT CEEPRMxx keyword) (V1.10)
- Separate load module dynamically loaded at run-time during region initialization
  - SCEESAMP(CEEWROPT)
- Must be found in search order, such as STEPLIB for IMS and batch, or DFHRPL for CICS TS
- Specify only those options you wish to change

CEEROPT CSECT 00110000
CEEROPT AMODE ANY 00120000
CEEROPT RMODE ANY 00130000
  CEEXOPT ALL31=((ON),OVR), x00170000
  STORAGE=((00,NONE,NONE,0K),OVR) 00210000
END
Setting Run-Time Options

- Region Level Overrides (CEEROPT) (*continued*)
  - Certain options can be overridden dynamically in CICS TS region via the CLER transaction
    - ALL31
    - CBLPSHPOP
    - CHECK
    - HEAPZONES
    - INFOMSGFILTER
    - RPTOPTS
    - RPTSTG
    - TERMTHDACT
    - TRAP
Setting Run-Time Options

- Application Level Overrides (CEEUOPT/CELQUOPT)
  - CSECT linked with the application
    - SCEESAMP(CEEWUOPT/CEEWQUOP)
  - Specify only those options you wish to change

```
CEEUOPT  CSECT                                                            00110000
CEEUOPT  AMODE ANY                                                      00120000
CEEUOPT  RMODE ANY                                                      00130000
    CEEXOPT  HEAP=(10M,10M,ANYWHERE,FREE),                         X00180000
              STACK=(1M,1M,ANYWHERE,KEEP)                              00250000
    END
```
Setting Run-Time Options

- Programmer Overrides
  - Compiled into program
    - `#pragma runopts` for C/C++
      ```
      #pragma runopts(ALL31(ON),ERRCOUNT(0),\
                      STACK(2M,1M,ANYWHERE,KEEP),\
                      HEAP(1M,500K,ANYWHERE,KEEP))
      ```
  - `PLIXOPT` for PL/I
    ```
    DCL PLIXOPT CHAR(140) VAR INIT('ALL31(ON)\n                                      ERRCOUNT(0) STACK(2M,1M,ANYWHERE,KEEP)\n                                      HEAP(1M,500K,ANYWHERE,KEEP)') STATIC EXTERNAL;
    ```
  - not available for COBOL
  - Internally generates CEEUOPT/CELQUOOPT
Setting Run-Time Options

- Program Invocation Overrides
  - In UNIX System Services shell (case sensitive)
    - `export _CEE_RUNOPTS='run-time options'`
  - In batch, on EXEC card
    - COBOL (with CBLOPTS(ON))
      - `PARM='program arguments/run-time options'`
    - C/C++, PL/I, FORTRAN, Language Environment-conforming Assembler
      - `PARM='run-time options/program arguments'`
    - First program must be Language Environment-conforming
    - The slash is required to delineate the run-time options, even when no program arguments.
    - Note that `PARM=` is limited to 100 characters
Setting Run-Time Options

- **DD:CEEOPTS Overrides**
  - Optional data set in which run-time options may be specified
  - Allows up to 3K characters
  - Allows run-time options to be passed to non-Language Environment conforming main routines

```plaintext
//MYAPPL01 EXEC
PROG=MYPRG, PARM='RPTOPTS (ON) '/
//CEEOPTS DD *
* THESE ARE MY OPTIONS:
  ALL31(ON), HEAP(64K),
  ENVAR("JOHN=MONTI"),
  TERMTHDACT(UADUMP)
/*