Language Environment for Dummies

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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, 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
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

- **USS Assembler Callable Services** – supported by the C/C++ specific portion of the Run-time
  - BPX prefixed
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'

Diagram showing the relationship between region, process, enclave, thread, main, sub, and 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

main

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
  - this LE instance 'registered' with UNIX System Services
  - condition handlers initialized
  - active member language specific run-time is initialized

- Control is given to the application code

- Once the application ends and 'returns' to LE
  - The LE environment is terminated
  - 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++
  - CEEDUMP and/or system dump
  - Run-time Options Report
  - Run-time Storage Report
Common LE Functions - Condition Handling

- LE Abend Codes
  - designated as USER abends
  - U4000-4095 - reserved for applications running under LE
  - many abends codes have associated reason codes to further isolate the problem
  - some abends are the result of LE problems while others are application problems
  - ‘special’ processing needed to generate U1000 style abend codes

- Additional information in SHARE Session:
  - Exploit Condition Handling in LE (Wed 9:30AM)
Common LE Functions - Message Services

- allows HLLs to 'issue' common messages
- messages written to a common place - LE's MSGFILE
- 'abstracts' system failures from the application
- 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

- To set default RTOs for applications across all systems
  - **Installation defaults** (CEEDOPT/CEECOPT/CELQDOPT)
    - SMP/E USERMOD used to update Language Environment modules
    - Note: USERMODs will be eliminated after V1R13!

- 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)
  - Installation Defaults (through V1R13)

- 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! (Mon 4:30PM)

• Diagnostics
  • Additional Information in SHARE sessions:
    • Introduction to IPCS for Application Programmers (Thu 8:00AM)
    • Finding Debugging Clues in LE Dumps (Thu 9:30AM)
    • Heap Damage, Is Your Insurance Up-to-Date? (Thu 4:30PM)
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

• TERMTHDACT(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 TERMTHDACT(UADUMP/UAONLY/UATRACE)
    - 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

- Full Speed Ahead with COBOL into the Future            Mon  11:00AM
- Look What I Found Under the Bar!                      Mon  4:30PM
- What’s New in Enterprise PL/I V4R3 and C/C++ V1.13   Tue  9:30AM
- REXX Language Coding Techniques                      Wed  8:00AM
- Exploit Condition Handling in LE                      Wed  9:30AM
- Make your PL/I and C/C++ Code FLY With the Right Compiler Options Wed  11:00AM
- COBOL Compiles on the Cloud                          Wed  3:00PM
- Language Environment Futures Workshop/AMODE 64 Discussion Wed  4:30PM
- Introduction to IPCS for Application Programmers      Thu  8:00AM
- Finding Debugging Clues in LE Dumps                   Thu  9:30AM
- COBOL Performance – Myths and Realities               Thu  1:30PM
- An Introduction to using REXX with Language Environment Thu  3:00PM
- Heap Damage, Is Your Insurance Up-to-Date?            Thu  4:30PM
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

Source Code

Assembler or compiler

Object modules

Program Mgmt Binder

Linkage Editor

PDSE

Program Objects or HFS

PDS

Load Modules

PM Batch Loader

Program in virtual storage ready for execution

LE libraries that may get involved:

SCEEMAC, SCEEH.*

SCEELKED, SCEELKEX,
SCEEOBJ, SCEECPP,
SCEELIB, SCEEBND2

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

- Installation defaults (CEEDOPT/CEECOPT/CELQDOPT)
  - Also referred to as system-wide defaults
  - SMP/E USERMOD to Language Environment modules
  - All options must be specified

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEDOPT CSECT</td>
<td>00110000</td>
</tr>
<tr>
<td>CEEDOPT AMODE ANY</td>
<td>00120000</td>
</tr>
<tr>
<td>CEEDOPT RMODE ANY</td>
<td>00130000</td>
</tr>
<tr>
<td>CEEOPT ABPERC= ( (NONE), OVR)</td>
<td>x00140000</td>
</tr>
<tr>
<td>ABTERMENC= ( (ABEND), OVR)</td>
<td>x00150000</td>
</tr>
<tr>
<td>AIXBLD= ( (OFF), OVR)</td>
<td>x00160000</td>
</tr>
<tr>
<td>ALL31= ( (ON), OVR)</td>
<td>x00170000</td>
</tr>
<tr>
<td>ANYHEAP= ( (16K, 8K, ANYWHERE, FREE), OVR)</td>
<td>x00180000</td>
</tr>
<tr>
<td>BELOWHEAP= ( (8K, 4K, FREE), OVR)</td>
<td>x00190000</td>
</tr>
</tbody>
</table>
Setting Run-Time Options

- System defaults
  - Options may be specified in a PARMLIB member
    - CEEPRMxx
  - Options may be specified with an operator command
    - SETCEE
  - Reduces the need to maintain USERMODs for CEEDOPT/CEECOPT/CELQDOPT
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(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(CEEWOPT)
  - 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

```plaintext
CEEROPT CSECT 00110000
CEEROPT AMODE ANY 00120000
CEEROPT RMODE ANY 00130000
  CEEXOPT ALL31=((ON),OVR),
    STORAGE=((00,NONE,NONE,0K),OVR)
  END 00210000
```
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
    - 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)\
                                       ERRCOUNT(0) STACK(2M,1M,ANYWHERE,KEEP)\
                                       HEAP(1M,500K,ANYWHERE,KEEP)') STATIC EXTERNAL;
  - not available for COBOL
  - Internally generates CEEUOPT/CELQUOPT
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)
/*
```