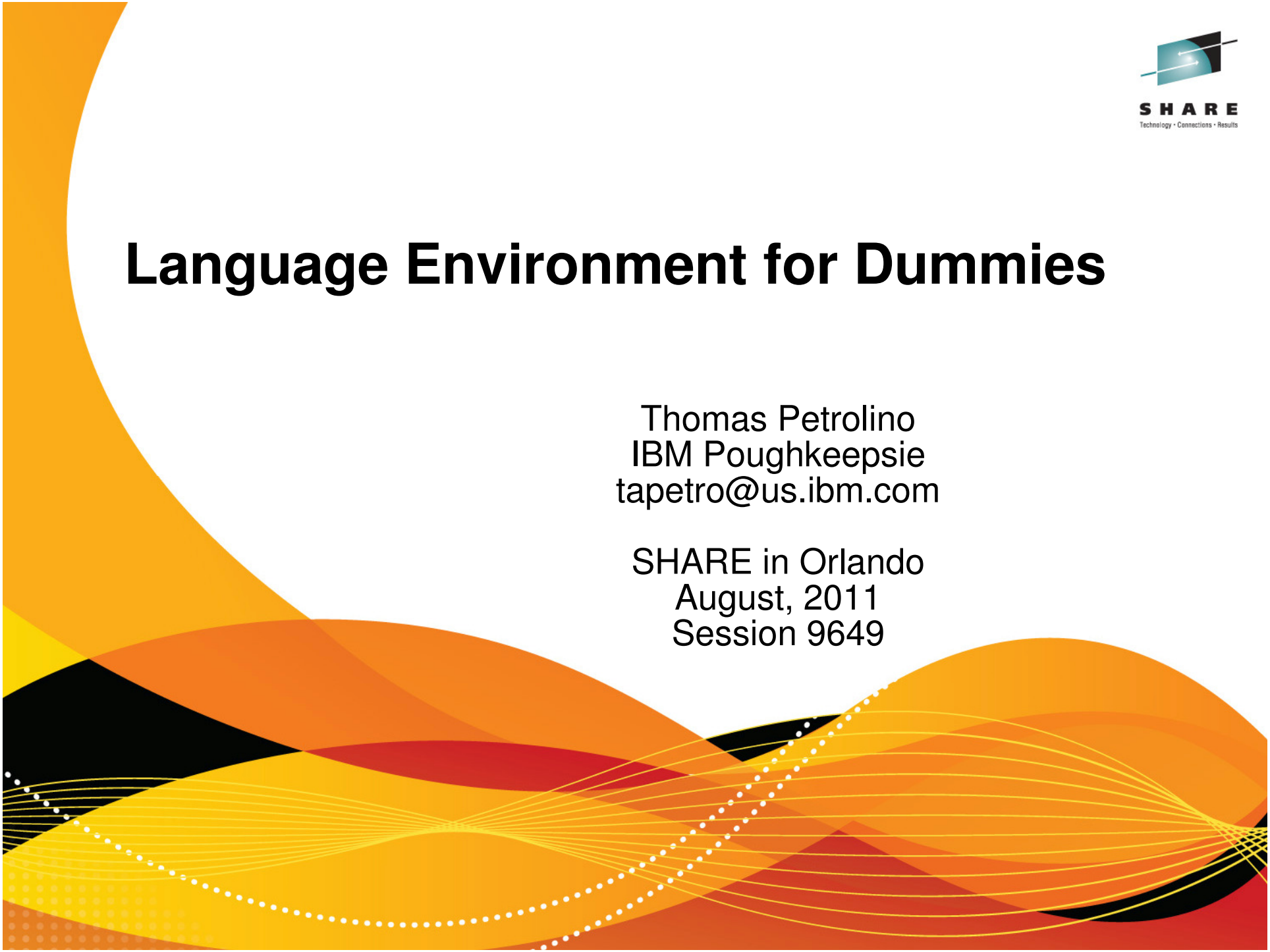

Language Environment for Dummies

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SHARE in Orlando
August, 2011
Session 9649

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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?

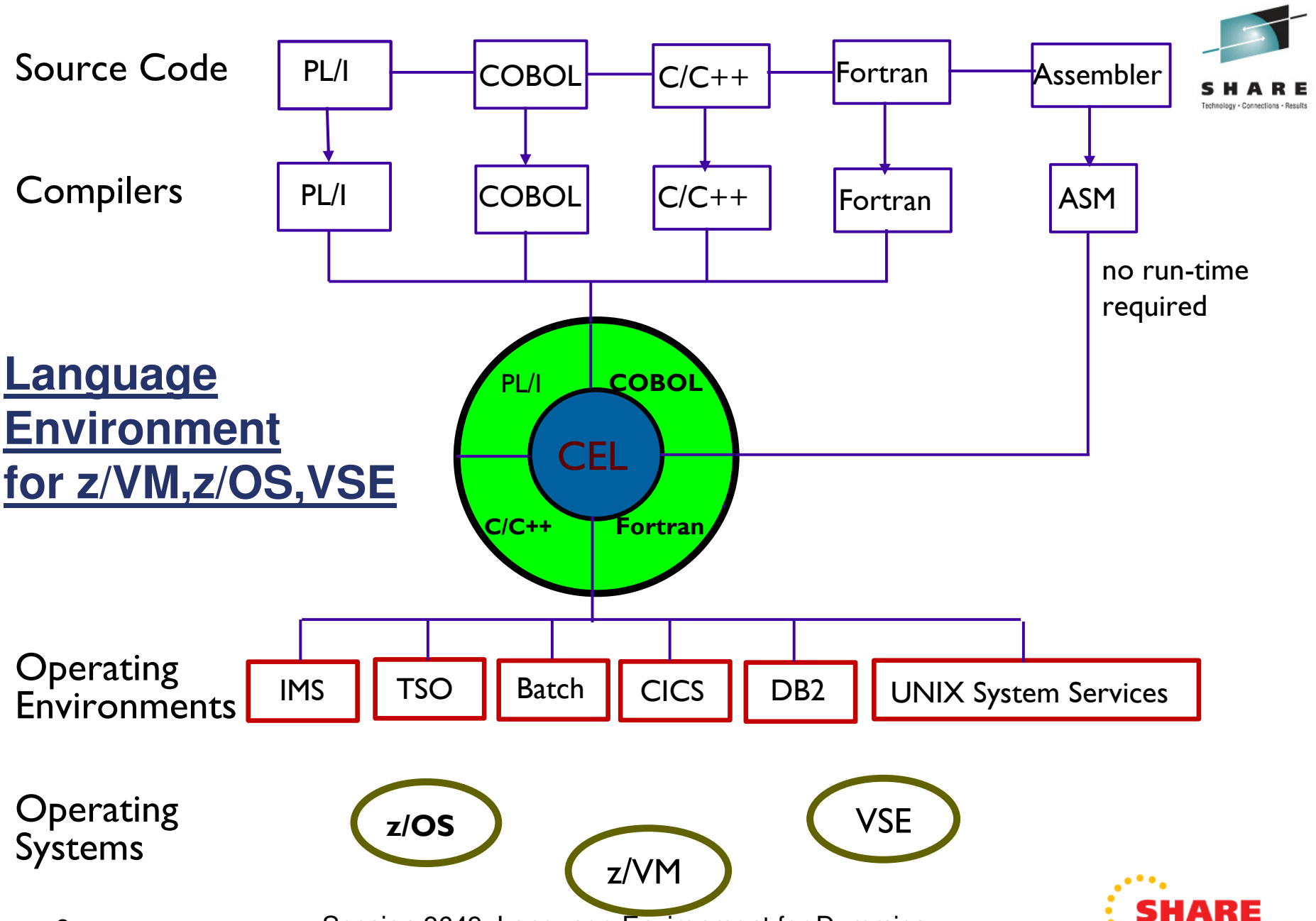
- Since their creation, customers were having trouble getting COBOL and PL/I to play nicely together
  - COBOL and PL/I each designed to be stand-alone, unaware of each other
    - When leaving a COBOL program to return to a PL/I program, the COBOL library might free storage that PL/I still wanted
    - 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


Source Code
PL/I
COBOL
C/C++
Fortran
Assembler
Compilers
PL/I
COBOL
C/C++
Fortran
ASM
no run-time required
Language Environment for z/VM,z/OS,VSE
PL/I
COBOL
CEL
C/C++
Fortran
Operating Environments
IMS
TSO
Batch
CICS
DB2
UNIX System Services
Operating Systems
z/OS
z/VM
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

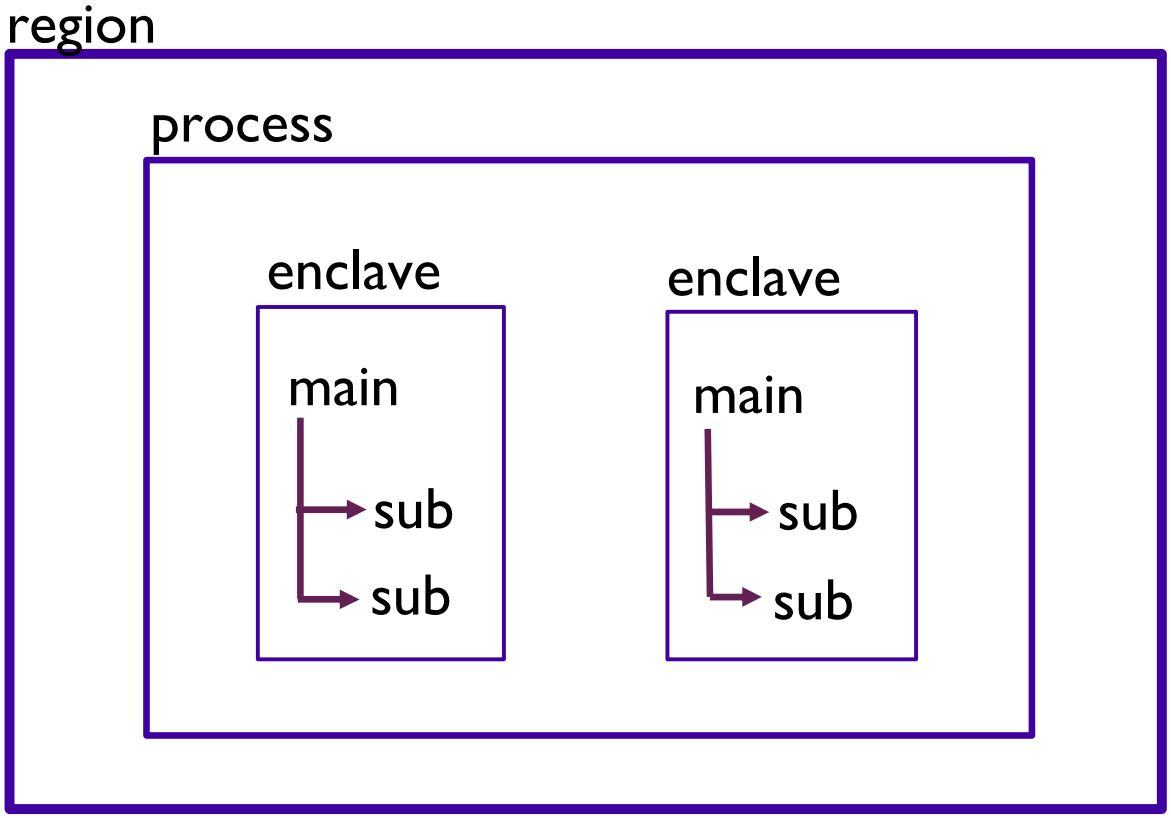
  - SHARE Session: Introducing LE Callable Services, plus a User's View of Why and How You Should Exploit Them in Your Applications – Fri 9:30AM

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

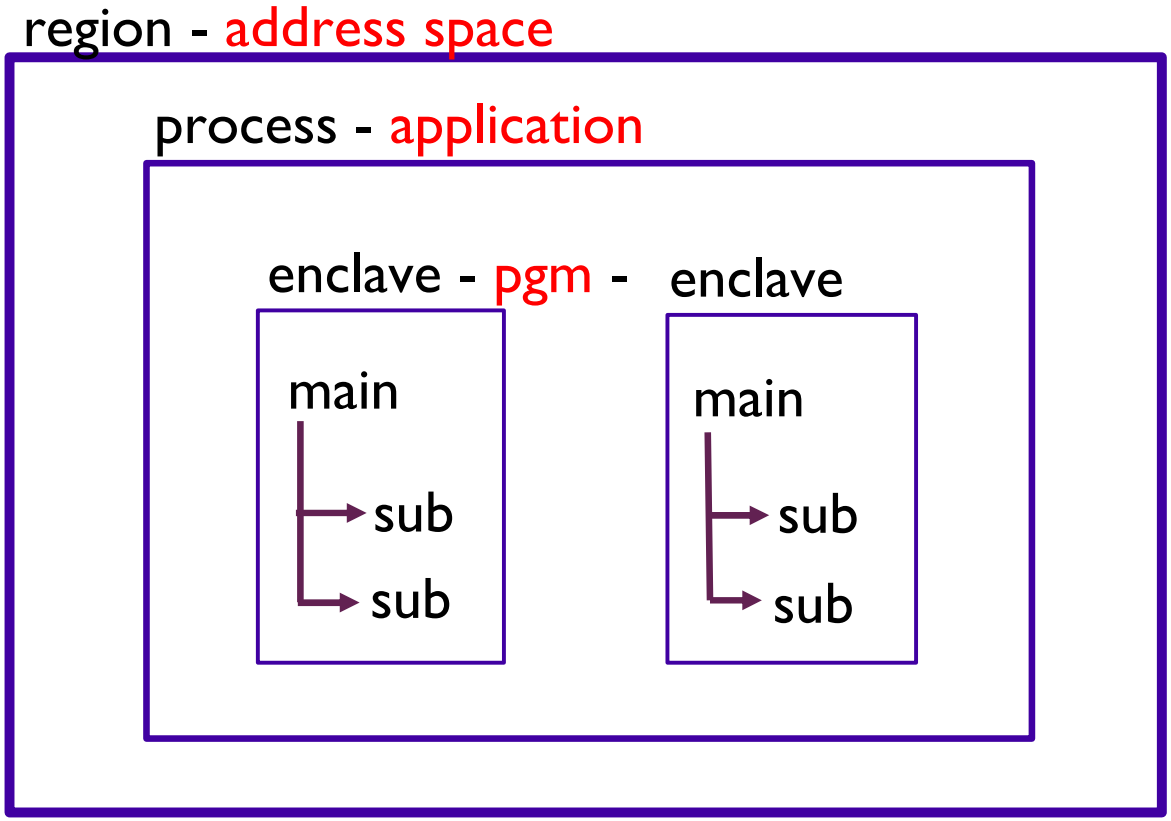
LE Terminology – Program Model

- **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

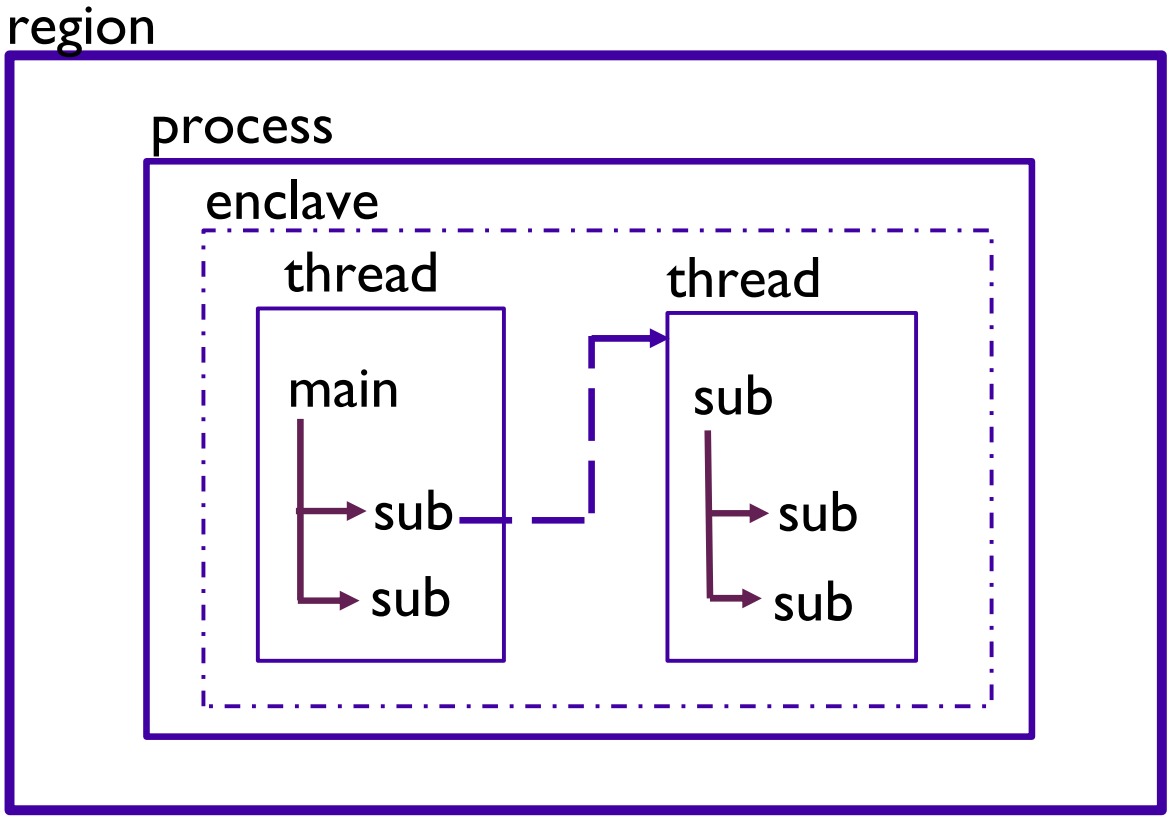
LE Terminology - Program Model



LE Terminology - MVS 'Model'



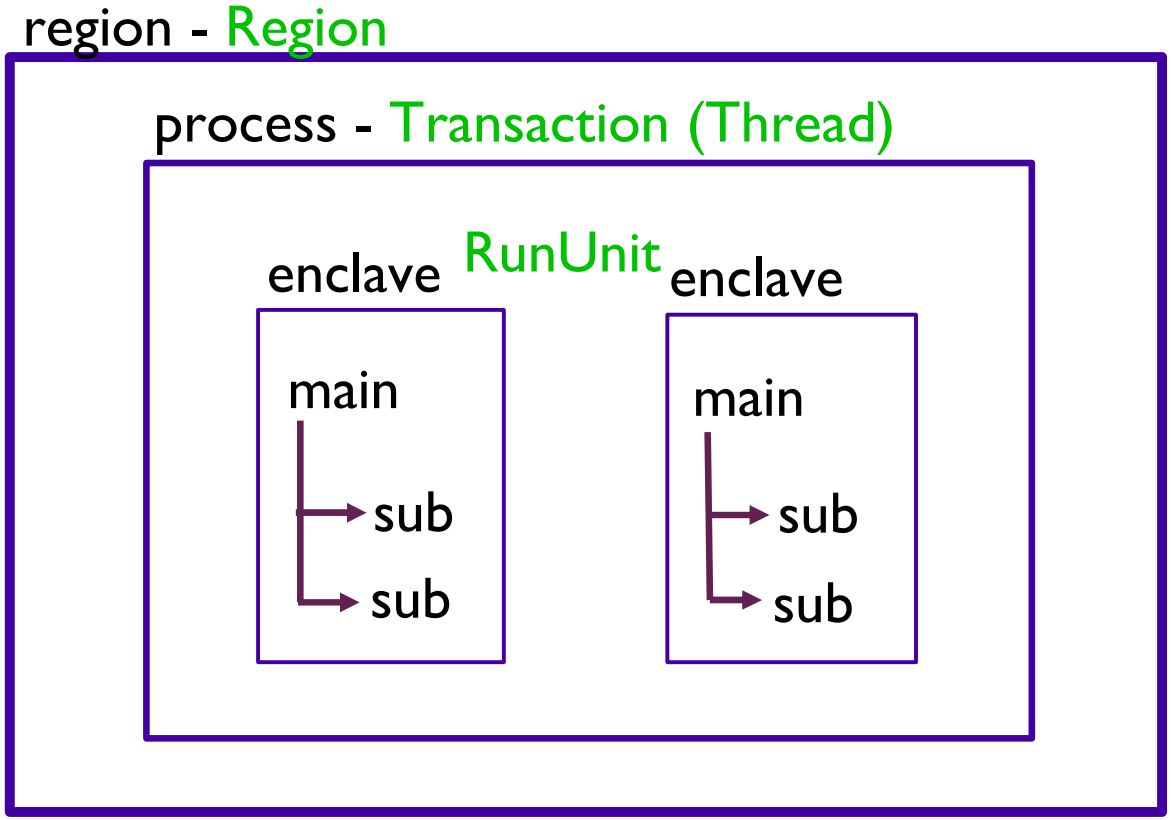
LE Terminology – Multi-threading 'Model'



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'



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

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:CEEOPTS 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! (Thu 3:00PM)
  - Diagnostics
    - Additional Information in SHARE sessions:
      - Heap Damage, Is Your Insurance Up-to-Date? (Fri 8:00AM)
      - LE Crime Scene Investigation (Fri 11:00AM)

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

- 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

- 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

- 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

What's New in LE for z/OS	Mon	11:00AM
What's New in Enterprise PL/I V4R1 and C/C++ V1.12	Mon	12:15PM
Full Speed Ahead with COBOL into the Future	Mon	1:30PM
REXX Language Coding Techniques	Tues	12:15PM
User Experience: Writing a Web-enabled CICS/COBOL Program	Wed	8:00AM
COBOL Performance – Myths and Realities	Wed	11:00AM
Language Environment Futures Workshop/AMODE 64 Discussion	Wed	4:30PM
An Introduction to using REXX with Language Environment	Thu	1:30PM
Look What I Found Under the Bar!	Thu	3:00PM
Heap Damage, Is Your Insurance Up-to-Date?	Fri	8:00AM
Introducing LE Callable Services, plus a User's View of Why and How You Should Exploit Them in Your Applications	Fri	9:30AM
LE Crime Scene Investigation - Finding debugging clues in LE dumps	Fri	11:00AM


LE
PL/I
C/C++
CEL
COBOL
Fortran

Appendix

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

Supported Releases

Supported Release Level	FMID	Support Withdrawn
z/OS V1.10	HLE7750	9/30/2011
z/OS V1.11	HLE7760	9/2012*
z/OS V1.12	HLE7770	
z/OS V1.13	HLE7780	

* Indicates Projected Date

Compilers Compatible with LE

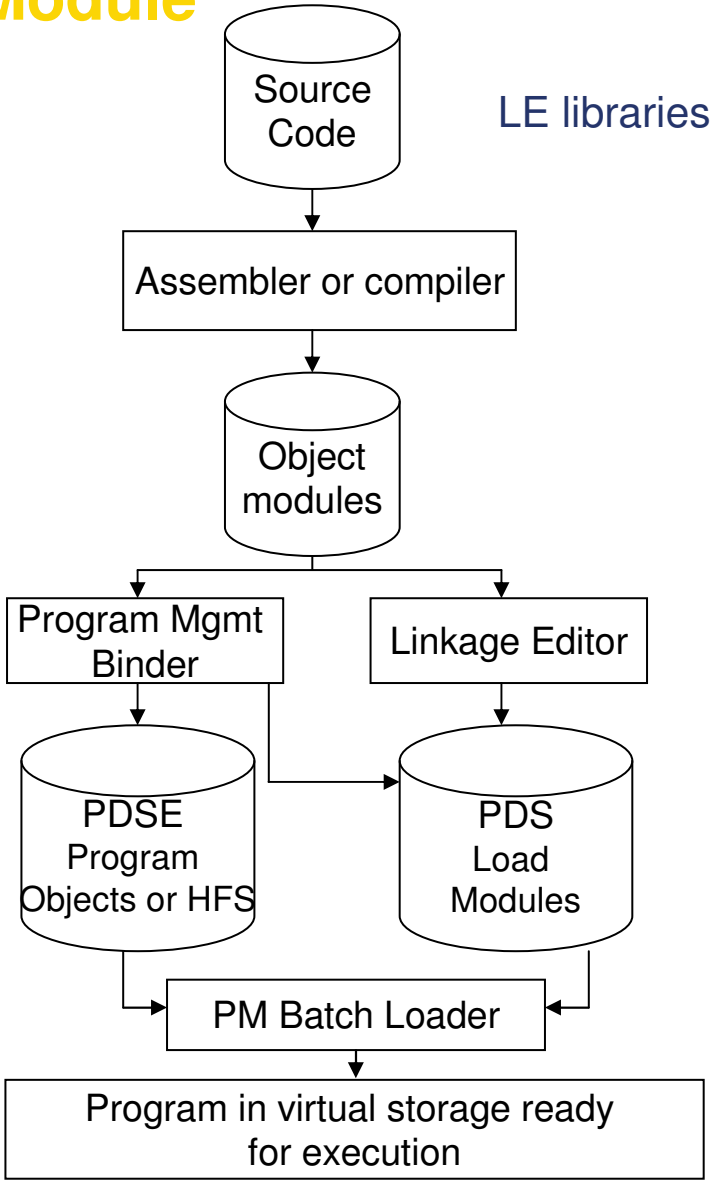
Object modules compiled with the following compilers **will run with LE without having to be re-linked or if linked with LE do not need to be recompiled:**

- 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

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

```
CEEDOPT  CSECT                                                  00110000
CEEDOPT  AMODE ANY                                              00120000
CEEDOPT  RMODE ANY                                              00130000
         CEEXOPT ABPERC=((NONE),OVR),                          X00140000
               ABTERMENC=((ABEND),OVR),                        X00150000
               AIXBLD=((OFF),OVR),                             X00160000
               ALL31=((ON),OVR),                               X00170000
               ANYHEAP=((16K,8K,ANYWHERE,FREE),OVR),           X00180000
               BELOWHEAP=((8K,4K,FREE),OVR),                   X00190000
```

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 */

CEECOPT(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
    - 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

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