

Language Environment for Dummies: What is LE and How Do I Get There?

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SHARE in Boston
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Agenda

- What is a Run-time environment?
- Why LE?
- LE Terminology
- LE CEL Functions
- The Life of a Module
- Setting Run-time Options
- Appendix

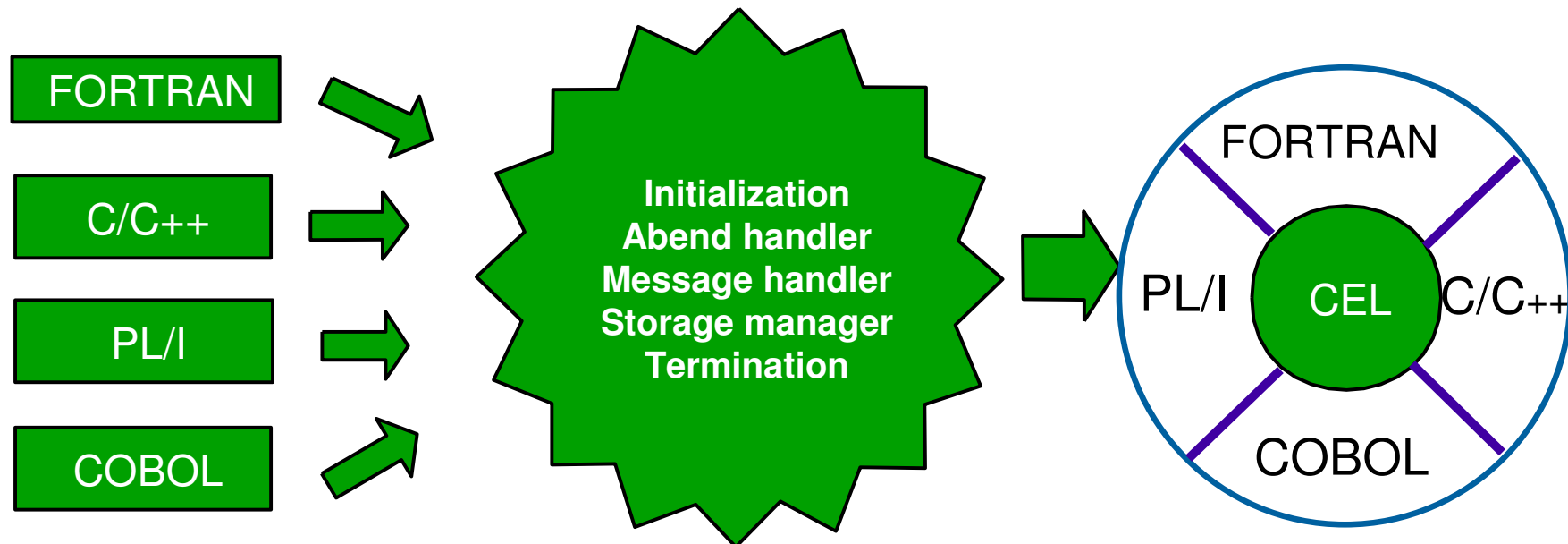
What is a Run-Time Environment?

- High level languages encapsulate complicated function into simpler language semantics, for example:
 - Obtain and manage storage
 - Obtain the system date and time
 - Read and write data
 - Perform math calculations
 - Handle exceptions
- The run-time environment aids in implementing these functions
 - 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
 - For example, when leaving a COBOL program to return to a PL/I program, the COBOL library might free storage that PL/I still wanted
- Customers at GUIDE and SHARE worked with IBM to design a solution
 - The result: **Language Environment**

Time to make the doughnut...



■ Pre-LE environment

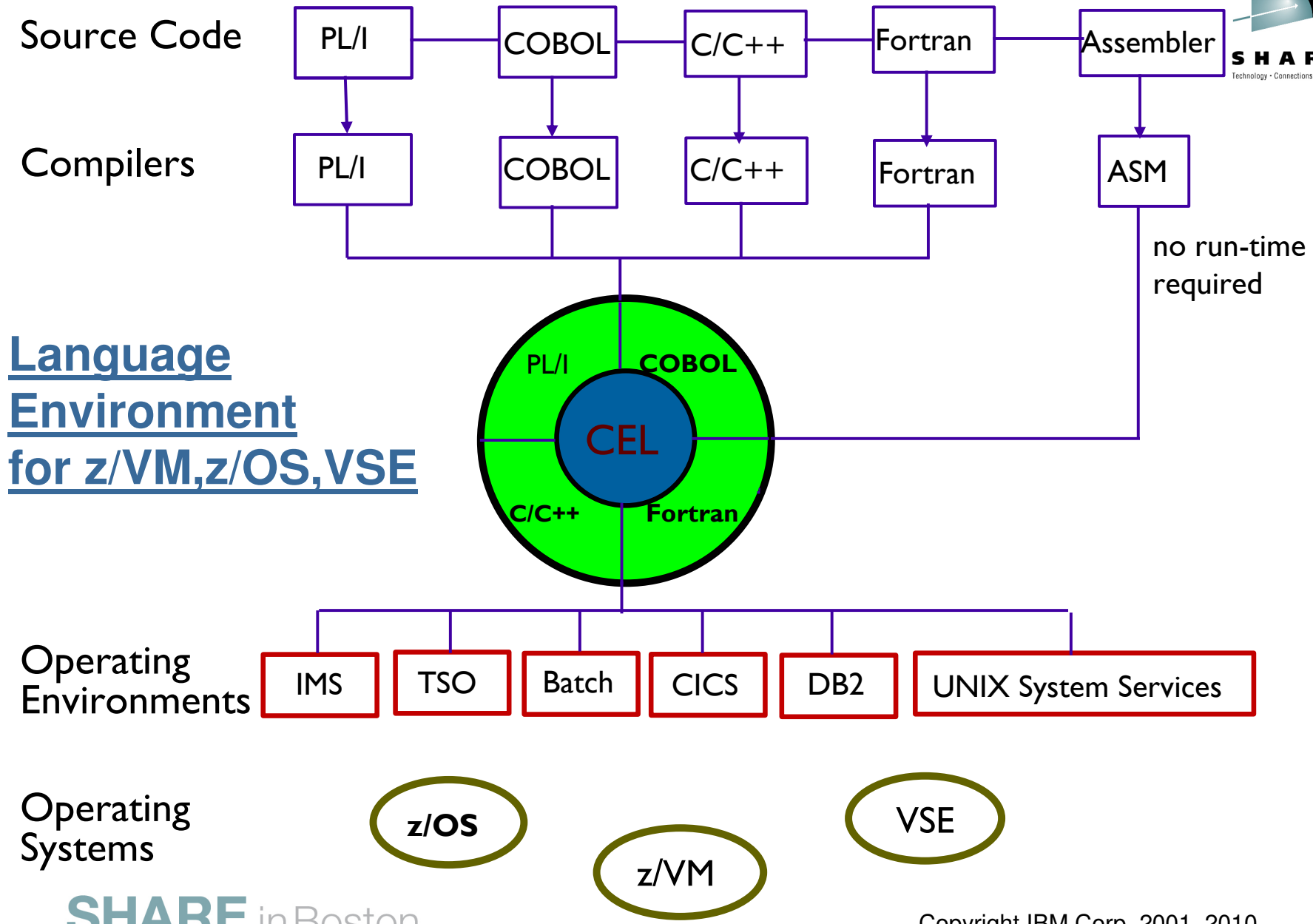
- 4 independent products
- upward incompatibilities
- loose adherence to standards
- purely a customer application enabler

■ 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, etc



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** – member language specific to an application
- **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

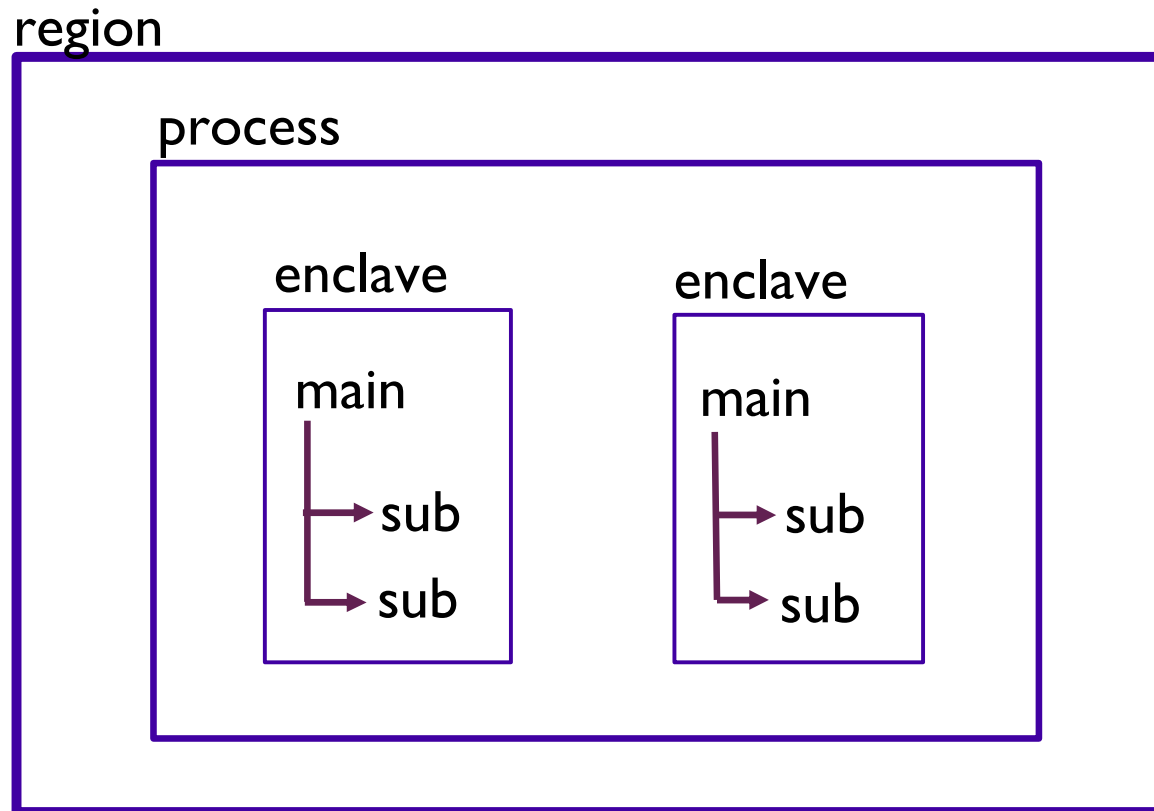
- SHARE Session: Introducing LE Callable Services, plus a User's View of Why and How You Should Exploit Them in Your Applications – Thu 9:30AM

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

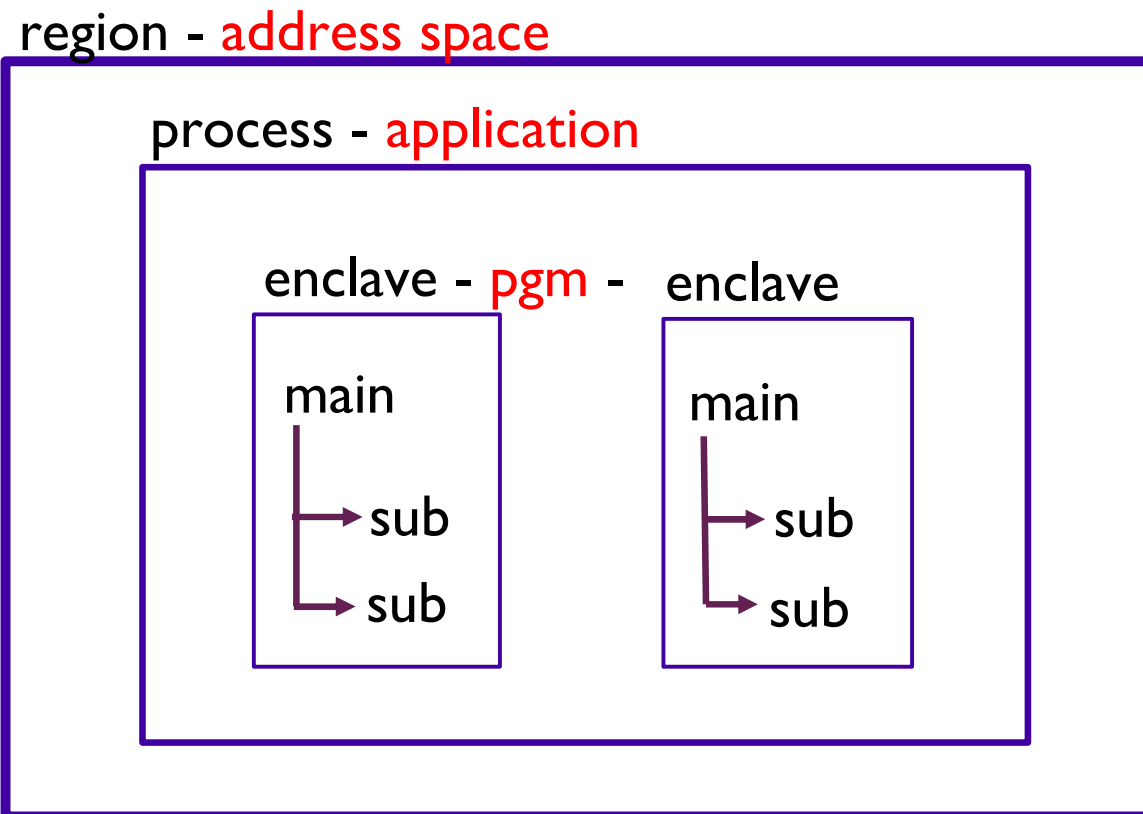
LE Terminology – Program Model

- **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

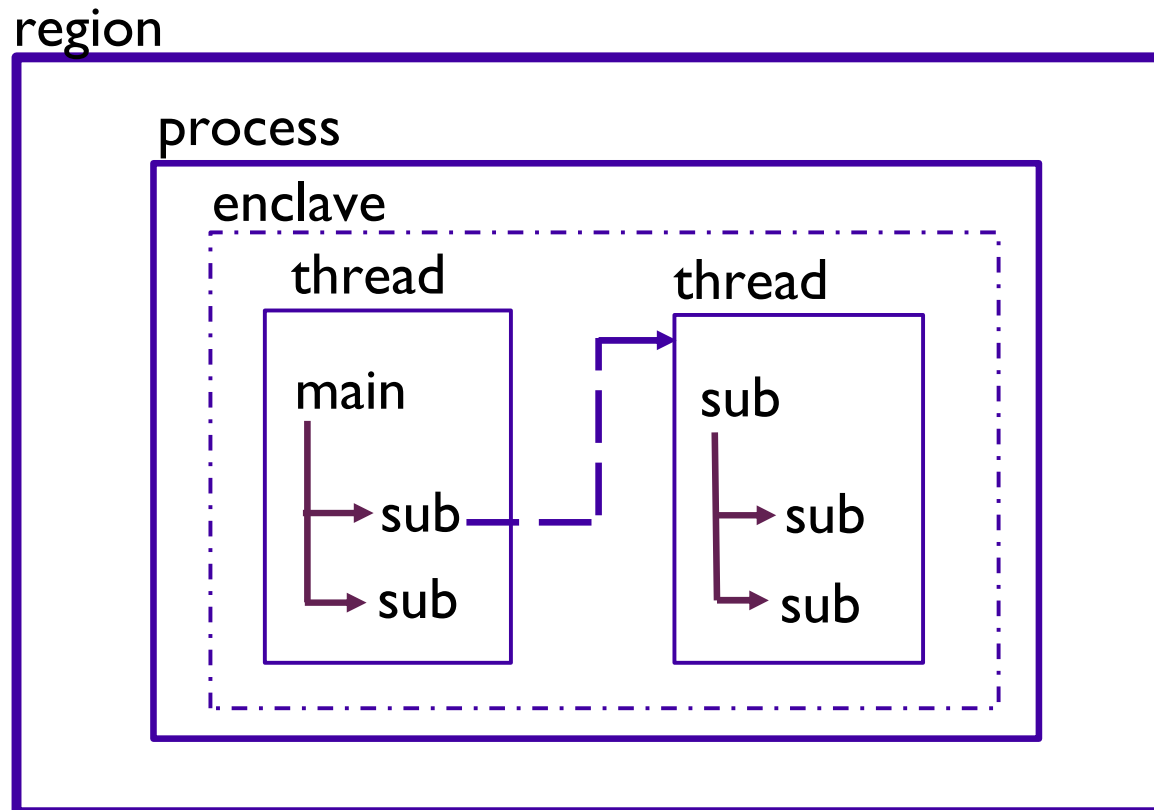
LE Terminology - Program Model



LE Terminology - MVS 'Model'



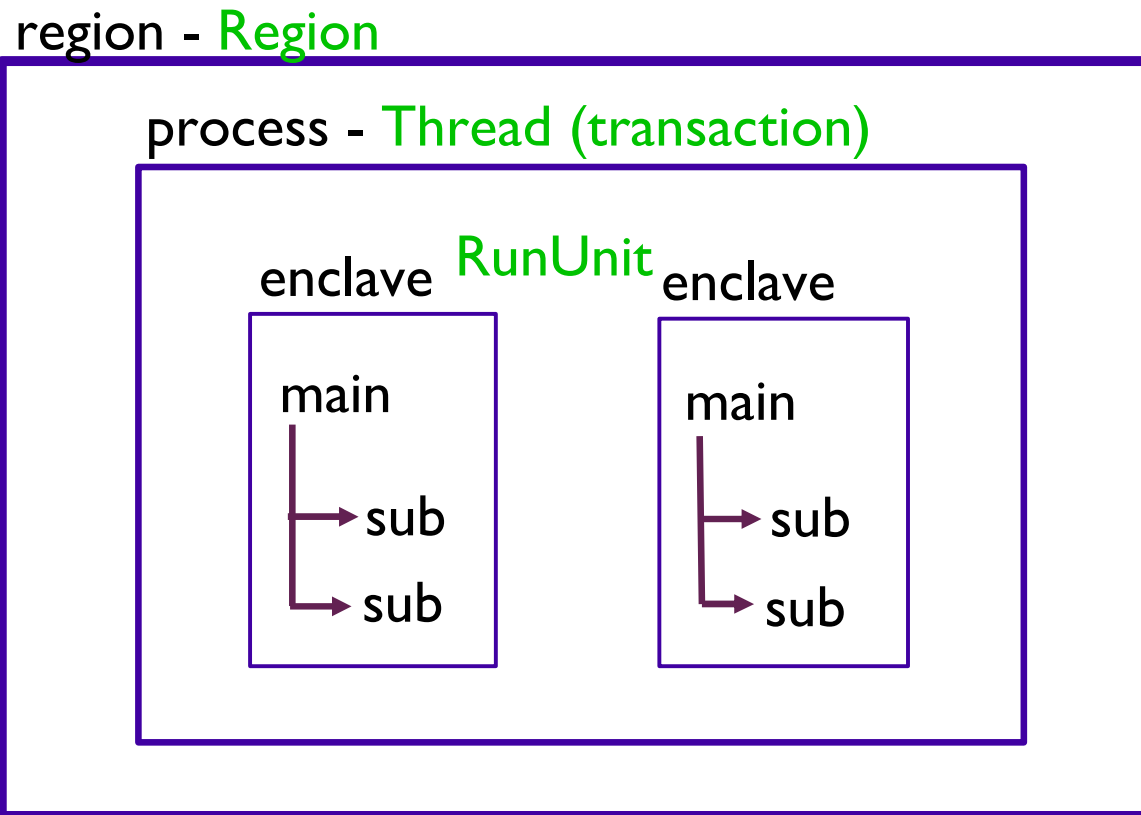
LE Terminology – Multi-threading 'Model'



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 USS
 - 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
- Required to accomplish re-entrancy

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)

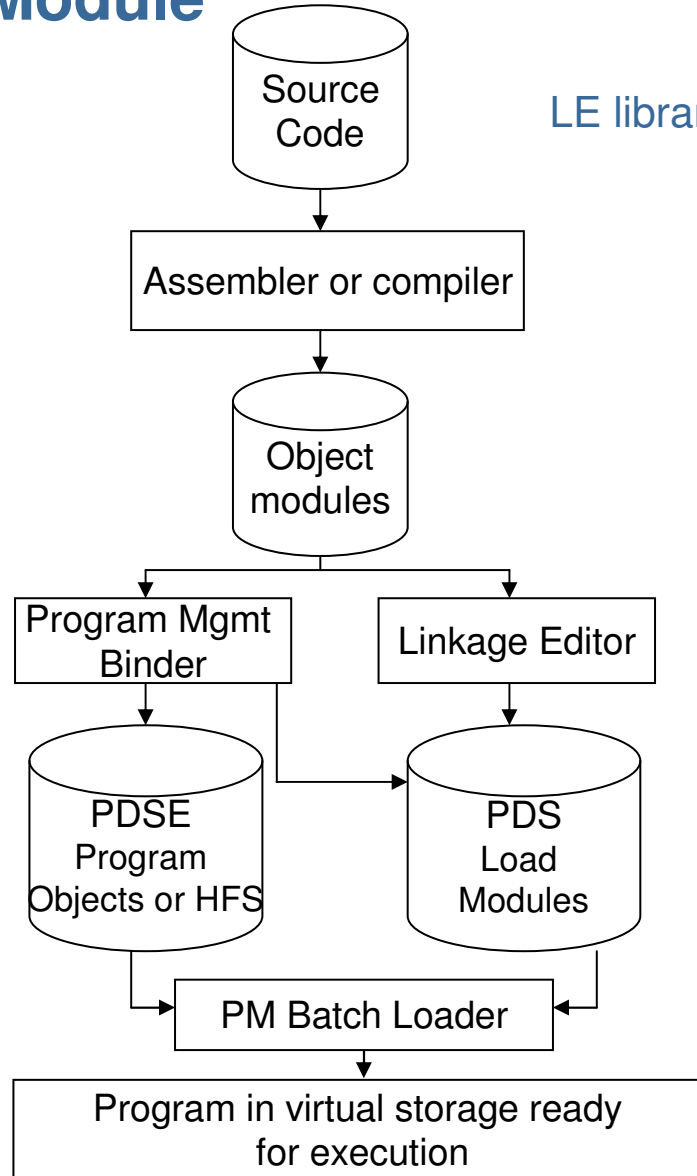
Common LE Functions – Date/Time Services

- 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

The Life of a Module



LE libraries that may get involved:

SCEEMAC, SCEEH.*

SCEELKED, SCEELKEX,
SCEE OBJ, SCEE CPP,
SCEELIB, SCEEBND2

SCEERUN, SCEERUN2,
SCEELPA, SCEE CICS

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 to Language Environment modules
 - Note: USERMODs will be eliminated in a future release!
- 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

- For more information on setting run-time options, see Appendix

Key Run-Time Options

- Subtopics
 - Tuning
 - Diagnostics
 - Additional Information:
SHARE session: LE Crime Scene Investigation (Thu 12:15pm)

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

- HEAPPOOLS(ON|OFF, size1, prcnt1, ..., size12, prcnt12)
 - size N Up to 12 cell pool sizes to be utilized
 - prcnt N Percentage of HEAP(initial) to be used for cell pool
- Notes:
 - C/C++ and Enterprise PL/I only
 - Use RPTSTG(ON) to tune settings for each application

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

- ABTERMENC(option)
 - ABEND Step will be ABENDED (job terminates)
 - RETCODE Step ends with return code (job continues)

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

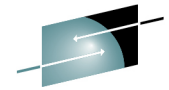
Key Run-Time Options - Diagnostics

- 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 | 1:30PM |
| ■ What's New in Enterprise COBOL Version 4.2 | Mon | 3:00PM |
| ■ What's New in Enterprise PL/I V3R9 and C/C++ V1.12 | Mon | 4:30PM |
| ■ Migrating to LE Conforming Assembler, If You Need To | Tue | 4:30PM |
| ■ So you want AMODE 64? But, are you sure you need it? | Wed | 11:00AM |
| ■ Language Environment Futures Workshop | Wed | 1:30PM |
| ■ Comparing and contrasting XML features of DB2 and COBOL | Thu | 9:30AM |
| ■ Introducing LE Callable Services, plus a User's View of Why and How You Should Exploit Them in Your Applications | Thu | 9:30AM |
| ■ User Experience: Writing a Web-enabled CICS/COBOL Program | Thu | 11:00AM |
| ■ LE Crime Scene Investigation - Finding debugging clues in LE dumps | Thu | 12:15PM |
| ■ Slowed down by LE? Perhaps the CEEPIPI service can help! | Thu | 6:00PM |



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Appendix

- Supported Releases
- Compilers Compatible With LE
- Compilers That Require LE
- Setting Run-time Options

Supported Releases

Supported Release Level	FMID	Support Withdrawn
z/OS V1.9	HLE7740	9/30/2010
z/OS V1.10	HLE7750	9/2011?
z/OS V1.11	HLE7760	
z/OS V1.12	HLE7770	

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)

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 be 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
          CEELOPT 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
          CEEUOPT 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)  
/*
```