



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

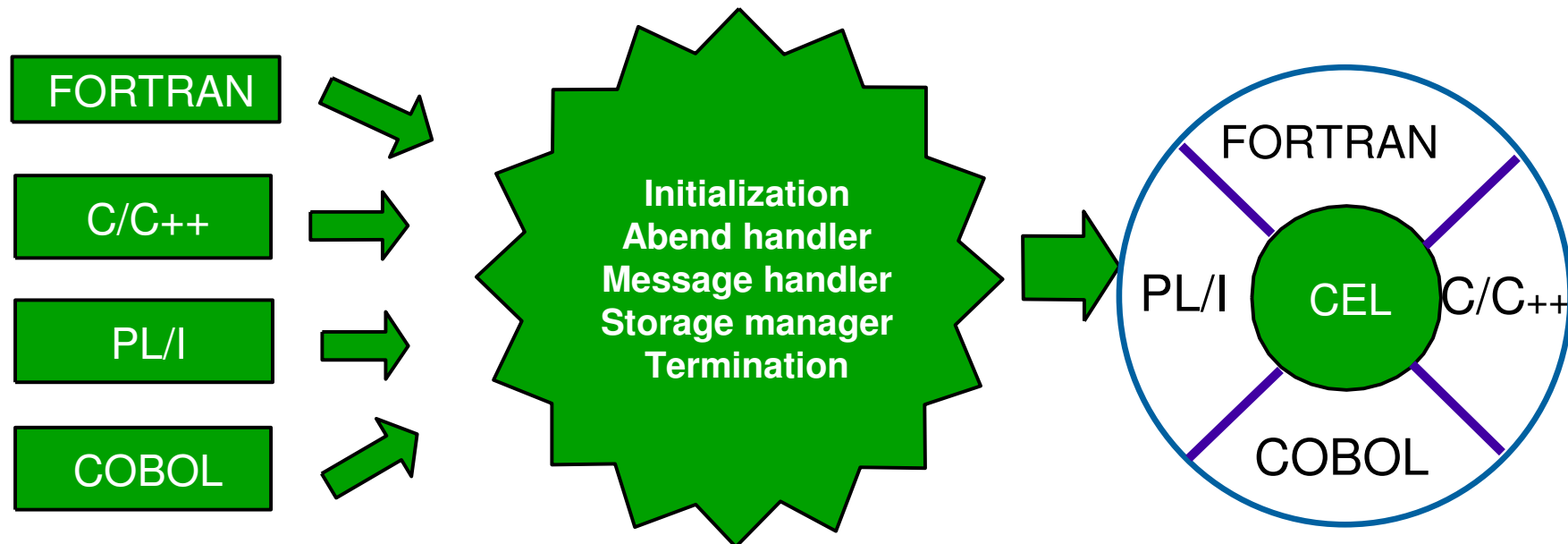
What is a Run-Time Library?

- 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

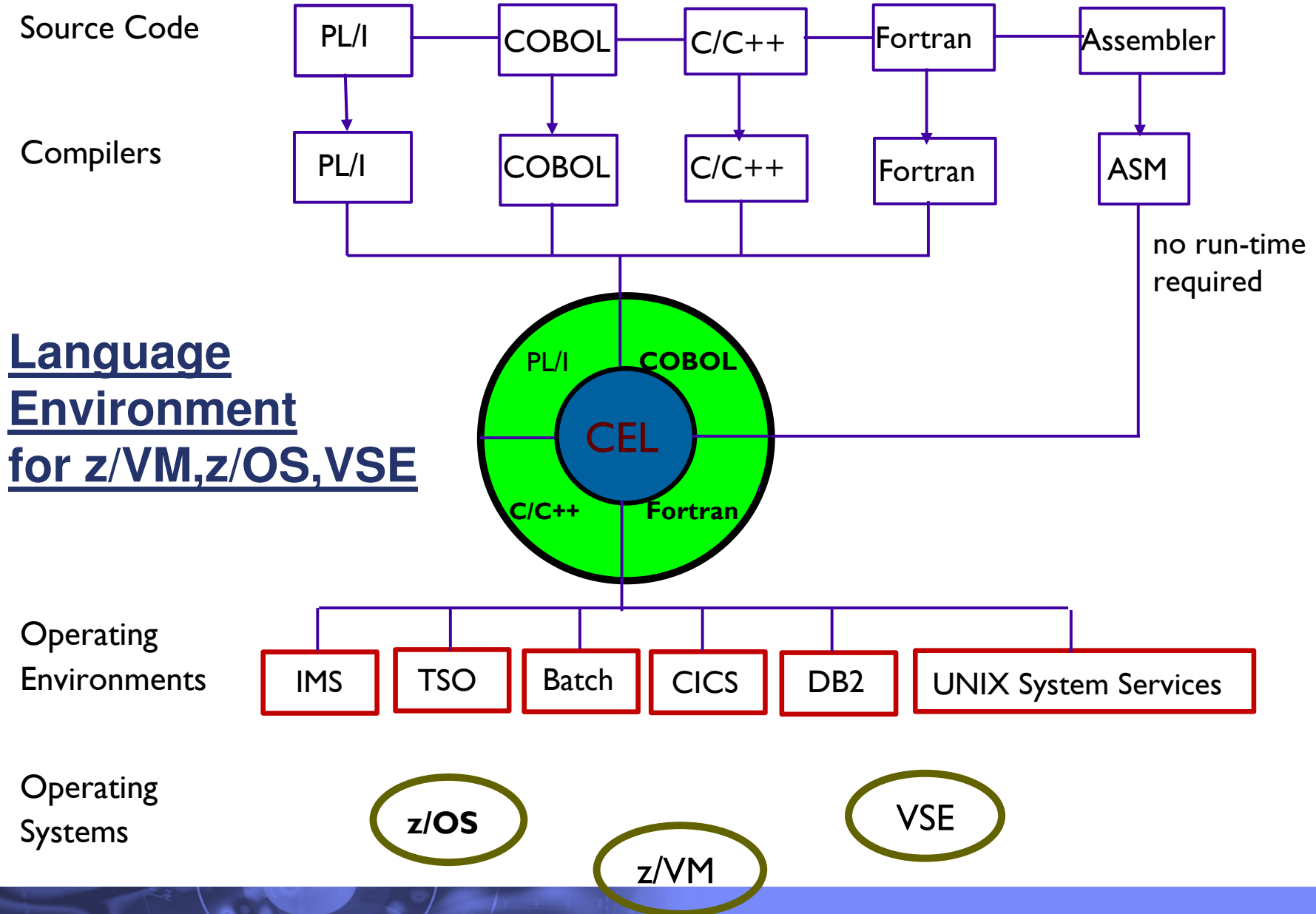
- 4 independent products
- upward incompatibilities
- loose adherence to standards
- purely a customer application enabler

■ 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



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

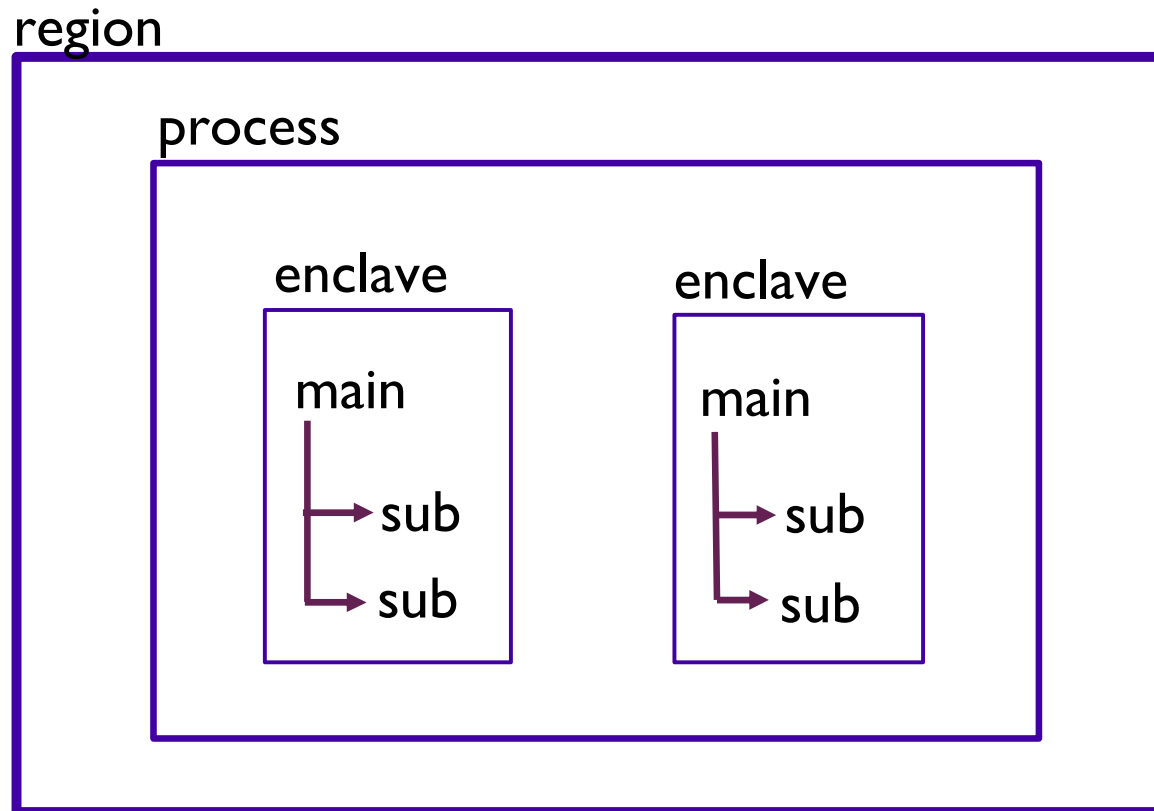
- **LE Callable Services** – programmatic way of utilizing LE services
 - AWI - Application Writer Interface
 - CWI - Compiler Writer Interface
 - CEE prefixed – general to all platforms
 - CEE3 prefixed – specific to only z/OS

- **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

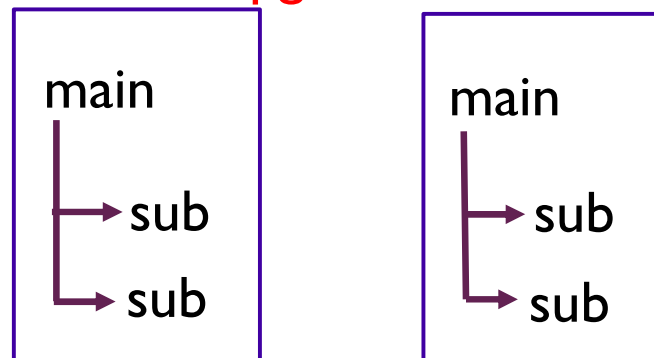


LE Terminology - MVS 'Model'

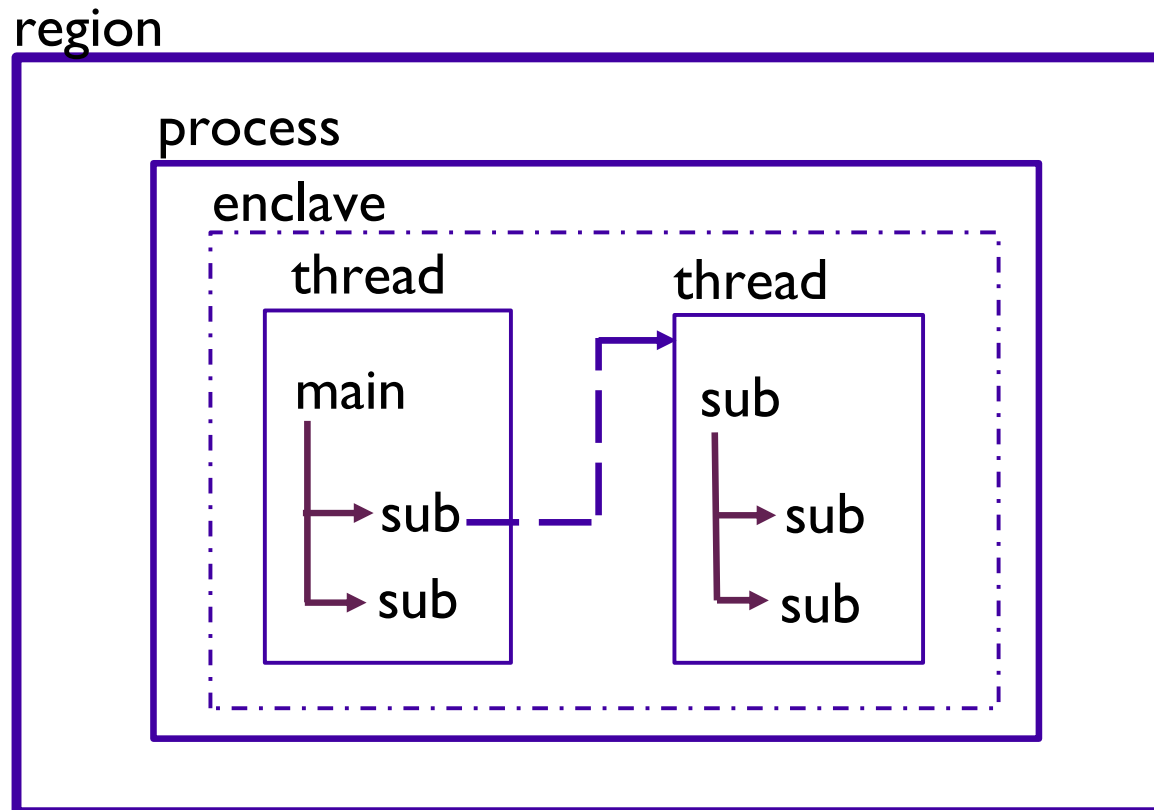
region - address space

process - application

enclave - pgm - enclave



LE Terminology – Multi-threading 'Model'



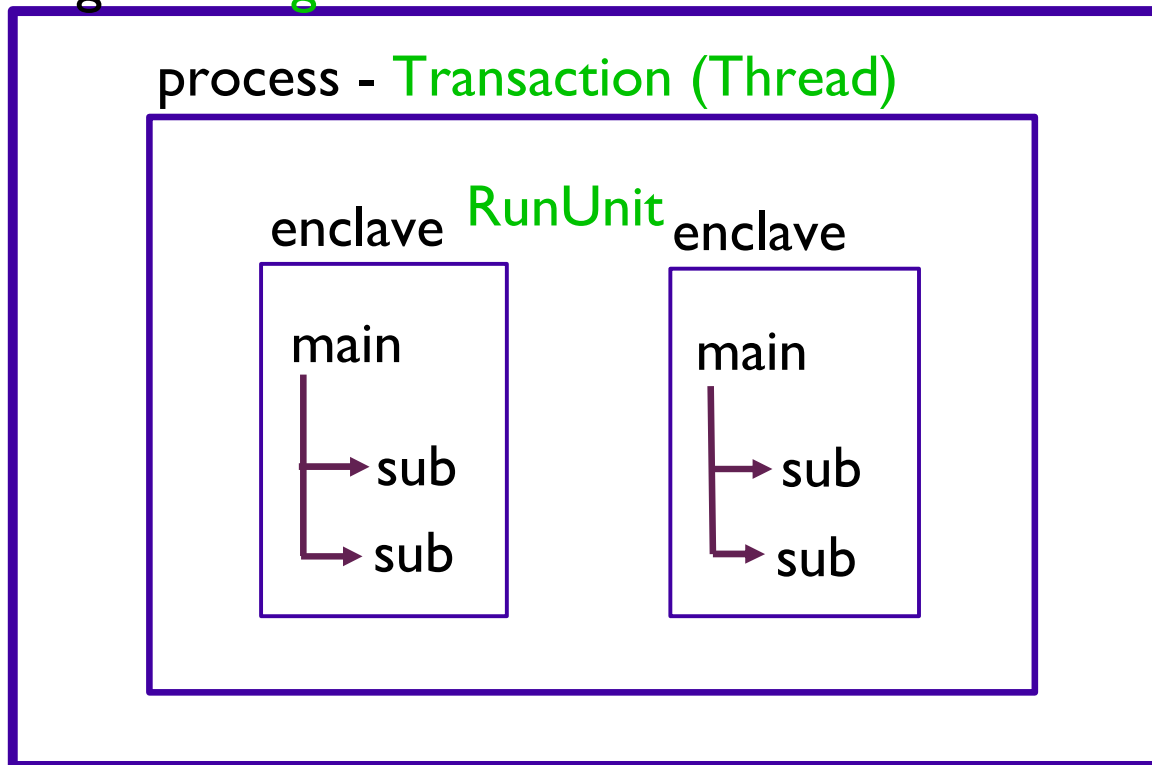
CICS Terminology

- **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'

region - **Region**

process - **Transaction (Thread)**



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

- 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: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)
 - 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! (Thu 8:00AM)
 - Diagnostics
 - Additional Information in SHARE sessions:
 - Heap Damage, Get Into the Zone! (Wed 9:30AM)

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

- | | | |
|--|-----|---------|
| ■ High Level Assembler Bootcamp – Part 1 of 3 | Mon | 11:00AM |
| ■ Heapzones and Pageframes and Blocks, Oh My! (z/OS 2.1) | Tue | 9:30AM |
| ■ Using the Binder to Build Your Application | Tue | 11:00AM |
| ■ PL/I – What’s New | Tue | 1:30PM |
| ■ An Introduction to Using REXX with Language Environment | Tue | 3:00PM |
| ■ High Level Assembler Bootcamp – Part 2 of 3 | Tue | 4:30PM |
| ■ High Level Assembler Bootcamp – Part 3 of 3 | Wed | 8:00AM |
| ■ Heap Damage, Get Into the Zone! | Wed | 9:30AM |
| ■ ZOMG The Next COBOL Compiler Has Arrived! Part 1 of 2 | Wed | 11:00AM |
| ■ ZOMG The Next COBOL Compiler Has Arrived! Part 2 of 2 | Wed | 1:30PM |
| ■ Dinner - LANG Project Rib Joint Expeditionary Force | Wed | 7:00PM |
| ■ Look What I Found Under the Bar! | Thu | 8:00AM |
| ■ How to Take Advantage of the New COBOL V5 Compiler – Migration | Thu | 9:30AM |
| ■ REXX Language Coding Techniques | Thu | 3:00PM |



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

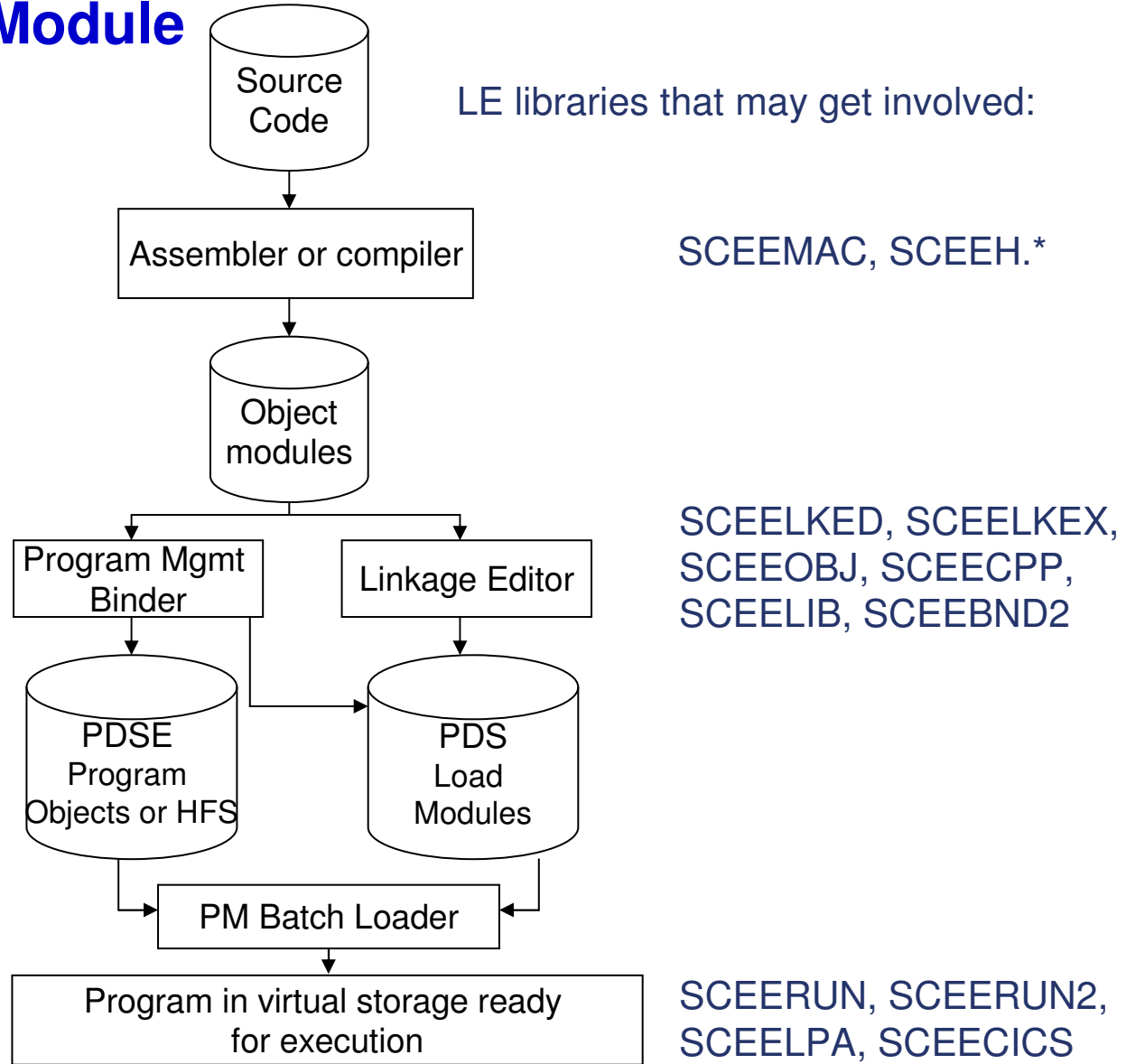
VisualAge PL/I for OS/390

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



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 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 ceeopt , 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
 - 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
CEEUOPT  CEEUOPT HEAP=(10M,10M,ANYWHERE,FREE) , X00180000
          STACK=(1M,1M,ANYWHERE,KEEP)         00250000
CEEUOPT  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)  
/*
```