



# 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

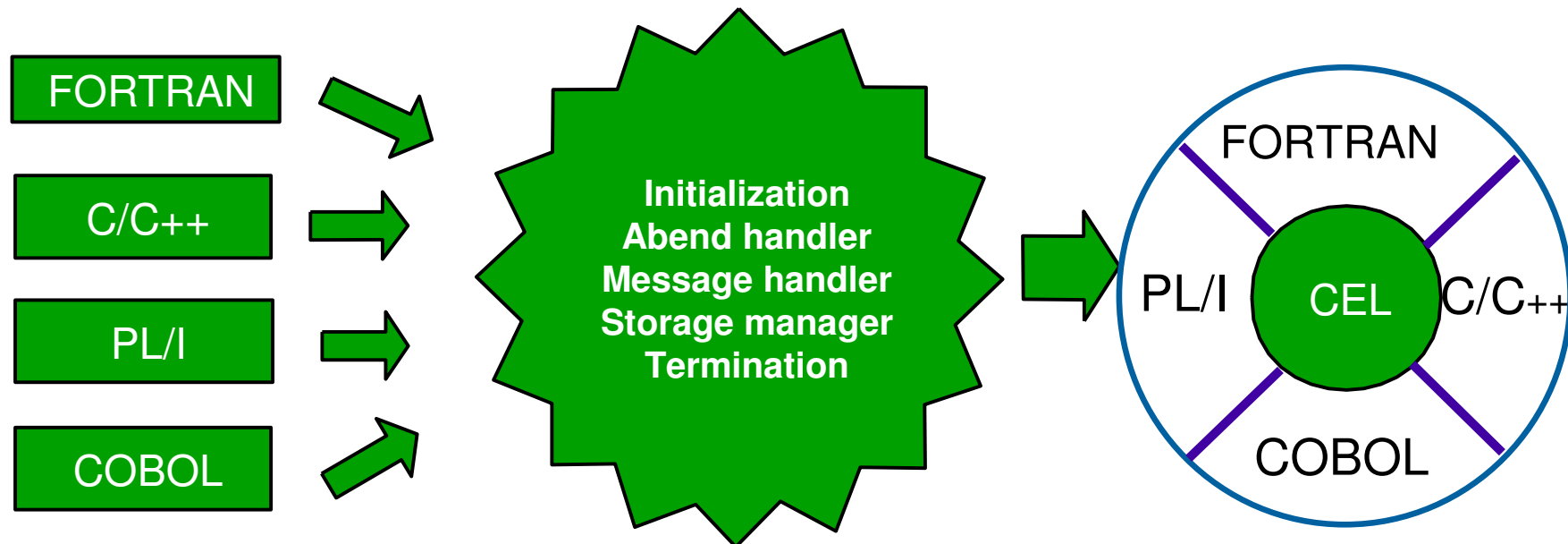
## What is a Run-Time Library?

- 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

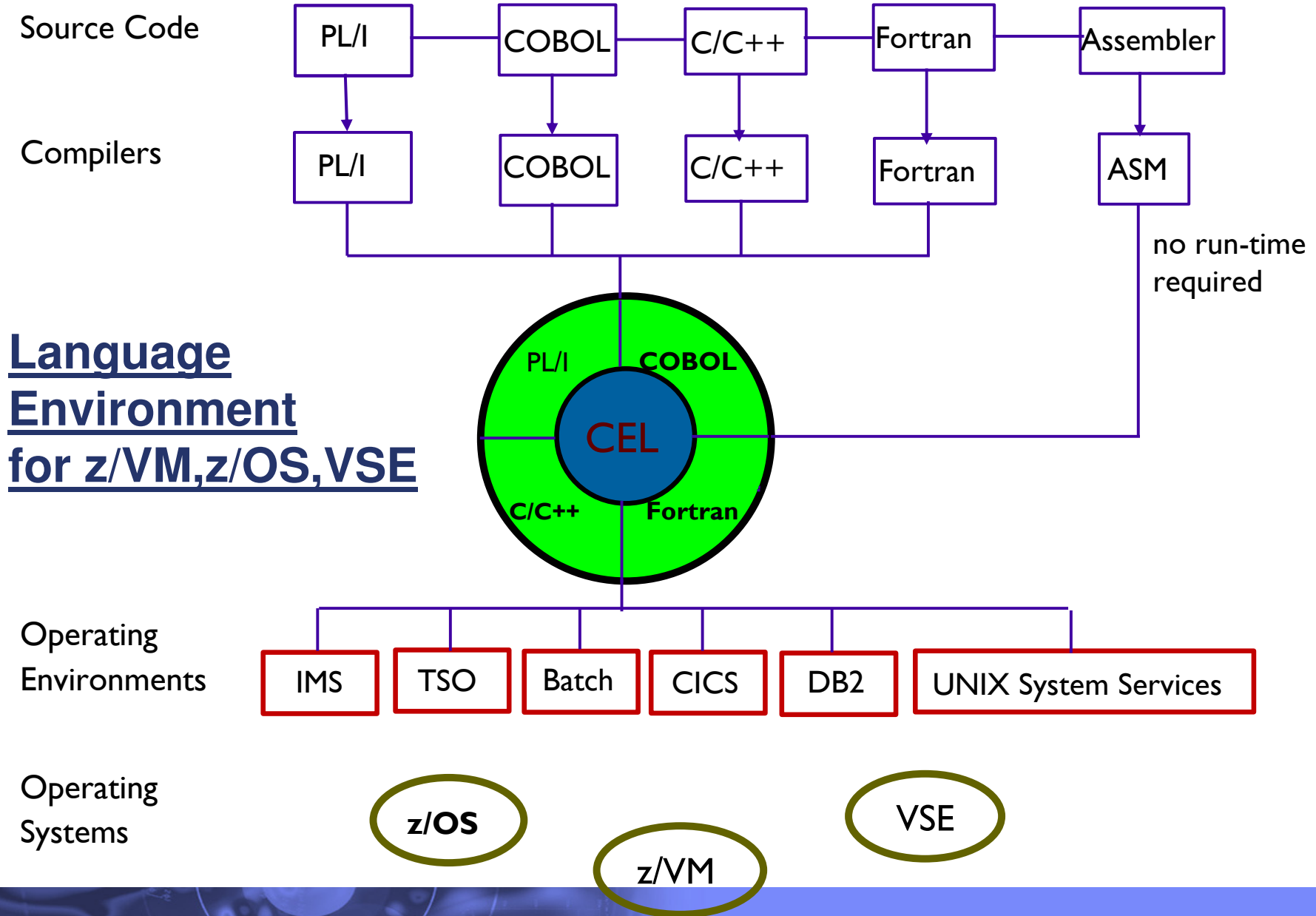
- 4 independent products
- upward incompatibilities
- loose adherence to standards
- purely a customer application enabler

### ■ 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.

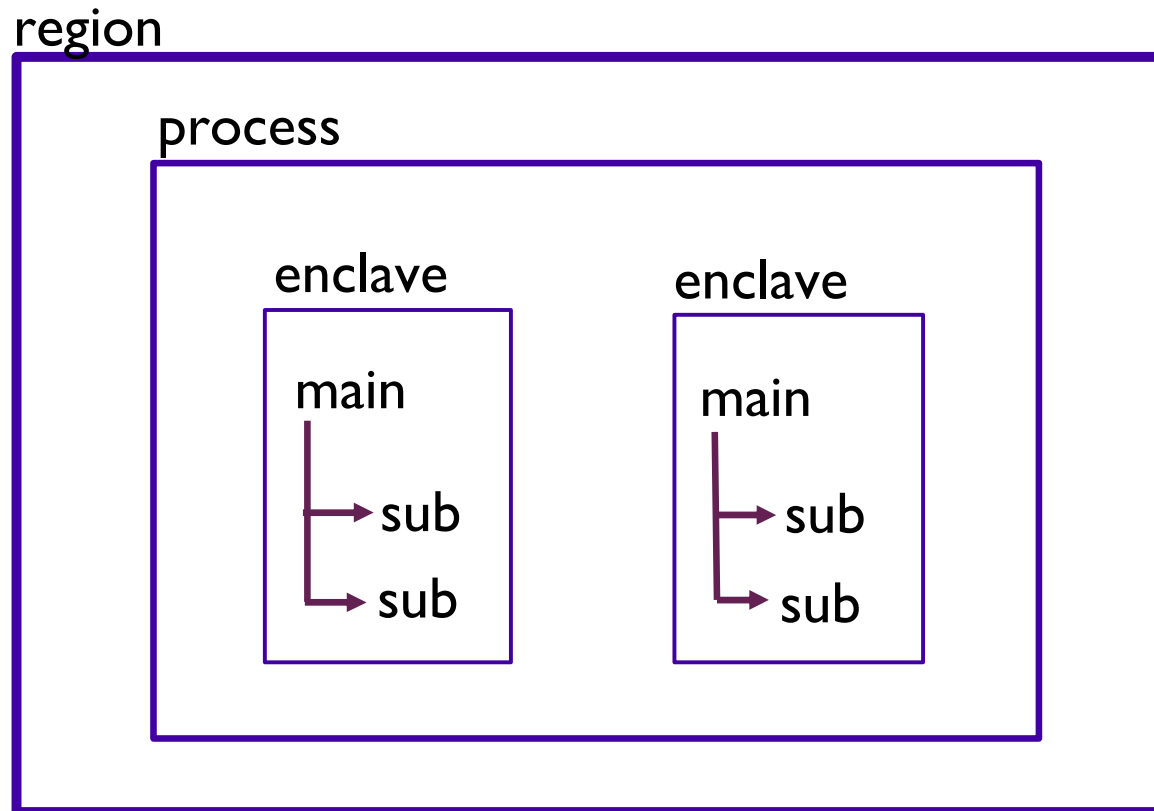
## LE Terminology – Callable Services

- **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

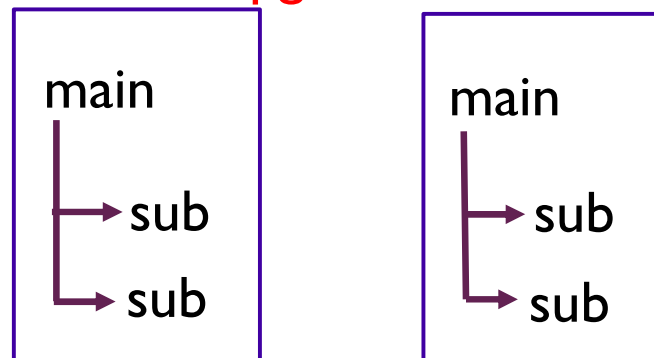


# LE Terminology - MVS 'Model'

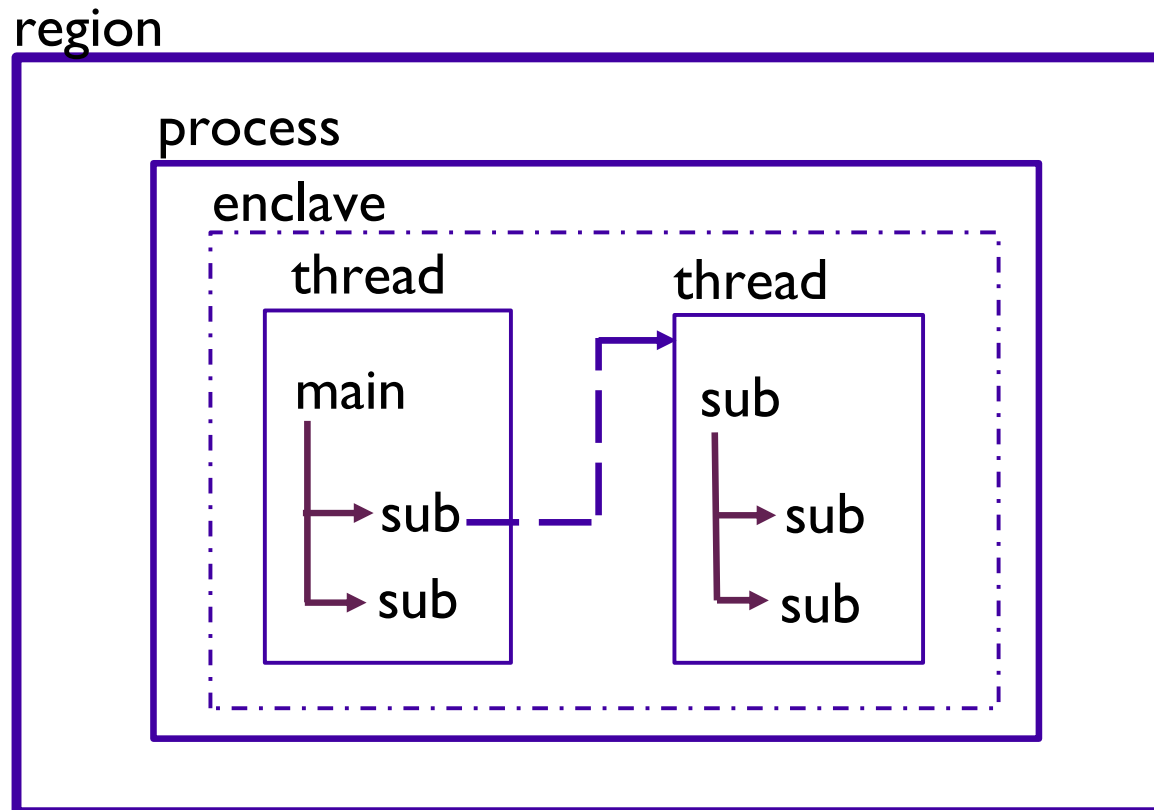
region - address space

process - application

enclave - pgm - enclave



# LE Terminology – Multi-threading 'Model'



## CICS Terminology

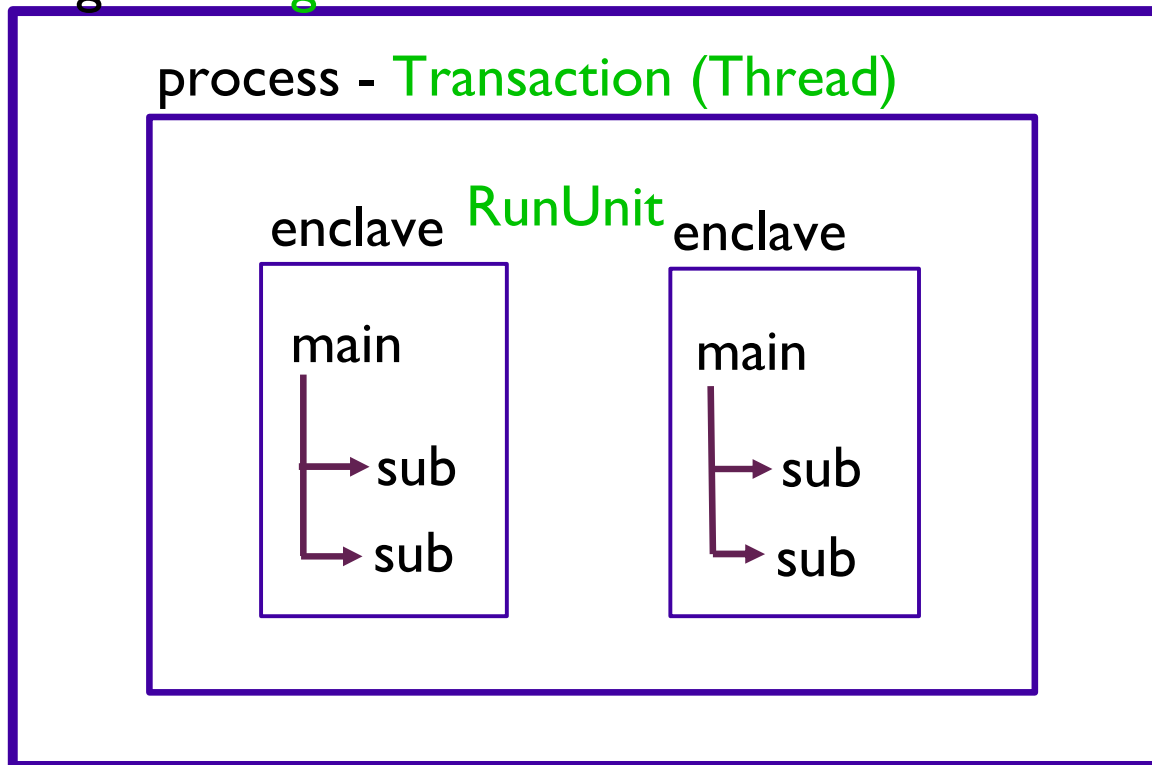
- **region** - the range of storage the application set runs in
- **transaction** - set of applications that accomplish a task
- **run-unit** - an application - set of modules that accomplish some subtask



# 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
  
- Additional information in SHARE Session:
  - Exploit Condition Handling in LE (Thu 11:00AM)

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

- 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

- |   |     |         |
|---|-----|---------|
| ■ Make your PL/I and C/C++ Code FLY With the Right Compiler Options | Mon | 11:00AM |
| ■ Full Speed Ahead with COBOL into the Future                       | Mon | 12:15PM |
| ■ An Introduction to using REXX with Language Environment           | Mon | 1:30PM  |
| ■ REXX Power Tools – The Parse Command                              | Tue | 9:30AM  |
| ■ REXX Language Coding Techniques                                   | Wed | 8:00AM  |
| ■ IBM Problem Determination Tools                                   | Wed | 3:00PM  |
| ■ Language Environment Futures Workshop/AMODE 64 Discussion         | Wed | 4:30PM  |
| ■ Look What I Found Under the Bar!                                  | Thu | 8:00AM  |
| ■ Finding Debugging Clues in LE Dumps                               | Thu | 9:30AM  |
| ■ Exploit Condition Handling in LE                                  | Thu | 11:00AM |
| ■ COBOL Performance – Myths and Realities                           | Thu | 12:15PM |
| ■ Introduction to IPCS for Application Programmers                  | Fri | 8:00AM  |
| ■ REXX – Trouble shooting   | Fri | 9:30AM  |
| ■ Heap Damage, Is Your Insurance Up-to-Date?                        | Fri | 11:00AM |



# 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

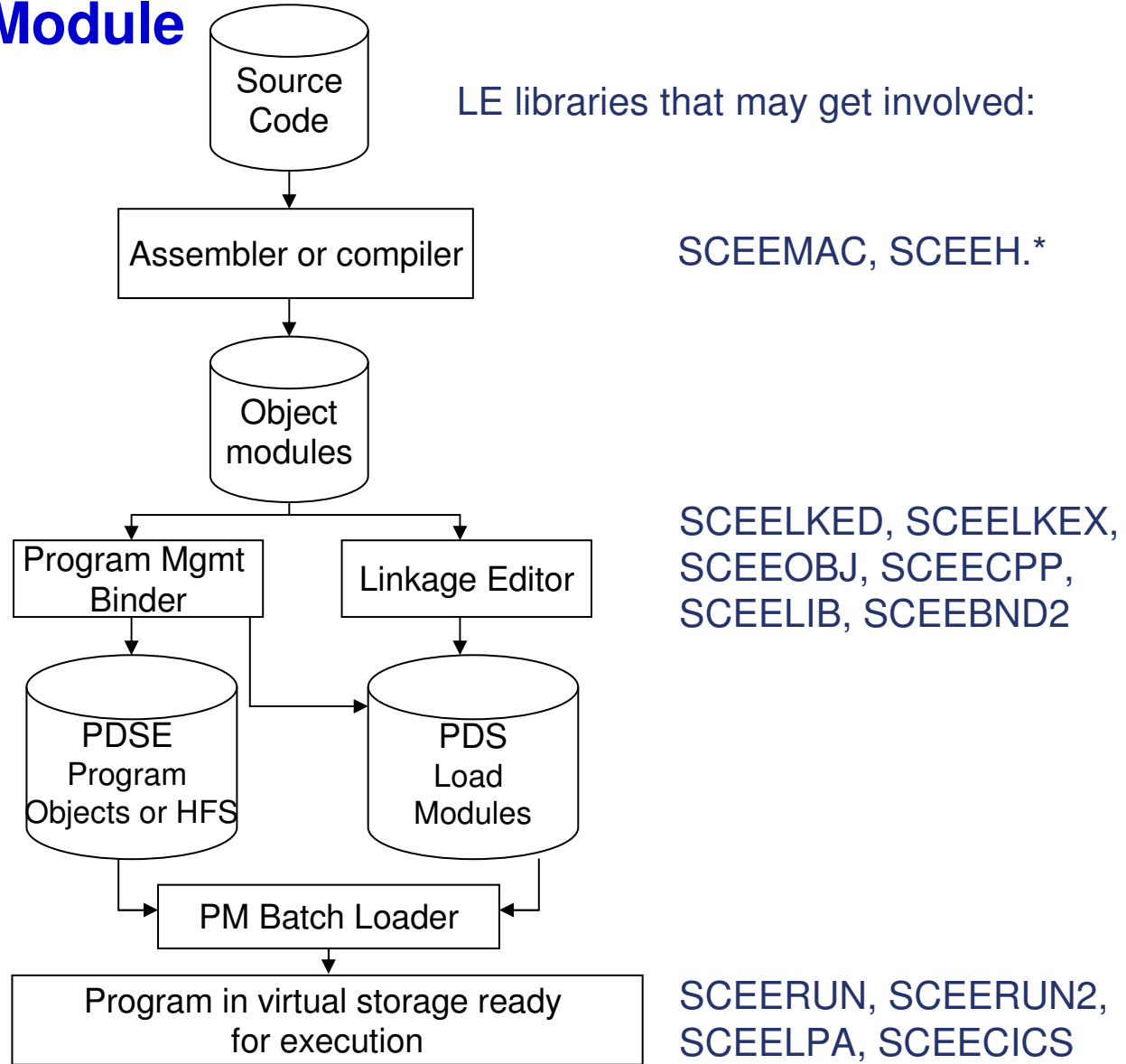
PL/I for MVS & VM

AD/Cycle PL/I for MVS & VM

VS FORTRAN and FORTRAN IV (in compatibility mode)



# The Life of a Module



## Setting Run-Time Options

- Installation defaults (CEEDOPT/CEEEOPT/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
	CEEEOPT 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 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
          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
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)  
/*
```