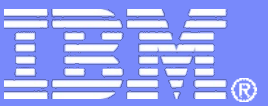

Language Environment for Dummies

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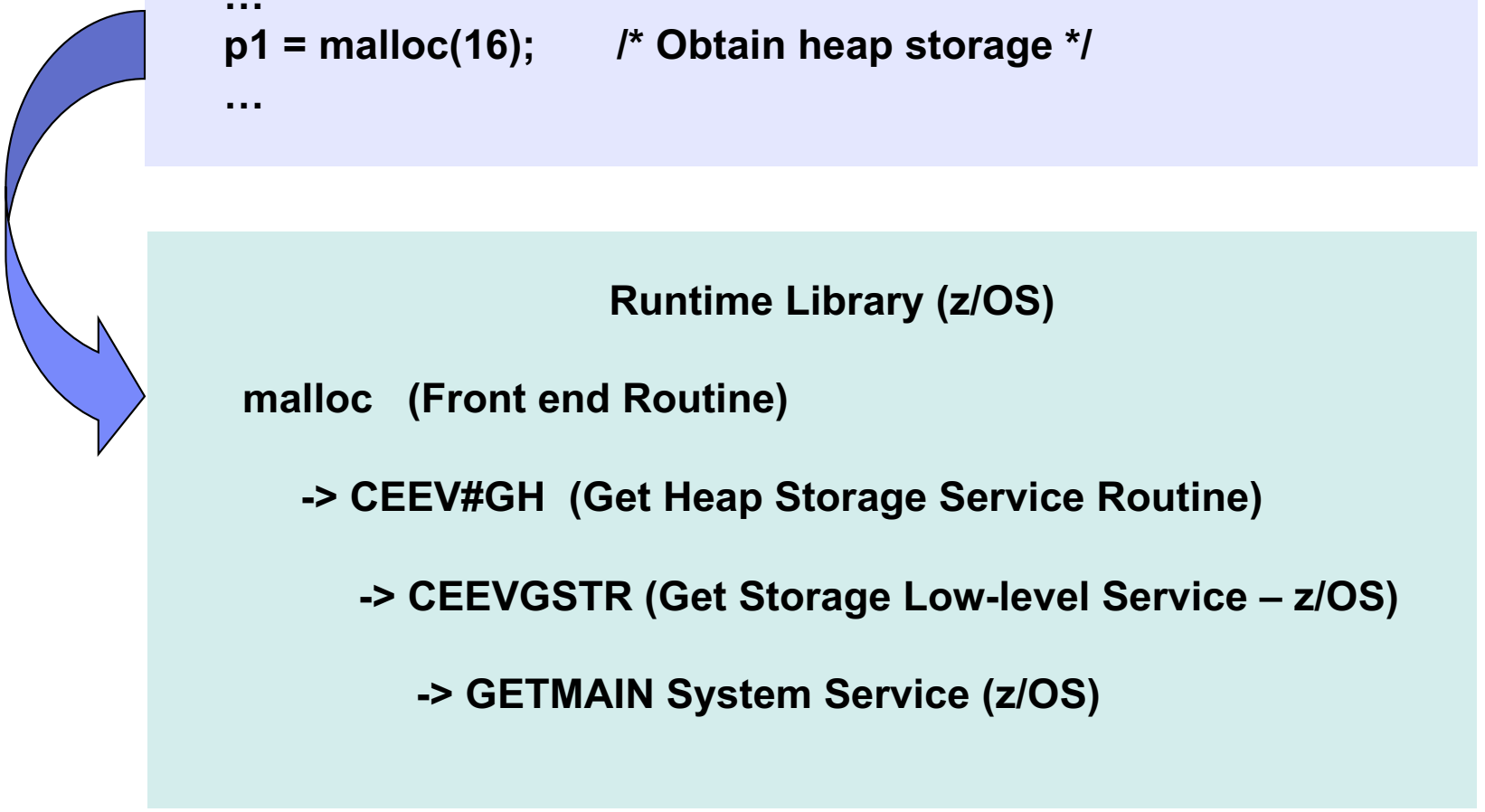
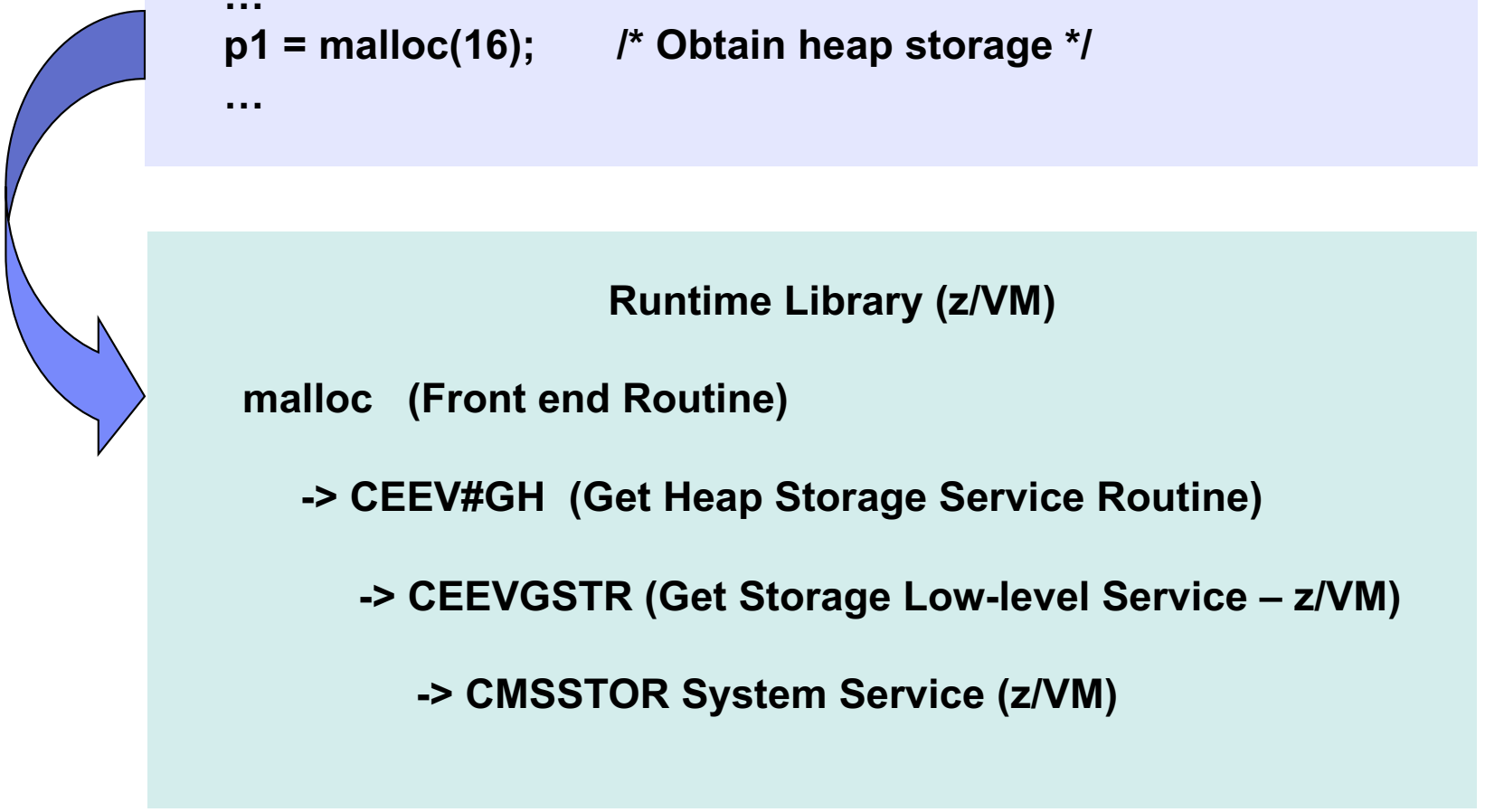
Agenda

- What is a Runtime Library?
- Why LE?
- LE Terminology
- LE CEL Functions
- Setting Runtime Options
- Appendix

What is a Runtime Library?



What is a Runtime Library?



What is a Runtime Library?

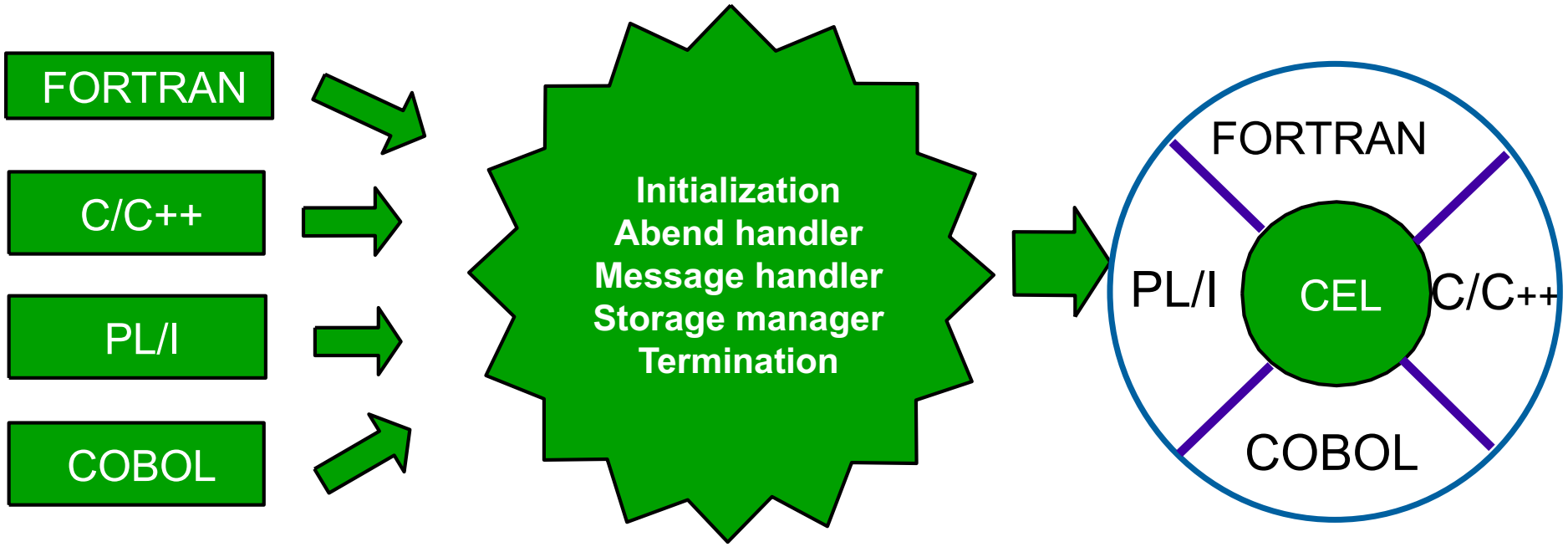
- A Runtime Library works together with the code produced by a compiler to provide functionality for an application
  - Obtain and manage storage
  - Read and write data
  - Perform math calculations

- There are advantages to providing function in a Runtime 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 runtime 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**

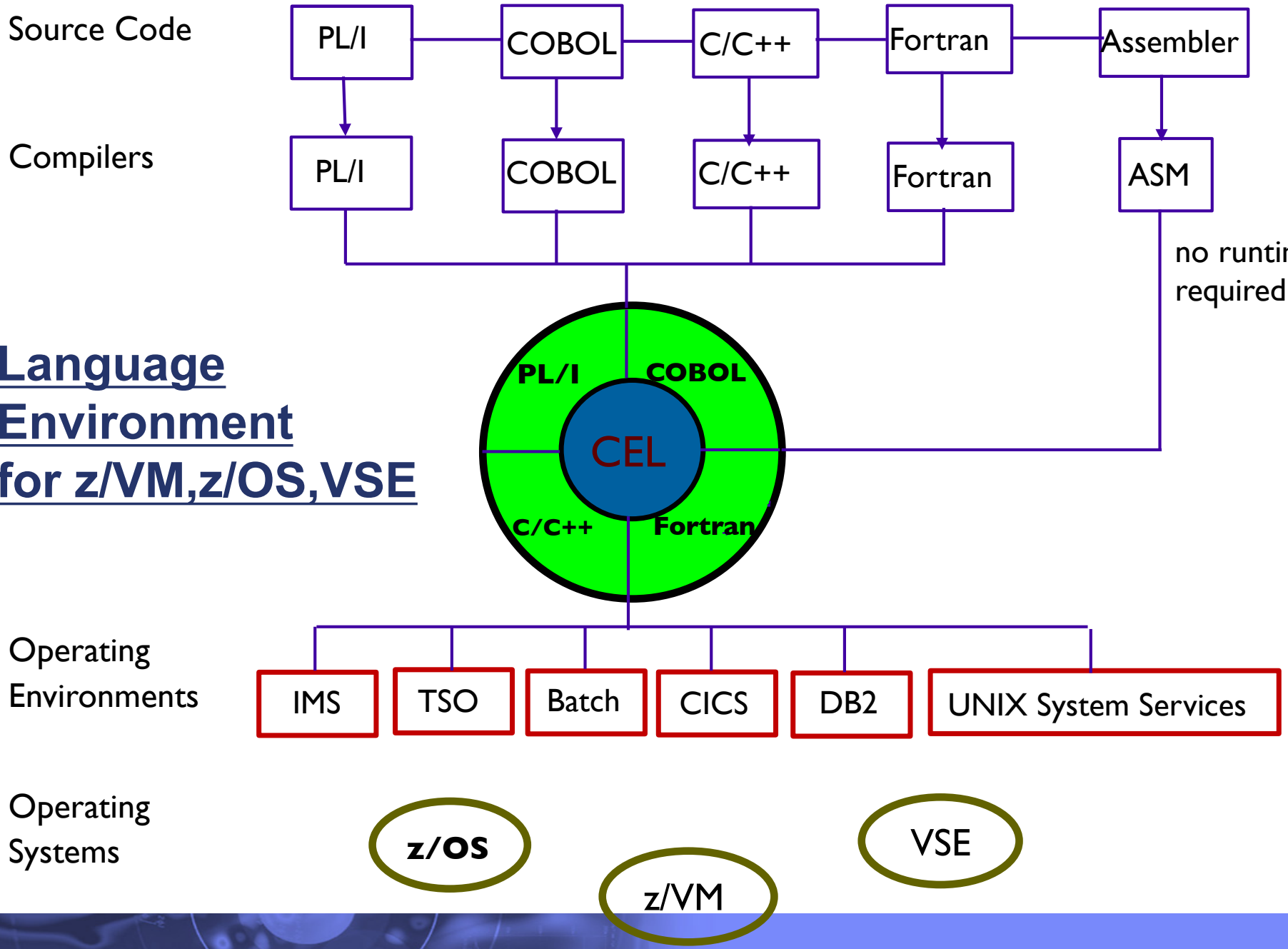
Time to make the doughnut…



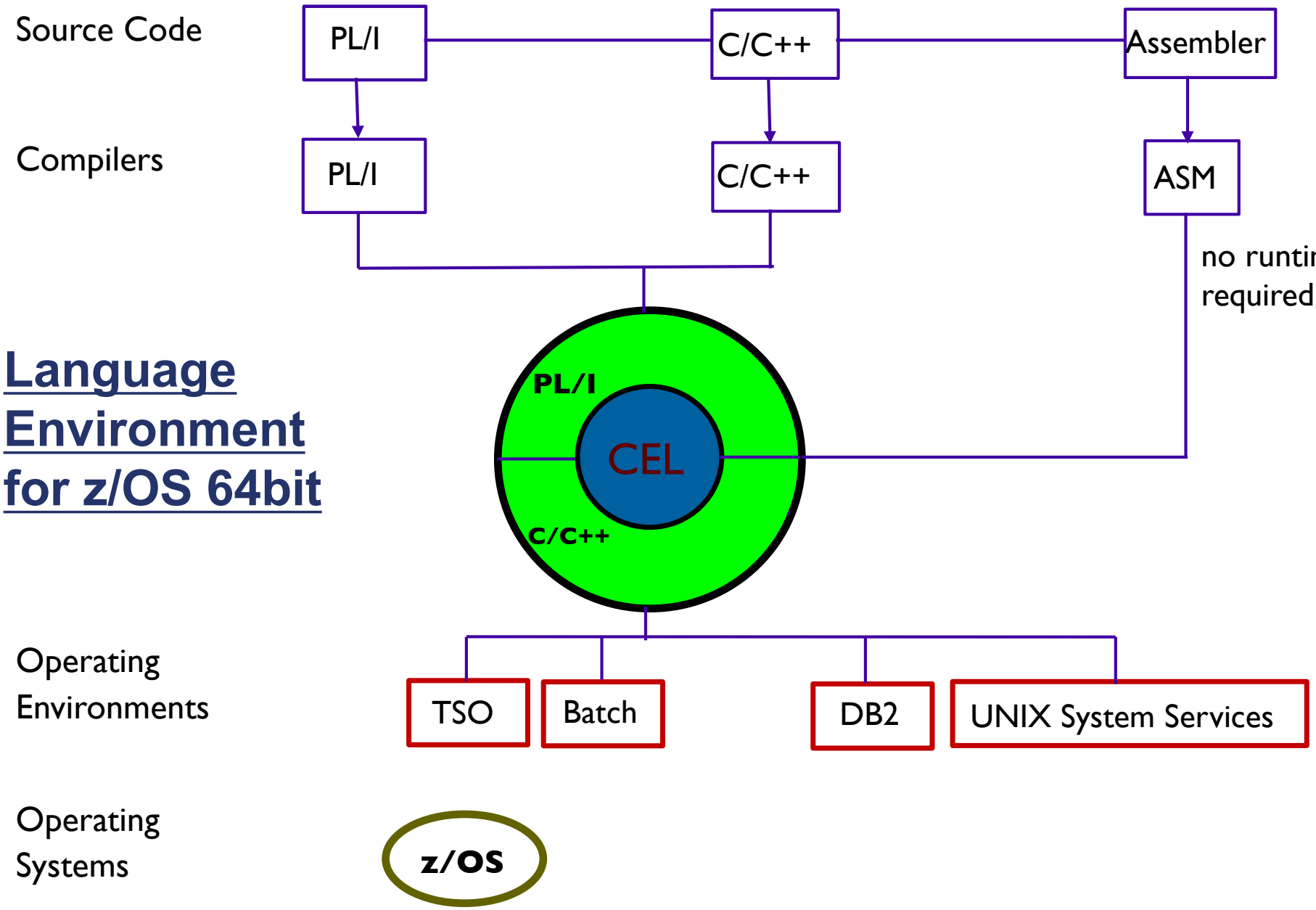
- Pre-LE environment
  - 4 independent products
  - upward incompatibilities
  - loose adherence to standards
  - purely a customer application enabler
- LE environment
  - 1 product for z/OS (also z/VM and VSE)
  - 100% upward/downward compatibility
  - strict adherence to standards
  - part of the 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 runtime 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

Language Environment for z/OS 64bit



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 runtime, and may also run with previous runtimes. Cannot make use of Language Environment callable services.
- **LE-Conforming** - Routine that can run only with the LE runtime library. Can make use of LE callable services.

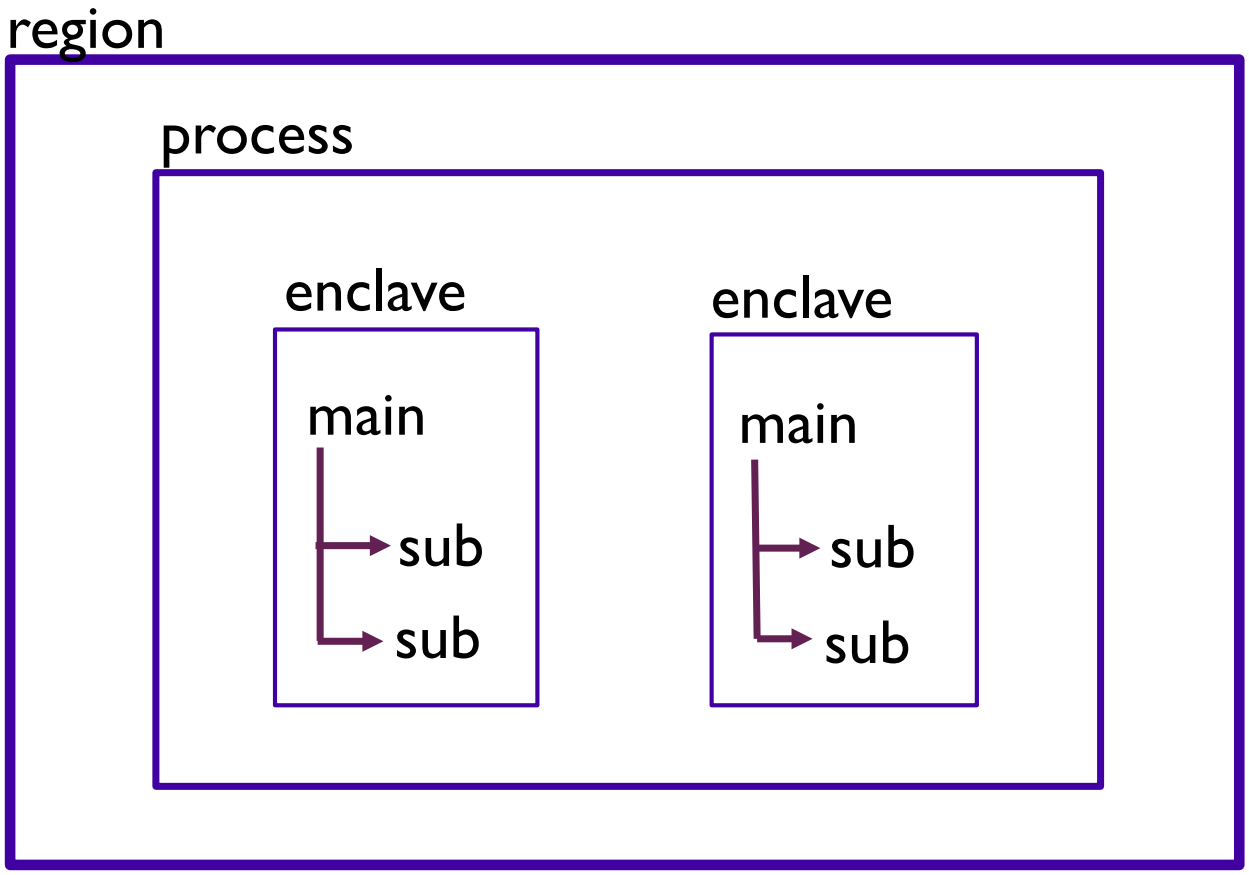
LE Terminology – Callable Services

- **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

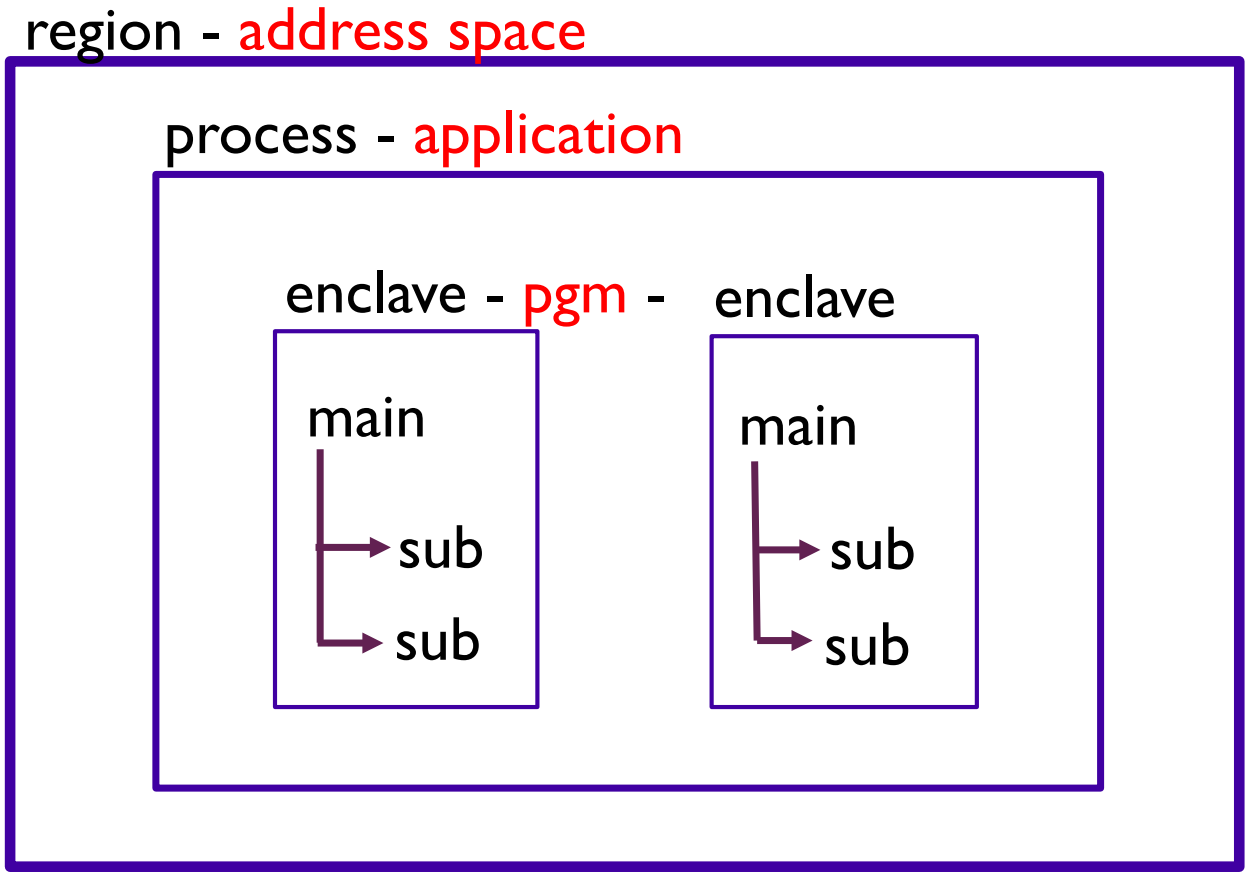
LE Terminology – Program Model

- **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

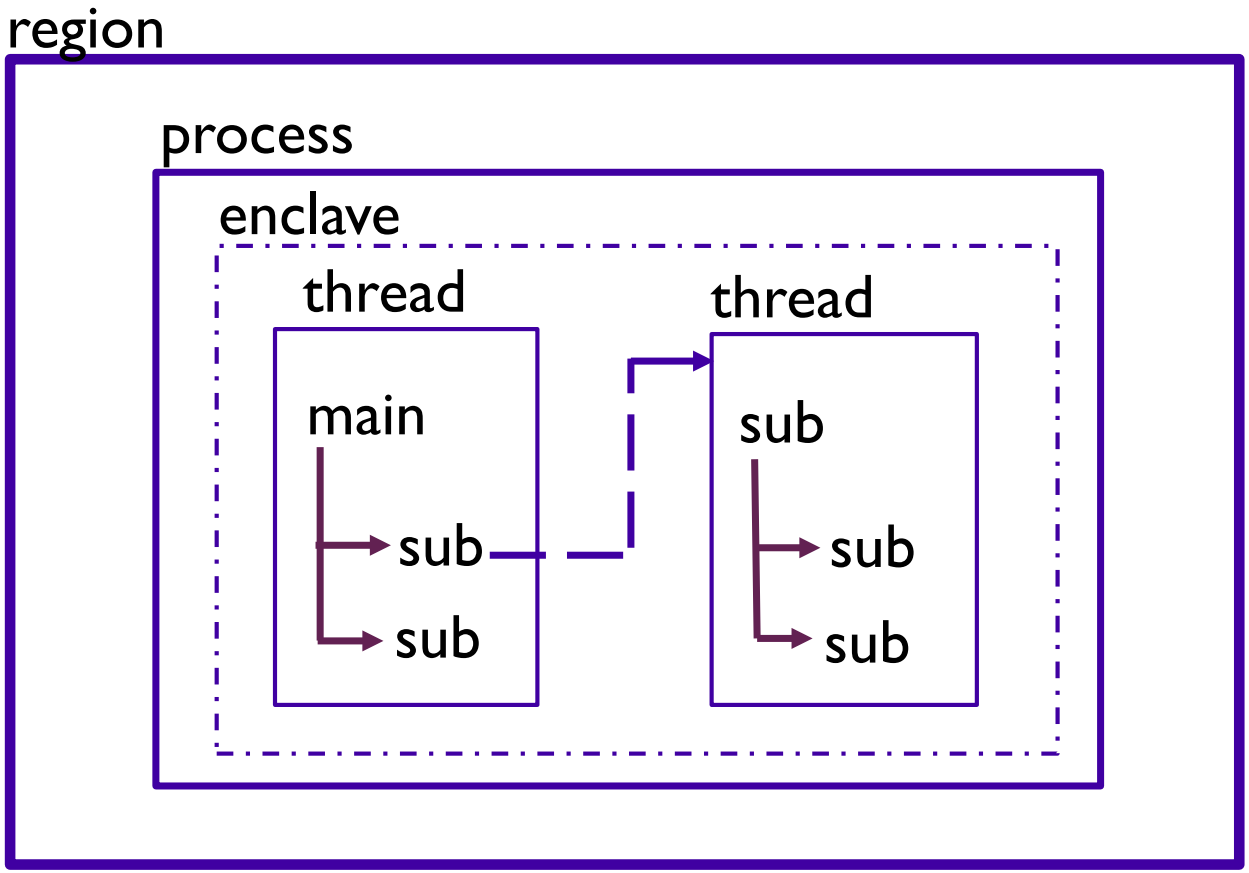
LE Terminology - Program Model



LE Terminology - MVS 'Model'



LE Terminology – Multi-threading 'Model'



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 Runtime Options

Common LE Functions – Initialization/Termination

- LE code linked with the module begins a bootstrap process to initialize LE
  - initial storage is obtained
  - LE Program Model levels are built
    - active member language specific runtime is initialized via event handler calls
- Control is given to the application code
- Once the application ends and 'returns' to LE
  - The LE environment is terminated via cleanup of Program Model levels
  - 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, PL/I ALLOCATE, and COBOL ALLOCATE (as of V6.1)
  - 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++
  - ABEND Codes
    - User ABENDs U4000-4095 reserved by LE
    - Usually have reason codes to help isolate the problem
  - CEEDUMP and/or system dump
  - Runtime Options Report
  - Storage Report

Common LE Functions - Message Services

- allows HLLs to issue common messages
- messages written to a common place - LE's MSGFILE
- 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

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

Runtime 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 Runtime Options

- The default RTOs for applications across all systems
  - **IBM-supplied defaults**
    - Base set of values for Language Environment RTOs
- 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 runtime during region initialization
    - CLER transaction for CICS environment (RTO subset)

Setting Runtime 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='runtime options'
    - In batch, on EXEC card: PARM=
  - **DD:CEEOPTS Overrides**
    - Optional data set in which runtime options may be specified

Setting Runtime 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

Key Runtime Options

- Subtopics
  - Tuning
  - Diagnostics

Key Runtime Options - Tuning

- ALL31
  - Indicates whether application runs entirely AMODE 31
- HEAP / ANYHEAP / BELOWHEAP
  - Controls size, location, and disposition of heap segments
- STACK
  - Controls size, location, and disposition of stack segments
- RPTSTG
  - Produces a report that aids in tuning storage usage

Key Runtime Options - Diagnostics

- TERMTHDACT
  - Tells LE what type of diagnostic information to produce
- DYNDUMP
  - Tells LE to produce a dynamically-allocated dump for diagnostics
- HEAPCHK
  - Performs diagnostic checks of the user heap

Key Runtime Options – Diagnostics…

- STORAGE
  - Controls initial contents of storage when obtained or freed
- TRAP
  - Controls LE's condition handling
- RPTOPTS
  - Produces a report of the runtime options settings for a specific run of an application


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