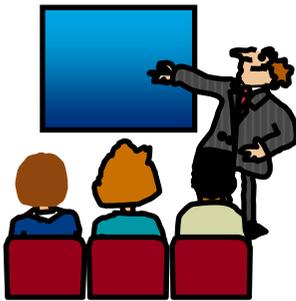


The Ins and Outs of Language Environment's CEEPIPI Service

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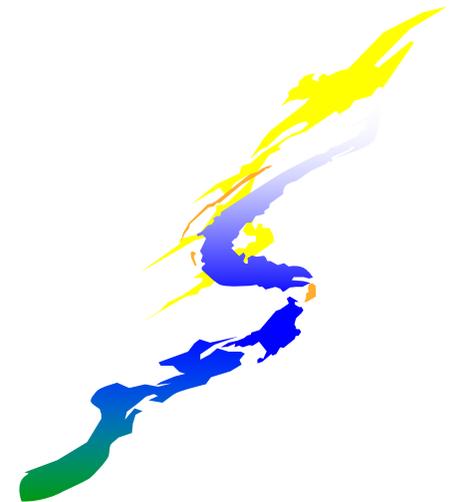
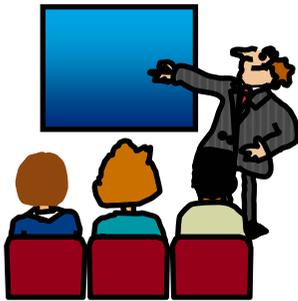
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Agenda

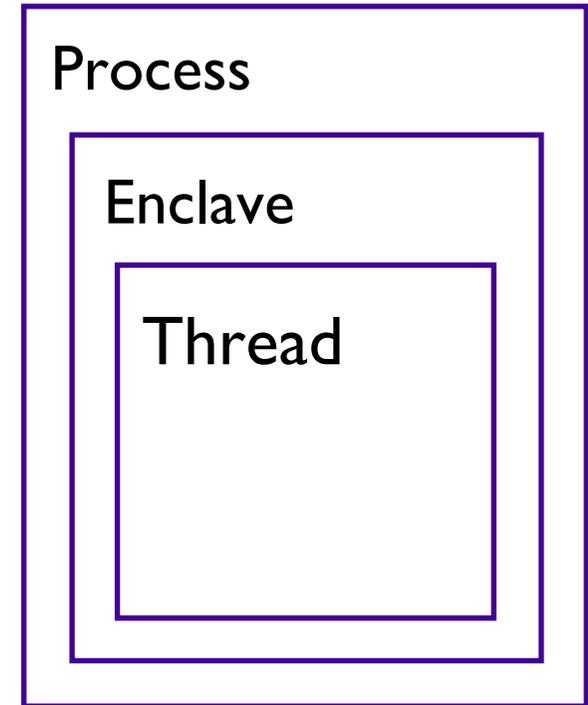
- Understanding The Basics of PreInitialization
- Using the Language Environment PreInitialization Programming Interface (Preinit)
- Preinit Interfaces
- Preinit Service Routines
- A Preinit Example
- Sources of Additional Information

Understanding The Basics of PreInitialization



Background - LE Init/Term

- Process - Collection of Resources (LE message file, library code/data)
 - unaffected by HLL semantics, logically independent address space
- Enclave - Collection of Routines (Load modules, Heap, external data)
 - defines scope of HLL semantics, first routine is designated "main"
- Thread - "thread" of execution (Stack, raised conditions)
 - share the resources of the enclave



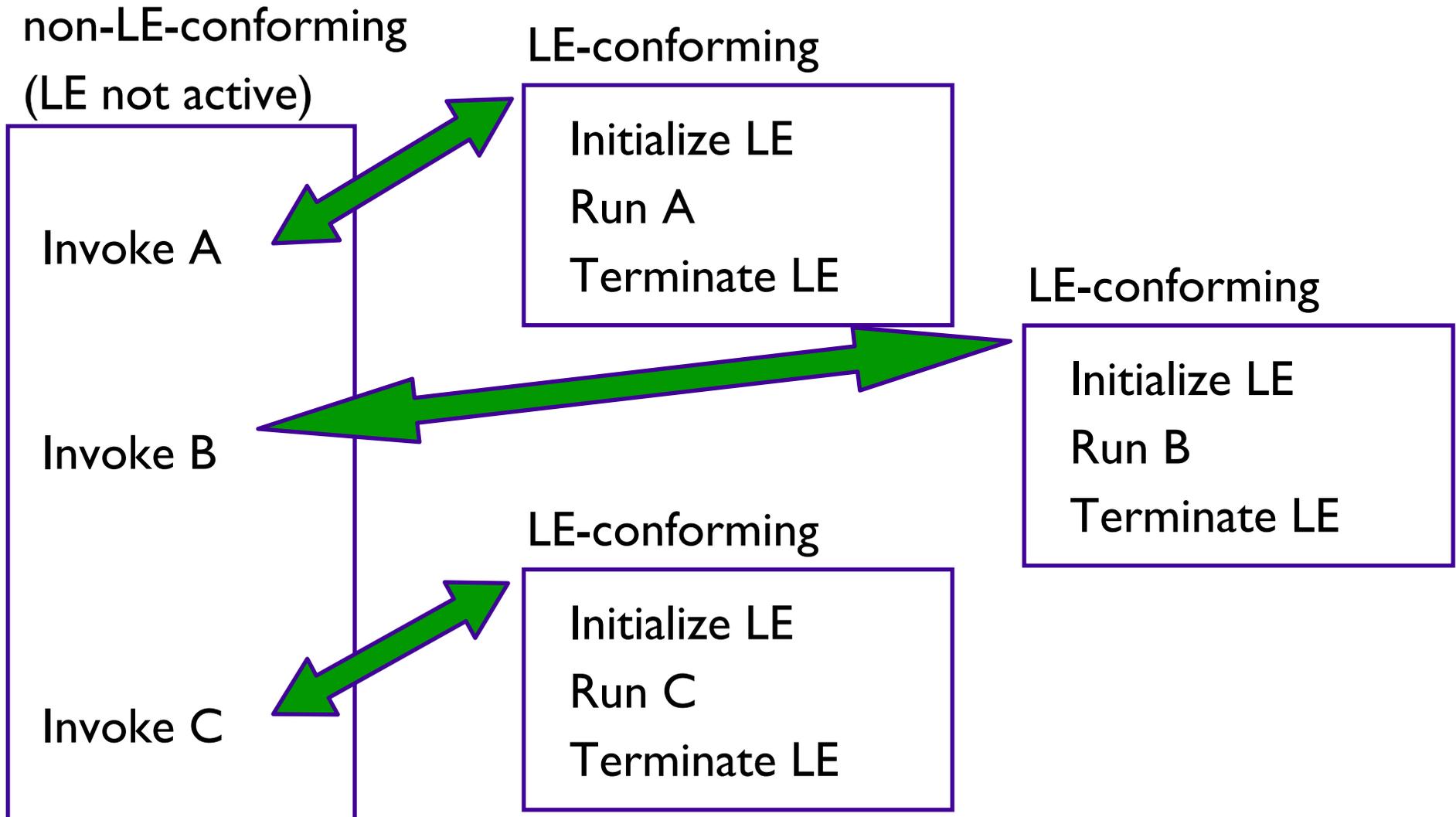
Understanding The Basics

- Read Language Environment Programming Guide, Chapter 30 "Using preinitialization services" (SA22-7561)
- Read Language Environment Programming Guide for 64-bit Virtual Addressing Mode, Chapter 22 "Using preinitialization services with AMODE 64" (SA22-7569)

Understanding The Basics...

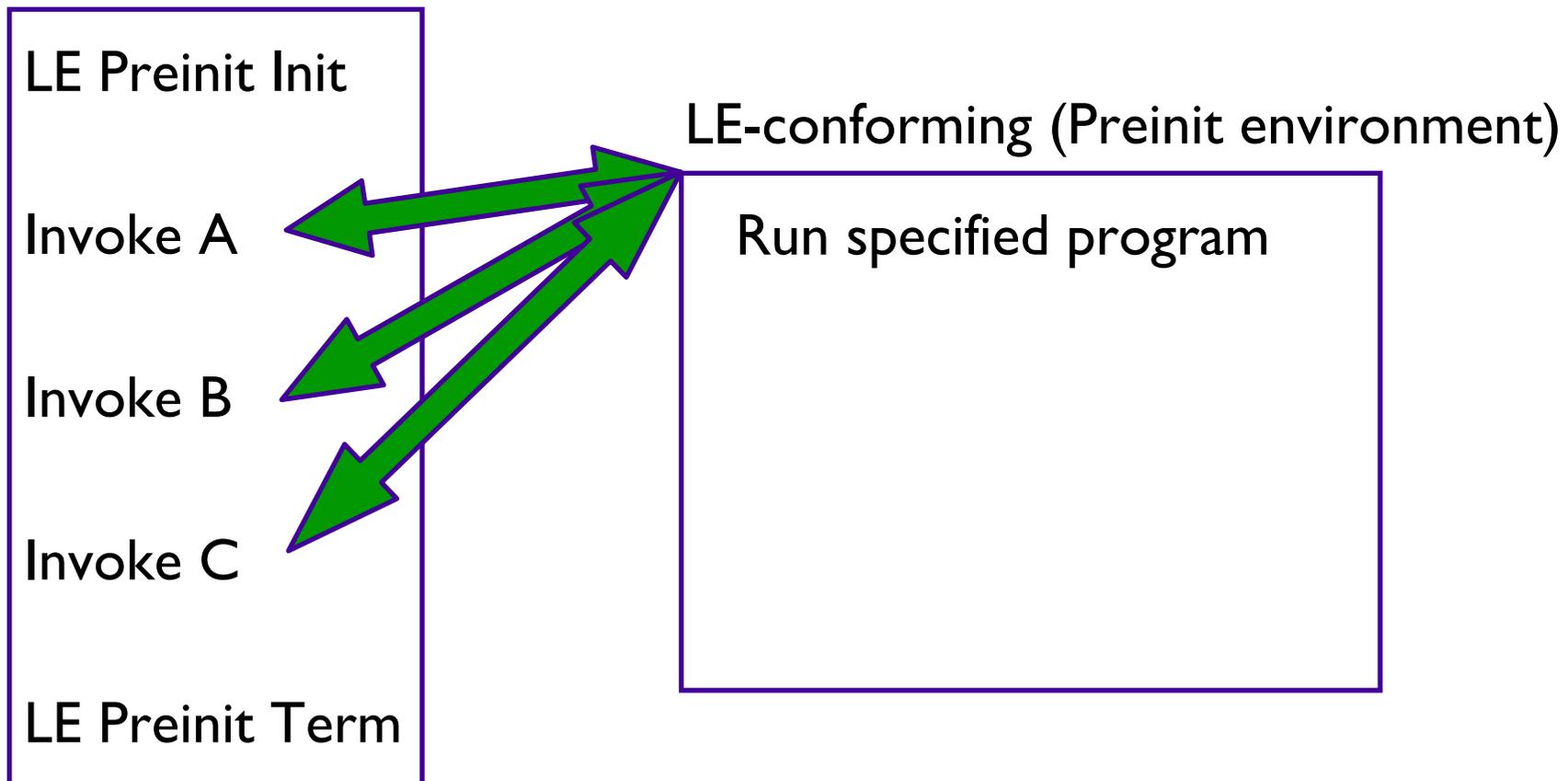
- You can use preinitialization to enhance the performance of certain applications
- Preinitialization lets a non-LE-conforming application (eg. Assembler) initialize an LE environment once, perform multiple executions of LE-conforming programs using that environment, and then explicitly terminate the LE environment
- Because the environment is initialized only once (even if you perform multiple executions), you free up system resources and allow for faster responses to your requests.

A non-Preinit scenario



Same application using Preinit

non-LE-conforming
(LE not active)



Older forms of preinitialization

- The following is a list of pre-LE language-specific forms of preinitialization. These environments are supported by LE but will not be enhanced.
 - C and PL/I -- supports prior form of C and PL/I preinitialization (PICI) through use of Extended Parameter List
 - C++ -- no prior form of preinitialization
 - COBOL -- supports the prior form of COBOL preinitialization through use of RTEREUS run-time option and ILBOSTP0 and IGZERRE functions
 - Fortran -- no prior form of preinitialization
- LE Library Routine Retention (LRR) is also supported but is not the "preferred" method

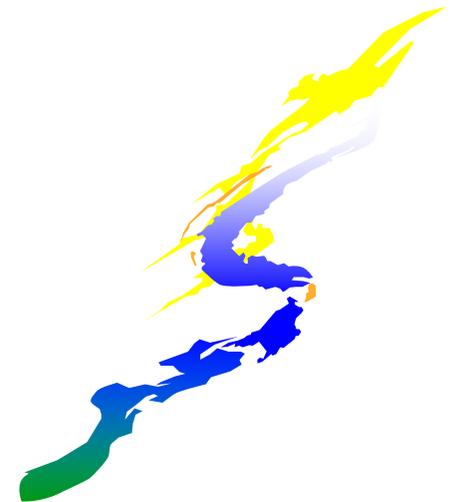
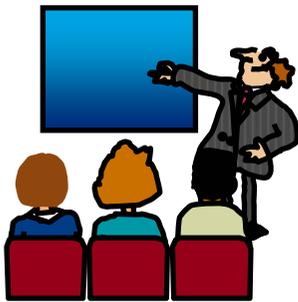
Restrictions on pre-LE preinitialization

- POSIX(ON)
- XPLINK
- AMODE 64

Users of preinitialization

- Numerous IBM products currently utilize preinitialization
 - Program Management Binder – for C++ demangler
 - DB2 – for stored procedures
 - CICS – TS V3.1 for recently announced XPLink support
 - . . .
- Many IBM customers...

Using the Language Environment PreInitialization Programming Interface (Preinit)



Using Preinit

- The main Preinit interface is the loadable module "CEEPIPI"
 - The AMODE 64 Preinit interface is the loadable module "CELQPIPI"
- CEEPIPI handles the requests and provides services for:
 - LE Environment Initialization
 - Application Invocation
 - LE Environment Termination
- All requests for services by CEEPIPI must be made from a non-Language Environment environment
- The parameter list for CEEPIPI is an OS standard linkage parameter list
 - First parameter on each call to CEEPIPI is a Preinit function code

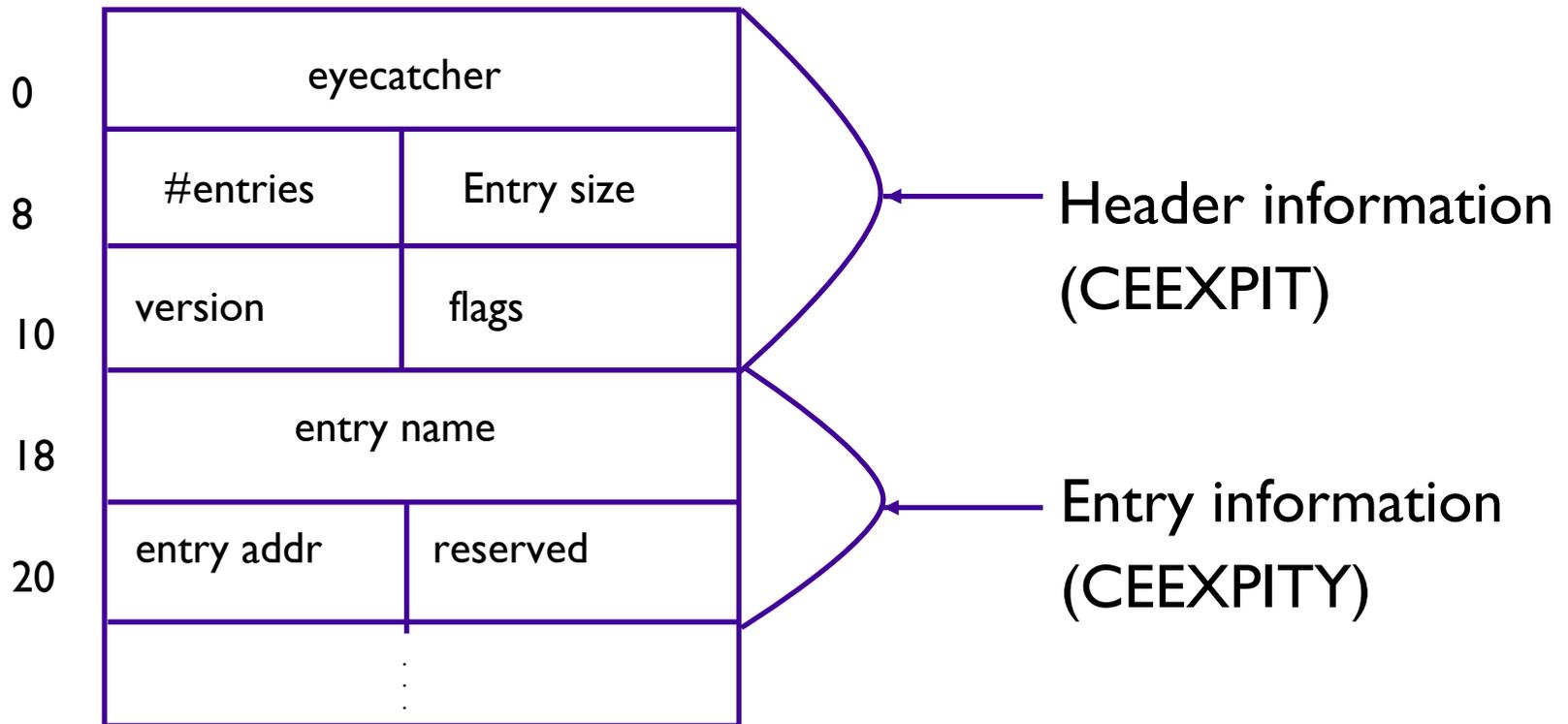
The Preinit table

- The Preinit table identifies routines to be executed (and optionally loaded) in a Preinit environment
 - It contains routine names and/or entry point addresses
 - It is possible to have an "empty" Preinit table with empty rows
 - routines can be added later using the Preinit *add_entry* interface
- In the Preinit table, entry point addresses are maintained with the High Order Bit set to indicate AMODE of routine
 - HOB on, routine is AMODE31 and invoked in 31 bit mode
 - HOB off, routine is AMODE24 and invoked in 24 bit mode
- CEEBXITA (Asm User Exit), CEEBINT (HLL User Exit), CEEUOPT are obtained from *first entry in Preinit table*

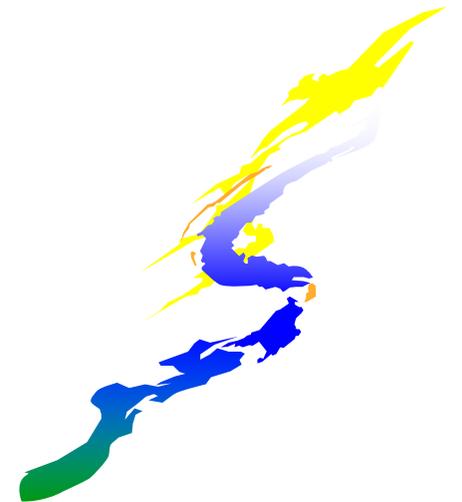
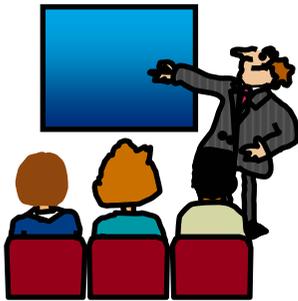
Generate the Preinit table

- LE provides the following assembler macros to generate the Preinit table
 - **CEEXPIT** generates a header for the Preinit table
 - **CEEXPITY** generates an entry within the Preinit table
 - specify entry *name* and/or *entry_point* address of the routine
 - each invocation generates a row in the Preinit table
 - if *name* is blank and *entry_point* is zero, then an empty row is added to the Preinit table
 - **CEEXPITS** identifies the end of the Preinit table
 - **CELQPIT, CELQPITY, CELQPITS** for AMODE 64
- The size of the Preinit table cannot be increased dynamically

Layout of Preinit Table



Preinit Interfaces



Preinit Initialization

- LE supports three forms of preinitialized environments
- They are distinguished by the level of initialization
 - **init_main** - supports the execution of main routine
 - initializes LE environment through process-level
 - each **call_main** invocation initializes enclave- and thread-level
 - **init_sub** - supports the execution of subroutines
 - initializes LE environment through process-, enclave-, and thread-level
 - each **call_sub** invocation has minimal overhead
 - **init_sub_dp** - a special form of the **init_sub** that allows multiple preinitialized environments, for executing subroutines, to be created under the same task (TCB). For AMODE 64 **init_sub** is comparable.
 - Only one POSIX(ON) environment per TCB

Preinit Initialization...

- **main** Environment

- Advantages

- A new, pristine environment is created
- Run-Time options can be specified for each application

- Disadvantages

- Poorer performance

- **sub** Environment

- Advantages

- Best performance

- Disadvantages

- The environment is left in what ever state the previous application left it (including WSA, working storage, etc)
- Run-Time options cannot be changed

Preinit Initialization Services

Syntax

Call **CEEPIPI|CELQPIPI** (*init_main*, *ceexptbl_addr*, *service_rtns*, *token*)

- *init_main* function code is 1
 - *ceexptbl_addr* is the address of the Preinit table
 - *service_rtns* not currently supported with **CELQPIPI**
 - *token* is returned and identifies this Preinit environment to subsequent calls to CEEPIPI
-  Register 15 contains a return code that indicates the success or failure of the Preinit service

Preinit Initialization Services...

Syntax

Call **CEEPIPI|CELQPIPI** (*init_sub*, *ceexptbl_addr*, *service_rtns*, *runtime_opts*, *token*)

Call **CEEPIPI** (*init_sub_dp*, *ceexptbl_addr*, *service_rtns*, *runtime_opts*, *token*)

- *init_sub* function code is 3, *init_sub_dp* function code is 9
- *ceexptbl_addr* is the address of the Preinit table
- *runtime_opts* is a string containing LE run-time options
- *token* is returned and identifies this Preinit environment to subsequent calls to CEEPIPI



Register 15 contains a return code that indicates the success or failure of the Preinit service

Preinit Application Invocation

- Language Environment provides services to invoke either a main routine or subroutine.
 - When invoking **main** routines, the environment must have been initialized with **init_main**
 - When invoking **subroutines**, the environment must have been initialized with **init_sub** or **init_sub_dp**
- The Preinit environment identified by **token** is activated before the specified routine is called
- After the called routine returns, the environment becomes "dormant"
- The parameter list is passed to the application as-is
 - XPLink & 64-bit convert from OS format to XPLink

Reentrancy Considerations

- You can make multiple calls to **main** routines or **subroutines**
- In general, you should specify only reentrant routines for multiple invocations:
 - Multiple calls to a reentrant **main** routine are not influenced by a previous execution of the same routine
 - For example, external variables are reinitialized for every call to a reentrant **main**
- 👉 If you have a nonreentrant COBOL program, condition IGZ0044S is signalled when the routine is invoked again
- 👉 If you have a nonreentrant C main() program that uses external variables, then when your routine is invoked again, the variables will be in last-use state
- 👉 Multiple calls to reentrant **subroutines** reuse the same working storage, it is only initialized once during (*call_sub*)

Preinit Application Invocation Services

Syntax

Call **CEEPIPI|CELQPIPI** (*call_main*, *ceexptbl_index*, *token*, *runtime_options*, *parm_ptr*, *enclave_return_code*, *enclave_reason_code*, *appl_feedback_code*)

- ***call_main*** function code is 2
- ***ceexptbl_index*** is the Preinit table row number of the main to call
- ***token*** identifies this Preinit environment (from ***init_main***)
- ***runtime_opts*** is a string containing LE run-time options
- ***parm_ptr*** in the format expected by the HLL language of main



Register 15 contains a return code that indicates the success or failure of the Preinit service

Preinit Application Invocation Services...

Syntax

Call CEEPIPI|CELQPIPI (*call_sub*, *ceexptbl_index*, *token*, *parm_ptr*,
sub_return_code, *sub_reason_code*, *sub_feedback_code*)

- ***call_sub*** function code is 4
 - ***ceexptbl_index*** is the Preinit table row number of the subrtn to call
 - ***token*** identifies this Preinit environment (from *init_sub* or *init_sub_dp*)
 - ***parm_ptr*** in the format expected by the HLL language of sub
-  Register 15 contains a return code that indicates the success or failure of the Preinit service

Preinit Application Invocation Services...

Syntax

Call **CEEPIPI**|**CELQPIPI** (*call_sub_addr*, *routine_addr*, *function_pointer*, *token*, *parm_ptr*, *sub_return_code*, *sub_reason_code*, *sub_feedback_code*)

- ***call_sub_addr*** function code is 10
- ***routine_addr*** is *doubleword* containing the address of the subrtn to call (loaded by driver program, *not* LE)
- ***function_pointer*** is extra 16 byte parameter for **CELQPIPI** only
- ***token*** identifies this Preinit environment (from *init_sub* or *init_sub_dp*)
- ***parm_ptr*** in the format expected by the HLL language of sub

 Register 15 contains a return code that indicates the success or failure of the Preinit service

Stop Semantics in Preinit subs

- When one of the following occurs within a preinitialized environment *for subroutines*, the logical enclave is terminated:
 - C `exit()`, `abort()`, or signal handling function specifying a normal or abnormal termination
 - COBOL `STOP RUN` statement
 - PL/I `STOP` or `EXIT`
 - an unhandled condition causing termination of the (only) thread
- The process level of the environment is retained
- Modules in Preinit table are not deleted
- The next call to a `subrtn` in this environment will initialize a new enclave (possibly with different user exits)

Preinit Termination Service

Syntax

Call **CEEPIPI|CELQPIPI** (*term, token, env_return_code*)

- ***term*** function code is 5
- ***token*** identifies this Preinit environment (from previous initialization call)
- ***env_return_code*** is set to the return code from the environment termination



Register 15 contains a return code that indicates the success or failure of the Preinit service

User Exit Invocation

	init_sub, init_sub_dp	call_main	call_sub or call_sub_addr ended with STOP semantics	term for "clean" init_sub or init_sub_dp environment	term
CEEBXITA (enclave init)	X	X	X(next call)		
CEEBINT (HLL exit)	X	X	X(next call)		
C atexit() functions		X	X	X	
CEEBXITA (enclave term)		X	X	X	
CEEBXITA (process term)				X	X

 CEEBXITA and CEEBINT application-specific user exits are taken from the first valid entry in Preinit table

 All other occurrences are ignored!

Updating the Preinit Table

Syntax

Call **CEEPIPI|CELQPIPI** (*add_entry*, *token*, *routine_name*,
routine_entry, *ceexptbl_index*)

- ***add_entry*** function code is 6
- ***token*** identifies a *dormant* Preinit environment (from previous initialization call)
- ***routine_name*** is char(8) name of routine to add (and optionally load), or blank
- ***routine_entry*** is entry point address of routine to add (or zero)
- ***ceexptbl_index*** is Preinit table row number where added



Register 15 contains a return code that indicates the success or failure of the Preinit service

Updating the Preinit Table...

Syntax

Call **CEEPIPI** (*delete_entry*, *token*, *ceexptbl_index*)

- ***delete_entry*** function code is 11
- ***token*** identifies a *dormant* Preinit environment (from previous initialization call)
- ***ceexptbl_index*** is Preinit table row number of the entry to delete (and delete from storage if it was loaded by LE)



Register 15 contains a return code that indicates the success or failure of the Preinit service

XPLINK Preinit

- Will allow users to run XPLINK-compiled programs in a Preinit environment.
- LE initializes *either* an XPLINK environment or a "regular" (non-XPLINK) environment
 - Never "both"
 - But we might switch - more later...

XPLINK Preinit...

- `init_main`

- If the first program in the Preinit table was compiled non-XPLINK...
 - Then a non-XPLINK Preinit main environment is initialized
- If the first program in the Preinit table was compiled XPLINK...
 - Then an XPLINK Preinit main environment is initialized
- If the Preinit table is empty at initialization time...
 - Then a non-XPLINK Preinit main environment is initialized

XPLINK Preinit...

- `init_sub` or `init_sub_dp`
 - If the first program in the Preinit table was compiled XPLINK...
 - Then an XPLINK Preinit sub environment is initialized
 - If the `XPLINK(ON)` run-time option is specified...
 - Then an XPLINK Preinit sub environment is initialized
 - If neither of the above are true...
 - Then a non-XPLINK Preinit sub environment is initialized

XPLINK Preinit...

- call_main
 - If the Preinit main environment is non-XPLINK *and* (the program to be invoked was compiled XPLINK) *or* (the XPLINK(ON) run-time option was specified)
 - Then rebuild as an XPLINK Preinit environment
- 👉 This Preinit environment will always remain an XPLINK Preinit environment (ie. we won't switch back).

XPLINK Preinit...

- `call_sub` or `call_sub_addr`
 - If the Preinit sub environment is non-XPLINK *and* the called subroutine was compiled XPLINK...
 - Then the call will return with a "mis-match" error and the subroutine will not be executed.

Note: XPLINK subroutines must be defined as fetchable

- `#pragma linkage (fetchable)` statement

Summary - Preinit Interfaces

Function Code	Integer Value	Service Performed
Initialization		
<i>init_main</i>	1	Create and initialize an environment for mains
<i>init_sub</i>	3	Create and initialize an environment for subs
<i>init_sub_dp</i>	9	Create and initialize an environment for subs
Termination		
<i>term</i>	5	Explicitly terminate an environment

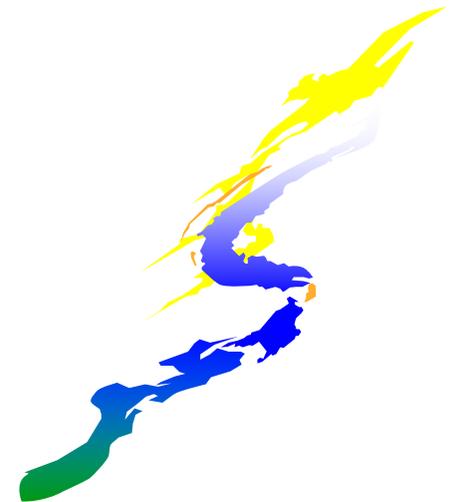
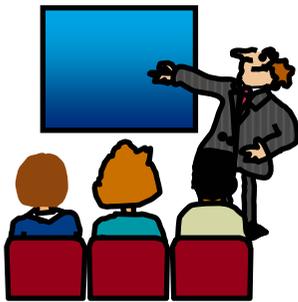
Summary - Preinit Interfaces...

Function Code	Integer Value	Service Performed
Application Invocation		
<i>call_main</i>	2	Invoke a main routine with an already init'd environment
<i>call_sub</i>	4	Invoke a subroutine with an already init'd environment
<i>call_sub_addr</i>	10	Invoke a subroutine by addr with an already init'd environment
Addition of an entry to Preinit table		
<i>add_entry</i>	6	Dynamically add a routine to the already init'd environment

Summary - Preinit Interfaces...

Function Code	Integer Value	Service Performed
Deletion of an entry to Preinit table		
<i>delete_entry</i>	11	Delete an entry from the Preinit table, making it available to later <i>add_entry</i>
Identification of the Preinit environment		
<i>identify_environment</i>	15	Identify the Preinit init'd environment (not available with CELQPIPI)
Identification of a Preinit table entry		
<i>identify_entry</i>	13	Identify the language of an entry in the Preinit table
<i>identify_attributes</i>	16	Identify the attributes of an entry in the Preinit table

Preinit Service Routines

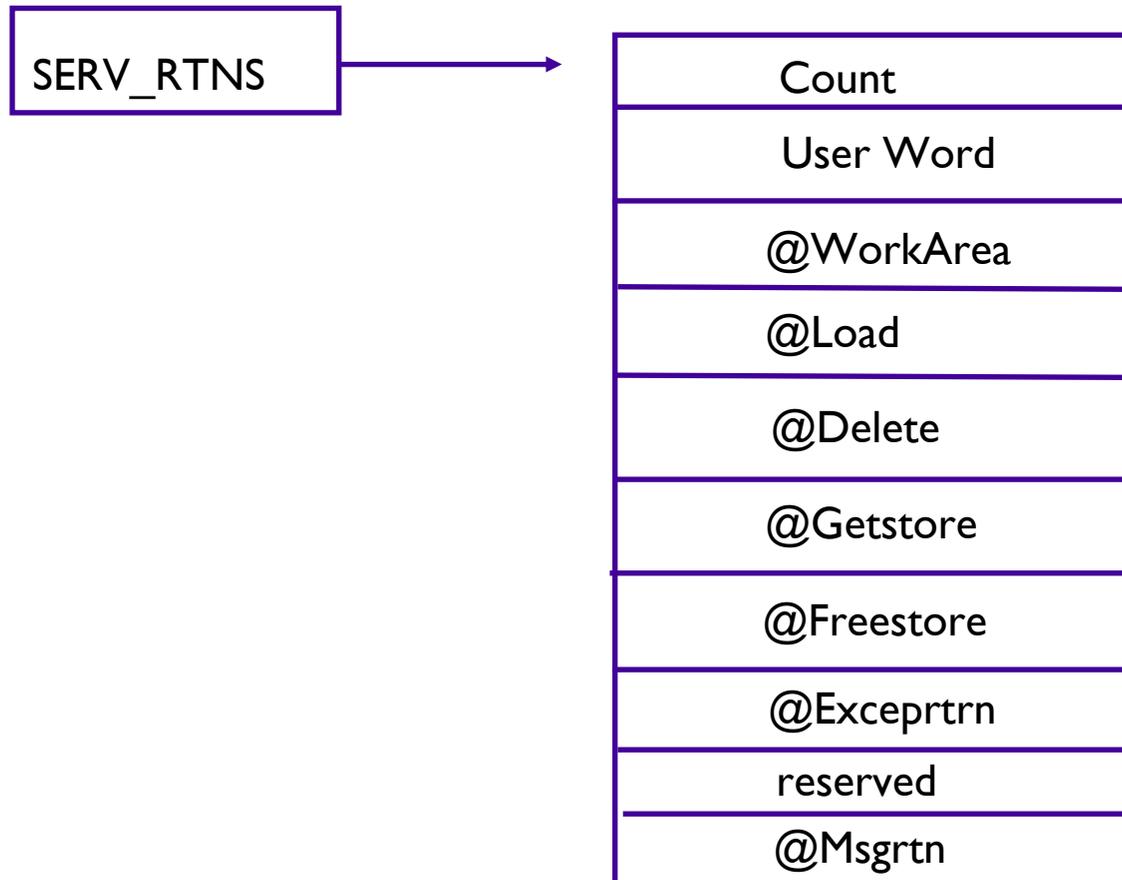


Service routines

- Under Language Environment, you can specify several service routines for use with running a main routine or subroutine in the preinitialized environment
- To use the routines, specify a list of addresses of the routines in a service routine vector
 - Pass the address of this list on the *init_main*, *init_sub*, or *init_sub_dp* interfaces
 - The *service_rtns* parameter that you specify contains the address of the vector itself
 - If this pointer is specified as zero (0), LE routines are used instead of the service routines
- Why?
 - Preinit environments to be used in SRB mode, where SVCs cannot be issued
 - Execution environment has its own storage or program management services

Service routines...

Format of Service Routine Vector



Service routines...

- Count
 - the number of fullwords that follow
- User Word
 - passed to the service routines
 - provides a means for your routine to communicate to the service routines
- @Workarea
 - address of a work area of at least 256 bytes that is doubled word aligned. First word contains the length of area provided. Required if service routines present in vector
- @Load
 - loads named routines for application management
- @Delete
 - deletes routines for application management

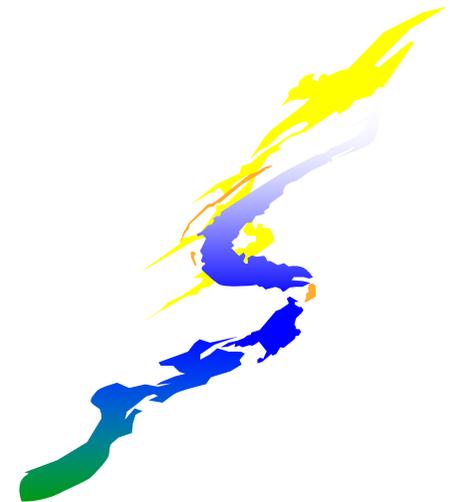
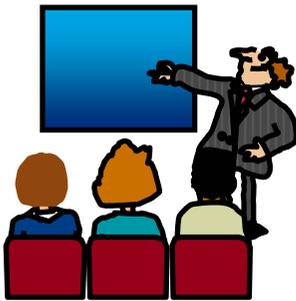
Service routines...

- @Getstore
 - allocates storage on behalf of the storage manager. This routine relies on the caller to provide a save area, which can be the @Workarea
- @Freestore
 - frees storage on behalf of storage manager
- @Exceprtn
 - traps program interrupts and abends for condition management
- @Msgtrtn
 - allows error messages to be processed by caller of the application

A Preinit Example

The following example provides an illustration of an assembler program **ASMPIPI ASSEMBLE** invoking **CEEPIPI** to:

- Initialize a LE Preinit subroutine environment
- Load and call a reentrant C/COBOL/PLI subroutine
- Terminate the LE Preinit environment



Example

- Following the assembler program are interchangeable examples of the program HLLPIPI written in:
 - C, COBOL, and PL/I
- HLLPIPI is called by an assembler program, ASMPIPI.
- ASMPIPI uses the Language Environment preinitialized program subroutine call interface
- You can use the assembler program to call the HLL versions of HLLPIPI.

Example...

```
*
*COMPILATION UNIT: LEASMPIP
*****
*
* Function: CEEPIPI - Initialize the Preinitialization
*               environment,call a Preinitialization
*               HLL program,and terminate the environment.
*
* 1. Call CEEPIPI to initialize a subroutine environment under LE.
* 2. Call CEEPIPI to load and call a reentrant HLL subroutine.
* 3. Call CEEPIPI to terminate the LE Preinitialization environment.
*
* Note: ASMPIPI is not reentrant.
*
*****
```

Example...

```
* =====  
* Standard program entry conventions.  
* =====
```

```
ASMPIPI  CSECT  
        STM   R14,R12,12(R13)      Save caller's registers  
        LR    R12,R15              Get base address  
        USING ASMPIPI,R12         Identify base register  
        ST    R13,SAVE+4          Back-chain the save area  
        LA    R15,SAVE             Get addr of this routine's save area  
        ST    R15,8(R13)          Forward-chain in caller's save area  
        LR    R13,R15             R13 -> save area of this routine
```

```
*  
* Load LE CEEPIPI service routine into main storage.  
*
```

```
        LOAD  EP=CEEPIPI          Load CEEPIPI routine dynamically  
        ST    R0,PPRTNPTR        Save the addr of CEEPIPI routine
```

Example...

*

* Initialize an LE Preinitialization subroutine environment.

*

INIT_ENV EQU *

LA R5,PPTBL Get address of Preinit Table

ST R5,@CEXPTBL Ceexptbl_addr ->Preinit Table

L R15,PPRTNPTR Get address of CEEPIPI routine

* Invoke CEEPIPI routine

CALL (15),(INITSUB,@CEXPTBL,@SRVRTNS,RUNTMOPT,TOKEN)

* Check return code:

LTR R2,R15 Is R15 = zero?

BZ CSUB Yes (success)..go to next section

* No (failure)..issue message

WTO 'ASMPIPI: call to (INIT_SUB) failed',ROUTCDE=11

C R2,=F'8' Check for partial initialization

BE TSUB Yes..go do Preinit termination

* No..issue message & quit

WTO 'ASMPIPI: INIT_SUB failure RC is not 8.',ROUTCDE=11

ABEND (R2),DUMP Abend with bad RC and dump memory

Example...

*

* Call the subroutine, which is loaded by LE

*

```
CSUB      EQU      *
          L        R15,PPRTNPTR          Get address of CEEPIPI routine
          CALL     (15),(CALLSUB,PTBINDEX,TOKEN,PARMPTR,          X
                  SUBRETC,SUBRSNC,SUBFBC)
```

* Check return code:

```
          LTR      R2,R15                Is R15 = zero?
          BZ       TSUB                   Yes (success)..go to next section
```

* No (failure)..issue message & quit

```
          WTO      'ASMPIPI: call to (CALL_SUB) failed',ROUTCDE=11
          ABEND    (R2),DUMP              Abend with bad RC and dump memory
```

Example...

```
*
* Terminate the environment
*
TSUB      EQU      *
          L        R15,PPRTNPTR          Get address of CEEPIPI routine
          CALL    (15),(TERM,TOKEN,ENV_RC)
* Check return code:
          LTR     R2,R15                 Is R15 = zero ?
          BZ      DONE                  Yes (success)..go to next section
* No (failure)..issue message & quit
          WTO     'ASMPIPI: call to (TERM) failed',ROUTCDE=11
          ABEND  (R2),DUMP              Abend with bad RC and dump memory
*
* Standard exit code.
*
DONE      EQU      *
          LA     R15,0                   Passed return code for system
          L     R13,SAVE+4              Get address of caller's save area
          L     R14,12(R13)            Reload caller's register 14
          LM    R0,R12,20(R13)        Reload caller's registers 0-12
          BR    R14                    Branch back to caller
```

Example...

```
* =====  
* CONSTANTS and SAVE AREA.  
* =====  
SAVE          DC      18F'0'  
PPRTNPTR     DS      A           Save the address of CEEPIPI routine  
*  
* Parameters passed to an (INIT_SUB) call.  
INITSUB      DC      F'3'         Function code to initialize for subr  
@CEXPTBL     DC      A(PPTBL)     Address of Preinitialization Table  
@SRVRTNS     DC      A(0)         Addr of service-rtns vector,0 = none  
RUNTMOPT     DC      CL255''      Fixed length string of runtime optns  
TOKEN        DS      F           Unique value returned(output)  
*  
* Parameters passed to a (CALL_SUB) call.  
CALLSUB      DC      F'4'         Function code to call subroutine  
PTBINDEX     DC      F'0'         The row number of Preinit Table entry  
PARMPTR      DC      A(0)         Pointer to @PARMLIST or zero if none  
SUBRETC      DS      F           Subroutine return code (output)  
SUBRSNC      DS      F           Subroutine reason code (output)  
SUBFBC       DS      3F          Subroutine feedback token (output)
```

Example...

```
*
* Parameters passed to a (TERM) call.
TERM      DC      F'5'                Function code to terminate
ENV_RC    DS      F                    Environment return code (output)
* =====
* Preinitialization Table.
* =====
*
PPTBL     CEEXPIT ,                    Preinitialization Table with index
          CEEXPITY HLLPIPI,0          0=dynamically loaded routine
          CEEXPITS ,                  Endof PreInit table
*
          LTORG
R0        EQU    0
R1        EQU    1
...
R14       EQU    14
R15       EQU    15
          END    ASMPIPI
```

Example...

C Subroutine Called by ASMPIPI

```
#include <stdio.h>

HLLPIPI ()
{
    printf("C subroutine beginning \n");
    printf("Called using LE PreInit call \n");
    printf("Subroutine interface.\n");
    printf("C subroutine returns to caller \n");
}
```

Example...

COBOL Program Called by ASMPIPI

```
CBL LIB,QUOTE
  *Module/File Name: IGZTPIPI
  ****
  *
  * HLLPIPI is called by an assembler program, ASMPIPI.
  * ASMPIPI uses the LE preinitialized program
  * subroutine call interface. HLLPIPI can be written
  * in COBOL, C, or PL/I.
  *
  ****
  IDENTIFICATION DIVISION.
  PROGRAM-ID. HLLPIPI.
  DATA DIVISION.
  WORKING-STORAGE SECTION.
  PROCEDURE DIVISION.
    DISPLAY "COBOL subprogram beginning".
    DISPLAY "Called using LE Preinitialization".
    DISPLAY "Call subroutine interface.".
    DISPLAY "COBOL subprogram returns to caller.".
  GOBACK.
```

Example...

PL/I Routine Called by ASMPIPI

```
/*Module/File Name: IBMPIPI */
/*****/
/*
/* HLLPIPI is called by an assembler program, ASMPIPI. */
/* ASMPIPI uses the LE preinitializedprogram */
/* subroutine call interface.HLLPIPI can be written */
/* in COBOL,C,or PL/I. */
/* */
/*****/
HLLPIPI: PROC OPTIONS(FETCHABLE);
    DCL RESULT FIXED BIN(31,0)INIT(0);
    PUT SKIP LIST
        ('HLLPIPI: PLI subroutine beginning. ');
    PUT SKIP LIST
        ('HLLPIPI: CalledLE Preinit Call ');
    PUT SKIP LIST
        ('HLLPIPI: Subroutine interface. ');
    PUT SKIP LIST
        ('HLLPIPI: PLI program returns to caller. ');
    RETURN;
END HLLPIPI;
```

Sources of Additional Information

- LE Debug Guide and Runtime Messages
- LE Programming Reference
- LE Programming Guide (64-bit too!)
- LE Customization
- LE Migration Guide
- LE Writing ILC Applications
- Web site
 - <http://www.ibm.com/servers/eserver/zseries/zos/le/>