Slowed down by LE?
Perhaps the CEEPIPI service can help!

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Agenda

• Understanding The Basics of PreInitialization
• Writing a Preinit Application
• Other Preinit Topics
• 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 (e.g., 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

non-LE-conforming (LE not active)

Invoke A

Invoke B

Invoke C

LE-conforming

Initialize LE
Run A
Terminate LE

LE-conforming

Initialize LE
Run B
Terminate LE

LE-conforming

Initialize LE
Run C
Terminate LE
Same application using Preinit

non-LE-conforming (LE not active)

- LE Preinit Init
- Invoke A
- Invoke B
- Invoke C
- LE Preinit Term

Run specified program

LE-conforming (Preinit environment)
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 XPLINK support
  - ...

- Many IBM customers…
Writing a Preinit Application
A Preinit application consists of:

- One or more HLL routines
- A Preinit Table
- A Preinit Assembler Driver
HLL Routines

An example subroutine: Notice anything unusual?

CBL LIB,QUOTE
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.

Your answer should be “Nope!”
HLL Routines

- Written in
  - C
  - C++
  - PL/I
  - COBOL

- May be main or subroutine
  - If using an XPLINK or AMODE 64 subroutine, it must be declared “fetchable”
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
The Preinit Table

Declared in the data section of the Preinit Assembler Driver:

```
* =====================================================================
* Preinitialization Table.                                          *
* =====================================================================
*                                                               *
PPTBL        CEEXPIT ,        Preinitialization Table with index
            CEEXPITY HLLPIPI,0       dynamically loaded routine
            CEEXPITY ,HLLEXTRN       statically-bound routine
            CEEXPITY ,            empty Table slot
            CEEXPITS ,            Endof PreInit table
*                                                               *
EXTRN        HLLEXTRN
*```


The Preinit Assembler Driver

- The Preinit Assembler Driver is responsible for:
  - Loading the Preinit Interface module
  - Initializing / Terminating the Preinit environment
  - Calling HLL routines using the Preinit environment
The Preinit Interface Module

- 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
Loading CEEPIPI

* Load LE CEEPIPI service routine into main storage.

* LOAD EP=CEEPIPI
  Load CEEPIPI routine dynamically

  ST R0,PPRTNPtr
  Save the addr of CEEPIPI routine
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 whatever state the previous application left it (including WSA, working storage, etc)
    - Run-Time options cannot be changed
**Initialize an LE Preinitialization main 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),(INITMAIN,@CEXPTBL,@SRVRTNS,TOKEN)

* Check return code:

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

* No (failure). issue message

WTO 'ASMPIPI: call to (INIT_MAIN) failed',ROUTCDE=11
C R2,=F’8’ Check for partial initialization
BE TMAIN Yes..go do Preinit termination

* No.. issue message & quit

WTO 'ASMPIPI: INIT_MAIN failure RC is not 8.',ROUTCDE=11
ABEND (R2),DUMP Abend with bad RC and dump memory
** 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,RUNTMOP,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
Calling the HLL Routine

• 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
Calling the HLL Routine... 

- It is important to provide the parameter list in the exact format that the compiled routine is expecting.
  - C Example: ‘TESTPGM 10 5’ when interactively invoked
  - C function prototype: main(int argc, char **argv)
  - Assembler parameter list layout:

```
PARMPTR   DC A(PARMLIST) Pointer to PARMLIST
 *         
PARMLIST  DS 0A Parameter List
ARGC      DC F'3' Number of arguments
ARGVPTR   DC A(ARGV) Pointer to Argument Array
 *         
ARGV      DS 0A Argument Array
ARGV0     DC A(ARGV0S) Pointer to Argument 1
ARGV1     DC A(ARGV1S) Pointer to Argument 2
ARGV2     DC A(ARGV2S) Pointer to Argument 3
 *         
ARGV0S    DC C'TESTPGM',X'00' Argument 1
ARGV1S    DC C'10',X'00' Argument 2
ARGV2S    DC C'5',X'00' Argument 3
```
Calling a HLL Main

* Call the main, which is loaded by LE

* CMAIN EQU *
  L R15,PPRTNPTR Get address of CEEPIPI routine
  CALL (15),(CALLMAIN,PTBINDEX,TOKEN,RUNTMOPT,PARMPTR,
        ENCRETC,ENCRCVNC,APPLFBC)

* Check return code:
  LTR R2,R15 Is R15 = zero?
  BZ TMAIN Yes (success)..go to next section

* No (failure)..issue message & quit
  WTO 'ASMPIPI: call to (CALL_MAIN) failed',ROUTCDE=11
  ABEND (R2),DUMP Abend with bad RC and dump memory

::
**Calling a HLL Subroutine**

* Call the subroutine, which is loaded by LE

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

*
Preinit Termination

- The Preinit application terminates the Preinit environment once it is no longer needed
- Termination performs cleanup of the resources associated with the environment
- A single Termination service handles all types of Preinit environments
Terminating the Preinit Environment

* 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

*
Other Preinit Topics
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**)
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)
Additional Preinit Services

- Calling a Subroutine By Address
  - call_sub_addr: Invoke a subroutine by address within an already initialized environment

- Improving Performance of a Sequence of Calls
  - start_seq: Start a sequence of uninterruptible calls to a number of subroutines
  - end_seq: Terminate a sequence of uninterruptible calls to a number of subroutines
Additional Preinit Services...

- Managing the Preinit Table
  - add_entry: Dynamically add a routine to an environment
  - delete_entry: Delete an entry from the Preinit table, making it available to a later add_entry

- Extracting Information from an Environment
  - identify_environment: Determine characteristics of a Preinit environment
  - identify_entry: Identify the language of an entry in the Preinit table
  - identify_attributes: Identify the attributes of an entry in the Preinit table
# User Exit Invocation

<table>
<thead>
<tr>
<th></th>
<th>init_sub, init_sub_dp</th>
<th>call_main</th>
<th>call_sub or call_sub_addr ended with STOP semantics</th>
<th>term for &quot;clean&quot; init_sub or init_sub_dp environment</th>
<th>term</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEBXITA (enclave init)</td>
<td>✗</td>
<td>✓</td>
<td>✗(next call)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEEBINT (HLL exit)</td>
<td>✗</td>
<td>✓</td>
<td>✗(next call)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C atexit() functions</td>
<td>✗</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEEBXITA (enclave term)</td>
<td>✗</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEEBXITA (process term)</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Main environments:** CEEBXITA and CEEBINT application-specific user exits are taken from the main routine being called.
- **Sub environments:** CEEBXITA and CEEBINT application-specific user exits are taken from the first entry in Preinit table.
- **All other occurrences are ignored!**
XPLINK Preinit

• Preinit applications can run XPLINK-compiled programs in a Preinit environment.
• LE initializes either an XPLINK environment or a "regular" (non-XPLINK) environment
  ▪ Main: XPLINK environment if routine in first Preinit Table entry is XPLINK
  ▪ Subroutine: XPLINK environment if routine in first Preinit Table entry is XPLINK, or if XPLINK(ON) run-time option is specified
**XPLINK Preinit...**

- `call_main` may cause an environment switch
  - If running a non-XPLINK environment, *and* either the program was compiled XPLINK or XPLINK(ON) was specified, the environment will be rebuilt XPLINK, *and remain that way.*

- Sub environments do not switch
  - A call to an XPLINK subroutine in a non-XPLINK environment will result in a “mismatch” error.

- **Recommendation:** Do not use non-XPLINK routines in an XPLINK Preinit environment.
Service routines

• Under Preinit, 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?
  ▪ Execution environment has its own storage or program management services.

• Now supported in AMODE 64 Language Environment:
  ▪ z/OS V1.9: `@Load` and `@Delete` service routines.
  ▪ z/OS V1.11: `@Getstore`, `@Freestore`, and `@Msgrtn` service routines.
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

• @Msgrtn
  ▪ allows error messages to be processed by caller of the application
Preinit Diagnostics

- Preinit Trace Table
- IPCS Support to format Preinit control blocks and trace table
Preinit Diagnostics...

- Preinit Trace Table Characteristics
  - Tracing is always active
    - Begins when the Preinit environment is initialized and ends when the environment is terminated
  - Trace is kept in an in-storage trace table
    - Fixed size (4096 bytes)
    - Wraps when the end has been reached
Preinit Diagnostics...

- New keyword for the LEDATA IPCS Verbexit:
  - **PTBL** (value) - Formats Preinit control block and trace table based on value:
    - "**CURRENT**“ - Preinit data associated with the current or specified TCB is displayed.
    - `<address>` - Preinit data at that address is displayed.
    - "**“*“** – Data for all active and dormant Preinit environments within the current address space are displayed; ***This option is time-consuming***.
    - "**ACTIVE**“ – Display Preinit data associated with each TCB in the address space.
Preinit Diagnostics...

LEDATA PTBL Output – Preinit Control Block

```bash
=== > VERBEXIT LEDATA ‘PTBL(CURRENT)’

PreInitialization Programming Interface Trace Data
CEEPIPI Environment Table Entry and Trace Entry :
  Active CEEPIPI Environment ( Address 25805CB0 )
  Eyecatcher : CEEXIPTB
  TCB address : 008D1B08

CEEPIPI Environment :
  Non-XPLINK Environment
  Environment Type : MAIN
  Sequence of Calls not active
  Exits not established
  Signal Interrupt Routines not registered
  Service Routines are not active

CEEPIPI Environment Enclave Initialized
Number of CEEPIPI Table Entries = 2
```
Preinit Diagnostics...

LEDATA PTBL Output – Preinit Control Block...

CEEPIPI Table Entry Information:

CEEPIPI Table Index 0  ( Entry 1   )
Routine Name      = HLLCRTN
Routine Type      = C/C++
Routine Entry Point = A5810B38
Routine Function Pointer = A5810CC0
Routine Entry is Non-XPLINK
Routine was loaded by Language Environment
Routine Address was resolved
Routine Function Descriptor was valid
Routine Return Code    = 0
Routine Reason Code    = 0
Preinit Diagnostics...

LEDATA PTBL Output – Preinit Control Block...

Entry of routine in CEEPIPI Table for Index 0 ( 25805DB8 )

+000000 25805DB8  A5810CC0 25811B30 80000000 00000000 00000000 00000000 | va...a......................... |
+000020 25805DD8  00000000 00000000 00000000 A5810B38 00000003 258117C8 00000003 25810B38 |

............ va......a.H......a.. |
+000040 25805DF8  A5810B38 000014C8 C8D3D3C3 D9E3D540 00000000 00000000 00000000 00000000 | va.....HHLLCRTCN ............... |

CEEPIPI Table Index 1  ( Entry 2   )  not in use.
Preinit Diagnostics...

LEDATA PTBL Output – Preinit Trace Table

CEEPIPI Trace Table Entries:
- Call Type = INIT_MAIN
- PIPI Driver Address = A5800A82
- Load Service Return Code = 0
- Load Service Reason Code = 0
- Most Recent Return Code = 0
- Most Recent Reason Code = 0

An ABEND will be issued if storage can not be obtained.
PreInit Environment will not allow EXEC CICS commands.
Service RC = 0 : A new environment was initialized.
Preinit Diagnostics...

LEDATA PTBL Output – Preinit Trace Table...

Call Type = ADD_ENTRY
Routine Table Index = 1
Routine Name = HLLPIPI
Routine Address = A5812E20
Load Service Return Code = 0
Load Service Reason Code = 3
Service RC = 0 :The routine was added to the PreInit table.

Call Type = CALL_MAIN
Routine Table Index = 1
Enclave Return Code = 0
Enclave Reason Code = 0
Routine Feedback Code = 0000000000000000
Service RC = 0 :The environment was activated and the routine called.
LEDATA PTBL Output – Preinit Trace Table...

Call Type = DELETE_ENTRY
Routine Table Index = 1
Routine Name = HLLCOBOL
Routine Address = A5812E20
Service RC = 0 : The routine was deleted from the PreInit table.

Call Type = CALL_MAIN
Routine Table Index = 0
Enclave Return Code = 0
Enclave Reason Code = 0
Routine Feedback Code = 0000000000000000
Service RC = 0 : The environment was activated and the routine called.
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...

* 
*COMPILETION UNIT: LEASMIPI

*****************************************************************************
*                                                                             *
* Function: CEEPIPI – Initialize the Preinitialization                        *
*                                                                             *
* Function: CEEPIPI – Initialize the Preinitialization                        *
*                                                                             *
* 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.                                            *
*                                                                             *
*****************************************************************************

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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,PPRTPNTR Get address of CEEPIPI routine

* Invoke CEEPIPI routine

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

* Check return code:

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

* No (failure) .. issue message

WTO 'ASMPAPI: 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 'ASMPAPI: INIT_SUB failure RC is not 8.',ROUTCDE=11
ABEND (R2),DUMP Abend with bad RC and dump memory
* Call the subroutine, which is loaded by LE

CSUB EQU *
L    R15,PPRTNPTR Get address of CEEPIPI routine
CALL  (15), (CALLSUB,PTBINDEX,TOKEN,PARMPTR,
       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  
  EZ DONE 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.

* Preinitialization Table with index

PPTBL    CEEXPIT ,
CEEXPRITY HLPPIPI,0 0=dynamically loaded routine
CEEXPITS ,

End of PreInit table

* LTORG

R0       EQU   0
R1       EQU   1
...  
R14      EQU   14
R15      EQU   15
END   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: IGZTPPI

******************************************************************************
*                                                                       *
* 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.
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