

z/OS



# Language Environment Concepts Guide



z/OS



# Language Environment Concepts Guide

**Note**

Before using this information and the product it supports, be sure to read the general information under "Notices" on page 61.

**Ninth Edition, September 2007**

This is a major revision of SA22-7567-07.

This edition applies to Language Environment in Version 1 Release 9 of z/OS (5694-A01) and to all subsequent releases and modifications until otherwise indicated in new editions.

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## About this document

IBM® z/OS™ Language Environment® (also called Language Environment) provides common services and language-specific routines in a single run-time environment for C, C++, COBOL, Fortran (z/OS only; no support for z/OS UNIX System Services, or CICS®), PL/I, and assembler applications. It offers consistent and predictable results for language applications, independent of the language in which they are written.

This document supports z/OS (5694-A01).

Language Environment is the prerequisite run-time environment for applications generated with the following IBM compiler products:

- z/OS XL C/C++
- OS/390 C/C++
- C/C++ Compiler for MVS/ESA™
- AD/Cycle® C/370™ 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)

Although not all compilers listed are currently supported, Language Environment supports the compiled objects that they created.

Language Environment supports, but is not required for, an interactive debug tool for debugging applications in your native z/OS environment. The IBM interactive Debug Tool is available with z/OS or with the latest releases of the COBOL and PL/I compiler products.

Language Environment supports, but is not required for, VS Fortran Version 2 compiled code (z/OS only).

Language Environment consists of the common execution library (CEL) and the run-time libraries for C/C++, COBOL, Fortran, and PL/I.

For more information on VisualAge® for Java, Enterprise Edition for OS/390®, program number 5655-JAV, see the product documentation.

This book introduces you to the Language Environment architecture, a system of constructs and interfaces that provides a common run-time environment and run-time services for all Language Environment-conforming programming language products (those products that adhere to Language Environment's common interface).

Language Environment is offered on z/OS.

The book contains an overview of Language Environment, descriptions of Language Environment’s full program model, callable services, and a glossary of Language Environment terms. This is not a programming manual, but rather a conceptual introduction to Language Environment.

*Language Environment Concepts Guide* should be read by those who design systems installations and develop application programs. This high-level guide will show how best to plan for systems to support your enterprise.

Terms that may be new to you are *italicized* on their first use. Definitions of these terms can be found in “Language Environment Glossary” on page 65.

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## Using your documentation

The publications provided with Language Environment are designed to help you:

- Manage the run-time environment for applications generated with a Language Environment-conforming compiler.
- Write applications that use the Language Environment callable services.
- Develop interlanguage communication applications.
- Customize Language Environment.
- Debug problems in applications that run with Language Environment.
- Migrate your high-level language applications to Language Environment.

Language programming information is provided in the supported high-level language programming manuals, which provide language definition, library function syntax and semantics, and programming guidance information.

Each publication helps you perform different tasks, some of which are listed in Table 1. All books are available in printable (PDF) and BookManager softcopy formats. For a complete list of publications that you may need, see “Bibliography” on page 85.

*Table 1. How to Use z/OS Language Environment Publications*

<b>To ...</b>	<b>Use ...</b>
Evaluate Language Environment	<i>z/OS Language Environment Concepts Guide</i>
Plan for Language Environment	<i>z/OS Language Environment Concepts Guide</i> <i>z/OS Language Environment Run-Time Application Migration Guide</i>
Install Language Environment	<i>z/OS Program Directory</i>
Customize Language Environment	<i>z/OS Language Environment Customization</i>
Understand Language Environment program models and concepts	<i>z/OS Language Environment Concepts Guide</i> <i>z/OS Language Environment Programming Guide</i> <i>z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode</i>
Find syntax for Language Environment run-time options and callable services	<i>z/OS Language Environment Programming Reference</i>
Develop applications that run with Language Environment	<i>z/OS Language Environment Programming Guide and your language programming guide</i>

Table 1. How to Use z/OS Language Environment Publications (continued)

To ...	Use ...
Debug applications that run with Language Environment, diagnose problems with Language Environment	<i>z/OS Language Environment Debugging Guide</i>
Get details on run-time messages	<i>z/OS Language Environment Run-Time Messages</i>
Develop interlanguage communication (ILC) applications	<i>z/OS Language Environment Writing Interlanguage Communication Applications</i> and your language programming guide
Migrate applications to Language Environment	<i>z/OS Language Environment Run-Time Application Migration Guide</i> and the migration guide for each Language Environment-enabled language

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## Product information on the World Wide Web

For information on the z/OS product and elements, see the z/OS home page on the Web at:

<http://www.ibm.com/servers/eserver/zseries/zos/webqs.html>

For information on z/OS Language Environment, see the Language Environment web site at:

<http://www.ibm.com/servers/eserver/zseries/zos/le/>



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## Where to find more information

Please see *z/OS Information Roadmap* for an overview of the documentation associated with z/OS, including the documentation available for z/OS Language Environment.

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## Using LookAt to look up message explanations

LookAt is an online facility that lets you look up explanations for most of the IBM messages you encounter, as well as for some system abends and codes. Using LookAt to find information is faster than a conventional search because in most cases LookAt goes directly to the message explanation.

You can use LookAt from these locations to find IBM message explanations for z/OS elements and features, z/VM<sup>®</sup>, z/VSE<sup>™</sup>, and Clusters for AIX<sup>®</sup> and Linux<sup>™</sup>:

- The Internet. You can access IBM message explanations directly from the LookAt Web site at [www.ibm.com/servers/eserver/zseries/zos/bkserv/lookat/](http://www.ibm.com/servers/eserver/zseries/zos/bkserv/lookat/).
- Your z/OS TSO/E host system. You can install code on your z/OS systems to access IBM message explanations using LookAt from a TSO/E command line (for example: TSO/E prompt, ISPF, or z/OS UNIX<sup>®</sup> System Services).
- Your Microsoft<sup>®</sup> Windows<sup>®</sup> workstation. You can install LookAt directly from the *z/OS Collection* (SK3T-4269) or the *z/OS and Software Products DVD Collection* (SK3T-4271) and use it from the resulting Windows graphical user interface (GUI). The command prompt (also known as the DOS > command line) version can still be used from the directory in which you install the Windows version of LookAt.
- Your wireless handheld device. You can use the LookAt Mobile Edition from [www.ibm.com/servers/eserver/zseries/zos/bkserv/lookat/lookatm.html](http://www.ibm.com/servers/eserver/zseries/zos/bkserv/lookat/lookatm.html) with a handheld device that has wireless access and an Internet browser (for example: Internet Explorer for Pocket PCs, Blazer or Eudora for Palm OS, or Opera for Linux handheld devices).

You can obtain code to install LookAt on your host system or Microsoft Windows workstation from:

- A CD-ROM in the *z/OS Collection* (SK3T-4269).
- The *z/OS and Software Products DVD Collection* (SK3T-4271).
- The LookAt Web site (click **Download** and then select the platform, release, collection, and location that suit your needs). More information is available in the LOOKAT.ME files available during the download process.

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## Using IBM Health Checker for z/OS

IBM Health Checker for z/OS is a z/OS component that installations can use to gather information about their system environment and system parameters to help identify potential configuration problems before they impact availability or cause outages. Individual products, z/OS components, or ISV software can provide checks that take advantage of the IBM Health Checker for z/OS framework. This book might refer to checks or messages associated with this component.

For additional information about checks and about IBM Health Checker for z/OS, see *IBM Health Checker for z/OS: User's Guide*.

SDSF also provides functions to simplify the management of checks. See *z/OS SDSF Operation and Customization* for additional information.

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## **Information updates on the web**

For the latest information updates that have been provided in PTF cover letters and Documentation APARs for z/OS, see the online document at: [http://publibz.boulder.ibm.com/cgi-bin/bookmgr\\_OS390/BOOKS/ZIDOCMST/CCONTENTS](http://publibz.boulder.ibm.com/cgi-bin/bookmgr_OS390/BOOKS/ZIDOCMST/CCONTENTS)

This document is updated weekly and lists documentation changes before they are incorporated into z/OS publications.



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# Summary of changes

## Summary of changes for SA22-7567-08 z/OS Version 1 Release 9

This book contains information previously presented in *z/OS Language Environment Concepts Guide*, SA22-7567-07, which supported z/OS Version 1 Release 8.

The following summarizes the changes to that information.

### New information

- **What's New for z/OS Version 1 Release 9:**

Enhancements for z/OS Version 1 Release 9 Language Environment are described in “What's New in Language Environment for z/OS Version 1 Release 9” on page 1.

New callable services are added to Chapter 4, “Language Environment Callable Services,” on page 41.

### Changed information

This book contains terminology, maintenance, and editorial changes. Technical changes or additions to the text and illustrations are indicated by a vertical line to the left of the change.

You may notice changes in the style and structure of some content in this book—for example, headings that use uppercase for the first letter of initial words only, and procedures that have a different look and format. The changes are ongoing improvements to the consistency and retrievability of information in our books.

## Summary of changes for SA22-7567-07 z/OS Version 1 Release 8

This book contains information previously presented in *z/OS Language Environment Concepts Guide*, SA22-7567-06, which supported z/OS Version 1 Release 7.

The following summarizes the changes to that information.

### New information

- **What's New for z/OS Version 1 Release 8:**

Enhancements for z/OS Version 1 Release 8 Language Environment are described in “What's New in Language Environment for z/OS Version 1 Release 8” on page 4.

New callable services are added to Chapter 4, “Language Environment Callable Services,” on page 41.

- **Glossary:**

The glossary is updated with new terms and definitions.

### Changed information

### Deleted information

The appendix on msys for Setup for Language Environment has been removed from this book.

**Summary of changes  
for SA22-7567-06  
z/OS Version 1 Release 7**

This book contains information previously presented in *z/OS Language Environment Concepts Guide*, SA22-7567-05, which supported z/OS Version 1 Release 6.

The following summarizes the changes to that information.

**New information**

- **What's New for z/OS Version 1 Release 7:**

Enhancements for z/OS Version 1 Release 7 Language Environment are described in "What's New in Language Environment for z/OS Version 1 Release 7" on page 6.

- **Glossary:**

The glossary is updated with new terms.

**Changed information**

References to OpenEdition have been replaced with z/OS UNIX System Services, or z/OS UNIX.

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# Chapter 1. What's New in Language Environment for z/OS

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## What's New in Language Environment for z/OS Version 1 Release 9

For z/OS Version 1 Release 9, Language Environment has the following changes:

- **AMODE 64 enhancements**

Language Environment provides the following support for AMODE 64 applications:

- **\_\_far\_jump() and \_\_le\_traceback()**

For AMODE 64 applications, there are two new C functions:

- \_\_far\_jump(), to perform non-local GOTO
- \_\_le\_traceback(), to assist in tracing the chain backward

For more information on \_\_far\_jump(), see *z/OS Language Environment Vendor Interfaces*.

For more information on \_\_le\_traceback(), see *z/OS XL C/C++ Run-Time Library Reference*.

- **CELQPIPI Service Routine Vector Support**

Language Environment provides LOAD and DELETE service routine vector support for CELQPIPI in AMODE 64 applications. Only the LOAD and DELETE user-replaceable services are supported.

For more information, see *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode*.

- **XPLINK for IMS**

Language Environment supports XPLINK applications running under the IMS environment with and without Library Routine Retention (LRR) support.

For more information, see *z/OS Language Environment Programming Guide*, *z/OS Language Environment Run-Time Application Migration Guide*, and *z/OS Language Environment Run-Time Messages*.

- **Performance**

Performance is enhanced with the following:

- **IEEE binary floating-point (BFP) math functions replaced**

Selected math functions have been rewritten for performance and accuracy.

For a detailed list, see *z/OS XL C/C++ Run-Time Library Reference* and *z/OS XL C/C++ Compiler and Run-Time Migration Guide for the Application Programmer*.

- **XPLINK**

- **XPLINK versions of functions**

Performance is improved by removing stack transitions for XPLINK applications performing multiplication and division of long long integers.

- **Heap pools performance improvements**

Language Environment enhances the usability of heap pools by:

- Creating cells that are aligned on 256-byte boundaries for better cache usage.
- Removing stack transitions for AMODE 31 XPLINK applications using heap pools.
- Creating cells on 16-byte boundaries for AMODE 64 applications using heap pools.

For more information on updates to the HEAPPOOLS and HEAPPOOLS64 run-time options, see *z/OS Language Environment Customization* and *z/OS Language Environment Programming Reference*.

For tips on using the ALIGN suboption, see *z/OS Language Environment Programming Guide* and *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode*.

For more information on heappools statistics, see *z/OS Language Environment Debugging Guide*.

- **Reliability, availability, and serviceability**

Language Environment is enhanced to provide the following:

- **CEEDUMP improvements**

Several enhancements are made to the CEEDUMP and IPCS Verbexit LEDATA reports. A new run-time option, CEEDUMP, controls CEEDUMP processing.

For more information on changes to CEEDUMP or IPCS Verbexit LEDATA, see *z/OS Language Environment Customization*, *z/OS Language Environment Programming Reference*, and *z/OS Language Environment Debugging Guide*.

- **Language Environment Preinitialization (Prelnit) services**

Language Environment provides diagnostic information for Prelnit environments with IPCS support to format the information in the Prelnit table and a mechanism to trace Prelnit calls. This improves diagnostics for the Prelnit service.

For more information, see *z/OS Language Environment Programming Guide* and *z/OS Language Environment Debugging Guide*.

- **Improvements to Dynamic Link Library (DLL) diagnostics**

Language Environment improves DLL error diagnostics so that you can more easily debug DLL application problems.

For more information, see *z/OS Language Environment Debugging Guide*, *z/OS XL C/C++ Programming Guide*, and *z/OS XL C/C++ Run-Time Library Reference*.

- **Miscellaneous utilities**

- **ceebldtx utility**

Language Environment modifies the ceebldtx utility to run in the z/OS UNIX shell environment in addition to the TSO/E interface.

For more information, see *z/OS Language Environment Programming Guide*, *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode* and *z/OS UNIX System Services Command Reference*.

- **edcmtext utility**

Language Environment provides the edcmtext utility (similar to bpxmtext), which allows faster error resolution when an errno2 is encountered in the C/C++ run-time library. The utility produces a description and action for the corresponding errno2 value. The bpxmtext utility calls edcmtext when the errno2 value is in the range reserved for the C/C++ run-time library or edcmtext can be invoked directly with the errno2 value as input.

For more information, see *z/OS Language Environment Debugging Guide*, *z/OS XL C/C++ Run-Time Library Reference*, and *z/OS UNIX System Services Command Reference*.

- **Decimal floating-point (DFP) support**

Language Environment provides initial support with a subset of decimal floating-point support based on the ISO Technical Report draft.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*, *z/OS Language Environment Programming Guide*, *z/OS Language Environment Vendor Interfaces*, *z/OS XL C/C++ User's Guide*, and *z/OS XL C/C++ Programming Guide*.

- **Globalization**

- **Locale support for Turkey**

- New locales are added in compliance with the Globalization White Paper. ASCII versions for a set of existing environments and locales are available. Locales for Turkey are available for the Turkish lira.

- For more information, see *z/OS XL C/C++ Programming Guide*.

- **iconv()**

- Language Environment modifies the iconv() family of functions to use Unicode Conversion Services.

- For more information, see *z/OS XL C/C++ Programming Guide* and *z/OS XL C/C++ Run-Time Library Reference*.

- **Providing National Language Support (NLS) for all output**

- Language Environment enhances National Language Support by:

- Removing lower-case English characters from CEEDUMP and from storage and options reports when the NATLANG run-time option is set to EUN or JPN.

- Creating a new callable service, CEE3MC2, that returns the alphabetic international currency symbol for a country, in addition to the default (graphical) currency symbol currently returned by CEE3MCS.

- For more information, see *z/OS Language Environment Programming Reference* and *z/OS XL C/C++ Run-Time Library Reference*.

- **CICS CLER enhancements**

- Enhancements are made in the CICS CLER transaction for displaying and modifying Language Environment run-time options.

- For more information, see *z/OS Language Environment Debugging Guide* and *z/OS Language Environment Programming Guide*.

- **Callable services CEE3DLY and CEEDLYM**

- Two new AMODE 31 callable services, CEE3DLY and CEEDLYM, suspend processing of the active enclave in a Language Environment-conforming application for a specified number of seconds and milliseconds respectively. CEE3DLY has a seconds parameter to specify the number of seconds that the active enclave should be suspended. CEEDLYM has a milliseconds parameter to specify the number of milliseconds that the active enclave should be suspended.

- For more information, see *z/OS Language Environment Programming Guide* and *z/OS Language Environment Programming Reference*.

- **Single UNIX Specification Version 3 (SUSv3)**

- Language Environment provides additional support in the C/C++ run-time library for SUSv3, including new APIs and behaviors for the pthread functions.

- For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **C API multicast source filtering support**

- Language Environment provides application programming interfaces (APIs) and socket options for multicast source filtering.

- For more information, see *z/OS XL C/C++ Run-Time Library Reference*. The Multicast Source Filter API is documented in RFC 3678 - Socket Interface Extensions for Multicast Source Filters and is available at: <http://www.faqs.org/rfcs/rfc3678.html>

- **UNIX System Services Support**

- **Terminating additional thread types**

Provides an updated method of terminating threads and their associated tasks. You can use a new environment variable, `_BPXK_FORCE_CANCEL`, to enable the `pthread_cancel()` service to terminate threads that it would not otherwise be allowed to cancel.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Using standard message queues to deliver asynchronous completion notifications (ICP)**

Provides another method of delivery for I/O completion notifications. Standard message queues are used to send the notifications.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Supporting memory map of files in key 2 storage areas**

Previously, memory maps could not be used from a key 2 environment. Support has been added for memory map of files in key 2 storage areas for PSW Key 2 callers.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Enabling callers running from server request blocks in AMODE 64 to use UNIX System Services**

Previously, callers running from a service request block (SRB) in AMODE 64 could not use UNIX System Services because the services were not supported. Support has been added to enable callers running from SRBs in AMODE 64 to use UNIX System Services.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Propagating the `setuid` indicator to child address spaces**

Previously, the `setuid` identity was not propagated across a `fork()` or `exec()`. A new environment variable, `_BPXK_SUID_FORK` can be set to indicate whether the `setuid` indicator is to be propagated from the parent to the child process.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

---

## What's New in Language Environment for z/OS Version 1 Release 8

For z/OS Version 1 Release 8, Language Environment has the following changes:

- **I/O changes**

The z/OS XL C/C++ run-time library:

- Is enhanced to provide support for VSAM data sets with extended addressability. This support is for key-sequenced (KSDS), entry-sequenced (ESDS), and relative-record data sets (RRDS).
- Provides full support of QSAM (opened with `NOSEEK` in C/C++) for large-format sequential DASD data sets that were introduced by `DFSMSDfp` in z/OS Version 1 Release 7, removing the constraint of 65535 tracks per volume for sequential data sets.
- Provides enhancements to the C run-time library functions `fgetpos()`, `fsetpos()`, and `fseek()`. This is intended to generally improve the performance of repositioning operations within multivolume data sets.

For more information, see *z/OS XL C/C++ Programming Guide*.

- **Migration aid**

The `STORAGE` run-time option now includes `CLEAR` as an acceptable value for the third sub-option. This new value causes the unused portion of the initial stack

segment to be cleared to binary zeroes, just prior to invoking the main procedure, as it was done by the pre-Language Environment PL/I run-time library. This support was rolled back to z/OS Version 1 Release 4 with APAR PK02614.

For more information, see *z/OS Language Environment Customization* and *z/OS Language Environment Programming Reference*.

- **Application Enablement**

The z/OS XL C/C++ run-time library is enhanced to provide the flockfile() family of common UNIX functions as found within the Single UNIX Specification Version 3 standards.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Language Environment-conforming assembler routines in CICS**

Customer Information Control System (CICS) Transaction Server for z/OS Version 3 Release 1 now supports Language Environment-conforming assembler MAIN routines. This support was rolled back to z/OS Version 1 Release 4 with documentation APAR PK02368.

For more information, see *z/OS Language Environment Programming Guide*.

- **XPLINK**

Language Environment provides a tracing capability that can be customized on or off to trace the transitions between upward (non-XPLINK) and downward (XPLINK) growing stacks and more easily diagnose the performance bottlenecks in the mixed XPLINK/non-XPLINK applications. This support is controlled by the TRACE run-time option.

For more information, see *z/OS Language Environment Customization*, *z/OS Language Environment Programming Reference*, and *z/OS Language Environment Debugging Guide*.

- **Callable Services**

Language Environment provides support for:

- A new service CEE3PR2, an enhancement to CEE3PRM, that supports longer parameter lists.
- A new service CEE3AB2, an enhancement to CEE3ABD, that supports the addition of a reason code to the ABEND. Both CEE3AB2 and CEE3ABD now allow for more control of diagnostic information collection.
- A new service, CEE3INF, that provides current Language Environment information about the enclave.
- A new service, CEEENV, that allows for querying, setting, and deleting of environment variables.

For more information, see *z/OS Language Environment Programming Reference*.

- **Reliability, Availability, and Serviceability**

Language Environment is enhanced to provide the following:

- Displaying source line numbers in the AMODE 64 Language Environment dump (CEEDUMP) traceback for C/C++ applications.
- Providing a way for the user to instruct Language Environment to capture an IPCS-readable dump when no SYSDUMP DD statement is available.

For more information, see *z/OS Language Environment Debugging Guide*.

- **Additional Euro and locale support**

Language Environment provides locale support for the Euro currency symbol for countries that have recently joined the European Union. This function is also available with APAR PQ99282 for z/OS Version 1 Release 4 and higher.

For more information, see *z/OS XL C/C++ Programming Guide*.

- **Removal of msys for Setup for Language Environment**  
Support for msys for Setup for Language Environment is removed.

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## What's New in Language Environment for z/OS Version 1 Release 7

For z/OS Version 1 Release 7, Language Environment provides the following:

- **Run-time options using parmlib**

Language Environment, along with z/OS, provides another level of run-time options through a member in the system parmlib. The member is identified during IPL by a CEE=xx statement, either in the IEASYSy dataset or in the IPL parameters.

For more information, see *z/OS Language Environment Customization* and *z/OS Language Environment Programming Reference*.

- **Run-time options using DD statement**

Language Environment supports the ability to provide additional run-time options at invocation through a DD statement. The name of the DD must be CEEOPTS.

For more information, see *z/OS Language Environment Customization* and *z/OS Language Environment Programming Reference*.

- **C99 standard**

z/OS V1R7 XL C is designed to support the ISO/IEC 9899:1999 standard, including:

- Locale, date, and time enhancements
- Numeric conversion function enhancements, including wide
- printf() and scanf() enhancements, including wide
- fwide()

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Hexadecimal floating-point support for AMODE 64 C/C++ applications**

z/OS XL C/C++ applications compiled using LP64 and FLOAT(HEX) can use the C/C++ run-time library math, numeric conversion, and formatted I/O functions that work with float, double, and long double data types. The initial C/C++ run-time library for AMODE 64 applications on z/OS V1R6 provided floating-point support for applications compiled using FLOAT(IEEE). This new support completes IBM's planned floating-point support within the C/C++ run-time library for AMODE 64 C/C++ applications.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Preinitialized Environments for Authorized Programs**

Language Environment allows an authorized AMODE 64 application to run z/OS XL C/C++ and Language Environment-conforming Assembler routines through the use of preinitialized environments.

For more information, see *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode*.

- **New SUSv3 application programming interfaces (APIs)**

Language Environment provides interfaces for pthread\_key\_delete() and pthread\_sigmask().

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **fork() in a multithreaded environment**

The fork() function is supported in a multithreaded environment.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **IPv6 advanced socket API functions support**



IPv6 support is provided for advanced socket APIs.

For more information, see RFC3542 at <http://www.ietf.org> and *z/OS XL C/C++ Run-Time Library Reference*.

- **XPCFTCH enhancements**

The process of specifying an alternative entry address is simplified in the XPCFTCH exit used under CICS. The CICS XPCFTCH exit enhancement requires CICS Transaction Server for z/OS Version 2.3 with PTF UQ95648.

For more information, see *z/OS Language Environment Customization*.

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## What's New in Language Environment for z/OS Version 1 Release 6

For z/OS Version 1 Release 6, Language Environment provides the following:

- **64-bit virtual addressing mode support**

With 64-bit virtual storage support, the maximum virtual addressability is up to 16 exabytes. For programs that need large data caches, migrating to 64-bit virtual addressing mode (AMODE 64) is reasonable. This enables applications to access storage and helps in porting applications from other platforms.

Language Environment provides 64-bit virtual support for XPLINK applications only. Applications compiled for AMODE 64 will run in this new form of Language Environment. Mixing of AMODE 31 and AMODE 64 applications is not supported.

For more information, see *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode* and *z/OS MVS Programming: Extended Addressability Guide*.

- **Assembler dynamic link libraries (DLL) support**

This support allows Language Environment-conforming Assembler applications to create and use DLLs.

For more information, see *z/OS Language Environment Programming Guide* and *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode*.

- **C/C++ run-time enhancements**

- The `dlopen()` family of functions is provided.
- Enhanced ASCII support is added for `__getenv()`, `rexec()`, and `rexec_af()`.
- The `popen()` function can now use `fork()` for `spawn()` based on the setting of the `_EDC_OPEN` environment variable.
- The `snprintf()` family of functions is provided.

For more information, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Condition variables and mutexes in shared memory**

Language Environment supports the z/OS UNIX System Services implementation of mutexes and condition variables in shared memory. Two new functions, `pthread_condattr_setpshared()` and `pthread_condattr_getpshared()` are provided.

For more information, see *z/OS XL C/C++ Run-Time Library Reference* and *z/OS UNIX System Services Planning*.

- **Language Environment support for CICS and Debug Tool enhancement**

Support is provided in CICS and the Debug Tool for improved debugging. This support dynamically triggers a Debug Tool session for any number of different programs for a unique terminal user under CICS. This allows a user to set up a Debug Tool profile and specify that the profile contains more than one program.

For more information, see *z/OS Language Environment Programming Guide*.

- **Removal of Run-Time Library Support (RTLs) from Language Environment**

The ability to allow application programs to use a lower level of the Language Environment libraries, for execution of the application, using run-time options and without using STEPLIB is removed in z/OS V1R6. Language Environment will no longer exploit the RTLS function of the operating system. Lower levels of Language Environment can still be accessed using STEPLIB.

For information about use of RTLS with Language Environment, see the following documents for the release from which you're migrating:

- *z/OS Language Environment Customization*
- *z/OS Language Environment Programming Reference*

- **Support for Euro Phase III and G11N currency**

Phase III of Euro support in locales is provided for National Language Standards. For more information, see *z/OS XL C/C++ Programming Guide*.

- **Memory leak analysis tool (memcheck) provided in Language Environment**

Language Environment now provides a heap storage analysis tool. This tool will be controlled using the vendor heap manager (VHM) and new environment variables.

For more information, see *z/OS Language Environment Debugging Guide*.

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## What's New in Language Environment for z/OS Version 1 Release 5

For z/OS Version 1 Release 5, Language Environment provides the following:

- **New and changed C/C++ functions**

- **putenv() changes for the X/Open CAE Specification**

The putenv() function complies with the X/Open POSIX standard to place the input string directly into the environment array, rather than a copy. For migration considerations, see *z/OS Language Environment Run-Time Application Migration Guide*. This function was rolled back with APAR PQ61928.

- **Additional Enhanced ASCII support**

For additional functions supported, see *z/OS XL C/C++ Run-Time Library Reference*.

- **Multilevel security support**

Multilevel security allows the classification of data and users based on a system of hierarchical security levels, combined with a system of non-hierarchical security categories. The security administrator classifies users and data, and the system then imposes mandatory access controls restricting which users can access data, based on a comparison of the classification of the users and the data.

Language Environment provides support for multilevel security through the following:

- A port of entry function, \_\_poe(), used to determine various levels of permission checking
- A \_\_writedown() function, used to query or change the setting of the write-down privilege
- Support for setting the new SECLABEL field in the \_\_chattr() and \_\_fchattr() functions and in related headers
- An \_\_lchattr() function to assign security labels to symbolic links
- Changes to the \_\_getipc() function and related header to support the IPCS display of \_map resources

See *z/OS XL C/C++ Run-Time Library Reference* for specific function descriptions.

- **Additional IEEE math functions**

For descriptions of the new and changed math functions, see *z/OS XL C/C++ Run-Time Library Reference*.

- **utoa() family of functions**

The itoa(), ltoa(), utoa() functions, and the unsigned versions utoa(), ultoa(), and ulltoa(), are provided for porting UNIX applications.

For descriptions of these functions, see *z/OS XL C/C++ Run-Time Library Reference*.

- **C Transactional VSAM**

For DFSMS 1.5, Transactional VSAM extends VSAM record level sharing by adding commit and logging support for batch. This allows for full concurrent sharing of batch and CICS online applications that use either recoverable or non-recoverable datasets.

- **Java Support**

- **Status stop**

Language Environment supports pthread\_quiesce\_and\_get\_np(), which uses the STATUS service to stop or freeze threads, and may improve performance in some cases.

- **Support of Java stack overflow error**

Support is added in Language Environment for the Java stack overflow error. This supports the detection, reporting, and handling of overflow by the Java-specified soft stack limit. Support is provided in 31-bit XPLINK only. Using the new \_set\_stack\_softlimit() and \_far\_jump() functions, you can set a soft stack limit and effectively perform a longjump() without a setjump(), thereby catching recursive storage leaks and avoiding setjump() overhead.

Details on these two new functions are provided in *z/OS Language Environment Vendor Interfaces*.

- **Reliability, availability, serviceability**

- **Heap pools serviceability**

Language Environment provides service support using tools and tracing capability to diagnose enabled heap pools.

- **Performance**

- **Heap pools cell size maximum increase**

The cell size maximum and the number of pools managed by the HEAPPOOLS run-time option are increased. This enhancement extends HEAPPOOLS support by allowing a greater number of buffer pools and by increasing the size of the storage blocks within the pools.

This improves the performance of multi-threaded applications with storage requests greater than 2KB and that use the HEAPPOOLS run-time option. The limit is increased to 64KB.

- **XPLINK**

- **XPLINK high-performance Language Environment functions**

Provides high-performance support for the following functions in an XPLINK environment:

- free() (non-heappools)
- malloc() (non-heappools)
- pthread\_mutex\_lock()

- pthread\_mutex\_unlock()
- pthread\_rwlock\_rdlock()
- pthread\_rwlock\_wrlock()
- pthread\_rwlock\_unlock()
- \_\_ufree()
- \_\_umalloc()
- **Debugging**
  - **Support for debugger application programming interface (API)**  
A new API has been added to set and reset hooks. There is also a new environment variable to specify the name of the debug event handler that can be loaded from the hierarchical file system (HFS).
  - **National Language Support (NLS)**
    - **Support for code pages IBM-4933 and IBM-13124**  
Support has been added to allow conversions with code pages IBM-4933 and IBM-13124.
    - **Additional G11N White Paper Currency Support**  
This support provides additional country support by locales. For more information, see *z/OS XL C/C++ Programming Guide*.

## What's New in Language Environment for z/OS Version 1 Release 4

For z/OS Version 1 Release 4, Language Environment provides the following:

- **Support of Debug Tool for DB2® Stored Procedures**  
Language Environment is enhanced to significantly improve debugging of DB2 stored procedures, regardless of language. Two new debugger event codes are provided for DB2 and the Debug Tool to debug the stored procedure repeatedly without having to recycle the stored procedure (SP) address.
- **CICS trace of an application domain**  
A new CICS trace allows users to monitor and determine the activity of a CICS transaction. This gives users the ability to trace key events in Language Environment while running CICS transactions. Every time CICS calls Language Environment, the feature trace is activated under the Extended Run-Time Library Interface (ERTLI). The CICS trace requires AP level 2 tracing to be active. By activating the feature trace records, trace points are added at strategic points.
- **Enhanced pthread\_quiesce\_and\_get\_np()**  
Enhancements are made within pthread\_quiesce\_and\_get\_np() to improve reliability and performance.

## What's New in C/C++ for z/OS Version 1 Release 4

This run-time library is shipped with Language Environment. For z/OS Version 1 Release 4, the C/C++ run-time library includes the following enhancements:

- **IPv6**  
Internet Protocol Version 6 (IPv6) is the base technology of the next generation Internet. z/OS provides IPv6 support in V1R4. Language Environment provides support for Communications Server through Application Programming Interfaces (APIs) and the C/C++ run-time library provides enhanced functions. For descriptions of the new and changed C functions, see *z/OS XL C/C++ Run-Time Library Reference*.

Language Environment headers are also updated to meet IPv6 standards. z/OS UNIX support is also provided.

- **Transport Layer Security (TLS) Certificate Support**

The `__certificate()` function is updated to allow authentication of digital certificates. This enables better password support for File Transfer Protocol (FTP).

- **iconv() support for code page IBM-5488**

Support has been added to allow conversions with code page IBM-5488.

- **G11N White Paper Currency Support**

This support provides additional country support by locales. For more information, see *z/OS XL C/C++ Programming Guide*.

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## What's New in Language Environment for z/OS Version 1 Release 3

For z/OS Version 1 Release 3, Language Environment provides the following:

- **z/OS.e**

z/OS.e is a version of the z/OS operating system intended to help you exploit the fast-growing world of next-generation workloads. Language Environment adds new messages that may be issued when errors occur in the z/OS.e environment.

**Restrictions:** The following restrictions apply to z/OS.e:

- The following compilers are not licensed for use on z/OS.e:
  - COBOL
  - PL/I
  - FORTRAN
- The following subsystems are not licensed for use on z/OS.e:
  - CICS
  - IMS™
- Execution of applications written in the following languages is not functionally supported on z/OS.e:
  - COBOL (except for precompiled COBOL DB2 stored procedures and other precompiled COBOL applications using the Language Environment preinitialization interface)
  - FORTRAN
- The following are not functional and/or not licensed for use on z/OS.e:
  - Language Environment Library Routine Retention (LRR)
  - Language Environment compatibility preinitialization for C and PL/I
  - Run-time library services (RTLs)
- Customers are not permitted to use lower levels of Language Environment on z/OS.e.

Customers will be able to run pre-compiled PL/I programs in z/OS.e. They will not be able to compile PL/I programs in z/OS.e.

- **z/OS Managed System Infrastructure for Setup**

z/OS msys for Setup provides a set of functions and services to simplify system management. Specifically for Language Environment in z/OS Version 1 Release 3, setup is simplified for:

- BATCH and CICS default options settings, by customizing a `++USERMOD`.
- Region-wide run-time options for CICS and IMS, by running an Assembler job.

- **OMVS outage avoidance**

OMVS outage avoidance provides the capability to IPL z/OS UNIX without bringing down the z/OS system, which allows for more timely debugging of z/OS UNIX.

- **Language Environment preinitialization services**  
Enhancements have been made to Language Environment preinitialization services to support XPLINK.
- **Vendor heap manager**  
This enables vendors to provide an alternate user heap manager for z/OS UNIX applications that can detect memory leaks or storage damage beyond what is already provided in Language Environment.
- **Thread-specific data performance enhancements**  
This optimizes the C/C++ `pthread_getspecific()` function to obtain peak performance in the z/OS UNIX environment.
- **Euro code page support**  
Support is extended for code pages currently supported within z/OS that have not yet been updated for Euro symbol support.

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## What's New in C/C++ for z/OS Version 1 Release 3

This run-time library is shipped with Language Environment. For z/OS Version 1 Release 3, the C/C++ run-time library includes the following enhancements:

- **BiDi layout transformation function and utility**  
As an extension to the BiDi layout services provided in z/OS Version 1 Release 2, this provides C/C++ support to perform code page conversion or BiDi layout transformation of a text string in one step. For more information, see *z/OS XL C/C++ Programming Guide*.
- **Access Control List (ACL) support**  
ACL support provides security support for z/OS UNIX users.

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## What's New in Language Environment for z/OS Version 1 Release 2

For z/OS Version 1 Release 2, Language Environment provides the following:

- **CICS dynamic storage tuning**  
When Language Environment is running with CICS, support for automatic storage tuning is provided to improve performance of applications running under CICS. Automatic storage tuning is controlled with the CICS system initialization parameter AUTODST. Automatic storage tuning reduces GETMAIN and FREEMAIN activity associated with acquiring Language Environment stack or heap increments.
- **Heap storage diagnostics support**  
A new report is provided in CEEDUMP that shows show traceback information for storage that was allocated but not freed.
- **Documentation improvements for traces**  
*z/OS Language Environment Debugging Guide* contains trace documentation improvements.
- **Use CICS dump services**  
The CICS transaction dump now includes CEEDUMP data.
- **Improvement in storage use**

Language Environment has been changed to favor 31-bit applications. This increases performance by eliminating the dependency for below-the-line storage in a 24-bit application.

- **Machine state control block**

All fields in the Language Environment machine state control block CEEMCH are externalized.

- **Removal of SOM™ Support from Language Environment**

SOMobjects® ADE and SOMobjects RTL have been removed from z/OS.

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## What's New in C/C++ for z/OS Version 1 Release 2

This run-time library is shipped with Language Environment. For z/OS Version 1 Release 2, the C/C++ run-time library includes the following enhancements:

- **Enhanced ASCII Functionality**

Enhanced ASCII functionality makes it easier to port internationalized applications developed on, or for, ASCII platforms to z/OS platforms by providing conversion from EBCDIC to ASCII and from ASCII to EBCDIC.

To complement this support, a file tagging mechanism is introduced, which allows programmers to tag text files with an identifier indicating the encoding used to write the data. These tags can be used to translate from one encoding to another. This allows the use of EBCDIC programs against ASCII data files.

This section explains under what conditions you can use Enhanced ASCII. For limitations of Enhanced ASCII, see *z/OS XL C/C++ Programming Guide*.

### Limitations of Enhanced ASCII

- A subset of C headers and functions is provided in ASCII. For more information, see *z/OS XL C/C++ Run-Time Library Reference*.
- The only way to get to the ASCII version of functions and the external variables `environ` and `tzname` is to use the appropriate IBM header files.
- ASCII environment variables may read, but not update, environment variables using the `environ` external variable. Updates to the environment variables using `environ` in an ASCII application causes unpredictable results and may result in an abend. Language Environment maintains two equivalent arrays of environment variables when running an ASCII application, one with EBCDIC encodings and the other with ASCII encodings. All ASCII compile units that use the `environ` external variable must include `<stdlib.h>` so that `environ` can be mapped to access the ASCII-encoded environment strings. If `<stdlib.h>` is not included, `environ` will refer to the EBCDIC representation of the environment variable strings.

Enhanced ASCII provides limited EBCDIC/ASCII conversion. The character set or alphabet that is associated with any locale consists of the following:

- A common, XPG4-defined subset of characters such as POSIX portable characters
- A unique, locale-specific subset of characters such as NLS characters

The conversion only applies to the portable subset of characters that are associated with a locale. Only the EBCDIC IBM-1047 encoding of portable characters is supported.

You might encounter unexpected results in the following situations:

- If Enhanced ASCII applications run in locales that contain non-Latin Alphabet Number 1 NLS characters, C-RTL functions might copy some of the locale's non-Latin 1 NLS characters into buffers that the application is writing to

- stdout or other HFS files. The non-Latin Alphabet Number 1 NLS characters would then cause problems during automatic conversion.
- Language Environment applications must select non-English message files. If the NATLANG run-time option is not UEN or ENU, conversion does not take place. The messages are presented to the file system write routine in EBCDIC, before any automatic conversion takes place. If the automatic conversion is to EBCDIC, there will be a problem because EBCDIC cannot be converted to EBCDIC.
- **ISO/IEC 14882:1998 Programming Language - C++**  
The new C++ compiler adheres to the latest ISO 1998 C++ standard, including a compiler implementation of the ISO Standard C++ library and the ANSI Standard Templated Library (STL). This supports IBM's continuing adherence to openness and offers customers the increased portability of applications to and from other platforms that support the ISO 1998 C++ standard.
  - **BiDi functionality and Arabic locale**  
Support is added for a BiDi routine to allow proper handling of Arabic and Hebrew data in applications. The interfaces handle the conversion of BiDi data from logical to visual and vice versa.
  - **Internet Protocol (IP) address conversion**  
IBM intends to provide an integrated Internet Protocol Version 6 (IPv6) implementation that will enable application access using the new TCP/IP standard. Support is added in the C/C++ run-time library for IPv6 functions `inet_pton()` and `inet_ntop()` and global variables.
  - **POSIX threads extensions**  
This support provides the `_r` functions that indicate thread-safe functions in UNIX 98 standards. Large applications in multi-threaded environments need verification that functions are thread safe.
  - **Eurocurrency support**  
Latin 9 support is provided for customers doing business in many different countries requiring National Language Support or Unicode support to operate efficiently on the z/OS platform.
  - **Goal mode support**  
A Language Environment transform is provided in support of z/OS UNIX System Services goal mode support for Workload Manager.
  - **Enhancement to the uname utility**  
This enhancement allows for continued support of the name OS/390 within the `uname()` field.
  - **Chinese code conversion standard**  
GB 18030 is a new code standard that provides encodings for approximately 30,000 Chinese characters. The `iconv()` function now supports GB18030 conversions. Customers can use this support to allow creation and processing of text documents containing these characters.
  - **Upgrade of IBM Open Class<sup>®</sup> Library**  
The IBM Open Class Library (OCL) is a library of C++ classes. z/OS Version 1 Release 2 includes a new level of IOC, which is consistent with that shipped in VisualAge C++ for AIX Version 5.0. This is intended to ease porting from AIX, but is not intended for use in new development. Support will be withdrawn in a future release. New application development involving C++ classes should make use of the C++ Standard Library rather than the IBM Open Class Library.
  - **Server thread task management**



As the complexity in managing many environments increases, this function provides automated management of server tasks running in the server space. Workload Manager can dynamically vary the number of server threads active to process work requests.

- **TCP/IP resolver enhancement**

DNS and BIND transform conversions are provided for Communications Server.

- **pread() and pwrite()**

The new pread() and pwrite() functions perform the same actions as read() and write(), except that they read or write from a given position in a file without changing the file pointer. This reduces system overhead and improves performance.

- **Reusable enclaves for CICS scalable Java Virtual Machine (JVM)**

Java™ programs can initialize once and then allow subsequent Java programs to begin running. A Language Environment enclave (CICS thread) remains active as needed.

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## What's New in Language Environment for z/OS Version 1 Release 1

Enhancements for z/OS Language Environment include the following Reliability, Availability, and Serviceability improvements:

- **LEDATA improvement to show tracebacks for all threads**

Provided by APAR PQ40654, the NTHREADS(value) parameter on VERBEXIT LEDATA lets you specify a number of threads for which Language Environment traceback data will be displayed. For more information, see *z/OS Language Environment Debugging Guide*.

- **Addition of IPCS ANALYZE exit for latches, mutexes and condition variables**

Provided by APAR PQ40654, Language Environment provides support for the IPCS ANALYZE exit. This assists in debugging system or address space hang situations. Language Environment latches, mutexes, and condition variables can be displayed if the CEEIPSCP member you are using is updated to identify the ANALYZE exit. For more information, see *z/OS Language Environment Debugging Guide*.

- **Displaying run-time options in CEEDUMP**

Provided by APAR PQ38324, the GENOPTS dump option of CEE3DMP provides a report of the run-time options in effect at the time of the dump. For more information, see *z/OS Language Environment Debugging Guide*.

- **Columns added in LEDATA**

Provided by APAR PQ40079, the traceback section of the IPCS LEDATA VERBEXIT dump will now include the load module and service level in columns 9 and 10. In addition, the header of that dump will include the dump-invocation string, and the Language Environment version and release. For more information, see *z/OS Language Environment Debugging Guide*.

- **Control the amount of storage dumped around registers**

Provided by APARs PQ39636 and PQ39927, a new dump option is added to the options of the CEE3DMP service. REGSTOR(reg\_stor\_amount) that controls the amount of storage to be dumped around registers. A similar suboption has been added to the TERMTHDACT run-time option. For more information, see *z/OS Language Environment Debugging Guide*.

- **New CICS transaction**

Provided by APAR PQ38838, a new CICS transaction (CLER) lets the user display all of the current Language Environment run-time options for a region, and also modify a subset of the options. For more information, see *z/OS Language Environment Debugging Guide*.

- **4083 Unique Message Codes**

Provided by APAR PQ38324, the 4083 error condition is clarified and the original error is displayed, if possible. The new codes are described in *z/OS Language Environment Run-Time Messages*.

- **Ability to format individual Language Environment control blocks**

Provided by APAR PQ39635, Language Environment supports a control block formatter interface to IPCS which has the ability to format individual Language Environment control blocks. For more information, see *z/OS Language Environment Debugging Guide*.

- **Isolation of Control Blocks from CICS applications**

Provided by APAR PQ37675, the STGPROT=YES run-time option prevents region destruction when caused by CICS region block overlays. For more information, see *z/OS Language Environment Debugging Guide*.

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## Chapter 2. Overview

Today, enterprises need efficient, consistent, and less complex ways to develop quality applications and to maintain their existing inventory of applications. The trend in application development is to modularize and share code, and to develop applications on a workstation-based front end. Language Environment gives you a common environment for all Language Environment-conforming high-level language (HLL) products. An HLL is a programming language above the level of assembler language and below that of program generators and query languages.

In the past, programming languages also have had limited ability to call each other and behave consistently across different operating systems. This has constrained those who wanted to use several languages in an application. Programming languages have had different rules for implementing data structures and condition handling, and for interfacing with system services and library routines.

Language Environment establishes a common run-time environment for all participating HLLs. It combines essential run-time services, such as routines for run-time message handling, condition handling, and storage management. All of these services are available through a set of interfaces that are consistent across programming languages. You may either call these interfaces yourself, or use language-specific services that call the interfaces. With Language Environment, you can use one run-time environment for your applications, regardless of the application's programming language or system resource needs.

Language Environment consists of:

- Basic routines that support starting and stopping programs, allocating storage, communicating with programs written in different languages, and indicating and handling conditions.
- Common library services, such as math services and date and time services, that are commonly needed by programs running on the system. These functions are supported through a library of callable services.
- Language-specific portions of the run-time library. Because many language-specific routines call Language Environment services, behavior is consistent across languages.

Figure 1 on page 18 shows the separate components that make up Language Environment. POSIX support is provided in the Language Environment base and in the C language-specific library.

## Language Environment

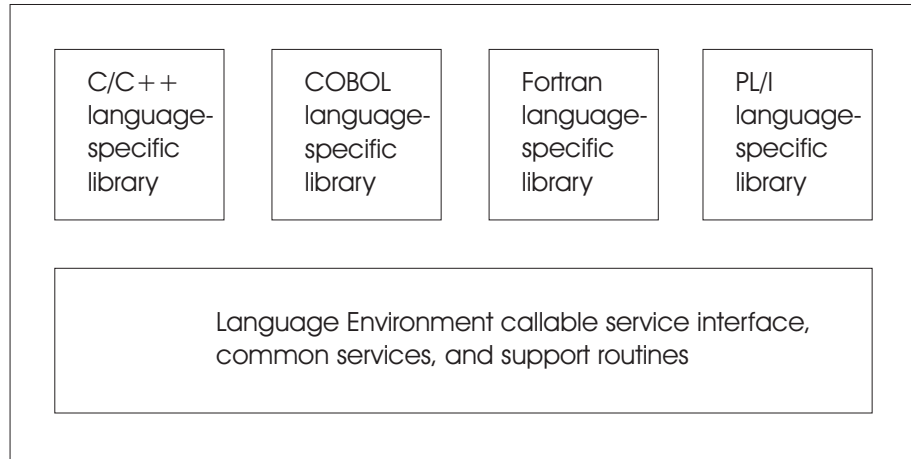


Figure 1. Components of Language Environment

z/OS Language Environment is the prerequisite run-time environment for applications generated with the following IBM compiler products:

- z/OS XL C/C++
- OS/390 C/C++
- C/C++ Compiler for MVS/ESA
- AD/Cycle C/370 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)

Although not all compilers listed are currently supported, Language Environment supports the compiled objects that they created.

Language Environment supports, but is not required for, VS Fortran Version 2 compiled code (OS/390 only).

In many cases, you can run compiled code generated from the previous versions of the above compilers. A set of assembler macros is also provided to allow assembler routines to run with Language Environment.

For more information on IBM VisualAge for Java, Enterprise Edition for OS/390, program number 5655-JAV, refer to the product documentation.

Figure 2 on page 19 illustrates the common environment that Language Environment creates.

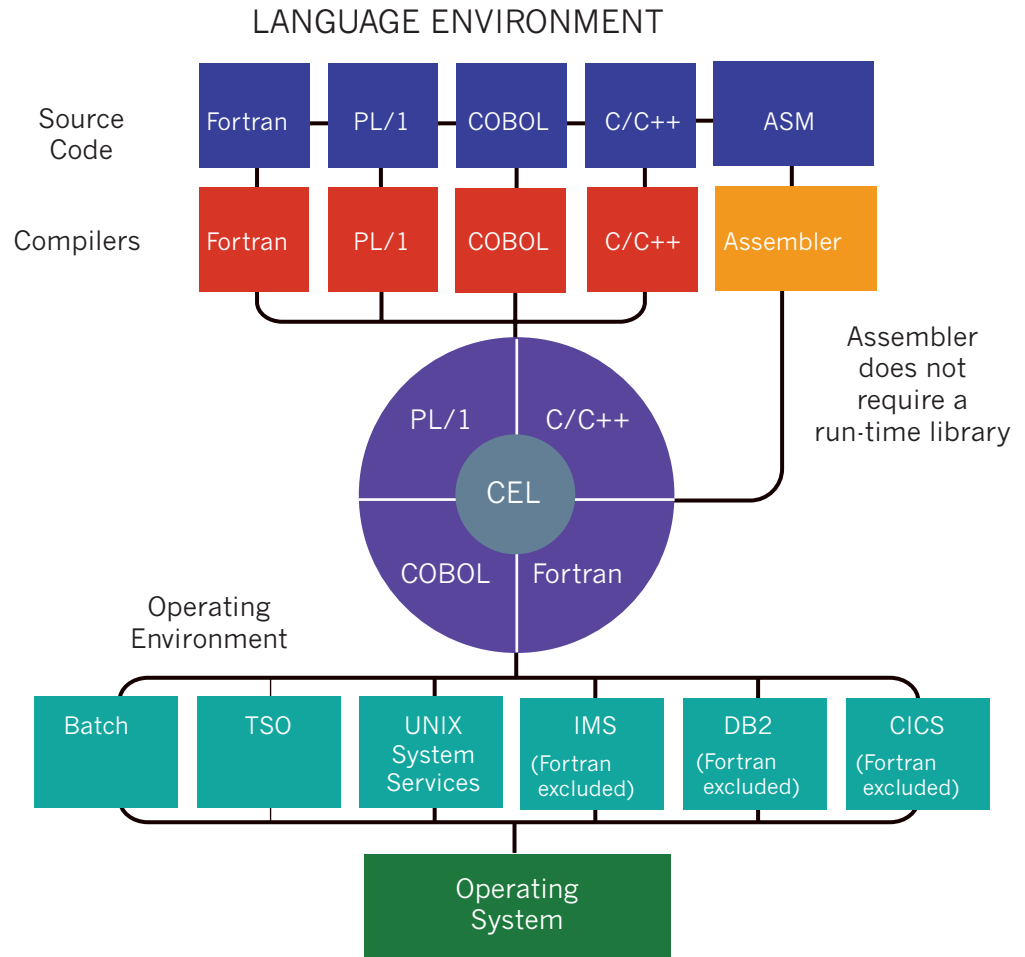


Figure 2. Language Environment's Common Run-Time Environment

Figure 3 on page 20 illustrates the common environment that Language Environment creates for AMODE 64.

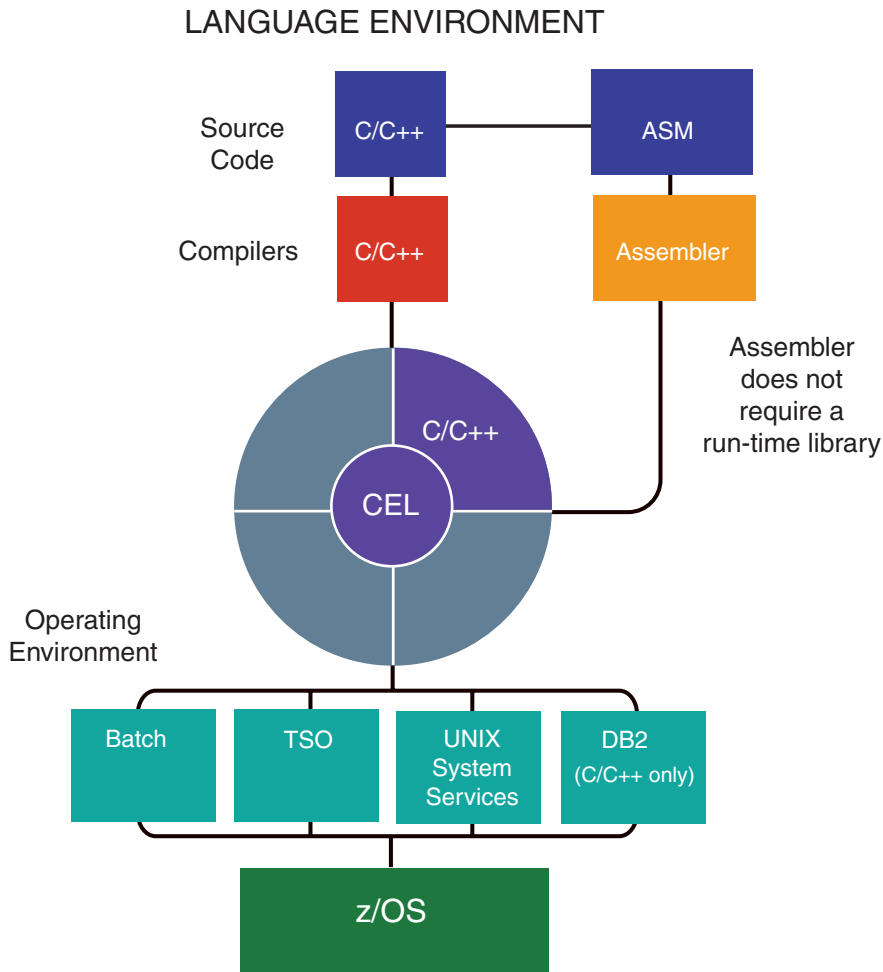


Figure 3. Language Environment's Common Run-Time Environment for AMODE 64

For more information, see *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode*.

Language Environment supports 64-bit addressing for applications written in C, C++, or *Language Environment-conforming Assembler*.

Before support for 64-bit addressing, Language Environment applications could be written in COBOL, PL/I, C, C++, FORTRAN, or *Language Environment-conforming Assembler*. These applications could run in either 24-bit addressing mode (AMODE 24) or 31-bit addressing mode (AMODE 31). Language Environment includes some support for compatibility between these two addressing modes. In AMODE 24, addresses are 24 bits in length, which allows access to virtual storage up to 16 Megabytes. This is often referred to as the "16-megabyte line." AMODE 31 applications use addresses that are 31 bits in length, which allows access to virtual storage up to 2 Gigabytes. This limit on 31-bit addressing is referred to as the "2-gigabyte bar." Both of these terms can be shortened to the "line" or the "bar" when used in the context of addressable storage.

In the 64-bit addressing mode (AMODE 64) supported by Language Environment, addresses are 64 bits in length, which allows access to virtual storage up to 16 exabytes. While this is an extremely high address, there are a few very important facts to consider:

- Existing or new Language Environment applications that use AMODE 24 or AMODE 31 can continue to run without change. They run using the same Language Environment services that existed before 64-bit addressing was introduced, and these services will continue to be supported and enhanced.
- Language Environment applications that use AMODE 64 are not compatible with applications that use AMODE 24 or AMODE 31. The only means of communication between AMODE 64 and AMODE 24 or AMODE 31 applications is through mechanisms that can communicate across processes or address spaces. However, Language Environment applications that use AMODE 64 can run with existing applications that use AMODE 24 or AMODE 31 on the same physical System Z.
- Where necessary, there are new Language Environment run-time options to support AMODE 64 applications. The new run-time options primarily support of the new stack and heap storage located above the bar. All other existing run-time options continue to be supported and enhanced for AMODE 24 and AMODE 31 applications.

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## What You Can Do with Language Environment

Language Environment helps you create mixed-language applications and gives you a consistent method of accessing common, frequently used services. Building mixed-language applications is easier with Language Environment-conforming routines because Language Environment establishes a consistent environment for all languages in the application.

## Common Use of System Resources Gives You Greater Control

Language Environment provides the base for future IBM language library enhancements in the z/OS environment. Many system dependencies have been removed from Language Environment-conforming language products.

Because Language Environment provides a common library, with services that you can call through a common callable interface, the behavior of your applications will be easier to predict. Language Environment's common library includes common services such as messages, date and time functions, math functions, application utilities, system services, and subsystem support. The language-specific portions of Language Environment provide language interfaces and specific services that are supported for each individual language.

Language Environment is accessed through defined common calling conventions, described in Chapter 4, "Language Environment Callable Services," on page 41.

## Consistent Condition Handling Simplifies Error Recovery

Language Environment establishes consistent condition handling for HLLs, debug tools, and assembler language routines. For languages with little or no condition handling function, like COBOL, Language Environment provides a user-controlled method that was not available before for predictable, robust error recovery. Language Environment condition handling honors single- and mixed-language semantics and is integrated with message handling services to provide you with specific information about each condition.

This language-independent condition handler, unlike some existing HLL condition semantics, is stack frame-based and delivers predictable behavior at a given stack

frame. Language Environment condition handling enables you to construct applications out of building blocks of modules and control which modules will handle certain conditions.

A complete description of Language Environment's condition handling model and message services is described in Chapter 3, "The Model for Language Environment," on page 27.

## **Language Environment Protects Your Programming Investment**

Language Environment provides compatible support for existing HLL applications. Applications linked with the migration tools provided with libraries that predate Language Environment do not need to be linked with the Language Environment library routines. For more information, see *z/OS Language Environment Writing Interlanguage Communication Applications*. For mixed-language applications, however, relinking with Language Environment may be required if the application was not previously relinked using migration tools available with pre-Language Environment libraries. Routines compiled with the new Language Environment-conforming compilers can be mixed with old routines in an application. Thus, applications can be enhanced or maintained selectively, without recompiling the whole application when a change is made to a single routine. Some modifications of existing applications may be required. See *z/OS Language Environment Run-Time Application Migration Guide* for more information.

## **ILC Capability Offers Greater Efficiency and Flexibility**

Language Environment eliminates incompatibilities among language-specific run-time environments. Routines call one another within one common run-time environment, eliminating the need for initialization and termination of a language-specific run-time environment with each call. This makes interlanguage communication (ILC) in mixed-language applications easier, more efficient, and more consistent.

This ILC capability also means that you can share and reuse code easily. You can write a service routine in the language of your choice—C/C++, COBOL, PL/I, or assembler—and allow that routine to be called from C/C++, COBOL, PL/I, or assembler applications. Similarly, vendors can write one application package in the language of their choice, and allow the application package to be called from C/C++, PL/I, and assembler routines or from Fortran or COBOL programs.

In addition, Language Environment lets you use the best language for any task. Some programming languages are better suited for certain tasks. Language Environment's improved interlanguage communication (ILC) allows the best language to be used for any given application task. Many programmers, each experienced in a different programming language, can work together to build applications with component routines written in a variety of languages. Language Environment's enhanced ILC allows you to build applications with component routines written in a variety of languages. The result is code that runs faster, is less prone to errors, and is easier to maintain.

## **Common Dump Puts All Debugging Information in One Place**

Language Environment provides a common dump for all conforming languages. The dump includes, in an easy-to-read format, a description of any relevant conditions and information on error location, variables, and storage.



With a common dump, you can locate precisely the module where an error occurred, saving you many hours of debugging, especially if your module is built with several languages. A common dump also allows programmers of differing language skills to collaborate effectively in determining the location of a problem that involves modules of different languages.

## POSIX-Conforming Application Support Enhances Code Portability

The IEEE *Portable Operating System Interface* (POSIX) standard is a series of industry standards for code and user interface portability. POSIX support allows applications written for a UNIX-like operating system to be run on z/OS. C language programmers can access operating system services through a set of standard language bindings. C language programmers who install z/OS UNIX System Services (z/OS UNIX) and z/OS Language Environment can call C language functions defined in the POSIX standard from their C applications and can run applications that conform to ISO/IEC 9945-1:1990.<sup>1</sup> C language programmers with z/OS UNIX installed can also call a subset of the proposed programming interface for thread management (a subset of draft 6 of *POSIX.4a*). Through C interfaces, Language Environment functions conform to XPG4.2 specifications and are branded by X/Open.

Applications that call POSIX functions can perform limited ILC under Language Environment (see *z/OS Language Environment Writing Interlanguage Communication Applications* for details). In addition, C POSIX-conforming applications may use all Language Environment services.

For an overview of z/OS UNIX, see *z/OS Introduction and Release Guide*.

## Locale Callable Services Enhance the Development of Internationalized Applications

Demand is steadily increasing in global markets for software products, and application developers are seeking to make their products available in multiple countries. While marketing their products globally, however, programmers must also make their applications function with the specific language and cultural conventions of the individual user's locale. With locale callable services, application developers can build programs that can be marketed globally, and still meet end users' needs to work with specific languages, cultures, and conventions.

Language Environment provides pre-defined locales, previously available to C/370 routines only, that your PL/I routines and COBOL programs can access at run time through the locale callable services. You can also create your own locales, or modify the IBM-supplied locales, using the C locale definition utility available with the C/C++ compiler.

While C routines can use the locale callable services, it is recommended that they use the equivalent native C library services instead for portability across platforms.

For a complete description of Language Environment locale support, see *z/OS Language Environment Programming Guide*.

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1. ISO/IEC 9945-1:1990, which is also ANSI-IEEE 1003.1-1990, is based on the POSIX.1 standard.

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## Debug Tool in Your Common Environment

Language Environment supports the IBM Debug Tool, a robust, interactive, interlanguage source-level debugging tool. Debug Tool helps you to examine, monitor, and control the execution of programs written in C/C++, COBOL, and PL/I. Debug Tool supports interactive and batch debugging of mixed-language applications.

Using Debug Tool, you can:

- Monitor and interrupt the flow of a program to identify errors easily and correct them quickly.
- Single step through your application or dynamically invoke Debug Tool when an error condition occurs.
- Add, remove, enable, or disable breakpoints dynamically.
- Display and change variables at breakpoints or monitor program variable changes as the program runs.

For more information, see *Debug Tool Users Guide*, SC18-9012.

You can also debug your host programs, including batch, by using Debug Tool with the VisualAge remote debugger, which provides a graphical user interface (GUI) on the workstation. This method of debugging can be used if you create applications using, for example, VisualAge for Java. For more information on the VisualAge Debugger, visit the IBM Software web site at:

<http://www.software.ibm.com/ad/>

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## IBM C/C++ Productivity Tools for OS/390

With the IBM C/C++ Productivity Tools for OS/390 product, you can expand your z/OS application development environment out to your workstation, while remaining close to your familiar host environment.

IBM C/C++ Productivity Tools for OS/390 include the following workstation-based tools to increase your productivity and code quality:

- A Performance Analyzer to help analyze, understand, and tune your C and C++ applications for improved performance. (References to the Performance Analyzer in this section refer to the Performance Analyzer included in the C/C++ Productivity Tools for OS/390 product.)
- A Distributed Debugger that allows you to debug C or C++ programs from the convenience of your workstation.
- A workstation editor to improve the productivity of your C and C++ source entry.
- Advanced online help, with full text search and hypertext topics as well as printable, viewable, and searchable Portable Document Format (PDF) documents.

In addition, IBM C/C++ Productivity Tools for OS/390 include the following host components:

- Debug Tool
- Host Performance Analyzer

Use the Performance Analyzer on your workstation to graphically display and analyze a profile of the running of your host z/OS C or C++ application. Use this information to time and tune your code so that you can increase the performance of your application.

Use the Distributed Debugger to debug your z/OS C/C++ application remotely from your workstation.

Set a break point with a click of the mouse. Use the windowing capabilities of your workstation to view multiple segments of your source and your storage, while monitoring a variable at the same time.

Use the workstation-based editor to quickly develop C and C++ application code that runs on z/OS. Context-sensitive help information is available to you when you need it.



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## Chapter 3. The Model for Language Environment

This chapter describes the Language Environment architecture, a system of user conventions, product conventions, and processing models that, when followed by HLL application programmers, provides a common, consistent run-time environment.

Models for program management, condition handling, message services, and storage management are outlined.

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### The Language Environment Program Management Model

The Language Environment program management model provides a framework within which an application runs. It is the foundation of all of the component models—condition handling, run-time message handling, and storage management—that comprise the Language Environment architecture. The program management model defines the effects of programming language semantics in mixed-language applications and integrates transaction processing and multithreading.

### Language Environment Program Management Model Terminology

Some terms used to describe the program management model are common programming terms; other terms are described differently in other languages. It is important that you understand the meaning of the terminology in a Language Environment context as compared to other contexts. For more detailed definitions of these and other Language Environment terms, consult the “Language Environment Glossary” on page 65.

- General Programming Terms:

#### **Application program**

A collection of one or more programs cooperating to achieve particular objectives, such as inventory control or payroll.

#### **Environment**

In Language Environment, normally a reference to the run-time environment of HLLs at the enclave level.

- Language Environment Terms and Their HLL Equivalents:

#### **Routine**

In Language Environment, refers to either a procedure, function, or subroutine.

Equivalent HLL terms: COBOL—program; C/C++—function; PL/I—procedure, BEGIN block.

#### **Enclave**

The enclave defines the scope of HLL semantics. In Language Environment, a collection of routines, one of which is named as the main routine. The enclave contains at least one thread.

Equivalent HLL terms: COBOL—run unit, C/C++—program, consisting of a main C function and its subfunctions, PL/I—main procedure and its subroutines, and Fortran—program and its subroutines.

#### **Process**

The highest level of the Language Environment program management

model. A process is a collection of resources, both program code and data, and consists of at least one enclave.

### **Thread**

An execution construct that consists of synchronous invocations and terminations of routines. The thread is the basic run-time path within the Language Environment program management model, and is dispatched by the system with its own run-time stack, instruction counter, and registers. Threads may exist concurrently with other threads.

- Terminology for Data:

#### **Automatic data**

Data that does not persist across calls. It is allocated with the same value on entry and reentry into a routine.

#### **External data**

Data that can be referenced by multiple routines and data areas. External data is known throughout an enclave.

#### **Local data**

Data that is known only to the routine in which it is declared.

Equivalent HLL terms: C/C++—local data, COBOL—WORKING-STORAGE data items and LOCAL-STORAGE data items, PL/I—data declared with the PL/I INTERNAL attribute.

## **Program Management**

Program management defines the program execution constructs of an application, and the semantics associated with the integration of various components management of such constructs.

Three entities—*process*, *enclave*, and *thread*—are at the core of the Language Environment program management model. They are described below.

Refer to Figure 4 on page 29 as you read the following discussion about processes, enclaves, and threads. This figure illustrates the simplest form of the Language Environment program management model and how resources such as storage are managed.

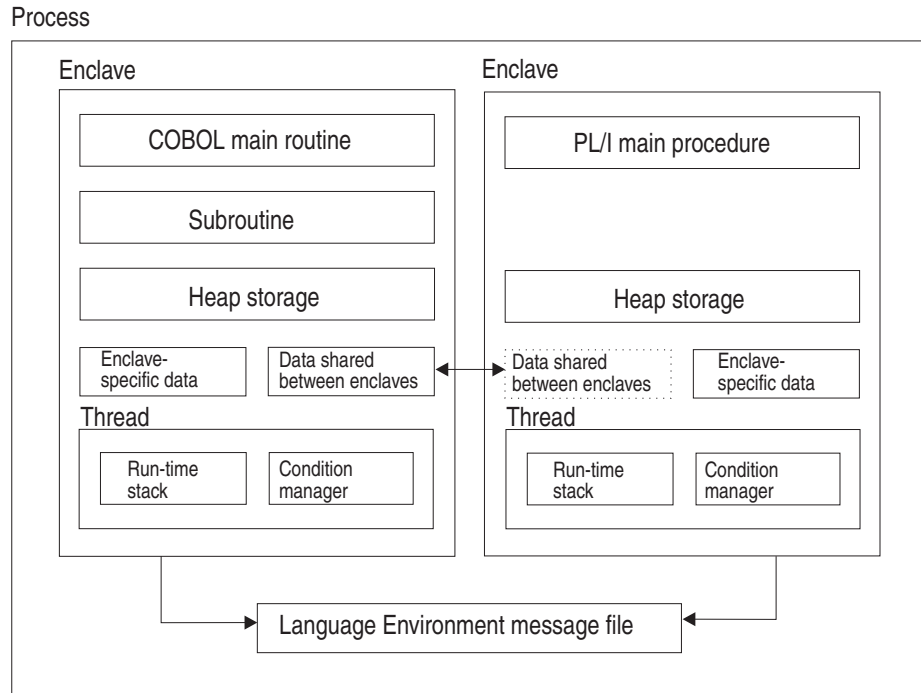


Figure 4. Language Environment Resource Ownership

## Processes

The highest level component of the Language Environment program model is the process. A process consists of at least one enclave and is logically separate from other processes. Processes do not share storage and are independent of and equal to each other; they are not hierarchically related.

Language Environment generally does not allow language file sharing across enclaves nor does it provide the ability to access collections of externally stored data.

However, in PL/I, SYSPRINT may be shared across enclaves if all the code in all the enclaves has been compiled either with PL/I for MVS & VM or with Enterprise PL/I for z/OS, but not both.

The Language Environment message file also may be shared across enclaves, since it is managed at the process level. The Language Environment message file contains messages from all routines running within a process, making it a useful central location for messages generated during run time.

Processes can create new processes and communicate to each other by using Language Environment-defined communication, for such things as indicating when a created process has been terminated.

## Enclaves

A key feature of the program management model is the enclave, a collection of the routines that make up an application. As mentioned in the terminology defined above, the enclave is the equivalent of any of the following:

- A *run unit*, in COBOL

- A *program*, consisting of a *main C function* and its *subfunctions*, in C and C++
- A *main procedure* and all of its *subroutines*, in PL/I
- A *program* and its *subroutines*, in Fortran

The enclave consists of one main routine and zero or more subroutines. (However, a POSIX application might not have a main routine active at a given time.) The main routine is the first to execute in an enclave; all subsequent routines are named as subroutines.

### Characteristics of the Enclave

The enclave logically owns resources normally associated with the running of a program. Some resources are owned directly, such as heap storage; some are owned indirectly, such as the run-time stack, which is owned by a thread. Heap storage, the run-time stack, and threads are discussed in the following sections.

Heap storage is shared among all routines in an enclave and can be allocated by a routine in one language and be freed by a routine in another language. For a discussion on stack and heap storage, see “Language Environment Storage Management Model” on page 38.

The enclave defines the scope—how far the semantic effects of language statements reach—of the language semantics for its component routines, just as a COBOL run unit defines the scope of semantics of a COBOL program.

The enclave defines the following in a Language Environment-conforming application:

- Scope of shared external data, such as COBOL EXTERNAL data and PL/I external data
- Scope of external files, such as COBOL EXTERNAL files <sup>2</sup>
- Scope of the effect of language statements, for example, STOP-like constructs, such as STOP RUN in COBOL or other terminating mechanisms
- Lifetime of heap storage, in its last-used state

## Threads

Each enclave consists of at least one thread, the basic instance of a particular routine. A thread is created during enclave initialization with its own run-time stack, which keeps track of the thread’s execution, as well as a unique instruction counter, registers, and condition-handling mechanisms. Each thread represents an independent instance of a routine running under an enclave’s resources.

Threads share all of the resources of an enclave. A thread can address all storage within an enclave. All threads are equal and independent of one another and are not related hierarchically. A thread can create a new enclave. Because threads operate with unique run-time stacks, they can run concurrently within an enclave and allocate and free their own storage. Because they may execute concurrently, threads can be used to implement parallel processing applications and event-driven applications.

Figure 5 on page 31 illustrates the full Language Environment program model, with its multiple processes, enclaves, and threads.

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2. The sharing of files across languages is not permitted in z/OS Language Environment.



As Figure 5 shows, each process is within its own address space. An enclave consists of one main routine, with any number of subroutines. A main routine might not be active at all times in a POSIX application, if the thread in which the main routine executes terminates before the other threads it created.

External data is available only within the enclave where it resides; notice that even though the external data may have identical names in different enclaves, the external data is unique to the enclave. The scope of external data, as described earlier, is the enclave. The threads can create enclaves, which can create more threads, and so on.

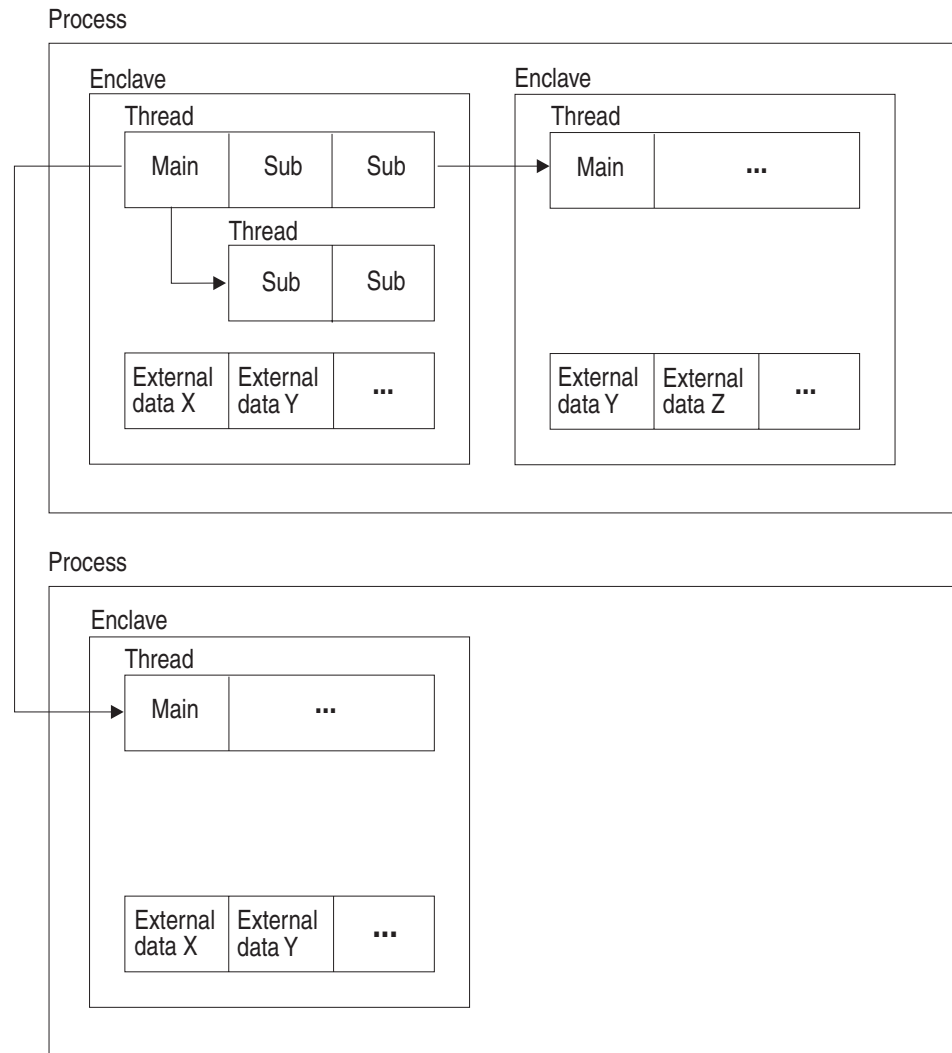


Figure 5. Language Environment Program Management

## Language Environment Condition-Handling Model

For single- and mixed-language applications, the Language Environment run-time library provides a consistent and predictable condition-handling facility. It does not replace current HLL condition handling, but instead allows each language to respond to its own unique environment as well as to a mixed-language environment.

Language Environment condition management gives you the flexibility to respond directly to conditions by providing callable services to signal conditions and to interrogate information about those conditions. It also provides functions for error diagnosis, reporting, and recovery.

Language Environment condition handling is based on the *stack frame*, an area of storage that is allocated when a routine runs and that represents the history of execution of that routine. It can contain automatic variables, information on program linkage and condition handling, and other information. Using the stack frame as the model for condition handling allows conditions to be handled in the stack frame in which they occur. This allows you to tailor condition handling according to a specific routine, rather than handle every possible condition that could occur within one global condition handler.

A unique feature of Language Environment condition handling is the condition token. The token is a 12-byte data type that contains an accumulation of information about each condition. The information can be returned to the user as a feedback code when calling Language Environment callable services. It can also be used as a communication vehicle within the run-time environment.

Serviceability is improved with interactive problem control system (IPCS) exits.

## Condition-Handling Terminology

Below is a list of terms you need to understand while reading the discussion on Language Environment condition handling. For more detailed definitions of these and other Language Environment terms, please consult the “Language Environment Glossary” on page 65.

### **Condition**

Any change to the normal programmed flow of a program. In Language Environment, a condition can be generated by an event that has historically been called an exception, interruption, or condition.

### **Condition handler**

A routine invoked by Language Environment that responds to conditions in an application. Condition handlers are registered through the CEEHDLR callable service, or provided by the language libraries, by such constructs as PL/I ON statements.

### **Condition token**

In Language Environment, a data type consisting of 12 bytes with structured fields that indicate various aspects of a condition, including severity, associated message number, and information that is specific to a given instance of the condition.

### **Feedback code**

A condition token value used to communicate information when using the Language Environment callable services.

### **Resume cursor**

Contains the address where execution resumes after a condition is handled. Initially, it will be the point in the application where a condition occurred when it is first reported to Language Environment.

### **Stack frame**

The physical representation of the activation of a routine. The stack frame is

allocated on a last in, first out (LIFO) basis and can contain automatic variables, information on program linkage and condition handling, and other information.

A stack frame is conceptually equivalent to a dynamic save area (DSA) in PL/I, or a save area in assembler.

## Condition-Handling Model Description

The Language Environment condition handler is based on a stack frame model. A stack frame is an area of storage that can contain automatic variables, information on program linkage and condition handling, and other information. The stack frame is allocated using Language Environment-managed storage, either HEAP or STACK, depending on the language being used. It is created through any of the following,

- A function call in C or C++
- Entry into a compile unit in COBOL
- Entry into a procedure or begin block in PL/I
- Entry into an ON-unit in PL/I

Each routine adds a unique stack frame, in a LIFO manner, to the Language Environment storage, either HEAP or STACK. User-written condition handlers (registered through CEEHDLR) are associated with each stack frame. In addition, HLL handling semantics can affect the processing conditions at each stack frame. For an illustration of the Language Environment run-time stack and its divisions into stack frames, see Figure 6.

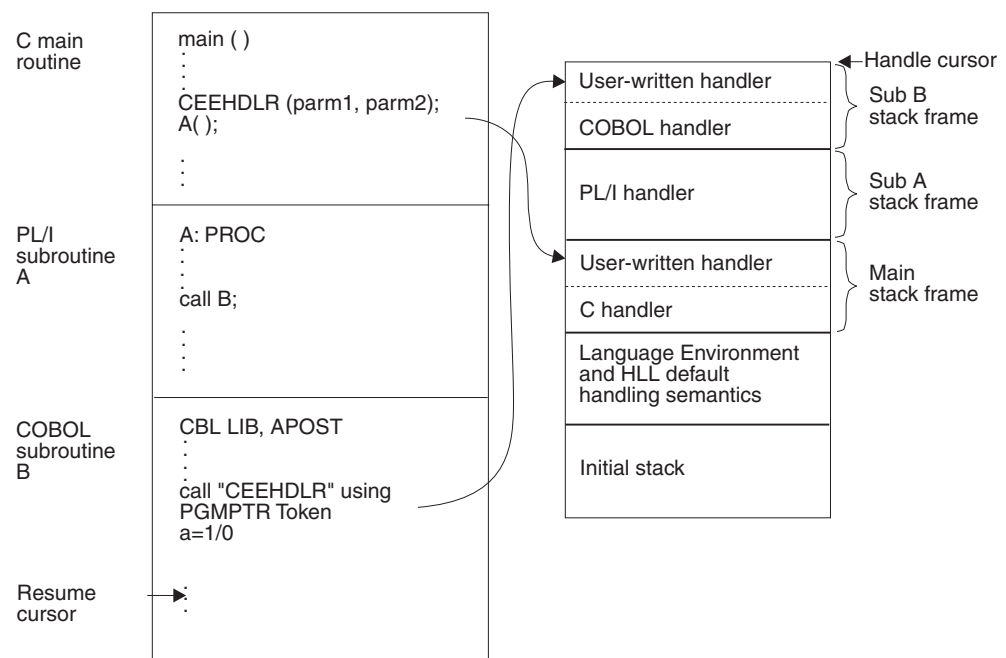


Figure 6. Condition-Handling Stack Configuration

Each Language Environment user condition handler is explicitly registered through the callable service CEEHDLR or through the USRHDLR run-time option. Language-defined handling mechanisms are registered through language-provided constructs, such as the PL/I ON statement or the C `signal()` function. When a routine returns to its caller, its stack frame is removed from the stack and the associated handlers are automatically unregistered. Semantics associated with a

routine are honored; for example, PL/I semantics on a return specify that any ON-units within a routine will be unregistered. If the USRHDLR run-time option is used, the user-written condition handler is registered at stack frame 0.

A condition is signaled within Language Environment as a result of one of the following occurrences:

- A hardware-detected interrupt
- An operating system-detected exception
- A condition generated by Language Environment callable services
- A condition explicitly signaled within a routine

The first three types of conditions are managed by Language Environment and signaled if appropriate. The last may be signaled by user-written code through a call to the service CEESGL or signaled by HLL semantics such as SIGNAL in PL/I or raise in C.

When a condition is signaled, whether by a user routine, by Language Environment in response to an operating system or hardware detected condition, or by a callable service, Language Environment directs the appropriate condition handlers in the stack frame to handle the condition. Condition handling proceeds first with user-written condition handlers in the queue, if present, then with any HLL-specific condition handlers, such as a PL/I ON-unit or a C signal handler, that may be established. The process continues for each frame in the stack, from the most recently allocated to the least recently allocated.

If a condition remains unhandled after the stack is traversed, the condition is handled by either Language Environment or by the default semantics of the language where the condition occurred.

### **How Conditions are Represented**

A condition token is used to communicate information about a condition to Language Environment, message services, callable services, and routines. The token is a 12-byte data type with fields that indicate the following information about a condition:

- Severity of a condition
- Associated message number
- Facility ID: This field identifies the owner of the condition (Language Environment, Language Environment component, or user-specified). It is also used to identify a file containing message text that is unique for the condition.
- Instance specific information: This field is created if the condition requires that data or text be inserted into a message, for example, a variable name. This field also contains qualifying data, which can be used to specify data (input or output) to be used when a routine resumes processing after a condition occurs.

### **How Condition Tokens are Created and Used**

If the condition is detected by the operating system or by the hardware, Language Environment will automatically build the condition token and signal the condition. With Language Environment callable services, you can create a condition token with corresponding message or data inserts and then signal the condition to the application running within Language Environment by returning the token.

When used in Language Environment callable services, the entire condition token represents a value called the feedback code. You can include a feedback parameter

to Language Environment callable services, and check the result of the call; or, in PL/I and C, you can omit the feedback parameter, and any errors in the call will be signaled to you.

For an illustration of the creation and use of condition tokens, see Figure 7 on page 36.

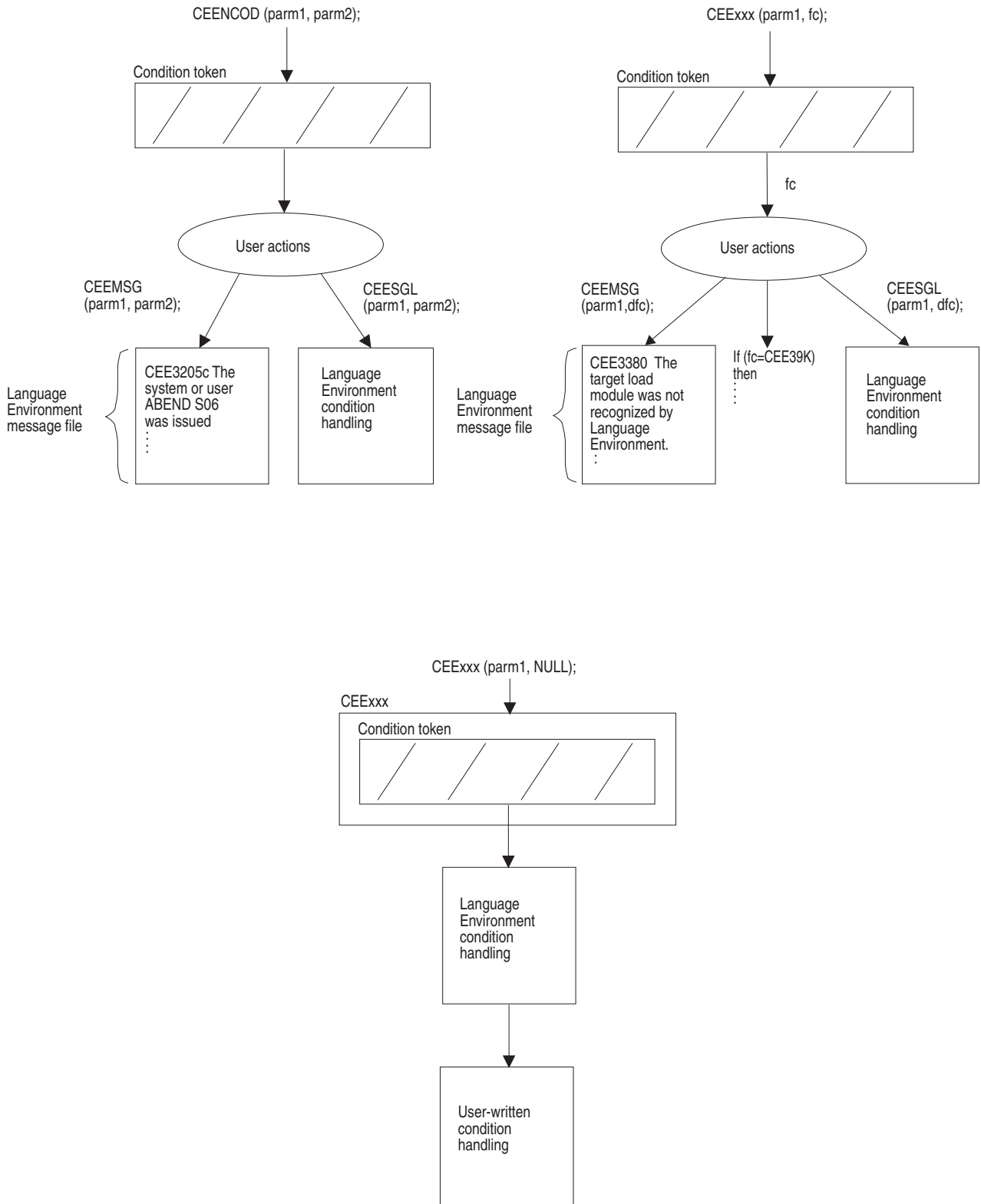


Figure 7. How Condition Tokens are Created and Used

## Condition-Handling Responses

Conditions are responded to in one of the following ways:

- *Resume* terminates condition handling and transfers control usually to the location immediately following the point where the condition occurred.  
A resume cursor points to the place where a routine should resume; it can be moved by the callable service CEEMRCCR to point to another resume point.
- *Percolate* defers condition handling for an unchanged condition. Condition handling continues at the next condition handler.
- *Promote* is similar to percolate in that it passes the condition on to the next condition handler; however, it transforms a condition to another condition, one with a new meaning. Condition handling then continues, this time with a new type of condition.

## Run-Time Dump Service Provides Information in One Place

The Language Environment callable service CEE3DMP dumps the run-time environment of Language Environment into one easily readable report. CEE3DMP can be called directly from an application to produce a dump that is formatted for printing. Depending on the options you choose, the dump report may contain information on conditions, tracebacks, variables, control blocks, stack and heap storage, file status and attributes, and language-specific information. The report can also be requested with the TERMTHDACT run-time option when a program terminates due to an unhandled condition.

Serviceability is improved with a traceback section in CEEDUMP.

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## Language Environment Message Handling Model and National Language Support

A set of common message handling services that create and send run-time informational and diagnostic messages is provided by Language Environment.

With the message handling services, you can use the condition token that is returned from a callable service or from some other signaled condition, format it into a message, and deliver it to a defined output device or to a buffer.

## National Language Support

Messages may be formatted according to national language support specifications for the following languages:

- Mixed-case American English (ENU)
- Uppercase American English (UEN)
- Japanese (JPN)

National language support callable services allow you to set a national language that affects the language of the error messages and the names of the day, week, and month. It also allows you to change the country setting, which affects the default date format, time format, currency symbol, decimal separator character, and thousands separator.

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## Language Environment Storage Management Model

Common storage management services are provided for all Language Environment-conforming programming languages; Language Environment controls stack and heap storage used at run time. It allows single- and mixed-language applications to access a central set of storage management facilities, and offers a multiple-heap storage model to languages that do not now provide one. The common storage model removes the need for each language to maintain a unique storage manager and avoids the incompatibilities between different storage mechanisms.

### Storage Management Terminology:

**Stack** An area of storage in which stack frames can be allocated. (For an explanation of stack frames, see “Language Environment Condition-Handling Model” on page 31).

**Heap** An area of storage used by Language Environment routines. The heap consists of the initial heap segment and zero or more increments. Heap storage contains storage acquired by the ALLOCATE statement in PL/I, and storage acquired by `malloc()` and `calloc()` in C.

### Heap element

A contiguous area of storage allocated by a call to the CEEGTST service. Heap elements are always allocated within a single heap segment.

### Heap increment

Additional heap segments allocated when the initial heap segment does not have enough free storage to satisfy a request for heap storage.

### Heap pool

A storage pool that, when used by the storage manager, can be used to improve the performance of heap storage allocation. This can improve the performance of a multi-threaded application.

### Heap segment

A contiguous area of storage obtained directly from the operating system.

## Stack Storage

In Language Environment, a run-time stack, or stack storage, is automatically created when a thread is created, and freed when the thread terminates. When a thread is created, Language Environment allocates an initial stack, which can have stack increments added to it as needed. Users can specify the sizes of the initial stack and additional stack increments; they can also tune the stack for better performance. For more information, see Chapter 14 in *z/OS Language Environment Programming Guide*.

For AMODE 64 support, users can specify a stack size above the bar, and can specify the maximum stack size. For more information, see *z/OS Language Environment Programming Guide for 64-bit Virtual Addressing Mode*.

In AMODE 31, each stack segment is allocated separately. In AMODE 64, the maximum possible stack size can be specified. A contiguous block of storage is allocated above the bar and each segment is unguarded as needed.

## Heap Storage

Heap storage can be allocated and freed in no particular order. (Stack storage, in contrast, is allocated when a routine is entered and freed when the routines ends.)



Language Environment provides multiple heaps that may be dynamically created and discarded by using Language Environment callable services. Language Environment's heap storage is reliable because it provides a level of isolation and prevents common errors such as attempting to free a heap element that has already been freed.

Heap storage is shared among all program units and all threads in an enclave. Allocated heap storage remains allocated until it is explicitly freed by a thread or until the enclave terminates. Heap storage is typically controlled by the programmer through Language Environment run-time options and callable services.

Heap storage consists of an initial heap segment that is allocated when the first heap element is allocated (by a call to CEEGTST). The Language Environment storage manager allocates heap increments as previously allocated segments become full.

Figure 8 illustrates heap storage.

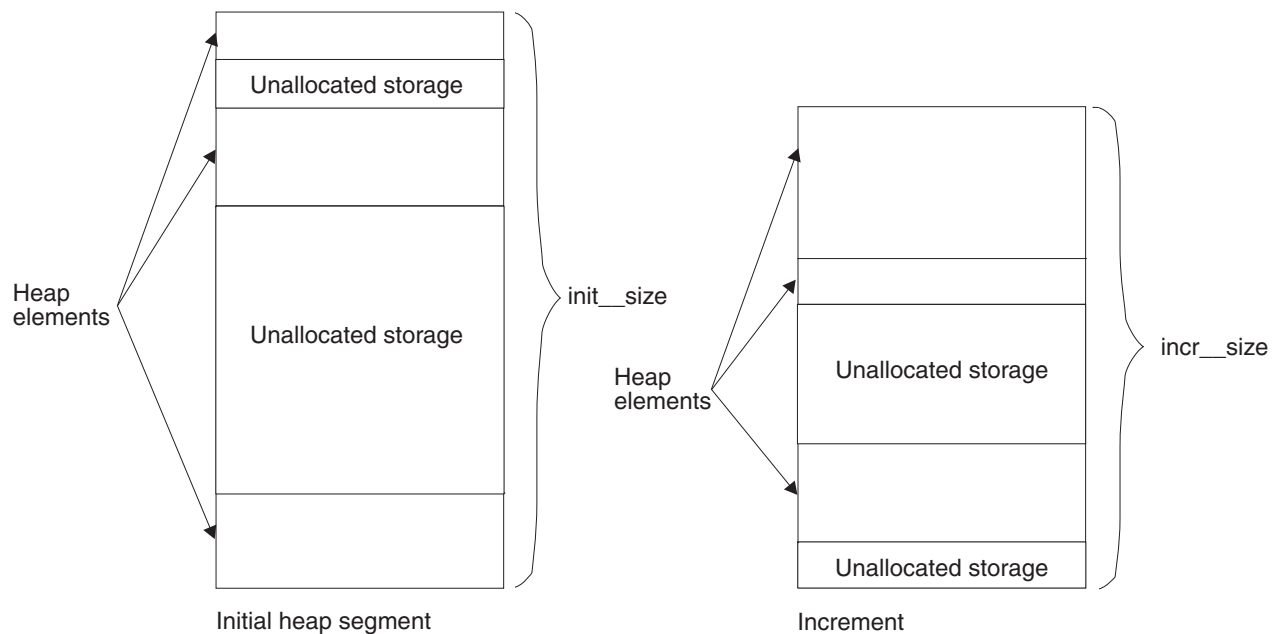


Figure 8. Language Environment Heap Storage

## Storage Management Options

### Storage Report

You can write a storage report using the run-time option RPTSTG. The report summarizes all heap and stack activity, including total amount of storage used, number of heap elements allocated and freed, number of operating system calls performed, and recommended heap and stack sizes. Proper setting of heap and stack sizes can significantly improve performance by reducing the number of operating system calls made to allocate and free storage.

### Storage Option

In Language Environment, the run-time option STORAGE may be used to automatically initialize all heap and stack storage to a specified character. This is useful as a debugging aid to find references to uninitialized program variables.

For AMODE 64 support, you must specify MEMLIMIT. The overall storage above the bar is controlled in MVS. For more information, see *z/OS MVS Programming: Extended Addressability Guide*.

---

## Chapter 4. Language Environment Callable Services

This chapter gives an overview of Language Environment callable services and the common calling procedure required to invoke them from C/C++, COBOL, PL/I, Fortran, and assembler.

This common set of callable services is designed to supplement your programming language's intrinsic capability. For example, COBOL application developers will find Language Environment's consistent condition handling services especially useful. All languages can benefit from the rich set of Language Environment common math services, as well as the date and time services.

The callable services described in this chapter are for AMODE 31 only. For AMODE 64, none of the application writer interfaces (AWIs) will be supported in their present form. There may be C functions that provide similar functionality for some of the AWIs. A few non-standard C functions have been added to provide the functionality of some of the AWIs. For details, see *z/OS XL C/C++ Run-Time Library Reference*.

Language Environment callable services are divided into the following groups:

- Communicating Conditions Services
- Condition Handling Services
- Date and Time Services
- Dynamic Storage Services
- General Callable Services
- Initialization/Termination Services
- Locale Callable Services
- Math Services
- Message Handling Services
- National Language Support Services

Direct invocation of Language Environment callable services is not supported from Fortran. However, support is provided to use callable services using a Fortran library subroutine service. For more information, see *Language Environment Fortran Run-Time Migration Guide*. Alternatively, a Fortran program can call another Language Environment-enabled high-level language or an assembler program that can invoke a Language Environment callable service.

Language-specific services, including those that call Language Environment callable services, are documented in the language publications.

---

## Language Environment Calling Conventions

Language Environment services can be invoked by HLL library routines, other Language Environment services, and user-written HLL calls. In many cases, services will be invoked by HLL library routines, as a result of a user-specified function, such as a COBOL intrinsic function.

Language Environment-conforming languages exhibit consistent behavior because language functions call Language Environment services. For example, C `malloc()` and PL/I `ALLOCATE` each directly or indirectly call `CEEGTST` to obtain storage.

The sections below show examples of the syntax used to invoke Language Environment callable services.

## Invoking Callable Services from C

In C, invoke a Language Environment callable service (with feedback code) using the syntax shown below:

```
#include <leawi.h>
main ()
{
  CEESERV(parm1, parm2, ... parmn, fc);
}
```

Figure 9. Sample Invocation of a Callable Service from C

leawi.h is a header file shipped with Language Environment that contains declarations of Language Environment callable services and OMIT\_FC, which is used to explicitly omit the feedback code parameter, as shown below.

```
#include <leawi.h>
main ()
{
  CEESERV(parm1, parm2, ... parmn, OMIT_FC);
}
```

Figure 10. Omitting the Feedback Code when Calling a Service from C

## Invoking Callable Services from COBOL

In COBOL, invoke a Language Environment callable service using the syntax shown below:

```
01 Feedback.
COPY CEEIGZCT
:
CALL "CEESERV" USING parm1 parm2 ... parmn fc
```

Figure 11. Sample Invocation of a Callable Service from COBOL

CEEIGZCT is an include file shipped with Language Environment that contains declarations of Language Environment symbolic feedback codes.

You may omit the feedback code parameter in COBOL for OS/390 & VM and COBOL for MVS & VM as shown in the following syntax:

```
01 Feedback.
COPY CEEIGZCT
CALL "CEESERV" USING parm1 parm2 ... parmn OMITTED
```

Figure 12. Omitting the Feedback Code when Calling a Service from COBOL

## Invoking Callable Services from PL/I

In PL/I, invoke a Language Environment callable service (with feedback code) using the syntax shown below:

```
%INCLUDE CEEIBMAW
:
CALL CEESERV (parm1, parm2, ... parmn, fc);
```

Figure 13. Sample Invocation of a Callable Service from PL/I

CEEIBMAW is an include file shipped with Language Environment that contains declarations of Language Environment callable services.



- Those services starting with CEE3 are services that exploit unique System/390 characteristics.

Table 2. Language Environment Callable Services

Service Name	Description
<b>Communicating Conditions Services</b>	
CEEDCOD—Decompose a Condition Token	Decomposes an existing condition token.
CEENCOD—Construct a Condition Token	Dynamically constructs a condition token. The condition token communicates with message services, condition management, Language Environment callable services, and user applications.
<b>Condition Handling Services</b>	
CEE3CIB—Return Pointer to Condition Information Block	Given a condition token passed to a user-written condition handler, CEE3CIB returns a pointer to the condition information block associated with a condition. Allows access to detailed information about the subject condition during condition handling.
CEE3GRN—Get Name of Routine that Incurred Condition	Obtains the name of the routine that is currently running when a condition is raised. If there are nested conditions, the most recently signaled condition is used.
CEE3GRO—Return Offset	Returns the offset of the location within the most current Language Environment-conforming routine where a condition occurred.
CEE3SPM—Query and Modify Language Environment Hardware Condition Enablement	Allows the user to manipulate the program mask by enabling or masking hardware interrupts.
CEE3SRP—Set Resume Point	Sets a resume point within user application code to resume from a Language Environment user condition handler.
CEEGQDT—Retrieve q_data_Token	Retrieves the q_data token from the Instance-Specific Information (ISI) to be used by user condition handlers.
CEEHDLR—Register a User Condition Handler	Registers a user condition handler for the current stack frame.
CEEHDLU—Unregister a User Condition Handler	Unregisters a user condition handler for the current stack frame.
CEEITOK—Return Initial Condition Token	Returns the initial condition token for the current condition.
CEEMRCE—Resume User Routine	Resumes execution of a user routine at the location established by CEE3SRP.
CEEMRCR—Move Resume Cursor Relative to Handle Cursor	Moves the resume cursor. You can either move the resume cursor to the call return point of the routine that registered the executing condition handler, or move the resume cursor to the caller of the routine that registered the executing condition handler.
CEESGL—Signal a Condition	Signals a condition to the Language Environment condition manager. It also may be used to provide qualifying data and create an instance specific information (ISI) field. The ISI contains information that is used by the Language Environment condition manager to identify and react to conditions.
<b>Date and Time Services</b>	
CEECBLDY—Convert Date to COBOL Lilian Format	Converts a string representing a date into a COBOL Lilian date format. The COBOL Lilian date format represents a date as the number of days since 31 December 1600.
CEEDATE—Convert Lilian Date to Character Format	Converts a number representing a Lilian date to a date written in character format. The output is a character string such as "1992/07/25".

Table 2. Language Environment Callable Services (continued)

Service Name	Description
CEEDATM—Convert Seconds to Character Timestamp	Converts a number representing the number of seconds since 00:00:00 14 October 1582 to a character format. The format of the output is a character string, such as “1992/07/26 20:37:00.”
CEEDAYS—Convert Date to Lilian Format	Converts a string representing a date into a Lilian format. The Lilian format represents a date as the number of days since 14 October 1582, the beginning of the Gregorian calendar.
CEEDYWK—Calculate Day of Week from Lilian Date	Calculates the day of the week on which a Lilian date falls. The day of the week is returned to the calling routine as a number between 1 and 7.
CEEGMT—Get Current Greenwich Mean Time	Returns the current Greenwich Mean Time (GMT) as both a Lilian date and as the number of seconds since 00:00:00 14 October 1582. These values are compatible with those generated and used by the other Language Environment date and time services.
CEEGMTO—Get Offset from Greenwich Mean Time to Local Time	Returns values to the calling routine which represent the difference between the local system time and Greenwich Mean Time.
CEEISEC—Convert Integers to Seconds	Converts separate binary integers representing year, month, day, hour, minute, second, and millisecond to a number representing the number of seconds since 00:00:00 14 October 1582. Use CEEISEC instead of CEESECS when the input is in numeric format rather than character format.
CEELOCT—Get Current Local Time	Returns the current local time in three formats: <ul style="list-style-type: none"> <li>• Lilian date (the number of days since 14 October 1582)</li> <li>• Lilian timestamp (the number of seconds since 00:00:00 14 October 1582)</li> <li>• Gregorian character string (in the form YYYYMMDDHHMISS999)</li> </ul>
CEEQCEN—Query the Century Window	Queries the century within which Language Environment assumes 2-digit year values lie. Use it in conjunction with CEESCEN when it is necessary to save and restore the current setting.
CEESCEN—Set the Century Window	Sets the century where Language Environment assumes 2-digit year values lie. Use it in conjunction with CEEDAYS or CEESECS when you process date values that contain 2-digit years (for example, in the YYMMDD format), or when the Language Environment default century interval doesn't meet the requirements of a particular application.
CEESECI—Convert Seconds to Integers	Converts a number representing the number of seconds since 00:00:00 14 October 1582 to seven separate binary integers representing year, month, day, hour, minute, second, and millisecond. Use CEESECI instead of CEEDATM when the output is needed in numeric format rather than character format.
CEESECS—Convert Timestamp to Number of Seconds	Converts a string representing a timestamp into a number representing the number of seconds since 00:00:00 14 October 1582. This service makes it easier to do time arithmetic, such as calculating the elapsed time between two timestamps.
CEEUTC—Get Coordinated Universal Time	CEEUTC is an alias of CEEGMT.
<b>Dynamic Storage Services</b>	
CEECRHP—Create New Additional Heap	Defines additional heaps. The heaps defined by CEECRHP can be used just like the Language Environment initial heap (heap id of 0). However, the entire heap created by CEECRHP may be quickly freed with a single call to the CEEDSHP (discard heap) service.

Table 2. Language Environment Callable Services (continued)

Service Name	Description
CEEZST—Reallocate (Change Size of) Storage	Changes the size of a previously allocated storage element while preserving its contents. Reallocation of a storage element is accomplished by allocating a new storage element of a new size and copying the contents of the old element to the new element.
CEEDSHP—Discard Heap	Discards an entire heap that you created previously with a call to CEECRHP.
CEEFRST—Free Heap Storage	Frees storage previously allocated by CEEGTST. It can be used to free both large and small blocks of storage efficiently because freed storage is retained on a free chain instead of being returned to the operating system.
CEEGTST—Get Heap Storage	Allocates storage from a heap whose ID you specify. It can be used to efficiently acquire both large and small blocks of storage.
<b>General Services</b>	
CEE3DLY—Suspend Processing of an Active Enclave in Seconds	Suspends processing of an active enclave for a specified number of seconds up to a maximum of one hour.
CEE3DMP—Generate Dump	Generates a dump of the run-time environment of Language Environment and of the member language libraries. The dump can be modified to selectively include such information as number and contents of enclaves and threads, traceback of all routines on a call chain, file attributes, and variable, register, and storage contents.
CEE3INF—Provide Enclave Information	Provides current Language Environment information about the enclave.
CEETDLI—Invoke IMS	Invokes IMS.
CEE3RPH—Set Report Heading	Sets the heading displayed at the top of the storage or run-time options report. Language Environment generates the storage report when the RPTSTG(ON) run-time option is specified, and the options report when the RPTOPTS(ON) run-time option is specified.
CEE3USR—Set or Query User Area Fields	Sets or queries one of two 4-byte fields in the enclave data block known as the user area fields. The user area fields are associated with an enclave and are maintained on an enclave basis. A user area might be used by vendor or applications to store a pointer to a global data area or keep a recursion counter.
CEEDLYM—Suspend Processing of an Active Enclave in Milliseconds	Suspends processing of an active enclave for a specific number of milliseconds up to a maximum of one hour.
CEEENV—Query, Set, or Delete Environment Variables	Allows for querying, setting, and deleting of environment variables.
CEEGPID—Retrieve the Language Environment Version and Platform ID	Retrieves the Language Environment version ID and the platform ID of the version and platform of Language Environment that is currently in use for processing the currently active condition.
CEERAN0—Calculate Uniform Random Numbers	Generates a sequence of uniform pseudo-random numbers between 0 and 1 using the multiplicative congruential method with a user-specified seed.
CEETEST—Invoke Debug Tool	Invokes a debug tool, such as Debug Tool.
<b>Initialization/Termination Services</b>	
CEE3ABD—Terminate Enclave with an Abend	Requests Language Environment to terminate the enclave via an abend. The abend can be issued either with or without cleanup.
CEE3AB2—Add a Reason Code to an Abend	Supports the addition of a reason code to the ABEND. This enhances CEE3ABD to allow for more control of diagnostic information collection.



Table 2. Language Environment Callable Services (continued)

Service Name	Description
CEE3GRC—Get the Enclave Return Code	Retrieves the current value of the user enclave return code.
CEE3PRM—Query Parameter String	Returns to the calling routine the parameter string that was specified at invocation of the program. The returned parameter string contains only user parameters. If no user parameters are available, a blank string is returned.
CEE3PR2—Supports longer parameter lists.	Supports longer parameter lists.
CEE3SRC—Set the Enclave Return Code	Modifies the user enclave return code. The value set will be used in the calculation of the final enclave return code at enclave termination.
<b>Locale Callable Services</b>	
CEEFMON—Format Monetary String	Converts numeric values to monetary strings.
CEEFMDS—Format Time and Date into Character String	Converts time and date specifications into a character string.
CEELCNV—Query Locale Numeric Conventions	Returns information about the LC_NUMERIC and LC_MONETARY categories of the locale.
CEEQDTC—Query Locale Date and Time Conventions	Queries the locale's date and time conventions.
CEEQRYL—Query Active Locale Environment	Allows the calling routine to query the current locale.
CEESCOL—Compare Collation Weight of Two Strings	Compares two character strings based on the collating sequence specified in the LC_COLLATE category of the locale.
CEESETL—Set Locale Operating Environment	Allows an enclave to establish a global operating environment. An enclave's National Language operating environment determines the behavior of character collation, character classification, date and time formatting, numeric punctuation, and message response.
CEESTXF—Transform String Characters into Collation Weights	Transforms each character in a character string into its collation weight and returns the length of the transformed string.
<b>Mathematical Services</b>	
<b>Language Environment math services are scalar routines. x is a data type variable.</b>	
CEESxABS	Absolute value
CEESxACS	Arccosine
CEESxASN	Arcsine
CEESxATH	Hyperbolic arctangent
CEESxATN	Arctangent
CEESxAT2	Arctangent x/y
CEESxCJG	Conjugate of complex
CEESxCOS	Cosine
CEESxCSH	Hyperbolic cosine
CEESxCTN	Cotangent
CEESxDIM	Positive difference
CEESxDVD	Floating complex divide
CEESxERF	Error function
CEESxEXP	Exponential (base e)
CEESxGMA	Gamma function
CEESxIMG	Imaginary part of complex

Table 2. Language Environment Callable Services (continued)

<b>Service Name</b>	<b>Description</b>
CEESxINT	Truncation
CEESxLGM	Log gamma function
CEESxLG1	Logarithm base 10
CEESxLG2	Logarithm base 2
CEESxLOG	Logarithm base e
CEESxMLT	Floating complex multiply
CEESxMOD	Modular arithmetic
CEESxNIN	Nearest integer
CEESxNWN	Nearest whole number
CEESxSGN	Transfer of sign
CEESxSIN	Sine
CEESxSNH	Hyperbolic sine
CEESxSQT	Square root
CEESxTAN	Tangent
CEESxTNH	Hyperbolic tangent
CEESxXPx	Exponentiation
<b>Message Handling Services</b>	
CEECMI—Store and Load Message Insert Data	Stores the message insert data and loads the address of that data into the instance specific information (ISI) field associated with the condition being processed, after optionally creating an ISI.
CEEMGET—Get a Message	Retrieves, formats, and stores a message in a buffer for manipulation or output by the caller.
CEEMOUT—Dispatch a Message	Dispatches a message to a destination which you specify.
CEEMSG—Get, Format, and Dispatch a Message	Gets/formats/dispatches a message corresponding to an input condition token received from a callable service. You can use this service to print a message after a call to any Language Environment service that returns a condition token.
<b>National Language Support Services</b>	
CEE3CTY—Set Default Country	Allows the calling routine to change or query the current national country setting. The country setting affects the date format, the time format, the currency symbol, the decimal separator character, and the thousands separator.
CEE3LNG—Set National Language	Allows the calling routine to change or query the current national language. The national languages may be recorded on a LIFO national language stack. Changing the national language changes the languages of error messages, the names of the days of the week, and the names of the months.
CEE3MCS—Obtain Default Currency Symbol	Returns the default currency symbol for the country specified.
CEE3MDS—Obtain Default Decimal Separator	Returns the default decimal separator for the country specified.
CEE3MTS—Obtain Default Thousands Separator	Returns the default thousands separator for the country specified.
CEEFMDA—Obtain Default Date Format	Returns to the calling routine the default date picture string for a specified country.
CEEFMDT—Obtain Default Date and Time Format	Returns to the calling routine the default date and time picture strings for the country specified.

Table 2. Language Environment Callable Services (continued)

Service Name	Description
CEEFM—Obtain Default Time Format	Returns to the calling routine the default time picture string for the country specified.



---

## Chapter 5. Sample Routines

This chapter includes sample routines that demonstrate several aspects of Language Environment.

- Assembler routine, Figure 17
- C/C++ routine, Figure 18 on page 52
- C routine with POSIX functions, Figure 19 on page 53
- COBOL program, Figure 20 on page 55
- PL/I routine, Figure 21 on page 56

---

### Sample Assembler Routine

```
* =====
*
* Shows a simple main assembler routine that brings up the environment,
* returns with a return code of 0, modifier of 0, and prints a
* message in the main routine.
*
* =====
MAIN      CEEENTRY PPA=MAINPPA
*
*
*          LA      1,PARMLIST
*          L       15,=V(CEEMOUT)
*          BALR   14,15
*
* Terminate the Language Environment environment and return to the caller
*
*          CEETERM RC=0,MODIFIER=0
* =====
*          CONSTANTS AND WORKAREAS
* =====
PARMLIST DC    AL4(String)
          DC    AL4(DEST)
          DC    X'80000000'      Omitted feedback code
*
STRING  DC    AL2(STRLEN)
STRBEGIN DC CL19'In the main routine'
STRLEN  EQU   *-STRBEGIN
DEST    DC    F'2'
MAINPPA CEEPPA      Constants describing the code block
          CEEDSA      Mapping of the dynamic save area
          CEECAA      Mapping of the common anchor area
          END  MAIN    Nominate MAIN as the entry point
```

Figure 17. A Simple Main Assembler Routine

---

### Sample C/C++ Routine

This routine demonstrates the following Language Environment callable services:

- CEEMOUT—Dispatch a message
- CEELOCT—Get current time
- CEEDATE—Convert Lillian date to character format

```

#include <leawi.h>
#include <string.h>
main ()
{
    _FEEDBACK    fbcode;           /* fbcode for all callable services */

    /******
    /* Parameters passed to CEEMOUT. Typedefs found in leawi.h.      */
    /******
    _VSTRING    msg;
    _INT4       destination;
    /******
    /* Parameters passed to CEEOCT. Typedefs found in leawi.h.      */
    /******
    _INT4       lildate;
    _FLOAT8     lilsecs;
    _CHAR17     greg;
    /******
    /* Parameters passed to CEEDATE. Typedefs found in leawi.h.      */
    /******
    _CHAR80     str_date;
    _VSTRING     pattern;
    /******
    /* Starting and ending messages                                  */
    /******
    _CHAR80     startmsg = "Callable service example starting (C/370).";
    _CHAR80     endingmsg = "Callable service example ending (C/370).";

    /******
    /* Start execution. Print the first message.                    */
    /******
    destination = 2;
    strcpy( msg.string, startmsg );
    msg.length = strlen( msg.string );
    CEEMOUT ( &msg, &destination, &fbcode );

    /******
    /* Get the local date and time, format it, and print it out.      */
    /******
    CEEOCT ( &lildate, &lilsecs, greg, &fbcode );
    strcpy ( pattern.string,\
            "Today is Wwwwwwwwwwz, Mmmmmmmmmz ZD, YYYY." );
    pattern.length = strlen( pattern.string );
    memset ( msg.string, ' ', 80 );
    CEEDATE ( &lildate, &pattern, msg.string, &fbcode );
    msg.length = 80;
    CEEMOUT ( &msg, &destination, &fbcode );
    /******
    /* Say goodbye.                                                  */
    /******
    strcpy ( msg.string, endingmsg );
    msg.length = strlen( msg.string );
    CEEMOUT ( &msg, &destination, &fbcode );
}

```

Figure 18. Sample C/C++ Routine

---

## Sample C Routine with POSIX Functions

This C routine creates multiple threads by using POSIX functions.

```

#pragma longname
#define _POSIX_SOURCE
#define _OPEN_THREADS
#pragma runopts (POSIX(ON))
#include <leawi.h>
#include <types.h>
#include <stdio.h>
#include <pthread.h>
#include <unistd.h>
#include <errno.h>

void * CEPSXT1(void *);

main()
{
pthread_t CEPSXT1_pid[3];

int status[2], i, j[2], rc, count=0;

fprintf(stderr, "\n Creating two threads.....\n");
fflush(stderr);
for(i=0; i<2; i++)
{
j[i] = i+1;
rc = pthread_create(&CEPSXT1_pid[i], NULL, &CEPSXT1, &j[i])
if (rc)
{
fprintf(stderr, "Thread creation unsuccessful;Error: %d",errno);
fprintf(stderr, "pthread_create() returns %d ",rc);
fflush(stderr);
exit(-1);
}
else
fprintf(stderr, "Thread %d created\n",j[i]);
}
for(i=0; i<2; i++)
{
j[i] = i+1;
if (!(rc = pthread_join(CEPSXT1_pid[i],(void*) &status[i])))
{
if (status[i] == 1)
count++;
}
else
{
fprintf(stderr, "pthread_join failed for thread %d\n",j[i]);
fflush(stderr);
exit(-1);
}
}
}

```

Figure 19. Sample C Routine Creating Threads with POSIX Functions (Part 1 of 2)

```

        if (count == 2)
            fprintf(stderr, "\n***** SUCCESS *****\n");
        else
            fprintf(stderr, "\n***** ERROR *****\n");
        fflush(stderr);
        pthread_exit(0);
    }

void * CEPSXT1(void *arg)
{
    int status=0, success=0;
    div_t ans;
    char path = '/';
    int i, rc;

    i = *((int *)arg);

    fprintf(stderr, "\n Call POSIX access() function in Thread %d", i);
    fflush(stderr);

    if (access(path, F_OK) == 0)
        fprintf(stderr, "\nPOSIX access() function succeeds in Thread %d\n", i);
    else
        fprintf(stderr, "Error generated by call to access() is %d", errno);

    fflush(stderr);

    status=1;

    fprintf(stderr, "***** Thread %d completed *****\n", i);
    fflush(stderr);
    pthread_exit( (void*) status);
}

```

*Figure 19. Sample C Routine Creating Threads with POSIX Functions (Part 2 of 2)*

---

## Sample COBOL Program

This program demonstrates the following Language Environment callable services:

- CEEMOUT—Dispatch a message
- CEELOCT—Get current time
- CEEDATE—Convert Lilian date to character format



```

*****
* This program demonstrates the following Language      *
* Environment callable                                *
* services : CEEMOUT, CEEOCT, CEEDATE                  *
*****

*****
**          I D          D I V I S I O N          ***
*****
Identification Division.
Program-id.  AWIXMP.
*****
**          D A T A          D I V I S I O N          ***
*****
Data Division.
Working-Storage Section.
*****
** Declarations for the local date/time service.
*****
01 Feedback.
COPY CEEIGZCT
02 Fb-severity      PIC 9(4) Binary.
02 Fb-detail        PIC X(10).
77 Dest-output      PIC S9(9) Binary.
77 Lildate          PIC S9(9) Binary.
77 Lilsecs          COMP-2.
77 Greg             PIC X(17).
*****
** Declarations for messages and pattern for date formatting.
*****
01 Pattern.
02                 PIC 9(4) Binary Value 45.
02                 PIC X(45) Value
    "Today is Wwwwwwwwwwwz, Mmmmmmmmmz ZD, YYYY.".

77 Start-Msg       PIC X(80) Value
    "Callable Service example starting.".

77 Ending-Msg      PIC X(80) Value
    "Callable Service example ending.".

01 Msg.
02 Stringlen      PIC S9(4) Binary.
02 Str            .
03                 PIC X Occurs 1 to 80 times
                    Depending on Stringlen.

```

Figure 20. Sample COBOL Program (Part 1 of 2)

```

*****
**          P R O C          D I V I S I O N          ***
*****
Procedure Division.
000-Main-Logic.
    Perform 100-Say-Hello.
    Perform 200-Get-Date.
    Perform 300-Say-Goodbye.
    Stop Run.

**
** Setup initial values and say we are starting.
**
100-Say-Hello.
    Move 80 to Stringlen.
    Move 02 to Dest-output.
    Move Start-Msg to Str.
    CALL "CEEMOUT" Using Msg      Dest-output Feedback.
    Move Spaces to Str.
    CALL "CEEMOUT" Using Msg      Dest-output Feedback.

**
** Get the local date and time and display it.
**
200-Get-Date.
    CALL "CEELOCT" Using Lildate Lilsecs      Greg      Feedback.
    CALL "CEEDATE" Using Lildate Pattern      Str      Feedback.
    CALL "CEEMOUT" Using Msg      Dest-output Feedback.
    Move Spaces to Str.
    CALL "CEEMOUT" Using Msg      Dest-output Feedback.

**
** Say Goodbye.
**
300-Say-Goodbye.
    Move Ending-Msg to Str.
    CALL "CEEMOUT" Using Msg      Dest-output Feedback.
End program AWIXMP.

```

Figure 20. Sample COBOL Program (Part 2 of 2)

---

## Sample PL/I Routine

This routine demonstrates the following Language Environment callable services:

- CEEMOUT—Dispatch a message
- CEELOCT—Get current time
- CEEDATE—Convert Lillian date to character format

```

*PROCESS MACRO;
/*compilation unit: cecgjmp          */
/*****/
/* This routine demonstrates the following LE/370 callable **/
/* services: CEEMOUT, CEELOCT, and CEEDATE.          **/
/*          **/
/*****/
cecgjmp: proc options(main);

```

Figure 21. Sample PL/I Routine (Part 1 of 3)

```

/* Declarations for callable services */
%INCLUDE CEEIBMAW;
%INCLUDE CEEIBMCT;

/* feedback code for all callable services*/
dcl 01 fc FEEDBACK;

/*****
/** Parameters passed to CEEMOUT.          **/
/**                                         **/
*****/
dcl startmsg CHAR80
    init('Callable service example starting (PL/I)');
dcl endmsg CHAR80
    init('Callable service example ending (PL/I)');
dcl strmsg CHAR80;
dcl destination real fixed binary ( 31,0 );
/*****
/** Parameters passed to CEEOCT.          **/
/**                                         **/
*****/
dcl l1ldate real fixed binary ( 31,0 );
dcl l1lsecs real float decimal ( 16 );
dcl greg character ( 17 );
/*****
/** Parameters for CEEDATE.              **/
/**                                         **/
*****/
dcl pattern CHAR80;
dcl chrdate CHAR80 init ((80)' ');
/*****
/** Start execution. Print the first message.  **/
/**                                         **/
*****/
destination = 2;
call CEEMOUT ( startmsg , destination , fc );
IF ¬ FBCHECK( fc, CEE000) THEN DO;
    DISPLAY( 'CEEMOUT failed with msg ' || fc.MsgNo );
    STOP;
END;

```

Figure 21. Sample PL/I Routine (Part 2 of 3)

```

/*****
/** Get the local date and time. Format it, and print it  **/
/** out.                                               **/
*****/
call CEELOCT ( lildate , lilsecs , greg , fc );
IF ¬ FBCECK( fc, CEE000) THEN DO;
  DISPLAY( 'CEELOCT failed with msg ' || fc.MsgNo );
  STOP;
END;

pattern = 'Today is Wwwwwwwwwwz, Mmmmmmmmmz, ZD, YYYY.';
call CEEDATE ( lildate , pattern , chrdate , fc );
IF ¬ FBCECK( fc, CEE000) THEN DO;
  DISPLAY( 'CEEDATE failed with msg ' || fc.MsgNo );
  STOP;
END;

strmsg = chrdate;
call CEEMOUT ( strmsg , destination , fc );
IF ¬ FBCECK( fc, CEE000) THEN DO;
  DISPLAY( 'CEEMOUT failed with msg ' || fc.MsgNo );
  STOP;
END;

/*****
/** Say good bye.                                     **/
/**                                               **/
*****/
call CEEMOUT ( endmsg , destination , fc );
IF ¬ FBCECK( fc, CEE000) THEN DO;
  DISPLAY( 'CEEMOUT failed with msg ' || fc.MsgNo );
  STOP;
END;

end;

```

Figure 21. Sample PL/I Routine (Part 3 of 3)

---

## Appendix. Accessibility

Accessibility features help a user who has a physical disability, such as restricted mobility or limited vision, to use software products successfully. The major accessibility features in z/OS enable users to:

- Use assistive technologies such as screen readers and screen magnifier software
- Operate specific or equivalent features using only the keyboard
- Customize display attributes such as color, contrast, and font size

---

### Using assistive technologies

Assistive technology products, such as screen readers, function with the user interfaces found in z/OS. Consult the assistive technology documentation for specific information when using such products to access z/OS interfaces.

---

### Keyboard navigation of the user interface

Users can access z/OS user interfaces using TSO/E or ISPF. Refer to *z/OS TSO/E Primer*, *z/OS TSO/E User's Guide*, and *z/OS ISPF User's Guide Vol I* for information about accessing TSO/E and ISPF interfaces. These guides describe how to use TSO/E and ISPF, including the use of keyboard shortcuts or function keys (PF keys). Each guide includes the default settings for the PF keys and explains how to modify their functions.

---

### z/OS information

z/OS information is accessible using screen readers with the BookServer/Library Server versions of z/OS books in the Internet library at:

<http://www.ibm.com/servers/eserver/zseries/zos/bkserv/>



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# Language Environment Glossary

This glossary defines technical terms and abbreviations used in z/OS Language Environment documentation. If you do not find the term you are looking for, refer to the index of the appropriate Language Environment manual or view IBM Glossary of Computing Terms, located at:

<http://www.ibm.com/ibm/terminology>

This glossary includes terms and definitions from: *Portable Operating System Interface (POSIX) Part 1: System Application Program Interface (API) [C Language]*, ISO/EIC 9945-1: 1990, IEEE Std 1003.1-1990, copyright 1992 by The Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017. These terms are identified by [POSIX.1].

## A

**abend.** Abnormal end of application.

**absolute value.** The magnitude of a real number regardless of its algebraic sign.

**active routine.** The currently executing routine.

**actual argument.** The Fortran term for the data passed to a called routine at the point of call. See also *dummy argument*.

**additional floating point registers (AFP).** For IEEE support, 12 additional floating point registers, for a total of 16 floating-point registers.

**additional heap.** A Language Environment heap created and controlled by a call to CEECRHP. See also *below heap*, *anywhere heap*, and *initial heap*.

**addressing mode.** An attribute that refers to the address length that a routine is prepared to handle upon entry. Addresses may be 24 or 31 bits long.

**address space.** Domain of addresses that are accessible by an application.

**AFP.** See *additional floating-point registers (AFP)*.

**aggregate.** A structured collection of data items that form a single data type. Contrast with *scalar*.

**AIB.** Application interface block.

**ALLOCATE command.** In MVS, the TSO command that serves as the connection between a file's logical name (the ddname) and the file's physical name (the data set name).

**American National Standard Code for Information Interchange (ASCII).** The code developed by the American National Standards Institute (ANSI) for information interchange among data processing systems, data communications systems, and associated equipment. The ASCII character set consists of 7-bit control characters and symbolic characters.

**AMODE.** Provided by the linkage editor, the attribute of a load module that indicates the addressing mode in which the load module should be entered.

**AMODE 31.** Addressing mode 31.

**AMODE 64.** Addressing mode 64.

**anywhere heap.** The Language Environment heap controlled by the ANYHEAP run-time option. It contains library data, such as Language Environment control blocks and data structures not normally accessible from user code. The anywhere heap may reside above 16M. See also *below heap*, *additional heap*, *initial heap*.

**APAR.** Authorized program analysis report.

**application.** A collection of one or more routines cooperating to achieve particular objectives.

**application interface block (AIB).** IMS interface between an application and an IMS database.

**application program.** A collection of software components used to perform specific types of work on a computer, such as a program that does inventory control or payroll.

**argument.** 1) An expression used at the point of a call to specify a data item or aggregate to be passed to the called routine. 2) The data passed to a called routine at the point of call or the data received by a called routine. See also *actual argument* and *dummy argument*.

**array.** An aggregate that consists of data objects, each of which may be uniquely referenced by subscripting.

**array element.** A data item in an array.

**ASCII.** American National Standard Code for Information Interchange.

**Asian date format.** In this book, Asian date format refers to the era picture strings associated with the Japanese or other era. Era picture strings begin with a less than character (<) and end with a greater than character (>). The characters inside are either capital Js or Cs.

**assembler.** Translates symbolic assembler language into binary machine language. The High Level Assembler is an IBM licensed program.

**assembler user exit.** A routine to tailor the characteristics of an enclave prior to its establishment. The name of the routine is CEEBXITA.

**async safe.** An application is able to mask off asynchronous signals when it is working with critical data or structures. The application can request to process the asynchronous signals when it has finished updated the critical data or structure.

**atexit list.** A list of actions specified in the C `atexit()` function that occur at normal program termination.

**authorized program analysis report (APAR).** A request for correction of a problem caused by a defect in a current unaltered release of a program.

**automatic call.** The process used by the linkage editor to resolve external symbols left undefined after all the primary input has been processed. See also *automatic call library*.

**automatic call library.** Contains load modules or object modules that are to be used as secondary input to the linkage editor to resolve external symbols left undefined after all the primary input has been processed.

The automatic call library may be:

- Libraries containing object modules, with or without linkage editor control statements
- Libraries containing load modules
- The library containing Language Environment run-time routines (SCEELKED) (SCEELKED and SAFHFORT)

**automatic conversion.** For Enhanced ASCII functionality, the automatic conversion of text data from EBCDIC to ASCII, or from ASCII to EBCDIC, as part of using internationalized applications developed on (or for) ASCII platforms and ported to z/OS platforms. See also *file tag* and *coded character set ID (CCSID)*.

**automatic data.** Data for a routine that is automatically allocated when the routine is called and automatically freed when the routine returns. Automatic data does not persist from one call of the routine to the next.

**automatic library call.** Automatic call. See also *automatic call library*.

**automatic storage.** Storage that is allocated on entry to a routine or block and is freed on the subsequent return. Sometimes referred to as *stack storage* or *dynamic storage*.

**AWI.** Application writer interface.

## B

**background process.** A process that is a member of a background process group. [POSIX.1]

**background process group.** Any process group, other than a foreground process group, that is a member of a session that has established a connection with a controlling terminal. [POSIX.1]

**base.** The core product, upon which features may be separately ordered and installed.

**batch.** Pertaining to activity involving little or no user action. Contrast with *interactive*.

**below heap.** The Language Environment heap controlled by the BELOWHEAP run-time option, which contains library data, such as Language Environment control block and data structures not normally accessible from user code. Below heap always resides below 16M. See also *anywhere heap*, *initial heap*, *additional heap*.

**BFP.** See *binary floating point (BFP)*.

**binary floating point.** For IEEE, binary floating point registers.

**binder.** The DFSMS component that processes the output of the language translators and compilers into an executable program (load module or program object). It replaces the linkage editor and batch loader in the MVS/ESA operating system.

**breakpoint.** A place in a program, usually specified by a command or a condition, where execution may be interrupted and control given to the workstation user or to a specified debug tool program.

**buffer.** An area of storage into which data is read or from which it is written. Typically, buffers are used only for temporary storage.

**by content.** See *pass by content*.

**by reference.** See *pass by reference*.

**by value.** See *pass by value*.

**byte.** The basic unit of storage addressability. It has a length of 8 bits.

## C

**C language.** A high-level language used to develop software applications in compact, efficient code that can be run on different types of computers with minimal change.

**C++ language.** An object-oriented high-level language that evolved from the C language. C++ exploits the

benefits of object-oriented technology such as code modularity, portability, and reuse.

**C-CAA.** C/370-specific common anchor area in the run-time environment.

**CAA.** Common anchor area.

**call chain.** A trace of all active routines and subroutines that can be constructed by the user from information included in a system dump, such as the locations of save areas and the names of routines.

**callable service stub.** A short routine that is link-edited with an application and that is used to transfer control from the application to a callable service.

**callable services.** A set of services that can be invoked by a Language Environment-conforming high-level language using the conventional Language Environment-defined call interface, and usable by all programs sharing the Language Environment conventions.

Use of these services helps to decrease an application's dependence on the specific form and content of the services delivered by any single operating system.

**called routine.** A routine or program that is invoked by another.

**callee.** A routine or program that is invoked by another.

**caller.** A routine or program that invokes another routine.

**calling routine.** A routine or program that invokes another routine.

**CASE.** Computer-aided software engineering.

**cast.** In C, an expression that converts the type of the operand to a specified data type (the operator).

**cataloged procedure.** A set of job control language (JCL) statements placed in a library and retrievable by name.

**CBIPO.** Custom-Built Installation Process Offering.

**CBPDO.** Custom-Built Product Delivery Offering.

**CCSID.** See *coded character set ID (CCSID)*.

**CEEDUMP.** A dump of the run-time environment for Language Environment and the member language libraries. Sections of the dump are selectively included, depending on options specified on the dump invocation. This is not a dump of the full address space, but a dump of storage and control blocks that Language Environment and its members control.

**century window.** The 100-year interval in which Language Environment assumes all 2-digit years lie. The Language Environment default century window begins 80 years before the system date.

**chained list.** Synonym for *linked list*.

**character.** A letter, digit, or other symbol. A letter, digit, or other symbol that is used as part of the organization, control, or representation of data. A character is often in the form of a spatial arrangement of adjacent or connected strokes.

**child enclave.** The *nested enclave* created as a result of certain commands being issued from a *parent enclave*.

**CIB.** Condition information block.

**CICS.** Customer Information Control System.

**CICS destination control table (DCT).** A table that contains an entry for each extrapartition, intrapartition, and indirect destination. Extrapartition entries address data sets external to the CICS region. Intrapartition destination entries contain the information required to locate the queue in the intrapartition data set. Indirect destination entries contain the information required to locate the queue in the intrapartition data set.

**CICS OTE.** CICS Open Transaction Environment.

**CICS run unit.** Consists of a statically and/or dynamically bound set of one or more load modules which can be loaded by a CICS loader. A CICS run unit is equivalent to a Language Environment *enclave*.

**CICS translator.** A routine that accepts as input an application containing EXEC CICS commands and produces as output an equivalent application in which each CICS command has been translated into the language of the source.

**CLIST.** TSO command list.

**CLLE.** COBOL load list entry.

**CMS.** Conversational monitor system.

**CMS extended parameter list.** A type of parameter list available in the CMS environment consisting of a string composed exactly as the user typed it at the terminal. There is no tokenization performed on the string.

**CMS tokenized parameter list.** A type of parameter list available in the CMS environment consisting of 8-byte tokens, folded to uppercase, terminating with a double word of X'FF'. Not supported under Language Environment.

**COBCOM.** Control block containing information about a COBOL partition.

**COBOL.** COmmon Business-Oriented Language. A high-level language, based on English, that is primarily used for business applications.

**COBOL load list entry (CLLE).** Entry in the load list containing the name of the program and the load address.

**COBOL run unit.** A COBOL-specific term that defines the scope of language semantics. Equivalent to a Language Environment *enclave*.

**COBPACK.** A collection of individual modules that are packaged into a single load module in order to reduce the time that would otherwise be needed to load the individual load modules.

**COBVEC.** A COBOL vector table containing the address of the COBOL library routines.

**coded character set ID (CCSID).** For Enhanced ASCII functionality, a 16-bit value is a number that represents a character set used by file tagging. It identifies the current character set of text strings within a program. This is stored in the file tag of new files or used for the automatic conversion of old files when automatic conversion is in effect. See also *automatic conversion* and *file tag*.

**command processor parameter list (CPPL).** The format of a TSO parameter list. When a TSO terminal monitor application attaches a command processor, register 1 contains a pointer to the CPPL, containing addresses required by the command processor.

**COMMAREA.** A communication area made available to applications running under CICS.

**common anchor area (CAA).** Dynamically acquired storage that represents a Language Environment thread. Thread-related storage/resources are anchored off of the CAA. This area acts as a central communications area for the program, holding addresses of various storage and error-handling routines, and control blocks. The CAA is anchored by an address in register 12.

**common block.** A storage area that may be referenced by one or more compilation units. It is declared in a Fortran program with the COMMON statement. See also *external data*.

**compilation unit.** An independently compilable sequence of HLL statements. Each HLL product has different rules for what makes up a compilation unit. Synonymous with *program unit*.

**compile-time options.** Keywords that can be specified to control certain aspects of compilation. Compiler options can control the nature of the load module generated by the compiler, the types of printed output to be produced, the efficient use of the compiler, the destination of error messages, and other things.

**compiler options.** Keywords that can be specified to control certain aspects of compilation. Compiler options can control the nature of the load module generated by the compiler, the types of printed output to be produced, the efficient use of the compiler, and the destination of error messages. See also *compiler-time options*.

**component.** A set of modules that performs a major function within a system.

**computer-aided software engineering (CASE).** A software engineering discipline for automating the application development process and thereby improving the quality of application and the productivity of application developers.

**condition.** An exception that has been enabled, or recognized, by Language Environment and thus is eligible to activate user and language condition handlers. Conditions can be detected by the hardware/operating system and result in an interrupt. They can also be detected by language-specific generated code or language library code.

**condition code.** A code that reflects the result of a previous input/output, arithmetic, or logical operation.

**condition handler.** A user-written routine or language-specific routine (such as a PL/I ON-unit or C `signal()` function call) invoked by the Language Environment *condition manager* to respond to conditions.

**condition handling.** In Language Environment, the diagnosis, reporting, and/or tolerating of errors that occur while a routine is running.

**condition information block (CIB).** The platform-specific data block used by the Language Environment condition manager as a repository for data about conditions raised in the Language Environment run-time environment.

**condition manager.** Manages conditions in the common execution environment by invoking various user-written and language-specific *condition handlers*.

**condition step.** The step of the Language Environment condition handling model that follows the enablement step. In the condition step, user-written condition handlers, C signal handlers, and PL/I ON-units are first given a chance to handle a condition. See also *enablement step* and *termination imminent step*.

**condition token.** In Language Environment, a data type consisting of 96 bits (12 bytes). The condition token contains structured fields that indicate various aspects of a condition including the severity, the associated message number, and information that is specific to a given instance of the condition.

**condition variable.** A data object that is used for waiting for long durations of time. An application can wait for the variable to become true before continuing processing. [POSIX.1]

**conflicting name.** One of 20 names that exist in both the Fortran and the C/C++ libraries. See also *conflicting reference*.

**conflicting reference.** An external reference from a Fortran or assembler language routine to a Fortran library routine with a name that is the same as the name of a C/C++ library routine. The reference is considered to be a conflicting reference only when the intended resolution is to the Fortran library routine rather than to the corresponding C/C++ library routine.

**constructed reentrancy.** The attribute of applications that contain external data and require additional processing to make them reentrant. Contrast with *natural reentrancy*.

**control block.** A storage area used by a computer program to hold control information.

**control section (CSECT).** The part of a program specified by the programmer to be a relocatable unit, all elements of which are to be loaded into adjoining main storage locations.

**control statement.** In programming languages, a statement that is used to alter the continuous sequential execution of statements; a control statement can be a conditional statement, such as IF, or an imperative statement, such as STOP. In JCL, a statement in a job that is used in identifying the job or describing its requirements to the operating system.

**conversational monitor system (CMS).** A virtual machine operating system that provides general interactive time sharing, problem solving, and program development capabilities, and operates only under the control of the VM/370 control program.

**CPPL.** Command processor parameter list.

**CSECT.** Control section.

**cumulative service tape.** A tape sent with a new function order, containing all current PTFs for that function.

**cursor.** One of two pointers managed by the condition manager as it processes a condition. See *handle cursor* and *resume cursor*.

**Custom-Built Installation Process Offering (CBIPO).** A CBIPO is a tape that has been specially prepared with the products (at the appropriate release levels) requested by the customer. A CBIPO simplifies installing various products together.

**Custom-Built Product Delivery Offering (CBPDO).** A CBPDO is a tape that has been specially prepared for installing a particular product and the related service requested by the customer. A CBPDO simplifies installing a product and the service for it.

**Customer Information Control System (CICS).** CICS is an OnLine Transaction Processing (OLTP) system that provides specialized interfaces to databases, files and terminals in support of business and commercial applications.

**CWI.** Compiler-writer interface.

## D

**dangling pointer.** A pointer to storage that has been freed.

**data, qualifying.** See *qualifying data*.

**data aggregate.** A logical collection of data elements that can be referred to either collectively or individually. In PL/I, an array or a structure.

**data division.** In COBOL, the part of a program that describes the files to be used in the program and the records contained within the files. It also describes any WORKING-STORAGE data items, LINKAGE SECTION data items, and LOCAL-STORAGE data items that are needed.

**data set.** Under MVS, a named collection of related data records that is stored and retrieved by an assigned name. Equivalent to a CMS *file*.

**data type.** The properties and internal representation that characterize data.

**datum, qualifying.** A single element of qualifying data associated with a condition. See *qualifying data*.

**DBCS.** Double-byte character set.

**DB2.** DATABASE 2; generally, one of a family of IBM relational database management systems and, specifically, the system that runs under MVS.

**DCLCB.** Declare control block.

**DCT.** Destination control table.

**DD statement.** In MVS, the data definition statement. A JCL control statement that serves as the connection between a file's logical name (the ddname) and the file's physical name (the data srt name).

**ddname.** Data definition name. The logical name of a file within an application. The ddname provides the means for the logical file to be connected to the physical file through a FILEDEF command, DD statement, or ALLOCATE command. DD statement or ALLOCATE command.

**decimal overflow.** A condition that occurs when one or more nonzero digits are lost because the destination field in a decimal operation is too short to contain the results.

**declare control block (DCLCB).** Control block containing file information.

**default.** A value that is used or an action that is taken when no alternative is specified.

**dereference.** In C, the application of the unary operator (\*) to a pointer to access the object the pointer points to. Also known as *indirection*.

**descriptor.** PL/I control block that holds information such as string lengths, array subscript bounds, and area sizes, and is passed from one PL/I routine to another during run time.

**descriptor, q\_data.** See *q\_data descriptor*.

**destination control table (DCT).** In CICS, a table containing an entry for each extrapartition, intrapartition, and indirect destination. Extrapartition entries address data sets external to the CICS region. Indirect destination entries redirect data to a destination controlled by another DCT entry. Intrapartition destination entries contain the information required to locate the queue in the intrapartition data set.

**device.** A computer peripheral or an object that appears to the application as such. [POSIX.1]

**direct argument passing.** A type of parameter passing in which the value of the argument is placed directly in the argument list body.

**directory entry.** An object that associates a filename with a file. Several directory entries can associate names with the same file. [POSIX.1]

**disabled/enabled.** See *enabled/disabled*.

**distribution libraries.** IBM-supplied partitioned data sets on tape containing one or more components that the user restores to disk for subsequent inclusion in a new system.

**distribution zone.** In SMP/E, a group of VSAM records that describe the SYSMODs and elements in the distribution libraries.

**double-byte character set (DBCS).** A collection of characters represented by a 2-byte code.

**downward-growing stack.** With Extra Performance Linkage (XPLINK), a stack that grows from high addresses to low addresses in memory.

**downwardly compatible.** The ability of applications that have been compiled and linked with Language Environment to run on previous releases of OS/390. In order for an application to be downwardly compatible, it

must not have exploited any new Language Environment function unavailable in the targeted release.

**double-precision.** Pertaining to the use of two computer words to represent a number in accordance with the required precision. See also *precision*, *single-precision*.

**doubleword.** A sequence of bits or characters that comprises eight bytes (two 4-byte words) and is referenced as a unit.

**doubleword boundary.** A storage location whose address is evenly divisible by 8.

**driving system.** The system used to install the program. Contrast with target system.

**DSA.** Dynamic storage area.

**dummy argument.** The Fortran term for the data received by a called routine. See also *actual argument*.

**dynamic call.** A call that results in locating a called routine at run time, that is, by loading the routine into virtual storage. Contrast with *static call*.

**dynamic loading.** See *dynamic call*.

**dynamic storage.** Storage acquired as needed at run time. Contrast with *static storage*.

**dynamic storage area (DSA).** An area of storage obtained during the running of an application that consists of a register save area and an area for automatic data, such as program variables. DSAs are generally allocated within Language Environment-managed stack segments. DSAs are added to the stack when a routine is entered and removed upon exit in a last in, first out (LIFO) manner. In Language Environment, a DSA is also known as a *stack frame*.

## E

**EBCDIC.** Extended binary-coded decimal interchange code.

**EIB.** EXEC interface block.

**enabled/disabled.** A condition is enabled when its occurrence will result in the execution of condition handlers or in the performance of a standard system action to handle the condition as defined by Language Environment.

A condition is disabled when its occurrence is ignored by the condition manager.

**enablement.** The determination by a language at run time that an exception should be processed as a condition. This is the capability to intercept an exception and to determine whether it should be ignored or not;



unrecognized exceptions are always defined to be enabled. Normally, enablement is used to supplement the hardware for capabilities that it does not have and language enforcement of a language's semantics. An example of supplementing the hardware is the specialized handling of exponent-overflow exceptions based on language standards.

**enablement step.** The first step of the Language Environment condition handling model. In the enablement step it is determined whether an exception is to be *enabled* and processed as a condition. See also *condition step* and *termination imminent step*.

**enclave.** In Language Environment, an independent collection of routines, one of which is designated as the main routine and is invoked first. An enclave is roughly analogous to a program or run unit. an executable program.

**enterprise.** The composite of all operational entities, functions, and resources that form the total business concern.

**entry name.** In assembler language, a programmer-specified name within a control section that identifies an entry point and can be referred to by any control section. See also *entry point*.

**entry point.** The address or label of the first instruction that is executed when a routine is entered for execution. Within a load module, the location to which control is passed when the load module is invoked.

**entry point name.** The symbol (or name) that represents an entry point. See also *entry point*.

**environment.** A set of services and data available to a program during execution. In Language Environment, environment is normally a reference to the run-time environment of HLLs at the enclave level.

**environment variable.** A variable that is included in the current software environment and is therefore available to any called program that requests it.

**epilog.** Code generated at the end of a routine, normally causing a return to the caller of the routine.

**euro.** The monetary unit of the European Monetary Union (EMU) that was introduced alongside national currencies on 01 January 1999.

**EuroReady product.** A product is EuroReady if the product, when used in accordance with its associated documentation, is capable of correctly processing monetary data in the euro denomination, respecting the euro currency formatting conventions (including the euro sign). This assumes that all other products (for example, hardware, software, and firmware) that are used with this product are also EuroReady. IBM hardware products that are EuroReady may or may not have an engraved euro sign key on their keyboards.

**EXEC interface block (EIB).** In CICS, a control block containing information useful in the execution of an application, such as a transaction identifier and a time and a date when the transaction is started.

**exception.** The original event such as a hardware signal, software detected event, or user-signaled event which is a potential condition. This action may or may not include an alteration in a program's normal flow. See also *condition*.

**execution time.** Synonym for *run time*.

**execution environment.** Synonym for *run-time environment*.

**extended binary-coded decimal interchange code (EBCDIC).** A set of 256 8-bit characters.

**exponent-overflow exception.** The program interruption that occurs when an overflow occurs during the execution of a floating-point instruction, that is, when the result value from the instruction has a characteristic that is larger than the floating-point data format can handle.

**exponent-underflow exception.** The program interruption that occurs when the result value from executing a floating-point instruction has a nonzero fraction and a characteristic is smaller than the floating-point data format can handle. This program interruption can be disabled through a program mask bit setting.

**extended error handling facility.** The VS FORTRAN facility that provided automatic error correction and control over both the handling of the errors and the printing of error messages.

**external data.** Data that persists over the lifetime of an enclave and maintains last-used values whenever a routine within the enclave is reentered. Within an enclave consisting of a single load module, it is equivalent to any C data objects that have static storage duration, a Fortran common block, and COBOL EXTERNAL data.

**external reference.** In an object module, a reference to a symbol, such as an entry point name, defined in another program or module.

**Extra Performance Linkage (XPLINK).** Extra Performance Linkage (XPLINK) is an enhanced linkage between programs that can significantly improve the performance of your C and C++ programs. The primary goal of XPLINK is to make subroutine calls as fast and efficient as possible by removing all nonessential instructions from the main program path. The XPLINK run-time option controls the initialization of the XPLINK environment.

## F

**FCB.** File control block.

**feature.** A part of an IBM product that may be ordered separately by a customer.

**feature code.** A four-digit code used by IBM to process hardware and software orders.

**feedback code (fc).** A condition token value. If you specify *fc* in a call to a callable service, a condition token indicating whether the service completed successfully is returned to the calling routine.

**fetch.** The dynamic load of a PL/I procedure.

**FIB.** File information block.

**file.** A named collection of related data records that is stored and retrieved by an assigned name. Equivalent to an MVS *data set*.

**file control block (FCB).** Block containing the addresses of I/O routines, information about how they were opened and closed, and a pointer to the file information block.

**FILEDEF.** File definition statement.

**file definition statement (FILEDEF).** In CMS, serves as the connection between the logical name of a file and the physical name of a file.

**file descriptor.** A per-process unique, nonnegative integer used to identify an open file for the purpose of file access. [POSIX.1]

**file information block (FIB).** A read-only block describing the characteristics of an I/O file.

**file system.** A collection of files and certain of their attributes. A file system provides a name space for file serial numbers referring to those files.

**file tag.** For Enhanced ASCII functionality, a file attribute that identifies the character set of the text data within a file and indicates whether the file is eligible for automatic conversion. See also *automatic conversion* and *coded character set ID (CCSID)*.

**fix.** A correction of an error in a program, usually a temporary correction or bypass of defective code.

**fix-up and resume.** The correction of a condition either by changing the argument or parameter and running the routine again or by providing a specific value for the result.

**fixed decimal.** See *packed decimal format*.

**fixed-point overflow exception.** A program interruption caused by an overflow during signed binary

arithmetic or signed left-shift operations. This program interruption can be disabled through a program mask bit setting.

**floating point control register (FPC register).** For IEEE, a floating point control register.

**FMID.** Function modification identifier.

**Fortran.** A high-level language used primarily for applications involving numeric computations. In previous usage, the name of the language was written in all capital letters, that is, FORTRAN.

**Fortran signature CSECT.** The resident routine that indicates that the load module in which it is present contains a Fortran routine.

**FORTRAN 66.** The FORTRAN language standard formally known as *American National Standard FORTRAN, ANSI X3.9-1966*. This language standard specifies the form and establishes the interpretation of programs written to conform to it.

**FORTRAN 77.** The FORTRAN language standard formally known as *American National Standard FORTRAN, ANSI X3.9-1978*. This language standard specifies the form and establishes the interpretation of programs written to conform to it.

**FPC.** See *floating point control register (FPC register)*.

**fullword.** A sequence of bits or characters that comprises four bytes (one word) and is referenced as a unit.

**fullword boundary.** A storage location whose address is evenly divisible by 4.

**function.** A routine that is invoked by coding its name in an expression. The routine passes a result back to the invoker through the routine name.

**function modification identifier (FMID).** The value used to distinguish separate parts of a product. A product tape or cartridge has at least one FMID.

## G

**GET.** Global error table.

**global error table (GET).** A method employed by some HLLs, for example, C and Fortran, to determine actions for handling conditions. Whereas Language Environment condition handling actions are defined at the stack frame level, actions defined using the global error table apply to an entire application until explicitly changed. See also *extended error handling facility*.

**Gregorian calendar.** The calendar in use since Friday, 15 October 1582 throughout most of the world. Used as the basis for the *Lilian date* used in many Language Environment date and time services.

**GTAB table.** Table in C/370 containing error information.

## H

**handle cursor.** A pointer used by the condition manager as it traverses the stack. The handle cursor points to the condition handler currently being invoked in the stack frame, whether it be a user-written condition handler or an HLL-specific condition handler.

**handled condition.** A condition that either a user-written condition handler or the HLL-specific condition handler has processed and for which the condition handler has specified that execution should continue.

**handler.** See *condition handler*.

**header file.** A file that contains system-defined control information that precedes user data.

**heap 0.** Synonymous with *initial heap*.

**heap.** An area of storage used for allocation of storage whose lifetime is not related to the execution of the current routine. The heap consists of the initial heap segment and zero or more increments. See *anywhere heap*, *below heap*, *initial heap*, and *additional heap*.

**heap element.** A contiguous area of storage allocated by a call to the CEEGTST service. Heap elements are always allocated within a single heap segment.

**heap increment.** See *increment*.

**heap pool.** A storage pool that, when used by the storage manager, can be used to improve the performance of heap storage allocation. This can improve the performance of a multi-threaded application.

**heap segment.** A contiguous area of storage obtained directly from the operating system. The Language Environment storage management scheme subdivides heap segments into individual heap elements. If the initial heap segment becomes full, Language Environment obtains a second segment, or increment, from the operating system.

**heap storage.** See *heap*.

**heavy weight thread.** A heavy weight thread has a one-to-one correspondence with an MVS task control block (TCB) in that the lifetime of the thread is the lifetime of the TCB. [POSIX.1]

**hexadecimal.** A base 16 numbering system. Hexadecimal digits range from 0 through 9 (decimal 0 to 9) and uppercase or lowercase A through F (decimal 10 to 15) and A through F, giving values of 0 through 15.

**high-level language (HLL).** A programming language above the level of assembler language and below that of program generators and query languages. Examples are C, C++, COBOL, Fortran, and PL/I.

**HLL.** High-level language.

**hook.** The location in a compiled program where the compiler inserts an instruction that allows the user to later interrupt the program (by setting breakpoints) for debugging purposes.

## I

**IBM service representative.** An individual in IBM who performs maintenance services for IBM products or systems.

**IBM Software Distribution (ISD).** The IBM department responsible for software distribution.

**IBM Support Center.** The IBM department responsible for software service.

**IBM systems engineer (SE).** An IBM service representative who performs maintenance services for IBM software in the field.

**implementation defined.** An indication that the implementation defines and documents the requirements for correct program constructs and correct data of a value or behavior. [POSIX.1]

**ILC.** Interlanguage communication.

**IMS.** Information Management System, IBM licensed product. IMS supports hierarchical databases, data communication, translation processing, and database backout and recovery.

**increment.** The second and subsequent segments of storage allocated to the stack or heap.

**indirect argument passing.** The body of the argument list contains a pointer to the argument value.

**indirection.** See *dereference*.

**initial heap.** The Language Environment heap controlled by the HEAP run-time option and designated by a *heap\_id* of 0. The initial heap contains dynamically allocated user data. See also *additional heap*.

**initial heap segment.** The first heap segment. A heap consists of the initial heap segment and zero or more additional segments or increments.

**Initial process thread (IPT).** See *initial thread*.

**initial program load (IPL).** The process of loading system programs and preparing a system to run jobs.

**initial stack segment.** The first stack segment. A stack consists of the initial stack segment and zero or more additional segments or increments.

**initial thread.** In terms of POSIX, either the thread established by the `fork()` that created the *process*, or the first thread that calls `main()` after an `exec`. Also known as *initial process thread (IPT)*. [POSIX.1]

**input procedure.** A set of statements, to which control is given during the execution of a SORT statement, for the purpose of controlling the release of specified records to be sorted.

**instance-specific information (ISI).** Located within the Language Environment condition token, information used by a condition handler or the condition manager to interpret and react to a specific occurrence of a condition. Qualifying data is an example of instance-specific information.

**integer.** A positive or negative whole number or zero.

**interactive.** Pertaining to a program or system that alternately accepts input and responds. In an interactive system, a constant dialog exists between user and system. Contrast with *batch*.

**interactive problem control system (IPCS).** A component of z/OS that permits online problem management, interactive problem diagnosis, online debugging for disk-resident CP abend dumps, problem tracking, and problem reporting.

**Interactive System Productivity Facility (ISPF).** A dialog manager for interactive applications. It provides control and services to permit execution of dialogs.

**interface validation exit.** A routine that, when used with the binder, automatically resolves conflicting references within Fortran routines.

**interlanguage communication (ILC).** The ability of routines written in different programming languages to communicate. ILC support allows the application writer to readily build applications from component routines written in a variety of languages.

**interrupt.** A suspension of a process, such as the execution of a computer program, caused by an event external to that process, and performed in such a way that the process can be resumed.

**interruption.** Synonym for *interrupt*.

**IPCS.** Interactive problem control system

**IPL.** Initial program load.

**ISI.** Instance specific information.

**ISPF.** Interactive System Productivity Facility.

## J

**JCL.** Job control language.

**job control language (JCL).** A sequence of commands used to identify a job to an operating system and to describe a job's requirements.

**job step.** The job control (JCL) statements that request and control execution of a program and that specify the resources needed to run the program. The JCL statements for a job step include one EXEC statement, which specifies the program or procedure to be invoked, followed by one or more DD statements, which specify the data sets or I/O devices that might be needed by the program.

**Julian date.** A date format that contains the year in positions 1 and 2, and the day in positions 3 through 5. The day is represented as 1 through 366, right-adjusted, with zeros in the unused high-order position.

## K

**kernel.** The part of the component that contains programs for such tasks as I/O, management, and communication.

**KSDS.** Key-sequenced data set. See also *VSAM*.

## L

**L-name.** In C, this is a mixed-case external identifier that is up to 255 characters long. See also *S-name*.

**Language Environment.** Short form of z/OS Language Environment. A set of architectural constructs and interfaces that provides a common run-time environment and run-time services for C, C++, COBOL, Fortran, PL/I, and Java applications compiled by Language Environment-conforming compilers.

**Language Environment-conforming.** Adhering to Language Environment's common interface conventions.

**Language Environment-enabled.** A program that has been link-edited with the routines or stubs provided with Language Environment.

**language-sensitive editing.** A set of editing functions that are responsive to the programming language, syntax, and environment of source programs as they are being edited. Typical language-sensitive editing features are automatic indenting, token highlighting, syntax checking, and language-sensitive help.

**LIBPACK.** A collection of individual modules that are packaged into a single load module in order to reduce the time that would otherwise be needed to load the individual load modules.

**library.** A collection of functions, subroutines, or other data.

**library latch.** An object similar to a mutex and used within the Language Environment library to synchronize access to resources shared among threads.

**library vector table (LIBVEC).** A vector table used to support access to library routines (Language Environment and HLLs) from compiler-generated code, user-written assembly language code, and other subroutines.

**library workspace (LWS).** Special register save areas for certain PL/I library routines, preallocated in nonstack storage.

**LIBVEC.** Library vector table.

**LIFO.** Last in, first out method of access. A queuing technique in which the next item to be retrieved is the item most recently placed in the queue.

**Lilian date.** The number of days since the beginning of the Gregorian calendar. Day one is Friday, 15 October 1582. The Lilian date format is named in honor of Luigi Lilio, the creator of the Gregorian calendar.

**link pack area (LPA).** In MVS, an area of main storage containing reenterable routines from system libraries. Their presence in main storage saves loading time when a reenterable routine is needed.

**link-edit.** To create a loadable computer program by means of a linkage editor or binder.

**linkage editor.** An operating system component that resolves cross-references between separately compiled or assembled modules and then assigns final addresses to create a single relocatable load module. The linkage editor then stores the load module in a load library on disk.

**linked list.** A list in which the data elements may be dispersed but in which each data element contains information for locating the next. Synonymous with *chained list*.

**load module.** A collection of one or more routines that have been stored in a library by the linkage or binder after having been compiled or assembled. External references have usually been—but are not necessarily—resolved. When the external references have been resolved, the load module is in a form suitable for execution.

**local data.** Data that is known only to the routine in which it is declared. Equivalent to local data in C and both WORKING-STORAGE and LOCAL-STORAGE in COBOL.

**locale.** An identifier that determines the way in which data is processed, printed, and displayed in a particular

user community. A locale includes conventions for a specific language and culture, with appropriate numeric representation, date and time formatting, and monetary formatting.

**locator.** PL/I control block that holds the address of data such as structures or arrays and the address of the *descriptor*.

**LPA.** Link pack area.

**LWS.** Library workspace.

## M

**machine readable.** Pertaining to data a machine can acquire or interpret (read) from a storage device, a data medium, or other source.

**main program.** The first routine in an enclave to gain control from the invoker. In Fortran, a main program does not have a FUNCTION, SUBROUTINE, or BLOCK DATA statement as its first statement. It could have a PROGRAM statement as its first statement. Contrast with *subprogram*.

**main task.** In the context of MVS multitasking and the C Multitasking Facility (MTF), the main program in a multitasking environment. The main task runs the *main task program*.

**main task program.** In the context of MVS multitasking and the C Multitasking Facility (MTF), the part of a program that controls overall processing. The main task program is run by the *main task*.

**mapped condition.** A condition that is generated by one component and converted, or mapped, to another component; for example, some Language Environment conditions, such as attention interrupts or the decimal divide condition, map directly to the PL/I ATTENTION and ZERODIVIDE conditions, respectively.

**megabyte (MB).** 1,048,576 bytes.

**medium weight thread.** A medium weight thread has a one-to-one correspondence with an MVS TCB except the lifetime of the TCB may exceed the lifetime of the thread. [POSIX.1]

**memory file control block (MFCB).** Block residing at thread level in C/370 containing the memory information about the file.

**MFCB.** Memory file control block.

**microfiche.** A sheet of microfilm capable of containing microimages in a grid pattern, usually containing a title that can be read without magnification.

**module.** A language construct that consists of procedures or data declarations and can interact with other such constructs. In PL/I, an external procedure.

**MTF.** Multitasking Facility.

**multilevel security.** Allows the classification of data and users based on a system of hierarchical security levels, combined with a system of non-hierarchical security categories. The security administrator classifies users and data, and the system then imposes mandatory access controls restricting which users can access data, based on a comparison of the classification of the users and the data.

**Multitasking Facility (MTF).** Facility provided separately by C and by Fortran to improve turnaround time on multiprocessor configurations by using MVS multitasking facilities. MTF is provided by C library functions or by Fortran callable services.

**multitasking.** A mode of operation in which two or more tasks can be performed at the same time.

**multithreading.** A mode of operation in which the operating system can run different parts of a program, called threads, simultaneously.

**mutex.** A mutual exclusive variable that is intended to serialize access to a shared data object for a short duration of time. [POSIX.1]

**MVS.** Multiple Virtual Storage operating system.

## N

**n-way ILC application.** An ILC application that includes three or more of the following: a C routine, a COBOL program, a Fortran program, and a PL/I routine.

**NAB.** Next available byte.

**name scope.** The portion of an application within which a particular declaration of external data applies or is known.

**name space.** The portion of a load module within which a particular declaration of external data applies or is known.

**named heap.** A heap set up specifically by the CEECRHP callable service. An identifier is returned when the heap is created.

**national language support.** Translation requirements affecting parts of licensed programs; for example, translation of message text and conversion of symbols specific to countries.

**natural reentrancy.** The attribute of applications that contain no static external data and do not require additional processing to make them reentrant. Contrast with *constructed reentrancy*.

**nested condition.** A condition that occurs during the handling of another, previous condition. Language Environment by default permits 10 levels of nested

conditions. This setting may be changed by altering the DEPTHCONDLMT run-time option.

**nested enclave.** A new enclave created by an existing enclave. The nested enclave that is created must be a new main routine within the process. See also *child enclave* and *parent enclave*.

**nested program.** In COBOL, a program that is directly contained within another program.

**next available byte (NAB).** The address of the next available byte of storage on a doubleword boundary. This address is a segment of stack storage.

**next sequential instruction.** The next instruction to be executed in the absence of any branch or transfer of control.

**nonreentrant.** A type of program that cannot be shared by multiple users.

**null.** Empty, having no meaning.

**null character.** A character that represents X'00'.

**null string.** A string containing no element. A character or bit string with a length of zero.

## O

**object module.** A collection of one or more control sections produced by an assembler or compiler and used as input to the linkage editor or binder. Synonym for *text deck* or *object deck*.

**offset.** The number of measuring units from an arbitrary starting point in a record, area, or control block, to some other point.

**omitted parameter.** A parameter not needed in a call.

**online.** Pertaining to a user's ability to interact with a computer. Pertaining to a user's access to a computer via a terminal.

**OpenExtensions.** VM/ESA services that support an environment within which operating systems, servers, distributed systems, and workstations share common interfaces. OpenExtensions supports standard application development across multi-vendor systems. It is required if you want to create and use VM/ESA applications that conform to the POSIX standard.

**operating system.** Software that controls the running of programs; in addition, an operating system may provide services such as resource allocation, scheduling, input/output control, and data management.

**OS PL/I.** See *PL/I*.

**out-of-storage condition.** A condition signaled when an application has used all of the storage allocated to it.

If the STORAGE run-time option is set to a value other than 0, Language Environment adds a reserve stack segment to the overflowing stack, and then signals the out-of-storage condition.

**output procedure.** A set of statements, to which control is given during the execution of a SORT statement after the sort function is completed, or during the MERGE statement after the merge function reaches a point at which it can select the next record in merged order when requested.

**overflow.** Exceeding the capacity of the intended unit of storage. See also *fixed-point overflow exception* and *exponent-overflow exception*.

**overlay.** To write over existing data in storage.

**owning stack frame.** Given the calling sequence of Routine 1 calling Routine 2 that in turn calls Routine 3, Routine 3 is the owning stack frame if a condition occurs while Routine 3 is executing.

**ON-unit.** The specified action to be taken upon detection of the condition named in the containing ON statement.

## P

**packed decimal format.** A format in which each byte in a field except the rightmost digit represents two numeric digits. The rightmost byte contains one digit and the sign. For example, the decimal value +123 is represented as 0001 0010 0011 1111.

**pad.** To fill unused positions in a field with dummy data, usually zeros, ones, or blanks.

**parallel function.** In the context of MVS multitasking and the C Multitasking Facility, those portions of a program that can run independently of the *main task program* and each other. *Subtasks* run the parallel functions.

**parallel program.** In the context of the Fortran parallel facility (not MTF), a program that uses parallel language constructs, invokes any of the parallel callable services, or was compiled with the PARALLEL compile-time option.

**parallel subroutine.** In the context of MVS multitasking and the Fortran Multitasking Facility, those portions of a program that can run independently of the main task program and each other. The parallel subroutines run in MVS subtasks.

**parameter.** 1) Data items that are received by a routine. 2) The term used in certain other languages for the Fortran term *dummy argument*. See *argument*, *actual argument*, and *dummy argument*.

**parent enclave.** The enclave that issues a call to system services or language constructs to create a nested (child) enclave. See also *child enclave* and *nested enclave*.

**partition.** A fixed-size division of storage.

**pass by content.** A COBOL argument passing style synonymous with passing an argument by value (indirect). In this style, R1 contains a pointer to a copy of the argument.

**pass by reference.** In programming languages, one of the basic argument passing semantics where the address of the object is passed. Any changes made by the callee to the argument value will be reflected in the calling routine at the time the change is made.

**pass by value.** In programming languages, one of the basic argument passing semantics where the value of the object is passed. Any changes made by the callee to the argument value will not be reflected in the calling routine.

**percolate.** The action taken by the condition manager when the returned value from a condition handler indicates that the handler could not handle the condition, and the condition will be transferred to the next handler.

**picture string.** Character strings used to specify date and time formats.

**PID.** Process ID.

**PL/I.** A general purpose scientific/business high-level language. PL/I is a high-powered procedure-oriented language especially well suited for solving complex scientific problems or running lengthy and complicated business transactions and record-keeping applications.

**pointer.** A data element that indicates the location of another data element.

**portability.** The ability to transfer an application from one platform to another with relatively few changes to the source code.

**Portable Operating System Interface (POSIX).** Portable Operating System Interface for computing environments, an interface standard governed by the IEEE and based on UNIX. POSIX is not a product. Rather, it is an evolving family of standards describing a wide spectrum of operating system components ranging from C language and shell interfaces to system administration.

**POSIX.** Portable Operating System Interface.

**POSIX process.** An address space and single thread of control that executes within that address space, and its required system resources. A process is created by another process issuing the `fork()` function. The

process that issues `fork()` is known as the parent process, and the new process created by the `fork()` is known as the child process. [POSIX.1]

**POSIX signal.** A mechanism by which a process may be notified of, or affected by, an event occurring in the system. Examples of such events include hardware exceptions and specific actions by processes. The term *signal* is also used to refer to the event itself. [POSIX.1]

**PPA1 entry point block.** Program Prolog Area. This block contains information about the compiled module.

**PPA2 entry point block.** An extension of the *PPA1 entry point block*.

**PPT.** Processing program table.

**precedence.** In programming languages, an order relation defining the sequence of the application of operations or options.

**precision.** A measure of the ability to distinguish between nearly equal values, usually with data of different lengths. See also *single-precision* and *double-precision*.

**preinitialization.** A facility that allows a routine to initialize the run-time environment once, perform multiple executions within the environment, then explicitly terminate the environment.

**Preinitialized Environments for Authorized Programs.** A facility that allows an authorized AMODE 64 application to run z/OS XL C/C++ and Language-Environment conforming Assembler routines through the use of preinitialized environments.

**pre-Language Environment-conforming.** Any HLL program that does not adhere to Language Environment's common interface. For example, VS COBOL II, OS/VS COBOL, OS PL/I, C/370 Version 1 and Version 2, VS FORTRAN Version 1, VS FORTRAN Version 2, FORTRAN IV G1, and FORTRAN IV H Extended are all pre-Language Environment-conforming HLLs.

**prelinker.** A utility that collects compile-time initialization information from one or more object modules into a single initialization unit. In the process, the static external data part is mapped.

**preprocessor.** A routine that examines application source code for preprocessor statements that are then executed, resulting in the alteration of the source.

**preventive service planning (PSP).** The online repository of program temporary fixes (PTFs) and other service information. This information could affect installation.

**procedure.** In COBOL, a procedure is a paragraph or section that can only be performed from within the

program. In PL/I, a named block of code that can be invoked externally, usually via a call.

**procedure library (PROCLIB).** A program library in direct access storage with job definitions. The reader/interpreter can be directed to read and interpret a particular job definition by an execute statement in the input stream.

**process.** The highest level of the Language Environment program management model. A process is a collection of resources, both program code and data, and consists of at least one enclave. See also *POSIX process*.

**process ID (PID).** The unique identifier representing a process. A process ID is a positive integer that can be contained in the data type *pid\_t*. A process ID shall not be reused by the system until the process lifetime ends. In addition, if there exists a process groups whose process group ID is equal to that process ID, the process ID shall not be reused by the system until the process group lifetime ends. A process that is not a system process shall not have a process ID of 1. [POSIX.1]

**processing program table (PPT).** Contains information about CICS load modules (whether the module is in storage or not, its language, use count and entry point address, etc.) needed to complete a transaction.

**program.** See *enclave*.

**program control data.** In PL/I, data used to affect how a program runs; that is, any data that is not string or arithmetic data.

**program interruption.** The interruption of the execution of a program due to some event such as an operation exception, an exponent-overflow exception, or an addressing exception.

**program level.** The modification level, release, version, and fix level.

**program management.** The functions within the system that provide for establishing the necessary activation and invocation for a program to run in the applicable run-time environment when it is called.

**program mask.** In bits 20 through 23 of the program status word (PSW), a 4-bit structure that controls whether each of the fixed-point overflow, decimal overflow, exponent-overflow, and significance exceptions should cause a program interruption. The bits of the program mask can be manipulated to enable or disable the occurrence of a program interruption.

**program number.** The seven-digit code (in the format xxxx-xxx) used by IBM to identify each program product.



**program specification block (PSB).** In IMS/VS, a control block that contains all database program communication blocks (DB PCB) that exist for a single application program. DB PCBs define which segments in a database an application can access.

**program status word (PSW).** A 64-bit structure that includes the instruction address, program mask, and other information used to control instruction sequencing and to determine the state of the CPU. See also *program mask*.

**program temporary fix (PTF).** A temporary solution or bypass of a problem diagnosed by IBM as resulting from a defect in a current unaltered release of the program.

**program unit.** Synonym for *compilation unit*.

**programmable workstation (PWS).** A workstation that has some degree of processing capability and that allows a user to change its functions.

**prolog.** The code sequence when a routine is entered.

**promote.** To change a condition to a different one by a condition handler. A condition handler routine promotes a condition because the error needs to be handled in a way other than that suggested by the original condition.

**PSB.** Program specification block.

**PSP.** Preventive service planning.

**PSW.** Program status word.

**PWS.** Programmable workstation.

## Q

**q\_data.** Qualifying data. Information that a user-written condition handler can use to identify and react to a given instance of a condition.

**q\_data descriptor.** A qualifying datum that contains the data type and length of the immediately following qualifying datum associated with a condition token.

**q\_data token.** An optional 32-bit data object that is placed in the ISI. It is used to access the qualifying data associated with a given instance of a condition.

**qualifier.** A modifier that makes a name unique.

**qualifying data.** *q\_data*. Unique information associated through a condition token with a given instance of a condition. A user-written condition handler uses qualifying data to identify and react to the condition.

**qualifying datum.** A single element of qualifying data associated with a condition. See *qualifying data*.

## R

**reason code.** 1) Return code to CICS only. 2) A value returned to the invoker of an enclave that indicates how the enclave terminated. The value reflects whether the enclave terminated successfully, or unsuccessfully, to an unhandled condition.

**recursive routine.** A routine that can call itself or be called by another routine that it has called.

**reenterable.** reentrant

**reentrant.** The attribute of a routine or application that allows more than one user to share a single copy of a load module.

**register.** Special processing areas that hold a specific amount of data and can process, load, and store this data quickly. To specify formally. In Language Environment, to register a condition handler means to add a user-written condition handler onto a routine's stack frame.

**register save area (RSA).** Area of main storage in which contents of registers are saved.

**regular file.** A file that is a randomly accessible sequence of bytes, with no further structure imposed by the system. [POSIX.1]

**relative pathname.** A pathname that does not begin with a slash. The predecessor of the first filename in the pathname is taken to be the current working directory of the process. [POSIX.1]

**reserved word.** In programming languages, a keyword that may not be used as an identifier.

**resident modules.** A module that remains in a particular area of storage.

**resident routines.** The Language Environment library routines linked with your application. They include such things as initialization routines and *callable service stubs*.

**resume.** To continue execution in an application at the point immediately after which a condition occurred. This occurs when a condition handler determines that a condition has been handled and normal application execution should continue.

**resume cursor.** The point in an application at which execution should continue if a condition handler requests the resume action for a condition it is processing. When a condition is signaled, the resume cursor is at the location at which the error occurred or at which the condition was first reported to the condition manager. The resume cursor can be moved with the CEEMRCE or CEEMRCR callable service.

**return code.** A code produced by a routine to indicate its success or failure. It may be used to influence the execution of succeeding instructions or programs.

**return\_code\_modifier.** A value set by Language Environment routines to indicate the severity of an unhandled condition. The `return_code_modifier` is a component of the return code that indicates the status of the execution of an enclave.

**RMODE.** Residence mode. Provided by the linkage editor, the attribute of a load module that specifies whether the module, when loaded, must reside below the 16MB virtual storage line or may reside anywhere in virtual storage.

**rollback.** The process of restoring data changed by an application to the state at its last commit point.

**root load module.** The load module containing a main routine and the first to be executed in an application.

**routine.** In Language Environment, refers to a PL/I procedure, a C function, a Fortran main program or subprogram, or a COBOL program or a separate subroutine.

**RSA.** Register save area.

**run.** To cause a program, utility, or other machine function to be performed.

**RUNCOM.** COBOL block containing the ID and address of the main program.

**run time.** Any instant at which a program is being executed. Synonymous with *execution time*.

**run-time environment.** A set of resources that are used to support the execution of a program. Synonymous with *execution environment*.

**run unit.** One or more object programs that are executed together. In Language Environment, a run unit is the equivalent of an *enclave*.

## S

**safe condition.** Any condition having a severity of 0 or 1. Such conditions are ignored if no condition handler handles the condition.

**save area.** Area of main storage in which contents of registers are saved.

**SBCS.** Single-byte character set.

**scalar.** A quantity characterized by a single value. Contrast with *aggregate*.

**scalar instruction.** An instruction, such as a load, store, arithmetic, or logical instruction, that operates on a scalar. Contrast with *vector instruction*.

**scope.** A term used to describe the effective range of the enablement of a condition and/or the establishment of a user-generated routine to handle a condition. Scope can be both statically and dynamically defined. The portion of an application within which the definition of a variable remains unchanged.

**scope terminator.** Variable at the end of a statement.

**segment.** See *stack segment*.

**severity code.** A part of run-time messages that indicates the severity of the error condition (1, 2, 3, or 4).

**shared segment.** In VM, a feature of a saved system that allows one or more segments of reentrant code in real storage to be shared among many virtual machines.

**shared storage.** An area of storage that is the same for each virtual address space. Because it is the same space for all users, information stored there can be shared and does not have to be loaded in the user region.

**shared virtual area (SVA).** In VSE, a high address area of virtual storage that contains a system directory list (SDL) of frequently used phases, resident programs that can be shared between partitions, and an area for system support.

**signal.** In C, signals are conditions that may or may not be reported during program execution, depending upon how they are defined to the condition handler. A condition is registered in C using the `signal()` function; a condition is raised using the `raise()` function. See also *POSIX signal* and *synchronous signal*. To make the condition manager aware of a condition for processing.

**signal catching function.** In POSIX, analogous to *signal handler*. The signal catching function is specified through the `sigaction()` function. [POSIX.1]

**signal handler.** In C, a function to be called when a *signal* is reported.

**signature CSECT.** The resident routine that indicates that the load module in which it is present contains a routine written in a particular language.

**significance exception.** The program interruption that occurs when the resulting fraction in a floating-point addition or subtraction instruction is zero. This program interruption can be disabled through a program mask bit setting.

**single-byte character set (SBCS).** A collection of characters represented by a 1-byte code.

**single-precision.** Pertaining to the use of one computer word to represent a number in accordance with the required precision. See also *precision* and *double-precision*.

**S-name.** In C, this is a single-case external identifier that is at most eight characters long. See also *L-name*.

**softcopy.** One or more files that can be electronically distributed, manipulated, and printed by a user. Contrasts with *hardcopy*.

**sort/merge program.** A processing program that can be used to sort or merge records in a prescribed sequence.

**source code.** The input to a compiler or assembler, written in a source language.

**source program.** A set of instructions written in a programming language that must be translated to machine language before the program can be run.

**stack.** An area of storage used for suballocation of stack frames. Such suballocations are allocated and freed on a LIFO (last in, first out) basis. A stack is a collection of one or more stack segments consisting of an initial stack segment and zero or more increments.

**stack frame.** The physical representation of the activation of a routine. The stack frame is allocated on a LIFO stack and contains various pieces of information including a save area, condition handling routines, fields to assist the acquisition of a stack frame from the stack, and the local, automatic variables for the routine. In Language Environment, a stack frame is synonymous with *DSA*.

**stack frame collapse.** An action that occurs when the condition manager skips over one or more active routines and execution resumes in an earlier routine on the stack. A stack frame collapse happens is an explicit GOTO is coded in a C or PL/I routine or if the resume cursor is moved with the CEEMRCR.

**stack increment.** See *increment*.

**stack segment.** A contiguous area of storage obtained directly from the operating system. The Language Environment storage management scheme subdivides stack segments into individual DSAs. If the initial stack segment becomes full, a second segment or increment is obtained from the operating system.

**stack storage.** See *stack* and *automatic storage*.

**standard system action.** The name given to the language-defined default action taken when a condition occurs and it is not handled by a condition handler.

**static call.** A call that results in the resolution of the called program during the link-edit of the application. Contrast with *dynamic call*.

**static data.** Data that retains its last-used state across calls.

**static storage.** Storage that persists and retains its value across calls. Contrast with *dynamic storage*.

**storage heap.** An unordered group of program stack areas that may be associated with programs running within a process.

**SUBCOM.** Control block containing information about multiple COBOL programs.

**suboption.** A value that can be provided as part of a compile-time or run-time option to further specify the meaning of the option.

**subpool storage.** All of the storage blocks allocated under a subpool number for a particular task.

**subprogram.** A program unit that is invoked or used by another program unit. In Fortran, a subprogram has a FUNCTION, SUBROUTINE, or BLOCK DATA statement as its first statement. Contrast with *main program*.

**SUBSET.** The value that specifies the FMID for a product level.

**subsystem.** A secondary or subordinate system, or programming support, usually capable of operating independently of or asynchronously with a controlling system. Examples are CICS and IMS.

**subtask.** In the context of MVS multitasking and the C Multitasking Facility (MTF), a task that is initiated and terminated by a higher order task (the *main task*). Subtasks run the *parallel functions*, those portions of the program that can run independently of the *main task program* and each other.

**SVC.** Supervisor call. A request that serves as the interface to certain functions, such as the allocation of storage.

**symbolic feedback code.** The symbolic representation of the first 8 bytes of the 12-byte condition token. In a condition-handling routine, a symbolic feedback code is substituted for the hexadecimal coding of the condition-handling routine.

**synchronous signal.** A signal attributable to a specific thread. Signals that can be generated synchronously are SIGABRT, SIGILL, SIGFPE, SIGPIPE, and SIGSEGV.

**syntax.** The rules governing the structure of a programming language and the construction of a statement in a programming language.

**system abend.** An abend caused by the operating system's inability to process a routine; may be caused by errors in the logic of the source routine.

**systems programming facility.** Run-time facilities provided by C that allow programs to be developed that do not require the Language Environment common library.

## T

**target libraries.** In SMP/E, a collection of data sets in which the various parts of an operating system are stored. These data sets are sometimes called system libraries.

**target zone.** In SMP/E, a collection of VSAM records describing the target system macros, modules, assemblies, load modules, source modules, and libraries copied from DLIBs during system generation, and the SYSMODs applied to the target system.

**task.** In a multiprogramming or multiprocessing environment, one or more sequences of instructions treated by a control program as an element of work to be accomplished by a computer.

**task control block (TCB).** An MVS related control block which contains information and pointers associated with the task in process.

**task global table (TGT).** Table with information about addresses and length of working storage and the program start address.

**TCB.** Task control block.

**termination imminent step.** The final step of the 3-step Language Environment condition handling model. In the termination imminent step, user-written condition handlers and PL/I ON-units are given one last chance to handle a condition or perform cleanup before the thread is terminated. See also *condition step* and *enablement step*.

**THDCOM.** Control block with COBOL thread information.

**thread.** The basic run-time path within the Language Environment program management model. It is dispatched by the system with its own instruction counter and registers. The thread is where actual code resides.

**thread safe.** A locking mechanism (mutex) that allows a thread to work with critical data or structures while preventing other threads from gaining access to the same data or structures. When the thread has finished processing the critical data or structures, it must release the lock to allow other threads to gain access to the data or structures. [POSIX.1]

**time sharing option (TSO/E).** An option on the operating system; for System/370, the option provides interactive time sharing from remote terminals.

**token.** See *condition token*.

**trace.** A record of the execution of a computer program. It exhibits the sequence in which the instructions were executed. To record a series of events as they occur.

**traceback.** A section of a dump that provides information about the stack frame (DSA), the program unit address, the entry point of the routine, the statement number, and status of the routines on the call-chain at the time the traceback was produced.

**translator.** See *CICS translator*.

**transient data queue.** A file to which run-time messages are written under CICS. Under Language Environment, the name of this file is CESE. Also a sequential data set used by the Folder Application Facility in CICS/MVS to log system messages.

**transient routines.** The Language Environment library routines that are loaded at run time. Contrast with *resident routines*.

**translator.** See *CICS translator*.

**TSO.** TSO/E.

**TSO/E.** Time Sharing Option Extensions. An MVS component that permits interactive compiling, link-editing, executing, and debugging of programs.

## U

**UCLIN.** In SMP/E, the command used to initiate changes to SMP/E data sets. Actual changes are made by subsequent UCL statements.

**underflow.** See *exponent-underflow exception*.

**unhandled condition.** A condition that isn't handled by any condition handler for any stack frame in the call chain. Contrast with *handled condition*.

**UNIX.** See *z/OS UNIX System Services*.

**unpacked decimal format.** A format for representing numbers in which the digit is contained in bits 4 through 7 and the sign is contained in bits 0 through 3 of the rightmost byte. Bits 0 through 3 of all other bytes contain 1s (hex F). For example, the decimal value of +123 is represented as 1111 0001 1111 0010 1111 0011. Synonymous with *zoned decimal format*.

**upward-growing stack.** With Extra Performance Linkage (XPLINK), a stack that grows from low addresses to high addresses in memory.

**upwardly compatible.** The ability for applications that have been linked with Language Environment to continue to run on later releases of OS/390 Language Environment, without the need to recompile or relink. Language Environment is guaranteed to be upwardly compatible.

**user abend.** A request made by user code to the operating system to abnormally terminate a routine. Contrast with *system abend*.

**user-written condition handler.** A routine that analyzes and possibly takes action on conditions presented to it by the condition manager. The condition handler is registered either by calling the CEEHDLR callable service or by specifying the USRHDLR run-time option.

**user exit.** A routine that takes control at a specific point in an application. Two assembler user exits and one HLL user exit are provided by Language Environment. They are invoked to perform initialization functions and both normal and abnormal termination functions.

**user heap.** See *initial heap*.

**usermod.** User modification.

**user stack.** An independent area of stack storage that may be located above or below 16M, designed to be used by both library routines and compiled code. See also *stack* and *stack frame*.

## V

**vector.** A linearly ordered collection of scalars of the same type. Each scalar is said to be an *element* of the vector. See also *array*. Contrast with *scalar*.

**vector instruction.** An instruction, such as a load, store, arithmetic, or logical instruction, that operates on vectors residing in storage or in a vector register in the vector facility. Contrast with *scalar instruction*.

**vendor.** A person or company that provides a service or product to another person or company.

**virtual origin.** The address of an element in an array whose subscripts are all zero.

**VO.** Virtual origin.

**void function.** The C representation of a procedure invocation. A void function is a function that does not return a value.

**VOLSER.** Volume serial number.

**volume.** A certain portion of data, together with its data carrier, that can be handled conveniently as a unit. A data carrier mounted and demounted as a unit; for example, a reel of magnetic tape, a disk pack.

**volume label.** An area on a standard label tape used to identify the tape volume and its owner. This area is the first 80 bytes and contains VOL 1 in the first four positions.

**volume serial number.** A number in a volume label assigned when a volume is prepared for use in a system.

**VSAM.** Virtual storage access method. A high-performance mass storage access method. Three types of data organization are available: entry sequenced data sets (ESDS), key sequenced data sets (KSDS), and relative record data sets (RRDS).

**VSTRING.** The VSTRING data type is used for the character string parameters in many of the Language Environment callable services. In z/OS Language Environment, VSTRING is a halfword length-prefixed character string for input, or a fixed-length 80-character string for output.

## W

**weak external reference.** A special type of external reference that is not to be resolved by automatic library calls unless an ordinary external reference to the same symbol is found. The external symbol dictionary entry specifies the symbol; the location is unknown.

**work registers.** Registers used by the PL/I compiler as required.

**WORKING-STORAGE.** In COBOL, the storage required for data items in the WORKING-STORAGE section. WORKING-STORAGE is a portion of main storage that is used by a computer program to hold data temporarily.

**workstation.** One or more programmable or nonprogrammable devices that allow a user to do work on a computer. See also *programmable workstation*.

**writable static.** In C, writable static may be any of the following:

- Program variables with the extern storage class
- Program variables with the static storage class
- Writable strings

The Language Environment term for writable static is *external data*.

## X

**XPG4.** This term refers to the XPG4 interface standard. The XPG4 standard is described in detail in *X/Open Specification Issue 4*.

**XPLINK (Extra Performance Linkage).** See *Extra Performance Linkage*.

## Z

**zoned decimal format.** Synonym for *unpacked decimal format*.

**z/OS Language Environment.** An element of z/OS that provides a common run-time environment and common run-time services for C/C++, COBOL, PL/I, and Fortran applications.

**z/OS UNIX System Services (z/OS UNIX).** The set of functions provided by the Shell and Utilities, kernel, debugger, file system, C/C++ Run-Time Library, Language Environment, and other elements of the z/OS operating system that allow users to write and run application programs that conform to UNIX standards.

**31-bit mode.** See AMODE 31.

**64-bit virtual mode.** See AMODE 64.

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## Bibliography

This section lists the books in the Language Environment library and other publications that may be helpful when using Language Environment.

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#### ***z/OS Language Environment***

- *z/OS Language Environment Concepts Guide*, SA22-7567
- *z/OS Language Environment Programming Guide*, SA22-7561
- *z/OS Language Environment Programming Reference*, SA22-7562
- *z/OS Language Environment Customization*, SA22-7564
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#### ***z/OS XL C/C++***

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- *Language Reference*, SC26-4769

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- *Installation and Customization under MVS*, SC26-4766
- *Reference Summary*, SX26-3788
- *Diagnosis Guide*, SC26-3138

### **VS COBOL II**

*VS COBOL II Application Programming Guide for MVS and CMS*, SC26-4045

### **Debug Tool**

- Debug Tool documentation is available at: <http://www.ibm.com/software/ad/debugtool/library/>

### **VS FORTRAN Version 2**

- *Language Environment Fortran Run-Time Migration Guide*, SC26-8499
- *Language and Library Reference*, SC26-4221
- *Programming Guide for CMS and MVS*, SC26-4222

### **Enterprise PL/I for z/OS**

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- *Enterprise PL/I for z/OS Programming Guide*, SC27-1457
- *Enterprise PL/I for z/OS Language Reference*, SC27-1460
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- *Enterprise PL/I for z/OS Messages and Codes*, SC27-1461

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- *PL/I for MVS & VM Diagnosis Guide*, SC26-3149

### **High Level Assembler for MVS & VM & VSE**

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- *CICS Operations and Utilities Guide*, SC34-6229
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- *CICS Application Programming Reference*, SC34-6232
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### **DB2**

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### **DFSMS/MVS**

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**IPCS**

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- *z/OS MVS IPCS Commands*, SA22-7594
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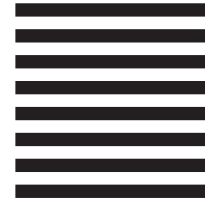
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