C/C++
Programming Guide
Fourth Edition (September 2002)

This edition applies to Version 1 Release 4 of z/OS C/C++ (5694-A01), Version 1 Release 4 of z/OS.e™ (5655-G52), and to all subsequent releases until otherwise indicated in new editions. This edition replaces SC09-4765-02 . Make sure that you use the correct edition for the level of the program listed above. Also, ensure that you apply all necessary PTFs for the program.

Order publications through your IBM® representative or the IBM branch office serving your location. Publications are not stocked at the address below. You can also browse the books on the World Wide Web by clicking on “The Library” link on the z/OS™ home page. The web address for this page is http://www.ibm.com/servers/eserver/zseries/zos/bkserv

IBM welcomes your comments. You can send your comments using any one of the following methods:

• Internet: mhvrcfs@us.ibm.com
  Be sure to include your e-mail address if you want a reply.

• By regular mail to the following address:
  
  International Business Machines Corporation
  Department 55JA, Mail Station P384
  2455 South Road
  Poughkeepsie, NY 12601-5400
  United States of America

Include the title and order number of this book, and the page number or topic related to your comment. When you send information to IBM, you grant IBM a nonexclusive right to use or distribute the information in any way it believes appropriate without incurring any obligation to you.

© Copyright International Business Machines Corporation 1996, 2002. All rights reserved.
US Government Users Restricted Rights — Use, duplication or disclosure restricted by GSA ADP Schedule Contract with IBM Corp.
# Contents

## Part 1. Introduction

<table>
<thead>
<tr>
<th>Chapter 1. About This Document</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who should use this document</td>
<td>3</td>
</tr>
<tr>
<td>A note about examples</td>
<td>3</td>
</tr>
<tr>
<td>How to read syntax diagrams</td>
<td>3</td>
</tr>
<tr>
<td>Symbols</td>
<td>3</td>
</tr>
<tr>
<td>Syntax items</td>
<td>4</td>
</tr>
<tr>
<td>Syntax examples</td>
<td>4</td>
</tr>
<tr>
<td>z/OS C/C++ and related publications</td>
<td>6</td>
</tr>
<tr>
<td>Hardcopy Documents</td>
<td>10</td>
</tr>
<tr>
<td>Softcopy documents</td>
<td>11</td>
</tr>
<tr>
<td>Softcopy examples</td>
<td>11</td>
</tr>
<tr>
<td>z/OS C/C++ on the World Wide Web</td>
<td>11</td>
</tr>
<tr>
<td>Where to find more information</td>
<td>12</td>
</tr>
<tr>
<td>Accessing z/OS licensed documents on the Internet</td>
<td>12</td>
</tr>
<tr>
<td>Using LookAt to look up message explanations</td>
<td>12</td>
</tr>
</tbody>
</table>

## Part 2. Input and Output

<table>
<thead>
<tr>
<th>Chapter 2. About IBM z/OS C/C++</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes for z/OS V1R4</td>
<td>15</td>
</tr>
<tr>
<td>The C/C++ compilers</td>
<td>15</td>
</tr>
<tr>
<td>The C language</td>
<td>15</td>
</tr>
<tr>
<td>The C++ language</td>
<td>16</td>
</tr>
<tr>
<td>Common features of the z/OS C and C++ compilers</td>
<td>16</td>
</tr>
<tr>
<td>z/OS C Compiler specific features</td>
<td>17</td>
</tr>
<tr>
<td>z/OS C++ Compiler specific features</td>
<td>18</td>
</tr>
<tr>
<td>Class libraries</td>
<td>18</td>
</tr>
<tr>
<td>IBM Open Class Library Source</td>
<td>19</td>
</tr>
<tr>
<td>Utilities</td>
<td>19</td>
</tr>
<tr>
<td>The Debug Tool</td>
<td>19</td>
</tr>
<tr>
<td>IBM C/C++ Productivity Tools for OS/390</td>
<td>20</td>
</tr>
<tr>
<td>z/OS Language Environment</td>
<td>20</td>
</tr>
<tr>
<td>z/OS Language Environment downward compatibility</td>
<td>21</td>
</tr>
<tr>
<td>About prelinking, linking, and binding</td>
<td>22</td>
</tr>
<tr>
<td>Notes on the prelinking process</td>
<td>23</td>
</tr>
<tr>
<td>File format considerations</td>
<td>23</td>
</tr>
<tr>
<td>The Program Management binder</td>
<td>23</td>
</tr>
<tr>
<td>z/OS UNIX System Services (z/OS UNIX)</td>
<td>24</td>
</tr>
<tr>
<td>z/OS C/C++ Applications with z/OS UNIX C/C++ functions</td>
<td>26</td>
</tr>
<tr>
<td>Input and output</td>
<td>26</td>
</tr>
<tr>
<td>I/O interfaces</td>
<td>26</td>
</tr>
<tr>
<td>File types</td>
<td>27</td>
</tr>
<tr>
<td>Additional I/O features</td>
<td>27</td>
</tr>
<tr>
<td>The System Programming C facility</td>
<td>28</td>
</tr>
<tr>
<td>Interaction with other IBM products</td>
<td>28</td>
</tr>
<tr>
<td>Additional features of z/OS C/C++</td>
<td>30</td>
</tr>
</tbody>
</table>

## Part 2. Input and Output

<table>
<thead>
<tr>
<th>Chapter 3. Introduction to C and C++ Input and Output</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of C and C++ Input and Output</td>
<td>35</td>
</tr>
<tr>
<td>Text Streams</td>
<td>35</td>
</tr>
</tbody>
</table>
Chapter 27. Handling Exceptions, Error Conditions, and Signals

Handling C Software Exceptions under C++ ........................................ 379
Handling Hardware Exceptions under C++ ...................................... 380
Tracebacks under C++ ........................................................................ 380
  CCNGCH1 ..................................................................................... 381
  CCNGCH2 ..................................................................................... 383
Handling Signals with POSIX(OFF) Using signal() and raise() ........ 384
Handling Signals Using Language Environment Callable Services.... 384
Handling Signals Using z/OS UNIX with POSIX(ON) ...................... 385
Asynchronous Signal Delivery under z/OS UNIX ......................... 387
C Signal Handling Features under z/OS C/C++ ................................. 388
  Establishing a Signal Handler ......................................................... 388
  Enabling a Signal .......................................................................... 389
  Interrupting a Program ................................................................. 389
  Raising a Signal ............................................................................ 389
  Identifying Hardware and Software Signals .............................. 389
  SIGABND Considerations ............................................................. 392
  SIGIOERR Considerations ............................................................ 392
  Default Handling of Signals ........................................................ 392
    MAP 0040: Summary of C Error Handling .................................. 396
Example of C Signal Handling under z/OS C or z/OS C++ ............... 398

Chapter 28. Optimizing Code ................................................................. 399
Input/Output Considerations ............................................................... 399
  When Accessing MVS Data Sets .................................................. 399
  When Accessing HFS Files ............................................................ 401
  When Using the C++ I/O Stream Libraries .................................. 402
  Using Library Extensions ............................................................. 402
Programming Recommendations ..................................................... 403
  Using Variables .......................................................................... 403
  Passing Function Arguments ...................................................... 404
  Coding Expressions ..................................................................... 404
  Coding Conversions ..................................................................... 405
Arithmetic Considerations ............................................................... 405
  Using Loops and Control Constructs .......................................... 405
Choosing a Data Type ........................................................................ 406
Part 7. Internationalization: Locales and Character Sets

Chapter 46. Introduction to Locale
Internationalization in Programming Languages
Elements of Internationalization
z/OS C/C++ Support for Internationalization
Locales and Localization
Locale-Sensitive Interfaces

Chapter 47. Building a Locale
Limitations of Enhanced ASCII
Using the charmap File
The CHARMAP Section
The CHARSETID Section
Locale Source Files
LC_CTYPE Category
LC_COLLATE Category
LC_MONETARY Category
LC_NUMERIC Category
LC_TIME Category
LC_MESSAGES Category
LC_TOD Category
LC_SYNTAX Category
Method Files
Using the localedef Utility
Locale Naming Conventions

Chapter 48. Customizing a Locale
Using the Customized Locale
Referring Explicitly to a Customized Locale
CCNGCL1
Referring Implicitly to a Customized Locale
CCNGCL2

Chapter 49. Customizing a Time Zone
Using the TZ or _TZ Environment Variable to Specify Time Zone
Relationship Between TZ or _TZ and LC_TOD

Chapter 50. Definition of S370 C, SAA C, and POSIX C Locales
Differences between SAA C and POSIX C Locales
CCNGDL1

Chapter 51. Code Set Conversion Utilities
The genxlt Utility
The iconv Utility
Code Conversion Functions
Code Set Converters Supplied
Universal Coded Character Set Converters
Coderset Conversion Using UCS-2
UCMAP Source Format

Chapter 52. Coded Character Set Considerations with Locale Functions
Variant Character Detail
Mappings of 13 PPCS Variant Characters
Mappings of Hex Encoding of 13 PPCS Variant Characters
Alternate Code Points
Appendix I. Using Built-In Functions ........................................ 881

Appendix J. Application Considerations for z/OS UNIX C/C++ .... 885
  Relationship to DB2 Universal Database .................................. 885
  Application Programming Environments Not Supported. ............. 885
  Support for the Curses Library. ........................................ 885

Appendix K. External Variables ........................................... 887
  errno ........................................ 887
  daylight ..................................... 887
  getdate_err ................................ 888
  h_errno ..................................... 888
  __loc1 ..................................... 888
  loc1 ......................................... 888
  loc2 ......................................... 888
  locs .......................................... 888
  optarg ....................................... 888
  opterr ....................................... 888
  optind ....................................... 889
  optopt ....................................... 889
  signgam ...................................... 889
  stdin ......................................... 889
  stderr ........................................ 889
  stdout ........................................ 889
  t_errno ....................................... 889
  timezone ..................................... 889
  tzname ....................................... 890

Appendix L. Accessibility ................................................... 891
  Using assistive technologies ........................................... 891
  Keyboard navigation of the user interface .............................. 891

Notices ................................................................................. 893
  Programming interface information ..................................... 894
  Trademarks. ....................................................................... 894
  Standards ...................................................................... 895

Glossary ................................................................................. 897

Bibliography ................................................................. 925
  z/OS .............................................. 925
  z/OS C/C++ ....................................... 925
  z/OS Language Environment ............................................... 925
  Assembler ..................................................................... 926
  COBOL ................................................................... 926
  PL/I ..................................................................... 926
  VS FORTRAN ....................................... 926
  CICS ................................................................... 926
  DB2 ..................................................................... 926
  IMS/ESA. .................................................................. 927
  QMF ................................................................... 927
  DFSMS .................................................. 927
Part 1. Introduction
Chapter 1. About This Document

This document provides information about implementing programs that are written in C and C++. It contains advanced guidelines and information for developing C and C++ programs to run under z/OS and z/OS.e. References to z/OS in the document refer to both z/OS and z/OS.e.

This document 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 of the contents in this document; 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 documents.

Who should use this document

To use this document, or any other documents in the library of z/OS C/C++ publications, you must have a working knowledge of the C/C++ programming language. In addition, you must have knowledge of the z/OS operating system, and where appropriate, the related products.

A note about examples

Examples that illustrate the use of the z/OS C/C++ compiler use a simple style. They are instructional examples, and do not attempt to minimize run time, conserve storage, or check for errors. The examples do not demonstrate all the uses of C and C++ language constructs. Some examples are only code fragments and will not compile without additional code.

Examples that illustrate the use of the z/OS C/C++ compiler and the IBM Open Class® Library use a simple style. They are instructional examples, and do not attempt to minimize run time, conserve storage, or check for errors. The examples do not demonstrate all the uses of C++ language constructs or IBM Open Class Library. Some examples are only code fragments and will not compile without additional code.

How to read syntax diagrams

This section describes how to read syntax diagrams. It defines syntax diagram symbols, items that may be contained within the diagrams (keywords, variables, delimiters, operators, fragment references, operands) and provides syntax examples that contain these items.

Syntax diagrams pictorially display the order and parts (options and arguments) that comprise a command statement. They are read from left to right and from top to bottom, following the main path of the horizontal line.

Symbols

The following symbols may be displayed in syntax diagrams:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
</table>

© Copyright IBM Corp. 1996, 2002
Syntax items
Syntax diagrams contain many different items. Syntax items include:

- Keywords - a command name or any other literal information.
- Variables - variables are italicized, appear in lowercase and represent the name of values you can supply.
- Delimiters - delimiters indicate the start or end of keywords, variables, or operators. For example, a left parenthesis is a delimiter.
- Operators - operators include add (+), subtract (-), multiply (*), divide (/), equal (=), and other mathematical operations that may need to be performed.
- Fragment references - a part of a syntax diagram, separated from the diagram to show greater detail.
- Separators - a separator separates keywords, variables or operators. For example, a comma (,) is a separator.

Keywords, variables, and operators may be displayed as required, optional, or default. Fragments, separators, and delimiters may be displayed as required or optional.

<table>
<thead>
<tr>
<th>Item type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td>Required items are displayed on the main path of the horizontal line.</td>
</tr>
<tr>
<td>Optional</td>
<td>Optional items are displayed below the main path of the horizontal line.</td>
</tr>
<tr>
<td>Default</td>
<td>Default items are displayed above the main path of the horizontal line.</td>
</tr>
</tbody>
</table>

Syntax examples
The following table provides syntax examples.

<table>
<thead>
<tr>
<th>Item</th>
<th>Syntax example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required item.</td>
<td>\texttt{\textbf{KEYWORD}--\texttt{required_item}\textbf{--}}</td>
</tr>
<tr>
<td>Required items appear on the main path of the horizontal line. You must specify these items.</td>
<td>\texttt{\textbf{KEYWORD}--\texttt{required_item}---}</td>
</tr>
<tr>
<td>Required choice.</td>
<td>\texttt{\textbf{KEYWORD}--\texttt{required_choice1}--\texttt{required_choice2}\textbf{--}}</td>
</tr>
<tr>
<td>A required choice (two or more items) appears in a vertical stack on the main path of the horizontal line. You must choose one of the items in the stack.</td>
<td>\texttt{\textbf{KEYWORD}--\texttt{required_choice1}--\texttt{required_choice2}--\texttt{required_choice3}\textbf{--}}</td>
</tr>
<tr>
<td>Item</td>
<td>Syntax example</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Optional item.</td>
<td></td>
</tr>
<tr>
<td>Optional items appear below the main path of the horizontal line.</td>
<td>![optional_item]</td>
</tr>
<tr>
<td>Optional choice.</td>
<td></td>
</tr>
<tr>
<td>A optional choice (two or more items) appear in a vertical stack below the main path of the horizontal line. You may choose one of the items in the stack.</td>
<td>![optional_choice1] &lt;br&gt; ![optional_choice2]</td>
</tr>
<tr>
<td>Default.</td>
<td></td>
</tr>
<tr>
<td>Default items appear above the main path of the horizontal line. The remaining items (required or optional) appear on (required) or below (optional) the main path of the horizontal line. The following example displays a default with optional items.</td>
<td>![default_choice1] &lt;br&gt; ![optional_choice2] &lt;br&gt; ![optional_choice3]</td>
</tr>
<tr>
<td>Variable.</td>
<td></td>
</tr>
<tr>
<td>Variables appear in lowercase italics. They represent names or values.</td>
<td>![variable]</td>
</tr>
<tr>
<td>Repeatable item.</td>
<td></td>
</tr>
<tr>
<td>An arrow returning to the left above the main path of the horizontal line indicates an item that can be repeated.</td>
<td>![repeatable_item]</td>
</tr>
<tr>
<td>An arrow returning to the left above a group of repeatable items indicates that one of the items can be selected, or a single item can be repeated.</td>
<td>![repeatable_item]</td>
</tr>
<tr>
<td>Fragment.</td>
<td></td>
</tr>
<tr>
<td>The |--\ symbol indicates that a labelled group is described below the main syntax diagram. Syntax is occasionally broken into fragments if the inclusion of the fragment would overly complicate the main syntax diagram.</td>
<td>![fragment: fragment: fragment:]</td>
</tr>
</tbody>
</table>

```
### z/OS C/C++ and related publications

This section summarizes the content of the z/OS C/C++ publications and shows where to find related information in other publications.

**Table 2. z/OS C/C++ Publications**

<table>
<thead>
<tr>
<th>Document Title and Number</th>
<th>Key Sections/Chapters in the Document</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>z/OS C/C++ Programming Guide, SC09-4765</strong></td>
<td>Guidance information for:</td>
</tr>
<tr>
<td></td>
<td>• C/C++ input and output</td>
</tr>
<tr>
<td></td>
<td>• Debugging z/OS C programs that use input/output</td>
</tr>
<tr>
<td></td>
<td>• Using linkage specifications in C++</td>
</tr>
<tr>
<td></td>
<td>• Combining C and assembler</td>
</tr>
<tr>
<td></td>
<td>• Creating and using DLLs</td>
</tr>
<tr>
<td></td>
<td>• Using threads in z/OS UNIX® applications</td>
</tr>
<tr>
<td></td>
<td>• Reentrancy</td>
</tr>
<tr>
<td></td>
<td>• Using the decimal data type in C and C++</td>
</tr>
<tr>
<td></td>
<td>• Handling exceptions, error conditions, and signals</td>
</tr>
<tr>
<td></td>
<td>• Optimizing code</td>
</tr>
<tr>
<td></td>
<td>• Optimizing your C/C++ code with Interprocedural Analysis</td>
</tr>
<tr>
<td></td>
<td>• Network communications under z/OS UNIX</td>
</tr>
<tr>
<td></td>
<td>• Interprocess communications using z/OS UNIX</td>
</tr>
<tr>
<td></td>
<td>• Structuring a program that uses C++ templates</td>
</tr>
<tr>
<td></td>
<td>• Using environment variables</td>
</tr>
<tr>
<td></td>
<td>• Using System Programming C facilities</td>
</tr>
<tr>
<td></td>
<td>• Library functions for the System Programming C facilities</td>
</tr>
<tr>
<td></td>
<td>• Using run-time user exits</td>
</tr>
<tr>
<td></td>
<td>• Using the z/OS C multitasking facility</td>
</tr>
<tr>
<td></td>
<td>• Using other IBM products with z/OS C/C++ (CICS®, CSP, DWS, DB2®, GDDM®, IMS™, ISPF, QMF™)</td>
</tr>
<tr>
<td></td>
<td>• Internationalization: locales and character sets, code set conversion utilities, mapping variant characters</td>
</tr>
<tr>
<td></td>
<td>• POSIX character set</td>
</tr>
<tr>
<td></td>
<td>• Code point mappings</td>
</tr>
<tr>
<td></td>
<td>• Locales supplied with z/OS C/C++</td>
</tr>
<tr>
<td></td>
<td>• Charmap files supplied with z/OS C/C++</td>
</tr>
<tr>
<td></td>
<td>• Examples of charmap and locale definition source files</td>
</tr>
<tr>
<td></td>
<td>• Converting code from coded character set IBM-1047</td>
</tr>
<tr>
<td></td>
<td>• Using built-in functions</td>
</tr>
<tr>
<td></td>
<td>• Programming considerations for z/OS UNIX C/C++</td>
</tr>
<tr>
<td><strong>z/OS C/C++ User’s Guide, SC09-4767</strong></td>
<td>Guidance information for:</td>
</tr>
<tr>
<td></td>
<td>• z/OS C/C++ examples</td>
</tr>
<tr>
<td></td>
<td>• Compiler options</td>
</tr>
<tr>
<td></td>
<td>• Binder options and control statements</td>
</tr>
<tr>
<td></td>
<td>• Specifying z/OS Language Environment® run-time options</td>
</tr>
<tr>
<td></td>
<td>• Compiling, IPA Linking, binding, and running z/OS C/C++ programs</td>
</tr>
<tr>
<td></td>
<td>• Utilities (Object Library, DLL Rename, CXXFILT, DSECT Conversion, Code Set and Locale, ar and make, BPXBATCH)</td>
</tr>
<tr>
<td></td>
<td>• Diagnosing problems</td>
</tr>
<tr>
<td></td>
<td>• Cataloged procedures and REXX EXECs supplied by IBM</td>
</tr>
<tr>
<td>Document Title and Number</td>
<td>Key Sections/Chapters in the Document</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------</td>
</tr>
</tbody>
</table>
| **C/C++ Language Reference,** SC09-4815 | Reference information for:  
  • The C and C++ languages  
  • Lexical elements of z/OS C and z/OS C++  
  • Declarations, expressions, and operators  
  • Implicit type conversions  
  • Functions and statements  
  • Preprocessor directives  
  • Compiler pre-defined macros  
  • C++ classes, class members, and friends  
  • C++ overloading, special member functions, and inheritance  
  • C++ templates and exception handling  
  • z/OS C and z/OS C++ compatibility |
| **z/OS C/C++ Messages,** GC09-4819 | Provides error messages and return codes for the compiler, utilities, and IBM Open Class Library. For the C/C++ run-time library messages, refer to *z/OS Language Environment Run-Time Messages,* SA22-7566. |
| **z/OS C/C++ Run-Time Library Reference,** SA22-7821 | Reference information for:  
  • Header files  
  • Feature test macros  
  • Library functions |
| **z/OS C Curses,** SA22-7820 | Reference information for:  
  • Curses concepts  
  • Key data types  
  • General rules for characters, renditions, and window properties  
  • General rules of operations and operating modes  
  • Use of macros  
  • Restrictions on block-mode terminals  
  • Curses functional interface  
  • Contents of headers  
  • The terminfo database |
| **z/OS C/C++ Compiler and Run-Time Migration Guide,** GC09-4913 | Guidance and reference information for:  
  • Common migration questions  
  • Application executable program compatibility  
  • Source program compatibility  
  • Input and output operations compatibility  
  • Class library migration considerations  
  • Changes between releases of z/OS  
  • C/370™ to current compiler migration  
  • Other migration considerations |
| **IBM Open Class Library User’s Guide,** SC09-4811 | Guidance information for:  
  • Using the Complex Math Class Library: Review of complex numbers, header files, constructing complex objects, mathematical operators for complex, friend functions for complex, handling complex mathematics errors  
  • Using the I/O Stream Class Library: Introduction, getting started, advanced topics, and manipulators  
  • Using the Collection Class Library: Overview, instantiating and using, element and key functions, tailoring a collection implementation, polymorphic use of collections, support for notifications, exception handling, problem solving, compatibility with previous releases, thread safety  
  • Using the Application Support Class Library: Introduction, String classes, Exception and Trace classes, Date and Time classes, controlling threads and protecting data, the IBM Open Class notification framework, Binary Coded (Packed) Decimal classes, text and internationalization framework, testing |
Table 2. z/OS C/C++ Publications (continued)

<table>
<thead>
<tr>
<th>Document Title and Number</th>
<th>Key Sections/Chapters in the Document</th>
</tr>
</thead>
</table>
| IBM Open Class Library Reference, Vol. 1, SC09-4812 | Reference information for:  
- Complex Math Class Library  
- I/O Stream Class Library  
- Collection Class Library  
- Application Support Class Library |
| Debug Tool User’s Guide and Reference, SC09-2137 | Guidance and reference information for:  
- Preparing to debug programs  
- Debugging programs  
- Using Debug Tool in different environments  
- Language-specific information  
- Debug Tool reference |
| Standard C++ Library Reference, available on the z/OS C/C++ library page on the World Wide Web | The documentation, which is available at [http://www.ibm.com/software/ad/c390/czos/czosdocs.html](http://www.ibm.com/software/ad/c390/czos/czosdocs.html), covers using the following three main components of the Standard C++ Library to write portable C++ code that complies with the ISO standards:  
- ISO Standard C Library  
- ISO Standard C++ Library  
- Standard Template Library (C++)  
The ISO Standard C++ library consists of 51 required headers. These 51 C++ library headers (along with the additional 18 Standard C headers) constitute a hosted implementation of the C++ library. Of these 51 headers, 13 constitute the Standard Template Library, or STL. |
| APAR and BOOKS files (Shipped with Program materials) | Partitioned data set CBC.SCCNDOC on the product tape contains the members, APAR and BOOKS, which provide additional information for using the z/OS C/C++ licensed program, including:  
- Isolating reportable problems  
- Keywords  
- Preparing an Authorized Program Analysis Report (APAR)  
- Problem identification worksheet  
- Maintenance on z/OS  
- Late changes to z/OS C/C++ publications |


The following table lists the z/OS C/C++ and related publications. The table groups the publications according to the tasks they describe.

Table 3. Publications by Task

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning, preparing, and migrating to z/OS C/C++</td>
<td></td>
</tr>
</tbody>
</table>
- [z/OS C/C++ Compiler and Run-Time Migration Guide, GC09-4913](http://www.ibm.com/software/ad/c390/czos/czosdocs.html)  
- [z/OS Language Environment Customization, SA22-7564](http://www.ibm.com/software/ad/c390/czos/czosdocs.html)  
- [z/OS UNIX System Services Planning, GA22-7800](http://www.ibm.com/software/ad/c390/czos/czosdocs.html)  
- [z/OS and z/OS.e Planning for Installation, GA22-7504](http://www.ibm.com/software/ad/c390/czos/czosdocs.html) |
<table>
<thead>
<tr>
<th>Tasks</th>
<th>Documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installing</td>
<td>z/OS Program Directory</td>
</tr>
<tr>
<td></td>
<td>z/OS and z/OS.e Planning for Installation, GA22-7504</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Customization, SA22-7564</td>
</tr>
<tr>
<td>Coding programs</td>
<td>z/OS C/C++ Run-Time Library Reference, SA22-7821</td>
</tr>
<tr>
<td></td>
<td>C/C++ Language Reference, SC09-4815</td>
</tr>
<tr>
<td></td>
<td>z/OS C/C++ Programming Guide, SC09-4765</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Concepts Guide, SA22-7567</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Programming Guide, SA22-7561</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Programming Reference, SA22-7562</td>
</tr>
<tr>
<td></td>
<td>IBM Open Class Library User’s Guide, SC09-4811</td>
</tr>
<tr>
<td></td>
<td>IBM Open Class Library Reference, Vol. 1, SC09-4812</td>
</tr>
<tr>
<td>Coding and binding programs with interlanguage calls</td>
<td>z/OS C/C++ Programming Guide, SC09-4765</td>
</tr>
<tr>
<td></td>
<td>C/C++ Language Reference, SC09-4815</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Programming Guide, SA22-7561</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Writing Interlanguage Communication Applications, SA22-7563</td>
</tr>
<tr>
<td></td>
<td>z/OS MVS Program Management: User’s Guide and Reference, SA22-7643</td>
</tr>
<tr>
<td></td>
<td>z/OS MVS Program Management: Advanced Facilities, SA22-7644</td>
</tr>
<tr>
<td>Compiling, binding, and running programs</td>
<td>z/OS C/C++ User’s Guide, SC09-4767</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Programming Guide, SA22-7561</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Debugging Guide, GA22-7566</td>
</tr>
<tr>
<td></td>
<td>z/OS MVS Program Management: User’s Guide and Reference, SA22-7643</td>
</tr>
<tr>
<td></td>
<td>z/OS MVS Program Management: Advanced Facilities, SA22-7644</td>
</tr>
<tr>
<td>Compiling and binding applications in the z/OS UNIX environment</td>
<td>z/OS C/C++ User’s Guide, SC09-4767</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services User’s Guide, SA22-7801</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services Command Reference, SA22-7802</td>
</tr>
<tr>
<td></td>
<td>z/OS MVS Program Management: User’s Guide and Reference, SA22-7643</td>
</tr>
<tr>
<td></td>
<td>z/OS MVS Program Management: Advanced Facilities, SA22-7644</td>
</tr>
<tr>
<td>Debugging programs</td>
<td>README file</td>
</tr>
<tr>
<td></td>
<td>Debug Tool User’s Guide and Reference, SC09-2137</td>
</tr>
<tr>
<td></td>
<td>z/OS C/C++ User’s Guide, SC09-4767</td>
</tr>
<tr>
<td></td>
<td>z/OS C/C++ Messages, GC09-4819</td>
</tr>
<tr>
<td></td>
<td>z/OS C/C++ Programming Guide, SC09-4765</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Programming Guide, SA22-7561</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Debugging Guide, GA22-7566</td>
</tr>
<tr>
<td></td>
<td>z/OS Language Environment Run-Time Messages, SA22-7566</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services Messages and Codes, SA22-7807</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services User’s Guide, SA22-7801</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services Command Reference, SA22-7802</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services Programming Tools, SA22-7805</td>
</tr>
<tr>
<td>Using shells and utilities in the z/OS UNIX environment</td>
<td>z/OS C/C++ User’s Guide, SC09-4767</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services Command Reference, SA22-7802</td>
</tr>
<tr>
<td></td>
<td>z/OS UNIX System Services Messages and Codes, SA22-7807</td>
</tr>
<tr>
<td>Using sockets library functions in the z/OS UNIX environment</td>
<td>z/OS C/C++ Run-Time Library Reference, SA22-7821</td>
</tr>
</tbody>
</table>
### Table 3. Publications by Task (continued)

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Documents</th>
</tr>
</thead>
</table>
| Porting a UNIX Application to z/OS                                    | - *z/OS UNIX System Services Porting Guide*  
  This guide contains useful information about supported header files and C functions, sockets in z/OS UNIX, process management, compiler optimization tips, and suggestions for improving the application’s performance after it has been ported. The Porting Guide is available as a PDF file which you can download, or as web pages which you can browse, at the following web address: http://www-1.ibm.com/servers/eserver/zseries/zos/unix/bpxa1por.html |
| Working in the z/OS UNIX System Services Parallel Environment         | - *z/OS UNIX System Services Parallel Environment: Operation and Use*, SA22-7810  
  - *z/OS UNIX System Services Parallel Environment: MPI Programming and Subroutine Reference*, SA22-7812 |
| Performing diagnosis and submitting an Authorized Program Analysis Report (APAR) | - *z/OS C/C++ User’s Guide*, SC09-4767  
  - CBC.SCCNDOC(APAR) on z/OS C/C++ product tape |
| Tuning Large C/C++ Applications on z/OS UNIX System Services           | - IBM Redbook called *Tuning Large C/C++ Applications on z/OS UNIX System Services*, which is available at: http://www.redbooks.ibm.com/abstracts/sg245606.html |
| C/C++ Applications on OS/390 UNIX                                       | - IBM Redbook called *C/C++ Applications on OS/390 UNIX*, which is available at: http://www.redbooks.ibm.com/abstracts/sg245992.html |
| Performance considerations for XPLINK                                  | - IBM Redbook called *XPLink: OS/390th Extra Performance Linkage*, which is available at: http://www.redbooks.ibm.com/abstracts/sg245991.html |

**Note:** For information on using the prelinker, see the appendix on prelinking and linking z/OS C/C++ programs in *z/OS C/C++ User’s Guide*. As of OS/390 Version 2 Release 4, this appendix contains information that was previously in the chapter on prelinking and linking z/OS C/C++ programs in *z/OS C/C++ User’s Guide*. It also contains prelinker information that was previously in *z/OS C/C++ Programming Guide*.

### Hardcopy Documents

As of z/OS V1R4, the following z/OS C/C++ documents are available in hardcopy:

- *z/OS C/C++ User’s Guide*, SC09-4767  
- *z/OS C/C++ Messages*, GC09-4819  
- *z/OS C Curses*, SA22-7820  
- *z/OS C/C++ Compiler and Run-Time Migration Guide*, GC09-4913  
- *Debug Tool User’s Guide and Reference*, SC09-2137

You can purchase these documents on their own, or as part of a set. You receive *z/OS C/C++ Compiler and Run-Time Migration Guide*, GC09-4913 at no charge. Feature code 8009 includes the remaining documents.
Softcopy documents

The z/OS C/C++ publications are supplied in PDF and BookMaster® formats on the following CD: z/OS Collection, SK3T-4269. They are also available at the following Web site:


To read a PDF file, use the Adobe Acrobat Reader. If you do not have the Adobe Acrobat Reader, you can download it for free from the Adobe Web site:

http://www.adobe.com

To read a file in BookManager® format, use BookManager READ/MVS Version 1 Release 3 (5695-046) or the Library Reader™ for DOS, OS/2® or Windows® supplied on the CD-ROMs containing BookManager documents.

If your system has BookManager Read installed, you can enter the command BOOKMGR to start BookManager and display a list of documents available to you. If you know the name of the document that you want to view, you can use the OPEN command to open the document directly.

Note: If your workstation does not have graphics capability, BookManager Read cannot correctly display some characters, such as arrows and brackets.

You can also browse the documents on the World Wide Web by clicking on “The Library” link on the z/OS home page. The web address for this page is:

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

Softcopy examples

Most of the larger examples in the following documents are available in machine-readable form:

- C/C++ Language Reference, SC09-4815
- z/OS C/C++ User’s Guide, SC09-4767
- z/OS C/C++ Programming Guide, SC09-4765
- IBM Open Class Library User’s Guide, SC09-4811

In the following documents, a label on an example indicates that the example is distributed in softcopy. The label is the name of a member in the data sets CBC.SCCNSAM or the directory /usr/lpp/ioclib/sample. The labels have the form CCNxyyy or CLBxyyy, where x refers to a publication:

- R and X refer to C/C++ Language Reference, SC09-4815
- G refers to z/OS C/C++ Programming Guide, SC09-4765
- U refers to z/OS C/C++ User’s Guide, SC09-4767

Examples labelled as CCNxyyy appear in C/C++ Language Reference, z/OS C/C++ Programming Guide, and z/OS C/C++ User’s Guide. Examples labelled as CLBxyyy appear in the z/OS C/C++ User’s Guide. Additional IBM Open Class samples are provided as softcopy only. They can be found in the /usr/lpp/ioclib/sample directory.

z/OS C/C++ on the World Wide Web

Additional information on z/OS C/C++ is available on the World Wide Web on the z/OS C/C++ home page at:

http://www.ibm.com/software/ad/c390/czos
This page contains late-breaking information about the z/OS C/C++ product, including the compiler, the class libraries, and utilities. It also contains a tutorial on the source level interactive debugger. There are links to other useful information, such as the z/OS C/C++ information library and the libraries of other z/OS elements that are available on the Web. The z/OS C/C++ home page also contains samples that you can download, and links to other related Web sites.

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.

Accessing z/OS licensed documents on the Internet

z/OS licensed documentation is available on the Internet in PDF format at the IBM Resource Link™ Web site at:

http://www.ibm.com/servers/resourcelink

Licensed documents are available only to customers with a z/OS license. Access to these documents requires an IBM Resource Link user ID and password, and a key code. With your z/OS order you received a Memo to Licensees, (GI10-0671), that includes this key code.

To obtain your IBM Resource Link user ID and password, log on to:

http://www.ibm.com/servers/resourcelink

To register for access to the z/OS licensed documents:

1. Sign in to Resource Link using your Resource Link user ID and password.
2. Select User Profiles located on the left-hand navigation bar.

Note: You cannot access the z/OS licensed documents unless you have registered for access to them and received an e-mail confirmation informing you that your request has been processed.

Printed licensed documents are not available from IBM.

You can use the PDF format on either z/OS Licensed Product Library CD-ROM or IBM Resource Link to print licensed documents.

Using LookAt to look up message explanations

LookAt is an online facility that allows you to look up explanations for most 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 access LookAt from the Internet at:


or from anywhere in z/OS where you can access a TSO/E command line (for example, TSO/E prompt, ISPF, z/OS UNIX System Services running OMVS). You can also download code from the z/OS Collection (SK3T-4269) and the LookAt Web site that will allow you to access LookAt from a handheld computer (Palm Pilot VIIx suggested).
To use LookAt as a TSO/E command, you must have LookAt installed on your host system. You can obtain the LookAt code for TSO/E from a disk on your z/OS Collection (SK3T-4269) or from the News section on the LookAt Web site.

Some messages have information in more than one document. For those messages, LookAt displays a list of documents in which the message appears.
Chapter 2. About IBM z/OS C/C++

The C/C++ feature of the IBM z/OS licensed program provides support for C and C++ application development on the z/OS platform. The C/C++ feature is based on the C/C++ for MVS/ESA™ product.

z/OS C/C++ includes:
- A C compiler (referred to as the z/OS C compiler)
- A C++ compiler (referred to as the z/OS C++ compiler)
- Support for the Standard C++ Library
- Application Support Class and Collection Class Library source
- A mainframe interactive Debug Tool (optional)
- Performance Analyzer host component, which supports the IBM C/C++ Productivity Tools for OS/390 product
- A set of utilities for C/C++ application development

IBM offers the C language on other platforms, such as the AIX®, OS/400®, VM/ESA®, and VSE/ESA™ operating systems. The AIX and OS/400 operating systems also offer the C++ language.

Changes for z/OS V1R4

Note: The z/OS V1R4 C/C++ compiler is functionally equivalent to the z/OS V1R2 C/C++ compiler. This section describes the changes that are specific to the z/OS V1R4 Language Environment.

For z/OS V1R4, Language Environment provides the following:
- Internet Protocol Version 6 (IPv6)
  Support for IPv6 is described in the chapter “Network Communications under UNIX System Services”.
- G11N White Paper Currency Support
  This support provides additional country support by locales.
- Enhanced Pthread Quiesce
  Information is added on SIGTHSTOP and SIGTHCONT in the chapter "Handling Exceptions, Error Conditions, and Signals”.
- z/OS.e
  Information is added to include Language Environment support in z/OS.e.

The C/C++ compilers

The following sections describe the C and C++ languages and the z/OS C/C++ compilers.

The C language

The C language is a general purpose, versatile, and functional programming language that allows a programmer to create applications quickly and easily. C provides high-level control statements and data types as do other structured programming languages. It also provides many of the benefits of a low-level language.
The C++ language

The C++ language is based on the C language and includes all of the advantages of C listed above. In addition, C++ also supports object-oriented concepts, type genericity or templates, and an extensive library. For a detailed description of the differences between z/OS C++ and z/OS C, refer to the z/OS C/C++ Language Reference.

The C++ language introduces classes, which are user-defined data types that may contain data definitions and function definitions. You can use classes from established class libraries, develop your own classes, or derive new classes from existing classes by adding data descriptions and functions. New classes can inherit properties from one or more classes. Not only do classes describe the data types and functions available, but they can also hide (encapsulate) the implementation details from user programs. An object is an instance of a class.

The C++ language also provides templates and other features that include access control to data and functions, and better type checking and exception handling. It also supports polymorphism and the overloading of operators.

Common features of the z/OS C and C++ compilers

The C and C++ compilers, when used with z/OS Language Environment, offer many features to help your work:

- Optimization support:
  - Algorithms to take advantage of the S/390® architecture to get better optimization for speed and use of computer resources through the OPTIMIZE and IPA compiler options.
  - The OPTIMIZE compiler option, which instructs the compiler to optimize the machine instructions it generates to produce faster-running object code, which improves application performance at run time.
  - Interprocedural Analysis (IPA), to perform optimizations across compilation units, thereby optimizing application performance at run time.

- DLLs (dynamic link libraries) to share parts among applications or parts of applications, and dynamically link to exported variables and functions at run time. DLLs allow a function reference or a variable reference in one executable to use a definition located in another executable at run time. You can use both load-on-reference and load-on-demand DLLs. When your program refers to a function or variable which resides in a DLL, z/OS C/C++ generates code to load the DLL and access the functions and variables within it. This is called load-on-reference. Alternatively, your program can use z/OS C library functions to load a DLL and look up the address of functions and variables within it. This is called load-on-demand. Your application code explicitly controls load-on-demand DLLs at the source level.
  
  You can use DLLs to split applications into smaller modules and improve system memory usage. DLLs also offer more flexibility for building, packaging, and redistributing applications.

- Full program reentrancy

  With reentrancy, many users can simultaneously run a program. A reentrant program uses less storage if it is stored in the LPA (link pack area) or ELPA (extended link pack area) and simultaneously run by multiple users. It also reduces processor I/O when the program starts up, and improves program performance by reducing the transfer of data to auxiliary storage. z/OS C programmers can design programs that are naturally reentrant. For those programs that are not naturally reentrant, C programmers can use constructed
reentry. To do this, compile programs with the RENT option and use the program management binder supplied with z/OS or the z/OS Language Environment prelinker and program management binder. The z/OS C++ compiler always ensures that C++ programs are reentrant.

- **INLINE compiler option**
  
  Additional optimization capabilities are available with the INLINE compiler option.

- **Locale-based internationalization support derived from IEEE POSIX 1003.2-1992 standard. Also derived from X/Open CAE Specification, System Interface Definitions, Issue 4 and Issue 4 Version 2. This allows programmers to use locales to specify language/country characteristics for their applications.**

- **The ability to call and be called by other languages such as assembler, COBOL, PL/1, compiled Java™, and Fortran, to enable programmers to integrate z/OS C/C++ code with existing applications.**

- **Exploitation of z/OS and z/OS UNIX technology.**
  
  z/OS UNIX is an IBM implementation of the open operating system environment, as defined in the XPG4 and POSIX standards.

- **Support for the following standards at the system level:**
  - A subset of the extended multibyte and wide character functions as defined by Programming Language C Amendment 1. This is ISO/IEC 9899:1990/Amendment 1:1994(E)
  - A subset of IEEE POSIX 1003.1a, Draft 6, July 1991
  - IEEE Portable Operating System Interface (POSIX) Part 2, P1003.2
  - A subset of IEEE POSIX 1003.4a, Draft 6, February 1992 (the IEEE POSIX committee has renumbered POSIX.4a to POSIX.1c)
  - X/Open CAE Specification, System Interfaces and Headers, Issue 4 Version 2
  - X/Open CAE Specification, Network Services, Issue 4

- **Year 2000 support**

- **Support for the Euro currency**

**z/OS C Compiler specific features**

In addition to the features common to z/OS C and C++, the z/OS C compiler provides you with the following capabilities:

- **The ability to write portable code that supports the following standards:**
  - All elements of the ISO standard ISO/IEC 9899:1990 (E)
  - X/Open Specification Programming Language Issue 3, Common Usage C
  - FIPS-160

- **System programming capabilities, which allow you to use z/OS C in place of assembler**

- **Extensions of the standard definitions of the C language to provide programmers with support for the z/OS environment, such as fixed-point (packed) decimal data support**
z/OS C++ Compiler specific features

In addition to the features common to z/OS C and C++, the z/OS C++ compiler supports the *International Standard for the C++ Programming Language (ISO/IEC 14882:1998)* specification.

Class libraries

z/OS V1R2 C/C++ provides the following class libraries, which are all thread-safe:
- Standard C++ Library, including the Standard Template Library (STL), and other library features of ISO C++ 1998
- IBM Open Class Library for z/OS V1R2
- IBM Open Class Library for OS/390 V2R10

Refer to [z/OS C/C++ Compiler and Run-Time Migration Guide, GC09-4913](#) and [IBM Open Class Library User’s Guide, SC09-4811](#) for more details on the components of these libraries.

For new code and enhancements to existing applications, the Standard C++ Library should be used. The Standard C++ Library includes the following:
- Stream classes for performing input and output (I/O) operations
- The Standard Template Library (STL) which is composed of C++ template-based algorithms, container classes, iterators, localization objects, and the string class

As of z/OS V1R2, an upgraded level of IOC is included, which is consistent with that shipped in VisualAge C++ for AIX V5.0. 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.

The z/OS V1R2 IBM Open Class Library includes:
- The Application Support Class Library which provides the basic abstractions that are needed during the creation of most C++ applications, including String, Date, Time, and Decimal. The Application Support Class Library corresponds to the IOC member in the data sets.
- The Collection Class Library implements a wide variety of classical data structures such as stack, tree, list, hash table, and so on. The Collection Class Library provides developers with a consistent set of building blocks from which they can derive application objects. The library design exploits features of the C++ language such as exception handling and template support. The Collection Class Library corresponds to the COLL member in the data sets.

The OS/390 V2R10 IBM Open Class Library and USL class libraries include the following:
- The USL I/O Stream Class Library (corresponds to the IOSTREAM member in the data sets)
- The USL Complex Mathematics Class Library (corresponds to the COMPLEX member in the data sets)
- The Application Support Class Library (corresponds to the APPSUPP member in the data sets)
- The Collection Class Library (corresponds to the COLLECT member in the data sets)
Note: Retroactive to OS/390 Version 1 Release 3, the IBM Open Class Library is licensed with the base operating system. This enables applications to use this library at run time without having to license the z/OS C/C++ compiler features or to use the DLL Rename Utility.

IBM Open Class Library Source

The IBM Open Class Library Source consists of the following:

- Application Support Class Library source code
- Collection Class Library source code

Utilities

The z/OS C/C++ compilers provide the following utilities:

- The CXXFILT utility to map z/OS C++ mangled names to the original source.
- The DSECT Conversion Utility to convert descriptive assembler DSECTs into z/OS C/C++ data structures.
- The localedef utility to read the locale definition file and produce a locale object that the locale-specific library functions can use.
- The makedepend utility to derive all dependencies in the source code and write these into the makefile for the make command to determine which source files to recompile, whenever a dependency has changed. This frees the user from manually monitoring such changes in the source code.

z/OS Language Environment provides the following utilities:

- The Object Library Utility (C370LIB) to update partitioned data set (PDS and PDSE) libraries of object modules and Interprocedural Analysis (IPA) object modules.
- The DLL Rename Utility to make selected DLLs a unique component of the applications with which they are packaged. The DLL Rename Utility does not support XPLINK.
- The prelinker which combines object modules that comprise a z/OS C/C++ application, to produce a single object module. The prelinker supports only object and extended object format input files, and does not support GOFF.

The Debug Tool

z/OS C/C++ supports program development by using the Debug Tool. This optionally available tool allows you to debug applications in their native host environment, such as CICS/ESA®, IMS/ESA®, DB2, and so on. The Debug Tool provides the following support and function:

- Step mode
- Breakpoints
- Monitor
- Frequency analysis
- Dynamic patching

You can record the debug session in a log file, and replay the session. You can also use the Debug Tool to help capture test cases for future program validation, or to further isolate a problem within an application.

You can specify either data sets or hierarchical file system (HFS) files as source files.
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 the workstation, while remaining close to your familiar host environment. IBM C/C++ Productivity Tools for OS/390 includes the following workstation-based tools to increase your productivity and code quality:

- A Performance Analyzer to help you analyze, understand, and tune your C and C++ applications for improved performance
- A Distributed Debugger that allows you to debug C or C++ programs from the convenience of the workstation
- A workstation-based 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 includes 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 execution 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 or C++ application remotely from your workstation. Set a break point with the simple 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.

References to Performance Analyzer in this document refer to the IBM OS/390 Performance Analyzer included in the C/C++ Productivity Tools for OS/390 product.

z/OS Language Environment

z/OS C/C++ exploits the C/C++ run-time environment and library of run-time services available with z/OS Language Environment (formerly OS/390 Language Environment, Language Environment for MVS™ & VM, Language Environment/370 and LE/370).

z/OS Language Environment consists of four language-specific run-time libraries, and Base Routines and Common Services, as shown below. z/OS Language
Environment establishes a common run-time environment and common run-time services for language products, user programs, and other products.

The common execution environment is composed of data items and services that are included in library routines available to an application that runs in the environment. The z/OS Language Environment provides a variety of services:

- Services that satisfy basic requirements common to most applications. These include support for the initialization and termination of applications, allocation of storage, interlanguage communication (ILC), and condition handling.
- Extended services that are often needed by applications. z/OS C/C++ contains these functions within a library of callable routines, and include interfaces to operating system functions and a variety of other commonly used functions.
- Run-time options that help in the execution, performance, and diagnosis of your application.
- Access to operating system services; z/OS UNIX services are available to an application programmer or program through the z/OS C/C++ language bindings.
- Access to language-specific library routines, such as the z/OS C/C++ library functions.

**Note:** The z/OS Language Environment runtime option TRAP(ON) should be set when using z/OS C/C++. Refer to the [z/OS Language Environment Programming Reference](#) for details on the z/OS Language Environment runtime options.

### z/OS Language Environment downward compatibility

z/OS Language Environment provides downward compatibility support. Assuming that you have met the required programming guidelines and restrictions, described in the [z/OS Language Environment Programming Guide](#), this support enables you to develop applications on higher release levels of z/OS for use on platforms that are running lower release levels of z/OS or OS/390. In C and C++, downward compatibility support is provided through the C/C++ TARGET compiler option. See [z/OS C/C++ User’s Guide](#) for details on this compiler option.

For example, a company may use z/OS V1R4 with Language Environment on a development system where applications are coded, link-edited, and tested, while using any supported lower release of OS/390 or z/OS Language Environment on their production systems where the finished application modules are used.
Downward compatibility support is not the roll-back of new function to prior releases of the operating system. Applications developed that exploit the downward compatibility support must not use any Language Environment function that is unavailable on the lower release of OS/390 or z/OS where the application will be used.

The downward compatibility support includes toleration PTFs for lower releases of OS/390 or z/OS to assist in diagnosing applications that do not meet the programming requirements for this support. (Specific PTF numbers can be found in the PSP buckets.)

The downward compatibility support provided by z/OS Language Environment and by the toleration PTFs does not change Language Environment's upward compatibility. That is, applications coded and link-edited with one release of OS/390 or z/OS Language Environment will continue to run on later releases of OS/390 or z/OS Language Environment without the need to recompile or re-link edit the application, independent of the downward compatibility support.

Downward compatibility is supported in earlier releases of OS/390 C/C++ (from Version 2 Release 6), but in OS/390 V2R6, the user is required to copy header files and link-edit SYSLIB data sets from the deployment release of OS/390. Starting with OS/390 Version 2 Release 10, the current level header files and SYSLIB can be used (the user no longer has to copy header files and SYSLIB data sets from the deployment release).

### About prelinking, linking, and binding

When describing the process to build an application, this document refers to the bind step.

Normally the Program Management Binder is used to perform the bind step. However, in many cases the prelink and link steps can be used in place of the bind step. When they cannot be substituted, and the Program Management binder alone must be used, it will be stated. For more information on the bind, prelink, and link steps, refer to [z/OS C/C++ User’s Guide](#).

The terms *bind* and *link* have multiple meanings.
- With respect to building an application:
  - In both instances, the program management binder is performing the actual processing of converting the object file(s) into the application executable module.
  - Object files with longname symbols, reentrant writable static symbols, and DLL-style function calls require additional processing to build global data for the application.
  - The term *link* refers to the case where the binder does not perform this additional processing, due to one of the following:
    - The processing is not required, because none of the object files in the application use constructed reentrancy, use long names, are DLL or are C++.
    - The processing is handled by executing the prelinker step before running the binder.
  - The term *bind* refers to the case where the binder is required to perform this processing.
- With respect to executing code in an application:
The linkage definition refers to the program call linkage between program functions and methods. This includes the passing of control and parameters. Refer to `C/C++ Language Reference` for more information on linkage specification.

Some platforms have a single linkage convention. S/390 has a number of linkage conventions, including standard operating system linkage, Extra Performance Linkage (XPLINK), and different non-XPLINK linkage conventions for C and C++.

**Notes on the prelinking process**

Note that you cannot use the prelinker if you are using the XPLINK or GOFF compiler options. Also, IBM recommends using the binder without the prelinker whenever possible.

Prior to OS/390 V2R4 C/C++, the `z/OS C/C++ User’s Guide` showed how to use the prelinker and linkage editor. Sections throughout the book discussed concepts of prelinking and linking. The prelinker was designed to process long names and support constructed reentrancy in earlier versions of the C compiler on the MVS and OS/390 operating systems. The prelinker, shipped with the z/OS C/C++ run-time library, provides output that is compatible with the linkage editor, that is shipped with the binder.

The binder is designed to include the function of the prelinker, the linkage editor, the loader, and a number of APIs to manipulate the program object. Thus, the binder is a superset of the linkage editor. Its functionality provides a high level of compatibility with the prelinker and linkage editor, but provides additional functionality in some areas. Generally, the terms binding and linking are interchangeable. For more information on the compatibility between the binder, and the linker and prelinker, see `z/OS DFSMS Program Management`.

Updates to the prelinking, linkage-editing, and loading functions that are performed by the binder are delivered through the binder. If you use the prelinker shipped with the z/OS C/C++ run-time library and the linkage editor (supplied through the binder) you have to apply the latest maintenance for the run-time library as well as the binder.

If you still need to use the prelinker and linkage editor, see `z/OS C/C++ User’s Guide`.

**File format considerations**

You can use the binder in place of the prelinker and linkage editor but there are exceptions, which are file format considerations. For further information, on when you cannot use the binder, see the chapter about binding z/OS C/C++ programs in the `z/OS C/C++ User’s Guide`.

**The Program Management binder**

The binder provided with z/OS combines the object modules, load modules, and program objects comprising an application. It produces a single z/OS output program object or load module that you can load for execution. The binder supports all C and C++ code, provided that you store the output program in a PDSE (Partitioned Data Set Extended) member or an HFS file.

If you cannot use a PDSE member or HFS file, and your program contains C++ code, or C code that is compiled with any of the RENT, LONGNAME, DLL or IPA compiler...
options, you must use the prelinker. C and C++ code compiled with the GOFF or XPLINK compiler options cannot be processed by the prelinker.

Using the binder without using the prelinker has the following advantages:

- Faster rebinds when recompiling and rebinding a few of your source files
- Rebinding at the single compile unit level of granularity (except when you use the IPA compile-time option)
- Input of object modules, load modules, and program objects
- Improved long name support:
  - Long names do not get converted into prelinker generated names
  - Long names appear in the binder maps, enabling full cross-referencing
  - Variables do not disappear after prelink
  - Fewer steps in the process of producing your executable program

Using the binder without using the prelinker has the following disadvantage:

- Long name maximum symbol length:
  - Long names currently processed by the binder are limited to 1024 characters. The prelinker supports up to \((32 \cdot K - 1)\) characters. IBM intends to bring the binder limit in line with the prelinker in a future release.

The prelinker provided with z/OS Language Environment combines the object modules comprising a z/OS C/C++ application and produces a single object module. You can link-edit the object module into a load module (which is stored in a PDS), or bind it into a load module or a program object (which is stored in a PDS, PDSE, or HFS file).

**Note:** For further information on the binder, refer to the DFSMS home page at http://www.ibm.com/storage/software/sms/smshome.htm.

### z/OS UNIX System Services (z/OS UNIX)

z/OS UNIX provides capabilities under z/OS to make it easier to implement or port applications in an open, distributed environment. z/OS UNIX Services are available to z/OS C/C++ application programs through the C/C++ language bindings available with z/OS Language Environment.

Together, the z/OS UNIX System Services, z/OS Language Environment, and z/OS C/C++ compilers provide an application programming interface that supports industry standards.

z/OS UNIX provides support for both existing z/OS applications and new z/OS UNIX applications through the following:

- C programming language support as defined by ISO C
- C++ programming language support as defined by ISO C++
- C language bindings as defined in the IEEE 1003.1 and 1003.2 standards; subsets of the draft 1003.1a and 1003.4a standards; X/Open CAE Specification: System Interfaces and Headers, Issue 4, Version 2, which provides standard interfaces for better source code portability with other conforming systems; and X/Open CAE Specification, Network Services, Issue 4, which defines the X/Open UNIX descriptions of sockets and X/Open Transport Interface (XTI)
- z/OS UNIX Extensions that provide z/OS-specific support beyond the defined standards
- The z/OS UNIX Shell and Utilities feature, which provides:
- A shell, based on the Korn Shell and compatible with the Bourne Shell
- A shell, tcsh, based on the C shell, csh
- Tools and utilities that support the X/Open Single UNIX Specification, also known as X/Open Portability Guide (XPG) Version 4, Issue 2, and provide z/OS support. The following is a partial list of utilities that are included:
  
  **ar** Creates and maintains library archives
  
  **BPXBATCH** Allows you to submit batch jobs that run shell commands, scripts, or z/OS C/C++ executable files in HFS files from a shell session
  
  **c89** Compiles, assembles, and binds z/OS UNIX C/C++ and assembler applications
  
  **dbx** Provides an environment to debug and run programs
  
  **gencat** Merges the message text source files message file (usually *.msg) into a formatted message catalog file (usually *.cat)
  
  **iconv** Converts characters from one code set to another
  
  **lex** Automatically writes large parts of a lexical analyzer based on a description that is supplied by the programmer
  
  **localedef** Creates a compiled locale object
  
  **make** Helps you manage projects containing a set of interdependent files, such as a program with many z/OS source and object files, keeping all such files up to date with one another
  
  **yacc** Allows you to write compilers and other programs that parse input according to strict grammar rules
  
- Support for other utilities such as:
  
  **c++** Compiles, assembles, and binds z/OS UNIX C++ applications
  
  **mkcatdefs** Preprocesses a message source file for input to the gencat utility
  
  **runcat** Invokes mkcatdefs and pipes the message catalog source data (the output from mkcatdefs) to gencat
  
  **dspcat** Displays all or part of a message catalog
  
  **dspmsg** Displays a selected message from a message catalog

- The z/OS UNIX Debugger feature, which provides the dbx interactive symbolic debugger for z/OS UNIX applications
- Access to a hierarchical file system (HFS), with support for the POSIX.1 and XPG4 standards
- z/OS C/C++ I/O routines, which support using HFS files, standard z/OS data sets, or a mixture of both
- Application threads (with support for a subset of POSIX.4a)
- Support for z/OS C/C++ DLLs

z/OS UNIX offers program portability across multivendor operating systems, with support for POSIX.1, POSIX.1a (draft 6), POSIX.2, POSIX.4a (draft 6), and XPG4.2.

For application developers who have worked with other UNIX environments, the z/OS UNIX Shell and Utilities are a familiar environment for C/C++ application development. If you are familiar with existing MVS development environments, you
may find that the z/OS UNIX environment can enhance your productivity. Refer to z/OS UNIX System Services User’s Guide for more information on the Shell and Utilities.

z/OS C/C++ Applications with z/OS UNIX C/C++ functions

All z/OS UNIX C functions are available at all times. In some situations, you must specify the POSIX(ON) run-time option. This is required for the POSIX.4a threading functions, and the system() and signal handling functions where the behavior is different between POSIX/XPG4 and ISO. Refer to z/OS C/C++ Run-Time Library Reference for more information about requirements for each function.

You can invoke a z/OS C/C++ program that uses z/OS UNIX C functions using the following methods:

- Directly from a shell.
- From another program, or from a shell, using one of the exec family of functions, or the BPXBATCH utility from TSO or MVS batch.
- Using the POSIX system() call.
- Directly through TSO or MVS batch without the use of the intermediate BPXBATCH utility. In some cases, you may require the POSIX(ON) run-time option.

Input and output

The C/C++ run-time library that supports the z/OS C/C++ compiler supports different input and output (I/O) interfaces, file types, and access methods. The Standard C++ Library provides additional support.

I/O interfaces

The C/C++ run-time library supports the following I/O interfaces:

C Stream I/O

This is the default and the ISO-defined I/O method. This method processes all input and output on a per-character basis.

Record I/O

The library can also process your input and output by record. A record is a set of data that is treated as a unit. It can also process VSAM data sets by record. Record I/O is a z/OS C/C++ extension to the ISO standard.

TCP/IP Sockets I/O

z/OS UNIX provides support for an enhanced version of an industry-accepted protocol for client/server communication that is known as sockets. A set of C language functions provides support for z/OS UNIX sockets. z/OS UNIX sockets correspond closely to the sockets used by UNIX applications that use the Berkeley Software Distribution (BSD) 4.3 standard (also known as OE sockets). The slightly different interface of the X/Open CAE Specification, Networking Services, Issue 4, is supplied as an additional choice. This interface is known as X/Open Sockets.

The z/OS UNIX socket application program interface (API) provides support for both UNIX domain sockets and Internet domain sockets. UNIX domain sockets, or local sockets, allow interprocess communication within z/OS, independent of TCP/IP. Local sockets behave like traditional UNIX sockets.
and allow processes to communicate with one another on a single system. With Internet sockets, application programs can communicate with each other in the network using TCP/IP.

In addition, the Standard C++ Library provides stream classes, which support formatted I/O in C++. You can code sophisticated I/O statements easily and clearly, and define input and output for your own data types. This helps improve the maintainability of programs that use input and output.

File types

In addition to conventional files, such as sequential files and partitioned data sets, the C/C++ run-time library supports the following file types:

**Virtual Storage Access Method (VSAM) Data Sets**
z/OS C/C++ has native support for three types of VSAM data organization:
- Key-sequenced data sets (KSDS). Use KSDS to access a record through a key within the record. A key is one or more consecutive characters that are taken from a data record that identifies the record.
- Entry-sequenced data sets (ESDS). Use ESDS to access data in the order it was created (or in reverse order).
- Relative-record data sets (RRDS). Use RRDS for data in which each item has a particular number (for example, a telephone system where a record is associated with each telephone number).

For more information on how to perform I/O operations on these VSAM file types, see Chapter 13, “Performing VSAM I/O Operations” on page 167.

**Hierarchical File System Files**
z/OS C/C++ recognizes Hierarchical File System (HFS) file names. The name specified on the fopen() or freopen() call has to conform to certain rules (described in z/OS C/C++ Programming Guide). You can create regular HFS files, special character HFS files, or FIFO HFS files. You can also create links or directories.

**Memory Files**
Memory files are temporary files that reside in memory. For improved performance, you can direct input and output to memory files rather than to devices. Since memory files reside in main storage and only exist while the program is executing, you primarily use them as work files. You can access memory files across load modules through calls to non-POSIX system() and C fetch(); they exist for the life of the root program. Standard streams can be redirected to memory files on a non-POSIX system() call using command line redirection.

**Hiperspace™ Expanded Storage**
Large memory files can be placed in Hiperspace expanded storage to free up some of your home address space for other uses. Hiperspace expanded storage or high performance space is a range of up to 2 GB of contiguous virtual storage space. A program can use this storage as a buffer (1 gigabyte(GB) = 2^30 bytes).

**Additional I/O features**
z/OS C/C++ provides additional I/O support through the following features:
• Large file support, which enables I/O to and from hierarchical file system (HFS) files that are larger than 2 GB (for more information on large file support in the Standard C++ Library, see z/OS C/C++ V1R2 Standard C++ Library Features at the following Web site: http://www.ibm.com/software/ad/c390/czos/czosdocs.html

• User error handling for serious I/O failures (SIGIOERR)

• Improved sequential data access performance through enablement of the DFSMS/MVS® support for 31-bit sequential data buffers and sequential data striping on extended format data sets

• Full support of PDSEs on z/OS (including support for multiple members opened for write)

• Overlapped I/O support under z/OS (NCP, BUFNO)

• Multibyte character I/O functions

• Fixed-point (packed) decimal data type support in formatted I/O functions

• Support for multiple volume data sets that span more than one volume of DASD or tape

• Support for Generation Data Group I/O

---

**The System Programming C facility**

The System Programming C (SPC) facility allows you to build applications that require no dynamic loading of z/OS Language Environment libraries. It also allows you to tailor your application for better utilization of the the low-level services available on your operating system. SPC offers a number of advantages:

• You can develop applications that can be executed in a customized environment rather than with z/OS Language Environment services. Note that if you do not use z/OS Language Environment services, only some built-in functions and a limited set of C/C++ run-time library functions are available to you.

• You can substitute the z/OS C language in place of assembler language when writing system exit routines, by using the interfaces that are provided by SPC.

• SPC lets you develop applications featuring a user-controlled environment, in which a z/OS C environment is created once and used repeatedly for C function execution from other languages.

• You can utilize co-routines, by using a two-stack model to write application service routines. In this model, the application calls on the service routine to perform services independent of the user. The application is then suspended when control is returned to the user application.

---

**Interaction with other IBM products**

When you use z/OS C/C++, you can write programs that utilize the power of other IBM products and subsystems:

• Cross System Product (CSP)

  Cross System Product/Application Development (CSP/AD) is an application generator that provides ways to interactively define, test, and generate application programs to improve productivity in application development. Cross System Product/Application Execution (CSP/AE) takes the generated program and executes it in a production environment.

  **Note:** You cannot compile CSP applications with the z/OS C++ compiler. However, your z/OS C++ program can use interlanguage calls (ILC) to call z/OS C programs that access CSP.
• Customer Information Control System (CICS)
You can use the CICS/ESA Command-Level Interface to write C/C++ application
programs. The CICS Command-Level Interface provides data, job, and task
management facilities that are normally provided by the operating system.

**Note:** Code preprocessed with CICS/ESA versions prior to V4R1 is not
supported for z/OS C++ applications. z/OS C++ code preprocessed on
CICS/ESA V4R1 cannot run under CICS/ESA V3R3.

• DB2 Universal Database™ (UDB) for z/OS
DB2 programs manage data that is stored in relational databases. You can
access the data by using a structured set of queries that are written in Structured
Query Language (SQL).
A DB2 program uses SQL statements that are embedded in the application
program. The SQL translator (DB2 preprocessor) translates the embedded SQL
into host language statements, which are then compiled by the z/OS C/C++
compilers.

**Note:** Alternatively, use the SQL compiler option to compile a DB2 program
without using the DB2 preprocessor.
The DB2 program processes requests, then returns control to the application
program.

• Data Window Services (DWS)
The Data Window Services (DWS) part of the Callable Services Library allows
your C or C++ program to manipulate temporary data objects that are known as
TEMPSPACE and VSAM linear data sets.

• Information Management System (IMS)
The Information Management System/Enterprise Systems Architecture (IMS/ESA)
product provides support for hierarchical databases.

• Interactive System Productivity Facility (ISPF)
z/OS C/C++ provides access to the Interactive System Productivity Facility
(ISPF) Dialog Management Services. A dialog is the interaction between a user
and a computer. The dialog interface contains display, variable, message, and
dialog services as well as other facilities that are used to write interactive
applications.

• Graphical Data Display Manager (GDDM)
GDDM provides a comprehensive set of functions to display and print
applications most effectively:
  – A windowing system that the user can tailor to display selected information
  – Support for presentation and keyboard interaction
  – Comprehensive graphics support
  – Fonts (including support for the double-byte character set)
  – Business image support
  – Saving and restoring graphic pictures
  – Support for many types of display terminals, printers, and plotters

• Query Management Facility (QMF)
z/OS C supports the Query Management Facility (QMF), a query and report
writing facility, which allows you to write applications through a callable interface.
You can create applications to perform a variety of tasks, such as data entry,
query building, administration aids, and report analysis.

• z/OS Java Support
The Java language supports the Java Native Interface (JNI) for making calls to and from C/C++. These calls do not use ILC support but rather the Java defined interface JNI. Java code, which has been compiled using the High Performance Compiler for Java (HPCJ), will support the JNI interface. Calls to C or C++ do not distinguish between compiled Java and interpreted Java.

### Additional features of z/OS C/C++

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>long long Data Type</strong></td>
<td>The z/OS C/C++ compiler supports long long as a native data type when the compiler option LANGLVL(LONGLONG) is turned on. This option is turned on by default by the compiler option LANGLVL(EXTENDED).</td>
</tr>
<tr>
<td><strong>Multibyte Character Support</strong></td>
<td>z/OS C/C++ supports multibyte characters for those national languages such as Japanese whose characters cannot be represented by a single byte.</td>
</tr>
<tr>
<td><strong>Wide Character Support</strong></td>
<td>Multibyte characters can be normalized by z/OS C library functions and encoded in units of one length. These normalized characters are called wide characters. Conversions between multibyte and wide characters can be performed by string conversion functions such as wcstombs(), mbstowcs(), wcsrtombs(), and mbstowcs(), as well as the family of wide-character I/O functions. Wide-character data can be represented by the wchar_t data type.</td>
</tr>
<tr>
<td><strong>Extended Precision Floating-Point Numbers</strong></td>
<td>z/OS C/C++ provides three S/390 floating-point number data types: single precision (32 bits), declared as float; double precision (64 bits), declared as double; and extended precision (128 bits), declared as long double. Extended precision floating-point numbers give greater accuracy to mathematical calculations. As of Release 6, z/OS C/C++ also supports IEEE 754 floating-point representation. By default, float, double, and long double values are represented in IBM S/390 floating point format. However, the IEEE 754 floating-point representation is used if you specify the FLOAT(IEEE754) compile option. For details on this support, see the description of the FLOAT option in z/OS C/C++ User’s Guide.</td>
</tr>
<tr>
<td><strong>Command Line Redirection</strong></td>
<td>You can redirect the standard streams stdin, stderr, and stdout from the command line or when calling programs using the system() function.</td>
</tr>
<tr>
<td><strong>National Language Support</strong></td>
<td>z/OS C/C++ provides message text in either American English or Japanese. You can dynamically switch between these two languages.</td>
</tr>
<tr>
<td><strong>Locale Definition Support</strong></td>
<td>z/OS C/C++ provides a locale definition utility that supports the creation of separate files of internationalization data, or locales. Locales can be used at run time to customize the behavior of an application to national language, culture, and coded character set (code page) requirements. Locale-sensitive library functions, such as isdigit(), use this information.</td>
</tr>
<tr>
<td><strong>Coded Character Set (Code Page) Support</strong></td>
<td>The z/OS C/C++ compiler can compile C/C++ source written in different EBCDIC code pages. In addition, the iconv utility converts data or source from one code page to another.</td>
</tr>
<tr>
<td><strong>Selected Built-in Library Functions</strong></td>
<td>Selected library functions, such as string and character functions, are built into the compiler to improve performance execution. Built-in functions are compiled into the executable, and no calls to the library are generated.</td>
</tr>
<tr>
<td><strong>Multi-threading</strong></td>
<td>Threads are efficient in applications that allow them to take advantage of any underlying parallelism available in the host environment. This underlying parallelism in the host can be exploited either by forking a process and creating a new address space, or by using multiple threads within a single process. For more information, refer to the Chapter 23, “Using Threads in z/OS UNIX Applications” on page 329.</td>
</tr>
</tbody>
</table>
Multitasking Facility (MTF) | Multitasking is a mode of operation where your program performs two or more tasks at the same time. z/OS C provides a set of library functions that perform multitasking. These functions are known as the Multitasking Facility (MTF). MTF uses the multitasking capabilities of z/OS to allow a single z/OS C application program to use more than one processor of a multiprocessing system simultaneously. Note: XPLINK is not supported in an MTF environment. You can also use threads to perform multitasking with or without XPLINK, as described in the Chapter 23, “Using Threads in z/OS UNIX Applications” on page 329.

Packed Structures and Unions | z/OS C provides support for packed structures and unions. Structures and unions may be packed to reduce the storage requirements of an z/OS C program or to define structures that are laid out according to COBOL or PL/I structure layout rules.

Fixed-point (Packed) Decimal Data | z/OS C supports fixed-point (packed) decimal as a native data type for use in business applications. The packed data type is similar to the COBOL data type COMP-3 or the PL/I data type FIXED DEC, with up to 31 digits of precision. The Application Support Class Library provides the Binary Coded Decimal Class for C++ programs.

Long Name Support | For portability, external names can be mixed case and up to 1024 characters in length. For C++, the limit applies to the mangled version of the name.

System Calls | You can call commands or executable modules using the system() function under z/OS, z/OS UNIX, and TSO. You can also use the system() function to call EXECs on z/OS and TSO, or Shell scripts using z/OS UNIX.

Exploitation of ESA | Support for z/OS, IMS/ESA, Hiperspace expanded storage, and CICS/ESA allows you to exploit the features of the ESA.

Exploitation of hardware | Use the ARCHITECTURE compiler option to select the minimum level of machine architecture on which your program will run. ARCH(2) instructs the compiler to generate faster instruction sequences that are available only on newer machines. ARCH(3) also generates these faster instruction sequences and enables support for IEEE 754 Binary Floating-Point instructions. Code compiled with ARCH(2) runs on G2, G3, G4, and 2003 processors and code compiled with ARCH(3) runs on a G5 or G6 processor, and follow-on models.

Use the TUNE compiler option to optimize your application for a specific machine architecture. TUNE impacts performance only; it does not impact the processor model on which you will be able to run your application. TUNE(3) optimizes your application for the newer G4, G5, and G6 processors. TUNE(2) optimizes your application for other architectures. For more information, refer to the ARCHITECTURE and TUNE compiler information in z/OS C/C++ User’s Guide.

Built-in Functions for Floating-Point and Other Hardware Instructions | Use built-in functions for floating-point and other hardware instructions that are otherwise inaccessible to C/C++ programs. Refer to Appendix I, “Using Built-In Functions” on page 881.
Part 2. Input and Output

This part describes the models of input and output available with IBM z/OS C/C++.

The C run-time functions are available if the corresponding C header files are used. C I/O can be used by C++ when the C run-time library functions are used.

The following references provide a complete description and examples of I/O streams:

- Chapter 3, “Introduction to C and C++ Input and Output” on page 35
- Chapter 4, “Understanding Models of C I/O” on page 37
- Chapter 5, “Using the Standard C++ Library I/O Stream Classes” on page 49
- Chapter 6, “Opening Files” on page 53
- Chapter 7, “Buffering of C Streams” on page 73
- Chapter 8, “Using ASA Text Files” on page 75
- Chapter 9, “z/OS C Support for the Double-Byte Character Set” on page 79
- Chapter 10, “Using C and C++ Standard Streams and Redirection” on page 87
- Chapter 11, “Performing OS I/O Operations” on page 107
- Chapter 12, “Performing UNIX File System I/O Operations” on page 143
- Chapter 13, “Performing VSAM I/O Operations” on page 167
- Chapter 14, “Performing Terminal I/O Operations” on page 205
- Chapter 15, “Performing Memory File and Hiperspace I/O Operations” on page 215
- Chapter 16, “Performing CICS I/O Operations” on page 229
- Chapter 17, “Language Environment Message File Operations” on page 231
- Chapter 18, “Debugging I/O Programs” on page 233
Chapter 3. Introduction to C and C++ Input and Output

This chapter provides you with a general introduction to C and C++ input and output (I/O). Three types of C and C++ input and output are discussed in this chapter:

- text streams
- binary streams
- record I/O

Types of C and C++ Input and Output

A stream is a flow of data elements that are transmitted or intended for transmission in a defined format. A record is a set of data elements treated as a unit, and a file (or data set) is a named set of records that is stored or processed as a unit.

The z/OS C/C++ compiler supports three types of input and output: text streams, binary streams, and record I/O. Text and binary streams are both ANSI standards; record I/O is an extension for z/OS C. Record I/O is not supported by either the USL I/O Stream Class Library or the Standard C++ I/O stream classes.

Note: If you have written data in one of these three types and try to read it as another type (for example, reading a binary file in text mode), you may not get the behavior that you expect.

Text Streams

Text streams contain printable characters and, depending on the type of file, control characters. Text streams are organized into lines. Each line ends with a control character, usually a new-line. The last record in a text file may or may not end with a control character, depending on what kind of file you are using. Text files recognize the following control characters:

\a Alarm.
\b Backspace.
\f Form feed.
\n New-line.
\r Carriage return.
\t Horizontal tab character.
\v Vertical tab character.
\x0E DBCS shift-out character. Indicates the beginning of a DBCS string, if \x0F DBCS shift-in character. Indicates the end of a DBCS string, if

Control characters behave differently in terminal files (see Chapter 14, “Performing Terminal I/O Operations” on page 205) and ASA files (see Chapter 8, “Using ASA Text Files” on page 75).
Binary Streams

Binary streams contain a sequence of bytes. For binary streams, the library does not translate any characters on input or output. It treats them as a continuous stream of bytes, and ignores any record boundaries. When data is written out to a record-oriented file, it fills one record before it starts filling the next. HFS streams follow the binary model, regardless of whether they are opened for text, binary, or record I/O. You can simulate record I/O by using new-line characters as record boundaries.

Record I/O

Record I/O is an extension to the ISO standard. For files opened in record z/OS C/C++ format, reads and writes one record at a time. If you try to write more data to a record than the record can hold, the data is truncated. For z/OS C/C++ fread() fwrite() record I/O, allows only the use of and to read fprintf() fscanf() getc() and write to files. Any other functions (such as , , putc() and ) will fail. For record-oriented files, records do not change size when you update them. If the new record has fewer characters than the original record, the new data fills the first \( n \) characters, where \( n \) is the number of characters of the new data. The record will remain the same size, and the old characters (those after \( n \)) are left unchanged. A subsequent update begins at the next boundary. For example, if you have the string ""abedefgh:"

```
a b c d e f g h
```

and you overwrite it with the string ""1234", the record will look like this:

```
1 2 3 4 e f g h
```

z/OS C/C++ record I/O is binary. That is, it does not interpret any of the data in a record file and therefore does not recognize control characters. The only exception is for file categories that do not support records, such as the Hierarchical File System (also known as POSIX I/O). For these files, uses new-line characters as record boundaries.
Chapter 4. Understanding Models of C I/O

This chapter describes z/OS C/C++ support for the major models of C I/O:

- The record model
- The byte stream model

The next chapter (Chapter 5, “Using the Standard C++ Library I/O Stream Classes” on page 49) describes a third major model, the object-oriented model.

The Record Model for C I/O

Almost all the kinds of I/O that z/OS C/C++ supports use this model. The only ones that do not are HFS, memory file, and Hiperspace I/O.

The record model consists of the following:

- A record, which is the unit of data transmitted to and from a program.
- A block, which is the unit of data transmitted to and from a device. Each block may contain one or more records.

In the record model of I/O, records and blocks have the following attributes:

- **RECFM** Specifies the format of the data or how the data is organized on the physical device.
- **LRECL** Specifies the length of logical records (as opposed to physical ones). Variable length records include a count field that is normally not available to the programmer.
- **BLKSIZE** Specifies the length of physical records (blocks on the physical device).

Record Formats

Use the **RECFM** attribute to specify the record format. The records in a file using the record model have one of the following formats:

- Fixed-length (F)
- Variable-length (V)
- Undefined-length (U)

Note: z/OS C/C++ does not support Format-D files.

These formats support the following additional options for **RECFM**:

- **A** Specifies that the file contains ASA control characters.
- **B** Specifies that a file is blocked. A blocked file can have more than one record in each block.
- **M** Specifies that the file contains machine control characters.
- **S** Specifies that a file is either in standard format (if it is fixed) or spanned (if it is variable). In a standard file, every block must be full before another one starts. In a spanned file, a record can be longer than a block. If it is, the record is divided into segments and stored in consecutive blocks.

The record formats and the additional options associated with them are discussed in the following sections.
Not all the I/O categories (listed in Table 5 on page 55) support all of these attributes. Depending on what category you are using, z/OS C/C++ ignores or simulates attributes that do not apply. For more information, on the record formats and the options supported for each I/O category, see Chapter 6, “Opening Files” on page 53.

**Fixed-Format Records**

**Record Format (RECFM)**

These are the formats you can specify for RECFM if you want to use a fixed-format file:

- **F** Fixed-length, unblocked
- **FA** Fixed-length, ASA print-control characters
- **FB** Fixed-length, blocked
- **FM** Fixed-length, machine print-control codes
- **FS** Fixed-length, unblocked, standard
- **FBA** Fixed-length, blocked, ASA print-control characters
- **FBM** Fixed-length, blocked, machine print-control codes
- **FBS** Fixed-length, blocked, standard
- **FSA** Fixed-length, unblocked, standard, ASA print-control characters
- **FSM** Fixed-length, unblocked, standard, machine print-control codes
- **FBSM** Fixed-length, blocked, standard, machine print-control codes
- **FBSA** Fixed-length, blocked, standard, ASA print-control characters.

**Note:** In general, all references in this guide to files with record format FB also refer to FBM and FBA. The specific behavior of ASA files (such as FBA) is explained in Chapter 8, “Using ASA Text Files” on page 75.

**Attention:** z/OS C/C++ distinguishes between FB and FBS formats, because an FBS file contains no embedded short blocks (the last block may be short). FBS files give you much better performance. The use of standard (S) blocks optimizes the sequential processing of a file on a direct-access device. With a standard format file, the file pointer can be directly repositioned by calculating the exact position in that file of a given record rather than reading through the entire file.

If the records are FB, some blocks may contain fewer records than others, as shown in Figure 2 on page 39.
Mapping C Types to Fixed Format: The following formats are discussed in this section:

- Binary
- Text (non-ASA)
- Text (ASA)
- Record

Binary

On binary input and output, data flows over record boundaries. Because all fixed-format records must be full, z/OS C/C++ completes any incomplete output record by padding it with nulls (‘\0’) when you close the file. Incomplete blocks are not padded. On input, nulls are visible and are treated as data.

For example, if record length is set to 10 and you are writing 25 characters of data, z/OS C/C++ will write two full records, each containing 10 characters, and then an incomplete record containing 5 characters. If you then close the file, z/OS C/C++ will complete the last record with 5 nulls. If you open the file for reading, z/OS C/C++ will read the records in order. z/OS C/C++ will not strip off the nulls at the end of the last record.

Text (non-ASA)

When writing in a text stream, you indicate the end of the data for a record by writing a new-line (‘\n’) or carriage return (‘\r’) to the stream. In a fixed-format file, the new-line or carriage return will not appear in the external file, and the record will be padded with blanks from the position of the new-line or carriage return to LRECL. (A carriage return is considered the same as a new-line because the ‘\r’ is not written to the file.)
For example, if you have set LRECL to 10, and you write the string "ABC\n" to a fixed-format text file, z/OS C/C++ will write this to the physical file:

```
A  B  C
```

A record containing only a new-line is written to the file as LRECL blanks.

When reading in a text stream, the I/O functions place a new-line character ("\n") in the buffer to indicate the end of data for the record. In a fixed-format file, the new-line character is placed at the start of the blank padding at the end of the data.

For example, if your file position points to the start of the following record in a fixed-format file opened as a text stream

```
A  B  C
```

and you call fgets() to read the line of text, fgets() places the string "ABC\n" in your input buffer.

**Attention:** Any blanks written immediately before a new-line or carriage return will be considered blank padding when the record is read back from the file. You cannot change the padding character.

When you are updating a fixed-format file opened as a text stream, you can update the amount of data in a record. The maximum length of the updated data is LRECL bytes plus the new-line character; the minimum length is zero data bytes plus the new-line character. Writing new data into an existing record replaces the old data. If the new data is longer or shorter than the old data, the number of blank padding characters in the record in the external file is changed. When you extend a record, thereby writing over the old new-line, there will be a new-line character implied after the new characters. For instance, if you were to overwrite the record mentioned in the previous example with the string "123456", the records in the physical file would then look like this:

```
1  2  3  4  5  6
```

The blanks at the end of the record imply a new-line at position 7. You can see this new-line by calling fflush() and then performing a read. The implied new-line is the first character returned from this read.

A fixed record can hold only LRECL characters. If you try to write more than that, z/OS C/C++ truncates the data unless you are using a standard
stream or a terminal file. In this case, the output is split across multiple records. If truncation occurs, z/OS C/C++ raises SIGIOERR and sets both errno and the error flag.

**Text (ASA)**

For ASA files, the first character of each record is reserved for the ASA control character that represents a new-line, a carriage return, or a form feed. This control character represents what should happen before the record is written.

<table>
<thead>
<tr>
<th>C Control Character</th>
<th>ASA Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\n \n \n</td>
<td>' '</td>
<td>skip one line</td>
</tr>
<tr>
<td>\n \n \n</td>
<td>'0'</td>
<td>skip two lines</td>
</tr>
<tr>
<td>\n \n \n</td>
<td>'1'</td>
<td>skip three lines</td>
</tr>
<tr>
<td>\f</td>
<td>'1'</td>
<td>new page</td>
</tr>
<tr>
<td>\r</td>
<td>'1'</td>
<td>overstrike</td>
</tr>
</tbody>
</table>

A control character that ends a logical record is represented at the beginning of the following record in the external file. Since the ASA control character is in the first byte of each record, a record can hold only LRECL - 1 bytes of data. As with non-ASA text files described above, z/OS C/C++ adds blank padding to complete any record shorter than LRECL - 1 when it writes the record to the file. On input, z/OS C/C++ removes all trailing blanks. For example, if LRECL is 10, and you enter the string:

```
\nABC\nDEF
```

the record in the physical file will look like this:

A B C

D E F ...

On input, this string is read as follows:

```
\nABC\nDEF
```

You can lengthen and shorten records the same way as you can for non-ASA files. For more information about ASA, refer to Chapter 8, “Using ASA Text Files” on page 75.

**Record**

As with fixed-format text files, a record can hold LRECL characters. Every call to fwrite() is considered to be writing a full record. If you write fewer than LRECL characters, z/OS C/C++ completes the record with enough nulls to make it LRECL characters long. If you try to write more than that, z/OS C/C++ truncates the data.

**Variable-Format Records**

In a file with variable-length records, each record may be a different length. The variable length formats permit both variable-length records and variable-length blocks. The first 4 bytes of each block are reserved for the Block Descriptor Word (BDW); the first 4 bytes of each record are reserved for the Record Descriptor Word.
Illustrations of variable-length records are shown in Figure 3 on page 43.

Once you have set the **LRECL** for a variable-format file, you can write up to **LRECL** minus 4 characters in each record. z/OS C/C++ does not let you see RDWs, BDWs, or SDWs when you open a file as variable-format. To see the RDWs or SDWs and BDWs, open the variable file as undefined-format, as described in “Undefined-Format Records” on page 44.

The value of **LRECL** must be greater than 4 to accommodate the RDW or SDW. The value of **BLKSIZE** must be greater than or equal to the value of **LRECL** plus 4. You should not use a **BLKSIZE** greater than **LRECL** plus 4 for an unblocked data set. Doing so results in buffers that are larger than they need to be. The largest amount of data that any one record can hold is **LRECL** bytes minus 4.

For striped data sets, a block is padded out to its full **BLKSIZE**. This makes specifying an unnecessarily large **BLKSIZE** very inefficient.

**Record Format (RECFM):** You can specify the following formats for variable-length records:

- **V** Variable-length, unblocked
- **VA** Variable-length, ASA print control characters, unblocked
- **VB** Variable-length, blocked
- **VM** Variable-length, machine print-control codes, unblocked
- **VS** Variable-length, unblocked, spanned
- **VBA** Variable-length, blocked, ASA print control characters
- **VBM** Variable-length, blocked, machine print-control codes
- **VBS** Variable-length, blocked, spanned
- **VSA** Variable-length, spanned, ASA print control characters
- **VSM** Variable-length, spanned, machine print-control codes
- **VBSA** Variable-length, blocked, spanned, ASA print control characters
- **VBSM** Variable-length, blocked, spanned, machine print-control codes

**Note:** In general, all references in this guide to files with record format **VB** also refer to **VBM** and **VBA**. The specific behavior of ASA files (such as **VBA**) is explained in Chapter 8, “Using ASA Text Files” on page 75.

**V**-format signifies unblocked variable-length records. Each record is treated as a block containing only one record.

**V8**-format signifies blocked variable-length records. Each block contains as many complete records as it can accommodate.

**Spanned Records:** A spanned record is opened using both **V** and **S** in the format specifier. A spanned record is a variable-length record in which the length of the record can exceed the size of a block. If it does, the record is divided into segments and accommodated in two or more consecutive blocks. The use of spanned records allows you to select a block size, independent of record length, that will combine optimum use of auxiliary storage with the maximum efficiency of transmission.
VS-format specifies that each block contains only one record or segment of a record. The first 4 bytes of a block describe the block control information. The second 4 bytes contain record or segment control information, including an indication of whether the record is complete or is a first, intermediate, or last segment.

VBS-format differs from VS-format in that each block in VBS-format contains as many complete records or segments as it can accommodate, while each block in VS-format contains at most one record per block.

V-format:

```
C1 C2 Record 1  C1 C2 Record 2  C1 C2
```

VB-format:

```
C1 C2 Record 1  C2 Record 2  C1 C2 Record 3
```

VS-format:

```
C1 C2 Record 1 (entire)  C1 C2 Record 2 (first segment)  C1 C2 Record 2 (next segment)
```

VBS-format:

```
C1 C2 Record 1 (entire)  C2 Record 2 (first segment)  C1 C2 Record 2 (last segment)  C2 Record 3
```

C1: Block control information  
C2: Record or segment control information  

Figure 3. Variable-Length Records on z/OS  

Mapping C Types to Variable Format:  

Binary  

On input and output, data flows over record boundaries. Any record will hold up to LRECL minus 4 characters of data. If you try to write more than that, your data will go to the next record, after the RDW or SDW. You will not be able to see the descriptor words when you read the file.  

Note: If you need to see the BDWs, RDWs, or SDWs, you can open and read a V-format file as a U-format file. See “Undefined-Format Records” on page 44 for more information.  

z/OS C/C++ never creates empty binary records for files opened in V-format. See “Writing to Binary Files” on page 129 for more information. An empty binary record is one that contains only an RDW, which is 4 bytes long. On input, empty records are ignored.
**Text (non-ASA)**

Record boundaries are used in the physical file to represent the position of the new-line character. You can indicate the end of a record by including a new-line or carriage return character in your data. In variable-format files, z/OS C/C++ treats the carriage return character as if it were a new-line. z/OS C/C++ does not write either of these characters to the physical file; instead, it creates a record boundary. When you read the file back, boundaries are read as new-lines.

If a record only contains a new-line character, the default behavior of z/OS C/C++ is to write a record containing a single blank to the file. Therefore, the string " \n" is treated the same as the string "\n"; both are read back as \n. All other blanks in your output are read back as is. Any empty (zero-length) record is ignored on input. However, if the environment variable _EDC_ZERO_RECLEN was set to Y at the time the file was opened, a single new-line is written to the file as an empty record, and a single blank represents " \n". On input, an empty record is treated as a single new-line and is not ignored.

After a record has been written to a file, you cannot change its length. If you try to shorten a logical record by writing a new, smaller amount of data into it, the C I/O library will add blank characters until the record is full. Writing more data to a record than it can hold causes your data to be truncated unless you are writing to a standard stream or a terminal file. In this case, your output is split across multiple records. If truncation occurs, z/OS C/C++ raises SIGIOERR and sets both errno and the error flag.

**Note:** If you did not explicitly set the _EDC_ZERO_RECLEN environment variable when you opened the file, you can update a record that contains a single blank to contain a non-blank character, thereby lengthening the logical record from \n to x\n), where x is the non-blank character.

**Text (ASA)**

z/OS C/C++ treats variable-format ASA text files similarly to the way it treats fixed-format ones. Empty records are always ignored in ASA variable-format files; for a record to be recognized, it must contain at least one character as the ASA control character.

For more information about ASA, refer to Chapter 8, “Using ASA Text Files” on page 75.

**Record**

Each call to fwrite() creates a record that must be shorter than or equal to the size established by LRECL. If you try to write more than LRECL bytes on one call to fwrite(), z/OS C/C++ will truncate your data. z/OS C/C++ never creates empty records using record I/O. On input, empty records are ignored unless you have set the _EDC_ZERO_RECLEN environment variable to Y. In this case, empty records are treated as records with length 0.

If your application sets _EDC_ZERO_RECLEN to Y, bear in mind that fread() returns back 0 bytes read, but does not set errno, and that both feof() and ferror() return 0 as well.

**Undefined-Format Records**

Everything in an undefined-format file is treated as data, including control characters and record boundaries. Blocks in undefined-format records are variable-length; each block is considered a record.
It is impossible to have an empty record. Whatever you specify for LRECL has no effect on your data, but the value of LRECL must be less than or equal to the value you specify for BLKSIZE. Regardless of what you specify, z/OS C/C++ sets LRECL to zero when it creates an undefined-format file.

Reading a file in U-format enables you to read an entire block at once.

**Record Format (RECFM):** You can specify the following formats for undefined-length records:

- **U** Undefined-length
- **UA** Undefined-length, ASA print control characters
- **UM** Undefined-length, machine print-control codes

U, UA, and UM formats permit the processing of records that do not conform to F- and V-formats. The operating system treats each block as a record; your program must perform any additional blocking or deblocking.

You can read any file in U-format. This is useful if, for example, you want to see the BDWs and RDWs of a file that you have written in V-format.

**Mapping C Types to Undefined Format:**

**Binary**

When you are writing to an undefined-format file, binary data fills a block and then begins a new block.

**Text (non-ASA)**

Record boundaries (that is, block boundaries) are used in the physical file to represent the position of the new-line character. You can indicate the end of a record by including a new-line or carriage return character in your data. In undefined-format files, z/OS C/C++ treats the carriage return character as if it were a new-line. z/OS C/C++ does not write either of these characters to the physical file; instead, it creates a record boundary. When you read the file back, these boundaries are read as new-lines.

If a record contains only a new-line character, z/OS C/C++ writes a record containing a single blank to the file regardless of the setting of the _EDC_ZERO_RECLEN environment variable. Therefore, the string ‘\n’ (a single blank followed by a new-line character) is treated the same way as ‘\n’; both are written out as a single blank. On input, both are read as ‘\n’. All other blank characters are written and read as you intended.

After a record has been written to a file, you cannot change its length. If you try to shorten a logical record by writing a new, smaller amount of data into it, the C I/O library adds blank characters until the record is full. Writing more data to a record than it can hold will cause your data to be truncated unless you are writing to a standard stream or a terminal file. In these cases, your output is split across multiple records. If truncation occurs, z/OS C/C++ raises SIGIOERR and sets both errno and the error flag.

**Note:** You can update a record that contains a single blank to contain a non-blank character, thereby lengthening the logical record from ‘\n’ to ‘x\n’), where x is the non-blank character.

**Text (ASA)**

For a record to be recognized, it must contain at least one character as the ASA control character.
For more information about ASA, refer to Chapter 8, “Using ASA Text Files” on page 75.

Record

Each call to fwrite() creates a record that must be shorter than or equal to the size established by BLKSIZE. If you try to write more than BLKSIZE bytes on one call to fwrite(), z/OS C/C++ truncates your data.

The Byte Stream Model for C I/O

The byte stream model differs from the record I/O model. In the byte stream model, a file is just a stream of bytes, with no record boundaries. New-line characters written to the stream appear in the external file.

If the file is opened in binary mode, any new-line characters previously written to the file are visible on input. z/OS C/C++ memory file I/O and Hiperspace memory file I/O are based on the byte stream model (see Chapter 15, “Performing Memory File and Hiperspace I/O Operations” on page 215 for more information).

Hierarchical File System (HFS) I/O, defined by POSIX, is also based on the byte stream model. Refer to Chapter 12, “Performing UNIX File System I/O Operations” on page 143 for information about I/O with HFS.

Mapping the C Types of I/O to the Byte Stream Model

Binary

In the byte stream model, files opened in binary mode do not contain any record boundaries. Data is written as is to the file.

Text

The byte stream model does not support ASA. New-lines, carriage returns, and other control characters are written as-is to the file.

Record

If record I/O is supported by the kind of file you are using, z/OS C/C++ simulates it by treating new-line characters as record boundaries. New-lines are not treated as part of the record. A record written out with a new-line inside it is not read back as it was written, because z/OS C/C++ treats the new-line as a record boundary instead of data.

HFS files support record I/O, but memory files do not.

As with all other record I/O, you can use only fread() and fwrite() to read from and write to files. Each call to fwrite() inserts a new-line in the byte stream; each call to fread() strips it off. For example, if you use one fwrite() statement to write the string ABC and the next to write DEF, the byte stream will look like this:

```
A B C \n D E F \n ... 
```

There are no limitations on lengthening and shortening records. If you then rewind the file and write new data into it, z/OS C/C++ will replace the old data. For example, if you used the rewind() function on the stream in the previous example and then called fwrite() to place the string 12345 into it,
the stream would look like this:

```
1 2 3 4 5 \n F \n ...```

If you are using files with this model, do not use new-line characters in your output. If you do, they will create extra record boundaries. If you are unsure about the data being written or are writing numeric data, use binary instead of text to avoid writing a byte that has the hex value of a new-line.
Chapter 5. Using the Standard C++ Library I/O Stream Classes

The object-oriented model for input and output (I/O) is a set of classes and header files that are provided by the Standard C++ Library. These classes implement and manage the stream buffers and the data held in the buffer. Stream buffers hold data sent to the program (input) and from the program (output), enabling the program to manipulate and format the data.

There are two base classes, ios and streambuf, from which all other I/O stream classes are derived. The ios class and its derivative classes are used to implement formatting of I/O and maintain error state information of stream buffers implemented with the streambuf class.

There are two shipped versions of the I/O stream classes:

- The Unix Systems Laboratories C++ Language System Release (USL) I/O Stream Class Library is declared in the iostream.h header file, and is shipped with the IBM Open Class Library. This version does not support ASCII and large files. For more information, see IBM Open Class Library User’s Guide and IBM Open Class Library Reference, Vol. 1.
- The Standard C++ I/O stream classes are declared in the iostream header file, and are shipped with the Language Environment. This version supports ASCII and large files. For more information, see Standard C++ Library Reference. This discusses the Standard C++ Library and the Standard Template Library (STL) implemented in the z/OS C++ compiler. It can be found at http://www.ibm.com/software/ad/c390/czos/czosdocs.html.

The I/O stream classes use OBJMODEL(COMPAT). They cannot be used with other classes that use OBJMODEL(IBM), within the same inheritance hierarchy. For more information, see the section about OBJMODEL in z/OS C/C++ User’s Guide.

This chapter includes the following topics:

- Advantages to using the C++ I/O Stream Library
- Predefined Streams for C++
- How C++ I/O Streams Relate to C Streams
- Specifying File Attributes

Advantages to Using the C++ I/O Stream Classes

Although input and output are implemented with streams for both C and C++, the C++ I/O stream classes provide the same facilities for input and output as C stdio.h. The I/O stream classes in the Standard C++ Library have the following advantages:

- The input (>>) operator and output (<<) operator are typesafe. These operators are easier to use than scanf() and printf().
- You can overload the input and output operators to define input and output for your own types and classes. This makes input and output across types, including your own, uniform.

Predefined Streams for C++

z/OS C++ provides the following predefined streams:

cin The standard input stream
cout  The standard output stream

cerr  The standard error stream, unit-buffered such that characters sent to this stream are flushed on each output operation

clog  The buffered error stream

All predefined streams are tied to cout. When you use cin, cerr, or clog, cout gets flushed sending the contents of cout to the ultimate consumer.

z/OS C standard streams create all I/O to I/O streams:
• Input to cin comes from stdin (unless cin is redirected)
• cout output goes to stdout (unless cout is redirected)
• cerr output goes to stderr (unit-buffered) (unless cerr is redirected)
• clog output goes to stderr (unless clog is redirected)

When redirecting or intercepting a C standard stream, the corresponding C++ standard stream becomes redirected. This applies unless you redirect an I/O stream. See Chapter 10, “Using C and C++ Standard Streams and Redirection” on page 87 for more information.

How C++ I/O Streams Relate to C Streams

The USL I/O Stream Class Library file I/O is implemented in terms of z/OS C file I/O, and is buffered from it. The only exception cerr is unit buffered (ios::unitbuf is set). A filebuf object is associated with each ifstream, ofstream, and fstream object. When the filebuf is flushed, it writes to the underlying C stream, which has its own buffer. The filebuf object follows every fwrite() to the underlying C stream with an fflush().

Mixing the Standard C++ I/O Stream Classes, USL I/O Stream Class Library, and C I/O

It is not recommended to mix the usage of the Standard C++ I/O stream classes, USL I/O Stream Class Library, and C I/O. The USL I/O Stream Library uses a separate buffer so you would need to flush the buffer after each call to cout by either setting unitbuf or sync_with_stdio(). You should avoid switching between the formatted extraction functions of the C++ I/O stream classes and C stdio library functions whenever possible. You should also avoid switching between versions of these classes.

For more information on mixing the I/O stream classes refer to “Interleaving the Standard Streams with sync_with_stdio()” on page 89 and “Interleaving the Standard Streams without sync_with_stdio()” on page 90.

Specifying File Attributes

The fstream, ifstream, and ofstream classes specialize stream input and output for files.

For z/OS C++, overloaded fstream, ifstream, and ofstream constructors, and open() member functions, with an additional parameter, are provided so you can specify z/OS C fopen() mode values. You can use this additional parameter to specify any z/OS C fopen() mode value except type=record. If you choose to use
a constructor without this additional parameter, you will get the default z/OS C fopen() file characteristics. [Table 7 on page 61](#) describes the default fopen() characteristics.
Chapter 6. Opening Files

This chapter describes how to open I/O files. You can open files using the Standard C fopen() and freopen() library functions. Alternatively, if you want to use the C++ I/O stream classes, you can use the constructors for the ifstream, ofstream or fstream classes, or the open() member functions of the filebuf, ifstream, ofstream or fstream classes.

To open a file stream with a previously opened HFS file descriptor, use the fdopen() function.

To open files with HFS low-level I/O, use the open() function. For more information about opening HFS files, see Chapter 12, “Performing UNIX File System I/O Operations” on page 143.

Prototypes of functions

The prototypes of these functions are:

C Library Functions:

FILE *fopen(const char *filename, const char *mode);
FILE *freopen(const char *filename, const char *mode, FILE *stream);
FILE *fdopen(int filedes, char *mode);

USL I/O Stream Library functions:

// ifstream constructor
ifstream(const char* fname, int mode=ios::in,
     int prot=filebuf::openprot);

// ifstream constructor; z/OS C++ extension
ifstream(const char* fname, const char* fattr,
     int mode=ios::in, int prot=filebuf::openprot);

// ifstream::open()
void open(const char* fname, int mode=ios::in,
     int prot=filebuf::openprot);

// z/OS C++ extension
void open(const char* fname, const char* fattr,
     int mode=ios::in, int prot=filebuf::openprot);

// ofstream constructor
ofstream(const char* fname, int mode=ios::out,
     int prot=filebuf::openprot);

// ofstream constructor; z/OS C++ extension
ofstream(const char* fname, const char* fattr,
     int mode=ios::out, int prot=filebuf::openprot);

// ofstream::open()
void open(const char* fname, int mode=ios::out,
     int prot=filebuf::openprot);

// z/OS C++ extension
void open(const char* fname, const char* fattr,
     int mode=ios::out, int prot=filebuf::openprot);

// fstream constructor

© Copyright IBM Corp. 1996, 2002
fstream(const char* fname, int mode,
    int prot=filebuf::openprot);

// fstream constructor; z/OS C++ extension
fstream(const char* fname, const char* fattr,
    int mode, int prot=filebuf::openprot);

// fstream::open()
void open(const char* fname, int mode,
    int prot=filebuf::openprot);

// z/OS C++ extension
void open(const char* fname, const char* fattr,
    int mode, int prot=filebuf::openprot);

// filebuf::open()
filebuf* open(const char* fname, int mode,
    int prot=filebuf::openprot);

// z/OS C++ extension
filebuf* open(const char* fname, const char* fattr,
    int mode, int prot=filebuf::openprot);

Standard C++ I/O stream functions:

// z/OS C++ Standard Library ifstream constructor
ifstream(const char *, ios_base::openmode, const char * _A)

// z/OS C++ Standard Library ifstream::open
void ifstream::open(const char *, ios_base::openmode, const char * _A)
void ifstream::open(const char *, ios_base::open_mode, const char * _A)

// z/OS C++ Standard Library ofstream constructor
ofstream(const char *, ios_base::openmode, const char * _A)

// z/OS C++ Standard Library ofstream::open
void ofstream::open(const char *, ios_base::openmode, const char * _A)
void ofstream::open(const char *, ios_base::open_mode, const char * _A)

// z/OS C++ Standard Library fstream constructor
fstream(const char *, ios_base::openmode, const char * _A)

// z/OS C++ Standard Library fstream::open
void fstream::open(const char *, ios_base::openmode, const char * _A)
void fstream::open(const char *, ios_base::open_mode, const char * _A)

// C++ Standard Library filebuf::open
filebuf::open(const char *, ios_base::openmode, const char * _A)
filebuf::open(const char *, ios_base::open_mode, const char * _A)

For more detailed information about I/O streaming see the following:

• [z/OS C/C++ Run-Time Library Reference](http://www.ibm.com/software/ad/c390/czos/czosdocs.html) discusses the C I/O stream functions.


## Categories of I/O

The following table lists the categories of I/O that z/OS C/C++ supports and points to the section where each category is described.

### Table 5. Kinds of I/O Supported by z/OS C/C++

<table>
<thead>
<tr>
<th>Type of I/O</th>
<th>Suggested Uses and Supported Devices</th>
<th>Model</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS I/O</td>
<td>Used for dealing with the following kinds of files:</td>
<td></td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>• Generation data group</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• MVS sequential DASD files</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Regular and extended partitioned data sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Tapes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Printers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Punch data sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Card reader data sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• MVS inline JCL data sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• MVS spool data sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Striped data sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Optical readers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hierarchical File</td>
<td>Used under z/OS UNIX System Services (z/OS UNIX) to support HFS data sets, and access the</td>
<td>Byte</td>
<td>143</td>
</tr>
<tr>
<td>System (HFS) I/O</td>
<td>byte-oriented HFS files according to POSIX .1 and XPG 4.2 interfaces. This increases the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>portability of applications written on UNIX-based systems to z/OS C/C++ systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSAM I/O</td>
<td>Used for working with VSAM data sets. Supports direct access to records by key,</td>
<td>Record</td>
<td>167</td>
</tr>
<tr>
<td></td>
<td>relative record number, or relative byte address. Supports entry-sequenced, relative record, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>key-sequenced data sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminal I/O</td>
<td>Used to perform interactive input and output operations with a terminal.</td>
<td>Record</td>
<td>205</td>
</tr>
<tr>
<td>Memory Files</td>
<td>Used for applications requiring temporary I/O files without the overhead of system data sets.</td>
<td>Byte</td>
<td>215</td>
</tr>
<tr>
<td></td>
<td>Fast and efficient.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hiperspace</td>
<td>Used to deal with memory files as large as 2 gigabytes.</td>
<td>Byte</td>
<td>215</td>
</tr>
<tr>
<td>Memory Files</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CICS Data Queues</td>
<td>Used under the Customer Information Control System (CICS). CICS data queues are automatically</td>
<td>Record</td>
<td>229</td>
</tr>
<tr>
<td></td>
<td>selected under CICS for the standard streams stdout and stderr for C, or cout and cerr for C++.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The CICS I/O commands are supported through the Command Level interface. The standard stream</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>stdin under C (or cin under C++) is treated as an empty file under CICS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>z/OS Language</td>
<td>Used when you are running with z/OS Language Environment. The message file is automatically</td>
<td>Record</td>
<td>231</td>
</tr>
<tr>
<td>Environment</td>
<td>selected for stderr under z/OS Language Environment. For C++, automatic selection is of cerr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Message File</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The following table lists the environments that z/OS C/C++ supports, and which categories of I/O work in which environment.

Table 6. I/O Categories and Environments That Support Them

<table>
<thead>
<tr>
<th>Type of I/O</th>
<th>MVS batch</th>
<th>IMS online</th>
<th>TSO</th>
<th>TSO batch</th>
<th>CICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS I/O</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>HFS I/O</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>VSAM I/O</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Terminal I/O</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Memory Files</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Hiperspace Memory Files</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>CICS Data Queues</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>z/OS Language Environment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Note: MVS batch includes IMS batch. TSO is interactive. TSO batch indicates an environment set up by a batch call to IKJEFT01. Programs run in such an environment behave more like a TSO interactive program than an MVS batch program.

Specifying What Kind of File to Use

This section discusses:

- the kinds of files you can use
- how to specify RECFM, LRECL, and BLKSIZE
- how to specify DDnames

OS Files

z/OS C/C++ treats a file as an OS file, provided that it is not a CICS data queue, or an HFS, VSAM, memory, terminal, or Hiperspace file.

HFS Files

When you are running under MVS, TSO (batch and interactive), or IMS, z/OS C/C++ recognizes an HFS I/O file as such if the name specified on the `fopen()` or `freopen()` call conforms to certain rules. These rules are described in "How z/OS C/C++ Determines What Kind of File to Open" on page 63.

VSAM data sets

z/OS C/C++ recognizes a VSAM data set if the file exists and has been defined as a VSAM cluster before the call to `fopen()`.

Terminal Files

When you are running with the run-time option `POSIX(0FF)` under interactive TSO, z/OS C/C++ associates streams to the terminal. You can also call `fopen()` to open the terminal directly if you are running under TSO (interactive or batch), and either the file name you specify begins with an asterisk (*), or the ddname has been allocated with a DSN of *.

When running with `POSIX(0N)`, z/OS C/C++ associates streams to the terminal under TSO and a shell if the file name you have specified fits one of the following criteria:
- **Under TSO (interactive and batch)**, the name must begin with the sequence `//*`, or the ddname must have been allocated with a DSN of `*`.
- **Under a shell**, the name specified on `fopen()` or `freopen()` must be the character string returned by `ttyname()`.

Interactive IMS and CICS behave differently from what is described here. For more information about terminal files with interactive IMS and CICS see [Chapter 10, "Using C and C++ Standard Streams and Redirection"](page 87) on page 87.

If you are running with POSIX(ON) outside a shell, you must use the regular z/OS C/C++ I/O functions for terminal I/O. If you are running with POSIX(ON) from a shell, you can use the regular z/OS C/C++ I/O functions or the POSIX low-level functions (such as `read()`) for terminal I/O.

### Memory Files and Hiperspace Memory Files

You can use regular memory files on all the systems that z/OS C/C++ supports. To create one, specify `type=memory` on the `fopen()` or `freopen()` call that creates the file. A memory file, once created, exists until either of the following happens:

- You explicitly remove it with `remove()` or `clrmemf()`
- The root program is terminated

While a memory file exists, you can just use another `fopen()` or `freopen()` that specifies the memory file’s name; you do not have to specify `type=memory`. For example:

```
CCNGOF1

/* this example shows how fopen() may be used with memory files */

#include <stdio.h>
char text[3], *result;
FILE * fp;

int main(void)
{
  fp = fopen("a.b", "w, type=memory"); /* Opens a memory file */
  fprintf(fp, "%d\n",10); /* Writes to the file */
  fclose(fp); /* Closes the file */
  fp = fopen("a.b", "r"); /* Reopens the same */
     /* file (already */
     /* a memory file) */
  if ((result=fgets(text,3,fp)) !=NULL) /* Retrieves results */
     printf("value retrieved is %s\n",result);
  fclose(fp); /* Closes the file */
  return(0);
}
```

*Figure 4. Memory File Example*

A valid memory file name will match current file restrictions on a real file. Thus, a memory file name that is classified as HFS can have more characters than can one classified as an MVS file name.

If you are not running under CICS, you can open a Hiperspace memory file as follows:

```
fp = fopen("a.b", "w, type=memory(hiperspace)");
```
If you specify hiperspace and you are running in a CICS environment, z/OS C/C++ opens a regular memory file. If you are running with the run-time options POSIX(ON) and TRAP(OFF), specifying hiperspace has no effect; z/OS C/C++ will open a regular memory file. You must specify TRAP(ON) to be able to create Hiperspace files.

CICS Data Queues

A CICS transient data queue is a pathway to a single predefined destination. The destination can be a ddname, another transient data queue, a VSAM file, a terminal, or another CICS environment. The CICS system administrator defines the queues that are active during execution of CICS. All users who direct data to a given queue will be placing data in the same location, in order of occurrence.

You cannot use fopen() or freopen() to specify this kind of I/O. It is the category selected automatically when you call any ANSI functions that reference stdout and stderr under CICS. If you reference either of these in a C or C++ program under CICS, z/OS C/C++ attempts to open the CESO (stdout) or CESE (stderr) queue. If you want to write to any other queue, you should use the CICS-provided interface.

z/OS Language Environment Message File

The z/OS Language Environment message file is managed by z/OS Language Environment and may not be directly opened or closed with fopen(), freopen() or fclose() within a C or C++ application. In z/OS Language Environment, output from stderr is directed to the z/OS Language Environment message file by default. You can use freopen() and fclose() to manage stderr, or you can redirect it to another destination. There are application writer interfaces (AWIs) that enable you to access the z/OS Language Environment message file directly. These are documented in z/OS Language Environment Programming Guide.


How to Specify RECFM, LRECL, and BLKSIZE

For OS files and terminal files, the values of RECFM, LRECL, and BLKSIZE are significant. When you open a file, z/OS C/C++ searches for the RECFM, LRECL, and BLKSIZE values in the following places:

1. The fopen() or freopen() statement that opens the file
2. The DD statement (described in DDnames on page 62)
3. The values set in the existing file
4. The default values for fopen() or freopen().

When you call fopen() and specify a write mode (w, wb, w+, wb+, w+b) for an existing file, z/OS C/C++ uses the default values for fopen() if:

- the data set is opened by the data set name or
- the data set is opened by ddname and the DD statement does not have any attributes filled in.

These defaults are listed in Table 7 on page 61. To force z/OS C/C++ to use existing attributes when you are opening a file, specify recfm=* on the fopen() or freopen() call.

recfm=* is valid only for existing DASD data sets. It is ignored in all other cases.
Notes:

1. When specifying a ddname on `fopen()` or `freopen()` you should be aware of the following when opening the ddname using one of the write modes:

2. If the ddname is allocated to an already existing file and that ddname has not yet been opened, then the DD statement will not contain the recfm, lrecl, or blksize. That information is not filled in until the ddname is opened for the first time. If the first open uses one of the write modes (w, wb, w+, wb+, w+b) and recfm=* is not specified, then the existing file attributes are not considered. Therefore, since the DD statement has not yet been filled in, the `fopen()` defaults are used.

3. If the ddname is allocated at the same time the file is created, then the DD statement will contain the same recfm, lrecl, and blksize specified for the file. If the first open uses one of the write modes (w, wb, w+, wb+, w+b) and recfm=* is not specified, then z/OS C/C++ picks up the existing file attributes from the DD statement since they were placed there at the time of allocation.

You can specify the record format in

- The RECFM parameter of the JCL DD statement under MVS
- The RECFM parameter of the ALLOCATE statement under TSO
- The __recfm field of the __dyn_t structure passed to the dynalloc() library function under MVS
- The RECFM parameter on the call to the `fopen()` or `freopen()` library function
- The __S99TXTPP text unit field on an SVC99 parameter list passed to the svc99() library function under MVS
- The ISPF data set utility under MVS

Certain categories of I/O may ignore or simulate some attributes such as BLKSIZE or RECFM that are not physically supported on the device. Table 5 on page 55 lists all the categories of I/O that z/OS C/C++ supports and directs you to where you can find more information about them.

You can specify the logical record length in

- The LRECL parameter of the JCL DD statement under MVS
- The LRECL parameter of the ALLOCATE statement under TSO
- The __lrecl field of the __dyn_t structure passed to the dynalloc() library function under MVS
- The LRECL parameter on the call to the `fopen()` or `freopen()` library function
- The __S99TXTPP text unit field on an SVC99 parameter list passed to the svc99() library function under MVS
- The ISPF data set utility

If you are creating a file and you do not select a record size, z/OS C/C++ uses a default. See “fopen() Defaults” on page 60 for details on how defaults are calculated.

You can specify the block size in

- The BLKSIZE parameter of the JCL DD statement
- The BLKSIZE parameter of the ALLOCATE statement under TSO
- The __blksize field of the __dyn_t structure passed to the dynalloc() library function under MVS
- The BLKSIZE parameter on a call to the `fopen()` or `freopen()` library function
• The __S99TXTTP text unit field on an SVC99 parameter list passed to the svc99() library function under MVS
• The ISPF data set utility

If you are creating a file and do not select a block size, z/OS C/C++ uses a default. The defaults are listed in Table 7 on page 61

fopen() Defaults

You cannot specify a file attribute more than once on a call to fopen() or freopen(). If you do, the function call fails. If the file attributes specified on the call to fopen() differ from the actual file attributes, fopen() usually fails. However, fopen() does not fail if:

• The file is opened for w, w+, wb, or wb+, and the file is neither an existing PDS or PDSE nor an existing file opened by a ddname that specifies DISP=MOD. In such instances, fopen() attributes override the actual file attributes. However, if recfm=* is specified on the fopen(), any attributes that are not specified either on the fopen() or for the ddname will be retrieved from the existing file. If the final combination of attributes is invalid, the fopen() will fail.
• The file is opened for reading (r or rb) with recfm=U. Any other specified attributes should be compatible with those of the existing data set.

In calls to fopen(), the LRECL, BLKSIZE, and RECFM parameters are optional. (If you are opening a file for read or append, any attributes that you specify must match the existing attributes.)

If you do not specify file attributes for fopen() (or for an I/O stream object), you get the following defaults.

RECFM Defaults

If recfm is not specified in a fopen() call for an output binary file, recfm defaults to:
• recfm=VB for spool (printer) files
• recfm=FB otherwise

If recfm is not specified in a fopen() call for an output text file, recfm defaults to:
• recfm=F if _EDC_ANSI_OPEN_DEFAULT is set to Y and no LRECL or BLKSIZE specified. In this case, LRECL and BLKSIZE are both defaulted to 254.
• recfm=VBA for spool (printer) files.
• recfm=U for terminal files.
• recfm=VB for MVS files.
• recfm=VB for all other OS files.

If recfm is not specified for a record I/O file, you will get the default of recfm=VB.

LRECL and BLKSIZE defaults

The following table shows the defaults for LRECL and BLKSIZE when z/OS C/C++ is creating a file, not appending or updating it. The table assumes that z/OS C/C++ has already processed any information from the fopen() statement or ddname. The defaults provide a basis for fopen() to select values for unspecified attributes when you create a file.
### Table 7. fopen() Defaults for LRECL and BLKSIZE when Creating OS Files

<table>
<thead>
<tr>
<th>irecl specified?</th>
<th>blksize specified?</th>
<th>RECFM</th>
<th>LRECL</th>
<th>BLKSIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>no</td>
<td>All F</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All FB</td>
<td>80</td>
<td>maximum integral multiple of 80 less than or equal to max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All V, VB, VS, or VBS</td>
<td>minimum of 1028 or max–4</td>
<td>max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All U</td>
<td>0</td>
<td>max</td>
</tr>
</tbody>
</table>

| yes              | no                 | All F | irecl | irecl   |
|                  |                    | All FB| irecl | maximum integral multiple of irecl less than or equal to max |
|                  |                    | All V | irecl | irecl+4 |
|                  |                    | All U | 0     | irecl   |

| no               | yes                | All F or FB | blksize | blksize |
|                  |                    | All V, VB, VS, or VBS | minimum of 1028 or blksize–4 | blksize |
|                  |                    | All U | 0     | blksize |

**Note:** “All” includes the standard (S) specifier for fixed formats, the ASA (A) specifier, and the machine control character (M) specifier.

In the preceding table, the value *max* represents the maximum block size for the device. These are the current default maximum block sizes for several devices that z/OS C/C++ supports:

<table>
<thead>
<tr>
<th>Device</th>
<th>Block Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASD</td>
<td>6144</td>
</tr>
<tr>
<td>3203 Printer</td>
<td>132</td>
</tr>
<tr>
<td>3211 Printer</td>
<td>132</td>
</tr>
<tr>
<td>4245 Printer</td>
<td>132</td>
</tr>
<tr>
<td>2540 Reader</td>
<td>80</td>
</tr>
<tr>
<td>2540 Punch</td>
<td>80</td>
</tr>
<tr>
<td>2501 Reader</td>
<td>80</td>
</tr>
<tr>
<td>3890 Document Processor</td>
<td>80</td>
</tr>
<tr>
<td>TAPE</td>
<td>32760</td>
</tr>
</tbody>
</table>

For more information about specific default block sizes, as returned by the DEVTYPE macro, refer to [[z/OS DFSMS: Using Data Sets](http://www.ibm.com)].

For DASD files that do not have recfm=U, if you specify blksize=0 on the call to fopen() or freopen() and you have DFP Release 3.1 or higher, the system determines the optimal block size for your file. If you do not have the correct level of DFP or you specify blksize=0 for a ddname instead of specifying it on the fopen() or freopen() call, z/OS C/C++ behaves as if you had not specified the blksize parameter at all.
For information about block sizes for different categories of I/O, see the chapters listed in Table 5 on page 55.

You do not have to specify the LRECL and BLKSIZE attributes; however, it is possible to have conflicting attributes when you do specify them. The restrictions are:
- For a V file, the LRECL must be greater than 4 bytes and must be at least 4 bytes smaller than the BLKSIZE.
- For an F file, the LRECL must be equal to the BLKSIZE, and must be at least 1.
- For an FB file, the BLKSIZE must be an integer multiple of the LRECL.
- For a U file, the LRECL must be less than or equal to the BLKSIZE and must be greater than or equal to 0. The BLKSIZE must be at least 1.
- In spanned files, the LRECL and the BLKSIZE attributes must be greater than 4.
- If you specify LRECL=X, the BLKSIZE attribute must be less than or equal to the maximum block size allowed on the device.

To determine the maximum LRECL and BLKSIZE values for the various file types and devices available on your operating system, refer to the chapters listed in Table 5 on page 55.

**DDnames**

DD names are specified by prefixing the DD name with DD:. All the following forms of the prefix are supported:
- **DD:**
- **dd:**
- **dD:**
- **Dd:**

The DD statement enables you to write C source programs that are independent of the files and input/output devices they will use. You can modify the parameters of a file (such as LRECL, BLKSIZE, and RECFM) or process different files without recompiling your program.

**How to Create a DDname Under MVS Batch**

To create a ddname under MVS batch, you must write a JCL DD statement. For the C file PARTS.INSTOCK, you would write a JCL DD statement similar to the following:

```
//STOCK DD DSN=PARTS.INSTOCK,...
```

HFS files can be allocated with a DD card. For example:

```
//STOCK DD PATH='/u/parts.instock',
  // PATHOPTS=(OWRONLY,OCREAT,OTRUNC),
  // PATHMODE=(SIRWXU,SIRWXO,SIRWXG)
```

When defining DD, do not use DD ... FREE=CLOSE for unallocating DD statements. The C library may close files to perform some file operations such as freopen(), and the DD statement will be unallocated.

For more information on writing DD statements, refer to the JCL manuals listed in [z/OS Information Roadmap](#).

**How to Create a DDname Under TSO**

To create a ddname under TSO, you must write an ALLOCATE command. For the declaration shown above for the C file STOCK, you should write a TSO ALLOCATE statement similar to the following:
ALLOCATE FILE(STOCK) DATASET('PARTS.INSTOCK')

You can also allocate HFS files with TSO ALLOCATE commands. For example:

```
ALLOC FILE(stock) PATH('/used/parts.stock') PATHOPTS(OWRONLY,CREAT)
PATHMODE(sirwxu,sirwxo,sirwxg)
```

See [z/OS Information Roadmap](#) for more information on TSO ALLOCATE.

### How to Create a DDname In Source Code

You can also use the z/OS C/C++ library functions `svc99()` and `dynalloc()` to allocate ddnames. See [z/OS C/C++ Run-Time Library Reference](#) for more information about these functions.

You do not always need to describe the characteristics of the data in files both within the program and outside it. There are, in fact, advantages to describing the characteristics of your data in only one place.

Opening a file by ddname may require the merging of information internal and external to the program. If any conflict is detected that will prevent the opening of a file, `fopen()` returns a NULL pointer to indicate that the file cannot be opened. See [z/OS C/C++ Run-Time Library Reference](#) for more information on `fopen()`.

If `DISP=MOD` is specified on a DD statement and if the file is opened in `w` or `wb` mode, the `DISP=MOD` causes the file to be opened in append mode rather than in write mode.

**Note:** You can open a ddname only with `fopen()` or `freopen()`. `open()` does not interpret ddnames as such.

### How z/OS C/C++ Determines What Kind of File to Open

This section describes the criteria that z/OS C/C++ uses to determine what kind of file it is opening. z/OS C/C++ goes through the categories listed in Table 5 on page 55 in the order that follows. If a category applies to a file, z/OS C/C++ stops searching.

**Note:** Files cannot be opened under CICS when you have specified the POSIX(ON) run-time option.

The following chart shows how z/OS C/C++ determines what type of file to open under TSO, MVS batch, and interactive IMS with POSIX(ON). For information on the types of files shown in the chart see the appropriate chapter in the I/O section.
MAP 0010: Under TSO, MVS Batch, IMS — POSIX(ON)

001

Is type=memory specified?
Yes  No

002

Does the name begin with // but NOT ///?
Yes  No

003

Continue at Step 017 on page 65

004

Continue at Step 008

005

Is hiperspace specified?
Yes  No

006

z/OS C/C++ opens a regular memory file.

007

z/OS C/C++ opens a memory file in Hiperspace.

008

Is the next character an asterisk?
Yes  No

009

Is name of form DDname?
Yes  No

010

Does the name specified match that of an existing memory file?
Yes  No

011

z/OS C/C++ opens an OS file.

012

z/OS C/C++ opens the existing memory file.
Are you running under TSO interactive?
Yes  No

z/OS C/C++ removes the asterisk from the name unless the asterisk is the only character, and proceeds to Step 028 on page 66.

z/OS C/C++ opens a terminal file.

Is the name of the form *DD:ddname or DD:ddname?
Yes  No

Does the name specified match that of an existing memory file?
Yes  No

z/OS C/C++ opens an HFS file.

z/OS C/C++ opens the existing memory file.

Does ddname exist?
Yes  No

Does a memory file exist?
Yes  No

z/OS C/C++ opens an HFS file called either *DD:ddname or DD:ddname.

z/OS C/C++ opens the existing memory file.
Is a path specified in `ddname`?
Yes  No

**026**

z/OS C/C++ opens an OS file.

**027**

z/OS C/C++ opens an HFS file.

**028**

Is the name of the form `*DD:ddname` or `DD:ddname`?
Yes  No

**029**

Does the name specified match that of an existing memory file?
Yes  No

**030**

z/OS C/C++ opens an OS file.

**031**

z/OS C/C++ opens the existing memory file.

**032**

Does `ddname` exist?
Yes  No

**033**

Does a memory file exist?
Yes  No

**034**

***ERROR***

**035**

z/OS C/C++ opens the existing memory file.

**036**

Is a path specified in `ddname`?
Yes  No

**037**

z/OS C/C++ opens an OS file.
z/OS C/C++ opens an HFS file.

The following chart shows how z/OS C/C++ determines what type of file to open under TSO, MVS batch, and interactive IMS with POSIX(OFF). For information on the types of files shown in the chart see the appropriate chapter in the I/O section.
MAP 0020: Under TSO, MVS Batch, IMS — POSIX(OFF)

001
Is type=memory specified?
Yes  No

002
Does the name begin with // but NOT ///?
Yes  No

003
Continue at Step 017 on page 69

004
Continue at Step 008

005
Is hiperspace specified?
Yes  No

006
z/OS C/C++ opens a regular memory file.

007
z/OS C/C++ opens a memory file in Hiperspace.

008
Is the next character an asterisk?
Yes  No

009
Is name of form DDname?
Yes  No

010
Does the name specified match that of an existing memory file?
Yes  No

011
z/OS C/C++ opens an OS file.

012
z/OS C/C++ opens the existing memory file.
Are you running under TSO interactive?
Yes  No

z/OS C/C++ removes the asterisk from the name unless the asterisk is the only character, and proceeds to Step 017.

z/OS C/C++ opens a terminal file.

Is the name of the form *DD:ddname or DD:ddname?
Yes  No

Does the name specified match that of an existing memory file?
Yes  No

z/OS C/C++ opens an OS file.

z/OS C/C++ opens the existing memory file.

Does ddname exist?
Yes  No

Does a memory file exist?
Yes  No

***ERROR***

z/OS C/C++ opens the existing memory file.
Is a path specified in ddname?
Yes  No

z/OS C/C++ opens an OS file.

z/OS C/C++ opens an HFS file.

The following chart shows how z/OS C/C++ determines what type of file to open under CICS. For information on the types of files shown in the chart see the appropriate chapter in the I/O section.
MAP 0030: Under CICS

001
Is type=memory specified?
Yes No

002
Does the name specified match that of an existing memory file?
Yes No

003
The fopen() call fails.

004
z/OS C/C++ opens that memory file.

005

006
z/OS C/C++ opens the specified memory file.

007
The fopen() call ignores the hiperspace specification and opens the memory file.
Chapter 7. Buffering of C Streams

This chapter describes buffering modes used by z/OS C/C++ library functions available to control buffering and methods of flushing buffers.

z/OS C/C++ uses buffers to map C I/O to system-level I/O. When z/OS C/C++ performs I/O operations, it uses one of the following buffering modes:

- **Line buffering** - characters are transmitted to the system as a block when a new-line character is encountered. Line buffering is meaningful only for text streams and HFS files.
- **Full buffering** - characters are transmitted to the system as a block when a buffer is filled.
- **No buffering** - characters are transmitted to the system as they are written. Only regular memory files and HFS files support the no buffering mode.

The buffer mode affects the way the buffer is flushed. You can use the `setvbuf()` and `setbuf()` library functions to control buffering, but you cannot change the buffering mode after an I/O operation has used the buffer, as all read, write, and reposition operations do. In some circumstances, repositioning alters the contents of the buffer. It is strongly recommended that you only use `setbuf()` and `setvbuf()` before any I/O, to conform with ANSI, and to avoid any dependency on the current implementation. If you use `setvbuf()`, z/OS C/C++ may or may not accept your buffer for its internal use. For a hiperspace memory file, if the size of the buffer specified to `setvbuf()` is 8K or more, it will affect the number of hiperspace blocks read or written on each call to the operating system; the size is rounded down to the nearest multiple of 4K.

Full buffering is the default except in the following cases:

- If you are using an interactive terminal, z/OS C/C++ uses line buffering.
- If you are running under CICS, z/OS C/C++ also uses line buffering.
- `stderr` is line-buffered by default.
- If you are using a memory file, z/OS C/C++ does not use any buffering.

For terminals, because I/O is always unblocked, line buffering is equivalent to full buffering.

For record I/O files, buffering is meaningful only for blocked files or for record I/O HFS files using full buffering. For unblocked files, the buffer is full after every write and is therefore written immediately, leaving nothing to flush. For blocked files or fully-buffered HFS files, however, the buffer can contain one or more records that have not been flushed and that require a flush operation for them to go to the system.

You can flush buffers to the system in several different ways.

- If you are using full buffering, z/OS C/C++ automatically flushes a buffer when it is filled.
- If you are using line buffering for a text file or an HFS file, z/OS C/C++ flushes a buffer when you complete it with a control character. Except for HFS files, specifying line buffering for a record I/O or binary file has no effect; z/OS C/C++ treats the file as if you had specified full buffering.
- z/OS C/C++ flushes buffers to the system when you close a file or end a program.
- z/OS C/C++ flushes buffers to the system when you call the `fflush()` library function, with the following restrictions:
  - A file opened in text mode does not flush data if a record has not been completed with a new-line.
  - A file opened in fixed format does not flush incomplete records to the file.
  - An FBS file does not flush out a short block unless it is a DISK file opened without the NOSEEK parameter.

- All streams are flushed across non-POSIX `system()` calls. Streams are not flushed across POSIX `system()` calls. For a POSIX system call, we recommend that you do a `fflush()` before the `system()` call.

If you are reading a record that another user is writing to at the same time, you can see the new data if you call `fflush()` to refresh the contents of the input buffer.

**Note:** This is not supported for VSAM files.

You may not see output if a program that is using input and output fails, and the error handling routines cannot close all the open files.
Chapter 8. Using ASA Text Files

This chapter describes the American Standards Association (ASA) text files, the control characters used in ASA files, how z/OS C/C++ translates the control characters, and how z/OS C/C++ treats ASA files during input and output. The first column of each record in an ASA file contains a control character (' ', '0', '−', '1', or '+') when it appears in the external medium.

z/OS C/C++ translates control characters in ASA files opened for text processing (r, w, a, r+, w+, a+ functions). On input, z/OS C/C++ translates ASA characters to sequences of control characters, as shown in Table 8. On output, z/OS C/C++ performs the reverse translation. The following sequences of control characters are translated, and the resultant ASA character becomes the first character of the following record:

Table 8. C Control to ASA Characters Translation Table

<table>
<thead>
<tr>
<th>C Control Character Sequence</th>
<th>ASA Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>' '</td>
<td>' '</td>
<td>skip one line</td>
</tr>
<tr>
<td>'0'</td>
<td>' '</td>
<td>skip two lines</td>
</tr>
<tr>
<td>'−'</td>
<td>' '</td>
<td>skip three lines</td>
</tr>
<tr>
<td>'1'</td>
<td>' '</td>
<td>new page</td>
</tr>
<tr>
<td>'+'</td>
<td>' '</td>
<td>overstrike</td>
</tr>
</tbody>
</table>

If you are writing to the first record or byte of the file and the output data does not start with a translatable sequence of C control characters, the ' ' ASA control character is written to the file before the specified data.

z/OS C/C++ does not translate or verify control characters when you open an ASA file for binary or record I/O.

Example of Writing to an ASA File

CCNGAS1

/* this example shows how to write to an ASA file */
#include <stdio.h>
#define MAX_LEN 80

int main(void) {
    FILE *fp;
    int i;
    char s[MAX_LEN+1];

    Figure 5. ASA Example (Part 1 of 2)
This program writes five records to the file *asa.file*, as follows:

```
0abcdef
1
+345
-
9034
```

Note that the last record is 9034. The last single ‘\n’ does not create a record with a single control character (' '). If this same file is opened for read, and the `getc()` function is called to read the file 1 byte at a time, the same characters as those that were written out by `fputs()` in the first program are read.

**ASA File Control**

ASA files are treated as follows:

- If the first record written does not begin with a control character, then a single new-line is written and then followed by data; that is, the ASA character defaults to a space when none is specified.
- In ASA files, control characters are treated the same way that they are treated in other text files, with the following exceptions:

  **'f' — form feed**
  
  Defines a record boundary and determines the ASA character of the following record. Refer to **Table 8 on page 75**.

  **'n' — new-line**
  
  Does either of these:
  - Define a record boundary and determines the ASA character of the following record (see translation table above).
  - Modify the preceding ASA character if the current position is directly after an ASA character of ' ' or '0' (see translation table above).

  **'r' — carriage return**
  
  Defines a record boundary and determines the ASA character of the following record (see translation table above).

  - Records are terminated by writing a new-line ('\n'), carriage return ('\r'), or form feed ('\f') character.
  - An ASA character can be updated to any other ASA character. Updates made to any of the C control characters that make up an ASA character cause the ASA character to change.

```c
fp = fopen("asa.file", "w, recfm=fba");
if (fp != NULL) {
   fputs("\n\nabcdef\f\r345\n\n", fp);
   fputs("\n\n9034\n", fp);
   fclose(fp);
   return(0);
}

fp = fopen("asa.file", "r");
for (i = 0; i < 5; i++) {
   fscanf(fp, "%s", s[0]);
   printf("string = %s\n",s);
}
```
If the file is positioned directly after a ' ' or '0' ASA character, writing a "n" character changes the ASA character to a '0' or '-' respectively. However, if the ASA character is a '-', '1' or '+', the "n" truncates the record (that is, it adds blank padding to the end of the record), and causes the following record's ASA character to be written as a ' '. Writing a '\f' or '\r' terminates the record and start a new one, but writing a normal data character simply overwrites the first data character of the record.

- You cannot overwrite the ASA character with a normal data character. The position at the start of a record (at the ASA character) is the logical end of the previous record. If you write normal data there, you are writing to the end of the previous record. z/OS C/C++ truncates data for the following files, except when they are standard streams:
  - Variable-format files
  - Undefined-format files
  - Fixed-format files in which the previous record is full of data

When truncation occurs, z/OS C/C++ raises SIGIOERR and sets both errno and the error flag.

- Even when you update an ASA control character, seeking to a previously recorded position still succeeds. If the recorded position was at a control character that no longer exists (because of an update), the reposition is to the next character. Often, this is the first data character of the record. For example, if you have the following string:

```
HELLO WORLD
```

You have saved the position of the third new-line. If you then update the ASA character to a form feed ('\f'), the logical ASA position x no longer exists:

```
\fHELLO WORLD
```

If you call fseek() with the logical position x, it repositions to the next valid character, which is the letter 'H':

```
HELLO WORLD
```

- If you try to shorten a record when you are updating it, z/OS C/C++ adds enough blank padding to fill the record.
- The ASA character can represent up to three new-lines, which can increase the logical record length by 1 or 2 bytes.
- Extending a fixed logical record on update implies that the logical end of the line follows the last written non-blank character.
- If an undefined text record is updated, the length of the physical records does not change. If the replacement record is:
- **Longer** - data characters beyond the record boundary are truncated. At the point of truncation, the User error flag is set and SIGIOERR is raised (if the signal is not set up to be ignored). Truncation continues until you do one of these:
  1. Write a new-line character, carriage return, or form feed to complete the current record
  2. Close the file explicitly or implicitly at termination
  3. Reposition to another position in the file.

- **Shorter** - the blank character is used to overwrite the rest of the record.

  * If you close an ASA file that has a new-line as its last character, z/OS C/C++ does not write the new-line to the physical file. The next time you read from the file or update it, z/OS C/C++ returns the new-line to the end of the file. An exception to this rule happens when you write only a new-line to a new file. In this case, z/OS C/C++ does not truncate the new-line; it writes a single blank to the file. On input, however, you will read two new-lines.

  * Using ASA format to read a file that contains zero-length records results in undefined behavior.

  * You may have trouble updating a file if two ASA characters are next to each other in the file. For example, if there is a single-byte record (containing only an ASA character) immediately followed by the ASA character of the next record, you are positioned at or within the first ASA character. If you then write a sequence of '\n' characters intended to update both ASA characters, the '\n's will be absorbed by the first ASA character before overflowing to the next record. This absorption may affect the crossing of record boundaries and cause truncation or corruption of data.

  * At least one normal intervening data character (for example, a space) is required between '\n' and '\n' to differentiate record boundaries.

**Note:** Be careful when you update an ASA file with data containing more than one consecutive new-line: the result of the update depends on how the original ASA records were structured.

  * If you are writing data to a non-blocked file without intervening flush or reposition requests, each record is written to the system on completion (that is, when a '\n', '\r' or '\f' character is written or when the file is closed).

  * If you are writing data to a blocked file without intervening flush or reposition requests, and the file is opened in full buffering mode, the block is written to the system on completion of the record that fills the block. If the blocked file is line buffered, each record is written to the system on completion.

  * If you are writing data to a spanned file without intervening flush or reposition requests, and the record spans multiple blocks, each block is written to the system once it is full and the user writes an additional byte of data.

  * If a flush occurs while an ASA character indicating more than one new-line is being updated, the remaining new-lines will be discarded and a read will continue at the first data character. For example, if '\n\n\n' is updated to be '\n\n\n' and a flush occurs, then a '0' will be written out in the ASA character position.
Chapter 9. z/OS C Support for the Double-Byte Character Set

The number of characters in some languages such as Japanese or Korean is larger than 256, the number of distinct values that can be encoded in a single byte. The characters in such languages are represented in computers by a sequence of bytes, and are called multibyte characters. This chapter explains how the z/OS C compiler supports multibyte characters.

Note: The z/OS C++ compiler does not have native support for multibyte characters. The support described here is what z/OS C provides; for C++, you can take advantage of this support by using interlanguage calls to C code. Please refer to Chapter 19, “Using Linkage Specifications in C or C++” on page 245 for more information.

The z/OS C compiler supports the IBM EBCDIC encoding of multibyte characters, in which each natural language character is uniquely represented by one to four bytes. The number of bytes that encode a single character depends on the global shift state information. If a stream is in initial shift state, one multibyte character is represented by a byte or sequence of bytes that has the following characteristics:

- It starts with the byte containing the shift-out (0x0e) character.
- The shift-out character is followed by 2 bytes that encode the value of the character.
- These bytes may be followed by a byte containing the shift-in (0x0f) character.

If the sequence of bytes ends with the shift-in character, the state remains initial, making this sequence represent a 4-byte multibyte character. Multibyte characters of various lengths can be normalized by the set of z/OS C library functions and encoded in units of one length. Such normalized characters are called wide characters; in z/OS C they are represented by two bytes. Conversions between multibyte format and wide character format can be performed by string conversion functions such as wcstombs(), mbstowcs(), wcsrtombs(), and mbsrtowcs(), as well as by the family of the wide character I/O functions. MB_CUR_MAX is defined in the stdlib.h header file. Depending on its value, either of the following happens:

- When MB_CUR_MAX is 1, all bytes are considered single-byte characters; shift-out and shift-in characters are treated as data as well.
- When MB_CUR_MAX is 4:
  - On input, the wide character I/O functions read the multibyte character from the streams, and convert them to the wide characters.
  - On output, they convert wide characters to multibyte characters and write them to the output streams.

Both binary and text streams have orientation. Streams opened with type=record do not. There are three possible orientations of a stream:

Non-oriented

A stream that has been associated with an open file before any operation other than setbuf() or setvbuf() is performed. Subsequent operations on a non-oriented stream change the orientation of the stream. You can use the setbuf() and setvbuf() functions only on a non-oriented stream. When you use these functions, the stream remains non-oriented. When you perform one of the wide character input/output operations on a non-oriented stream,
the stream becomes wide-oriented. When you perform one of the byte input/output operations on a non-oriented stream, the stream becomes byte-oriented.

**Wide-oriented**

A stream on which any wide character input/output functions are guaranteed to operate correctly. Conceptually, wide-oriented streams are sequences of wide characters. The external file associated with a wide-oriented stream is a sequence of multibyte characters. Using byte I/O functions on a wide-oriented stream results in undefined behavior. A stream opened for record I/O cannot be wide-oriented.

**Byte-oriented**

A stream on which any byte input/output functions are guaranteed to operate properly. Using wide character I/O functions on a byte input/output stream results in undefined behavior. Byte-oriented streams have minimal support for multibyte characters.

Calls to the clearerr(), feof(), ferror(), fflush(), fgetpos(), or ftell() functions do not change the orientation.

Once you have established a stream's orientation, the only way to change it is to make a successful call to the freopen() function, which removes a stream's orientation.

The wchar.h header file declares the WEOF macro and the functions that support wide character input and output. The macro expands to a constant expression of type wint_t. Certain functions return WEOF type when the end-of-file is reached on the stream.

**Note:** The behavior of the wide character I/O functions is affected by the LC_CTYPE category of the current locale, and the setting of MB_CUR_MAX. Wide-character input and output should be performed under the same LC_CTYPE setting. If you change the setting between when you read from a file and when you write to it, or vice versa, you may get undefined behavior. If you change it back to the original setting, however, you will get the behavior that is documented. See the introduction of this chapter for a discussion of the effects of MB_CUR_MAX.

---

**Opening Files**

You can use the fopen() or freopen() library functions to open I/O files that contain multibyte characters. You do not need to specify any special parameters on these functions for wide character I/O.

**Reading Streams and Files**

Wide character input functions read multibyte characters from the stream and convert them to wide characters. The conversion process is performed in the same way that the mbtowc() function performs conversions.

The following z/OS C library functions support wide character input:

- fgetwc()
- fgetws()
- getwc()
- getwchar()
In addition, the following byte-oriented functions support handling multibyte characters by providing conversion specifiers to handle the `wchar_t` data type:

- `swscanf()`
- `scanf()`
- `fscanf()`
- `sscanf()`

All other byte-oriented input functions treat input as single-byte.

For a detailed description of unformatted and formatted I/O functions, refer to the `z/OS C/C++ Run-Time Library Reference`.

The wide-character input/output functions maintain global shift state for multibyte character streams they read or write. For each multibyte character they read, wide-character input functions change global shift state as the `mbrtowc()` function would do. Similarly, for each multibyte character they write, wide-character output functions change global shift state as the `wcrtomb()` function would do.

When you are using wide-oriented input functions, multibyte characters are converted to wide characters according to the current shift state. Invalid double-byte character sequences cause conversion errors on input. As z/OS C uses wide-oriented functions to read a stream, it updates the shift state when it encounters shift-out and shift-in characters. Wide-oriented functions always read complete multibyte characters. Byte-oriented functions do not check for complete multibyte characters, nor do they maintain information about the shift state. Therefore, they should not be used to read multibyte streams.

For binary streams, no validation is performed to ensure that records start or end in initial shift state. For text streams, however, all records must start and end in initial shift state.

### Writing Streams and Files

Wide character output functions convert wide characters to multibyte characters and write the result to the stream. The conversion process is performed in the same way that the `wcrtomb()` function performs conversions.

The following z/OS C functions support wide character output:

- `fputwc()`
- `fputws()`
- `swprintf()`
- `vswprintf()`
- `putwc()`
- `putwchar()`

In addition, the following byte-oriented functions support handling multibyte characters by providing conversion specifiers to handle the `wchar_t` data type:

- `printf()`
- `fprintf()`
- `sprintf()`
All other output functions do not support the wchar_t data type. However, all of the output functions support multibyte character output for text streams if MB_CUR_MAX is 4.

For a detailed description of unformatted and formatted I/O functions, refer to the z/OS C/C++ Run-Time Library Reference.

Writing Text Streams

When you are using wide-oriented output functions, wide characters are converted to multibyte characters. For text streams, all records must start and end in initial shift state. The wide-character functions add shift-out and shift-in characters as they are needed. When the file is closed, a shift-out character may be added to complete the file in initial shift state.

When you are using byte-oriented functions to write out multibyte data, z/OS C starts each record in initial shift state and makes sure you complete each record in initial shift state before moving to the next record. When a string starts with a shift-out, all data written is treated as multibyte, not single-byte. This means that you cannot write a single-byte control character (such as a new-line) until you complete the multibyte string with a shift-in character.

Attempting to write a second shift-out character before a shift-in is not allowed. z/OS C truncates the second shift-out and raises SIGIOERR if SIGIOERR is not set to SIG_IGN.

When you write a shift-in character to an incomplete multibyte character, z/OS C completes the multibyte character with a padding character (0xfe) before it writes the shift-in. The padding character is not counted as an output character in the total returned by the output function; you will never get a return code indicating that you wrote more characters than you provided. If z/OS C adds a padding character, however, it does raise SIGIOERR, if SIGIOERR is not set to SIG_IGN.

Control characters written before the shift-in are treated as multibyte data and are not interpreted or validated.

When you close the file, z/OS C ensures that the file ends in initial shift state. This may require adding a shift-in and possibly a padding character to complete the last multibyte character, if it is not already complete. If padding is needed in this case, z/OS C does not raise SIGIOERR.

Multibyte characters are never split across record boundaries. In addition, all records end and start in initial shift state. When a shift-out is written to the file, either directly or indirectly by wide-oriented functions, z/OS C calculates the maximum number of complete multibyte characters that can be contained in the record with the accompanying shift-in. If multibyte output (including any required shift-out and shift-in characters) does not fit within the current record, the behavior depends on what type of file it is (a memory file has no record boundaries and so never has this particular problem). For a standard stream or terminal file, data is wrapped from one record to the next. Shift characters may be added to ensure that the first record ends in initial shift state and that the second record starts in the required shift state.

For files that are not standard streams, terminal files, or memory files, any attempt to write data that does not fit into the current record results in data truncation. In such a case, the output function returns an error code, raises SIGIOERR, and sets
errno and the error flag. Truncation continues until initial state is reached and a
new-line is written to the file. An entire multibyte stream may be truncated, including
the shift-out and shift-in, if there are not at least two bytes in the record. For a
wide-oriented stream, truncation stops when a wchar_t new-line character is written
out.

Updating a wide-oriented file or a file containing multibyte characters is strongly
discouraged, because your update may overwrite part of a multibyte string or
character, thereby invalidating subsequent data. For example, you could
inadvertently add data that overwrites a shift-out. The data after the shift-out is
meaningless when it is treated in initial shift state. Appending new data to the end
of the file is safe.

**Writing Binary Streams**

When you are using wide-oriented output functions, wide characters are converted
to multibyte characters. No validation is performed to ensure that records start or
end in initial shift state. When the file is closed, any appends are completed with a
shift-in character, if it is needed to end the stream in initial shift state. If you are
updating a record when the stream is closed, the stream is flushed. See [Flushing
Buffers](#) for more information.

Byte-oriented output functions do not interpret binary data. If you use them for
writing multibyte data, ensure that your data is correct and ends in initial shift state.

Updating a wide-oriented file or a file containing multibyte characters is strongly
discouraged, because your update may overwrite part of a multibyte string or
character, thereby invalidating subsequent data. For example, you could
inadvertently add data that overwrites a shift-out. The data after the shift-out is
meaningless when it is treated in initial shift state. Appending new data to the end
of the file is safe for a wide-oriented file.

If you update a record after you call fgetpos(), the shift state may change. Using
the fpos_t value with the fsetpos() function may cause the shift state to be set
incorrectly.

**Flushing Buffers**

You can use the library function fflush() to flush streams to the system. For more
information about fflush(), see the [z/OS C/C++ Run-Time Library Reference](#).

The action taken by the fflush() library function depends on the buffering mode
associated with the stream and the type of stream. If you call one z/OS C program
from another z/OS C program by using the ANSI system() function, all open
streams are flushed before control is passed to the callee. A call to the POSIX
system() function does not flush any streams to the system. For a POSIX system
call, we recommend that you do a fflush() before the system call.

**Flushing Text Streams**

When you call fflush() after updating a text stream, fflush() calculates your
current shift state. If you are not in initial shift state, z/OS C looks forward in the
record to see whether a shift-in character occurs before the end of the record or
any shift-out. If not, z/OS C adds a shift-in to the data if it will not overwrite a
shift-out character. The shift-in is placed such that there are complete multibyte
characters between it and the shift-out that took the data out of initial state. z/OS C
may accomplish this by skipping over the next byte in order to leave an even number of bytes between the shift-out and the added shift-in.

Updating a wide-oriented or byte-oriented multibyte stream is strongly discouraged. In a byte-oriented stream, you may have written only half of a multibyte character when you call `fflush()`. In such a case, z/OS C adds a padding byte before the shift-out. For both wide-oriented and byte-oriented streams, the addition of any shift or padding character does not move the current file position.

Calling `fflush()` has no effect on the current record when you are writing new data to a wide-oriented or byte-oriented multibyte stream, because the record is incomplete.

**Flushing Binary Streams**

In a wide-oriented stream, calling `fflush()` causes z/OS C to add a shift-in character if the stream does not already end in initial shift state. In a byte-oriented stream, calling `fflush()` causes no special behavior beyond what a call to `fflush()` usually does.

**ungetwc() Considerations**

`ungetwc()` pushes wide characters back onto the input stream for binary and text files. You can use it to push one wide character onto the `ungetwc()` buffer. Never use `ungetc()` on a wide-oriented file. After you call `ungetwc()`, calling `fflush()` backs up the file position by one wide character and clears the pushed-back wide character from the stream. Backing up by one wide character skips over shift characters and backs up to the start of the previous character (whether single-byte or double-byte). For text files, z/OS C counts the new-lines added to the records as single-byte characters when it calculates the file position. For example, if you have the following stream: you can run the following code fragment:

```
AB C

fp

fgetwc(fp); /* Returns X'00C1' (the hexadecimal */ /* wchar representation of A) */
fgetwc(fp); /* Returns X'00C2' (the hexadecimal */ /* wchar representation of B) */
fgetwc(fp); /* Returns X'7FFE' (the hexadecimal */ /* wchar representation of the DBCS */ /* character) between the SO and SI */ /* characters; leaves file position at C */
ungetwc('Z',fp); /* Logically inserts Z before SI character */
fflush(fp); /* Backs up one wchar, leaving position at */ /* beginning of X'7FFE' DBCS char */ /* and DBCS state in double-byte mode; */ /* clears Z from the logical stream */
```

*Figure 6. ungetwc() Example*

You can set the _EDC_COMPAT environment variable before you open the file, so that `fflush()` ignores any character pushed back with `ungetwc()` or `ungetc()`, and leaves
the file position where it was when ungetwc() or ungetc() was first issued. Any characters pushed back are still cleared. For more information about _EDC_COMPAT, see Chapter 33, “Using Environment Variables” on page 479.

Setting Positions within Files

The following conditions apply to text streams and binary streams.

Repositioning within Text Streams

When you use the fseek() or fsetpos() function to reposition within files, z/OS C recalculates the shift state.

If you update a record after a successful call to the fseek() function or the fsetpos() function, a partial multibyte character can be overwritten. Calling a wide character function for data after the written character can result in undefined behavior.

Use the fseek() or fsetpos() functions to reposition only to the start of a multibyte character. If you reposition to the middle of a multibyte character, undefined behavior can occur.

Repositioning within Binary Streams

When you are working with a wide-oriented file, keep in mind the state of the file position that you are repositioning to. If you call ftell(), you can seek with SEEK_SET and the state will be reset correctly. You cannot use such an ftell() value across a program boundary unless the stream has been marked wide-oriented. A seek specifying a relative offset (SEEK_CUR or SEEK_END) will change the state to initial state. Using relative offsets is strongly discouraged, because you may be seeking to a point that is not in initial state, or you may end up in the middle of a multibyte character, causing wide-oriented functions to give you undefined behavior. These functions expect you to be at the beginning or end of a multibyte character in the correct state. Using your own offset with SEEK_SET also does the same. For a wide-oriented file, the number of valid bytes or records that ftell() supports is cut in half.

When you use the fsetpos() function to reposition within a file, the shift state is set to the state saved by the function. Use this function to reposition to a wide character that is not in the initial state.

ungetwc() Considerations

For text files, the library functions fgetpos() and ftell() take into account the character you have pushed back onto the input stream with ungetwc(), and move the file position back by one wide character. The starting position for an fseek() call with a whence value of SEEK_CUR also takes into account this pushed-back wide character. Backing up one wide character means backing up either a single-byte character or a multibyte character, depending on the type of the preceding character. The implicit new-lines at the end of each record are counted as wide characters.

For binary files, the library functions fgetpos() and ftell() also take into account the character you have pushed back onto the input stream with ungetwc(), and adjust the file position accordingly. However, the ungetwc() must push back the same type of character just read by fgetwc(), so that ftell() and fgetpos() can save the state correctly. An fseek() with an offset of SEEK_CUR also accounts for the
pushed-back character. Again, the `ungetwc()` must unget the same type of character for this to work properly. If the `ungetwc()` pushes back a character in the opposite state, you will get undefined behavior.

You can make only one call to `ungetwc()`. If the current logical file position is already at or before the first wchar in the file, a call to `ftell()` or `fgetpos()` after `ungetwc()` fails.

When you are using `fseek()` with a whence value of SEEK_CUR, the starting point for the reposition also accounts for the presence of `ungetwc()` characters and compensates as `ftell()` and `fgetpos()` do. Specifying a relative offset other than 0 is not supported and results in undefined behavior.

You can set the `_EDC_COMPAT` environment variable to specify that `ungetwc()` should not affect `fgetpos()` or `fseek()`. (It will still affect `ftell()`.) If the environment variable is set, `fgetpos()` and `fseek()` ignore any pushed-back wide character. See Chapter 33, “Using Environment Variables” on page 479 for more information about `_EDC_COMPAT`.

If a repositioning operation fails, z/OS C attempts to restore the original file position by treating the operation as a call to `fflush()`. It does not account for the presence of `ungetwc()` characters, which are lost.

Closing Files

z/OS C expects files to end in initial shift state. For binary byte-oriented files, you must ensure that the ending state of the file is initial state. Failure to do so results in undefined behavior if you reaccess the file again. For wide-oriented streams and byte-oriented text streams, z/OS C tracks new data that you add. If necessary, z/OS C adds a padding byte to complete any incomplete multibyte character and a shift-in to end the file in initial state.

Manipulating Wide Character Array Functions

In order to manipulate wide character arrays in your program, the following functions can be used:

Table 9. Manipulating wide character arrays

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>wmemcmp()</td>
<td>Compare wide character</td>
</tr>
<tr>
<td>wmemchr()</td>
<td>Locate wide character</td>
</tr>
<tr>
<td>wmemcp()</td>
<td>Copy wide character</td>
</tr>
<tr>
<td>wmemmove()</td>
<td>Move wide character</td>
</tr>
<tr>
<td>wmemset()</td>
<td>Set wide character</td>
</tr>
<tr>
<td>wcrtomb()</td>
<td>Convert a wide character to a multibyte character</td>
</tr>
<tr>
<td>wcscat()</td>
<td>Append to wide-character string</td>
</tr>
<tr>
<td>wcschr()</td>
<td>Search for wide-character substring</td>
</tr>
<tr>
<td>wcscmp()</td>
<td>Compare wide-character strings</td>
</tr>
</tbody>
</table>

For more information about these functions, refer to the z/OS C/C++ Run-Time Library Reference.
Chapter 10. Using C and C++ Standard Streams and Redirection

The standard streams are declared in the C header file `stdio.h` or in the C++ header files `iostream.h` or `iostream`. Table 10 below shows the C standard streams and the functions that use them, as well as the C++ standard streams and the operators typically used to perform I/O with them.

By default, the standard streams are opened implicitly the first time they are referenced. You do not have to declare them or call their `open()` member functions to open them. For example, with no preceding declaration or `open()` call, the following statement writes the decimal number n to the `cout` stream.

```c
cout << n << endl;
```

For more detailed information about I/O streaming see the following:

- [z/OS C/C++ Run-Time Library Reference](http://www.ibm.com/software/ad/c390/czos/czosdocs.html) discusses the C I/O stream functions.

### Table 10. Standard C and C++ streams

<table>
<thead>
<tr>
<th>C standard streams and their related functions</th>
<th>Functions that use it</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of stream</strong></td>
<td><strong>Purpose</strong></td>
</tr>
<tr>
<td>stdin</td>
<td>The input device from which your C program usually retrieves its data.</td>
</tr>
<tr>
<td>stdout</td>
<td>The output device to which your C program normally directs its output.</td>
</tr>
<tr>
<td>stderr</td>
<td>The output device to which your C program directs its diagnostic messages. z/OS C/C++ uses stderr to collect error messages about exceptions that occur.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C++ standard streams and the operators typically used with them</th>
<th>Common usage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of stream</strong></td>
<td><strong>Purpose</strong></td>
</tr>
<tr>
<td>cin</td>
<td>The object from which your C++ program usually retrieves its data. In z/OS C++, input from cin comes from stdin by default.</td>
</tr>
<tr>
<td>cout</td>
<td>The object to which your C++ program normally directs its output. In z/OS C++, output to cout goes to stdout by default.</td>
</tr>
<tr>
<td>cerr</td>
<td>The object to which your C++ program normally directs its diagnostic messages. In z/OS C++, output to cerr goes to stderr by default. cerr is unbuffered, so each character is flushed as you write it.</td>
</tr>
</tbody>
</table>
Table 10. Standard C and C++ streams (continued)

<table>
<thead>
<tr>
<th>clog</th>
<th>Another object intended for error messages. In z/OS C++, output to clog goes to stderr by default. Unlike cerr, clog is buffered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;&lt;</td>
<td>the output (insertion) operator</td>
</tr>
</tbody>
</table>

On I/O operations requiring a file pointer, you can use stdin, stdout, or stderr in the same manner as you would any other file pointer.

If you are running with POSIX(ON), standard streams are opened during initialization of the process, before the application receives control. With POSIX(OFF), the default behavior is for the C standard streams to open automatically on first reference. You do not have to call fopen() to open them. For example:

```c
printf("%d\n", n);
```

with no preceding fopen() statement writes the decimal number n to the stdout stream.

By default, stdin interprets the character sequence /* as indicating that the end of the file has been reached. See Chapter 14, "Performing Terminal I/O Operations" on page 205 for more information.

Default Open Modes

The default open modes for the C standard streams are:

```text
stdin  r  
stdout w  
stderr w
```

Where the streams go depends on what kind of environment you are running under. These are the defaults:

- **Under interactive TSO**, all three standard streams go to the terminal.
- **Under MVS batch, TSO batch, and IMS (batch and interactive):**
  - stdin goes to dd:sysin. If dd:sysin does not exist, all read operations from stdin will fail.
  - stdout goes first to dd:sysprint. If dd:sysprint does not exist, stdout looks for dd:system and then dd:syserr. If neither of these files exists, z/OS C/C++ opens a sysout=* data set and sends the stdout stream to it.
  - stderr will go to the z/OS Language Environment message file.
- **Under CICS**, stdout and stderr are assigned to transient data queues, allocated during CICS initialization. The CICS standard streams can be redirected only to or from memory files. You can do this by using freopen().
- **Under z/OS UNIX**, if you are running in one of the z/OS UNIX shells, the shell controls redirection. See z/OS UNIX System Services User’s Guide and z/OS UNIX System Services Command Reference for information.

You can also redirect the standard streams to other files. See Redirecting Standard Streams and sections following.
Interleaving the Standard Streams with `sync_with_stdio()`

The `sync_with_stdio()` function allows you to interleave C standard streams with standard streams from either the Standard C++ Library or the USL I/O Stream Class Library. A call to `sync_with_stdio()` does the following:

- `cin`, `cout`, `cerr`, and `clog` are initialized with `stdiobuf` objects associated with `stdin`, `stdout`, and `stderr`.
- The flags `unitbuf` and `stdio` are set for `cout`, `cerr`, and `clog`.

This ensures that subsequent standard streams may be mixed on a per-character basis. However, a run-time performance penalty is incurred to ensure this synchronization.

```c
// Example of interleaving USL I/O with sync_with_stdio()
// tsyncws.cxx
#include <stdio.h>
#include <fstream.h>
int main() {
    ios::sync_with_stdio();
    cout << "object: to show that sync_with_stdio() allows interleaving\n";
    cout << " standard input and output on a per character basis\n" << endl;
    printf( "line 1 ");
    cout << "rest of line 1\n";
    cout << "line 2 ";
    printf( "rest of line 2\n\n");
    char string1[80] = "";
    char string2[80] = "";
    char string3[80] = "";
    char* rc = NULL;
    cout << "type the following 2 lines:\n";
    cout << "hello world, here I am\n";
    cout << "again\n" << endl;
    cin.get(string1[0]);
    string1[1] = getchar();
    cin.get(string1[2]);
    cout << "\nstring1[0] is '" << string1[0] << "'
" << "string1[1] is '" << string1[1] << "'
" << "string1[2] is '" << string1[2] << "'
" << endl;
    cin >> &string1[3];
    rc = gets(string2); // note: reads to end of line, so
    cin >> string3; // this line waits for more input
    cout << "\nstring1 is " << string1 << "\n" << "string2 is " << string2 << "\n" << "string3 is " << string3 << "\n" << flush;
}
```

Figure 7. Interleaving I/O with `sync_with_stdio()` (Part 1 of 2)
Interleaving the Standard Streams without `sync_with_stdio()`

Output can be interleaved without `sync_with_stdio()`, since the C++ standard streams are based on z/OS C I/O. That is, `cout` can be interleaved with `stdout`, and `clog` can be interleaved with `stderr`. This is done by explicitly flushing `cout` or `clog` before calling the z/OS C output function. Results of attempting to interleave these streams without explicitly flushing, are undefined. Output to `cerr` doesn't have to be explicitly flushed, since `cerr` is unit-buffered.

Input to `cin` may be interleaved with input to `stdin`, without `sync_with_stdio()`, on a line-by-line basis. Results of attempting to interleave on a per-character basis are undefined.

---

Figure 7. Interleaving I/O with `sync_with_stdio()` (Part 2 of 2)
// Example of interleaving I/O without sync_with_stdio()
//
// tsyncwos.cxx
#include <stdio.h>
#include <fstream.h>
int main() {
  cout << "object: to illustrate interleaving input and output\n   " 
       "without sync_with_stdio()\n" << endl;
  printf("interleaving output ");
  cout << "works with an (end of line 1) \n" << flush;
  cout << "explicit flush of cout " << flush;
  printf("(end of line 2)\n\n");
  char string1[80] = "";
  char string2[80] = "";
  char string3[80] = "";
  char* rc = NULL;
  cout << "type the following 3 lines:\n" 
       "interleaving input\n" 
       "on a per-line basis\n" 
       "is supported\n" << endl;
  cin.getline(string1, 80);
  rc = gets(string2);
  cin.getline(string3, 80);
  cout << "string1 is " << string1 << "\n" 
       "string2 is " << string2 << "\n" 
       "string3 is " << string3 << "\n" << endl;
  char char1 = '\0';
  char char2 = '\0';
  char char3 = '\0';
  cout << "type the following 2 lines:\n" 
       "results of interleaving input on a per-\n" 
       "character basis are not defined\n" << endl;
  cin >> char1;
  char2 = (char) getchar();
  cin >> char3;
  cout << "\nchar1 is " << char1 << "\n" 
       "char2 is " << char2 << "\n" 
       "char3 is " << char3 << "\n" << flush;
}

Figure 8. Interleaving I/O without sync_with_stdio() (Part 1 of 2)
Redirecting Standard Streams

This section describes redirection of standard streams:

- From the command line
- By assignment
- With freopen()
- With the MSGFILE run-time option

Note that, C++ standard streams are implemented in terms of C standard streams. Therefore, cin, cout, cerr, and clog are implicitly redirected when the corresponding C standard streams are redirected. These streams can be redirected by assignment, as described in "Assigning the Standard Streams" on page 94. If freopen() is applied to a C standard stream, creating a binary stream or one with "type=record", then behavior of the related stream is undefined.

Redirecting Streams from the Command Line

To redirect a standard stream to a file from the command line, invoke your program by entering the following:

1. Program name
2. Any parameters your program requires (these may be specified before and after the redirection)
3. A redirection symbol followed by the name of the file that is to be used in place of the standard stream

**Note:** If you specify a redirection in a `system()` call, after `system()` returns, the streams are redirected back to those at the time of the `system()` call.

### Using the Redirection Symbols

The following table lists the redirection symbols supported by z/OS C/C++ (when not running under one of the z/OS UNIX shells) for redirection of C standard streams from the command line or from a `system()` call. 0, 1, and 2 represent stdin, stdout, and stderr, respectively.

**Table 11. z/OS C/C++ Redirection Symbols**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;fn</code></td>
<td>associates the file specified as <code>fn</code> with stdin; reopens <code>fn</code> in mode r.</td>
</tr>
<tr>
<td><code>0&lt;fn</code></td>
<td>associates the file specified as <code>fn</code> with stdin; reopens <code>fn</code> in mode r.</td>
</tr>
<tr>
<td><code>&gt;fn</code></td>
<td>associates the file specified as <code>fn</code> with stdout; reopens <code>fn</code> in mode w.</td>
</tr>
<tr>
<td><code>1&gt;fn</code></td>
<td>associates the file specified as <code>fn</code> with stdout; reopens <code>fn</code> in mode w.</td>
</tr>
<tr>
<td><code>&gt;&gt;fn</code></td>
<td>associates the file specified as <code>fn</code> with stdout; reopens <code>fn</code> in mode a.</td>
</tr>
<tr>
<td><code>2&gt;fn</code></td>
<td>associates the file specified as <code>fn</code> with stderr; reopens <code>fn</code> in mode w.</td>
</tr>
<tr>
<td><code>2&gt;&gt;fn</code></td>
<td>associates the file specified as <code>fn</code> with stderr; reopens <code>fn</code> in mode a.</td>
</tr>
<tr>
<td><code>2&gt;&amp;1</code></td>
<td>associate stderr with stdout; same file and mode.</td>
</tr>
<tr>
<td><code>1&gt;&amp;2</code></td>
<td>associate stdout with stderr; same file and mode.</td>
</tr>
</tbody>
</table>

**Notes:**
1. If you use the NOREDIR option on a `#pragma runopts` directive, or the NOREDIR compile-time option, you cannot redirect standard streams on the command line using the preceding list of symbols.
2. If you want to pass one of the redirection symbols as an argument, you can enclose it in double quotation marks. For example, the following passes the string "here are the args including a <" to prog and redirects stdout to redir1 output a.
   ```
   prog "here are args including a <" >"redir1 output a"
   ```
3. TSO (batch and online) and MVS batch support command line arguments. CICS and IMS do not.
4. When two options specifying redirection conflict with each other, or when you redirect a standard stream more than once, the redirection fails. If you do the latter, you will get an abend. For example, if you specify
   ```
   2>&1
   ```
   and then
   ```
   1>&2
   ```
   z/OS C/C++ uses the first redirection and ignores any subsequent ones. If you specify
   ```
   >a.out
   ```
   and then
   ```
   1>&2
   ```
the redirection fails and the program abends.

5. A failed attempt to redirect a standard stream causes your program to fail in initialization.

Assigning the Standard Streams

This method of redirecting streams is known as direct assignment. You can redirect a C standard stream by assigning a valid file pointer to it, as follows:

```c
FILE *stream;
stream = fopen("new.file", "w+);
stdout = stream;
```

You must ensure that the streams are appropriate; for example, do not assign a stream opened for write to stdin. Doing so would cause a function such as `getchar()` called for the stream to fail, because `getchar()` expects a stream to be opened for read access.

Similarly, you can redirect a standard stream under C++ by assignment:

```c
ofstream myfile("myfile.data");
cout = myfile;
```

Again, you must ensure that the assigned stream is appropriate; for example, do not assign an fstream opened for `ios::out` only to `cin`. This will cause a subsequent read operation to fail.

Using the freopen() Library Function

You can use the `freopen()` C library function to redirect C standard streams in all environments.

Redirecting Streams with the MSGFILE Option

You can redirect `stderr` by specifying a ddname on the MSGFILE run-time option and not redirecting `stderr` elsewhere (such as on the command line). The default ddname for the z/OS Language Environment MSGFILE is SYSOUT. See z/OS Language Environment Programming Guide for more information on MSGFILE.

MSGFILE Considerations

z/OS C/C++ makes a distinction between types of error output according to whether the output is directed to the MSGFILE, to `stderr`, or to `stdout`:

<table>
<thead>
<tr>
<th>Destination of Output</th>
<th>Type of Message</th>
<th>Produced by</th>
<th>Default Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSGFILE output</td>
<td>z/OS Language Environment messages (CEExxxx)</td>
<td>z/OS Language Environment conditions</td>
<td>MSGFILE ddname</td>
</tr>
<tr>
<td></td>
<td>z/OS C/C++ language messages (EDCxxxx)</td>
<td>z/OS C/C++ unhandled conditions</td>
<td>MSGFILE ddname</td>
</tr>
<tr>
<td>stderr messages</td>
<td>perror() messages (EDCxxxx)</td>
<td>Issued by a call, for example, to: perror()</td>
<td>MSGFILE ddname ¹</td>
</tr>
<tr>
<td>User output sent</td>
<td>Issued by a call to printf()</td>
<td></td>
<td>MSGFILE ddname</td>
</tr>
<tr>
<td>explicitly to stdout</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 12. Output Destinations under z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Destination of Output</th>
<th>Type of Message Produced by Default</th>
<th>Default Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>stdout messages</td>
<td>User output sent explicitly to stdout</td>
<td>stdout (^2)</td>
</tr>
</tbody>
</table>

All stderr output is by default sent to the MSGFILE destination, while stdout output is sent to its own destination. When stderr is redirected to stdout, both share the stdout destination. When stdout is redirected to stderr, both share the stderr destination.

If you specified one of the DDs used in the stdout open search order as the DD for the MSGFILE option, then that DD will be ignored in the stdout open search.

Table 13 describes the destination of output to stderr and stdout after redirection has occurred. Whenever stdout and stderr share a common destination, the output is interleaved. The default case is the one where stdout and stderr have not been redirected.

Table 13. z/OS C/C++ Interleaved Output

<table>
<thead>
<tr>
<th>stdout not redirected</th>
<th>stderr redirected to destination other than stdout</th>
<th>stderr redirected to stdout</th>
</tr>
</thead>
<tbody>
<tr>
<td>stdout not redirected</td>
<td>stdout to itself stderr to MSGFILE</td>
<td>Both to stdout</td>
</tr>
<tr>
<td>stdout redirected to destination other than stderr</td>
<td>stdout to its other destination stderr to MSGFILE</td>
<td>Both to the new stdout destination</td>
</tr>
<tr>
<td>stderr redirected to stdout</td>
<td>Both to MSGFILE</td>
<td>Both to the new stderr destination stderr to stdout</td>
</tr>
</tbody>
</table>

z/OS C/C++ routes error output as follows:

- **MSGFILE output**
  - z/OS Language Environment messages (messages prefixed with CEE)
  - Language messages (messages prefixed with EDC)
- **stderr output**
  - perror messages (messages prefixed with EDC and issued by a call to perror())
  - Output explicitly sent to stderr (for example, by a call to fprintf())

By default, z/OS C/C++ sends all stderr output to the MSGFILE destination and stdout output to its own destination. You can change this by using z/OS C/C++ redirection, which enables you to redirect stdout and stderr to a ddname, file name, or each other. Unless you have redirected stderr, it always uses the MSGFILE destination. When you redirect stderr to stdout, stderr and stdout share the stdout destination. When you redirect stdout to stderr, they share the stderr destination.

1. When you are using one of the z/OS UNIX shells, stderr will go to file descriptor 2, which is typically the terminal. See Chapter 17, “Language Environment Message File Operations” on page 231 for more information about z/OS Language Environment message files.

2. When you are using one of the z/OS UNIX shells, stdout will go to file descriptor 1, which is typically the terminal.
Redirecting Streams under z/OS

This section describes how to redirect C standard streams under MVS batch and under TSO.

Under MVS Batch

You can redirect standard streams in the following ways:

- From the `freopen()` library function call
- On the `PARM` parameter of the `EXEC` used to invoke your C or C++ program
- Using `DD` statements

Because the topic of JCL statements goes beyond the scope of this book, only simple examples will be shown here.

Using the PARM Parameter of the EXEC Statement

The following example shows an excerpt taken from a job stream. It demonstrates both the redirection of `stdout` using the `PARM` parameter of the `EXEC` statement, and the way to redirect to a fully qualified data set. You can use the redirection symbols described in Table 11 on page 93.

Suppose you have a program called `BATCHPGM` with 1 required parameter 'DEBUG'. The output from `BATCHPGM` is to be directed to a sequential data set called 'MAINT.LOG_LISTING'. You can use the following JCL statements:

```
//JOBname JOB...
//STEP01 EXEC PGM=BATCHPGM,PARM='DEBUG > MAINT.LOG_LISTING'
```

The following JCL redirects output to an unqualified data set using the same program name, parameter and output data set as the example above:

```
//STEP01 EXEC PGM=BATCHPGM,PARM='DEBUG >LOG_LISTING'
```

If your userid were TSOU812, `stdout` would be sent to TSOU812.LOG_LISTING.

Using DD Statements

When you use `DD` statements to redirect standard streams, the standard streams will be associated with ddnames as follows:

- `stdin` will be associated with the `SYSIN` ddname. If `SYSIN` is not defined, no characters can be read in from `stdin`.
- `stdout` will be associated with the `SYSPRINT` ddname. If `SYSPRINT` is not defined, the C library will try to associate `stdout` with `SYSTERM`, and if `SYSTERM` is also not defined, the C library will try to associate `stdout` with `SYSERR`. If any of the above `DD` statements are used as the `MSGFILE DD`, then that `DD` statement will not be considered for use as the `stdout DD`.
- `stderr` will be associated with the `MSGFILE`, which defaults to `SYSOUT`. See z/OS Language Environment Programming Guide for more information on `MSGFILE`.
- If you are running with the run-time option `POSIX(ON)`, you can redirect standard streams with ddnames only for MVS data sets, not for HFS files.
- If the ddname for `stdout` is not allocated to a device or data set, it is dynamically allocated to the terminal in an interactive environment or to `SYSOUT=*` in an MVS batch environment.
The following table summarizes the association of streams with ddnames:

<table>
<thead>
<tr>
<th>Standard stream</th>
<th>ddname</th>
<th>Alternate ddname</th>
</tr>
</thead>
<tbody>
<tr>
<td>stdin</td>
<td>SYSIN</td>
<td>none</td>
</tr>
<tr>
<td>stdout</td>
<td>SYSPRINT</td>
<td>SYSTERM, SYSERR</td>
</tr>
<tr>
<td>stderr</td>
<td>DD associated with MSGFILE</td>
<td>None</td>
</tr>
</tbody>
</table>

The following MVS example shows an excerpt taken from a job stream demonstrating the redirection of the three standard streams by using ddnames.

In the example, your program name is MONITOR and the input to MONITOR is to be retrieved from a sequential data set called 'SAFETY.CHEM.LIST'. The output of MONITOR is to be directed to a partitioned data set member called 'YEAREND.ACTION(CHEM)', and any errors generated by MONITOR are to be written to a sequential data set called 'YEAREND.MONITOR.ERRLIST'. To redirect the standard streams using DD statements you could use the following JCL statements:

```c
//JOBname  JOB...
//STEP01   EXEC PGM=MONITOR,PARM='MSGFILE(SYSERR)/
          : ;
//SYSIN    DD DSN=SAFETY.CHEM.LIST,DISP=OLD
//SYSERR   DD DSN=YEAREND.MONITOR.ERRLIST,DISP=MOD
//SYSPRINT DD DSN=YEAREND.ACTION(CHEM),DISP=OLD ...
```

The following example shows how to get stdout and stderr to share the same file where: the program name is HOCKEY and the input to HOCKEY is to be retrieved from a sequential data set called 'HOCKEY.PLAYER.LIST'. The output of HOCKEY is to be directed to a sequential data set called 'HOCKEY.OUTPUT' and any errors generated by HOCKEY are also to be written to the sequential data set 'HOCKEY.OUTPUT'. You could use the following JCL statements:

```c
//JOBname  JOB...
//STEP01   EXEC PGM=HOCKEY,PARM='? 2>&1'
//SYSIN    DD DSN=HOCKEY.PLAYER.LIST,DISP=SHR
//SYSPRINT DD DSN=HOCKEY.OUTPUT,DISP=(OLD),DCB=...
```

stderr shares stdout because of the 2>&1 redirection statement.

If you want to redirect to an HFS file, you can modify the above examples to use the PATH and PATHOPT options described in "DDnames" on page 62.

**Under TSO**

You can redirect standard streams in the following ways:

- From the freopen() library function call
- From the command line
- Using the parameter list in a CALL command

**From the Command Line**

The following example illustrates the redirection of stdin under TSO. The program in this example is called BUILD and it has 2 required parameters, 'PLAN' and 'JOHNSTON'. The input to BUILD is to be retrieved from a partitioned data set member called 'CONDO(SPRING)'. To redirect stdin in this example under TSO you can use the following command:
BUILD PLAN JOHNSTON <'CONDO(SPRING)'

Notes:
1. If the data set name is not enclosed in quotation marks, your user prefix will be appended to the data set name specified.
2. If you specify a redirection in a system() call, after system() returns, the streams are redirected back to those at the time of the system() call.

Using the Parameter List in a CALL Command
You can also redirect the output to a file with a ddname in TSO by specifying the output file in the parameter list like the following:

```
CALL 'PREFIX.PROGRAM' >DD:OUTFILE
```

The ddname can be created by an ALLOCATE command.

Under IMS

Under IMS online and batch, you can redirect the C standard streams in any of the following ways:
- with direct assignment
- with the freopen() function
- with ddnames

For details on ddnames, see "Using DD Statements" on page 96

Under CICS

There are several ways to redirect C standard streams under CICS:
- You can assign a memory file to the stream (for example, stdout=myfile).
- You can use freopen() to open a standard stream as a memory file.
- You can use CICS facilities to direct where the stream output goes.

If you assign a file pointer to a stream or use freopen() on it, you will not be able to use C functions to direct the information outside or elsewhere in the CICS environment. Once access to a CICS transient data queue has been removed, either by a call to freopen() or fclose(), or by the assignment of another file pointer to the stream, z/OS C/C++ does not provide a way to regain access. Once C functions have lost access to the transient data queues, you must use the CICS-provided facilities to regain it.

CICS provides a facility that enables you to direct where a given transient data queue, the default standard stream implementation, will go, but you must configure this facility before a CICS cold start.

Passing C and C++ Standard Streams Across a system() Call

A system() call occurs when one z/OS C/C++ program calls another z/OS C/C++ program by using the ANSI system() function, which z/OS C/C++ uses if you are not running with POSIX(ON). Standard streams are inherited across calls to the ANSI system() function. With a POSIX system() function, file descriptors 0, 1, and 2 will be mapped to standard streams stdin, stdout and stderr in the child process. The behavior of these streams is similar to binary streams called with the ANSI system() function.

Inheritance includes any redirection of the stream as well as the open mode of the stream. For example, if program A reopens stdout as "A.B" for "wb" and then calls
program B, program B inherits the definition of stdout. If program B reopens stdout as "C.D" for "ab" and then uses system() to call program C, program C inherits stdout opened to "C.D" for append. Once control returns to the calling program, the definitions of the standard streams from the time of the system() call are restored. For example, when program B finally returns control to program A, stdout is restored to "A.B" opened for "wb".

The file position and the amount of data that is visible in the called and calling programs depend on whether the standard streams are opened for binary, text, or record I/O.

The behavior of the C standard streams across a system() call indicates the behavior of all standard streams since they are implemented in terms of the C standard streams.

**Passing Binary Streams**

If the standard stream being passed across a system() call is opened in binary mode, any reads or writes issued in the called program occur at the next byte in the file. On return, the position of the file is wherever the called program is positioned. This includes any possible repositions made by the called program if the file is enabled for positioning. Because output to binary files is done byte by byte, all bytes are written to stdout and stderr in the order they are written. This is shown in the following example:

```c
printf("123");
printf("456");
system("CHILD");

------- int main(void) { putc('7',stdout);}
printf("89");
```

The output from this example is:

```
123456789
```

Memory files are always opened in binary mode, even if you specify text. Any standard streams redirected to memory files and passed across system() calls will be treated as binary files. HFS files are also treated as binary files, because they do not contain any real record boundaries. Memory files are not passed across calls to the POSIX system() function.

If freopen() is applied to a C standard stream, thereby creating a binary stream, then the results of I/O to the associated standard stream across a system() call are undefined.

**Passing Text Streams**

If the C standard stream being passed across a system() call is opened in text mode (the default), the file position in the called program is placed at the next record boundary, if it is not already at the start of a record. Any data in the current record that is unread is skipped. Here is an example:
When you write to a spanned file, the file position moves to the beginning of the next record, if that record exists. If not, the position moves to the end of the incomplete record.

For non-spanned standard streams opened for output, if the caller has created a text record missing an ending control character, the last record is hidden from the called program. The called program can append new data if the stream is open in append mode. Any appends made by the called program will be after the last record that was complete at the time of the system() call.

When the called program terminates, it completes any new unfinished text record with a new-line; the addition of the new-line does not move the file position. Once any incomplete record is completed, the file position moves to the next record boundary, if it is not already on a record boundary or at EOF.

When control returns to the original caller, any incomplete record hidden at the time of the system() call is restored to the end of the file. If the called program is at EOF when it is terminated and the caller was within an incomplete record at the time of the system() call, the position upon return is restored to the original record offset at the time of the system() call. This position is usually the end of the incomplete record. Generally, if the caller is writing to a standard stream and does not complete the last record before it calls system(), writes continue to add to the last record when control returns to the caller. For example:

```
printf("test");
printf("abc");
system("hello");  -------> int main(void) { printf("hello world\n");}
printf("def\n");
```

The output from this example is as follows:

test
hello world
abcdef

If stdout had been opened for ",w+" in this example, and a reposition had been made to the character 'b' before the system() call, upon return, the incomplete record "abc" would have been restored and the position would have been at the 'b'. The subsequent write of def would have performed an update to give test hello world adef.

### C++ Standard Streams Considerations

The following sections are considerations for C++ standard streams.
Output with sync_with_stdio(): When a standard output stream is open in text mode (the default), and sync_with_stdio() has been called, the output across a system() call behaves the same as a C standard stream:

- If the parent program writes a newline character, the line will be flushed before the child program is invoked;
- Otherwise, the output from the parent will be held in a buffer until the child returns.

Output without sync_with_stdio(): When a standard output stream is open in text mode, and sync_with_stdio() has not been called, the behavior is as follows:

- If the parent program writes a newline character, and explicitly flushes it, the line will be written out before the child program is invoked;
- Otherwise, the behavior is undefined.

Input with sync_with_stdio(): When cin is open in text mode (the default), and sync_with_stdio() has been called, the input across a system() call behaves the same as stdin:

- The child program begins reading at the next record boundary, that is, unread data in the current record in the parent is hidden.
- When the child program returns, the parent program begins reading at the next record boundary, that is, unread data in the current record in the child is lost.

Input without sync_with_stdio(): When cin is open in text mode, and sync_with_stdio() has not been called, the behavior is as follows:

- The parent program must either not read from cin before calling the child, or must read to the end of a complete record.
- The child program begins reading at the next record boundary, that is, unread data in the current record in the parent is hidden.
- When the child program returns, the parent program begins reading at the next record boundary, that is, unread data in the current record in the child is lost.
- If the parent program read only part of a record before calling the child, the behavior upon returning from the child is undefined.

Passing Record I/O Streams

For record I/O, all reads and writes made by the called program occur at the next record boundary. Since complete records are always read and written, there is no change in the file position across a system() call boundary.

In the following example, stdout is a variable-length record I/O file.

```c
fwrite("test",1,4,stdout);
fwrite("abc",1,3,stdout);
system("hello");  ------> int main(void) {
fwrite("def",1,3,stdout); fwrite("hello world",1,11,stdout)
}
```

The output from this code fragment is as follows:

test
abc
hello world
def
If `freopen()` is applied to a C standard stream, creating a stream with "type=record", then behavior of the associated I/O stream is undefined across a `system()` call.

**Using Global Standard Streams**

In the default inheritance model, the behavior of C standard streams is such that a child `main()` function cannot affect the standard streams of the parent. The child can use the parent's definition or redirect a standard stream to a new location, but when control returns to the parent, the standard stream reverts back to the definition of the parent. In the global model, the C standard streams, `stdin`, `stdout`, and `stderr`, can be redirected to a different location while running in a child `main()` function and have that redirection stay in effect when control returns to the parent. You can use the `_EDC_GLOBAL_STREAMS` environment variable to set standard stream behavior to the global model. For more information, see "_EDC_GLOBAL_STREAMS" on page 491.

Table 15 highlights the standard stream behavior differences between the default inheritance model and the global model.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Default Inheritance Model</th>
<th>Global Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSIX(OFF)</td>
<td>Standard streams are opened automatically on first reference.</td>
<td>(Same)</td>
</tr>
<tr>
<td>POSIX(ON)</td>
<td>Standard streams are opened during initialization of the process, before the application receives control.</td>
<td>Not supported.</td>
</tr>
<tr>
<td>default open modes</td>
<td>As currently described in &quot;Default Open Modes&quot; on page 88.</td>
<td>(Same)</td>
</tr>
<tr>
<td>default locations</td>
<td>As currently described in this chapter.</td>
<td>(Same)</td>
</tr>
<tr>
<td>command line redirection</td>
<td>Changes the location for the main being called and subsequent child programs.</td>
<td>Changes the location for the entire C environment.</td>
</tr>
<tr>
<td>direct assignment</td>
<td>Affects the current main and subsequent child programs.</td>
<td>Affects the current main only. This definition is not passed on to a subsequent child program. The child gets the current global definition, if there is one defined.</td>
</tr>
<tr>
<td><code>freopen()</code></td>
<td>Changes location for the main from which it is called and affects any subsequent child programs.</td>
<td>Changes location for the entire C environment.</td>
</tr>
<tr>
<td>MSGFILE() run-time option</td>
<td>Redirects <code>stderr</code> for the main being invoked and affects any subsequent child programs. When control returns to a parent program, <code>stderr</code> reverts back to the definition of the parent. If <code>stderr</code> is also redirected on the command line, that redirection takes precedence.</td>
<td>(Same)</td>
</tr>
<tr>
<td><code>fclose()</code></td>
<td>Closes the standard stream in current main only.</td>
<td>Closes the standard stream for the entire C environment. The standard stream cannot be global anymore. Only direct assignment can be used to use the standard stream, and that would only be for the main in which it is assigned.</td>
</tr>
</tbody>
</table>
Table 15. Standard Stream Behavior Differences (continued)

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Default Inheritance Model</th>
<th>Global Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>file position and visible data</td>
<td>As currently described in this chapter.</td>
<td>File position and visible data across mains are as if there were only one main. No special processing occurs during the ANSI system() call. The standard streams are left untouched. When either entering or returning from a child program, reading or writing to the standard streams begin where previously left off.</td>
</tr>
<tr>
<td>C++ I/O Stream</td>
<td>cin defaults to stdin &lt;br&gt; cout defaults to stdout &lt;br&gt; cerr defaults to stderr (unbuffered) &lt;br&gt; clog defaults to stderr (buffered)</td>
<td>(Same)</td>
</tr>
</tbody>
</table>

Notes:

1. The following environments do not allow global standard stream behavior as an option:
   • POSIX(ON)
   • CICS
   • SPC

2. You must identify the behavior of the standard streams to the C run-time library before initialization of the first C main in the environment. The default behavior uses the inheritance model. Once you set the standard stream behavior, it cannot be changed. Attempts to change the behavior after the first C main has been initialized are ignored.

3. The value of the environment variable, when queried, does not necessarily reflect the standard stream behavior being used. This is because the value of the environment variable can be changed after the standard stream behavior has been set.

4. The behaviors described in Table 15 on page 102 only apply to the standard streams that use the global behavior.

Command Line Redirection

In the C standard stream global model, command line redirection of the standard streams is supported, but has much different behavior than the C standard stream inheritance model.

The most important difference is that when redirection is done at system() call time, the redirection takes effect for the entire C environment. When the child program terminates, the standard stream definitions do not revert back to what they were before the system() call.

Redirection of any of the standard streams, except when stderr is redirected to stdout or vice versa, causes the standard stream to be flushed. This is because an freopen() is done under the covers, which first closes the stream before reopening it. Since the standard stream is global, the close causes the flush.

Redirecting stderr to stdout, or stdout to stderr, does not flush the redirected stream. Any data in the buffer remains there until the stream is redirected again, to something other than stdout or stderr. Only then is the buffer flushed.
Consider the following example:

```c
#include <stdio.h>
#include <stdlib.h>
main() {
    int rc;
    printf("line 1\n");
    printf("line 2\n");
    fprintf(stderr,"line 3\n");
    fprintf(stderr,"line 4\n");
    rc=system("PGM=CHILD,PARM="/ >stdout.file 2>&1;")
    printf("line 5\n");
    fprintf(stderr,"line 6\n");
}
```

Figure 9. PARENT.C

```c
#include <stdio.h>
main() {
    printf("line 7\n");
    fprintf(stderr,"line 8\n");
    stderr = freopen("stderr.file","w",stderr);
    printf("line 9\n");
    fprintf(stderr,"line 10\n");
}
```

Figure 10. CHILD.C

When run from TSO terminal using the following command:

```
parent ENVAR(_EDC_GLOBAL_STREAMS=7)/
```

the output will be as follows:

```
(terminal)  stdout.file  stderr.file
line 1    line 7    line 10
line 3    line 8    line 6
line 2    line 9
line 4    line 5
```

**Attention:** If the stdout or stderr stream has data in its buffer and it is redirected to stderr or stdout, then the data is lost if stdout or stderr is not redirected again.

**Note:** If either stdout or stderr is using global behavior, but not both, then any redirection of stdout or stderr to stderr or stdout is ignored.

**Direct Assignment**

You can directly assign the C standard streams in any main program. This assignment does not have any effect on the global standard stream. No flush is done and the new definition is not passed on to a child program nor back to a parent program. Once you directly assign a standard stream, there is no way to re-associate it with the global standard stream.

**freopen()**

When you use `freopen()` to redirect a standard stream, the stream is closed, causing a flush, and then redirected. The new definition affects all C mains currently using the global stream.
MSGFILE() Run-Time Option

The MSGFILE() run-time option redirects the stderr stream similar to command line redirection. However, this redirection is controlled by the Common Execution Library and does not apply to all C mains in the environment. When control returns to a parent program, stderr reverts back to the definition of the parent.

fclose()

When a global standard stream is closed, only direct assignment can be used to begin using the standard stream again. That use would only be for the main performing the direct assignment. There is no way to get back global behavior for the standard stream that was closed.

File Position and Visible Data

The file position and amount of visible data in the called and calling program is as if there is only one program. There is no data hidden from a called program. A child program continues where the parent program left off. This is true for all types of I/O: binary, text, and record.

C++ I/O Stream Library

Since cin, cout, cerr and clog are initially based on stdin, stdout and stderr, they continue to be in the global model. For example, if stdout is redirected using freopen() in a child program, then both stdout and cout retain that redirection when control returns to the parent.
Chapter 11. Performing OS I/O Operations

This chapter describes using OS I/O, which includes support for the following:

- Regular sequential DASD (including striped data sets)
- Partitioned DASD (PDS and PDSE)
- Tapes
- SYSOUT
- Printers
- In-stream JCL

**Note:** z/OS C/C++ does not support BDAM or ISAM data sets.

OS I/O supports text, binary, and record I/O, in three record formats: fixed (F), variable (V), and undefined (U). For information about using wide-character I/O with z/OS C/C++, see Chapter 9, “z/OS C Support for the Double-Byte Character Set” on page 79.

This chapter describes C I/O stream functions as they can be used within C++ programs. If you want to use the C++ I/O stream classes instead, see Chapter 5, “Using the Standard C++ Library I/O Stream Classes” on page 49, for more detailed information about I/O streaming.


Opening Files

To open an OS file, you can use the Standard C functions `fopen()` or `freopen()`. These are described in general terms in [Z/OS C/C++ Run-Time Library Reference](http://www.ibm.com/software/ad/c390/czos/czosdocs.html). Details about them specific to all z/OS C/C++ I/O are discussed in the “Opening Files” section. This section describes considerations for using `fopen()` and `freopen()` with OS files.

**Using fopen() or freopen()**

When you open a file using `fopen()` or `freopen()`, you must specify the file name (a data set name) or a ddname.

**Using a Data Set Name**

Files are opened with a call to `fopen()` or `freopen()` in the format:

```
fopen("filename", "mode")
```

The following diagram shows the syntax for the `filename` argument on your `fopen()` or `freopen()` call:
Note: The single quotation marks in the `filename` syntax diagram must be matched; if you use one, you must use the other.

A sample construct is:
```
'qualifier1.qualifier2(member)'
```
// Specifying these slashes indicates that the filename refers to a non-POSIX file or data set.

**qualifier**

Each qualifier is a 1- to 8-character name. These characters may be alphanumeric, national ($, #, @), the hyphen, or the character X'C0'. The first character should be either alphabetic or national. Do not use hyphens in names for RACF-protected data sets.

You can join qualifiers with periods. The maximum length of a data set name is as follows:

- Generally, 44 characters, including periods.
- For a generation data group, 35 characters, including periods.

These numbers do not include a member name or GDG number and accompanying parentheses.

Specifying one or two ampersands before a single qualifier opens a temporary data set. Multiple qualifiers are not valid after ampersands, because the system generates additional qualifiers. Opening two temporary data sets with the same name creates two distinct files. If you open a second temporary data set using the same name as the first, you get a distinct data set. For example, the following statements open two temporary data sets:
```
fp  = fopen("//&&myfile","wb+");  
fp2 = fopen("//&&myfile","wb+");  
```

You cannot fully qualify a temporary data set name. The file is created at open time and is empty. When you close a temporary data set, the system removes it.

**(member)**

If you specify a member, the data set you are opening must be a PDS or a PDSE. For more information about PDSs and PDSEs, see Regular and Extended Partitioned Data Sets on page 114. For members, the member name (including trailing blanks) can be up to 8 characters long. A member name cannot begin with leading blanks. The characters in a member name may be alphanumeric, national ($, #, @), the hyphen, or the character X'C0'. The first character should be either alphabetic or national.
You specify a Generation Data Group (GDG) by using a plus (+) or minus (−) to precede the version number, or by using a 0. For more information about GDGs, see "Generation Data Group I/O" on page 110.

The Resource Access Control Facility (RACF) expects the data set name to have a high-level qualifier that is defined to RACF. RACF uses the entire data set name when it protects a tape data set.

When you enclose a name in single quotation marks, the name is fully qualified. The file opened is the one specified by the name inside the quotation marks. If the name is not fully qualified, z/OS C/C++ does one of the following:

- If your system does not use RACF, z/OS C/C++ does not add a high-level qualifier to the name you specified.
- If you are running under TSO (batch or interactive), z/OS C/C++ appends the TSO user prefix to the front of the name. For example, the statement `fopen("a.b","w")` opens a data set `tsoid.A.B`, where `tsoid` is the user prefix. If the name is fully qualified, z/OS C/C++ does not append a user prefix. You can set the user prefix by using the TSO PROFX command with the `PREFIX` parameter.
- If you are running under z/OS batch or IMS (batch or online), z/OS C/C++ appends the RACF user ID to the front of the name.

If you want your code to be portable between the VM/CMS and z/OS systems and between memory files and disk files, use a name of the format `name1.name2`, where `name1` and `name2` are up to 8 characters and are delimited by a period, or use a ddname. You can also add a member name.

For example, the following piece of code can run under Language Environment for VM and z/OS Language Environment:

```c
FILE *stream;
stream = fopen("parts.instock", "r");
```

**Using a DDname**

The DD statement enables you to write C or C++ source programs that are independent of the files and input/output devices they use. You can modify the parameters of a file or process different files without recompiling your program.

Use ddnames if you want to use non-DASD devices.

If you specify `DISP=MOD` on a DD statement and `w` or `wb` mode on the `fopen()` call, z/OS C/C++ treats the file as if you had opened it in append mode instead of write mode.

To open a file by ddname under z/OS batch, you must define the ddname first. You can do this in any of the following ways:

- In batch (z/OS, TSO, or IMS), you can write a JCL DD statement. For the declaration shown above for the C or C++ file `PARTS.INSTOCK`, you write a JCL DD statement similar to the following:
  ```
  //STOCK  DD DSN=USERID.PARTS.INSTOCK,DISP=SHR
  ```

When defining DD, do not use `DD ... FREE=CLOSE` for unallocating DD statements. The C library may close files to perform some file operations such as `freopen()`, and the DD statement will be unallocated.
If you use `SPACE=RLSE` on a DD statement, z/OS C/C++ releases space only if all of the following are true:

- The file is open in `w`, `wb`, `a`, or `ab` mode
- It is not simultaneously open for read
- No positioning functions (`fseek()`, `ftell()`, `rewind()`, `fgetpos()`, `fsetpos()`) have been performed.

For more information on writing DD statements, refer to the job control language (JCL) manuals listed in z/OS Information Roadmap.

- Under TSO (interactive and batch), you can issue an `ALLOCATE` command. The DD definition shown above for the C file `STOCK` has an equivalent TSO `ALLOCATE` command, as follows:

  ```
  ALLOCATE FILE(STOCK) DATASET(PARTS.INSTOCK) SHR
  ```

  See z/OS Information Roadmap for manuals containing information on TSO `ALLOCATE`.

- In the z/OS environment, you can use the `svc99()` or `dynalloc()` library functions to define ddnames. For information about these functions, refer to z/OS C/C++ Run-Time Library Reference.

**DCB Parameter:** The DCB (data control block) parameter of the DD statement allows you to describe the characteristics of the data in a file and the way it will be processed at run time. The other parameters of the DD statement deal chiefly with the identity, location, and disposition of the file. The DCB parameter specifies information required for the processing of the records themselves. The subparameters of the DCB parameter are described in z/OS MVS JCL User's Guide.

The DCB parameter contains subparameters that describe:

- The organization of the file and how it will be accessed. Parameters supplied on `fopen()` override those specified in DCB.
- Device-dependent information such as the recording technique for magnetic tape or the line spacing for a printer (for example: `CODE`, `DEN`, `FUNC`, `MODE`, `OPTCD=J`, `PRTSP`, `STACK`, `SPACE`, `UNIT` and `TRTCH` subparameters).
- The data set format (for example: `BLKSIZE`, `LRECL`, and `RECFM` subparameters).

You cannot use the DCB parameter to override information already established for the file in your C or C++ program (by the file attributes declared and the other attributes that are implied by them). DCB subparameters that attempt to change information already supplied by `fopen()` or `freopen()` are ignored.

An example of the DCB parameter is:

```
DCB=(RECFM=FB,BLKSIZE=400,LRECL=40)
```

It specifies that fixed-length records, 40 bytes in length, are to be grouped in a block 400 bytes long. You can copy attributes from another data set by either setting the DCB parameter to `DCB=(dsname)` or using the SVC 99 services provided by the `svc99()` and `dynalloc()` library functions.

**Generation Data Group I/O**

A Generation Data Group (GDG) is a group of related cataloged data sets. Each data set within a generation data group is called a generation data set. Generation data sets have sequentially ordered absolute and relative names that represent their age. The absolute generation name is the representation used by the catalog management routines in the catalog. The relative name is a signed integer used to...
refer to the latest (0), the next to the latest (-1), and so forth, generation. The relative number can also be used to catalog a new generation (+1). For more information on GDGs, see [z/OS DFSMS: Using Data Sets](#).

If you want to open a generation data set by data set name with `fopen()` or `freopen()`, you will require a model. This model specifies parameters for the group, including the maximum number of generations (the generation index). You can define such a model by using the Access Method Services `DEFINE` command. For more information on the `DEFINE` command, see [z/OS DFSMS Access Method Services for Catalogs](#). Note also that `fopen()` does not support a `DCB=` parameter. If you want to change the parameters, alter the JCL that describes the model and open it in `w` mode.

z/OS uses an absolute generation and version number to catalog each generation. The generation and version numbers are in the form `GxxxxVyy`, where `xxxx` is an unsigned 4-digit decimal generation number (0001 through 9999) and `yy` is an unsigned 2-digit decimal version number (00 through 99). For example:

- A.B.C.G0001V00 is generation data set 1, version 0, in generation data group A.B.C.
- A.B.C.G0009V01 is generation data set 9, version 1, in generation data group A.B.C.

The number of generations kept depends on the size of the generation index.

When you open a GDG by relative number, z/OS C/C++ returns the relative generation in the `__dsname` field of the structure returned by the `fldata()` function. You cannot use the `rename()` library function to rename GDGs by relative generation number; rename GDG data sets by using their absolute names.

The following example defines a GDG. The `fopen()` fails because it tries to change the `RECFM` of the data set.
This example is valid only for C:

```c
#include <stdio.h>
#include <errno.h>

int main(void)
{
    FILE *fp;
    fp = fopen("MYGDG(+1)", "a, recfm=F");
    if (fp == NULL)
    {
        printf("Error...Unable to open file\n");
        printf("errno ... \%d\n", errno);
        perror("perror ...");
    }
    printf("Finished\n");
}>
```

Figure 11. Generation Data Group Example for C
This example is valid for C++:

```c
#include <stdio.h>
#include <errno.h>

int main(void)
{
    FILE *fp;
    fp = fopen("MYGDG(+1)", "a,recfm=F");
    if (fp == NULL)
    {
        printf("Error...Unable to open file\n");
        printf("errno ... %d\n",errno);
        perror("perror ... ");
    }
    printf("Finished\n");
    return 0;
}
```

Figure 12. Generation Data Group Example for C++

A relative number used in the JCL refers to the same generation throughout a job. The (+1) used in the example above exists for the life of the entire job and not just the step, so that `fopen()`'s reference to (+1) did not create another new data set but accessed the same data set as in previous steps.
Note: You cannot use fopen() to create another generation data set because fopen() does not fully support the DCB parameter.

Regular and Extended Partitioned Data Sets
Partitioned data sets (PDS) and partitioned data sets extended (PDSE) are DASD data sets divided into sections known as members. Each member can be accessed individually by its unique 1- to 8-character name.

PDSEs are similar to PDSs, but contain a number of enhancements.

Table 16. PDSE and PDS Differences

<table>
<thead>
<tr>
<th>PDSE Characteristics</th>
<th>PDS Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data set has a 123-extent limit</td>
<td>Data set has a 16-extent limit</td>
</tr>
<tr>
<td>Directory is open-ended and indexed by member name; faster to search directory</td>
<td>Fixed-size directory is searched sequentially</td>
</tr>
<tr>
<td>PDSEs are device-independent: records are reblockable</td>
<td>Block sizes are device-dependent</td>
</tr>
<tr>
<td>Uses dynamic space allocation and reclamation</td>
<td>Must use IEBCOPY COMPRESS to reclaim space</td>
</tr>
<tr>
<td>Supports creation of more than one member at a time*</td>
<td>Supports creation of only one member at a time</td>
</tr>
</tbody>
</table>

Note: *z/OS C/C++ allows you to open two separate members of a PDSE for writing at the same time. However, you cannot open a single member for writing more than once.

You specify a member by enclosing its name in parentheses and placing it after the data set name. For example, the following JCL refers to member A of the data set MY.DATA:

```
//MYDD DD DSN=userid.MY.DATA(A),DISP=SHR
```

You can specify members on calls to fopen() and freopen(). You can specify members when you are opening a data set by its data set name or by a ddname. When you use a ddname and a member name, the definition of the ddname must not also specify a member. For example, using the DD statement above, the following will fail:

```
f = fopen("dd:MYDD(B)","r");
```

You cannot open a PDS or PDSE member using the modes a, ab, a+, a+b, w+, w+b, or wb+. If you want to perform the equivalent of the w+ or wb+ mode, you must first open the file as w or wb, write to it, and then close it. Then you can perform updates by reopening the file in r+ or rb+ mode. You can use the C library functions ftell() or fgetpos() to obtain file positions for later updates to the member. Normally, opening a file in r+ or rb+ mode enables you to extend a file by writing to the end; however, with these modes you cannot extend a member. To do so, you must copy the contents of the old member plus any extensions to a new member. You can remove the old member by using the remove() function and then rename the new member to the old name by using rename().

All members have identical attributes for RECFM, LRECL, and BLKSIZE. For PDSs, you cannot add a member with different attributes or specify a RECFM of FBS, FBSA, or FBSM. z/OS C/C++ verifies any attributes you specify.

For PDSEs, z/OS C/C++ checks to make sure that any attributes you specify are compatible with those of the existing data set. Compatible attributes are those that
specify the same record format (F, V, or U) and the same LRECL. Compatibility of attributes enables you to choose whether to specify blocked or unblocked format, because PDSEs reblock all the records. For example, you can create a PDSE as FB LRECL=40 BLKSIZE=80, and later open it for read as FB LRECL=40 BLKSIZE=1600 or F LRECL=40 BLKSIZE=40. The LRECL cannot change, and the BLKSIZE must be compatible with the RECFM and LRECL. Also, you cannot change the basic format of the PDSE from F to V or vice versa. If the PDS or PDSE already exists, you do not need to specify any attributes, because z/OS C/C++ uses the previously existing ones as its defaults.

At the start of each partitioned data set is its directory, a series of records that contain the member names and starting locations for each member within the data set. You can access the directory by specifying the PDS or PDSE name without specifying a member. You can open the directory only for read; update and write modes are not allowed. The only RECFM that you can specify for reading the directory is RECFM=U. However, you do not need to specify the RECFM, because z/OS C/C++ uses U as the default.

z/OS DFSMS: Using Data Sets contains more detailed explanations about how to use PDSs and PDSEs.

Partitioned and Sequential Concatenated Data Sets

There are two forms of concatenated data sets: partitioned and sequential. You can open concatenated data sets only by ddname, and only for read or update. Specifying any of the write, or append modes fails. As with PDS members, you cannot extend a concatenated data set.

Partitioned concatenation consists of specifying multiple PDSs or PDSEs under one ddname. When you access the concatenation, it acts as one large PDS or PDSE, from which you can access any member. If two or more partitioned data sets in the concatenation contain a member with the same name, using the concatenation ddname to specify that member refers to the first member with that name found in the entire concatenation. You cannot use the ddname to access subsequent members. For example, if you have a PDS named PDS1, with members A, B, and C, and a second PDS named PDS2, with members C, D, and E, and you concatenate the two data sets as follows:

```bash
//MYDD DD userid.PDS1,DISP=SHR
// DD userid.PDS2,DISP=SHR
```

and perform the following:

```c
fp = fopen("DD:MYDD(C)","r");
fp2 = fopen("DD:MYDD(D)","r");
```

the first call to fopen() finds member C from PDS1, even though there is also a member C in PDS2. The second call finds member D from PDS2, because PDS2 is the first PDS in the concatenation that contains this member. The member C in PDS2 is inaccessible.

When you are concatenating partitioned data sets, be aware of the DCB attributes for them. The concatenation is treated as a single data set with the following attributes:

- RECFM= the RECFM of the first data set in the concatenation
- LRECL= the LRECL of the first data set in the concatenation
- BLKSIZE= the largest BLKSIZE of any data set in the concatenation
These are the rules for compatible concatenations:

Table 17. Rules for Possible Concatenations

<table>
<thead>
<tr>
<th>RECFM of first data set</th>
<th>RECFM of subsequent data sets</th>
<th>LRECL of subsequent data sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECFM=F</td>
<td>RECFM=F</td>
<td>Same as that of first one</td>
</tr>
<tr>
<td>RECFM=FB</td>
<td>RECFM=F or RECFM=FB</td>
<td>Same as that of first one</td>
</tr>
<tr>
<td>RECFM=V</td>
<td>RECFM=V</td>
<td>Less than or equal to that of first one</td>
</tr>
<tr>
<td>RECFM=VS</td>
<td>RECFM=V or RECFM=VS</td>
<td>Less than or equal to that of first one</td>
</tr>
<tr>
<td>RECFM=VB</td>
<td>RECFM=V or RECFM=VB</td>
<td>Less than or equal to that of first one</td>
</tr>
<tr>
<td>RECFM=VBS</td>
<td>RECFM=V, RECFM=VB, RECFM=VS, or RECFM=VBS</td>
<td>Less than or equal to that of first one</td>
</tr>
<tr>
<td>RECFM=U</td>
<td>RECFM=U or RECFM=F (see note below)</td>
<td></td>
</tr>
</tbody>
</table>

Note: You can use a data set in V-format, but when you read it, you will see all of the BDWs and RDWs or SDWs with the data.

If the first data set is in ASA format, all subsequent data sets must be ASA as well. The preceding rules apply to ASA files if you add an A to the RECFMs specified.

If you do not follow these rules, undefined behavior occurs. For example, trying to read a fixed-format member as RECFM=V could cause an exception or abend.

Repositioning is supported as it is for regular PDSs and PDSEs. If you try to read the directory, you will be able to read only the first one.

Sequential concatenation consists of treating multiple sequential data sets or partitioned data set members as one long sequential data set. For example,

```c
//MYDD DD userid.PDS1(A),DISP=SHR
// DD userid.PDS2(E),DISP=SHR
// DD userid.DATA,DISP=SHR
```

creates a concatenation that contains two members and a regular sequential data set. You can read or update all of these in order. In partitioned concatenations, you can read only one member at a time.

z/OS C/C++ does not support concatenating data sets that do not have compatible DCB attributes. The rules for compatibility are the same as those for partitioned concatenations.

If all the data sets in the concatenation support repositioning, you can reposition within a concatenation by using the functions `fseek()`, `ftell()`, `fgetpos()`, `fsetpos()`, and `rewind()`. If the first one does not, all of the repositioning functions except `rewind()` fail for the entire concatenation. If the first data set supports repositioning but a subsequent one does not, you must specify the `noseek` parameter on the `fopen()` or `freopen()` call. If you do not, `fopen()` or `freopen()` opens the file successfully; however, an error occurs when the read position gets to the data set that does not support repositioning.
In-stream Data Sets

An in-stream data set is a data set contained within a set of JCL statements. In-stream data sets (also called inline data sets) begin with a DD * or DD DATA statement. These DD statements can have any valid ddname, including SYSIN. If you omit a DD statement before the input data, the system provides a DD * statement with the ddname of SYSIN. This example shows you how to indicate an in-stream data set:

```
//MYDD DD *
record 1
record 2
record 3
/*
```

The // at the beginning of the data set starts in column 1. The statement `fopen("DD:MYDD","rb");` opens a data set with lrec=80, blksize=80, and recfm=FB. In this example, the delimiter indicating the end of the data set is /*. In some cases, your data may contain this string. For example, if you are using C source code that contains comments, z/OS C/C++ treats the beginning of the first comment as the end of the in-stream data set. To avoid this occurrence, you can change the delimiter by specifying DLM=nn, where nn is a two-character delimiter, on the DD statement that identifies the file. For example:

```
//MYDD DD *,DLM=¢¢
#include <stdio.h>
/* Hello, world program */
int main() {printf("Hello, world\n");}
@@
```

For more information about in-stream data sets, see z/OS MVS JCL User’s Guide.

To open an in-stream data set, call the fopen() or freopen() library function and specify the ddname of the data set. You can open an in-stream data set only for reading. Specifying any of the update, write, or append modes fails. Once you have opened an in-stream data set, you cannot acquire or change the file position except by rewinding. This means that calls to the fseek(), ftell(), fgetpos(), and fsetpos() for in-stream data sets fail. Calling rewind() causes z/OS C/C++ to reopen the file, leaving the file position at the beginning.

You can concatenate regular sequential data sets and in-stream data sets. If you do so, note the following:

- If the first data set is in-stream, you cannot acquire or change the file position for the entire concatenation.
- If the first data set is not in-stream and supports repositioning, you must specify the noseek parameter on the fopen() or freopen() call that opens the concatenation. If you do not, fopen() or freopen() opens the file successfully; however, an error occurs when the read position gets to the in-stream.
- The in-stream data set is treated as FB 80 and the concatenation rules for sequential concatenation apply.

SYSOUT Data Sets

You can specify a SYSOUT data set by using the SYSOUT parameter on a DD statement. z/OS C/C++ supports opening SYSOUT data sets in two ways:

1. Specifying a ddname that has the SYSOUT parameter. For information about defining ddnames, see "Using a DDname" on page 109
2. Specifying a data set name of * on a call to fopen() or freopen() while you are running under z/OS batch or IMS online or batch.
On a DD statement, you specify SYSOUT=x, where x is the output class. If the class matches the JOB statement MSGCLASS, the output appears with the job log. You can specify a SYSOUT data set and get the job MSGCLASS by specifying SYSOUT=* If you want to create a job stream within your program, you can specify INTRDR on the DD statement. This sends your SYSOUT data set to the internal reader to be read as an input job stream. For example,

//MYDD DD SYSOUT=(A,INTRDR)

For more details about the SYSOUT parameter, refer to z/OS MVS JCL User’s Guide

You can specify DCB attributes for a SYSOUT data set on a DD statement or a call to fopen() or freopen(). If you do not, z/OS C/C++ uses the following defaults:

**Binary or Record I/O**

```
RECFM=VB LRECL=137 BLKSIZE=882
```

**Text I/O**

```
RECFM=VBA LRECL=137 BLKSIZE=882
```

### Tapes

z/OS C/C++ supports standard label (SL) tapes. If you are creating tape files, you can only open them by ddname. z/OS C/C++ provides support for opening tapes in read, write, or append mode, but not update. When you open a tape for read or append, any data set control block (DCB) characteristics you specify must match those of the existing data set exactly. The repositioning functions are available only when you have opened a tape for read. For tapes opened for write or append, calling rewind() has no effect; calls to any of the other repositioning functions fail. To open a tape file for write, you must open it by ddname.

Opening FBS-format tape files with append-only mode is not supported.

When you open a tape file for output, the data set name you specify in the JCL must match the data set name specified in the tape label, even if the existing tape file is empty. If this is not the case, you must either change the JCL to specify the correct data set name or write to another tape file, or reinitialize the tape to remove the tape label and the data. You can use IEBGENER with the following JCL to create an empty tape file before passing it to the subsequent steps:

```
//ALLOC EXEC PGM=IEBGENER
//SYSUT1 DD *
/*/SYSUT2 DD DSN=name-of-OUTPUT-tape-file,UNIT=xxxx,LABEL=(x,SL),
//DISP=(NEW,PASS),(DCB=LRECL=xx,BLKSIZE=xx,RECFM=xx),
//VOL=SER=xxx
//SYSIN DD DUMMY
//SYSPRINT DD SYSOUT=* 
```

**Note:** For tapes, the value for UNIT= can be TAPE or CART.

Because the C library does not create tape files, you can append only to a tape file that already exists. Attempting to append to a file that does not already exist on a tape will cause an error. You can create an empty data set on a tape by using the utility IEBGENER.

### Multivolume Data Sets

z/OS C/C++ supports data sets that span more than one volume of DASD or tape. To open a multivolume data set for write, you must open it by ddname.
You can open multivolume tape data sets only for read or write. Opening them for update or append is not supported.

You can open multivolume DASD data sets for read, write, or update, but not for append. If you open one in r+ or rb+ mode, you can read and update the file, but you cannot extend the data set.

The repositioning functions are available only when you have opened a multivolume data set for read. For multivolume data sets opened for write, calling rewind() has no effect; calls to any of the other repositioning functions fail. Here is an example of a multivolume data set declaration:

```
//MYDD DD DSNAME=TEST.TWO,DISP=(NEW,CATLG),
// VOLUME=(,,3,SER=(333001,333002,333003)),
// SPACE=(TRK,(9,10)),UNIT=(3390,P)
```

This creates a data set that may span up to three volumes. For more information about the VOLUME parameter on DD statements, refer to [z/OS MVS JCL User's Guide](https://www.ibm.com/support/knowledgecenter/S56410_1.11.0/com.ibm.com.zos/v2r1.jclf/index.html).

### Striped Data Sets

A striped data set is a special data set organization introduced with DFSMS Version 1 Release 1.0. Stripping spreads a data set over a specified number of volumes such that I/O parallelism can be exploited. Unlike a multivolume data set in which physical record n follows record n-1, a striped data set has physical records n and n-1 on separate volumes. This enables asynchronous I/O to perform parallel operations, making requests for multiple reads and writes faster. Striped data sets also facilitate repositioning once the relative block number is known. z/OS C/C++ exploits this capability when it uses fseek() to reposition. This can result in substantial savings for applications that use ftell() and fseek() with data sets that have RECFMs of V, U, and F8 (not FBS). data sets. When a data set is striped, an fseek() can seek directly to the specified block just as an fseekpos() or rewind() can. For a normal data set with the aforementioned RECFMs, z/OS C/C++ has to read forward or rewind the data set to get to the desired position. Depending on how large the data set is, this can be quite inefficient compared to a direct reposition. Note that for such data sets, striping pads blocks to their maximum size. Therefore, you may be wasting space if you have short records.

If your system has DFSMS Version 1 Release 1.0 and higher, you may not be able to use striped data sets. This is because there is a hardware requirement by DFSMS that all volumes of a striped data set be attached to ESCON channels. Contact your system administrator for details on whether striped data sets are available on your system and how to specify them.

### Other Devices

z/OS C/C++ supports several other devices for input and output. You can open these devices only by ddname. The following table lists a number of these devices and tells you which record formats are valid for them.

<table>
<thead>
<tr>
<th>Device</th>
<th>Valid open modes</th>
<th>Repositioning?</th>
<th>fldata()__device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printer</td>
<td>w, wb, a, ab</td>
<td>No</td>
<td>__PRINTER</td>
</tr>
<tr>
<td>Card reader</td>
<td>r, rb</td>
<td>rewind() only</td>
<td>__OTHER</td>
</tr>
<tr>
<td>Card punch</td>
<td>w, wb, a, ab</td>
<td>No</td>
<td>__OTHER</td>
</tr>
</tbody>
</table>
Table 18. Other Devices Supported for Input and Output (continued)

<table>
<thead>
<tr>
<th>Device</th>
<th>Valid open modes</th>
<th>Repositioning?</th>
<th>fldata() device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical reader</td>
<td>r, rb</td>
<td>rewind() only</td>
<td>__OTHER</td>
</tr>
<tr>
<td>DUMMY data set</td>
<td>r, rb, r+, rb+, w, wb, w+, wb+, w+b, a, ab, a+, ab+, a+b</td>
<td>rewind() only</td>
<td>__DUMMY</td>
</tr>
</tbody>
</table>

**Note:** For all devices above that support open modes a or ab, the modes are treated as if you had specified w or wb.

None of the devices listed above can be opened for update except the DUMMY data set.

z/OS C/C++ queries each device to find out its maximum BLKSIZE.

The DUMMY data set is not truly a device, although z/OS C/C++ treats it as one. To use the DUMMY data set, specify DD DUMMY in your JCL. On input, the DUMMY data set always returns EOF; on output, it is always successful. This is the way to specify a DUMMY data set:

```
//MYDD DD DUMMY
```

For more information on DUMMY data sets, see z/OS MVS JCL User’s Guide.

**fopen() and freopen() Parameters**

The following table lists the parameters that are available on the fopen() and freopen() functions, tells you which ones are allowed and applicable for OS I/O, and lists the option values that are valid for the applicable ones. Detailed descriptions of these options follow the table.

Table 19. Parameters for the fopen() and freopen() Functions for z/OS OS I/O

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Allowed?</th>
<th>Applicable?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>rcfm=</td>
<td>Yes</td>
<td>Yes</td>
<td>Any of the 27 record formats available under z/OS C/C++, plus * and A are valid.</td>
</tr>
<tr>
<td>lrecl=</td>
<td>Yes</td>
<td>Yes</td>
<td>0, any positive integer up to 32760, or X is valid. See the parameter list below.</td>
</tr>
<tr>
<td>blksize=</td>
<td>Yes</td>
<td>Yes</td>
<td>0 or any positive integer up to 32760 is valid.</td>
</tr>
<tr>
<td>space=</td>
<td>Yes</td>
<td>Yes</td>
<td>Valid only if you are opening a new data set by its data set name. See the parameter list below.</td>
</tr>
<tr>
<td>type=</td>
<td>Yes</td>
<td>Yes</td>
<td>May be omitted. If you do specify it, type=record is the only valid value.</td>
</tr>
<tr>
<td>acc=</td>
<td>Yes</td>
<td>No</td>
<td>Not used for OS I/O.</td>
</tr>
<tr>
<td>password=</td>
<td>Yes</td>
<td>No</td>
<td>Not used for OS I/O.</td>
</tr>
<tr>
<td>asis</td>
<td>Yes</td>
<td>No</td>
<td>Used to specify mixed-case file names. Not recommended.</td>
</tr>
<tr>
<td>bytesseek</td>
<td>Yes</td>
<td>Yes</td>
<td>Used for binary files to specify that the seeking functions should use relative byte offsets instead of encoded offsets.</td>
</tr>
<tr>
<td>noseek</td>
<td>Yes</td>
<td>Yes</td>
<td>Used to disable seeking functions for improved performance.</td>
</tr>
</tbody>
</table>
Table 19. Parameters for the fopen() and freopen() Functions for z/OS OS I/O (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Allowed?</th>
<th>Applicable?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>Yes</td>
<td>No</td>
<td>Ignored.</td>
</tr>
</tbody>
</table>

**recfm=**

z/OS C/C++ allows you to specify any of the 27 possible RECFM types (listed in [Fixed-Format Records](#) on page 38, [Variable-Format Records](#) on page 41, and [Undefined-Format Records](#) on page 44), as well as the z/OS C/C++ RECFMs * and A.

When you are opening an existing file for read or append (or for write, if you have specified DISP=MOD), any RECFM that you specify must match that of the existing file, except that you may specify recfm=U to open any file for read, and you may specify recfm=FBS for a file created as recfm=FB. Specifying recfm=FBS indicates to z/OS C/C++ that there are no short blocks within the file. If there are, undefined behavior results.

For variable-format OS files, the RDW, SDW, and BDW contain the length of the record, segment, and block as well as their own lengths. If you open a file for read with recfm=U, z/OS C/C++ treats each physical block as an undefined-format record. For files created with recfm=V, z/OS C/C++ does not strip off block descriptor words (BDWs) or record descriptor words (RDWs), and for blocked files, it does not deblock records. Using recfm=U is helpful for viewing variable-format files or seeing how records are blocked in the file.

When you are opening an existing PDS or PDSE for write and you specify a RECFM, it must be compatible with the RECFM of the existing data set. FS and FBS formats are invalid for PDS members. For PDSs, you must use exactly the same RECFM. For PDSEs, you may choose to change the blocked attribute (B), because PDSEs perform their own blocking. If you want to read a PDS or PDSE directory and you specify a RECFM, it must be recfm=U.

Specifying recfm=A indicates that the file contains ASA control characters. If you are opening an existing file and you specify that ASA characters exist (>recfm=A) when they do not, the call to fopen() or freopen() fails. If you create a file by opening it for write or append, the A attribute is added to the default RECFM. For more information about ASA, see [Chapter 8, “Using ASA Text Files”](#) on page 75.

Specifying recfm=* causes z/OS C/C++ to fill in any attributes that you do not specify, taking the attributes from the existing data set. This is useful if you want to create a new version of a data set with the same attributes as the previous version. If you open a data set for write and the data set does not exist, z/OS C/C++ uses the default attributes specified in [fopen() Defaults](#) on page 60.

This parameter has no effect when you are opening for read or append, and when you use it for non-DASD files.

**lrecl= and blksize=**

The LRECL that you specify on the fopen() call defines the maximum record length that the C library allows. Records longer than the maximum record length are not written to the file. The first 4 bytes of each block and the first 4 bytes of each record of variable-format files are used for control information. For more information, see [“Variable-Format Records”](#) on page 41.

The maximum LRECL supported for fixed, undefined, or variable-blocked-spanned format sequential disk files is 32760. For other variable-length format disk files the maximum LRECL is 32756. Sequential disk files for any format have a maximum BLKSIZE of 32760. The record length can be any size when opening
a spanned file and specifying lrecl=X. You can now specify lrecl=X on the fopen() or freopen() call for spanned files. If you are updating an existing file, the file must have been originally opened with lrecl=X for the open to succeed. lrecl=X is useful only for text and record I/O.

When you are opening an existing file for read or append (or for write, if you have specified DISP=MOD), any LRECL or BLKSIZE that you specify must match that of the existing file, except when you open an F or FB format file on a disk device without specifying the noseek parameter. In this case, you can specify the S attribute to indicate to z/OS C/C++ that the file has no imbedded short blocks. Files without short blocks improve z/OS C/C++’s performance.

When you are opening an existing PDS or PDSE for write and you specify an LRECL or BLKSIZE, it must be compatible with the LRECL or BLKSIZE of the existing data set. For PDSs, you must use exactly the same values. For PDSEs, the LRECL must be the same, but the BLKSIZE may be different if you have changed the blocking attribute as described under the RECFM parameter above. You can change the blocking attribute, because PDSEs perform their own blocking. The BLKSIZE you choose should be compatible with the RECFM and LRECL. When you open the directory of a PDS or PDSE, do not specify LRECL or BLKSIZE; z/OS C/C++ uses the defaults. See Table 20 on page 126 for more information.

space=(units,(primary,secondary,directory))
This keyword enables you to specify the space parameters for the allocation of a z/OS data set. It applies only to z/OS data sets that you open by filename and do not already exist. If you open a data set by ddname, this parameter has no effect. You cannot specify any whitespace inside the value for the space keyword. You must specify at least one value with this parameter. Any parameter that you specify will be validated for syntax. If that validation fails, then the fopen() or freopen() will fail even if the parameter would have been ignored.

The supported values for units are as follows:
• Any positive integer indicating BLKSIZE
• CYL (mixed case)
• TRK (mixed case)

The primary quantity, the secondary quantity, and the directory quantity all must be positive integers.

If you specify values only for units and primary, you do not have to specify the inside set of parentheses. You can use a comma to indicate a quantity is to take the default value. For example:

space=(cy1,(100,,10)) - default secondary value
space=(trk,(100,,)) - default secondary and directory value
space=(500,(100,)) - default secondary, no directory

You can specify only the values indicated on this parameter. If you specify any other values, fopen() or freopen() fails.

Any values not specified are omitted on the allocation. These values are filled by the system during SVC 99 processing.

type=
You can omit this parameter. If you specify it, the only valid value for OS I/O is type=record, which opens a file for record I/O.
This parameter is not valid for OS I/O. If you specify it, z/OS C/C++ ignores it.

password=
This parameter is not valid for OS I/O. If you specify it, z/OS C/C++ ignores it.

asis
If you use this parameter, z/OS C/C++ does not convert your file names to upper case. The use of the asis parameter is strongly discouraged, because most of the I/O services used by z/OS C/C++ require uppercase file names.

byteseek
When you specify this parameter and open a file in binary mode, all repositioning functions (such as fseek() and ftell()) use relative byte offsets from the beginning of the file instead of encoded offsets. In previous releases of z/OS C/C++, byteseeking was performed only for fixed format binary files. To have the byteseek parameter set as the default for all your calls to fopen() or freopen(), you can set the environment variable _EDC_BYTESEEK to Y. See Chapter 33, “Using Environment Variables” on page 479 for more information.

noseek
Specifying this parameter on the fopen() call disables the repositioning functions ftell(), fseek(), fgetpos(), and fsetpos() for as long as the file is open. When you have specified NOSEEK and have opened a disk file for read only, the only repositioning function allowed on the file is rewind(), if the device supports rewinding. Otherwise, a call to rewind() sets errno and raises SIGIOERR, if SIGIOERR is not set to SIG_IGN. Calls to ftell(), fseek(), fsetpos(), or fgetpos() return EOF, set errno, and set the stream error flag on.

The use of the noseek parameter may improve performance when you are reading and writing data sets.

Note: If you specify the NOSEEK parameter when you open a file for writing, you must specify NOSEEK on any subsequent fopen() call that simultaneously opens the file for reading; otherwise, you will get undefined behavior.

OS
If you specify this parameter, z/OS C/C++ ignores it.

Buffering

z/OS C/C++ uses buffers to map C I/O to system-level I/O.

When z/OS C/C++ performs I/O operations, it uses one of the following buffering modes:

- Line buffering — characters are transmitted to the system when a new-line character is encountered. Line buffering is meaningless for binary and record I/O files.
- Full buffering — characters are transmitted to the system when a buffer is filled.

C/C++ provides a third buffering mode, unbuffered I/O, which is not supported for OS files.

You can use the setvbuf() and setbuf() library functions to set the buffering mode before you perform any I/O operation to the file. setvbuf() fails if you specify unbuffered I/O. It also fails if you try to specify line buffering for an FBS data set opened in text mode, where the device does not support repositioning. This failure
happens because z/OS C/C++ cannot deliver records at line boundaries without violating FBS format. Do not try to change the buffering mode after you have performed any I/O operation to the file.

For all files except stderr, full buffering is the default, but you can use setvbuf() to specify line buffering. For binary files, record I/O files, and unblocked text files, a block is written out as soon as it is full, regardless of whether you have specified line buffering or full buffering. Line buffering is different from full buffering only for blocked text files.

### Multiple Buffering

Multiple buffering (or asynchronous I/O) is supported for z/OS data sets. Multiple buffering is not supported for a data set opened for read at the same time that another file pointer has it opened for write or append. When you open files for multiple buffering, blocks are read into buffers before they are needed, eliminating the delay caused by waiting for I/O to complete. Multiple buffering may make I/O less efficient if you are seeking within or writing to a file, because seeking or writing may discard blocks that were read into buffers but never used.

To specify multiple buffering, code either the NCP=xx or BUFNO=yy subparameter of the DCB parameter on the JCL DD statement (or allocation), where xx is an integer number between 02 and 99, and yy is an integer number normally between 02 and 255. Whether z/OS C/C++ uses NCP or BUFNO depends on whether you are using BSAM or QSAM, respectively. NCP is supported under BSAM; BUFNO is supported under QSAM. BSAM and QSAM are documented in [z/OS DFSMS: Using Data Sets](https://www.ibm.com/support/knowledgecenter/en/SS3Q00_1.11.0/com.ibm.dfsms.open.mfc.doc/dsmfcchapd/dsmfcs40.htm). If you specify noseek, z/OS C/C++ uses QSAM if possible. If z/OS C/C++ is using BSAM and you specify a value for BUFNO, z/OS C/C++ maps this value to NCP. If z/OS C/C++ is using QSAM and you specify a value for NCP, z/OS C/C++ maps this value to BUFNO.

If you specify both NCP and BUFNO, z/OS C/C++ takes the greater of the two values, up to the maximum for the applicable value. For example, if you specify a BUFNO of 120 and you are using BSAM, which uses NCP instead, z/OS C/C++ will use NCP=99.

If you do not specify either, z/OS C/C++ defaults to single buffering, except in the following cases, where z/OS C/C++ uses the system’s default BUFNO and performs multiple buffering for both reading and writing:

- If you open a device that does not support repositioning, and specify read-only or write-only mode (r, rb, w, wb, a, ab).

- If you specify the NOSEEK parameter on the call to fopen() or freopen(), and specify read-only or write-only mode. When you specify NOSEEK, you get multiple buffering for both reads and writes.

Here is an example of how to specify BUFNO:

```bash
//DD5 DD DSNAME=TORONTO.BLUEJAYS,DISP=SHR,DCB=(BUFNO=5)
```

You may need to update code from previous releases that relies on z/OS C/C++ ignoring NCP or BUFNO parameters.
DCB (Data Control Block) Attributes

For OS files, the C run-time library creates a skeleton data control block (DCB) for the file when you open it. File attributes are determined from the following sources in this order:

1. The fopen() or freopen() function call
2. Attributes for a ddname specified previously (if you are opening by ddname)
3. Existing file attributes (if you specify recfm=* or you are opening an existing file for read or append)
4. Defaults from fopen() or freopen() for creating a new file.

If you do not specify RECFM when you are creating a new file, z/OS C/C++ uses the following defaults:

If recfm is not specified in a fopen() call for an output binary file, recfm defaults to:
- recfm=VB for spool (printer) files,
- recfm=FB otherwise.

If recfm is not specified in a fopen() call for an output text file, recfm defaults to:
- recfm=F if _EDC_ANSI_OPEN_DEFAULT is set to Y and no LRECL or BLKSIZE specified.
  In this case, LRECL and BLKSIZE are both defaulted to 254.
- recfm=VBA for spool (printer) files.
- recfm=U for terminal files
- recfm=V if the LRECL or BLKSIZE is specified
- recfm=VB for all other OS files.

If recfm is not specified for a record I/O file, you will get the default of recfm=VB.

The following table shows the defaults for LRECL and BLKSIZE when the z/OS C/C++ compiler creates an OS file.
### Table 20. fopen() Defaults for LRECL and BLKSIZE when Creating OS Files

<table>
<thead>
<tr>
<th>Irecl specified?</th>
<th>Blksize specified?</th>
<th>RECFM</th>
<th>LRECL</th>
<th>BLKSIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>no</td>
<td>All F</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All FB</td>
<td>80</td>
<td>maximum integral multiple of 80 less than or equal to max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All V, VB, VS, or VBS</td>
<td>minimum of 1028 or max–4</td>
<td>max</td>
</tr>
<tr>
<td>yes</td>
<td>no</td>
<td>All F</td>
<td>Irecl</td>
<td>Irecl</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All FB</td>
<td>Irecl</td>
<td>maximum integral multiple of Irecl less than or equal to max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All V</td>
<td>Irecl</td>
<td>Irecl+4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All U</td>
<td>0</td>
<td>Irecl</td>
</tr>
<tr>
<td>no</td>
<td>yes</td>
<td>All F or FB</td>
<td>blksize</td>
<td>blksize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All V, VB, VS, or VBS</td>
<td>minimum of 1028 or blksize–4</td>
<td>blksize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All U</td>
<td>0</td>
<td>blksize</td>
</tr>
</tbody>
</table>

**Note:** All includes the standard (S) specifier for fixed formats, the ASA (A) specifier, and the machine control character (M) specifier.

In Table 20, the value *max* represents the maximum reasonable block size for the device. These are the current default maximum block sizes for several devices that z/OS C/C++ supports:
<table>
<thead>
<tr>
<th>Device</th>
<th>Default Maximum Block Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASD</td>
<td>6144</td>
</tr>
<tr>
<td>3203 Printer</td>
<td>132</td>
</tr>
<tr>
<td>3211 Printer</td>
<td>132</td>
</tr>
<tr>
<td>4245 Printer</td>
<td>132</td>
</tr>
<tr>
<td>2540 Reader</td>
<td>80</td>
</tr>
<tr>
<td>2540 Punch</td>
<td>80</td>
</tr>
<tr>
<td>2501 Reader</td>
<td>80</td>
</tr>
<tr>
<td>3890 Document Processor</td>
<td>80</td>
</tr>
<tr>
<td>TAPE</td>
<td>32760</td>
</tr>
</tbody>
</table>

For more information about specific default block sizes as returned by the DEVTYPE macro, refer to [z/OS DFSMS: Using Data Sets](#).

You can perform multiple buffering under z/OS. See [Multiple Buffering](#) on page 124 for details.

### Reading from Files

You can use the following library functions to read from a file:

- `fread()`
- `fgetc()`
- `fgets()`
- `fscanf()`
- `getc()`
- `gets()`
- `getchar()`
- `scanf()`

`fread()` is the only interface allowed for reading record I/O files. A read operation directly after a write operation without an intervening call to `fflush()`, `fsetpos()`, `fseek()`, or `rewind()` fails. z/OS C/C++ treats the following as read operations:

- Calls to read functions that request 0 bytes
- Read requests that fail because of a system error
- Calls to the `ungetc()` function

z/OS C/C++ does not consider a read to be at EOF until you try to read past the last byte visible in the file. For example, in a file containing three bytes, the `feof()` function returns `FALSE` after three calls to `fgetc()`. Calling `fgetc()` one more time causes `feof()` to return `TRUE`.

You can set up a `SIGIOERR` handler to catch read or write system errors. See the debugging section in this book for more details.

### Reading from Binary Files

z/OS C/C++ reads binary records in the order that they were written to the file. Any null padding is visible and treated as data. Record boundaries are meaningless.
Reading from Text Files

For non-ASA variable text files, the default for z/OS C/C++ is to ignore any empty physical records in the file. If a physical record contains a single blank, z/OS C/C++ reads in a logical record containing only a new-line. However, if the environment variable _EDC_ZERO_RECLEN was set to Y, z/OS C/C++ reads an empty physical record as a logical record containing a new-line, and a physical record containing a single blank as a logical record containing a blank and a new-line. z/OS C/C++ differentiates between empty records and records containing single blanks, and does not ignore either of them. For more information about how z/OS C/C++ treats empty records in variable format, see "Mapping C Types to Variable Format" on page 43.

For ASA variable text files, if a file was created without a control character as its first byte, the first byte defaults to the ' ' character. When the file is read back, the first character is read as a new-line.

On input, ASA characters are translated to the corresponding sequence of control characters. For more information about using ASA files, refer to Chapter 8, "Using ASA Text Files" on page 75.

For undefined format text files, reading a file causes a new-line character to be inserted at the end of each record. On input, a record containing a single blank character is considered an empty record and is translated to a new-line character. Trailing blanks are preserved for each record.

For files opened in fixed text format, rightmost blanks are stripped off a record at input, and a new-line character is placed in the logical record. This means that a record consisting of a single new-line character is represented by a fixed-length record made entirely of blanks.

Reading from Record I/O Files

For files opened in record format, fread() is the only interface that supports reading. Each time you call fread() for a record I/O file, fread() reads one record. If you call fread() with a request for less than a complete record, the requested bytes are copied to your buffer, and the file position is set to the start of the next record. If the request is for more bytes than are in the record, one record is read and the position is set to the start of the next record. z/OS C/C++ does not strip any blank characters or interpret any data.

fread() returns the number of items read successfully, so if you pass a size argument equal to 1 and a count argument equal to the maximum expected length of the record, fread() returns the length, in bytes, of the record read. If you pass a size argument equal to the maximum expected length of the record, and a count argument equal to 1, fread() returns either 0 or 1, indicating whether a record of length size read. If a record is read successfully but is less than size bytes long, fread() returns 0.

A failed read operation may lead to undefined behavior until you reposition successfully.
Writing to Files

You can use the following library functions to write to a file:
- fwrite()
- printf()
- fprintf()
- vprintf()
- vfprintf()
- puts()
- fputc()
- fputs()
- putchar()

fwrite() is the only interface allowed for writing to record I/O files. See z/OS C/C++ Run-Time Library Reference for more information on these library functions.

A write operation directly after a read operation without an intervening call to fflush(), fsetpos(), fseek(), or rewind() fails unless the read operation has reached EOF. The file pointer does not reach EOF until after you have tried to read past the last byte of the file.

z/OS C/C++ counts a call to a write function writing 0 bytes or a write request that fails because of a system error as a write operation.

If you are updating a file and a system failure occurs, z/OS C/C++ tries to set the file position to the end of the last record updated successfully. For a fully-buffered file, this is at the end of the last record in a block. For a line-buffered file, this may be any record in the current block. If you are writing new data at the time of a system failure, z/OS C/C++ puts the file position at the end of the last block of the file. In files opened for blocked output, you may lose data written by other writes to that block before the system failure. The contents of a file after a system write failure are indeterminate.

If one user opens a file for writing, and another later opens the same file for reading, the user who is reading the file can check for records that may have been written past the end of the file by the other user. If the file is a spanned variable text file, the reader can read part of a spanned record and reach the end of the file before reading in the last segment of the spanned record.

Writing to Binary Files

Data flows over record boundaries in binary files. Writes or updates past the end of a record go to the next record. When you are writing to files and not making any intervening calls to fflush(), blocks are written to the system as they are filled. If a fixed record is incomplete when you close the file, z/OS C/C++ completes it with nulls. You cannot change the length of existing records in a file by updating them.

If you are using variable binary files, note the following:
- On input and on update, records that have no length are ignored; you will not be notified. On output, zero-length records are not written. However, in spanned files, if the first segment of a record has been written to the system, and the user flushes or closes the file, a zero-length last segment may be written to the file.
If you are writing new data in a recfm=VB file, z/OS C/C++ may add a short record at the end of a block, to fill the block out to the full block size.

If your file is spanned, records are written up to length LRECL, spanning multiple blocks if necessary. You can create a spanned file by specifying a RECFM containing V and S on the fopen() call.

Writing to Text Files

z/OS C/C++ treats the control characters as follows when you are writing to a non-ASA text file:

\a Alarm. Placed directly into the file; z/OS C/C++ does not interpret it.
\b Backspace. Placed directly into the file; z/OS C/C++ does not interpret it.
\f Form feed. Placed directly into the file; z/OS C/C++ does not interpret it.
\n New-line. Defines a record boundary; z/OS C/C++ does not place it in the file.
\r Carriage return. Defines a record boundary; z/OS C/C++ does not place it in the file. Treated like a new-line character.
\t Horizontal tab character. Placed directly into the file; z/OS C/C++ does not interpret it.
\v Vertical tab character. Placed directly into the file; z/OS C/C++ does not interpret it.
\x0E DBCS shift-out character. Indicates the beginning of a DBCS string, if MB_CUR_MAX > 1. Placed into the file.
\x0F DBCS shift-in character. Indicates the end of a DBCS string, if MB_CUR_MAX > 1. Placed into the file. See Chapter 9, “z/OS C Support for the Double-Byte Character Set” on page 79 for more information about MB_CUR_MAX.

The way z/OS C/C++ treats text files depends on whether they are in fixed, variable, or undefined format, and whether they use ASA.

As with ASA files in other environments, the first character of each record is reserved for the ASA control character that represents a new-line, a carriage return, or a form feed.

Table 21. C Control to ASA Characters

<table>
<thead>
<tr>
<th>C Control Character Sequence</th>
<th>ASA Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\n</td>
<td>' '</td>
<td>skip one line</td>
</tr>
<tr>
<td>\n\n</td>
<td>'0'</td>
<td>skip two lines</td>
</tr>
<tr>
<td>\n\n\n</td>
<td>'1'</td>
<td>skip three lines</td>
</tr>
<tr>
<td>\r</td>
<td>'+'</td>
<td>overstrike</td>
</tr>
</tbody>
</table>

See Chapter 8, “Using ASA Text Files” on page 75 for more information.

Writing to Fixed-Format Text Files

Records in fixed-format files are all the same length. You complete each record with a new-line or carriage return character. For fixed text files, the new-line character is not written to the file. Blank padding is inserted to the LRECL of each record of the
A logical record can be shortened to be an empty record (containing just a new-line) or extended to a record containing LRECL bytes of data plus a new-line. Because the physical record represents the new-line position by using padding blanks, the new-line position can be changed on an update as long as it is within the physical record.

**Note:** Using ftell() or fgetpos() values for positions that do not exist after you have shortened records results in undefined behavior.

When you are updating a file, writing new data into an existing record replaces the old data and, if the new data is longer or shorter than the old data, changes the size of the logical record by changing the number of blank characters in the physical record. When you extend a record, thereby writing over the old new-line, a new-line character is implied after the last character of the update. Calling fflush() flushes the data out to the file and inserts blank padding between the last data character and the end of the record. Once you have called fflush(), you can call any of the read functions, which begin reading at the new-line. Once the new-line is read, reading continues at the beginning of the next record.

**Writing to Variable-Format Text Files**

In a file with variable-length records, each record may be a different length. The variable length formats permit both variable-length records and variable-length blocks. The first 4 bytes of each block are reserved for the Block Descriptor Word (BDW); the first 4 bytes of each record are reserved for the Record Descriptor Word (RDW).

For ASA and non-ASA, the ‘\n’ (new-line) character implies a record boundary. On output, the new-line is not written to the physical file; instead, it is assumed to follow the data of the record.

If you have not set _EDC_ZERO_RECLEN, z/OS C/C++ writes out a record containing a single blank character to represent a single new-line. On input, a record containing a single blank character is considered an empty record and is translated to a new-line character. Note that a single blank followed by a new-line is written out as a single blank, and is treated as just a new-line on input. When _EDC_ZERO_RECLEN is set, writing a record containing only a new-line results in a zero-length variable record.

For more information about environment variables, refer to Chapter 33, “Using Environment Variables” on page 479. For more information about how z/OS C/C++ treats empty records in variable format, see “Mapping C Types to Variable Format” on page 43.

Attempting to shorten a record on update by specifying less data before the new-line causes the record to be padded with blanks to the original record size. For spanned records, updating a record to a shorter length results in the same blank padding to the original record length, over multiple blocks, if applicable.

Attempts to lengthen a record on update generally result in truncation. The exception to this rule is extending an empty record to a 1-byte record when the environment variable _EDC_ZERO_RECLEN is not set. Because the physical representation for an empty record is a record containing one blank character, it is possible to extend the logical record to a single non-blank character followed by a
new-line character. For standard streams, truncation in text files does not occur; data is wrapped automatically to the next record as if you had added a new-line.

When you are writing data to a non-blocked file without intervening flush or reposition requests, each record is written to the system when a new-line or carriage return character is written or when the file is closed.

When you are writing data to a blocked file without intervening flush or reposition requests, if the file is opened in full buffering mode, the block is written to the system on completion of the record that fills the block. If the blocked file is line buffered, each record is written to the system when it is completed. If you are using full buffering for a VB format file, a write may not fill a block completely. The data does not go to the system unless a block is full; you can complete the block with another write. If the subsequent write contains more data than is needed to fill the block, it flushes the current block to the system and starts writing your data to a new block.

When you are writing data to a spanned file without intervening flush or reposition requests, if the record spans multiple blocks, each block is written to the system once it is full and the user writes an additional byte of data.

For ASA variable text files, if a file was created without a control character as its first byte or record (after the RDW and BDW), the first byte defaults to the ‘ ‘ character. When the file is read back, the first character is read as a new-line.

**Writing to Undefined-Format Text Files**

In an undefined-format file, there is only one record per block. Each record may be a different length, up to a maximum length of BLKSIZE. Each record is completed with a new-line or carriage return character. The new-line character is not written to the physical file; it is assumed to follow the data of the record. However, if a record contains only a new-line character, z/OS C/C++ writes a record containing a single blank to the file to represent an empty record. On input, the blank is read in as a new-line.

Once a record has been written, you cannot change its length. If you try to shorten a logical record by updating it with a shorter record, z/OS C/C++ completes the record with blank padding. If you try to lengthen a record by updating it with more data than it can hold, z/OS C/C++ truncates the new data. The only instance in which this does not happen is when you extend an empty record so that it contains a single byte. Any data beyond the single byte is truncated.

**Truncation Versus Splitting**

If you try to write more data to a record than z/OS C/C++ allows, and the file you are writing to is not one of the standard streams (the defaults, or those redirected by freopen() or command-level redirection), output is cut off at the record boundary and the remaining bytes are discarded. z/OS C/C++ does not count the discarded characters as characters that have been written out successfully.

In all truncation cases, the SIGIOERR signal is raised if the action for SIGIOERR is not SIG_IGN. The user error flag is set so that ferror() will return TRUE. For more information about SIGIOERR, ferror(), and other I/O-related debugging tools, see Chapter 18, “Debugging I/O Programs” on page 233. z/OS C/C++ continues to discard new output until you complete the current record by writing a new-line or carriage return character, close the file, or change the file position.
If you are writing to one of the standard streams, attempting to write more data than a record can hold results in the data being split across multiple records.

**Writing to Record I/O Files**

`fwrite()` is the only interface allowed for writing to a file opened for record I/O. Only one record is written at a time. If you attempt to write more new data than a full record can hold or you try to update a record with more data than it currently has, z/OS C/C++ truncates your output at the record boundary. When z/OS C/C++ performs a truncation, it sets `errno` and raises `SIGIOERR`, if `SIGIOERR` is not set to `SIG_IGN`.

When you update a record, you can update less than the full record. The remaining data that you do not update is left untouched in the file.

When you are writing new records to a fixed-record I/O file, if you try to write a short record, z/OS C/C++ pads the record with nulls out to LRECL.

At the completion of an `fwrite()`, the file position is at the start of the next record. For new data, the block is flushed out to the system as soon as it is full.

**Flushing Buffers**

You can use the library function `fflush()` to flush streams to the system. For more information about `fflush()`, see *z/OS C/C++ Run-Time Library Reference*.

The action taken by the `fflush()` library function depends on the buffering mode associated with the stream and the type of streams. If you call one z/OS C/C++ program from another z/OS C/C++ program by using the ANSI `system()` function, all open streams are flushed before control is passed to the callee, and again before control is returned to the caller. If you are running with `POSIX(ON)`, a call to the POSIX `system()` function does not flush any streams to the system.

**Updating Existing Records**

Calling `fflush()` while you are updating flushes the updates out to the system. If you call `fflush()` when you are in the middle of updating a record, z/OS C/C++ writes the partially updated record out to the system. A subsequent write continues to update the current record.

**Reading Updated Records**

If you have a file open for read at the same time that the file is open for write in the same application, you will be able to see the new data if you call `fflush()` to refresh the contents of the input buffer, as in the following example:
Writing New Records

Writing new records is handled differently for:

- Binary streams
- Text streams
- Record I/O

Binary Streams

z/OS C/C++ treats line buffering and full buffering the same way for binary files.

If the file has a variable length or undefined record format, fflush() writes the current record out. This may result in short records. In blocked files, this means that the block is written to disk, and subsequent writes are to a new block. For fixed files, no incomplete records are flushed.

For single-volume disk files in FBS format, fflush() flushes complete records in an incomplete block out to the file. For all other types of FBS files, fflush() does not flush an incomplete block out to the file.

Figure 14. Example of Reading Updated Records

```c
#include <stdio.h>

int main(void)
{
    FILE * fp, * fp2;
    int rc, rc2, rc3, rc4;
    fp = fopen("a.b","w+");
    fprintf(fp,"first record");
    fp2 = fopen("a.b","r"); /* Simultaneous Reader */
    /* following gets EOF since fp has not completed first line *
     * of output so nothing will be flushed to file yet */
    rc = fgetc(fp2);
    printf("return code is %i\n", rc);
    fputc(\n', fp); /* this will complete first line */
    fflush(fp);   /* ensures data is flushed to file */
    rc2 = fgetc(fp2); /* this gets 'f' from first record */
    printf("value is now %c\n", rc2);
    rewind(fp);
    fprintf(fp, "some updates\n");
    rc3 = fgetc(fp2); /* gets 'i' doesn't know about update */
    printf("value is now %c\n", rc3);
    fflush(fp); /* ensure update makes it to file */
    fflush(fp2); /* this updates reader's buffer */
    rc4 = fgetc(fp2); /* gets 'm', 3rd char of updated record */
    printf("value is now %c\n", rc4);
    return(0);
}
```
For files in FB format, fflush() always flushes out all complete records in the current block. For sequential DASD files, new completed records are added to the end of the flushed block if it is short. For non-DASD or non-sequential files, any new record will start a new block.

**Text Streams**

- **Line-Buffered Streams**
  
  fflush() has no effect on line-buffered text files, because z/OS C/C++ writes all records to the system as they are completed. All incomplete new records remain in the buffer.

- **Fully Buffered Streams**
  
  Calling fflush() flushes all completed records in the buffer, that is, all records ending with a new-line or carriage return (or form feed character, if you are using ASA), to the system. z/OS C/C++ holds any incomplete record in the buffer until you complete the record or close the file.

For ASA text files, if a flush occurs while an ASA character that indicates more than one new-line is being updated, the remaining new-lines will be discarded and a read will continue at the first data character. For example, if '\n\n\n' is updated to be '\n\n' and a flush occurs, then a '0' will be written out in the ASA character position.

**Record I/O**

z/OS C/C++ treats line buffering and full buffering the same way for record I/O. For files in FB format, calling fflush() writes all records in the buffer to the system. For single-volume disk files in FBS format, fflush() will flush complete records in an incomplete block out to the file. For all other types of FBS files, fflush() will not flush an incomplete block out to the file. For all other formats, calling fflush() has no effect, because fwrite() has already written the records to disk.

**ungetc() Considerations**

ungetc() pushes characters back onto the input stream for binary and text files. ungetc() handles only single-byte characters. You can use it to push back as many as four characters onto the ungetc() buffer. For every character pushed back with ungetc(), fflush() backs up the file position by one character and clears all the pushed-back characters from the stream. Backing up the file position may end up going across a record boundary. Remember that for text files, z/OS C/C++ counts the new-lines added to the records as single-byte characters when it calculates the file position.

For example, given the stream you can run the following code fragment:

```c
fgetc(fp); /* Returns A and puts the file position at */
/* the beginning of the character B */
ungetc('Z',fp); /* Logically inserts Z ahead of B */
fflush(fp); /* Moves the file position back by one to A, */
/* removes Z from the logical stream */
```
If you want fflush() to ignore ungetc() characters, you can set the _EDC_COMPAT environment variable. See Chapter 33, "Using Environment Variables" on page 479 for more information.

---

Repositioning within Files

You can use the following library functions to help you position within an OS file:

- fseek()
- ftell()
- fgetpos()
- fsetpos()
- rewind()

See z/OS C/C++ Run-Time Library Reference for more information on these library functions.

Opening a file with fopen() and specifying the NOSEEK parameter disables all of these library functions except rewind(). A call to rewind() causes the file to be reopened, unless the file is a non-disk file opened for write-only. In this case, rewind() sets errno and raises SIGIOERR (if SIGIOERR is not set to SIG_IGN, which is its default).

Calling any of these functions flushes all complete and updated records out to the system. If a repositioning operation fails, z/OS C/C++ attempts to restore the original file position and treats the operation as a call to fflush(), except that it does not account for the presence of ungetc() or ungetwc() characters, which are lost. After a successful repositioning operation, feof() always returns 0, even if the position is just after the last byte of data in the file.

The fsetpos() and fgetpos() library functions are generally more efficient than ftell() and fseek(). The fgetpos() function can encode the current position into a structure that provides enough room to hold the system position as well as position data specific to C or C++. The ftell() function must encode the position into a single word of storage, which it returns. This compaction forces fseek() to calculate certain position information specific to C or C++ at the time of repositioning. For variable-format binary files, you can choose to have ftell() return relative byte offsets. In previous releases, ftell() returned only encoded offsets, which contained the relative block number. Since you cannot calculate the block number from a relative byte offset in a variable-format file, fseek() may have to read through the file to get to the new position. fsetpos() has system position information available within the the fpos_t structure and can generally reposition directly to the desired location.

You can use the ftell() and fseek() functions to set the current position within all types of files except for the following:

- Files on non-seekable devices (for example, printers)
- Files on tapes opened for write
- Partitioned data sets opened in w or wb mode.

ungetc() Considerations

For binary and text files, the library functions fgetpos() and ftell() take into account the number of characters you have pushed back onto the input stream with ungetc(), and adjust the file position accordingly. ungetc() backs up the file position
by a single byte each time you call it. For text files, z/OS C/C++ counts the new-lines added to the records as single-byte characters when it calculates the file position.

If you make so many calls to ungetc() that the logical file position is before the beginning of the file, the next call to ftell() or fgetpos() fails.

When you are using fseek() with a whence value of SEEK_CUR, the starting point for the reposition also accounts for the presence of ungetc() characters and compensates as ftell() and fgetpos() do.

If you want fgetpos() and fseek() to ignore ungetc() characters, you can set the _EDC_COMPAT environment variable. See Chapter 33, “Using Environment Variables” on page 479 for details. ftell() is not affected by the setting of _EDC_COMPAT.

**How Long fgetpos() and ftell() Values Last**

As long as you do not re-create a file or shorten logical records, you can rely on the values returned by ftell() and fgetpos(), even across program boundaries and calls to fclose(). (Calling fopen() or freopen() with any of the w modes re-creates a file.) Using ftell() and fgetpos() values that point to information deleted or re-created results in undefined behavior. For more information about shortening records, see “Writing to Variable-Format Text Files” on page 131.

**Using fseek() and ftell() in Binary Files**

With binary files, ftell() returns two types of positions:
- Relative byte offsets
- Encoded offsets

**Relative Byte Offsets**

You get byte offsets by default when you are seeking or positioning in fixed-format binary files. You can also use byte offsets on a variable or undefined format file opened in binary mode with the BYTESEEK parameter specified on the fopen() or freopen() function call. You can specify BYTESEEK to be the default for fopen() calls by setting the environment variable _EDC_BYTESEEK to Y. See Chapter 33, “Using Environment Variables” on page 479 for information on how to set environment variables.

You do not need to acquire an offset from ftell() to seek to a relative position; you may specify a relative offset to fseek() with a whence value of SEEK_SET. However, you cannot specify a negative offset to fseek() when you have specified SEEK_SET, because a negative offset would indicate a position before the beginning of the file. Also, you cannot specify a negative offset with whence values of SEEK_CUR or SEEK_END such that the resulting file position would be before the beginning of the file. If you specify such an offset, fseek() fails.

If your file is not opened read-only, you can specify a position that is beyond the current EOF. In such cases, a new end-of-file position is created; null characters are automatically added between the old EOF and the new EOF.

fseek() support of byte offsets in variable-format files generally requires reading all records from the whence value to the new position. The impact on performance is greatest if you open an existing file for append in BYTESEEK mode and then call ftell(). In this case, ftell() has to read from the beginning of the file to the current position to calculate the required byte offset. Support for byteseeking is

Chapter 11. Performing OS I/O Operations 137
intended to ease portability from other platforms. If you need better performance, consider using ftell()-encoded offsets, discussed in the next section.

Encoded Offsets
If you do not specify the BYTESEEK parameter and you set the _EDC_BYTESEEK variable to N, any variable- or undefined-format binary file gets encoded offsets from ftell(). This keeps this release of z/OS C/C++ compatible with code generated by old releases of C/370.

Encoded offsets are values representing the block number and the relative byte within that block, all within one long int. Because z/OS C/C++ does not document its encoding scheme, you cannot rely on any encoded offset not returned by ftell(), except 0, which is the beginning of the file. This includes encoded offsets that you adjust yourself (for example, with addition or subtraction). When you call fseek() with the whence value SEEK_SET, you must use either 0 or an encoded offset returned from ftell(). For whence values of SEEK_CUR and SEEK_END, however, you specify relative byte offsets. If you want to seek to a certain relative byte offset, you can use SEEK_SET with an offset of 0 to rewind the file to the beginning, and then you can use SEEK_CUR to specify the desired relative byte offset.

In earlier releases, ftell() could determine position only for files with no more than 131,071 blocks. In the new design, this number increases depending on the block size. From a maximum block size of 32,760, every time this number decreases by half, the number of blocks that can be represented doubles.

If your file is not opened read-only, you can use SEEK_CUR or SEEK_END to specify a position that is beyond the current EOF. In such cases, a new end-of-file position is created; null characters are automatically added between the old EOF and the new EOF. This does not apply to PDS members, as they cannot be extended. For SEEK_SET, because you are restricted to using offsets returned by ftell(), any offset that indicates a position outside the current file is invalid and causes fseek() to fail.

Using fseek() and ftell() in Text Files (ASA and Non-ASA)
In text files, ftell() produces only encoded offsets. It returns a long int, in which the block number and the byte offset within the block are encoded. You cannot rely on any encoded offset not returned by ftell() except 0. This includes encoded offsets that you adjust yourself (for example, with addition or subtraction).

When you call fseek() with the whence value SEEK_SET, you must use an encoded offset returned from ftell(). For whence values of SEEK_CUR and SEEK_END, however, you specify relative byte offsets. If you want to seek to a certain relative byte offset, you can use SEEK_SET with an offset of 0 to rewind the file to the beginning, and then you can use SEEK_CUR to specify the desired relative byte offset. z/OS C/C++ counts new-line characters and skips to the next record each time it reads one.

Unlike binary files you cannot specify offsets for SEEK_CUR and SEEK_END that set the file position past the end of the file. Any offset that indicates a position outside the current file is invalid and causes fseek() to fail.

In earlier releases, ftell() could determine position only for files with no more than 131071 blocks. In the new design, this number increases depending on the block size. From a maximum block size of 32760, every time this number decreases by half, the number of blocks that can be represented doubles.
Repositioning flushes all updates before changing position. An invalid call to fseek() is now always treated as a flush. It flushes all updated records or all complete new records in the block, and leaves the file position unchanged. If the flush fails, any characters in the ungetc() buffer are lost. If a block contains an incomplete new record, the block is saved and will be completed by another write or by closing the file.

**Using fseek() and ftell() in Record Files**

For files opened with type=record, ftell() returns relative record numbers. The behavior of fseek() and ftell() is similar to that when you use relative byte offsets for binary files, except that the unit is a record rather than a byte. For example,

```c
fseek(fp,-2,SEEK_CUR);
```

seeks backward two records from the current position.

```c
fseek(fp,6,SEEK_SET);
```

seeks to relative record 6. You do not need to get an offset from ftell().

You cannot seek past the end or before the beginning of a file.

The first record of a file is relative record 0.

**Porting Old C Code That Uses fseek() or ftell()**

The encoding scheme used by ftell() in non-BYTESEEK mode in the z/OS C/C++ RTL is different from that used in the C/C++ run-time library prior to C/370 Release 2.2 and Language Environment prior to release 1.3.

- If your code obtains ftell() values and passes them to fseek(), the change to the encoding scheme should not affect your application. On the other hand, your application may not work if you have saved encoded ftell() values in a file and your application reads in these encoded values to pass to fseek(). For non-record I/O files, you can set the environment variable _EDC_COMPAT with the ftell() encoding set to tell z/OS C/C++ that you have old ftell() values. Files opened for record I/O do not support old ftell() values saved across the program boundary.

- In previous versions, the fseek() support for the ftell() encoding scheme inadvertently supported seeking from SEEK_SET with a byte offset up to 32K. This is no longer be supported. Users of this support must change to BYTESEEK mode. You can do this without changing your source code; just use the _EDC_BYTE_SEEK environment variable.

**Closing Files**

Use the fclose() library function to close a file. z/OS C/C++ automatically closes files on normal program termination and attempts to do so under abnormal program termination or abend. See z/OS C/C++ Run-Time Library Reference for more information on this library function.

For files opened in fixed binary mode, incomplete records will be padded with null characters when you close the file.

For files opened in variable binary mode, incomplete records are flushed to the system. In a spanned file, closing a file can cause a zero-length segment to be written. This segment will still be part of the non-zero-length record. For files opened in undefined binary mode, any incomplete output is flushed on close.
Closing files opened in text mode causes any incomplete new record to be completed with a new-line character. All records not yet flushed to the file are written out when the file is closed.

For files opened for record I/O, closing causes all records not yet flushed to the file to be written out.

When fclose() is used to close a stream associated with a z/OS data set, some failures may be unrecoverable, and will result in an ABEND. These ABENDs may include I/O ABENDs of the form x14 and x37. Control will not be returned to the caller of fclose() to report the error. To process these types of errors, applications need to use z/OS Language Environment condition handling to receive control (see z/OS Language Environment Programming Guide), or register a signal handler for SIGABND (see Chapter 27, "Handling Exceptions, Error Conditions, and Signals" on page 379).

### Renaming and Removing Files

You can remove or rename a z/OS data set that has an uppercase filename by using the `remove()` or `rename()` library functions, respectively. `rename()` and `remove()` both accept data set names. `rename()` does not accept ddnames, but `remove()` does. You can use `remove()` or `rename()` on individual members or entire PDSs or PDSEs. If you use `rename()` for a member, you can change only the name of the member, not the name of the entire data set. To rename both the member and the data set, make two calls to `rename()`, one for the member and one for the whole PDS or PDSE.

### fldata() Behavior

The format of the `fldata()` function is as follows:

```c
int fldata(FILE *file, char *filename, fldata_t *info);
```

The `fldata()` function is used to retrieve information about an open stream. The name of the file is returned in `filename` and other information is returned in the `fldata_t` structure, shown in the figure below. Values specific to this category of I/O are shown in the comment beside the structure element. Additional notes pertaining to this category of I/O follow the figure.

For more information on the `fldata()` function, refer to z/OS C/C++ Run-Time Library Reference.
Notes:

1. If you have opened the file by its data set name, filename is fully qualified, including quotation marks. If you have opened the file by ddname, filename is dd:ddname, without any quotation marks. The ddname is uppercase. If you specified a member on the fopen() or freopen() function call, the member is returned as part of filename.

2. Any of the _recfm bits may be set on for OS files.

3. The _dsorgPO bit will be set on only if you are reading a directory or member of a partitioned data set, either regular or extended, regardless of whether the member is specified on a DD statement or on the fopen() or freopen() function call. The _dsorgPS bit will be set on for all other OS files.

4. The _dsorgPDSE bit will be set when processing an extended partitioned data set (PDSE).

Figure 15. fldata() Structure

Chapter 11. Performing OS I/O Operations 141
5. The __dsorgConcat bit will be set on for a concatenation of sequential data sets, but not for a concatenation of partitioned data sets.
6. The __dsorgTemp bit will be set on only if the file was created using the tmpfile() function.
7. The __blksize value may include BDW and RDWs.
8. The __maxreclen value may include the ASA character.
9. The __recfm bits and the __blksize and __maxreclen values correspond to the attributes of the open stream. They do not necessarily reflect the attributes of the existing data set.
10. The __dsname field is filled in for __DISK files with the data set name. The member name is added if the file is a member of a partitioned data set, either regular or extended. The __dsname value is uppercase unless the asis option was specified on the fopen() or freopen() function call. The __dsname field is set to NULL for all other OS files.
Chapter 12. Performing UNIX File System I/O Operations

You can create the following HFS file types:

- Regular
- Link
- Directory
- Character special
- FIFO

The Single UNIX Specification defines another type of file called STREAMS. Even though the system interfaces are provided, it is impossible to have a valid STREAMS file descriptor. These interfaces will always return a return code of -1 with errno set to indicate an error such as, EBADF, EINVAL, or ENOTTY.

HFS streams follow the binary model, regardless of whether they are opened for text, binary, or record I/O. You can simulate record I/O by using new-line characters as record boundaries.

For information on the hierarchical file system and access to files within it from other than the C or C++ language, see z/OS UNIX System Services User’s Guide.


This chapter describes C I/O stream functions as they can be used within C++ programs. If you want to use the C++ I/O stream classes instead, see Chapter 5, “Using the Standard C++ Library I/O Stream Classes” on page 49 for more general information. For more detailed information about I/O streaming see the following:


For information about using wide-character I/O with z/OS C/C++, see Chapter 9, “z/OS C Support for the Double-Byte Character Set” on page 79.

Creating Files

You can use library functions to create the following types of HFS files:

- Regular Files
- Link and Symbolic Link Files
- Directory Files
- Character Special Files
- FIFO Files

Regular Files

Use any of the following C functions to create HFS regular files:

- creat()
• fopen()
• freopen()
• open()

For a description of these and other I/O functions, see z/OS C/C++ Run-Time Library Reference.

Link and Symbolic Link Files
Use either of the following C functions to create HFS link or symbolic link files:
• link()
• symlink()

Directory Files
Use the following C function to create an HFS directory file:
• mkdir()

Character Special Files
Use the following C function to create an HFS character special file:
• mknod()

You must have superuser authority to create a character special file.

Other functions used for character special files are:
• ptsname()
• grantpt()
• unlockpt()
• tcgetsid()
• ttname()
• isatty()

FIFO Files
Use the following C function to create an HFS FIFO file (named pipe):
• mkfifo()

To create an unnamed pipe, use the following C function:
• pipe()

Opening Files

This section discusses the use of the fopen() or freopen() library functions to open Hierarchical File System (HFS) I/O files. You can also access HFS files using low-level I/O open() function. See “Low-Level z/OS UNIX I/O” on page 156 for information about low-level I/O, and z/OS C/C++ Run-Time Library Reference for information about any of the functions listed above.

The name of an HFS file can include characters chosen from the complete set of character values, except for null characters. If you want a portable filename, then choose characters from the POSIX .1 portable filename character set.
The complete *pathname* can begin with a slash and be followed by zero, one, or more filenames, each separated by a slash. If a directory is included within the pathname, it may have one or more trailing slashes. Multiple slashes following one another are interpreted as one slash.

If your program is running under **POSIX(ON)**, all valid POSIX names are passed as is to the POSIX open function.

You can access either HFS files or MVS data sets from programs. Programs accessing files or data sets can be executed with either the **POSIX(OFF)** or **POSIX(ON)** run-time options. There are basic file naming rules that apply for HFS files and MVS data sets. However, there are also special z/OS C/C++ naming considerations that depend on how you execute your program.

The POSIX run-time option determines the type of z/OS C/C++ services and I/O available to your program. (See z/OS C/C++ User’s Guide for a discussion of the z/OS UNIX programming environment and overview of binding z/OS UNIX C/C++ applications.)

Both the basic and special z/OS C/C++ file naming rules for HFS files are described in the sections that follow. Examples are provided. All examples must be run with the **POSIX(ON)** option. For information about MVS data sets, see Chapter 11, "Performing OS I/O Operations" on page 107.

### Using fopen() or freopen()

When you open a file with *fopen()* or *freopen()* , you must specify the file name (a data-set name) or a ddbname.

**File Naming Considerations**

Files are opened with a call to *fopen()* or *freopen()* in the format

```c
fopen("filename", "mode")
```

**HFS Files:** The following is the format for the *pathname* argument on the *fopen()* or *freopen()* function:

```c
"pathname"
```

The POSIX.1 standard defines *pathname* as the information that identifies a file. For the z/OS UNIX implementation of the POSIX.1 standard, a pathname can be up to 1024 characters—including the null-terminating character. Optionally, it can begin with a slash character (/) followed by directory names separated by slash characters and a filename. For the pathname, each directory name or the filename can be up to 255 characters long.

**Note:** Regardless of whether your program is run under z/OS UNIX or as a traditional MVS application, if the *pathname* that you attempt to open using *fopen()* or *freopen()* contains a slash character but does not begin with exactly two slashes, an HFS file is opened. For example, if you code:

```c
fopen("tradnsell\parts.order", "w+")
```

the HFS file tradnsell\parts.order from the working directory is opened.
If you begin the *pathname* value with `./*`, the specified HFS file in the working directory is opened:

```c
fopen("./parts.order", "w+")
```

Likewise, if you begin the *pathname* value with `/`, the specified HFS file in the root directory is opened:

```c
fopen("/parts.order", "w+")
```

If you specify more than two consecutive slash characters anywhere in a pathname, all but the first slash character is ignored, as in the following examples:

- `"/a.b"
  - MVS data set `prefix.a.b`
- `"///a.b"
  - HFS file `/a.b`
- `"///a.b"
  - HFS file `/a.b`
- `"a///b.c"
  - HFS file `a/b.c`
- `"/a.b"
  - HFS file `/a.b`
- `"/a///b.c"
  - HFS file `/a/b.c`

If you specify `/dd:pathname` or `.//dd:pathname`, a file named `dd:pathname` is opened in the file system root directory or your working directory, respectively. For example, if you code:

```c
fopen("/dd:parder", "w+")
```

the file `dd:parder` is opened in the HFS root directory.

For HFS files, leading and trailing white spaces are *significant*.

**Opening a File by Name**

Which type of file (HFS or MVS data set) you open may depend on whether the z/OS C/C++ application program is running under POSIX(ON).

For an application program that is to be run under POSIX(ON), you can include in your program statements similar to the following to open the HFS file `parts.instock` for reading in the working directory:

```c
FILE *stream;
stream = fopen("parts.instock", "r");
```

To open the MVS data set `user-prefix.PARTS.INSTOCK` for reading, include statements similar to the following in your program:

```c
FILE *stream;
stream = fopen("//parts.instock", "r");
```

For an application program that is to be run as a traditional z/OS C/C++ application program, with POSIX(OFF), to open the MVS data set `user-prefix.PARTS.INSTOCK` for reading, include statements similar to the following in your program:

```c
FILE *stream;
stream = fopen("parts.instock", "r");
```

To open the HFS file `parts.instock` in the working directory for reading, include statements similar to the following in your program:
FILE *stream;
stream = fopen("./parts.instock", "r");

Opening a File by DDname
The DD statement enables you to write z/OS C/C++ source programs that are independent of the files and I/O devices they will use. You can modify the parameters of a file or process different files without recompiling your program.

When \texttt{dd:ddname} is specified to \texttt{fopen()} or \texttt{freopen()}, the z/OS C/C++ library looks to find and resolve the data definition information for the filename to open. If the data definition information points to an MVS data set, MVS data set naming rules are followed. If an HFS file is indicated using the \texttt{PATH} parameter, a \texttt{ddname} is resolved to the associated pathname.

\textbf{Note:} Use of the z/OS C/C++ fork() library function from an application program under z/OS UNIX does not replicate the data definition information of the parent process for the child process. Use of any of the exec() library functions deallocates the data definition information for the application process.

For the declaration just shown for the HFS file \texttt{parts.instock}, you should write a JCL DD statement similar to the following:

```
//PSTOCK DD PATH='/u/parts.instock',...
```

For more information on writing DD statements, you should refer to the job control language (JCL) manual \texttt{z/OS MVS JCL Reference}.

To open the file by DD name under TSO/E, you must write an \texttt{ALLOCATE} command.

For the declaration of an HFS file \texttt{parts.instock}, you should write a TSO/E \texttt{ALLOCATE} command similar to the following:

```
ALLOCATE DDNAME(PSTOCK) PATH(''/u/parts.instock')...
```

See \texttt{z/OS TSO/E Command Reference} for more information on TSO \texttt{ALLOCATE}.

\textbf{fopen()} and \textbf{freopen()} Parameters
The following table lists the parameters that are available on the \texttt{fopen()} and \texttt{freopen()} functions, tells you which ones are useful for HFS I/O, and lists the values that are valid for the applicable ones.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|l|}
\hline
\textbf{Parameter} & \textbf{Allowed?} & \textbf{Applicable?} & \textbf{Notes} \\
\hline
\texttt{recfm=} & Yes & No & HFS I/O uses a continuous stream of data as its file format. \\
\hline
\texttt{lrecl=} & Yes & No & HFS I/O uses a continuous stream of data as its file format. \\
\hline
\texttt{blksize=} & Yes & No & HFS I/O uses a continuous stream of data as its file format. \\
\hline
\texttt{space=} & Yes & No & Not used for HFS I/O. \\
\hline
\texttt{type=} & Yes & Yes & May be omitted. If you do specify it, \texttt{type=record} is the only valid value. \\
\hline
\texttt{acc=} & Yes & No & Not used for HFS I/O. \\
\hline
\texttt{password=} & Yes & No & Not used for HFS I/O. \\
\hline
\end{tabular}
\end{table}
Table 22. Parameters for the fopen() and freopen() functions for HFS I/O (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Allowed?</th>
<th>Applicable?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>asis</td>
<td>Yes</td>
<td>No</td>
<td>Not used for HFS I/O.</td>
</tr>
<tr>
<td>byteseek</td>
<td>Yes</td>
<td>No</td>
<td>Not used for HFS I/O.</td>
</tr>
<tr>
<td>noseek</td>
<td>Yes</td>
<td>No</td>
<td>Not used for HFS I/O.</td>
</tr>
<tr>
<td>0S</td>
<td>Yes</td>
<td>No</td>
<td>Not used for HFS I/O.</td>
</tr>
</tbody>
</table>

recfm=
Ignored for HFS I/O.

lrecl= and blksize=
Ignored for HFS I/O, except that lrecl affects the value returned in the __maxreclen field of fldata() as described below.

acc=
Ignored for HFS I/O.

password
Ignored for HFS I/O.

space=
Ignored for HFS I/O.

type=
The only valid value for this parameter under HFS is type=record. If you specify this, your file follows the HFS record I/O rules:
1. One record is defined to be the data up to the next new-line character.
2. When an fwrite() is done the data will be written from the user buffer with a new-line character added by the RTL code. Data is written up to the number of bytes specified on the fwrite(), or until a new-line character or EOF is found. The new-line character is not included.
3. When an fwrite() is done the data will be written from the user buffer with a new-line character added by the RTL code. Data is written up to the number of bytes specified on the fwrite(); the new-line is added by the RTL and is not included in the return value from fwrite().
4. If you have specified an lrecl and type=record, fldata() of this stream will return the lrecl you specified, in the __maxreclen field of the __fileData return structure of stdio.h. If you specified type=record but no lrecl, the __maxreclen field will contain 1024.
   If type=record is not in effect, fldata() of this stream will return 0 in the __maxreclen field of the __fileData return structure of stdio.h.

asis
Ignored for HFS I/O.

byteseek
Ignored for HFS I/O.

noseek
Ignored for HFS I/O.

0S
Ignored for HFS I/O.
Reading from HFS Files

You can use the following library functions to read in information from HFS files:

- fread()
- fgets()
- gets()
- fgetc()
- getc()
- getchar()
- scanf()
- fscanf()
- read()
- pread()

fread() is the only interface allowed for reading record I/O files. See z/OS C/C++ Run-Time Library Reference for more information on all of the above library functions.

For z/OS UNIX low-level I/O, you can use the read() and readv() function.

See “Low-Level z/OS UNIX I/O” on page 156.

Opening and Reading from HFS Directory Files

To open an HFS directory, you can use the opendir() function.

You can use the following library functions to read from and position within HFS directories:

- readdir()
- seekdir()
- telldir()

To close a directory, use the closedir() function.

Writing to HFS Files

You can use the following library functions to write to HFS files:

- fwrite()
- printf()
- fprintf()
- vprintf()
- vfprintf()
- puts()
- fputs()
- fprintf()
- printf()
- putc()
- putchar()
- write()
- pwrite()
fwrite() is the only interface allowed for writing to record I/O files. See z/OS C/C++ Run-Time Library Reference for more information on all of the above library functions. For z/OS UNIX low-level I/O, you can use the write() and writev() function.

### Flushing Records

You can use the library function fflush() to flush streams to the system. For more information about fflush(), see z/OS C/C++ Run-Time Library Reference.

The action taken by the fflush() library function depends on the buffering mode associated with the stream and the type of streams. If you call one z/OS C/C++ program from another z/OS C/C++ program by using the ANSI system() function, all open streams are flushed before control is passed to the callee, and again before control is returned to the caller. A call to the POSIX system() function does not flush any streams.

For HFS files, the fflush() function copies the data from the run-time buffer to the file system. The fsync() function copies the data from the file system buffer to the storage device.

### Setting Positions within Files

You can use the following library functions to help you reposition within a regular file:

- fseek()
- ftell()
- fgetpos()
- fsetpos()
- rewind()
- lseek()

You can use the following library functions for 64 bit offset and file sizes.

- fseeko()
- ftello()

See z/OS C/C++ Run-Time Library Reference for more information on these library functions.

### Closing Files

You can use fclose(), freopen(), or close() to close a file. z/OS C/C++ automatically closes files on normal program termination, and attempts to do so under abnormal program termination or abend. See z/OS C/C++ Run-Time Library Reference for more information on these library functions. For z/OS UNIX low-level I/O, you can use the close() function. When you use any exec() or fork() function, files defined as “marked to be closed” are closed before control is returned.
Deleting Files

Use the `unlink()` or `remove()` z/OS C/C++ function to delete the following types of HFS files:
- Regular
- Character special
- FIFO
- Link files

Use the `rmdir()` z/OS C/C++ function to delete an HFS directory file. See z/OS C/C++ Run-Time Library Reference for more information about these functions.

Pipe I/O

POSIX.1 pipes represent an I/O channel that processes can use to communicate with other processes. Pipes are conceptually like HFS files. One process can write data into a pipe, and another process can read data from the pipe.

z/OS UNIX C/C++ supports two types of POSIX.1-defined pipes: unnamed pipes and named pipes (FIFO files).

An unnamed pipe is accessible only by the process that created the pipe and its child processes. An unnamed pipe does not have to be opened before it can be used. It is a temporary file that lasts only until the last file descriptor that references it is closed. You can create an unnamed pipe by calling the `pipe()` function.

A named pipe can be used by independent processes and must be explicitly opened and closed. Named pipes are also referred to as first-in, first-out (FIFO) files, or FIFOs. You can create a named pipe by calling the `mkfifo()` function. If you want to stream I/O after a `pipe()` function, call the `fdopen()` function to build a stream on one of the file descriptors returned by `pipe()`. If you want to stream I/O on a FIFO file, open the file with `fdopen()` together with one of `fopen()`, `freopen()`, or `open()`. When the stream is built, you can then use Standard C I/O functions, such as `fgets()` or `printf()`, to carry out input and output.

Using Unnamed Pipes

If your z/OS UNIX C/C++ application program forks processes that need to communicate among themselves for work to be done, you can take advantage of POSIX.1-defined unnamed pipes. If your application program’s processes need to communicate with other processes that it did not fork, you should use the POSIX.1-defined named pipe (FIFO special file) support. See “Using Named Pipes” on page 152 for more information.

When you code the `pipe()` function to create a pipe, you pass a pointer to a two-element integer array where `pipe()` puts the file descriptors it creates. One descriptor is for the input end of the pipe, and the other is for the output end of the pipe. You can code your application so that one process writes data to the input end of the pipe and another process reads from the output end on a first-in-first-out basis. You can also build a stream on the pipe by using `fdopen()`, and use buffered I/O functions. The result is that you can communicate data between a parent process and any of its child processes.

The opened pipe is assigned the two lowest-numbered file descriptors available.
z/OS UNIX provide no security checks for unnamed pipes, because such a pipe is accessible only by the parent process that creates the pipe and any of the parent process’s descendant processes. When the parent process ends, an unnamed pipe created by the process can still be used, if needed, by any existing descendant process that has an open file descriptor for the pipe.

Consider the following example, where you open a pipe, do a write operation, and later do a read operation from the pipe.

**CCNGHF1**

/* this example shows how unnamed pipes may be used */

```c
#include <unistd.h>
#include <stdio.h>
#include <errno.h>

int main() {
  int ret_val;
  int pfd[2];
  char buff[32];
  char string1[]="String for pipe I/O";

  ret_val = pipe(pfd);    /* Create pipe */
  if (ret_val != 0) {    /* Test for success */
    printf("Unable to create a pipe; errno=%d\n",errno);
    exit(1);    /* Print error message and exit */
  }

  if (fork() == 0) {    /* child program */
    close(pfd[0]);    /* close the read end */
    ret_val = write(pfd[1],string1,strlen(string1)); /*Write to pipe*/
    if (ret_val != strlen(string1)) {
      printf("Write did not return expected value\n");
      exit(2);    /* Print error message and exit */
    }
  }
  else {    /* parent program */
    close(pfd[1]);    /* close the write end of pipe */
    ret_val = read(pfd[0],buff,strlen(string1)); /* Read from pipe */
    if (ret_val != strlen(string1)) {
      printf("Read did not return expected value\n");
      exit(3);    /* Print error message and exit */
    }
    printf("parent read %s from the child program\n",buff);
  }
  exit(0);
}
```

*Figure 16. Unnamed Pipes Example*

For more information on the `pipe()` function and the file I/O functions, see [z/OS C/C++ Run-Time Library Reference](#).

**Using Named Pipes**

If the z/OS UNIX C/C++ application program you are developing requires its active processes to communicate with other processes that are active but may not be from the same program, code your application program to create a named pipe (FIFO file). Named pipes allow transfer of data between processes in a FIFO manner and
synchronization of process execution. Use of a named pipe allows processes to communicate even though they do not know what processes are on the other end of the pipe. Named pipes differ from standard unnamed pipes, created using the pipe() function, in that they involve the creation of a real file that is available for I/O operations to properly authorized processes.

Within the application program, you create a named pipe by coding a mkfifo() or mknod() function. You give the FIFO a name and an access mode when you create it. If the access mode allows all users read and write access to the named pipe, any process that knows its name can use it to send or receive data.

Processes can use the open() function to access named pipes and then use the regular I/O functions for files, such as read(), write(), and close(), when manipulating named pipes. Buffered I/O functions can also be used to access and manipulate named pipes. For more information on the mkfifo() and mknod() functions and the file I/O functions, see z/OS C/C++ Run-Time Library Reference.

z/OS UNIX does security checks on named pipes.

The following steps outline how to use a named pipe from z/OS UNIX C/C++ application programs:
1. Create a named pipe using the mkfifo() function. Only one of the processes that use the named pipe needs to do this.
2. Access the named pipe using the appropriate I/O method.
3. Communicate through the pipe with another process using file I/O functions:
   a. Write data to the named pipe.
   b. Read data from the named pipe.
4. Close the named pipe.
5. If the process created the named pipe and the named pipe is no longer needed, remove that named pipe using the unlink() function.

A process running the following simple example program creates a new named pipe with the file pathname pointed to by the path value coded in the mkfifo() function. The access mode of the new named pipe is initialized from the mode value coded in the mkfifo() function. The file permission bits of the mode argument are modified by the process file creation mask.

As an example, a process running the following program code creates a child process and then creates a named pipe called fifo.test. The child process then writes a data string to the pipe file. The parent process reads from the pipe file and verifies that the data string it reads is the expected one.

Note: The two processes are related and have agreed to communicate through the named pipe. They need not be related, however. Other authorized users can run the same program and participate in (or interfere with) the process communication.
/* this example shows how named pipes may be used */
#define _OPEN_SYS
#include <stdio.h>
#include <unistd.h>
#include <errno.h>
#include <fcntl.h>
#include <wait.h>

/* Sample use of mkfifo() */

main()
{
    /* start of program */

    int flags, ret_value, c_status;
    pid_t pid;
    size_t n_elements;
    char char_ptr[32];
    char str[] = "string for fifo ";
    char fifoname[] = "temp.fifo";
    FILE *rd_stream,*wr_stream;

    if ((mkfifo(fifoname,S_IRWXU)) != 0) {
        printf("Unable to create a fifo; errno=%d\n",errno);
        exit(1); /* Print error message and return */
    }

    if ((pid = fork()) < 0) {
        perror("fork failed");
        exit(2);
    }

    if (pid == (pid_t)0) /* CHILD process */
    {
        /* issue fopen for write end of the fifo */
        rd_stream = fopen(fifoname,"w");
        if (rd_stream == (FILE *) NULL) {
            printf("In child process
Read from a NULL expected valid stream\n");
            exit(100);
        }

        /* perform a write */
        n_elements = fwrite(str,strlen(str),wr_stream);
        if (n_elements != (size_t) strlen(str)) {
            printf("fwrite returned %d, expected %d\n",
                    (int)n_elements,strlen(str));
            exit(101);
        }
        exit(0); /* return success to parent */
    }

    exit(0);
}

Figure 17. Named Pipes Example (Part 1 of 3)
```c
else { /* PARENT process */

    /* issue fopen for read */
    rd_stream = fopen(fifoname,"r");
    if (rd_stream == (FILE *) NULL) {
        printf("In parent process\n");
        printf("fopen returned a NULL, expected valid pointer\n");
        exit(2);
    }

    /* get current flag settings of file */
    if ((flags = fcntl(fileno(rd_stream),F_GETFL)) == -1) {
        printf("fcntl returned -1 for %s",fifoname);
        exit(3);
    }

    /* clear O_NONBLOCK and reset file flags */
    flags &= (O_NONBLOCK);
    if ((fcntl(fileno(rd_stream),F_SETFL,flags)) == -1) {
        printf("fcntl returned -1 for %s",fifoname);
        exit(4);
    }

    /* try to read the string */
    ret_value = fread(char_ptr,sizeof(char),strlen(str),rd_stream);
    if (ret_value != strlen(str)) {
        printf("Fread did not read %d elements as expected ",
                strlen(str));
        printf("ret_value is %d ",ret_value);
        exit(6);
    }

    if (strncmp(char_ptr,str,strlen(str))) {
        printf("contents of char_ptr are %s ",
                char_ptr);
        printf("contents of str are %s ",
                str);
        printf("These should be equal");
        exit(7);
    }

    ret_value = fclose(rd_stream);
    if (ret_value != 0) {
        printf("Fclose failed for %s",fifoname);
        printf("errno is %d",errno);
        exit(8);
    }

Figure 17. Named Pipes Example (Part 2 of 3)
```
Character Special File I/O

A named pipe (FIFO file) is a type of character special file. Therefore, it obeys the I/O rules for character special files rather than the rules for regular files:

- It cannot be opened in read/write mode. A process must open a named pipe in either write-only or read-only mode.
- It must be opened in read mode by a process before it can be opened in write mode by another process. Otherwise, the file is blocked from use for I/O by processes. Blocked processes can cause an application program to hang.

A single process intending to access a named pipe can use an open() function with O_NONBLOCK to open the read end of the named pipe. It can then open the named pipe in write mode.

Note: The fopen() function cannot be used to accomplish this.

Low-Level z/OS UNIX I/O

Low-level z/OS UNIX I/O is the POSIX.1-defined I/O method. All input and output is processed using the defined read(), readv(), write(), and writev() functions.

For application programmers used to a UNIX environment, z/OS UNIX behaves in familiar and predictable ways. Standard UNIX programming practices for shared resources, along with designing applications to respect locks put on files by multiple threads running in a process, will ensure that data is handled predictably.


Example of HFS I/O Functions

The following example demonstrates the use of z/OS UNIX stream input/output by writing streams to a file, reading the input lines, and replacing a line.
/* this example uses HFS stream I/O */

#define _OPEN_SYS
#include <stdlib.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>
#include <fcntl.h>
#include <sys/types.h>
#undef _OPEN_SYS
FILE *stream;

char string1[] = "A line of text."; /* NOTE: There are actually 16 */
char string2[] = "Find this line."; /* characters in each line of */
char string3[] = "Another stream."; /* text. The 16th is a null */
char string4[16]; /* terminator on each string. */
long position, strpos; /* Since the null character */
int i, result, fd; /* is not being written to */
int rc; /* the file, 15 is used as */
/* the data stream length. */

ssize_t x;
char buffer[16];

int main(void)
{

/* Write continuous streams to file */

if ((stream = fopen("./myfile.data","wb"))==NULL) {
    perror("Error opening file");
    exit(0);
}

for(i=0; i<12; i++) {
    int len1 = strlen(string1);
    rc = fwrite(string1, 1, len1, stream);
    if (rc != len1) {
        perror("fwrite failed");
        printf("\ti = %d\n", i);
        exit(99);
    }
}

Figure 18. Example of HFS Stream Input and Output Functions (Part 1 of 3)
```c
rc = fwrite(string2, 1, sizeof(string2)-1, stream);
if (rc != sizeof(string2)-1) {
    perror("fwrite failed");
    exit(99);
}
for (i=0; i<12; i++) {
    rc = fwrite(string1, 1, sizeof(string1)-1, stream);
    if (rc != sizeof(string1)-1) {
        perror("fwrite failed");
        printf("i = %d\n", i);
        exit(99);
    }
}
fclose(stream);
/* Read data stream and search for location of string2. */
/* EOF is not set until an attempt is made to read past the */
/* end-of-file, thus the fread is at the end of the while loop */
stream = fopen("./myfile.data", "rb");
if ((position = ftell(stream)) == -1L)
    perror("Error saving file position.");
rc = fread(string4, 1, sizeof(string2)-1, stream);
while (!feof(stream)) {
    if (rc != sizeof(string2)-1) {
        perror("fread failed");
        exit(99);
    }
    if (strstr(string4, string2) != NULL) /* If string2 is found */
        strpos = position; /* then save position. */
    if ((position = ftell(stream)) == -1L)
        perror("Error saving file position.");
    rc = fread(string4, 1, sizeof(string2)-1, stream);
}
```

Figure 18. Example of HFS Stream Input and Output Functions (Part 2 of 3)
To use 64 bit offset and file sizes, you must make the following changes in your code:

1. Change any variables used for offsets in fseek() or ftell() that are int or long to the off_t data type.
2. Define the _LARGE_FILES 1 feature test macro.
3. Replace fseek() / ftell() with fseeko() / ftello(). See z/OS C/C++ Run-Time Library Reference for descriptions of these functions.
4. Compile with the LANGLVL(LIBEXT) compiler option.

**Note:** These changes are compatible with your older files.

The following example provides the same function as CCNGHF3, but it uses 64 bit offsets. The changed lines are marked in a **bold** font.
/* this example uses HFS stream I/O and 64 bit offsets*/

#define _OPEN_SYS
#define _LARGE_FILES 1
#include <stdlib.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>
#include <fcntl.h>
#include <sys/types.h>
#undef _OPEN_SYS
FILE *stream;

char string1[] = "A line of text."; /* NOTE: There are actually 16 */
char string2[] = "Find this line."; /* characters in each line of */
char string3[] = "Another stream."; /* text. The 16th is a null */
char string4[16]; /* terminator on each string. */
off_t position, strpos;
/* Since the null character */
int i, result, fd; /* is not being written to */
int rc; /* the file, 15 is used as */
/* the data stream length. */
ssize_t x;
char buffer[16];

int main(void)
{

    /* Write continuous streams to file */

    if ((stream = fopen("./myfile.data","wb")) == NULL) {
        perror("Error opening file");
        exit(0);
    }

    for(i=0; i<12;i++) {
        int len1 = strlen(string1);
        rc = fwrite(string1, 1, len1, stream);
        if (rc != len1) {
            perror("fwrite failed");
            printf("i = %d\n", i);
            exit(99);
        }
    }

Figure 19. Example of HFS Stream Input and Output Functions (Part 1 of 3)
Figure 19. Example of HFS Stream Input and Output Functions (Part 2 of 3)
The format of the fldata() function is as follows:

```c
int fldata(FILE *file, char *filename, fldata_t *info);
```

The fldata() function is used to retrieve information about an open stream. The name of the file is returned in `filename` and other information is returned in the `fldata_t` structure, shown in the figure below. Values specific to this category of I/O are shown in the comment beside the structure element. Additional notes pertaining to this category of I/O follow the figure.

For more information on the fldata() function, refer to [z/OS C/C++ Run-Time Library Reference](http://www.ibm.com/support/docdisplay?rs=120&lid=546&xmlid=cts07012&sc_lang=en).
struct __fileData {
    unsigned int __recfmF : 1, /* always off */
    __recfmV : 1, /* always off */
    __recfmU : 1, /* always on */
    __recfmS : 1, /* always off */
    __recfmBlk : 1, /* always off */
    __recfmA : 1, /* always off */
    __recfM : 1, /* always off */
    __dsorgPO : 1, /* N/A -- always off */
    __dsorgPDsmem : 1, /* N/A -- always off */
    __dsorgPDsd : 1, /* N/A -- always off */
    __dsorgPS : 1, /* N/A -- always off */
    __dsorgConcat : 1, /* N/A -- always off */
    __dsorgMem : 1, /* N/A -- always off */
    __dsorgHiper : 1, /* N/A -- always off */
    __dsorgTemp : 1, /* N/A -- always off */
    __dsorgVSAM : 1, /* N/A -- always off */
    __dsorgHFS : 1, /* always on */
    __openmode : 2, /* one of: */
        /* __BINARY */
        /* __RECORD */
    __modeflag : 4, /* combination of: */
        /* __READ */
        /* __WRITE */
        /* __APPEND */
        /* __UPDATE */
    __dsorgPDSE : 1, /* N/A -- always off */
    __reserve2 : 8; /* */
    __device_t __device; /* __HFS */
    unsigned long __blksize, /* 0 */
    __maxreclen; /* */
    unsigned short __vsamtype; /* N/A */
    unsigned long __vsamkeylen; /* N/A */
    unsigned long __vsamRKP; /* N/A */
    char * __dsname; /* */
    unsigned int __reserve4; /* */
};
typedef struct __fileData fldata_t;

Figure 20. fldata() Structure

Notes:
1. The filename is the same as specified on the fopen() or freopen() function call.
2. The __maxreclen value is 0 for regular I/O (binary). For record I/O the value is lrec1 or the default of 1024 when lrec1 is not specified.
3. The __dsname value is the real POSIX pathname.

File Tagging and Conversion

In general, the file system knows the contents of a file only as a set of bytes. Applications which create and process bytes in a file know whether these bytes represent binary data, text (character) data, or a mixture of both. File tags are file metadata fields which describe the contents of a file. Enhanced ASCII includes the following file tag fields:

txtflag  A flag indicating whether or not a file consists solely of character data encoded by a single coded character set ID (CCSID).

file ccsid
A 16 bit field specifying the CCSID of characters in the file.
Applications can explicitly tag files via new open() or fcntl() options, or applications can allow the logical file system (LFS) to tag new files on first write, fopen(). A new environment variable, _BPXK_CCSID, is used to assign a program CCSID to an application, which LFS will use to tag new files on first write. LFS also uses the program CCSID derived from _BPXK_CCSID to set up auto-conversion of pure text datastreams. LFS attempts to set up auto-conversion when:

- Auto-conversion is enabled for an application by the _BPXK_AUTOCVT environment variable
- The file txtflag flag is set indicating a pure text file
- The file and program CCSIDs do not match.

Automatic file conversion and file tagging include the following facilities:
- _OPEN_SYS_FILE_EXT feature test macro. For more information, see z/OS C/C++ Run-Time Library Reference.
- _BPXK_AUTOCVT and _BPXK_CCSIDS environment variables. For more information, see Chapter 33, “Using Environment Variables” on page 479.
- z/OS Language Environment FILETAG run-time option. For more information, see z/OS Language Environment Programming Reference.
- __chattr() and __fchattr() functions; F_SETTAG and F_CONTROL_CVT arguments for the fcntl() function; options for the fopen(), popen(), stat(), fstat(), and lstat() functions. For more information, see z/OS C/C++ Run-Time Library Reference.

---

**Access Control Lists (ACLs)**

Access control lists (ACLs) enable you to control access to files and directories by individual user (UID) and group (GID). ACLs are used in conjunction with permission bits. You can create, modify, and delete ACLs using the following functions:

- acl_create_entry()
- acl_delete_entry()
- acl_delete_fd()
- acl_delete_file()
- acl_first_entry()
- acl_free()
- acl_from_text()
- acl_get_entry()
- acl_get_fd()
- acl_get_file()
- acl_init()
- acl_set_fd()
- acl_set_file()
- acl_sort()
- acl_to_text()
- acl_update_entry()
- acl_valid()
For descriptions of these functions see z/OS C/C++ Run-Time Library Reference.
For more information on using ACLs to protect file system resources see z/OS UNIX System Services Planning and z/OS Security Server RACF Security Administrator’s Guide.
Chapter 13. Performing VSAM I/O Operations

This chapter outlines the use of Virtual Storage Access Method (VSAM) data sets in z/OS C/C++. Three I/O processing modes for VSAM data sets are available in z/OS C/C++:

- Record
- Text Stream
- Binary Stream

Because VSAM is a record-based access method, record mode is the logical processing mode and is specified by coding the `type=record` keyword parameter on the ` fopen()` function call. z/OS C/C++ also provides limited support for VSAM text streams and binary streams. Because of the record-based nature of VSAM, this chapter is organized differently from the other chapters in this section. The focus of this chapter is on record I/O, and only those aspects of text and binary I/O that are specific to VSAM are also discussed.

For more information about the facilities of VSAM, see the list of "DFSMS" on page 927.

See Chapter 9, “z/OS C Support for the Double-Byte Character Set” on page 79 for information about using wide-character I/O with z/OS C/C++.

Notes:
1. This chapter describes C I/O as it can be used within C++ programs.
2. The C++ I/O stream libraries cannot be used for VSAM I/O because these do not support the record processing mode (where `type=record` is specified).

VSAM Types (Data Set Organization)

There are three types of VSAM data sets supported by z/OS C/C++, all of which are held on direct-access storage devices.

- Key-Sequenced Data Set (KSDS) is used when a record is accessed through a key field within the record (for example, an employee directory file where the employee number can be used to access the record). KSDS also supports sequential access. Each record in a KSDS must have a unique key value.
- Entry-Sequenced Data Set (ESDS) is used for data that is primarily accessed in the order it was created (or the reverse order). It supports direct access by Relative Byte Address (RBA), and sequential access.
- Relative Record Data Set (RRDS) is used for data in which each item has a particular number, and the relevant record is accessed by that number (for example, a telephone system with a record associated with each number). It supports direct access by Relative Record Number (RRN), and sequential access.

In addition to the primary VSAM access described above, for KSDS and ESDS, there is also direct access by one or more additional key fields within each record. These additional keys can be unique or nonunique; they are called an alternate index (AIX).

Note: VSAM Linear Data Sets are not supported in z/OS C/C++ I/O.
Access Method Services

Access Method Services are generally known by the name IDCAMS on MVS. For more information, see z/OS DFSMS Access Method Services for Catalogs.

Before a VSAM data set is used for the first time, its structure is defined to the system by the Access Method Services DEFINE CLUSTER command. This command defines the type of VSAM data set, its structure, and the space it requires.

Before a VSAM alternate index is used for the first time, its structure is defined to the system by the Access Method Services DEFINE ALTERNATEINDEX command. To enable access to the base cluster records through the alternate index, use the DEFINE PATH command. Finally, to build the alternate index, use the BLDINDEX command.

When you have built the alternate index, you call fopen() and specify the PATH in order to access the base cluster through the alternate index. Do not use fopen() to access the alternate index itself.

Note: You cannot use the BLDINDEX command on an empty base cluster.

Choosing VSAM Data Set Types

When you plan your program, you must first decide the type of data set to use. Figure 21 on page 169 shows you the possibilities available with the types of VSAM data sets.
When choosing the VSAM data set type, you should base your choice on the most common sequence in which you require data. You should follow a procedure similar to the one suggested below to help ensure a combination of data sets and indexes that provide the function you require.

The diagrams show how the information contained in the family tree below could be held in VSAM data sets of different types.

**ANDREW SMITH & VALERIE SUZIE ANN MORGAN (1967)**

|-------------|-------------|-------------|-------------|

**Key-Sequenced Data Set**

- **Prime Index**
  - ANDY
  - FRED
  - JANE
  - SUZAN

- **Data component**
  - ANDY: 70 M
  - FRED: 69 M
  - JANE: 75 F
  - SUZAN: 72 F

- **Alternate Indexes**
  - By Birthdate (unique)
    - 69
    - 70
    - 72
    - 75
  - By sex (non-unique)
    - F
    - M

**Entry-Sequenced Data Set**

- **Relative byte addresses**
- **Data component**
  - FRED: 69 M
  - ANDY: 70 M
  - SUZAN: 72 F
  - JANE: 75 F

- **Alternate Indexes**
  - Alphabetically by name (unique)
    - ANDY
    - FRED
    - JANE
    - SUZAN
  - By sex (non-unique)
    - F
    - M

**Relative Record Data Set**

- **Relative record numbers**
- **Data component**
  - Slot 1: FRED: 69 M
  - Slot 2: ANDY: 70 M
  - Slot 3: empty space for 71
  - Slot 4: SUZAN: 72 F
  - Slot 5: empty space for 73
  - Slot 6: empty space for 74
  - Slot 7: JANE: 75 F
  - Slot 8: empty space for 76

- **No Alternate Indexes**

---

*Figure 21. Types and Advantages of VSAM Data Sets*
1. Determine the type of data and its primary access.
   - sequentially — favors ESDS
   - by key — favors KSDS
   - by number — favors RRDS

2. Determine whether you require access through an alternate index path. These are only supported on KSDS and ESDS. If you do, determine whether the alternate index is to have unique or nonunique keys. You should keep in mind that making an assumption that all future records will have unique keys may not be practical, and an attempt to insert a record with a nonunique key in an index that has been created for unique keys causes an error.

3. When you have determined the data sets and paths that you require, ensure that the operations you have in mind are supported.

**Keys, RBAs and RRNs**

All VSAM data sets have keys associated with their records. For KSDS, KSDS AIX, and ESDS AIX, the key is a defined field within the logical record. For ESDS, the key is the relative byte address (RBA) of the record. For RRDS, the key is a relative record number (RRN).

**Keys for Indexed VSAM Data Sets**
For KSDS, KSDS AIX, and ESDS AIX, keys are part of the logical records recorded on the data set. For KSDS, the length and location of the keys are defined by the DEFINE CLUSTER command of Access Method Services. For KSDS AIX and ESDS AIX, the keys are defined by the DEFINE ALTERNATEINDEX command.

**Relative Byte Addresses**
Relative byte addresses enable you to access ESDS files directly. The RBAs are unsigned long int fields, and their values are computed by VSAM.

**Notes:**

1. KSDS can also use RBAs. However, because the RBA of a KSDS record can change if an insert, delete or update operation is performed elsewhere in the file, it is not recommended.

2. You can call flocate() with RBA values in an RRDS cluster, but flocate() with RBA values does not work across control intervals. Therefore, using RBAs with RRDS clusters is not recommended. The RRDS access method does not support RBAs. z/OS C/C++ supports the use of RBAs in an RRDS cluster by translating the RBA value to an RRN. It does this by dividing the RBA value by the LRECL.

3. Alternate indexes do not allow positioning by RBA.

The RBA value is stored in the C structure __amrc, which is defined in the C <stdio.h> header file. You can access the field __amrc->__RBA as shown in the following example.
CCNGVS1

/* this example shows how to access the __amrc->__RBA field */
/* it assumes that an ESDS has already been defined, and has been */
/* assigned the ddname ESOSCLUS */

#include <stdio.h>
#include <stdlib.h>

main() {
    FILE *ESDSfile;
    unsigned long myRBA;
    char recbuff[100]="This is record one."
    int w_retcd;
    int l_retcd;
    int r_retcd;

    printf("calling fopen("dd:esdsclus","rb+,type=record");\n");
    ESDSfile = fopen("dd:esdsclus", "rb+,type=record");
    printf("=fopen() returned 0X%.8x",ESDSfile);
    if (ESDSfile==NULL) exit;

    w_retcd = fwrite(recbuff, 1, sizeof(recbuff), ESDSfile);
    printf("fwrite() returned %d",w_retcd);
    if (w_retcd != sizeof(recbuff)) exit;
    myRBA = __amrc->__RBA;

    l_retcd = flocate(ESDSfile, &myRBA, sizeof(myRBA), __RBA_EQ);
    printf("flocate() returned %d",l_retcd);
    if (l_retcd !=0) exit;

    r_retcd = fread(recbuff, 1, sizeof(recbuff), ESDSfile);
    printf("fread() returned %d",r_retcd);
    if (l_retcd !=0) exit;

    return(0);
}

Figure 22. VSAM Example

For more information about the __amrc structure, refer to Chapter 18, “Debugging I/O Programs” on page 233

Relative Record Numbers
Records in an RRDS are identified by a relative record number that starts at 1 and is incremented by 1 for each succeeding record position. Only RRDS files support accessing a record by its relative record number.

Summary of VSAM I/O Operations
Table 23 summarizes VSAM data set characteristics and the allowable I/O operations on them.

Table 23. Summary of VSAM Data Set Characteristics and Allowable I/O Operations

<table>
<thead>
<tr>
<th></th>
<th>KSDS</th>
<th>ESDS</th>
<th>RRDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record Length</td>
<td>Variable. Length can be changed by update.</td>
<td>Variable. Length cannot be changed by update.</td>
<td>Fixed.</td>
</tr>
<tr>
<td>Alternate index</td>
<td>Allows access using unique or nonunique keys.</td>
<td>Allows access using unique or nonunique keys.</td>
<td>Not supported by VSAM.</td>
</tr>
</tbody>
</table>
### Table 23. Summary of VSAM Data Set Characteristics and Allowable I/O Operations (continued)

<table>
<thead>
<tr>
<th></th>
<th>KSDS</th>
<th>ESDS</th>
<th>RRDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Record Read</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sequential)</td>
<td>The order is determined by the VSAM key.</td>
<td>By entry sequence. Reads proceed in key sequence for the key of reference.</td>
<td>By relative record number.</td>
</tr>
<tr>
<td><strong>Record Write</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Direct)</td>
<td>Position determined by the value in the field designated as the key.</td>
<td>Record written at the end of the file.</td>
<td>By relative record number.</td>
</tr>
<tr>
<td><strong>Positioning for</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Record Read</td>
<td>By key or by RBA value. Positioning by RBA value is not recommended because changes to the file change the RBA.</td>
<td>By RBA value. Alternate index allows use by key.</td>
<td>By relative record number.</td>
</tr>
<tr>
<td><strong>Delete</strong></td>
<td>If not already in correct position, reposition the file; read the record using fwrite(); delete the record using fdelrec(). fread() must immediately precede fdelrec().</td>
<td>Not supported by VSAM.</td>
<td>If not already in correct position, position the file; read the record using fwrite(); delete the record using fdelrec(). fread() must immediately precede fdelrec().</td>
</tr>
<tr>
<td><strong>Update</strong></td>
<td>If not already in correct position, reposition the file; read the record using fwrite(); update the record using fupdate(). fread() must immediately precede fupdate().</td>
<td>If not already in correct position, reposition the file; read the record using fwrite(); update the record using fupdate(). fread() must immediately precede fupdate().</td>
<td>If not already in correct position, reposition the file; read the record using fwrite(); update the record using fupdate(). fread() must immediately precede fupdate().</td>
</tr>
<tr>
<td><strong>Empty the file</strong></td>
<td>Define the file as reusable using DEFINE CLUSTER definition, and then open the data set in write (&quot;wb,type=record&quot; or &quot;wb+,type=record&quot;) mode. Not supported for alternate indexes.</td>
<td>Define the file as reusable using DEFINE CLUSTER definition, and then open the data set in write (&quot;wb,type=record&quot; or &quot;wb+,type=record&quot;) mode. Not supported for alternate indexes.</td>
<td>Define the file as reusable using DEFINE CLUSTER definition, and then open the data set in write (&quot;wb,type=record&quot; or &quot;wb+,type=record&quot;) mode.</td>
</tr>
<tr>
<td><strong>Stream Read</strong></td>
<td>Supported by z/OS C/C++.</td>
<td>Supported by z/OS C/C++.</td>
<td>Supported by z/OS C/C++.</td>
</tr>
<tr>
<td><strong>Stream Write/Update</strong></td>
<td>Not supported by z/OS C/C++.</td>
<td>Supported by z/OS C/C++.</td>
<td>Supported by z/OS C/C++.</td>
</tr>
<tr>
<td><strong>Stream Repositioning</strong></td>
<td>Supported by z/OS C/C++.</td>
<td>Supported by z/OS C/C++.</td>
<td>Supported by z/OS C/C++.</td>
</tr>
</tbody>
</table>
Opening VSAM Data Sets

To open a VSAM data set, use the Standard C library functions fopen() and freopen() just as you would for opening non-VSAM data sets. The fopen() and freopen() functions are described in z/OS C/C++ Run-Time Library Reference.

This section describes considerations for using fopen() and freopen() with VSAM files. Remember that a VSAM file must exist and be defined as a VSAM cluster before you call fopen().

Using fopen() or freopen()

This section covers using file names for MVS data sets, specifying fopen() and freopen() keywords, and buffering.

File Names for MVS Data Sets: Using a Data Set Name
The following diagram shows the syntax for the filename argument on your fopen() or freopen() call:

```
// qualifier
```

The following is a sample construct:

```
'qualifier1.qualifier2'
```

Single quotation marks indicate that you are passing a fully-qualified data set name, that is, one which includes the high-level qualifier. If you pass a data set name without single quotation marks, the z/OS C/C++ compiler prefixes the high-level qualifier (usually the user ID) to the name. See Chapter 11, "Performing OS I/O Operations" on page 107 for information on fully qualified data set names.

// Specifying these slashes indicates that the file names refer to MVS data sets.

```
qualifier
```

Each qualifier is a 1- to 8-character name. These characters may be alphanumeric, national ($, #, @), the hyphen, or the character \xC0. The first character should be either alphabetic or national. Do not use hyphens in names for RACF-protected data sets.

You can join qualifiers with periods. The maximum length of a data set name is generally 44 characters, including periods.

To open a data set by its name, you can code something like the following in your C or C++ program:

```
infile=fopen("VSAM.CLUSTER1", "ab+, type=record");
```

File Names for MVS Data Sets: Using a DDname
To access a cluster or path by ddname, you can write the required DD statement and call fopen() as shown in the following example.

If your data set is VSAM.CLUSTER1, your C or C++ program refers to this data set by the ddname CFILE, and you want exclusive control of the data set for update, you can write the DD statement:

```
//CFILE DD DSNAME=VSAM.CLUSTER1,DISP=OLD
```
and code the following in your C or C++ source program:

```c
#include <stdio.h>

FILE *infile;
main()
{
    infile=fopen("DD:CFILE", "ab+, type=record");
    ...
}
```

To share your data set, use DISP=SHR on the DD statement. DISP=SHR is the default for fopen() calls that use a data set name and specify any of the r, rb, rb+, and r+b open modes.

**Note:** z/OS C/C++ does not check the value of shareoptions at fopen() time, and does not provide support for read-integrity and write-integrity, as required to share files under shareoptions 3 and 4.

For more information on shareoptions, see the information on DEFINE CLUSTER in the books listed in "DFSMS" on page 927.

**Specifying fopen() and freopen() Keywords**

The mode argument is a character string specifying the type of access requested for the file.

The mode argument contains one positional parameter (access mode) followed by keyword parameters. A description of these parameters, along with an explanation of how they apply to VSAM data sets is given in the following sections.

**Specifying Access Mode:** The access mode is specified by the positional parameter of the fopen() function call. The possible record I/O and binary modes you can specify are:

- **rb** Open for reading. If the file is empty, fopen() fails.
- **wb** Open for writing. If the cluster is defined as reusable, the existing contents of the cluster are destroyed. If the cluster is defined as not reusable (clusters with paths are, by definition, not reusable), fopen() fails. However, if the cluster has been defined but not loaded, this mode can be used to do the initial load of both reusable and non reusable clusters.
- **ab** Open for writing.
- **rb+ or r+b** Open for reading, writing, and/or updating.
- **wb+ or w+b** Open for reading, writing, and/or updating. If the cluster is defined as reusable, the existing contents of the cluster are destroyed. If the cluster is defined as not reusable (clusters with paths are, by definition, not reusable), fopen() fails. However, if the cluster has been defined but not loaded, this mode can be used to do the initial load of both reusable and non reusable clusters.
- **ab+ or a+b** Open for reading, writing, and/or updating.

For text files, you can specify the following modes: r, w, a, r+, w+, and a+.

**Note:** For KSDS, KSDS AIX and ESDS AIX in text and binary I/O, the only valid modes are r and rb, respectively.
**fopen() and freopen() Keywords**

The following table lists the keywords that are available on the `fopen()` and `freopen()` functions, tells you which ones are useful for VSAM I/O, and lists the values that are valid for the applicable ones.

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Allowed?</th>
<th>Applicable?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>recfm=</td>
<td>Yes</td>
<td>No</td>
<td>Ignored.</td>
</tr>
<tr>
<td>lrecl=</td>
<td>Yes</td>
<td>No</td>
<td>Ignored.</td>
</tr>
<tr>
<td>blksize=</td>
<td>Yes</td>
<td>No</td>
<td>Ignored.</td>
</tr>
<tr>
<td>space=</td>
<td>Yes</td>
<td>No</td>
<td>Ignored.</td>
</tr>
<tr>
<td>type=</td>
<td>Yes</td>
<td>Yes</td>
<td>May be omitted. If you do specify it, <code>type=record</code> is the only valid value.</td>
</tr>
<tr>
<td>acc=</td>
<td>Yes</td>
<td>Yes</td>
<td>Specifies the access direction for VSAM data sets. Valid values are <code>BWD</code> and <code>FWD</code>.</td>
</tr>
<tr>
<td>password=</td>
<td>Yes</td>
<td>Yes</td>
<td>Specifies the password for a VSAM data set.</td>
</tr>
<tr>
<td>asis</td>
<td>Yes</td>
<td>No</td>
<td>Enables the use of mixed-case file names. Not supported for VSAM.</td>
</tr>
<tr>
<td>bytesseek</td>
<td>Yes</td>
<td>Yes</td>
<td>Used for binary stream files to specify that the seeking functions should use relative byte offsets instead of encoded offsets. This is the default setting.</td>
</tr>
<tr>
<td>noseek</td>
<td>Yes</td>
<td>No</td>
<td>Ignored.</td>
</tr>
<tr>
<td>OS</td>
<td>Yes</td>
<td>No</td>
<td>Ignored.</td>
</tr>
<tr>
<td>rls=</td>
<td>Yes</td>
<td>Yes</td>
<td>Indicates the VSAM RLS access mode in which a VSAM file is to be opened.</td>
</tr>
</tbody>
</table>

**Keyword Descriptions**

**recfm=**

Any values passed into `fopen()` are ignored.

**lrecl= and blksize=**

These keywords are set to the maximum record size of the cluster as initialized in the cluster definition. Any values passed into `fopen()` are ignored.

**space=**

This keyword is not supported under VSAM.

**type=**

If you use the `type=` keyword, the only valid value for VSAM data sets is `type=record`. This opens a file for record I/O.

**acc=**

For VSAM files opened with the keyword `type=record`, you can specify the direction by using the `acc=access_type` keyword on the `fopen()` function call. For text and binary files, the access direction is always forward. Attempts to open a VSAM data set with `acc=BWD` for either binary or text stream I/O will fail.

The `access_type` can be one of the following:

- **FWD** The `acc=FWD` keyword specifies that the file be processed in a forward direction. When the file is opened, it will be positioned at the beginning of the first physical record, and any subsequent read operations sets the file position indicator to the beginning of the next record.
The default value for the access keyword is acc=FWD.

BWD The acc=BWD keyword specifies that the file be processed in a backward direction. When the file is opened, it is positioned at the beginning of the last physical record and any subsequent read operation sets the file position indicator to the beginning of the preceding record.

You can change the direction of sequential processing (from forward to backward or from backward to forward) by using the flocate() library function. For more information about flocate(), see "Repositioning within Record I/O Files" on page 181.

Note: When opening paths, records with duplicate alternate index keys are processed in order of arrival time (oldest to newest) regardless of the current processing direction.

password=
VSAM facilities provide password protection for your data sets. You access a data set that has password protection by specifying the password on the password keyword parameter of the fopen() function call; the password resides in the VSAM catalog entry for the named file. There can be more than one password in the VSAM catalog entry; data sets can have different passwords for different levels of authorization such as reading, writing, updating, inserting, or deleting. For a complete description of password protection on VSAM files, see the list of publications given on "DFSMS" on page 927.

The password keyword has the form:

    password=nx

where x is a 1- to 8-character password, and n is the exact number of characters in the password. The password can contain special characters such as blanks and commas.

If a required password is not supplied, or if an incorrect password is given, fopen() fails.

asis
This keyword is not supported for VSAM.

byteseek
When you specify this keyword and open a file in binary stream mode, fseek() and ftell() use relative byte offsets from the beginning of the file. This is the default setting.

noseek
This keyword is ignored for VSAM data sets.

OS
This keyword is ignored for VSAM data sets.

rls=
Indicates the VSAM RLS access mode in which a VSAM file is to be opened. This keyword is ignored for non-VSAM files. The following values are valid:

- nri — No Read Integrity
- cr — Consistent Read

Note: When the RLS keyword is specified, DISP is changed to default to SHR when dynamic allocation of the data set is performed. In the rare case when a batch job must use RLS without sharing the data set with other
tasks, DISP should be OLD. To set DISP to OLD, the application must specify DISP=OLD in the DD statement and start the application using JCL. You cannot specify DISP in the fopen() mode argument.

Buffering

Full buffering is the default. You can specify line buffering, but z/OS C/C++ treats line buffering as full buffering for VSAM data sets. Unbuffered I/O is not supported under VSAM; if you specify it, your setvbuf() call fails.

To find out how to optimize VSAM performance by controlling the number of VSAM buffers used for your data set, refer to z/OS DFSMS Access Method Services for Catalogs.

Record I/O in VSAM

This section describes how to use record I/O in VSAM. The following topics are covered:
- RRDS Record Structure
- Reading Record I/O Files
- Writing to Record I/O Files
- Updating Record I/O Files
- Deleting Records
- Repositioning within Record I/O Files
- Flushing Buffers
- Summary of VSAM Record I/O Operations
- Reading from Text and Binary I/O Files
- Writing to and Updating Text and Binary I/O Files
- Deleting Records in Text and Binary I/O Files
- Repositioning within Text and Binary I/O Files
- Flushing Buffers
- Summary of VSAM Text I/O Operations
- Summary of VSAM Binary I/O Operations

RRDS Record Structure

For RRDS files opened in record mode, z/OS C/C++ defines the following key structure in the C header file <stdio.h>:

```c
typedef struct {
    long unsigned int __fill,
    __recnum; /* the RRN, starting at 1 */
}__rrds_key_type;
```

In your source program, you can define an RRDS record structure as either:

```c
struct {
    __rrds_key_type rrds_key; /* __fill value always 0 */
    char data[MY_REC_SIZE];
} rrds_rec_0;
```

or:
struct {
    __rrds_key_type rrds_key; /* __fill value always 1 */
    char *data;
} rrds_rec_1;

The z/OS C++ library recognizes which type of record structures you have used by the value of rrds_key.__fill. Zero indicates that the data is contiguous with rrds_key and 1 indicates that a pointer to the data follows rrds_key.

**Reading Record I/O Files**

To read from a VSAM data set opened with `type=record`, use the Standard C `fread()` library function. If you set the `size` argument to 1 and the `count` argument to the maximum record size, `fread()` returns the number of bytes read successfully. For more information on `fread()`, see [z/OS C++ Run-Time Library Reference](#).

`fread()` reads one record from the system from the current file position. Thus, if you want to read a certain record, you can call `flocate()` to position the file pointer to point to it; the subsequent call to `fread()` reads in that record.

If you use an `fread()` call to request more bytes than the record about to be read contains, `fread()` reads the entire record and returns the number of bytes read. If you use `fread()` to request fewer bytes than the record about to read contains, `fread()` reads the number of bytes that you specified and returns your request.

z/OS C++ VSAM Record I/O does not allow a read operation to immediately follow a write operation without an intervening reposition. z/OS C++ treats the following as read operations:

- Calls to read functions that request 0 bytes
- Read requests that fail because of a system error
- Calls to the `ungetc()` function

Calling `fread()` several times in succession, with no other operations on this file in between, reads several records in sequence (sequential processing), which can be forward or backward, depending on the access direction, as described in the following.

- **KSDS, KSDS AIX and ESDS AIX**
  The records are retrieved according to the sequence of the key of reference, or in reverse key sequence.

  **Note:** Records with duplicate alternate index keys are processed in order of arrival time (oldest to newest) regardless of the current processing direction.

- **ESDS**
  The records are retrieved according to the sequence they were written to the file (entry sequence), or in reverse entry sequence.

- **RRDS**
  The records are retrieved according to relative record number sequence or reverse relative record number sequence.

  When records are being read, RRNs without an associated record are ignored. For example, if a file has relative records of 1, 2, and 5, the nonexistent records 3 and 4 are ignored.

  By default, in record mode, `fread()` must be called with a pointer to an RRDS record structure. The field __rrds_key_type.__fill must be set to either 0 or 1.
indicating the type of the structure, and the `count` argument must include the length of the `_rrds_key_type`. `fread()` returns the RRN number in the `_recnum` field, and includes the length of the `_rrds_key_type` in the return value. You can override these operations by setting the `_EDC_RRDS_HIDE_KEY` environment variable to `Y`. Once this variable is set, `fread()` is called with a data buffer and not an RRDS data structure. The return value of `fread()` is now only the length of the data read. In this case, `fread()` cannot return the RRN. For information on setting environment variables, see Chapter 33, "Using Environment Variables" on page 479.

**Writing to Record I/O Files**

To write new records to a VSAM data set opened with `type=record`, use the Standard C `fwrite()` library function. If you set `size` to 1 and `count` to the desired record size, `fwrite()` returns the number of bytes written successfully. For more information on `fwrite()` and the `type=record` parameter, see z/OS C/C++ Run-Time Library Reference.

In general, C I/O does not allow a write operation to follow a read operation without an intervening reposition or `fflush()`. z/OS C/C++ counts a call to a write function writing 0 bytes or a write request that fails because of a system error as a write operation. However, z/OS C/C++ VSAM record I/O allows a write to directly follow a read. This feature has been provided for compatibility with earlier releases.

The process of writing to a data set for the first time is known as initial loading. Using the `fwrite()` function, you can write to a new VSAM file in initial load mode just as you would to a file not in initial load mode. Writing to a KSDS PATH or an ESDS PATH in initial load mode is not supported.

If your `fwrite()` call does not try to write more bytes than the maximum record size, `fwrite()` writes a record of the length you asked for and returns your request. If your `fwrite()` call asks for more than the maximum record size, `fwrite()` writes the maximum record size, sets `errno`, and returns the maximum record size. In either case, the next call to `fwrite()` writes to the following record.

**Note:** If an `fwrite()` fails, you must reposition the file before you try to read or write again.

- **KSDS, KSDS AIX**
  Records are written to the cluster according to the value stored in the field designated as the prime key.
  You can load a KSDS in any key order but it is most efficient to perform the `fwrite()` operations in key sequence.

- **ESDS, ESDS AIX**
  Records are written to the end of the file.

- **RRDS**
  Records are written according to the value stored in the relative record number field.
  `fwrite()` is called with the RRDS record structure.
  By default, in record mode, `fwrite()` and `fupdate()` must be called with a pointer to an RRDS record structure. The `_rrds_key_type` fields `_fill` and `_recnum` must be set. `_fill` is set to 0 or 1 to indicate the type of the structure. The `_recnum` field specifies the RRN to write, and is required for `fwrite()` but not
fupdate(). The count argument must include the length of the __rrds_key_type.
fwrite() and fupdate() include the length of the __rrds_key_type in the return
value.

Updating Record I/O Files

The fupdate() function, a z/OS C/C++ extension to the SAA C library, is used to
update records in a VSAM file. For more information on this function, see z/OS
C/C++ Run-Time Library Reference

- KSDS, ESDS, and RRDS
To update a record in a VSAM file, you must perform the following operations:
1. Open the VSAM file in update mode (rb+/r+b, wb+/w+b, or ab+/a+b specified
   as the required positional parameter of the fopen() function call and
type=record).
2. If the file is not already positioned at the record you want to update,
   reposition to that record.
3. Read in the record using fread().
   Once the record you want to update has been read in, you must ensure that
   no reading, writing, or repositioning operations are performed before
   fupdate().
4. Make the necessary changes to the copy of the record in your buffer area.
5. Update the record from your local buffer area using the fupdate() function.
   If an fupdate() fails, you must reposition using fllocate() before trying to
   read or write.

Notes:
1. If a file is opened in update mode, a read operation can result in the locking
   of control intervals, depending on shareoptions specification of the VSAM
   file. If after reading a record, you decide not to update it, you may need to
   unlock a control interval by performing a file positioning operation to the same
   record, such as an fllocate() using the same key.
2. If fupdate() wrote out a record the file position is the start of the next record.
   If the fupdate() call did not write out a record, the file position remains the
   same.

- KSDS and KSDS PATH
You can change the length of the record being updated. If your request does not
exceed the maximum record size of the file, fupdate() writes a record of the
length requested and returns the request. If your request exceeds the maximum
record size of the file, fupdate() writes a record that is the maximum record size,
sets errno, and returns the maximum record size.
You cannot change the prime key field of the record, and in KSDS AIX, you
cannot change the key of reference of the record.

- ESDS
You cannot change the length of the record being updated. If the size of the
record being updated is less than the current record size, fupdate() updates the
amount you specify and does not alter the data remaining in the record. If your
request exceeds the length of the record that was read, fupdate() writes a
record that is the length of the record that was read, sets errno, and returns the
length of the record that was read.

- ESDS PATH
You cannot change the length of the record being updated or the key of
reference of the record. If the size of the record being updated is less than the
current record size, fupdate() updates the amount you specify and does not alter the data remaining in the record. If your request exceeds the length of the record that was read, fupdate() writes a record that is the length of the record that was read, sets errno, and returns the length of the record that was read.

- **RRDS**

  RRDS files have fixed record length. If you update the record with less than the record size, only those characters specified are updated, and the remaining data is not altered. If your request exceeds the record size of the file, fupdate() writes a record that is the record size, sets errno, and returns the length of the record that was read.

**Deleting Records**

To delete records, use the library function fdelrec(), a z/OS C/C++ extension to the SAA C library. For more information on this function, see [z/OS C/C++ Run-Time Library Reference](#).

- **KSDS, KSDS PATH, and RRDS**

  To delete records, you must perform the following operations:
  1. Open the VSAM file in update mode (rb+/r+b, ab+/a+b, or wb+/w+b specified as the required positional parameter of the fopen() function call and type=record).
  2. If the file is not already positioned at the record you want to delete, reposition to that record.
  3. Read the record using the fread() function.
     
     Once the record you want to delete has been read in, you must ensure that no reading, writing, or repositioning operations are performed before fdelrec().
  4. Delete the record using the fdelrec() function.

  **Note:** If the data set was opened with an access mode of rb+ or r+b, a read operation can result in the locking of control intervals, depending on shareoptions specification of the VSAM file. If after reading a record, you decide not to delete it, you may need to unlock a control interval by performing a file-positioning operation to the same record, such as an flocate() using the same key.

- **ESDS and ESDS PATH**

  VSAM does not support deletion of records in ESDS files.

**Repositioning within Record I/O Files**

You can use the following functions to locate a record within a VSAM data set:

- flocate()
- ftell() and fseek()
- fgetpos() and fsetpos()
- rewind()

For complete details on these library functions, see [z/OS C/C++ Run-Time Library Reference](#).

**flocate()**

The flocate() C library function can be used to locate a specific record within a VSAM data set given the key, relative byte address, or the relative record number. The flocate() function also sets the access direction.
The following `flocate()` parameters set the access direction to **forward**:

- `__KEY_FIRST` (the key and `key_len` parameters are ignored)
- `__KEY_EQ`
- `__KEY_GE`
- `__RBA_EQ`

The following `flocate()` parameters all set the access direction to **backward** and are only valid for record I/O:

- `__KEY_LAST` (the key and `key_len` parameters are ignored)
- `__KEY_EQ_BWD`
- `__RBA_EQ_BWD`

**Note:** The `__RBA_EQ` and `__RBA_EQ_BWD` parameters are not valid for paths and are not recommended for KSDS and RRDS data sets.

You can use the `rewind()` library function instead of calling `flocate()` with `__KEY_FIRST`.

- **KSDS, KSDS AIX, and ESDS AIX**
  The key parameter of `flocate()` for the options `__KEY_EQ`, `__KEY_GE`, and `__KEY_EQ_BWD` is a pointer to the key of reference of the data set. The `key_len` parameter is the key length as defined for the data set for a full key search, or less than the defined key length for a generic key search (a partial key match).
  For KSDSs, `__RBA_EQ` and `__RBA_EQ_BWD` are supported, but are not recommended. Alternate indexes do not allow positioning by RBA.

- **ESDS**
  The key parameter of `flocate()` is a pointer to an unsigned long integer containing the specified RBA value. The `key_len` parameter is 4, because RBAs are unsigned long integers.

- **RRDS**
  For `__KEY_EQ`, `__KEY_GE`, and `__KEY_EQ_BWD`, the key parameter of `flocate()` is a pointer to an unsigned long integer containing the specified relative record number. For `__RBA_EQ` and `__RBA_EQ_BWD`, the key parameter of `flocate()` is a pointer to an unsigned long integer containing the specified RBA. However, seeking to RBA values is not recommended, because it is not supported across control intervals. The `key_len` parameter is 4, because RRNs and RBAs are unsigned long integers.

`fgetpos()` and `fsetpos()`
`fgetpos()` is used to store the current file position and access direction. `fsetpos()` is used to relocate to a file position stored by `fgetpos()` and restore the saved access direction.

- **KSDS**
  `fgetpos()` stores the RBA value. This RBA value may be invalidated by subsequent insertions, deletions, or updates.

- **KSDS AIX and ESDS AIX**
  `fgetpos()` and `fsetpos()` are not supported for PATHs.

- **ESDS and RRDS**
  There are no special considerations.
ftell() and fseek()

ftell() is used to store the current file position. fseek() is used to relocate to one of the following:

- A file position stored by ftell()
- A calculated record number (SEEK_SET)
- A position relative to the current position (SEEK_CUR)
- A position relative to the end of the file (SEEK_END).

ftell() and fseek() offsets in record mode I/O are relative record offsets. For example, the following call moves the file position to the start of the previous record:

```
seek(fp, -1L, SEEK_CUR);
```

You cannot use fseek() to reposition to a file position before the beginning of the file or to a position beyond the end of the file.

**Note:** In general, the performance of this method is inferior to flocate().

The access direction is unchanged by the repositioning.

- **KSDS and RRDS**
  - There are no special considerations.

- **KSDS AIX and ESDS AIX**
  - ftell() and fseek() are not supported.

- **ESDS**
  - ftell() is not supported.

- **RRDS**
  - fseek() seeks to a relative position in the file, and not to an RRN value. For example, in a file consisting of RRNs 1, 3, 5 and 7, fseek(fp, 3L, SEEK_SET); followed by an fread() would read in RRN 7, which is at offset 3 in the file.

rewind()

The rewind() function repositions the file position to the beginning of the file, and clears the error setting for the file.

rewind() does not reset the file access direction. For example, a call to flocate() with __KEY_LAST sets the file pointer to the end of the file and sets the access direction to backwards. A subsequent call to rewind() sets the file pointer to the beginning of the file, but the access direction remains backwards.

**Flushing Buffers**

You can use the C library function fflush() to flush buffers. However, fflush() writes nothing to the system, because all records have already been written there by fwrite().

fflush() after a read operation does not refresh the contents of the buffer.

For more information on fflush(), see the z/OS C/C++ Run-Time Library Reference.
Summary of VSAM Record I/O Operations

Table 25. Summary of VSAM Record I/O Operations

<table>
<thead>
<tr>
<th></th>
<th>KSDS</th>
<th>ESDS</th>
<th>RRDS</th>
<th>PATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>fopen(), freopen()</td>
<td>rb+, ab+, wb+, ab+ (empty cluster or reuse specified for wb &amp; wb+)</td>
<td>rb+, ab+, wb+, ab+ (empty cluster or reuse specified for wb &amp; wb+)</td>
<td>rb+, ab+, wb+, ab+ (empty cluster or reuse specified for wb &amp; wb+)</td>
<td>rb+, ab+, ab+</td>
</tr>
<tr>
<td>fwrite()</td>
<td>rb+, ab+, wb+, ab+</td>
<td>rb+, ab+, wb+, ab+</td>
<td>rb+, ab+, ab+, wb+</td>
<td>rb+, ab+, ab+</td>
</tr>
<tr>
<td>fread()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>ftell()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>fseek()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>fgetpos()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>fsetpos()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>flocate()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>rewind()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>fflush()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>fdelrec()</td>
<td>rb+, ab+, wb+</td>
<td>rb+, ab+, wb+</td>
<td>rb+, ab+, wb+</td>
<td>rb+, ab+ (not ESDS)</td>
</tr>
<tr>
<td>fupdate()</td>
<td>rb+, ab+, wb+</td>
<td>rb+, ab+, wb+</td>
<td>rb+, ab+, wb+</td>
<td>rb+, ab+</td>
</tr>
<tr>
<td>ferror()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>feof()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>clearerr()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>fclose()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
<tr>
<td>fldata()</td>
<td>rb, rb+, ab+, wb+, ab+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+</td>
</tr>
</tbody>
</table>

VSAM Record Level Sharing

VSAM Record Level Sharing (RLS) provides for the sharing of VSAM data at the record level, using the locking and caching functions of the coupling facility hardware. For more information on Record Level Sharing, see z/OS DFSMS Introduction.

3. The saved position is based on the relative position of the record within the data set. Subsequent insertions or deletions may invalidate the saved position.

4. The saved position is based on the RBA of the record. Subsequent insertions, deletions or updates may invalidate the saved position.
The C/C++ run-time library provides the following support for VSAM RLS:

- Specification of RLS-related keywords in the mode string of `fopen()` and `freopen()`.
- Specification of RLS-related text unit key values in the `__dyn_t` structure, which is used as input to the `dynalloc()` function.
- Provides the application with VSAM return and reason codes for VSAM I/O errors.
- Performs implicit positioning for files opened for RLS access.

VSAM RLS has two read integrity file access modes. These modes tell VSAM the level of locking to perform when records are accessed within a file that has not been opened in update mode. The access modes are:

- **nri** No Read Integrity indicates that requests performed by the application are not to be serialized with updates or erases of the records by other calling programs. VSAM accesses the records without obtaining a lock on the record.
- **cr** Consistent Read indicates that requests performed by the application are to be serialized with updates or erases of the records by other calling programs. VSAM obtains a share lock when accessing the record. This lock is released once the record has been returned to the caller.

VSAM RLS locks records to support record integrity. An application may wait for an exclusive record lock if another user has the record locked. The application is also subject to new locking errors such as deadlock or timeout errors.

If the file has been opened in update mode, and RLS=CR is specified, VSAM also serializes access to the records within the file. However, the type of serialization differs from non-update mode in the following ways:

- A reposition within the file causes VSAM to obtain a share lock for the record.
- A read of a record causes VSAM to obtain an exclusive lock for the record. The lock is held until the record is updated in the file, or another record is read.

Notes:
1. When a file is opened, it is implicitly positioned to the first record to be accessed.
2. You can also specify the RLS keyword on the JCL DD statement. When specified on both the JCL DD statement and in the mode string on `fopen()` or `freopen()`, the read integrity options specified in the mode string override those specified on the JCL DD statement.
3. VSAM RLS access is supported for the 3 types of VSAM files that the C/C++ run-time library supports: Key-Sequenced (KSDS), Entry-Sequenced (ESDS), and Relative Record (RRDS) data sets.
4. VSAM RLS functions require the use of a Coupling Facility. For more information on using the Coupling Facility, see [z/OS DFSMS Introduction](http://www-01.ibm.com/support/docview.wss?uid=swg21175354) and [z/OS Parallel Sysplex Overview](http://www-01.ibm.com/support/docview.wss?uid=swg21175354).
5. In an environment where one thread opens and another thread issues record management requests, VSAM RLS requires that record management requests be issued from a thread whose Task Control Block (TCB) is subordinate to the TCB of the thread which opened the file.
6. VSAM RLS does not support the following:
   - Key range data sets
   - Direct open of an AIX cluster as a KSDS
Error Reporting

Errors are reported through the __amrc structure and the SIGIOERR signal. The following are additional considerations for error reporting in a VSAM RLS application:

- VSAM RLS uses the SMSVSAM server address space. If a file open fails because the server is not available, the C run-time library places the error return code and error value in the __amrc structure, and returns a null file descriptor. Record management requests return specific error return/reason codes, if the SMSVSAM server is not available. The server address space is automatically restarted. To recover from this type of error, an application should first close the file to clean up the file status, and then open the file prior to attempting record management requests. The close for the file returns a return code of 4, and an error code of 170(X'AA'). This is the expected result. It is not an error.

- Opening a recoverable file for output is not supported. If you attempt to do so, the open will fail with error return code 255 in the __amrc structure.

- Some of the VSAM errors, that are reported in the __amrc structure, are situations from which an application can recover. These are problems that can occur unpredictably in a sharing environment. Usually, the application can recover by simply accessing another record. Examples of such errors are the following:
  - RC 8, 21(X'15'): Request cancelled as part of deadlock resolution.
  - RC 8, 22(X'16'): Request cancelled as part of timeout resolution.
  - RC 8, 24(X'18'): Request cancelled because transaction backout is pending on the requested record.
  - RC 8, 29(X'14'): Intra-luwid contention between threads under a given TCB.

The application can intercept errors by registering a condition handler for the SIGIOERR condition. Within the condition handler, the application can examine the information in the __amrc structure and determine how to recover from each specific situation.

Refer to z/OS DFSMS Macro Instructions for Data Sets for a complete list of return and reason codes.

Text and Binary I/O in VSAM

Because VSAM is primarily record-based, this section only discusses those aspects of text and binary I/O that are specific to VSAM. For general information on text and binary I/O, refer to the respective sections in Chapter 11, “Performing OS I/O Operations” on page 107.

Reading from Text and Binary I/O Files

- RRDS

  All the read functions support reading from text and binary RRDS files. fread() is called with a character buffer instead of an RRDS record structure.

Writing to and Updating Text and Binary I/O Files

- KSDS, KSDS AIX, and ESDS AIX
z/OS C/C++ VSAM support for streams does not provide for writing and updating these types of data sets opened for text or binary stream I/O.

- **ESDS**
  Writes are supported for ESDSs opened as binary or text streams. Updating data in an ESDS stream cannot change the length of the record in the external file. Therefore, in a binary stream:
  - updates for less than the existing record length leave existing data beyond the updated length unchanged;
  - updates for longer than the existing record length flow over the record boundary and update the start of the next record.

In text streams:
  - updates that specify records shorter than the original record pad the updated record to the existing record length with blanks;
  - updates for longer than the existing record length result in truncation, unless the original record contained only a new-line character, in which case it may be updated to contain one byte of data plus a new-line character.

- **RRDS**
  fwrite() is called with a character buffer instead of an RRDS record structure. Records are treated as contiguous. Once the current record is filled, the next record in the file is written to. For example, if the file consisted of only record 1, record 5, and record 28, a write would complete record 1 and then go directly to record 5.

  Writing past the last record in the file is allowed, up to the maximum size of the RRDS data set. For example, if the last record in the file is record 28, the next record to be written is record 29.

  Insertion of records is not supported. For example, in a file of records 1, 5, and 28, you cannot insert record 3 into the file.

---

**Deleting Records in Text and Binary I/O Files**

fde1rec() is not supported for text and binary I/O in VSAM.

---

**Repositioning within Text and Binary I/O Files**

You can use the following functions to locate a record within a VSAM data set:

- flocate()
- ftell() and fseek()
- fgetpos() and fsetpos()
- rewind()

For complete details on these library functions, see [z/OS C/C++ Run-Time Library Reference](#).

**flocate()**

The flocate() C library function can be used to reposition to the beginning of a specific record within a VSAM data set given the key, relative byte address, or the relative record number. For more information on this function, see [z/OS C/C++ Run-Time Library Reference](#).

The following flocate() parameters set the direction access to forward:

- ___KEY_FIRST (the key and key_len parameters are ignored)
- ___KEY_EQ
The following `flocate()` parameters all set the access direction to backward and are not valid for text and binary I/O, because backwards access is not supported:

- `__KEY_LAST` (the key and `key_len` parameters are ignored)
- `__KEY_EQ_BWD`
- `__RBA_EQ_BWD`

You can use the `rewind()` library function instead of calling `flocate()` with `__KEY_FIRST`.

**KSDS, KSDS AIX, and ESDS AIX**

The key parameter of `flocate()` for the options `__KEY_EQ` and `__KEY_GE` is a pointer to the key of reference of the data set. The `key_len` parameter is the key length as defined for the data set for a full key search, or less than the defined key length for a generic key search (a partial key match).

Alternate indexes do not allow positioning by RBA.

**Note:** The `__RBA_EQ` parameter is not valid for paths and is not recommended.

**ESDS**

The key parameter of `flocate()` is a pointer to an unsigned long integer containing the specified RBA value. The `key_len` parameter is 4, because RBAs are unsigned long integers.

**RRDS**

For `__KEY_EQ` and `__KEY_GE`, the key parameter of `flocate()` is a pointer to an unsigned long integer containing the specified relative record number. For `__RBA_EQ`, the key parameter of `flocate()` is a pointer to an unsigned long integer containing the specified RBA. However, seeking to RBA values is not recommended, because it is not supported across control intervals. The `key_len` parameter is 4, because RRNs and RBAs are unsigned long integers.

**fgetpos() and fsetpos()**

`fgetpos()` saves the access direction, an RBA value, and the file position, and `fsetpos()` restores the saved access direction.

`fgetpos()` accounts for the presence of characters in the `ungetc()` buffer unless you have set the `_EDC_COMPAT` variable. See Chapter 33, “Using Environment Variables” on page 479 for information about `_EDC_COMPAT`. If `ungetc()` characters back the file position up to before the start of the file, calls to `fgetpos()` fail.

**KSDS**

`fgetpos()` stores the RBA value. This RBA value may be invalidated by subsequent insertions, deletions or updates.

**KSDS PATH and ESDS PATH**

`fgetpos()` and `fsetpos()` are not supported for PATHs.

**ESDS and RRDS**

There are no special considerations.

**ftell() and fseek()**

Using `fseek()` to seek beyond the current end of file in a writable ESDS or RRDS binary file results in the file being extended with nulls to the new position. An incomplete last record is completed with nulls, records of length `lrecl` are added as required, and the current record is filled with the remaining number of nulls and left...
in the current buffer. This is supported for relative byte offset from SEEK_SET, SEEK_CUR and SEEK_END. Table 26 provides a summary of the fseek() and ftell() parameters in binary and text.

Table 26. Summary of fseek() and ftell() parameters in text and binary

<table>
<thead>
<tr>
<th>Type</th>
<th>Mode</th>
<th>fseek() SEEK_SET</th>
<th>ftell() return values</th>
<th>fseek() SEEK_CUR</th>
<th>fseek() SEEK_END</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSDS</td>
<td>Binary</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
</tr>
<tr>
<td></td>
<td>Text</td>
<td>not supported</td>
<td>zero only</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
</tr>
<tr>
<td>ESDS</td>
<td>Binary</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
</tr>
<tr>
<td></td>
<td>Text</td>
<td>not supported</td>
<td>zero only</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
</tr>
<tr>
<td>RRDS</td>
<td>Binary</td>
<td>encoded byte offset</td>
<td>encoded byte offset</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
</tr>
<tr>
<td></td>
<td>Text</td>
<td>encoded byte offset</td>
<td>encoded byte offset</td>
<td>relative byte offset</td>
<td>relative byte offset</td>
</tr>
<tr>
<td>PATH</td>
<td>Binary</td>
<td>not supported</td>
<td>not supported</td>
<td>not supported</td>
<td>not supported</td>
</tr>
<tr>
<td></td>
<td>Text</td>
<td>not supported</td>
<td>not supported</td>
<td>not supported</td>
<td>not supported</td>
</tr>
</tbody>
</table>

### Flushing Buffers

You can use the C library function fflush() to flush data.

For text files, calling fflush() to flush an update to a record causes the new data to be written to the file.

If you call fflush() while you are updating, the updates are flushed out to VSAM.

For more information on fflush(), see [z/OS C/C++ Run-Time Library Reference](#).

### Summary of VSAM Text I/O Operations

Table 27. Summary of VSAM Text I/O Operations

<table>
<thead>
<tr>
<th>KSDS</th>
<th>ESDS</th>
<th>RRDS</th>
<th>PATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>fopen(), freopen()</td>
<td>r</td>
<td>r, r+, a, a+, w, w+ (empty cluster or reuse specified for w &amp; w+)</td>
<td>f</td>
</tr>
<tr>
<td>fwrite()</td>
<td>r+, a, a+, w, w+</td>
<td>f+, a, a+, w, w+</td>
<td>f, a, a+, w, w+</td>
</tr>
<tr>
<td>fprintf()</td>
<td>r+, a, a+, w, w+</td>
<td>f+, a, a+, w, w+</td>
<td>f, a, a+, w, w+</td>
</tr>
<tr>
<td>fputs()</td>
<td>r+, a, a+, w, w+</td>
<td>f+, a, a+, w, w+</td>
<td>f, a, a+, w, w+</td>
</tr>
<tr>
<td>fputc()</td>
<td>r+, a, a+, w, w+</td>
<td>f+, a, a+, w, w+</td>
<td>f, a, a+, w, w+</td>
</tr>
<tr>
<td>putc()</td>
<td>r+, a, a+, w, w+</td>
<td>f+, a, a+, w, w+</td>
<td>f, a, a+, w, w+</td>
</tr>
<tr>
<td>vfprintf()</td>
<td>r+, a, a+, w, w+</td>
<td>f+, a, a+, w, w+</td>
<td>f, a, a+, w, w+</td>
</tr>
<tr>
<td>vprintf()</td>
<td>r+, a, a+, w, w+</td>
<td>f+, a, a+, w, w+</td>
<td>f, a, a+, w, w+</td>
</tr>
<tr>
<td>fread()</td>
<td>r</td>
<td>r, r+, a, a+, w+</td>
<td>f</td>
</tr>
<tr>
<td>fscanf()</td>
<td>r</td>
<td>r, r+, a, a+, w+</td>
<td>f</td>
</tr>
<tr>
<td>fgets()</td>
<td>r</td>
<td>r, r+, a, a+, w+</td>
<td>f</td>
</tr>
<tr>
<td>fgetc()</td>
<td>r</td>
<td>r, r+, a, a+, w+</td>
<td>f</td>
</tr>
</tbody>
</table>
### Summary of VSAM Binary I/O Operations

**Table 28. Summary of VSAM Binary I/O Operations**

<table>
<thead>
<tr>
<th>KSDS</th>
<th>ESDS</th>
<th>RRDS</th>
<th>PATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>fopen(), freopen()</td>
<td>rb</td>
<td>rb, rb+, ab, ab+, wb, wb+ (empty cluster or reuse specified for wb &amp; wb+)</td>
<td>rb, rb+, ab, ab+, wb, wb+ (empty cluster or reuse specified for wb &amp; wb+)</td>
</tr>
<tr>
<td>fwrite()</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fprintf()</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fputs()</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fputc()</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
</tbody>
</table>
Table 28. Summary of VSAM Binary I/O Operations (continued)

<table>
<thead>
<tr>
<th>KSDS</th>
<th>ESDS</th>
<th>RRDS</th>
<th>PATH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>putc()</td>
<td>rb, ab, ab+, wb, wb+</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>vfprintf()</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>vprintf()</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td>rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fread()</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td></td>
</tr>
<tr>
<td>fscanf()</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td></td>
</tr>
<tr>
<td>fgets()</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td></td>
</tr>
<tr>
<td>fgetc()</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td></td>
</tr>
<tr>
<td>ungetc()</td>
<td>rb, rb+, ab+, wb+</td>
<td>rb, rb+, ab+, wb+</td>
<td></td>
</tr>
<tr>
<td>ftell()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fseek()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fgetpos()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fsetpos()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>flocate()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>rewind()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fflush()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>ferror()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fdelrec()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fupdate()</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>feof()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>clearerr()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fclose()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
<tr>
<td>fldata()</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td>rb, rb+, ab, ab+, wb, wb+</td>
<td></td>
</tr>
</tbody>
</table>

Closing VSAM Data Sets

To close a VSAM data set, use the Standard C `fclose()` library function as you would for closing non-VSAM files. See z/OS C/C++ Run-Time Library Reference for more details on the `fclose()` library function.

For ESDS binary files, if `fclose()` is called and there is a new record in the buffer that is less than the maximum record size, this record is written to the file at its
current size. A new RRDS binary record that is incomplete when the file is closed is filled with null characters to the record size.

A new ESDS or RRDS text record that is incomplete when the file is closed is completed with a new-line.

---

**VSAM Return Codes**

When failing return codes are received from z/OS C/C++ VSAM I/O functions, you can access the __amrc__ structure to help you diagnose errors. The __amrc_type__ structure is defined in the header file stdio.h (when the compiler option LANGLVL(LIBEXT) is used).

**Note:** The __amrc struct is global and can be reset by another I/O operation (such as printf()).

The following fields of the structure are important to VSAM users:

- __amrc.__code.__feedback.__rc__
  Stores the VSAM R15.

- __amrc.__code.__feedback.__fdbk__
  Stores the VSAM error code or reason code.

- __amrc.__RBA__
  Stores the RBA after some operations.

- __amrc.__last_op__
  Stores a code for the last operation. The codes are defined in the header file stdio.h.

- __amrc.__rplfdbwd__
  Stores the feedback code from the IFGRPL control block.

For definitions of these return codes and feedback codes, refer to the publications listed in [DFSMS](#) on page 927.

You can set up a SIGIOERR handler to catch read or write system errors. See Chapter 18, "Debugging I/O Programs" on page 233 for more information.

---

**VSAM Examples**

This section provides several examples of using I/O under VSAM.

**KSDS Example**

The example below shows two functions from an employee record entry system with a mainline driver to process selected options (display, display next, update, delete, create).

The update routine is an example of KSDS clusters, and the display routine is an example of both KSDS clusters and alternate indexes.

For these examples, the clusters and alternate indexes should be defined as follows:

- The KSDS cluster has a record size of 150 with a key length of 4 with offset 0.
- The unique KSDS AIX has a key length of 20 with an offset of 10.
- The non-unique KSDS AIX has a key length of 40 with an offset of 30.
The update routine is passed the following:
- `data_ptr`, which points to the information that is to be updated
- `orig_data_ptr`, which points to the information that was originally displayed using the display option
- A file pointer to the KSDS cluster

The display routine is passed the following:
- `data_ptr`, which points to the information that was entered on the screen for the search query
- `orig_data_ptr`, which is returned with the information for the record to be displayed if it exists
- File pointers for the primary cluster, unique alternate index and non-unique alternate index

By definition, the primary key is unique and therefore the employee number was chosen for this key. The `user_id` is also a unique key; therefore, it was chosen as the unique alternate index key. The name field may not be unique; therefore, it was chosen as the non-unique alternate index key.

**CCNGVS2**

/* this example demonstrates the use of a KSDS file */
/* part 1 of 2-other file is CCNGVS3 */

```
#include <stdio.h>
#include <string.h>

/* global definitions */

struct data_struct {
    char emp_number[4];
    char user_id[8];
    char name[20];
    char pers_info[37];
};

#define REC_SIZE 69
#define CLUS_KEY_SIZE 4
#define AIX_UNIQUE_KEY_SIZE 8
#define AIX_NONUNIQUE_KEY_SIZE 20

static void print_amrc() {
    __amrc_type currErr = **amrc; /* copy contents of __amrc */
    /* structure so that values */
    /* don't get jumbled by printf */
    printf("R15 value = %d\n", currErr.__code.__feedback.__rc);
    printf("Reason code = %d\n", currErr.__code.__feedback.__fdbk);
    printf("RBA = %d\n", currErr.__RBA);
    printf("Last op = %d\n", currErr.__last_op);
    return;
}
```

Figure 23. KSDS Example (Part 1 of 6)
/* update_emp_rec() function definition */

int update_emp_rec(struct data_struct *data_ptr,
    struct data_struct *orig_data_ptr,
    FILE *fp)
{
    int rc;
    char buffer[REC_SIZE+1];

    /* Check to see if update will change primary key (emp_number) */
    if (memcmp(data_ptr->emp_number,orig_data_ptr->emp_number,4) != 0) {
        /* Check to see if changed primary key exists */
        rc = flocate(fp,&(data_ptr->emp_number),CLUS_KEY_SIZE,___KEY_EQ);
        if (rc == 0) {
            print_amrc();
            printf("Error: new employee number already exists\n");
            return 10;
        }
        clearerr(fp);
    }

    /* Write out new record */
    rc = fwrite(data_ptr,1,REC_SIZE,fp);
    if (rc != REC_SIZE || ferror(fp)) {
        print_amrc();
        printf("Error: write with new employee number failed\n");
        return 20;
    }

    /* Locate to old employee record so it can be deleted */
    rc = flocate(fp,&(orig_data_ptr->emp_number),CLUS_KEY_SIZE,___KEY_EQ);
    if (rc != 0) {
        print_amrc();
        printf("Error: flocate to original employee number failed\n");
        return 30;
    }

    rc = fread(buffer,1,REC_SIZE,fp);
    if (rc != REC_SIZE || ferror(fp)) {
        print_amrc();
        printf("Error: reading old employee record failed\n");
        return 40;
    }

    rc = fdelrec(fp);
    if (rc != 0) {
        print_amrc();
        printf("Error: deleting old employee record failed\n");
        return 50;
    }

    Figure 23. KSDS Example (Part 2 of 6)
} /* end of checking for change in primary key */
else { /* Locate to current employee record */
  rc = flocate(fp,&(data_ptr->emp_number),CLUS_KEY_SIZE,__KEY_EQ);
  if (rc == 0) {
    /* record exists, so update it */
    rc = fread(buffer,1,REC_SIZE,fp);
    if (rc != REC_SIZE || ferror(fp)) {
      print_amrc();
      printf("Error: reading old employee record failed\n");
      return 60;
    }
    rc = fupdate(data_ptr,REC_SIZE,fp);
    if (rc == 0) {
      print_amrc();
      printf("Error: updating new employee record failed\n");
      return 70;
    }
  }
  else { /* record doesn't exist so write out new record */
    clearerr(fp);
    printf("Warning: record previously displayed no longer\n");
    printf("exists, new record being created\n");
    rc = fwrite(data_ptr,1,REC_SIZE,fp);
    if (rc != REC_SIZE || ferror(fp)) {
      print_amrc();
      printf("Error: write with new employee number failed\n");
      return 80;
    }
  }
}
return 0;

/* display_emp_rec() function definition */

int display_emp_rec (struct data_struct *data_ptr,
  struct data_struct *orig_data_ptr,
  FILE *clus_fp, FILE *aix_unique_fp,
  FILE *aix_non_unique_fp)
{
  int  rc = 0;
  char buffer[REC_SIZE+1];

  /* Primary Key Search */
  if (memcmp(data_ptr->emp_number, "\0\0\0\0", 4) != 0) {
    rc = flocate(clus_fp,&(data_ptr->emp_number),CLUS_KEY_SIZE,
                    __KEY_EQ);
    if (rc != 0) {
      printf("Error: flocate with primary key failed\n");
      return 10;
    }
  }

  /* Read record for display */
  rc = fread(orig_data_ptr,1,REC_SIZE,clus_fp);
  if (rc != REC_SIZE || ferror(clus_fp)) {
    printf("Error: reading employee record failed\n");
    return 15;
  }

  return 0;
}
/* Unique Alternate Index Search */
else if (data_ptr->user_id[0] != '\0') {
    rc = flocate(aix_unique_fp, data_ptr->user_id, AIX_UNIQUE_KEY_SIZE, __KEY_EQ);
    if (rc != 0) {
        printf("Error: flocate with user id failed\n");
        return 20;
    }

    /* Read record for display */
    rc = fread(orig_data_ptr, 1, REC_SIZE, aix_unique_fp);
    if (rc != REC_SIZE || ferror(aix_unique_fp)) {
        printf("Error: reading employee record failed\n");
        return 25;
    }
}

/* Non-unique Alternate Index Search */
else if (data_ptr->name[0] != '\0') {
    rc = flocate(aix_non_unique_fp, data_ptr->name, AIX_NONUNIQUE_KEY_SIZE, __KEY_GE);
    if (rc != 0) {
        printf("Error: flocate with name failed\n");
        return 30;
    }

    /* Read record for display */
    rc = fread(orig_data_ptr, 1, REC_SIZE, aix_non_unique_fp);
    if (rc != REC_SIZE || ferror(aix_non_unique_fp)) {
        printf("Error: reading employee record failed\n");
        return 35;
    }
} else {
    printf("Error: invalid search argument; valid search arguments
" " : are either employee number, user id, or name\n");
    return 40;
}

/* display record data */
printf("Employee Number: %.4s\n", orig_data_ptr->emp_number);
printf("Employee Userid: %.8s\n", orig_data_ptr->user_id);
printf("Employee Name: %.20s\n", orig_data_ptr->name);
printf("Employee Info: %.37s\n", orig_data_ptr->pers_info);
return 0;

Figure 23. KSDS Example (Part 4 of 6)
int main() {
    FILE* clus_fp;
    FILE* aix_ufp;
    FILE* aix_nufp;
    int i;
    struct data_struct buf1, buf2;

    char data[3][REC_SIZE+1] = {
        " 1LARRY LARRY HI, I'M LARRY, ",
        " 2DARRYL1 DARRYL AND THIS IS MY BROTHER DARRYL, ",
        " 3DARRYL2 DARRYL "
    };

    /* open file three ways */
    clus_fp = fopen("dd:cluster", "rb+,type=record");
    if (clus_fp == NULL) {
        print_amrc();
        printf("Error: fopen("dd:cluster"...) failed\n");
        return 5;
    }

    /* assume base cluster was loaded with at least one dummy record */
    /* so aix could be defined */
    aix_ufp = fopen("dd:aixuniq", "rb,type=record");
    if (aix_ufp == NULL) {
        print_amrc();
        printf("Error: fopen("dd:aixuniq"...) failed\n");
        return 10;
    }

    /* assume base cluster was loaded with at least one dummy record */
    /* so aix could be defined */
    aix_nufp = fopen("dd:aixnuniq", "rb,type=record");
    if (aix_nufp == NULL) {
        print_amrc();
        printf("Error: fopen("dd:aixnuniq"...) failed\n");
        return 15;
    }

    /* load sample records */
    for (i = 0; i < 3; ++i) {
        if (fwrite(data[i],1,REC_SIZE,clus_fp) != REC_SIZE) {
            print_amrc();
            printf("Error: fwrite(data[%d]...) failed\n", i);
            return 66+i;
        }
    }
}

Figure 23. KSDS Example (Part 5 of 6)
The following JCL can be used to test the previous example.

**CCNGVS3**

```c
/* display sample record by primary key */
mempcpy(buf1.emp_number, " 1", 4);
if (display_emp_rec(&buf1, &buf2, clus_fp, aix_ufp, aix_nufp) != 0)
return 69;

/* display sample record by nonunique aix key */
mempset(buf1.emp_number, '\0', 4);
buf1.user_id[0] = '\0';
mempcpy(buf1.name, "DARRYL", 20);
if (display_emp_rec(&buf1, &buf2, clus_fp, aix_ufp, aix_nufp) != 0)
return 70;

/* display sample record by unique aix key */
mempcpy(buf1.user_id, "DARRYL2 ", 8);
if (display_emp_rec(&buf1, &buf2, clus_fp, aix_ufp, aix_nufp) != 0)
return 71;

/* update record just read with new personal info */
mempcpy(&buf1, &buf2, REC_SIZE);
mempcpy(buf1.pers_info, "AND THIS IS MY OTHER BROTHER DARRYL. ", 37);
if (update_emp_rec(&buf1, &buf2, clus_fp) != 0) return 72;

/* display sample record by unique aix key */
if (display_emp_rec(&buf1, &buf2, clus_fp, aix_ufp, aix_nufp) != 0)
return 73;
return 0;
}
```

**Figure 23. KSDS Example (Part 6 of 6)**

The following JCL can be used to test the previous example.

**CCNGVS3**

```c
/* this example illustrates the use of a KSDS file */
/* part 2 of 2-other file is CCNGVS2 */
/* Delete cluster, and AIX and PATH */

//DELETEC EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=* 
//DELETE - 
//userid.KSDS.CLUSTER - 
//CLUSTER - 
//PURGE - 
//ERASE - 
```

**Figure 24. KSDS Example (Part 1 of 3)**
/*
//------------------------------------------------------------------
// Define KSDS
//------------------------------------------------------------------
DEFINE EXEC PGM=IDCAMS
//VOLUME DD UNIT=SYSDA,DISP=SHR,VOL=SER=(XXXXXX)
//SYSPRINT DD SYSOUT=* 
//SYSIN DD *
DEFINE CLUSTER - 
   (NAME(userid.KSDS.CLUSTER) - 
    FILE(VOLUME) - 
    VOL(XXXXXX) - 
    TRK(4 4) - 
    RECSZ(69 100) - 
    INDEXED - 
    NOREUSE - 
    KEYS(4 0) - 
    OWNER(userid ) - 
    DATA - 
      (NAME(userid.KSDS.DA)) - 
    INDEX - 
      (NAME(userid.KSDS.IX))

/*
//------------------------------------------------------------------
// Repro data into KSDS
//------------------------------------------------------------------
REPRO EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=* 
//SYSIN DD *
REPRO IN DATASET(userid.DUMMY.DATA) - 
   OUT DATASET(userid.KSDS.CLUSTER)

/*
//------------------------------------------------------------------
// Define unique AIX, define and build PATH
//------------------------------------------------------------------
DEFAIX EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=* 
//SYSIN DD *
DEFINE AIX - 
   (NAME(userid.KSDS.UAIX) - 
    RECORDS(25) - 
    KEYS(8,4) - 
    VOL(XXXXXX) - 
    UNIQUEKEY - 
    RELATE(userid.KSDS.CLUSTER)) - 
DATA - 
   (NAME(userid.KSDS.UAIXDA)) - 
INDEX - 
   (NAME(userid.KSDS.UAIXIX))
DEFINE PATH - 
   (NAME(userid.KSDS.UPATH) - 
    PATHENTRY(userid.KSDS.UAIX))
BLDINDEX - 
   IN DATASET(userid.KSDS.CLUSTER) - 
   OUT DATASET(userid.KSDS.UAIX)
/

Figure 24. KSDS Example (Part 2 of 3)
The following program illustrates the use of an RRDS file. It performs the following operations:

1. Opens an RRDS file in record mode (the cluster must be defined)
2. Writes three records (RRN 2, RRN 10, and RRN 32)
3. Sets the file position to the first record
4. Reads the first record in the file
5. Deletes it

```c
/*
 *------------------------------------------------------------------
 * Define nonunique AIX, define and build PATH
 *------------------------------------------------------------------
 */

DEFINE AIX -
  (NAME(userid.KSDS.NUAIX) -
   RECORDS(25) -
   KEYS(20, 12) -
   VOL(XXXXXX) -
   NONUNIQUEKEY -
   RELATE(userid.KSDS.CLUSTER)) -
DATA -
  (NAME(userid.KSDS.NUAIXDA)) -
INDEX -
  (NAME(userid.KSDS.NUAIXIX))
DEFINE PATH -
  (NAME(userid.KSDS.NUPATH) -
   PATHENTRY(userid.KSDS.NUAIX))
BLINDEX -
  INDATASET(userid.KSDS.CLUSTER) -
  OUTDATASET(userid.KSDS.NUAIX)

/*
 *------------------------------------------------------------------
 * Run the testcase
 *------------------------------------------------------------------
 */

GO EXEC PGM=CCNGVS2,REGION=5M
/STEPLIB DD DSN=userid.TEST.LOAD,DISP=SHR
 // DD DSN=CEE.SCEERUN,DISP=SHR
//SYSPRINT DD SYSOUT**
//SYSTERM DD SYSOUT**
//SYSSOUT DD SYSOUT**
//PLIDUMP DD SYSOUT**
//SYSSABEND DD SYSOUT**
//SYSSUDUMP DD SYSOUT**
//AIXUNIQ DD DSN=userid.KSDS.CLUSTER,DISP=SHR
//AIXNUNIQ DD DSN=userid.KSDS.NPATH,DISP=SHR
/*
 *------------------------------------------------------------------
 * Print out the cluster
 *------------------------------------------------------------------
 */

PRINT EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT**
//SYSSIN DD *
  PRINT -
    INDATASET(userid.KSDS.CLUSTER) CHAR
/*

Figure 24. KSDS Example (Part 3 of 3)

RRDS Example

The following program illustrates the use of an RRDS file. It performs the following operations:

1. Opens an RRDS file in record mode (the cluster must be defined)
2. Writes three records (RRN 2, RRN 10, and RRN 32)
3. Sets the file position to the first record
4. Reads the first record in the file
5. Deletes it

200  z/OS V1R4.0 C/C++ Programming Guide
6. Locates the last record in the file and sets the access direction to backwards
7. Reads the record
8. Updates the record
9. Sets the _EDC_RRDS_HIDE_KEY environment variable
10. Reads the next record in sequence (RRN 10) into a character string

CCNGVS4

/* this example illustrates the use of an RRDS file */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <env.h>

struct rrds_struct {
    rrds_key_type rrds_key;
    char *rrds_buf;
};

typedef struct rrds_struct RRDS_STRUCT;

main() {
    FILE *fileptr;
    RRDS_STRUCT RRDSstruct;
    RRDS_STRUCT *rrds_rec = &RRDSstruct;
    char buffer1[80] = "THIS IS THE FIRST RECORD IN THE FILE. I" "T WILL BE WRITTEN AT RRN POSITION 2. ";
    char buffer2[80] = "THIS IS THE SECOND RECORD IN THE FILE. I" "T WILL BE WRITTEN AT RRN POSITION 10. ";
    char buffer3[80] = "THIS IS THE THIRD RECORD IN THE FILE. I" "T WILL BE WRITTEN AT RRN POSITION 32. ";
    char outputbuf[80];
    unsigned long flocate_key = 0;

    Figure 25. RRDS Example (Part 1 of 3)
/* select RRDS record structure 2 by setting __fill to 1 */
/* */
/* 1. open an RRDS file record mode (the cluster must be defined) */
/* 2. write three records (RRN 2, RRN 10, RRN 32) */
/* */

rrds_rec->rrds_key.__fill = 1;

fileptr = fopen("DD:RRDSFILE", "wb+,type=record");
if (fileptr == NULL) {
  perror("fopen");
  exit(99);
}
rrds_rec->rrds_key.__recnum = 2;
rrds_rec->rrds_buf = buffer1;
fwrite(rrds_rec,1,88, fileptr);

rrds_rec->rrds_key.__recnum = 10;
rrds_rec->rrds_buf = buffer2;
fwrite(rrds_rec,1,88, fileptr);

rrds_rec->rrds_key.__recnum = 32;
rrds_rec->rrds_buf = buffer3;
fwrite(rrds_rec,1,88, fileptr);

/* 3. set file position to the first record */
/* 4. read the first record in the file */
/* 5. delete it */

flocate(fileptr, &flocate_key, sizeof(unsigned long), __KEY_FIRST);
memset(outputbuf,0x00,80);
rrds_rec->rrds_buf = outputbuf;

fread(rrds_rec,1, 88, fileptr);
printf("The first record in the file (this will be deleted):
");
printf("RRN %d: %s\n",rrds_rec->rrds_key.__recnum,outputbuf);
fdelrec(fileptr);

Figure 25. RRDS Example (Part 2 of 3)
fldata() Behavior

The format of the fldata() function is as follows:

```c
int fldata(FILE *file, char *filename, fldata_t *info);
```

The fldata() function is used to retrieve information about an open stream. The name of the file is returned in `filename` and other information is returned in the `fldata_t` structure, shown in the figure below. Values specific to this category of I/O are shown in the comment beside the structure element. Additional notes pertaining to this category of I/O follow the figure.

For more information on the fldata() function, refer to [z/OS C/C++ Run-Time Library Reference](#).
struct __fileData {
    unsigned int __recfmF : 1, /* */
    __recfmV : 1, /* */
    __recfmU : 1, /* */
    __recfmS : 1, /* always off */
    __recfmBlk : 1, /* always off */
    __recfmASA : 1, /* always off */
    __recfmM : 1, /* always off */
    __dsorgPO : 1, /* N/A -- always off */
    __dsorgPDSmem : 1, /* N/A -- always off */
    __dsorgPS : 1, /* N/A -- always off */
    __dsorgConcat : 1, /* N/A -- always off */
    __dsorgMem : 1, /* N/A -- always off */
    __dsorgHiper : 1, /* N/A -- always off */
    __dsorgTemp : 1, /* N/A -- always off */
    __dsorgVSAM : 1, /* always on */
    __dsorgHFS : 1, /* N/A -- always off */
    __openmode : 2, /* one of: */
        /* ___TEXT */
        /* ___BINARY */
        /* ___RECORD */
    __modeflag : 4, /* combination of: */
        /* ___READ */
        /* ___WRITE */
        /* ___APPEND */
        /* ___UPDATE */
    __dsorgPDSE: 1, /* N/A -- always off */
    __vsamRLS : 3, /* One of: */
        /* ___NORLS */
        /* ___RLS */
    __device_t __device; /* ___DISK */
    unsigned long __blksize, /* */
    __maxreclen; /* */
    unsigned short __vsamtype; /* one of: */
        /* ___ESDS */
        /* ___KSDS */
        /* ___RRDS */
        /* ___ESDS_PATH */
        /* ___KSDS_PATH */
    unsigned long __vsamkeylen; /* */
    unsigned long __vsamRKP; /* */
    char * __dsname; /* */
    unsigned int __reserve4; /* */
};

typedef struct __fileData fldata_t;

Figure 26. fldata() Structure

Notes:
1. If you have opened the file by its data set name, the filename is fully qualified, including quotation marks. If you have opened the file by ddname, filename is dd:ddname, without any quotation marks. The ddname is uppercase.

2. The __dsname field is filled in with the data set name. The __dsname value is uppercase unless the asis option was specified on the fopen() or freopen() function call.
Chapter 14. Performing Terminal I/O Operations

This chapter describes how to use input and output interactively with a terminal (using TSO or z/OS UNIX).

Terminal I/O supports text, binary, and record I/O, in undefined, variable and fixed-length formats, except that ASA format is not valid for any text terminal files.

**Note:** You cannot use the z/OS C/C++ I/O functions for terminal I/O under either IMS or CICS. Terminal I/O under CICS is supported through the CICS command level interface.

This chapter describes C I/O streams as they can be used within C++ programs. If you want to use the C++ I/O stream classes instead, see Chapter 5, “Using the Standard C++ Library I/O Stream Classes” on page 49 for general information. For more detailed information about I/O streaming see the following:


Opening Files

You can use the library functions `fopen()` or `freopen()` to open a file.

Using `fopen()` and `freopen()`

This section covers:
- Opening a file by data set name
- Opening a file by DD name
- `fopen()` and `freopen()` keywords
- Opening a terminal file under a shell

**Opening a File by Data Set Name**

Files are opened with a call to `fopen()` or `freopen()` in the format `fopen("filename", "mode")`. The first character of the filename must be an asterisk (*).

**z/OS UNIX Considerations:** If you have specified POSIX(ON), `fopen("*file.data","r")` does not open a terminal file. Instead, it opens a file called *file.data in the HFS file system. To open a terminal file under POSIX, you must specify two slashes before the asterisk, as follows:

```
fopen("//*file.data","r"):  
```

Terminal files cannot be opened in update mode.

Terminal files opened in append mode are treated as if they were opened in write mode.

**Opening a File by DD Name**

The data set name that is associated with the DD statement must be an asterisk(*). For example:
The following table lists the keywords that are available on the `fopen()` and `freopen()` functions, tells you which ones are useful for terminal I/O, and lists the values that are valid for the applicable ones.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Allowed?</th>
<th>Applicable?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>recfm=</td>
<td>Yes</td>
<td>Yes</td>
<td>F, V, U and additional keywords A, B, S, M are the valid values. A, B, S, and M are ignored.</td>
</tr>
<tr>
<td>lrecl=</td>
<td>Yes</td>
<td>Yes</td>
<td>See below.</td>
</tr>
<tr>
<td>blksize=</td>
<td>Yes</td>
<td>Yes</td>
<td>See below.</td>
</tr>
<tr>
<td>space=</td>
<td>Yes</td>
<td>No</td>
<td>Has no effect for terminal I/O.</td>
</tr>
<tr>
<td>type=</td>
<td>Yes</td>
<td>Yes</td>
<td>May be omitted. If you do specify it, type=record is the only valid value.</td>
</tr>
<tr>
<td>acc=</td>
<td>No</td>
<td>No</td>
<td>Not used for terminal I/O.</td>
</tr>
<tr>
<td>password=</td>
<td>No</td>
<td>No</td>
<td>Not used for terminal I/O.</td>
</tr>
<tr>
<td>asis</td>
<td>Yes</td>
<td>No</td>
<td>Has no effect for terminal I/O.</td>
</tr>
<tr>
<td>bytesseek</td>
<td>Yes</td>
<td>No</td>
<td>Has no effect for terminal I/O.</td>
</tr>
<tr>
<td>noseek</td>
<td>Yes</td>
<td>No</td>
<td>Has no effect for terminal I/O.</td>
</tr>
<tr>
<td>OS</td>
<td>Yes</td>
<td>No</td>
<td>Not used for terminal I/O.</td>
</tr>
</tbody>
</table>

recfm=

z/OS C/C++ allows you to specify any of the 27 possible RECFM types (listed in [Fixed-Format Records](#) on page 38, [Variable-Format Records](#) on page 41 and [Undefined-Format Records](#) on page 44). The default is recfm=U.

Any specification of ASA for the record format is ignored.

lrecl= and blksize=

The lrecl and blksize parameters allow you to set the record size and block size, respectively.

The maximum limits on lrecl values are as follows:

- **32771** For input z/OS variable terminals (data length of 32767)
- **32767** For input z/OS fixed and undefined terminals
- **32770** For output z/OS variable terminals (data length of 32766)
- **32766** For output z/OS fixed and undefined terminals

In fixed and undefined terminal files, blksize is always the size of lrecl. In variable terminal files, blksize is always the size of lrecl plus 4 bytes. It is not necessary to specify values for lrecl and blksize. If neither is specified, the default values are used. The default lrecl sizes (not including the extra 4 bytes in the lrecl of variable length types) are as follows:

- Screen width for output terminals
- 1000 for input z/OS text terminals
- 254 for all other input terminals
space=
    This parameter is accepted as an option for terminal I/O, but it is ignored. It
does not generate an error.

type=
    type=record specifies that the file is to be opened for sequential record I/O. The
    file must be opened as a binary file.

acc=
    This parameter is not valid for terminal I/O. If you specify it, your fopen() call
    fails.

password=
    This parameter is not valid for terminal I/O. If you specify it, your fopen() call
    fails.

asis
    This parameter is accepted as an option for terminal I/O, but it is ignored. It
does not generate an error.

byteseek
    This parameter is accepted as an option for terminal I/O, but it is ignored. It
does not generate an error.

noseek
    This parameter is accepted as an option for terminal I/O, but it is ignored. It
does not generate an error.

OS
    This parameter is not valid for terminal I/O. If you specify it, your fopen() call
    fails.

When you perform input and output in an interactive mode with the terminal, all
standard streams and all files with * as the first character of their names are
associated with the terminal. Output goes to the screen; input comes from the
keyboard.

An input EOF can be generated by a /* if you open a stream in text mode. If you
open the stream in binary or record mode, you can generate an
EOF by entering a null string.

ASA characters are not interpreted in terminal I/O.

**Opening a Terminal File Under a Shell**

Files are opened with a call to fopen() in the format fopen("/dev/tty", "mode").

**Buffering**

z/OS C/C++ uses buffers to map byte-level I/O (data stored in records and blocks)
to system-level C I/O.

In terminal I/O, line buffering is always in effect.

The setvbuf() and setbuf() functions can be used to control buffering before any
read or write operation to the file. If you want to reset the buffering mode, you must
call setvbuf() or setbuf() before any other operation occurs on a file, because you
cannot change the buffering mode after an I/O operation to the file.
Reading from Files

You can use the following library functions to read in information from terminal files:

- fread()
- fgets()
- gets()
- fgetc()
- getc()
- getchar()
- scanf()
- fscanf()

See [z/OS C/C++ Run-Time Library Reference](#) for more information on these library functions.

You can set up a `SIGIOERR` handler to catch read or write system errors. See [Chapter 18, “Debugging I/O Programs” on page 233](#) for more information.

A call to the `rewind()` function clears unread input data in the terminal buffer so that on the next read request, the system waits for more user input.

With z/OS Language Environment, an empty record is considered EOF in binary mode or record mode. This remains in effect until a `rewind()` or `clearerr()` is issued. When the `rewind()` is issued, the buffer is cleared and reading can continue.

Under TSO, the virtual line size of the terminal is used to determine the line length.

When reading from the terminal and the `RECFM` has been set to be `F` (for example, by an `ALLOCATE` under TSO) in binary or record mode, the input is padded with blanks to the record length.

On input, all terminal files opened for output flush their output, no matter what type of files they are and whether a record is complete or not. This includes fixed terminal files that would normally withhold output until a record is completed, as well as text records that normally wait until a new-line or carriage return. In all cases, the data is placed into one line with a blank added to separate output from different terminal files. Fixed terminal files do not pad the output with blanks when flushing this way.

Note: This flush is not the same as a call to `fflush()`, because fixed terminal files do not have incomplete records and text terminal files do not output until the new-line or carriage return. This flush occurs only when actual input is required from the terminal. When data is still in the buffer, that data is read without flushing output terminal files.

Reading from Binary Files

This discussion includes reading from fixed binary files and from variable or undefined binary files.

Reading from Fixed Binary Files

- Any input that is smaller than the record length is padded with blanks to the record length. The default record length is 254.
- The carriage return or new-line is not included as part of the data.
- An input line longer than the record length is returned to the calling program on subsequent system reads.
For example, suppose a program requests 30 bytes of user input from an input fixed binary terminal with record length 25. The full 30 bytes of user input returns to satisfy the request, so that you do not need to enter a second line of input.

- An empty input line indicates EOF.

**Reading from Variable or Undefined Binary Files**
These files behave like fixed-length binary files, except that no padding is performed if the input is smaller than the record length.

**Reading from Text Files**
This discussion includes reading from fixed text files and from variable or undefined text files.

**Reading from Fixed Text Files**
- The carriage return indicates the end of the record.
- A new-line character is added as part of the data to indicate the end of an input line.
- If the input is larger than the record length, it is truncated to the record length. The truncation causes SIGIOERR to be raised, if the default action for SIGIOERR is not SIG_IGN.
- When an input line is smaller than the record length, it is not padded with blanks.
- The character sequence /* indicates that the end of the file has been reached.

**Reading from Variable or Undefined Text Files**
These files behave like fixed-length text files.

**Reading from Record I/O Files**
This discussion includes reading from fixed record I/O files and from variable or undefined record I/O files.

**Reading from Fixed Record I/O Files**
- Records smaller than the record length are padded with blanks up to the record length. The default record length is 254.
- Input record terminal records have an implicit logical record boundary at the record length if the input size exceeds the record length.
  - If you enter input data larger than the record length, each subsequent block of record-length bytes from the user input satisfies successive read requests.
  - The carriage return or new-line is not included as part of the data.
  - An empty line indicates an EOF.

**Reading from Variable or Undefined Record I/O Files**
These files behave like fixed-length record files, except that no padding is performed.

**Writing to Files**
You can use the following library functions to write to a terminal file:
- fwrite()
- printf()
- fprintf()
- vprintf()
- vfprintf()
- puts()
Writing to Binary Files

This discussion includes writing to fixed binary files and to variable or undefined binary files.

Writing to Fixed Binary Files
- Output data is sent to the terminal when the last character of a record is written.
- When closing an output terminal, any unwritten data is padded to the record length with blanks before it is flushed.

Writing to Variable or Undefined Binary Files
These files behave the same as fixed-length binary files, except that no padding occurs for output that is smaller than the record length.

Writing to Text Files

The following control characters are supported:
\a Alarm. Causes the terminal to generate an audible beep.
\b Backspace. Backs up the output position by one byte. If you are at the start of the record, you cannot back up to previous record, and backspace is ignored.
\f Form feed. Sends any unwritten data to the terminal and clears the screen if the environment variable _EDC_CLEAR_SCREEN is set. If the variable is not set, the \f character is written to the screen.
\n New-line. Sends the preceding unwritten character to the terminal. If no preceding data exists, it sends a single blank character.
\t Horizontal tab. Pads the output record with blanks up to the next tab stop (set at eight characters).
\v Vertical tab. Placed in the output as is.
\r Carriage return. Treated as a new-line, sends preceding unwritten data to the terminal.

Writing to Fixed Text Files
- Lines that are longer than the record length are not truncated. They are split across multiple lines, each LRECL bytes long. Subsequent writes begin on a new line.
• Output data is sent to the terminal when one character more than the record length is written, or when a \r, \n, or \f character is written. In the case of \f, output is displayed only if the _EDC_CLEAR_SCREEN environment variable is set.

• No padding occurs on output when a record is smaller than the record length.

Writing to Variable or Undefined Text Files
These terminal files behave like fixed-length terminal files.

Writing to Record I/O Files
This discussion includes writing to fixed record I/O files and to variable or undefined record I/O files.

Writing to Fixed Record I/O Files
• Any output record that is smaller than the record length is padded to the record length with blanks, and trailing blanks are displayed.
• If a record is longer than the record length, all data is written to the terminal, wrapping at the record length.
• Output data is sent to the terminal with every record write.

Writing to Variable or Undefined Record I/O Files
These files behave like fixed-length record files except that no padding occurs when the output record is smaller than the record length.

flushing records
The action taken by the fflush() library function depends on the file mode. The fflush() function only flushes buffers in binary files with Variable or Undefined record format.

If you call one z/OS C/C++ program from another z/OS C/C++ program by using the ANSI system() function, all open streams are flushed before control is passed to the callee, and again before control is returned to the caller. If you are running with POSIX(ON), a call to the POSIX system() function does not flush any streams to the system.

Text Streams
• Writing a new record:
  Because a new-line character has not been encountered to indicate the end-of-line, fflush() takes no action. The record is written as a new record when one of the following takes place:
  – A new-line character is written.
  – The file is closed.
• Reading a record:
  fflush() clears a previous ungetc() character.

Binary Streams
• Writing a new record:
  If the file is variable or undefined length in record format, fflush() causes the current record to be written out, which in turn causes a new record to be created for subsequent writes. If the file is of fixed record length, no action is taken.
• Reading a record:
  fflush() clears a previous ungetc() character.
Record I/O

- Writing a new record: `fflush()` takes no action.
- Reading a record: `fflush()` takes no action.

Repositioning within Files

In terminal I/O, `rewind()` is the only positioning library function available. Using the library functions `fseek()`, `fgetpos()`, `fsetpos()`, and `ftell()` generates an error.

See [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/pages/z-os-c-c-run-time-library-reference) for more information on these library functions.

When an input terminal reaches an EOF, the `rewind()` function:
1. Clears the EOF condition.
2. Enables the terminal to read again.

You can also use `rewind()` when reading from the terminal to flush out your record buffer for that stream.

Closing Files

Use the `fclose()` library function to close a file. z/OS C/C++ automatically closes files on normal program termination and attempts to do so under abnormal program termination or abend. When closing a fixed binary terminal, z/OS C/C++ pads the last record with blanks if it is incomplete.

See [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/pages/z-os-c-c-run-time-library-reference) for more information on this library function.

fldata() Behavior

The format of the `fldata()` function is as follows:

```c
int fldata(FILE *file, char *filename, fldata_t *info);
```

The `fldata()` function is used to retrieve information about an open stream. The name of the file is returned in `filename` and other information is returned in the `fldata_t` structure, shown in the figure below. Values specific to this category of I/O are shown in the comment beside the structure element. Additional notes pertaining to this category of I/O follow the figure.

For more information on the `fldata()` function, refer to [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/pages/z-os-c-c-run-time-library-reference)
struct __fileData {
    unsigned int __recfmF : 1, /* */
    __recfmV : 1, /* */
    __recfmU : 1, /* */
    __recfmS : 1, /* always off */
    __recfmBlk : 1, /* always off */
    __recfmASA : 1, /* always off */
    __recfmM : 1, /* always off */
    __dsorgPO : 1, /* N/A -- always off */
    __dsorgPDSmem : 1, /* N/A -- always off */
    __dsorgPDSdir : 1, /* N/A -- always off */
    __dsorgPS : 1, /* N/A -- always off */
    __dsorgConcat : 1, /* N/A -- always off */
    __dsorgMem : 1, /* N/A -- always off */
    __dsorgHiper : 1, /* N/A -- always off */
    __dsorgTemp : 1, /* N/A -- always off */
    __dsorgVSAM : 1, /* N/A -- always off */
    __dsorgHFS : 1, /* N/A -- always off */
    __openmode : 2, /* one of: */
    /* __TEXT */
    /* __BINARY */
    /* __RECORD */
    __modeflag : 4, /* combination of: */
    /* __READ */
    /* __WRITE */
    /* __APPEND */
    __dsorgPDS: 1, /* N/A -- always off */
    __reserve2 : 8; /* */
    __device_t __device; /* __TERMINAL */
    unsigned long __blksize; /* */
    __maxrecrlen; /* */
    unsigned short __vsamtype; /* N/A */
    unsigned long __vsamkeylen; /* N/A */
    unsigned long __vsamRKP; /* N/A */
    char * __dsname; /* N/A -- always NULL */
    unsigned int __reserve4; /* */
};

typedef struct __fileData fldata_t;

Figure 27. fldata() Structure

Notes:
1. The filename value is dd:ddname if the file is opened by ddname; otherwise, the
   value is *. The ddname is uppercase.
2. Either __recfmF, __recfmV, or __recfmU will be set according to the recfm
   parameter specified on the fopen() or freopen() function call.
This chapter describes how to perform memory file and hiperspace I/O operations.

z/OS C/C++ supports files known as memory files. Memory files are temporary work files that are stored in main memory rather than in external storage.

There are two types of memory files:
- Regular memory files, which exist in your virtual storage
- Hiperspace memory files, which use special storage areas called hiperspaces. You cannot share hiperspace memory files with an AMODE=24 C or C++ program.

Memory files can be written to, read from, and repositioned within like any other type of file. Memory files exist for the life of your root program, unless you explicitly delete them by using the `remove()` or `clrmemf()` functions. The root program is the first `main()` to be invoked. Any `main()` program called by a `system()` call is known as a child program. When the root program terminates, z/OS C/C++ removes memory files automatically. Memory files may give you better performance than other types of files.

**Note:** There may not be a one-to-one correspondence between the bytes in a memory file and the bytes in some other external representation of the file, such as a disk file. Applications that mix open modes on a file (for example, writing a file as text file and reading it back as binary) may not port readily from external I/O to memory file I/O.

This chapter describes C I/O functions as they can be used within C++ programs. If you want to use the C++ I/O stream classes instead, see Chapter 5, “Using the Standard C++ Library I/O Stream Classes” on page 49 for general information. For more detailed information about I/O stream classes see the following:

### Using Hiperspace Operations

On MVS/ESA systems that support hiperspaces, large memory files can be placed in hiperspaces to reduce memory requirements within your address space.

If your installation is MVS/ESA and supports hiperspaces, and you are not using CICS, you can use hiperspace memory files (see the appropriate book as listed in z/OS Information Roadmap for more information on hiperspaces). Whereas a regular memory file stores all the file data in your address space, a hiperspace memory file uses one buffer in your address space, and keeps the rest of the data in the hiperspace. Therefore, a hiperspace memory file requires only a certain amount of storage in your address space, regardless of how large the file is. If you use `setvbuf()`, z/OS C/C++ may or may not accept your buffer for its internal use. For a hiperspace memory file, if the size of the buffer specified to `setvbuf()` is 4K.
or more, it will affect the number of hiperspace blocks read or written on each call to the operating system; the size is rounded down to the nearest multiple of 4K.

Hiperspace memory files may not be shared by multiple threads. A Hiperspace memory file that is created on one thread can only be read/written/closed by the same thread.

Opening Files

Use the Standard C `fopen()` or `freopen()` library functions to open a memory file. Details about these functions that apply to all z/OS C/C++ I/O operations are discussed in Chapter 6, “Opening Files” on page 53.

Using fopen() or freopen()

This section describes considerations for using `fopen()` and `freopen()` with memory files. Memory files are always treated as binary streams of bytes, regardless of the parameters you specify on the function call that opens them.

File-Naming Considerations

When you open a file using `fopen()` or `freopen()`, you must specify the filename (a data set name) or the ddname.

Using a Data Set Name: Files are opened with a call to `fopen()` or `freopen()` in the format `fopen("filename", "mode")`. The following diagram shows the syntax for the `filename` argument on your `fopen()` or `freopen()` call:

```
// qualifier
/member
```

The following is a sample construct:

```
'qualifier1.qualifier2(member)'
```

// Ignored for memory files.

**qualifier**

There is no restriction on the length of each qualifier. All characters are considered valid. The total number of characters for all of the qualifiers, including periods and a TSO prefix, cannot exceed 44 characters when running POSIX(OFF). Under POSIX(ON), the TSO prefix is not added, and the total number of characters is not limited, except that the full file name, including the member, cannot exceed the limit for a POSIX pathname, currently 1024 characters.

**(member)**

If you specify a member, the data set you are opening is considered to be a simulated PDS or a PDSE. For more information about PDSs and PDSEs, see “Simulating Partitioned Data Sets” on page 220. For members, the member name (including trailing blanks) can be up to 8 characters long. A member name cannot begin with leading blanks.

When you enclose a name in single quotation marks, the name is fully qualified. The file opened is the one specified by the name inside the quotation marks. If the name is not fully qualified, z/OS C/C++ does one of the following:
If your system does not use RACF, z/OS C/C++ does not add a high-level qualifier to the name you specified.

If you are running under TSO (batch or interactive), z/OS C/C++ appends the TSO user prefix to the front of the name. For example, the statement `fopen("a.b","w");` opens a data set `tsopref.A.B`, where `tsopref` is the user prefix. You can set the user prefix by using the TSO `PROFILE` command with the `PREFIX` parameter.

Note: The TSO prefix is not added when running POSIX(ON).

If you are running under MVS batch or IMS (batch or online), z/OS C/C++ appends the RACF user ID to the front of the name.

Using a DDname: You can specify names that begin with `dd:`, but z/OS C/C++ treats the `dd:` as part of the file name.

z/OS UNIX Considerations: Using the `fork()` library function from z/OS UNIX application programs causes the memory file to be copied into the child process. The memory file data in the child is identical to that of the parent at the time of the `fork()`. The memory file can be used in either the child or the parent, but the data is not visible in the other process.

fopen() and freopen() Keywords

The following table lists the keywords that are available on the `fopen()` and `freopen()` functions, tells you which ones are useful for memory file I/O, and lists the values that are valid for the applicable ones.

**Table 30. Keywords for the fopen() and freopen() Functions for Memory File I/O**

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Allowed?</th>
<th>Applicable?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>recfm=</td>
<td>Yes</td>
<td>No</td>
<td>This parameter is ignored for memory file and hiperspace I/O. If you specify a <code>RECFM</code>, it must have correct syntax. Otherwise the <code>fopen()</code> call fails.</td>
</tr>
<tr>
<td>lrecl=</td>
<td>Yes</td>
<td>No</td>
<td>This parameter is ignored for memory file and hiperspace I/O. If you specify an <code>LRECL</code>, it must have correct syntax. Otherwise <code>fopen()</code> call fails.</td>
</tr>
<tr>
<td>blksize=</td>
<td>Yes</td>
<td>No</td>
<td>This parameter is ignored for memory file and hiperspace I/O. If you specify a <code>BLKSIZE</code>, it must have correct syntax. Otherwise <code>fopen()</code> call fails.</td>
</tr>
<tr>
<td>acc=</td>
<td>Yes</td>
<td>No</td>
<td>This parameter is ignored for memory file and hiperspace I/O. If you specify an <code>ACC</code>, it must have correct syntax. Otherwise <code>fopen()</code> fails.</td>
</tr>
<tr>
<td>password=</td>
<td>No</td>
<td>No</td>
<td>Ignored for memory files.</td>
</tr>
<tr>
<td>space=</td>
<td>Yes</td>
<td>No</td>
<td>This parameter is ignored for memory file and hiperspace I/O. If you specify a <code>SPACE</code>, it must have correct syntax. Otherwise, <code>fopen()</code> fails.</td>
</tr>
<tr>
<td>type=</td>
<td>Yes</td>
<td>Yes</td>
<td>Valid values are <code>memory</code> and <code>memory(hiperspace)</code>. See the parameter list below.</td>
</tr>
<tr>
<td>asis</td>
<td>Yes</td>
<td>Yes</td>
<td>Enables the use of mixed-case file names.</td>
</tr>
</tbody>
</table>
Table 30. Keywords for the fopen() and freopen() Functions for Memory File I/O (continued)

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Allowed?</th>
<th>Applicable?</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>byteseek</td>
<td>Yes</td>
<td>No</td>
<td>Ignored for memory files, as they use byteseeking by default.</td>
</tr>
<tr>
<td>noseek</td>
<td>Yes</td>
<td>No</td>
<td>This parameter is ignored for memory file and hiperspace I/O.</td>
</tr>
<tr>
<td>OS</td>
<td>No</td>
<td>No</td>
<td>This parameter is not valid for memory file and hiperspace I/O. If you specify OS, your fopen() call fails.</td>
</tr>
</tbody>
</table>

**recfm=**

z/OS C/C++ parses your specification for these values. If they do not have the correct syntax, your function call fails. If they do, z/OS C/C++ ignores their values and continues.

**lrec= and blksize=**

z/OS C/C++ parses your specification for these values. If they do not have the correct syntax, your function call fails. If they do, z/OS C/C++ ignores their values and continues.

**acc=**

z/OS C/C++ parses your specification for these values. If they do not have the correct syntax, your function call fails. If they do, z/OS C/C++ ignores their values and continues.

**password=**

This parameter is not valid for memory file and hiperspace I/O. If you specify PASSWORD, your fopen() call fails.

**space=**

z/OS C/C++ parses your specification for these values. If they do not have the correct syntax, your function call fails. If they do, z/OS C/C++ ignores their values and continues.

**type=**

To create a memory file, you must specify type=memory. You cannot specify type=record; if you do, fopen() or freopen() fails.

To create a hiperspace memory file, you must specify type=memory(hiperspace).

**asis**

If you use this parameter, you can specify mixed-case filenames such as JaMeS dAtA or pErCy.FILE. If you are running with POSIX(ON), asis is the default.

**byteseek**

This parameter is ignored for memory file and hiperspace I/O.

**noseek**

This parameter is ignored for memory file and hiperspace I/O.

**OS**

This parameter is not allowed for memory file and hiperspace I/O. If you specify OS, your fopen() call fails.

Once a memory file has been created, it can be accessed by the module that created it as well as by any function or module that is subsequently invoked (including modules that are called using the system() library function), and by any modules in the current chain of system() calls, if you are running with POSIX(OFF). If
you are running with POSIX(ON), the system() function is the POSIX one, not the ANSI one, and it does not propagate memory files to a child program. Once the file has been created, you can open it with the same name, without specifying the type=memory parameter. You cannot specify type=record for a memory file.

This is how z/OS C/C++ searches for memory files:

1. fopen("my.file","w....,type=memory"); z/OS C/C++ checks the open files to see whether a file with that name is already open. If not, it creates a memory file.

2. fopen("my.file","w....."); z/OS C/C++ checks the open files to see whether a file with that name is already open. If not, it then checks to see whether a memory file exists with that name. If so, it opens the memory file; if not, it creates a disk file.

3. fopen("my.file","a......,type=memory"); z/OS C/C++ checks the open files to see whether a file with that name is already open. If not, it searches the existing memory files to see whether a memory file exists with that name. If so, z/OS C/C++ opens it; if not, it creates a new memory file.

4. fopen("my.file","a....") ; z/OS C/C++ checks the open files to see whether a file with that name is already open. If not, z/OS C/C++ searches existing files (both disk and memory) according to file mode, and opens the first file that has that name. If there is no such file, z/OS C/C++ creates a disk file.

5. fopen("my.file","r....,type=memory"); z/OS C/C++ searches the memory files to see whether a file with that name exists. If one does, z/OS C/C++ opens it. Otherwise, the fopen() call fails.

6. fopen("my.file","r....."); z/OS C/C++ searches first through memory files. If it does not find the specified one, it then tries to open a disk file.

If you specify a memory file name that has an asterisk (*) as the first character, a name is created for that file. (You can acquire this name by using fldata().) For example, you can specify fopen("*","type=memory");. Opening a memory file this way is faster than using the tmpnam() function.

You cannot have any blanks or periods in the member name of a memory file. Otherwise, all valid data set names are accepted for memory files. Note that if invalid disk file names are used for memory files, difficulties could occur when you try to port memory file applications to disk-file applications.

Memory files are always opened in fixed binary mode regardless of the open mode. There is no blank padding, and control characters such as the new line are written directly into the file (even if the fopen() specifies text mode).

Opening Hiperspace Files

To create a memory file in hiperspace, specify type=memory(hiperspace) on the fopen() call that creates the file. If hiperspace is not available, you get a regular memory file. Under systems that do not support hiperspaces, as well as when you are running with POSIX(ON) and TRAP(OFF), a specification of type=memory(hiperspace) is treated as type=memory. Use of TRAP(OFF) is not recommended.

You must decide whether a file is to be a hiperspace memory file before you create it. You cannot change a memory file to a hiperspace memory file by specifying type=memory(hiperspace) on a subsequent call to fopen() or freopen(). If the hiperspace to store the file cannot be created, the fopen() or freopen() call fails.
Once you have created a hiperspace memory file, you do not have to specify type=memory(hiperspace) on subsequent function calls that open the file.

If you open a hiperspace memory file for read at the same time that it is opened for write, you can attempt to read extensions made by the writer, even after the EOF flag has been set on by a previous read. If such a read succeeds, the EOF flag is set off until the new EOF is reached. If you have opened a file once for write and one or more times for read, a reader can now read past the original EOF.

**Simulating Partitioned Data Sets**

You can create memory files that are conceptually grouped as a partitioned data set (PDS). Grouping the files in this way offers the following advantages:

- You can remove all the members of a PDS by stating the data set name.
- You can rename the qualifiers of a PDS without renaming each member individually.

Once you have established that a memory file has members, you can rename and remove all the members by specifying the file name and no members, just as with a PDS or PDSE. None of the members can be open for you to perform this action. Once a memory file is created with or without a member, another memory file with the same name (with or without a member) cannot be created as well. For example, if you open memory file a.b and write to it, z/OS C/C++ does not allow a memory file named a.b(c) until you close and remove a.b. Also, if you create a memory file named a.b(mbr1), you cannot open a file named a.b until you close and remove a.b(mbr1).

The following example demonstrates the removal of all the members of the data set a.b. After the call to remove(), neither a.b(mbr1) nor a.b(mbr2) exists.
The following example demonstrates the renaming of a PDS from `a.b` to `c.d`.

```c
/* this example shows how to remove members of a PDS */

#include <stdio.h>

int main(void)
{
    FILE * fp1, * fp2;
    fp1=fopen("a.b(mbr1)","w,type=memory");
    fp2=fopen("a.b(mbr2)","w,type=memory");
    fwrite("hello, world\n", 1, 13, fp1);
    fwrite("hello, world\n", 1, 13, fp2);
    fclose(fp1);
    fclose(fp2);
    remove("a.b");
    fp1=fopen("a.b(mbr1)","r,type=memory");
    if (fp1 == NULL) {
        perror("fopen()");
        printf("fopen("a.b(mbr1)"...) failed as expected: "
             "the file has been removed\n");
    }
    else {
        printf("fopen() should have failed\n");
    }
    return(0);
}
```

Figure 28. Removing Members of a PDS

The following example demonstrates the renaming of a PDS from `a.b` to `c.d`. 
Note: If you are using simulated PDSs, you can change either the name of the
PDS, or the member name. You cannot rename \texttt{a.b(mbr1)} to either
\texttt{c.d(mbr2)} or \texttt{c.d}, but you can rename \texttt{a.b(mbr1)} to \texttt{a.b(mbr2)}, and \texttt{a.b} to
\texttt{c.d}.

Memory files that are open as a sequential data set cannot be opened again with a
member name specified. Also, if a data set is already open with a member name,
the sequential data set version with only the data set name cannot be opened.
These operations result in \texttt{fopen()} returning NULL. For example, \texttt{fopen()} returns
NULL in the second line of the following:
\begin{verbatim}
fp = fopen("a.b","w,type=memory");
fp1 = fopen("a.b(mbr1)","w,type=memory");
\end{verbatim}

You cannot use the \texttt{rename()} or \texttt{remove()} functions on open files.

**Buffering**

Regular memory files are not buffered. Any parameters passed to \texttt{setvbuf()} are
ignored. Each character that you write is written directly to the memory file.
Hiperspace memory files are fully buffered. The default size of the I/O buffer in your own address space is 16KB. You can override this buffer size by using the `setvbuf()` function (see z/OS C/C++ Run-Time Library Reference for more information).

If you call `setvbuf()` for a hiperspace memory file:

- If the `size` value is greater than or equal to 4K, it will be rounded down to the nearest multiple of 4K and this buffer size will be used. Otherwise, the `size` value is ignored.
- If a pointer to a buffer is passed, the buffer size is greater than or equal to 4K, and the buffer is aligned on a 4K boundary, the buffer may be used. Otherwise, z/OS C/C++ will allocate a buffer.

**Reading from Files**

You can use the following library functions to read information from memory files:

- `fread()`
- `fgets()`
- `gets()`
- `fgetc()`
- `getc()`
- `getchar()`
- `scanf()`
- `fscanf()`

See z/OS C/C++ Run-Time Library Reference for more information on these library functions.

The `gets()`, `getchar()`, and `scanf()` functions read from `stdin`, which can be redirected to a memory or hiperspace memory file.

You can open an existing file for read one or more times, even if it is already open for write. You cannot open a file for write if it is already open (for either read or write). If you want to update or truncate a file or append to a file that is already open for reading, you must first close all the other streams that refer to that file.

For memory files, a read operation directly after a write operation without an intervening call to `fflush()`, `fsetpos()`, `fseek()`, or `rewind()` fails. z/OS C/C++ treats the following as read operations:

- Calls to read functions that request 0 bytes
- Read requests that fail because of a system error
- Calls to the `ungetc()` function

You can set up a `SIGIOERR` handler to catch read or write system errors that happen when you are using hiperspace memory files. See Chapter 18, “Debugging I/O Programs” on page 233 for more information.
Writing to Files

You can use the following library functions to write to a file:
- fwrite()
- printf()
- fprintf()
- fprintf()
- printf()
- puts()
- fputs()
- fputc()
- putc()
- putchar()

See z/OS C/C++ Run-Time Library Reference for more information on these library functions.

The printf(), puts(), putchar(), and vprintf() functions write to stdout, which can be redirected to a memory or hiperspace memory file.

In hiperspace memory files, each library function causes your data to be moved into the buffer in your address space. The buffer is written to hiperspace each time it is filled, or each time you call the fflush() library function.

z/OS C/C++ counts a call to a write function writing 0 bytes or a write request that fails because of a system error as a write operation. For regular memory files, the only possible system error that can occur is an error in acquiring storage.

flushing Records

fflush() does not move data from an internal buffer to a memory file, because the data is written to the memory file as it is generated. However, fflush() does make the data visible to readers who have a regular or hiperspace memory file open for reading while a user has it open for writing.

Hiperspace memory files are fully buffered. The fflush() function writes data from the internal buffer to the hiperspace.

Any repositioning operation writes data to the hiperspace.

The fclose() function also invokes fflush() when it detects an incomplete buffer for a file that is open for writing or appending.

ungetc() Considerations

ungetc() pushes characters back onto the input stream for memory files. ungetc() handles only single-byte characters. You can use it to push back as many as four characters onto the ungetc() buffer. For every character pushed back with ungetc(), fflush() backs up the file position by one character and clears all the pushed-back characters from the stream. Backing up the file position may end up going across a record boundary.
If you want `fflush()` to ignore ungetc() characters, you can set the _EDC_COMPAT environment variable. See Chapter 33, “Using Environment Variables” on page 479 for more information.

Repositioning within Files

You can use the following library functions to help you position within a memory or hiperspace memory file:

- `fgetpos()`
- `fsetpos()`
- `fseek()`
- `ftell()`
- `rewind()`

See z/OS C/C++ Run-Time Library Reference for more information on these library functions.

Using `fseek()` to seek past the end of a memory file extends the file using null characters. This may cause z/OS C/C++ to attempt to allocate more storage than is available as it tries to extend the memory file.

When you use the `fseek()` function with memory files, it supports byte offsets from SEEK_SET, SEEK_CUR, and SEEK_END.

All file positions from `ftell()` are relative byte offsets from the beginning of the file. `fseek()` supports these values as offsets from SEEK_SET.

`fgetpos()`, `fseek()` with an offset of SEEK_CUR, and and `ftell()` handle ungetc() characters unless you have set the _EDC_COMPAT environment variable, in which case `fgetpos()` and `fseek()` do not. See Chapter 33, “Using Environment Variables” on page 479 for more information about _EDC_COMPAT. If in handling these characters, if the current position goes beyond the start of the file, `fgetpos()` returns the EOF value, and `ftell()` returns -1.

`fgetpos()` values generated by code from previous releases of the z/OS C/C++ compiler are not supported by `fsetpos()`.

Closing Files

Use the `fclose()` library function to close a regular or hiperspace memory file. See z/OS C/C++ Run-Time Library Reference for more information on this library function. z/OS C/C++ automatically closes memory files at the termination of the C root main environment.

Performance Tips

You should use hiperspace memory files instead of regular memory files when they will be large (1MB or greater).

Regular memory files perform more efficiently if large amounts of data (10K or more) are written in one request (that is, if you pass 10K or more of data to the `fwrite()` function). You should use `fopen("*", "type=memory")` both to generate a name for a memory file and to open the file instead of calling `fopen()` with a name returned by `tmpnam()`. You can acquire the file's generated name by using `fldata()`.
Removing Memory Files

The memory file remains accessible until the file is removed by the remove() or clrmemf() library functions or until the root program has terminated. You cannot remove an open memory file, except when you use clrmemf(). See z/OS C/C++ Run-Time Library Reference for more information on these library functions.

fldata() Behavior

The format of the fldata() function is as follows:

```c
int fldata(FILE *file, char *filename, fldata_t *info);
```

The fldata() function is used to retrieve information about an open stream. The name of the file is returned in filename and other information is returned in the fldata_t structure, shown in the figure below. Values specific to this category of I/O are shown in the comment beside the structure element. Additional notes pertaining to this category of I/O follow the figure. For more information on the fldata() function, refer to z/OS C/C++ Run-Time Library Reference.

```c
struct __fileData {
  unsigned int __recfmF : 1, /* always on */
  __recfmV : 1, /* always off */
  __recfmU : 1, /* always off */
  __recfmS : 1, /* always off */
  __recfmBlk : 1, /* always off */
  __recfmASA : 1, /* always off */
  __recfmMM : 1, /* always off */
  __dsorgPO : 1, /* N/A -- always off */
  __dsorgPDOSmem : 1, /* N/A -- always off */
  __dsorgPDOSdir : 1, /* N/A -- always off */
  __dsorgPS : 1, /* N/A -- always off */
  __dsorgConcat : 1, /* N/A -- always off */
  __dsorgMem : 1, /* */
  __dsorgHiper : 1, /* */
  __dsorgTemp : 1, /* N/A -- always off */
  __dsorgVSAM : 1, /* N/A -- always off */
  __dsorgHFS : 1, /* N/A -- always off */
  __openmode : 2, /* __BINARY */
  __modeflag : 4, /* combination of: */
    /* __READ */
    /* __WRITE */
    /* __APPEND */
    /* __UPDATE */
  __dsorgPDSE : 1, /* N/A -- always off */
  __reserve2 : 8; /* */
  __device_t __device; /* one of: */
    /* __MEMORY */
    /* __HIPERSPACE */
  unsigned long blksize, /* */
  __maxreclen; /* */
  unsigned short vsamtype; /* N/A */
  unsigned long vsamkeylen; /* N/A */
  unsigned long vsamRKP; /* N/A */
  char * dsname; /* */
  unsigned int __reserve4; /* */
};
```

typedef struct __fileData fldata_t;

Figure 30. fldata() Structure
Notes:
1. The filename is the fully qualified version of the filename specified on the fopen() or freopen() function call. There are no quotation marks. However, if the filename specified on the fopen() or freopen() function call begins with an ", a unique filename is generated in the format ((n)), where n is an integer.
2. The __dsorgMem bit will be set on only for regular memory files.
3. The __dsorgHiper bit will be set on only for hiperspace memory files.
4. The __dsname is identical to the filename value.

Example Program

The following example shows the use of a memory file. The program PROGA creates a memory file, calls program PROGB, and redirects the output of the called program to the memory file. When control returns to the first program, the program reads and prints the string in the memory file.

For more information on the system() library function, see z/OS C/C++ Run-Time Library Reference.

CCNGMF3

/* this example demonstrates the use of a memory file */
/* part 1 of 2-other file is CCNGMF4 */
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
int main(void)
{
   FILE *fp;
   char buffer[20];
   char *rc;
   /* Open the memory file to create it */
   fp = fopen("PROG.DAT","wb+,type=memory") != NULL)
   { /* Close the memory file so that it can be used as stdout */
      fclose(fp);
      system("CCNGMF4 >PROG.DAT");
   } /* Call CCNGMF4 and redirect its output to memory file */
   /* CCNGMF4 must be an executable MODULE */
   system("CCNGMF4 >PROG.DAT");
   /* Now print the string contained in the file */
   fp = fopen("PROG.DAT","rb");
   rc = fgets(buffer,sizeof(buffer),fp);
   if (rc == NULL)
      { perror(" Error reading from file ");
      exit(99);
      }
   printf("%s", buffer);
   return(0);
}
/* this example demonstrates the use of a memory file */
/* part 2 of 2-other file is CCNGMF3 */

#include <stdio.h>
#include <stdlib.h>

int main(void)
{
    char item1[] = "Hello World\n";
    int rc;

    /* Write the data to the stdout which, at this point, has been redirected to the memory file */
    rc = fputs(item1,stdout);
    if (rc == 0) {
        perror("Error putting to file ");
        exit(99);
    }

    return(0);
}

Figure 32. Memory File Example
Chapter 16. Performing CICS I/O Operations

z/OS C/C++ under CICS supports only three kinds of I/O:

**CICS I/O**

z/OS C/C++ applications can access the CICS I/O commands through the CICS command level interface. [CICS Application Programming Guide, SC34-5993](http://www.ibm.com/software/ad/c390/czos/czosdocs.html) and [CICS Application Programming Reference, SC34-5994](http://www.ibm.com/software/ad/c390/czos/czosdocs.html) discuss this interface in detail.

**Files**

Memory files are the only type of file that z/OS C/C++ supports under CICS. Hiperspace files are not supported.

VSAM files can be accessed through the CICS command level interface.

**CICS data queues**

Under CICS, z/OS C/C++ implements the standard output (stdout) and standard error (stderr) streams as CICS transient data queues. These data queues must be defined in the CICS Destination Control table (DCT) by the CICS system administrator before the CICS cold start. Output from all users’ transactions that use stdout (or stderr) is written to the queue in the order of occurrence. To help differentiate the output, place a user’s terminal name, the CICS transaction identifier, and the time at the beginning of each line printed to the queue.

The queues are as follows:

<table>
<thead>
<tr>
<th>Stream</th>
<th>Queue</th>
</tr>
</thead>
<tbody>
<tr>
<td>stdout</td>
<td>CESO</td>
</tr>
<tr>
<td>stderr</td>
<td>CESE</td>
</tr>
<tr>
<td>stdin</td>
<td>Not supported</td>
</tr>
</tbody>
</table>

To access any other queues, you must use the command level interface.

**Note:** If you are using the C++ I/O stream classes, the standard stream `cout` maps to `stdout`, which maps to CESO. The standard stream `cerr` and `clog` both map to `stderr`, which maps to CESE. The standard stream `cin` is not supported under CICS.

For more general information about C++ I/O streaming, see Chapter 5, “Using the Standard C++ Library I/O Stream Classes” on page 49. For more detailed information about I/O streaming see the following:


For complete information about using z/OS C/C++ and z/OS C/C++ I/O under CICS, see “Using Input and Output” on page 598.

For information on using wide characters in the CICS environment, see Chapter 9, “z/OS C Support for the Double-Byte Character Set” on page 79.
Chapter 17. Language Environment Message File Operations

This chapter describes input and output with the z/OS Language Environment message file. This file is write-only. That is, it is nonreadable and nonseekable.

The default open mode for the z/OS Language Environment message file is text. Binary and record I/O modes are not supported.

This chapter also describes C I/O streams as they can be used within C++ programs. If you want to use the C++ I/O stream classes instead, see Chapter 5, "Using the Standard C++ Library I/O Stream Classes" on page 49 for general information. For more detailed information about I/O streaming see the following:


The standard stream `stderr` defaults to using the z/OS Language Environment message file. `stderr` will be directed to file descriptor 2, which is typically your terminal if you are running under one of the z/OS UNIX shells. There are some exceptions, however:

- If the application has allocated the ddname in the MSGFILE(ddname) run-time parameter, your output will go there. The default is MSGFILE(SYSOUT).
- If the application has issued one of the POSIX exec() functions, or it is running in an address space created by the POSIX fork() function and the application has not dynamically allocated a ddname for MSGFILE, then the default is to use file descriptor 2, if one exists. If it doesn't, then the default is to create a message file in the user's current working directory. The message file will have the name that is specified on the message file run-time option, the default being SYSOUT.

### Opening Files

The default is for `stderr` to go to the message file automatically. The message file is available only as `stderr`; you cannot use the fopen() or freopen() library function to open it.

- freopen() with the null string ("") as filename string will fail.
- Record format (RECFM) is always treated as undefined (U). Logical record length (LRECL) is always treated as 255 (the maximum length defined by z/OS Language Environment message file system write interface).

### Reading from Files

The z/OS Language Environment message file is non-readable.

### Writing to Files

- Data written to the z/OS Language Environment message file is always appended to the end of the file.
• When the data written is longer than 255 bytes, it is written to the z/OS Language Environment message file 255 bytes at a time, with the last write possibly less than 255 bytes. No truncation will occur.

• When the output data is shorter than the actual LRECL of the z/OS Language Environment message file, it is padded with blank characters by the z/OS Language Environment system write interface.

• When the output data is longer than the actual LRECL of the z/OS Language Environment message file, it is split into multiple records by the z/OS Language Environment system write interface. The z/OS Language Environment system write interface splits the output data at the last blank before the LRECL-th byte, and begins writing the next record with the first non-blank character. Note that if there are no blanks in the first LRECL bytes (DBCS for instance), the z/OS Language Environment system write interface splits the output data at the LRECL-th byte. It also closes off any DBCS string on the first record with a X'0F' character, and begins the DBCS string on the next record with a X'0E' character.

• The hex characters X'0E' and X'0F' have special meaning to the z/OS Language Environment system write interface. The z/OS Language Environment system write interface removes adjacent pairs of these characters (normalization).

• You can set up a SIGIOERR handler to catch system write errors. See Chapter 18, "Debugging I/O Programs" on page 233 for more information.

flushing buffers

The fflush() function has no effect on the z/OS Language Environment message file.

repositioning within files

The ftell(), fgetpos(), fseek(), and fsetpos() functions are not allowed, because z/OS Language Environment message file is a non-seekable file. The rewind() function only resets error flags.

You cannot call fseek() on stderr when it is mapped to MSGFILE (the default routing of stderr).

closing files

Do not use the fclose() library function to close the z/OS Language Environment message file. z/OS C/C++ automatically closes files on normal program termination and attempts to do so under abnormal program termination or abend.
Chapter 18. Debugging I/O Programs

This chapter will help you locate and diagnose problems in programs that use input and output. It discusses several diagnostic methods specific to I/O. Diagnostic methods for I/O errors include:

- Using return codes from I/O functions
- Using errno values and the associated perror() message
- Using the __amrc structure
- Using the __amrc2 structure

The information provided with the return code of I/O functions and with the perror() message associated with errno values may help you locate the source of errors and the reason for program failure. Because return codes and errno values do not exist for every possible system I/O failure, return codes and errno values are not useful for diagnosing all I/O errors. This chapter discusses the use of the __amrc structure and the __amrc2 structure. For information on return codes from I/O functions see z/OS C/C++ Run-Time Library Reference. For information on errno values and the associated perror() message see z/OS Language Environment Debugging Guide.

Using the __amrc Structure

__amrc is a structure defined in stdio.h (when the compile-time option LANGLEVEL(LIBEXT) is in effect) to help you determine errors resulting from an I/O operation. This structure is changed during system I/O and some C specific error situations.

Note: __amrc is not used to record I/O errors in HFS files.

When looking at __amrc, be sure to copy the structure into a temporary structure of __amrctype since any I/O function calls will change the value of __amrc.

Figure 33 on page 234 shows the __amrc structure as it appears in stdio.h.
typedef struct __amrctype {
    union {
        long int __error;  
        
        struct {
            unsigned short __syscode,  
            __rc;
        } __abend;  
        struct {
            unsigned char __fdbk_fill,  
            __rc,  
            __ftncd,  
            __fdbk;
        } __feedback;  
        struct {
            unsigned short __svc99_info,  
            __svc99_error;
        } __alloc;  
    } __code;
    unsigned long __RBA;
    unsigned int __last_op;
    struct {
        unsigned long __len_fill;
        unsigned long __len;
        char __str[120];
        unsigned long __parmr0;
        unsigned long __parmr1;
        unsigned long __fill2[2];
        char __str2[64];
    } __msg;
    unsigned char __rplfdbwd[4];
} __amrc_type;

Figure 33. __amrc Structure

1 union {...} __code
   The error or warning value from an I/O operation is in either __error, __abend, __feedback, or __alloc. You must look at __last_op to determine how to interpret the __code union.

2 __error
   error contains the return code from the system macro or utility. Refer to Table 31 on page 237 for further information.

3 __abend
   This struct contains the abend code when errno is set to indicate a recoverable I/O abend. __syscode is the system abend code and __rc is the return code. For more information on the abend codes, see the System Codes manual as listed in z/OS Information Roadmap. The macros __abendcode() and __rsnccode() may be set to the abend code and reason code of a TSO CLIST or command when invoked with system().

4 __feedback
   This struct is used for VSAM only. The __rc stores the VSAM register 15, __fdbk stores the VSAM error code or reason code, and __RBA stores the RBA after some operations.

5 __alloc
   This struct contains errors during fopen() or freopen() calls when defining
files to the system using SVC 99. See the Systems Macros manual, as listed in z/OS Information Roadmap for more information on these fields as set by SVC 99.

6 _RBA
This is the RBA value returned by VSAM after an ESDS or KSDS record is written out. For a RRDS, it is the calculated value from the record number. It may be used in subsequent calls to flocate().

7 _last_op
This field contains a value that indicates the last I/O operation being performed by z/OS C/C++ at the time the error occurred. These values are shown in Table 31 on page 237.

8 _msg
This may contain the system error messages from read or write operations emitted from the BSAM SYNADAF macro instruction. This field will not always be filled. If you print this field using the %s format, you should print the string starting at the sixth position because of possible null characters found in the first 6 characters. Special messages for PDSEs are contained in the positions 136 through 184. See the Data Administration manual as listed in z/OS Information Roadmap for more information.

This field is used by the SIGIOERR handler.

9 _rplfdbwd
This field contains feedback information related to a VSAM RLS failure. This is the feedback code from the IFGRPL control block.

Figure 34 demonstrates how to print the _amrc structure after an error has occurred to get information that may help you to diagnose an I/O error.

CCNGDI1

/* this example demonstrates how to print the _amrc structure */
#include <stdio.h>
#include <errno.h>
#include <stdlib.h>
#include <string.h>

int main(void) {
    FILE *fp;
    _amrc_type save_amrc;
    char buffer[80];
    int i = 0;

    /* open an MVS binary file */
    fp = fopen("testfull.file","wb, recfm=F, lrecl=80");
    if (fp == NULL) exit(99);
    memset(buffer, 'A', 80);

    Figure 34. Example of Printing the _amrc Structure (Part 1 of 2)
The program writes to a file until it is full. When the file is full, the program fails. Following the I/O failure the program makes a copy of the __amrc structure, and prints the number of successful writes to the file, the errno, the __last_op code, the abend system code and the return code.

Using the __amrc2 Structure

The __amrc2 structure is an extension of __amrc. Only 2 fields are defined for __amrc2. Like the __amrc structure, __amrc2 is changed during system I/O and some C specific error situations.

Note: See "Using the SIGIOERR Signal" on page 240 for information on restrictions that exist when comparing file pointers if you are using the __amrc2 structure.

Figure 35 shows the __amrc2 structure as it appears in stdio.h.

```c
struct {
    long int __error2;  /*
    FILE *__fileptr;    */
    long int __reserved[6];
}__amrc2;
```

This field is a secondary error code that is used to store the reason code from specific macros. The __last_op codes that can be returned to __amrc2 are __BSAM_STOW, __BSAM_BLDL, __IO_LOCATE, __IO_RENAME, __IO_CATALOG and __IO_UNCATALOG. For information on the macros associated with these codes see Table 31 on page 237.

For further information about the macros see z/OS DFSMSdfp Diagnosis Reference.

This field, __fileptr, of the __amrc2 structure is used by the signal SIGIOERR to pass back a FILE pointer that can then be passed to fldata() to get the name of the file causing the error. The __amrc2__fileptr will be NULL if a SIGIOERR is raised before the file has been successfully opened.
Using `__last_op` Codes

The `__last_op` field is the most important of the `__amrc` fields. It defines the last I/O operation z/OS C/C++ was performing at the time of the I/O error. You should note that the structure is neither cleared nor set by non-I/O operations so querying this field outside of a SIGIOERR handler should only be done immediately after I/O operations. Table 31 lists `__last_op` codes you may receive and where to look for further information.

<table>
<thead>
<tr>
<th>Code</th>
<th>Further Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>__BSAM_BLDL</code></td>
<td>Sets <code>__error</code> with return code from OS BLDL macro.</td>
</tr>
<tr>
<td><code>__BSAM_CLOSE</code></td>
<td>Sets <code>__error</code> with return code from OS CLOSE macro.</td>
</tr>
<tr>
<td><code>__BSAM_CLOSE_T</code></td>
<td>Sets <code>__error</code> with return code from OS CLOSE TYPE=T.</td>
</tr>
<tr>
<td><code>__BSAM_NOTE</code></td>
<td>NOTE returned 0 unexpectedly, no return code.</td>
</tr>
<tr>
<td><code>__BSAM_OPEN</code></td>
<td>Sets <code>__error</code> with return code from OS OPEN macro.</td>
</tr>
<tr>
<td><code>__BSAM_POINT</code></td>
<td>This will not appear as an error <code>lastop</code>.</td>
</tr>
<tr>
<td><code>__BSAM_READ</code></td>
<td>No return code (either <code>__abend</code> (<code>errno == 92</code>) or <code>__msg</code> (<code>errno == 66</code>) filled in).</td>
</tr>
<tr>
<td><code>__BSAM_STOW</code></td>
<td>Sets <code>__error</code> with return code from OS STOW macro.</td>
</tr>
<tr>
<td><code>__BSAM_WRITE</code></td>
<td>No return code (either <code>__abend</code> (<code>errno == 92</code>) or <code>__msg</code> (<code>errno == 65</code>) filled in).</td>
</tr>
<tr>
<td><code>__C_CANNOT_EXTEND</code></td>
<td>This occurs when an attempt is made to extend a file that allows writing, but cannot be extended. Typically this is a member of a partitioned data set being opened for update.</td>
</tr>
<tr>
<td><code>__C_DBCS_SI_TRUNCATE</code></td>
<td>This occurs only when there was not enough room to start a DBCS string and data was written anyway, with an SI to end it. Cannot happen if MB_CUR_MAX is 1.</td>
</tr>
<tr>
<td><code>__C_DBCS_SO_TRUNCATE</code></td>
<td>This occurs when there is not enough room in a record to start any DBCS string or else when a redundant SO is written to the file before an SI. Cannot happen if MB_CUR_MAX is 1.</td>
</tr>
<tr>
<td><code>__C_DBCS_TRUNCATE</code></td>
<td>This occurs when writing DBCS data to a text file and there is no room left in a physical record for anymore double byte characters. A new-line is not acceptable at this point. Truncation will continue to occur until an SI is written or the file position is moved. Cannot happen if MB_CUR_MAX is 1.</td>
</tr>
<tr>
<td><code>__C_DBCS_UNEVEN</code></td>
<td>This occurs when an SI is written before the last double byte character is completed, thereby forcing z/OS C/C++ to fill in the last byte of the DBCS string with a padding byte X’FE’. Cannot happen if MB_CUR_MAX is 1.</td>
</tr>
<tr>
<td><code>__C_FCBCHECK</code></td>
<td>Set when z/OS C/C++ FCB is corrupted. This is due to a pointer corruption somewhere. File cannot be used after this.</td>
</tr>
<tr>
<td><code>__C_TRUNCATE</code></td>
<td>Set when z/OS C/C++ truncates output data. Usually this is data written to a text file with no newline such that the record fills up to capacity and subsequent characters cannot be written. For a record I/O file this refers to an fwrite() writing more data than the record can hold. Truncation is always of rightmost data. There is no return code.</td>
</tr>
</tbody>
</table>

Table 31. `__last_op` Codes and Diagnosis Information
<table>
<thead>
<tr>
<th>Code</th>
<th>Further Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>__HSP_CREATE</td>
<td>Indicates last op was a DSPSERV CREATE to create a hiperspace for a hiperspace memory file. If CREATE fails, stores abend code in __amrc._code._abend._syscode, reason code in __amrc._code._abend._rc.</td>
</tr>
<tr>
<td>__HSP_DELETE</td>
<td>Indicates last op was a DSPSERV DELETE to delete a hiperspace for a hiperspace memory file during termination. If DELETE fails, stores abend code in __amrc._code._abend._syscode, reason code in __amrc._code._abend._rc.</td>
</tr>
<tr>
<td>__HSP_EXTEND</td>
<td>Indicates last op was a HSPSERV EXTEND during a write to a hiperspace. If EXTEND fails, stores abend code in __amrc._code._abend._syscode, reason code in __amrc._code._abend._rc.</td>
</tr>
<tr>
<td>__HSP_READ</td>
<td>Indicates last op was a HSPSERV READ from a hiperspace. If READ fails, stores abend code in __amrc._code._abend._syscode, reason code in __amrc._code._abend._rc.</td>
</tr>
<tr>
<td>__HSP_WRITE</td>
<td>Indicates last op was a HSPSERV WRITE to a hiperspace. If WRITE fails, stores abend code in __amrc._code._abend._syscode, reason code in __amrc._code._abend._rc.</td>
</tr>
<tr>
<td>__IO_CATALOG</td>
<td>Sets __error with return code from I/O CAMLST CAT. The associated macro is CATALOG.</td>
</tr>
<tr>
<td>__IO_DEVTYPE</td>
<td>Sets __error with return code from I/O DEVTYPE macro.</td>
</tr>
<tr>
<td>__IO_INIT</td>
<td>Will never be seen by SIGIOERR exit value given at initialization.</td>
</tr>
<tr>
<td>__IO_LOCATE</td>
<td>Sets __error with return code from I/O CAMLST LOCATE.</td>
</tr>
<tr>
<td>__IO_OBTAIN</td>
<td>Sets __error with return code from I/O CAMLST OBTAIN.</td>
</tr>
<tr>
<td>__IO_RDJFCB</td>
<td>Sets __error with return code from I/O RDJFCB macro.</td>
</tr>
<tr>
<td>__IO_RENAME</td>
<td>Sets __error with return code from I/O CAMLST RENAME.</td>
</tr>
<tr>
<td>__IO_TRKCALC</td>
<td>Sets __error with return code from I/O TRKCALC macro.</td>
</tr>
<tr>
<td>__IO_UNCATALOG</td>
<td>Sets __error with return code from I/O CAMLST UNCAT. The associated macro is CATALOG.</td>
</tr>
<tr>
<td>__LFS_CLOSE</td>
<td>Sets __error with reason code from HFS services. Reason code from HFS services must be broken up. The low order 2 bytes can be looked up in z/OS UNIX System Services Programming: Assembler Callable Services Reference</td>
</tr>
<tr>
<td>__LFS_FSTAT</td>
<td>Sets __error with reason code from HFS services. Reason code from HFS services must be broken up. The low order 2 bytes can be looked up in z/OS UNIX System Services Programming: Assembler Callable Services Reference</td>
</tr>
<tr>
<td>__LFS_LSEEK</td>
<td>Sets __error with reason code from HFS services. Reason code from HFS services must be broken up. The low order 2 bytes can be looked up in z/OS UNIX System Services Programming: Assembler Callable Services Reference</td>
</tr>
<tr>
<td>__LFS_OPEN</td>
<td>Sets __error with reason code from HFS services. Reason code from HFS services must be broken up. The low order 2 bytes can be looked up in z/OS UNIX System Services Programming: Assembler Callable Services Reference</td>
</tr>
<tr>
<td>Code</td>
<td>Further Information</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>__LFS_READ</td>
<td>Sets __error with reason code from HFS services. Reason code from HFS services must be broken up. The low order 2 bytes can be looked up in <a href="https://www.ibm.com/support/knowledgecenter/en/SSLVMB_7.1.0/com.ibm.zos.v2r10.svc.doc/">Z/OS UNIX System Services Programming: Assembler Callable Services Reference</a>.</td>
</tr>
<tr>
<td>__LFS_STAT</td>
<td>Sets __error with reason code from HFS services. Reason code from HFS services must be broken up. The low order 2 bytes can be looked up in <a href="https://www.ibm.com/support/knowledgecenter/en/SSLVMB_7.1.0/com.ibm.zos.v2r10.svc.doc/">Z/OS UNIX System Services Programming: Assembler Callable Services Reference</a>.</td>
</tr>
<tr>
<td>__LFS_WRITE</td>
<td>Sets __error with reason code from HFS services. Reason code from HFS services must be broken up. The low order 2 bytes can be looked up in <a href="https://www.ibm.com/support/knowledgecenter/en/SSLVMB_7.1.0/com.ibm.zos.v2r10.svc.doc/">Z/OS UNIX System Services Programming: Assembler Callable Services Reference</a>.</td>
</tr>
<tr>
<td>__OS_CLOSE</td>
<td>Sets __error to result of OS CLOSE macro.</td>
</tr>
<tr>
<td>__OS_OPEN</td>
<td>Sets __error to result of OS OPEN macro.</td>
</tr>
<tr>
<td>__QSAM_FREEPOOL</td>
<td>This is an intermediate operation. You will only see this if an I/O abend occurred.</td>
</tr>
<tr>
<td>__QSAM_GET</td>
<td>__error is not set (if abend (errno == 92), __abend is set, otherwise if read error (errno == 66), look at __msg.</td>
</tr>
<tr>
<td>__QSAM_PUT</td>
<td>__error is not set (if abend (errno == 92), __abend is set, otherwise if write error (errno == 65), look at __msg.</td>
</tr>
<tr>
<td>__QSAM_TRUNC</td>
<td>This is an intermediate operation. You will only see this if an I/O abend occurred.</td>
</tr>
<tr>
<td>__SVC99_ALLOC</td>
<td>Sets __alloc structure with info and error codes from SVC 99 allocation.</td>
</tr>
<tr>
<td>__SVC99_ALLOC_NEW</td>
<td>Sets __alloc structure with info and error codes from SVC 99 allocation of NEW file.</td>
</tr>
<tr>
<td>__SVC99_UNALLOC</td>
<td>Sets __alloc structure with info and error codes from SVC 99 unallocation.</td>
</tr>
<tr>
<td>__TGET_READ</td>
<td>Sets __error with return code from TSO TGET macro.</td>
</tr>
<tr>
<td>__TPUT_WRITE</td>
<td>Sets __error with return code from TSO TPUT macro.</td>
</tr>
<tr>
<td>__VSAM_CLOSE</td>
<td>Set when the last op was a low level VSAM CLOSE; if the CLOSE fails, sets __rc and __fdbk in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_ENDREQ</td>
<td>Set when the last op was a low level VSAM ENDREQ; if the ENDREQ fails, sets __rc and __fdbk in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_ERASE</td>
<td>Set when the last op was a low level VSAM ERASE; if the ERASE fails, sets __rc and __fdbk in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_GENCB</td>
<td>Set when a low level VSAM GENCB macro fails, sets __rc and __fdbk fields in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_GET</td>
<td>Set when the last op was a low level VSAM GET; if the GET fails, sets __rc and __fdbk in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_MDCB</td>
<td>Set when a low level VSAM MDCB macro fails, sets __rc and __fdbk fields in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_OPEN_ESDS</td>
<td>Does not indicate an error; set when the low level VSAM OPEN succeeds, and the file type is ESDS.</td>
</tr>
<tr>
<td>__VSAM_OPEN_ESDS_PATH</td>
<td>Does not indicate an error; set when the low level VSAM OPEN succeeds, and the file type is ESDS.</td>
</tr>
<tr>
<td>__VSAM_OPEN_FAIL</td>
<td>Set when a low level VSAM OPEN fails, sets __rc and __fdbk fields in the __amrc struct.</td>
</tr>
</tbody>
</table>
Table 31. __last_op Codes and Diagnosis Information  (continued)

<table>
<thead>
<tr>
<th>Code</th>
<th>Further Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>__VSAM_OPEN_KSDS</td>
<td>Does not indicate an error; set when the low level VSAM OPEN succeeds, and the file type is ESDS.</td>
</tr>
<tr>
<td>__VSAM_OPEN_KSDS_PATH</td>
<td>Does not indicate an error; set when the low level VSAM OPEN succeeds, and the file type is ESDS.</td>
</tr>
<tr>
<td>__VSAM_OPEN_RRDS</td>
<td>Does not indicate an error; set when the low level VSAM OPEN succeeds, and the file type is ESDS.</td>
</tr>
<tr>
<td>__VSAM_POINT</td>
<td>Set when the last op was a low level VSAM POINT; if the POINT fails, sets __rc and __fdbk in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_PUT</td>
<td>Set when the last op was a low level VSAM PUT; if the PUT fails, sets __rc and __fdbk in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_SHOWCB</td>
<td>Set when a low level VSAM SHOWCB macro fails, sets __rc and __fdbk fields in the __amrc struct.</td>
</tr>
<tr>
<td>__VSAM_TESTCB</td>
<td>Set when a low level VSAM TESTCB macro fails, sets __rc and __fdbk fields in the __amrc struct.</td>
</tr>
</tbody>
</table>

Using the SIGIOERR Signal

SIGIOERR is a signal used by the library to pass control to an error handler when an I/O error occurs. The default action for this signal is SIG_IGN. Setting up a SIGIOERR handler is like setting up any other error handler. The example in Figure 36 adds a SIGIOERR handler to the example shown in Figure 34 on page 235. Note the way fldata() and the __amrc2 field __fileptr are used to get the name of the file that caused the error.

CCNGDI2

```c
#include <stdio.h>
#include <signal.h>
#include <errno.h>
#include <stdlib.h>
#include <string.h>

#ifdef __cplusplus
extern "C" {
#endif

Figure 36. Example of Using SIGIOERR (Part 1 of 2)
When control is given to a SIGIOERR handler, the __amrc2 structure field __fileptr will be filled in with a file pointer. The __amrc2__fileptr will be NULL if a SIGIOERR is raised before the file has been successfully opened. The only operation permitted on the file pointer is fldata(). This operation can be used to extract information about the file that caused the error. Other than freopen() and fclose(), all I/O operations will fail since the file pointer is marked invalid. Do not issue freopen() or fclose() in a SIGIOERR handler that returns control. This will result in unpredictable behavior, likely an abend.

```c
int main(void) {
    FILE *fp;
    char buffer[80];
    int i = 0;

    signal(SIGIOERR, iohdlr);

    /* open an MVS binary file */
    fp = fopen("testfull.file","wb, recfm=F, lrecl=80");
    if (fp == NULL) exit(99);

    memset(buffer, 'A', 80);
    /* write to MVS file until it runs out of extents */
    while (fwrite(buffer, 1, 80, fp) == 80)
        ++i;

    printf("number of successful fwrites of 80 bytes = %d\n", i);
    return 0;
}

void iohdlr (int signum) {
    __amrc_type save_amrc;
    __amrc2_type save_amrc2;
    char filename[FILENAME_MAX];
    fldata_t info;

    save_amrc = *__amrc; /* need copy of __amrc structure */
    save_amrc2 = *__amrc2; /* need copy of __amrc2 structure */

    /* get name of file causing error from fldata */
    if (fldata(save_amrc2.__fileptr, filename, &info) == 0)
        printf("error on file %s\n", filename);
    perror("io handler"); /* give errno message */
    printf("lastop=%d syscode=%X rc=%d\n",
            save_amrc.__last_op,
            save_amrc.__code.__abend.__syscode,
            save_amrc.__code.__abend.__rc);

    signal(SIGIOERR, iohdlr);
}
```

Figure 36. Example of Using SIGIOERR (Part 2 of 2)
If you choose not to return from the handler, the file is still locked from all operations except fldata(), freopen(), or fclose(). The file is considered open and can prevent other incorrect access, such as an MVS sequential file opened more than once for a write. Like all other files, the file is closed automatically at program termination if it has not been closed explicitly already.

When you exit a SIGIOERR handler and do not return, the state of the file at closing is indeterminate. The state of the file is indeterminate because certain control block fields are not set correctly at the point of error and they do not get corrected unless you return from the handler.

For example, if your handler were invoked due to a truncation error and you performed a longjmp() out of your SIGIOERR handler, the file in error would remain open, yet inaccessible to all I/O functions other than fldata(), fclose(), and freopen(). If you were to close the file or it was closed at termination of the program, it is still likely that the record that was truncated will not appear in the final file.

You should be aware that for a standard stream passed across a system() call, the state of the file will be indeterminate even after you return to the parent program. For this reason, you should not jump out of a SIGIOERR handler. For further information on system() calls and standard streams, see Chapter 10, “Using C and C++ Standard Streams and Redirection” on page 87.

I/O with files other than the file causing the error is perfectly valid within a SIGIOERR handler. For example, it is valid to call printf() in your SIGIOERR handler if the file causing the error is not stdout. Comparing the incoming file pointer to the standard streams is not a reliable mechanism of detecting whether any of the standard streams are in error. This is because the file pointer in some cases is only a pointer to a file structure that points to the same __file as the stream supplied by you. The FILE pointers will not be equal if compared, but a comparison of the __file fields of the corresponding FILE pointers will be. See the stdio.h header file for details of type FILE.

If stdout or stderr are the originating files of a SIGIOERR, you should open a special log file in your handler to issue messages about the error.
This part describes z/OS C/C++ considerations about interlanguage calls in the z/OS Language Environment. For complete information about interlanguage calls (ILC) with z/OS C/C++ and z/OS Language Environment, refer to z/OS Language Environment Writing Interlanguage Communication Applications.

- Chapter 19, “Using Linkage Specifications in C or C++” on page 245
- Chapter 20, “Combining C or C++ and Assembler” on page 251
This section describes how you can make calls between C or C++ programs and assembler, COBOL, PL/I, or FORTRAN programs, or other C or C++ programs. For more complete information on making interlanguage calls to and from C or C++, see z/OS Language Environment Writing Interlanguage Communication Applications.

With XPLINK compilation, the linkage and parameter passing mechanisms for C and C++ are identical. If you link to a C function from a C++ program, you should still specify extern "C" to avoid name mangling. For more information about XPLINK, see z/OS Language Environment Programming Guide.

### Syntax for Linkage in C or C++
You can specify one of the following linkage types:

- **C**  
  C linkage (C++ only)

- **C++**  
  C++ linkage (C++ only, the default for C++)

- **COBOL**  
  Previously used for linkage to COBOL routines. Maintained for compatibility with COBOL/370 and VS COBOL II. With newer COBOL products, use the REFERENCE, OS, or C linkage type instead.

- **FORTRAN**  
  FORTRAN linkage

- **OS**  
  Operating System linkage

- **OS_DOWNSTACK**  
  XPLINK-enabled operating system linkage

- **OS_NOSTACK**  
  Minimal operating system linkage (for use with XPLINK)

- **OS_UPSTACK**  
  Complete operating system linkage (for use with XPLINK)

- **OS31_NOSTACK**  
  Same as OS_NOSTACK

- **PLI**  
  Maintained for compatibility with PL/I products prior to the VisualAge PL/I product. With newer PL/I products use the C linkage type instead.

- **REFERENCE**  
  A Language Environment reference linkage that has the same syntax and semantics with and without XPLINK. Unlike OS linkage, REFERENCE linkage is not affected by the OSCALL suboption of XPLINK. It is equivalent to OS_DOWNSTACK in XPLINK mode and OS_UPSTACK in non-XPLINK mode.

### Syntax for Linkage in C
You can create linkages between C and other languages by using linkage specifications with the following #pragma linkage directive:

`#pragma linkage(identifier, linkage)`

where *identifier* specifies the name of the function and *linkage* specifies the linkage associated with the function.
Syntax for Linkage in C++

You can create linkages between C++ and other languages by using linkage specifications with the following syntax:

```
extern "linkage" { [declaration-list] }
```

```
extern "linkage" declaration
```

```
declaration-list:
  declaration
  declaration-list declaration
```

where `linkage` specifies the linkage associated with the function. If z/OS C++ does not recognize the linkage type, it uses C linkage.

Kinds of Linkage used by C or C++ Interlanguage Programs

The following table describes the kinds of linkage used by C++ interlanguage programs.

<table>
<thead>
<tr>
<th>What calls or is called by a C or C++ program</th>
<th>Kind of linkage used</th>
<th>Description of linkage</th>
<th>C++ Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDDM, ISPF, or non-Language Environment conforming assembler</td>
<td>OS</td>
<td>Basic linkage defined by the operating system. OS Linkage allows integer, pointer, and floating point return types. Use of OS linkage with assembler is detailed in &quot;Specifying Linkage for C or C++ to Assembler&quot; on page 251.</td>
<td>extern &quot;OS&quot; { ... }</td>
</tr>
<tr>
<td>Language Environment conforming assembler, NOXPLINK-compiled C or C++ declared with OS linkage (or C linkage, passing each parameter as a pointer) is to be called from XPLINK-compiled C or C++. Cannot be used on a function definition in XPLINK-compiled code.</td>
<td>OS_UPSTACK</td>
<td>This is the same as OS linkage in NOXPLINK-compiled programs. It is declared this way by the caller when the caller is XPLINK-compiled. The compiler will call glue code to transition from the XPLINK caller to the non-XPLINK callee. Also see the OSCALL suboption of the XPLINK option in z/OS C/C++ User’s Guide.</td>
<td>extern &quot;OS_UPSTACK&quot; { ... }</td>
</tr>
<tr>
<td>Assembler which does not follow Language Environment conventions.</td>
<td>OS_NOSTACK, OS31_NOSTACK</td>
<td>The compiler does not generate any glue code for this call. It provides the called program with a 72-byte save area pointed to by Register 13, as does OS_UPSTACK, but the save area may not be initialized. In particular, the Language Environment Next Available Byte (NAB) field may not be present. On entry to the called function, Register 15 contains the entry point address and Register 14 contains the return address. Register 1 points to an OS-style argument list. Typically a program would declare an operating system or subsystem assembler routine with this linkage, where such a routine was not Language Environment enabled.</td>
<td>extern &quot;OS31_NOSTACK&quot; { ... }</td>
</tr>
<tr>
<td>What calls or is called by a C or C++ program</td>
<td>Kind of linkage used</td>
<td>Description of linkage</td>
<td>C++ Example</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------------</td>
<td>------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>XPLINK-compiled C or C++ using OS_DOWNSTACK linkage, or XPLINK-enabled assembler.</td>
<td>OS_DOWNSTACK</td>
<td>As with OS linkage in NOXPLINK-compiled C or C++, the parameters are passed by reference rather than by value. However, parameter and stack management use XPLINK conventions. Also see the OSCALL suboption of the XPLINK option in <a href="https://www.ibm.com/support/docview.wss?uid=swg21232865">z/OS C/C++ User's Guide</a>.</td>
<td>extern &quot;OS_DOWNSTACK&quot; { ... }</td>
</tr>
</tbody>
</table>
| The following programs, using by-reference parameter passing:  
  • XPLINK-compiled C/C++ programs calling XPLINK functions (C, C++, or Language Environment conforming assembler)  
  • NOXPLINK-compiled C/C++ programs calling NOXPLINK functions (C, C++, or Language Environment conforming assembler) | REFERENCE | This is the same as OS_DOWNSTACK linkage in XPLINK-compiled programs and OS_UPSTACK in NOXPLINK-compiled programs. Use this for Language Environment-conforming assembler linkage. | extern "REFERENCE" { ... } |
| PL/I | PLI | Modification of OS linkage. It forces the compiler to read and write parameter lists using PL/I linkage conventions. This linkage type extends OS linkage by allowing structures as return types. (When the return type is a structure, the caller allocates a buffer large enough to receive the returned structure and passes it, by reference, as a hidden final argument.) This linkage type is maintained for compatibility with PL/I products prior to the VisualAge PL/I product. With newer PL/I products use the C linkage type instead. | extern "PLI" { ... } |
What calls or is called by a C or C++ program | Kind of linkage used | Description of linkage | C++ Example
---|---|---|---
COBOL | COBOL | Forces the compiler to read and write parameter lists using COBOL linkage conventions. All calls from C++ to COBOL must be **void** functions.
This linkage type is maintained for compatibility with COBOL/370 and VS COBOL II. With newer COBOL products, you can call COBOL functions with the **REFERENCE** and **OS** linkage types, which allow integer return types. If the COBOL routine receives parameters by value (a pragmaless call), you can use the **C** linkage type.
`extern "COBOL" { ... }`

FORTRAN | FORTRAN | Forces the compiler to read and write parameter lists using **FORTRAN** linkage conventions.
`extern "FORTRAN" { ... }`

C | C | Use in C++ to force the compiler to read and write parameter lists using C linkage conventions. C code and the Data Window Services (DWS) product both use C linkage.
With XPLINK, C and C++ use the same linkage conventions. When this linkage is specified in C++ code, the specified function is known by its function name alone rather than its name and argument types. It cannot be overloaded.
`extern "C" { ... }`

---

**Using Linkage Specifications in C++**

In the following example, a function is prototyped in a piece of C++ code and uses, by default, C++ linkage.
```cpp
void CXX_FUNC (int); // C++ linkage
```

Note that C++ is case-sensitive, but PL/I, COBOL, assembler, and FORTRAN are not. In these languages, external names are mapped to uppercase. To ensure that external names match across interlanguage calls, code the names in uppercase in the C++ program, supply an appropriate `#pragma map` specification, or use the `NOLONGNAME` compiler option. This will truncate and uppercase names for functions without C++ linkage.

To reference functions defined in other languages, you should use a linkage specification with a literal string that is one of the following:
- `C`
- `COBOL`
- `FORTRAN`
- `OS`
- `OS_DOWNSTACK`
- `OS_NOSTACK`
For example:

```c
extern "OS" {
    int ASMFUNC1(void);
    int ASMFUNC2(int);
}
```

This specification declares the two functions ASMFUNC1 and ASMFUNC2 to have operating system linkage. The function names are case-sensitive and must match the definition exactly. You should also limit identifiers to 8 or fewer characters.

Use the reference type parameter (type&) in C++ prototypes if the called language does not support pass-by-value parameters or if the called routine expects a parameter to be passed by reference.

- z/OS C/C++ supports the long long type for FORTRAN linkage functions.
- A C or C++ signed long long int maps to a FORTRAN INTEGER.
- A C or C++ unsigned long long int maps to FORTRAN LOGIC.
- z/OS C/C++ does not support other non-C or C++ linkage functions.

**Note:** To have your program be callable by any of these other languages, include an extern declaration for the function that the other language will call.
This chapter describes how to communicate between z/OS C/C++ and assembler programs.

To write assembler code that can be called from z/OS C/C++, use the prolog and epilog macros described in this chapter. For more information on how the z/OS Language Environment works with assembler, see z/OS Language Environment Writing Interlanguage Communication Applications.

Access to z/OS UNIX is intended to be through the z/OS UNIX C/C++ extensions only. The z/OS C/C++ compiler does not support the direct use of z/OS UNIX callable services such as the assembler interfaces. You should not directly use z/OS UNIX callable services from your z/OS C/C++ application programs, because problems can occur with the processing of the following:

- Signals
- Library transfers
- fork()
- exec()
- Threads

There are comparable z/OS C/C++ functions for most z/OS UNIX callable services, and you should use those instead. Do not call assembler programs that access z/OS UNIX callable services.

Establishing the z/OS C/C++ Environment

Before you can call a C or C++ function from assembler, you must establish a suitable environment. To establish the environment, do one of the following:

- Call the assembler program from within the C or C++ program (from main() or another function). Since the assembler call is from within the C or C++ program, the environment has already been established. It is often simplest to call the assembler using OS linkage conventions.

  **Note:** In this chapter, “OS linkages” and “OS linkage” conventions refer to the following group of specifications: OS, OS_UPSTACK, OS_DOWNSTACK, OS_NOSTACK, OS31_NOSTACK and REFERENCE. “OS” is used in syntax diagrams and examples as a representative specification. These specifications use different stack conventions. For more information on these specifications, see Chapter 19, “Using Linkage Specifications in C or C++” on page 245.

- Use preinitialization to set up the z/OS Language Environment. See “Retaining the C Environment Using Preinitialization” on page 262 for information.

Once you are in the assembler program you can call other C or C++ programs from the assembler.

  **Note:** Under XPLINK, calling other C or C++ programs from the assembler is not supported.

Specifying Linkage for C or C++ to Assembler

The process for specifying the linkage to assembler differs for C and for C++. In C, a #pragma linkage directive is used, while in C++ a linkage specifier is used.
• Under C, a #pragma linkage directive enables the compiler to generate and accept parameter lists, using a linkage convention known as OS linkage. Although functionally different, both calling an assembler routine and being called by one are handled by the same #pragma. Its format is:

```c
#pragma linkage(identifier, OS)
```

where identifier is the name of the assembler function to be called from C or the C function to be called from assembler. The #pragma linkage directive must occur before the call to the entry point.

• Under C++, a linkage specifier enables the compiler to generate and accept parameter lists, using a linkage convention known as OS linkage. Although functionally different, both calling an assembler routine and being called by one are handled by the same linkage specifier. The format of the linkage specifier is:

```c
extern "OS" {
    fn1 desc;
    fn2 desc;
    ...
}
```

where fnx desc is the name of the OS entry point.

For C and C++: In XPLINK compiled code, the OS_UPSTACK and OS_NOSTACK (or OS31_NOSTACK) linkages are used for declaring the linkage convention of a routine that the C or C++ code is calling. You cannot define C or C++ entry points as having OS_NOSTACK linkage. You define C or C++ entry points with OS_UPSTACK linkage by compiling the translation units containing them with the NOXPLINK compiler option. In NOXPLINK compiled code, the OS_DOWNSTACK linkage is used to declare the linkage convention for a routine that the C or C++ code is calling. You define C or C++ entry points with OS_DOWNSTACK linkage by compiling the translation units containing them with the XPLINK compiler option.

Just as C (or C++) linkage programs can call OS linkage programs, OS linkage programs can call C linkage programs. An example of C linkage calling OS linkage, which in turn calls C linkage (in this case, one of the z/OS C/C++ library functions) is shown in Figure 38 on page 258.

In general, any type that can be passed between C and assembler can also be passed between C++ and assembler. However, if a C++ class that uses features not available to assembler (such as virtual functions, virtual base classes, private and protected data, or static data members) is passed to assembler, the results will be undefined.

Note: In C++, a structure is just a class declared with the keyword struct. Its members and base classes are public by default. A union is a class declared with the keyword union its members are public by default, and it holds only one member at a time.

Parameter List for OS Linkage

A parameter list for OS linkage is a list of pointers. The most significant bit of the last parameter in the parameter list is turned on by the compiler when the list is created.
If a parameter is an address-type parameter, the address itself is directly stored into the parameter list. Otherwise, a copy is created for a value parameter and the address of this copy is stored into the parameter list.

The type of a parameter is specified by the prototype of a function. In the absence of a prototype, the creation of a parameter list is determined by the types of the actual parameters passed to the function. Figure 37 shows an example of the parameter list for OS linkage.

In the list, the first and third parameters are value parameters, and the second is an address parameter.

```
R1
  ptr of P1 copy  P2  ptr of P3 copy  ...
  copy of P1  
  copy of P3  
```

Figure 37. Example of Parameter Lists For OS Linkages

**XPLINK Assembler**

The XPLINK support provided by the assembler macros EDCXPRLG and EDCXEPGLG allows XPLINK C and C++ code to call routines that can be coded for performance, or to perform a function that cannot be readily done in C/C++. There is no CALL macro support for calling other XPLINK routines from an XPLINK assembler routine. Most XPLINK assembler routines will be leaf routines that perform their function and return. (Leaf routines do not call any other functions.)

The following z/OS Language Environment books provide more information on XPLINK that may be useful to assembler programmers:

- [z/OS Language Environment Programming Guide](#) — provides an overview of XPLINK and what it means to the application programmer.
- [z/OS Language Environment Writing Interlanguage Communication Applications](#) — provides information on how assembler routines interact with routines coded in other high level languages.
- [z/OS Language Environment Debugging Guide](#) — provides details on XPLINK, including information on building parameter lists for calling other XPLINK routines.

Coding XPLINK assembler routines differs from traditional non-XPLINK assembler in the following ways:

- You use the EDCXPRLG and EDCXEPGLG macros for entry/exit code. These are documented in the section “Using Standard Macros” on page 255.
- You use the following XPLINK register conventions within the XPLINK assembler routine:
  - XPLINK parameter passing conventions: Registers 1, 2, and 3 are used to pass up to the first 3 integral values, and floating point registers will be used to pass floating point parameters.
XPLINK DSA format: Note that the stack register (reg 4) is “biased”. This means that you must add 2K (2048) to the stack register to get the actual start of the current routine’s DSA. The z/OS Language Environment mapping macro CEEDSA contains a mapping of the XPLINK DSA, including the 2K bias (CEEDSAH_BIAS). The caller’s registers are saved in the DSA obtained by the callee. The callee’s parameters (other than those passed in registers, if any), are built in the argument list in the callers DSA, and addressed there directly by the callee. There is no indirect access to the parameters via Register 1 as in OS linkage.

- While EDCXPRLG and EDCXEPLG allow Language Environment conforming XPLINK assembler routines to be written, another alternative for XPLINK C/C++ callers is to designate the linkage as OS31_NOSTACK. For more information on OS31_NOSTACK see Chapter 19, “Using Linkage Specifications in C or C++” on page 245. When the C/C++ caller designates the assembler routine as OS31_NOSTACK linkage, the assembler code can be written without using EDCXPRLG or EDCXEPLG (or any other Language Environment prolog or epilog macros). This can only be done when the assembler code has no dynamic stack storage requirements. With OS31_NOSTACK, standard OS linkage rules apply:
  - Register 1 will be used to point to the parameter list.
  - Register 13 will point to an 18 word savearea, provided to the callee for saving and restoring registers.
  - Register 14 will be the return address for branching back to the caller.
  - Register 15 will contain the address of the callee.

Table 32 shows the layout of the XPLINK interface.

<table>
<thead>
<tr>
<th></th>
<th><strong>Non-XPLINK</strong></th>
<th><strong>XPLINK</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack Pointer</td>
<td>Reg 13</td>
<td>Reg 4 (biased)</td>
</tr>
<tr>
<td>Return Address</td>
<td>Reg 14</td>
<td>Reg 7</td>
</tr>
<tr>
<td>Entry point on entry</td>
<td>Reg 15</td>
<td>Reg 6 (not guaranteed; a routine may be called via branch relative)</td>
</tr>
<tr>
<td>Environment</td>
<td>Reg 0 (writeable static)</td>
<td>Reg 5</td>
</tr>
<tr>
<td>CAA Address</td>
<td>Reg 12</td>
<td>Reg 12</td>
</tr>
<tr>
<td>Input Parameter List</td>
<td>address in R1</td>
<td>Located at fixed offset 64 (’40’x) into the caller’s stack frame (remember the 2K bias on R4). Additionally, any of General Registers 1, 2, and 3, and Floating Point Registers 0, 2, 4, and 6, may be used to pass parameters instead of the caller’s stack frame.</td>
</tr>
<tr>
<td>Return code</td>
<td>Reg 15</td>
<td>R3 (extended return value in R1,R2)</td>
</tr>
<tr>
<td>Start address of callee’s stack frame</td>
<td>Caller’s NAB value</td>
<td>Caller’s Reg 4 - DSA size</td>
</tr>
<tr>
<td>End address of callee’s stack frame</td>
<td>Caller’s NAB value + DSA size</td>
<td>Caller’s Reg 4</td>
</tr>
</tbody>
</table>
Table 32. Comparison of non-XPLINK and XPLINK Register Conventions (continued)

<table>
<thead>
<tr>
<th>Where caller's registers are saved</th>
<th>Non-XPLINK</th>
<th>XPLINK</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0-R12 saved in caller’s stack frame</td>
<td>R0 not saved, not preserved</td>
<td></td>
</tr>
<tr>
<td>R13 saved in callee’s stack frame</td>
<td>R1-R3 not saved, not preserved</td>
<td></td>
</tr>
<tr>
<td>R14-R15 saved in caller’s stack frame</td>
<td>R4 not saved, recalculated (or saved, restored)</td>
<td></td>
</tr>
<tr>
<td>R5 not saved, not preserved</td>
<td>R5 not saved, not preserved</td>
<td></td>
</tr>
<tr>
<td>R6 saved in callee’s stack frame, not restored</td>
<td>R7-R15 saved in callee’s stack frame (R7 is the return register and is not guaranteed to be restored)</td>
<td></td>
</tr>
</tbody>
</table>

See [z/OS Language Environment Vendor Interfaces](https://www.ibm.com/support/docview.wss?uid=swg27024054) for additional information about register usage and conventions, especially for details about passing parameters with XPLINK. For information on the registers which are saved in the register savearea of the XPLINK stack frame see [z/OS Language Environment Programming Guide](https://www.ibm.com/support/docview.wss?uid=swg27000000).

### Using Standard Macros

To communicate properly, assembler routines must preserve the use of certain registers and particular storage areas, in a way that is consistent with code from the C or C++ compiler. z/OS C/C++ provides macros for use with assembler routines. These macros are in CEE.SCEEMAC. The High-Level Assembler for MVS & VM & VSE must be used when assembling with these macros. The macros are:

- **EDCPRLG**: Generates the prolog for non-XPLINK assembler code
- **EDCEPIL**: Generates the epilog for non-XPLINK assembler code
- **EDCXPRLG**: Generates the prolog for XPLINK assembler code
- **EDCXEPLG**: Generates the epilog for XPLINK assembler code
- **EDCDSAD**: Accesses automatic memory in the non-XPLINK stack. For the XPLINK stack, use the **CEEDSA** macro, described in [z/OS Language Environment Programming Guide](https://www.ibm.com/support/docview.wss?uid=swg27000000).

EDCPROL, the old version of EDCPRLG, is shipped for compatibility with Version 1 of C/370 and is unchanged. However, you should use EDCPRLG if you can.

The advantage of writing assembler code using these macros is that the assembler routine will then participate fully in the z/OS C/C++ environment, enabling the assembler routine to call z/OS C/C++ functions. The macros also manage automatic storage, and make the assembler code easier to debug because the z/OS Language Environment control blocks for the assembler function will be displayed in a formatted traceback or dump. See [Debug Tool User's Guide and Reference](https://www.ibm.com/support/docview.wss?uid=swg21260000) for further information on z/OS Language Environment tracebacks and dumps.

**Note**: Only non-XPLINK Assembler code can call z/OS C/C++ functions.

### Non-XPLINK Assembler Prolog

Use the **EDCPRLG** macro to generate non-XPLINK assembler prolog code at the start of assembler routines.
name Is inserted in the prolog. It is used in the processing of certain exception conditions and is useful in debugging and in reading memory dumps. If name is absent, the name of the current CSECT is used.

USRDSAL=ulen Is used only when automatic storage (in bytes) is needed. To address this storage, see the EDCDSAD macro description. The ulen value is the requested length of the user space in the DSA.

BASEREG=register Designates the required base register. The macro generates code needed for setting the value of the register and for establishing addressability. The default is Register 3. If register equals NONE, no code is generated for establishing addressability.

DSALEN=dlen Is the total requested length of the DSA. The default is 120. If fewer than 120 bytes are requested, 120 bytes are allocated. If both dlen and ulen are specified, then the greater of dlen or ulen+120 is allocated. If DSALEN=NONE is specified, no code is generated for DSA storage allocation, and R13 will still point to the caller’s DSA. Therefore, you should not use the EDCEPIL macro to terminate the assembler routine. Instead, you have to restore the registers yourself from the current DSA. To do this, you can use an assembler instruction such as

```
LM 14,12,12(R13)
BR 14
```

You should not use EDCDSAD to access automatic memory if you have specified DSALEN=NONE, since DSECT is addressable using R13.

**Non-XPLINK Assembler Epilog**

Use the EDCEPIL macro to generate non-XPLINK assembler epilog code at the end of assembler routines. Do not use this macro in conjunction with an EDCPRLG macro that specifies DSALEN=NONE.

name Is the optional name operand, which then becomes the label on the exit from this code. The name does not have to match the prolog.

**XPLINK Assembler Prolog**

Use the EDCXPRLG macro to generate XPLINK assembler prolog code at the start of assembler routines.
name If EN Ti NAME=epname is specified then name is used as the name of the XPLINK entry marker, else name is the name of the entry point and name#C is used as the name of the XPLINK entry marker.

DSASIZE=len Specifies automatic storage requirements (in bytes). Specify a len of 0 if the XPLINK assembler routine is a leaf routine with no automatic storage requirements. XPLINK leaf routines must preserve registers 4, 6, and 7 throughout their execution. This is a required parameter, the minimum size of an XPLINK DSA (80 bytes) or more must be specified if DSASIZE is not zero.

PARMWRDS=numwrds Specifies the number of 4-byte words in the input parameter list. If this is omitted, then the routine will be treated as vararg, and it will adversely affect performance if the call to this routine results in a stack overflow.

ENTNAME=epname Is the optional name of the XPLINK assembler routine entry point.

BASEREG=register Designates the required base register. The macro generates code needed for setting the value of the register and for establishing addressability. The default is register 8. If register equals NONE, no code is generated for establishing addressability.

PSECT=pname Is the name to be assigned to the XPLINK assembler routine PSECT area. For more information about the PSECT area see HLASM Language Reference.

GT2KSTK=YES If GT2KSTK=YES is specified, then an unconditional "large stack frame" prolog will be used that checks for the XPLINK stack floor in the CAA, instead of depending on the write-protected guard page. This parameter must be specified if the len on the DSASIZE parameter is greater than 2048 (ie. 2K).

**XPLINK Assembler Epilog**

Use the EDCXEPLG macro to generate XPLINK assembler epilog code at the end of assembler routines. This macro must always be used with a matching EDCXPRLG macro, even if the EDCXPRLG macro specified DSASIZE=0.

name Is the optional name operand, which then becomes the label on the exit from this code. The name does not have to match the prolog.

**Accessing Automatic Memory in the Non-XPLINK Stack**

Use the EDCDSAD macro to access automatic memory in the non-XPLINK stack. Automatic memory is reserved using the USRDSAL, or the DSALEN operand of the
The EDCPRLG macro. The length of the allocated area is derived from the `ulen` and/or `dlen` values specified on the EDCPRLG macro. EDCDSAD generates a DSECT, which reserves space for the stack frame needed for the C or C++ environment.

`name` is the optional name operand, which then becomes the name of the generated DSECT.

The DSECT is addressable using Register 13. Register 13 is initialized by the prolog code. If you have specified `DSALEN=NONE` with EDCPRLG you should not use EDCDSAD.

The Language Environment mapping macro CEEDSA can be used to map a DSA, either non-XPLINK or XPLINK or both.

There are other SECTYPE operands. `SECTYPE=XPLINK` will only produce an XPLINK DSA mapping. For more information on CEEDSA see z/OS Language Environment Programming Guide.

### Calling C Code from Assembler — C Example

The following C example shows how to call C code from assembler. This example is non-XPLINK only. XPLINK assembler cannot call C functions. There are three parts to this example. The first part, shown in Figure 38, is a trivial C routine that establishes the C run-time environment.

#### CCNGCA4

```c
/* this example demonstrates C/Assembler ILC */
/* part 1 of 3 (other files are CCNGCA2, CCNGCA5) */
#pragma linkage(CALLPRTF, OS)

int main(void) {
    CALLPRTF();
    return(0);
}
```

*Figure 38. Establishing the C Run-Time Environment*

The second part of the example, shown in Figure 39 on page 259, is the assembler routine. It calls an intermediate C function that invokes a run-time library function.
Finally, the intermediate C routine calls a run-time library function as shown in Figure 40.

```
/* this example demonstrates ILC with Assembler-part 2 of 3
CALLPRTF CSECT
EDCPRLG
   LA 1,ADDR_BLK    parameter address block in r1
   L 15,=V(@PRINTF4) address of routine
   BALR 14,15 call it
EDCEPIL
ADDR_BLK   DC A(FMTSTR)    parameter address block with..
            DC A(X'80000000'+INTVAL) ..high bit on the last address
FMTSTR     DC CSample formatting string'
            DC C'which includes an int -- %d --'
            DC AL1(NEWLINE,NEWLINE)
            DC C'and two newline characters'
            DC A1(NULL)
*
INTVAL     DC F'222'        The integer value displayed
*
NULL       EQU X'00'       C NULL character
NEWLINE    EQU X'15'       C \n character
END
```

**Figure 39. Calling an Intermediate C Function from Assembler OS Linkage**

Finally, the intermediate C routine calls a run-time library function as shown in Figure 40.

```
/* this example demonstrates C/Assembler ILC */
/* part 3 of 3 (other files are CCNGCA2, CCNGCA4) */
/*******************/
* This routine is an interface between assembler code *
* and the C/C++ library function printf(). *
* OS linkage will not tolerate C-style variable length *
* parameter lists, so this routine is specific to a *
* formatting string and a single 4-byte substitution *
* parameter. It's specified as an int here. *
*/
#pragma linkage(_printf4,OS) /*function will be called from assembler*/
#include <stdio.h>
#pragma map(_printf4,"PRINTF4")
int _printf4(char *str,int i) {
   return printf(str,i);       /* call run-time library function */
}
```

**Figure 40. Intermediate C Routine Calling a Run-Time Library Function**
Calling Run-Time Library Routines from Assembler — C++ Example

The following C++ example shows how to call library routines from assembler. There are three parts to this example. The first part shown in [Figure 41] is a trivial C/C++ routine that establishes the C/C++ run-time environment. It uses extern OS to indicate the OS linkage and calls the assembler routine.

**CCNGCA1**

```c
// this example demonstrates C++/Assembler ILC
// part 1 of 3 (other files are CCNGCA2, CCNGCA3)

extern "OS" int CALLPRTF(void);

int main(void) {
    CALLPRTF();
}
```

*Figure 41. Establishing the C/C++ Run-Time Environment*

The second part of this example, shown in [Figure 42] is the assembler routine. It calls an intermediate C/C++ routine that invokes a run-time library function.

**CCNGCA2**

```assembly
* this example demonstrates ILC with Assembler (part 2 of 3)

CALLPRTF CSECT
EDCPRLG
LA 1,ADDR_BLK parameter address block in r1
L 15,=V(@PRINTF4) address of routine
BALR 14,15 call it
EDCEPIL

ADDR_BLK DC A(FMTSTR) parameter address block with..
   DC A(X'80000000'+INTVAL) ..high bit on the last address

FMTSTR DC C'Sample formatting string'
   DC C' which includes an int -- %d --'
   DC AL1(NEWLINE,NEWLINE)
   DC C'and two newline characters'
   DC AL1(NULL)

* INTVAL DC F'222' The integer value displayed
* NULL EQU X'00' C NULL character
NEWLINE EQU X'15' C \n character
END
```

*Figure 42. Calling an Intermediate C/C++ Function from Assembler using OS Linkage*

The third part of the example, shown in [Figure 43 on page 261] is an intermediate C/C++ routine that calls a run-time library function.
Register Content at Entry to a Non-XPLINK ASM Routine Using OS linkage

When control is passed to an assembler routine that uses OS linkage, the contents of the registers are as follows:

<table>
<thead>
<tr>
<th>Register</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>Undefined.</td>
</tr>
<tr>
<td>R1</td>
<td>Points to the parameter list. The parameter list consists of a vector of addresses, each of which points to an actual parameter. The address of the last parameter has its high-order bit set on, to indicate the end of the list.</td>
</tr>
<tr>
<td>R2 to R11</td>
<td>Undefined.</td>
</tr>
<tr>
<td>R12</td>
<td>Points to an internal control block. It can be used by the called routine but must be restored to its entry value if it calls a routine that expects z/OS Language Environment.</td>
</tr>
<tr>
<td>R13</td>
<td>Points to the caller’s DSA. Part of the DSA is used by EDCPRLG and EDCEPIL to save and restore registers. EDCPRLG can change R13 so that it points to the called routine's DSA from the caller's DSA.</td>
</tr>
<tr>
<td>R14</td>
<td>The return address.</td>
</tr>
<tr>
<td>R15</td>
<td>The address of the entry point being called.</td>
</tr>
</tbody>
</table>

Register Content at Exit from a Non-XPLINK ASM Routine to z/OS C/C++

Registers have the following content when control returns to the point of call:

<table>
<thead>
<tr>
<th>Register</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>Undefined.</td>
</tr>
<tr>
<td>R1</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>
R2 to R13 Must be restored to entry values. This is done by EDCEPIL and EDCPRLG.

R14 Return address.

R15 Return value for integer types (long int, short int, char) and pointer types. Otherwise set to 0.

FP0 Returns value for float or double parameters.

FP0 Returns value if long double is passed.

FP2 Returns value if long double is passed.

Note: When in FLOAT(AFP) mode the callee must save and restore FPR’s 8 through 15.

All other floating point registers are undefined.

Retaining the C Environment Using Preinitialization

If an assembler routine called the same C or C++ program repeatedly, the creation and termination of the C/C++ environment for each call would be inefficient. The solution is to create the C/C++ environment only once by preinitializing the C or C++ program. The Language Environment preinitialization services are the strategic form of preinitialization. For information on the Language Environment preinitialization services, see z/OS Language Environment Programming Guide. This section discusses the z/OS C preinitialization interface only for reasons of compatibility.

Notes:
1. This information pertains only to users of C programs.
2. XPLINK applications are not supported under Preinitialized Compatibility Interface (PICI) environments.

Under the z/OS Language Environment, you should use the callable service CEEPIPI instead of preinitializing the environment for your applications. For more information about this service, see z/OS Language Environment Writing Interlanguage Communication Applications.

If you are calling a C program multiple times from an assembler program, you can establish the C environment and then repeatedly invoke the C program using the already established C environment. You incur the overhead of initializing and terminating the C environment only once instead of every time you invoke the C program.

Because C detects programs that can be preinitialized dynamically during initialization, you do not have to recompile the program or link-edit it again.

To maintain the C environment, you start the program with the C entry CEESTART, and pass a special Extended Parameter List that indicates that the program is to be preinitialized.

When you use preinitialization, you are initializing the library yourself with the INIT call and terminating it yourself with the TERM call. In a non-preinitialized program, the library closes any files you left open and releases storage. It does not do this in a preinitialized program. Therefore, for every invocation of your preinitialized program, you must release all allocated resources as follows:

- Close all files that were opened.
• Free all allocated storage
• Release all fetched modules

If you do not release all allocated resources, you will waste memory.

Setting Up the Interface for Preinitializable Programs

The interface for preinitializing programs is shown in Figure 44.
The LL field is a halfword containing the value of 16. The halfword that follows must contain 0 (zero).

The Request field is 8 characters that can contain:

'INIT '

Initializes the C environment and, returns two tokens that represent the...
environment, but does not run the program. Token 1 and token 2 must both have the value of zero on an INIT call; otherwise, preinitialization fails.

You can initialize only one C environment at a time. However, you can make the sequence of calls to INIT, CALL, and TERM more than once.

'CALL'

Runs the C program using the environment established by the INIT request, and exits from the environment when the program completes. The CALL request uses the two tokens that were returned by the INIT request so that C can recognize the proper environment.

You can also initialize and call a C program by passing the CALL parameter with two zero tokens. The C program processes this request as an INIT followed by a CALL. You can still call the program repeatedly, but you should pass the two zero tokens only on the first call. Once the C environment is initialized, the values of the tokens are changed, and must not be modified on any subsequent calls.

Calling a C program other than the one used to initialize the C environment is not supported, especially if write-able static is needed by the program being called. This is because write-able static was allocated and initialized based upon the program used to initialize the C environment.

'TERM'

Terminates the C environment but does not run the program.

The program used to terminate the C environment should be the same as the program used to initialize the C environment. Usage of a different program to terminate the C environment is unsupported.

'EXECUTE'

Performs INIT, CALL, and TERM in succession.

No other value is valid.

The Extended PLIST address field is a pointer to the Extended Parameter List (EPL). The EPL is a vector of fullwords that consists of:

Length of Extended Parameter List
The length includes the 4 bytes for the length field. Valid decimal values are 20, 28, and 32.

First and Second C Environment Tokens
These tokens are automatically returned during initialization; or, you can use zeros for them when requesting a preinitialized CALL, and the effect is that both an INIT and a CALL are performed.

Pointer to Your Program Parameters
The layout of the parameters is shown in Figure 44 on page 264. Interface for Preinitialization Programs. If no parameter is specified, use a fullword of zeros.

Pointer to Your Run-Time Options
To point to the character string of run-time options, refer to Figure 44. The character string consists of a halfword LL field that contains the length of the list of run-time options, followed by the actual list of run-time options.

Pointer to an Alternative Main
This field is not supported in C. However, if you want to use the seventh or eighth fields, use a full word of zeros as a place holder.
Pointer to the Service Vector

If you want certain services (such as load and delete) to be carried out by other code supplied by you (instead of, for example, by the LOAD and DELETE macros), use this field to point to the service vector. See Figure 44 on page 264.

Request Modifier Code

When your request is INIT, CALL, or EXECUTE, you can specify any of the following request modifier codes:

0  Does not change the request.
1  Loads all common library modules as part of the preinitialized environment.
2  Loads all common and C library modules as part of the preinitialized environment.
3  Reinitializes the environment. If the environment is already established, frees all HEAP storage and any ISA overflow segments.
   Do not use this code if subsequent calls depend on storage that is still being allocated by previous calls.
4  Allows you to create more than one environment. The new environment is chained with existing request modifier 4 environments or a batch environment, where possible, so that C memory file sharing among the environments is possible. Details on chaining and C memory file sharing support are covered in "Preinitialization Compatibility Interface C Environments" on page 274.
   The user-supplied service routine vector is not supported when you use request modifier value 4 in the extended parameter list. Do not code this if you are using the service routine vector. If you do, an abnormal end will occur.
5  Allows you to create more than one environment. The new environment is separated from other environments which may already exist. This environment does not support sharing of C memory files with other preinitialization compatibility interface environments.

When your request is TERM, you can specify either of the following request modifier codes:

0  Does not change the request.
1  Forces termination. Ends the C environment without any of the usual checks.
   Code this field only when you cannot request normal termination.
   You must ensure that the environment you are forcing to end is not in use.

The length you specify in the first field of the extended parameter list makes it known whether you have specified a request modifier code or not.

Run-Time options are applied only at initialization and remain until termination. You must code PLIST(MVS) in the called C program in order for the preinitialization to work.
The options ARGPARSE|NOARGPARSE have no effect on preinitialized programs. The assembler program has to provide parameters in the form expected by the C program. Thus, if the C program is coded for the NOARGPARSE option, the argc should be set to 2, and parameters passed as a single string.

Preinitializing a C Program

A preinitialized C program is displayed in Figure 45 on page 268 which shows how to:

- Establish the C environment using an INIT request
- Pass run-time parameters to the C initialization routine
- Set up a parameter to the C program
- Repeatedly call a C program using the CALL request
- Communicate from the C program to the driving program using a return code
- End the C program using the TERM request

The example C program is very simple. The parameters it expects are the file name in argv[1] and the return code in argv[2]. The C program printf()s the value of the return code, writes a record to the file name, and decrements the value in return code.

The assembler program that drives the C program establishes the C environment and repeatedly invokes the C program, initially passing a value of 5 in the return code. When the return code set by the C program is zero, the assembler program terminates the C environment and exits.

The program in Figure 45 on page 268 does not include the logic that would verify the correctness of any of the invocations. Such logic is imperative for proper operations.
CCNGCA6

CCNGCA6 TITLE 'TESTING PREINITIALIZED C PROGRAMS'
******************************************************************************************
*** this example shows how to preinitialize a C program
*** part 1 of 3 (other files are CCNGCA7 and CCNGCA8)
*** Function: Demonstrate the use of Preinitialized C programs
*** Requests used: INIT, CALL, TERM
*** Parameters to C program: FILE_NAME, RUN_INDEX
*** Return from C Program: RUN_INDEX
******************************************************************************************
CCNGCA6 CSECT
CCNGCA6 RMODE ANY
CCNGCA6 AMODE ANY
    EXTRN CEESTART C Program Entry
    STM R14,R12,12(R13) Save registers
    BALR R3,0 Set base register
    USING *,R3 Establish addressability
    ST R13,SVAR+4 Set back chain
    LA R13,SVAR Set this module's save area

******************************************************************************************
*** Initialize
******************************************************************************************
    P_INIT DS 0H
    MVC P_RQ,INIT Set INIT as the request
    LA R1,PALIPT Load Parameter pointer
    L R15,CEP Load C Entry Point
    BALR R14,R15 Invoke C Program

******************************************************************************************
*** The C environment has been established.
*** Parameters include RUN_INDEX which will be counted down
*** by the C program. When the RUN_INDEX is zero, termination
*** will be requested.
*** The following code will set up C program parameters and
*** CALL request, invoke the C program and test for termination.
******************************************************************************************
    LA R1,PGPAPT Pointer to C program parameters
    ST R1,EP_PGP... to extended parameter list
    DO_CALL DS 0H
    MVC P_RQ,CALL set up CALL request
    LA R1,PALIPT set parameter pointer
    L R15,CEP set entry point
    BALR R14,R15 invoke C program
    L R0,RUN_INDEX Test Return Code
    LTR R0,R0
    BNZ DO_CALL Repeat CALL

Figure 45. Preinitializing a C Program (CCNGCA6) (Part 1 of 3)
*** C requested termination.
*** Set up TERM request and terminate the environment

**DO_TERM** DS 0H
MVC P_RQ,TERM set up TERM request
SR R1,R1 mark no parameters
ST R1,EP_PGPA
LA R1,PALIPT set parameter pointer
L R15,CEP set entry point
BALR R14,R15 invoke termination

*** Return to system

**XIT** DS 0H
L R13,4(13)
LM R14,R12,12(13)
BR R14

*** Constants and work areas

**VARCON** DS 0D
PALIPT DC A('X'80000000'+PALI) Address of Parameter list
CEP DC A(CEESTART) Entry point address

**PALI** DS 0F Parameter list
_P_LG DC H'16' Length of the list
DC H'0' Must be zero
P_RQ DC CLB ' ' Request - INIT, CALL, TERM, EXECUTE
P_EP_PT DC A(EPALI) Address of extended plist

**EPALI** DS 0F Extended Parameter list
EP_TCA DC A(0) First token
EP_PRV DC A(0) Second token
EP_PGPA DC A(PGPAPT) Address of C program plist
EP_XOPT DC A(XOPTPT) Address of run-time options
EP_LG EQU *-EPALI Length of this list

*** C program plist in argc, argv format

PGPAPT DC F'3' Number of parameters (argc)
DC A(PGVPTPT) parameter vector pter (argv)
PGVTPT DS 0A Parameter Vector
DC A(PGNM) Program name pointer (argv1)
DC A(FILE_NAME) File name pointer (argv2)
DC A(RUN_INDEX) Run index pointer (argv3)
DC X4'00000000' NULL pointer

Figure 45. Preinitializing a C Program (CCNGCA6) (Part 2 of 3)
The program shown in Figure 46 on page 271 shows how to use the preinitializable program.
CCNGCA7

/* this example shows how to use a preinitializable program */
/* part 2 of 3 (other files are CCNGCA6 and CCNGCA8) */

#pragma runopts(PLIST(MVS))
#include <stdio.h>
#include <stdlib.h>
#define MAX_MSG 50
#define MAX_FNAME 8
typedef int (*f_ptr)(int, char*); /* pointer to function returning int*/

int main(int argc, char **argv)
{
    FILE *fp; /* File to be written to */
    int *ptr_run; /* Pointer to the "run index" */
    char *ffmsg; /* a pointer to the "fetched function msg"*/
    char fname[MAX_FNAME+1]; /* name of the function to be fetched */
    int fetch_rc; /* Return value of function invocation */
    f_ptr fetch_ptr; /* Function pointer to fetched function */

    /* Get the pointer to the "run index" */
    ptr_run = (int *)argv[2];

    if ((fp = fopen(argv[1],"a")) == NULL)
    {
        printf("Cannot open file %s\n",argv[1]);
        *ptr_run = 0; /* Set to zero so it won’t be called again */
        return(0); /* Return to Assembler program */
    }

    /* Write the record to the file */
    fprintf(fp,"Run index was %d\n",*ptr_run);

    /* Allocate the message returned from the fetched function */
    if (( ffmsg=(char *)malloc(MAX_MSG + 1)) == NULL )
    printf("ERROR -- malloc returned NULL\n");

    /* fetch the function */
    fetch_ptr = (f_ptr) fetch("MYFUNC");
    if (fetch_ptr == NULL)
    printf("ERROR - Fetch returned a null pointer\n");

    /* execute the function */
    fetch_rc = fetch_ptr(*ptr_run, ffmsg);

    /* Figure 46. Using the Preinitializable Program (CCNGCA7) (Part 1 of 2) */
Return Codes
Preinitialized programs do not put their return codes in R15. If the address of the return code is required, specify a parameter. Figure 45 on page 268 shows how you can use the RUN_INDEX parameter to evaluate the address of a return code.

User Exits in Preinitializable Programs
C invokes user exits when initialization and termination are actually performed. That is, the initialization user exit is invoked during the INIT request or the CALL with the zero token request. Similarly, the termination user exit is called only during the TERM request.

Run-Time Options
If run-time options are specified in the assembler program, the C program must be compiled with EXECOPS in effect. EXECOPS is the default.

Calling a Preinitializable Program
Figure 48 on page 273 shows sample JCL to run a preinitializable program in the z/OS environment.
Figure 48. JCL for Running a Preinitializable C Program (Part 1 of 2)
Multiple Preinitialization Compatibility Interface C Environments

To establish multiple Preinitialized Compatibility Interface (PICI) environments, you must specify either request modifier 4 or request modifier 5 in the extended parameter list (EPL) at environment initialization.

Request Modifier 4 Environment Characteristics

Use request modifier 4 to establish an environment which is tolerant of an existing environment. When a request modifier 4 environment is dormant, it is immune to creation or termination of other environments.

Environments created using request modifier 4 normally intend to share C memory files, but it is not required for the application to take advantage of this support. A new environment of this type is chained to the currently active environment that supports chaining, or it will set up a dummy environment which supports chaining. This allows for C memory files to be shared.

The sharing of C memory files across request modifier 4 environments is only supported within the boundary of the application. There are really only two types of applications where request modifier 4 environments are involved. The first type is a set of pure request modifier 4 environments; there are no batch environments. The second type allows a single batch environment. In the second type, the batch environment must be the first initialized and the last terminated.

If starting with non z/OS Language Environment enabled assembler, the first request modifier 4 environment creates a dummy environment (z/OS Language Environment region-level control blocks) in addition to its own. The dummy

Figure 48. JCL for Running a Preinitializable C Program (Part 2 of 2)
environment remains pointed to by the TCB when the initialization is complete. The next initialization using request modifier 4 recognizes an existing environment that supports chaining and the new environment will be chained. This permits the two environments to share C memory files. Request modifier 4 environments in this model can be initialized and terminated in any order.

If starting with a batch environment (for example, COBOL, PL/I or C), which supports chaining by default, and during execution within that environment a call is made to an assembler routine which initializes a request modifier 4 environment, the z/OS Language Environment batch environment is recognized and the new environment will be chained. This allows an initial batch environment to share C memory files with the request modifier 4 environment. Request modifier 4 environments in this model can be initialized and terminated in any order, but all request modifier environments must be terminated before the batch environment is terminated.

Notes:

1. When a batch environment is chained with request modifier 4 environments, the z/OS Language Environment batch environment must be the first environment that is initialized and the last environment that is terminated. All request modifier 4 environments initialized within the scope of a batch environment must be terminated prior to exiting the batch environment. Failure to do so will leave the request modifier 4 environments in a state such that attempted call or termination requests will result in unpredictable behavior.

2. Initialization of a request modifier 4 environment while running in a non-sharable environment, such as a request modifier 5 environment, causes the new request modifier 4 environment to be non-sharable.

Sharing C Memory Files with Request Modifier 4 Environments: You can use request modifier 4 to create multiple Preinitialized Compatibility Interface (PICI) C environments. When you create a new request modifier 4 environment, it is chained under certain circumstances to the current environment.

The following list identifies the specific features that are or are not supported in the multiple PICI C environment scenario:

- C memory files will be shared across all C environments (as long as at least one C environment exists) that are on the chain. This includes all PICI C environments that are initialized and possibly an initial batch C environment.

- Because the PICI C environments are chained, initialization and termination of these PICI C environments can be performed in any order. The chaining also requires that the C run-time library treat each PICI C environment as equal. In C run-time library terms, each PICI C environment is considered a root enclave (depth=0).

- Because there can be multiple C root enclaves, sharing of C standard streams across the C root enclaves exhibits a special behavior. When a C standard stream is referenced for the first time, its definition is made available to each of the C root enclaves.

- C standard streams are inherited across the system() call boundary. When a PICI C environment is initialized from a nested enclave, it does not inherit the standard streams of the nested enclave. Instead, it shares the C standard stream definitions at the root level.

- C regular (nonmemory, nonstandard stream) files are also shared across the PICI C environments.

- Nested C enclaves are created using the system() call. The depth is relative to the root enclave that owns the system() call chain. You can have two C
enclaves, other than the C root enclaves, with the same depth. You can do this by calling one of the PICI C environments from a nested enclave and then using `system()` in the PICI C environment.

- C regular (nonmemory, nonstandard stream) files opened in a `system()` call enclave are closed automatically when the enclave ends.
- C regular (nonmemory, nonstandard stream) files that are opened in a PICI C environment root enclave are not closed automatically until the PICI C environment ends. Before returning to the caller, you should close streams that are opened by the PICI C environment. If you do not, undefined behavior can occur.
- C memory files are not removed until the last PICI C environment is ended.
- The `clrmemf()` function will only remove C memory files created within the scope of the C root enclave from which the function is called.
- When a PICI C environment is called, flushing of open streams is not performed automatically as it is when you use the `system()` call.
- This function is not supported under CICS.
- This function is not supported under System Programming C (SP C).
- Use of `POSIX(ON)` is not supported with this feature.

**Request Modifier 5 Environment Characteristics**

Use request modifier 5 to establish an environment which is tolerant of an existing environment. When a request modifier 5 environment is dormant, it is immune to creation or termination of other environments.

Request modifier 5 environments cannot share C memory files with other environments. Each environment of this type is created as a separate entity, not connected to any other environment. Request modifier 5 environments can be initialized and terminated in any order.

**Restrictions on Using batch Environments with Preinitialization Compatibility Interface C Environments**

If a batch environment is to participate in C memory file sharing, such as with a request modifier 4 environment, then the batch environment must be the first environment created and the last one terminated. All PICI environments initialized within the scope of the batch environment must be terminated before the batch environment is terminated. This is required because the PICI environment shares control blocks that belong to the batch environment. If the batch environment is terminated, storage for those control blocks is released. Attempts to use or terminate a PICI environment after the batch environment has terminated will result in unpredictable behavior.

**Behaviors When Mixing Request Modifier 4 and Request Modifier 5**

While running in a request modifier 5 environment, initializing another environment with request modifier 4 creates a new environment that is separated from the rest. The new environment will not be able to share C memory files with any other request modifier 4 environment that may already exist.

While running in a request modifier 4 environment, initialization of a request modifier 5 environment creates a new environment that is separated from the rest. If the new request modifier 5 environment is within the scope of a batch environment, this new environment does not need to be terminated before the batch environment is terminated.
Using the Service Vector and Associated Routines

The service vector is a list of addresses of user-supplied service routines. The interface requirements for each of the service routines that you can supply, including sample routines for some of the services, are provided in the following sections.

Using the Service Vector

If you want certain services like load and delete to be carried out by other programs supplied by you (instead of, for example, by the LOAD and DELETE macros), you must place the address of your service vector in the seventh fullword field of the extended parameter list. Define the service vector according to the pattern shown in the following example:

```
SRV_COUNT DS F Count of fields defined
SRV_USER_WORD DS F User-defined word
SRV_WORKAREA DS A Addr of work area for DSAs etc
SRV_LOAD DS A Addr of load routine
SRV_DELETE DS A Addr of delete routine
SRV_GETSTOR DS A Addr of get-storage routine
SRV_FREESTOR DS A Addr of free-storage routine
SRV_EXCEP_RTR DS A Addr of exception router
SRV_ATTN_RTR DS A Addr of attention router
SRV_MSG_RTR DS A Addr of message router
```

Although you need not use labels identical to those above, you must use the same order. The address of your load routine is “fourth”, and the address of your free-storage routine is “seventh”.

Some other constraints apply:

- You cannot omit any fields on the template that precede the last one you specify from your definition of the service vector. You can supply zeros for the ones you want ignored.
- The field count does not count itself. The maximum value is therefore 9.
- You must specify an address in the work area field if you specify addresses in any of the subsequent fields.
- This work area must begin on a doubleword boundary and start with a fullword that specifies its length. This length must be at least 256 bytes.
- For the load and delete routines, you cannot specify one of the pair without the other; if one of these two fields contains a value of zero, the other is automatically ignored. The same is true for the get-storage and free-storage pair.
- If you specify the get-storage and free-storage services, you must also specify the load and delete services.

You must supply any service routines pointed to in your service vector. When called, these service routines require the following:

- Register 13 points to a standard 18–fullword save area.
- Register 1 points to a list of addresses of parameters available to the routine.
- The third parameter in the list must be the address of the user word you specified in the second field of the service vector.

The parameters available to each routine, and the return and reason codes that each routine uses, are shown in the following section. The parameter addresses are passed in the same order in which the parameters are listed.
Load Service Routine
The load routine loads named modules. The LOAD macro usually provides this service.

The parameters passed to the load routine are shown in Table 33.

Table 33. Load Service Routine Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address of module name</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Length of name</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>User word</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>(Reserved field)</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Address of load point</td>
<td>DS A</td>
<td>Output</td>
</tr>
<tr>
<td>Size of module</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

The name length must not be zero. You can ignore the reserved field. It will contain zeros.

The load routine can set the following return/reason codes:

- 0/0     successful
- 4/4     unsuccessful — module loaded above line when in AMODE 24
- 8/4     unsuccessful — load failed
- 16/4    unrecoverable error occurred

Delete Service Routine
The delete routine deletes named modules. The DELETE macro usually provides this service.

The parameters passed to the delete routine are shown in Table 34.

Table 34. Delete Service Routine Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address of module name</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Length of name</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>User word</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>(Reserved field)</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

The name length must not be zero. You can ignore the reserved field. It will contain zeros. Every delete action must have a corresponding load action, and the task that does the load must also do the delete. Counts of deletes and loads performed must be maintained by the service routines.

The delete routine can set the following return/reason codes:
The get-storage routine obtains storage. The GETMAIN macro usually provides this service.

The parameters passed to the get-storage routine are shown in Table 35.

Table 35. Get-Storage Service Routine Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount desired</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Subpool number</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>User word</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Flags</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Address of obtained storage</td>
<td>DS A</td>
<td>Output</td>
</tr>
<tr>
<td>Amount obtained</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

The get-storage routine can set the following return/reason codes:

0/0    successful
8/4    unsuccessful — delete failed
16/4   unrecoverable error occurred

The free-storage routine frees storage. The FREEMAIN macro usually provides this service.

The parameters passed to the free-storage routine are shown in Table 36.

Table 36. Free-Storage Service Routine Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount to be freed</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Subpool number</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>User word</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Address of storage</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

The free-storage routine can set the following return/reason codes:

0/0    successful
16/4   unrecoverable error occurred
Exception Router Service Routine

The exception router traps and routes exceptions. The ESTAE and ESPIE macros usually provide this service.

The parameters passed to the exception router are shown in Table 37.

Table 37. Exception Router Service Routine Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address of exception handler</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Environment token</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>User word</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Abend flags</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Check flags</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

During initialization, if the ESTAE and/or ESPIE options are in effect, the common library puts the address of the common library exception handler in the first field of the above parameter list, and sets the environment token field to a value that is passed on to the exception handler. It also sets abend and check flags as appropriate, and then calls your exception router to establish an exception handler.

The meaning of the bits in the abend flags are given by the following structure:

```c
struct {
    struct {
        unsigned short abends : 1, /*control for system abends*/
        reserved : 15;
    } system;
    struct {
        unsigned short abends : 1, /*control for user abends*/
        reserved : 15;
    } user;
} abendflags;
```

The meaning of the bits in the check flags are given by the following structure:

```c
struct {
    struct {
        unsigned short reserved : 1,
        operation : 1,
        privileged_operation : 1,
        execute : 1,
        protection : 1,
        addressing : 1,
        specification : 1,
        data : 1,
        fixed_overflow : 1,
        fixed_divide : 1,
        decimal_overflow : 1,
        decimal_divide : 1,
        exponent_overflow : 1,
        exponent_divide : 1,
        significance : 1,
        float_divide : 1;
    } type;
    unsigned short reserved;
} checkflags;
```
The exception router service routine can set the following return/reason codes:

0/0  successful
4/4  unsuccessful — the exit could not be (de)-established
16/4 unrecoverable error occurred

**Attention Router Service Routine**
The attention router traps and routes attention interrupts. The STAX macro usually provides this service.

The parameters passed to the attention router are shown in Table 38.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address of attention router</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Environmental token</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>User word</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

The attention router routine can set the following return/reason codes:

0/0  successful
4/4  unsuccessful — the exit could not be (de)-established
16/4 unrecoverable error occurred

When an attention interrupt occurs, your attention router must invoke the attention handler. Use the address in the attention handler field passing the parameters shown in Table 39.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment token</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

The return/reason codes upon return from the attention handler are:

0/0  The attention interrupt has been or will be handled

If an attention interrupt occurs in the attention handler or when an attention handler is not started, your attention router should ignore the attention interrupt.

**Message Router Service Routine**
The message router routes messages written by the run-time library. These messages are normally written to the Language Environment Message File.
The parameters passed to the message router are shown in Table 40.

Table 40. Message Router Service Routine Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ASM Attributes</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address of message</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Message length in bytes</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>User word</td>
<td>DS A</td>
<td>Input</td>
</tr>
<tr>
<td>Line length</td>
<td>DS F</td>
<td>Input</td>
</tr>
<tr>
<td>Return code</td>
<td>DS F</td>
<td>Output</td>
</tr>
<tr>
<td>Reason code</td>
<td>DS F</td>
<td>Output</td>
</tr>
</tbody>
</table>

If the address of the message is zero, your message router is expected to return the size of the line to which messages are written (in the length field). The length field allows messages to be formatted correctly, for example, broken at blanks.

The message routine must use the following return/reason codes:

- **0/0** successful
- **16/4** unrecoverable error occurred
Part 4. Coding: Advanced Topics

This part contains the following coding topics:

- Chapter 21, “Building and Using Dynamic Link Libraries (DLLs)” on page 285
- Chapter 22, “Building Complex DLLs” on page 303
- Chapter 23, “Using Threads in z/OS UNIX Applications” on page 329
- Chapter 24, “Reentrancy in z/OS C/C++” on page 343
- Chapter 25, “Using the Decimal Data Type in C” on page 351
- Chapter 27, “Handling Exceptions, Error Conditions, and Signals” on page 379
- Chapter 28, “Optimizing Code” on page 399
- Chapter 29, “Optimizing Your C/C++ Code with Interprocedural Analysis” on page 421
- Chapter 30, “Network Communications under UNIX System Services” on page 435
- Chapter 31, “Interprocess Communication Using z/OS UNIX” on page 463
- Chapter 32, “Structuring a Program That Uses C++ Templates” on page 467
- Chapter 33, “Using Environment Variables” on page 479
Chapter 21. Building and Using Dynamic Link Libraries (DLLs)

A dynamic link library (DLL) is a collection of one or more functions or variables in an executable module that is executable or accessible from a separate application module. In an application without DLLs, all external function and variable references are resolved statically at bind time. In a DLL application, external function and variable references are resolved dynamically at run-time.

This chapter defines DLL concepts and shows how to build simple DLLs. Chapter 22, “Building Complex DLLs” on page 303 shows how to build complex DLLs and discusses some of the compatibility issues of DLLs.

There are two types of DLLs: simple and complex. A simple DLL contains only DLL code in which special code sequences are generated by the compiler for referencing functions and external variables, and using function pointers. With these code sequences, a DLL application can reference imported functions and imported variables from a DLL as easily as it can non-imported ones.

A complex DLL contains mixed code, that is, some DLL code and some non-DLL code. A typical complex DLL would contain some C++ code, which is always DLL code, and some C object modules compiled with the NODLL compiler option bound together.

The object code generated by the z/OS C++ compiler is always DLL code. Also, the object code generated by the z/OS C compiler with either the DLL compiler option or the XPLINK compiler option is DLL code. Other types of object code are non-DLL code. For more information about compiler options for DLLs, see the z/OS C/C++ User’s Guide.

XPLINK compiled code and non-XPLINK compiled code cannot be statically mixed (with the exception of OS_UPSTACK and OS_NOSTACK (or OS31_NOSTACK) linkages). The XPLINK compiled code can only be bound together with other XPLINK-compiled code. You can mix non-XPLINK compiled DLLs with XPLINK compiled DLLs (the same is true for routines which you load with fetch()). The z/OS C++ run-time library manages the transitions between the two different linkage styles across the DLL and fetch() boundaries.

Note: There is inherent performance degradation when the z/OS C++ run-time library transitions across these boundaries. In order for your application to perform well, these transitions should be made infrequently. When using XPLINK, recompile all parts of the application with the XPLINK compiler option wherever possible.

Notes:
1. As of OS/390 Version 2, the C/C++ IBM Open Class Library is licensed with the base operating system and enables access to the C/C++ Class Library by applications that require the library at execution time. This eliminates the need to license the C/C++ Compiler features or to use the DLL Rename Utility. Provided you use the base operating system, the DLL Rename Utility discussed in this chapter is not applicable.

2. If your application uses the IBM-supplied C++ Class Library DLLs for execution on a system prior to OS/390 Version 2, you must rename them using the DLL Rename utility. See the z/OS C/C++ User’s Guide for more information on using this utility.
Support for DLLs

DLL support is available for applications running under the following systems:

- z/OS batch
- CICS
- IMS
- TSO
- z/OS UNIX

It is not available for applications running under SPC, CSP or MTF.

Note: All potential DLL executable modules are registered in the CICS PPT control table in the CICS environment and are invoked at run time.

DLL Concepts and Terms

Application
All the code executed from the time an executable program module is invoked until that program, and any programs it directly or indirectly calls, is terminated.

DLL
An executable module that exports functions, variable definitions, or both, to other DLLs or DLL applications.

DLL application
An application that references imported functions, imported variables, or both, from other DLLs.

DLL code
Object code resulting when C source code is compiled with the DLL or XPLINK compiler options. C++ code is always DLL code.

Executable program (or executable module)
A file which can be loaded and executed on the computer. z/OS supports two types:

Load module
An executable residing in a PDS.

Program object
An executable residing in a PDSE or in the HFS.

Exported functions or variables
Functions or variables that are defined in one executable module and can be referenced from another executable module. When an exported function or variable is referenced within the executable module that defines it, the exported function or variable is also non-imported.

Function descriptor
An internal control block containing information needed by compiled code to call a function.

Imported functions and variables
Functions and variables that are not defined in the executable module where the reference is made, but are defined in a referenced DLL.

Non-imported functions and variables
Functions and variables that are defined in the same executable module where a reference to them is made.
Object code (or object module)
A file output from a compiler after processing a source code module, which can subsequently be used to build an executable program module.

Source code (or source module)
A file containing a program written in a programming language.

Variable descriptor
An internal control block containing information about the variable needed by compiled code.

Writable Static Area (WSA)
An area of memory that is modifiable during program execution. Typically, this area contains global variables and function and variable descriptors for DLLs.

XPLINK application
An application that is made up of C and/or C++ object modules that were compiled with the XPLINK compiler option. XPLINK applications are always DLL applications. Since the C/C++ run-time library for XPLINK is packaged as a DLL, any XPLINK executable module that calls a C/C++ run-time library is also importing from a DLL.

XPLINK code
Object code resulting when C or C++ source code is compiled with the XPLINK compiler option. XPLINK code is always DLL code.

Loading a DLL
The DLL is loaded implicitly when an application references an imported variable or calls an imported function. DLLs can be explicitly loaded by calling dllload(). Due to optimizations performed, the DLL implicit load point may be moved and the DLL will be loaded only if the actual reference occurs.

Loading a DLL Implicitly
When an application uses functions or variables defined in a DLL, the compiled code loads the DLL. This implicit load is transparent to the application. The load establishes the required references to functions and variables in the DLL by updating the control information contained in function and variable descriptors.

If the DLL contains static classes, constructors are run when the DLL is loaded. This loading may occur before main(); in this case, the corresponding destructors are run once when main() returns.

To implicitly load a DLL, do one of the following:
1. Statically initialize a variable pointer to the address of an exported DLL variable.
2. Reference a function pointer that points to an exported function.
3. Call an exported function.
4. Reference (use, modify, or take the address of) an exported variable.
5. Call through a function pointer that points to an exported function.

In the first situation, the DLL is loaded before main() is invoked, and if the DLL contains C++ code, constructors are run before main() is invoked. In the other situations, the DLL loading may be delayed until the time of the implicit call, although optimization may move this load earlier.
If the DLL application references (imports) an exported DLL variable, that DLL may be implicitly loaded before that DLL application is invoked (not necessarily before main() is invoked). With XPLINK, the DLL will always be implicitly loaded before invoking the DLL application that references (imports) a DLL variable or takes the address of a DLL function.

**Note:** When a DLL is loaded, its writable static is initialized. If the DLL load module contains C++ code, static constructors are run once at initial load time, and static destructors are run once at program termination. Static destructors are run in the reverse order of the static constructors.

### Loading a DLL Explicitly

The use of DLLs can also be explicitly controlled by the application code at the source level. The application uses explicit source-level calls to one or more run-time services to connect the reference to the definition. The connections for the reference and the definition are made at run-time.

The DLL application writer can explicitly call the following run-time services:

- `dllload()`, which loads the DLL and returns a handle to be used in future references to this DLL
- `dllqueryfn()`, which obtains a pointer to a DLL function
- `dllqueryvar()`, which obtains a pointer to a DLL variable
- `dllfree()`, which frees a DLL loaded with `dllload()`

For more information about the run-time services, see the [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/knowledgecenter/en/SSYQJQ_2.4.5/). To explicitly call a DLL in your application:

- Determine the names of the exported functions and variables that you want to use. You can get this information from the DLL provider’s documentation or by looking at the definition side-deck file that came with the DLL. A definition side-deck is a directive file that contains an IMPORT control statement for each function and variable exported by that DLL.
- Include the DLL header file `dll.h` in your application.
- Compile your source as usual.
- Bind your object with the binder using the same AMODE value as the DLL.

**Note:** You do not need to bind with the definition side-deck if you are calling the DLL explicitly with the run-time services, since there are no references from the source code to function or variable names in the DLL, for the binder to resolve. Therefore the DLL will not be loaded until you explicitly load it with the `dllload()` run-time service.

[Figure 49 on page 289](#) is an example of an application that uses explicit DLL calls.

### Explicit Use of a DLL in an Application

The following example shows explicit use of a DLL in an application.
#include <dll.h>
#include <stdio.h>
#include <string.h>

#ifdef __cplusplus
    extern "C" {
#endif

typedef int (DLL_FN)(void);

#ifdef __cplusplus
}
#endif

#define FUNCTION "FUNCTION"
#define VARIABLE "VARIABLE"

static void Syntax(const char* progName) {
    fprintf(stderr, "Syntax: %s <DLL-name> <type> <identifier>
        where
        " <DLL-name> is the DLL to load,
        " <type> can be one of FUNCTION or VARIABLE
        " and <identifier> is the function or variable
        " to reference
        ", progName);
    return;
}

main(int argc, char* argv[]) {
    int value;
    int* varPtr;
    char* dll;
    char* type;
    char* id;
    dllhandle* dllHandle;

    if (argc != 4) {
        Syntax(argv[0]);
        return(4);
    }

    Figure 49. Explicit Use of a DLL in an Application (Part 1 of 2)
For more information on the DLL functions, see the z/OS C/C++ Run-Time Library Reference.

Managing the Use of DLLs When Running DLL Applications

This section describes how z/OS C/C++ manages loading, sharing and freeing DLLs when you run a DLL application.

Loading DLLs

When you load a DLL for the first time, either implicitly or via an explicit `dllload()`, writable static is initialized. If the DLL is written in C++, constructors are run.

dll = argv[1];
type = argv[2];
id = argv[3];

dllHandle = dllload(dll);
if (dllHandle == NULL) {
    perror("DLL-Load");
    fprintf(stderr, "Load of DLL %s failed\n", dll);
    return(8);
}

if (strcmp(type, FUNCTION)) {
    if (strcmp(type, VARIABLE)) {
        fprintf(stderr,
            "Type specified was not " FUNCTION " or " VARIABLE "\n\n";
        Syntax(argv[0]);
        return(8);
    }
    /* variable request, so get address of variable */
    varPtr = (int*)(dllqueryvar(dllHandle, id));
    if (varPtr == NULL) {
        perror("DLL-Query-Var");
        fprintf(stderr, "Variable %s not exported from %s\n", id, dll);
        return(8);
    }
    value = *varPtr;
    printf("Variable %s has a value of %d\n", id, value);
}
else {
    /* function request, so get function descriptor and call it */
    DLL_FN* fn = (DLL_FN*) (dllqueryfn(dllHandle, id));
    if (fn == NULL) {
        perror("DLL-Query-Fn");
        fprintf(stderr, "Function %s() not exported from %s\n", id, dll);
        return(8);
    }
    value = fn();
    printf("Result of call to %s() is %d", id, value);
}
dllfree(dllHandle);
return(0);

Figure 49. Explicit Use of a DLL in an Application (Part 2 of 2)
You can load DLLs from an HFS as well as from conventional data sets. The following list specifies the order of a search for unambiguous and ambiguous file names.

**Unambiguous file names**
- If the file has an unambiguous z/OS UNIX HFS name (it starts with a ./ or contains a /), the file is searched for only in the HFS.
- If the file has an unambiguous MVS name, and starts with two slashes (/), the file is only searched for in MVS.

**Ambiguous file names**
For ambiguous cases, the settings for POSIX are checked.
- When specifying the POSIX(ON) run-time option, the run-time library attempts to load the DLL as follows:
  1. An attempt is made to load the DLL from the HFS. This is done using the system service BPX1LOD. For more information on this service, see z/OS UNIX System Services Programming: Assembler Callable Services Reference. If the environment variable LIBPATH is set, each directory listed will be searched for the DLL. See Chapter 33, “Using Environment Variables” on page 479 for information on LIBPATH. Otherwise the current directory will be searched for the DLL. Note that a search for the DLL in the HFS is case-sensitive.
    - If the DLL is found and contains an external link name of eight characters or less, the uppercase external link name is used to attempt a LOAD from the caller’s MVS load library search order. If the DLL is not found or the external link name is more than eight characters, then the load fails.
    - If the DLL is found and its sticky bit is on, any suffix is stripped off. Next, the name is converted to uppercase, and the base DLL name is used to attempt a LOAD from the caller’s MVS load library search order. If the DLL is not found or the base DLL name is more than eight characters, the version of the DLL in the HFS is loaded.
    - If the DLL is found and does not fall into one of the previous two cases, a load from the HFS is attempted.
  2. If the DLL could not be loaded from the HFS, an attempt is made to load the DLL from the caller’s MVS load library search order. This is done by calling the z/OS service LOAD with the DLL name, which must be eight characters or less and is converted to uppercase. LOAD searches data sets in the following order:
    a. Run-time library services (if active)
    b. Job Pack Queue
    c. Current STEPLIB/JOBLIB
    d. LPA
    e. Link List
- When POSIX(OFF) is specified the sequence is reversed.
  - An attempt to load the DLL is made from the caller’s MVS load library search order.
  - If the DLL could not be loaded from the caller’s MVS load library then an attempt is made to load the DLL from the HFS.
Sharing DLLs

DLLs are shared at the enclave level (as defined by the z/OS Language Environment). A referenced DLL is loaded only once per enclave and only one copy of the writable static is created or maintained per DLL per enclave. Thus, one copy of a DLL serves all modules in an enclave regardless of whether the DLL is loaded implicitly or explicitly. You can access the same DLL within an enclave both implicitly and by explicit run-time services.

All accesses to a variable in a DLL in an enclave refer to the only copy of that variable. All accesses to a function in a DLL in an enclave refer to the only copy of that function.

Although only one copy of a DLL is maintained per enclave, multiple logical loads are counted and used to determine when the DLL can be deleted. For a given DLL in a given enclave, there is one logical load for each explicit dllload() request.

DLLs are not shared in a nested enclave environment. Only the enclave that loaded the DLL can access functions and variables.

Freeing DLLs

You can free explicitly loaded DLLs with a dllfree() request. This request is optional because the DLLs are automatically deleted by the run-time library when the enclave is terminated.

Implicitly loaded DLLs cannot be deleted from the DLL application code. They are deleted by the run-time library at enclave termination. Therefore, if a DLL has been both explicitly and implicitly loaded, the DLL can only be deleted by the run-time when the enclave is terminated.

Creating a DLL or a DLL Application

Building a DLL or a DLL application is similar to creating a C or C++ application. It involves the following steps:

1. Writing your source code
2. Compiling your source code
3. Binding your object modules

Building a Simple DLL

This section shows how to build a simple DLL.

Writing Your C Code

To build a simple C DLL, write code using the #pragma export directive to export specific external functions and variables as shown in Figure 50 on page 293.
For the previous example, the functions bopen(), bclose(), bread(), and bwrite() are exported; the variable berror is exported; and the variable buffer is not exported.

**Note:** To export all defined functions and variables with external linkage in the compilation unit to the users of the DLL, compile with the EXPORTALL compile option. All defined functions and variables with external linkage will be accessible from this DLL and by all users of this DLL. However, exporting all functions and variables has a performance penalty, especially with IPA. When you use EXPORTALL you do not need to include #pragma export in your code.

**Writing Your C++ Code**

To create a simple C++ DLL:

- Ensure that classes and class members are exported correctly, especially if they use templates.
- Use _Export or the #pragma export directive to export specific functions and variables.

For example, to create a DLL executable module TRIANGLE, export the getarea() function, the getperim() function, the static member objectCount and the constructor for class triangle using #pragma export:

```c++
#pragma export(bopen)
#pragma export(bclose)
#pragma export(bread)
#pragma export(bwrite)
int bopen(const char* file, const char* mode) {
...
}
int bclose(int) {
...
}
int bread(int bytes) {
...
}
int bwrite(int bytes) {
...
}
#pragma export(berror)
int berror;
char buffer[1024];
...
```

Figure 50. Using #pragma export to Create a DLL Executable Module Named BASICIO

For the previous example, the functions bopen(), bclose(), bread(), and bwrite() are exported; the variable berror is exported; and the variable buffer is not exported.
Do not inline the function if you apply the _Export keyword to the function declaration.

Always export constructors and destructors when using the _Export keyword.

Apply the _Export keyword to a class. This keyword automatically exports static members and defined functions of that class, constructors, and destructors.

To export all external functions and variables in the compilation unit to the users of this DLL, you can also use the compiler option EXPORTALL. This compiler option is described in the z/OS C/C++ User’s Guide and #pragma directives are described in detail in the C/C++ Language Reference. If you use the EXPORTALL option, you do not need to include #pragma export or _Export in your code.

Compiling Your Code

For C source code compiled without using the DLL or XPLINK compiler options, that code cannot reference (import) functions or variables that are exported by a DLL. NODLL is the default when compiling C source code, and the XPLINK compiler option is not used. C source code compiled with the DLL or XPLINK compiler options, and all C++ source code, can reference exported functions and variables. Source code that can reference exported functions and variables is called DLL application code. It need not itself be a DLL, in that it may not itself export any functions or variables.

When compiling DLL application source code, the compiler generates object code in such a way that references to external functions and variables can be resolved statically or dynamically (that is, resolved to a DLL). If you are uncertain whether

```c++
class triangle : public area
{
    public:
        static int objectCount;
        getarea();
        getperim();
        triangle::triangle(void);
    }
    #pragma export(triangle::objectCount)
    #pragma export(triangle::getarea())
    #pragma export(triangle::getperim())
    #pragma export(triangle::triangle(void))
};
```

Figure 51. Using #pragma Export to Create a DLL Executable Module TRIANGLE

- Do not inline the function if you apply the _Export keyword to the function declaration.

```c++
class triangle : public area
{
    public:
        static int _Export objectCount;
        double _Export getarea();
        double _Export getperim();
        _Export triangle::triangle(void);
    }
};
```

Figure 52. Using _export to Create DLL Executable Module TRIANGLE

- Always export constructors and destructors when using the _Export keyword.
- Apply the _Export keyword to a class. This keyword automatically exports static members and defined functions of that class, constructors, and destructors.

```c++
class _Export triangle
{
    public:
        static int objectCount;
        double getarea();
        double getperim();
        triangle::triangle(void);
    }
};
```

Compiling Your Code

For C source code compiled without using the DLL or XPLINK compiler options, that code cannot reference (import) functions or variables that are exported by a DLL. NODLL is the default when compiling C source code, and the XPLINK compiler option is not used. C source code compiled with the DLL or XPLINK compiler options, and all C++ source code, can reference exported functions and variables. Source code that can reference exported functions and variables is called DLL application code. It need not itself be a DLL, in that it may not itself export any functions or variables.

When compiling DLL application source code, the compiler generates object code in such a way that references to external functions and variables can be resolved statically or dynamically (that is, resolved to a DLL). If you are uncertain whether
non-XPLINK C source code references a DLL, you should specify the DLL or XPLINK compiler options. Compiling source code as DLL application code eliminates the potential compatibility problems that may occur when binding DLL application code with non-DLL application code. See Chapter 22, “Building Complex DLLs” on page 303 for more information on compatibility issues.

The decision to use XPLINK needs to be made independently from the decision to build a DLL application. While XPLINK compiled code is always DLL application code, the XPLINK and non-XPLINK function call linkages are different. There is DLL compatibility for XPLINK and non-XPLINK at the DLL boundary, but XPLINK and non-XPLINK object modules cannot be mixed in the same DLL. Also, there is a performance penalty when transitioning between XPLINK and non-XPLINK DLLs (and vice versa). It is best to have a DLL application made up of all XPLINK or all non-XPLINK executable modules to the extent that is possible. For more information on XPLINK, see “Using XPLINK” on page 417.

### Binding Your Code

When creating a DLL, the binder automatically creates a definition side-deck that describes the functions and the variables that can be imported by DLL applications. You must provide the generated definition side-deck to all users of the DLL. Any DLL application that implicitly loads the DLL must include the definition side-deck when they bind.

**Note:** You can choose to store your DLL in a PDS load library, but only if it is non-XPLINK. Otherwise, it must be stored in a PDSE load library or in the HFS. To target a PDS load library, prelink and link your code rather than using the binder. For information on prelinking and linking, see the appendix on the Prelinker in z/OS C/C++ User's Guide.

When binding the C object module as shown in Figure 50 on page 293, the binder generates the following definition side-deck:

```
IMPORT CODE, BASICIO, 'bopen'
IMPORT DATA, BASICIO, 'bclose'
IMPORT DATA, BASICIO, 'bread'
IMPORT DATA, BASICIO, 'bwrite'
IMPORT DATA, BASICIO, 'berror'
```

**Note:** You should also provide a header file containing the prototypes for exported functions and external variable declarations for exported variables.

When binding the C++ object modules shown in Figure 51 on page 294, the binder generates the following definition side-deck:

```
IMPORT CODE, TRIANGLE, 'getarea__8triangleFv'
IMPORT CODE, TRIANGLE, 'getperim__8triangleFv'
IMPORT CODE, TRIANGLE, '__ct__8triangleFv'
```

You can edit the definition side-deck to remove any functions and variables that you do not want to export. You must maintain the file as a binary file with fixed format and a record length of 80 bytes. Also, use proper binder continuation rules if the IMPORT statement spans multiple lines, and you change the length of the statement. In the above example, if you do not want to expose getperim(), remove the control statement IMPORT CODE , TRIANGLE, getperim__8triangleFv from the definition side-deck.
Notes:
1. Removing functions and variables from the definition side-deck does not minimize the performance impact caused by specifying the EXPORTALL compiler option.
2. Editing the side-deck is not recommended. If the DLL name needs to be changed, you should bind using the appropriate name. Instead of using the EXPORTALL compiler option, you should remove unnecessary IMPORT statements by using explicit #pragma export statements or _Export directives.

The definition side-deck contains mangled names of exported C++ functions, such as getarea__8triangleFv. To find the original function or variable name in your source module, review the compiler listing, the binder map, or use the CXXFILT utility, if you do not have access to the listings. This will permit you to see both the mangled and demangled names. For more information on the CXXFILT utility, see the z/OS C/C++ User’s Guide.

Building a Simple DLL Application

A simple DLL application contains object modules that are made up of only DLL-code. The application may consist of multiple source modules. Some of the source modules may contain references to imported functions, imported variables, or both.

To use an implicitly loaded DLL (sometimes called a load-on-call DLL) in your simple DLL application:
1. Write your code as you would if the functions were statically bound.
2. Compile as follows:
   • Compile your non-XPLINK application C source files with the following compiler options:
     – DLL
     – RENT
     – LONGNAME
     These options instruct the compiler to generate special code when calling functions and referencing external variables. If you are using z/OS UNIX, RENT and LONGNAME are already the defaults, so compile as:
     c89 -W c,DLL ...
   • Compile your C++ source files normally. A C++ application is always DLL code.
   • For XPLINK, compile your C and C++ source files with the XPLINK compiler option. XPLINK compiled C and C++ source is always DLL code.
3. Bind your object modules as follows.
   • If you are using z/OS Batch, use the IBM-supplied procedure when you bind your object modules. You must chose the appropriate procedures for XPLINK or non-XPLINK.
   • If you are not using the IBM-supplied procedure, specify the RENT, DYNAM(DLL), and CASE(MIXED) binder options when you bind your object modules.

   Note: XPLINK and non-XPLINK use different z/OS Language Environment libraries, and XPLINK requires the C run-time library side-deck for
resolution of C run-time library function calls. For more information, see "Planning to Link-Edit and Run" in z/OS Language Environment Programming Guide.

- If you are using z/OS UNIX specify the following option for the bind step for c89 or c++:
  
c89 -W 1,DLL

If you are using XPLINK, also add the XPLINK option, so that c89 will use the correct z/OS Language Environment libraries and side-decks:
  
c89 -W 1,DLL,XPLINK ...

- Include the definition side-deck from the DLL provider in the set of object modules to bind. The binder uses the definition side-deck to resolve references to functions and variables defined in the DLL. If you are referencing multiple DLLs, you must include multiple definition side-decks.

  **Note:** Definition side-decks can not be resolved by automatic library call (autocall) processing, so you must specify an INCLUDE statement to explicitly include a definition side-deck for each referenced DLL.

The following is a code fragment illustrating how an application can use the DLL described previously. Compile normally and bind with the definition side-deck provided with the TRIANGLE DLL:

```c
extern int getarea(); /* function prototype */
main () {
  ...
  getarea(); /* imported function reference */
  ...
}
```

See Figure 53 on page 298 for a summary of the processing steps required for the application (and related DLLs).

### Creating and Using DLLs

Figure 53 on page 298 summarizes the use of DLLs for both the DLL provider and for the writer of applications that use them. In this example, application ABC is referencing functions and variables from two DLLs, XYZ and PQR. The connection between DLL preparation and application preparation is shown. Each DLL shown contains a single compilation unit. The same general scheme applies for DLLs composed of multiple compilation units, except that they have multiple compiles and a single bind for each DLL. For simplicity, this example assumes the following:

- ABC does not export variables or functions.
- XYZ and PQR do not use other DLLs.
- The application is completely non-XPLINK and written in C.
DLL Restrictions

Consider the following restrictions when creating DLLs and DLL applications:

- The entry point for a DLL must be either z/OS C/C++ or Language Environment conforming. An entry point is considered Language Environment conforming if it includes CEESTART or if it was compiled using a Language Environment conforming compiler.

---

298  z/OS V1R4.0 C/C++ Programming Guide
Note: If the entry point for a DLL does not meet either of the above conditions, Language Environment issues an error and terminates the application.

- In a DLL application that contains main(), main() cannot be exported.
- The AMODE of a DLL application must be the same as the AMODE of the DLL that it calls.
- DLL facilities are not available:
  - Under MTF, CSP or SPC
  - To application programs with main() written in PL/I that dynamically call z/OS C functions
- You cannot implicitly or explicitly perform a physical load of a DLL while running C++ static destructors. However, a logical load of a DLL (meaning that the DLL has previously been loaded into the enclave) is allowed from a static destructor. In this case, references from the load module containing the static destructor to the previously-loaded DLL are resolved.
- If a DLL contains static objects, the constructors are called during DLL load. ISO C++ requires that the global objects must be defined within the same compilation unit, but does not specify any order for these to be called; hence the objects are constructed in the order that they are defined. z/OS C/C++ enhances the standard behavior by providing #pragma priority to control the construction order for all global objects within the same execution load module. Please refer to the C/C++ Language Reference for the details of this pragma. A DLL is one execution load module and the #pragma priority allows you to control global object construction within a single DLL. On the other hand, you still have no control over the initialization order across different DLLs, or across a DLL application and the DLLs it references. If such order is important, the DLL provider has to define a protocol for applications to follow so that the interaction between the DLL and the applications happens in the required manner. The protocol must be part of the DLL interface design. Take note of the restriction in the previous bullet when defining such a protocol. A simple example would be requiring an application to call a setup() function, which is exported by a DLL, before any other references to the same DLL are made. More elaborate designs are possible. The techniques for controlling static initialization are well-discussed in C++ literature; you can reference, for example, Item 47 of Scott Meyers’s Effective C++, 50 Specific Ways to Improve Your Programs and Designs.
- You cannot use the functions set_new_handler() or set_unexpected() in a DLL if the DLL application is expected to invoke the new handler or unexpected function routines.

When using the explicit DLL functions in a multithreaded environment, avoid any situation where one thread frees a DLL while another thread calls any of the DLL functions. For example, this situation occurs when a main() function uses dllload() to load a DLL, and then creates a thread that uses the ftw() function. The ftw() target function routine is in the DLL. If the main() function uses dllfree() to free the DLL, but the created thread uses ftw() at any point, you will get an abend.

To avoid a situation where one thread frees a DLL while another thread calls a DLL function, do either of the following:
  - Do not free any DLLs by using dllfree() (the z/OS Language Environment will free them when the enclave is terminated).
  - Have the main() function call dllfree() only after all threads have been terminated.
- For DLLs to be processed by IPA, they must contain at least one function or method. Data-only DLLs will result in a compilation error.
Use of circular DLLs may result in unpredictable behavior related to the initialization of non-local static objects. For example, if a static constructor (being run as part of loading DLL "A") causes another DLL "B" to be loaded, then DLL "B" (or any other DLLs that "B" causes to be loaded before static constructors for DLL "A" have completed) cannot expect non-local static objects in "A" to be initialized (that is what static constructors do). You should ensure that non-local static objects are initialized before they are used, by coding techniques such as counters or by placing the static objects inside functions.

Improving Performance

This section contains some hints on using DLLs efficiently. Effective use of DLLs may improve the performance of your application. Following are some suggestions that may improve performance:

- If you are using a particular DLL frequently across multiple address spaces, the DLL can be installed in the LPA or ELPA. When the DLL resides in a PDSE, the dynamic LPA services should be used (this will always be the case for XPLINK applications). Installing in the LPA/ELPA may give you the performance benefits of a single rather than multiple load of the DLL.

- When writing XPLINK applications, avoid frequent calls from XPLINK to non-XPLINK DLLs, and vice-versa. These transitions are expensive, so you should build as much of the application as possible as either XPLINK or non-XPLINK. When there is a relatively large amount of function calls compared to the rest of the code, the performance of an XPLINK application can be significantly better than non-XPLINK. It is acceptable to make calls between XPLINK and non-XPLINK, when a relatively large amount of processing will be done once the call is made.

- Be sure to specify the RENT option when you bind your code. Otherwise, each load of a DLL results in a separately loaded DLL with its own writable static. Besides the performance implications of this, you are likely to get incorrect results if the DLL exports variables (data).

- Group external variables into one external structure.

- When using z/OS UNIX avoid unnecessary load attempts.

z/OS Language Environment supports loading a DLL residing in the HFS or a data set. However, the location from which it tries to load the DLL first varies depending whether your application runs with the run-time option POSIX(ON) or POSIX(OFF).

If your application runs with POSIX(ON), z/OS Language Environment tries to load the DLL from the HFS first. If your DLL is a data set member, you can avoid searching the HFS directories. To direct a DLL search to a data set, prefix the DLL name with two slashes (//) as is in the following example.

```
//MYDLL
```

If your application runs with POSIX(OFF), z/OS Language Environment tries to load your DLL from a data set. If your DLL is an HFS file, you can avoid searching a data set. To direct a DLL search to the HFS, prefix the DLL name with a period and slash (./) as is done in the following example.

```
./mydll
```

Note: DLL names are case sensitive in the HFS. If you specify the wrong case for your DLL that resides in the HFS, it will not be found in the HFS.

- For IPA, you should only export subprograms (functions and C++ methods) or variables that you need for the interface to the final DLL. If you export subprograms or variables unnecessarily (for example, by using the EXPORTALL
option), you severely limit IPA optimization. In this case, global variable coalescing and pruning of unreachable or 100% inlined code does not occur. To be processed by IPA, DLLs must contain at least one subprogram. Attempts to process a data-only DLL will result in a compilation error.

- The suboption NOCALLBACKANY of the compiler option DLL is more efficient than the CALLBACKANY suboption. The CALLBACKANY option calls z/OS Language Environment at run-time. This run-time service enables direct function calls. Direct function calls are function calls through function pointers that point to actual function entry points rather than function descriptors. The use of CALLBACKANY will result in extra overhead at every occurrence of a call through a function pointer. This is unnecessary if the calls are not direct function calls.
Chapter 22. Building Complex DLLs

Before you attempt to build complex DLLs it is important to understand the differences between the terms DLL, DLL code, and DLL application.

A DLL (Dynamic Link Library) is a file containing executable code and data bound to a program at run time. The code and data in a DLL can be shared by several applications simultaneously. It is important to note that compiling code with the DLL option does not mean that the produced executable will be a DLL. To create a DLL, you must use the \#pragma export or EXPORTALL compiler option.

**DLL code** is code that can use a DLL. The following are DLL code:
- C++ code
- C code compiled using the DLL or XPLINK option

Code written in languages other than C++ and compiled without the DLL or XPLINK option is non-DLL code.

A DLL application is an application that can use exported functions or variables that are bound with DLL code. All of the source files that make up a DLL application do not need to be compiled with the DLL or XPLINK option, only the source files that reference exported functions and exported global variables.

If you link DLL code with non-DLL code, the resulting DLL or DLL application is called complex. You might compile your code as non-DLL for the following reasons:
1. Source modules do not use C or C++.
2. To prevent problems which occur when a non-DLL function pointer call uses DLL code. This problem takes place when a function makes a call through a function pointer that points to a function entry rather than a function descriptor.

For complex DLLs and DLL applications that you compile without XPLINK, you can use the CBA suboption of the DLL|NODLL compiler option. With this suboption, a call is made to z/OS Language Environment at run-time for each function call through a function pointer. This call eliminates the error that would occur when a non-DLL function pointer passes to DLL code.

**Note:** In this book, unless otherwise specified, all references to the DLL|NODLL compiler option assume suboption NOCBA. For more information on the compiler option DLL, see [z/OS C/C++ User’s Guide](#).

If you specify the XPLINK compiler option, the CBA and NOCBA suboptions of DLL|NODLL are ignored.

There are two ways to combine XPLINK and non-XPLINK code in the same application:
- Compile each entire DLL with XPLINK or without XPLINK. The only interaction between XPLINK and non-XPLINK code occurs at a DLL or fetch() boundary.
- Use the OS_UPSTACK, OS_NOSTACK, and OS31_NOSTACK linkage directive. For more information, see the description of \#pragma linkage in [C/C++ Language Reference](#).

The steps for creating a complex DLL or DLL application are:
1. Determining how to compile your source modules.
2. Modifying the source modules that do not meet all the DLL rules.
3. Compiling the source modules to produce DLL code and non-DLL code as determined in the previous steps.
4. Binding your DLL or DLL application.

The focus of this chapter is step 1 and step 2. You perform step 3 the same way you would for any other C or C++ application. "Binding Your Code" on page 295 explains step 4.

---

**Rules for Compiling Source Code**

The instructions for XPLINK and non-XPLINK applications are different. For information about how to decide whether to use XPLINK, see [z/OS C/C++ User’s Guide](https://www.ibm.com/support/documentation/docview.wss?uid=swg24050267).

**XPLINK Applications**

XPLINK provides compatibility with non-XPLINK functions when calls are made across executable modules, using either the DLL or `fetch()` call mechanism. You should make a reference from XPLINK code into non-XPLINK code only if the reference is by an imported function or variable, or the function pointer is a parameter into the XPLINK code. This prevents incompatible references to a non-XPLINK function entry point.

If the non-XPLINK code exposes a function entry point directly to the XPLINK code (as a global variable, as part of a structure that is passed as a parameter, or by passing an explicit return value), the XPLINK code will not be able to correctly use it.

These are the only factors that you need to consider when building non-XPLINK DLLs that will be used by XPLINK applications.

There is also a restriction in passing a function pointer from a non-XPLINK application into an XPLINK function. By default, a function pointer that is used as a callback must be passed explicitly as an argument into the XPLINK function. That is, you cannot pass a function pointer as a member of a structure that is itself an argument to the XPLINK function.

**Modifying Noncompliant Source**

For each function pointer, make sure that one of the following is true:

- The function pointer is passed as a parameter to the XPLINK code.
- The indirectly-referenced function pointer was imported by this DLL.
- The indirectly-referenced function pointer was imported by another XPLINK or non-XPLINK DLL.

**Non-XPLINK Applications**

To create a complex DLL or DLL application, you must comply with the following rules that dictate how you compile source modules. The first decision you must make is how you should compile your code. You determine whether to compile with either the DLL or NODLL compiler option based on whether or not your code references any other DLLs. Even if your code is a DLL, it is safe to compile your code with the NODLL compiler option if your code does not reference other DLLs.

The second decision you must make is whether to compile with the default compiler suboption for DLL|NODLL, which is NOCBA, or use the alternative suboption CBA. This decision is based upon your knowledge of the code you reference. If you are sure
that you do not reference any function calls through function pointers that point to a function entry rather than a function descriptor, use the NOCBA suboption. Otherwise, you should use the CBA suboption.

As of V2R4 of OS/390 C/C++, use the following options to ensure that you do not have undefined results as a result of the function pointer pointing to a function entry rather than a function descriptor:

1. Compile your source module with the CBA suboption of DLL|NODLL. This option inserts extra code whenever you have a function call through a function pointer. The inserted code invokes a run-time service of z/OS Language Environment which enables direct function calls through C/C++ function pointers. Direct function calls are function calls through function pointers that point to actual function entry points rather than function descriptors. The drawback of this method is that your code will run slower. This occurs because whenever you have function calls through function pointers z/OS Language Environment is called at run-time to enable direct function calls. See Figure 64 on page 315 for an example of the CBA suboption and an explanation of what the called z/OS Language Environment routine does at run-time when using the CBA suboption.

2. Compile your C source module with the NOCBA suboption of DLL|NODLL. This option has the benefit of faster running but with more restrictions placed on your coding style. If you do not follow the restrictions, your code may behave unpredictably. See "DLL Restrictions" on page 298 for more information.

Compile your C source modules as DLL when:

1. Your source module calls imported functions or imported variables by name.
2. Your source module contains a comparison of function pointers that may be DLL function pointers.
   The comparisons shown in "Function Pointer Comparison in Non-DLL Code" on page 317 are undefined. To obtain valid comparisons, compile the source modules as DLL code.
3. Your source module may pass a function pointer to DLL code through a parameter or a return value.
   If the sort() routine in Figure 63 on page 314 is compiled as DLL code instead of non-DLL code, non-DLL applications can no longer call it. To be able to call the DLL code version of sort(), the original non-DLL application must be recompiled as DLL code.
4. Your source module may define a global function pointer and another source module changes it.
   Consider Figure 54 on page 306 and Figure 55 on page 306. You have the following two options when compiling them.
   a. If source module 1 is compiled as DLL code, source module 2 must also be compiled as DLL code.
   b. Alternately, you can compile source module 1 as DLL and source module 2 as NODLL(CBA).
void (*fp)(void);
extern void goo (void);
void main() {
  goo();
  (*fp)();  /* call hello function */
}

Figure 54. Source Module 1

#include <stdio.h>
extern void (*fp)(void);
void hello(void) {
  printf("hello\n");
}
void goo(void) {
  fp = hello;
}

Figure 55. Source Module 2

The following table summarizes some of the ways that you could compile the two source modules and lists the results. Both modules are linked into a single executable.

<table>
<thead>
<tr>
<th>How Modules Were Compiled</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source module 1 NODLL(NOCBA) source module 2 DLL(NOCBA)</td>
<td>fp contains a function descriptor. Execution of fp will succeed because it is valid to the address of a function descriptor.</td>
</tr>
<tr>
<td>Source module 1 DLL(NOCBA) Source module 2 NODLL(NOCBA)</td>
<td>fp contains the address of hello. The execution of fp would abend because source module 1 expects fp to contain a function descriptor for hello.</td>
</tr>
<tr>
<td>Source module 1 DLL(CBA) Source module 2 DLL(NOCBA)</td>
<td>fp contains a function descriptor. The generated code will function correctly. It will run slower than if the source modules were compiled as DLL(NOCBA) because it will use Language Environment to make the function call.</td>
</tr>
<tr>
<td>Source module 1 NODLL(CBA) Source module 2 DLL(NOCBA)</td>
<td>A call to Language Environment made by the function call through the function pointer prevents a problem that would have occurred had a direct function call been made.</td>
</tr>
</tbody>
</table>

If you do not use the DLL compiler option, and your source module calls imported functions or imported variables by name, there will be unresolved references to these variables and functions at bind time. A DLL or DLL application that does not comply with these rules may produce undefined run-time behavior. For a detailed explanation of incompatibilities between DLL and non-DLL code, see "Compatibility Issues Between DLL and Non-DLL Code" on page 307.

Modifying Noncompliant Source
Sometimes source modules of a complex DLL or DLL application do not simultaneously meet all the DLL rules. These rules are documented in the section "Rules for Compiling Source Code" on page 304. When these situations occur, you can use the following methods to solve the problem:

- Use the CBA suboption.
• Rewrite the source in C. Only C source can be compiled as either DLL or non-DLL code. C++ source code is always DLL code.
• Split a C source module in two so that one of the new files is compiled as DLL code and the other is compiled as non-DLL code.

  **Note:** In rare cases, you may have to split a function into two functions before you can successfully split the file.

An example of noncompliant source is a C++ source module that contains a function call through a pointer that may be either a DLL pointer to a function descriptor or a direct function pointer. Convert it to C code and compile as non-DLL code or, preferably, as DLL(CBA) and recompile.

---

**Compatibility Issues Between DLL and Non-DLL Code**

This section describes the differences between DLL code and non-DLL code, and discusses the related compatibility issues for linking them to create complex DLLs.

**Note:** This section does not apply to XPLINK applications. XPLINK code is always DLL code.

The following table and [Figure 56 on page 308](#) illustrate DLL code referencing functions and variables.
Referencing Functions and External Variables

### DLL

**Imported Functions**
- A function descriptor is created by the binder. The descriptor is in the WSA class and contains the address of the function and the address of the writable static area associated with that function. The function address and the address of the WSA associated with the function is resolved when the DLL is loaded.

**Nonimported Functions**
- Also called through the function descriptor but the function address is resolved at link time.

**Imported Variables**
- A variable descriptor is created in the WSA by the binder. It contains addressing information for accessing an imported variable. The address is resolved when the DLL is loaded.

**Nonimported Variables**
- Direct access

---

### DLL Application

- DLL Code
  - `extern int f(void);`  
  - `int g(void);`  
  - `extern int x;`  
  - `int y;`  
  - `f(); 1`  
  - `x = 1; 2`  
  - `g(); 3`  
  - `int g(void) { ... }`  
  - `y = 2; 4`  

- Data
  - `int x;`  
  - `int f(void);`  
  - `int y;`  

### DLL

- DLL Code
  - `int f(void);`  
  - `int g(void);`  
  - `int x;`  

- Data
  - `int f(void) { ... }`  

---

**Figure 56. Referencing Functions and External Variables in DLL code**

**Table 41. Referencing Functions and External Variables**

<table>
<thead>
<tr>
<th>DLL</th>
<th>DLL Application</th>
<th>DLL Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Imported Functions</strong></td>
<td>A function descriptor is created by the binder. The</td>
<td><a href="https://example.com">Code example</a></td>
</tr>
<tr>
<td></td>
<td>descriptor is in the WSA class and contains the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>address of the function and the address of the writable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>static area associated with that function. The function</td>
<td></td>
</tr>
<tr>
<td></td>
<td>address and the address of the WSA associated with the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>function is resolved when the DLL is loaded.</td>
<td></td>
</tr>
<tr>
<td><strong>Nonimported Functions</strong></td>
<td>Also called through the function descriptor but the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>function address is resolved at link time.</td>
<td></td>
</tr>
<tr>
<td><strong>Imported Variables</strong></td>
<td>A variable descriptor is created in the WSA by the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>binder. It contains addressing information for accessing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>an imported variable. The address is resolved when the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DLL is loaded.</td>
<td></td>
</tr>
<tr>
<td><strong>Nonimported Variables</strong></td>
<td>Direct access</td>
<td></td>
</tr>
</tbody>
</table>
Pointer Assignment

In DLL code and non-DLL code, the actual address of a variable is assigned to a variable pointer. A valid variable pointer always points to the variable itself and causes no compatibility problems.

Function Pointers

In non-DLL code, the actual address of a nonimported function is assigned to a function pointer. In DLL code, the address of a function descriptor is assigned to a function pointer.

If you assign the address of an imported function to a pointer in non-DLL code, the link step will fail with an unresolved reference. In a complex DLL or DLL application, a pointer to a function descriptor may be passed to non-DLL code. A direct function pointer (pointer to a function entry point) may be passed to DLL code.5

In a complex DLL or DLL application, a function pointer may point either to a function descriptor or to a function entry, depending on the origin of the code. The different ways of dereferencing a function pointer causes the compatibility problem in linking DLL code with non-DLL code.

In Figure 57 on page 310, 1 assigns the address of the descriptor for the imported function f to fp. 2 assigns the address of the imported variable x to xp. 3 assigns the address of the descriptor for the nonimported function g to gp. 4 assigns the address of the non-imported variable y to yp.

5. A parameter, a return value, or an external variable can pass a function pointer or an external variable.
In Figure 58 on page 311, 1 causes a bind error because the assignment to fp is undefined. 2 causes a binder error because the assignment to xp is undefined. 3 assigns gp to the address of the nonimported function, g. 4 assigns the address of the nonimported variable y to yp.

Figure 57. Pointer Assignment in DLL code
DLL Function Pointer Call in Non-DLL Code

Because z/OS C/C++ supports a DLL function pointer call in non-DLL code, you are able to create a DLL to support both DLL and non-DLL applications. The z/OS C/C++ compiler inserts glue code at the beginning of a function descriptor to allow branching to a function descriptor. Glue code is special code that enables function pointer calls from non-DLL code to DLL code, including XPLINK code.

A function pointer in non-DLL code points to the function entry and a function pointer call branches to the function address. However, a DLL function pointer points to a function descriptor. A call made through this pointer in non-DLL code results in branching to the descriptor.

z/OS C/C++ executes a DLL function pointer call in non-DLL code by branching to the descriptor and executing the glue code that invokes the actual function.

---

**Figure 58. Pointer Assignment in Non-DLL code**
The following examples and Figure 63 on page 314 show a DLL function pointer call in non-DLL code, where a simplified sort() routine is used. Note that the sort() routine compiled as non-DLL code can be called from both a DLL application and a non-DLL application.

C Example

File 1 and File 2 are bound together to create application A. File 1 is compiled with the NODLL option. File 2 is compiled with the DLL option (so that it can call the DLL function sort()). File 3 is compiled as DLL to create application B. Application A and B can both call the imported function sort() from the DLL in file 4.

File 1 of Complex DLL Application compiled with NODLL option.

typedef int CmpFP(int, int);
void sort(int* arr, int size, CmpFP*); /* sort routine in DLL */
void callsort(int* arr, int size, CmpFP* fp); /* routine compiled as DLL */
/* which can call DLL */
/* routine sort() */

int comp(int e1, int e2) {
    if (e1 == e2) {
        return(0);
    }
    else if (e1 < e2) {
        return(-1);
    }
    else {
        return(1);
    }
}

main() {
    CmpFP* fp = comp;
    int a[2] = {2,1};
    callsort(a, 2, fp);
    return(0);
}

Figure 59. File 1. Application A.

File 2 of Complex DLL Application compiled with DLL option.

typedef int CmpFP(int, int);
void sort(int* arr, int size, CmpFP*); /* sort routine in DLL */
void callsort(int* arr, int size, CmpFP* fp) {
    sort(arr, size, fp);
}

Figure 60. File 2. Application A

312  z/OS V1R4.0 C/C++ Programming Guide
Simple DLL Application compiled with DLL option.

```c
int comp(int e1, int e2) {
    if (e1 == e2)
        return(0);
    else if (e1 < e2)
        return(-1);
    else
        return(1);
}

int (*fp)(int e1, int e2);
main()
{
    int a[2] = {2, 1};
    fp = comp; /* assign function address */
    sort(a, 2, fp); /* call sort */
}
```

Figure 61. File 3. Application B

File 4 is compiled as NODLL and bound into a DLL. The function `sort()` will be exported to users of the DLL.

**DLL Compiled with NODLL Option**

```c
typedef int CmpFP(int, int);
int sort(int* arr, int size, CmpFP* fp) {
    int i,j,temp,rc;
    for (i=0; i<size; ++i) {
        for (j=1; j<size-1; ++j) {
            rc = fp(arr[j-1], arr[j]); /* call 'fp' which may be DLL or no-DLL code */
            if (rc > 0) {
                temp = arr[j];
                arr[j] = arr[j-1];
                arr[j-1] = temp;
            }
        }
    }
    return(0);
}
#pragma export(sort)
```

Figure 62. File 4. DLL

**Note:** Non-DLL function pointers can only safely be passed to a DLL if the function referenced is naturally reentrant, that is, it is C code compiled with the NORENT compiler option, or is C code with no global or static variables. See the discussion on the CBA option to see how to make a DLL that can be called by applications that pass constructed reentrant function pointers.
Non-DLL Function Pointer Call in DLL(CBA) Code

The following figure illustrates one situation where you could use the CBA suboption. In the example, the DLL provider provides stub routines which the application programmer can bind with their applications. These stub routines allow an application programmer to use a DLL without recompiling the application with the DLL option. This is an important consideration for library providers that want to move from a static version of a library to a dynamic one. Stub routines are not mandatory, however if they are provided, the application programmer only needs to rebind, but not recompile the application. If stub routines are not provided by the DLL provider, the application programmer must recompile the application.

Figure 63. DLL Function Pointer Call in non-DLL code
In the previous example, the DLL provider:

- Compiles the DLL parts as either DLL(CBA) or NODLL(CBA).
- Exports function dllsort() for use by other applications.
- Binds the DLL to produce a DLL executable module and a DLL definition side-deck.
- Creates a stub function for every function exported from the DLL. The stub function calls a corresponding function in the DLL. This routine is compiled with the DLL option. The stub functions are provided to the application programmer in a static library to be bound with the application.

The Application Programmer:

- Codes the program using any of the following compiler options;
  - DLL
  - NODLL
  - RENT
  - NORENT
- Calls the stub routines, not the exported functions.

**Note:** The stub routines must be called because the application programmer may have compiled his code with the NODLL compiler option. Otherwise, references to the DLL functions will be unresolved at bind time. Providing the stub routines allows an application programmer to use a DLL without recompiling the application with the DLL option. This is an important consideration for library providers that want to move from a static version...
of a library to a dynamic one. Providing stub routines requires the application programmer to rebind but not recompile the application.

- Statically binds the definition side-deck, provided by the DLL provider, and the stub routines with their program.
- Binds the DLL to produce a DLL executable module and a DLL definition side-deck
- Creates a stub function for every function exported from the DLL. The stub function calls the DLL directly

The reference keys in Figure 64 on page 315 illustrate the sequence of events. Note that in 3, the user does not explicitly make a call to Language Environment. The generated code for the fp function call makes the call to z/OS Language Environment. z/OS Language Environment does the following at point 4 in the figure:

- Saves the DLL environment
- Establishes the application environment
- Branches to the user’s function
- Reestablishes the DLL environment after execution of the function
- Returns control to the DLL.

**Non-DLL Function Pointer Call in DLL Code**

In DLL code, it is assumed that a function pointer points to a function descriptor. A function pointer call is made by first obtaining the function address through dereferencing the pointer; and then, branching to the function entry. When a non-DLL function pointer is passed to DLL code, it points directly to the function entry. An attempt to dereference through such a pointer produces an undefined function address. The subsequent branching to the undefined address may result in an exception. The following is an example of passing a non-DLL function pointer to DLL code via an external variable. Its behavior is undefined as shown in the following example:

**C and C++ Example**

```c
#include <stdio.h>
extern void (*fp)(void);
void hello(void) {
   printf("hello\n");
}
void goo(void) {
   fp = hello; /* assign address of hello, to fp */
   /* (refer to Figure 58 on page 311). */
}
```

*Figure 65. C Non-DLL Code*
In the following example, a non-DLL function pointer call to an assembler function is resolved.

```c
extern void goo(void);
void (*fp)(void);
void main (void) {
  goo();
  (*fp)();    /* Expect a descriptor, but get a function address, */
              /* so it dereferences to an undefined address and */
              /* call fails */
}
```

Figure 66. C DLL Code

```c
extern "C" void goo(void);
void (*fp)(void);
void main (void) {
  goo();
  (*fp)();    /* Expect a descriptor, but get a function address, */
              /* so it dereferences to an undefined address and */
              /* call fails */
}
```

Figure 67. C++ DLL Code

In the following example, a non-DLL function pointer call to an assembler function is resolved.

```c
/*
 * This function must be compiled as DLL(CBA)
 */

extern "OS" {
  typedef void OS_FP(char *, int *);
}

extern "OS" OS_FP* ASMFN(char*);

int CXXFN(char* p1, int* p2) {
  OS_FP* fptr;
  fptr = ASMFN("ASM FN"); /* returns pointer to address of function */
  if (fptr) {
    fptr(p1, p2); /* call asm function through fn pointer */
  }
  return(0);
}
```

Figure 68. C++ DLL Code Calling an Assembler Function

Function Pointer Comparison in Non-DLL Code

In non-DLL code, the results of the following function pointer comparisons are undefined:

- Comparing a DLL function pointer to a non-DLL function pointer
- Comparing a DLL function pointer to another DLL function pointer
- Comparing a DLL function pointer to a constant function address

Comparing a DLL function pointer to a non-DLL function pointer

In Figure 71 on page 318 both the DLL function pointer and the non-DLL function pointer point to the same function, but the pointers when compared are unequal.
C Example

```c
#include <stdio.h>
extern int foo(int (*fp1)(const char *, ...));
main ()
{
    int (*fp)(const char *, ...);
    fp = printf;  /* assign address of a descriptor that points to printf. */
    if (foo(fp))
        printf("Test result is undefined\n");
}
```

**Figure 69. C DLL code**

```c
int foo(int (*fp1)(const char *, ...))
{
    int (*fp2)(const char *, ...);
    fp2 = printf;  /* assign the address of printf. */
    if (fp1 == fp2)  /* comparing address of descriptor to address of printf results in unequal. */
        return(0);
    else
        return(1);
}
```

**Figure 70. C Non-DLL code**

In the preceding examples, DLL code and non-DLL code can reside either in the same executable file or in different executable files.

**Figure 71. Comparison of Function Pointers in non-DLL code**

Comparing a DLL function pointer to another DLL function pointer

The example in **Figure 75 on page 320** compares addresses of function descriptors. In the following examples, both of the DLL function pointers point to the same function, but they compare unequal.
C Example

```c
#include <stdio.h>
extern int goo(int (*fp1)(const char *, ...));
main ()
{
    int (*fp)(const char *, ...);
    fp = printf; /* assign address of a descriptor that */
    /* points to printf. */
    if (goo(fp))
        printf("Test result is undefined\n");
}
```

Figure 72. File 1 C DLL Code

```c
#include <stdio.h>
extern int foo(int (*fp1)(const char *, ...),
    int (*fp2)(const char *, ...));
int goo(int (*fp1)(const char *, ...) )
{
    int (*fp2)(const char *, ...);
    fp2 = printf; /* assign address of a different */
    /* descriptor that points to printf. */
    return (foo(fp1, fp2));
}
```

Figure 73. File 2 C DLL Code

```c
int foo(int (*fp1)(const char *, ...),
    int (*fp2)(const char *, ...))
{
    if (fp1 == fp2) /* comparing the addresses of two */
        /* descriptors results in unequal. */
        return(0);
    else
        return(1);
}
```

Figure 74. File 3 C Non-DLL Code

**Comparison of Two DLL Function Pointers in Non-DLL code**

File 1 and file 2 reside in different executable modules. File 3 can reside in the same executable module as file 1 or file 2 or it can reside in a different executable module. In all cases, the addresses of the function descriptors will not compare equally.
Comparing a DLL function pointer to a constant function address other than NULL

Here, you are comparing the constant function address to an address of a function descriptor.

Note: Comparing a DLL function pointer to NULL is well defined, because when a pointer variable is initialized to NULL in DLL code, it has a value zero.

Function Pointer Comparison in DLL Code

In XPLINK code, function pointers are compared using the address of the descriptor. No special considerations, such as dereferencing, are required to initialize the function pointer prior to comparison. Function descriptors are guaranteed to be unique throughout the XPLINK application for a particular function, so this comparison of function descriptor addresses will yield the correct results even if the function pointer is passed between executable modules within the XPLINK application. The remainder of this section does not apply to XPLINK applications.

In non-XPLINK DLL code, a function pointer must be NULL before it is compared. For a non-NULL pointer, the pointer is further dereferenced to obtain the function address that is used for the comparison. For an uninitialized function pointer that has a non-zero value, the dereference can cause an exception to occur. This happens if the storage that the uninitialized pointer points to is read-protected.

Usually, comparing uninitialized function pointers results in undefined behavior. You must initialize a function pointer to NULL or the function address (from source view). Two examples follow.

Figure 75. Comparison of Two DLL Function Pointers in Non-Dll Code
Figure 77 shows that, when fp1 points to a read-protected memory block, an exception occurs.

```
#include <stdio.h>
int (*fp2)(const char *, ...) /* Initialize to point to the */
    = printf; /* descriptor for printf */
int goo(void);
int (*fp2)(void) = goo;
int goo(void) {
    int (*fp1)(void);
    if (fp1 == fp2)
        return (0);
    else
        return (1);
}
void check_fp(void (*fp)()) {
    /* exception likely when -1 is dereferenced below */
    if (fp == (void (*)())-1)
        printf("Found terminator\n");
    else
        fp();
}
void dummy() {
    printf("In function\n");
}
main() {
    void (*fa[2])();
    int i;

    fa[0] = dummy;
    fa[1] = (void (*)())-1;

    for(i=0;i<2;i++)
        check_fp(fa[i]);
}
```

Figure 77. Comparison of Function Pointers in DLL code (C or C++)

Following is an example of valid comparisons in DLL code:
Using DLLs That Call Each Other

An application can use DLLs that call each other. There are two methods for building these applications, as illustrated in the examples that follow:

- In the first method, the loop is broken by manually creating IMPORT statements for the referenced DLLs, when binding one of the DLLs (APPL2D3).
- In the second method, an initial bind is done on APPL2D3 using the binder NCAL parameter, which will be done again after the referenced DLLs are built.

In both cases, the result is that the side-deck is produced for APPL2D3, so that the DLLs that reference APPL2D3 can be built.

The APPL2 application (Figure 79 on page 323) imports functions and variables from three DLLs: Figure 80 on page 323, Figure 81 on page 324, and Figure 82 on page 324.

```c
#include <stdio.h>

int (*fp1)(const char *, ...); /* An extern variable is implicitly*/
    /* initialized to zero */
    /* if it has not been explicitly */
    /* initialized in source. */

int (*fp2)(const char *, ...) /* Initialize to point to the */
    = printf; /* descriptor for printf */

int foo(void) {
    if (fp1 != fp2 )
        return (0);
    else
        return (1);
}
```

*Figure 78. Valid Comparisons in DLL Code (C or C++)*
The following application APPL2D1 imports functions from Figure 81 on page 324 and Figure 82 on page 324.

#include <stdlib.h>
#include <stdio.h>

int main() {
  int rc = 0;
  printf("+-APPL2::main() starting \n");
  /* ref DLL1 */
  if (var1_d1 == 100) {
    printf("| var1_d1=<%d>, var1_d1++\n", var1_d1);
    func1_d1(var1_d1);
  }
  /* ref DLL2 */
  if (var1_d2 == 200) {
    printf("| var1_d2=<%d>, var1_d2++\n", var1_d2);
    func1_d2(var1_d2);
  }
  /* ref DLL3 */
  if (var1_d3 == 300) {
    printf("| var1_d3=<%d>, var1_d3++\n", var1_d3);
    func1_d3(var1_d3);
  }
  printf("+-APPL2::main() Ending \n");
}

#include <stdio.h>

int func1_d1(); /* A function to be externalized */
int var1_d1 = 100; /* export this variable */

int main() {
  printf("+-APPL2::main() starting \n");
  int rc = 0;
  int rc2 = 0;
  int rc3 = 0;
  printf("| +-APPL2D1() func1_d1() starting. Input is %d\n", input);
  rc2 = func1_d2(200);
  rc3 = func1_d3(300);
  printf("| | func1_d1() dll1 - rc2=<%d>, rc3=<%d>\n", rc2, rc3);
  printf("| | func1_d1() dll2 - rc2=<%d>, rc3=<%d>\n", rc2, rc3);
  printf("+-APPL2D1() func1_d1() ending. \n");
}

Figure 79. Application APPL2

The following application APPL2D1 imports functions from Figure 81 on page 324 and Figure 82 on page 324.

#include <stdio.h>

int func1_d2(int); /*imported from APPL2D2 */
int func1_d3(int); /*imported from APPL2D3 */

int main() {
  printf("+-APPL2::main() starting \n");
  /* ref DLL1 */
  if (var1_d1 == 100) {
    printf("| var1_d1=<%d>, var1_d1++\n", var1_d1);
    func1_d1(var1_d1);
  }
  /* ref DLL2 */
  if (var1_d2 == 200) {
    printf("| var1_d2=<%d>, var1_d2++\n", var1_d2);
    func1_d2(var1_d2);
  }
  /* ref DLL3 */
  if (var1_d3 == 300) {
    printf("| var1_d3=<%d>, var1_d3++\n", var1_d3);
    func1_d3(var1_d3);
  }
  printf("+-APPL2::main() Ending \n");
}

#include <stdio.h>

int func1_d2(int); /*imported from APPL2D2 */
int func1_d3(int); /*imported from APPL2D3 */

int main() {
  printf("+-APPL2::main() starting \n");
  int rc = 0;
  int rc2 = 0;
  int rc3 = 0;
  printf("| +-APPL2D1() func1_d1() starting. Input is %d\n", input);
  rc2 = func1_d2(200);
  rc3 = func1_d3(300);
  printf("| | func1_d1() dll1 - rc2=<%d>, rc3=<%d>\n", rc2, rc3);
  printf("| | func1_d1() dll2 - rc2=<%d>, rc3=<%d>\n", rc2, rc3);
  printf("+-APPL2D1() func1_d1() ending. \n");
}

Figure 80. Application APPL2D1

The following application APPL2D2 imports a function from Figure 82 on page 324.
The following application APPL2D3 imports variables from Figure 80 on page 323 and Figure 81. The first method uses the JCL in Figure 83 on page 325. The following processing occurs:

1. APPL2D3 is compiled and bound to create a DLL. The binder uses the control cards supplied through SYSIN to import variables from APPL2D1 and APPL2D2. The binder also generates a side-deck APPL2D3 that is used in the following steps.

2. APPL2D2 is compiled and bound to create a DLL. The binder uses the control cards supplied through SYSIN to include the side-deck from APPL2D3. The following steps use the binder which generates the side-deck APPL2D2.

3. APPL2D1 is compiled and bound to create a DLL. The binder uses the control cards supplied through SYSIN to include the side-decks from APPL2D2 and APPL2D3. The following steps show the binder generating the side-deck APPL2D1.

4. APPL2 is compiled, bound, and run. The binder uses the control statements supplied through SYSIN to include the side-decks from APPL2D1, APPL2D2, and APPL2D3.

```
#include <stdio.h>

int func1_d2(); /* A function to be externalized */
int var1_d2 = 200;

extern int func1_d3(int); /* import this function */

int func1_d2 (int input)
{
    int rc3 =0;
    printf("| | | -APPL2D2() func1_d2() starting. Input is %d\n", input);
    rc3 = func1_d3(300);
    printf("| | | | func1_d2() dll2 - rc3=<%d>\n", rc3);
    printf("| | | -APPL2D2() func1_d2() ending\n");
}
```

Figure 81. Application APPL2D2

The following application APPL2D3 imports variables from Figure 80 on page 323 and Figure 81.

```
#include <stdio.h>

int func1_d3(); /* A function to be externalized */
int var1_d3 = 300;

extern int var1_d1; /* imported variable from appl2D1 */
extern int var1_d2; /* imported variable from appl2D2 */

int func1_d3 (int input)
{
    int rc3 =0;
    printf("| | | +APPL2D3()-func1_d3() starting. Input is %d\n", input);
    printf("| | | | value of var1_d1=%d var1_d2=%d\n", var1_d1, var1_d2);
    printf("| | | +APPL2D3()-func1_d3() ending\n");
}
```

Figure 82. Application APPL2D3
The second method uses the JCL in Figure 84 on page 326. The following processing occurs:

```plaintext
//jobcard information...
//*
// CBDDL3: -Compile and bind APPL2D3
//  -Explicit import of variables from APPL2D1 and APPL2D2
//  -Generate the side-deck APPL2D3
//*
//CBDDL3 EXEC EDCCB,INFILE='myid.SOURCE(APPL2D3)',
//  CPARM='SO,LIST,DLL,EXPO,RENT,LONG',
//  OUTFILE='myid.LOAD,DISP=SHR'
//BIND.SYSIN DD *
IMPORT DATA APPL2D1 var1_d1
IMPORT DATA APPL2D2 var1_d2
NAME APPL2D3(R)
/*
//BIND.SYSDEFSD DD DSN=myid.IMPORT(APPL2D3),DISP=SHR
//*
//CBDDL2: -Compile and bind APPL2D2
//  -Include the side-deck APPL2D3
//  -Generate the side-deck APPL2D2
//*
//CBDDL2 EXEC EDCCB,INFILE='myid.SOURCE(APPL2D2)',
//  CPARM='SO,LIST,DLL,EXPO,RENT,LONG',
//  OUTFILE='myid.LOAD,DISP=SHR'
//BIND.SYSIN DD *
INCLUDE DSD(APPL2D3)
NAME APPL2D2(R)
/*
//BIND.SYSDEFSD DD DSN=myid.IMPORT(APPL2D2),DISP=SHR
//BIND.DSD DD DSN=myid.IMPORT,DISP=SHR
//*
// CBDDL1: -Compile and bind APPL2D1
//  -Include the side-deck APPL2D2 and APPL2D3
//  -Generate the side-deck APPL2D1
//*
//CBDDL1 EXEC EDCCB,INFILE='myid.SOURCE(APPL2D1)',
//  CPARM='SO,LIST,DLL,EXPO,RENT,LONG',
//  OUTFILE='myid.LOAD,DISP=SHR'
//BIND.SYSIN DD *
INCLUDE DSD(APPL2D1)
INCLUDE DSD(APPL2D2)
NAME APPL2D1(R)
/*
//BIND.SYSDEFSD DD DSN=myid.IMPORT(APPL2D1),DISP=SHR
//BIND.DSD DD DSN=myid.IMPORT,DISP=SHR
//*
// CBAPP2: -Compile, bind and run APPL2
//  -Include the side-deck APPL2D1, APPL2D2 and APPL2D3
//*
//CBAPP2 EXEC EDCCBG,INFILE='myid.SOURCE(APPL2)',
//  CPARM='SO,LIST,DLL,RENT,LONG',
//  OUTFILE='myid.LOAD(APPL2),DISP=SHR'
//BIND.SYSIN DD *
INCLUDE DSD(APPL2D1)
INCLUDE DSD(APPL2D2)
INCLUDE DSD(APPL2D3)
NAME APPL2(R)
/*
//BIND.DSD DD DSN=myid.IMPORT,DISP=SHR
//GO.STEPLIB DD
// DD DSN=myid.LOAD,DISP=SHR
```

Figure 83. Method 1 JCL
1. Once compiled, the object module APPL2D2 is saved for the following steps.
2. APPL2D1 is compiled, the object module is saved for the following steps.
3. APPL2D3 is compiled and bound to generate the side-deck and the object module is not used in the following steps. The load module for this step is not saved, as it is not being used. The load module for APPL2D3 is generated at a later step.
4. APPL2D2 is bound to create a DLL. The binder takes as input the object module APPL2D2 and the side-deck APPL2D3. It also generates the side-deck APPL2D2 that is used in the following steps.
5. APPL2D1 is bound to create a DLL. The binder takes as input the object module APPL2D1 and the side-decks APPL2D3 and APPL2D2. It also generates the side-deck APPL2D1 that is used in the following steps.
6. APPL2D3 is bound to create a DLL. The binder takes as input the object module APPL2D3 and the side-decks APPL2D1 and APPL2D2. It also generates the side-deck APPL2D3 that is used in the following step.
7. APPL2 is compiled, bound, and run. The binder takes as input the object module APPL2 and the side-decks APPL2D1, APPL2D2, and APPL2D3.

//jobcard information...
/* CDLL2: -Compile APPL2D2 */
//CDLL2 EXEC EDCC,INFILE='myid.SOURCE(APPL2D2)',
// OUTFILE='myid.OBJ(APPL2D2),DISP=SHR',
// CPARM='SO,LIST,DLL,EXPO,RENT,LONG'
/*
/* CDLL1: -Compile APPL2D1 */
//CDLL1 EXEC EDCC,INFILE='myid.SOURCE(APPL2D1)',
// OUTFILE='myid.OBJ(APPL2D1),DISP=SHR',
// CPARM='SO,LIST,DLL,EXPO,RENT,LONG'
/*
/* CBDDL3: -Compile and bind APPL2D3 with NCAL
/* -Generate the side-deck APPL2D3
/* -The load module will not be kept, as it will not be
/* used
/*
//CBDDL3 EXEC EDCCB,INFILE='myid.SOURCE(APPL2D3)',
// CPARM='SO,LIST,DLL,EXPO,RENT,LONG',
// B Parm='NCAL'
//COMPILE.SYSLIN DD DSN=myid.OBJ(APPL2D3),DISP=SHR
//BIND.SYSLIN DD DSN=myid.OBJ(APPL2D3),DISP=SHR
//BIND.SYSIN DD *
INCLUDE OBJ(APPL2D2)
INCLUDE OBJ(APPL2D1)
NAME APPL2D3(R)
/*
//BIND.SYDEFSD DD DSN=myid.IMPORT(APPL2D3),DISP=SHR
//BIND.OBJ DD DSN=myid.OBJ,DISP=SHR
/*

Figure 84. Method 2 JCL (Part 1 of 2)
Figure 84. Method 2 JCL (Part 2 of 2)
Chapter 23. Using Threads in z/OS UNIX Applications

A thread is a single flow of control within a process. The following section describes some of the advantages of using multiple threads within a single process, and functions that can be used to maintain this environment.

Models and Requirements

Threads are efficient in applications that allow them to take advantage of any underlying parallelism available in the host environment. This underlying parallelism in the host can be exploited either by forking a process and creating a new address space, or by using multiple threads within a single process. There are advantages and disadvantages to both techniques, but it primarily comes down to a compromise between the efficiency of using multiple threads versus the security of working in separate address spaces. The POSIX(ON) run-time option must be specified to use threads.

Functions

The following table lists the functions provided to implement a multi-threaded application:

Table 42. Functions used in creating multi-threaded applications

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_create()</td>
<td>Create a thread</td>
</tr>
<tr>
<td>pthread_join()</td>
<td>Wait for thread termination</td>
</tr>
<tr>
<td>pthread_exit()</td>
<td>Terminate a thread normally</td>
</tr>
<tr>
<td>pthread_detach()</td>
<td>Detach a thread</td>
</tr>
<tr>
<td>pthread_self()</td>
<td>Get your thread ID</td>
</tr>
<tr>
<td>pthread_equal()</td>
<td>Compare thread IDs</td>
</tr>
<tr>
<td>pthread_once()</td>
<td>Run a function once per process</td>
</tr>
<tr>
<td>pthread_yield()</td>
<td>Yield the processor</td>
</tr>
</tbody>
</table>

Creating a Thread

To use a thread you must first create a thread attribute object with the pthread_attr_init() function. A thread attribute object defines the modifiable characteristics that a thread may have. Refer to the description of pthread_attr_init() in z/OS C/C++ Run-Time Library Reference for a list of the attributes and their default values. When the thread attribute object has been created, you may use the following functions to change the default attributes.

Table 43. Functions to change default attributes

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_attr_init()</td>
<td>Initialize a thread attribute object</td>
</tr>
<tr>
<td>pthread_attr_destroy()</td>
<td>Delete a thread attribute object</td>
</tr>
<tr>
<td>pthread_attr_getstacksize()</td>
<td>Gets the stacksize for thread attribute object</td>
</tr>
<tr>
<td>pthread_attr_setstacksize()</td>
<td>Sets the stacksize for thread attribute object</td>
</tr>
<tr>
<td>pthread_attr_getdetachstate()</td>
<td>Returns current value of detachstate for thread attribute object</td>
</tr>
</tbody>
</table>
Table 43. Functions to change default attributes (continued)

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_attr_setdetachstate()</td>
<td>Alters the current detachstate of thread attribute object</td>
</tr>
<tr>
<td>pthread_attr_getweight_np()</td>
<td>Obtains the current weight of thread setting</td>
</tr>
<tr>
<td>pthread_attr_setweight_np()</td>
<td>Alters the current weight of thread setting</td>
</tr>
<tr>
<td>pthread_attr_getsynctype_np()</td>
<td>Returns the current synctype setting of thread attribute object</td>
</tr>
<tr>
<td>pthread_attr_setsynctype_np()</td>
<td>Alters the synctype setting of thread attribute object</td>
</tr>
</tbody>
</table>

The attribute object is only used when the thread is created. You can reuse it to create other threads with the same attributes, or you can modify it to create threads with other attributes. You can delete the attribute object with the pthread_attr_destroy() function.

After you create the thread attribute object, you can then create the thread with the pthread_create() function.

When a daughter thread is created, the function specified on the pthread_create() as the start routine begins to execute concurrently with the thread that issued the pthread_create(). It may use the pthread_self() function to determine its thread ID. The daughter thread will continue to execute until a pthread_exit() is issued, or the start routine ends. The function that issued the pthread_create() resumes as soon as the daughter thread is created. The daughter thread ID is returned on a successful pthread_create(). This thread ID, for example, can be used to send a signal to the daughter thread using pthread_kill() or it can be used in pthread_join() to cause the initiating thread to wait for the daughter thread to end.

The following functions can be used to control the behavior of the individual threads in a multi-threaded application.

Table 44. Functions used to control individual threads in a multi-threaded environment

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_equal()</td>
<td>Compares two thread IDs</td>
</tr>
<tr>
<td>pthread_yield()</td>
<td>Allows threads to give up control</td>
</tr>
</tbody>
</table>

Refer to [z/OS C/C++ Run-Time Library Reference](#) for more information on these functions.

**Synchronization Primitives**

This section covers the control of multiple threads that may share resources. In order to maintain the integrity of these resources, a method must exist for the threads to communicate their use of, or need to use, a resource. The threads can be within a common process or in different processes.

**Models**

Mutexes, condition variables, and read-write locks are used to communicate between threads. These constructs may be used to synchronize the threads themselves, or they can also be used to serialize access to common data objects shared by the threads.
• The mutex, which is the simple type of lock, is exclusive. If a thread has a mutex locked, the next thread that tries to acquire the same mutex is put in a wait state. This is beneficial when you want to serialize access to a resource. This might cause contention however if several threads are waiting for a thread to unlock a mutex. Therefore, this form of locking is used more for short durations. If the mutex is a shared mutex, it must be obtained in shared memory accessible among the cooperating processes.

A thread in mutex wait will not be interrupted by a signal.

• A condition variable provides a mechanism by which a thread can suspend execution when it finds some condition untrue, and wait until another thread makes the condition true. For example, threads could use a condition variable to insure that only one thread at a time had write access to a data set.

Threads in condition wait can be interrupted by signals.

• A read-write lock can allow many threads to have simultaneous read-only access to data while allowing only one thread at a time to have write access. The read-write lock must be allocated in memory that is writable. If the read-write lock is a shared read-write lock, it must be obtained in shared memory accessible among the cooperating processes.

Functions
The following functions allow for synchronization between threads:

Table 45. Functions that allow for synchronization between threads

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_mutex_init()</td>
<td>Initialize a Mutex</td>
</tr>
<tr>
<td>pthread_mutex_destroy()</td>
<td>Destroy a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_init()</td>
<td>Initialize Default Attribute Object for a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_destroy()</td>
<td>Destroy Attribute Object for a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_getkind_np()</td>
<td>Get Kind Attribute for a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_setkind_np()</td>
<td>Set Kind Attribute for a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_gettype()</td>
<td>Get Type Attribute for a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_settype()</td>
<td>Set Type Attribute for a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_getpshared()</td>
<td>Get Process-shared Attribute for a Mutex</td>
</tr>
<tr>
<td>pthread_mutexattr_setpshared()</td>
<td>Set Process-shared Attribute for a Mutex</td>
</tr>
<tr>
<td>pthread_mutex_lock()</td>
<td>Acquire a Mutex Lock</td>
</tr>
<tr>
<td>pthread_mutex_unlock()</td>
<td>Release a Mutex Lock</td>
</tr>
<tr>
<td>pthread_mutex_trylock()</td>
<td>Allows lock to be tested</td>
</tr>
<tr>
<td>pthread_cond_init()</td>
<td>Initialize a Condition Variable</td>
</tr>
<tr>
<td>pthread_cond_destroy()</td>
<td>Destroy a Condition Variable</td>
</tr>
<tr>
<td>pthread_condattr_init()</td>
<td>Initialize Default Attribute Object for a Condition Variable</td>
</tr>
<tr>
<td>pthread_condattr_destroy()</td>
<td>Destroy Attributes Object for a Condition Variable</td>
</tr>
<tr>
<td>pthread_condattr_getkind_np()</td>
<td>Get Attribute for Condition Variable object</td>
</tr>
<tr>
<td>pthread_condattr_setkind_np()</td>
<td>Set Attribute for Condition Variable object</td>
</tr>
<tr>
<td>pthread_cond_wait()</td>
<td>Wait for a Condition Variable</td>
</tr>
<tr>
<td>pthread_cond_timedwait()</td>
<td>Timed wait for a Condition Variable</td>
</tr>
<tr>
<td>pthread_cond_signal()</td>
<td>Signal a Condition Variable</td>
</tr>
</tbody>
</table>
### Table 45. Functions that allow for synchronization between threads (continued)

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_cond_broadcast()</td>
<td>Broadcast a Condition Variable</td>
</tr>
<tr>
<td>pthread_rwlock_init()</td>
<td>Initialize a Read-Write Lock</td>
</tr>
<tr>
<td>pthread_rwlock_destroy()</td>
<td>Destroy a Read-Write Lock</td>
</tr>
<tr>
<td>pthread_rwlock_rdlock()</td>
<td>Wait for a Read Lock</td>
</tr>
<tr>
<td>pthread_rwlock_tryrdlock()</td>
<td>Allows Read Lock to be Tested</td>
</tr>
<tr>
<td>pthread_rwlock_trywrlock()</td>
<td>Allows Read-Write Lock to be Tested</td>
</tr>
<tr>
<td>pthread_rwlock_unlock()</td>
<td>Release a Read-Write Lock</td>
</tr>
<tr>
<td>pthread_rwlock_wrlock()</td>
<td>Wait for a Read-Write Lock</td>
</tr>
<tr>
<td>pthread_rwlockattr_init()</td>
<td>Initialize Default Attribute Object for a Read-Write Lock</td>
</tr>
<tr>
<td>pthread_rwlockattr_destroy()</td>
<td>Destroy Attribute Object for a Read-Write Lock</td>
</tr>
<tr>
<td>pthread_rwlockattr_getpshared()</td>
<td>Get Process-shared Attribute for a Read-Write Lock</td>
</tr>
<tr>
<td>pthread_rwlockattr_setpshared()</td>
<td>Set Process-shared Attribute for a Read-Write Lock</td>
</tr>
</tbody>
</table>

### Creating a Mutex

To use the mutex lock you must first create a mutex attribute object with the `pthread_mutexattr_init()` function. A mutex attribute object defines the modifiable characteristics that a mutex may have. Refer to the description of `pthread_mutexattr_init()` in [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/knowledgecenter/en/SSLVMB_1.4.4/com.ibm.zos.v1r4.0/c/libref/index.html) for a list of these attributes and their defaults.

After the mutex attribute object has been created, you can use the following functions to change the default attributes.

- `pthread_mutexattr_getkind_np()`
- `pthread_mutexattr_setkind_np()`
- `pthread_mutexattr_gettype()`
- `pthread_mutexattr_settype()`
- `pthread_mutexattr_getpshared()`
- `pthread_mutexattr_setpshared()`

The mutex attribute object is used only when creating the mutex. It can be used to create other mutexes with the same attributes or modified to create mutexes with different attributes. You can delete a mutex attribute object with the `pthread_mutexattr_destroy()` function.

After the mutex attribute object has been created, the mutex can be created with the `pthread_mutex_init()` function.

While using mutexes as the locking device, the following functions can be used:

- `pthread_mutex_lock()`
- `pthread_mutex_unlock()`
- `pthread_mutex_trylock()`

To remove the mutex, use the `pthread_mutex_destroy()` function.
Creating a Condition Variable
Before creating a condition variable, you need to create a mutex (as shown above), then you must use the `pthread_condattr_init()` function to create a condition variable attribute object. This attribute object, like the mutex attribute object, defines the modifiable characteristics that a condition variable may have. Refer to the description of `pthread_condattr_init()` in z/OS C/C++ Run-Time Library Reference for a list of these attributes and their defaults.

After the condition variable attribute object has been created, you may use the following functions to change the default attributes:

```c
pthread_condattr_getkind_np()
pthread_condattr_setkind_np()
```

The condition variable attribute object is used only when creating the condition variable. It can be used to create other condition variables with the same attributes or modified to create condition variables with different attributes. You can delete a condition variable attribute object with the `pthread_condattr_destroy()` function.

After a condition variable attribute object has been created, the condition variable itself can be created with the `pthread_cond_init()` function.

Condition variables can then be used as a synchronization primitive using the following functions:

```c
pthread_cond_wait()
pthread_cond_timedwait()
pthread_cond_signal()
pthread_cond_broadcast()
```

The condition variable can be removed with the `pthread_cond_destroy()` function.

Creating a Read-Write Lock
To use a read-write lock you must first create a read-write attribute object with the `pthread_rwlockattr_init()` function. A read-write attribute object defines the modifiable characteristics that a read-write lock may have. Refer to the description of `pthread_rwlockattr_init()` in z/OS C/C++ Run-Time Library Reference for a list of these attributes and their defaults.

After the read-write lock attribute object has been created, you can use the following functions to change the default attributes.

- `pthread_rwlockattr_getpshared()`
- `pthread_rwlockattr_setpshared()`

The read-write lock attribute object is used only when creating the read-write lock. It can be used to create other read-write locks with the same attributes or modified to create read-write locks with different attributes. You can delete a read-write attribute object with the `pthread_rwlockattr_destroy()` function.

After the read-write attribute has been created, the read-write lock can be created with the `pthread_rwlock_init()` function.

While using read-write locks as the locking device, the following functions can be used:

- `pthread_rwlock_rdlock()`
- `pthread_rwlock_tryrdlock()`
• `pthread_rwlock_wrlock()`
• `pthread_rwlock_trywrlock()`
• `pthread_rwlock_unlock()`

To remove the read-write lock, use the `pthread_rwlock_destroy()` function.

**Thread-specific Data**

While all threads can access the same memory, it is sometimes desirable to have data that is (logically) local to a specific thread. The **key/value** mechanism provides for global (process-wide) keys with value bindings that are unique to a thread.

You can also use the `pthread_tag_np()` function to set and query 65 bytes of thread tag data associated with the caller’s thread.

**Model**

The **key/value mechanism** associates a data key with each data item. When the association is made, the key identifies the data item with a particular thread. This data key is a transparent data object of type `pthread_key_t`. The contents of this key are not exposed to the user.

The user gets a key by issuing the `pthread_key_create()` function. One of the arguments on the `pthread_key_create()` function is a pointer to a local variable of type `pthread_key_t`. This variable is then used with the `pthread_set_specific()` function to establish a unique key value.

`pthread_key_create()` creates a unique identifier (a key) that is visible to all of the threads in a process. This data key is returned to the caller of `pthread_key_create()`. Threads can associate a thread unique data item with this key using the `pthread_setspecific()` call. A thread can get its unique data value for a key using the `pthread_getspecific()` call. In addition, a key can have an optional “destructor” routine associated with it. This routine is executed during thread termination and is passed the value of the key for the thread being terminated. A typical use of a key and destructor is to have storage obtained by a thread using `malloc()` and returned within the destructor at thread termination by using `free()`.

**Functions**

The following functions are used with thread-specific data:

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>pthread_key_create()</code></td>
<td>Create a thread-specific data key</td>
</tr>
<tr>
<td><code>pthread_getspecific()</code></td>
<td>Retrieve the value associated with a thread-specific key</td>
</tr>
<tr>
<td><code>pthread_setspecific()</code></td>
<td>Associate a value with a thread-specific key</td>
</tr>
<tr>
<td><code>pthread_tag_np()</code></td>
<td>Set and query the contents of the calling thread's tag data</td>
</tr>
</tbody>
</table>

**Creating Thread-specific Data**

The following example uses thread-specific data to insure that storage acquired by a specific thread is freed when the thread ends.
Signals

Each thread has an associated signal mask. The signal mask contains a flag for each signal defined by the system. The flag determines which signals are to be blocked from being delivered to a particular thread.

Unlike the signal mask, there is one signal action per signal for all of the threads in the process. Some signal functions work on the process level, having an impact on multiple threads, while others work on the thread level, and only affect one particular thread. For example, the function kill() operates at the process level, whereas the functions pthread_kill() and sigwait() operate at the thread level.

The following are some other signal functions that operate on the process level and can influence multiple threads:

- alarm()
- bsd_signal()
Generating a Signal

A signal can be generated explicitly with the `raise()`, `kill()`, `killpg()`, or `pthread_kill()` functions or implicitly with functions such as `alarm()` or by the system when certain events occur. In all cases, the signal will be directed to a specific thread running in a process.

The two primary functions for controlling signals are `sigaction()` and `sigprocmask()`. `sigaction()` also includes `bsd_signal()`, `signal()`, and `sigset()`.

`sigaction()`

`sigaction()` specifies the action when a signal is processed by the system. This function is process-scoped instead of thread-specific. When a signal is generated for a process, the state of each thread within that process determines which thread is affected.

The three types of signal actions are:

- **catcher**
  Specifies the address of a function that will get control when the signal is delivered

- **SIG_DFL**
  Specifies that the system should perform default processing when this signal type is generated

- **SIG_IGN**
  Specifies that the system should ignore all signals of this type.

**Attention:** If a signal whose default action is to terminate is delivered to a thread running in a process where there are multiple threads running, and no signal catcher is designated for the signal, the entire process is terminated. You can avoid this by blocking each of the terminating signals, or by establishing a signal catcher for each of them.

In a multi-threaded application, when a signal is generated by a function or action that is not thread specific, and the process has some threads set up for signals and some threads that are not set up for signals, then the kernel’s signal processing determines which thread has the most interest in the signal.

The following is a list of signal interest rules in their order of priority:

1. When threads are found in a `sigwait()` for this signal type, the signal is delivered to the first thread found in a `sigwait()`.
2. When all threads are blocking this signal type, the signal is left pending in the kernel at the process level. The `sigpending` function moves blocked pending signals at the process level to the thread level.
3. When all of the following are true:
   - One or more threads are set up for signals
• All threads set up for signals have the signal blocked
• A thread not set up for signals has not blocked the signal

The signal is left pending in the kernel on the first thread set up for signals. The signal remains pending on that thread until the thread unblocks the signal.

4. When the signal action is to catch, the signal is delivered to one of the threads that has the signal unblocked.

**sigprocmask()**

*sigprocmask()* specifies a way to control which set of signals interrupt a specific thread. Because *sigprocmask()* is thread-scoped, it blocks the signal for only the thread that issues the function.

### Thread Cancellation

When multiple threads are running in a process, thread cancellation permits one thread to cancel another thread in that process. This is done with the *pthread_cancel()* function, which causes the system to generate a cancel interrupt and direct it to the thread specified on the *pthread_cancel()* function. Each thread can control how the system generates this cancel interrupt by altering the interrupt state and type.

A thread may have the following interrupt states, in descending order of control:

**disabled**

For short code sequences, the entire code sequence can be disabled to prevent cancel interrupts. The *pthread_setintr()* function enables or disables cancel interrupts in this manner.

**controlled**

For larger code sequences where you want some control over the interrupts but cannot be entirely disabled, set the interrupt type to controlled and the interrupt state to enabled. The *pthread_setintrtype()* function allows for this type of managed interrupt delivery by introducing the concept of cancellation points.

Cancellation points consist of calls to a limited set of library functions. Refer to the description of *pthread_setintrtype()* in *z/OS C/C++ Run-Time Library Reference* for a list of these cancellation points. The user program can implicitly or explicitly solicit interrupts by invoking one of the library functions in the set of cancellation points, thus allowing the user to control the points within their application where a cancel may occur.

**asynchronous**

For code sequences where you do not need any control over the interrupt, set *pthread_setintr()* to enable and *pthread_setintrtype()* to asynchronous. This will allow cancel interrupts to occur at any point within your program.

For example, if you have a critical code section (a sequence of code that needs to complete), you would turn cancel off or prevent the sequence from being interrupted. If the code is relatively long, consider running using the controlled interrupt and as long as the critical code section doesn’t contain any of the functions that are considered cancellation points, it will not be unexpectedly canceled.

For C++, destructors for automatic objects on the stack are run when a thread is cancelled. The stack is unwound and the destructors are run in reverse order.
Functions

Table 47. Functions used to control cancellability

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_cancel()</td>
<td>Cancel a thread</td>
</tr>
<tr>
<td>pthread_setintr()</td>
<td>Set thread cancellability state</td>
</tr>
<tr>
<td>pthread_setintrtype()</td>
<td>Set thread cancellability type</td>
</tr>
<tr>
<td>pthread_testintr()</td>
<td>Establish a cancellability point</td>
</tr>
</tbody>
</table>

Cancelling a Thread

Three possible scenarios may cancel a thread, one for each of the interrupt states of the thread being canceled.

- One thread issues `pthread_cancel()` to another thread whose cancellability state is enabled and controlled. In this case the thread being canceled continues to run until it reaches an appropriate cancellation point. When the thread is eventually cancelled, just prior to termination of the thread, any cleanup handlers which have been pushed and not yet popped will be executed. Then if the thread has any thread-specific data, the destructor functions associated with this data will be executed.

- One thread issues `pthread_cancel()` to another thread whose interruption state is enabled and asynchronous. In this case the thread being canceled is terminated immediately, after any cleanup handlers and thread-specific data destructor functions are executed, as in the first scenario.

- One thread issues `pthread_cancel()` to another thread whose interruption state is disabled. In this case the cancel request is ignored and the thread being canceled continues to run normally.

In the first two interrupt states above, the caller of `pthread_cancel()` may get control back before the thread is actually canceled.

Cleanup for Threads

Cleanup handlers are routines written by the user that include any special processing the user finds necessary for termination of a thread. As the user’s routine executes, it pushes cleanup handlers on to a stack. As the thread continues to run and the routine progresses, these cleanup handlers can be taken off of the stack by the user’s routine.

A list or stack of cleanup handlers is maintained for each thread. When the thread ends, all pushed but not yet popped cleanup routines are popped from the cleanup stack and executed in last-in-first-out (LIFO) order. This occurs when the thread:

- Calls `pthread_exit()`
- Does a return from or reaches the end of the start routine (that gets controls as a result of a `pthread_create()`)  
- Is canceled because of a `pthread_cancel()`.

Functions

Table 48. Functions used for cleanup purposes

<table>
<thead>
<tr>
<th>Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>pthread_cleanup_push()</td>
<td>Establish a cleanup handler</td>
</tr>
</tbody>
</table>
### Behaviors and Restrictions in z/OS UNIX Applications

The following are implementation-specified behaviors and restrictions that apply to the C/C++ library functions when running a multi-threaded z/OS UNIX application.

#### Using Threads with MVS Files

MVS files that are opened by data-set names or ddnames are thread-specific in the following ways:

- **Note:** These restrictions specifically do not apply to Hierarchical File System (HFS) files.

All opens and closes by the C library that result in calls to an underlying access method for a given MVS file must occur on the same thread. Apart from this requirement, file pointers can be freely used for any type of file access (reading, writing, repositioning, and so forth) from any thread. Therefore, the following specific functions are prohibited from any thread except the owning thread (the one that does the initial `fopen()` of the file):

- `fclose`
- `freopen`
- `rewind`

Multivolume data sets and files that are part of a concatenated ddname are further restricted in multithreaded applications. All I/O operations are restricted to the thread on which the file is opened.

The above thread affinity restrictions on the use of MVS files apply to hiperspace memory files but not to regular memory files.

When standard streams are directed to MVS files, they are governed by the above restrictions. Standard streams are directed to MVS files in one of two ways:

- By default when a `main()` program is run from the TSO ready prompt or by a JCL EXEC PGM= statement, that is, whenever it is not initiated by the `exec()` function. This is regardless of whether you are running with POSIX(ON) or POSIX(OFF). In these cases, the owning thread is the initial processing thread (IPT), the thread on which `main()` is executed.
- By explicit action when the user redirects the streams by using command line redirection, `fopen()`, or `freopen()`. The thread that is redirected (the IPT, if you are using command line redirection) becomes the owning thread of the particular standard stream. The usual MVS file thread affinity restrictions outlined above apply until the end of program or until the stream is redirected to the HFS.

Any operation that violates these restrictions causes SIGIOERR to be raised and `errno` to be set with the following associated message:

`EDC5024I: An attempt was made to close a file that had been opened on another thread.`
All MVS files opened from a given thread and still open when the thread is terminated are closed automatically by the library during thread termination.

The `getc()`, `getchar()`, `putc()`, and `putchar()` functions have two versions, one that is defined in the header file, `stdio.h`, which is a macro and the other which is an actual library routine. The macros have better performance than their respective function versions, but these macros are not thread safe, so in a multithreaded application where `_OPEN_THREADS` feature test macro is defined, the macro version of these functions are not exposed. Instead, the library functions are used. This is done to ensure thread safety while multiple threads are executing.

Having more than one writer use separate file pointers to a single data set or ddname is prohibited as always, regardless of whether the file pointers are used from multiple threads or a single thread.

**Thread-Scoped Functions**

Thread-scoped functions are functions that execute independently on each thread without sharing intermediate state information across threads. For example, `strtok()` preserves pointers to tokens independently on each thread, regardless of the fact that multiple threads may be examining the same string in a `strtok()` operation. Some examples of thread-scoped functions are:

- `strtok()`
- `rand()`, `srand()`
- `mblen()`, `mbtowc()`
- `strerror()`
- `asctime()`, `ctime()`, `gmtime()`, `localtime()`
- `clock()`

The following are examples of process-scoped functions, which means that a call to these functions on one thread influences the results of calls to the same function on another thread. For example, `tmpnam()` is required to return a unique name for every invocation during the life of the process, regardless of which thread issues the call.

- `tmpnam()`
- `getenv()`
- `setenv()`
- `clearenv()`
- `putenv()`

**Unsafe Thread Functions**

The following functions are not thread-safe. In a multithreaded application, therefore, they should only be used before the first invocation of `pthread_create()`.

- `setlocale()` - (returns `NULL` if issued after `pthread_create()`)
- `tzset()`
- `fork()`

**Fetched Functions and Writable Statics**

Fetched functions are recorded globally at the process level. Therefore a function fetched from one thread can be executed from any thread.

Module boundary crossings are thread-scoped. Writable statics have a scope between process and thread. They are process-scoped except that module crossings are thread-scoped. This means that:
- All threads initially inherit the writable statics of the creating thread at the time of the creation.
- When any thread executes a function pointer supplied by the `fetch()` function and crosses a module boundary, only that thread has access to the writable statics of the fetched module.

**MTF and z/OS UNIX Threading**

MTF is not supported from applications running under POSIX(ON). A return value of `EWRONGOS` is issued when running in a POSIX(ON) environment. An application that requires multithreading must either use MTF with POSIX(OFF) or `pthread_create()` with POSIX(ON).

**Thread Queuing Function**

The thread queuing function allows you to control whether or not threads should be queued up while waiting for TCBs to become available. You can accomplish this by switching the synctype attribute of a thread between synchronous and asynchronous mode. With synchronous mode for example, if a process can only have 50 TCBs active at any one time, then only 50 threads can be created. The 51st thread create results in an error. With asynchronous mode, however, you can set the synctype attribute for a thread such that the 51st thread is created. This thread will not start until one of the other threads finishes and releases a TCB.

Functions that relate to the ability to control thread queuing are:

- `pthread_set_limit_np()`
- `pthread_attr_getsynctype_np()`
- `pthread_attr_setsynctype_np()`

**Thread Scheduling**

You can use the `pthread_attr_setweight_np()` and `pthread_attr_setsynctype_np()` functions to establish priorities for threads. The `pthread_attr_setweight_np()` threadweight variable can be set to the following:

___MEDIUM_WEIGHT___
Each thread runs on a task. When the current thread exits, the task waits for another thread to do a `pthread_create()`. The new thread runs on that task.

___HEAVY_WEIGHT___
The task is attached on `pthread_create()` and terminates when the thread exits. When the thread exits, the associated task can no longer request threads to process, and full MVS EOT resource manager cleanup occurs.

You can use the `pthread_addt_setsynctype_np()` function to set the `__PTATASYNCHRONOUS` value. This enables you to create more threads than there are TCBs available. For example, you could run 50 TCBs and create hundreds of threads. The kernel queues the threads until a task is available. This frees your application from managing the work. While a thread is queued and not executing on an MVS task, you can still interact with the thread via `pthread` functions, such as `pthread_join()` and `pthread_kill()`.

**iconv() Family of Functions**

The conversion descriptor returned from a successful `iconv_open()` may be used safely within a single thread for conversion purposes. It may, however, be opened on one thread (`iconv_open()`), closed on another thread (`iconv_close()`), and used
on a third thread (iconv()). However, it is the user’s responsibility to ensure operations are synchronized if they are used across multiple threads.
Chapter 24. Reentrancy in z/OS C/C++

This chapter describes the concept of reentrancy. It tells you how to use reentrancy in C programs to help make your programs more efficient, and how C++ achieves constructed reentrancy.

Reentrant programs are structured to allow multiple users to share a single copy of an executable module or to use an executable module repeatedly without reloading. C and C++ achieve reentrancy by splitting your program into two parts, which are maintained in separate areas of memory until the program terminates:

- The first part, which consists of executable code and constant data, does not change during program execution.
- The second part contains persistent data that can be altered. This part includes the dynamic storage area (DSA) and a piece of storage known as the writable static area.

For XPLINK, the writable static area is further logically subdivided into areas called environments. Environments are optional, and each function can have its own environment. When an XPLINK function is called, the caller must load general purpose register 5 with the address of the environment of the called function before control is given to the entry point of the called function.

If the program is installed in the Link Pack Area (LPA) or Extended Link Pack Area (ELPA) of your operating system, only a single copy of the first (constant or reentrant) part exists within a single address space. This occurs regardless of the number of users that are running the program simultaneously. This reentrant part may be shared across address spaces or across sessions. In this case, the executable module is loaded only once. Separate concurrent invocations of the program share or reenter the same copy of the write-protected executable module. If the program is not installed in the LPA or ELPA area, each invocation receives a private copy of the code part, but this copy may not be write-protected.

The modifiable writable static part of the program contains:

- All program variables with the static storage class
- All program variables receiving the extern storage class
- All writable strings
- All function linkage descriptors for all referenced DLL functions
- Function linkage descriptors for all referenced DLL functions that are used by multiple compilation units in the program, but are not imported (XPLINK, RENT)
- All variable pointers for imported variables (non-XPLINK)
- All function pointers for imported functions (XPLINK, RENT)
- All variable linkage descriptors to reference imported variables (non-XPLINK)

Each user running the program receives a private copy of the second (data or non-reentrant) part. This part, the data area, is modifiable by each user.

The code part of the program contains:

- Executable instructions
- Read-only constants
- Global objects compiled with the #pragma variable(identifier, NORENT)
Note: The ROCONST compiler option implicitly inserts a `#pragma variable(identifier, NORENT)` for const qualified variables.

Natural or Constructed Reentrancy

Natural Reentrancy

C programs that contain no references to the writable static objects listed in the previous section have natural reentrancy. You do not need to compile naturally reentrant C programs with the RENT compiler option or bind them with the binder.

Constructed Reentrancy

C++ programs, and C programs that contain references to writable static objects, can have constructed reentrancy. You must bind these programs with the binder. For C programs, you must use the RENT compiler option.

If you use the XPLINK option, RENT is the default. If you override this default by specifying NORENT, any parts of the program that are normally stored in the writable static area go instead into a static area. If this static area is write-protected, you will get a run-time failure because the function pointers for imported functions cannot be modified to point to the function when the DLL containing the function is loaded and the function address determined. For programs that are both XPLINK and NORENT, all functions must be statically bound or explicitly loaded (dllload(), or fetch()).

Limitations of Constructed Reentrancy for C Programs

Even if a C program is large and will have more than one user at the same time, there are also these limitations to consider:

- The binder is required for code that you compile with XPLINK.
- If the prelinker, rather than the binder, will process code that is compiled with NOXPLINK, RENT:
  - The resultant load module referring to the writable area cannot be reprocessed.
  - The resultant program may reside in a PDS.
- If the binder is used, and not the prelinker, the resultant program must reside in a PDSE or HFS. If a PDSE member should be installed into LPA or ELPA, it can only be installed into dynamic LPA.
- A system programmer can install only the shared portion of your program in the LPA or ELPA of your operating system.

Controlling External Static in C Programs

Certain program variables with the extern storage class may be constant and never written. If this is the case, every user does not need to have a separate copy of these variables. In addition, there may be a need to share constant program variables between C and another language.

You can force an external variable to be the part of the program that includes executable code and constant data by using the `#pragma variable(varname, NORENT)` directive. The following program fragment illustrates how this is accomplished:
In this example, the source file is compiled with the RENT option. The external variable rates are included in the executable code because #pragma variable(rates, NORENT) is specified. The variable totals are included with the writable static. Each user has a copy of the array totals, and the array rates are shared among all users of the program.

The #pragma variable(varname, NORENT) does not apply to, and has no effect on, program variables with the static storage class. Program variables with the static storage class are always included in the writable static. An informational message will appear if you do try to write to a non-reentrant variable when you specify the CHECKOUT compiler option.

When specifying #pragma variable(varname, NORENT), ensure that this variable is never written; if it is written, program exceptions or unpredictable program behavior may result. In addition, you must include #pragma variable(varname, NORENT) in every source file where the variable is referenced or defined. It is good practice to put these pragmas in a common header file.

**Note:** You can also use the keyword const to ensure that a variable is not written. See the [C/C++ Language Reference](https://pubs.opengroup.org/onlinepubs/9699919799/) for more information on this keyword.

The ROCONST compiler option has the same effect as specifying the #pragma variable(varname, NORENT) for all constant variables (i.e. const qualified variables). The option gives the compiler the choice of allocating const variables outside of the Writable Static Area (WSA). For more information on using ROCONST, see [z/OS C/C++ User's Guide](https://www.ibm.com/support/knowledgecenter/SSEPGG_18.1.0/rm0210236.html).

### Controlling Writable Strings

In a large number of C programs, character strings may be constant and never written to. If this is the case, every user does not need a separate copy of these strings.

You can force all strings in a given source file to be the part of the program that includes executable code and constant data by using #pragma strings(readonly) or the ROSTRING compiler option. "CCNGRE1" on page 346 illustrates one way to make the strings constant.
Controlling the Memory Area in C++

In C++, some objects may be constant and never modified. If your program is reentrant, having such objects exist in the code part is a storage and performance benefit.

As a programmer, you control where objects with global names and string literals exist. You can use the `#pragma variable(objname, NORENT)` directive to specify that the memory for an object with a global name is to be in the code area. You can use the `ROCONST` compiler option to specify that all `const` variables go into the code area.

```c
#define _NO_REENTRANT_ 1

/* RATES is constant and in code area */
#pragma variable(RATES, NORENT)
const float RATES[5] = { 1.0, 1.5, 2.25, 3.375, 5.0625 };
float totals[5];

In this example, the variable RATES exists in the executable code area because `#pragma variable(RATES, NORENT)` has been specified. The variable totals exists in writable static area. All users have their own copies of the array totals, but the array RATES is shared among all users of the program.

When you specify `#pragma variable(objname, NORENT)` for an object, and the program is to be reentrant, you must ensure that this object is never modified, even by constructors or destructors. Program exceptions or unpredictable behavior may result. Also, you must include `#pragma variable(objname, NORENT)` in every source
file where the object is referenced or defined. Otherwise, the compiler will generate inconsistent addressing for the object, sometimes in the code area and sometimes in the writable static area.

Controlling Where String Literals Exist in C++ Code

In z/OS C/C++, the string literals exist in the code part by default, and are not modifiable if the code is reentrant. In a large number of programs, string literals may be constant. In this case, every user does not need a separate copy of these strings.

By using the `#pragma strings(writable)` directive, you can ensure that the string literals for that compilation unit will exist in the writable static area and be modifiable. `CCNGRE2` illustrates how to make the string literals modifiable:

```
CCNGRE2

/* this example demonstrates how to make string literals modifiable */

#pragma strings(writable)
#include <iostream.h>
int main(void)
{
  char * s;
  s = "wall\n"; // point to string literal
  *(s+3) = 'k'; // modify string literal
  cout << s; // output "walk\n"
}
```

Figure 88. How to Make String Literals Modifiable

In this example, the string "wall\n" will exist in the writable static area because `#pragma strings(writable)` is specified. This modifies the fourth character.

Using Writable Static in Assembler Code

Programming in C or C++ can eliminate most of the need to code in assembler. However, in cases where you must code in assembler, you may have a need to modify data in the writable static area of a C or C++ program, from within an assembler program.

Notes:
1. To call assembler from C++, you must use `extern "OS"` as documented in Chapter 19, “Using Linkage Specifications in C or C++” on page 245.
2. The following macros, and access to writable static data from assembler are not supported for XPLINK programs.

One way to modify data in the writable static area is to pass the address of the writable static data item as a parameter to the assembler program. This may be difficult in some cases. The following assembler macros makes this easier:
- EDCDXD
- EDCLA
- EDCDPLNK
These are in CEE.SCEEMAC(EDCDXD,EDCLA,EDCDPLNK). The restriction on the names of writable static objects accessible in assembler code is that they are S-names. This means that they may be at most 8 characters long and may contain only characters allowed in external names by the assembler code.

The macro EDCDXD declares a writable static data item. EDCLA loads the address of the writable static data item into a register. Using the EDCLA macro in assembler code necessitates coding EDCDXD as well.

The EDCDPLNK macro defines reference writable static data with the z/OS binder. This macro must appear before the first executable control section is initiated in the assembler source module. If there is more than one assembler source program in the input file, EDCDPLNK must precede every assembler source program in any input file that defines or references writable static data.

"CCNGRE3" illustrates their use:

**CCNGRE3**

*********************************************************************
* this example shows how to reference objects in the writable * 
* static area, from assembler code * 
* part 1 of z(other file is CCNGRE4) * 
* * 
* parameters: none * 
* return: none * 
* action: store contents of register 13 (callers dynamic * 
* storage area) in variable DSA which exists in * 
* the writable static area * 
* * 
* Macros: EDCPRLG, EDCEPIL, EDCDXD, EDCLA in CEE.SCEEMAC * 
*********************************************************************

XOBJHDR EDCDPLNK ;generate an XOBJ header
GETDSA CSECT
GETDSA AMODE ANY
GETDSA RMODE ANY
   EDCPRLG ;prolog (save registers etc.)
   EDCLA 1,DSA ;load register 1 with address of DSA
   ST 13,0(,1) ;store contents of reg 13 in DSA
   EDCEPIL ;epilog (restore registers etc.)
   DSA EDCDXD 0F ;declaration of DSA in writable static
   TBLDSA EDCDXD 20F ;definition of TBLDSA in writable static
END

Figure 89. Referencing Objects in the Writable Static Area-Part 1

In this example, the external variable TBLDSA is declared using the EDCDXD macro. The size value of 0F (zero fullwords) indicates that DSA will be treated as an extern declaration in C or C++. Because TBLDSA is an extern declaration and not a definition, DSA must be defined in another C, C++, or assembler program. The EDCLA macro loads the general purpose register 1 with the address of DSA, which exists in the writable static area.

The external variable TBLDSA is declared using the EDCDXD macro. It is defined because its size is 20F (20 fullwords or 80 bytes) and corresponds to an external data definition in C or C++. When the program starts, TBLDSA is initialized to zero. Because TBLDSA is an external data definition, there should not be another definition of it in a C++, C, or assembler program.
When these macros are used, these pseudo-registers cannot be used within the same assembler program.

There are no assembler macros for static initialization of a variable with a nonzero value. You can do this by defining and initializing the variable in C or C++ and making an extern declaration for it in the assembler program. In the example assembler program, DSA is declared this way.

"CCNGRE4" illustrates how to call the above assembler program.

**CCNGRE4**

```c
#include <stdio.h>

#ifdef __cplusplus
extern "OS" {
#endif

void GETDSA(void); /* assembler routine modifies DSA */

#ifdef __cplusplus
}
#endif

const int sz = 20; /* maximum call depth */
extern void * TBLDSA[sz]; /* defined in assembler program */

void * DSA; /* define it here, source name */

/* same as assembler name */

/* call yourself deeper and deeper */
/* save DSA pointers as you go */
void deeper( int i)
{
    if (i >= sz) /* if deep enough just return */
        return;
    GETDSA(); /* assign value to DSA */
    TBLDSA[i] = DSA; /* save value in table */
    deeper(i+1); /* go deeper in call chain */
}

int main(void) {
    int i;
    deeper(0);
    for(i=0; i<sz; i++)
    {
        printf("depth %3d, DSA was at %p
", i, TBLDSA[i]);
    }
    return 0;
}
```

Figure 90. Referencing Objects in the Writable Static Area-Part 2
Chapter 25. Using the Decimal Data Type in C

This chapter refers to fixed-point decimal data types as “decimal types”. The decimal type is an extension of the ANSI C language definition. You can use decimal types to represent large numbers accurately, especially in business and commercial applications for financial calculations. Decimal types are available only if the LANGLEVEL is EXTENDED by specifying the LANGLEVEL(EXTENDED) compiler option. For more details on this compiler option, see z/OS C/C++ User’s Guide.

The decimal types allow expressions of up to DEC_DIG significant digits including integral and fractional parts. The header file <decimal.h> specifies the value of DEC_DIG.

You can pass decimal arguments in function calls and define macros. You can also declare decimal variables, typedefs, arrays, structures, and unions having decimal members. The following operators apply on decimal variables:

- **Arithmetic**
- **Relational**
- **Assignment**
- **Comma**
- **Conditional**
- **Equality**
- **Logical**
- **Primary**
- **Unary**

When using the decimal types, you must include the decimal.h header file in your source code.

### Declaring Decimal Types

Use the type specifier `decimal(n,p)` to declare decimal variables and to initialize them with fixed-point decimal constants. The `decimal()` macro is defined in `<decimal.h>`.

The `decimal(n,p)` type specifier designates a decimal number with `n` digits and `p` decimal places. In this specifier, `n` is the total number of digits for the integral and decimal parts combined and `p` is the number of digits for the decimal part only. For example, `decimal(5,2)` represents a number, such as 123.45, where `n=5` and `p=2`. Specifying the value for `p` is optional. If omitted, `p` has a default value of 0.

`n` and `p` have a range of allowed values according to the following rules:

\[ p \leq n \]
\[ 1 \leq n \leq \text{DEC_DIG} \]
\[ 0 \leq p \leq \text{DEC_PRECISION} \]

**Note:** The header file `<decimal.h>` defines DEC_DIG (the maximum number of digits `n`) and DEC_PRECISION (the maximum precision `p`). Currently, there is a limit of a maximum of 31 digits.
Declaring Fixed-Point Decimal Constants

The syntax for fixed-point decimal constants is:

```
fractional-constant fixed-point-decimal-suffix
```

**fractional-constant** (use any one of the following formats):

- digit-sequence . digit-sequence
- . digit-sequence
- digit-sequence .
- digit-sequence

**digit-sequence** (use any one of the following formats):

- digit
- digit-sequence digit

**fixed-point-decimal-suffix** (use any one of the following formats):

- D
- d

A fixed-point decimal constant has a numeric part and a suffix that specifies its type. The components of the numeric part may include a digit sequence representing the integral part, followed by a decimal point (.), followed by a digit sequence representing the fractional part. Either the integral part, the fractional part, or both are present.

Each fixed-point decimal constant has the attributes **number of digits** (*digits*) and **number of decimal places** (*precision*). Leading or trailing zeros are not discarded when the *digits* and the *precision* are determined.

The following table gives examples of fixed-point decimal constants and their corresponding attributes:

<table>
<thead>
<tr>
<th>Fixed-Point Decimal Constant</th>
<th>(digits, precision)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234567890123456D</td>
<td>(16, 0)</td>
</tr>
<tr>
<td>12345678.12345678D</td>
<td>(16, 8)</td>
</tr>
<tr>
<td>12345678.d</td>
<td>(8, 0)</td>
</tr>
<tr>
<td>.1234567890d</td>
<td>(10, 10)</td>
</tr>
<tr>
<td>12345.99d</td>
<td>(7, 2)</td>
</tr>
<tr>
<td>000123.990d</td>
<td>(9, 3)</td>
</tr>
<tr>
<td>0.00D</td>
<td>(3, 2)</td>
</tr>
</tbody>
</table>

Declaring Decimal Variables

The following example shows how you can declare a variable as a decimal type:

```
decimal(10,2) x;
decimal(5,0) y;
decimal(5) z;
decimal(18,10) *ptr;
decimal(8,2) arr[100];
```

In the previous example:

- *x* can have values between -99999999.99D and +99999999.99D.
• $y$ and $z$ can have values between $-99999D$ and $+99999D$.
• $ptr$ is a pointer to type $\text{decimal}(18,10)$.
• $arr$ is an array of 100 elements, where each element is of type $\text{decimal}(8,2)$.

The syntax for the decimal type specifier is as follows:

\[ \text{decimal} \left( \text{constant-expression} \right) \]

The constant-expression is evaluated as a positive integral constant expression. Specifying a second constant-expression is optional. If left out, the default value is 0. Decimal variables $\text{decimal}(n,0)$ and $\text{decimal}(n)$ are type compatible.

### Defining Decimal-Related Constants

Use the following numerical limits to define the decimal value in assignments and expressions. `<decimal.h>` contains these predefined values.

- The smallest number in a decimal type
  
  $\text{DEC_MIN} \quad -9999999999999999999999999999999D$

- The largest positive number in a decimal type
  
  $\text{DEC_MAX} \quad +9999999999999999999999999999999D$

- The smallest number greater than zero in a decimal type
  
  $\text{DEC_EPSILON} \quad .00000000000000000000000000000001D$

- Maximum number of significant digits that decimal types can hold
  
  $\text{DEC_DIG} \quad 31$

- Maximum number of decimal places that decimal types can hold
  
  $\text{DEC_PRECISION} \quad 31$

### Using Operators

You can use arithmetic, relational, assignment, comma, conditional, equality, logical, primary, and unary cast operators on a decimal data type. Conversions follow these arithmetic conversion rules:

- First, if the type of either operand is long double, the other operand becomes long double.
- Otherwise, if the type of either operand is double, the other operand becomes double.
- Otherwise, if the type of either operand is float, the other operand becomes float.
- Otherwise, if the type of either operand is decimal, the other operand becomes decimal.
- Otherwise, the integral promotions are performed on both operands. Then the following rules are applied:
  - If the type of either operand is unsigned long int, the other operand becomes unsigned long int.
– Otherwise, if the type of one operand is long int and the other is unsigned int, the operand of type unsigned int is converted to long int, if the long int can represent all values of an unsigned int. If a long int cannot represent all the values of an unsigned int, both operands become unsigned long int.
– Otherwise, if the type of either operand is long int, the other operand becomes long int.
– Otherwise, if the type of either operand is unsigned int, the other operand becomes unsigned int.
– Otherwise, the type of both operands is int.

Arithmetic Operators

Figure 91 shows how to use arithmetic operators, and then describes certain arithmetic, assignment, unary, and cast operators in more detail. It summarizes how to add, subtract, multiply and divide decimal variables.

CCNGDC1

/*this example demonstrates arithmetic operations on decimal variables*/

#include <decimal.h> /* decimal header file */
#include <stdio.h>

int main(void)
{

decimal(10,2) op_1 = 12d;
decimal(5,5) op_2 = -.12345d;
decimal(24,12) op_3 = 12.34d;
decimal(20,5) op_4 = 11.01d;
decimal(14,5) res_add;
decimal(25,2) res_sub;
decimal(15,7) res_mul;
decimal(31,14) res_div;

res_add = op_1 + op_2;
res_sub = op_3 - op_1;
res_mul = op_2 * op_1;
res_div = op_3 / op_4;

printf("res_add =%D(*,*)\n",digitsof(res_add),
precisionof(res_add),res_add);
printf("res_sub =%D(*,*)\n",digitsof(res_sub),
precisionof(res_sub),res_sub);
printf("res_mul =%D(*,*)\n",digitsof(res_mul),
precisionof(res_mul),res_mul);
printf("res_div =%D(*,*)\n",digitsof(res_div),
precisionof(res_div), res_div);

return(0);
}

Figure 91. Arithmetic Operators Example

Additive Operators

Additive and multiplicative operators follow the arithmetic conversion rules defined in "Using Operators" on page 353.

Note: For performance reasons, generating negative zero is possible.
Refer to "Intermediate Results" on page 356 for details on how to get the conversion type during alignment of the decimal point.

**Relational Operators**

Relational operators follow the arithmetic conversion rules defined in "Using Operators" on page 353.

Figure 92 shows you how to use a relational expression less than (<) for decimals. In this example, decimal types are compared with other arithmetic types (integer, float, double, long double). In addition, the implicit conversion of the decimal types is performed using the arithmetic conversion rules in "Converting Decimal Types" on page 358. Leading zeros in the example are shown to indicate the number of digits in the decimal type. You do not need to enter leading zeros in your decimal type variable initialization.

**CCNGDC2**

/* this example shows how to use a relational expression with the */
/* decimal type */

```c
#include <decimal.h>

decimal(10,3) pdval = 0000023.423d; /* Decimal declaration*/
int ival = 1233; /* Integer declaration*/
float fval = 1234.34; /* Float declaration*/
double dval = 251.5832; /* Double declaration*/
long double lval = 37486.234; /* Long double declaration*/

int main(void)
{
    decimal(15,6) value = 000485860.085999d;
    /*Perform relational operation between other data types and decimal*/
    if (pdval < ival) printf("pdval is the smallest !\n");
    if (pdval < fval) printf("pdval is the smallest !\n");
    if (pdval < dval) printf("pdval is the smallest !\n");
    if (pdval < lval) printf("pdval is the smallest !\n");
    if (pdval < value) printf("pdval is the smallest !\n");

    return(0);
}
```

Figure 92. Relational Operators Example

Refer to "Intermediate Results" on page 356 for details on how to get the conversion type during alignment of the decimal point.

**Equality Operators**

Equality operators follow the arithmetic conversions defined in "Using Operators" on page 353. Where the operands have types and values suitable for the relational operators, the semantics for relational operators applies.

**Note:** Positive zero and negative zero compare equal. In the following example, the expression always evaluates to TRUE:

```
(-0.00d == +0.00000d)
```

Refer to "Intermediate Results" on page 356 for details on how to get the convert type during alignment of the decimal point.
Conditional Operators

Conditional operators follow the arithmetic conversions defined in "Using Operators" on page 353. If both the second and third operands have an arithmetic type, the usual arithmetic conversions are performed to bring them to a common type. If both operands are decimal types, the operands are converted to the convert type and the result has that type.

Refer to "Intermediate Results" for details on how to get the convert type during alignment of the decimal point.

Intermediate Results

Use one of the following tables to calculate the size of the result. The tables summarize the intermediate expression results with the four basic arithmetic operators and conditional operators when applied to the decimal types. Most of the time, you can use Table 50 to calculate the size of the result. It assumes no overflow. If overflow occurs, use Table 51 to determine the resulting type.

Both tables assume the following:

- x has type decimal(n₁, p₁)
- y has type decimal(n₂, p₂)
- decimal(n, p) is the resulting type

Table 50. Intermediate Results (without overflow in n or p)

<table>
<thead>
<tr>
<th>Expression</th>
<th>(n, p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x * y</td>
<td>n = n₁ + n₂, p = p₁ + p₂</td>
</tr>
<tr>
<td>x / y</td>
<td>n = DEC_DIG, p = DEC_DIG - (n₁ - p₁) + p₂</td>
</tr>
<tr>
<td>x + y</td>
<td>p = max(p₁, p₂), n = max(n₁ - p₁, n₂ - p₂) + p + 1</td>
</tr>
<tr>
<td>x − y</td>
<td>same rule as addition</td>
</tr>
<tr>
<td>z ? x : y</td>
<td>p = max(p₁, p₂), n = max(n₁ - p₁, n₂ - p₂) + p</td>
</tr>
</tbody>
</table>

You can use Table 51 to calculate the size of the result, whether there is an overflow or not.

Table 51. Intermediate Results (in the general form)

<table>
<thead>
<tr>
<th>Expression</th>
<th>(n, p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x * y</td>
<td>n = min(n₁ + n₂, DEC_DIG), p = min(p₁ + p₂, DEC_DIG - min(n₁ - p₁, n₂ - p₂) + p₂), 0</td>
</tr>
<tr>
<td>x / y</td>
<td>n = DEC_DIG, p = max(DEC_DIG - (n₁ - p₁) + p₂), 0</td>
</tr>
<tr>
<td>x + y</td>
<td>ir = min(max(n₁ - p₁, n₂ - p₂) + 1, DEC_DIG), p = min(max(p₁, p₂), DEC_DIG - ir), n = ir + p</td>
</tr>
<tr>
<td>x − y</td>
<td>same rule as addition</td>
</tr>
<tr>
<td>z ? x : y</td>
<td>ir = max(n₁ - p₁, n₂ - p₂), p = min(max(p₁, p₂), DEC_DIG - ir), n = ir + p</td>
</tr>
</tbody>
</table>

If overflow occurs in n or p, a compile-time warning message is issued and the decimal places are truncated. As much of the integral part is reserved as possible. If the integral part is truncated as an expression in the static or extern initialization,
an error message is issued. If the integral part is truncated inside the block scope, a warning is issued. On each operation, the complete result is calculated before truncation occurs.

Assignment Operators

Assignment operators follow the arithmetic conversion rules defined in "Using Operators" on page 353.

When values are assigned, an SIGFPE exception may be raised if the operands contain values that are not valid.

Unary Operators

Use the following unary operators to determine the digits in a decimal type:

- `sizeof` Determines the total number of bytes occupied by the decimal type
- `digitsof` Determines the number of digits (n)
- `precisionof` Determines the number of decimal digits (p)

**sizeof Operator**

When you use the `sizeof` operator with `decimal(n, p)`, the result is an integer constant. The `sizeof` operator returns the total number of bytes occupied by the decimal type.

Each decimal digit occupies a halfbyte. In addition, a halfbyte represents the sign. The number of bytes used by `decimal(n, p)` is the smallest whole number greater than or equal to \((n + 1)/2\), that is, `sizeof(decimal(n, p)) = ceil((n + 1)/2)`. The `sizeof` result is calculated using this method because the z/OS C compiler uses packed decimal to implement decimal types.

The following example shows you how to determine the total number of bytes occupied by the decimal type:

```c
int y;
decimal (5, 2) x;
y = sizeof x; /* This would be calculated to be 3 bytes*/
    /* (5+1)/2 = 3. */
```

**digitsof Operator**

When you use the `digitsof` operator with a decimal type, the result is an integer constant. The `digitsof` operator returns the number of significant digits (n) in a decimal type.

This example gives you the number of digits (n) in a decimal type.

```c
decimal (5, 2) x;
int n;
n = digitsof x; /* the result is n=5 */
```

**Note:** Apply `digitsof` only to a decimal type.

**precisionof Operator**

When you use the `precisionof` operator with a decimal type, the result is an integer constant. The `precisionof` operator tells you the number of decimal digits (p) of the decimal type.

This example gives you the number of decimal digits (p) of the decimal type.
decimal (5, 2) x;
int p;
p = precisionof x; /* the result is p=2 */

**Note:** Apply precisionof only to a decimal type.

### Cast Operator

You can convert the following types explicitly:

- **Decimal types to decimal types**
- **Decimal types to and from floating types**
- **Decimal types to and from integer types**

**Notes:**

1. When you are explicitly casting to a decimal type, the discarding of the leading nonzero digits does not cause an exception at run-time. For more information about suppressing compiler messages and run-time exceptions, refer to “Converting Decimal Types” on page 358.
2. An implicit conversion to a decimal type with an even number of digits may not clear the pad digit, but an explicit cast will clear the pad digit.

### Summary of Operators Used With Decimal Types

Table 52 summarizes all of the operators to be used with decimal types.

**Table 52. Operators Used With Decimal Types**

<table>
<thead>
<tr>
<th>Operator Name</th>
<th>Associativity</th>
<th>Operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>left to right</td>
<td>()</td>
</tr>
<tr>
<td>Unary</td>
<td>right to left</td>
<td>++ -- + - ! &amp; (typename) sizeof digitsof precisionof</td>
</tr>
<tr>
<td>Multiplicative</td>
<td>left to right</td>
<td>* /</td>
</tr>
<tr>
<td>Additive</td>
<td>left to right</td>
<td>+ -</td>
</tr>
<tr>
<td>Relational</td>
<td>left to right</td>
<td>&lt; &gt; &lt;= &gt;=</td>
</tr>
<tr>
<td>Equality</td>
<td>left to right</td>
<td>== !=</td>
</tr>
<tr>
<td>Conditional</td>
<td>right to left</td>
<td>? :</td>
</tr>
<tr>
<td>Assignment</td>
<td>right to left</td>
<td>= += -= *= /=</td>
</tr>
<tr>
<td>Comma</td>
<td>left to right</td>
<td>,</td>
</tr>
</tbody>
</table>

### Converting Decimal Types

The z/OS C compiler implicitly converts the following types:

- **Decimal types to decimal types**
- **Decimal types to and from floating types**
- **Decimal types to and from integer types**

### Converting Decimal Types to Decimal Types

If the value of the decimal type to be converted is within the range of values that can be represented exactly, the value of the decimal type is not changed.

If the value of the decimal type to be converted is outside the range of values that can be represented, the value of the decimal type is truncated. Truncation may occur on either the integral part or the fractional part or both.
When truncation occurs on the fraction part, no compile-time message or a run-time exception occurs.

When truncation occurs on the integral part, a compile-time message, a run-time exception or both are generated as follows:

- In the initialization of static or external variables
  - Compile-time error if nonzero digits are truncated in the integral part
- In the initialization of automatic variables, an assignment or function call with prototype
  - Checkout warning at compile time
  - Run-time exception SIGFPE may occur if nonzero digits are truncated in the integral part at run time.

**Note:** An explicit cast is used to suppress compile-time messages and run-time exceptions. A run-time exception may occur if any leading nonzero digits are discarded and the operation is not an explicit cast operation.

**Examples**

In the following examples, message represents a compile-time message and exception represents a run-time exception (that is, SIGFPE is raised).

**Fractional Part Cannot Be Represented:** Conversion of one decimal object to another decimal object with smaller precision involves truncation on the right of the decimal point.

```c
#include <decimal.h>

void func(void);
void dec_func(decimal( 7, 1 ));
decimal( 7, 4 ) x = 123.4567D;
decimal( 7, 1 ) y;
decimal( 7, 1 ) z = 123.4567D; /* z = 000123.4D <-- No message, */
                  /* No exception */
void func(void) {
    decimal( 7, 1 ) a = 123.4567D; /* a = 000123.4D <-- No message, */
                          /* No exception */
y = x; /* y = 000123.4D <-- No message, No exception */
y = 123.4567D; /* y = 000123.4D <-- No message, No exception */
dec_func(x); /* <-- No message, No exception */
}
```

*Figure 93. Fractional Part Cannot be Represented*

**Integral Part Cannot Be Represented:** Conversion of one decimal object to another decimal object with fewer digits involves truncation on the left of the decimal point.
Converting Decimal Types to and from Integer Types

Conversion to Integer Types
When a value of decimal type is converted to integer type, the fractional part is discarded. If the value of the integral part cannot be represented by the integer type, the behavior is undefined.

When a negative decimal type is converted to an unsigned integer type, the conversion proceeds as though these steps are followed:
1. The decimal type is converted to a signed integer type with the same size as the unsigned integer type.
2. The signed integer type is converted to the unsigned integer type.

Example of Conversion to Integer Type

```c
int i = 1234.5678d;     /* i = 1234 */
int j = -789d;         /* j = -789 */
int k = 9876543210d;  /* k is undefined */
```

Conversion from Integer Types
When a value of integer type is implicitly converted to decimal type, the integer type is converted to type decimal(10,0).

```
void func(void) {
    decimal( 5, 2 ) a = 123456.78D;
    decimal( 5, 2 ) a1 = (decimal( 5, 2 )) 123456.78D;
    y = w;     /* y = 456.78D <-- No message, No exception */
    y = x;     /* y = 456.78D <-- No message, No exception */
    y = 123456.78D;     /* y = 456.78D <-- No message, No exception */
    dec_func();         /* y = 456.78D <-- No message, No exception */
}
```

Figure 94. Integral Part Cannot be Represented

Figure 95. Conversion to Integer Type
When a value of integer type is explicitly converted to decimal type, the conversion proceeds as though these two steps are followed:

1. The integer type is converted to type `decimal(10,0)`. A run-time exception can never occur in this step.
2. Type `decimal(10,0)` is then converted to `decimal(n,p)`. All rules for decimal type to decimal type conversion apply in this step.

An unsigned integer type is converted to a positive decimal value.

If the value of the integral part cannot be represented by the decimal type, the behavior is undefined.

**Example of Conversion from Integer Type**

```c
#include <decimal.h>

decimal(10,2) pd01 = 1234; /* pd01 = 00001234.00d */
decimal(5,0) pd02 = 987654; /* compile-time error */
int main(void) {
    decimal(5,0) pd03 = 987654; /* run-time exception */
decimal(13,4) pd04;
    /* The number 321 is converted to decimal(10,0) before the */
    /* addition is performed. */
    pd04 = 1234.56d + 321; /* pd04 = 000001555.5600d */
}
```

*Figure 96. Conversion from Integral Type*

**Converting Decimal Types to and from Floating Types**

**Conversion to Floating Types**

The result of the conversion might not be exact due to:

- The limitations of significant digits in different floating types
- The degree to which a value can be stored exactly in a floating type
- The loss of precision during conversion

In the following example, the content of each floating type variable depends on their limitation of significant digits that are specified in `<float.h>`.

```c
float a = 12345678901234567890.1234567890d;
double b = 12345678901234567890.1234567890d;
long double c = 12345678901234567890.1234567890d;
```

*Figure 97. Conversion to Floating Type*

**Conversion from Floating Types**

When a value of floating type is converted to decimal type and the value being converted cannot be represented by the decimal type, the result is rounded towards zero. If the value of the floating type to be converted is within the range of values that can be represented, but cannot be represented exactly, the result is also rounded towards zero. The result retains as much value as possible. When any leading nonzero digits are suppressed and the operation is not an explicit cast operation, a decimal overflow exception occurs at run time and an SIGFPE exception is raised.
When a conversion from a floating type is made with static or external variable initialization, a compile-time error message is issued.

The result of the conversion may not be exact because the internal representation of System/370 floating-point instructions is hexadecimal based if FLOAT(HEX) mode is used. The mapping between the two representations is not one-to-one, even when the value of a float type is within the range of the decimal type.

**Example of Conversion from Floating Type**

```c
#include <decimal.h>

decimal(10,2) pd11 = 1234.0; /* pd11 = 00001234.00 */
decimal(5,0) pd12 = 987654.0; /* compile-time error */
int main(void) {
    decimal(5,0) pd13 = 987654.0; /* run-time exception */
    decimal(13,4) pd14 = 12.34567890; /* fractional part is truncated */
}
```

*Figure 98. Conversion from Floating Type*

**Calling Functions**

There are no default argument promotions on arguments that have type decimal when the called function does not include a prototype. If the expression for the called function has a type that includes a prototype, the behavior is as documented in ANSI, with the exception of prototype with an ellipsis (...). If the prototype ends with an ellipsis (...), default argument promotions are not performed on arguments with decimal types.

A function may change the values of its parameters, but these changes cannot affect the values of the arguments. However, it is possible to pass a pointer to a decimal object, and the function may change the value of the decimal object to which it points.

**Using Library Functions**

You can use variable arguments and I/O operations with decimals.

**Using Variable Arguments with Decimal Types**

You can use the `va_arg` macro with a decimal type `decimal(n,p)`${\text{var_type va_arg( va_list arg_ptr, var_type );}}$

Each invocation of `va_arg` modifies `arg_ptr` so that the values of successive arguments are returned in turn.

**Formatting Input and Output Operations**

Use the following functions to print the value of a decimal type:

- `fprintf()`
- `printf()`
- `sprintf()`
- `vfprintf()`
- `vprintf()`
- `vsprintf()`
Use the following functions to read the value of a decimal type:

- `fscanf()`  
- `scanf()`  
- `sscanf()`  

The conversion specifier for decimal types is one of the following:

- `%D(n,p)`  
- `%D(n)`

For more information about these functions and their keywords, see the z/OS C/C++ Run-Time Library Reference.

### Validating Values

It is possible to have nonvalid representation of decimal value stored in memory, such as input from file or overlay memory. If the nonvalid decimal value is used in an operation or assignment, the result may not be as expected. A built-in function can be used to report whether the decimal representation is valid or not. The function call can be in the following form:

```c
status = decchk(x);
```

The built-in function `decchk()` accepts a decimal-type expression as argument and returns a status value of type `int`.

The status can be interpreted as follows:

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Valid decimal representation value (including nonpreferred but valid sign, A-F)</td>
</tr>
<tr>
<td>1</td>
<td>Leftmost halfbyte is not zero in a decimal-type number that has an even number of digits (for example, 123 is stored in decimal(2,0))</td>
</tr>
<tr>
<td>2</td>
<td>Incorrect digits (not 0-9)</td>
</tr>
<tr>
<td>4</td>
<td>Incorrect sign (not A-F)</td>
</tr>
</tbody>
</table>

Macro define names for function return status (in `<decimal.h>`):

```c
#define DEC_VALUE_OK 0
#define DEC_BAD_NIBBLE 1
#define DEC_BAD_DIGIT 2
#define DEC_BAD_SIGN 4
```

The function return status is the OR of all errors that were detected.

### Fix Sign

A built-in function can be used to fix nonpreferred sign variables. The function call can be in the following form:

```c
x = decfix(x);
```

The built-in function `decfix()` accepts a decimal-type expression as argument and returns a decimal value that has the same size (that is, same decimal types) and same value as the argument, but with the correct preferred sign. The function does not change the content of the argument.
Decimal Absolute Value

The built-in function `decabs()` accepts a decimal-type expression as argument and returns the absolute value of the decimal argument (the same decimal type as the argument, and the same magnitude, but positive). The function does not change the content of the argument. The function call can be in the following form:

\[ y = \text{decabs}(x); \]

See the [z/OS C/C++ Run-Time Library Reference](#) for more information on the `decabs()`, `decchk()`, and `decfix()` library functions.
/* this example demonstrates the use of the decimal type */
/* always include decimal.h when decimal type is used */

#include <decimal.h>

/* Declares a decimal(10,2) variable */
decimal(10,2) pd01;

/* Declares a decimal(15,4) variable and initializes it with the */
/* value 1234.56d */
decimal(15,4) pd02 = 1234.56d;

/* Structure that has decimal-related members */
struct pdec {
    /* members' data types */
    int m; /* - integer */
    decimal(23,10) pd03; /* - decimal(23,10) */
    decimal(10,2) pd04[3]; /* - array of decimal(10,2) */
    decimal(10,2) *pd05; /* - pointer to decimal(10,2) */
} pd06,
    *pd07 = &pd06; /* pd07 points to pd06 */

/* Array of decimal(31,30) */
decimal(31,30) pd08[2];

/* Prototype for function that accepts decimal(10,2) and int as */
/* arguments and has return type decimal(25,5) */
decimal(25,5) product(decimal(10,2), int);

decimal(5,2) PdCnt; /* decimal loop counter */
int i;

int main(void)
{
    pd01 = -789.45d; /* simple assignment */
    pd06.m = digitsof(pd06.pd03) + precisionof(pd02); /* 23 + 4 */
    pd06.pd03 = sizeof(pd01);
    pd06.pd04[0] = pd02 + pd01; /* decimal addition */
    *(pd06.pd04 + 1) = (decimal(10,2)) product(pd07->pd04[0], pd07->m);
    pd07->pd04[2] = product(pd07->pd04[0], pd07->pd04[1]);
    pd07->pd05 = &pd01; /* taking the address of a */
    /* decimal variable */

    /* These two statements are different */
    pd08[0] = 1 / 3; /* 0.00 */
    pd08[1] = 1d / 3d;

    printf("pd01 = %D(10,2)\n", pd01);
    printf("pd02 = %*.d(\*)\n", 20, 5, digitsof(pd02), precisionof(pd02), pd02);
    printf("pd06.m = %d, pd07->m = %d\n", pd06.m, pd07->m);
    printf("pd06.pd03 = %D(23,10), pd07->pd03 = %D(23,10)\n", pd06.pd03, pd07->pd03);
}

Figure 99. Decimal Type — Example 1 (Part 1 of 2)
Output from Programming Example One

pd01 = -789.45
pd02 = 1234.56000
pd06.m = 27, pd07->m = 27
pd06.pd03 = 6.0000000000, pd07->pd03 = 6.0000000000
pd06.pd04[0] = 445.11, pd07->pd04[0] = 445.11
pd06.pd04[1] = 12017.97, pd07->pd04[1] = 12017.97
*(pd06.pd05) = -789.45, *(pd07->pd05) = -789.45
pd08[0] = 0.3333333333333333333330000000
pd08[1] = 0.333333333333333333333333333333

Figure 99. Decimal Type — Example 1 (Part 2 of 2)
CCNGDC4

/* this example demonstrates the use of the decimal type */

#include <decimal.h>

decimal(31,4) pd01 = 1234.5678d;
decimal(29,4) pd02 = 1234.5678d;

int main(void)
{
    /* The results are different in the next two statements */
    pd01 = pd01 + 1d;
    pd02 = pd02 + 1d;

    printf("pd01 = %D(31,4)\n", pd01);
    printf("pd02 = %D(29,4)\n", pd02);

    /* Warning: The decimal variable with size 31 should not be */
    /* used in arithmetic operation. */
    /* In the above example: (31,4) + (1,0) ==> (31,3) */
    /* (29,4) + (1,0) ==> (30,4) */

    return(0);
}

Figure 100. Decimal Type — Example 2

Note: See Intermediate Results on page 356 to understand the output from this example and to see why decimal variables with size 31 should be used with caution in arithmetic operations.

Output from Programming Example Two

pd01 = 1235.5670
pd02 = 1235.5678

Decimal Exception Handling

z/OS C decimal instructions produce the following exceptions that are unique to decimal operations:

- Data exception (interrupt code hex '7')
  This may be caused by nonvalid sign or digit codes in a packed decimal number operated on by packed decimal instructions, for example, ADD DECIMAL or COMPARE DECIMAL.

  When an operation is performed on decimal operands and the assignment is not through an explicit cast operation, the following situations cause run-time exceptions at execution time and SIGFPE is raised.

- Decimal-overflow exception (interrupt code hex 'A')
  This exception may be caused when nonzero digits are lost because the destination field in a decimal operation is too short to contain the result.

Note: The following unhandled decimal overflow message is the same for both decimal overflow and fixed overflow conditions:

CEE3210S The system detected a Decimal-overflow exception.
However, because the fixed overflow condition is normally disabled (masked) and is ignored at run time, fixed overflow conditions should not occur.

- **Decimal-divide exception (interrupt code hex 'B')**
  This exception may be caused when, in decimal division, the divisor is zero, or the quotient exceeds the specified data-field size. The decimal divide is indicated if the sign codes of both the divisor and dividend are valid, and if the digit or digits used in establishing the exception are valid.

  **Note:** The following unhandled divide message does not distinguish between a decimal-divide condition and a fixed divide-by-zero condition:
  
  CEE3211S The system detected a Decimal-divide exception.

  Both are mapped into the same error message.

- A decimal exception may be produced by the **printf()** family when processing an nonvalid decimal operand. This may result in abnormal termination of your program with the run-time message: Under z/OS:
  
  CEE3207S The system detected a Data exception.

  Under CICS:
  
  EDCK007 ABEND=8097 Data Exception

Other exceptions indicated by the decimal instruction set are not unique.

### System Programming Calls Restrictions
Decimal overflow conditions are supported for System Programming Calls only with the run-time library.

### printf() and scanf() Restrictions
You must ensure that valid packed decimal data is present when attempting to use it with run-time library decimal routines. No additional validation is performed on decimal to ensure format correctness. Use the **decchk()** routine to validate decimal data operands in such circumstances.

### Additional Considerations
- When the operands of a decimal operation contain nonvalid digits, the result is undefined, and a run-time exception can occur. To validate a decimal number, call the **decchk()** built-in function in your code.
- Code should be written in a manner that does not depend on the ability of the run-time library to recover from a decimal overflow exception.
- In a multiprocessor configuration, decimal operations cannot be used safely to update a shared storage location when the possibility exists that another processor may also be updating that location. This possibility arises because the bytes of a decimal operand are not necessarily accessed concurrently.
- If a decimal exception occurs in user code or library routines, the expected results of the instruction causing the exception or the library routine where the exception occurred are undefined. The results produced by the library routine’s execution are also undefined.
- If a **SIGFPE** handler is coded to handle decimal exceptions, it should reenable itself before resuming normal execution or recovery from the error. This reestablishes the exception environment and is consistent with good programming practice.
Error Messages

If an overflow occurs at run time, the exception handler issues the following run-time error messages:

IBM482I 'ONCODE'=0310 'FIXEDOVERFLOW' CONDITION RAISED

Unhandled exception. This result may be produced in a C-only environment only for decimal overflow conditions. Fixed-point overflow exception is not allowed in the Program Mask.

Note: The Program Mask in the Program Status Word (PSW) is enabled for decimal overflow exceptions.

IBM301I 'ONCODE'=0320 'ZERODIVIDE' CONDITION RAISED

Unhandled decimal or fixed overflow. Fixed overflow is normally masked and ignored at C run time, but it may occur in interlanguage calls.

IBM537I 'ONCODE'=8097 DATA EXCEPTION

Unhandled data exception

The error messages for FIXEDOVERFLOW and ZERODIVIDE mean that either the fixed-point overflow condition or the decimal overflow condition has caused the condition reported.

Under CICS

Decimal overflow condition exceptions are supported in CICS with C and the following run-time message is produced:

EDCK017 ABEND=0320 Fixed or Decimal Overflow

Decimal Exceptions and Assembler Interlanguage Calls

Calls to an assembler language procedure or function assume that the called routine will save and restore the value of the Program Mask if the routine alters it. Ensure that the Program Mask is preserved across an assembler language interface. If it is not preserved, the recognition of subsequent decimal overflow exceptions in C code will be unpredictable.
Chapter 26. Using the Decimal Data Type in C++

This section describes how you use the IBinaryCodedDecimal class and the decimal class to represent numerical quantities accurately in C++ business and commercial applications for financial calculations.

The IBinaryCodedDecimal Class

The IBinaryCodedDecimal class allows representation of up to 31 significant digits, including integral and fractional parts. Two digits can represent the fractional part of a dollar accurately following the decimal point. You do not have to use floating-point arithmetic, which is more suitable for scientific and engineering computations. These computations often use numbers much larger than the largest that the IBinaryCodedDecimal object can store.

The same declarations and operators that you use on other data types, such as float, are applied to IBinaryCodedDecimal objects. You can declare typedefs, arrays, and structures that have IBinaryCodedDecimal objects. You can apply arithmetic, relational, assignment, comma, conditional, equality, logical, primary, and unary operators on the IBinaryCodedDecimal object. You can pass IBinaryCodedDecimal objects in function calls.

Header File and Constants for IBinaryCodedDecimal

You must include this statement in any file that uses the IBinaryCodedDecimal class:

```
#include <idecimal.hpp>
```

The file must be included before any use of the IBinaryCodedDecimal object.

Constants Defined in idecimal.hpp

Table 53 lists the binary coded decimal constants that the Binary Coded Decimal Class Library defines:

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEC_DIG</td>
<td>The maximum number of significant digits that IBinaryCodedDecimal can hold.</td>
</tr>
<tr>
<td>DEC_MIN</td>
<td>The minimum value that IBinaryCodedDecimal can hold.</td>
</tr>
<tr>
<td>DEC_MAX</td>
<td>The maximum value that IBinaryCodedDecimal can hold.</td>
</tr>
<tr>
<td>DEC_EPSILON</td>
<td>The smallest incremental or decremental value that IBinaryCodedDecimal can hold.</td>
</tr>
<tr>
<td>DFT_DIG</td>
<td>The default number of digits (15) for the default constructor.</td>
</tr>
<tr>
<td>DFT_PREC</td>
<td>The default number of digits after the decimal point (5) for the default constructor.</td>
</tr>
<tr>
<td>DFT_LNG_DIG</td>
<td>The default number of digits (20) for a long type.</td>
</tr>
</tbody>
</table>
Constructing IBinaryCodedDecimal Objects

You can use the IBinaryCodedDecimal constructor to construct IBinaryCodedDecimal objects or arrays of IBinaryCodedDecimal objects. The following example shows how to construct an IBinaryCodedDecimal object to have a value (12) with DFT_LNG_DIG, number of digits (20) and number of digits after the decimal point (0):

```
IBinaryCodedDecimal a(12L);
```

The following example shows how to construct an IBinaryCodedDecimal object to have a value INT_MAX with number of digits (16) and number of digits after the decimal point (5):

```
IBinaryCodedDecimal b(16,5,INT_MAX);
```

IBinaryCodedDecimal Input and Output

You can use the input and output operators for the I/O Stream Library to perform input and output operations on IBinaryCodedDecimal. See IBM Open Class Library User's Guide and IBM Open Class Library Reference, Vol. I for more detailed information about I/O streaming.

Arithmetic Operators for IBinaryCodedDecimal

The IBinaryCodedDecimal class defines a set of arithmetic operators with the same precedence as the corresponding real operators. With these operators, you can code expressions on IBinaryCodedDecimal objects such as the expressions shown in the example below:

```
IBinaryCodedDecimal BCD_1(2.220446049250313L);
IBinaryCodedDecimal BCD_2 = + BCD_1;
IBinaryCodedDecimal BCD_1 = BCD_2 + BCD_1;
IBinaryCodedDecimal BCD_2 = -BCD_1;
```

Relational Operators

You can use the relational operators <, >, <=, and >= for IBinaryCodedDecimal objects and compare IBinaryCodedDecimal objects with other arithmetic types (integer, float, double, and long double):

```
IBinaryCodedDecimal BCD_1(15);
IBinaryCodedDecimal BCD_2(-15);
if (BCD_1 < BCD_2)
```

Equality Operators

You can use equality operators with IBinaryCodedDecimal objects to compare IBinaryCodedDecimal objects for equality.

```
IBinaryCodedDecimal BCD_1(15);
IBinaryCodedDecimal BCD_2(-15);
if ( BCD_1 != BCD_2 )
```

Converting IBinaryCodedDecimal Objects

The IBinaryCodedDecimal class defines a set of conversion operators. With these operators you can convert IBinaryCodedDecimal objects to other data types.
An IBinaryCodedDecimal Object to an IBinaryCodedDecimal Object

If the value of an IBinaryCodedDecimal object that is to be converted to another IBinaryCodedDecimal object is not within the range of values that can be represented exactly, the value of the IBinaryCodedDecimal object to be converted is truncated. If truncation occurs in the fractional part, there is no exception raised. If assignment causes truncation in the integral part, then there is an exception in which a DecimalDataError object is thrown. This exception occurs when an integral value is lost during conversion to a different type, regardless of what operation requires the conversion:

```cpp
IBinaryCodedDecimal targ_1(4,2);
IBinaryCodedDecimal targ_2(4,2);
IBinaryCodedDecimal op_1("1234.56");
IBinaryCodedDecimal op_2("12.34");

targ_1=op_1; // An exception is generated because the integral // part is truncated; targ_1=("34.56").
targ_2=op_2; // No exception is generated because neither the // integral nor the fractional part is truncated; // targ_2=("12.34").
```

An exception occurs on assignment to a smaller target only when the integral part is truncated.

When assigning one IBinaryCodedDecimal object to another IBinaryCodedDecimal object with a smaller precision, the result is truncation of the fractional part:

```cpp
IBinaryCodedDecimal x("123.4567");
IBinaryCodedDecimal y(7,1);
y = x; // y = ("123.4")
```

When assigning one IBinaryCodedDecimal object with another IBinaryCodedDecimal object with a smaller integral part, the result is truncation of the integral part. An exception occurs if the value is too large to fit:

```cpp
IBinaryCodedDecimal x("123456.78");
IBinaryCodedDecimal y(5,2);
y = x; // y = ("456.78")
```

When assigning one IBinaryCodedDecimal object to another IBinaryCodedDecimal object with a smaller integral part, and smaller precision, the result is truncation of the integral, and fractional parts. An exception occurs if the value is too large to fit:

```cpp
IBinaryCodedDecimal x("123456.78");
IBinaryCodedDecimal y(4,1);
y = x; // y = ("456.7")
```

Number of Digits in an IBinaryCodedDecimal Object

When you use the member function digitsOf() with an IBinaryCodedDecimal object, you can find out the total number of digits \( n \) in an IBinaryCodedDecimal object:

```cpp
int n;
IBinaryCodedDecimal x(5, 2);
N = x.digitsOf(); // the result is \( n = 5 \)
```
Precision of a IBinaryCodedDecimal Object

When you use the member function precisionOf() with an IBinaryCodedDecimal object, you can find out the number of decimal digits \( p \) in an IBinaryCodedDecimal object:

```c
int p;
IBinaryCodedDecimal x(5, 2);
p=x.precisionOf(); // The result is p=2
```

IBinaryCodedDecimal Object Exceptions

The IDecimalDataError exception class is thrown whenever the integral part is truncated as the result of any arithmetic operation.

The Decimal Class

z/OS C++ supports the decimal data type through the IBinaryCodedDecimal class as well as the decimal class. Use the decimal class to improve the performance of your applications relative to using the IBinaryCodedDecimal class. The decimal class is compatible with the decimal data type in C. This class permits you to represent up to 31 significant digits, including integral and fractional parts.

You can declare typedefs, arrays, and structures that have decimal objects. You can apply arithmetic, relational, assignment, equality, and unary operators on the decimal object. You can pass decimal objects in function calls.

Header File for the Decimal Class

You must include this statement in any file that uses the decimal class:

```c
#include <idecimal.hpp>
```

The file must be included before any use of the decimal object.

Constructing Decimal Objects

You can use the decimal constructor to construct decimal objects or arrays of decimal objects.

Use the template specifier `decimal<w,p>` to declare decimal objects. The template specifier `decimal<w,p>` designates a decimal number with \( w \) digits, and \( p \) decimal places. In the specifier, \( w \) is the total number of digits for the integral and decimal parts combined, and \( p \) is the number of digits for the decimal part only. For example, `decimal <5,2>` represents a number, such as 123.45, where \( w=5 \) and \( p=2 \). Specifying the value for \( p \) is optional. If the value for \( p \) is omitted, z/OS C++ uses a default value of 0.

In the specifier, \( w \) and \( p \) have a range of allowed values according to the following rules:

\[
0 \leq p \leq w \\
1 \leq w \leq 31
\]

You can construct a decimal object using an integer, a char *, an IBinaryCodedDecimal object, or another decimal object. The decimal class does not support other object types.

The following example shows how you can construct a decimal type:
decimal<10,2> x("4.67");  // char *
decimal<5,0>  y(7);        // integer
decimal<5>    z=y;          // another decimal object
decimal<18,10> *ptr;       // pointer
decimal<8,2>  arr[100];    // array
IBinaryCodedDecimal a(12);  //another IBinaryCodedDecimal object
decimal<10,3> b(a);

In the previous example:
- x has a value of +4.67.
- y and z have a value of +7.
- ptr is a pointer to type decimal <18,10>.
- arr is an array of 100 elements, where each element is of type decimal <8,2>.
- b has the value of the IBinaryCodedDecimal object a, +12.

**Decimal Class Input and Output**

You can use the input and output operators for the I/O Stream Library to perform input and output operations on decimal. See [IBM Open Class Library User’s Guide](http://ibm.com) and [IBM Open Class Library Reference, Vol. 1](http://ibm.com) for more detailed information on using the I/O stream library.

**Operators for Decimal Class**

**Arithmetic Operators**

The decimal class defines a set of arithmetic operators with the same precedence as the corresponding real operators. With these operators, you can perform arithmetic calculations between two decimal objects, or between a decimal object and an integer.

decimal<5,2> x("9.45");
decimal<8,3> y(-3);
decimal <20,13> sum=x+y;

**Intermediate Results:** Use one of the following tables to calculate the size of the result. The tables summarize the intermediate expression results with the four basic arithmetic operators when applied to the decimal types. Most of the time, you can use Table 54 to calculate the size of the result. It assumes no overflow. If overflow occurs, use Table 55 to determine the resulting type.

Both tables assume the following:
- x has type decimal <w₁, p₁>
- y has type decimal <w₂, p₂>
- decimal<w,p> is the resulting type

<table>
<thead>
<tr>
<th>Expression</th>
<th>(w, p)</th>
</tr>
</thead>
</table>
| x * y      | w = w₁ + w₂  
|            | p = p₁ + p₂ |
| x / y      | w = 31 
|            | p = 31 - (w₁ * p₁) + p₂ |
| x + y      | p = max(p₁, p₂) 
|            | w = max(w₁ - p₁, w₂ - p₂) + p + 1 |
| x - y      | same rule as addition |
You can use Table 55 to calculate the size of the result, whether there is an overflow or not.

**Table 55. Intermediate Results (in the general form)**

<table>
<thead>
<tr>
<th>Expression</th>
<th>((w, p))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x \times y)</td>
<td>(w = \min(w_1 + w_2, 31)) (p = \min(p_1 + p_2, 31 - \min((w_1 - p_1) + (w_2 - p_2), 31)))</td>
</tr>
<tr>
<td>(x / y)</td>
<td>(w = 31) (p = \max(31 - ((w_1 - p_1) + p_2), 0))</td>
</tr>
<tr>
<td>(x + y)</td>
<td>(ir = \min(\max(w_1 - p_1, w_2 - p_2) + 1, 31)) (p = \min(\max(p_1, p_2), 31 - ir)) (w = ir + p)</td>
</tr>
<tr>
<td>(x - y)</td>
<td>same rule as addition</td>
</tr>
</tbody>
</table>

**Relational Operators**

You can use the relational operators <, >, <=, and >= for decimal objects. You can compare two decimal objects, or a decimal object with an integer.

```c
decimal<5,2> x("10.0");
decimal<8,3> y("-2.3");
if (x < y) ...
```

**Equality Operators**

You can use equality operators with decimal objects to compare decimal equality operators != == for decimal objects. You can compare two decimal objects, or a decimal object with an integer for equality.

The following example compares two decimal objects with an integer for equality.

```c
decimal<5,2> x(15);
decimal<5,2> y(-15);
if (x != y) ...
```

The following example compares a decimal object with an integer for equality.

```c
decimal<5,2> x(15);
if (x != -15)
```

**Converting Decimal Objects**

The decimal class defines a set of conversion operators and functions. With these operators and functions, you can convert decimal objects to and from other data types.

If the value that is to be converted is not within the range of values that can be represented exactly, z/OS C++ truncates this value. If truncation occurs in the fractional part, z/OS C++ does not raise an exception. If assignment causes truncation in the integral part, z/OS C++ raises an exception. This exception occurs when an integral value is lost during conversion to a different type, regardless of the operation requires the conversion.

**Decimal Object to a Decimal Object**

The following is an example of converting a decimal object to another decimal object:
decimal <5,2> x(3);
decimal <31,15> y;

y = x;

**Decimal Object to an IString Object**

z/OS C++ provides a member function, `asString()`, to convert a decimal object to an IString object. The following is an example of such a conversion:

decimal<5,2> x("3.46");
IString y = x.asString();

**Decimal Object From a char * Type**

The following is an example of converting a char * type to a decimal object:

char * x = "1234.5";
decimal<5,2> y;

y = x;

**Decimal Object From an Integer Type**

The following is an example of converting an integer to a decimal object:

int x=3;
decimal<3,1> y=x;

**Decimal Object to and from an IBinaryCodedDecimal Object**

The following is an example of converting a decimal object from an IBinaryCodedDecimal object:

IBinaryCodedDecimal y(12);
decimal<5,2> x(y);

decimal<5,2> x("3.46");
IBinaryCodedDecimal y = x.asBCD();

**Number of Digits in a Decimal Object**

When you use the member function `digitsOf()` with a decimal object, you can find out the total number of digits w in a decimal object:

```c
int w;
decimal<5,2> x;
w = x.digitsOf(); // the result is w=5
```

**Precision of a Decimal Object**

When you use the member function `precisionOf()` with a decimal object, you can find out the number of decimal digits p in a decimal object:

```c
int p;
decimal<5,2> x;
p=x.precisionOf(); // The result is p=2
```

**Decimal Object Exceptions**

z/OS C++ decimal instructions produce the following exceptions:

- Data exception (interrupt code hex '7')
  - This may be caused by invalid sign or digit codes in a packed decimal number operated on by packed decimal instructions.
- Decimal-overflow exception (interrupt code hex 'A')
  - This exception may be caused when nonzero digits are lost because the destination field in a decimal operation is too short to contain the result.
CEE3210S The system detected a Decimal-overflow exception.

- **Decimal-divide exception (interrupt code hex 'B')**

  This exception may be caused when, in decimal division, the divisor is zero, or the quotient exceeds the specified data-field size. The decimal divide is indicated if the sign codes of both the divisor and dividend are valid, and if the digit or digits used in establishing the exception are valid.

  **Note:** The following unhandled divide message does not distinguish between a decimal-divide condition and a fixed divide-by-zero condition:

  CEE3211S The system detected a Decimal-divide exception.

  Both are mapped into the same error message.

- **SIGFPG exception**

  During the conversion of char * to the decimal object, there is a possibility that the value of the integer part cannot be represented by the decimal type. In that case, the result of the conversion is undefined and z/OS C++ raises a SIGFPG exception.
Chapter 27. Handling Exceptions, Error Conditions, and Signals

This chapter discusses how to handle error conditions and signals with z/OS C++. It describes how to establish, enable and raise a signal, and provides a list of signals supported by z/OS C++. 

This chapter also describes some aspects of C++ object-oriented exception handling. The object-oriented approach uses the try, throw, and catch mechanism. Refer to C/C++ Language Reference for a complete description. Some library functions (abort(), atexit(), exit(), setjmp() and longjmp()) are affected by C++ exception handling; refer to z/OS C/C++ Run-Time Library Reference for more information.

C++ exception handling is supported in all z/OS environments that are supported by C++ (including CICS and IMS); you must run your application with the TRAP(ON) run-time option. To turn off C++ exception handling, use the compiler option NOEXH.

Note: If C++ exception handling is turned off you will get code which runs faster but is not ANSI conformant.

The C error handling approach using signals is supported in a z/OS C++ program, but there are some restrictions (refer to Handling C Software Exceptions under C++).

z/OS Language Environment uses a stack-based model to handle error conditions. This environment establishes a last-in, first-out (LIFO) queue of 0 or more user condition handlers for each stack frame. The z/OS Language Environment condition handler calls the user condition handler at each stack frame to handle error conditions when they are detected. For more information about the callable services in z/OS Language Environment, refer to Handling Signals Using Language Environment Callable Services on page 384.

The basis for error handling in z/OS UNIX C/C++ application programs is the generation, delivery, and handling of signals. Signals can be generated and delivered as a result of system events or application programming. You can code your application program to generate and send signals and to handle and respond to signals delivered to it.

Two types of signal handling are supported for catching signals: ANSI C and POSIX.1. Each of these has standard signal delivery rules, which are discussed in this chapter. Asynchronous signal delivery under z/OS UNIX is also discussed. For additional information on the subject of POSIX-conforming signals, see The POSIX.1 Standard: A Programmer’s Guide, by Fred Zlotnick, (Redwood City, CA: The Benjamin/Cummings Publishing Company, Inc., 1991).

Handling C Software Exceptions under C++

Using the C and C++ condition handling schemes together in a C++ program may result in undefined behavior. This applies to the use of try, throw and catch with signal() and raise(), with z/OS Language Environment condition handlers such as CEEHDLR, or with CICS HANDLE ABEND under CICS. The behavior with respect to running destructors for automatic objects is undefined, due to control being
transferred to non-C++ exception handlers (such as signal handlers) and stacks being collapsed. If a C software exception is not handled and results in program termination, the behavior for destructors for static non-local objects will also be undefined.

With z/OS UNIX, in a multithreaded environment, z/OS C++ exception stacks are managed on a per-thread basis. This means an exception thrown on one thread cannot be caught on another thread, including the IPT where main() was started. If the exception is not handled by the thread from which it was thrown, then the terminate() function is called.

---

**Handling Hardware Exceptions under C++**

You cannot use try, throw, and catch to handle hardware exceptions.

If a hardware exception resulting in abnormal termination occurs in a z/OS C++ program, destructors for static and automatic objects are not run. If a hardware exception occurs, and a handler was registered for the exception using signal(), the behavior of destructors for automatic objects is undefined.

---

**Tracebacks under C++**

A traceback is not produced if a thrown object was caught and handled.

If an object is thrown, and no catch clauses exist that will handle the thrown object, the program will call terminate(). By default, terminate() calls abort(), and the traceback produced will show that this has occurred. The traceback will not show the point from which the object was originally thrown. Instead, it will show that the object was thrown from the last encountered catch clause.

In the following example, sub1() throws object a. Because sub1() does not have any catch clauses to handle a, C++ attempts to find a suitable catch clause in the calling sub function, and then in the main function. Because no catch clauses can be found to handle object a, the traceback will show that object a was thrown from main().
If an object is thrown and a catch clause catches but then rethrows that object, or
throws another object, and no catch clauses exist for the rethrown or subsequently
thrown object, the traceback starts at the point from which the rethrow or
subsequent throw occurred. The first object thrown is considered to have been
catched and handled.

Figure 101. Example Illustrating C++ Exception Handling/Traceback
In the following example, the traceback would show that the testeh function rethrows an integer. Because there is no catch clause to handle the rethrown integer, the traceback will also show that terminate() and then abort() were called.
/* example of C++ exception handling */

#include <iostream.h>
#include <stdlib.h>

int testeh(void);

class A {
   int i;
public:
   A(int j) {i = j; cout << "A ctor: i= " << i << '\n';}
   A() { cout << "A dtor: i= " << i << '\n';}
};

class B {
   char c;
public:
   B(char d) {c = d; cout << "B ctor: c= " << c << '\n';}
   B() { cout << "B dtor: c= " << c << '\n';}
};

A staticA(333);
B staticB('z');
void sub();

main() {
   sub();
   return(55);
}

void sub() {
   A c(3001);
   try {
      cout << "calling testeh" << '\n';
      testeh(); // int will be rethrown from testeh()
   } // no catch clauses for the rethrown int
   catch(char c) { cout << "caught char" << '\n'; }
   catch(short s) { cout << "caught short s = " << s << '\n'; }  
   cout << "this line should not be printed" << '\n';
   return;
}

testeh() {
   A a(2001),a1(1001);
   B b('k');
   short k=12;
   int j=0,i=0;
   try {
      cout << "testeh running" << '\n';
      throw(6); // first throw: an int
   }
   catch(char c) { cout << "testeh caught char" << '\n';}
   catch(int j) { cout << "testeh caught int j = " << j << '\n';
                  try { // int should be caught here
                     cout << "testeh again rethrowing" << '\n';
                     throw; // rethrow the int
                  }
                  catch(char d) { cout << "char d caught" << '\n'; }
   }
   cout << "this line should not be printed" << '\n';
   return(0);
}

Figure 102. Example Illustrating C++ Exception Handling/Traceback
Handling Signals with POSIX(OFF) Using signal() and raise()

The z/OS C environment provides two functions that alter the signal handling capabilities available in the run-time environment: signal() and raise(). The signal() function registers a condition handler and the raise() function raises the condition.

In general, for C++ programs you are encouraged to use try, throw, and catch to perform exception handling. However, you can also use the z/OS C signal() and raise() functions.

You can use the signal() function to perform one of the following actions:

- Ignore the condition. For example, use the SIG_IGN condition to specify signal(SIGFPE,SIG_IGN).
- Reset the Global Error Table for default handling. For example, use the SIG_DFL condition to specify signal(SIGSEGV,SIG_DFL).
- Register a function to handle the specific condition. For example, pass a pointer to a function for the specific condition with signal(SIGILL,cfunc1). The function registered for signal() must be declared with C linkage.

Handling Signals Using Language Environment Callable Services

You can set up user signal handlers with the z/OS Language Environment condition handling services. Some of the z/OS Language Environment callable services available for condition handling are:

CEEHDLR
   Register a user-written condition handler.

CEEHDLU
   Remove a registered user-written condition handler.

CEESGL
   Raise z/OS Language Environment condition.

In addition, with z/OS Language Environment, when an exception occurs after an interlanguage call, the exception may be handled where it occurs, or percolated to its caller (written in any z/OS Language Environment-conforming language), or promoted. For more information on how to handle exceptions under the z/OS Language Environment condition handling model, refer to z/OS Language Environment Programming Guide.

Specific considerations for C and C++ under z/OS Language Environment:

1. The TRAP run-time option (equivalent to the former C/370 run-time options SPIE and STAE) determines how the z/OS Language Environment condition manager is to act upon error conditions and program interrupts. If the TRAP(OFF) run-time option is in effect, conditions detected by the operating system, often due to machine interrupts, will not be handled by the z/OS Language Environment environment and thus cannot be handled by a z/OS C/C++ program.

   **Note:** TRAP(OFF) only blocks the handling of hardware (program checks) and operating system (abend) conditions. It does not block software conditions such those that are associated with a raise or CEESGL. Any conditions that are blocked because of TRAP(OFF) are not presented to any handlers (whether registered by a signal or by CEEHDLR). In particular, even for TRAP(OFF), conditions that are initiated by a signal or by CEESGL are presented to handlers registered by either signal() or CEEHDLR.
The use of the TRAP(OFF) option is not recommended; refer to z/OS Language Environment Programming Reference for more information.

2. You can use the ERRCOUNT run-time option to specify how many errors are to be tolerated during the execution of your program before an abend occurs. The counter is incremented by one for every severity 2, 3, or 4 condition that occurs. Both hardware-generated and software-generated signals increment the counter.

If your C++ program uses try, throw, and catch, it is recommended that you specify either ERRCOUNT(0), which allows an unlimited number of errors, or ERRCOUNT(n), where n is a fairly high number. This is because z/OS C++ generates a severity 3 condition for each thrown object. In addition, each catch clause has the potential to rethrow an object or to throw a new object. In a large C++ program, many conditions can be generated as a result of objects being thrown, and thus the ERRCOUNT can be exceeded if the value used for it is too low. The installation default used for ERRCOUNT is usually a low number.

Note: The z/OS C/C++ registered condition handlers (those registered by signal() and raise()), are activated after the z/OS Language Environment registered condition handlers for the current stack frame are activated. This means that if there are condition handlers for both z/OS C/C++ and z/OS Language Environment, the z/OS Language Environment handlers are activated first.

Combining C++ condition handling (using try, throw, and catch), with z/OS Language Environment condition handling may result in undefined behavior.

Handling Signals Using z/OS UNIX with POSIX(ON)

z/OS UNIX signal processing allows flags to control the behavior of signal processing. Using these flags, you can simulate these signals and a wide variety of other signals such as ANSI, POSIX.1, and BSD.

ANSI C has the following standard signal delivery rules:

• Traditionally, signal actions are established only through the signal().
• During signal delivery, the signal action is reset to SIG_DFL before the user signal action catcher function receives control.
• During signal delivery to a user signal catcher function, the signal mask is not changed.

POSIX.1 has the following standard signal delivery rules:

• Signal actions are typically established through the sigaction() function. With the addition of XPG4 support, there are a number of new flags that have been defined for sigaction() that extend its flexibility.
• During signal delivery, the signal action is not changed.
• During signal delivery to a user signal catcher function, the signal mask is changed to the union of:
  – The signal mask at the time of the interruption
  – A signal mask that blocks the signal type being delivered

The signal mask is restored when the signal catcher function returns.

BSD signals for the most part are consistent with the POSIX rules above except for the following:

• BSD signal mask is a 32-bit mask whereas the z/OS UNIX signal mask is a 64-bit mask. The relationship of the bits to specific signals is not the same.
Therefore, we recommend you change to use the sigset manipulation functions, such as, sigadd(), sigdelete(), sigempty().

- Traditionally, for BSD to generate a signal action, the signal() function was used. However, because the signal() function is used in ANSI, BSD applications should be changed to use the bsd_signal() function.
- During signal delivery, the signal action is not changed.
- During signal delivery to a user signal catcher function, the signal mask is changed to the union of:
  - The signal mask at the time of the interruption
  - The signal mask specified in the sa_mask field of the sigaction() function

The signal mask is restored once the signal catcher function returns.

For compatibility, z/OS C/C++ supports the three standards listed above, and additional functions provided by XPG4.

Under z/OS C/C++, the primary function for establishing signal action is the sigaction() function. However, there are a number of other functions that you can use to effect signal processing. All signal types are accessible regardless of the function used to establish the signal action.

The following list includes functions that will establish a signal handler for a signal action:

<table>
<thead>
<tr>
<th>BSD Function</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>bsd_signal()</td>
<td>BSD version of signal()</td>
</tr>
<tr>
<td>sigaction()</td>
<td>Examine and/or change a signal action</td>
</tr>
<tr>
<td>sigignore()</td>
<td>Set disposition to ignore a signal</td>
</tr>
<tr>
<td>sigset()</td>
<td>Change a signal action and/or a thread's signal mask</td>
</tr>
<tr>
<td>signal()</td>
<td>Specify signal handling</td>
</tr>
</tbody>
</table>

The following is a list of other signal related functions:

<table>
<thead>
<tr>
<th>Other Signal Related Functions</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>abort()</td>
<td>Stop a program</td>
</tr>
<tr>
<td>kill()</td>
<td>Send a signal to a process</td>
</tr>
<tr>
<td>pthread_kill()</td>
<td>Send a signal to a thread</td>
</tr>
<tr>
<td>raise()</td>
<td>Send a signal to yourself</td>
</tr>
<tr>
<td>sigaddset()</td>
<td>Add a signal to a signal set</td>
</tr>
<tr>
<td>sigdelset()</td>
<td>Delete a signal from a signal set</td>
</tr>
<tr>
<td>sigemptyset()</td>
<td>Initialize a signal set to exclude all signals</td>
</tr>
<tr>
<td>sigfillset()</td>
<td>Initialize a signal set to include all signals</td>
</tr>
<tr>
<td>sighold()</td>
<td>Add a signal to a thread's signal mask</td>
</tr>
<tr>
<td>siginterrupt()</td>
<td>Allow signals to interrupt functions</td>
</tr>
<tr>
<td>sigismember()</td>
<td>Test if a signal is in a signal set</td>
</tr>
<tr>
<td>sigpause()</td>
<td>Unblock a signal and wait for a signal</td>
</tr>
<tr>
<td>sigprocmask()</td>
<td>Examine and/or change a thread's signal mask</td>
</tr>
</tbody>
</table>
Asynchronous Signal Delivery under z/OS UNIX

Your z/OS UNIX application program might require its active processes to be able to react and respond to events occurring in the system or resulting from the actions of other processes communicating with its processes. One way of accomplishing such interprocess communication is for you to code your application program to identify signal conditions and determine how to react or respond when a signal condition is received from another application process.

Before you attempt to code your z/OS UNIX C/C++ application program to deliver and handle signals, you should identify all the processes that might cause signal conditions to be received by your application program’s processes. You also need to know which signal condition codes are valid for your z/OS UNIX C/C++ application program and where the `signal.h` header file will be located and available to your application program. Your system programmer or the application program’s designer should provide this information.

**Note:** Signal condition codes are defined in the `signal.h` include file.

A *signal* is a mechanism by which a process can 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* also refers to an event itself.

The POSIX.1-defined `sigaction()` function allows a calling application process to examine a specific signal condition and specify the processing action to be associated with it.

You can code your application program to use the `sigaction()` function in different ways. Two simplistic examples of using signals within z/OS UNIX C/C++ application programs follow:

1. A process is forked but the process is *aborted* if the signal handler receives an incorrect value.
2. A request is received from a *client* process to provide information from a database. The *server* process is a single point of access to the database.

If coded properly for handling and delivering interprocess signals, your application program can receive signals from other processes and interpret those signals such that the appropriate processing procedure occurs for each specific signal condition.

---

<table>
<thead>
<tr>
<th>Other Signal Related Functions</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>sigqueue()</td>
<td>Queue a signal to a process</td>
</tr>
<tr>
<td>sigrelse()</td>
<td>Remove a signal from a thread’s signal mask</td>
</tr>
<tr>
<td>sigstack()</td>
<td>Set and/or get signal stack context</td>
</tr>
<tr>
<td>sigaltstack()</td>
<td>Set and/or get signal alternate stack context</td>
</tr>
<tr>
<td>sigsuspend()</td>
<td>Change mask and suspend the thread</td>
</tr>
<tr>
<td>sigwait()</td>
<td>Wait for asynchronous signal</td>
</tr>
<tr>
<td>sigpending()</td>
<td>Examine pending signals</td>
</tr>
<tr>
<td>sigtimedwait()</td>
<td>Wait for queued signals</td>
</tr>
<tr>
<td>sigwaitinfo()</td>
<td>Wait for queued signals</td>
</tr>
</tbody>
</table>
received. Your application program also can send signals and wait for responses to signal handling events from other application processes. Note that signals are not the best method of interprocess communication, because they can easily be lost if more than one is delivered at the same time. You may want to use other methods of interprocess communication, such as pipes, message queues, shared memory, or semaphores.

For descriptions of the supported z/OS C/C++ signal handling functions, see z/OS C/C++ Run-Time Library Reference.

Note: If your z/OS UNIX C/C++ application program calls a program written in a high-level language other than z/OS UNIX C/C++, you need to disable signal handling to block all signals from the z/OS UNIX C/C++ application program. If the called program encounters a program interrupt check situation, the results are unpredictable.

C Signal Handling Features under z/OS C/C++

The terms used to describe implementation features and concepts are:

- Establishing a signal handler
- Enabling a signal
- Interrupting a program
- Raising a signal

Establishing a Signal Handler

A signal handler for a signal, **sig_num**, becomes established when `signal(sig_num, sig_handler)` is executed. (Two values of `sig_handler` are reserved: SIG_IGN and SIG_DFL. They are special values that establish the action taken.) `sig_handler` is a pointer to a function to be called when the signal is raised. This function is also known as a signal handler. Under C++, the signal handler function must have C linkage, by declaring it as `extern "C"`. Under C, the function must be written in C with the default linkage in effect. That is, `sig_handler` cannot have OS, PLI, C++, or COBOL linkage. The signal handler for the signal ceases to be established when:

- The signal is explicitly reset to the system default by using `signal(sig_num, SIG_DFL)`.
- You indicate that a signal is to be ignored by using `signal(sig_num, SIG_IGN)`.
- The signal is implicitly reset to the system default when the signal is raised. When `sig_handler` is called, signal handling is reset to the default as if an implicit `signal(sig_num, SIG_DFL)` had been executed. Depending on the purpose of the signal handler, you may want to reestablish the signal from within the signal handler.
- Under C, a loaded executable is deleted using the `release()` function and a signal handler for the signal resides in the executable. In this case, default handling will be reset for all the affected signals.
- A DLL module is explicitly loaded using `dllload()`, a function pointer in that module is obtained using `dllqueryfn()`, a signal handler is establishing using that function, and the DLL module is then explicitly deleted using `dllfree()`. Default handling will be reset for the affected signal.

Note: A C signal handler can be written in C, or can be written in C++ and declared as extern "C" so that it has C linkage.
Enabling a Signal

A signal is enabled when the occurrence of the condition will result in either the execution of an established signal handler or the default system response. The signal is disabled when the occurrence is to be ignored, such as, when the signal action is SIG_IGN. This can be done by making the call signal(sig_num, SIG_IGN). Using z/OS UNIX with POSIX(ON), SIG_IGN may be set with several other functions, such as, sigaction(). In addition to changing the signal action to SIG_IGN, the signal can be enabled or disabled (blocked) using the sigprocmask() function.

Interrupting a Program

Program interrupts or errors detected by the hardware and identified to the program by operating system mechanisms are known as hardware signals. For example, the hardware can detect a divide by zero and this result can be raised to the program.

Raising a Signal

Signals that are explicitly raised by the user, by using the raise() function or using z/OS UNIX with POSIX(ON) using the kill(), killpg(), or pthread_kill() functions, are known as software signals.

Identifying Hardware and Software Signals

The following is a list of signals supported with z/OS C/C++ with POSIX(OFF):

- **SIGABND**: System abend.
- **SIGABRT**: Abnormal termination (software only).
- **SIGFPE**: Erroneous arithmetic operation (hardware and software).
- **SIGILL**: Invalid object module (hardware and software).
- **SIGINT**: Interactive attention interrupt by raise() (software only).
- **SIGIOERR**: Serious software error such as a system read or write. You can assign a signal handler to determine the file in which the error occurs or whether the condition is an abort or abend. This minimizes the time required to locate the source of a serious error.
- **SIGSEGV**: Invalid access to memory (hardware and software).
- **SIGTERM**: Termination request sent to program (software only).
- **SIGUSR1**: Reserved for user (software only).
- **SIGUSR2**: Reserved for user (software only).

The following is a list of the z/OS C/C++ supported signals (when running on z/OS UNIX with POSIX(ON)):

- **SIGABND**: System abend.
- **SIGABRT**: Abnormal termination (software only).
- **SIGNALRM**: Asynchronous timeout signal generated as a result of an alarm().
- **SIGBUS**: Bus error.
- **SIGCHLD**: Child process terminated or stopped.
- **SIGCONT**: Continue execution, if stopped.
- **SIGDCE**: DCE event.
SIGFPE  Erroneous arithmetic operation (hardware and software).
SIGHUP  Hangup, when a controlling terminal is suspended or the controlling process ended.
SIGILL  Invalid object module (hardware and software).
SIGINT  Asynchronous CNTL-C from one of the z/OS UNIX shells or a software generated signal.
SIGIO   Completion of input or output.
SIGIOERR Serious software error such as a system read or write. Assign a signal handler to determine the file in which the error occurs or whether the condition is an abort or abend. Minimize the time required to locate the source of a system error.
SIGKILL An unconditional terminating signal.
SIGPIPE Write on a pipe with no one to read it.
SIGPOLL Pollable event.
SIGPROF Profiling timer expired.
SIGQUIT Terminal quit signal.
SIGSEGV Invalid access to memory (hardware and software).
SIGSTOP The process is stopped.
SIGSYS  Bad system call.
SIGTERM Termination request sent to program (software only).
SIGTCONT The specific thread is resumed.
SIGTSTOP The specific thread is stopped.
SIGTRAP Debugger event.
SIGTSTP  Terminal stop signal.
SIGTTIN  Background process attempting read.
SIGTTOU Background process attempting write.
SIGURG  High bandwidth is available at a socket.
SIGUSR1  Reserved for user (software only).
SIGUSR2  Reserved for user (software only).
SIGVTALRM Virtual timer expired.
SIGXCPU  CPU time limit exceeded.
SIGXFSZ  File size limit exceeded.

The applicable hardware signals or exceptions are listed in Table 56 on page 391. It also lists those hardware exceptions that are not supported (for example, fixed-point overflow) and are masked.

The applicable software signals or exceptions that are supported with POSIX(OFF) are listed in Table 57 on page 391 (see Table 58 on page 393 for the POSIX(ON) signals).
### Table 56. Hardware Exceptions - Default Run-Time Messages and System Actions

<table>
<thead>
<tr>
<th>C Signal</th>
<th>Hardware Exception</th>
<th>Default Run-Time Message with z/OS Language Environment</th>
<th>Default System Action with z/OS Language Environment Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGILL</td>
<td>Operation exception</td>
<td>CEE3201 Abnormal termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Privileged operation exception</td>
<td>CEE3202</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Execute exception</td>
<td>CEE3203</td>
<td></td>
</tr>
<tr>
<td>SIGSEGV</td>
<td>Protection exception</td>
<td>CEE3204 Abnormal termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addressing exception</td>
<td>CEE3205</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specification exception</td>
<td>CEE3206</td>
<td></td>
</tr>
<tr>
<td>SIGFPE</td>
<td>Data exception</td>
<td>CEE3207 Abnormal termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed-point divide</td>
<td>CEE3209</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decimal overflow (for C only)</td>
<td>CEE3210</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decimal divide</td>
<td>CEE3211</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exponent overflow</td>
<td>CEE3212</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floating point divide</td>
<td>CEE3215</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Under TSO, SIGINT will not be raised if you press the attention key. It must be raised using raise().

The default run-time program mask is enabled for decimal overflow exceptions.

---

### Table 57. Software Exceptions - Default Run-Time Messages and System Actions

<table>
<thead>
<tr>
<th>C Signal</th>
<th>Software Exception</th>
<th>Default Run-Time Message with z/OS Language Environment</th>
<th>Default System Action with z/OS Language Environment Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGILL</td>
<td>raise(SIGILL)</td>
<td>EDC6001 Abnormal Termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td>SIGSEGV</td>
<td>raise(SIGSEGV)</td>
<td>EDC6002 Abnormal Termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td>SIGFPE</td>
<td>raise(SIGFPE)</td>
<td>EDC6002 Abnormal Termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td>SIGABND</td>
<td>raise(SIGABND)</td>
<td>EDC6003 Abnormal Termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td>SIGTERM</td>
<td>raise(SIGTERM)</td>
<td>EDC6004 Abnormal Termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td>SIGINT</td>
<td>raise(SIGINT)</td>
<td>EDC6005 Abnormal Termination MVS rc=3000</td>
<td></td>
</tr>
<tr>
<td>SIGABRT</td>
<td>raise(SIGABRT)</td>
<td>EDC6006 Abnormal Termination MVS rc=2000</td>
<td></td>
</tr>
</tbody>
</table>
Table 57. Software Exceptions - Default Run-Time Messages and System Actions with POSIX(OFF) (continued)

<table>
<thead>
<tr>
<th>C Signal</th>
<th>Software Exception</th>
<th>Default Run-Time Message with z/OS Language Environment</th>
<th>Default System Action with z/OS Language Environment Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGUSR1</td>
<td>raise(SIGUSR1)</td>
<td>EDC6007</td>
<td>Abnormal Termination MVS rc=3000</td>
</tr>
<tr>
<td>SIGUSR2</td>
<td>raise(SIGUSR2)</td>
<td>EDC6008</td>
<td>Abnormal Termination MVS rc=3000</td>
</tr>
<tr>
<td>SIGIOERR</td>
<td>raise(SIGIOERR)</td>
<td>EDC6009</td>
<td>Signal is ignored</td>
</tr>
</tbody>
</table>

**SIGABND Considerations**

When the SIGABND signal is registered with an address of a C handler using the `signal()` function, control cannot resume at the instruction following the abend or the invocation of `raise()` with SIGABND. If the C signal handler is returned, the abend is percolated and the default behavior occurs. The `longjmp()` or `exit()` function can be invoked from the handler to control the behavior.

If SIG_IGN is the specified action for SIGABND and an abend occurs (or SIGABND was raised), the abend will not be ignored because a resume cannot occur. The abend will percolate and the default action will occur.

Two macros are available in `signal.h` header file that provide information about an abend. The `__abendcode()` macro returns the abend that occurred and `__rsncode()` returns the corresponding reason code for the abend. These values are available in a C signal handler that has been registered with the SIGABND signal. If you are looking for the abend and reason codes, using these macros, they should only be checked when in a signal handler. The values returned by the `__abendcode()` and `__rsncode()` macros are undefined if the macros are used outside a registered signal handler.

**SIGIOERR Considerations**

When the SIGIOERR signal is raised, codes for the last operation will be set in the `__amrc` structure to aid you in error diagnosis.

**Default Handling of Signals**

The run-time environment will perform default handling of a given signal unless the signal is established (`signal(sig_num, sig_handler)`) or the signal is disabled (`signal(sig_num, SIG_IGN)`). A user can also set or reset default handling by coding:

```
signal(sig_num, SIG_DFL);
```

The default handling depends upon the signal that was raised. Refer to the two preceding tables for information on the default handling of a given signal.

**Note:** When using the `atexit()` library function, the atexit list will not be run if the application is abnormally terminated.

**Using z/OS UNIX**

The following table describes the default actions for signals that may be delivered to z/OS UNIX C/C++ application programs:
Table 58. Default Signal Processing with POSIX(ON)

<table>
<thead>
<tr>
<th>Signal</th>
<th>Default Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGABND</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5204, and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system. If the signal is generated as a result of an abend condition, as opposed to being software generated by a <code>raise()</code>, <code>kill()</code> or <code>pthread_kill()</code> function, the CEE5204 message is issued along with a trace-back message indicating a user function was in control when the abend occurred.</td>
</tr>
<tr>
<td>SIGABRT</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5207 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGALRM</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5214 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGCHLD</td>
<td>The signal is ignored.</td>
</tr>
<tr>
<td>SIGCONT</td>
<td>The process is continued if it was stopped. Otherwise, the signal is ignored.</td>
</tr>
<tr>
<td>SIGDCE</td>
<td>The signal is ignored.</td>
</tr>
<tr>
<td>SIGFPE</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5201, and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system. If the signal is generated as a result of an abend condition, as opposed to being software generated by a <code>raise()</code>, <code>kill()</code> or <code>pthread_kill()</code> function, the CEE5201 message is issued along with a trace-back message indicating a user function was in control when the abend occurred.</td>
</tr>
<tr>
<td>SIGHUP</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5210 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGILL</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5202, and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system. If the signal is generated as a result of an abend condition, as opposed to being software generated by a <code>raise()</code>, <code>kill()</code> or <code>pthread_kill()</code> function, the CEE5202 message is issued along with a trace-back message indicating a user function was in control when the abend occurred.</td>
</tr>
<tr>
<td>SIGINT</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5206 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system. In past releases, the default action for this signal was to ignore the signal.</td>
</tr>
<tr>
<td>SIGIO</td>
<td>The signal is ignored.</td>
</tr>
<tr>
<td>SIGIOERR</td>
<td>The signal is ignored. In a POSIX application running on z/OS UNIX SIGIOERR is not supported directly by the kernel. Instead, z/OS C/C++ maps SIGIOERR to SIGIO. Any application using SIGIOERR should not also use SIGIO.</td>
</tr>
<tr>
<td>SIGKILL</td>
<td>End the process with no z/OS C/C++ run-time cleanup.</td>
</tr>
<tr>
<td>SIGPIPE</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5213 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
</tbody>
</table>
Table 58. Default Signal Processing with POSIX(ON) (continued)

<table>
<thead>
<tr>
<th>Signal</th>
<th>Default Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGQUIT</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5220 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGSEGV</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5203 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGSTOP</td>
<td>The process is stopped.</td>
</tr>
<tr>
<td>SIGTERM</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5205 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGTCONT</td>
<td>The specific thread is resumed.</td>
</tr>
<tr>
<td>SIGTSTOP</td>
<td>The specific thread is stopped.</td>
</tr>
<tr>
<td>SIGTRAP</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5222 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGTSTP</td>
<td>The process is stopped.</td>
</tr>
<tr>
<td>SIGTIN</td>
<td>The process is stopped.</td>
</tr>
<tr>
<td>SIGTTOU</td>
<td>The process is stopped.</td>
</tr>
<tr>
<td>SIGUSR1</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5208 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system. In past releases, the default action for this signal was to ignore the signal.</td>
</tr>
<tr>
<td>SIGUSR2</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5209 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system. In past releases, the default action for this signal was to ignore the signal.</td>
</tr>
<tr>
<td>SIGPOLL</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5225 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGURG</td>
<td>The signal is ignored.</td>
</tr>
<tr>
<td>SIGBUS</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5227 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGSYS</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5228 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGWINCH</td>
<td>The signal is ignored.</td>
</tr>
<tr>
<td>SIGXCPU</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5230 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
</tbody>
</table>
Table 58. Default Signal Processing with POSIX(ON) (continued)

<table>
<thead>
<tr>
<th>Signal</th>
<th>Default Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGXFSZ</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5231 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGVTALRM</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5232 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
<tr>
<td>SIGPROF</td>
<td>Clean up the z/OS C/C++ run-time library, issue message CEE5233 and end the process. The signal exit status is returned to the parent process if it is waiting for a child process to end. If the program is not running in a forked process, so that no parent process exists to return the signal status to, the return code 3000 is returned to the system.</td>
</tr>
</tbody>
</table>

**Dubbed Process:** A process that is not from a call to a `fork()` function or to a program `main()` function through an `exec()` function.

The following chart shows how the C and z/OS Language Environment error handling approaches interact.
MAP 0040: Summary of C Error Handling

001
Signal is raised. Is SIG_IGN set for the signal? Or is the signal blocked?
Yes  No

002
Continue at Step 006

003
Is the signal for a SIGABND?
Yes  No

004
Resume at the next instruction.

005
Condition is percolated for default behavior.

006
Is the signal asynchronous (or previously blocked)?
Yes  No

007
Is z/OS Language Environment user handler registered?
Yes  No

008
Is a C handler established for the signal by signal() or sigaction() with the SA_OLD_STYLE or SA_RESETHAND flag set?
Yes  No

009
Continue at Step 017 on page 397

010
Run C handler using ANSI rules and resume at the next instruction.

011
Run z/OS Language Environment user handler. The handler can resume, percolate or promote the signal. See z/OS Language Environment Programming Guide for more details.
Is a C handler established for the signal?
Yes  No

Perform default processing.

Was the C handler established by signal() or sigaction() with the
SA_OLD_STYLE or SA_RESETHAND flag set?
Yes  No

Run C handler using POSIX rules and transfer control to the next instruction
following the asynchronous interrupt.

Run C handler using ANSI rules and transfer control to the next instruction following
asynchronous interrupt.

At stack frame 0?
Yes  No

Default handling for the signal and percolate to next stack frame.

Was a C handler established?
Yes  No

Perform default processing.

Run C handler using POSIX signal delivery rules and resume at next instruction.

Signal Considerations using z/OS UNIX
The following restrictions and inconsistencies exist for z/OS UNIX C/C++ application
program signal handling:
• Signal processing is blocked by the kernel when an application program is
  running on a request block (RB) other than the one the main() routine was
  started on.
• An application program should not use the longjmp() function to exit from a
  signal catcher established through the use of sigaction(). The sigsetjmp() and
  siglongjmp() functions should be used instead of setjmp() and longjmp(). The
  longjmp() function can be used if the signal() function was used to established
  the signal catcher.
• An application program must not use the macro versions of the `getc()`, `putc()`, `getchar()`, and `putchar()` functions to perform I/O to the same file from an asynchronous signal catcher function.

• Floating point registers are saved before a call to the signal catcher function and restored when the signal catcher returns. This is done for all signals.

• For z/OS UNIX C/C++ application programs, the `errno` value is saved before a call to the signal catcher function and restored when the signal catcher returns.

Example of C Signal Handling under z/OS C or z/OS C++

In the following example, the call to `signal()` in `main()` establishes the function `signal handler` to process the interrupt signal when it occurs. An error value returned from this call to `signal()` causes the program to end with a printed error message. The `signal handler` function asks you to enter a `y` or `Y` from the keyboard if you want to halt the program. Entering any other character causes the program to resume operation.

```c
/* this example demonstrates signal handling */

#include <stdio.h>
#include <signal.h>
#include <stdlib.h>

#ifdef __cplusplus /* __cplusplus is implicitly defined when */
    extern "C" { /* the program is compiled with the z/OS C++ */
#endif /* compiler */

void handler(int);

#ifdef __cplusplus
}
#endif

int main(void) {
    if (signal(SIGINT, handler) == SIG_ERR) {
        perror("Could not set SIGINT");
        abort();
    }
    /* add code here if desired */
    raise(SIGINT);
    /* add code here if desired */
    return(0);
}

void handler(int sig_num) {
    char ch;

    signal(SIGINT, handler);
    printf("End processing?\n");
    ch = getchar();
    if (ch == 'y' || ch == 'Y')
        exit(0);
}

Figure 103. Example Illustrating Signal Handling
Chapter 28. Optimizing Code

This chapter describes ways to make an application compiled by the z/OS C/C++ compiler perform better under z/OS. The chapter contains the following sections.

1. “Input/Output Considerations”
   Things you should consider for efficient I/O processing.

2. “Programming Recommendations” on page 403
   Things you should consider when designing, writing, and modifying your program to help the compiler generate better code.

3. “Compiler Options to Improve Performance” on page 410
   How to use the compiler and library to tune your program for better performance.

4. “Memory Optimization” on page 417
   How to optimize your use of dynamic memory.

5. “Using XPLINK” on page 417
   The performance implications of using XPLINK, not using XPLINK, or mixing XPLINK and non-XPLINK routines in an application.

6. “Compile Time Considerations” on page 418
   Things you should consider when compiling your code.

Interprocedural Analysis (IPA), through the IPA compiler option, can also improve the execution time of your z/OS C/C++ application. IPA is a mechanism for performing optimizations across compilation unit boundaries. It also performs optimizations not otherwise available with the z/OS C/C++ compiler, such as:
- Inlining across compilation units
- Program partitioning
- Coalescing of global variables
- Code straightening
- Unreachable code elimination
- Call graph pruning of unreachable functions

For an overview of IPA, refer to Chapter 29, “Optimizing Your C/C++ Code with Interprocedural Analysis” on page 421.

You may also find useful information in the IBM Redbook Tuning Large C/C++ Applications on z/OS UNIX System Services. This Redbook is available on the web at:

Input/Output Considerations

When Accessing MVS Data Sets

- Consider the use of the file when choosing DCB parameters:
  - Specify largest possible BLKSIZE (blocked files).
  - Use recfm = FBS or F over FB unless dealing with a PDS. The use of standard (S) blocks optimizes the sequential processing of a file on a direct-access device.
fseek() on sequential files is most efficient when using recfm = F or recfm = FBS.

If you are accessing an existing sequential file created as FB, and you know that there are no short blocks in the file, specify FBS on the call to fopen() or freopen() to enable the library to perform faster repositions.

The proper choice of file attributes is important for efficient I/O.

- When you do not need to reposition within a file, take advantage of NOSEEK for more efficient reading and writing to a data set. You can also specify NCP or BUFNO on the DD statement for MVS DASD data sets, thereby reducing the clock time of the application. See "Multiple Buffering" on page 124 for more information.

- If possible, read or write a block at a time to minimize the I/O overhead and elapsed time.

- Using text I/O for writing can be slower than using binary or record I/O. When you use binary or record I/O, the application ensures that the data is written to the file in the correct format.

- If you are using FB or FBS files, use binary I/O instead of record I/O. This way, you can read or write more than one record at a time.

- Use fread() instead of fgets(), and fwrite() in place of fputs(), wherever possible.

- Use putc() instead of fputc(), and getc() instead of fgetc(), if you must read or write a character. The fputc() function, as defined by ANSI, puts a single character to the text stream. Special action occurs when writing a control character. On the other hand, the putc() macro buffers characters in storage and invokes fputc() only when encountering a control character. This reduces call overhead when you are writing one character at a time.

- If you are using hiperspace memory files, you can use setvbuf() to set the buffer size.

  The default buffer size for memory files in hiperspace is 16K. You can override this by calling setvbuf() after fopen(), but before performing any I/O operations on the file. The minimum buffer size is 4K. If you specify a smaller size, it is ignored, and the default is used instead.

  If your file will be large, you can improve execution time by increasing the buffer size. This will result in less frequent flushing of the buffer to the hiperspace, but will cost you memory in the user address space for the larger buffers. For example,

  ```
  rc = setvbuf(fp, NULL, _IOFBF, 32768);
  ```

  Alternatively, if your memory is constrained, you can reduce requirements for memory in the user address space by reducing the buffer size. This will result in more frequent flushing of the buffer to the hiperspace. For example,

  ```
  rc = setvbuf(fp, NULL, _IOFBF, 4096);
  ```

  Please refer to Chapter 15, “Performing Memory File and Hiperspace I/O Operations” on page 215 for more information on hiperspace memory files.

- When writing to text files that do not use DBCS characters, ensure that MB_CUR_MAX is set to 1 for the current locale. This will prevent internal I/O checks for DBCS strings.

- Avoid using fscanf() or fprintf() if you can use other I/O routines instead. For example, use fwrite() rather than fprintf() to write out a format string with no substitution variables.
• When using `fflush()` beware of NULL file pointers; `fflush(NULL)` flushes all open streams.

• Specify DCB parameters on `fopen()` only when you are creating the file. When you are appending, updating or reading a file, these attributes are retrieved from the existing file. Many file attributes (DCB parameters) are possible when you open a file with z/OS C/C++. DCB parameters specified on `fopen()` must be compatible with those of the file or the ddname. This checking may cause unwanted overhead.

• Use `fgetpos()` and `fsetpos()` instead of `ftell()` and `fseek()` when you are saving a position you will return to later. `fgetpos()` saves more information about the position than `ftell()`.

• Where possible, use striped data sets. These data sets improve overall I/O throughput.

• For temporary files, use memory files rather than files created with `tmpfile()`. You can use MVS memory files from z/OS UNIX C++ application programs. However, use of the `fork()` function from the program clears a memory file and removes access from a hiperspace memory file for the child process. Use of an `exec` function from the program clears a memory file when the process address space is cleared.

• For large memory files (1MB or larger) in which you perform random seeking, use hiperspace memory files, if they are available.

• When your library is below the 16MB line, use hiperspace memory files. The non-hiperspace files use up your storage from below the line. Hiperspace memory files do not reside in user virtual storage. Changing a memory file to a hiperspace memory file saves user virtual storage only if the file is larger than one hiperspace memory file buffer.

• For VSAM I/O use VSAM buffers appropriately and use `flocate()` instead of `ftell()` and `fseek()`.

When Accessing HFS Files

• Use `fread()` instead of `fgets()`, and `fwrite()` in place of `fputs()`, wherever possible.

• Use `putc()` instead of `fputc()`, and `getc()` instead of `fgetc()`, if you must write or read a character.

• When using `fflush()`, beware of NULL file pointers; `fflush(NULL)` flushes all open streams.

• Changing the buffer size for access to HFS may provide advantages. You may want to set the buffer size to be the length of the read or write operation that you normally do. Use the `setvbuf()` function to change the buffer size.

Note: When you include the header file `stdio.h`, macros are defined for `getc()`, `putc()`, `getchar()`, and `putchar()`. In order to use the function calls instead of the macro calls, use `#undef` after the `stdio.h` header file is included. If you are working with a threaded application, these macros are automatically undefined forcing the application to use function calls, which are thread safe. The feature test macro `_ALL_SOURCE` causes these four macros to be undefined. However, if you require `_ALL_SOURCE`, and want these macros to be used in a non multi-threaded application, you can use feature test macro `_ALL_SOURCE_NOTHREADS`. 

Chapter 28. Optimizing Code  401
When Using the C++ I/O Stream Libraries

The following are applicable to the USL I/O Stream Class Library and to the Standard C++ I/O stream classes.

- Unit-buffering incurs a significant performance penalty. Unit-buffering can be enabled by setting the `ios::unitbuf` flag. It is enabled for the `cerr` object by default.
- The `sync_with_stdio()` function enables unit-buffering of standard streams, to ensure their synchronization with C standard streams. However, a run-time performance penalty is incurred to ensure this synchronization. For more information about `sync_with_stdio()`, see...
- In many cases, the C I/O functions are faster than using the C++ I/O stream classes, but using both to access the same file will cause undefined results.

Using Library Extensions

If you are using C, consider `fetch()` or DLLs instead of `system()` for calling other C modules; if you are using C++, use DLLs.

Effective use of DLLs may improve the performance of your application. Following are some suggestions that may improve performance:

- If you are using a particular DLL frequently across multiple address spaces, the DLL can be installed in the LPA or ELPA. When the DLL resides in a PDSE, the dynamic LPA services should be used. Installing in the LPA/ELPA may give you the performance benefits of a single rather than multiple load of the DLL.
- Be sure to specify the `RENT` option when you bind your code. Otherwise, each load of a DLL results in a separately loaded DLL with its own writable static.
- Group external variables into one external structure.
- When using z/OS UNIX avoid unnecessary load attempts.

z/OS Language Environment supports loading a DLL residing in the HFS or a data set. However, the location from which it tries to load the DLL first varies depending whether your application runs with the run-time option `POSIX(ON)` or `POSIX(OFF)`.

If your application runs with `POSIX(ON)`, z/OS Language Environment tries to load the DLL from the HFS first. If your DLL is a data set member, you can avoid searching the HFS directories. To direct a DLL search to a data set, prefix the DLL name with two slashes (`/`), as shown in the following example.

```
//MYDLL
```

If your application runs with `POSIX(OFF)`, z/OS Language Environment tries to load your DLL from a data set. If your DLL is an HFS file, you can avoid searching a data set. To direct a DLL search to the HFS, prefix the DLL name with a period and slash (`./`), as shown in the following example.

```
./mydll
```

**Note:** DLL names are case sensitive in the HFS. If you specify the wrong case for your DLL that resides in the HFS, it will not be found in the HFS.

- For IPA, you should only export subprograms (functions and C++ methods) or variables that you need for the interface to the final DLL. If you export subprograms or variables unnecessarily (for example, by using the `EXPORTALL` option), you severely limit IPA optimization. In this case, global variable coalescing and pruning of unreachable or 100% inlined code does not occur. To be processed by IPA, DLLs must contain at least one subprogram. Attempts to process a data-only DLL will result in a compilation error.
The suboption NOCALLBACKANY of the compiler option DLL is more efficient than the CALLBACKANY suboption. The CALLBACKANY option calls a Language Environment routine at run-time. This run-time service enables direct function calls. Direct function calls are function calls through function pointers that point to actual function entry points rather than function descriptors. The use of CALLBACKANY will result in extra overhead at every occurrence of a call through a function pointer. This is unnecessary if the calls are not direct function calls.

A system() call does full environment initialization and termination, but a fetched module and a DLL shares the environment of the calling routine.

**Note:** Compiling source with the DLL option may cause a degradation in performance.

Use memory files as efficient temporary files by specifying the type=memory attribute in fopen() before creating the temporary file. Some applications use temporary files to pass data between program modules.

When using one of the z/OS UNIX shells, an MVS memory file may or may not make an efficient temporary file. This depends on whether your z/OS UNIX C/C++ application program uses fork() and exec() functions to call another program to run in a child process. The child process does not inherit MVS memory files after an exec() function.

### Programming Recommendations

This section contains tips on how to write code to get the best results from the optimization techniques used by the compiler.

### Using Variables

Keep the following in mind when you choose the variables and data structures for your application:

- Use local variables, preferably automatic variables, as much as possible. The compiler can accurately analyze the use of local variables, while it has to make several worst-case assumptions about global variables. These assumptions tend to hinder optimizations. For example, if you code a function that uses external variables, and calls several external functions, the compiler assumes that every call to an external function could change the value of every external variable.
- In some cases using local copies of global variables will help performance. If none of the function calls will affect the global variables being used, and you have to read them frequently with function calls interspersed, copy the global variables to local variables. Next, use these local variables to help the compiler perform optimizations that otherwise would not be done. Using IPA can improve the performance of code written using global variables, because it coalesces global variables. IPA puts global variables into one or more structures and accesses them using offsets from the beginning of the structures.
- If you need to share variables only between functions within the same compilation unit, use static variables instead of external variables. Organize your source code so references to a given set of externally defined variables occur only in one source file, and then use static variables instead of external variables.
In a file with several related functions and static variables, the optimizer can gather and use more information about the variables.

Use a local static variable instead of an external variable or a variable defined outside the scope of a function.

The \#pragma isolated_call preprocessor directive can improve the run-time performance of optimized code by allowing the compiler to make fewer assumptions about the storage of external and static variables. Refer to \textit{C/C++ Language Reference} for more information about the \#pragma isolated_call directive.

IPA global variable coalescing helps improve optimization in the same way that changing external variables to static variables does. Global variable coalescing causes variables that are frequently used together to be mapped close together in memory.

- Group external data into structures (all elements of an external structure use the same base address) or arrays wherever it makes sense to do so.

  To access an external variable, the compiler has to make an extra memory access to obtain the variable's address. The compiler removes extraneous address loads, but this means that the compiler has to use a register to keep the address. Using many external variables simultaneously requires many registers, thereby causing spilling of registers to storage.

- The compiler treats register variables the same way it treats automatic variables that do not have their address taken.

- Minimize the use of pointers.

  Use of pointers inhibits most memory optimizations such as dead store elimination in C and C++.

  Using the z/OS C \#pragma disjoint directive to list identifiers that do not share the same physical storage can improve the run-time performance of optimized code. See \textit{C/C++ Language Reference} for more information on the \#pragma disjoint directive.

**Passing Function Arguments**

Optimization is effective when using function arguments. It is usually better to pass a value as an argument to a function than to let the function take the value from a global variable.

The \#pragma isolated_call preprocessor directive lists functions that have no side effects, that is, that do not modify global storage. Using it can improve the run-time performance of optimized code. Refer to \textit{C/C++ Language Reference} for examples and more information about this directive.

**Coding Expressions**

When coding expressions consider the following recommendations:

- If components of an expression are duplicate expressions, code them either at the left end of the expression or within parentheses. For example:

  ```c
  a = b*(x*y); /* Duplicates recognized */
  c = x*y*z*d;
  e = f + (x + y);
  g = x + y + h;
  
  a = b*x*y*z; /* No duplicates recognized */
  c = x*y*z*d;
  e = f + x + y;
  g = x + y + h;
  ```
The compiler can recognize \( x*y*z \) and \( x + y \) as duplicate expressions because they are coded in parentheses or coded at the left end of the expression.

- When components of an expression in a loop are constant, code the constant expressions either at the left end of the expression or within parentheses. If \( c, d, \) and \( e \) are constant and \( v, w, \) and \( x \) are variable, the following examples show the difference in evaluation:

\[
v*w*x*(c*d*e); \quad /* \text{Constant expressions recognized} */
\]
\[
c + d + e + v + w + x;
\]
\[
v*w*x*c*d*e; \quad /* \text{Constant expressions not recognized} */
\]
\[
v + w + x + c + d + e;
\]

### Coding Conversions

Avoid forcing the compiler to convert numbers between integer and floating-point internal representations. Conversions require several instructions, including some double-precision floating-point arithmetic. For example:

```
CCNGOP3

/* this example shows how numeric conversions are done */

int main(void)
{
    int i;
    float array[10]={1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0}
    float x = 1.0;
    for (i = 0; i < 10; i++)
    {
        array[i] = array[i]*x; /* No conversions needed */
        x = x + 1.0;
    }
    for (i = 1; i <= 9; i++)
        array[i] = array[i]*i; /* Conversions may be needed */
    return(0);
}
```

*Figure 104. Numeric Conversions Example*

When you must use mixed-mode arithmetic, code the integral, floating-point, and decimal arithmetic in separate computations as much as possible.

### Arithmetic Considerations

- Wherever possible, use multiplication rather than division. For example,

\[
x* (1.0/3.0); \quad /* \text{1.0/3.0 is evaluated at compile time} */
\]

produces faster code than:

\[
x/3.0;
\]

- Assign the divisor’s reciprocal to a temporary variable and then multiply by that variable. Divide many values by the same number in your code.

### Using Loops and Control Constructs

For the for-loop index variable:

- Use a `long` type variable whenever possible. In the current implementation, `long` and `int` are equivalent, but `long` is better for portability.
- Use the auto or register storage class over the extern or static storage class.
- If you use an enum variable, expand the variable to be a fullword.
- Do not use the address operator (&) on the index.
- The index should not be a member of a union.

When using if statements:
- Order the if conditions efficiently; put the most decisive tests first and the most expensive tests last.
  By performing the most common tests first, you increase the efficiency of your code; fewer tests are required to meet the test conditions.
  ```c
  if (command.is_classg &&
    command.len == 6 &&
    !strcmp (command.str, "LOGON")) /* call to strcmp() most expensive */
  logon();
  ```

Choosing a Data Type

- Use the int data type instead of char when performing arithmetic operations.
  ```c
  char_var = '0';
  int_var = '0';  /* better */
  ```
- A char type variable is efficient when you are:
  - Assigning a literal to a char variable
  - Comparing the variable with a char literal
    ```c
    char_var = 27;
    if (char_var == 'D')
    ```
- These data types are more expensive to reference:

<table>
<thead>
<tr>
<th>More Expensive</th>
<th>Less Expensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>unsigned short</td>
<td>signed short (Although unsigned short is less expensive on many systems, the z/OS implementation of signed short is less expensive.)</td>
</tr>
<tr>
<td>signed char</td>
<td>unsigned char</td>
</tr>
<tr>
<td>long double</td>
<td>double</td>
</tr>
<tr>
<td>Longer decimal</td>
<td>Shorter decimal</td>
</tr>
<tr>
<td>IBinaryCodedDecimal</td>
<td>decimal (for limitations, see Chapter 25, &quot;Using the Decimal Data Type in C&quot; on page 351)</td>
</tr>
</tbody>
</table>

- For storage efficiency, the compiler will pack enumeration variables in 1, 2 or 4 bytes, depending on the largest value of a constant.
  If performance is critical, expand the size to a fullword by adding an enumeration constant with a large value, or by specifying the ENUMSIZE compiler option.
  ```c
  enum byte { land, sea, air, space };
  enum word { low, medium, high, expand_to_fullword = INT_MAX };
  ```
  This is equivalent to using the ENUMSIZE(INT) compiler option with the following code:
  ```c
  enum word { low, medium, high };
  ```
For example, fullword enumeration variables are preferred when used as function parameters.

- For efficient use of extern variables:
  - Place scalars ahead of arrays in extern struct.
  - Copy heavily referenced scalars to auto or register variables (especially in a loop).

- Consider the following points when using float:
  - When passing variables of type float to a function, an implicit widening to double occurs (which takes time).
  - On some machines divides of type float are faster than those of type double.

- When using bit fields:
  - Even though the compiler supports a bit field spanning more than 4 bytes, the cost of referencing it is higher.
  - An unsigned bit field is preferred over a signed bit field.
  - A bit field used to store integer values should have a length of 8, 16, or 24 bits and be on a byte boundary.

```c
struct { unsigned xval :8,
          xbool :1,
          xmany :6,
          xset :1;
     } b;

if (b.xval == 3)
   :
   if (b.xmany + 5 == x) /* inefficient because it does not */
       /* fall on a byte boundary */
   :
   if (b.xbool)
   :
```

**Using Built-In Library Functions and Macros**

- Include the appropriate library header files to trigger the use of built-in functions (that is, compiler-generated expansion for the function). You can also use floating-point built-in functions, which provide access to specific hardware instructions. For a list of the built-in functions, see Appendix I, “Using Built-In Functions” on page 881.

  Including the proper library header files also prevents parameter type mismatch and ensures optimal performance. If you want to call a built-in function explicitly, enclose the function name in parentheses when you make the call, as follows: `(memcpy)(buf1, buf2, len)`.

  **Note:** At `N0OPT` the compiler may not expand all built-in functions.

- You should always include the `ctype.h` header file to use the following macros rather than their equivalent functions:

  | isalpha() | islower() | isupper() |
  | isalnum() | isprint() | isxdigit() |
  | iscntrl() | ispunct() | toupper() |
  | isdigit() | isspace() | tolower() |
  | isgraph() |

- If you are using the `_cs1` or `_cds1` function with arguments other than the ones declared in the prototypes in `stdlib.h`, the compiler may not be able to generate correct code at OPT. In this case, use the `NOANSIALIAS` option.
**Note:** As of z/OS V1R2, the new forms for `cs()` and `cds()` are `cs1` and `cds1`, respectively. Please refer to Appendix I, "Using Built-In Functions" on page 881 for more information.

- Arrays are compared using a loop (one element at a time). When comparing two arrays for equality, the loop is replaced with a `memcmp()`. In some cases, this means that the execution of many machine instructions are replaced by the execution of a few.

  For example:
  ```c
  if (!memcmp (a, b, sizeof(a)))
      /* arrays are equal */
  ```

  is more efficient than a comparison in a loop such as:
  ```c
  int a[1000], b[1000];
  for (i = 0; i < 1000; ++i)
      if (a[i] != b[i])
          break;
  if (i == 1000)
      /* arrays are equal */
  ```

- Neither the C nor C++ language allows structure comparison, because structures may contain padding bytes with undefined values. In cases where you know that no padding bytes exist, use `memcmp()` to compare structures. The z/OS AGGREGATE compiler option for C is used to obtain a structure and union map.

- The `memset()` library function should be used to initialize a character buffer and to initialize an array to a repetitive byte pattern (such as zeros).

- Use `memset()` to clear structs, unions, arrays or character buffers as follows:

  ```c
  char c[10];
  for (i = 0; i < 10; i++) /* do not use */
      c[i] = ' ';
  memset (c, ' ', sizeof (c)); /* better */
  ```

- Use the `alloca()` function to automatically allocate memory from the stack. This function frees memory at the end of a function call when z/OS C/C++ collapses the stack. See the z/OS C/C++ Run-Time Library Reference for more information on this function.

- When using `strlen()`, do not hide size information. Less code is needed for `strlen()` when the upper bound is known at compile time.

  ```c
  char small_str_array[100];
  char *small_str_ptr;
  :
  x = strlen(small_str_ptr); /* unknown upper bound */
  x = strlen(small_str_array); /* better */
  ```

- If you are concatenating strings, use `strcat()`.

- If you are performing character to integer conversions, use `atoi()` rather than `sscanf()`.

- Try to replace `strxxx()` functions with their corresponding `memxxx()` functions, because `memxxx()` functions are more efficient. To minimize the execution cost of a `strxxx()` function, use fixed-length character buffers or to save the length of incoming string (including null terminator) for subsequent calls to `memcpy()` and `memcmp()`.

  ```c
  total_len = strlen (s) + 1;
  for (i = 0; i < 10; i++)
  ```
if (memcmp (s, t[i], total_len) == 0) /* total_len ≤ sizeof(t) */
    :

memcpy (a, s, total_len);

Note: You cannot replace all strcmp() calls with a memcmp() call taking a
strlen() value of one of the strings. memcmp() will not stop comparing
strings when it encounters a null in one of the strings. This may result in
an attempt to access protected storage which follows the shorter string.
This, in turn, could result in an exception.

Using pragmas to Improve Performance
This section describes pragmas that can affect performance. For information about
using these pragmas, see C/C++ Language Reference.

#pragma disjoint
Lists identifiers that do not share the same physical storage, which provides more
opportunities for optimizations.

#pragma export
Selectively exports functions or variables from a DLL module. The EXPORTALL
compiler option exports all functions or variables, which may result in larger
executables.

#pragma inline (C only)
Together with the INLINE compiler option, ensures that frequently used functions
are inlined.

This directive is only supported in C; however, you can use the inline keyword in
C++.

#pragma isolated_call
Lists functions that have no side effects (that do not modify global storage). This
directive can improve the run-time performance of optimized code by allowing the
compiler to make fewer assumptions about the storage of external and static
variables.

#pragma leaves
Specifies that a function never returns to the instruction following a call to that
function. This directive provides information to the compiler that enables it to
explore additional opportunities for optimization.

#pragma noinline
Prevents infrequently used functions, such as routines for debugging and handling
exceptions, from being inlined.

#pragma option_override
Allows you to specify optimization options on a per-routine basis rather than on only
a per-compilation basis. It enables you to specify which functions you do not want
to optimize while compiling the rest of the program optimized. This directive helps
you to isolate which function is causing problems under optimization.

#pragma reachable
Declares that the point in the program after the specified function can be the target
of a branch from some unknown location. That is, you can reach the instruction
after the specified function from a point in your program other than the return
statement in the named function.
This directive provides information to the compiler that enables it to explore additional opportunities for optimization.

**#pragma strings**
Indicates whether strings should be placed in read-only memory or read/write memory.

To reduce the memory requirements for DLLs, specify #pragma strings(readonly), so that string literals are not placed in the writable static area.

Alternatively, you can also use the ROSTRING compiler option (the default), which informs the compiler that string literals are read-only.

**#pragma variable**
Indicates if a named external object is used in reentrant or non-reentrant fashion. If an object is marked as RENT, its references or its definition will be in the writable static area, which is in modifiable storage. If an object is marked as NORENT, its references or its definition will be in the code area.

To reduce the memory requirements for DLLs, specify #pragma variable(var_name,NORENT), so that constant variables are not placed in the writable static area.

Alternatively, you can also use the ROCONST compiler option to inform the compiler that constant variables are not to be placed in the writable static area.

---

### Compiler Options to Improve Performance

The z/OS C/C++ compiler provides several facilities to allow you to tune your code for performance:

- The OPTIMIZE option (see “Using the OPTIMIZE Option”)
- The XPLINK option (see “Using XPLINK” on page 417)
- INLINE tuning options for C and C++ (see “Inlining” on page 412)
- Additional tuning options (see “Additional Compiler Options that Affect Performance” on page 415)
- Interprocedural Analysis (IPA) as provided by the IPA compile-time option. Refer to Chapter 29, “Optimizing Your C/C++ Code with Interprocedural Analysis” on page 421 for an overview.

### Using the OPTIMIZE Option

During optimization, the compiler changes the unoptimized code sequences, derived from the source code, into equivalent code sequences that execute faster and usually require less memory space. It is possible for an expression that would normally cause an exception to be removed by optimization, thus preventing the exception.

**Note:** The z/OS C/C++ compiler provides one level of optimization. Optimized code takes significantly more time to compile than unoptimized code, but will likely result in faster running code.

Because the optimization is achieved by transforming the code using knowledge obtained from a larger program context, the direct correspondence between source and object code is often lost. Optimized code is also more sensitive to subtle coding errors.
One example of a subtle coding error is to type cast a pointer variable incorrectly. The compiler assumes ISO conformance when doing optimization. If your program does not conform, you may receive undefined results. Refer to the ANSIALIAS option in the z/OS C/C++ User's Guide for more information.

Optimizations Performed by the Compiler
The compiler performs several optimizations, including:

**Inlining**
Inlining replaces certain function calls with the actual code of the function being performed. For more information on inlining, see "Inlining" on page 412.

For z/OS C/C++ automatic inlining is performed by default when you specify OPTIMIZE. You can override this inlining by using the NOINLINE option. For further information on the INLINE option, refer to the z/OS C/C++ User's Guide.

**Value Numbering**
Value numbering involves local constant propagation, local expression elimination, and folding several instructions into a single instruction.

**Straightening**
Straightening is rearranging the program code to minimize branching logic and to combine physically separate blocks of code.

**Common Expression Elimination**
Common expressions recalculate the same value in a subsequent expression. The duplicate expression can be eliminated by using the previous value. This is done even for intermediate expressions within expressions. For example, if your program contains the following statements:

```c
a = c + d;
.
.
f = c + d + e;
```

the common expression \(c + d\) is saved from its first evaluation and is used in the subsequent statement to determine the value of \(f\).

**Code Motion**
If variables used in a computation within a loop are not altered within the loop, it may be possible to perform the calculation outside of the loop and use the results within the loop.

**Strength Reduction**
Less efficient instructions are replaced with more efficient ones. For example, in array addressing, an add instruction replaces a multiply.

**Constant Propagation**
Constants used in an expression are combined and new ones generated. Some mode conversions are done, and compile-time evaluation of some intrinsic functions takes place.

**Instruction Scheduling**
Instructions are reordered to minimize execution time.

**Dead Store Elimination**
The compiler eliminates stores when the value stored is never referred to again. For example, if two stores to the same location have no intervening load, the first store is unnecessary, and is therefore removed.
Dead Code Elimination
The compiler may eliminate code for calculations that are not required. Other optimization techniques may cause code to become dead.

Graph Coloring Register Allocation
The compiler uses a global register allocation for the whole function, thereby allowing variables to be kept in registers rather than in memory.

These optimization techniques may be performed both locally and globally. Increases in storage and compilation time requirements over NOOPT will occur.

Inlining
Inlining replaces certain function calls with the actual code of the function and is performed before all other optimizations. Inlining not only eliminates the linkage overhead but also exposes the entire function to the caller and thus enables the compiler to better optimize your code.

Note: See “Inlining under IPA” on page 415 for information on differences in inlining under IPA.

Two types of calls are not inlined:
• A call where the number of parameters on the call does not match that on the function definition. An example of this is a variable argument function call.
• A call that is directly recursive; the routine calls itself.

Consider the following C program:

CCNGOP1

/* this example demonstrates optimization */

#include <stdio.h>
#pragma inline (which_group)
int which_group (int a) {
  if (a < 0) {
    printf("first group\n");
    return(99);
  }
  else if (a == 0) {
    printf("second group\n");
    return(88);
  }
  else {
    printf("third group\n");
    return(77);
  }
}

int main (void) {
  int j;
  j = which_group (7);
  return(j);
}

Figure 105. Optimization Example
In this example, if you specify the `#pragma inline` directive for the function `which_group()`, and compile with `OPTIMIZE`, after optimizations, the compiler determines that the above code is equivalent to:

**CCNGOP2**
The z/OS C/C++ inliner supports two modes of running: selective and automatic.

```c
/* this example demonstrates optimization */
#include <stdio.h>

int main(void) {
    printf("third group\n"); /* a lot less code generation */
    return(77);
}
```

*Figure 106. Optimization Example*

**Selective Mode**
Selective mode enables you to specify in your source code the functions that you do and do not want inlined. If you know which functions are frequently invoked from within a compile unit, using C you can simply add the appropriate `#pragma inline` directives in your source and compile with `INLINE (NOAUTO,REPORT,,)`. For a C++ program, just add `inline` keywords to your source and compile with `INLINE (NOAUTO,REPORT,,)`.

If your code contains complex macros, the macros can be made into static routines at no execution-time cost. All static routines that are interfaces to a data object can be placed into a header file.

**Automatic Mode**
Automatic mode assists you with starting to optimize your code. It allows the compiler to choose potential functions to inline. The compiler will inline all routines that are less than the `threshold` in abstract code units (ACUs) until the function that the functions are inlined into is greater than `limit` abstract code units. The `threshold` and `limit` parameters are defined as follows:

- **threshold**: Maximum relative size of a function to inline. The default value is 100 Abstract Code Units (ACUs), both for C and C++. ACUs are proportional in size to the executable code in the function; your code is translated into ACUs by the compiler. Specifying a threshold of 0 is equivalent to specifying `NOAUTO`.

  Note that the proportion of ACUs to executable code in a function is different under IPA.

- **limit**: Maximum relative size a function can grow before auto-inlining stops. The default is 1000 ACUs for the specific function. Specifying a limit of 0 is equivalent to specifying `NOAUTO`.

*Note:* When functions become too large, run-time performance can degrade.

Under the z/OS UNIX shell, to provide assistance in choosing which routines to inline, use the `c89 -W` option to pass the `INLRPT` option to the z/OS C/C++ compiler. At `NOOPT`, you will also need to specify the `INLINE` option. The default at `NOOPT` is `NOINLINE`. 
For example, at NOOPT, to get INLINE(AUTO,REPORT,100,1000) for a C program, use one of the following c89 commands:

c89 -W "0,inline{{REPORT,,}}" example.c  
c89 -W "0,inline,inlrpt" example.c

To get the same value at OPT for a C program, pass the INLRPT option to the z/OS C/C++ compiler as follows:

c89 -2 -W "0,inlrpt"

Note: Inlining debugging functions or functions that are rarely invoked can degrade performance. Use the #pragma noinline directive to instruct the automatic inliner to not inline these types of functions. The #pragma inline and the #pragma noinline directives and the inline keyword are honored by automatic inlining regardless of the limit and threshold you have specified. See the C/C++ Language Reference for more information on the inline pragmas and the inline keyword.

Improving Your Performance
While automatic inlining is the best choice the compiler can make for you, you can further improve your performance. Use #pragma inline and #pragma noinline to reduce the need to modify your inlining choices when you change your application. You may want to wait until you have a stable application before you do the following steps.

1. Compile with the OPTIMIZE option and ask for a report from the inliner by specifying the compiler options INLINE({REPORT,},) or INLRPT and OPTIMIZE.

2. Look at the report to see if anything was inlined that should not have been; for example, routines for debugging or handling exceptions. Add #pragma noinline to your source to insure that these functions do not get inlined.

3. Add the inline keyword (for C++) or the #pragma inline directive (for C) to any frequently used routines to ensure that it gets inlined.

4. Recompile with OPTIMIZE then, regenerate the inline report and reanalyze for functions that should and should not be inlined.

5. You should also vary the limit and threshold values.
   - The inline report tells you the abstract code units (ACUs) for each function. These should help you determine an appropriate threshold to start from. In general your initial threshold should be as small as possible, and your initial limit should be in the 1000 to 2000 range.
   - Increase the threshold by an increment small enough to catch a few more routines each time.
   - Change the limit when you wish. Because performance will improve as a function of both the limit and the threshold values, it is not recommended that you change both the limit and threshold at the same time.

6. Repeat the process until you feel that you have found the best performance parameters. You should run your application to determine if the tuning has found the best performance parameters.

7. When you are satisfied with the selection of inlined routines, add the appropriate #pragma inline directives or inline keywords to the source. That is, when the selected routines are forced with these directives, you can then compile the program in selective mode. This way, you do not need to be affected by changes made to the heuristics used in the automatic inliner.

Inline defaults
Automatic and selective inlining are performed when the OPTIMIZE compiler option is specified. You can override this by specifying the NOINLINE option when you specify
your optimization level. You can also override this by specifying the #pragma noinline directive for a particular function. See C/C++ Language Reference for more information on this directive.

**Inlining under IPA**
The IPA Inliner functions differently from the regular inliner:

- It performs inlining across compilation units, rather than within a compilation unit.
- It handles inlining of functions with variable argument lists.
- It inlines calls from recursive cycles (for example, where function A calls function B calls function C calls function A). However, it avoids making the functions too large.

**Additional Compiler Options that Affect Performance**
The following sections describe compiler options that affect performance. For information about using these options, see z/OS C/C++ User’s Guide.

**ANSIALIAS**
The ANSIALIAS option specifies whether type-based aliasing is to be used during optimization. Type-based aliasing will improve optimization.

**ARCHITECTURE and TUNE**
The ARCHITECTURE option specifies which architecture the executable program’s instructions will be generated for; the TUNE option specifies which architecture the executable program will be optimized for. ARCHITECTURE allows the optimizer to take advantage of specific hardware instruction sets. TUNE allows the optimizer to take advantage of architectural differences such as scheduling of instructions.

**COMPRESS**
Use the COMPRESS option to suppress the generation of function names in the function control block to reduce the size of your application’s load module. The amount of reduction depends on the average function size in the application, as compared to the length of the function name.

**COMPACT**
When the COMPACT option is active, the compiler favors optimizations that tend to limit the growth of the code. Depending on your specific program, the object size may increase or decrease and the execution time may increase or decrease.

Any time you change your program, or change the release of the compiler, you should reevaluate your use of the COMPACT option.

**CVFT (C++ Only)**
Use the NOCVFT option to reduce the size of the writable static area for constructors that call virtual functions within the class hierarchy where virtual inheritance is used.

**EXH (C++ Only)**
To improve run time of your C++ code, consider using NOEXH. The resultant code will run faster, but will not be ISO-compliant if the program uses exception handling.

**EXPORTALL**
Use the EXPORTALL option only if you want to export all external functions and variables in the source file so that a DLL application can use them. If you only need to export some externally defined functions and variables, use the #pragma export directive or the _Export C++ keyword instead of EXPORTALL.

Using EXPORTALL can severely limit IPA optimization, and can cause your modules to be larger than necessary.
IGNERRNO
The IGNERRNO option informs the compiler that the program is not using errno, allowing the compiler more freedom in exploring optimization opportunities for certain library functions (for example, sqrt). You need to include the system header files to get the full benefit of this option.

IPA
The IPA option specifies that the compiler uses interprocedural analysis. This can lead to significant performance improvements. For more information, see Chapter 29, “Optimizing Your C/C++ Code with Interprocedural Analysis” on page 421.

LIBANSI
The LIBANSI option specifies whether or not all functions with the name of an ANSI C library function are in fact the system functions. This allows the optimizer to generate code based on existing knowledge concerning the behavior of the function (for example, whether or not any side effects are associated with a particular library function).

OBJECTMODEL
z/OS V1R2 includes two ways to compile your programs using different object models. The two object models differ in the following areas:
• Layout for the virtual function table
• Virtual base class support
• Name mangling scheme

The OBJECTMODEL compiler option sets the type of object model, either COMPAT or IBM. The compiler option has the following suboptions:
• COMPAT - uses the object model compatible with previous versions of the compiler.
• IBM - uses the new object model and should be selected if you want improved performance. This is especially true for class hierarchies with many virtual base classes. The size of the derived class is considerably smaller and access to the virtual function table is faster.

All classes in the same inheritance hierarchy must have the same object model.

Use the #pragma object_model directive to specify an object model in your source. For more information on this directive see C/C++ Language Reference.

ROCONST
The ROCONST option specifies that the const qualifier is respected by the program. Variables that are defined with the const keyword are not overridden by a casting operation.

ROSTRING
The ROSTRING option specifies that strings are placed in read-only memory. It has the same effect as the #pragma strings(readonly) directive.

SPILL
Specifying a very large spill size may force the compiler to generate less than optimal code. For this reason, you may not want to specify the large spill size for the entire application. For example, you can specify the large spill size for only the one particular compilation unit that needs it or use #pragma option_override.
**STRICT INDUCTION**

With strict induction, induction (loop counter) variables are not optimized. This guards against problems that can occur if an optimized induction variable overflows.

If it is certain that the induction variables will not overflow, use the NOSTRICT_INDUCTION option. This option can improve the performance of induction variables that are smaller than the register size on the processor.

---

**Memory Optimization**

Memory allocations can significantly affect your application's performance. Use the following run-time options to optimize your run-time space requirements: ANYHEAP, BELOWHEAP, HEAP, HEAPPOOLS, LIBSTACK, THREADSTACK, STACK, and STORAGE.

You can use the RPTSTG(ON) option to find out about your storage usage for the given run of your application. You can then use the STACK and HEAP run-time options to ensure that the initial stacks and heaps are sufficiently large, and that increments are of the optimal size. The initial STACK size should be large enough that it will not need to be extended during the program’s execution.

You can also tune I/O storage by using the _EDC_STOR_INITIAL and _EDC_STOR_INCREMENT environment variables. The I/O storage usage is not in the storage report.

You can use the __heaprpt() function to obtain a summary heap storage report while your application is running, without having to specify the RPTSTG(ON) option. See z/OS C/C++ Run-Time Library Reference for more information on the __heaprpt() function.

If your application is multi-threaded or often uses malloc(), realloc(), calloc(), and free(), you should consider using the HEAPPOOLS run-time option. Although storage requirements may increase, you can expect better performance. See z/OS Language Environment Programming Guide for more information on run-time storage.

---

**Using XPLINK**

Applications that make many calls to small functions get the most benefit from using XPLINK. Many C++ applications are structured this way, because of the object oriented programming model. C applications that make many function calls may also be suitable for XPLINK.

To further enhance the performance of an XPLINK application, specify the FLOAT(IEEE) compiler option. This option means that you use the IEEE binary floating-point math library, which has been recompiled entirely in XPLINK. The hexadecimal math library remains non-XPLINK, and therefore requires a call through glue code from XPLINK applications.

You should also use the HEAPPOOLS(ON) run-time option. This reduces latch contention on malloc() and free(), which have also been recompiled entirely in XPLINK. If HEAPPOOLS(OFF) is in effect, calls to malloc() and free() require a call through glue code from XPLINK applications.
When You Should Not Use XPLINK

Functions compiled XPLINK and NOXPLINK cannot be combined in the same program object, unless you use an OS linkage specification as described in Chapter 19, “Using Linkage Specifications in C or C++” on page 245 and z/OS Language Environment Writing Interlanguage Communication Applications.

XPLINK provides a significant performance enhancement to some applications, but can degrade the performance of applications that are not suitable for XPLINK.

One way to call an XPLINK function from a non-XPLINK program object is to use the DLL call mechanism. There is an overhead cost associated with calls made from non-XPLINK to XPLINK, and from XPLINK to non-XPLINK. This overhead includes the need to swap from one stack type to another and to convert the passed parameters to the style accepted by the callee. Applications that make a large number of these "cross-linkage" calls may lose any benefit obtained from the parts that have been compiled XPLINK, and in fact performance could be degraded from the pure non-XPLINK case. If the number of pure XPLINK function calls is significantly greater than the number of "cross-linkage" calls, the cost saved on XPLINK calls will offset the costs associated with calls that involve stack swapping.

When you introduce an XPLINK program object into your application, for example an XPLINK version of a vendor-DLL which your application uses, your application must now run in an XPLINK environment (this is controlled by the XPLINK run-time option). In an XPLINK environment, an XPLINK version of the C/C++ Run-Time Library (RTL) is used. You cannot have both the non-XPLINK and XPLINK versions of the C/C++ RTL active at the same time, so non-XPLINK callers of the C/C++ RTL will also incur this stack swapping overhead in an XPLINK environment.

The maximum performance improvement can be achieved by recompiling an entire application XPLINK. The further the application gets from pure XPLINK, the less the performance improvement. At some point, you may actually see a performance degradation.

The only compiler that currently supports the XPLINK compiler option is the z/OS C/C++ compiler. All COBOL and PL/I programs are non-XPLINK. Calls between COBOL or PL/I and XPLINK-compiled C/C++ are cross-linkage calls and will incur the stack swapping overhead.

For more information on making ILC calls with XPLINK, refer to z/OS Language Environment Writing Interlanguage Communication Applications.

Applications that use Language Environment facilities that are not supported in an XPLINK environment, or that use products that are not supported in an XPLINK environment (for example, CICS), can not be recompiled as XPLINK applications.

For more information about XPLINK, see z/OS Language Environment Programming Guide and the IBM Redbook called XPLink: OS/390 Extra Performance Linkage, which is available at: http://www.redbooks.ibm.com/abstracts/sg245991.html.

Compile Time Considerations

This section contains tips on what you can do to improve compile time.
Programmer Tips

- You can add code to the beginning and end of a header file to ensure that it is not processed unnecessarily during compilation. The following example contains code that is included in a header file called myheader.

```c
#ifndef __myheader
  #ifdef __COMPILER_VER__
    #pragma filetag ("IBM-1047")
  #endif
  #define __myheader 1
  .
  .
  . /* header file contents */
#endif
```

You must ensure that the filetag statement, if used, appears before the first statement or directive except for any conditional compilation directives. The ifndef statement is the first non-comment statement in the header file (the actual token used after the ifndef statement is your choice). The define statement must follow; it cannot appear before the filetag statement, but it must appear before any other preprocessor statement (other than comments).

Note that the header can contain comment statements.

- Use the system header files from HFS instead of partitioned data sets to improve compile time. Specify the following compiler options to do this:
  - For C++: NOSEARCH SEARCH(’/usr/include/’, ’/usr/lpp/ioclib/include/’)
  - For C: NOSEARCH SEARCH(’/usr/include/’)

- With the MEMORY compiler option (the default), the compiler uses a memory file in place of a work file if possible. This option increases compilation speed, but you may require additional memory to use it. If the compilation fails because of a storage error, increase your storage size or recompile your program using the NOMEMORY option.

- If your application has many recursive templates, the FASTTEMPINC compiler option may improve the compilation time. This option defers generating object code until the final versions of all template definitions have been determined. Then, a single compilation pass generates the final object code. Time is not wasted generating object code that will be discarded and generated again. If your application has very few recursive template definitions, NOFASTTEMPINC may be faster than FASTTEMPINC.

- If a source file does not have try/catch blocks or throws objects, the NOEXH C++ compiler option may improve the compilation time. The resultant code will not be ANSI-compliant if the program uses exception handling.

- To improve your OPT compile time at the expense of run-time performance, you can specify:

  **MAXMEM**
  Limits the amount of memory used for local tables of specific, memory intensive optimizations. If this amount of memory is insufficient for a particular optimization, the compiler performs somewhat poorer optimization and issues a warning message. Reducing the MAXMEM value from 2G to 10M may disable some optimizations, which may cause some decrease in execution performance.

  **NOINLINE**
  Disables inlining, and may decrease the compile time with a decrease in execution performance.
System Programmer Tips

- If you do a lot of application development on your machine, put the compiler and run-time library in the LPA. Similarly, if you are working in z/OS UNIX System Services also put the c89/cxx/cc utilities in the dynamic LPA, LPA or linklist.
- Use packs that are cached with DASD fast write.
  If you are working in z/OS UNIX System Services, give each user a separate mountable file system to avoid I/O contention. This lets you spread user file systems across multiple DASD devices.
  If the compiler is not in LPA, tune your jobs to avoid channel and pack contention when the headers and the compiler are on the same pack and multiple compile jobs are executing.
- You can use the filecache command to store frequently used header files in an HFS file system. If you use the makedepend utility to generate dependency information, use the LIST option to generate a listing from makedepend. The summary section of this listing shows a list of the most frequently called headers and the frequency of these calls. Use this information to determine which headers should be cached.
- You can define /tmp as a RAM disk by specifying:

  FILESYSTYPE TYPE(TFS) ENTRYPOINT(BPXTFS)

  This is described in more detail in z/OS UNIX System Services Planning.
Chapter 29. Optimizing Your C/C++ Code with Interprocedural Analysis

This chapter describes how you can optimize your code using z/OS C/C++ Interprocedural Analysis (IPA).

Types of Procedural Analysis

The z/OS C/C++ compiler performs both intraprocedural and interprocedural analysis.

Intraprocedural analysis is a mechanism for performing optimization for each function in a compilation unit, using only the information available for that function and compilation unit.

Interprocedural analysis is a mechanism for performing optimization across function boundaries. The C/C++ compiler performs limited interprocedural analysis if inlining is in effect. But this form of interprocedural analysis only applies within a compilation unit.

Interprocedural analysis through the IPA compiler option improves upon the limited interprocedural analysis described above. When you invoke interprocedural analysis through the IPA option, the compiler performs optimizations across the entire program. It also performs optimizations not otherwise available with the C/C++ compiler. The types of optimizations performed include:

**Inlining across compilation units**
Inlining replaces certain function calls with the actual code of the function. Inlining not only eliminates the linkage overhead but also exposes the entire function to the caller and thus enables the compiler to better optimize your code.

**Program partitioning**
Program partitioning improves performance by reordering functions to exploit locality of reference. Functions that call each other frequently will be closer together in memory.

**Coalescing of global variables**
The compiler puts global variables into one or more structures and accesses the variables by calculating the offsets from the beginning of the structures. This lowers the cost of variable access and exploits data locality.

**Code straightening**
Code straightening streamlines the flow of your program.

**Unreachable code elimination**
Unreachable code elimination removes unreachable code within a function.

**Call graph pruning of unreachable functions**
Call graph pruning of unreachable functions removes code that is 100% inlined or never referenced.

**Intraprocedural constant and set propagation**
IPA propagates floating point and integer constants to their uses and computes constant expressions at compile time. Also, variable uses that are known to be one of several constants can result in the folding of conditionals and switches.
Intraprocedural pointer alias analysis
IPA tracks pointer definitions to their uses, resulting in more refined information about memory locations that a pointer dereference may use or define. This enables other parts of the compiler to better optimize code around such dereferences. IPA tracks data and function pointer definitions. When a pointer dereference can only refer to a single memory location or function, the dereference is rewritten to be an explicit reference to the memory location or function.

Intraprocedural copy propagation
IPA propagates expressions defining some variables to the uses of the variable. This creates additional opportunities for constant expression folding. It also eliminates redundant variable copies.

Intraprocedural unreachable code and store elimination
IPA removes definitions of variables that cannot be reached, along with the computation feeding the definition.

Conversion of reference (address) arguments to value arguments
IPA converts reference (address) arguments to value arguments when the formal parameter is not written in the called procedure.

Conversion of static variables to automatic (stack) variables
IPA converts static variables to automatic (stack) variables when their use is limited to a single procedure invocation.

The execution time for code optimized using IPA (IPA compile and link) is normally faster than for code optimized using interprocedural analysis (IPA compile only) or the OPT compiler option. Not all applications are suited for IPA optimization, however, and the performance gains realized from using IPA will vary.

This chapter provides an overview of the Interprocedural Analysis (IPA) processing that is available through the IPA compiler option. For more information about the effects of IPA on compiling, compiler options, and compiler listings, refer to the z/OS C/C++ User's Guide. For more information about the effects of IPA on pragmas, refer to the C/C++ Language Reference.

Compiler Processing Flow
IPA changes the flow of compiler processing. This section explains the differences.

Regular Compiler Execution
If you specify the NOIPA compiler option (the default), the compiler processes source files as shown in Figure 107 on page 423. The output is an object module for each source file processed. You can then bind the object modules to produce an executable module.
Compiler Execution with IPA

IPA processing consists of two steps: IPA Compile and IPA Link. You run the IPA Compile step once for each compilation unit, and run the IPA Link step once for the program as a whole. The final output is a single IPA-optimized object module which you must bind with the binder to produce an executable load module. To get the maximum benefit from IPA, run both the IPA Compile and IPA Link steps.

You can invoke the IPA Compile step in the same environments that you use for a regular compilation. You can only invoke the IPA Link step in MVS batch (without the ISPF interface provided with the compiler) or in one of the z/OS UNIX shell environments through the c89 utility.

This section describes the flow of IPA processing under MVS batch. The flow of processing with the c89 utility is the same, but there are differences in how you invoke IPA. Refer to "Invoking IPA from the c89 Utility" on page 430 for more information.

IPA Compile Step Processing
You invoke the IPA Compile step by specifying the IPA(NOLINK) compiler option (NOLINK is the default suboption). During the IPA Compile step, the compiler creates optimized objects. These objects contain information that the IPA Link step can use for further optimization.

The following processing takes place for each compilation unit that you specify for the IPA Compile step:
1. The compiler determines the final suboptions for the IPA option, based upon the compiler options and IPA suboptions that you specified. This is necessary because the compiler does not support some combinations of compiler options and IPA suboptions. The compiler issues a warning message if it finds unsupported combinations.
2. The compiler promotes some IPA suboptions based upon the presence of related compiler options and issues informational messages if it does so. Refer to the Compiler Options chapter in the z/OS C/C++ User's Guide for more information.
3. The compiler generates an IPA object file. This object file contains control information for a compilation unit required for the IPA Link step.
The IPA object module produced by IPA (NOLINK,NOOBJECT) has the same structure as a regular object module. It can not be used as input to the prelinker, linker, or binder. If attempted, the binder will generate the following error diagnostic message:

IEW2696E 3D01 AN ERROR WAS DETECTED IN AN EXTENDED OBJECT MODULE AT RECORD 4 WITHIN MEMBER CBC3BG07 IDENTIFIED BY DDNAME SYSLIN. ERRORID = 566.
IEW2307E 1032 CURRENT INPUT MODULE NOT INCLUDED BECAUSE OF INVALID DATA.

The prelinker and linker will appear to process these files correctly. To locate this problem, the IPA object contains an external reference to @@DOIPA. This reference remains unresolved unless the file is processed by the IPA Link step. If you attempt to link the IPA object file, the linker issues an error message.

Each IPA object contains a CSECT that includes the ESD name @@IPAOBJ.

4. If you specify the OBJECT suboption of the IPA option, the compiler produces a combined IPA and conventional object file. The IPA object connection occurs through the conventional object through END records. While the conventional object file is not required by the IPA Link step, creating it permits you to bind this file to create an executable module without IPA optimization. It is difficult to debug IPA optimized code. You can use an executable module that is not optimized to debug your program.

During the IPA Compile step, the compiler generates information that allows you to create object libraries with the C370LIB utility or to create z/OS UNIX archives with the ar utility. The information consists of XSD and ESD records for the external symbols that were defined in the compilation units of your program. You can use the object libraries and z/OS UNIX archives for autocall searching in the IPA Link step. During autocall searching, the IPA Link step searches these libraries and archives for external references from your program.

IPA Compile step processing is shown in Figure 108 on page 425.
IPA Link Step Processing

You invoke the IPA Link step by specifying the IPA(LINK) compiler option. During this step, the compiler links the IPA objects that were produced by the IPA Compile step (along with non-IPA object files and load modules, if specified), does partitioning, performs optimizations, and generates the final object code.

The following processing takes place:

1. The compiler determines the final suboptions for the IPA option, based upon the compiler options and IPA suboptions you specify. This is necessary because some combinations of compiler options and IPA suboptions are unsupported. The compiler issues informational and warning messages for unsupported combinations.

2. The compiler links IPA object files, as well as non-IPA object files and load modules (if specified). The compiler also merges information from the IPA Compile step.

Input for the Link step comes from one of three sources:

- The primary input file (specified by the SYSIN ddname). This can be either:
  - A set of IPA Link control statements that you create
    These may be INCLUDE and LIBRARY IPA Link control statements that explicitly identify secondary input files. IPA uses the same control statement format (with some exceptions) used by the binder.
  - The IPA object file from the compilation unit that contains the main function or fetchable entry point. If you specify this file, the compiler searches for all other IPA files using the SYSLIB ddname.
One or more secondary input files

The secondary input file may contain:
- IPA object files or PDS libraries
- Conventional object files or PDS libraries
- Load module libraries
- z/OS UNIX archive libraries
- IPA Link control statements

These secondary input files are to be used for autocall searches. You can specify these files through the SYSLIB ddname or explicitly include them through INCLUDE or LIBRARY IPA Link control statements on the IPA Link step.

Load module libraries are used to support library interface routines (such as CICS and Language Environment) that are implemented as load module libraries. Since IPA must resolve all parts of your application program before beginning optimization, make all of these libraries as well as your application object modules available to the IPA Link step.

The IPA Link step resolves external references using explicit and autocall resolution. This allows IPA to identify the static and global data and the external references for the whole program.

Ensure that you do not accidentally specify FB, LRECL 80 source files as input to the IPA Link step. The IPA Link step will assume that records from these files contain valid object information, and will retain them in the object file. When the linkage editor processes the object file, it will determine the records to be invalid, and will issue diagnostic messages.

• The IPA Link step control file. This file contains additional IPA control directives. The CONTROL suboption of the IPA compiler option identifies this file.

Refer to "Object Record Formats" on page 428 for more information about the format of object records that you can specify on the IPA Link step. Refer to the z/OS C/C++ User’s Guide for more information about the IPA Link step control file.

3. As objects are processed, IPA Link Step builds the program call graph, merging the IPA object code according to its place in the call graph. If necessary, IPA Link Step stores non-IPA object code for inclusion in the final object file, and converts load module library members into object format for inclusion in the final object file.

4. The compiler performs optimizations across the call graph. You specify the type and extent of optimizations using the LEVEL suboption of the IPA compiler option.

5. IPA Link Step divides the program call graph into separate units called partitions. Refer to "Partitioning" on page 429 for more information. Partitioning of the call graph is controlled by:
   - The partition size limit that is specified in the IPA control file (refer to the z/OS C/C++ User’s Guide for a description of this file).
   - The connectivity of your program. IPA places code that is isolated from the rest of the program into a separate partition.
   - Resolution of conflicting effects between the compiler options and pragmas specified for compilation units processed during the IPA Compile step. These
are the compiler options and pragmas that generate information during the analysis phase of the compiler for input to the code—generation phase.

IPA Link Step produces a final single object module for the program from these partitions.

You must bind the IPA single object module to produce the executable module.

**Note:** IPA Compile and IPA Link as follows:

- An object file produced by an IPA Compile that contains IPA Object or combined IPA and conventional object information can be used as input to the z/OS C/C++ IPA Link of the same or later Version/Release.
- An object file produced by an IPA Compile that contains IPA Object or combined IPA and conventional object information cannot be used as input by the z/OS C/C++ IPA Link of an earlier Version/Release. If this is attempted, the IPA Link will issue an error diagnostic message.
- If the IPA object is recompiled by a later z/OS C/C++ IPA Compile, additional optimizations may be performed and the resulting application program may perform better.

An exception to this is the IPA object files produced by the OS/390 Release 2 C IPA Compile. These must be recompiled from the program source using a compiler that is version OS/390 Release 3 or later before attempting to process them with the current IPA Link.

IPA Link step processing is shown in **Figure 109**.
Object File Formats
There are two object file formats generated by the High Level Assembler (HLASM) and other z/OS compilers and language translators.

Object File Format
The standard S/370 “TEXT” object format, packaged as fixed-length 80 byte records. Extensions to the basic format support long external symbols when the z/OS C/C++ compiler “LONGNAME” option is in effect. The object file format is supported as input to IPA Link. The z/OS C/C++ compiler produces only object file format files.

Generalized Object File Format (GOFF)
A hierarchical object file format introduced with HLASM R2, and the z/OS Binder. This format is supported as input to IPA Link.

Refer to z/OS DFSMS Program Management for more information on object file formats.

Object Record Formats
There are two basic types of object records which may be present in a file of object file format. The descriptions follow below. For more information, refer to the IPA Link chapter in the z/OS C/C++ User’s Guide.

Note: You cannot use the vi editor to create these records. Only an editor that supports fixed-length binary records may be used.

Binary Object Records: Binary records may include IPA object information, or they may include code and data generated through the OBJECT suboption of the IPA compiler option during the IPA Compile step. The records include the following types:
- ESD
- XSD
- TXT
- END
- RLD

The z/OS C/C++ compiler or an equivalent language translator may generate these object records.

IPA Link Control Statements: The syntax and format of IPA Link control statements are similar to those of the statements processed by the binder, Prelinker, and Linkage Editor. These statements can include the following types:
- ALIAS
- INCLUDE
- IMPORT
- LIBRARY
- NAME
- RENAME

The INCLUDE and LIBRARY control statements explicitly identify secondary input files.
You can specify the statements in a file or in a DD * stream. The logical records can span multiple fixed-block, 80–column–wide physical records. The IPA Link step allows but ignores blank records and comment control statements (those starting with an asterisk in column 1).

The compiler performs syntax checking on the IPA Link Control Statement object records. If it finds an error, it issues a diagnostic message and indicates the location of the error.

**Creating IPA Link Control Statements in Makefiles**

An easy way to create a control statement object record is to use the shell printf statement. For example, to create the object files foo.o and bar.o containing ALIAS control statements for their respective uppercased names, specify:

```bash
foo.o bar.o:
  printf "%-80s" "ALIAS $(@:b) " | tr [:lower:] [:upper:] \
    >$(@:b).o 2>$(@:b).err
```

**Partitioning**

The final object file created by the IPA Link step is comprised of partitions. Partitions have three purposes:

- They improve the locality of reference in a program by concentrating related code in the same regions of storage. This improves load module execution time. This improvement may be less dramatic for program objects which are paged into storage on demand.
- They reduce the compiler memory requirements during object code generation for that partition.
- They allow you to create programs larger than the 16MB limit for code and data in an individual S/370 object code CSECT.

There are four types of partitions:

- An initialization partition. This contains initialization code and data, and comment data (which ensures that #pragma comment information is clearly visible at the beginning of the program file and storage region).
- The primary partition. This contains the information for the main function.
- Secondary or other partitions.
- Residual CSECT name partitions. These contain CSECT definitions for all CSECTs provided by the user in csect directives in the IPA Link control file which were not used for generating initialization, primary, or secondary partitions.

IPA determines the number of each type of partition through the following:

- The partition directive in the control file specified by the CONTROL suboption of the IPA option. Abstract Code Units (ACU’s) define the partition directive.

**Note:** There is a 16MB limit on the size of a CSECT. If the length of a CSECT in a partition exceeds this limit, the compiler issues a severe error message and stops code generation. You can resolve the error by specifying a smaller value for the partition directive. Refer to the [IBM z/OS C/C++ User’s Guide](https://www.ibm.com/support/knowledgecenter/en/SSLTBK_382/com.ibm.hndbk_cplus_plus_user.doc_6.3.0/hsprguide/hsprguide.htm) for more information about the IPA Link step control file.

- The connectivity within the program call graph. Connectivity refers to the volume of calls between functions in a program.
- Conflict resolution between pragmas and compiler options specified for different compilation units. IPA attempts to resolve conflicts by applying a common option
across all compilation units. If it cannot, it forces the compilation units for which
the effects of the original option or #pragma are to be maintained into
separate partitions.

Refer to the z/OS C/C++ User’s Guide for an example of the Partition Map listing
section.

Invoking IPA from the c89 Utility

You can invoke the IPA Compile step, the IPA Link step, or both. The step that c89
invokes depends upon the invocation parameters and type of files you specify. You
must specify the I phase indicator along with the W option of the c89 utility. You can
specify IPA suboptions as keywords separated by commas.

If you invoke the c89 utility with at least one source file and the -c c89 compiler
option, c89 automatically specifies the IPA(NOLINK) option and invokes the IPA
compile step. For example, the following command invokes the IPA Compile step
for the source file hello.c:

c89 -c -WI hello.c

If you invoke the c89 utility with at least one object file, do not specify the -c
option and do not specify any source files. c89 automatically specifies IPA(LINK) and
automatically invokes the IPA Link step and the binder. For example, the following
command invokes the IPA Link step and the binder, to create a program called
hello:

c89 -o hello -WI hello.o

If you invoke c89 with at least one source file for compilation and any number of
object files, and do not specify the -c c89 compiler option, c89 automatically invokes
the IPA Compile step once for each compilation unit and the IPA Link step once for
the entire program. It then invokes the binder. For example, the following command
invokes the IPA Compile step, the IPA Link step, and the binder to create a program
called foo:

c89 -o foo -WI,object foo.c

Specifying Options

When using c89, you can pass options to IPA, as follows:

- If you specify -WI, followed by IPA suboptions, the compiler passes those
  suboptions to both the IPA Compile step and the IPA Link step.
- If you specify -Wc, followed by compiler options, the compiler passes those
  options only to the IPA Compile step.
- If you specify -Wl,I, followed by compiler options, the compiler passes those
  options only to the IPA Link step.

The following is an example of passing options:

c89 -2 -WI,noobject -Wc,source -Wl,I,"maxmem(2048)" file.c

If you specify the previous command, you pass the IPA(N0OBJECT) option to both
the IPA Compile and IPA Link steps, the SOURCE option to only the IPA Compile step,
and the MAXMEM(2048) option to only the IPA Link step.

Other Considerations

The c89 utility automatically generates all INCLUDE and LIBRARY IPA Link control
statements.

IPA under c89 supports the following types of files:
• MVS PDS members
• sequential files
• Hierarchical File System (HFS) files
• z/OS UNIX archive (.a) files

Refer to the "z/OS UNIX System Services Command Reference" for more information about the c89 utility.

Controlling IPA Execution

There are three ways to control IPA execution:
• Compiler options, including the IPA compiler option and its suboptions
• Compiler #pragma directives
• IPA Link step control file directives

This section discusses the first two methods. Refer to the chapter on the IPA Link step in the "z/OS C/C++ User’s Guide" for information about the control file.

Specifying Compiler Options with IPA

The IPA compiler option that invokes IPA includes suboptions that are not discussed in this chapter. Refer to the "z/OS C/C++ User’s Guide" for a complete description of the IPA option.

You should keep the following points in mind when specifying compiler options for an IPA Compile or IPA Link step. Refer to the compiler options section of the "z/OS C/C++ User’s Guide" for more information on specifying compiler options under IPA.

• Many compiler options do not have any special effect on IPA. For example, the PPONLY option, used for source control, processes source code prior to IPA Compile step analysis.
• Any compiler options that affect the way an object module is generated for a regular compilation have the same effect for an object module generated with the OBJECT suboption of the IPA compiler option.
• Some compiler options specified for the IPA Compile step generate information for the IPA Link step. You must specify these options on both steps. This is the situation for options that control code generation.

You must specify compiler options that affect the IPA Link step when you invoke that step, even if you specified the same options on the IPA Compile step. The IPA Link step uses defaults for options that are not specified.
• Some compiler options have special behavior or restrictions other than the description above.
• #pragma directives that you specify in your source code may conflict across compilation units with compiler options that you specify for the IPA Compile step. #pragma directives that you specify in your source code or compiler options that you specify for the IPA Compile step may conflict with options you specify for the IPA Link step.

IPA will detect such conflicts and apply default resolutions with appropriate diagnostic messages. The IPA Link step Compiler Options Map listing section displays the conflicts and resolutions.

To avoid problems, use the same options and suboptions on the IPA Compile and IPA Link steps. Also, if you use #pragma directives in your source code, specify the corresponding options (if they exist) for the IPA Link step.
• You must specify either the LONGNAME compiler option or the \#pragma longname preprocessor directive for the IPA Compile step (unless you invoke the step through the c89 utility). Otherwise, the compiler generates an unrecoverable error.

• If you specify a compiler option that is irrelevant for a particular step, IPA ignores it (without issuing a message).

• During the IPA Compile step, IPA handles conflicting effects between IPA suboptions and certain compiler options that affect code generation. The compiler uses a combination of compiler options and IPA suboptions to determine the information that the IPA object contains.

Specifying Pragmas under IPA

Many \#pragma s do not have any special behavior under IPA. They have the same effect on a program compiled with the IPA option as they do for a program compiled without the IPA option.

The following \#pragma s do have special behavior under IPA. Refer to the Language Reference for details.

- comment
- csect
- export
- longname
- option_override
- options
- pagesize
- runopts
- strings
- target

IPA may detect conflicting effects from \#pragma s or compiler options that you specified for different compilation units in the IPA Compile step. It resolves these conflicting effects during the IPA Link step. There may also be conflicting effects between \#pragma s and equivalent compiler options specified for the IPA Link step. IPA resolves these conflicts similarly to the way it resolves conflicting effects from compiler options specified for the IPA Compile and IPA Link steps. The Compiler Options Map section of the IPA Link step listing lists the conflicting effects of options and \#pragma s, and the corresponding resolutions.

You must specify either the LONGNAME compiler option or the \#pragma longname preprocessor directive for the IPA Compile step (unless you invoke the step through the c89 utility). Otherwise, the compiler generates an unrecoverable error.

Effects of IPA on Your Program

If you compile your program with IPA, the execution time for your program is normally faster than it would be if you requested inlining or other forms of optimization.

For best optimization results, specify both the OPT and IPA options.

You should be aware that not all programs benefit equally from IPA. Those most likely to show performance gains are those that:
• Contain a large number of functions
• Contain a large number of compilation units
• Contain a large number of functions that are not in the same compilation units as their callers
• Do not perform a large number of input/output operations

You should debug your code before attempting to use IPA. The IPA(NOLINK, OBJECT) option can help, by allowing you to create a conventional object that you can bind without running the IPA Link step first.

In some cases, incorrect code may compile successfully without IPA but not compile with IPA. This is because the IPA Link step enforces more rules than the regular compiler does. The IPA Link step knows about your entire program.

The regular compiler only has an isolated (compilation unit based) view of your program, and must assume that you have coded your entire application consistently.

Other effects of IPA:
• IPA affects compilation time:
  – If you invoke the IPA Compile step for each compilation unit in your program, and the IPA Link step for the program as a whole, the combined compilation time is higher than it is for a program compiled without IPA. This is due to the IPA-specific optimizations that the IPA Compile and IPA Link steps perform.
  – If you specify IPA(N0OBJECT) for the IPA Compile step, the compilation time for the IPA Compile step is comparable to that for a program compiled without IPA. If you specify IPA(OBJECT), compilation time for the IPA Compile step increases, but the benefit is that you can use the created object to build an executable module for debugging.
• If you compile with the IPA compiler option, the size of your object file is larger than it would be if you compiled without IPA. This is due to the extra information that the IPA Compile step stores in the object file for the IPA Link step.
• If you specify the OPT option on the IPA Link step, and your program is complex, you may require 256 MB or more of memory.

Restrictions

You should be aware of the following restrictions when using IPA:
• IPA is not supported in an MTF environment.
• IPA is supported in an SP C environment only when the main function is present.

Locale Support

The LOCALE compiler option has the following effects on IPA:
• It triggers the processing of #pragma filetag. This only applies to the IPA Compile step, as source code is only processed during this step.
• It indicates the code page to be used to generate the listings.
• It indicates the date and time formats to be used to generate the listings.

The LOCALE option only controls processing for the IPA step for which it is specified. The locale that you specify for the IPA Compile step does not determine the locale that the IPA Link step uses.
During the IPA Compile step, the compiler converts source code by using the code page identified by the LOCALE compiler option. As with non-IPA compilations, the conversion applies to identifiers, literals, and listings. The locale that you specify for the IPA Compile step becomes recorded in the IPA object file.

The LOCALE option specified for the IPA Link step is used:

- For the encoding of the message and listing text
- For date and time formatting in the Source File Map section of the listing
- In the text in the object comment string that records the date and time of IPA Link step processing

You should use the same code page for IPA Compile step processing for all of the source files in your program. This code page should match the code page of the run-time environment. Otherwise, your application may not run correctly. If the code page used for any compilation unit for the IPA Compile step does not match the code page used for the IPA Link step, the IPA Link step issues an informational message.

**Date and Time Stamps Within IPA Objects**

IPA Compile step processing determines the values specified by the date and time stamps. If you run the IPA Link step, the date and time stamps will reflect the compilation date and time from the IPA Compile step. They will not reflect the date and time when the IPA Link step generated the code.
This chapter discusses interprocess communication, including MVS Sockets for z/OS UNIX and the X/Open Transport Interface (XTI) for z/OS UNIX and the internetworking involved.

Many products today supply a socket interface. The three types of Application Programmer’s Interfaces (API) for the sockets which will be covered in this chapter are:

- **X/Open Socket**
- **Berkeley Socket**

If you are running with some other socket API, this material will not necessarily apply.

Your z/OS UNIX C/C++ application program can take advantage of sockets or XTI to communicate with a related application (server or client).

The X/Open Transport Interface (XTI) defines an independent transport service interface that allows multiple users to communicate at the transport level of the OSI reference model. More information can be found at the end of this chapter.

### Understanding z/OS UNIX Sockets and Internetworking

z/OS UNIX provides support for an enhanced version of an industry-accepted protocol for client/server communication known as sockets. The three types of Application Programmer’s Interfaces (API), for the sockets which will be covered in this chapter are:

- **X/Open Socket**: The API type of socket as defined by X/Open in XPG4.2.
- **Berkeley Socket**: The socket API that represents a migration path for programs coded under the HOT1120 and HOT1130 elements. It allows use of the BSD4.3 interface and function in the X/Open environment. Its purpose is to expedite the porting of existing BSD4.3 applications.

The z/OS UNIX socket API provides support for both UNIX domain sockets and Internet domain sockets. UNIX domain sockets, or local sockets, allow interprocess communication within MVS independent of TCP/IP. Local sockets behave like traditional UNIX-domain sockets and allow processes to communicate with one another on a single system. Internet sockets allow application programs to communicate with others in the network using TCP/IP.

This chapter provides some background information about z/OS UNIX sockets and about network communication in general. It is intended to provide an overview of the programming concepts associated with using z/OS UNIX sockets and network communication.

For information about using the socket API, see [z/OS C/C++ Run-Time Library Reference](#).
The Basics of Network Communication

This section takes a look at network communication from a very high level and defines some terms used throughout the book. For more detailed information on z/OS network communication and TCP/IP sockets, see z/OS Communications Server: IP Configuration Guide and z/OS Communications Server: IP Programmer’s Reference. For more detailed information on IPv6 network communication and AF_INET6 sockets, see z/OS Communications Server: IPv6 Network and Application Design Guide.

Network communication, or internetworking, defines a set of protocols (that is, rules and standards) that allow application programs to talk with each other without regard to the hardware and operating systems where they are run. Internetworking allows application programs to communicate independently of their physical network connections.

The internetworking technology called TCP/IP is named after its two main protocols: Transmission Control Protocol (TCP) and Internet Protocol (IP). To understand TCP/IP, you should be familiar with the following terms:

- **client**: A process that requests services on the network.
- **server**: A process that responds to a request for service from a client.
- **datagram**: The basic unit of information, consisting of one or more data packets, which are passed across an Internet at the transport level.
- **packet**: The unit or block of a data transaction between a computer and its network. A packet usually contains a network header, at least one high-level protocol header, and data blocks. Generally, the format of data blocks does not affect how packets are handled. Packets are the exchange medium used at the Internetwork layer to send data through the network.

Transport Protocols for Sockets

A **protocol** is a set of rules or standards that each host must follow to allow other hosts to receive and interpret messages sent to them. There are two general types of transport protocols:

- **A connectionless protocol** is a protocol that treats each datagram as independent from all others. Each datagram must contain all the information required for its delivery.

  An example of such a protocol is **User Datagram Protocol (UDP)**. UDP is a datagram-level protocol built directly on the IP layer and used for application-to-application programs on a TCP/IP host. UDP does not guarantee data delivery, and is therefore considered unreliable. Application programs that require reliable delivery of streams of data should use TCP.

- **A connection-oriented protocol** requires that hosts establish a logical connection with each other before communication can take place. This connection is sometimes called a **virtual circuit**, although the actual data flow uses a packet-switching network. A connection-oriented exchange includes three phases:
  1. Start the connection
  2. Transfer data
  3. End the connection

  An example of such a protocol is **Transmission Control Protocol (TCP)**. TCP provides a reliable vehicle for delivering packets between hosts on an Internet.
TCP breaks a stream of data into datagrams, sends each one individually using IP, and reassembles the datagrams at the destination node. If any datagrams are lost or damaged during transmission, TCP detects this and retransmits the missing datagrams. The data stream that is received is therefore a reliable copy of the original.

These types of protocols are illustrated in Figure 111 on page 445 and in Figure 112 on page 446.

What Is a Socket?

A *socket* can be thought of as an endpoint in a two-way communication channel. Socket routines create the communication channel, and the channel is used to send data between application programs either locally or over networks. Each socket within the network has a unique name associated with it called a *socket descriptor*—a fullword integer that designates a socket and allows application programs to refer to it when needed.

Using an electrical analogy, you can think of the communication channel as the electrical wire with its plug and think of the port, or socket, as the electrical socket or outlet, as shown in Figure 110.

![Figure 110. An Electrical Analogy Showing the Socket Concept](image)

This figure shows many application programs running on a client and many application programs on a server. When the client starts a socket call, a socket connection is made between an application on the client and an application on the server.

Another analogy used to describe socket communication is a telephone conversation. Dialing a phone number from your telephone is similar to starting a socket call. The telephone switching unit knows where to logically make the correct switch to complete the call at the remote location. During your telephone conversation, this connection is present and information is exchanged. After you hang up, the connection is broken and you must start it again. The client uses the `socket()` function call to start the logical switch mechanism to connect to the server.
As with file access, user processes ask the operating system to create a socket when one is needed. The system returns an integer, the socket descriptor (sd), that the application uses every time it wants to refer to that socket. The main difference between sockets and files is that the operating system binds file descriptors to a file or device when the `open()` call creates the file descriptor. With sockets, application programs can choose to either specify the destination each time they use the socket—for example, when sending datagrams—or to bind the destination address to the socket.

Sockets behave in some respects like UNIX files or devices, so they can be used with such traditional operations as `read()` or `write()`. For example, after two application programs create sockets and open a connection between them, one program can use `write()` to send a stream of data, and the other can use `read()` to receive it. Because each file or socket has a unique descriptor, the system knows exactly where to send and to receive the data.

You can wait on a socket using the following asynchronous I/O functions:
- `aio_read()` - Asynchronous read from a socket
- `aio_write()` - Asynchronous write to a socket
- `aio_cancel()` - Cancel an asynchronous I/O request
- `aio_suspend()` - Wait for an asynchronous I/O request
- `aio_error()` - Retrieve error status for an asynchronous I/O operation
- `aio_return()` - Retrieve return status for an asynchronous I/O operation

You can suspend the invoking thread until a specified asynchronous I/O event, timeout, or signal occurs. These functions are described in z/OS C/C++ Run-Time Library Reference.

### z/OS UNIX Socket Families

In z/OS UNIX, the following socket families are supported:
- UNIX Domain Sockets, known as local sockets, which are part of the UNIX Address Family (AF_UNIX)
- Internet Protocol Sockets, which are part of the Internet Address Family (AF_INET for IPv4 and AF_INET6 for IPv6)

AF_UNIX sockets provide communication between processes on a single system. This socket family supports two types of sockets—stream and datagram sockets. These socket types are described in the next section.

AF_INET and AF_INET6 sockets provide a means of communicating between application programs that are on different systems using the Transport Control Protocol provided by a TCP/IP product. This socket family supports both stream and datagram sockets. Each of these socket types is described in the next section.

### z/OS UNIX Socket Types

The z/OS UNIX socket API provides application programs with a network interface that hides the details of the physical network. The socket API supports both stream sockets and datagram sockets, each providing different services for application programs. Stream and datagram sockets interface to the transport layer protocols, UDP and TCP. You choose the appropriate interface for an application.

#### Stream Sockets

Stream sockets act like streams of information. There are no boundaries between data, so communicating processes must agree on their own mechanism to
distinguish information. Usually, the process sending information sends the length of the data, followed by the data itself. The process receiving information reads the length and then loops, accepting data until all of it has been transferred. Stream sockets guarantee delivery of the data in the order it was sent and without duplication. The stream socket interface defines a reliable connection-oriented service. Data is sent without errors or duplication and is received in the same order as it is sent. Flow control is built in, to avoid data overruns. No boundaries are imposed on the data; the data is considered to be a stream of bytes.

Stream sockets are more common, because the burden of transferring the data reliably is handled by the system rather than by the application.

**Datagram Sockets**
The *datagram socket* interface defines a connectionless service. Datagrams are sent as independent packets. The service provides no guarantees; data can be lost or duplicated, and datagrams can arrive out of order. The size of a datagram is limited to the size that can be sent in a single transaction. No disassembly and reassembly of packets is performed.

**Guidelines for Using Socket Types**
This section describes criteria to help you choose the appropriate socket type for an application program.

If you are communicating with an existing application program, you must use the same protocols as the existing application program. For example, if you communicate with an application that uses TCP, you must use stream sockets. For other application programs, you should consider the following factors:

- **Reliability.** Stream sockets provide the most reliable connection. Datagram sockets are unreliable, because packets can be discarded, corrupted, or duplicated during transmission. This may be acceptable if the application program does not require reliability, or if the application program implements the reliability on top of the sockets interface. The trade-off is the increased performance available with datagram sockets.
- **Performance.** The overhead associated with reliability, flow control, packet reassembly, and connection maintenance degrade the performance of stream sockets in comparison with datagram sockets.
- **Data transfer.** Datagram sockets impose a limit on the amount of data transferred in a single transaction. If you send less than 2048 bytes at a time, use datagram sockets. As the amount of data in a single transaction increases, use stream sockets.

**Addressing within Sockets**
The following sections describe the different ways to address within the socket API.

**Address Families**
Address families define different styles of addressing. All hosts in the same address family use the same scheme for addressing socket endpoints. z/OS UNIX supports three address families—AF_INET, AF_INET6, and AF_UNIX. The AF_INET and AF_INET6 address families define addressing in the IP domain. The AF_UNIX address family defines addressing in the z/OS UNIX domain. In the z/OS UNIX domain, address spaces can use the socket interface to communicate with other address spaces on the same host.

**Note:** In this case, the z/OS UNIX domain is used in much the same way as the UNIX domain on other UNIX-type systems.
Socket Address
A socket address is defined by the sockaddr structure in the sys/socket.h include file. The structure has three fields, as shown in the following example:

```c
struct sockaddr {
    unsigned char sa_len;
    unsigned char sa_family;
    char sa_data[14]; /* variable length data */
};
```

The sa_len field contains the length of the sa_data field. The sa_family field contains the address family. It is AF_INET or AF_INET6 for the Internet domain and AF_UNIX for the UNIX domain. The sa_data field is different for each address family. Each address family defines its own structure, which can be overlaid on the sockaddr structure. See "Addressing within the AF_INET Domain" and "Addressing within the AF_INET6 Domain" on page 441 for more information about the Internet domain, and "Addressing within the AF_UNIX Domain" on page 442 for more information about the UNIX domain.

Internet Addresses
Internet addresses represent a network interface. Every Internet address within an administered AF_INET domain must be unique. On the other hand, it is not necessary that every host have a unique Internet address; in fact, a host has as many Internet addresses as it has network interfaces.

Ports
A port is used to distinguish between different application programs using the same network interface. It is an additional qualifier used by the system software to get data to the correct application program. Physically, a port is a 16-bit integer. Some ports are reserved for particular application programs or protocols and are called well-known ports.

Network Byte Order
Ports and addresses are usually specified to calls using the network byte ordering convention. This convention is a method of sorting bytes under specific machine architectures. There are two common methods:

- **Big-endian** byte ordering places the most significant byte first. This method is used in IBM mainframe processors and Motorola microprocessors.
- **Little-endian** byte ordering places the least significant byte first. This method is used in Intel microprocessors.

Using network byte ordering for data exchanged between hosts allows hosts using different architectures to exchange address information. See references in figures Figure 114 on page 447, Figure 115 on page 448, and Figure 117 on page 449 for examples of using the htons() call to put ports into network byte order. For more information about network byte order, see z/OS C/C++ Run-Time Library Reference.

**Note:** The socket interface does not handle application program data byte ordering differences. Application program writers must handle byte order differences themselves.

Addressing within the AF_INET Domain
A socket address in the Internet address family comprises the following fields: the address family (AF_INET), an Internet address, the length of that Internet address,
a port, and a character array. The structure of the Internet socket address is defined by the following `sockaddr_in` structure, which is found in the `netinet/in.h` include file:

```c
struct in_addr {
    ip_addr_t s_addr;
}

struct sockaddr_in {
    unsigned char sin_len;
    unsigned char sin_family;
    unsigned short sin_port;
    struct in_addr sin_addr;
    unsigned char sin_zero[8];
};
```

The `sin_len` field is set to the length of the `sockaddr_in` structure.

The `sin_family` field is set to AF_INET. The `sin_port` field is the port used by the application program, in network byte order. The `sin_zero` field should be set to all zeros.

### Addressing within the AF_INET6 Domain

A socket address in the Internet address family comprises the following fields: the address family (AF_INET6), an Internet address, the length of that Internet address, a port, flow information, and scope information. The structure of the Internet socket address is defined by the following `sockaddr_in6` structure, which is found in the `netinet/in.h` include file:

```c
struct in6_addr {
    union {
        uint8_t _S6_u8[16];
        uint32_t _S6_u32[4];
    } _S6_un;
};
#define s6_addr _S6_un._S6_u8

struct sockaddr_in6 {
    uint8_t sin6_len;
    sa_family_t sin6_family;
    in_port_t sin6_port;
    uint32_t sin6_flowinfo;
    struct in6_addr sin6_addr;
    uint32_t sin6_scope_id;
};
```

The `sin6_len` field is set to the length of the `sockaddr_in6` structure.

The `sin6_family` field is set to AF_INET6.

The `sin6_port` field is the port used by the application program, in network byte order.

The `sin6_flowinfo` field is a 32–bit field that contains the traffic class and the flow label.

The `sin6_addr` field is a single `in6_addr` structure. This field holds one 128–bit IPv6 address stored in network byte order.

The `sin6_scope_id` field is a 32 bit integer that identifies a set of interfaces as appropriate for the scope of the address carried in the `sin6_addr` field.
IPv6 structures are exposed by defining the _OPEN_SYS_SOCK_IPV6 feature test macro.

Addressing within the AF_UNIX Domain

A socket address in the AF_UNIX address family is comprised of three fields: the address family (AF_UNIX), the length of the following pathname, and the pathname itself. The structure of an AF_UNIX socket address is defined as follows:

```c
struct sockaddr_un {
    unsigned char sun_len;
    unsigned char sun_family;
    char sun_path[108]; /* pathname */
};
```

This structure is defined in the `sockaddr_un` structure found in `sys/un.h` include file. The `sun_family` field is set to AF_UNIX; `sun_path` contains the null-terminated pathname; and `sun_len` contains the length of the `sockaddr_un` structure.

The Conversation

The client and server exchange data using a number of functions. They can send data using `send()`, `sendto()`, `sendmsg()`, `write()`, or `writev()`. They can receive data using `recv()`, `recvfrom()`, `recvmsg()`, `read()`, or `readv()`. The following is an example of the `send()` and `recv()` call:

```c
send(s, addr_of_data, len_of_data, 0);
recv(s, addr_of_buffer, len_of_buffer, 0);
```

The `send()` and `recv()` function calls specify the sockets on which to communicate, the address in memory of the buffer that contains, or will contain, the data (`addr_of_data`, `addr_of_buffer`), the size of this buffer (`len_of_data`, `len_of_buffer`), and a flag that tells how the data is to be sent. Using the flag 0 tells TCP/IP to transfer the data normally. The server uses the socket that is returned from the `accept()` call.

These functions return the amount of data that was either sent or received. Because stream sockets send and receive information in streams of data, it can take more than one call to `send()` or `recv()` to transfer all the data. It is up to the client and server to agree on some mechanism of signaling that all the data has been transferred.

When the conversation is over, both the client and server call the `close()` function to end the connection. The `close()` function also deallocates the socket, freeing its space in the table of connections. To end a connection with a specific client, the server closes the socket returned by `accept()`. If the server closes its original socket, it can no longer accept new connections, but it can still converse with the clients it is connected to. The following is an example of the `close()` call:

```c
close(s);
```

The Server Perspective

Before the server can accept any connections with clients, it must register itself with TCP/IP and “listen” for client requests on a specific port.

Allocation with socket()

The server must first allocate a socket. This socket provides an endpoint that clients connect to.
A socket is actually an index into a table of connections, so socket numbers are usually assigned in ascending order. In the C language, the programmer calls the `socket()` function to allocate a new socket, as shown in the following example:
```
s = socket(AF_INET, SOCK_STREAM, 0);
```

The `socket()` function requires the address family (`AF_INET`), the type of socket (`SOCK_STREAM`), and the particular networking protocol to use (when 0 is specified, the system automatically uses the appropriate protocol for the specified socket type). A new socket is allocated and returned.

**bind()**
At this point, an entry in the table of communications has been reserved for your application program. However, the socket has no port or IP address associated with it until you use the `bind()` function, which requires the following:

- The socket the server was just given
- The number of the port on which the server wishes to provide its service
- The IP address of the network connection on which the server is listening (to understand what is meant by “listening”, see “listen()”

In C language, the server puts the port number and IP address into a `sockaddr_in` structure, passing it and the socket to the `bind()` function. For example:
```
bind(s, (struct sockaddr *)&server, sizeof(struct sockaddr_in));
```

**listen()**
After the bind, the server has specified a particular IP address and port. Now it must notify the system that it intends to listen for connections on this socket. In C, the `listen()` function puts the socket into passive open mode and allocates a backlog queue of pending connections. In passive open mode, the socket is open for clients to contact. For example:
```
listen(s, backlog_number);
```

The server gives the socket on which it will be listening and the number of requests that can be queued (known as the `backlog_number`). If a connection request arrives before the server can process it, the request is queued until the server is ready.

**accept()**
Up to this point, the server has allocated a socket, bound the socket to an IP address and port, and issued a passive open. The next step is for the server actually to establish a connection with a client. The `accept()` call blocks the server until a connection request arrives, or, if there are connection requests in the backlog queue, until a connection is established with the first client in the queue. The following is an example of the `accept()` call:
```
client_sock = accept(s, &clientaddr, &addrlen);
```

The server passes its socket to the `accept()` call. When the connection is established, the `accept()` call returns a new socket representing the connection with the client. When the server wishes to communicate with the client or end the connection, it uses this new socket, `client_sock`. The original socket `s` is now ready to accept connections with other clients. The original socket is still allocated, bound, and opened passively. To accept another connection, the server calls `accept()` again. By repeatedly calling `accept()`, the server can establish almost any number of connections at once.

**select()**
The server is now ready to start handling requests on this port from any client with the server’s IP address and port number. Up to this point, it has been assumed that
the server will be handling only one socket. However, an application program is not limited to one socket. Typically, a server listens for clients on a particular socket but allocates a new socket for each client it handles. For maximum performance, a server should operate only on those sockets that are ready for communication. The select() call allows an application program to test for activity on a group of sockets.

**Note:** The select() function can also be used with other descriptors, such as file descriptors, pipes, or character special files.

To allow you to test any number of sockets with just a single call to select(), place the sockets to test into a bit set, passing the bit set to the select() call. A bit set is a string of bits where each possible member of the set is represented by a 0 or a 1. If the member’s bit is 0, the member is not in the set. If the member’s bit is 1, the member is in the set. Sockets are actually small integers. If socket 3 is a member of a bit set, then the bit that represents it is set to 1 (on).

In C, the functions to manipulate the bit sets are the following:

- **FD_SET** Sets the bit corresponding to a socket
- **FD_ISSET** Tests whether the bit corresponding to a socket is set or cleared
- **FD_ZERO** Clears the whole bit set
- **FD_CLR** Clears a bit within the bit set

To be active, a socket is ready for reading data or for writing data, or an exceptional condition may have occurred. Therefore, the server can specify three bit sets of sockets in its call to the select() function: one bit set for sockets on which to receive data; another for sockets on which to write data; and any sockets with exception conditions. The select() call tests each socket in each bit set for activity and returns only those sockets that are active.

A server that processes many clients at the same time can easily be written so that it processes only those clients that are ready for activity.

**The Client Perspective**

The client first issues the socket() function call to allocate a socket on which to communicate:

```
s = socket(AF_INET, SOCK_STREAM, 0);
```

To connect to the server, the client places the port number and the IP address of the server into a sockaddr_in structure. If the client does not know the server’s IP address, but does know the server’s host name, the gethostbyname() function or the getaddrinfo() function is called to translate the host name into its IP address. The client then calls connect(). The following is an example of the connect() call:

```
connect(s, (struct sockaddr *)&server, sizeof(struct sockaddr_in));
```

When the connection is established, the client uses its socket to communicate with the server.

**A Typical TCP Socket Session**

You can use TCP sockets for both passive (server) and active (client) processes. Whereas some functions are necessary for both types, some are role-specific. After you make a connection, it exists until one of the following has occurred:
• The socket is closed by client or server
• A shutdown is performed by client or server for both read and write
• The socket is _unconnected_ using a blank `sockaddr` structure with another `connect()` call to the socket

During the connection, data is either delivered or an error code is returned by TCP/IP.

See [Figure 111](#) for the general sequence of calls to be followed for most socket routines using TCP, or stream sockets.

![Figure 111. A Typical Stream Socket Session](#)

**A Typical UDP Socket Session**

User Datagram Protocol (UDP) socket processes, unlike TCP socket processes, are not clearly distinguished by server and client roles. The distinction is between connected and unconnected sockets. An unconnected socket can be used to communicate with any host; but a connected socket, because it has a dedicated destination, can send data to, and receive data from, only one host.
Both connected and unconnected sockets send their data over the network without verification. Consequently, after a packet has been accepted by the UDP interface, the arrival and integrity of the packet cannot be guaranteed.

See Figure 112 for the general sequence of calls to be followed for most socket routines using UDP, or datagram, sockets.

**A Typical Datagram Socket Session**

![Diagram of a typical datagram socket session](image)

- **Client**
  - Create a datagram socket `s` with the `socket()` call.
  - Bind socket `s` to a local address with the `bind()` call.
  - (Optional) Connect socket `s` using the `connect()` call to associate `s` with the server address.
  - Send and receive data on socket `s`, using the `sendto()` and `recvfrom()` calls, until all the data has been exchanged. Use the `send()` and `recv()` calls if `connect()` was called.
  - Close socket `s` and end the session with the `close()` call.

- **Server**
  - Create a datagram socket `s` with the `socket()` call.
  - Bind socket `s` to a local address with the `bind()` call.
  - (Optional) Connect socket `s` using the `connect()` call to associate `s` with the server address.
  - Send and receive data on socket `s`, using the `sendto()` and `recvfrom()` calls, until all the data has been exchanged. Use the `send()` and `recv()` calls if `connect()` was called.
  - Close socket `s` and end the session with the `close()` call.

*Figure 112. A Typical Datagram Socket Session*

**Locating the Server’s Port**

In the client/server model, the server provides a resource by listening for clients on a particular port. Such application programs as FTP, SMTP, and Telnet listen on a well-known port—a port assigned for use to a specific application program or protocol. However, for your own client/server application programs, you need a method of assigning port numbers to represent the services you intend to provide. An easy method of defining services and their ports is to enter them into the `/etc/services` file or the `tcpip.ETC.SERVICES` data set. In C, the programmer uses the `getservbyname()` function or `getaddinfo()` function to determine the port for a particular service. If the port number for a particular service changes, only the `/etc/services` file or the `tcpip.ETC.SERVICES` data set must be modified.

*Note:* TCP/IP is shipped with a `tcpip.ETC.SERVICES` file containing such well-known services as FTP, SMTP, and Telnet.
Network Application Example

The following example illustrates using socket functions in a network application program. The steps are written using many of the basic socket functions, C socket syntax, and conventions described in this book.

1. First, an application program must get a socket descriptor using the socket() call, as in the example listed in Figure 113. For a complete description, see z/OS C/C++ Run-Time Library Reference.

   ```c
   #include <sys/socket.h>
   ...
   int s;
   ...
   s = socket(AF_INET, SOCK_STREAM, 0);
   
   Figure 113. An Application Using socket()
   
   The code fragment in Figure 113 allocates a socket descriptor s in the Internet address family. The domain parameter is a constant that specifies the domain where the communication is taking place. A domain is the collection of application programs using the same addressing convention. z/OS UNIX supports three domains: AF_INET, AF_INET6, and AF_UNIX. The type parameter is a constant that specifies the type of socket, which can be SOCK_STREAM, or SOCK_DGRAM.

   The protocol parameter is a constant that specifies the protocol to use. For AF_INET, it can be set to IPPROTO_UDP for SOCK_DGRAM and IPPROTO_TCP for SOCK_STREAM. Passing 0 chooses the default protocol. If successful, the socket() call returns a positive integer socket descriptor. For AF_UNIX, the protocol parameter must be 0. These values are defined in the netinet/in.h include file.

2. After an application program has a socket descriptor, it can explicitly bind a unique address to the socket, as in the example listed in Figure 114. For a complete description, see z/OS C/C++ Run-Time Library Reference.

   ```c
   int bind(int s, struct sockaddr *name, int namelen);
   ...
   int rc;
   int s;
   struct sockaddr_in myname;

   /* clear the structure to be sure that the sin_zero field is clear */
   memset(&myname, 0, sizeof(myname));
   myname.sin_family = AF_INET;
   myname.sin_addr = inet_addr("129.5.24.1");
   /* specific interface */
   myname.sin_port = htons(1024);
   ...
   rc = bind(s, (struct sockaddr *)&myname, sizeof(myname));
   
   Figure 114. An Application Using bind()
   
   This example binds socket descriptor s to the address 129.5.24.1 and port 1024 in the Internet domain. Servers must bind to an address and port to become accessible to the network. The example in Figure 114 shows two useful utility routines:
inet_addr() takes an IPv4 Internet address in dotted-decimal form and returns it in network byte order. Note that the inet_pton() function can take either an IPv4 or IPv6 Internet address in its standard text presentation form and return it in its numeric binary form. For a complete description, see z/OS C/C++ Run-Time Library Reference.

htons() takes a port number in host byte order and returns the port in network byte order. For a complete description, see z/OS C/C++ Run-Time Library Reference.

Figure 115 shows another example of the bind() call. It uses the utility routine gethostbyname() to find the Internet address of the host, rather than using inet_addr() with a specific address.

```c
int bind(int s, struct sockaddr_in name, int namelen);
...;
int rc;
int s;
char *hostname = "myhost";
struct sockaddr_in myname;
struct hostent *hp;

hp = gethostbyname(hostname);

/*clear the structure to be sure that
the sin_zero field is clear*/
memset(&myname,0,sizeof(myname));
myname.sin_family = AF_INET;
myname.sin_addr.s_addr = *((ip_addr_t *)hp->h_addr);
myname.sin_port = htons(1024);
...;
rc = bind(s,(struct sockaddr *)&myname, sizeof(myname));
```

Figure 115. A bind() Function Using gethostbyname()

3. After binding to a socket, a server that uses stream sockets must indicate its readiness to accept connections from clients. The server does this with the listen() call, as illustrated in the example in Figure 116.

```c
int listen(int s, int backlog);
...
int s;
int rc;
...;
rc = listen(s, 5);
```

Figure 116. An Application Using listen()

The listen() call tells the TCP/IP address space that the server is ready to begin accepting connections, and that a maximum of five connection requests can be queued for the server. Additional requests are ignored. For a complete description, see z/OS C/C++ Run-Time Library Reference.

4. Clients using stream sockets begin a connection request by calling connect(), as shown in the following example.
The `connect()` call attempts to connect socket descriptor `s` to the server with an address `servername`. This could be the server that was used in the previous `bind()` example. The caller optionally blocks, until the connection is accepted by the server. After a successful return, the socket descriptor `s` is associated with the connection to the server. For a complete description, see [z/OS C/C++ Run-Time Library Reference](#).

5. Servers using stream sockets accept a connection request with the `accept()` call, as shown in the example listed in Figure 118.

```c
int accept(int s, struct sockaddr *addr, int *addrlen);
```

If connection requests are not pending on socket descriptor `s`, the `accept()` call optionally blocks the server. When a connection request is accepted on socket descriptor `s`, the name of the client and length of the client name are returned, along with a new socket descriptor. The new socket descriptor is associated with the client that began the connection, and `s` is again available to accept new connections. For a complete description, see [z/OS C/C++ Run-Time Library Reference](#).

6. Clients and servers have many calls from which to choose for data transfer. The `read()` and `write()`, `readv()` and `writev()`, and `send()` and `recv()` calls can be used only on sockets that are in the connected state. The `sendto()` and `recvfrom()` calls, and `sendmsg()` and `recvmsg()` calls can be used at any time on datagram sockets. The example listed in Figure 119 on page 450 illustrates the use of `send()` and `recv()`.

---

**Figure 117. An Application Using connect()**

The `connect()` call attempts to connect socket descriptor `s` to the server with an address `servername`. This could be the server that was used in the previous `bind()` example. The caller optionally blocks, until the connection is accepted by the server. After a successful return, the socket descriptor `s` is associated with the connection to the server. For a complete description, see [z/OS C/C++ Run-Time Library Reference](#).

```c
int connect(int s, struct sockaddr *name, int namelen);
```

```c
int s;
struct sockaddr_in servername;
int rc;
:
memset(&servername, 0,sizeof(servername));
servername.sin_family = AF_INET;
servername.sin_addr = htonl("129.5.24.1");
servername.sin_port = htons(1024);
:
rc = connect(s, (struct sockaddr *) &servername, sizeof(servername));
```

**Figure 118. An Application Using accept()**

If connection requests are not pending on socket descriptor `s`, the `accept()` call optionally blocks the server. When a connection request is accepted on socket descriptor `s`, the name of the client and length of the client name are returned, along with a new socket descriptor. The new socket descriptor is associated with the client that began the connection, and `s` is again available to accept new connections. For a complete description, see [z/OS C/C++ Run-Time Library Reference](#).

```c
int accept(int s, struct sockaddr *addr, int *addrlen);
```

```c
int accept(int s, struct sockaddr *addr, int *addrlen);
int clientsocket;
int s;
struct sockaddr clientaddress;
int addrlen;
:
addrlen = sizeof(clientaddress);
:
clientsocket = accept(s, &clientaddress, &addrlen);
```
The example in Figure 119 shows an application program sending data on a connected socket and receiving data in response. The flags field can be used to specify additional options to `send()` or `recv()`, such as sending out-of-band data. For more information see z/OS C/C++ Run-Time Library Reference.

7. If the socket is not in a connected state, additional address information must be passed to `sendto()` and can be optionally returned from `recvfrom()`. An example of the use of the `sendto()` and `recvfrom()` calls is listed in Figure 120.

8. The `writev()`, `readv()`, `sendmsg()`, and `recvmsg()` calls provide the additional features of scatter and gather data—two related operations where data is

```c
int send(int socket, char *buf, int buflen, int flags);
int recv(int socket, char *buf, int buflen, int flags);

int bytes_sent;
int bytes_received;
char data_sent[256];
char data_received[256];
int s;

bytes_sent = send(s, data_sent, sizeof(data_sent), 0);

bytes_received = recv(s, data_received, sizeof(data_received), 0);
```

Figure 119. An Application Using `send()` and `recv()`

The example in Figure 119 shows an application program sending data on a connected socket and receiving data in response. The flags field can be used to specify additional options to `send()` or `recv()`, such as sending out-of-band data. For more information see z/OS C/C++ Run-Time Library Reference.

```c
int sendto(int socket, char *buf, int buflen, int flags, struct sockaddr *addr, int addrlen);
int recvfrom(int socket, char *buf, int buflen, int flags, struct sockaddr *addr, int *addrlen);

int bytes_sent;
int bytes_received;
char data_sent[256];
char data_received[256];
struct sockaddr_in to;
struct sockaddr from;
int addrlen;
int s;

memset(&to, 0, sizeof(to));
to.sin_family = AF_INET;
to.sin_addr = inet_addr("129.5.24.1");
to.sin_port = htons(1024);

bytes_sent = sendto(s, data_sent, sizeof(data_sent), 0, &to, sizeof(to));

addrlen = sizeof(from); /* must be initialized */
bytes_received = recvfrom(s, data_received, sizeof(data_received), 0, &from, &addrlen);
```

Figure 120. An Application Using `sendto()` and `recvfrom()`

The `sendto()` and `recvfrom()` calls take additional parameters that allow the caller to specify the recipient of the data or to be notified of the sender of the data. For more information see z/OS C/C++ Run-Time Library Reference. Usually, `sendto()` and `recvfrom()` are used for datagram sockets, and `send()` and `recv()` are used for stream sockets.

8. The `writev()`, `readv()`, `sendmsg()`, and `recvmsg()` calls provide the additional features of scatter and gather data—two related operations where data is
received and stored in multiple buffers (scatter data), and then taken from multiple buffers and transmitted (gather data). Scattered data can reside in multiple data buffers. The `writev()` and `sendmsg()` calls gather the scattered data and send it. The `readv()` and `recvmsg()` calls receive data and scatter it into multiple buffers.

9. Applications can handle multiple descriptors. In such situations, use the `select()` call to determine the descriptors that have data to be read, those that are ready for data to be written, and those that have pending exceptional conditions. An example of how the `select()` call is used is listed in Figure 121.

```c
fd_set readsocks;
fd_set writesocks;
fd_set exceptsocks;
struct timeval timeout;
int number_of_sockets;
int number_found;
...
/* number_of_sockets previously set to the socket number of largest
 * integer value.
 * Clear masks out.
 */
FD_ZERO(&readsocks);; FD_ZERO(&writesocks); FD_ZERO(&exceptsocks);
/* Set masks for socket s only */
FD_SET(s, &readsocks)
FD_SET(s, &writesocks)
FD_SET(s, &exceptsocks)
;
/* go into select wait for 5 minutes waiting for socket s to become
ready or the timer has popped*/
rc = select(number_of_sockets+1,
   &readsocks, &writesocks, &exceptsocks, &timeout);
;
/* Check rc for condition set upon exiting select */
number_found = select(number_of_sockets,
   &readsocks, &writesocks, &exceptsocks, &timeout);
```

Figure 121. An Application Using select()

In this example, the application program uses bit sets to indicate that the sockets are being tested for certain conditions and also indicates a timeout. If the timeout parameter is NULL, the `select()` call blocks until a socket becomes ready. If the timeout parameter is nonzero, `select()` waits up to this amount of time for at least one socket to become ready on the indicated conditions. This is useful for application programs servicing multiple connections that cannot afford to block, waiting for data on one connection. For a complete description, see z/OS C/C++ Run-Time Library Reference.

10. In addition to `select()`, application programs can use the `ioctl()` or `fcntl()` calls to help perform asynchronous (nonblocking) socket operations. An example of the use of the `ioctl()` call is listed in Figure 122 on page 452.
This example causes the socket descriptor s to be placed into nonblocking mode. When this socket is passed as a parameter to calls that would block, such as `recv()` when data is not present, it causes the call to return with an error code, and the global errno value is set to EWOULDBLOCK. Setting the mode of the socket to be nonblocking allows an application program to continue processing without becoming blocked. For a complete description, see z/OS C/C++ Run-Time Library Reference.

11. A socket descriptor, s, is deallocated with the `close()` call. (For a complete description, see z/OS C/C++ Run-Time Library Reference. An example of `close()` is shown next.

```c
int close(int s);
...
int rc; int s;
rc = close(s);
```

Figure 123. An Application Using close()

Using Common INET

With Common INET (CINET), you have the capability to define up to 32 AF_INET or dual AF_INET/AF_INET6 transport providers or stacks. The stacks can all be active at the same time. The information for modifying BPXPRMxx and bringing up Common INET is in z/OS UNIX System Services Planning.

For a server that you want to be able to listen to all of the available stacks at the same time, specify INADDR_ANY and it will be listening to all at once. Note that for an IPv6 server, IN6ADDR_ANY can be specified allowing the server to listen for IPv4 and IPv6 connections from all stacks.

The z/OS UNIX Common INET layer performs a multiplexing/demultiplexing function when more than one stack is activated under z/OS UNIX. Each stack has its own home IP addresses and when a program binds to a specific IP address that socket becomes associated with the one stack that is that IP address. When a program binds to NADDR_ANY (0.0.0.0) or IN6ADDR_ANY (::), the socket remains available to all the stacks.
There are three ways that an INADDR_ANY or IN6ADDR_ANY program can associate itself with a single stack:

- Call setibmopt(IBMTCP_IMAGE) - This sets a process so all future socket() calls create sockets with only the one specified stack.
- The _BPXK_SETIBMOPT_TRANSPORT environment variable can be used in the PARM= parameter of an MVS started proc to effectively issue a SETIBMOPT outside of the program.
- Call ioctl(SIOCSSETRTTD) - This associates an existing socket with the one specified stack, removing the others.

Also, you should be able to set up things so gethostbyname() or getaddrinfo() returns the home IP address of the local TCP/IP you are interested. With that, you can issue a specific bind() to that IP address. This may not be useful though, if that stack has multiple IP addresses and you really want to use INADDR_ANY to service all of them. Applications can bind to IN6ADDR_ANY to service both IPv4 and IPv6 clients when TCP/IP is enabled for IPv6.

### Compiling and Binding

This section describes how to bind, load, and run z/OS C programs containing z/OS UNIX sockets. This information is specific to the z/OS UNIX application program interface and assumes that you are familiar with the information on compiling and binding z/OS UNIX application programs in [z/OS C/C++ Programming Guide](#) and [z/OS Language Environment Programming Guide](#). C++ programs can also use z/OS UNIX sockets, but C++ programs cannot use Berkley Sockets, they must always use X/Open Sockets.

You compile and bind your sockets application program in the same way as for any other C language program. The process is shown conceptually in Figure 124 on page 454. You must make sure that the z/OS UNIX socket application programs have access to the files they need to compile and bind.
As shown, whether an application program’s I/O request is targeted at the network (TCP/IP) or at a file, the z/OS UNIX logical file system (LFS) will route the request to the appropriate physical file system (PFS).

If your C language statements contain information, such as sequence numbers, which are not part of the input for the z/OS C compiler, you must include the following pragma directive in your program:

```c
#pragma margins(1,72)
```

**Note:** In order to use AF_INET sockets, you must have release 3.1 or a later level of TCP/IP installed on your system. In order to use AF_INET6 sockets, you must have release z/OS V1R4 or later of TCP/IP installed on your system.

### Using TCP/IP APIs

If you will be using the TCP/IP socket API, also called non-Berkeley sockets, you will need to read and understand this section.

When a C/C++ application program running under z/OS UNIX needs to communicate with another program that is running simultaneously, it needs to...
exploit, from within itself, both z/OS UNIX POSIX.1 and one or more of the following application programming interfaces (APIs) provided with the IBM product TCP/IP:

- Socket APIs
  - C sockets
  - Inter-User Communication Vehicle (IUCV) sockets
- X Window System 7 interface
- remote procedure call (RPC)

With the exception of described restrictions, you can code z/OS UNIX C/C++ application programs to take advantage of the documented APIs available as part of the Communications Server IP.

z/OS UNIX application programs can use socket API calls from the TCP/IP product to access HFS files or MVS data sets, communicate with other systems running TCP/IP, or establish communication with and request services from a workstation system acting as an X Windows server.

Note: For HFS file access to TCP/IP, the TCP/IP socket API calls must be used instead of the POSIX file access functions to preserve the uniqueness of file descriptors in the hierarchical file system (HFS).

Before you attempt to code your application program to use TCP/IP APIs, you should understand the X Windows protocol running on the workstations that will be used as application clients. You will also need to know how to invoke X Windows to create a connection to the server on the workstation or z/OS system.

Restrictions for Using MVS TCP/IP API with z/OS UNIX

The restrictions can be grouped into categories:

- **Header Files**
  - Header file conflicts between TCP/IP and z/OS C/C++. z/OS C/C++ and TCP/IP have header files with the same name and overlapping function. For example, both have a types.h file. If you use TCP/IP API functions in your application but the z/OS C/C++ header file is searched for and used, the TCP/IP function does not work as intended.

You can circumvent this problem by developing your application program with separate compilation source files for TCP/IP function and normal z/OS C/C++ function. You can then compile the TCP/IP source files separately from the normal z/OS C/C++ source files. Use the c89 -I option to point to the MVS data sets to search for the TCP/IP header files. Finally, you can bind all the application object files together to produce the application executable file. For the bind step, use the c89 -l option to point to the correct TCP/IP libraries on MVS. For example:

```
c89 -I "//'tcpip.sezacmac" pgm.c -l "//'tcpip.sezarnt1" ...
```

- **TCP/IP Socket API.** Both z/OS UNIX POSIX.1-defined support and the TCP/IP for z/OS socket API use a small subset of common function calls that cannot be resolved correctly between them:
  - close()
  - fcntl()
  - read()
  - write()
Use of these calls should be reserved for one or the other, but not both, of these programming interfaces. For example, if an application program is written to use the open(), close(), read(), and write() functions for z/OS TCP/IP socket communication, it cannot use them for HFS file access. z/OS C/C++ stream I/O functions (fopen(), fclose(), fread(), and fwrite()) must be used for HFS file access. See z/OS Communications Server: IP Application Programming Interface Guide for more information.

- **Creating Child Processes.** Generally speaking, an application program cannot have a parent process open resources—in this case sockets—and then support those resources for a child process created through a fork() function or in a process following use of an exec function. The new child process does not inherit sockets from the parent process if forked. If the child process needs sockets, it must request TCP/IP for z/OS socket support independently of the parent process. In fact, if a child process is to be forked by an application program using TCP/IP sockets under z/OS UNIX, all MVS resources to be opened should be opened by the child process rather than by the parent process.

- **TCP/IP Configuration File Access.** An application executable file that uses TCP/IP APIs and was bound with the c89 utility cannot locate the necessary TCP/IP configuration files, because they reside in MVS sequential data sets rather than in HFS files.

To circumvent this problem, have the system programmer copy the TCP/IP configuration data sets into the HFS root directory exactly as shown:

```
OPUT 'tcpip.tcpip.data' 'etc/resolv.conf' text
```

Copy the address of the name server, the name, and the domain name from tcpip.HOST.LOCAL to etc/hosts. You should not copy the entire file directly because you only need the address and name. The entry in the etc/hosts file follows the BSD format. The case of the filenames and the use of the quote characters as part of the name are significant. Use the TSO/E OPUT command to copy the MVS sequential data sets to the HFS root directory. (Placing files in the root file system requires superuser authority.)

- **Program Reentrancy.** The TCP/IP sockets and X Windows reentrant libraries must have a special C370LIB-directory member created for them before an application program using TCP/IP functions can be bound. The system administrator must run the C370LIB DIR function against the reentrant libraries to create it. The system administrator must do this once per library for an MVS system.

Specify the TCP/IP libraries to search on the c89 utility when binding the application program. For example:

```
c89 -I"//tcpip.sezacmac" pgm.c -I"//tcpip.sezarnt1" ...
```

For information on C370LIB, see z/OS C/C++ User’s Guide.

### Using z/OS UNIX Sockets

The following list describes the files that each z/OS UNIX socket application program must have access to in order to compile:

- **List of z/OS C include files:**

  In an MVS PDS or in the HFS directory

  - CEE.SCEEH.H /usr/include
  - CEE.SCEEH.ARPA.H /usr/include/arpa
  - CEE.SCEEH.NET.H /usr/include/net
  - CEE.SCEEH.NETINET.H /usr/include/netinet
  - CEE.SCEEH.SYS.H /usr/include/sys
— which contains all the C include files required by the z/OS UNIX socket API, as well as the z/OS C include files.

**Note:** The data set prefix for each of the previous files must match the name used at your installation. CEE is the default for z/OS Language Environment.

For **Berkeley SOCKETS** or **X/OPEN SOCKETS**, all you need are the z/OS C include files.

**Note:** The data set prefix for each of these files must match the name used at your installation. CEE is the default for the z/OS C library.

You must compile your application program using all include files in order to access the entire z/OS UNIX socket API. To compile a program written using a particular API, you must include certain files specific to that API even though your program may not require all of them.

See *z/OS C/C++ Run-Time Library Reference*. It lists the header files that must be included for each type API. They may be different for **Berkeley Sockets** and **X/Open Sockets**.

The following list describes the files that each z/OS UNIX socket application program must have access to in order to bind:

- CEE.SCEELKED contains stub routines in the link library that are used to resolve external references to z/OS C and z/OS UNIX socket APIs.
- CEE.SCEELKEX contains LONGNAME stub routine object modules for a large portion of the Language Environment function library, including the z/OS C and z/OS UNIX socket APIs. When you IPA Link your application program, place the SCEELKEX library ahead of the SCEELKED Load Module library in the search order. This preserves long run-time function names in the object module and listings generated by IPA Link. When you bind your application program, place the SCEELKEX library ahead of the SCEELKED Load Module library in the search order. This preserves long run-time function names in the executable module and listings generated by the binder.
- CEE.SCEERUN contains the z/OS C and z/OS UNIX socket run-time libraries.

**Compiling under MVS Batch for Berkeley Sockets**

You can use several methods to compile, bind, and run your sockets program. This section describes one way to compile and bind your C source program, under MVS batch, using the IBM-supplied EDCCB cataloged procedure.

**Note:** If you are planning on developing your application as a C++ application and use sockets, you must use X/Open Sockets for your application. See section “Compiling under MVS Batch for X/Open Sockets” on page 458 for more information.

**Sample Cataloged Procedure Additions and Changes**

The following steps describe how to compile, and bind your program. For more information about the z/OS C/C++ cataloged procedures refer to the *z/OS C/C++ User’s Guide*.

You must make changes to the cataloged procedure, which is supplied with z/OS C/C++ Compiler. After you select the procedure you want to use from those...
available in the C/C++ supplied data set, CBC.SCCNPRC, you modify it. For example, if you choose EDCC then you modify it as follows:

1. Change the CPARM parameters to:

   ```
   CPARM="DEF(MVS,_OE_SOCKETS,_POSIX1_SOURCE=1),RENT,LO",
   ```

   RENT is the reentrant option and L0 is the long name option. You must specify these options to use POSIX functions `read()`, `write()`, `fcntl()`, and `close()` that are all included in z/OS C.

   You must specify the feature test macro, _POSIX1_SOURCE=1 to access the `read()`, `write()`, `fcntl()`, and `close()` functions in the z/OS C include files. Or, if you choose to access all z/OS UNIX POSIX functions supported by z/OS C, you can specify the _OPEN_SYS feature test macro. The _OE_Sockets feature test macro exposes the socket-related definitions in all of the include files. For information on binding C code compiled with the RENT and L0NGNAME options, see z/OS C/C++ User’s Guide.

2. To run your program under TSO/E, type the following:

   ```
   CALL 'USER.MYPROG.LOAD(PROGRAM1)' 'POSIX(ON)/'
   ```

   This loads the run-time library from CEE.SCEERUN and/or SCEERUN2.

   To use the POSIX z/OS C functions, you must either specify the run-time option POSIX(ON), or include the following statement in your C source program:

   ```
   #pragma runopts(POSIX(ON))
   ```

   The z/OS C/C++ Run-Time Library Reference identifies the POSIX z/OS C functions, in the standards information at the beginning of each function description.

### Compiling under MVS Batch with X Windows for Berkeley Sockets

If you are using z/OS UNIX sockets with the latest announced release level of TCP/IP X Windows, and compiling and binding under MVS batch, you must do the following:

- Bind your application program with the latest announced release level of TCP/IP X Windows libraries that are enabled for use with z/OS UNIX sockets.

For a complete discussion of compiling and binding z/OS UNIX sockets with TCP/IP, see z/OS Communications Server: IP Programmer’s Reference.

#### Compiling Using the c89 Utility for Berkeley Sockets

If you want to use the c89 utility to compile and bind your program, you must use the following define options on the c89 command:

```
-D MVS
-D _OE_SOCKETS
```

For more information about compiling and binding, see z/OS C/C++ User’s Guide.

#### Compiling Using c89 with X Windows

See z/OS Communications Server: IP Programmer’s Reference for a complete discussion of compiling and binding with X Windows.

### Compiling under MVS Batch for X/Open Sockets

You can use several methods to compile, bind, and run your sockets program. This section describes one way to compile and link-edit your C source program, under MVS batch, using the IBM-supplied EDCCB cataloged procedure.
Sample Cataloged Procedure Additions and Changes
The following steps describe how to compile, bind, and run your program. For more information about the z/OS C/C++ cataloged procedures refer to the z/OS C/C++ User’s Guide.

You must make changes to the cataloged procedure, which is supplied with z/OS C/C++ Compiler. After you select the procedure you want to use from those available in the C/C++ supplied data set, CBC.SCCNPRC, you modify it. For example, if you choose EDCCB then you modify it as follows:

1. Change the CPARM parameters to:

   CPARM='DEF(MVS,_XOPEN_SOURCE_EXTENDED=1,_POSIX1_SOURCE=1),
   RENT,LO',

   RENT is the reentrant option and LO is the long name option. You must specify these options to use POSIX functions read(), write(), fcntl(), and close() that are all included in z/OS C.

   You must specify the feature test macro, _POSIX1_SOURCE=1 to access the read(), write(), fcntl(), and close() functions in the z/OS C include files. Or, if you choose to access all z/OS UNIX POSIX functions supported by z/OS C, you can specify the _OPEN_SYS feature test macro. The _XOPEN_SOURCE_EXTENDED feature test macro exposes the socket-related definitions in all of the include files.

   Note: Because you are now required to compile with the RENT and LONGNAME options, you must bind your sockets application with the z/OS binder.

2. To run your program under TSO/E, type the following:

   CALL 'USER.MYPROG.LOAD(PROGRAM1)
   POSIX(ON)/'

   To use the POSIX z/OS C functions, you must either specify the run-time option POSIX(ON), or include the following statement in your C source program:

   #pragma runopts(POSIX(ON))

Using API Data Sets and Files for Sockets

- CEE.SCEELKED contains stub routines in the link library that are used to resolve external references to z/OS C and z/OS UNIX socket APIs.

- CEE.SCEELKEX contains LONGNAME stub routine object modules for a large portion of the Language Environment function library, including the z/OS C and z/OS UNIX socket APIs. When you IPA Link or bind your application program, place the SCEELKEX library ahead of the SCEELKED Load Module library in the search order. This preserves long run-time function names in the object module and listings generated by IPA Link or the binder.

- CEE.SCEERUN contains the z/OS C and z/OS UNIX socket run-time libraries.

   Notes:

   1. The data set prefix for each the previous files must match the name used at your installation. CEE is the default for z/OS Language Environment.

   2. Applications developed for Open Sockets can continue to use the linkage editor but cannot be compiled.
Understanding The X/Open Transport Interface (XTI)

The X/Open Transport Interface (XTI) specification defines an independent transport-service interface that allows multiple users to communicate at the transport level of the OSI reference model. Transport-layer protocols support the following characteristics:

- connection establishment
- state change support
- event handling
- data transfer
- option manipulation

Although all transport-layer protocols support these characteristics, they vary in their level of support and their interpretation of format.

In the next section we will discuss the TCP transport provider, since it is the only one currently supported.

Transport endpoints

A transport endpoint specifies a communication path between a transport user and a specific transport provider, which is identified by a local file descriptor (fd). When a user opens a transport endpoint, a local file descriptor fd is returned which identifies the endpoint. A transport provider is defined to be the transport protocol that provides the services of the transport layer. All requests to the transport provider must pass through a transport endpoint. The file descriptor fd is returned by the function `t_open()` and is used as an argument to the subsequent functions to identify the transport endpoint. A transport endpoint can support only one established transport connection at a time.

To be active, a transport endpoint must have a transport address associated with it by the `t_bind()` function. A transport connection is characterized by the association of two active endpoints, made by using the transport connection establishment functions `t_listen()`, `t_accept()`, `t_connect()`, and `t_rcvconnect()`.

Transport providers for X/Open Transport Interface

The transport layer may comprise one or more transport providers at the same time. The identifier parameter of the transport provider passed to the `t_open()` function determines the required transport provider. To keep the applications portable, the identifier parameter of the transport provider should not be hard-coded into the application source code.

Currently, the only valid value for the `identifier` parameter for the `t_open()` function is `/dev/tcp`, indicating the TCP transport provider. Even though no device with this pathname actually exists, the library uses this value to determine which transport provider to use.

General Restrictions for z/OS UNIX

The following restrictions apply when you use XTI under z/OS UNIX.

- If an endpoint is being shared among multiple processes, events such as, `T_LISTEN`, `T_DATA`, and `T_EXDATA`, can be consumed by another process in the time between calls to `t_look()` and `t_rcv()` or `t_accept()`. In order to avoid processes not being aware of events occurring on endpoints, you should provide explicit synchronization mechanisms between processes.
• If an endpoint is shared:
  – The process that issues the \texttt{t\_listen()} should also issue for the pending connection \texttt{t\_accept()}.  
  – If any other process accesses the endpoint in the time between the listen and the accept, the behavior is undefined. In order to avoid this, you should provide explicit synchronization between processes.

• If a process dies while an endpoint it was accessing is in T\_INCON state, it is impossible for any other sharing endpoints to bring it out of that state.

• If access to endpoints is shared, the participating processes are responsible for serialization of access to the endpoints. If no synchronization is performed, the behavior is undefined.

• Functions are thread-safed; therefore, no two threads in a process can manipulate an endpoint at the same time. Serialization of access to endpoints beyond this level is the responsibility of the threads sharing the endpoint.
Chapter 31. Interprocess Communication Using z/OS UNIX

z/OS UNIX offers software vendors and customers several ways for programming processes to communicate:

- Message queues
- Semaphores
- Shared memory
- Memory mapping
- Issuing TSO commands from a shell

These forms of interprocess communication extend the possibilities provided by the simpler forms of communication: pipes, named pipes or FIFOs, signals, and sockets. Like these forms, message queues, semaphores, and shared memory are used for communication between processes. (Sockets are the most common form of interprocess communication across different systems.) For more information on these communication forms, see z/OS UNIX System Services Planning.

Message Queues

XPG4 provides a set of C functions that allow processes to communicate through one or more message queues in an operating system’s kernel. A process can create, read from, or write to a message queue. Each message is identified with a “type” number, a length value, and data (if the length is greater than 0).

A message can be read from a queue based on its type rather than on its order of arrival. Multiple processes can share the same queue. For example, a server process can handle messages from a number of client processes and associate a particular message type with a particular client process. Or the message type can be used to assign a priority in which a message should be dequeued and handled.

A common client/server implementation on the same system uses two message queues for communication between client and server. An inbound message queue allows group write access and limits read access to the server. An outbound message queue allows universal read access and limits write access to the server. This implementation allows users to place invalid messages on the inbound queue or remove messages belonging to another process from the outbound queue. To solve this problem, you can use two new z/OS message queue types, `ipc_SndTypePID` and `ipc_RcvTypePID` to enforce source and destination process identification.

Create the inbound queue to the server with `ipc_SndTypePID` and the outbound queue from the server with `ipc_RcvTypePID`. This arrangement guarantees that the server knows the process ID of the client, and that the client is the only process that can receive the server’s returned message. The server can also issue `msgrcv()` with TYPE=0 to see if any messages belong to process IDs that have gone away. Security checks on clients are not needed, since clients are unable to receive messages intended for another process.

The `ipc_PL0` constants provide possible message queue performance improvements based on workload. For information on the `ipc_PL0` constants, see the `msgget()` function in the z/OS C/C++ Run-Time Library Reference.
Semaphores

Semaphores, unlike message queues and pipes, are not used for exchanging data, but as a means of synchronizing operations among processes. A semaphore value is stored in the kernel and then set, read, and reset by sharing processes according to some defined scheme. A semaphore is created or an existing one is located with the semget() function. Typical uses include resource counting, file locking, and the serialization of shared memory.

A semaphore can have a single value or a set of values; each value can be binary (0 or 1) or a larger value, depending on the implementation. For each value in a set, the kernel keeps track of the process ID that did the last operation on that value, the number of processes waiting for the value to increase, and the number of processes waiting for the value to become 0.

If you define a semaphore set without any special flags, semop() processing obtains a kernel latch to serialize the semaphore set for each semop() or semctl() call. The more semaphores you define in the semaphore set, the higher the probability that you will experience contention on the semaphore latch. One alternative is to define multiple semaphore sets with fewer semaphores in each set. To get the least amount of latch contention, define a single semaphore in each semaphore set.

z/OS has added the __IPC_BINSEM option to semget(). The __IPC_BINSEM option provides significant performance improvement on semop() processing. __IPC_BINSEM can only be specified if you use the semaphore as a binary semaphore and do not specify UNDO on any semop() calls. __IPC_BINSEM also allows semop() to use special hardware instructions to further reduce contention. With __IPC_BINSEM, you can define many semaphores in a semaphore set without impacting performance.

Shared Memory

Shared memory provides an efficient way for multiple processes to share data (for example, control information that all processes require access to). Commonly, the processes use semaphores to take turns getting access to the shared memory. For example, a server process can use a semaphore to lock a shared memory area, then update the area with new control information, use a semaphore to unlock the shared memory area, and then notify sharing processes. Each client process sharing the information can then use a semaphore to lock the area, read it, and then unlock it again for access by other sharing processes.

Processes can also use shared mutexes and shared read-write locks to communicate. For more information on mutexes and read-write locks see "Synchronization Primitives" on page 330.

Memory Mapping

In z/OS, a programmer can arrange to transparently map into a hierarchical file system (HFS) file process storage.

The use of memory mapping can reduce the number of disk accesses required when randomly accessing a file.

The related mmap(), mprotect(), msync(), and munmap() functions that provide memory mapping are part of the X/Open CAE Specification.
TSO Commands from a Shell

In z/OS UNIX, users of the z/OS UNIX shells can issue TSO/E commands. The user simply enters the shell command `tso`, followed by a TSO command string. The user can specify whether the TSO command is to be run through the shell (in which case the output will be displayed on the screen) or through a TSO environment (in which case the command output will be written to the defined standard output). For more information about running the command through the shell or through a TSO environment, see [z/OS UNIX System Services Command Reference](z/OS UNIX System Services Command Reference).
Chapter 32. Structuring a Program That Uses C++ Templates

C++ allows programmers to extend the language’s type system by creating user-defined types. Most C++ classes are examples of user-defined types. Furthermore, C++ supports type generality by allowing programmers to define class templates (including struct templates). Class templates are generic entities that can be instantiated to create specific user-defined types. User-defined types that are created in this manner are called template class specializations. A single class template may be instantiated multiple times to create multiple unique specializations.

Similarly, C++ permits the creation of function templates. Function templates are generic entities that can be instantiated to create specific functions. Functions that are created in this manner are called template function specializations. A single function template may be instantiated multiple times to create multiple unique specializations.

For more detailed discussion about templates, see C/C++ Language Reference.

C++ templates are a more complex language feature than compilers and their build environment generally have to deal with. Because multiple compilation units can potentially instantiate the same template with the same set of arguments, the build environment must ensure that each needed template instance occurs exactly once in the program and that no extra instances are generated. There are three basic approaches to this problem.

Leave It to the User
This is the least usable approach. You must know where every template definition is, and where every template instantiation is required. Then you must organize your source code so that at link time,

- The object files contain only one instance of each required instantiation.
- The object files do not contain unused instantiations.

Instantiate at Every Occurrence
In this method the compiler generates code for every instantiation that it encounters. The advantage of this model is that the binder only needs to consider the object files themselves; there are no external complexities to worry about. The disadvantage is that compilation time increases due to repeated compilation of template code. Code written for this model tends to include definitions of all templates in the header file, as these must be seen in order to be instantiated. The binder will leave the duplicate instantiations within the executable, so this method will tend to result in executables that are larger than executables produced by means of the other methods described in this section.

This is done when NOTEMPINC and NOTEMPLATEREGISTRY compiler options are both set.

Intelligent Instantiation
This method relies on the notion of a template repository where template instances are stored and maintained automatically. Two mechanisms are provided to accomplish this: the TEMPINC compiler option and the TEMPLATEREGISTRY compiler option. TEMPINC requires a specific structure for the template header and template definition files; TEMPLATEREGISTRY does not. The compiler option defaults are TEMPINC and NOTEMPLATEREGISTRY. TEMPINC cannot be used with TEMPLATEREGISTRY.
Template Terms

The following list contains template terms and descriptions. For a more detailed discussion, see C/C++ Language Reference.

Template Instantiation
Template instantiation is the act of creating a new definition of a function, class, or member of a class from a template declaration and one or more template arguments.

Class Template Definition
A class template can be instantiated to create a specialization. Specializations of class templates are always class types. A class template definition describes various characteristics of the class types that are its specializations. These characteristics include the names and types of data members of specializations, the signatures and definitions of member functions, accessibility of members, and base classes. Syntactically, a class template definition resembles a class definition preceded by a template key consisting of the keyword template and a template parameter list enclosed between the “<” and “>” symbols.

Class Template Declaration
A class template declaration introduces the name of a class template and specifies its template parameter list. A class template declaration may optionally include a class template definition.

Function Template Definition
A function template can be instantiated to create a specialization. Specializations of function templates are always functions. A function template definition describes the statements that are contained by the functions that are its specializations. Syntactically, a function template definition resembles a function definition preceded by a template key consisting of the keyword template and a template parameter list enclosed between the “<” and “>” symbols.

Function Template Declaration
A function template declaration introduces the name of a function template and specifies its template parameter list, return type, function parameter list, and possibly an exception specification. A function template declaration may optionally include a function template definition.

Linkage
Linkage refers to the binding between a reference and a definition. By default, functions have external linkage, even when they are defined in the definition of a class, or are declared with the inline keyword. A function has internal linkage if it is a nonmember function declared with the static keyword or it is a nonmember function declared in the unnamed namespace. All other functions have external linkage.

Explicit Specialization
When you instantiate a template with a given set of template arguments the compiler generates a new definition based on those template arguments. You can override this behavior of definition generation. You can instead specify the definition the compiler uses for a given set of template arguments.
Generating Template Functions

When you use class templates and function templates in your program, the compiler instantiates function bodies for all template functions that are referenced.

The compiler follows four basic rules to determine when and where to instantiate template functions, and applies them in the following order:

1. If a template function has internal linkage, the compiler instantiates the function within the compilation unit. Multiple compilation units do not share it.

2. If a template function is referenced in a compilation unit and has external linkage, the compiler looks for a template definition of the function in the same compilation unit. If a definition appears, the function in the same compilation unit is instantiated. If the TEMPLATEREGISTRY option is turned on and this function instantiation has already been done in another compilation unit, it is not instantiated.

3. A template instantiation file is created if a template function is declared but not defined in the same compilation unit and the TEMPINC option has been specified. The functions required by the program are instantiated when the template instantiation file compiles.

4. If a template function is declared but not defined in the same compilation unit, and the NOTEMPINC option has been specified, the function is not instantiated. This function must be instantiated in another compilation unit.

Class Template Example

The following class template Stack, illustrates the rules shown previously. The Stack implements a stack of items.

Template Declaration

The declaration of the Stack class template is in the stack.h file. In this example, the constructor is defined inline.

---

```
//stack.h
#ifndef STACK_H
#define STACK_H
template <class Item, int size> class Stack {
    public:
    void push(Item item); // Push operator
    Item pop(); // Pop operator
    int isEmpty(){
        return (top==0); // Returns true if empty, otherwise false
    }
    Stack() { top = 0; } // Constructor defined inline

    private:
    Item stack[size]; // The stack of items
    int top; // Index to top of stack
};
#ifndef __TEMPINC__
#include stack.c
#endif
#endif
```

Figure 125. stack.h File

These are applicable to the TEMPLATEREGISTRY compiler option, which is discussed in “Using the TEMPLATEREGISTRY Option” on page 477.
Template Function Definition
The definitions of the other functions declared in the class template Stack are contained in the stack.c file.

//stack.c
template <class Item, int size>
void Stack<Item,size>::push(Item item) {
  if (top >= size) throw size;
  stack[top++] = item;
}
template <class Item, int size>
Item Stack<Item,size>::pop() {
  if (top == 0) throw size;
  Item item = stack[--top];
  return(item);
}

Figure 126. Definition of Operator Functions in stack.c

Use of the Stack Template
When you compile the following code, an object is created and the necessary member functions are instantiated.

#include "stack.h"
#include "stack.c"
Stack<int,40> s; // declaration of a stack of ints

Figure 127. Use of Stack Template

Generation of Template Function Instantiations
If NOTEMPLATEREGISTRY is in effect:
• If a compilation unit declares, defines, and references a template function, the compiler instantiates the code for the function within the compilation unit.
• If multiple compilation units declare, define, and instantiate the same template function, multiple definitions for the same function are generated.

Refer to “Using the TEMPLATEREGISTRY Option” on page 477 for using TEMPLATEREGISTRY.

In the Stack class template example, any compilation units that include the file stack.c will instantiate all Stack functions referenced in that compilation unit. Consider the following example:

#include "stack.h"
#include "stack.c"
void Swap(int i&, Stack<int,20>& s) {
  int j;
  j=s.pop();
  s.push(i);
  i = j;
}

Any compilation unit that contains the preceding code fragment will automatically instantiate the following functions that defines the class stack<int,20>:

Stack<int,20>::push(int)
int Stack<int,20>::pop()
Resolving Multiple Definitions of the Same Function

Multiple function definitions are resolved as follows:

- If a function has both a specialization and an instantiation, the specialization takes precedence.
- If there is more than one specialization, the binder issues a warning message.

Because the bind step does not remove unused instantiations from the executable program, instantiating the same functions in multiple compilation units may generate very large executable programs. This may be avoided by using TEMPINC or TEMPLATEREGISTRY compiler options, which are discussed in “Using the TEMPINC Option” and “Using the TEMPLATEREGISTRY Option” on page 477.

Using the TEMPINC Option

Instead of instantiating multiple copies of the same template functions, you can use the compiler to instantiate the functions only once for the entire program. This section describes how to do this by using the TEMPINC compiler option (with NOTEMPLATEREGISTRY as default).

Organizing Source Code for the TEMPINC Option

Follow these steps to organize your source code:

1. In addition to your source file, you need to create two other files: the template-declaration file and the template-definition file.
2. The template-declaration file contains the declarations of any class or function templates. Name this file as in the following examples:
   a. In the HFS: /usr/src/stack.h
   b. In a PDS: MYUSERID.USER.H(STACK)
3. The template-definition file is a header file in which you must place the class of function template definitions. Name this file as in the following examples:
   a. In the HFS: /usr/src/stack.c
   b. In a PDS: MYUSERID.USER.C(STACK)
4. Inside your source program, you must have the following:
   a. #include stack.h  // template-declaration file
   b. #include stack.c  // template-definition file
   c. Also include the declarations of any classes that are referenced by the template-declaration file.

Instantiating the Functions

During compilation of your program, the compiler builds a template instantiation file for each header file that contains template functions for instantiation. The compiler creates the tempinc location if it does not already exist. By default, the compiler stores the instantiation files as follows:

1. In the HFS, it is stored in subdirectory tempinc of the working directory, for example:
   /usr/src/tempinc/stack.C
2. In a PDS called TEMPINC under your TSO userid, for example:
   MYUSERID.TEMPINC(STACK)

If you use the c++ shell utility to compile your source, the compiler does the following before linking your program:

1. Checks the contents of the TEMPINC destination
2. Compiles the template-instantiation files that it built
3. Generates the necessary template function definitions

If you use the TSO CXX utility or JCL to compile your source, compile the TEMPINC destination PDS explicitly before binding your code.

When you build the TEMPINC destination, repeat any compiler options that you specified at compile time. Make sure that you compile the TEMPINC destination in one step; do not compile the files individually. Using the same compiler options enables the compiler to find the template-instantiation files that it generated at compile time. In particular, use the same path names for the SEARCH and LSEARCH options, so that the compiler uses the same include files.

**Examples of Source Files**
The following two compilation units use the push and pop functions defined in the Stack template. The two source files are stackadd.cpp and stackops.cpp. stackops.h contains the prototype for a function used in both. The declaration of the Stack class template is in the stack.h file (shown in Figure 125 on page 469); the definitions of the other functions declared are contained in the stack.c file (shown in Figure 126 on page 470).

**stackadd.cpp**

```c++
#include <iostream.h>
#include "stack.h"
#include "stackops.h"

main() {
    Stack<int, 50> s;       // create a stack of ints
    int left=10, right=20;
    int sum;

    s.push(left);           // push 10 on the stack
    s.push(right);          // push 20 on the stack
    add(s);                 // pop the 2 numbers off the stack
    sum = s.pop();          // and push the sum onto the stack

    cout << "The sum of: " << left << " and: " << right << " is: " << sum << endl;
    return(0);
}
```

*Figure 128. stackadd.cpp File*

**stackops.cpp**

```c++
#include "stack.h"
#include "stackops.h"

void add(Stack<int, 50>& s) {
    int tot = s.pop() + s.pop();
    s.push(tot);
    return;
}
```

*Figure 129. stackops.cpp File*

The following file contains the prototype for a function used in both source files.
stackops.h

    void add(Stack<int, 50>& s);

Figure 130. stackops.h File

**JCL to Compile Examples**

Figure 131 contains the JCL that does the following:

1. Compiles both cpp files and creates the TEMPINC destination, which is a sequential file with the following data set name:

   MYUSERID.TEMPINC

2. Compiles the template instantiation file in the TEMPINC destination.

```c
//CC EXEC CBCC,
// INFILE='MYUSERID.USER.CPP(STACKADD)',
// OUTFILE='MYUSERID.USER.OBJ(STACKADD),DISP=SHR',
// CPARM='LSEARCH(USER.+)'  
//                *-------------------------------------------------------------------
//CC EXEC CBCC,
// INFILE='MYUSERID.USER.CPP(STACKOPS)',
// OUTFILE='MYUSERID.USER.OBJ(STACKOPS),DISP=SHR',
// CPARM='LSEARCH(USER.+)'  
//                *-------------------------------------------------------------------
//CC EXEC CBCC,
// INFILE='MYUSERID.TEMPINC',
// OUTFILE='MYUSERID.USER.OBJ,DISP=SHR',
// CPARM='LSEARCH(USER.+)'  
//                *-------------------------------------------------------------------
//BIND EXEC CBCBG,
// INFILE='MYUSERID.USER.OBJ(STACKADD)',
// OUTFILE='MYUSERID.USER.LOAD(STACKADD),DISP=SHR'
//BIND.OBJ DD DSN=MYUSERID.USER.OBJ,DISP=SHR
//BIND.SYSIN DD *
//    INCLUDE OBJ(STACKOPS)
//    INCLUDE OBJ(STACK)
/*
```

Figure 131. JCL to Compile Source Files and TEMPINC Destination

**Syntax to Compile under the z/OS Shell**

Here is the syntax you would use to compile the program within the z/OS shell.

```bash
export _CXX_CXXSUFFIX=cpp
c++ stackadd.cpp stackops.cpp
```

Figure 132. z/OS UNIX Syntax

**Regenerating the Template-Instantiation File**

The compiler builds a template-instantiation file, in the HFS tempinc directory or the TEMPINC PDS, corresponding to each template-declaration file. With each compilation, the compiler may add information to the file but it never removes information from the file.

As you develop your program, you may remove template function references or reorganize your program so that the template-instantiation files become obsolete. Because the compiler does not remove information from the template-instantiation files, you may want to delete these files and recompile your program periodically.
Normally it is not necessary or advisable to edit these files. To regenerate all of the template-instantiation files, delete the TEMPINC destination and recompile your program.

Contents of Template-Instantiation Files
This section contains two examples of template-instantiation files. Figure 133 is the file produced for the Stack class template example; Figure 134 is an example showing the information that would be in a typical template-instantiation file.

```c
#include "//MYUSERID.USER.H(STACK)"
#include "//MYUSERID.USER.C(STACK)"
template void Stack<int,50>::push(int);
template int Stack<int,50>::pop();
```

Figure 133. Contents of the Template-Instantiation File

The following example shows the layout of a typical template-instantiation file generated by the compiler:

```c
#include "/home/myapp/src/list.h"
#include "/home/myapp/src/list.c"
#include "/home/myapp/src/mytype.h"
#include "/usr/include/iostream.h"
template List<MyType>::List<MyType>();
template List<MyType>::add(MyType);
template unsigned long List<MyType>::listSize =0;
```

Figure 134. A Typical Template-Instantiation File

1. `list.h` is the template-declaration file.
2. `list.c` is the template-definition file that corresponds to the template-declaration file in line 1.
3. `mytype.h` is another header file that the compiler needs to compile the template declaration file. All other header files that the compiler needs to compile the template include file are inserted at this point. In this example, the type `MyType` is used as a template argument and is defined in the `mytype.h` header file.
4. `iostream.h` is an include file inserted by the compiler. It is needed by the definition of `MyType`.
5. The compiler inserts explicit instantiations for all of the instantiations of the function templates, class template member functions, and class template static data members that have been referenced in the program.

Using the NOTEMPINC Option
This section shows how to structure your program to define the template functions directly in your compilation units, by using NOTEMPINC (with NOTEMPLATEREGISTRY as default). If you know the instances of a particular template function that is required, you can define both the template functions and the necessary declarations in one compilation unit.
If you use NOTEMPINC, you do not have to reference compiler-generated files. However, if you change the body of the function template, you may have to recompile many of the files. Compile and link time may be longer, and the object file produced may become quite large.

Specify the NOTEMPINC option so that the compiler does not generate template-instantiation files. For more information see z/OS C/C++ User's Guide.

Organizing Source Code for the NOTEMPINC Option

Follow these steps to organize your source code:

1. Place the template function definitions into one or more of your compilation units.
2. Place a reference for each template instantiation to be generated in a compilation unit that also contains a definition of the function.

For a nonmember function, you can reference the function by calling it, or with an explicit instantiation.

For a member of a template class, reference the function by calling it, or with an explicit instantiation. To have class members instantiated all at once, explicitly instantiate the class (this is equivalent to #pragma define on a class).

You can insert these directives anywhere a declaration is allowed.

In the List class template example (see Figure 135), you can cause the compiler to generate the necessary functions by including both list.h and list.c in all compilation units that use instances of the list class. This will instantiate the necessary functions, but may instantiate them multiple times and thus cause the object files to be very large. Alternatively, if you know the instances of the List class used, you can instruct the compiler to instantiate the necessary functions in a separate compilation unit.

Example of Source Code Organized for the NOTEMPINC Option

```cpp
#include "list.h"
#include "list.c"
#include "myclass.h" // Declaration of "myClass" class
template class List<int>;
template class List<myClass>;
```

Figure 135. listinst.cpp File

Using TEMPINC or NOTEMPINC

To use either TEMPINC or NOTEMPINC without restructuring your code, include a multipurpose header file in each of your source files that use templates. If you specify TEMPINC, this file will not include the .c file. If you specify NOTEMPINC, the .c file will be included.

Example of a Multipurpose Header File

Figure 136 on page 476 is an example of a multipurpose header file:
Example of Source Code with Multipurpose Header File

Figure 137 is an example of a source file in which you would place the multipurpose header file.

```c
#include "list.h"
#include "myclass.h" // Declaration of "myClass" class
template class List<int>;
template class List<myClass>;
```

Figure 137. listinst.cpp File

If NOTEMPINC is specified at compile time, list.c is included; if TEMPINC is specified list.c is not included.

TEMPINC Considerations for Shared Libraries

In a traditional application development environment, different applications can share both source files and compiled files. If you decide to use templates, applications can share source files but cannot share compiled files.

If you use templates:

- Each application must have its own template directory.
- You must compile all of the files for the application, even if some of the files have already been compiled for another application.

Under MVS, you can easily assign a separate template PDS for each application.

Under z/OS UNIX System Services, the template directory is always ./tempinc. To create a separate template directory, you must change the current directory. For example:

1. In the makefile, define a .SOURCE directive for each source type. The path must be absolute, not relative.
2. Similarly, define a .SOURCE directive for each output type. The path must be absolute, not relative.
3. In the recipe section of the makefile:
Using the TEMPLATEREGISTRY Option

Unlike the TEMPINC template instantiation mechanism, the TEMPLATEREGISTRY option does not impose specific requirements on the organization of your source code. Any program that compiles successfully when both NOTEMPINC and NOTEMPLATEREGISTRY are in effect (i.e., the “instantiate at every occurrence” approach described at the beginning of this chapter), will also compile when TEMPLATEREGISTRY is in effect.

The TEMPLATEREGISTRY option relies on a "first come first served" type of algorithm. When a program references a new instantiation for the first time, it is instantiated in the compilation in which it occurs. When another compilation unit references the same instantiation, it is not instantiated at this time; thus, only one copy is generated for the entire program. The information to accomplish this is stored in a template registry file, and you must use the same registry file for the entire program. The default file name for the compiler option is templreg in the HFS and TEMPLREG in batch (a sequential file), but you can specify any other valid file name to override this default. When cleaning your program build environment before starting a fresh or scratch build, you must delete the registry file along with the old object files.

TEMPLATEREGISTRY must not be used in combination with TEMPINC. Before initiating a build that uses the TEMPLATEREGISTRY option, ensure that there are no instantiation files in subdirectory tempinc of your working directory, or in a PDS called TEMPINC under your TSO userid.

Converting a TEMPINC Example Into TEMPLATEREGISTRY

This section describes how TEMPLATEREGISTRY works with the example in “Using the TEMPINC Option” on page 471.

- You can code the #ifndef directive in the template declaration file stack.h (shown as comments in Figure 125 on page 469), or you can simply merge stack.h and stack.c.
- Figure 138 on page 478 contains the JCL that compiles both cpp files and creates the TEMPLREG destination as follows:
  - In MVS, it is a sequential file with low-level qualifier of TEMPLREG, for example: MYUSERID.TEMPLREG
  - In the HFS, it is a file called templreg in the working directory, for example: /usr/src/templreg
Recompiling Parts of Your Program After Making Source Changes

If you change your source code and recompile only the affected parts, you could possibly change the dependencies between compilation units. The template registry handles this automatically because it stores all references to templates as well as all the instantiations. For example, if you have compilation units A and B that both reference the same instantiation and you compile A first, then A's object file will contain the code for the instantiation. If you modify A so that it no longer references the instantiation, and you recompile A only, then its object file will no longer contain the code for the instantiation. Without further action an undefined symbol error will occur. To handle this situation the compiler will automatically recompile B using the same compiler options as it did for A, so that B's object file contains the code for the instantiation.

Note: If necessary, automatic recompilation of dependent compilation units can be disabled using the NOTEMPLATERECOMPILE option. A valid short form of this option is NOTEMPLREC.
Chapter 33. Using Environment Variables

This chapter describes environment variables that affect the z/OS C/C++ environment. You can use environment variables to define the characteristics of a specific environment. They may be set, retrieved, and used during the execution of a z/OS C/C++ program.

The following environment variables affect the z/OS C/C++ environment if they are on when an application program runs. The variables that begin with _EDC_ and _CEE_ are described in detail in “Environment Variables Specific to the z/OS C/C++ Library” on page 487. See “Locale Source Files” on page 684 for more information on the locale-related environment variables.

Note: The settings of these variables affect your environment even if you are using the C++ I/O stream classes. For more detailed information about I/O streaming see the following:


For information on environment variables used in z/OS UNIX System Services see *z/OS UNIX System Services Command Reference* and *z/OS UNIX System Services User’s Guide*.

_BIDIATTR_

Used to specify the attributes which will determine the way the bidirectional layout transformation takes place. For example:

```
export _BIDIATTR="@ls typeoftext=visual:implicit, orientation=ltr:ltr,
numerals=nominal:national"
```

If _BIDIATTR_ is not specified or contains erroneous values, the default values will be used. For a detailed description of the bidirectional layout transformation, see Chapter 53, “Bidirectional Language Support” on page 791.

_BIDION_

Used to specify whether iconv will perform bidirectional layout transformation beside the basic main function (code page conversion), or not. The value of this variable is either set to TRUE to activate the bidirectional layout transformation, or FALSE to prevent the bidirectional layout transformation. If this variable is not defined in the environment it defaults to FALSE.

_BPXK_AUTOCVT_

Activates or deactivates automatic text conversion of tagged HFS files.

The value of this environment variable is interrogated during initialization of the C main(), and at each pthread initialization in order to set the autoconversion state for the thread. The autoconversion state for the thread is looked at by the logical file system (LFS) when determining if automatic text conversion should be performed during read/write operations to tagged HFS files.
**Note:** The default autoconversion state is unset, meaning that the LFS must look to the BPXPRMxx AUTOCVT parameter, which is either ON or OFF. When set to a valid value, this environment variable overrides the BPXPRMxx AUTOCVT parameter.

During main() initialization, the following behavior is defined for this environment variable:

**Setting** | **Autoconversion State for the Thread**
--- | ---
ON | Activated
OFF | Deactivated
<other> | Treated as unset. Autoconversion defers to BPXPRMxx AUTOCVT parameter

Changing the value of this environment variable using setenv(), putenv(), or clearenv() during execution of the application will behave in the following manner:

- Ignored after the first pthread create, although getenv() might show otherwise. The autoconversion state will remain unchanged.
- Deleting or clearing the environment variable, or setting the value to an invalid value before the first pthread create will change the autoconversion state to unset.
- Has no effect on initially untagged HFS files that have already been opened using fopen() or freopen() on the current thread and FILETAG(AUTOCVT,) is in effect. These files were specifically marked, or not marked, for automatic text conversion, at the file descriptor level, at the time they were opened. The text conversion state for the already opened file descriptors depended on whether or not autoconversion for the thread was activated or deactivated at the time of the open.
- The standard streams may have already been setup for automatic text conversion, before the main() begins execution, using EBCDIC CCSID 1047 as the File CCSID. Therefore, changing the autoconversion state using one of these methods will not affect the standard streams. Specifically, an application running with ASCII CCSID 819 as the Program CCSID will continue to have text conversion with the standard streams.

**Note:** Changing the value of this environment variable using any other mechanism is ignored, although getenv() might show otherwise. You can use setenv() with a value of NULL to delete an environment variable.

**_BPXK_CCSIDS**

Defines the EBCDIC<->ASCII pair of coded character set IDs (CCSIDS) to be used when converting text data, and for automatic tagging new or empty HFS files. The syntax of the environment variable value is as follows:

```
_BPXK_CCSIDS=(e,a)
```

where e is the EBCDIC CCSID and a is the ASCII CCSID.

Language Environment C/C++ applications will initialize with the default IBM-1047<->ISO8859-1 pair. This is equivalent to specifying:

```
_BPXK_CCSIDS=(1047,819)
```
The value of this environment variable is interrogated during initialization of the C main(), and at each pthread initialization in order to set the Program CCSID for the thread. For the main(), the Program CCSID is set to the ASCII value of the pair when the main() is part of an ASCII compile unit, otherwise it is set to the EBCDIC value of the pair. The Program CCSID for a thread is set based on the compiled codeset of the thread start routine. When ASCII, the ASCII value of the CCSID pair is used, else the EBCDIC value.

Changing the value of this environment variable using setenv(), putenv(), or clearenv() during execution of the application will behave in the following manner:

- Ignored after the first pthread create, although getenv() might show otherwise. The current CCSID pair used for conversion & tagging purposes will remain unchanged.
- Deleting or clearing the environment variable before the first pthread create will result in the default CCSID pair (1047,819) being used for conversion and tagging purposes.
- Using improper syntax before the first pthread create will result in the CCSID pair being set to (0,0). This will prevent any further conversion.
- Has no effect on initially untagged new or empty HFS files that have already been opened using fopen(), fropen(), or popen() on the current thread and FILETAG(AUTOTAG) is in effect. These files were setup for tagging upon first write at the time they were opened. The File CCSID was set to what the Program CCSID was at the time of the open.
- The standard streams may have already been setup for automatic text conversion, before the main() begins execution, using EBCDIC CCSID 1047 as the File CCSID, therefore changing the CCSID pair using one of these methods will not affect the standard streams.

**Note:** Changing the value of this environment variable using any other mechanism is ignored, although getenv() might show otherwise. You can use setenv() with a value of NULL to delete an environment variable.

**_BPXK_SIGDANGER**

Set to either YES or NO, this variable modifies the process termination mechanism used during UNIX System Services Shutdown. During Shutdown the kernel sends a signal to each non-permanent non-blocking process. If _BPXK_SIGDANGER is not in the environment, or if its value is not YES, then SIGTERM is sent to these processes. If _BPXK_SIGDANGER is present in the environment and has the value YES then signal SIGDANGER will be sent instead of SIGTERM. The default action for SIGTERM is to terminate the process, but the default action for SIGDANGER is to ignore the signal. The application may register a SIGDANGER signal catcher function to handle shutdowns. If the process does not end in a short while after being sent the first signal, the kernel will send SIGKILL to the process. If the process does not end in a short while after the second signal is sent, the process will be brought down using CALLRTM ABTERM=YES.

**Note:** The program should not use the environ external variable to put this or any other "_BPXK_" environment variable into its own environment. The Kernel will not be told about the environment variable setting when it is added to the environment this way.
The program should use an environ pointer to put this variable into the environment of a new process created with spawn() or exec(). In this case the kernel will notice _BPXK_ environment variables being created for a new program image. In addition, the kernel will correctly detect _BPXK_ environment variables generated into child processes created via fork() and spawn.

_CEWindows="_CEE_DMPTARG"

Used to specify the directory in which Language Environment dumps (CEEDUMPs) are written for applications that are running as the result of a fork, exec, or spawn. This environment variable is ignored if the application is not run as a result of a fork, exec, or spawn.

_CEWindows="_CEE_ENVFILE"

Used to specify a file from which to read environment variables.

_CEWindows="_CEE_HEAP_MANAGER"

Used to specify the DLL name for the Vendor Heap Manager to be used during execution of the application.

_CEWindows="_CEE_RUNOPTS"

Used to specify Language Environment run-time options to a program invoked by using one of the exec functions, such as a program which is invoked from one of the z/OS UNIX shells.

_EDC_ADD_ERRNO2

Appends errno2 information to the output of perror() and strerror().

_EDC_ANSI_OPEN_DEFAULT

Affects the characteristics of MVS text files opened with the default attributes.

_EDC_BYTE_SEEK

Specifies that fseek() and ftell() should use relative byte offsets.

_EDC_CLEAR_SCREEN

Affects the behavior of output text terminal files.

_EDC_COMPAT

Specifies that C/C++ should use specific functional behavior from previous releases of C/370.

_EDC_ERRNO_DIAG

Indicates if additional diagnostic information should be generated, when the perror() or strerror() functions are called to produce an error message.

_EDC_GLOBAL_STREAMS

Allows the C standard streams stdin, stdout and stderr to have global behavior.

_EDC_IP_CACHE_ENTRIES

Sets the size of the cache used for host names and IP addresses returned by gethostbyaddr() and gethostbyname() calls that are resolved by a domain name server.

_EDC_RRDS_HIDE_KEY

Relevant for VSAM RRDS files opened in record mode. Enables calls to fread() that specify a pointer to a character string and do not append the Relative Record Number to the beginning of the string.

_EDC_STOR_INCREMENT

Sets the size of increments to the internal library storage subpool.
**_EDC_STOR_INITIAL_**
Sets the initial size of the internal library storage subpool.

**_EDC_UMASK_DFLT_**
Allows the user to control how the C library sets the default umask used when the program runs. If z/OS UNIX services are available, the possible values of the _EDC_UMASK_DFLT environment variable are:
- NO - the library will not change the value
- a valid octal value - the library sets this as the default
- any other value - the library uses 022 octal as the value.

**_EDC_ZERO_RECLEN_**
Enables processing of zero-length records in an MVS data set opened in variable format.

**LANG**
Determines the locale to use for the locale categories when neither the LC_ALL environment variable nor the individual locale environment variables specify locale information. This environment variable does not interact with the language setting for messages.

**LC_ALL**
Determine the locale to be used to override any values for locale categories specified by the settings of the LANG environment variable or any individual locale environment variables.

**LC_COLLATE**
Determines the behavior of ranges, equivalence classes, and multicharacter collating elements.

**LC_CTYPE**
Determines the locale for the interpretation of byte sequences of text data as characters (for example, single-byte versus multibyte characters in arguments and input files).

**LC_MESSAGES**
Determines the language in which messages are to be written.

**LC_MONETARY**
Determines the locale category for monetary-related numeric formatting information.

**LC_NUMERIC**
Determines the locale category for numeric formatting (for example, thousands separator and radix character) information.

**LC_TIME**
Determines the locale category for date and time formatting information.

**LC_TOD**
Determines the locale category for time of day and Daylight Savings Time formatting information.

**LIBPATH**
Allows an absolute or relative pathname to be searched when loading a DLL. If the input filename contains a slash (/), it is used as is to locate the DLL. If the input filename does not contain a slash, then LIBPATH is used to determine the pathname to load. LIBPATH specifies a list of directories separated by colons. If the LIBPATH begins or ends with a colon, then the working directory is also searched first or last, depending on the position of the stand-alone colon. The "::" specification can only occur at the beginning or end of the list of directories. If you are running POSIX(ON), then HFS is
searched first followed by MVS. If you are running POSIX(OFF), then MVS is searched first followed by HFS. This double search can be avoided by using unambiguous DLL names.

**LOCPATH**

Tells the `setlocale()` function the name of the directory in the HFS from which to load the locale object files. It specifies a colon separated list of HFS directories.

If LOCPATH is defined, `setlocale()` searches HFS directories in the order specified by LOCPATH for locale object files it requires. Locale object files in the HFS are produced by the localedef utility running under z/OS UNIX.

If LOCPATH is not defined and `setlocale()` is called by a POSIX program, `setlocale()` looks in the default HFS locale directory, `/usr/lib/nls/locale`, for locale object files it requires. If `setlocale()` does not find a locale object it requires in the HFS, it converts the locale name to a PDS member name and searches locale PDS load libraries associated with the program calling `setlocale()`.

**Note:** XPLINK locales have an `.xplink` suffix added to the end of the locale name. For more information about XPLINK locale names, see [“Locale Naming Conventions” on page 712](#).

**PATH**

The set of HFS directories that some z/OS C/C++ functions, such as `EXECVP`, use in trying to locate an executable. The directories are separated by a colon (`:`) delimiter. If the pathname contains a slash, the PATH environment variable will not be used.

**__POSIX_SYSTEM**

Determines the behavior of the `system()` function when the POSIX(ON) run-time option has been specified. If __POSIX_SYSTEM=NO, then `system()` behaves as in Language Environment/370 1.2: it creates a nested enclave within the same process as the invoker (allowing such things as sharing of memory files). Otherwise, `system()` performs a `fork()` and `exec()`, and the target program runs in a separate process (preventing such things as sharing of memory files).

**STEPLIB**

Determines the STEPLIB environment that is created for an executable file. It can be a sequence of MVS data set names separated by a colon (`:`), or can contain the value CURRENT or NONE. If you do not want a STEPLIB environment propagated to the environment of the executable file, specify NONE. The STEPLIB environment variable defaults to the value CURRENT, which will propagate your current environment to that of the executable file.

See [z/OS UNIX System Services Command Reference](#) for more information on the use of the STEPLIB variable and changing the search order for z/OS programs.

**TZ or _TZ**

Time zone information. The TZ and _TZ environment variables are typically set when you start a shell session, either through `/etc/profile` or `.profile` in your home directory. For more information on TZ and _TZ see [Chapter 49, “Customizing a Time Zone” on page 729](#).
Working with Environment Variables

The following library functions affect environment variables:

- `setenv()`
- `clearenv()`
- `getenv()`
- `__getenv()`
- `putenv()`

The `setenv()` function adds, changes, and deletes environment variables in the Environment Variable Table. The `getenv()` function retrieves the values from the table. If it does not find an environment variable, `getenv()` returns `NULL`. The `clearenv()` function clears the environment variable table, and resets to default behavior the actions affected by z/OS C/C++-specific environment variables.

The `__getenv()` function behaves almost the same as `getenv()` except `getenv()` returns the address of the environment variable value string that has been copied into a buffer, whereas `__getenv()` returns the address of the actual value string in the environment variable array. Because the value is not buffered, `__getenv()` cannot be used in a multithreaded application or in a single threaded application where the function `setenv()` changes the value of the variables.

The `putenv()` function provides a subset of the function of `setenv()` and is provided for convenience in porting UNIX applications. `putenv(env_var)` is the same as `setenv(var_name, var_value, i)` where `env_var` represents the string `var_name=var_value`.

For a complete description of these functions, refer to z/OS C/C++ Run-Time Library Reference.

Environment variables may be set any time in an application program or user exit. You can use the exit routine `CEEINT` to set environment variables through calls to `setenv()`. For more information on the z/OS Language Environment user exit `CEEINT`, refer to “Using Run-Time User Exits in z/OS Language Environment” on page 549. You can also set environment variables by using the `ENVAR` run-time option. The syntax for this option is `ENVAR("1st_var=1st_value", "2nd_var=2nd_value")`.

For more information on this run-time option, refer to z/OS Language Environment Programming Reference.

Specifying the `_CEE_ENVFILE` environment variable with a filename on the `ENVAR` option enables you to read more environment variables from that file. See “Environment Variables Specific to the z/OS C/C++ Library” on page 487 for more information about `_CEE_ENVFILE`.

Environment variables set with the `setenv()` function exist only for the life of the program, and are not saved before program termination. Child programs are initialized with the environment variables of the parent. However, environment variables set by a child program are not propagated back to the parent upon termination of the child program.
**Note:** If you are running with POSIX(ON), environment variables are copied from a parent process to a child process when a fork() function is called, and are inherited by the new process image when an EXEC function is called.

When a parent process invokes a child process by using system(), using the ANSI form of the system function, the child receives its environment variables from the value of the ENVAR run-time option specified on the invocation of system(). For example:

```c
system("PGM=CHILD,PARM="ENVAR(ABC=5)/");
```

**Naming Conventions**

Avoid the following when creating names for environment variables:

- `=` This is invalid and will generate an error message.
- `_CBC_` This is reserved for z/OS C/C++ specific environment variables.
- `_CCN_` This is reserved for z/OS C/C++ specific environment variables.
- `_EDC_` This is reserved for z/OS C/C++ specific environment variables.
- `_CEE_` This is reserved for z/OS C/C++ specific environment variables used with z/OS Language Environment. See "Environment Variables Specific to the z/OS C/C++ Library" on page 487 for more information.
- `_BPX_` This is reserved for z/OS C/C++ specific environment variables used in the kernel. See the spawn callable service in z/OS UNIX System Services Programming: Assembler Callable Services Reference for more information.

**DBCS Characters**

Multibyte and DBCS characters should not be used in environment variable names. Their use can result in unpredictable behavior.

Multibyte and DBCS characters are allowed in environment variable values; however, the values are not validated, and redundant shifts are not removed.

**white space**

Blank spaces are valid characters and should be used carefully in environment variable names and values.

For example, setenv(" my name"," David ",1) sets the environment variable <space><space>my<space><space>name to <space><space>David>. A call to getenv(" my name"); returns NULL indicating that the variable was not found. You must specifically query getenv(" my name") to retrieve the value of "David".

The environment variable names are case-sensitive.

The empty string is a valid environment variable name.

**Note:** In general, it is a good idea to avoid special characters, and to use portable names containing just upper and lower case alaphabetics, numerics, and underscore characters. Environment variable names containing certain
special characters, such as slash (/), are not propagated by the z/OS UNIX shells. Therefore, these variable names are not available to a program called using the POSIX system() function.

Environment Variables Specific to the z/OS C/C++ Library

The following z/OS C/C++ specific environment variables are supported to provide various functions. z/OS C/C++ variables have the prefix _CEE_ or _EDC_. You should not use these prefixes to name your own variables.

- _CEE_DMPTARG
- _CEE_ENVFILE
- _CEE_HEAP_MANAGER
- _CEE_RUNOPTS
- _EDC_ADD_ERRNO2
- _EDC_ANSI_OPEN_DEFAULT
- _EDC_BYTE_SEEK
- _EDC_CLEAR_SCREEN
- _EDC_COMPAT
- _EDC_ERRNO_DIAG
- _EDC_GLOBAL_STREAMS
- _EDC_IP_CACHE_ENTRIES
- _EDC_RRDS_HIDE_KEY
- _EDC_STOR_INCREMENT
- _EDC_STOR_INITIAL
- _EDC_UMASK_DFLT
- _EDC_ZERO_RECLEN

There are no default settings for the environment variables that begin with _EDC_. There are, however, default actions that occur if these environment variables are undefined or are set to invalid values. See the descriptions of each variable below.

The z/OS C/C++ specific environment variables may be set with the `setenv()` function.

_*CEE_DMPTARG_*

Specifies the directory in which Language Environment dumps (CEEDUMPs) are written for applications that are running as the result of a fork, exec, or spawn. This environment variable is ignored if the application is not run as a result of a fork, exec, or spawn. When _CEE_DMPTARG_ is set in one of these environments, its value is used as the directory name in which to place CEEDUMPs. For example, if in a shell, you set the environment variable as follows:

```bash
export _CEE_DMPTARG=/u/userid/dmpdir
```

Language Environment dumps will be written to directory `/u/userid/dmpdir`. If in a shell, you set the environment variable as follows:

```bash
export _CEE_DMPTARG=dmpdir
```

Language Environment dumps will be written to directory `"cwd"/dmpdir` where `"cwd"` is the current working directory.
**_CEE_ENVFILE_**

Enables a list of environment variables to be set from a specified file. This environment variable only takes effect when it is set through the run-time option ENVAR on initialization of a parent program.

When _CEE_ENVFILE_ is defined under these conditions, its value is taken as the name of the file to be used. For example, to read the DDfile MYVARS, you would call your program with the ENVAR run-time option as follows:

```
ENVAR("_CEE_ENVFILE=DD:MYVARS")
```

The specified file is opened as a variable length record file. For an MVS data set, the data set must be allocated with RECFM=V. RECFM=F is not recommended, since RECFM=F enables padding with blanks, and the blanks are counted when calculating the size of the line. Each record consists of NAME=VALUE. For example, a file with the following two records:

```
_EDC_RRDS_HIDE_KEY=Y
World_Champions=New_York_Yankees
```

would set the environment variable _EDC_RRDS_HIDE_KEY_ to the value Y, and the environment variable World_Champions to the value New_York_Yankees.

**Notes:**

1. Using _CEE_ENVFILE_ to set environment variables through a file is not supported under CICS.
2. z/OS Language Environment searches for an equal sign to delimit the environment variable from its value. If an equal sign is not found, the environment variable is skipped and the rest of the text is treated as comments.
3. Each record of the file is processed independently from any other record in the file. Data within a record is used exactly as input with no substitution. A file containing:

```
FRED=WILMA
FRED=$FRED:BAMBAM
```

will result in the environment variable FRED being set to $FRED:BAMBAM, rather than to WILMA:BAMBAM as would be the case if the same statements were processed by a UNIX shell.

**_CEE_HEAP_MANAGER_**

Specifies the name of the Vendor Heap Manager (VHM) DLL that will be used to manage the user heap. You set the environment variable as follows:

```
CEE_HEAP_MANAGER=dllname
```

This environment variable must be set using one of the following mechanisms:

- **ENVAR** run-time option
- **inside the file specified by the _CEE_ENVFILE_ environment variable.**

Either of these mechanisms is before any user code gets control. This means prior to the HLL user exit, static constructors, and/or main getting control. Setting of this environment variable once the user code has begun execution will not activate the VHM, but the value of the environment variable will be updated.

See [z/OS Language Environment Vendor Interfaces](#) for more information on the Vendor Heap Manager support.
_CEE_RUNOPTS
Used to specify Language Environment run-time options to a program invoked by using one of the exec functions, such as a program which is invoked from one of the z/OS UNIX shells. You can set the _CEE_RUNOPTS value string from z/OS UNIX shells (by using the export command) or by using the setenv() or putenv() function. The format of the environment variable is:

CEE_RUNOPTS=value

where value is a null-terminated character string of Language Environment run-time options. For example, you could specify the following:

CEE_RUNOPTS="stack(,,any,) termthdact(dump)"

When one of the exec family of functions is invoked, any run-time option specified upon invocation of the calling application (and not explicitly specified by the user in a _CEE_RUNOPTS environment variable) is added to this variable. Thus, invocation run-time options are propagated across the exec. To set the _CEE_RUNOPTS value string from a shell, you could issue the export command and specify the following run-options, for example:

export _CEE_RUNOPTS="stack(,,any,) termthdact(dump)"

_EDC_ADD_ERRNO2
Appends errno2 information to the output of perror() and strerror(). For example, for perror() if errno was 121, then the output would be “EDC5121I Invalid argument.” If _EDC_ADD_ERRNO2 was defined, the output would be “EDC5121I Invalid argument. (errno2=0x0C0F8402)”.

_EDC_ADD_ERRNO2 is set with the command:

setenv("_EDC_ADD_ERRNO2","1",1);

Note: errno2 is a residual error field. It contains the errno2 from the last kernel failure. This errno2 value may or may not be related to the errno error message.

_EDC_ANSI_OPEN_DEFAULT
Affects the characteristics of MVS text files opened with the default attributes.

Issuing the following command causes text files opened with the default characteristics to be opened with a record format of FIXED and a logical record length of 254 in accordance with the ANSI standard for C.

setenv("_EDC_ANSI_OPEN_DEFAULT","Y",1);

When this environment variable is not specified and a text file is created without its record format or LRECL defined, then the default is a variable record format.

_EDC_BYTE_SEEK
Indicates to z/OS C/C++ that, for all binary files, ftell() should return relative byte offsets, and fseek() should use relative byte offsets as input. The default behavior is for only binary files with a fixed record format to support relative byte offsets.

_EDC_BYTE_SEEK is set with the command:

setenv("_EDC_BYTE_SEEK","Y",1);
**_EDC_CLEAR_SCREEN_**

Applies to output text terminal files.

_EDC_CLEAR_SCREEN_ is set with the command:

```c
setenv("_EDC_CLEAR_SCREEN","Y",1);
```

When _EDC_CLEAR_SCREEN_ is set, writing a \f (form feed) character to a text terminal sends all preceding unwritten data in the terminal buffer to the screen, and then clears the screen.

When _EDC_CLEAR_SCREEN_ in not set, writing a \f (form feed) character to a text terminal results in the character being treated as a non-control character. The character is written to the terminal buffer as \f.

**_EDC_COMPAT_**

Indicates to z/OS C/C++ that it should use old functional behavior for various items in code ported from old releases of C/370. These functional items are specified by the value of the environment variable. _EDC_COMPAT_ is set with the command

```c
setenv("_EDC_COMPAT","x",1);
```

where x is an integer. z/OS C/C++ converts the string "x" into its decimal integer equivalent, and treats this value as a bit mask to determine which functions to use in compatibility mode. The following table interprets the least significant bit as bit zero.

<table>
<thead>
<tr>
<th>Bit</th>
<th>Function Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ungetc()</td>
</tr>
<tr>
<td>1</td>
<td>ftell()</td>
</tr>
<tr>
<td>2</td>
<td>fclose()</td>
</tr>
<tr>
<td>3 through 31</td>
<td>Unused</td>
</tr>
</tbody>
</table>

For this release, calls to fseek() with an offset of SEEK_CUR, fgetpos(), and fflush() take into account characters pushed back with the ungetc() library function. You must set the _EDC_COMPAT environment variable for ungetc() if you want these functions to ignore ungetc() characters as they did in old C/370 code.

For ftell(), z/OS C/C++ uses an encoding scheme that varies according to the attributes of the underlying data set. You must set the _EDC_COMPAT environment variable for ftell() if you want to use encoded ftell() values generated in old C/370 code.

You can set _EDC_COMPAT_ to indicate that fclose() should not unallocate the SYSOUT=* data set when it is closing "*" data sets created under batch. This is to ensure that such data sets can be concatenated with the Job Log, if their attributes are compatible.

Here are some examples of how you can set _EDC_COMPAT_:

- `setenv("_EDC_COMPAT","1",1);` invokes old ungetc() behavior.
- `setenv("_EDC_COMPAT","2",1);` invokes old ftell() behavior.
- `setenv("_EDC_COMPAT","3",1);` invokes both old ungetc() behavior and old ftell() behavior.
• setenv("_EDC_COMPAT","4",1); invokes old behavior for spool data sets created by opening "*" in MVS or IMS batch.

_EDC_ERRNO_DIAG
Indicates if additional diagnostic information should be generated, when the perror() or strerror() functions are called to produce an error message. This environment variable also controls how much additional information is produced. _EDC_ERRNO_DIAG is set with the command

setenv("_EDC_ERRNO_DIAG","x,y",1);

where x is an integer and y is a list of integer errno values, for which additional diagnostic information is desired. The list of errno values must be separated by commas. If the y value is omitted, then additional diagnostic information is generated for all errno values. If a non-numeric errno value is found in y, it is treated as 0. Acceptable values for x are as follows:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No additional diagnostic information is generated (This is the default if _EDC_ERRNO_DIAG is not set).</td>
</tr>
<tr>
<td>1</td>
<td>The ctrace() function is called to generate additional diagnostic information.</td>
</tr>
<tr>
<td>2</td>
<td>The csnap() function is called to generate additional diagnostic information.</td>
</tr>
<tr>
<td>3</td>
<td>The cdump() function is called to generate additional diagnostic information.</td>
</tr>
</tbody>
</table>

See [z/OS C/C++ Run-Time Library Reference](https://publib.boulder.ibm.com/infocenter/cconserv/v1r13/index.jsp) for details on the level of diagnostic information provided by the above functions.

Examples:
• setenv("_EDC_ERRNO_DIAG","0",1); No additional diagnostic information is produced.
• setenv("_EDC_ERRNO_DIAG","1",1); The ctrace() function is called for any errno when perror() or strerror() are called.
• setenv("_EDC_ERRNO_DIAG","2,121",1); The csnap() function is called only when errno equals 121 when perror() or strerror() are called.
• setenv("_EDC_ERRNO_DIAG","3,121,129",1); The cdump() function is called only when errno equals either 121 or 129 when perror() or strerror() are called.

_EDC_GLOBAL_STREAMS
Used during initialization of the first C main in the environment to allow the C standard streams stdin, stdout, and stderr to have global behavior. The environment variable settings and standard streams using the global behavior, are as follows:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Standard Streams Using Global Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>none</td>
</tr>
<tr>
<td>1</td>
<td>stderr</td>
</tr>
<tr>
<td>2</td>
<td>stdout</td>
</tr>
<tr>
<td>3</td>
<td>stderr,stdout</td>
</tr>
<tr>
<td>4</td>
<td>stdin</td>
</tr>
<tr>
<td>5</td>
<td>stderr,stdin</td>
</tr>
</tbody>
</table>
stdout, stdin

stderr, stdout, stdin

**Note:** The first C main would include any Pre-Init Compatibility Interface initialization.

You can use one of the following methods to set the environment variable _EDC_GLOBAL_STREAMS:

- **CEEBXITA assembler user exit**
  You can modify the sample CSECT and assemble and link with the application. The run-time options specified in the CEEBXITA assembler user exit override all other sources of run-time options except those that are specified as NONOVR in the installation default run-time options. These options are honored only during initialization of the first enclave.

- **ENVAR(_EDC_GLOBAL_STREAMS=<setting>)**
  You can call your program with the ENVAR run-time option. This overrides the application defaults specified using CEEUOPT or the #pragma runopts directive.

- **#pragma runopts(ENVAR(_EDC_GLOBAL_STREAMS=<setting>))**
  Use the #pragma runopts directive in your application source code.

- **CEEUOPT application defaults**
  Modify the sample CSECT and assemble and link with the application. This overrides corresponding overrideable CEEDOPT options.

- **CEEDOPT installation defaults**
  This is not recommended. Do not use this method.

**Notes:**
1. Attempts to set this environment variable in the file specified by the _CEE_ENVFILE environment variable are ignored. The standard streams are initialized before that file is read.
2. You cannot use the CEEBINT user exit to set this environment variable. The CEEBINT user exit gets control after the standard streams have been initialized.

**_EDC_IP_CACHE_ENTRIES**
Sets the size of the cache used for host names and IP addresses returned by gethostbyaddr() and gethostbyname() calls that are resolved by a domain name server. This cache is searched first before sending the next gethostbyaddr() or gethostbyname() request to a domain name server. The size of the cache is set only once. The first call to either gethostbyaddr() or gethostbyname() uses the value of the _EDC_IP_CACHE_ENTRIES environment variable to set the size of the cache. Setting the size to 0 disables the cache. If you do not specify a value for this environment variable, the default size is 20.

_EDC_IP_CACHE_ENTRIES is set with the command:

```
setenv("_EDC_IP_CACHE_ENTRIES", "50", 1);
```

**_EDC_RRDS_HIDE_KEY**
Applies to VSAM RRDS files opened in record mode. When this environment variable is set, you can call fread() with a pointer to a character string, and the Relative Record Number is not appended to the beginning of the record.

The _EDC_RRDS_HIDE_KEY environment variable is set with the command

```
setenv("_EDC_RRDS_HIDE_KEY","Y",1);
```
By default, when you open a VSAM record in record mode, the fwrite() function is called with the RRDS record structure, and the record is preceded by the Relative Record Number.

_EDC_STOR_INCREMENT
Sets the size of increments to the internal library storage subpool. By default, when the storage subpool is filled, its size is incremented by 8K. When _EDC_STOR_INCREMENT is set, its value string is translated to its decimal integer equivalent. This integer is then the new setting of the subpool storage increment size.

The _EDC_STOR_INCREMENT value must be greater than zero, and must be a multiple of 4K. If the value is less than zero, the default setting of 8K is used. If the value is not a multiple of 4K, then it is rounded up to the next 4K interval. If _EDC_STOR_INCREMENT is set to an invalid value that must be modified internally to be divisible by 4K, this modification is not reflected in the character string that appears in the environment variable table.

Consider the case where setenv() is called as follows:

```
setenv("_EDC_STOR_INCREMENT","9000",1);
```

Internally, the storage subpool increment value is set to 12288 (that is, 12K). However, the subsequent call

```
getenv("_EDC_STOR_INCREMENT");
```

returns "9000", as set by the call to setenv().

_EDC_STORE_INITIAL
Sets the initial size of the internal library storage subpool. The default subpool storage size is 12K. When _EDC_STORE_INITIAL is set, its value string is translated to its decimal integer equivalent. This integer is then the new setting of the subpool storage increment size.

The _EDC_STORE_INITIAL value must be greater than zero, and must be a multiple of 4K. If the value is less than zero, the default setting of 12K is used. If the value is not a multiple of 4K, then it is rounded up to the next 4K interval. If _EDC_STORE_INITIAL is set to an invalid value that must be modified internally to be divisible by 4K, this modification is not reflected in the character string that appears in the environment variable table.

Consider the case where setenv() is called from CEEBINT as follows:

```
setenv("_EDC_STORE_INITIAL","16000",1);
```

with the CEEBINT user exit linked to the application.

Internally, the storage subpool is initialized to 16384 (that is, 16K). However, the subsequent call

```
getenv("_EDC_STORE_INITIAL");
```

returns "16000" as set by the setenv() call.

_EDC_ZERO_RECLEN
Allows processing of zero-length records in an MVS Variable file opened in either record or text mode.
Note: This environment variable has no effect on streams based on HFS files. You can always read and write zero-byte records in HFS files.

_EDC_ZERO_RECLEN is set with the command:
setenv("_EDC_ZERO_RECLEN","Y",1);

For details on the behavior of this environment variable, refer to [Chapter 11, “Performing OS I/O Operations” on page 107](#).

Example

The following example sets the environment variable _EDC_ANSI_OPEN_DEFAULT. A child program is then initiated by a system call. This example illustrates that environment variables are propagated forward, but not backward.

CCNGEV1

```c
/* this example shows how environment variables are propagated */
/* part 1 of 2-other file is CCNGEV2 */
#include <stdio.h>
#include <stdlib.h>

int main(void) {
    char *x;
    /* set the environment variable _EDC_ANSI_OPEN_DEFAULT */
    setenv("_EDC_ANSI_OPEN_DEFAULT","Y",1);
    /* set x to the current value of _EDC_ANSI_OPEN_DEFAULT */
    x = getenv("_EDC_ANSI_OPEN_DEFAULT");
    printf("ccngev1 _EDC_ANSI_OPEN_DEFAULT = %s\n", (x != NULL)?x: "undefined");
    /* call the child program */
    system("ccngev2");
    /* set x to the current value of _EDC_ANSI_OPEN_DEFAULT */
    x = getenv("_EDC_ANSI_OPEN_DEFAULT");
    printf("ccngev1 _EDC_ANSI_OPEN_DEFAULT = %s\n", (x != NULL)?x: "undefined");
    return(0);
}
```

Figure 139. Environment Variables Example-Part 1
CCNGEV2

/* this example shows how environment variables are propagated */
/* part 2 of 2-other file is CCNGEV1 */

#include <stdio.h>
#include <stdlib.h>

int main(void) {
    char *x;

    /* set x to the current value of _EDC_ANSI_OPEN_DEFAULT */
    x = getenv("_EDC_ANSI_OPEN_DEFAULT");
    printf("ccngev2 _EDC_ANSI_OPEN_DEFAULT = %s\n", (x != NULL)?x: "undefined");

    /* clear the Environment Variables Table */
    clearenv();

    /* set x to the current value of _EDC_ANSI_OPEN_DEFAULT */
    x = getenv("_EDC_ANSI_OPEN_DEFAULT");
    printf("ccngev2 _EDC_ANSI_OPEN_DEFAULT = %s\n", (x != NULL)?x: "undefined");

    return(0);
}

Figure 140. Environment Variables Example-Part 2

The preceding program produces the following output:

cbcgev1 _EDC_ANSI_OPEN_DEFAULT = Y
ccngev2 _EDC_ANSI_OPEN_DEFAULT = Y
ccngev2 _EDC_ANSI_OPEN_DEFAULT = undefined
ccngev1 _EDC_ANSI_OPEN_DEFAULT = Y
This part describes the different z/OS C/C++ environments. Note that the MultiTasking Facility and the System Programming C Facilities are not available for z/OS C++. If you attempt to run an SPC application under z/OS C++, it will abend.

- Chapter 34, “Using the System Programming C Facilities” on page 499
- Chapter 35, “Library Functions for System Programming C” on page 543
- Chapter 36, “Using Run-Time User Exits” on page 549
- Chapter 37, “Using The z/OS C MultiTasking Facility” on page 567
Chapter 34. Using the System Programming C Facilities

This chapter explains how to use the system programming C (SPC) facilities with z/OS C.

Notes:
1. Using the system programming C facilities, by programs which have been compiled with z/OS C++ is not supported.
2. IPA is not supported in an SPC environment unless there is a main() function present.
3. XPLINK is not supported by the SPC facilities.

When z/OS C applications are compiled, many routines are needed to support the z/OS C environment that are not included in your executable. These routines, which are in z/OS Language Environment, are dynamically loaded at run time. This reduces the size of the program to its practical minimum and provides for the sharing of z/OS C library code by allowing its placement in Extended Link Pack Areas.

z/OS Language Environment provides facilities to set up the environment, handle termination, provide storage management, error handling, interlanguage calls and debugging support. Also, the C library functions are provided with z/OS Language Environment. In situations where not all of these services are needed or available, or more control over the executive environment is required, the system programming C facilities can provide a reduced customizable environment for your application.

System programming facilities enable you to run applications without z/OS Language Environment or with just the z/OS C library functions available. You can:
• Use a subset of the C language to develop specialized applications that do not require z/OS Language Environment on the machines where the application will run.
  You can write freestanding applications that:
  – Do not use the dynamic run-time library.
  – Use only the C-specific library functions without any z/OS Language Environment facilities to manage the execution environment.

  For example, a system programming application could use the C-specific library function printf() but not have the common run time initialize the environment. The system programming facilities would handle initialization.

  For more information on this type of application, see "Creating Freestanding Applications" on page 502.
• Use z/OS C as an assembler language alternative, such as for writing exit routines for MVS, TSO, or JES.
  For more information on this type of application, see "Creating System Exit Routines" on page 508.
• Develop applications featuring a persistent C environment, where a z/OS C environment is created once and used repeatedly for C function execution.
  For more information on this type of application, see "Creating and Using Persistent C Environments" on page 512.
• Develop co-routines using a two-stack model, as used in client-server style applications. In this style, the user application calls upon the applications server to perform services independently of the user and then returns to the user.

For more information on this type of application, see “Developing Services in the Service Routine Environment” on page 517.

Note: Using the decimal data type and its related functions (decabs(), decchk(), and decfix()) without z/OS Language Environment is not supported.

Using Functions in the System Programming C Environment

If you do not want to use the z/OS Language Environment run-time library and the z/OS C run-time component within z/OS Language Environment the following functions are available in the SPC environment:

• The following library functions are available as built-in so that they can be used without the run-time library:

  Mathematical
  abs(), fabs()

  Memory manipulation
  memchr(), memcmp(), memcpy(), memset(), cds(), cs()

  String operations
  strcat(), strchr(), strcmp(), strcpy(), strlen(), strrchr()

The built-in versions of these functions are available only if the appropriate header file (string.h, math.h, or stdlib.h) is included in the source file. The use of these functions is described in z/OS C/C++ Run-Time Library Reference.

• The memory management functions, including complete support for:
  – The malloc() function
  – The calloc() function
  – The realloc() function
  – The free() function
  – The HEAP run-time option

• The exit() function

• The sprintf() function.

Note: The use of floating point conversion specifiers (e,E,f,g or G) is not supported without the Language Environment run-time.

Additional memory management functions are available in the system programming C environment, as follows:

  __4kmalc() to allocate page-aligned storage

  __24malc() to allocate storage below the 16MB line in ESA systems (where MB is 1048576 bytes) even when HEAP(ANYWHERE) is specified.

Storage allocated by these functions is not part of the heap, so freeing it is your responsibility. You can use the free() function to free the storage before the environment is terminated. Storage allocated using these functions is not automatically freed when the environment is terminated.
In this environment, low-level memory management functions and contents supervision (loading and deleting executable code) are supported by low-level routines that you can replace to support non-standard environments. This is described in "Tailoring the System Programming C Environment" on page 535.

System Programming C Facility Considerations and Restrictions

When using any system programming C environment, consider the following:

- The long long data type is not supported for the function `sprintf()` under SPC. If you need to use the long long data type, you must use the C/C++ Run-Time library version of the `sprintf()` function.

- The `fetch()` function is not supported when you are running in a system programming C environment. You can use the `EDCXLOAD` routine, as described in "EDCXLOAD" on page 539, to simulate some of the functionality of the `fetch()` function.

- The IMS parameter list established by the `#pragma runopts(PLIST(IMS))` directive is not supported in any of the system programming environments. However, this does not preclude the use of IMS within these environments, because the registers upon entry are available using the `__xregs()` function and `ctdli()` is bound statically. For more information on `__xregs()`, refer to "__xregs() — Get Registers on Entry" on page 545.

- Interlanguage calls to COBOL and PL/I are not supported. However, an SPC program can use the `system()` function to call modules written in other languages.

- SPC is not supported under CICS or MTF.

- Library functions for use with HFS I/O are not supported under SPC. Calling them causes unpredictable results.

- All run-time options are ignored except for:
  - STACK
  - HEAP
  - TRAP.

- Redirection of standard streams is not supported.

- The default initial stack size is the minimum size required to start the C program. (This default is different from the non-systems programming C environments.) If a size is specified, that actual value is used, provided it is large enough. If the value specified is smaller than the requirements for the program, the required value is used.

- The default value for the HEAP run-time option is `HEAP(12K,4K,ANY,FREE)`.

- When you are running a service routine, you should with `#pragma runopts(TRAP(OFF))`.

- Exception handling is not supported in a persistent environment.

- Invoking the `system()` function from an `atexit()` function results in undefined behavior.

- When using the `atexit()` function from a persistent environment, the `atexit` list will not be run until the persistent environment has been terminated by the `__xhott()` library function. For more information about this function, see "__xhott() — Terminate a Persistent C Environment" on page 544.

- Calls to math library functions can be made in a system programming C environment using the dynamic library. For the most efficient use of calls to math library functions, you should enclose the function name in parentheses (). For example, if you make a call to `sin()`, use:
z = (sin)(x);

- You cannot call ctrace(), csnap(), cdump(), or ctest() because they rely on z/OS Language Environment callable services.
- System programming C environments are disjointed from each other; that is, memory files cannot be passed and file control is not maintained across environments. Thus, memory files cannot be passed between a C program and a callee that is written as an assembler exit.

An exception is between environments where the target environment is built with EDCXSTR or EDCXSTRX but does not represent a server. For example, if a C program invokes a freestanding SPC application that is not a server by using system(), a memory file can be passed successfully between the programs.

- When developing an application with an interface with assembler, you can use the DSECT Conversion Utility to build structures mapping to the data types of your DSECTs.
- The POSIX locale features and coded character set conversion routines are supported only for system programming applications that use z/OS Language Environment. They are not available for freestanding applications.

---

**Creating Freestanding Applications**

Freestanding applications are C modules that run either:

- Without z/OS Language Environment and the z/OS C library (using EDCXSTRT)
- Without z/OS Language Environment but with the z/OS C library functions (using EDCXSTRL)

Three initialization routines are provided by SPC for building freestanding applications:

**EDCXSTRT**

For building completely freestanding applications. The applications can use no z/OS C run-time library functions and can have no z/OS Language Environment attachment.

**EDCXSTRL**

For building applications that use z/OS C run-time library functions but have no z/OS Language Environment attachment.

**EDCXSTRX**

This routine accepts a parameter to choose whether your application should behave as if it was initialized with either EDCXSTRT or EDCXSTRL. This parameter is described further in "Setting up a C Environment with Preallocated Stack and Heap" on page 504.

Certain restrictions apply to freestanding applications initialized by the routines EDCXSTRT, EDCXSTRL, and EDCXSTRX. These restrictions are as follows:

- They cannot perform interlanguage calls, except with assembler language routines that preserve register 12 and use the IBM-supplied macros for entry and exit.
- The parameters received by the main() function (normally argc and argv) are undefined. __xregs() (described in "__xregs() — Get Registers on Entry" on page 545) can be used to examine the parameters passed by the calling environment.
- They cannot do arithmetic using long double variables on pre-XA machines (that is, on machines that do not support the DXR instruction).
Creating Modules without CEESTART

In many of the environments described in this chapter, the initialization normally performed by z/OS Language Environment is replaced by special-purpose routines that are tailored to the specific requirements of the type of application. This requires replacing the initialization routine (CEESTART) normally used by z/OS C.

When you do not use the System Programming C Facilities, the compiler generates a CEESTART CSECT (control section) whenever a main() or fetchable function is encountered in the source file. With the NOSTART compiler option, described in the z/OS C/C++ User’s Guide, you can suppress the generation of CEESTART for source files that contain a main() function where this is required. In a system programming C environment, you must compile using the NOSTART option. The object modules created will then be suitable for inclusion in applications that use the alternative initialization routines described in this chapter.

Including an Alternative Initialization Routine under z/OS

When NOSTART is used to suppress the generation of CEESTART, an alternative initialization routine must be explicitly included in the executable by the user at Link Edit. Use the Linkage Editor INCLUDE and ENTRY control statements. To include the alternative initialization routines described in this chapter, allocate CEE.SCEESPC to the SYSLIB DD. For example, you can use the following linkage editor statements to specify EDCXSTRT as an alternative initialization routine:

```
//SYSLIN DD *
    INCLUDE SYSLIB(EDCXSTRT)
    ENTRY EDCXSTRT
    INCLUDE OBJECT(main-function)
/*
```

Figure 141. Specifying Alternative Initialization at Link Edit

Another example of specifying alternative initialization under z/OS is shown in Figure 143 on page 506.

Initializing a Freestanding Application without Language Environment.

EDCXSTRT

This routine is for C applications that do not use any z/OS Language Environment facilities or z/OS C facilities or library functions. It must be explicitly included in the program and specified as the program entry point if it is to be used.

Under this environment, only the following library routines are supported:

- Built-in compiler functions. For a list of these functions, see "Using Functions in the System Programming C Environment" on page 500.
- Memory management routines, including malloc(), calloc(), realloc(), and free().
- The exit() and sprintf() functions.

Note: The use of floating point conversion specifiers (e, E, f, g or G) is not supported without the Language Environment run-time. Since the use of EDCXSTRT allows the application to execute without the use of the Language Environment run-time, the use of the above conversion specifiers with sprintf() in this environment is not supported.

- The __4kmalc() and __24malc() functions.
The value returned to the host system will be the return value from `main()`.

The RENT compiler option is supported in this environment.

**Initializing a Freestanding Application Using C Functions**

**EDCXSTRL**
This routine is the analog of `CEESTART` for C applications that use the z/OS C library functions only. `EDCXSTRL` supports the full library of C functions except for functions such as `cdump()`, `csnap()`, `ctest()`, or `ctrace()`. `EDCXSTRL` must be explicitly included in the program and specified as the program entry point if it is to be used.

The value returned to the host system will be the return value from `main()`.

The RENT compiler option is supported in this environment.

Service routines (described in “Developing Services in the Service Routine Environment” on page 517) require this routine (or `EDCXSTRT` if they do not require z/OS Language Environment) for their initialization.

Applications initialized with this routine will run in any environment supported by z/OS Language Environment.

**Setting up a C Environment with Preallocated Stack and Heap**

**EDCXSTRX**
This routine is the analog of `CEESTART` for an application where you want to have more control over contents supervision and storage management. Unlike `EDCXSTRT`, `EDCXSTRL`, and `CEESTART`, this routine cannot be entered directly from the operating system (that is, from JCL, REXX EXECs, CLISTs, or the TSO command line). It requires a structured parameter list (OS linkage) containing:

**Parameters**

1. The parameter list to be passed to `main()`. `_xregs()` can be used to examine the parameters passed by the calling environment. This list cannot be accessed by `argc` or `argv`.
2. The address of the initial storage area. This area must be doubleword aligned with its first word containing its total length. It must be large enough to accommodate the entire stack requirements of the application.
3. The address of the complete heap allocation (or NULL if no `malloc()` family storage is required by the called routines). This area must be doubleword aligned with its first word containing its total length. This area must include sufficient space for the control structures required to manage the heap (currently a minimum of 40 bytes). Applications that use the z/OS C library functions will always require heap space; the amount required depends on the structure of the application and may vary from run to run if external characteristics (file block sizes, for example) change.

Any heap increments that occur because the size of the initial heap is not large enough will not be freed at termination by the system programming environment. If no initial heap allocation is specified, and a heap is required (because the z/OS C library functions are required, for example), it will not be freed by the System Programming C Environment. If this behavior is detected, the program will run to completion, but will abend during `EDCXSTRX` termination with abend code 2108 and reason code 7207.
Heap increments will be freed if you explicitly free the memory (using the free() function) and the run-time option HEAP(FREE) has been specified. You should specify a heap value of at least 4K if you are running with the z/OS C library functions.

4. The address of the z/OS C run-time library or NULL. Use CEEEV003 (or EDCZV, if you want to maintain compatibility with previous releases of OS/390 Language Environment).

The parameters (argc and argv) passed to the main() function are undefined. There is no argument parsing (argc and argv) or redirection of standard streams.

If the z/OS C library functions are required, the routine EDCXABRT must be explicitly included during the link edit. This routine enables exception handling for EDCXSTRX. If it is not explicitly included, abend code 2107 with reason code 7206 will terminate the program.

The RENT compiler option is supported in this environment only if the z/OS C library functions are used.

**Determining ISA requirements**

**EDCXISA**

This entry point is available to the caller of EDCXSTRX to determine the stack space overhead for the environment being created. Add stack space required by the application to the value returned by this routine to determine the size of the area to be passed as the second parameter to EDCXSTRX. If the routine is called from assembler, the value should be expected in Register 15. The routine should be declared as:

```c
#include <stdio.h>

int main(void) {
    puts("Hello, World");
    return 3999;
}
```

**Building Freestanding Applications to Run under z/OS**

When you are building freestanding applications under z/OS, CEE.SCEESPC must be included in the binder SYSLIB concatenation before CEE.SCEELKED.

The routines to support this function (EDCXSTRT, EDCXSTRL, and EDCXSTRX) are CEESTART replacements (described in "Creating Modules without CEESTART" on page 503) in your module. Therefore, the appropriate EDCXSTRn routine must be explicitly included ahead of the module at link edit.

A simple freestanding routine that requires the library is shown in Figure 142.

**CCNGSP1**

/* this is an example of a freestanding routine */

```c
#include <stdio.h>

int main(void) {
    puts("Hello, World");
    return 3999;
}
```

*Figure 142. Sample Freestanding z/OS Routine*
This routine is compiled normally and link edited using control statements shown in Figure 143. The CEE.SCEERUN load library must be available at run time because it contains the C library function puts().

```
INCLUDE SYSLIB(EDCXSTRL)
INCLUDE OBJECT
ENTRY EDCXSTRL
```

Figure 143. Link Edit Control Statements Used to Build a Freestanding z/OS Routine

Figure 144 shows how to compile and link a freestanding program using the cataloged procedure EDCCL.

```
//JOBC JOB CARD STATEMENTS
/**************************************************************
/************************** COMPILE AND LINK FOR STRL ENTRY POINT 
/**************************************************************
//C106001 EXEC EDCCL,
// INFILE='USERID.SPC.SOURCE(C106000)',
// OUTFILE='USERID.SPC.LOAD(C106000),DISP=SHR',
// CPARM='OPT,NOSQ,NOMAR,NOSTART',
// LPARM='RMODE=ANY,AMODE=31'
//COMPILE.USERLIB DD DSN=userid.HDR.FILES,DISP=SHR
//LKED.SYSLIB DD DSN=CEE.SCEESPC,DISP=SHR
// DD DSN=CEE.SCEELKED,DISP=SHR
//LKED.SYSIN DD *
// INCLUDE SYSLIB(EDCXSTRL)
// ENTRY EDCXSTRL
/*
```

Figure 144. Compile and Link Using EDCCL

Special Considerations for Reentrant Modules

A simple freestanding routine that does not require the library is shown in Figure 145. To develop a reentrant module, this routine must be compiled with both the RENT (because the module contains writable static at [2]) and NOSTART (because this is a system programming environment) compiler options. This routine uses the exit() function, which is normally part of the z/OS Language Environment library. Like sprintf(), it is available to freestanding routines without requiring the dynamic library.

```
CCNGSP2

/* this is an example of a reentrant freestanding routine */
#include <stdlib.h>
int main() {
    static int i[5]={0,1,2,3,4};
    exit(320+i[1]);
}
```

Figure 145. Sample Reentrant Freestanding z/OS Routine

JCL Required

The JCL required to build and execute this routine is shown in Figure 146 on page 507.
The z/OS Language Environment prelinker must be used for modules compiled with the RENT compiler option.

This is the object module created by compiling the sample module with the RENT and NOSTART compiler options.

The output from the prelinker is made available to the linkage editor.

The alternative initialization routine (EDCXSTRT in this example) must be included explicitly in the module. If this is not the first CSECT in the module, it must be explicitly named as the module entry point.

The prelinked output is included in the load module.

EDCXEXIT must be explicitly included if the exit() function is used in the application.

The routine EDCRCINT must be explicitly included in the module if the RENT compiler option is used. No error will be detected at load time if this routine is not explicitly included. At execution time, abend 2106, reason code 7205, will result if EDCRCINT is required but not included.

**Parts Used for Freestanding Applications**

Table 60 on page 508 lists the parts used for freestanding applications and their function and location. The SYSLIB specified is CEE.SCEEESPC.
### Table 60. Parts Used for Freestanding Applications

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Function</th>
<th>Inclusion in Program</th>
<th>Notes</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDCXSTRT</td>
<td>This module is the mainline for applications that do not require the z/OS Language Environment or z/OS C run-time library.</td>
<td>1</td>
<td>This CSECT must be the module entry point.</td>
<td>Member of SCEESPC</td>
</tr>
<tr>
<td>EDCXSTRL</td>
<td>This module is the mainline for applications that require only the C-specific library functions.</td>
<td>1</td>
<td>This CSECT must be the module entry point.</td>
<td>Member of SCEESPC</td>
</tr>
<tr>
<td>EDCXSTRX</td>
<td>This module is the mainline for applications that receive a structured parameter list that includes preallocated storage management areas.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXISA</td>
<td>Get ISA requirements for EDCXSTRX.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXSPRT</td>
<td>System programming version of sprintf().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXEXIT</td>
<td>System programming version of exit().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXMEM</td>
<td>System programming version of malloc(), calloc(), realloc(), free(), _4kmalc() and _24malc().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCRCINT</td>
<td>This must be included if the compiler option RENT is to be used.</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXABRT</td>
<td>System programming version of exception handling.</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. This module must be explicitly included in the program using the binder INCLUDE control statement.
2. This module will normally be included by automatic call.
3. This module must be explicitly included if you want to use the system programming version of the function.

### Creating System Exit Routines

z/OS C allows the creation of routines that have no environmental requirements on entry except:

- Register 13 must point to a 72-byte save area
- Register 14 must contain the return address
- Register 15 must contain the entry address

There is no requirement on the name of the entry point (that is, it does not have to be `main()`), so several different entry points, with names specified by the calling environment, can be combined in the same program.

Routines that do not require the z/OS C environment should specify one of these two pragma forms:

- `#pragma environment(function-name), if the library is required, or`
- `#pragma environment(function-name,nolib), if no library is required.`

This pragma causes the compiler to generate a different prolog for the specified function. The prolog contains the instructions at the beginning of the routine that perform the housekeeping necessary for the function to run, including allocation of...
the function’s automatic storage. This prolog will set up a C environment sufficient for both the function in which it is specified and any function that may be called. Called functions should not specify this pragma, unless they are called elsewhere without a C environment present. This new prolog will load and initialize the module containing the C library functions if this choice is specified.

For more information on the #pragma environment, see z/OS C/C++ Run-Time Library Reference.

The RENT compiler option is not supported in this environment; if you require reentrant system exit routines, the routine must be naturally reentrant. See z/OS Language Environment Programming Guide for more information about reentrancy.

System exit routines can be linked with their callers or dynamically loaded and invoked.

Building System Exit Routines under z/OS

The CEE.SCEESPC object library must be available at link-edit time. If the C library is required by the exit routines, CEE.SCEELKED must also be made available after CEE.SCEESPC. You should explicitly name the entry point with an ENTRY statement.

An Example of a System Exit

Table 61 on page 512 lists the parts used by exit The following C program is a system exit that gains control from the system when an unknown CLIST subroutine is encountered. It checks if the name is recognized as a user-specific subroutine before returning control to the system. For more information on this system exit, see z/OS TSO/E Customization.
/* this is an example of a system exit */
#pragma environment(IKJCT44B,nolib) 1
/* */
/* IKJCT44B CLIST EXIT */
/* */
#include <stdio.h>
#include <stdlib.h>
#include <spc.h>

struct parmentry { int key;
    int len;
    char *pt; }

typedef struct parmentry P_ENT;

#define REVERSE 0
#define FLIPCHR 1
/* Valid commands */
static char *cmds[] =
{
    "SYSXTREV", "SYSXTFLIP" 2
};

void revstring( P_ENT *p11, P_ENT *p12 );
void flipstring( P_ENT *p11, P_ENT *p12 );
int IKJCT44B() {
    int **parme;
    struct parmentry *e7, *e10, *e11, *e12, *e13;

    /* Get registers on entry */
    parme = (void *)__xregs(1); 3
    /* Get the parameter entry values for those relevant for CLISTS */
    e7 = (struct parmentry *)parme[6]; /* exit return */
    e10 = (struct parmentry *)parme[9]; 4
    e11 = (struct parmentry *)parme[10];
    e12 = (struct parmentry *)parme[11];
    e13 = (struct parmentry *)parme[12];

    Figure 147. System Exit Example (Part 1 of 2)
The #pragma environment directive sets up an entry point IKJCT44B other than main().

This is the list of user-specific subroutines that are available in this system exit.
The function __xregs() is used to retrieve the parameters available to the system exit in R1 from the operating system.

The parameters are parameter entries passed from TSO to this system exit and are used for the following reasons:

- **e7**: Exit reason code
- **e10**: Name of subroutine
- **e11**: Arguments
- **e12**: Result

The list of user-specific subroutines is checked and if the unknown CLIST subroutine is recognized, the subroutine is called. Otherwise, the function returns in error.

Table 61 lists the parts used by the routines, and their function and location in MVS. The SYSLIB specified is CEE.SCEESPC.

### Table 61. Parts Used by Exit Routines

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Function</th>
<th>Inclusion in Program</th>
<th>Notes</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDCXENV</td>
<td>Extended prolog code for exits that do not require the library.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXENVL</td>
<td>Extended prolog code for exits that require the library.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXSPRT</td>
<td>System programming version of sprintf().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXEXIT</td>
<td>System programming version of exit().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXMEM</td>
<td>System programming version of malloc(), calloc(), realloc(), free(), __4kmalc() and __24malc().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXABRT</td>
<td>System programming version of exception handling.</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. This module must be explicitly included in the program using the binder INCLUDE control statement.
2. This module will normally be included by automatic call.
3. This module must be explicitly included if you want to use the system programming version of the function.

---

**Creating and Using Persistent C Environments**

Four routines are available to create and use a persistent C environment. These routines are used by an assembler language application that needs a C environment available to support the C functions (not including main()) that it calls.
An initialization routine, EDCXHOTC or EDCXHOTL (depending upon whether the called C subroutines will need the z/OS C library functions), is called to create a C environment. This call returns a handle that can be used (through EDCXHOTU) to call C subroutines. The environment persists until it is explicitly terminated by calling EDCXHOTT.

The four routines are:

- **EDCXHOTC**  
  Sets up a persistent C environment (no library)

- **EDCXHOTL**  
  Sets up a persistent C environment (with library)

- **EDCXHOTU**  
  Runs a function in a persistent C environment

- **EDCXHOTT**  
  Terminates a persistent C environment

The functions that act as entry points for these routines are __xhotc(), __xhotl(), __xhotu(), and __xhott(), respectively. For more information on these four functions, refer to Chapter 35, “Library Functions for System Programming C” on page 543.

The RENT compiler option is not supported in the persistent environment described in this chapter.

Exception handling is not supported in persistent C environments.

As an alternative to the persistent environments, you can also create and retain a C environment using the preinitialized programming interface. This interface supports the RENT compiler option, but is less versatile in other respects. z/OS Language Environment provides a callable service for preinitialization called CEEPIPI. This is described in z/OS Language Environment Programming Guide. You may also find information in “Retaining the C Environment Using Preinitialization” on page 262 helpful.

Building Applications That Use Persistent C Environments

There are no special restrictions for building applications that use persistent C environments. The automatic call facility will cause the correct routines from the SYSLIB to be included.

If any C library function is required by any routine called in this environment, the stub routines library CEE.SCEELKED should be made available at link time after CEE.SCEESPC.

An Example of Persistent C Environments

The assembler routine shown in Figure 149 on page 515 illustrates the use of this feature to call a C function shown in Figure 148 on page 514.
This C function accepts two parameters: an integer and a printf()-style formatting string. The formatting string has a maximum length of 300 bytes; it is terminated by an @ if shorter. This routine must use OS linkage (1). The routine scans the formatting string for the terminator, copies it to a local work area, adds a trailing newline and NULL character, and prints the integer according to the formatting string.

The structure of the assembler caller is shown in Figure 149 on page 515.
* this example demonstrates a persistent C environment
* part 2 of 2-other file is CCNGSP4

```assembly
ENVA CSECT
ENVA AMODE ANY
ENVA RMODE ANY
STM R14,R12,12(R13) 1
LR R3,R15
USING ENVA,R3
GETMAIN R,LV=DSALEN
ST R13,4(R1)
LR R13,R1
USING DSA,R13
LA R4,HANDLE 2
LA R5,STKSIZE
LA R6,STKLOC
STM R4,R6,PARMLIST
OI PARMLIST+8,X'80'
LA R1,PARMLIST
L R15,=V(EDCXHOTL)
BALR R14,R15
LA R8,10 3
LOOP DS OH
ST R8,LOOPCTR 4
LA R4,HANDLE
LA R5,USEFN
LA R6,LOOPCTR
LA R7,FMTSTR1
STM R4,R7,PARMLIST
OI PARMLIST+12,X'80'
LA R1,PARMLIST
L R15,=V(EDCXHOTU)
BALR R14,R15
LA R7,FMTSTR2 5
STM R4,R7,PARMLIST
OI PARMLIST+12,X'80'
L R15,=V(EDCXHOTU)
BALR R14,R15
BCT R8,LOOP
```

Figure 149. Using a Persistent C Environment (Part 1 of 2)
This routine is entered with standard linkage conventions. It saves the registers in the save area pointed to by register 13, acquires a dynamic storage area for its own use, and chains the save areas together.

A C environment that includes support for the z/OS C library is created by calling EDCXHOTL. The parameter list for this call is the address of the handle (for the persistent C environment created), the address of a word containing the initial stack size, and the address of a word containing the initial stack location (0 for below the 16MB line and 1 for above). This parameter list uses the normal OS linkage format.

The routine loops 10 times calling the C function crtn twice each time through the loop.

The parameter list for the first call is the address of the handle, the address of a word pointing to the function, and the parameters to be received by the function. EDCXHOTUL is called. This causes the specified C function, crtn() to be given control with register 1 pointing to the remaining parameters, LOOPCTR and FMTSTR1.

The C function is called again, this time with FMTSTR2 as the second parameter.
When the loop ends, EDCXHOTT is called to terminate the environment created at \[2\].

The routine terminates by freeing its dynamic storage area and returning to its caller.

Table 62 lists the parts used by persistent environments and their function and location. The SYSLIB is CEE.SCEESPC.

### Table 62. Parts Used by Persistent Environments

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Function</th>
<th>Inclusion in Program</th>
<th>Notes</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDCXHOTC</td>
<td>This module is called to set up a C environment without z/OS Language Environment.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXHOTL</td>
<td>This module is called to set up a C environment with the z/OS C library functions available.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXHOTT</td>
<td>This module is called to terminate a C environment set up by EDCXHOTC or EDCXHOTL.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXHOTU</td>
<td>This module is called to use a C environment set up by EDCXHOTC or EDCXHOTL.</td>
<td>2</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXSPRT</td>
<td>System programming version of sprintf().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXEXIT</td>
<td>System programming version of exit().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXMEM</td>
<td>System programming version of malloc(), calloc(), realloc(), free(), __4kmalc() and __24malc().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. This module must be explicitly included in the program using the binder INCLUDE control statement.
2. This module will normally be included by automatic call.
3. This module must be explicitly included if you want to use the system programming version of the function.

## Developing Services in the Service Routine Environment

The purpose of an application service routine environment is to allow the development, using z/OS C, of services that can be developed, tested, and packaged independently of their intended users. You can:
- Isolate the service code from its user
- Specify and enforce a clearly defined Application Programming Interface (API) between the user (another application program) and the service routine
Share server code among more than one (perhaps different) user applications simultaneously
Enhance or maintain the service routine code with no disruption to its various user applications

In this environment, a service application is developed as a `main()` function together with any functions it may call, and packaged as a complete program. This program, if it is reentrant, can be freely installed in the ELPA and shared by all of its users.

To provide the service to a user application, the developer of the service must offer small assembler language stub routines that are link-edited with the user code. These stub routines use services provided by the System Programming Facilities to load or locate the server code and pass messages to it for execution. Examples of these stub routines are shown in "Constructing User-Server Stub Routines" on page 534.

Using Application Service Routine Control Flow

In this section examples are based on a service routine that manages a storage queue. This server might be used by languages that do not support dynamic memory allocation, or by applications that do not want to concern themselves with the management of such data structures. The operations supported by this service routine are:

- Initialize
- Terminate
- Add an element to the head of the queue (last in, first out)
- Add an element to the tail of the queue (first in, first out)
- Get the element at the head of the queue

Service Routine User Perspective

A conversation is initiated when a user routine calls a startup routine supplied by the author of the service to establish a connection between the user and the server. This routine returns a handle to the user that represents the server environment. User routines may establish connections with many different services or many times with the same server as long as the needed resources, principally memory, are available in the system. Each connection has a different handle, and it is the user routine's responsibility to keep track of them.

Note: Memory files cannot be shared between the user routines and the server.

Once the user has initialized the server, it uses other server-supplied stub routines to send requests (messages) to the server for action. One of the parameters to this routine will be the handle returned by the initialize call. These request stubs would typically return a feedback code to indicate success or failure as well as any other information requested. The server defines the parameter list to be passed and the feedback codes to be given to the user.

When the user is finished with the server, it calls yet another stub routine to terminate the server.

This structure is illustrated in a sample user routine shown in Figure 150 on page 519.
The user routine sets up a variable that will be used to hold the handle returned by the server. The form taken by this handle is up to the supplier of the service, but a fullword (4 bytes) should be regarded as typical.

The user routine calls the initialize routine to set up the connection between the user routine and the server.

The user routine adds three strings to the queue. In this example, the first character of the string indicates the order in which the user expects to retrieve the strings.

The user enters a loop in which the strings are retrieved from the queue.

The user routine prints out the strings passed back by the call to the server. If there is no string remaining in the queue a null string (zero length) is returned.

Before ending, the user routine closes down the server.

This routine is linked normally with the server-supplied stub routines (described in “Constructing User-Server Stub Routines” on page 534).
Service Routine Perspective
A service routine is a complete, stand alone module that runs in its own C environment. Its environment is created on demand by user application routines that call it using stub routines supplied by the server. When this happens, the server code enters at its main() entry point and, typically, goes into a loop that contains a function call to get the next to-do. One possible to-do is terminate; when this command is received the server should exit() or return from its main() function. The environment created when the server was started terminates and all resources held by the server are freed (except storage acquired by __24malc() or __4kmalc(), as described in "__24malc() — Allocate Storage below 16MB Line" on page 547 and "__4kmalc() — Allocate Page-Aligned Storage" on page 547.

This structure is illustrated in a sample user routine shown in Figure 151:

**CCNGSP7:**

```c
/* this is an example of an application service routine */

#include <spc.h>
#include <stdlib.h>
#include <string.h>

#define LIFO 1
#define FIFO 2
#define GET 3
#define TERM -1

int main(void) {

    int retcode=0;

    /* data structures to manage the queue */
    struct queue_entry {
        struct queue_entry *next;
        int length;
        char val[1];
    };

    struct queue_entry *head;
    struct queue_entry *tail;
```

Figure 151. Example of application service routine (Part 1 of 3)
struct {
    int code;
    union info *plist;
} *req;

union info {
    struct {
        int *length;
        char *string;
    } lifo;
    struct {
        int *length;
        char *string;
    } fifo;
    struct {
        int *length;
        char *string;
    } get;
};

/* initialize the queue pointers */
head = NULL;
tail = NULL;
/* the main processing loop goes on until a termination signal
is sent */

for(;;) {
    union info *info;
    int length;
    char *string;
    struct queue_entry *ent;
    /* get a message from the user routine */
    req = __xsrvc(retcode);
    info = req->plist;
    switch(req->code) {
    case LIFO: {
        length = *(*info).lifo.length;
        string = (*info).lifo.string;
        ent = malloc(sizeof *ent - 1 + length);
        memcpy((ent).val, string, length);
        __xsacc(0);
        (ent).length = length;
        (ent).next = head;
        head = ent;
        if (NULL == tail) tail = ent;
        break;
    }
    }
    
    Figure 151. Example of application service routine (Part 2 of 3)
The server routine should include the appropriate header files. `spc.h` contains the function prototypes for the routines that are used to maintain the conversation between the server routine and the user routine. `string.h` is required if string or memory functions are used in the code and z/OS Language Environment will not be available at run time; this header file contains the directives necessary to use these built-in functions.

These are the command codes of the requests that can be sent to this server.

The server begins with a `main()` function. This function gets control when the user calls `QMGINIT`.

This server manages an in-storage queue of unstructured elements. It does this by maintaining a linked list of elements. The structure `queue_entry` contains an individual entry; `head` and `tail` point to the first and last entries in the queue.

Requests come to the server in the form of a pointer to a structure containing a command code (in this case, one of LIFO, FIFO, GET, or TERM) and a pointer to a parameter list associated with the command code. The parameter list is what follows `HANDLE` and `FEEDBACK` in the calls to `QMGLIFO`, `QMGGETH`, `QMGETFIFO`, and `QMGETTERM`.

```c
void main()
{
  // Initial code
  switch (cmd_code) {
  case FIF0: { /* Code for FIF0 */ }
  case GET: { /* Code for GET */ }
  case TERM: /* Code for TERM */
  default: /* Code for default */
  }
}
```

Figure 151. Example of application service routine (Part 3 of 3)
QMGFIFO, and QMGGET. Like the command codes, the structure of this parameter list is established in concert with the stub routines.

In this example, all the commands have exactly the same format. This may not generally be the case, so a union of the various parameter list formats is appropriate. Then the interface can be expanded without disrupting existing code.

Before accepting commands, required initialization is performed.

This server is structured as an endless loop. This loop terminates when a terminate message sends control to a return statement at 17.

At this point, the server is ready for work. The call to __xsrvc() causes the user routine to resume execution at the place it left off when it last called the server. The value passed as the parameter is made available to the stub routines for use as a feedback code. This function will not return until the user application sends a request (using one of the stub routines, in this example QMGLIFO, QMGFIFO, QMGGET, or QMGTERM).

Extract the parameters from the structure pointed to by the call to __xsrvc().

Examine the request code sent by the user application.

The LIFO request code is handled here.

These library functions (and many others, the complete list is given in "Using Functions in the System Programming C Environment" on page 500) are normally available in this environment even though z/OS Language Environment is not available at run time.

The amount of storage allocated is the size of the queue entry (defined at 4) minus 1 (because the definition of the entry allowed for 1 character of value) plus the length actually required for the value.

This function should be used to indicate that the server has completed its use of any data structures (parameters and data areas pointed to by the parameters) belonging to the user application. The value passed to this function or the value passed by the next call to __xsrvc() (which ever is greater in magnitude) will be passed to the stub routine for use as a feedback code.

The handling of FIFO and GET is similar.

When a terminate request is received, the server returns. This terminates the loop (at 8) and the environment set up when the server was first called.

If the command code is not recognized the server acknowledges the request and sets a return code that can be analyzed by the stub routine or the user application.

The server returns to the request for another to-do. The value passed as a parameter here or the last value passed to __xsacc(), whichever has the greater magnitude, is passed to the stub routine for use as a feedback code.

The server is built as a freestanding C application as described in "Creating Freestanding Applications" on page 502.

You must specify EDCXSTRT, QMGSERV, EDCXMEM and EDCXEXIT when you link edit.
Understanding the Stub Perspective

The stub routines provide the link between the user application and the application service module. They are responsible for:

- Locating or loading the server code
- Providing the Application Programming Interface (API) seen by the user.

Many choices are available in the design of the API and how single calls in the user are mapped. For example, the initialize call could accept parameters governing the behavior of the session being established and pass them to the server as commands once the server has been initialized. In the example the interactions are straightforward, the initialize only starts up the server, and the message calls send single messages, untouched and unexamined, to the server.

There are two kinds of stubs: the initialization stub and the message stubs. Termination is a special case of a message stub. These stubs are most appropriately written in assembler so that they can run in any language environment with minimal performance cost.

The initialization stub is responsible for loading and calling the server. It can use the low-level storage management and contents supervision routines supplied in SCEESPC. These routines are described in Tailoring the System Programming C Environment on page 535. The structure of an initialization stub is shown in Figure 152 on page 525.
Stub routines are presumed to have a save area available at the location pointed to by register 13.

The parameter list passed to stub routines is OS linkage; that is, register 1 points to a list of addresses. In this example, the initialization stub receives only one parameter, the handle, that gets the address of a control block representing the environment.

For efficiency, this routine gets a work area that will be used by all the stub routines. The low level storage management routine EDCXGET, (described in “EDCXGET” on page 536) is available for this purpose. This area will be the DSA for this and all other stub routines. It begins with a 18-word save area for use by routines called by this stub. It will be freed by the “terminate” stub.

When a save area is available, EDCXLOAD (described in “EDCXLOAD” on page 539) is called to load the server.
EDCXSRSVI is called to initialize the server. When control is returned from this call, the server has built a complete environment and has asked for something to do.

The value returned by EDCXSRSVI is the address of a control block that is used to manage the interface between the user application and the service application module. The first 3 words (12 bytes) of this control block are reserved for the exclusive use of the stub routines. The fields following the first 3 words may not be used by either the stub routines or the user, nor may their values be altered. In this example, an eye-catcher (often useful for debugging) is moved into the first word.

The address of the work area acquired for dynamic storage requirements is moved into the second word. The address of this control block is stored in the user’s handle.

The address of the control block from EDCXSRSVI is placed in the user routine’s handle. The user routine has no knowledge of the contents or format of this field; it is simply a token that is passed to other stub routines to manage the conversation between the user and the service routine.

Having initialized the server, the stub returns to the user at 2 in Figure 150 on page 519.

Message stubs are responsible for passing requests from the user application to the service application. Like the initialization stub, they are free to use the low-level storage management and contents supervision routines supplied with the system programming facilities. Example message stubs are shown in Figure 153 on page 527, Figure 154 on page 528, Figure 155 on page 530, and Figure 156 on page 532.
Like the initialize stub, the QMGLIFO message stub expects a standard save area pointed to by register 13. The parameters are passed with standard OS linkage (register 1 pointing to a list of addresses).

The handle contains the value that was placed there by the initialization stub at \(\text{Figure 152 on page 525}\). This is the address of the control block that is used to manage the interface between the user application and the server.

Recover the address of the stub work area for use as a Dynamic Storage Area (DSA). This value was saved here by the initialization stub at The save area back chain field is set according to usual conventions.

A parameter list consisting of the handle (as returned by EDCXSRSVI at \(\text{Figure 152 on page 525}\) in the initialization stub), code for LIFO, and the address of the remaining parameters.

---

**Figure 153. Example of Server Message Stub-LIFO**

1. Like the initialize stub, the QMGLIFO message stub expects a standard save area pointed to by register 13. The parameters are passed with standard OS linkage (register 1 pointing to a list of addresses).

2. The handle contains the value that was placed there by the initialization stub at \(\text{Figure 152 on page 525}\). This is the address of the control block that is used to manage the interface between the user application and the server.

3. Recover the address of the stub work area for use as a Dynamic Storage Area (DSA). This value was saved here by the initialization stub at The save area back chain field is set according to usual conventions.

4. A parameter list consisting of the handle (as returned by EDCXSRSVI at \(\text{Figure 152 on page 525}\) in the initialization stub), code for LIFO, and the address of the remaining parameters.
Call EDCXSRVN to re-awaken the server. This causes the server to resume control at $SF580000$ in Figure 151 on page 520 in the server. The server has control until it asks for the next to-do, in this example at $SF580009$.

The value passed to \_\_xsrvc() appears as the return code from EDCXSRVN. This value is passed back to the user application in the second parameter. This is part of the API defined by this particular server, not something inherent in the user-server relationship.

Control is returned to the user in the usual way.

This routine uses functions supplied in SCEESPC to load or locate the server code and initialize its environment.

**CCNGSPD**

* this is an example of a server message stub
QMGFIFO TITLE 'SERVER supplied stub for feeding strings FIFO'
QMGFIFO CSECT
QMGFIFO AMODE ANY
QMGFIFO RMODE ANY

```
STM R14,R12,12(R13)  
LR R3,R15
USING QMGFIF0,R3
LR R5,R1
USING INPARMS,R5
L R6,HANDLE@
L R6,0,(R6)
L R1,4,(R6)
USING WA,R1
ST R13,SA+4
Keep savearea passed into us
LR R13,R1
USING WA,R13
LA R7,FIFO
LA R8,INPARMS+8
User parms start at 3rd handle, FIFO, Other parms
STM R6,R8,PLIST
LA R1,PLIST
L R15,=V(EDCXSRVN)  
BALR R14,R15
L R1,FEEDBK@
ST R15,0,(R1)
L R13,4,(R13)
L R14,12(R13)
LM R0,R12,20(R13)
BR R14
```

INPARMS DSECT
HANDLE@ DS F
FEEDBK@ DS F
LENGTH@ DS F
STRING@ DS F
WA DSECT
SA DS 18F
PLIST DS 4F
WALEN EQU \_\_xsrvc() -WA
LIFO EQU 1
FIFO EQU 2
GET EQU 3
TERM EQU -1
YREGS
END

Figure 154. Example of Server Message Stub-FIFO

Like the initialize stub, the QMGFIFO message stub expects a standard
save area pointed to by register 13. The parameters are passed with standard OS linkage (register 1 pointing to a list of addresses).

2 The *handle* contains the value that was placed there by the initialization stub at 8 in Figure 152 on page 525. This is the address of the control block that is used to manage the interface between the user application and the server.

3 Recover the address of the stub work area for use as a Dynamic Storage Area (DSA). This value was saved here by the initialization stub at 7 in Figure 152 on page 525. The save area back chain field is set according to usual conventions.

4 A parameter list consisting of the handle (as returned by EDCXSRSVI at 5 in Figure 152 on page 525), code for FIFO, and the address of the remaining parameters.

5 Call EDCXSRSVN to *re-awaken* the server. This causes the server to resume control at 9 in Figure 151 on page 520 in the server. The server has control until it asks for the next to-do, in this example at 9 in Figure 151 on page 520, again.

6 The value passed to __xsrvc() appears as the return code from EDCXSRSVN. This value is passed back to the user application in the second parameter. *This is part of the API defined by this particular server, not something inherent in the user-server relationship."

7 Control is returned to the user in the usual way.

This routine uses functions supplied in SCEESPC to load or locate the server code and initialize its environment.
Like the initialize stub, the QMGGET message stub expects a standard save area pointed to by register 13. The parameters are passed with standard OS linkage (register 1 pointing to a list of addresses).

The handle contains the value that was placed there by the initialization stub at Figure 152 on page 525. This is the address of the control block that is used to manage the interface between the user application and the server.

Recover the address of the stub work area for use as a Dynamic Storage Area (DSA). This value was saved here by the initialization stub at Figure 152 on page 525. The save area back chain field is set according to usual conventions.
A parameter list consisting of the handle (as returned by EDCXSRVI at Figure 152 on page 525 in the initialization stub), code for GET, and the address of the remaining parameters.

Call EDCXSrvn to re-awaken the server. This causes the server to resume control at 9 in Figure 151 on page 520 in the server. The server has control until it asks for the next to-do, in this example at 9 in Figure 151 on page 520, again.

The value passed to __xsvc() appears as the return code from EDCXSrvn. This value is passed back to the user application in the second parameter. This is part of the API defined by this particular server, not something inherent in the user-server relationship.

Control is returned to the user in the usual way.

This routine uses functions supplied in SCEESPC to load or locate the server code and initialize its environment.
* this is an example of a server message stub
QMTERMTITLE 'SERVER supplied stub for feeding strings TERM'
QMTERMSECT
QMTERAMODE ANY
QMTERMRMODE ANY

STMR14,R12,12(R13)  
LRR3,R15
USINGQMTERM,R3
LRR5,R1
USINGINPARMS,R5
L R6,HANDLE@
L R6,0,(R6)  
Poineto the handle
L R1,4,(R6)  
Point to work area got by QMGINIT
USINGWA,R1
ST R13,SA+4
LR R13,R1
USINGINPARMS,R13
ST R6,PLIST
MVCPLIST+4,=A(TERM)  
Code for termination
LAR1,PLIST
LR R15,=V(EDCXSRVN)  

BALRR14,R15
LR R13,4,(R13)  
L R14,12(R13)
LM R0,R12,20(R13)
BR R14

INPARMSDSECT
HANDLE@DS F
FEEDBK@DS F
LENGTH@DS F
STRING@DS F
WA DSECT
SA DS 18F
PLISTDS 4F
WALEN EQU =*-WA
LIFO EQU 1
FIFO EQU 2
GET EQU 3
TERM EQU -1
YREGSEND

Figure 156. Example of Server Message Stub-TERM

1 Like the initialize stub, the QMTERMT message stub expects a standard
save area pointed to by register 13. The parameters are passed with
standard OS linkage (register 1 pointing to a list of addresses).

2 The handle contains the value that was placed there by the initialization
stub at 3 in Figure 152 on page 525. This is the address of the control
block that is used to manage the interface between the user application and
the server.

3 Recover the address of the stub work area for use as a Dynamic Storage
Area (DSA). This value was saved here by the initialization stub at 7 in
Figure 152 on page 525. The save area back chain field is set according to
usual conventions.

4 A parameter list consisting of the handle (as returned by EDCXSRVI at 5 in
Figure 152 on page 525), code for TERM, and the address of the remaining
parameters.
Call EDCXSRVN to re-awaken the server. This causes the server to resume control at \( 5 \) in Figure 151 on page \( 520 \) in the server. The server has control until it asks for the next to-do, in this example at \( 6 \) in Figure 151 on page \( 520 \) again.

Control is returned to the user in the usual way.

The routines in the following section are used to create and use a persistent C environment for a server co-routine, written using z/OS C and EDCXSTRT, or EDCXSTRL and callable by a user application written in any language.

An initialization routine, EDCXSRVI, is called to start up a server. Control returns from the initialization call with the server code started and waiting for work.

As with the persistent C environment, the initialization call returns a handle that is used by EDCXSRVN for further communication with the created environment. EDCXSRVN suspends the execution of the calling routine and sends a message to the waiting server. When the server completes the function called for by the message its execution is suspended and the caller of EDCXSRVN resumes.

The server environment is terminated when a Terminate message is sent to the server.

Establishing a Server Environment

EDCXSRVI
This routine creates a z/OS C environment for the server part of user-server application. It is intended that this routine be called by a stub routine supplied by the server and statically bound with the user application. The stub routine is responsible for loading the server application code.

Parameters
1. The address of the entry point of the server code. This must be the address of the EDCXSTRT or EDCXSTRL entry point.
2. The value to be in R1 when the server entry point is called. This can be used for communication between the initialization stub and the server mainline; its value can be retrieved in the server code. \( __\_x{\_x}{\_x}{\_x}re{\_x}{\_x}{\_x}{\_x}gs(1) \) will return a pointer to this list of parameters.
3. The address of a low-level get-storage routine (meeting the same interface as EDCXGET, but not necessarily EDCXGET).
4. The address of a low-level free-storage routine (meeting the same interface as EDCXFREE, but not necessarily EDCXFREE).

Return
When this routine returns the server environment is fully established and waiting for a message from the user. R15 points to a handle that is used in subsequent calls to EDCXSRVN to send messages to the server.

Initiating a Server Request

EDCXSRVN
This routine is used by the stub routines that are linked with user application routines to send a message to an active server in a user-server application.
Parameters
1. The address of the handle returned by EDCXSRSVI.
2. The function code for the function to be performed. The value -1 is used to indicate that the server should terminate. This value should not be used for any other purpose.
3. Other parameters, which are passed to the server code.

Return
R15 will contain the return code supplied by the server (as the parameter to EDCXSACC) for this service.

Accepting a Request for Service
EDCXSACC
This routine operates in the server part of a user-server application. It is used to indicate acceptance or rejection of the last-requested service.

Parameters
1. The return code of the last-requested service 0 indicating that the request was accepted and will be processed.

For more information on EDCXSACC, see "xsacc() — Accept Request for Service" on page 546.

Returning Control from Service
EDCXSRVC
This routine operates in the server part of a user-server application. It is used to indicate completion of the last-requested service and to get information required for the next service to be performed.

Parameters
1. The return code for the last-requested service.

For more information on EDCXSRVC, see "xsrvc() — Return Control from Service" on page 546.

Constructing User-Server Stub Routines
Part of building a server for use in a user-server environment is the construction of stub routines that load and initialize the server, pass messages to the server, and terminate the server. These stub routines are typically written in assembler language to allow them to be freely called from other environments without regard to the characteristics of the calling environment.

Building User-Server Environments
To build your server application, follow the rules for building a freestanding application as described in "Building Freestanding Applications to Run under z/OS" on page 505.

There are no special considerations for building user applications. The automatic call facility will cause the correct routines from CEE.SCEESPC to be included.
### Table 63. Parts used by or with Application Server Routines

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Function</th>
<th>Inclusion in Program</th>
<th>Notes</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDCXSRVI</td>
<td>This module is used by a server-supplied stub routine to start up a server.</td>
<td>2</td>
<td>in the user module</td>
<td>Member of SCEESPC</td>
</tr>
<tr>
<td>EDCXSRVN</td>
<td>This module is used by a server-supplied stub routine to send a service-request message to a server.</td>
<td>2</td>
<td>in the user module</td>
<td>Member of SCEESPC</td>
</tr>
<tr>
<td>EDCXRVC</td>
<td>This module is used by a server to wait for the next message to process.</td>
<td>2</td>
<td>in the user module</td>
<td>Member of SCEESPC</td>
</tr>
<tr>
<td>EDCXSACC</td>
<td>This module is used by a server to accept the last message received.</td>
<td>2</td>
<td>in the user module</td>
<td>Member of SCEESPC</td>
</tr>
<tr>
<td>EDCXSPRT</td>
<td>System programming version of sprintf().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXEXIT</td>
<td>System programming version of exit().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
<tr>
<td>EDCXMEM</td>
<td>System programming version of malloc(), calloc(), realloc(), free(), _4kmalc() and _24malc().</td>
<td>3</td>
<td>Member of SCEESPC</td>
<td></td>
</tr>
</tbody>
</table>

### Notes:
1. This module must be explicitly included in the program using the binder INCLUDE control statement.
2. This module will normally be included by automatic call.
3. This module must be explicitly included if you want to use the system programming version of the function.

---

### Tailoring the System Programming C Environment

Depending on the environment under which you want to run your z/OS C routines, you might want to replace some of the following routines for system-specific routines. To work correctly, your routines should match the interface as documented in this section.

The routines as supplied by IBM with z/OS C meet the interface as documented.

### Generating Abends

**EDCXABND**

This routine is called to generate an abend if there is an internal error during initialization or termination of a system programming C environment.

**Parameter**

**R1**  The address of the abend code and reason code
This routine is not provided with a save area. In addition to the linkage registers, this routine may freely alter registers 2 and 4.

This module must have the entry point name of @XABND.

**CCNGSPA:**

* this is an example of a routine to generate an abend
@@XABEND TITLE 'Generate an Abend'
EDCXABND CSECT
EDCXABND AMODE ANY
EDCXABND RMODE ANY
@@XABND DS 0H
ENTRY @@XABND
BALR R2,0
USING *,R2
SPACE 1
*
  USING PARMS,R1
L R4,REAS_RC get reason code
L R2,ERROR_RC get error code
DROP R1,R2
ABEND ABEND (R2),REASON=(R4)
*
  LTORG
EJECT
PARMS DSECT
ERROR_RC DS F
REAS_RC DS F
*
R1 EQU 1
R2 EQU 2
R3 EQU 3
R4 EQU 4
END

*Figure 157. Example of Routine to Generate Abend*

**Getting Storage**

**EDCXGET**

This routine is called to get storage from the operating system.

**Parameter**

R0   The requested length, in bytes. If the high-order bit is zero or if the request was made in 24-bit addressing mode, the storage will be allocated below the 16M line. If the high-order bit is on and the request is made in 31-bit addressing mode, storage will be allocated anywhere with a preference for storage above the 16M line if available.

**Return**

R0   The length of the storage block acquired, in bytes.
R1   The address of the acquired area or NULL.
R15  A system dependent return code, which must be zero on success and non-zero otherwise.

This routine is not provided with a save area. In addition to the linkage registers, this routine may freely alter registers 2 and 4.
The entry point name for this routine must be @@XGET.

If you provide your own EDCXGET routine, it will be used when C library functions explicitly get storage. Whenever the library functions invoke operating system services, there may be implicit requests for storage that cannot be tailored.

**CCNGSPB**

* this is an example of a routine to get storage
@@XGET TITLE 'Obtain memory as specified in R0'
EDCXGET CSECT
EDCXGET AMODE ANY
EDCXGET RMODE ANY
@@XGET DS 0H
ENTRY @@XGET
SPACE 1
BALR R2,R0
USING *,R2
LTR R0,R0 Memory above or below?
BNL BELOW
SLL R0,1 Want memory anywhere
SRL R0,1
LTR R2,R2 are we running above the line?
BNL BELOW no, so ignore above request
GETMAIN RC,SP=0,LV=(R0),LOC=ANY
LTR R15,R15 Was it successful?
BZR R14 Yes...
SR R1,R1 No, indicate failure
BR R14

* Figure 158. Example of routine to get storage (Part 1 of 2)

BELOW DS 0H Get memory below the line
GETMAIN RC,SP=0,LV=(R0),LOC=BELOW
LTR R15,R15 Was it successful?
BZR R14 Yes...
SR R1,R1 No, indicate failure in R1
BR R14

* Figure 158. Example of routine to get storage (Part 2 of 2)

**Getting Page-Aligned Storage**

**EDCX4KGT**
This routine is called to get page-aligned storage from the operating system.

**Parameter**

R0 The requested length, in bytes. If the high-order bit of this register is zero or if the request was made in 24-bit addressing mode, the storage is allocated below the 16M line. If the high-order bit is on and the request is made in
31-bit addressing mode, storage is allocated above the 16M line. If this space is not available, storage is allocated elsewhere.

Return
R0  The length of the storage block acquired, in bytes. This length may be greater than the size requested.
R1  The address of the acquired area or NULL.
R15 A system-dependent return code, which must be zero on success and nonzero otherwise.

This routine is not provided with a save area. In addition to the linkage registers, this routine may freely alter registers 2 and 4.

Its entry point must be @0X4KGET.

Freeing Storage

EDCXFREE
This routine is called to return storage to the operating system.

Parameters
R0  The length of storage to be freed, in bytes
R1  The address of the area to be freed

Return
R15 A system-dependent return code, which must be zero on success and nonzero otherwise

This routine is not provided with a save area. In addition to the linkage registers, this routine may freely alter registers 2 and 4.

Its entry point must be @0XFREE.

If you provide your own EDCXFREE routine, it will be used when C library functions explicitly free storage. Whenever the library functions invoke operating-system services, there may be implicit requests to free storage that cannot be tailored.

CCNGSPC
Loading a Module

**EDCXLOAD**
This routine is called to load a named module into storage.

**Parameter**
R1 Points to the name of the routine to be loaded

**Return**
R1 the address and amode of the routine or 0
R15 A system-dependent return code, which must be zero on success and nonzero otherwise

This routine is provided with a save area. Apart from the linkage registers, it must save and restore all registers used.

Its entry point must be @@XLOAD.

Deleting a Module

**EDCXUNLD**
This routine is called to delete a named module from storage.

**Parameter**
R1 Points to the name of the routine to be deleted

**Return**
R15 A system-dependent return code, which must be zero on success and nonzero otherwise

This routine is provided with a save area. Apart from the linkage registers, it must save and restore all registers used.

Its entry point must be @@XUNLD.
Including a Run-Time Message File

When you are running a freestanding environment and run-time messages are required, you must explicitly include a message file at link-edit time. One of the three following modules can be included to produce these messages:

EDCXLANE
Creates run-time error messages in uppercase and lowercase English

EDCXLANU
Creates run-time error messages in uppercase English

EDCXLANK
Creates run-time error messages in Kanji

If one of these message routines is not included and an exception occurs, the program could terminate without displaying a message. These error messages are directed to stderr. Refer to z/OS Language Environment Debugging Guide for more information.

The following tables contain the abend codes and reason codes specific to the system programming facilities.

Table 64. Abend Codes Specific to System Programming Environments

<table>
<thead>
<tr>
<th>Abend Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2100</td>
<td>No storage abend code</td>
</tr>
<tr>
<td>2101</td>
<td>Error freeing storage</td>
</tr>
<tr>
<td>2102</td>
<td>Error finding stack seg home</td>
</tr>
<tr>
<td>2103</td>
<td>Error loading library</td>
</tr>
<tr>
<td>2104</td>
<td>Error with heap allocation</td>
</tr>
<tr>
<td>2105</td>
<td>Error with system level command</td>
</tr>
<tr>
<td>2106</td>
<td>Error initializing statics</td>
</tr>
<tr>
<td>2107</td>
<td>Error establishing error handler for EDCXSTRX</td>
</tr>
<tr>
<td>2108</td>
<td>Error cleaning up heap for EDCXSTRX</td>
</tr>
<tr>
<td>4000</td>
<td>Error when handling abend</td>
</tr>
</tbody>
</table>

Table 65. Reason Codes Specific to System Programming Environments

<table>
<thead>
<tr>
<th>Reason Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7201</td>
<td>Error in initialization.</td>
</tr>
<tr>
<td>7202</td>
<td>Error in termination.</td>
</tr>
<tr>
<td>7203</td>
<td>Error when extending stack.</td>
</tr>
<tr>
<td>7204</td>
<td>Error during longjmp/setjmp.</td>
</tr>
<tr>
<td>7205</td>
<td>Can not locate static init. The routine EDCRCINT must be included in your module if you use the RENT compiler option.</td>
</tr>
<tr>
<td>7206</td>
<td>Module EDCXABRT was not explicitly included at link edit time.</td>
</tr>
<tr>
<td>7207</td>
<td>No initial heap allocation is specified and a heap is required.</td>
</tr>
</tbody>
</table>
Additional Library Routines

The following routines provide additional support that is unique to applications running in a system programming C environment. These routines are packaged as part of the link library.

- __xregs() Get registers on entry
- __xusr() Get address of User Word
- __xusr2() Get address of User Word
- __4kmalc() Allocate page-aligned storage
- __24malc() Allocate storage below 16mb line

For more information on these routines refer to Chapter 35, “Library Functions for System Programming C” on page 543.

Summary of Application Types

Table 66 shows the summary of application types, how they are called, and the module entry points.

Table 66. Summary of Types

<table>
<thead>
<tr>
<th>Type of Application</th>
<th>How It Is Called</th>
<th>Module Entry Point</th>
<th>Data Sets Required at Execution Time</th>
<th>Run-Time Options (1) and Other Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A mainline function that requires no dynamic library facilities</td>
<td>From the command line, JCL, or an EXEC or CLIST.</td>
<td>EDCXSTRT, which must be explicitly included at bind time</td>
<td>None.</td>
<td>Run-Time options are specified by #pragma runopts in compilation unit for the main() function. The heap and stack options are honored. The stack defaults to be above the line.</td>
</tr>
<tr>
<td>A mainline function that requires the z/OS C library functions</td>
<td>From the command line, JCL, or an EXEC or CLIST.</td>
<td>EDCXSTRL, which must be explicitly included at bind time</td>
<td>CEE.SCEERUN is required</td>
<td>Run-Time options are specified by #pragma runopts in the compile unit for the entry point. The heap and stack options are honored, except that the stack will default to be above the line. The SPIE option is honored if a library is called for.</td>
</tr>
<tr>
<td>Type of Application</td>
<td>How It Is Called</td>
<td>Module Entry Point</td>
<td>Data Sets Required at Execution Time</td>
<td>Run-Time Options (1) and Other Considerations</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------</td>
<td>--------------------</td>
<td>--------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>A C subroutine called from assembler language using a pre-established persistent environment</td>
<td>A handle, the address of the subroutine and a parameter list are passed to EDCXHOTU.</td>
<td>CEE.SCEERUN is optional, depending upon the way the handle was set up.</td>
<td>Run-Time options are specified by #pragma runopts in any compile unit. The heap and stack options are honored, except that the stack will default to be above the line. The SPIE option is honored if a library is called for. The runopts in the first object module in the link edit that contains runopts will prevail, even if this compilation unit is part of the calling application. The environment is established by calling EDCXHOTC (or EDCXHOTL if library facilities are required). These functions return a value (the handle) which is used to call functions that use the environment.</td>
<td></td>
</tr>
<tr>
<td>A Server</td>
<td>User code includes a stub routine that calls EDCXSRVI. This causes the server to be loaded and control to be passed to its entry point.</td>
<td>EDCXSTRT, or EDCXSTRL, depending upon whether the server needs the C run-time library or not</td>
<td>CEE.SCEERUN if required by the server code.</td>
<td>Run-Time options are the same as for EDCXSTRL or EDCXSTRT. The author of the server must supply stub routines which call EDCXSRVI and EDCXSRVN to initialize and communicate with the server. These are bound with the user application.</td>
</tr>
<tr>
<td>A User of an Application Server</td>
<td></td>
<td>The server and CEE.SCEERUN if required by the server.</td>
<td></td>
<td>The author of the server must supply stub routines which call EDCXSRVI and EDCXSRVN to initialize and communicate with the server.</td>
</tr>
</tbody>
</table>
This chapter describes the library functions specific to the System Programming C environment:

- `__xhotc()`
- `__xhotl()`
- `__xhott()`
- `__xhotu()`
- `__xregs()`
- `__xsacc()`
- `__xsrvc()`
- `__xusr()`
- `__xusr2()`
- `__24malc()`
- `__4kmalc()`

### __xhotc() — Set Up a Persistent C Environment (No Library)

#### Format

```c
#include <spc.h>

void *__xhotc(void *handle, int stack, int location);
```

#### Description

The function creates a persistent C environment that does not require the dynamic library facilities of z/OS Language Environment at run time. The parameters are fullwords (four bytes).

1. `handle` is the field for the token (or handle) which is returned.
2. `stack` is the initial stack allocation required for the environment.
3. `location` is the location of the stack:

   - 0 Below the line
   - 1 Above the line

`__xhotc()` is specific to SP C. It is part of the group serving the persistent C environment.

The function is also available under the name `EDCXHOTC`.

#### Returned Value

`__xhotc()` returns a token (or handle) which is used in subsequent calls to `__xhotu()` and `__xhott()` to use or terminate a persistent C environment. This handle is found in both the first parameter passed and R15.

The RENT compiler option is not supported for routines called using this environment.
Example

For an extensive example of the use of __xhotc() see "Creating and Using Persistent C Environments" on page 512.

__xhotl() — Set Up a Persistent C Environment (With Library)

Format

```c
#include <spc.h>

void *__xhotl(void *handle, int stack, int location);
```

Description

The function creates a persistent C environment that will use the dynamic z/OS C/C++ library functions. All library facilities are available in this environment except:

- The RENT compiler option is not supported in the persistent environment described in this chapter.
- Exception handling is not supported in persistent C environments.

The following parameters are fullwords (four bytes):

1. `handle` is the field for the token (or handle) which is returned.
2. `stack` is the initial stack allocation required for the environment.
3. `location` is the location of the stack:
   - 0 Below the line
   - 1 Anywhere

__xhotl() is specific to SP C. It is part of the group serving the persistent C environment.

The function is also available under the name EDCXHOTL.

Returned Value

This routine returns a token (or handle) which is used in subsequent calls to __xhotu() and __xhott() to use or terminate a persistent C environment. This handle is found in both the first parameter passed and R15.

Example

For an extensive example of the use of __xhotl() see "Creating and Using Persistent C Environments" on page 512.

__xhott() — Terminate a Persistent C Environment

Format

```c
#include <spc.h>

void __xhott(void *handle);
```

Description

This function terminates a persistent C environment created by __xhotc() or __xhotl().

The parameter of __xhott() is a handle returned by __xhotc() or __xhotl().

__xhott() is specific to SP C. It is part of the group serving the persistent C environment.
The function is also available under the name EDCXHOTT.

**Example**
For an extensive example of the use of __xhotu() see "Creating and Using Persistent C Environments" on page 512.

---

__xhotu() — Run a Function in a Persistent C Environment

**Format**

```c
#include <spc.h>

void *__xhotu(void *handle, void *function, ...);
```

**Description**
This function is used to run a function in a persistent C environment. The parameters are fullwords (four bytes):
1. `handle` is a handle—returned by __xhotc() or __xhotl()
2. `function` is a function pointer, which points to the desired C function
3. First parameter to pass to the function
4. Second parameter to pass to the function
   : 

This routine, and the C function being called, must use OS linkage. As a result, you cannot make direct use of z/OS C/C++ Library functions with this function. C functions being invoked using __xhotu() must be compiled with #pragma linkage(func_name,OS).

__xhotu() is specific to SP C. It is part of the group serving the persistent C environment.

The function is also available under the name EDCXHOTU.

**Returned Value**
The returned value from __xhotu() is the returned value from the function run in the persistent C environment.

**Example**
For an extensive example of the use of __xhotu() see "Creating and Using Persistent C Environments" on page 512.

---

__xregs() — Get Registers on Entry

**Format**

```c
#include <spc.h>

int __xregs(int register);
```

**Description**
This routine finds the value a specified register had on entry to EDCXSTRT, EDCXSTRL, EDCXSTRX, or the main routine of an exit routine compiled with #pragma environment(...).

__xregs() is available in these environments only. For more information about EDCXSTRT, EDCXSTRL, or EDCXSTRX, see "Creating Freestanding Applications" on page 502.
__xregs() is specific to SP C. It is part of the client-server group of functions.

The function is also available under the name EDCXREGS.

Returned Value
__xregs() returned the value found.

__xsacc() — Accept Request for Service

Format
#include <spc.h>

void __xsacc( int message );

Description
This routine operates in the server part of a user-server application. It is used to indicate acceptance or rejection of the last-requested service.

Calls to __xsacc are optional but, if made, should be when the request is validated and all server references to user-owned storage are complete. __xsacc does not cause a return of control to the user; its sole purpose is to indicate that user-owned storage is no longer required by the application server.

In the case of a request that cannot be processed, possibly because the user’s command is not recognized by the server or the parameter format is invalid, the call to __xsacc should be omitted.

__xsacc() is specific to SP C. It is part of the client-server group of functions.

The function is also available under the name EDCXSACC.

Returned Value
The return code for the last-requested service, zero indicating that the request was accepted and will be processed.

__xsrvc() — Return Control from Service

Format
#include <spc.h>

void *__xsrvc(int message);

Description
This routine operates in the server part of a user-server application. It is used to indicate completion of the last-requested service and to get the information required for the next service to be performed.

message is the return code for the last-requested service.

__xsrvc() is specific to SP C. It is part of the client-server group of functions.

The function is also available under the name EDCXSRC.
__xusr() - __xusr2() — Get Address of User Word

Format
#include <spc.h>

void *__xusr(void);
void *__xusr2(void);

Description
Two words in an internal control block are available for customer use. These words have an initial value of zero (that is, all bits are 0), but are otherwise ignored by compiled code, and by the z/OS C/C++-specific Library. The values in these words may be freely queried or set by application code using the pointers returned by these functions.

__xusr() and __xusr2() are specific to SP C.

The __xusr() and __xusr2() functions are also available under the names EDCXUSR and EDCXUSR2, respectively.

Returned Value
__xusr() and __xusr2() return the addresses of these user words. The words, and indeed __xusr() and __xusr2() themselves, are available in any environment, not only the system programming environments.

__24malc() — Allocate Storage below 16MB Line

Format
#include <spc.h>

void *__24malc(size_t size);

Description
This function performs in the same manner as malloc except that it allocates storage below the 16MB line in XA or ESA systems even when the run-time option HEAP(ANYWHERE) is specified.

Storage allocated by this function is not part of the heap, so you must free this storage explicitly using the free() function before this environment is terminated.

Storage allocated using __24malc() is not automatically freed when the environment is terminated.

The function is available under the System Programming Environment.

__4kmalc() — Allocate Page-Aligned Storage

Format
#include <spc.h>

void *__4kmalc(size_t size);

Description
This function performs in the same manner as malloc() except that it allocates page-aligned storage.
Storage allocated by this function is not part of the heap, so you must free this storage explicitly using the `free()` function before this environment is terminated. Storage allocated using `__4kmalloc()` is not automatically freed when the environment is terminated.

The function is available under the System Programming Environment.
Chapter 36. Using Run-Time User Exits

This chapter shows how to use run-time user exits with the z/OS Language Environment run-time library. This is general-use programming interface information and associated guidance information for using the library.

This section is provided here for your convenience. For further information on using run-time user exits in the z/OS Language Environment environment, refer to *z/OS Language Environment Programming Guide*.

Using Run-Time User Exits in z/OS Language Environment

z/OS Language Environment provides user exits that you can use for functions at your installation. You can use the assembler user exit (CEEBXITA) or the HLL user exit (CEEINT). This section provides information about using these run-time user exits.

**Note:** You cannot code either the CEEBXITA user exit or the CEEINT user exit as an XPLINK application.

Understanding the Basics

User exits are invoked under z/OS Language Environment to perform enclave initialization functions and both normal and abnormal termination functions. User exits offer you a chance to perform certain functions at a point where you would not otherwise have a chance to do so. In an assembler initialization user exit, for example, you can specify a list of run-time options that establish characteristics of the environment. This is done before the actual execution of any of your application code. Another example is using an assembler termination user exit to request a dump after your application has terminated with an abend.

In most cases, you do not need to modify any user exit to run your application. Instead, you can accept the IBM-supplied default versions of the exits, or the defaults as defined by your installation. To do so, run your application normally and the default versions of the exits are invoked. You may also want to read the sections "User Exits Supported under z/OS Language Environment" on page 550 and "Order of Processing of User Exits" on page 550, which provide an overview of the user exits and describe when they are invoked.

If you plan to modify either of the user exits to perform some specific function, you must link the modified exit to your application before running, as described in "Using Installation-Wide or Application-Specific User Exits" on page 551. In addition, the sections "Using the Assembler User Exit" on page 552 and "High Level Language User Exit Interface" on page 563 describe the respective user exit interfaces to which you must adhere to change an assembler or HLL user exit.

PL/I and C/370 Compatibility

For more information on compatibility support for the IBMXITA and IBMFXITA assembler user exits, see "PL/I and C/370 Compatibility" on page 562. Refer to IBM C/370 Library Version 2 Release 2 Programming Guide or to PL/I for MVS & VM Compiler and Run-Time Migration Guide for information about the IBMBINT HLL user exit. IBMBINT is not available under C++.
User Exits Supported under z/OS Language Environment

z/OS Language Environment provides two user exit routines, one written in assembler and the other in an HLL. You can find sample jobs containing these user exits in the SCEESAMP sample library.

The user exits supported by z/OS Language Environment are shown in Table 67.

Table 67. User Exits Supported under z/OS Language Environment

<table>
<thead>
<tr>
<th>Name</th>
<th>Type of User Exit</th>
<th>When Invoked</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEBXITA</td>
<td>Assembler user exit</td>
<td>Enclave initialization, Enclave termination, Process termination</td>
</tr>
<tr>
<td>CEEBINT</td>
<td>HLL user exit. CEEBINT can be written in z/OS C, PL/I, z/OS Language Environment-conforming assembler, or in C++ (see restrictions in &quot;Order of Processing of User Exits&quot;).</td>
<td>Enclave initialization</td>
</tr>
</tbody>
</table>

Order of Processing of User Exits

The location and order in which user exits are driven for your application are summarized in Figure 160.

In Figure 160, run-time user exits are invoked in the following sequence:
1. Assembler user exit is invoked for enclave initialization.

   The assembler user exit (CEEBXITA) is invoked very early during the initialization process, before the enclave initialization is complete. Early invocation of the assembler exit allows the enclave initialization code to benefit from any changes that might be contained in the exit. If run-time options are provided in the assembler exit, the enclave initialization code is aware of the new options.
2. Environment is established.

3. HLL user exit is invoked.

The HLL initialization exit (CEEBINT) is invoked just before the invocation of the application code. In z/OS Language Environment, this exit can be written in z/OS C, PL/I, z/OS Language Environment-conforming assembler, or z/OS C++. However, you can only write CEEBINT in z/OS C++ if the following conditions are met:

- CEEBINT must be declared with C linkage, i.e., it must be declared with `extern "C"`. If you are using C, you must compile your application code with the `RENT` compile-time option.
- You must bind your application code with the z/OS binder.
- CEEBINT must be used as an application-specific user exit, rather than as an installation-wide user exit (refer to "Using Installation-Wide or Application-Specific User Exits" for more information).

The HLL initialization exit cannot be written in COBOL, although COBOL applications can use this HLL user exit. At the time when CEEBINT is invoked, the run-time environment is fully operational and all z/OS Language Environment-conforming HLLs are supported.

4. Main routine is invoked.

5. Main routine returns control to caller.

6. Environment is terminated.

7. Assembler user exit is invoked for termination of the enclave.

CEEBXITA is invoked for enclave termination processing after all application code in the enclave has completed, but before any enclave termination activity.

8. Assembler user exit is invoked for termination of the process.

CEEBXITA is invoked again when the z/OS Language Environment process terminates.

Although both the assembler and HLL exits are invoked for initialization, they do not perform exactly the same functions. See "CEEBXITA Behavior during Enclave Initialization" on page 552 and "High Level Language User Exit Interface" on page 563 for a detailed description of each exit.

z/OS Language Environment provides the CEEBXITA assembler user exit for termination but does not provide a corresponding HLL termination user exit.

### Using Installation-Wide or Application-Specific User Exits

IBM offers default versions of CEEBXITA and CEEBINT. You can use the IBM-supplied default version of either exit, or you can customize CEEBXITA or CEEBINT for use on an installation-wide basis. When CEEBXITA or CEEBINT is linked with the z/OS Language Environment initialization/termination library routines during installation, it functions as an installation-wide user exit.

Finally, you can customize CEEBXITA or CEEBINT yourself for use on your application. When CEEBXITA or CEEBINT is linked in your program, it functions as an application-specific user exit. The application-specific exit is used only when you run that application. The installation-wide assembler user exit is not executed.

To obtain an application-specific user exit, you must explicitly include it at bind time in the application using a binder INCLUDE control statement. Any time that the application-specific exit is modified, it must be relinked with the application.
Using the Assembler User Exit

The assembler user exit CEEBXITA tailors the characteristics of the enclave before it is established. CEEBXITA must be written in assembler language because an HLL environment may not yet be established when the exit is invoked. CEEBXITA is driven for enclave initialization and enclave termination regardless of whether the enclave is the first enclave in the process or a nested enclave. CEEBXITA can differentiate easily between first and nested enclaves. For more information about nested enclaves, see z/OS Language Environment Programming Guide.

CEEBXITA behaves differently depending on when it is invoked, as described in the following sections.

Using Sample Assembler User Exits

Sample assembler user exit programs are distributed with z/OS Language Environment. You can use them and modify the code for the requirements of your own application. Choose a sample program appropriate for your application. The following assembler exit user programs are delivered with z/OS Language Environment.

Table 68. Sample Assembler User Exits for z/OS Language Environment

<table>
<thead>
<tr>
<th>Example User Exit</th>
<th>Operating System</th>
<th>Language (if Language Specific)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEBXITA</td>
<td>MVS (default)</td>
<td></td>
</tr>
<tr>
<td>CEEBXITC</td>
<td>TSO</td>
<td></td>
</tr>
<tr>
<td>CEECXITA</td>
<td>CICS (default)</td>
<td></td>
</tr>
<tr>
<td>CEEBX05A</td>
<td>MVS</td>
<td>COBOL</td>
</tr>
</tbody>
</table>

Note:
1. CEEBXITA and CEECXITA are the defaults on your system for MVS and CICS, if z/OS Language Environment is installed at your site without modification.
2. The source code for CEEBXITA, CEEBXITC, CEEDXITA, and CEEBX05A can be found on MVS in the sample library SCEEISAMP.
3. CEEBX05A is an example user exit program for COBOL applications on z/OS.

CEEBXITA Behavior during Enclave Initialization

The CEEBXITA assembler user exit is invoked before enclave initialization is performed. You can use it to help guide the establishment of the environment in which your application runs. For example, you can allocate data sets in the assembler user exit. The user exit can interrogate program parameters supplied in the JCL and change them if desired. In addition, you can specify run-time options in the user exit using the CEEAUE_OPTIONS field of the assembler interface (see “Assembler User Exit Interface” on page 554 for information about how to do this).

CEEBXITA performs no special tasks other than to return control to z/OS Language Environment initialization.

CEEBXITA Behavior during Enclave Termination

The CEEBXITA assembler exit is invoked after the user code for the enclave has completed, but before the occurrence of any enclave termination activity. For example, CEEBXITA is invoked before the storage report is produced (if one was
requested), before data sets are closed, and before HLLs are invoked for enclave
termination. In other words, the assembler user exit for termination is invoked when
the environment is still active.

The assembler user exits allow you to request an abend. Under z/OS (as well as
TSO and CICS), you can also request a dump to assist in problem diagnosis. Note
that termination activities have not yet begun when the user exit is invoked. Thus,
the majority of storage has not been modified when the dump is produced.

It is possible to request an abend and dump in the enclave termination user exit for
all enclave-terminating events.

Example code that shows how to request an abend and dump when there is an
unhandled condition of severity 2 or greater can be found in the member CEEBX05A
in the sample library.

**CEEBXITA Behavior during Process Termination**
The CEEBXITA assembler exit is invoked after:

- All enclaves have terminated.
- The enclave resources have been relinquished.
- Any z/OS Language Environment-managed files have been closed.
- Debug Tool has terminated.

This allows you to free files at this time, and it presents another opportunity to
request an abend.

During termination, CEEBXITA can interrogate the z/OS Language Environment
reason and return codes and, if necessary, request an abend with or without a
dump. This can be done at either enclave or process termination.

The IBM-supplied CEEBXITA performs no special tasks other than to return control to
z/OS Language Environment termination.

**Specifying Abend Codes to Be Percolated by z/OS Language
Environment**
The assembler user exit, when invoked for initialization, can return a list of abend
codes that are to be percolated by z/OS Language Environment. On non-CICS
systems, this list is contained in the CEEAUE_A_AB_CODES field of the assembler user
exit interface. (See **"Assembler User Exit Interface"** on page 554) Both system
abends and user abends can be specified in this list.

When TRAP(ON) is in effect, and the abend code is in the CEEAUE_A_AB_CODES list,
z/OS Language Environment percolates the abend. Normal z/OS Language
Environment condition handling is never invoked to handle these abends. This
feature is useful when you do not want z/OS Language Environment condition
handling to intervene for some abends, for example, when IMS issues abend code
777.

When TRAP(OFF) is specified, the condition handler is not invoked for any abends or
program interrupts. The use of TRAP(OFF) is not recommended; refer to z/OS
**Language Environment Programming Reference** for more information.
Actions Taken for Errors that Occur within the Assembler User Exit
If any errors occur during the enclave initialization user exit, the standard system action occurs because z/OS Language Environment condition handling has not yet been established.

Any errors occurring during the enclave termination user exit lead to abnormal termination (through an abend) of the z/OS Language Environment environment.

If a program check occurs during the enclave termination user exit and TRAP(ON) is in effect, the application ends abnormally with ABEND code 4044 and reason code 2. If a program check occurs during the enclave termination exit and "TRAP(OFF)" has been specified, the application ends abnormally without additional error checking support. z/OS Language Environment provides no condition handling; error handling is performed by the operating system. The use of TRAP(OFF) is not recommended; refer to z/OS Language Environment Programming Guide for more information.

z/OS Language Environment takes the same actions as described above for program checks during the process termination user exit.

Assembler User Exit Interface
You can modify CEEBXITA to perform any function desired, although the exit must have the following attributes after you modify it:

- The user-supplied exit must be named CEEBXITA.
- The exit must be reentrant.
- The exit must be capable of executing in AMODE(ANY) and RMODE(ANY).
- The exit must be relinked with the application after modification (if you want an application-specific user exit), or relinked with z/OS Language Environment initialization/termination routines after modification (if you want an installation-wide user exit).

If a user exit is modified, you are responsible for conforming to the interface shown in Figure 161 on page 555. This user exit must be written in assembler.
When the user exit is called, register 1 (R1) points to a word that contains the address of the CXIT control block. The high order bit is on.

The CXIT control block contains the following fullwords:

**CEEAUE_LEN** (input parameter)
A fullword integer that specifies the total length of this control block. For z/OS Language Environment, the length is 48 bytes.

**CEEAUE_FUNC** (input parameter)
A fullword integer that specifies the function code. In z/OS Language Environment, the following function codes are supported:
1 - initialization of the first enclave within a process
2 - termination of the first enclave within a process
3 - nested enclave initialization
4 - nested enclave termination
5 - process termination

The user exit should ignore function codes other than those numbered from 1 through 5.

**CEEAUE_RETC** (input/output parameter)
A fullword integer that specifies the return or abend code. CEEAUE_RETC has different meanings depending on the flag CEEAUE_ABND:
- As an input parameter, this fullword is the enclave return code.
As an output parameter, if the flag CEEAU_ABND is on, this fullword is interpreted as an abend code that is used when an abend is issued. (This could be either an EXEC CICS ABEND or an SVC 13.)

If the flag CEEAU_ABND is off, this fullword is interpreted as the enclave return code that might have been modified by the exit.

See [z/OS Language Environment Programming Guide](#) for more information about how z/OS Language Environment computes return and reason codes.

**CEEAUE_RSNC** (input/output parameter)
A fullword integer that specifies the reason code for CEEAU_RETC.

- As an input parameter, this fullword is the z/OS Language Environment return code modifier.
- As an output parameter, if the flag CEEAU_ABND is on, CEEAU_RETC is interpreted as an abend reason code that is used when an abend is issued. (This field is ignored when an EXEC CICS ABEND is issued.)
- If the flag CEEAU_ABND is off, this fullword is the z/OS Language Environment return code modifier that might have been modified by the exit.

See [z/OS Language Environment Programming Guide](#) for more information about how z/OS Language Environment computes return and reason codes.

**CEEAUE_FLAGS** (input/output parameter)
Contains four flag bytes. CEBXITA uses only the first byte but reserves the remaining bytes. All unspecified bits and bytes must be zero. The layout of these flags is shown in [Figure 162](#).

![Figure 162. CEEAU_FLAGS Format](#)

**Byte 0**
- CEEAU_ABTERM
- 0... - Normal termination
- 1... - Abnormal termination
- .x... - CEEAU_ABND
- .0... - Terminate with CEEAU_RETC
- .1... - Abend with CEEAU_RETC and CEEAU_RSNC given
- ..x... - CEEAU_DUMP
- ..0... Reserve for future use

**Byte 1**
- 00 - Reserved for future use

**Byte 2**
- 00 - Reserved for future use

**Byte 3**
- 00 - Reserved for future use

**Figure 162. CEEAU_FLAGS Format**

Byte 0 (CEEAUE_FLAG1) has the following meaning:

**CEEAUE_ABTERM** (input parameter)
When OFF, the enclave terminates normally (severity 0 or 1 condition).
When ON, the enclave terminates with the z/OS Language Environment return code modifier of 2 or greater. This could, for example, indicate that a condition of severity 2 or greater was raised that was unhandled.

**CEEAUE_ABND** (output parameter)
When OFF, the enclave terminates without an abend. CEEAUE_RETC and CEEAUE_RSNC are placed in register 15 and register 0 and returned to the enclave creator.

When ON, the enclave terminates with an abend. Thus, CEEAUE_RETC and CEEAUE_RSNC are used by z/OS Language Environment in the invocation of the abend. While executing in CICS, an EXEC CICS ABEND command is issued.

CEEAUE_RSNC is ignored under CICS. The TRAP option does not affect the setting of CEEAUE_ABND.

**CEEAUE_DUMP** (output parameter)
When OFF and you request an abend, an abend is issued without requesting a system dump.

When ON and you request an abend, an abend is issued requesting a system dump.

**CEEAUE_STEPS** (output parameter)
When OFF and you request an abend, one is issued to abend the entire task.

When ON and you request an abend, one is issued to abend the step.

**Note:** This fullword is ignored under CICS.

**CEEAUE-A-CC-PLIST** (input/output parameter)
A fullword pointer to the parameter address list of the application program.

As an input parameter, this fullword contains the register 1 value passed to the main routine. The exit can modify this value, and the value is then passed to the main routine. If run-time options are present in the invocation command string, they are stripped off before the exit is called.

If the parameter inbound to the main routine is a character string, CEEAUE-A-CC-PLIST contains the address of a fullword address that points to a halfword prefixed string. If this string is altered by the user exit, the string must not be extended in place.

**CEEAUE_WORK** (input parameter)
Contains a fullword pointer to a 256-byte work area that the exit can use. On entry, it contains binary zeros and is doubleword-aligned.

This area does not persist across exits.

**CEEAUE_OPTIONS** (output parameter)
On return, this field contains a fullword pointer to the address of a halfword length prefixed character string that contains run-time options. These options are only processed for enclave initialization. When invoked for enclave termination, this field is ignored.

These run-time options override all other sources of run-time options except those that are specified as non-overrideable in the installation default run-time options.

Under CICS, the STACK run-time option cannot be modified using the assembler user exit.
CEEAE_USERWD (input/output parameter)
Contains a fullword whose value is maintained without alteration and passed to every user exit. On entry to the enclave initialization user exit, it is zero. Thereafter, the value of the user word is not altered by z/OS Language Environment or any member libraries. The user exit can change the value of this field and z/OS Language Environment maintains this value. This allows a user exit to initialize the fullword and pass it to subsequent user exits.

CEEAE_A_AB_CODES (output parameter)
During the initialization exit, this field contains the fullword address of a table of abend codes that the z/OS Language Environment condition handler percolates while in the (E)STAE exit. Therefore, the application is not given the opportunity to field the abend. The table consists of:
- A fullword count of the number of abend codes that are to be percolated
- A fullword for each of the particular abend codes that are to be percolated

The abend codes can be user abend codes or system abend codes. User abend codes are specified by F'uuu'. For example, if you wanted user abend 777 to be percolated, an F'777' would be coded. System abend codes are specified by X'00sss000'. Avoid specifying the values 0C0 through 0CF as 'sss'. Language Environment ignores values between OCO and OCF. No abend is percolated, and z/OS Language Environment condition handling semantics are in effect.

This function is not enabled under CICS.

CEEAE_FBCODE (input parameter)
Contains the fullword address of the condition token with which the enclave terminated. If the enclave terminates normally (that is, not because of a condition), the condition token is zero.

CEEAE_PAGE (input/output parameter)
Usage of this field is related to PL/I BASED variables that are allocated storage outside of AREAs. You can indicate whether storage should be allocated on a 4K-page boundary. You can specify the minimum number of bytes of storage that you want allocated. Your allocation request must be an exact multiple of 4K. The IBM-supplied default setting for CEEAE_PAGE is 32768 (32K).

If CEEAE_PAGE is set to zero, PL/I BASED variables can be placed on other than 4K-page boundaries.

CEEAE_PAGE is honored only during enclave initialization (that is, when CEEAE_FUNC is 1 or 3).

The offset of CEEAE_PAGE under z/OS Language Environment is different from the offset of IBMBXITA under OS PL/I Version 2 Release 3.

Parameter Values in the Assembler User Exit
The parameters described in the following sections contain different values depending on how the user exit is used. Possible values are shown for the parameters based on how the assembler user exit is invoked.

First Enclave within Process Initialization—Entry
CEEAE_LEN 48
CEEAE_FUNC 1 (first enclave within process initialization function code).
CEEAE_RETC 0
**First Enclave within Process Initialization—Return**

- **CEEAEU_RETC**: 0, or if `CEEAEU_ABND = 1`, the abend code.
- **CEEAEU_RSNC**: 0, or if `CEEAEU_ABND = 1`, the reason code for `CEEAEU_RETC`.
- **CEEAEU_FLAGS**: `CEEAEU_ABND = 1` if an abend is requested, or 0 if the enclave should continue with termination processing.
  - `CEEAEU_DUMP = 1` if the abend should request a dump.
  - `CEEAEU_STEPS = 1` if the abend should abend the step, or 0 if the abend should abend the task.
- **CEEAEU_A-CC-PLIST**: Register 1, used as the new parameter list.
- **CEEAEU_OPTIONS**: Pointer to the address of a halfword prefixed character string containing run-time options, or 0.
- **CEEAEU_USERWD**: Value of `CEEAEU_USERWD` for all subsequent exits.
- **CEEAEU_A_AB_CODES**: Pointer to the abend code table, or 0.
- **CEEAEU_PAGE**: User-specified `PAGE` value. Minimum number of storage bytes to be allocated for PL/I BASED variables (default = 32768).

**First Enclave within Process Termination—Entry**

- **CEEAEU_LEN**: 48
- **CEEAEU_FUNC**: 2 (first enclave within process termination function code).
- **CEEAEU_RETC**: Return code issued by the application that is terminating.
- **CEEAEU_RSNC**: Reason code that accompanies `CEEAEU_RETC`.
- **CEEAEU_FLAGS**: `CEEAEU_ABTERM = 1` if the application is terminating with the z/OS Language Environment return code modifier of 2 or greater, or 0 otherwise.
  - `CEEAEU_ABND = 0`
  - `CEEAEU_DUMP = 0`
  - `CEEAEU_STEPS = 0`
- **CEEAEU_WORK**: Address of a 256-byte work area of binary zeros.
CEEAE_USERWD  Return value from the previous exit.
CEEAE_FBCODE  Feedback code causing termination.

First Enclave within Process Termination—Return
CEEAE_RETC  If CEEAE_ABND = 0, the return code placed in register 15 when the enclave terminates.
            If CEEAE_ABND = 1, the abend code.
CEEAE_RSNC  If CEEAE_ABND = 0, the enclave reason code.
            If CEEAE_ABND = 1, the abend reason code.
CEEAE_FLAGS  CEEAE_ABND = 1 if an abend is requested, or 0 if the enclave should continue with termination processing.
            CEEAE_DUMP = 1 if the abend should request a dump.
            CEEAE_STEPS = 1 if the abend should abend the step, or 0 if the abend should abend the task.
CEEAE_USERWD  The value of CEEAE_USERWD for all subsequent exits.

Nested Enclave Initialization—Entry
CEEAE_LEN  48
CEEAE_FUNC  3 (nested enclave initialization function).
CEEAE_RETC  0
CEEAE_RSNC  0
CEEAE_FLAGS  0
CEEAE-A-CC-PLIST  The register 1 value discovered in a nested enclave creation.
CEEAE_WORK  Address of a 256-byte work area of binary zeros.
CEEAE_USERWD  The return value from previous exit.
CEEAE_FBCODE  0
CEEAE_PAGE  Minimum number of storage bytes to be allocated for PL/I BASED variables (default = 32768).

Nested Enclave Initialization—Return
CEEAE_RETC  0, or if CEEAE_ABND = 1, the abend code.
CEEAE_RSNC  0, or if CEEAE_ABND = 1, the reason code for CEEAE_RETC.
CEEAE_FLAGS  CEEAE_ABND = 1 if an abend is requested, or 0 if the enclave should continue with termination processing.
            CEEAE_DUMP = 1 if the abend should request a dump.
            CEEAE_STEPS = 1 if the abend should abend the step, or 0 if the abend should abend the task.
<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEAUE-A-CC-PLIST</td>
<td>Register 1 used as the new parameter list.</td>
</tr>
<tr>
<td>CEEAUE_OPTIONS</td>
<td>Pointer to a fullword address that points to a halfword prefixed string containing run-time options, or 0.</td>
</tr>
<tr>
<td>CEEAUE_USERWD</td>
<td>The value of CEEAUE_USERWD for all subsequent exits.</td>
</tr>
<tr>
<td>CEEAUE_A_AB_CODES</td>
<td>Pointer to the abend code table, or 0.</td>
</tr>
<tr>
<td>CEEAUE_PAGE</td>
<td>User-specified PAGE value. Minimum number of storage bytes to be allocated for PL/I BASED variables (default = 32768).</td>
</tr>
</tbody>
</table>

**Nested Enclave Termination—Entry**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEAUE_LEN</td>
<td>48</td>
</tr>
<tr>
<td>CEEAUE_FUNC</td>
<td>4 (termination function).</td>
</tr>
<tr>
<td>CEEAUE_RETC</td>
<td>Return code issued by the enclave that is terminating.</td>
</tr>
<tr>
<td>CEEAUE_RSNC</td>
<td>Reason code that accompanies CEEAUE_RETC.</td>
</tr>
<tr>
<td>CEEAUE_FLAGS</td>
<td>CEEAUE_ABTERM = 1 if the application is terminating with the z/OS Language Environment return code modifier of 2 or greater, or 0 otherwise.</td>
</tr>
<tr>
<td></td>
<td>CEEAUE_ABND = 0</td>
</tr>
<tr>
<td></td>
<td>CEEAUE_DUMP = 0</td>
</tr>
<tr>
<td></td>
<td>CEEAUE_STEPS = 0</td>
</tr>
<tr>
<td>CEEAUE_WORK</td>
<td>Address of a 256-byte work area of binary zeros.</td>
</tr>
<tr>
<td>CEEAUE_USERWD</td>
<td>Return value from previous exit.</td>
</tr>
<tr>
<td>CEEAUE_FBCODE</td>
<td>Feedback code causing termination.</td>
</tr>
</tbody>
</table>

**Nested Enclave Termination—Return**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEAUE_RETC</td>
<td>If CEEAUE_ABND = 0, the return code from the enclave.</td>
</tr>
<tr>
<td></td>
<td>If CEEAUE_ABND = 1, the abend code.</td>
</tr>
<tr>
<td>CEEAUE_RSNC</td>
<td>If CEEAUE_ABND = 0, the enclave reason code.</td>
</tr>
<tr>
<td></td>
<td>If CEEAUE_ABND = 1, the enclave reason code.</td>
</tr>
<tr>
<td>CEEAUE_FLAGS</td>
<td>CEEAUE_ABND = 1 if an abend is requested, or 0 if the enclave should continue with termination processing.</td>
</tr>
<tr>
<td></td>
<td>CEEAUE_DUMP = 1 if the abend should request a dump.</td>
</tr>
<tr>
<td></td>
<td>CEEAUE_STEPS = 1 if the abend should abend the step, or 0 if the abend should abend the task.</td>
</tr>
<tr>
<td>CEEAUE_USERWD</td>
<td>Value of CEEAUE_USERWD for all subsequent exits.</td>
</tr>
</tbody>
</table>

**Process Termination—Entry**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEAUE_LEN</td>
<td>48</td>
</tr>
</tbody>
</table>
CEEAUE_FUNC  5 (process termination function).
CEEAUE_RETC  Return code presented to the invoking system in register 15 that reflects the value returned from the first enclave within process termination.
CEEAUE_RSNC  Reason code accompanying CEEAUE_RETC that is presented to the invoking system in register 0 and reflects the value returned from the first enclave within process termination.
CEEAUE_FLAGS  CEEAUE_ABTERM = 1 if the last enclave is terminating abnormally (that is, the z/OS Language Environment return code modifier is 2 or greater). This reflects the value returned from the first enclave within process termination (function code 2).

CEEAUE_ABND = 1 if an abend is requested, or 0 if the enclave should continue with termination processing first enclave within process termination (function code 2).

CEEAUE_DUMP = 0
CEEAUE_STEPS = 0

CEEAUE_WORK  Address of a 256-byte work area of binary zeros.
CEEAUE_USERWD  The return value from previous exit.
CEEAUE_FBCODE  The feedback code causing termination.

Process Termination—Return

CEEAUE_RETC  If CEEAUE_ABND = 0, the return code from the process.
If CEEAUE_ABND = 1, the abend code.

CEEAUE_RSNC  If CEEAUE_ABND = 0, the reason code for CEEAUE_RETC from the process.
If CEEAUE_ABND = 1, reason code for the CEEAUE_RETC abend reason code.

CEEAUE_FLAGS  CEEAUE_ABND = 1 if an abend is requested, or 0 if the enclave should continue with termination processing.

CEEAUE_DUMP = 1 if the abend should request a dump.
CEEAUE_STEPS = 1 if the abend should abend the step, or 0 if the abend should abend the task.

CEEAUE_USERWD  The value of CEEAUE_USERWD for all subsequent exits.

PL/I and C/370 Compatibility

The following OS PL/I Version 2 Release 3 assembler user exits are supported for compatibility under z/OS Language Environment:

IBMBXITA (MVS Batch version)
IBMFXITA (CICS version)

562  z/OS V1R4.0 C/C++ Programming Guide
For more information about IBMBXITA see PL/I for MVS & VM Compiler and Run-Time Migration Guide. These user exits are available only under C, not C++.

Default versions of the above exits are not supplied under z/OS Language Environment; instead, z/OS Language Environment supplies a default version of CEEBXITA. Table 69 describes the order of precedence if the IBMBXITA and IBMFXITA user exits are found in the same root program with CEEBXITA.

Table 69. Interaction of Assembler User Exits

<table>
<thead>
<tr>
<th>CEEBXITA Present</th>
<th>IBMBXITA Present under MVS Batch, IBMFXITA Present under CICS</th>
<th>Exit Driven</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>Default version of CEEBXITA</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>CEEBXITA</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>IBMBXITA under MVS Batch; IBMFXITA under CICS</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>CEEBXITA</td>
</tr>
</tbody>
</table>

CXIT FUNC in IBMBXITA will map to CEEBXITA as follows:
- CXIT FUNC = 1 when IBMBXITA is invoked for initial enclave initialization or nested enclave initialization
- CXIT FUNC = 2 when IBMBXITA is invoked for initial enclave termination or nested enclave termination

CXIT USERWD in IBMBXITA will persist across enclaves (for example, in system() calls).

High Level Language User Exit Interface

z/OS Language Environment provides CEEBINT, an HLL user exit, for enclave initialization. You can code CEEBINT in z/OS C, PL/I, or z/OS C++ (subject to the restrictions in “Order of Processing of User Exits” on page 550), or z/OS Language Environment-conforming assembler. The HLL user exit cannot be written in COBOL. COBOL programmers can use an HLL exit written in z/OS C, PL/I, z/OS Language Environment-conforming assembler, z/OS C++ (again, subject to the restrictions in “Order of Processing of User Exits” on page 550), or default to the IBM-supplied default HLL user exit.

The HLL enclave initialization exit is invoked after the enclave has been established, after the Debug Tool initial command string has been processed, and prior to the invocation of compiled code. When invoked, it is passed a parameter list that conforms to the z/OS Language Environment definition. The parameters are all fullwords and are defined as follows:

Number of arguments in parameter list (input)
- A fullword binary integer.
  - On entry: Contains 7.
  - On exit: Not applicable.

Return code (output)
- A fullword binary integer.
  - On entry: 0.
  - On exit: Able to be set by the exit, but not interrogated by z/OS Language Environment.
Reason code (output)
A fullword binary integer.
- On entry: 0
- On exit: Able to be set by the exit, but not interrogated by z/OS Language Environment.

Function code (input)
A fullword binary integer.
- On entry: 1, indicating the exit is being driven for initialization.
- On exit: Not applicable.

Address of the main program entry point (input)
A fullword binary address.
- On entry: The address of the routine that gains control first.
- On exit: Not applicable.

User word (input/output)
A fullword binary integer.
- On entry: Value of the user word (CEEAUE_USERWD) as set by the assembler user exit.
- On exit: The value set by the user exit, maintained by z/OS Language Environment and passed to subsequent user exits.

Exit List Address (output)
A fullword binary integer reserved for future use.
This allows the establishment of one or more user exits when the enclave user exit sets this field to a list of user exits. Currently, only one user exit is supported in z/OS Language Environment.

A_Exits
The address of the exit list control block, Exit_list.
- On entry: 0.
- On exit: 0, unless you establish a hook exit, in which case you would set this pointer and fill in relevant control blocks. The control blocks for Exit_list and Hook_exit are shown in the following figure.

As supplied, CEEBINT has only one exit defined that you can establish: the hook exit described by the Hook_exit control block. This exit gains control when hooks generated by the PL/I compile-time TEST option are executed. You can establish this exit by setting appropriate pointers (A_Exits to Exit_list to Hook_exit).

Figure 163 on page 565 illustrates the Exit_list and Hook_exit control blocks.
The control block Exit_list exit contains the following fields:

**Exit_list_len**
The length of the control block. It must be 1.

**Exit_list_hooks**
The address of the Hook_exit control block.

The control block for the hook exit must contain the following fields:

**Hook_exit_len**
The length of the control block.

**Hook_exit_rtn**
The address of a routine you want invoked for the exit. When the routine is invoked, it is passed the address of this control block. Because this routine is invoked only if the address you specify is nonzero, you can turn the exit on and off.

**Hook_exit_fnccode**
The function code with which the exit is invoked. This is always 1.

**Hook_exit_retcode**
The return code set by the exit. You must ensure it conforms to the following specifications:

- 0  Requests that Debug Tool be invoked next
- 4  Requests that the program resume immediately
Requests that the program be terminated

Hook_exit_rsncode
The reason code set by the exit. This is always zero.

Hook_exit_userid
The user word passed to the user exits.

Hook_exit_ptr
An exit-specific user word.

Hook_exit_reserved
Reserved.

Hook_exit_dsa
The contents of register 13 when the hook was executed.

Hook_exit_addr
The address of the hook instruction executed.

Usage Requirements
1. The user exit must not be a main-designated routine. For example, it cannot be a z/OS C or a z/OS C++ main() function.
2. The HLL exit routines must be linked with compiled code. If you do not provide an initialization user exit, an IBM-supplied default, which returns control to your application, is linked with the compiled code.
3. The exit cannot be written in COBOL/370.
4. The exit should be coded so that it returns for all unknown function codes.
5. z/OS C constructs such as the exit(), abort(), raise(SIGTERM), and raise(SIGABRT) functions terminate the enclave.
6. A PL/I EXIT or STOP statement terminates the enclave.
7. Use the callable service IBMHKS to turn hooks on and off. For more information about IBMHKS, see PL/I for MVS & VM Compiler and Run-Time Migration Guide.
Chapter 37. Using The z/OS C MultiTasking Facility

This chapter describes how to use the MultiTasking Facility (MTF) with z/OS C. It explains how to organize, code, compile, link, and run a program using MTF. It also lists restrictions while using MTF.

MTF is a facility available under z/OS that can be used by application programs to improve turnaround time on multiprocessor and attached-processor configurations. When a program uses MTF on such a system, the elapsed time required to run the program can be reduced. You can run tasks, which can run independently of each other, simultaneously.

MTF is easy to use and requires very little knowledge of the multitasking capabilities upon which it depends. From the programmer’s perspective, multitasking facilities are available through the library functions of z/OS C. Because of this simplicity, it is easy to introduce MTF to existing applications and code new MTF applications to gain the benefits of multitasking.

Notes:

1. Except for a few differences, the MTF support for z/OS C is the same as for the equivalent FORTRAN multitasking facilities. MTF is not supported under CICS, IMS, DB2, C++, or z/OS UNIX. In addition, IPA is not supported in an MTF environment.
2. XPLINK is not supported in an MTF environment.

Organizing a Program with MTF

MTF takes advantage of the multitasking capabilities of the operating system to enable a single z/OS C application program to use more than one processor of a multiprocessor configuration simultaneously. The z/OS operating system organizes all work into units called tasks. These tasks are used by the operating system to assign work to the processors of the multiprocessor configuration.

MTF’s facilities allow a single z/OS C application to be organized so it can be run in a main task and in one or more subtasks. As a result of this organization, the system can schedule these individual tasks to run simultaneously. This can significantly reduce the elapsed time needed to run the program.

When a program is organized in this manner, the main task runs the part of the program that controls the overall processing. This part is referred to as the main task program throughout this manual.

The subtasks run the portions of the program that can run independently of the main task program and of each other. These portions of the program are referred to as parallel functions. The library functions provided by MTF allow the main task program to schedule parallel functions and allow them to run independently. Parallel functions are queued for execution on the next available subtask. Scheduling a parallel function does not require that there be a free subtask at the time of the scheduling. MTF allows the main task program to schedule more parallel functions than there are actual MVS subtasks.

The parallel functions are coded the same way as normal C functions, with the exception of a few rules discussed in "Designing and Coding Applications for MTF" on page 575. In particular, parallel functions cannot issue MTF calls.
MTF applications are link-edited as two separate load modules: a main task load module (containing the main task program) and a parallel load module (containing all parallel functions).

z/OS C provides the following MTF functions:

- `tinit()` to initialize the MTF environment
- `tsched()` to schedule parallel functions to run
- `tsyncro()` to synchronize the completion of parallel functions
- `tterm()` to terminate all executing parallel functions.

For details on the library functions, refer to the `z/OS C/C++ Run-Time Library Reference`.

z/OS C also provides the header file `mtf.h`, which must be included in your main task program if you are going to use the MTF facilities. The `mtf.h` header file contains the macros `MTF_ANY` and `MTF_ALL`, as well as the error-return codes and prototypes for library functions.

### Ensuring Computational Independence

To use multitasking successfully, the parallel functions must have computational independence. This means that no data modified by either the main task program or a parallel function is examined or modified by a parallel function that might be running simultaneously.

In the following figure, you see a graphic example of hypothetical data in an array subscripted by I, J, and K. Each of the three divisions of the box represents a section of the array that can be operated on independently of the other sections. The same parallel function could be scheduled three times, with each instance of the function processing one of the three sections of the array.

![Figure 164. Computational Independence](image)

Your application may not have computational independence along the same subscript axis of K, as in this picture. The divisions might have been along one of the other subscript axes, I or J. Also, the computational independence in your application may not fall into neat, box-like divisions.

It is also possible to have computational independence that is not based on sections of the same array, but rather on separate arrays (perhaps with completely
different types of data), the values of which do not depend on each other. In this case, separate parallel functions could be scheduled, with each function processing its own unique data.

Computational independence also applies to input/output files. One parallel function should not use a file while another is updating it. However, different functions can successfully read the same file. No single file pointer should be used concurrently by multiple parallel functions, because the behavior is undefined in such a case.

**Running a C Program without MTF**

The following diagrams illustrate the way a z/OS C program runs without multitasking. The program and its functions must run in a strictly sequential manner, function following function, using one processor at a time. Consequently, your program takes more elapsed time to complete than it would if it could use several processors at the same time.

In the following example, without multitasking, the z/OS C program and all its functions can only use one processor.
While running, your program may be switched back and forth between the processors, but it can only run on one processor at a time.

**Running a C Program with MTF**

To illustrate the concept of multitasking, this section shows three examples of running a z/OS C program with MTF. These examples show programs using:

- One parallel function
- Two different functions
- Two or more instances of the same function

Each example provides an illustration of how the processors are used and how the program is organized to accomplish the particular use of the processors.

**Running a C Program with One Parallel Function**

If your C program uses MTF, the main task program and a computationally-independent parallel function can run concurrently.
In the previous illustration, only the function suba has computations that can be done independently of the main task program, which includes the C main program plus its functions.

With the appropriate MTF request, the parallel function, suba, is scheduled to run in a subtask.

The arrows to Processor 1 and Processor 2 are for illustration only. The main task program could have run on Processor 2 and the parallel function, suba, on Processor 1; in fact, while they run, they may be switched between the processors.
Sample Program

```c
#include <mtf.h>
.
.
tinit("plmod",1);
.
.
tsched(MTF_ANY, "suba", arglist);
.
.
subb();
.
.
subn();

tsyncro(MTF_ALL);
.
.
Function subb()  
.
.
Function subn()
```

What the MTF functions do:
1. `tinit()` names the parallel load module `plmod` and specifies one subtask.
2. `tsched()` schedules the parallel function `suba` to run. `suba` is computationally-independent of the main task.
3. At this point, `tsyncro()` makes the main task program wait until `suba` is finished before the main task program continues.

Running a C Program with Two Different Parallel Functions
If your C program uses MTF, the main task program and several different computationally-independent parallel functions can run concurrently.

Processor Use
In the previous illustration, functions suba and subc are independent of each other and of the main task program.

The arrows to Processors 1, 2, and 3 are for illustration only. The main task program and the parallel functions could run on any of the processors.

Sample Program

```c
#include <mtf.h>
... 
  tinit("plmod",2);
  ...
  tsched(MTF_ANY, "suba", arglist1);
  ...
  tsched(MTF_ANY, "subc", arglist2);
  ...
  subb();
  ...
  tsyncro(MTF_ALL);
  ...
```

Main Task Program

What the MTF functions do:

The logic is similar to that for only one parallel function and can be extended to as many parallel functions as necessary to complete the logic of the program.

1. `tinit()` names the parallel load module `plmod` and specifies two subtasks.
2. Each call to `tsched()` schedules one of the parallel functions, passing different data to each for processing. `suba` and `subc` are computationally-independent parallel functions.
3. At this point, `tsyncro()` makes the main task program wait until both `suba` and `subc` are finished before the main task program continues its processing.

z/OS C with Multiple Instances of the Same Parallel Function

If your C program uses MTF, the main task program and multiple instances of the same parallel function can run concurrently.
Processor Use

In this illustration, parallel function suba has data you can divide, so two instances of suba run independently of the main task program and of each other.

Sample Program

```c
#include <mtf.h>

... tinit("plmod",2);
... tsched(MTF_ANY, "suba", arglist1);
... tsched(MTF_ANY, "suba", arglist2);
... subb();
... tsyncro(MTF_ALL);
...

Function subb()
```

What the MTF functions do:

1. `tinit()` names the parallel load module plmod and specifies two subtasks.
2. Each call to `tsched()` schedules one instance of the parallel function to run and supplies separate data to be processed by that instance of suba. The data to be processed by each instance of the parallel function could be two different sections of the same array. Both instances of suba are computationally-independent of the main task program and each other, because each instance of suba processes different data.
At this point, \texttt{tsyncro()} makes the main task program wait until all instances of \texttt{suba} finish before the main task program continues.

### Designing and Coding Applications for MTF

You can use the following steps when preparing a z/OS C application to work with MTF:

1. Identify computationally-independent code
2. Create parallel functions
3. Insert calls to parallel functions in main task program

New programs can be designed to use MTF, and existing programs can be reconstructed.

#### Step 1: Identifying Computationally-Independent Code

The first step in adapting an application program for MTF is to identify groups of computations that can be performed in parallel. To produce correct results, the computations that are done in parallel must be computationally-independent. This is further explained under "Ensuring Computational Independence" on page 568.

#### Step 2: Creating Parallel Functions

After the segments of code that are computationally-independent are identified, they are separated from the main task program and placed in parallel functions. A parallel function is coded as a normal C function that follows several rules required for correct operation with MTF. Besides to data independence, there are rules for:

- Parallel functions
- Calling other functions
- Separate storage for separate modules
- Passing data
- Input and output
- Exception/signal handling
- Function termination

#### Parallel Functions

- A parallel function must be written only in C.
- The return value of a parallel function must be \texttt{void}. If a parallel function attempts to return a value, the behavior will be undefined.
- External parallel function names must be 8 characters or shorter in length and will be uppercased.

#### Calling Other Functions

- A parallel function may actually be coded as a series of functions that call one another. All of these functions operate in the parallel function's subtask environment and must follow the rules of a parallel function except that they can be written in assembler as well as C, and they can have return values.
- A parallel function cannot call the MTF library functions \texttt{tinit()}, \texttt{tsched()}, \texttt{tsyncro()}, or \texttt{tterm()}. Such calls can only be used in the main task.

#### Separate Storage for Separate Modules

- Every MTF application consists of two modules: the main task module which runs on the main task, and the parallel module that runs on the subtask(s). Each task
(main or sub) has its own unique run-time storage structure consisting of ISA, heap, and residual storage. Each task has:

- Separate writable static (whether reentrant or not)
- Separate library-internal storage (for example, file and storage management control blocks)
- Separate exception and signal-handling environment (for example, errno, __amrc)

- Usually, functions must abide by the restrictions inherent in this arrangement. The remaining rules in this section mostly arise from this arrangement.
Passing Data

A parallel function is always invoked in its last-used state. If, for example, a parallel function has defined a static variable with an initializer, then the variable has that value the first time the parallel function executes on a given task. Should the value be modified, the modification is available the next time that parallel function is run only if the function is scheduled to the same task. If you don’t

Notes:

1. Each task has private and separate storage structure that leads to most of the parallel function idiosyncrasies:
   - All file operations from same task.
   - Storage must be malloc() or free()d from same task.
   - Independent signal handling environments.
2. MTF library functions are only operational in the main task.
3. call/return used for invocation within a task.
4. MTF only supports parallel load modules in a PDS. Parallel load modules in a PDSE are NOT supported.

Figure 165. Basic MTF Layout
schedule the parallel function to the same task, you cannot depend upon residual values from previous invocations of the function.

- Data can be passed between the main task program and parallel functions, and between parallel functions by passing a pointer to the storage area as a parameter. Care must be taken to ensure that the data remains valid and available until completion of the particular parallel function instance being scheduled.

- If heap storage is obtained on a given task, it must be freed on that task and no other. Other tasks may be given access to that storage by passing pointers but no other task can use that pointer to free the storage.

**Input/Output**

- File pointers must not be shared across subtasks. A given file pointer must only be used (for file access and closing) on the same task on which it was created (using `fopen()`). File pointers must be utilized as a serial resource. z/OS C does not protect against misuse, and a program will have unpredictable behavior if this rule is not enforced.

- Each parallel function updates (writes or changes) a file as if it had complete control over the file; therefore, there should be no simultaneous read or update of a given file while any function on any task is updating that file (even if separate file pointers are used).

- Memory files cannot be shared across subtasks.

**Exception/Signal Handling**

- The parallel functions on the subtasks run with TRAP(ON) run-time option, and each has a signal handling environment entirely independent from that of each other task. All signals are initialized to default handling on each task, and can be modified for a given task only through a signal statement from a parallel function on that task.

- All signal interrupts are eligible to be raised from the operating system or by the `raise()` function during execution of parallel functions. All signals, however, require special handling in the case of parallel functions because of the requirement that parallel functions always return normally. Signals must either be ignored or a handler must be established that does not terminate the program. If these signals are left to default handling or a handler is established that terminates the program, MTF will treat this as an abnormal termination of the parallel function.

**Function Termination**

- Parallel functions run as called functions (from EDCMTFS, the z/OS C library supplied main function for parallel modules) and must terminate by simple return (to EDCMTFS). For more information on EDCMTFS, see "Creating the Parallel Functions Load Module" on page 585.

- Termination with `exit()` and `abort()` calls is invalid because these functions interfere with EDCMTFS operation and they are treated by MTF as abnormal terminations.

- On the first valid call to MTF (`tsched()`, `tsyncro()`, `tterm()`) from the main task program after a parallel function has abnormally terminated (via `exit()/abort()` or otherwise) MTF will:
  - Abort all parallel functions scheduled or in progress
  - Remove the MTF environment
  - Return ETASKABND on that MTF call
A subsequent \texttt{tterm()} call is unnecessary and will simply return \texttt{EINACTIVE}. A \texttt{tinit()} can be reissued, but depending on the severity of the condition that caused the \texttt{ETASKABND}, the \texttt{tinit()} may or may not be successful.

**Step 3: Inserting Calls to Parallel Functions**

In the main task, insert a call to \texttt{tinit()} to initialize the MTF environment before to any other MTF function call, or after \texttt{tterm()} is invoked. Replace each segment of code that was identified for parallel computation with a call to \texttt{tsched()} which schedules the corresponding parallel function. If more parallel function instances are scheduled than tasks are currently available, the additional instances are queued for subsequent execution in the order in which they were scheduled. They are queued for any task or to a particular task according to the \texttt{task_id} parameter supplied on the \texttt{tsched()} call. If parallel operation is to be achieved by scheduling the same function multiple times with different data, the function call may be placed within a loop.

The arguments passed to the parallel function may be:

- A variable
- An array element
- An array name
- A constant
- A structure

The following items must not be used as the arguments supplied to the parallel function using \texttt{tsched()}:

- Function pointers
- A pointer to data or storage that will be modified or released before a \texttt{tsyncro()}.

After inserting calls to the parallel functions, insert a call to \texttt{tsyncro()} wherever the program requires that any subtask, one particular subtask, or all of the subtasks have finished executing the parallel functions previously scheduled to them. As the last MTF call, insert a call to \texttt{tterm()} before to exit/return from the main task program to remove the MTF environment.

To properly use MTF from the main task program it is necessary to include the \texttt{mtf.h} header file before to the first MTF call in your program. MTF calls themselves can be issued from non-main as well as main functions within the main task program, subject only to the restrictions already described above. MTF calls, however, can only be issued from C functions and not from functions written in any other language.

The next sections show examples of how to change existing C programs to use MTF following the steps just outlined.

**Changing an Application to Use MTF**

The following examples show how to change an application to use MTF by creating parallel functions and inserting calls to these functions.

**Example 1**

Figure 166 on page 580 shows a computation of the dot product on two long one-dimensional arrays of data. The processing within the loop structure may be separated so that the dot product is not a result of serial calculations but a result of parallel calculations. This is because the first part of the array is not dependent on
the results computed in any other section of the array. Thus the calculations are therefore computationally independent of each other, and can be performed at the same time.

double dotprod(double *a, double *b, int len)
{
    int i;
    double res = 0;
    for (i=0; i < len; ++i)
        res += *a++ * *b++;
    return(res);
}

Figure 166. Identifying Computationally-Independent Code

Create Parallel Functions
The segments of the program that have been identified to run as parallel functions are then recoded as new z/OS C functions. In this case, there will be one parallel function, multiple instances of which will be scheduled. The parallel function corresponding to the code in Figure 166 now looks like Figure 167.

void pdotprod(double *a, double *b, int len, int m, int n, double *pres)
    /* m = the section of the array */
    /* n = the number of subtasks. n must be a factor of len */
{
    int i, from, to;
    *pres = 0;
    /* Determine which section of the array to operate on */
    from = (m-1) * len / n;
    to = (m*len) / n;
    /* Calculate the partial result on part of the array */
    for (a+= from, b+=from, i=from; i < to; ++i)
        *pres += *a++ * *b++;
}

Figure 167. The Sample Code as a Parallel Function

The variables to and from are used to determine on which part of the array the parallel function is to perform.

Insert Calls to Parallel Functions
The segments of the program that have been removed to form parallel functions are replaced by calls to these new parallel functions. For the sample code in Figure 166 on page 580, sub:exph. is scheduled for each subtask that will be used at run time. In order to do this, the computations controlled by the k index must be divided so that each instance of the function sub operates on a different part of the original range of the k variable. See Figure 168 for an example of how two instances of a parallel function can be scheduled.
Also, within the main task program, the subtasks must be initialized and eventually terminated as shown in Figure 169.

```
# include <mtf.h>

double dotprod(double *a, double *b, int len)
{
    int i;
    double res = 0;
    double pres[MAXTASK];

    /* Schedule the parallel functions according to */
    /* how many subtasks exist */
    for (i=1; i < n, ++i)
        tsched(MTF_ANY,"pdotprod",a,b,i,n,&pres[i-1]);

    /* Perform the calculations on the last part of the array */
    pdotprod(a,b,len,n,n,&pres[n-1]);

    /* Wait until all of the partial results are determined */
    tsyncro(MTF_ALL);

    /* Add all the partial results to determine the final dot product*/
    for (i=0; i < n, ++i)
        res += pres[i];

    return(res);
}
```

Figure 168. Scheduling Instances of a Parallel Function

Also, within the main task program, the subtasks must be initialized and eventually terminated as shown in Figure 169.

```
# include <mtf.h>

int main(void)
{
    ...  
    /* other code */
    /* Attach and initialize a subtask */
    tinit(load_sub_name, n);

    ...  
    result = dotprod(vector1,vector2,len);

    ...  
    /* Terminate subtasks */
    tterm();
    /* more code */
}
```

Figure 169. Main Task Program to Call Dot Product Function

**Example 2**

Not all application programs contain parallelism within the iterations of a loop structure. The following example illustrates parallel computations that appear as different segments of code in the original program. Also illustrated is the use of pointer arguments for passing data, and I/O operations to files in parallel functions.
Figure 170 shows two calls to the same function that performs the dot product on the values in two files of data. The values are read from each file and the function performs the dot product upon these values. The loop ends when the end of either file is reached. The two computations are independent of each other and thus can be performed simultaneously in two different parallel functions.

CCNGMT1:

/* MTF example 2 */
#include <stdio.h>

void fdotprod(char *fn1, char *fn2)
{
  int i, res1;
  double result=0, val1, val2;
  FILE *file1, *file2;

  file1 = fopen(fn1, "r");
  file2 = fopen(fn2, "r");

  while (1)
  {
    res1 = fscanf(file1, "%lf", &val1);
    res1 += fscanf(file2, "%lf", &val2);
    if (res1 != 2)
      break;
    result += val1 * val2;
  }
  if (res1 == 1)
    printf("Error: Files of unequal length\n");
  else
    printf("Result: %lf\n", result);
}

int main(void)
{
  fdotprod("a.input", "b.input");
  fdotprod("c.input", "d.input");
  return(0);
}

Figure 170. Sample Code to Be Changed to Use MTF

Create Parallel Functions
The fdotprod routine is identified as a parallel function so it is recoded as a new C function in a separate file. Data is passed from the main function to the parallel functions by means of pointer arguments. The parallel functions are shown in Figure 172 on page 584. The main task program is shown in Figure 171 on page 583.
CCNGMT2:

/* MTF example 2 */
/* part 2 of 2-other file is CCNGMT1 */

#include <stdio.h>
#include <mtf.h>

int main(void)
{
    tinit("plmod", 2);
    tsched(MTF_ANY, "fdotprod", "a.input", "b.input");
    tsched(MTF_ANY, "fdotprod", "c.input", "d.input");
    tsyncro(MTF_ALL);
    tterm();

    return(0);
}

void fdotprod(char *fn1, char *fn2)
{
    int i, res1;
    double result=0, val1, val2;
    FILE *file1, *file2;

    file1 = fopen(fn1, "r");
    file2 = fopen(fn2, "r");

    while(1)
    {
        res1 = fscanf(file1, "%lf", &val1);
        res1 += fscanf(file2, "%lf", &val2);
        if (res1 != 2)
            break;
        result += val1 * val2;
    }
    if (res1 == 1)
        printf("Error: Files of unequal length\n");
    else
        printf("Result: %lf\n", result);
}

Figure 171. The Sample Code
/* MTF example 2 */
/* part 2 of 2-other file is CCNGMT2 */
#include <stdio.h>

void fdotprod(char *fn1, char *fn2)
{
    int i, res1;
    double result=0, val1, val2;
    FILE *file1, *file2;

    file1 = fopen(fn1, "r");
    file2 = fopen(fn2, "r");

    while(1)
    {
        res1 = fscanf(file1, "%lf", &val1);
        res1 += fscanf(file2, "%lf", &val2);
        if (res1 != 2)
            break;
        result += val1 * val2;
    }
    if (res1 == 1)
        printf("Error: Files of unequal length\n");
    else
        printf("Result: %lf\n", result);
}

Figure 172. The Sample Code

Compiling and Linking Programs That Use MTF

Programs that use MTF run using two MVS load modules: a load module that contains the main task program, and a load module that contains the parallel functions. You compile and link-edit the main task program in the same procedure as non-MTF C programs. The parallel function is compiled in the same procedure as non-MTF C programs and is linked with EDCMTFS.

Creating the Main Task Program Load Module

The main task program load module is the load module that first receives control when MVS starts running your program. It is the load module named in the PGM keyword of the EXEC statement. This load module contains your application's C main() function plus all other functions that are to run as part of the main task. The MTF functions can be invoked from any of the C functions contained in the main task load module and do not necessarily have to be invoked from the C function called main().

The procedures that you usually use to compile and link-edit a z/OS C program can be used to create the main task program load module. For example, the following JCL sequence (see Figure 173 on page 585) uses the standard z/OS C cataloged procedure EDCCL to compile and link-edit the C source for the main task program (stored in data set USERPGM.C(MTASKPGM)) and create a main task program load module named MTASKPGM in data set USERPGM.LOAD.
Creating the Parallel Functions Load Module

The parallel functions load module is the load module named in the call to the MTF library function `tinit()`. This single load module contains all of your main task program’s parallel functions. It must not contain any user’s C `main()` programs. z/OS C itself provides the EDCMTFS module to act as the C `main()` function in the parallel module. EDCMTFS controls processing of the parallel functions as they are scheduled (by way of `tsched()` calls) to the subtasks. The source code for the EDCMTFS module is included in Figure 175 on page 586.

Note: The executable module for parallel function program must be a load module (in a PDS data set), created using the linkage editor (and prelinker if required due to the presence of C++ code or C code compiled with the RENT option). The MTF library functions used to access the parallel functions are not compatible with a program object executable module (in a PDSE data set).

The procedures that you usually use to compile and link-edit a z/OS C program must be modified such that the library module `CEESTART` will be the entry point of the parallel functions load module.

When you link-edit this load module, include the following linkage editor control statements:

```
INCLUDE SYSLIB(EDCMTFS)
ENTRY CEESTART
```

For example, the following JCL sequence uses the standard z/OS C cataloged procedure EDCCL to compile and link-edit the C source for the parallel functions stored in data set `USERPGM.C(SUBTASK)` and create a parallel functions load module named `PLMOD` in data set `USERPGM.LOAD`. This load module contains the module EDCMTFS, and has EDCMTFS as the load module’s entry point.

```
//MTASKPGM EXEC EDCCL,
// INFILE='CBC.SCCNSAM(CCNGMT2)',
// OUTFILE='USERPGM.LOAD(CCNGMT2),DISP=SHR'
/*
//PFUNC EXEC EDCCL,
// INFILE='CBC.SCCNSAM(CCNGMT3)',
// OUTFILE='USERPGM.LOAD(PLMOD),DISP=SHR'
//LKED.SYSLIN DD
INCLUDE SYSLIB(EDCMTFS)
ENTRY CEESTART
/*
```

Figure 174. Sample JCL to Compile and Link Parallel Functions

Note: First we have a step that compiles and link-edits the main task program.
Specifying the Linkage-Editor Option

Do not specify the NE linkage-editor option when link-editing the parallel functions load module. MTF cannot schedule parallel functions that are contained in a load module link-edited with the NE option.

Modifying Run-Time Options

You can alter the #pragma runopts options STACK and HEAP within the EDCMTFS module for each subtask, but you must recompile the module under the same name. The source code for EDCMTFS is shown in Figure 175.

```c
#pragma runopts(STACK(8K,4K,ANY,FREE),HEAP(4K,4K,ANY,FREE))
```

Running Programs That Use MTF

To run your program, use the usual MVS JCL for z/OS C programs, plus a few additional JCL statements that are required to run MTF.

STEPLIB DD Statement

You must ensure that the library containing the load modules is specified on the STEPLIB DD statement in your JCL, as well as the other libraries usually specified, as follows:

```
//STEPLIB   DSN=user.dsn,DISP=SHR
```

where:

- user.dsn
  
  is the name of the load module library that contains the parallel functions load module.

  The parallel functions load module (\texttt{parallel_loadmod\_name}), specified on the call to \texttt{tinit()}, must be in this data set.

  You must allocate the ddname EDCMTF to the user.dsn data set as well as adding user.dsn to the STEPLIB concatenation list.
**DD Statements for Standard Streams**

For standard streams, MTF assigns a unique run-time output file to each parallel function. These output files contain diagnostic messages that the library can issue while the parallel functions are running. They also contain output directed to the standard streams (stderr and stdout) by parallel functions and input from the standard stream stdin.

Because these files are automatically allocated while the program is running, you need not supply DD statements for them unless you wish to override the default device type or other file characteristics. The default device type is a terminal in TSO or SYSOUT= in batch.

If you do supply DD statements, use the following ddnames:

- stdinstn for files containing input for operations such as getc()
- stderrstn for files containing diagnostic messages
- stdoutstn for files containing output from operations such as printf()

Where stn is the 2-digit subtask number; that is, 01, 02, 03, and so on. Thus, for example, if you had four subtasks and the first two used printf() functions, you would use the ddnames stdout01, stdout02, stderr01, stderr02, stderr03, and stderr04.

**Example of JCL**

An example of the run-time JCL to run a program that uses MTF is shown in Figure 176 on page 587. This figure shows the JCL that is unique to running MTF, as well as the other JCL the program would typically require. (Some programs might require additional DD statements.)

```jcl
//GO EXEC PGM=MTASKPGM
//STEPLIB DD DSN=USERPGM.LOAD,DISP=SHR
//STDIN01 DD DSN=USERPGM.INPUT,DISP=SHR
//STDOUT02 DD SYSOUT=S,DCB=(RECFM=F)
```

*Figure 176. Example Run-Time JCL*

MTASKPGM is the name of the main task program load module, and is the load module that gets control when MVS first starts running the program. In this example, this load module is contained in data set USERPGM.LOAD, which is referred to by the STEPLIB DD statement. USERPGM.LOAD also contains the parallel functions.

The STDIN01 DD statement specifies the data set that contains the program’s input data for the first task. The STDOUT02 DD statement specifies that printed output aside from run-time error messages from the second subtask is to be written to SYSOUT class S and that the record format is to be fixed-length. These DD statements are necessary only if you do not want to accept the defaults.

**Debugging Programs That Use MTF**

Debug Tool can be used to interactively debug your main task program. It cannot, however, be used to debug your parallel functions.

**Avoiding Undesirable Results when Using MTF**

To prevent undesirable results, be aware of the following concerns and restrictions:

- MTF only supports parallel load modules in a PDS. Parallel load modules in a PDSE are NOT supported.
• Do not update a file with one task if the other tasks read the same file. Files can be destroyed if this is attempted.

• The following products should not be used from the main task or any subtasks while MTF is active:
  – Information Management System (IMS)
  – The CICS command level interface

• The following products should not be used from subtasks while MTF is active but can be used from the main task:
  – Data Window Services (DWS)
  – Interactive System Productivity Facility (ISPF)
  – Graphical Data Display Manager (GDDM)

• All library functions can be issued from the main task program.

• The following library functions should not be issued from parallel functions (see “Function Termination” on page 578):
  – exit()
  – abort()
  – atexit()

• The following library functions can be used with some restrictions from parallel functions:
  – setjmp()/longjmp() can be used from within any task/subtask but must not be used across tasks. That is, the stack environment saved via setjmp() on a given task may be restored by a longjmp() from that task but from no other task.
  – setlocale()/localeconv() are only effective within a task. Each task has its own distinct locale information. Thus setlocale()/localeconv() issued from one task have no effect on such functions issued from other tasks.
  – tmpnam() may produce identical file names across tasks and should be restricted to being invoked from a single task (subtask or main task).
  – rand()/srand() produce entirely independent series of pseudorandom integers on each task
  – All file manipulation functions (such as fopen()/freopen()...) - were identified earlier under the rules for parallel functions in "Designing and Coding Applications for MTF" on page 575 These functions can only be used on the same task.

  Note: When opening files under MTF, you incur additional overhead when fopen() and freopen() are called. This overhead would normally be performed at the first read or write to the stream and will not affect the performance of a program that does indeed perform at least one read or write to the stream.
  – fetch()/release() must only be issued from the same task.
  – free() must be issued on the same task as the malloc()/calloc()/realloc() functions were issued. Note also that a realloc() must be issued in the same task as the malloc().
  – signal()/raise() also identified earlier under the rules for parallel functions in "Designing and Coding Applications for MTF" on page 575. Basically, each task has its own distinct interrupt environment. Thus signal()/raise() issued from one task have no effect on the operation of any other task.
  – PL/I and COBOL interlanguage calls must not be made from parallel functions.
Busy waits (loops that iterate until a flag is changed by a cooperating task) violate the requirement for computational independence. In particular, they can result in deadlock because of the scheduling algorithm used by MVS. They must be avoided.
Part 6. Programming with Other Products

This part contains the following programming product information:

- Chapter 38, “Using the Customer Information Control System (CICS)” on page 593
- Chapter 39, “Using Cross System Product (CSP)” on page 617
- Chapter 40, “Using Data Window Services (DWS)” on page 631
- Chapter 41, “Using DB2 Universal Database” on page 633
- Chapter 42, “Using Graphical Data Display Manager (GDDM)” on page 639
- Chapter 43, “Using the Information Management System (IMS)” on page 645
- Chapter 44, “Using the Interactive System Productivity Facility (ISPF)” on page 655
- Chapter 45, “Using the Query Management Facility (QMF)” on page 661
Chapter 38. Using the Customer Information Control System (CICS)

This chapter describes how to develop C and C++ programs for the Customer Information Control System (CICS). The z/OS Language Environment library provides support for z/OS C++ programs that run under CICS/ESA Version 4 Release 1 or later, and z/OS C programs that run under CICS/ESA Version 3 Release 3 or later. You can find more information about the general features of z/OS Language Environment and CICS in z/OS Language Environment Programming Guide.

For information on using CSP/AD or CSP/AE under CICS, see Chapter 39, "Using Cross System Product (CSP)" on page 617.

Notes:
1. As of this publication, the CICS translator does not recognize the C compiler’s support for alternative locales and coded character sets. Therefore, you should write all your CICS C code in coded character set IBM-1047 (APL 293).
2. XPLINK applications are not supported in a CICS environment.

Developing C and C++ Programs for the CICS Environment

When developing a program to run under CICS you must:
1. Prepare CICS for use with z/OS Language Environment.
2. Design and code the CICS program.
3. Translate and compile the translated source for reentrancy.
4. Prelink and link all object modules with the CICS stub.
5. Define the program to CICS.

Preparing CICS for Use with z/OS Language Environment

This section gives general instructions on enabling z/OS Language Environment to use a new CICS environment or to add z/OS Language Environment to an existing CICS environment. For more detailed information on CICS, refer to the manuals listed in "CICS" on page 926.

After CICS has been installed on your system, you must perform the following tasks:
• Create a CICS environment if one does not already exist. This involves creating a CICS System Definition (CSD), journals, and a Global Catalog Set (GCD).
• Copy CEECCICS from SCEERUN to an Authorized Program Facility (APF) data set. The data set should be concatenated in the STEPLIB when CICS is cold started.
• Create the CES0 and CESE Transient Data Queues. Sample Destination Control Table (DCT) definitions are supplied in SCEESAMP(CEECDCT).
• Add required definitions to the CSD. Sample CSD definitions are provided in SCEESAMP(CEECCSD). These sample definitions create a group called CEE, which must be added to the installation LIST.
• Add SCEERUN and SCEECICS to the DFHRPL concatenation.

The C run-time event handler module CEEEV003 is required for CICS support (in addition to the z/OS Language Environment interface modules). CEEEV003 must be link-edited as AMODE=31, RMODE=ANY, and loaded above the 16M line.
If you will be using the I/O stream library, complex mathematics, collection, or Application Support Class DLLs provided with the z/OS C++ compiler, you must define these DLLs in the CSD. Sample CICS CSD definitions can be found in CBC.SCLBJCL(CLB3YCS).

Designing and Coding for CICS

This section describes what you must do differently when designing and coding a z/OS C/C++ program for CICS, such as using EXEC CICS commands in your code, using input and output, using z/OS C/C++ functions, managing storage, using interlanguage calls, and exception handling.

Using the CICS Command-Level Interface

CICS/ESA provides a set of commands to access CICS. The format of a CICS command is:

```
EXEC CICS function [option[(arg)]]...;
```

In the following CICS command, the function is \texttt{SEND TEXT}. This function has 4 options: FROM, LENGTH, RESP and RESP2. In this case, each of the options takes one argument.

```
EXEC CICS SEND TEXT FROM(mymsg)
    LENGTH(mymsglen)
    RESP(myresp)
    RESP2(myresp2);
```

For further information on the \texttt{EXEC CICS} interface and a list of available CICS functions, refer to \textit{CICS Application Programming Guide, SC34-5993} and \textit{CICS Application Programming Reference, SC34-5994}.

When you are designing and coding your CICS application, remember the following:

- The \texttt{EXEC CICS} command and options should be in uppercase. The arguments follow general C or C++ conventions.
- Before any \texttt{EXEC CICS} command is issued, the \texttt{EXEC Interface Block (EIB)} must be addressed by the \texttt{EXEC CICS ADDRESS EIB} command.
- z/OS C/C++ does not support the use of \texttt{EXEC CICS} commands in macros.

The examples in \texttt{Figure 177 on page 595} show the use of several \texttt{EXEC CICS} commands.
/* program : GETSTAT */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define FILE_LEN 40

void check_4_down_status( char *status_record ) ;
void sendmsg( char* status_record ) ;
void unexpected_prob( char* desc, int rc) ;

struct com_struct {
    unsigned int quiet ;
} *commarea ;

DFHEIBLK *dfheiptr ;

main ()
{
    long int vsamrrn;
    signed short int vsamlen;
    unsigned char status_record[41];
    signed long int myresp;
    signed long int myresp2;

    /* get addressability to the EIB first */
    EXEC CICS ADDRESS EIB(dfheiptr); 1

    /* access common area sent from caller */
    EXEC CICS ADDRESS COMMAREA(commarea); 2

    /* call the CATCHIT prog. if it abends */
    EXEC CICS HANDLE ABEND PROGRAM("CATCHIT"); 3

    vsamrrn = 1;
    vsamlen = FILE_LEN;

    /* read the status record from the file*/
    EXEC CICS READ FILE("STATFILE") 4
    UPDATE
    INTO(status_record)
    RIDFLD(vsamrrn)
    RRN
    LENGTH(vsamlen)
    RESP(myresp)
    RESP2(myresp2);

Figure 177. Example Illustrating How to Use EXEC CICS Commands (Part 1 of 4)
/* check cics response */
/* -- non 0 implies a problem */
if (myresp != DFHRESP(NORMAL))
    unexpected_prob("Unable to read from file",61);

printf("The status_record from READ in GETSTAT = %s\n", status_record);

if (memcmp(status_record,"DOWNTME ",8) == 0)
    check_4_down_status(status_record);

if (commarea->quiet != 1)
    sendmsg(status_record);

exit(11);
}

void check_4_down_status( char *status_record )
{
    unsigned char uptime[9];
    unsigned char update[9];
    char curabs[8];
    unsigned char curtime[9];
    unsigned char curdate[9];
    long int vsmrrn;
    signed short int vsmlen;
    signed long int dnresp;
    signed long int dnresp2;

    strncpy((status_record+8),update,8);
    strncpy((status_record+16),uptime,8);
    update[8] = '\0';
    uptime[8] = '\0';

    /* get the current time/date */
    EXEC CICS ASKTIME ABSTIME(curabs)   5
        RESP(dnresp)
        RESP2(dnresp2);

    if (dnresp != DFHRESP(NORMAL))
        unexpected_prob("Unexpected prob with ASKTIME",dnresp);

    /* format current date to YYMMDD */
    /* format current time to HHMMSS */
    EXEC CICS FORMATTIME ABSTIME(curabs)   6
        YYMMDD(curdate)
        TIME(curtime)
        TIMESEP
        DATESEP;

Figure 177. Example Illustrating How to Use EXEC CICS Commands (Part 2 of 4)
if (dnresp != DFHRESP(NORMAL))
  unexpected_prob("Unexpected prob with FORMATTIME", dnresp);

curdate[8] = '\0';
curtime[8] = '\0';

if ((atoi(curdate) > atoi(update)) ||
   (atoi(curdate) == atoi(update) && atoi(curtime) >= atoi(uptime)))
{
  strcpy(status_record, "OK ");

  vsmrrn = 1;
  vsmlen = FILE_LEN;

  /* update the first record to OK */
  EXEC CICS REWRITE FILE("STATFILE")
    FROM(status_record)
    LENGTH(vsmlen)
    RESP(dnresp)
    RESP2(dnresp2);

  if (dnresp != DFHRESP(NORMAL)) {
    printf("The dnresp from REWRITE = %d\n", dnresp);
    printf("The dnresp2 from REWRITE = %d\n", dnresp2);
    unexpected_prob("Unexpected prob with WRITE", dnresp);
  }

  printf("%s %s Changed status from DOWNTME to OK\n", curdate, curtime);
}

void sendmsg( char* status_record )
{
  long int msgresp, msgresp2;
  char outmsg[80];
  int outlen;

  if (memcmp(status_record, "OK ", 3) == 0)
    strcpy(outmsg,"The system is available.");
  else if (memcmp(status_record, "DOWNTME ", 8) == 0)
    strcpy(outmsg,"The system is down for regular backups.");
  else
    strcpy(outmsg,"SYSTEM PROBLEM -- call help line for details.");

  printf("%s\n", outmsg);
  outlen=strlen(outmsg);

Figure 177. Example Illustrating How to Use EXEC CICS Commands (Part 3 of 4)
Both of these examples use EXEC CICS commands to:

1. Initialize the CICS interface
2. Access the storage passed from the caller
3. Handle unexpected abends
4. and 7. I/O to RRDS files
5. and 6. Requesting and formatting time

Using Input and Output

This section describes how to use z/OS C/C++ I/O with CICS. It describes the file and device support and the type of I/O used with CICS.

Note: You can set up a SIGIOERR handler to catch read or write system errors. See Chapter 18, “Debugging I/O Programs” on page 233 for more information.

Standard Stream Support

Under CICS, if you are using the z/OS C++ standard streams, documented in IBM Open Class Library User’s Guide and IBM Open Class Library Reference, Vol. 1, note the following:

- cin is not supported under CICS.
- cout maps to the Standard C I/O stream stdout.
- cerr and clog both map to the C standard stream stderr.

stdout and stderr are assigned to transient data destinations (queues). The type of queue, intrapartition or extrapartition, is determined during CICS initialization.
Intrapartition queues are used for queueing messages and data within a CICS region. Extrapartition queues are used to send data outside the CICS region or to receive data from outside the CICS region.

The transient data queues associated with `stdout` and `stderr` are CESO and CESE respectively. z/OS C/C++ supports VA and VBA queues with an lrecl of at least 137 bytes.

Records sent to the transient data queues associated with `stdout` and `stderr` take the form of a message. The entire message record can be preceded by an ASA Standard control character. Figure 178 illustrates the recommended message format.

In Figure 178:
- **ASA** is the carriage-control character.
- **terminal id** is a 4-character terminal identifier.
- **transaction id** is a 4-character transaction identifier.
- **sp** is a space.
- **Time Stamp** is the date and time displayed in the format YYYYMMDDHHMMSS.
- **data** is the data that is output to the standard streams `stdout` and `stderr`.

The following are sample messages of data written to a CICS data queue:

- **SAMATST1** 19940401080523 Hello World - from transaction TST1!
- **BOBATST3** 19940401112348 Hello World - from transaction TST3!
- **TEDATST2** 19940401112348 Hello World - from transaction TST2!

Standard streams can only be redirected to or from memory files.

Because only one transient data queue can be associated with each of `stdout` and `stderr`, these queues can contain output written in chronological order from many C and C++ programs. This output must be sorted as necessary into the desired sequence.

**Full Memory File Support**

The full set of C I/O library functions is supported under CICS for memory files. Memory files are created with the parameter `type` set to `memory` on the `fopen()` call. If you are using C++, you can also use the I/O stream library to create and access memory files. Hiperspace memory files are not supported.

**Support for Disk Files and Other Devices**

There is no support by the C I/O library or the I/O stream library for using disk files and other devices with CICS. I/O to access methods supported by CICS must use the CICS Application Programming Interface.
Using z/OS C/C++ Library Support

This section discusses restrictions and support for the z/OS C/C++ library with
CICS.

Arguments to C or main()
When a z/OS C/C++ program is running under CICS, you cannot pass command
line arguments to it. The values for argc and argv have the following settings:

argc 1
argv[0] 4-character CICS transaction ID

Run-Time Options
Command line run-time options cannot be passed in CICS. To specify run-time
options in C/C++, you must include the #pragma runopts directive in the code.
Figure 177 on page 595 shows how to do this. See z/OS Language Environment
Programming Guide for information on other ways to supply run-time options when
you are running under CICS.

Using Packed Decimal with CICS
The packed decimal data type is supported under CICS. However, the CICS
translator does not support packed decimal. CICS expects packed decimal streams
to be passed to it as arrays of characters. If you want to manipulate these arrays as
a packed decimal number, you should define the array of characters in union with
the appropriate packed decimal definition. Refer to the CICSPlex SM Application
Programming Guide for information on how to define the data fields for the EXEC
CICS commands you are using.

Note: The z/OS C++ compiler does not support packed decimal data. Any program
using the C or C++ character data type to handle packed decimal data must
have its own functions for the manipulation of this data.

Locales
All locale functions are supported for locales that have been defined in the CSD.
CSD definitions for the IBM-supplied locales are provided in SCEESAMP(CEECCSD).
setlocale() returns NULL if the locales are not defined.

Code Set Conversion Tables
The code set conversion tables that are used by the iconv() functions must be
defined in the CSD.

POSIX
There is no support for POSIX functions that are not already defined as part of
ANSI/ISO. z/OS UNIX is not supported under CICS.

Multitasking Facility
MTF functions are not supported under CICS.

System Programming C Facilities
There is no support for the System Programming C facilities (SP C) under CICS.

SVC99 and Dynamic Allocation Functions
svc99() and the dynamic allocation functions dynalloc(), dynfree(), and dyninit()
are not supported under CICS. The svc99() function returns 0 if the input is NULL,
otherwise the return value is undefined.
IMS
There is no support for the ctdli() function under CICS. If you call ctdli() under CICS, the return value is -1. Refer to the CICSPlex SM Application Programming Guide for information on the CICS method to access IMS.

Dump Functions
The dump functions csnap(), cdump(), and ctrace() are supported under CICS. The output is sent to the CESE transient data queue. The dump can not be written if the queue does not have a sufficient LRECL. An LRECL of at least 161 is recommended.

Dynamic Linked Libraries (DLL)
All DLLs must be defined in the CSD.

fetch()
The fetch() function is supported under CICS. Modules to be fetched must be defined to the CSD and installed in the PPT.

release()
The release() function is supported under CICS.

system()
The system() function is not supported under CICS. However, there are two EXEC CICS commands that give you similar functionality:

EXEC CICS LINK
This command enables you to transfer control to another program and return to the calling program later. See Figure 179 on page 605.

EXEC CICS XCTL
This command enables you to transfer control to another program. Control does not return to the caller after completion of the called program.

Time Functions
All time functions are supported except the clock() function, which returns the value (time_t)(-1) if it is used under CICS.

iscics()
The iscics() function is an extension to the C library. It returns a non-zero value if your program is currently running under CICS. If your program is not running under CICS, iscics() returns the value 0. The following example shows how to use iscics() in your C or C++ program to specify non-CICS or CICS specific behavior.

```c
if (iscics() == 0)
   < non-CICS behavior>
else
   < CICS-specific behavior>
```

Floating Point Arithmetic
The simulation of extended precision floating point is not supported in CICS.

Program Termination
A C or C++ program running under CICS will terminate when:

- An exit() function call or a return statement is issued in the C or C++ program. The atexit list of functions is run when the C or C++ program terminates.

  Note: On return from a C or C++ application, the return statement or values passed by C or C++ through the exit() function are saved in the EIBRESP2 field of the EIB.

- An abend occurs and is not handled.
• An EXEC CICS RETURN is issued in your C or C++ program. The atexit list of functions runs after these calls.
• The abort() function is started.

Storage Management
A z/OS C/C++ program can acquire storage from and release storage to CICS/ESA implicitly or explicitly.

Storage is acquired and released implicitly by the run-time environment. This storage is used for automatic, external, and static variables. External variables are valid until program completion.

Storage is acquired and released explicitly by the user with the C library functions malloc(), calloc(), realloc(), or free(), with z/OS Language Environment Callable Services (refer to z/OS Language Environment Programming Guide), with the C++ new and delete operators, or with the EXEC CICS commands EXEC CICS GETMAIN, or EXEC CICS FREEMAIN.
• If you request the storage by using the C functions malloc(), realloc(), or calloc() you must deallocate it by using C functions as well.
• If you request the storage by using z/OS Language Environment Callable Services, you must deallocate it by using z/OS Language Environment Callable Services.
• If you request the storage by using EXEC CICS GETMAIN, you must deallocate it by using EXEC CICS FREEMAIN.
• If you request storage using the C++ new operator, you must deallocate it by using the C++ delete operator.

All other combinations of methods of requesting and deallocating storage are unsupported and lead to unpredictable behavior.

Partial deallocations are not supported. All storage allocated at a given time must be deallocated at the same time.

Under the z/OS Language Environment library, z/OS C/C++ uses the z/OS Language Environment Callable Services to allocate and free storage. Refer to z/OS Language Environment Programming Guide for specific information on memory and storage manipulation in CICS.

The z/OS C/C++ library functions acquire all storage from the Extended Dynamic Storage Area (EDSA) unless you specify otherwise using the ANYHEAP, BELOWHEAP, HEAP, STACK, or LIBSTACK run-time options.

Storage that is acquired with the EXEC CICS GETMAIN command exists for the duration of the CICS task.

If your application is multi-threaded or often uses malloc(), realloc(), calloc(), and free(), you should consider using the HEAPPOOLS run-time option. Although storage requirements may increase, you can expect better performance.

Using Interlanguage Support
The z/OS Language Environment library supports a variety of different types of interlanguage calls (ILC) with CICS. For information on supported configurations, please refer to z/OS Language Environment Writing Interlanguage Communication Applications.
Exception Handling

You can use three different kinds of exception handlers when running C programs in a CICS environment: CICS exception handlers, z/OS Language Environment abend handlers, and C exception handlers. If you are using C++, you can use any of these three, or the C++ exception handling approach using `try`, `throw`, and `catch`. When a CICS condition is not handled under C++, the behavior of constructors and destructors for objects is undefined.

If the CICS command `EXEC CICS HANDLE ABEND PROGRAM(name)` was specified in the application, it will be called for any program exception that occurs (such as an operation exception or a protection exception) as well as for any `EXEC CICS ABEND ABCODE(...)` command that is run.

z/OS Language Environment provides facilities to set up a user handler. These facilities are discussed in detail in z/OS Language Environment Programming Guide.

In CICS, the C error handling facilities have almost the same behavior as discussed in Chapter 27, “Handling Exceptions, Error Conditions, and Signals” on page 379. A signal raised with the `raise()` function is handled by its corresponding signal handler or the default actions if no handler is installed. If a program exception such as a protection exception occurs, it is handled by the appropriate C handler if no CICS or z/OS Language Environment handler is present.

When a C or C++ application is invoked by an `EXEC CICS LINK PROGRAM(...)`, the invoked program inherits any handlers registered by `EXEC CICS HANDLE ABEND PROGRAM(...)` in the parent program. Any handlers registered in the child override the inherited handlers. C signal handlers are not inherited.

The following chart shows the process for handling abends in CICS.
MAP 0050: Error Handling in CICS

001

Is this the result of a call to \texttt{raise()}?  
\begin{itemize}
\item Yes
\item No
\end{itemize}

002

Has \texttt{EXEC CICS HANDLE ABEND} been issued?  
\begin{itemize}
\item Yes
\item No
\end{itemize}

Continue at Step 005.

004

Call z/OS C/C++-CICS interface for termination of program. CICS turns off signal and runs program in handler.

005

Is \texttt{SIG_IGN} set for the signal?  
\begin{itemize}
\item Yes
\item No
\end{itemize}

006

Is z/OS Language Environment handler registered?  
\begin{itemize}
\item Yes
\item No
\end{itemize}

007

Is a C or C++ handler established?  
\begin{itemize}
\item Yes
\item No
\end{itemize}

Default handling the program check and percolate to next stack frame.

009

Run C or C++ handler.

010

Run z/OS Language Environment user handler. See \texttt{z/OS Language Environment Programming Guide} for more details.

011

Resume at the next instruction.

Example of Error Handling in CICS

The examples in Figure 179 on page 605 show how to handle errors when using z/OS C/C++ with CICS.
/* program : CHKSTAT */
/* transaction : called stand alone from transaction CHST */
/* is also used by other transactions to determine system status */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <signal.h>

#define FILE_LEN 40

void status_not_ok(int sig);
void unexpected_prob(char* desc, int rc);
volatile unsigned char status_record [41];

struct com_struct {  
    int quiet;
} com_reg;

main (int argc, char *argv [])
{
    long int vsamrrn;
    signed short int vsamlen;
    signed long int myresp;
    signed long int myresp2;
    unsigned char status_downtme [41];
    
    if (strcmp(argv[0],"CHST") !=0) {
        printf("argv[0] = %s\n", argv[0]) ;
        com_reg.quiet = 1;
    } else
        com_reg.quiet = 0;

    EXEC CICS ADDRESS EIB(dfheiptr);
    EXEC CICS HANDLE ABEND PROGRAM("CATCHIT ");
    signal(SIGUSR1,status_not_ok);
    EXEC CICS LINK PROGRAM("GETSTAT ")
        RESP(myresp)
        RESP2(myresp2)
        COMMAREA(&com_reg)
        LENGTH(4);

Figure 179. Example Illustrating Error Handling under CICS (Part 1 of 3)
/* check for failure in linked-to program */
if (myresp != DFHRESP(NORMAL)) {
    printf("The RESP of LINK = %d\n", myresp);
    printf("The RESP2 of LINK = %d\n", myresp2);
    unexpected_prob("CICS failure on EXEC CICS LINK\n", 51);
}
if (myresp2 != 11)
    unexpected_prob("Unexpected rc from GETSTAT\n", myresp2);
vsamrrn = 1;
vsamlen = FILE_LEN;

/* following READ for UPDATE is for test purpose only. */
EXEC CICS READ FILE("STATFILE")
    UPDATE
    INTO(status_record)
    RIDFLD(vsamrrn)
    RRN
    LENGTH(vsamlen)
    RESP(myresp)
    RESP2(myresp2);

/* check for cics response - non-0 implies problem */
if (myresp != DFHRESP(NORMAL))
    unexpected_prob("Unable to read from file", 52);

/* write DOWNTME back to file - for test purpose only */
strcpy(status_downtme,"DOWNTME\n");
EXEC CICS REWRITE FILE("STATFILE")
    FROM(status_downtme)
    LENGTH(vsamlen)
    RESP(myresp)
    RESP2(myresp2);

if (myresp != DFHRESP(NORMAL)) {
    printf("The dnresp from REWRITE = %d\n", myresp);
    printf("The dnresp2 from REWRITE = %d\n", myresp2);
    unexpected_prob("Unexpected prob with WRITE\n", myresp);
}
if (memcmp(status_record,"OK \n", 3) != 0)
    raise(SIGUSR1);
exit(11);
}

void unexpected_prob( char* desc, int rc)
{
    long int msgresp, msgresp2;
    int msglen;
    msglen = strlen(desc);

Figure 179. Example Illustrating Error Handling under CICS (Part 2 of 3)
The program CATCHIT has been installed as the CICS abend handler. Because this CICS abend handler is installed, C exception handlers will only catch signals raised with the `raise()` function.

Install a C signal handler to catch the user defined signal SIGUSR1. This handler will only be called if `raise(SIGUSR1)` is run.

This command causes the flow of control to shift to a child program called GETSTAT. GETSTAT will inherit CHKSTAT's CICS abend handler.

The C signal handler `status_not_OK` that was will be invoked if this line is run. The `raise()` function will not trigger the CICS abend handler.

### ABEND Codes and Error Messages under z/OS C/C++

For information on ABEND Codes and error messages used by the z/OS Language Environment library, refer to [z/OS Language Environment Programming Guide](#) and [z/OS Language Environment Debugging Guide](#).

### Coding Hints and Tips

- Do not use EXEC CICS commands in macros.
- Do not use EXEC CICS commands in header files. This makes the translation process much simpler.
- Do not set `atexit()` routines before an EXEC CICS XCTL. You will get unpredictable results.
- If you call `fclose()` or `freopen()` for a standard stream, you cannot redirect or reopen the link to the transient data queue. z/OS C/C++ does not provide a method of opening or reopening the transient data queues.
- The actual transient data queue is not closed when you call `fclose()` or `freopen()` for a standard stream; however, the transaction will lose access to the stream.
- You should not use the `stdin` stream unless you are redirecting it from a memory file.
• Closing the cout, cerr, or clog standard streams in a C++ application has the same effect as closing stdout or stderr.

• When CICS handlers (using EXEC CICS HANDLE ABEND PROG) are activated along with C or C++ signal handlers, the CICS handler is invoked when an abend occurs. The C or C++ signal handler that corresponds to that class of abends is ignored.

  Note: The handler mentioned here is not a catch clause. It is a C signal handler exception registered by a C++ routine.

• If you do an EXEC CICS RETURN out of an atexit() routine, the resulting return code (RESP2) is undefined.

Translating and Compiling for Reentrancy

This section discusses and provides examples of using the CICS language translator and compiling for CICS. It also discusses reentrancy issues with respect to CICS.

Translating

CICS/ESA provides a utility program called the CICS language translator. This program translates the EXEC CICS statements into C or C++ code.

Note:

  If you are using C++, you must use the CPP translator option to indicate to the compiler that you are using the C++ language, rather than the C language. The use of the CPP parameter specifies that the translator is to translate z/OS C++ programs.

  Code translated without the CPP option or with a translator released before version 4.1 of CICS is not supported by the z/OS C++ compiler and will not compile.

  The translator supplies a control block (DFHEIBLK) for passing information between CICS/ESA and the application program. C or C++ function references for the EXEC CICS commands are generated. The translation step is not required if you do not use EXEC CICS statements.

  The CICS translator does not evaluate preprocessor statements such as #include or #define. You should ensure that all EXEC CICS statements are translated.

Translating Example

Figure 180 on page 609 shows pieces of C and C++ code before they are translated with the CICS language translator. Figure 181 on page 610 shows the corresponding programs after translation.
In Figure 180 observe the following:

These programs each contain two EXEC CICS commands to be translated by the CICS translator. A single instance of the EXEC CICS ADDRESS EIB command is required before any other call to the EXEC CICS interface. In this case, the main program (see Figure 177 on page 595) issues the ADDRESS EIB command. Since the two pieces of code make up one program there is no need to ADDRESS the EIB again.

The programs once translated appear as follows:
```c
#ifndef __dfheitab
#define __dfheitab 1
char *dfhldver = "LD TABLE DFHEITAB 320.";
unsigned short int dfheib0 = 0;
char *dfheid0 = "\x00\x00\x00\x0c";
char *dfheicb = " ";
typedef struct {
    unsigned char eibtime[4];
    unsigned char eibdate[4];
    unsigned char eibtrnid[4];
    unsigned char eibtaskn[4];
    unsigned char eibtrmid[4];
    signed short int eibfil01;
    signed short int eibcposn;
    signed short int eibcalen;
    unsigned char eibaid;
    unsigned char eibfn[2];
    unsigned char eibrcode[6];
    unsigned char eibds[8];
    unsigned char eibreqid[8];
    unsigned char eibrsrce[8];
    unsigned char eibsync;
    unsigned char eibfree;
    unsigned char eibrecv;
    unsigned char eibfil02;
    unsigned char eibatt;
    unsigned char eibeoc;
    unsigned char eibfmh;
    unsigned char eibcompl;
    unsigned char eibsig;
    unsigned char eibconf;
    unsigned char eiberr;
    unsigned char eiberrcd[4];
    unsigned char eibsynrb;
    signed long int eibresp;
    signed long int eibresp2;
    unsigned char eibrldbk;
} DFHEIBLK;
DFHEIBLK *dfheiptr;
#endif
```

Figure 181. Child C program after Translation (Part 1 of 3)
/* this is an example of a CICS program for C */
/* program : GETSTAT ( part 2 - infrequent use routines ) */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>

void unexpected_prob( char* desc, int rc);

void sendmsg( char* status_record )
{
    long int msgresp, msgresp2;
    char outmsg[80];
    int outlen;

    if (memcmp(status_record,"OK ",3)==0)
        strcpy(outmsg,"The system is available.");
    else if (memcmp(status_record,"DOWNTME ",8)==0)
        strcpy(outmsg,"The system is down for regular backups.");
    else
        strcpy(outmsg,"SYSTEM PROBLEM -- call help line for details.");

    outlen=strlen(outmsg);
}

Figure 181. Child C program after Translation (Part 2 of 3)
In Figure 181 on page 610 observe the following:

3 This structure, DFHEIBLK, is used for passing information between CICS and the application program.

4 This is the CICS command that was interpreted by the translator. The translator comments out the EXEC CICS commands.

5 The translator inserts this call to the function dfhexec and comments out the EXEC CICS commands for further processing by the z/OS C/C++ compiler. The values msgresp and msgresp2 are set from the values in the DFHEIBLK structure.

6 This EXEC CICS command is similar in format to the one discussed in 4. However, you should note that the generated call to dfhexec is different. For this reason it is important that EXEC CICS commands are not imbedded in macros.

Figure 181. Child C program after Translation (Part 3 of 3)
Compiling

CICS requires that programs be reentrant at CICS entry points. If you are using C, this means:

- If your program is not naturally reentrant, you must compile with the RENT compiler option.
- If you are compiling code that was translated by the CICS translator, you must compile with the RENT compiler option. The CICS translator puts external writable static in the program.

For both C and C++, this means that if your program is naturally reentrant and has not been translated, you can compile and link it just as you would a non-CICS program.

Sample JCL to Translate and Compile

The sample JCL in Figure 182 and Figure 183 on page 614 shows you how to translate and compile C and C++ modules.

```plaintext
// *--------------------------------------------------------------------
// | Translate a C-CICS program |
// *--------------------------------------------------------------------
// | Translate a C program for CICS |
// *--------------------------------------------------------------------
// */TRANSTEP EXEC PGM=DFHEDP1$, |
// | REGION=2048K, |
// | PARM= 'MAR(1,80,0),OM(1,80,0),NOS' |
// | STEPLIB DD DSN=CICS.SDFHLOAD,DISP=SHR |
// | SYSPRINT DD SYSPUNCH DD DSN=MYID.CHKSTAT.C,DISP=SHR |
// | SYSIN DD DSN=MYID.MYHDR.FILES,DISP=SHR |
// *--------------------------------------------------------------------
// */ C0010308 EXEC EDCC, |
// | INFILE='MYID.CHKSTAT.C', |
// | OUTFILE='MYID.OBJECT(CHKSTAT),DISP=SHR', |
// | CPARM='OPT(0) NOSEQ NOMAR RENT ', |
// | SYSOUT='*'
// | SYSIN DD DSN=**,DISP=(OLD,DELETE)
// | USERLIB DD DSN=MYID.MYHDR.FILES,DISP=SHR |
```

Figure 182. JCL to Translate and Compile a C Program
Prelinking and Linking All Object Modules

If you are using C++, or if you have compiled your C source with the RENT compile-time option, you must prelink all of the object modules together. The prelinker accepts one or more object modules, combines them, and generates a single output object module which can then be linked. For further information on the prelinker, see the z/OS C/C++ User’s Guide.

When you are prelinking for CICS, you should expect some unresolved external references and a return code of 4. These unresolved references should be resolved at link time.

CICS provides a stub called DFHELII, which must be link-edited with the load module. For your convenience, the linkage editor commands required for CICS are provided with CICS in the DFHEILID member of the SDFHC370 data set. The DFHEILID member must be reblocked before it is passed to the linkage editor. A name card should also be passed to the linkage editor. All applications must run AMODE=31. It is recommended that the object module is linked with AMODE(31) and RMODE(ANY). CICS does not require any other linkage editor options.

If you are using C, and your program will reside in one of the DFHRPL libraries, you do not need to link-edit the module with the RENT option. However, if the program is to be installed in one of the link pack areas, STEPLIBs, or data sets in the system link list, you should link-edit the module with the RENT option.

The example in Figure 184 on page 615 shows you how to prelink and link C and C++ modules.

```c
//** Translate a C++-CICS program
//**--------------------------------------------------------------------
//** Translate C++ program for CICS
//**--------------------------------------------------------------------
//TRANSTEP EXEC PGM=DFHEDP1$,
   // REGION=2048K,
   //   PARM= 'MAR(1,80,0),OM(1,80,0),NOS,CPP'
   //STEPLIB DD DSN=CICS.SDFHLOAD,DISP=SHR
   //SYSPRINT DD SYSPUT**
   //SYSPUNCH DD DSN=&SYSCIN,DISP=(,PASS),UNIT=VIO,
   //   DCB=BLKSIZE=400,SPACE=(400,(400,100))
   //SYSIN DD DSN=MYID.CHIKSTAT.C,DISP=SHR
   //**--------------------------------------------------------------------
   //** Compile the translated C++ source.
   //**--------------------------------------------------------------------
   //C0010308 EXEC CBCC,
   //   OUTFILE='MYID.OBJECT(CHKSTAT),DISP=SHR',
   //   CPARM='NOSEQ NOMAR RENT ',
   //   SYSOUT6='*'
   //SYSIN DD DSN=*.TRANSTEP.SYSPUNCH,DISP=(OLD,DELETE)
```

Figure 183. JCL to Translate and Compile a C++ Program
Defining and Running the CICS Program

This section discusses the implications of program processing, link considerations for C programs, and CSD considerations. Sample JCL to install z/OS C/C++ application programs is provided.

Program Processing

In a CICS environment, a single copy of a program is used by several transactions concurrently. One section of a program can process a transaction and then be suspended (usually as a result of an EXEC CICS command); another transaction can then start or resume processing the same or any other section of the same application program. This behavior requires that the program be reentrant.

Link Considerations for C Programs

If your C program will reside in one of the DFHRPL libraries, following the translate, compile, and link steps detailed earlier in this chapter is sufficient; there is no requirement to link-edit the module with the RENT linkage editor option.
However, if the program is to be installed in one of the link pack areas, STEPLIBs, or data sets in the system link list, the module should be link-edited with the RENT option.

**CSD Considerations**

Before you can run a program, you must define it in the CICS CSD. When defining a program to CICS, you should use `LANGUAGE(LE)`. However, if the program is in C and does not use ILC support, you can use `LANGUAGE(C)`.

If you use a copy of a reentrant C or C++ application program that has been installed in the link pack area, you must specify `USELPACOPY(YES)` in the resource definition when you define the program in the CSD. You can use the CICS-supplied procedure `DFYEITDL` to translate, compile, prelink, and link-edit C or C++ programs. For C programs, you may have to change the compile step of this procedure. You will have to change the compile step to use it with the C++ compiler.

**Sample JCL to Install z/OS C/C++ Application Programs**

This is the sample JCL to install a C or C++ application program.

```
//jobname JOB accounting info,name,MSGLEVEL=1
// EXEC PROC=DFHEXTEL
# //TRN.SYSIN DD *
# pragma XOPTS(Translator options...)
::
   z/OS C/C++ source statements
::
/*
   //LKED.SYSIN DD *
   NAME  anyname(R)
/*
```

*Figure 185. JCL to Install z/OS C/C++ Application Programs*

Your application is `anyname`. `x` can resolve to `I` or `X`. 
Chapter 39. Using Cross System Product (CSP)

This chapter briefly describes the interface between z/OS C and applications generated through the Cross System Product/Application Development (CSP/AD) and the Cross System Product/Application Execution (CSP/AE) Version 3 Release 2 Modification 2 or later. CSP refers to both CSP/AD and CSP/AE.

CSP/AD is an interactive application generator that provides methods for interactively defining, testing, and generating application programs. It can aid in improving productivity in application development.

CSP/AE takes the generated program and executes it in a production environment.

Note: XPLINK is not supported in a CSP environment.

Common Data Types

Table 70 lists the data types common to both CSP and z/OS C.

<table>
<thead>
<tr>
<th>z/OS C</th>
<th>CSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>signed short</td>
<td>BIN - 2 bytes</td>
</tr>
<tr>
<td>signed int/long</td>
<td>BIN - 4 bytes</td>
</tr>
<tr>
<td>struct</td>
<td>RECORD</td>
</tr>
<tr>
<td>char array(size)</td>
<td>Characters</td>
</tr>
</tbody>
</table>

You must use the function __csplist to receive the parameter list from a CSP application. See z/OS C/C++ Run-Time Library Reference for more information on this function.

Passing Control

You can pass control between CSP and z/OS C as follows:

**CALL**

Calls another application or subroutine to be run. When execution is completed, control is returned to the statement following the CALL statement in the original application.

**XFER|DXFR**

Transfers control and initiates execution of a CSP application or non-CSP program or transaction. The current application is terminated when the transfer statement is executed.

Under CICS, XFER is used to transfer control to another CICS transaction, while DXFR is used to transfer control to an application or program. If the target name is an application, control remains in CSP and the application is initiated immediately. If the target name is a program, CSP issues CICS XCTL to the program name.

Note: From a z/OS C program, you can pass control to a CSP application but you cannot pass control to another z/OS Language Environment-enabled...
language (COBOL, PL/I) from that CSP application. Only one z/OS Language Environment-enabled language can be in the chain of calls.

Running CSP under MVS

This section covers:
- Calling CSP applications from z/OS C
- Calling z/OS C from CSP

Calling CSP Applications from z/OS C

To call a CSP application from z/OS C, you must:
1. Define the CSP program to be called one of the following:
   - DCGCALL - calling under MVS/TSO
   - DCGXFER - transferring control under MVS/TSO with OS pragma linkage
2. Fetch the program dynamically.
3. Transfer control to the program. You must pass at least one parameter when calling CSP from z/OS C. This is the pointer to the ALF name and application name.

Examples

The following example program CALLs a CSP application in the z/OS environment.
You must receive a structure.

CCNGCP1

```c
/* this example shows how to CALL CSP from C under TSO */

/* CALL */
/* CCNGCP1 ===> R924A6 */
/* R924A6 is a CSP application */

#include <stdlib.h>
#include <math.h>

#pragma linkage(DCGCALL,OS)

void main(int argc, char * argv[])
{
    int ctr, base, power;

    typedef void ASM_VOID();

    #pragma linkage (ASM_VOID,OS)

    ASM_VOID * fetch_ptr;

    int rc = 0;
    char module [ 8] = "DCGCALL " ;
    struct tag_a6progc {
        char alfx [ 8];
        char applx [ 8];
    } ;

    Figure 186. C/370 CALLing CSP under TSO (Part 1 of 2)
struct tag_a6rec {
  char a6ct [ 4];
  char a6lan [ 4];
  char fil1 [ 8];    /* packed fields for PLI */
  char fil2 [ 8];    /* packed fields for PLI */
  char fil3 [ 8];    /* packed fields for PLI */
  int a6xbc;
  int a6ybc;
  int a6zbc;
};
struct {
  char s_parm [ 240];
} s_parms = {"ALF=C "};
struct tag_a6progc a6_progc = {"FZERSAM.","R924A6 "} ;
_Packed struct tag_a6rec a6_rec = {"CALL",
  "C ",
  "0000110C",
  "0000220C",
  "0000330C",
  12, 2, 0
};
base = atoi(argv[1]) ;
power= atoi(argv[2]) ;
a6_rec.a6xbc = base;
a6_rec.a6ybc = power;
a6_rec.a6zbc = (int) pow((double) a6_rec.a6xbc,
                          (double) a6_rec.a6ybc);
if ((fetch_ptr = (ASM_VOID *) fetch(module)) == NULL ) {
  printf (" failed on fetch of CSP %s module \n", module);
} else {
  fetch_ptr (&a6_progc, &a6_rec);
  rc = release((void (*)()) fetch_ptr) ;
  if ( rc != 0 ) {
    printf ("CCNGCP1: rc from release =%d\n", rc );
  }
}

Figure 186. C/370 CALLing CSP under TSO (Part 2 of 2)

Note: CSP cannot pass the DXFR statement to z/OS C under TSO.

The following example program uses an XFER command to transfer control to a CSP application. You must pass a structure.
This example shows how to transfer control to CSP from C under TSO, using XFER.

XFER
CCNGCP2 ===> R924A5
R924A5 is a CSP application.

#include <stdlib.h>
#include <math.h>
#pragma linkage(DCGXFER,OS)

void main(int argc, char * argv[])
{
    int ctr, base, power;
    int rc = 0;
    char module[8] = "DCGXFER";

    typedef void ASM_VOID();
    #pragma linkage(ASM_VOID,OS)
    ASM_VOID * fetch_ptr;

    struct tag_a5ws
    {
        short length;
        char filler[8];
        char a5ct[4];
        char a5lan[4];
        char fil1[8]; /* packed fields for PLI */
        char fil2[8]; /* packed fields for PLI */
        char fil3[8]; /* packed fields for PLI */
        int a5xbc;
        int a5ybc;
        int a5zbc;
    };

    struct tag_a5progx
    {
        char alfx[8];
        char applx[8];
    };

    struct
    {
        char s_parm[240];
    } s_parms = "ALF=C ";

Figure 187. z/OS C Transferring control to CSP under TSO using the XFER/DXFR statement (Part 1 of 2)
Calling z/OS C from CSP

To call a z/OS C program from CSP:

- **PLIST(OS)** must be specified in the z/OS C program so that input parameters will not be processed by the run-time environment.
- When CSP passes a parameter list to a z/OS C function, the list is in a different format from what z/OS C expects in a normal z/OS environment. To receive the parameters, use the macro __csplist, found in the csp.h header file and described in [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/docview.wss?uid=swg27013268).

**Notes:**

1. **PLIST(OS)** must be specified in the z/OS C program so that input parameters will not be processed by the run-time environment.
2. When CSP passes a parameter list to a z/OS C function, the list is in a different format from what z/OS C expects in a normal z/OS environment. To receive the parameters, use the macro __csplist, found in the csp.h header file and described in [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/docview.wss?uid=swg27013268).

**Examples**

The following example program shows how parameters are received from a CSP application that uses a CALL statement to transfer control. You must pass three parameters:

- An int
- A string

```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <math.h>

struct tag_a5progx a5_progx = {"FZERSAM.", "R924A5 "};
_Packed struct tag_a5ws a5_ws = { 54,
    "CCNGCP2",
    "XFER",
    "C",
    "0000110C",
    "0000220C",
    "0000330C",
    12, 2, 0
};

base = atoi(argv[1])
power= atoi(argv[2])

a5_ws.a5xbc = base;
a5_ws.a5ybc = power;
a5_ws.a5zbc = (int) pow((double) a5_ws.a5xbc,
                          (double) a5_ws.a5ybc);

if ((fetch_ptr = (ASM_VOID *) fetch(module)) == NULL) {
    printf(" failed on fetch of CSP %8s module \n", module);
} else {
    fetch_ptr (&a5_ws, &a5_progx);
    rc = release((void (*)(void *))fetch_ptr);
    if (rc != 0) {
        printf("CCNGCP2: rc from release =%d\n", rc);
    }
}
```

Figure 187. z/OS C transferring control to CSP under TSO using the XFER/DXFR statement (Part 2 of 2)
A struct

CCNGCP3

/* this example shows how to CALL C from CSP under TSO */

#pragma runopts (plist(os))
#include <csp.h>
#include <math.h>
#include <stdlib.h>

void main()
{

struct date {
    char yy[2];
    char mm[2];
    char dd[2];
};
int *parm1_ptr;
char *parm2_ptr;
struct date * parm3_ptr;

    parm1_ptr = (int *) __csplist[0];       /* get 1st parm */
    parm2_ptr = (char  *) __csplist[1];   /* get 2nd parm */
    parm3_ptr = (struct date  *) __csplist[2]; /* get 3rd parm */
}

Figure 188. CSP CALLing z/OS C under TSO

The following example program shows how parameters are received from a CSP application that uses an XFER/DXFR statement to transfer control. You must pass a structure.

Notes:
1. Under TSO, CSP/AD cannot use the XFER statement to transfer control to z/OS C.
2. Under TSO, you cannot use the DXFR statement to transfer control to CSP.
/* this example shows how to transfer control from CSP to C */

/* This program will be called from CSP through */
/* "XFER" or DXFR call. */
/* Parameters are passed as a working storage record */
/* plus 10 bytes of filler information */
/* 2 bytes length */
/* 8 bytes filler */
/* n bytes working storage record. */

#pragma runopts (plist(os))
#include <stdlib.h>
#include <csp.h>
#include <math.h>
#include <string.h>

#pragma linkage(DCGXFER,OS)
#pragma linkage(DCGCALL,OS)

void xfer_rtn ();
void call_rtn ();

struct tag_a3ws {
  short length;
  char filler [8];
  char a3ct [4];
  char a3lan [4];
  char fil1 [8]; /* packed fields for PLI */
  char fil2 [8]; /* packed fields for PLI */
  char fil3 [8]; /* packed fields for PLI */
  int a3xbc;
  int a3ybc;
  int a3zbc;
};

struct tag_a3progx {
  char a1fx [8];
  char applx [8];
};

Figure 189. CSP Transferring Control to z/OS C under TSO Using the XFER Statement (Part 1 of 3)
void main()
{

__Packed struct tag_a3ws *parm1;
__Packed struct tag_a3ws a3_ws;

parm1 = (__Packed struct tag_a3ws *)__csplist[0];
parm1->a3zbc = (int) pow((double) parm1->a3xbc,
(double) parm1->a3ybc);

if (parm1->a3zbc > 255)
  xfer_rtn(parm1); /* xfer to csp */
else
  call_rtn(parm1); /* call to csp */
}

void xfer_rtn(_Packed struct tag_a3ws * parm1 )
{

#pragma linkage (ASM_VOID,OS)

typedef void ASM_VOID();

ASM_VOID * fetch_ptr;

struct tag_a3progx a3_progx = {"FZERSAM.","R924A5 "} ;
int rc = 0;
char pgm_xfer [ 8] = {"DCGXFER "} ;

if ((fetch_ptr = (ASM_VOID *) fetch(pgm_xfer)) == NULL ) {
    printf (" failed on fetch of CSP %8s module \n", pgm_xfer);
}
else {
    fetch_ptr (parm1, &a3_progx);
    rc = release((void (*)()) fetch_ptr) ;
    if ( rc != 0 ) {
        printf("xfer_rtn: rc from release =%d\n", rc );
    }
}
}

Figure 189. CSP Transferring Control to z/OS C under TSO Using the XFER Statement (Part 2 of 3)
Running under CICS Control

CSP-CICS Note: Because all z/OS C applications running under CICS must run with AMODE=31, when passing parameters to CSP, you must either
- Pass parameters below the line, or
- Relink the CSP load library with AMODE=31

Examples

The following example program shows how parameters are received from a CSP application that uses a CALL statement to transfer control. The z/OS C program is expecting to receive an int as a parameter.

Figure 189. CSP Transferring Control to z/OS C under TSO Using the XFER Statement (Part 3 of 3)
The following example program shows how parameters are received from a CSP application that uses an XFER statement to transfer control.

```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <math.h>

main()
{
    struct tag_commarea { /* commarea passed to z/OS C from R924A1 */
        int *ptr1;
        int *ptr2;
        int *ptr3;
    } *ca_ptr; /* commarea ptr */
    int *parm1_ptr;
    int *parm2_ptr;
    int *parm3_ptr; /* addressability to EIB control block */
    EXEC CICS ADDRESS EIB(dfheiptr) COMMAREA(ca_ptr);
    parm1_ptr = ca_ptr->ptr1;
    parm2_ptr = ca_ptr->ptr2;
    parm3_ptr = ca_ptr->ptr3;
    *parm3_ptr = (int) pow((double) *parm1_ptr, (double) *parm2_ptr);
    EXEC CICS RETURN;
}

Figure 190. CSP CALLing z/OS C under CICS

The following example program shows how parameters are received from a CSP application that uses an XFER statement to transfer control.
CCNGCP6

/* this example shows how to XFER control to C from CSP under CICS */
/* XFER CALL */
/* R924A3 ===> CCNGCP6 ===> R924A6 */
/* R924A3 and R924A6 are CSP applications */

#include <math.h>
#include <string.h>

/* structure passed to R924A6*/
void main()
{
 struct {
    char *appl_ptr;
    _Packed struct tag_a3rec *rec3_ptr;
 } parm_ptr;
 /* Structure received R924A3*/
 struct tag_a3rec {
    char a3ct [ 4];
    char a3lan [ 4];
    char fill1 [ 8]; /* packed fields for PLI */
    char fill2 [ 8]; /* packed fields for PLI */
    char fill3 [ 8]; /* packed fields for PLI */
    int a3xbc; /* int field 1 for z/OS C */
    int a3ybc; /* int field 2 for z/OS C */
    int a3zbc; /* int field 3 for z/OS C */
    }
    _Packed struct tag_a3rec a3rec ;
 char lk_appl[16] = "USR5ALF.R924A6 " ;
 struct tag_a3progx {
    char alfx [ 8];
    char applx [ 8];
    }
    _Packed struct tag_a3progx a3progx = {"USR5ALF." ,"R924A6 "} ;
 short length_a3rec = sizeof(a3rec) ;
 char * pa3rec ;
 short i ;

.MEDIA

 Figure 191. CSP transferring control to z/OS C under CICS using the XFER statement (Part 1 of 2)
The following example program shows how parameters are received from a CSP application that uses a DXFR statement to transfer control. You must receive a structure.

**CCNGCP7**

```c
/* this example shows how to transfer control to C from CSP under CICS, using the DXFR statement */

/* DXFR XCTL (equivalent to dxfr) */
/* R924A3 ===> CCNGCP7 ===> DCBINIT (appl R924A5) */
/* R924A3 is a CSP application */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <math.h>

main ()
{
    struct tag_a3rec {
        char a3ct [ 4];
        char a3lan [ 4];
        char fil1 [ 8]; /* packed fields for PLI */
        char fil2 [ 8]; /* packed fields for PLI */
        char fil3 [ 8]; /* packed fields for PLI */
        int a3xbc;
        int a3ybc;
        int a3zbc;
    };
```

Figure 192. CSP Transferring Control to z/OS C under CICS Using the DXFR Statement (Part 1 of 2)
/* commarea passed to C/370 from R924A3 */

struct tag_commarea {
    char a3ct [ 4] ;
    char a3lan [ 4];
    char fil1 [ 8]; /* packed fields for PLI */
    char fil2 [ 8]; /* packed fields for PLI */
    char fil3 [ 8]; /* packed fields for PLI */
    int a3xbc;
    int a3ybc;
    int a3zbc;
} * ca_ptr ; /* commarea ptr */

struct tag_a5progc {
    char alfc [ 8] ;
    char applc [ 8];
    struct tag_a3rec a3rec;
} a5progc = {"USR5ALF.","R924A5 "};

short length_a3rec = sizeof(struct tag_a3rec);
short length_a5progc = sizeof(struct tag_a5progc);

/* addressability to EIB control block */
/* and COMMUNICATION AREA */

EXEC CICS ADDRESS EIB(dfheiptr) COMMAREA(ca_ptr) ;

if (dfheiptr->eibcalen == length_a3rec ) {
    memcpy(&a5progc.a3rec, ca_ptr , length_a3rec);

    /* calculate the pow(x,y) */
    a5progc.a3rec.a3zbc = (int) pow((double) a5progc.a3rec.a3xbc,
    (double) a5progc.a3rec.a3ybc);

    EXEC CICS XCTL
    PROGRAM("DCBINIT ")
    COMMAREA(a5progc)
    length(length_a5progc) ;

    if (dfheiptr->eibresp2 != DFHRESP(NORMAL)) {
        printf("CCNGCP7: failed on xctl call to DCBINIT\n");
        printf("\n");
    }
    else {
    printf("CCNGCP7:length of COMMAREA is different from expected\n");
    printf("expected %d, actual %d\n", length_a3rec, dfheiptr->eibcalen);
    printf("\n");
    EXEC CICS RETURN;
    }
}

EXEC CICS RETURN;

Figure 192. CSP Transferring Control to z/OS C under CICS Using the DXFR Statement (Part 2 of 2)
Chapter 40. Using Data Window Services (DWS)

Data Window Services (DWS) is part of the CSL (Callable Services Library). DWS gives your C or C++ program the ability to manipulate data objects (temporary data objects known as TEMPSPACE, and VSAM linear data sets).

Note: XPLINK is not supported with DWS.

To use DWS functions with C code, you do not have to specify a linkage pragma or add any specialized code. Code the DWS function call directly inside your z/OS C program just as you would a call to a C or C++ library function and then link-edit the DWS module containing the function you want (such as CSRIDAC, CSRVIEW, CSRSCOT, CSRSAVE or CSRRREFR) with your C or C++ program.

To use DWS functions with C++ code, you must specify C linkage for any DWS function that you use. For example, if you wished to use CSRIDAC, you would use a code fragment like this one:

```c
/* this example shows how DWS may be used with C++ */
#include <stdlib.h>
extern "C" {
    void csridac( char*, char*, char*, char*, char*,
                 char*, long int*, char*, long int*,
                 long int*, long int*);
}

int main(void)
{
    /* Set up the parameters that will be used by CSRIDAC. */
    char op_type[6] = "BEGIN";
    char object_type[10] = "TEMPSPACE";
    char object_name[45] = "DWS.FILE ";
    char scroll_area[4] = "YES";
    char object_state[4] = "NEW";
    char access_mode[7] = "UPDATE";
    long int object_size = 8;
    char object_id[9];
    long int high_offset, return_code, reason_code;

    /* Access a DWS TEMPSPACE data object. */
    csridac(op_type, object_type, object_name, scroll_area, object_state,
            access_mode,object_size,object_id,&high_offset,
            &return_code,&reason_code);

    /* INSERT ADDITIONAL CODE HERE */
}
```

Figure 193. Example Using DWS and C++

At link-edit time, you should link-edit the DWS module containing the function you want, just as you would for a C program.
In DWS the data types of the parameters are specified differently from z/OS C/C++ data types. When invoking DWS functions from your C or C++ program, you must specify:

- A long int data type for DWS parameters of integer (I*4) type.
- Character strings (of the required length) for DWS parameters of character type.

For example, if the DWS function requires a 9-character object name (in this example we will set the object name to TEMPSPACE) you can declare the parameter in your C or C++ function as follows:

```c
char object_type[9] = "TEMPSPACE";
```

For more information on DWS, see [z/OS MVS Programming: Callable Services for HLL](#).

### Example

The following is an excerpt from a C program that shows parameter declarations for the DWS CSRIDAC function and the function call.

```c
CCNGDW1
/* this example shows how DWS may be used with C */

int main(void)
{
    /* Set up the parameters that will be used by CSRIDAC. */

    char op_type[5] = "BEGIN";
    char object_type[9] = "TEMPSPACE";
    char object_name[45] = "DWS.FILE ";
    char scroll_area[3] = "YES";
    char object_state[3] = "NEW";
    char access_mode[6] = "UPDATE";
    long int object_size = 8;
    char object_id[8];
    long int high_offset, return_code, reason_code;

    /* Access a DWS TEMPSPACE data object. */
    csridac(op_type, object_type, object_name, scroll_area, object_state,
            access_mode,OBJECT_size,OBJECT_id,&high_offset,
            &return_code,&reason_code);

    /* INSERT ADDITIONAL CODE HERE */

    return 0;
}
```

Figure 194. z/OS C/C++ Using Data Window Services
Both z/OS Language Environment and z/OS C/C++ provide an interface to the IBM DB2 Universal Database Licensed Program. Refer to "DB2" on page 926 for a list of books describing DB2.

An application program requests DB2 services using SQL statements imbedded in the program. This source code is translated into host language statements that perform assignments and call a database language interface module. DB2 processes a request and then returns to the application. Any errors occurring during database processing are handled by the database product. If a program is terminated, DB2 takes appropriate action depending on the nature of termination.

The DB2 SQL preprocessor converts code with embedded SQL statements into compilable code. It supports C and C++. DB2 can also be accessed through C code that is statically or dynamically called by C++. The DB2 SQL preprocessor does not recognize the z/OS C/C++ compiler’s support for alternative locales and codepages. Therefore, all DB2 z/OS C/C++ code should be written in codepage IBM-1047 (APL293).

Note: Applications compiled XPLINK can invoke DB2 services that are called through stubs defined as #pragma linkage(..., OS). The SQL commands are one example of this. DB2 stored procedures cannot be compiled XPLINK.

C++ Example

Examples CCNGDB1 and CCNGDB2, demonstrate how to use DB2 with C++. To use the examples, precompile example CCNGDB2 (Figure 196 on page 634) with the DB2 precompiler (compiled in C) and then prelink the resulting code with CCNGDB1. Bind the C++ extended object modules to produce the executable program object.

CCNGDB1

/* this example shows how to use DB2 with C++ */
/* part 1 of 2-other file is CCNGDB2 */

/* this file is to be compiled with C++, */
/* and then prelinked with CCNGDB2 */

#include <stdlib.h>
#include <iostream.h>

Figure 195. Using DB2 with C++ (Part 1 of 2)
extern "C" {
    int CreaTab(void);
    int DropTab(void);
}

int main(void)
{
    if (CreaTab() == -1)
    {
        cout << "Test Failed in table-creation." << endl;
        exit(-1);
    }

    if (DropTab() == -1)
    {
        cout << "Test Failed in table-dropping." << endl;
        exit(-1);
    }
    cout << "Test Successful." << endl;
    return 0;
}

Figure 195. Using DB2 with C++ (Part 2 of 2)

CCNGDB2

/* this example demonstrates how to use DB2 with C++ */
/* part 2 of 2-other file is CCNGDB1 */

/* this file is to be precompiled with the DB2 precompiler, */
/* compiled in C, and then prelinked with CCNGDB1 */

#include <string.h>
#include <stdio.h>

EXEC SQL INCLUDE SQLCA;

/*
 * This routine creates the table CTAB1 and inserts some values
 * into it
 */

Figure 196. Using DB2 with C++ (Part 1 of 2)
int CreaTab(void)
{

EXEC SQL CREATE TABLE CTAB1
( EMPNO CHAR(6) NOT NULL,
FIRSTNME VARCHAR(12) NOT NULL,
LASTNME VARCHAR(15) NOT NULL,
WORKDEPT CHAR(3) NOT NULL,
PHONENO CHAR(7),
EDUC_LVL SMALLINT,
SALARY FLOAT(21) ) IN DATABASE DSNÚCOMP;

if (sqlca.sqlcode != 0)
{
    printf("ERROR - SQL code returned non-zero for "
    "creation of CTAB1, received %d\n",sqlca.sqlcode);
    return(-1);
}
/* Now insert some values into the table */

EXEC SQL INSERT INTO CTAB1 VALUES
( '097892','John','Adams','003','8883945',3,29500.00 );
EXEC SQL INSERT INTO CTAB1 VALUES
( '000002','Joe','Smith','004','8883791',NULL,25500.00 );
EXEC SQL INSERT INTO CTAB1 VALUES
( '043929','Ralph','Holland','001','8888734',1,NULL);
EXEC SQL INSERT INTO CTAB1 VALUES
( '000010','Holly','Waters','001','8884590',3,29550.00 );

if (sqlca.sqlcode != 0)
{
    printf("ERROR - SQL code returned non-zero for "
    "insert into tables, received %d\n",sqlca.sqlcode);
    return(-1);
}
return(0);

} /* This routine will drop the table. */

int DropTab(void)
{

EXEC SQL DROP TABLE CTAB1;
if (sqlca.sqlcode != 0)
{
    printf("ERROR - SQL code returned non-zero for "
    "drop of CTAB1 received %d\n",sqlca.sqlcode);
    return(-1);
}
EXEC SQL COMMIT WORK;
return(0);
}

Figure 196. Using DB2 with C++ (Part 2 of 2)
C Example

In Figure 197, a C program creates a table called CTAB1, inserts values into the table and then drops the table. To use this example, run the program through the DB2 SQL preprocessor, and compile the generated code. Bind the C extended object modules to produce the executable program object.

CCNGDB4

/* this example demonstrates how to use SQL with C */
#include <string.h>
#include <stdio.h>
EXEC SQL INCLUDE SQLCA;
int main(void)
{
    if (CreaTab() == -1)
    {
        printf("Test Failed in table-creation.\n");
        exit(-1);
    }
    if (DropTab() == -1)
    {
        printf("Test Failed in table-dropping.\n");
        exit(-1);
    }
    printf("Test Successful.\n");
    return(0);
}

/*
 * This routine creates the table CTAB1 and inserts some values
 * into it
 */
int CreaTab(void)
{
    EXEC SQL CREATE TABLE CTAB1
        ( EMPNO CHAR(6) NOT NULL,
          FIRSTNME VARCHAR(12) NOT NULL,
          LASTNME VARCHAR(15) NOT NULL,
          WORKDEPT CHAR(3) NOT NULL,
          PHONENO CHAR(7),
          EDUCLVL SMALLINT,
          SALARY  FLOAT(21) );
    if (sqlca.sqlcode != 0)
    {
        printf("ERROR - SQL code returned non-zero for ",
            "creation of CTAB1, received %d\n",sqlca.sqlcode);
        return(-1);
    }

Figure 197. Using DB2 with C (Part 1 of 2)
/* Now insert some values into the table */

EXEC SQL INSERT INTO CTAB1 VALUES
  ('097892', 'John', 'Adams', '003', '8883945', 3, 29500.00);
EXEC SQL INSERT INTO CTAB1 VALUES
  ('000002', 'Joe', 'Smith', '004', '8883791', NULL, 25500.00);
EXEC SQL INSERT INTO CTAB1 VALUES
  ('043929', 'Ralph', 'Holland', '001', '8888734', 1, NULL);
EXEC SQL INSERT INTO CTAB1 VALUES
  ('000010', 'Holly', 'Waters', '001', '8884590', 3, 29550.00);

if (sqlca.sqlcode != 0)
{
  printf("ERROR - SQL code returned non-zero for "
         "insert into tables, received %d\n", sqlca.sqlcode);
  return(-1);
}
return(0);

/*
 * This routine will drop the table.
 */

int DropTab(void)
{
  EXEC SQL DROP TABLE CTAB1;
  if (sqlca.sqlcode != 0)
  {
    printf("ERROR - SQL code returned non-zero for "
           "drop of CTAB1 received %d\n", sqlca.sqlcode);
    return(-1);
  }
  EXEC SQL COMMIT WORK;
  return(0);
}

Figure 197. Using DB2 with C (Part 2 of 2)
Chapter 42. Using Graphical Data Display Manager (GDDM)

The Graphical Data Display Manager (GDDM*) provides programmers with a comprehensive set of functions for displaying or printing information in the most effective manner.

The major functions provided are:

- A windowing system that the user can tailor to display selected information
- Support for presentation and interaction through the keyboard
- Comprehensive graphics support
- Fonts, including support for double-byte character sets (DBCS)
- Business image support
- Saving and restoring graphics pictures
- Support for many types of display terminals, printers, and plotters.

Because GDDM uses OS-style linkage, calls from C to GDDM require the #pragma linkage pragma, as in the following example:

```c
#pragma linkage(identifier, OS)
```

In C++ code, calls to and from GDDM require that any GDDM functions you use be prototyped as extern "OS", as in the following example:

```c
extern "OS" {
    ASREAD( int *type, int *num, int *count );
    CHAATT( int num, int *attrib );
    CHHATT( int num, int *attrib );
}
```

Because C++ does not support #pragma linkage, any existing C code that you are moving to C++ should use the extern "OS" specification instead.

When linking a GDDM application, you must add the GDDM library to your SYSLIB concatenation.

**Note:** XPLINK is not supported by GDDM.

---

**Example**

The following example demonstrates the interface between C and GDDM by drawing a polar chart to compare the characteristics of two cars.
/* this example demonstrates the use of C and GDDM */
#include <string.h>
#pragma linkage(asread,OS)
#pragma linkage(chaatt,OS)
#pragma linkage(chhatt,OS)
#pragma linkage(chhead,OS)
#pragma linkage(chkatt,OS)
#pragma linkage(chkey,OS)
#pragma linkage(chnatt,OS)
#pragma linkage(chnoff,OS)
#pragma linkage(chnote,OS)
#pragma linkage(chpolr,OS)
#pragma linkage(chset,OS)
#pragma linkage(chxlab,OS)
#pragma linkage(chxlat,OS)
#pragma linkage(chxtic,OS)
#pragma linkage(chyrng,OS)
#pragma linkage(chyset,OS)
#pragma linkage(fsinit,OS)
#pragma linkage(fsterm,OS)

/* Arrays are expected for int * and float * */
/* char * can be an array or a string */
extern int asread (int *type, int *num, int *count);
extern int chaatt (int num, int *attrib);
extern int chhatt (int num, int *attrib);
extern int chkatt (int num, int *attrib);
extern int chkey (int, int, char *);
extern int chnatt (int num, int *attrib);
extern int chnoff (double, double);
extern int chnote (char *string, int num, char *title);
extern int chpolr (int, int, float *xdata, float *ydata);
extern int chset (char *charactr);
extern int chxlab (int num, int, char *);
extern int chxlat (int num, int *attrib);
extern int chxtic (double x, double y);
extern int chyrng (double from, double to);
extern int chyset (char *charactr);
extern int fsinit (void);
extern int fsterm (void);

/**********************************************
** Attribute arrays used for the chart.  **
**********************************************/

int i;
int h_attrs[4] = {3, 3, 0, 175}; /* Head text attribute */
int n_attrs[4] = {7, 3, 0, 200}; /* Note text attribute */
int a_attrs[2] = {7, 1}; /* X-axis color and line */
int xl_attrs[1] = {5}; /* X-label color */
int k_attrs[1] = {5}; /* Key text color */
int type, num, count;

float x_data[8] = {0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0};
float y_data[16] = {
  14190.0, 260.0, 0.21, 0.066, 83.3, 6.0, 19.1, 14190.0,
  12986.0, 290.0, 0.23, 0.066, 95.6, 5.0, 16.2, 12986.0
};
float maxvals[16] = {
  15000.0, 300.0, 0.25, 0.070, 100.0, 6.0, 20.0, 15000.0,
  15000.0, 300.0, 0.25, 0.070, 100.0, 6.0, 20.0, 15000.0
};

Figure 198. Example Using GDDM and C (Part 1 of 2)
```c
int main(void)
{
    fsinit();
    chhatt(4, h_attrs);
    chhead(40, "TWO CARS COMPARED USING SEVEN PARAMETERS");
    chaatt(2, a_attrs);
    chxtic(1.0, 0.0);
    chxlabel(7, 31, "PURCHASE PRICE; $15,000 INSURANCE; $300/YEAR 
" "$0.25/MILE; SERVICING $0.070/MILE; FUEL 
" " 100 BHP/TON; POWER/WT RATIO; 6; SEATS 
" " BAGGAGE SPACE; 20 CU FT");
    chyrange(0.5, 1.0);
    chyset("NOAXIS");
    chyset("NOLABEL");
    chyset("PLAIN");
    chset("KBOX");
    chkatt(1, k_attrs);
    chkey(2, 5, "CAR ACAR B");
    for(i=0; i<16; ++i)
        y_data[i] = y_data[i] / maxvals[i];
    chpolr(2, 8, x_data, y_data);
    chnatts(4, n_atts);
    chnoff(0.0, 0.53);
    chnote("Z2", 1, "+");
    chset("BNOTE");
    n_atts[3] = 75;
    chnatts(4, n_atts);
    chnoff(0.0, 0.60);
    chnote("Z2", 12, "CENTER VALUE");
    chnoff(0.0, 0.55);
    chnote("Z2", 23, "+= 1/2 X PERIMETER VALUE");

    /******************************************************************************
    ** Issue a screen read. When any interrupt is generated **
    ** by the terminal operator, the program terminates. **
    *****************************************************************************/
asread(&type, &num, &count);
    fsterm();
    exit(0);
}
```

*Figure 198. Example Using GDDM and C (Part 2 of 2)*

This is a similar example, in C++:
/* this example demonstrates the use of C++ and GDDM */
#include <stdlib.h>
#include <string.h>
/* Arrays are expected for int * and float * */
/* char * can be an array or a string */
extern "OS" {
    int asread (int *type, int *num, int *count);
    int chaatt (int num, int *attrib);
    int chhatt (int num, int *attrib);
    int chkatt (int num, int *attrib);
    int chkey (int, int, char *);
    int chhead(int, int, char *);  
    int chnatt (int num, int *attrib);
    int chnoff (double, double);
    int chnote (char *string, int num, char *title);
    int chpoir (int, int, float *xdata, float *ydata);
    int chset (char *charactr);
    int chxlab (int num, int, char *);
    int chxlat (int num, int *attrib);
    int chxtic (double x, double y);
    int chyng (double from, double to);
    int chyset (char *charactr);
    int fsinit (void);
    int fsterm (void);
}
/**********************************************
** Attribute arrays used for the chart. **
***********************************************/
int i;
int h_attrs[4]={3,3,0,175}; /* Head text attribute */
int n_attrs[4]={7,3,0,200}; /* Note text attribute */
int a_attrs[2]={7,1}; /* X-axis color and line */
int x1_attrs[1]={5}; /* X-label color */
int k_attrs[1]={5}; /* Key text color */
int type, num, count;
float x_data[8]={0.0,1.0,2.0,3.0,4.0,5.0,6.0,7.0};
float y_data[16]={
    14190.0, 260.0, 0.21, 0.066, 83.3, 6.0, 19.1, 14190.0,
    12986.0, 290.0, 0.23, 0.066, 95.6, 5.0, 16.2, 12986.0};
float maxvals[16]={
    15000.0, 300.0, 0.25, 0.070, 100.0, 6.0, 20.0, 15000.0,
    15000.0, 300.0, 0.25, 0.070, 100.0, 6.0, 20.0, 15000.0};

Figure 199. Example Using GDDM and C++ (Part 1 of 2)
int main(void)
{
    fsinit();
    chhattr(4, h_attrs);
    chhead(40,"TWO CARS COMPARED USING SEVEN PARAMETERS");
    chaatt(2, a_attrs);
    chxtic(1.0, 0.0);
    chxlat(1, xl_atrtrs);
    chxlab(7, 31,
        "PURCHASE PRICE ; $15,000 INSURANCE ;$300/YEAR 
        "$0.25/MILE ;SERVICING $0.070/MILE ;FUEL 
        " 100 BHP/TON; POWER/WT RATIO 6; SEATS" 
        " BAGGAGE SPACE; 20 CU FT");
    chyrng(0.5,1.0);
    chyset("NOAXIS");
    chyset("NOLABEL");
    chyset("PLAIN");
    chset("KBOX");
    chkatt(1, k_attrs);
    chkey(2, 5, "CAR ACAR B");
    for(i=0; i<16; ++i)
        y_data[i] = y_data[i] / maxvals[i];
    chpolr(2, 8, x_data, y_data);
    chnatt(4, n_attrs);
    chnoff(0.0, 0.53);
    chnote("Z2", 1, "+");
    chset("BNOTE");
    n_attrs[3] = 75;
    chnatt(4, n_attrs);
    chnoff(0.0, 0.60);
    chnote("Z2", 12, "CENTER VALUE");
    chnoff(0.0, 0.55);
    chnote("Z2", 23, "= 1/2 X PERIMETER VALUE");
    /**************************************************
     ** Issue a screen read. When any interrupt is generated **
     ** by the terminal operator, the program terminates. **
     ***************************************************/
    asread(&type, &num, &count);
    fsterm();
    exit(0);
}

Figure 199. Example Using GDDM and C++ (Part 2 of 2)
Chapter 43. Using the Information Management System (IMS)

This chapter explains how the Information Management System (IMS) and z/OS C/C++ coordinate error handling, and describes the limitations to using IMS with z/OS C/C++.

z/OS C/C++ provides the `ctdli()` C library function to invoke IMS facilities (see z/OS C/C++ Run-Time Library Reference for more information).

You can also invoke IMS facilities with the callable service `CEETDLI` which is provided by the z/OS Language Environment. The CEETDLI interface performs essentially the same functions as `ctdli()`, but it offers some advantages, particularly if you plan to run an ILC application in IMS. If you use the CEETDLI interface instead of `ctdli()`, condition handling is improved because of the coordination between z/OS Language Environment and IMS condition handling facilities. For complete information on the CEETDLI interface, see z/OS Language Environment Programming Guide.

For a description of writing IMS batch and online programs in C or C++, see the appropriate book listed in “IMS/ESA” on page 927.

To use IMS from z/OS C/C++, you must keep the following in mind:

- The file `<ims.h>` must be included in the program.
- `PLIST(OS)` and `TARGET(IMS)` must be used to compile IMS z/OS C and C++ application programs. `PLIST(OS)` establishes the correct parameter list format when invoked under IMS and `TARGET(IMS)` establishes the correct operating environment. These compile-time options can alternatively be specified using `#pragma runopts`. The `PLIST(OS)` compiler option is equivalent to `#pragma runopts(ENV(IMS))`. The descriptions that follow use the compile-time options, but the `#pragma runopts` equivalents can be used instead.
- `TARGET(IMS)` is mandatory, as it establishes the correct operating environment. `PLIST(OS)` must also be used if the program is the initial `main()` program called under IMS. Programs in nested enclaves do not need to be compiled with `PLIST(OS)`.
- When you specify `PLIST(OS)` the argument count (`argc`) will be set to one (1), and the first element in the argument vector (`argv[0]`) will contain a NULL string.
- IMS provides a language interface module (DFSLI000) that gives a common interface to IMS and DL/I. This module must be link-edited with the application program.

The rest of this chapter is based on the assumption that you are using the `ctdli()` interface.

Handling Errors

The IMS environments are sensitive to errors and error-handling issues. A failing IMS transaction or program can potentially corrupt an IMS database. IMS must know about the failure of a transaction or program that has been updating a database so that it can back out any updates made by that failing program.

z/OS C/C++ provides extensive error-handling facilities for the programmer, but special steps are required to coordinate IMS and C or C++ error handling so that IMS can do its database rollbacks when a program fails.
When you are using IMS from C or C++:

- Run your C or C++ program with the TRAP(ON) option, and use IMS interfaces by calling the ctdli() library function. If your application programs also use SQL facilities provided by DB2, you must modify the user exit CEEBXITA to add the user abend codes 777 and 778 to prevent the error handler from trapping these abends. This will allow deadlocks to be successfully resolved by IMS. See [z/OS Language Environment Programming Guide](https://www.ibm.com/support/knowledgecenter/STXKQY_2.6.0/com.ibm.zos.v2r6.imse.doc/cmg_see_list.html) for more information on CEEBXITA.

- The ctdli() library function will keep track of calls to and returns from IMS. If an abend or program check occurs and the C or C++ error handler gets control, it can determine if the problem arose on the IMS side of the interface or on the C or C++ side.

- If a program check or abend occurs in IMS, when the C or C++ exception handler gets control, it immediately issues an ABEND. The IMS Region Controller gets control next and ensures that the integrity of the database is preserved.

- If a program check occurs in the C or C++ program rather than in IMS, all the facilities of C or C++ error handling apply, provided that you meet certain conditions when you code your program. For any error condition that arises, you must do one of the following:
  1. Resolve the error completely so that the application can continue.
  2. Have IMS back out the program’s updates by issuing a rollback call to IMS, and then terminate the program.
  3. Make sure that the program terminates abnormally and provide an installation-modified run-time user exit that turns all abnormal terminations into operating system ABENDs to effect IMS rollbacks. See [z/OS Language Environment Programming Guide](https://www.ibm.com/support/knowledgecenter/STXKQY_2.6.0/com.ibm.zos.v2r6.imse.doc/cmg_see_list.html) for more information.

The errors you most likely can fix in your program are arithmetic exception (SIGFPE) conditions. It is unlikely that you can resolve other types of program checks or system abends in your program.

Any program that invokes IMS by way of some other IMS interface should be executed with TRAP(OFF). You should be sure that the program contains code to issue a rollback call to IMS before terminating after an error. Refer to [z/OS Language Environment Programming Reference](https://www.ibm.com/support/knowledgecenter/STXKQY_2.6.0/com.ibm.zos.v2r6.imse.doc/cmg_see_list.html) for more information about the limitations of using TRAP(OFF).

### Other Considerations

A *program communication block* (PCB) is a control block used by IMS to describe results of a DL/I call (DB PCB) or the results of a message retrieval or insertion (I/O PCB) made by your program. A valid PCB is one that has been correctly initialized by IMS and passed to you through your C or C++ program. For details on PCBs, refer to the “IMS/ESA” on page 927. See also the sample C-IMS and C++-IMS programs in [z/OS C/C++ Run-Time Library Reference](https://www.ibm.com/support/knowledgecenter/STXKQY_2.6.0/com.ibm.zos.v2r6.imse.doc/cmg_see_list.html).

If you are running an IMS C/MVS program under TSO or IMS, you should be aware of the effects of specifying PLIST(OS), ENV(IMS), and their combinations with the #pragma runopts preprocessor directive. The following chart shows the combinations of PLIST(OS) and ENV(IMS) and the resulting PCB generated under each of the environments:
Table 71. PCB Generated under TSO and IMS

<table>
<thead>
<tr>
<th>Combination</th>
<th>Running under TSO</th>
<th>Running under IMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENV(IMS) only</td>
<td>Invalid PCB</td>
<td>Valid PCB</td>
</tr>
<tr>
<td>PLIST(OS) only</td>
<td>Null PCB</td>
<td>Null PCB</td>
</tr>
<tr>
<td>ENV(IMS) and PLIST(OS)</td>
<td>Invalid PCB</td>
<td>Valid PCB</td>
</tr>
</tbody>
</table>

For more information on the run-time options ENV and PLIST, see [z/OS Language Environment Programming Reference](#).

If you are running an IMS C or z/OS C++ program under TSO or IMS, you should be aware of the effects of specifying compiler options PLIST(OS), TARGET(IMS), and their combinations. The following chart shows the combinations of PLIST(OS) and TARGET(IMS) and the resulting PCB generated under each of the environments:

Table 72. PCB Generated under TSO and IMS

<table>
<thead>
<tr>
<th>Combination</th>
<th>Running under TSO</th>
<th>Running under IMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TARGET(IMS) only</td>
<td>Invalid PCB</td>
<td>Valid PCB</td>
</tr>
<tr>
<td>PLIST(OS) only</td>
<td>Null PCB</td>
<td>Null PCB</td>
</tr>
<tr>
<td>TARGET(IMS) and PLIST(OS)</td>
<td>Invalid PCB</td>
<td>Valid PCB</td>
</tr>
</tbody>
</table>

For both C and C++, specifying PLIST(OS) under either TSO or IMS results in an argc value of 1 (one), and argv[0] = NULL.

For more information on the compiler options TARGET(IMS) and PLIST(OS), see [z/OS C/C++ User’s Guide](#).

**Examples**

The following C++ program CCNGIM1 makes an IMS call and checks the return code status of the call in IMS batch. Header file CCNGIM3 (shown at the end of this chapter) is included by this program.
CCNGIM1

/* this is an example of how to use IMS with C++ */

#pragma runopts(env(ims),plist(os))
#include <ims.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include "ccngim3.h"

int main(void) {
    PCB_STRUCT_8_TYPE *locdb_ptr,*orddb_ptr;

    auto IOA2 aio_area, a2io_area;
    static IOA2 sio_area;
    IOA2 *io_area;

    static char qual0[] = "ORDER (ORDKEY =333333)";
    static char qual1[] = "ORDITEM ";
    static char qual2[] = "DELIVERY ";
    static int six   = 6;
    static int four  = 4;
    static char gu[5] = "GU ";
    static char isrt[5] = "ISRT";

    int rc;
    int failed = 0; /* Indicate if any part of test case failed */

Figure 200. C++ Program Using IMS (Part 1 of 2)
The following C program CCNGIM2 makes an IMS call and checks the return code status of the call in IMS batch. Header file CCNGIM3 is included by this program.
/* This is an example of how to use IMS with C */

#include <ims.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include "ccngim3.h"

int main(void) {
    PCB_STRUCT_8_TYPE *locdb_ptr,*orddb_ptr;

    auto IOA2 aio_area, a2io_area;
    static IOA2 sio_area;
    IOA2 *io_area;

    static char qual0[] = "ORDER (ORDKEY =333333)";
    static char qual1[] = "ORDITEM ";
    static char qual2[] = "DELIVERY ";
    static int six = 6;
    static int four = 4;
    static char gu[4] = "GU ";
    static char isrt[4] = "ISRT";

    int rc;
    int failed = 0; /* Indicate if any part of test case failed. */

    Figure 201. C Program Using IMS (Part 1 of 2)
The following header file is used by both the C and the C++ examples.

```c
/* Get the pointers to the databases from the parameter list */
locdb_ptr = (_pcblist[1]);
orddb_ptr = (_pcblist[2]);
/* Make some calls to the database and change its contents */

printf("IMS Test starting\n");
io_area = malloc(sizeof(IOA2));
/* Issue a DL/I call with arguments below the line (using CTDLI) */
rc = ctdli(six,gu,orddb_ptr,&aio_area,qual0,qual1,qual2);
if ((orddb_ptr->stat_code[0] == ' ' && orddb_ptr->stat_code[1] == ' ')
    && (rc == 0))
    printf("Call to CTDLI returned successfully\n");
else
{
    printf("Call to CTDLI returned status of %c%c.\n",
        orddb_ptr->stat_code[0],orddb_ptr->stat_code[1]);
    failed = 1;
}
if (failed == 0)
    printf("Test Successful\n");
else printf("Test Failed");
return(0);
```

Figure 201. C Program Using IMS (Part 2 of 2)

The following header file is used by both the C and the C++ examples.
CCNGIM3

/* this header file is used with the IMS example */

/*------------------*/
/* DB PCB */
/*------------------*/
typedef struct {
    char db_name[8];
    char seg_level[2];
    char stat_code[2];
    char proc_opt[4];
    int dli;
    char seg_name[8];
    int len_kfb;
    int no_senseg;
    char key_fb[2];
} DB_PCB;

/*------------------*/
/* IO PCB */
/*------------------*/
typedef struct {
    char term[8];
    char ims_res[2];
    char stat_code[2];
    char date[4];
    char time[4];
    int input_seq;
    char output_mesg[8];
    char mod_nme[8];
    char user_id[8];
} IO_AREA;

/*------------------*/
/* SPA DATA */
/*------------------*/
typedef struct {
    short int uosplth;
    char uospres1[4];
    char uosptran[8];
    char uospuser;
    char fill[85];
} SPA_DATA;

Figure 202. Header File for IMS Example (Part 1 of 2)
/*------------------*/
/* INPUT MESSAGE */
/*------------------*/
typedef struct {
    short int ll;
    char zz[2];
    char fill[2];
    char numb[4];
    char nme[6];
} IN_MSG;

/*----------------*/
/* OUTPUT MESSAGE */
/*----------------*/
typedef struct {
    short int ll;
    char z1;
    char z2;
    char fill[2];
    char sca[2];
} OUT_MSG;

/*----------------*/
/* IO AREA */
/*----------------*/
typedef struct {
    char key[20];
} IOA1;

typedef struct {
    char item[40];
} IOA2;

Figure 202. Header File for IMS Example (Part 2 of 2)
Chapter 44. Using the Interactive System Productivity Facility (ISPF)

z/OS C/C++ allows access to the Interactive System Productivity Facility (ISPF) Dialog Management Services. Some of the services provided by ISPF include:

- Display services
- Variable services
- Message services
- Dialog control services

For C applications, two interfaces may be used with ISPF: ISPLINK and ISPEXEC. Because ISPF uses OS style linkage, calls from C to ISPF require the following pragma statements for ISPLINK and ISPEXEC respectively:

```c
#pragma linkage(ISPLINK, OS)
#pragma linkage(ISPEXEC, OS)
```

For C++ applications, two interfaces may be used with ISPF: ISPLINK and ISPEXEC. Because ISPF uses OS style linkage, calls from C++ to ISPF require that ISPLINK and ISPEXEC be prototyped as extern "OS", as follows:

```c
extern "OS"
{
    int ISPLINK(char*,...);
}

extern "OS"
{
    int ISPEXEC(int, char*,...);
}
```

Consult [z/OS ISPF Dialog Developer’s Guide and Reference](http://www.ibm.com) for specific information about using the ISPF Dialog Management Services.

**Note:** XPLINK is not supported by ISPF.

**Examples**

To run the following example under C:

1. Compile and link the CCNGIS3 C source file using the EDCCL procedure. Override the SYSLIB DD statement on the LKED step to use the ISPF load library available on your system. Your JCL should appear similar to the fragment below:

```c
//CISPF EXEC EDCCL,
//   INFIL='userid.C(CCNGIS3)',
//   OUTFIL='userid.LOADLIB(CCNGIS3),DISP=SHR'
//LKED.SYSLIB DD
//   DSN=ISP.SISPLOAD,DISP=SHR
//LKED.SYSIN DD DATA,DLM='/'
NAME CCNGIS3(R)
/
```

2. Copy the CCNGIS2 and CCNGIS4 menus, and the CCNGIS5 panel to your own ISPLIB data set. Copy CCNGIS1 to your own CLIST data set.

3. Ensure that your ISPLIB data set is allocated to the ISPLIB dname. The data set containing the CCNGIS3 program, and the SCEERUN data set, should be allocated to the STEPLIB dname.
4. Run the CLIST. The opening menu of the example will be displayed. Choose the first option to call the program that starts the C to ISPF interface and displays a secondary menu. You can either exit from this menu or press the help key for a help panel.

**CCNGIS1**

```c
/* THIS CLIST STARTS THE ISPF EXAMPLE */
ISPEXEC SELECT PANEL(CCNGIS2)
```

Figure 203. CCNGIS1 CLIST

**CCNGIS2**

```c
)ATTR DEFAULT(%+_
/* this menu is used by the ISPF example */
/* % TYPE(TEXT) INTENS(HIGH) defaults displayed for */
/* + TYPE(TEXT) INTENS(LOW) information only */
)BODY
%--------------------- SAMPLE ISPF DIALOG PANEL --------------------------
%OPTION ===> _ZCMD
  + ¾+ SELECTION 1 CALL C PROGRAM.
  ¾2+ FUTURE NOT IMPLEMENTED.
  ¾3+ FUTURE NOT IMPLEMENTED.
  +ENTER %END+COMMAND TO TERMINATE.
)PROC
  &ZSEL=TRANS(TRUNC(&ZCMD,'.'))
  1,'PGM(CCNGIS3)'
  *,'?'
)END
```

Figure 204. CCNGIS2 Menu
/* this program shows how to use ISPF with C */

#include <stdio.h>
#include <stdlib.h>

#pragma linkage(ISPLINK,OS)
extern ISPLINK();

int rc,buflen;
char buffer[20];

int main(void)
{
/* Retrieve the panel definition CCNGIS4 and display it. */

    strcpy(buffer,"PANEL(CCNGIS4)");
    buflen = strlen(buffer);
    rc = ISPLINK("SELECT", buflen, buffer);
}

Figure 205. C Program CCNGIS3

)ATTR DEFAULT(%+_)
/* this menu is used by the ISPF example */
/* % TYPE(TEXT) INTENS(HIGH) defaults displayed for */
/* + TYPE(TEXT) INTENS(LOW) information only*/
/* _ TYPE(INPUT) INTENS(HIGH) CAPS(ON) JUST(LEFT) */

)%------------------------ A SAMPLE ISPF MENU ------------------------
)BODY

OPTION ===>_ZCMD
+ %1+ SELECTION 1 NOT IMPLEMENTED.
%2+ SELECTION 2 EXIT
 + %END+ TO EXIT.

)INIT
 .HELP = ccngis5
)PROC
 &ZSEL=TRANS(TRUNC(&ZCMD,'.'))
    2,'EXIT'
    ,,'?')
)END

Figure 206. CCNGIS4 Menu-ISPEXC or ISPLINK Example
To run the following example under C++:

1. Compile and bind the C++ source file using the CBCCB procedure. You can use either the ISPLINK version of the code (CCNGIS8) or the ISPEXEC version of the code (CCNGISB). Override the SYSLIB DD statement for the BIND step to use the ISPF load library. Your JCL should appear similar to the JCL below:

   //CXXISPF EXEC CBCCB,
   // INFILE='userid.C(CCNGIS8)',
   // OUTFILE='userid.LOADLIB(CCNGIS8),DISP=SHR'
   //LKED.SYSLIB DD
   // DD
   // DD
   // DD DSN=ISP.SISPLOAD,DISP=SHR
   //LKED.SYSIN DD DATA,DLM='>'
   NAME CCNGIS8(R)

2. Copy the CCNGIS7 menu (if you are using ISPLINK) or the CCNGISA menu (if you are using ISPEXEC) to your own ISPPLIB data set. Copy the CCNGIS4 menu and CCNGIS5 panel to your ISPPLIB data set as well. Copy the CCNGIS6 CLIST (if you are using ISPLINK) or the CCNGIS9 CLIST (if you are using ISPEXEC) to your own CLIST data set.

3. Ensure that your ISPPLIB data set is allocated to the ISPPLIB ddname. The data set containing the CCNGIS8 or CCNGISB program, and the SCEERUN data set, should be allocated to the STEPLIB ddname.

4. Run the CLIST. The opening menu of the example will be displayed. Choose the first option to call the program that starts the C++ to ISPF interface and displays a secondary menu. You can either exit from this menu or press the help key for a help panel.

CCNGIS6

/* THIS CLIST STARTS THE ISPF EXAMPLE */
ISPEXEC SELECT PANEL(CCNGIS7)

Figure 208. CCNGIS6 CLIST-ISPLINK Example
**)ATTR DEFAULT(%+_)**
/* this menu is used by the ISPF example */
/* % TYPE(TEXT) INTENS(HIGH) defaults displayed for */
/* + TYPE(TEXT) INTENS(LOW) information only */

)BODY

+--------------------- SAMPLE ISPF DIALOG PANEL -----------------------------
+OPTION ===>_ZCMD
+ 1+ SELECTION 1 CALL C PROGRAM.
+ 2+ FUTURE NOT IMPLEMENTED.
+ 3+ FUTURE NOT IMPLEMENTED.
+ENTER %END+COMMAND TO TERMINATE.

PROC

&ZSEL=TRANS(TRUNC(&ZCMD,
1,'PGM(CCNGIS9')
*,'?'))

)END

---

Figure 209. CCNGIS7 Menu-ISPLINK Example

CCNGIS8

/* this program shows how to use ISPF with C++, using ISPLINK */

#include <stdlib.h>
#include <stdio.h>
#include <string.h>

extern "OS" {
  int ISPLINK(char*,...);
}

int rc,buflen;
char buffer[20];

int main(void)
{
  /* Retrieve the panel definition CCNGIS4 and display it. */

  strcpy(buffer,"PANEL(CCNGIS4)");
  buflen = strlen(buffer);
  rc = ISPLINK("SELECT", buflen, buffer);
}

---

Figure 210. C++ Program CCNGIS8-ISPLINK Example

CCNGIS9

/* THIS CLIST STARTS THE ISPF EXAMPLE */

ISPEXEC SELECT PANEL(CCNGISA)

---

Figure 211. CCNGIS9 CLIST-ISPEXEC Example
CCNGISA

```plaintext
/* this menu is used by the ISPF example */
/* % TYPE(TEXT) INTENS(HIGH) defaults displayed for */
/* + TYPE(TEXT) INTENS(LOW) information only */

/*--------------------- SAMPLE ISPF DIALOG PANEL -----------------------------
%OPTION ===>_ZCMD +
+ %1+ SELECTION 1 CALL C PROGRAM.
%2+ FUTURE NOT IMPLEMENTED.
%3+ FUTURE NOT IMPLEMENTED.
+ ENTER %END+COMMAND TO TERMINATE.

%PROC
 &ZSEL=TRANS(TRUNC(&ZCMD,'.'))
     1,'PGM(CCNGISB)'
     *,'?')
%END
```

Figure 212. CCNGISA Menu-ISPEXEC Example

CCNGISB

```plaintext
/* this program shows how to use ISPF with C++, using ISPEXEC */
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
extern "OS" {
    int ISPEXEC(int, char*);
}

int rc,buflen;
char buffer[20];

int main(void)
{
    /* Retrieve the panel definition CCNGIS4 and display it. */
    strcpy(buffer,"SELECT PANEL(CCNGIS4)");
    buflen = strlen(buffer);
    rc = ISPEXEC(buflen, buffer);
}
```

Figure 213. C++ Program CCNGISB-ISPEXEC Example
Chapter 45. Using the Query Management Facility (QMF)

The z/OS C/C++ compiler's support of the Query Management Facility (QMF) interface, a query and report writing facility, enables you to write applications through the SAA callable interface. You can create applications to perform a variety of tasks such as data entry, query building, administration aids, and report analysis.

The z/OS C++ compiler itself does not support QMF. However, QMF can be accessed through C code that is statically or dynamically called from C++.

You must include the header file DSQCOMMC.H (provided with the QMF application), which contains the function and structure definitions necessary to use the QMF interface.

For information on how to write your z/OS C/C++ applications with the QMF interface, see the appropriate manual listed in "QMF" on page 927.

Note: XPLINK is not supported by QMF.

Example

The following example demonstrates the interface between the QMF facility and the z/OS C/C++ compiler.

CCNGQM1

/* this example shows how to use the interface between QMF and C */
#include <string.h>
#include <stdlib.h>
#include <DSQCOMMC.H> /* QMF header file */

int main(void)
{
    struct dsqcomm communication_area; /* found in DSQCOMMC */

    /*********************************************************************/
    /* Query interface command length and commands */
    /*********************************************************************/
    signed long command_length;
    static char start_query_interface [] = "START";
    static char set_global_variables [] = "SET GLOBAL";
    static char run_query [] = "RUN QUERY Q1";
    static char print_report [] = "PRINT REPORT (FORM=F1)";
    static char end_query_interface [] = "EXIT";

    Figure 214. QMF Interface Example (Part 1 of 3)
/********************************************************************/
/* Query command extension, number of parameters and lengths */
********************************************************************/
signed long number_of_parameters;
signed long keyword_lengths[10];
signed long data_lengths[10];

/*********************************************************/
/* Variable data type constants */
/*********************************************************/
static char char_data_type[] = DSQ_VARIABLE_CHAR;
static char int_data_type[] = DSQ_VARIABLE_FINT;

/*********************************************************/
/* Keyword parameter and value for START command */
/*********************************************************/
static char start_keywords[] = "DSQSCMD";
static char start_keyword_values[] = "USERCMD1";

/*********************************************************/
/* Keyword parameter and value for SET command */
/*********************************************************/
#define SIZE_VAL 8
char set_keywords[3][SIZE_VAL];
signed long set_values[3];

/*********************************************************/
/* Start a Query Interface Session */
/*********************************************************/
number_of_parameters = 1;
command_length = sizeof(start_query_interface);
keyword_lengths[0] = sizeof(start_keywords);
data_lengths[0] = sizeof(start_keyword_values);
dsqcice(&communication_area,
    &command_length,
    START_query_interface[0],
    &number_of_parameters,
    &keyword_lengths[0],
    START_keywords[0],
    &data_lengths[0],
    START_keyword_values[0],
    char_data_type[0]);

Figure 214. QMF Interface Example (Part 2 of 3)
The following example demonstrates how a C++ program may call a C program that accesses QMF.

```c
/**************************************************************************/ /* Set numeric values into query using SET command */
/**************************************************************************/  
number_of_parameters = 3;
command_length = sizeof(set_global_variables);
strcpy(set_keywords[0],"MYVAR01");
strcpy(set_keywords[1],"SHORT");
strcpy(set_keywords[2],"MYVAR03");
keyword_lengths[0] = SIZE_VAL;
keyword_lengths[1] = SIZE_VAL;
keyword_lengths[2] = SIZE_VAL;
data_lengths[0] = sizeof(long);
data_lengths[1] = sizeof(long);
data_lengths[2] = sizeof(long);
set_values[0] = 20;
set_values[1] = 40;
set_values[2] = 84;
dsqcice(&communication_area,
    &command_length,
    &set_global_variables[0],
    &number_of_parameters,
    &keyword_lengths[0],
    &set_keywords[0],
    &data_lengths[0],
    &set_values[0],
    &int_data_type[0]);

/**************************************************************************/ /* Run a Query */
/**************************************************************************/  
command_length = sizeof(run_query);
dsqcic(&communication_area, &command_length,
    &run_query[0]);

/**************************************************************************/ /* Print the results of the query */
/**************************************************************************/  
command_length = sizeof(print_report);
dsqcic(&communication_area, &command_length,
    &print_report[0]);

/**************************************************************************/ /* End the query interface session */
/**************************************************************************/  
command_length = sizeof(end_query_interface);
dsqcic(&communication_area, &command_length,
    &end_query_interface[0]);

return 0;
}```

Figure 214. QMF Interface Example (Part 3 of 3)
```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>

extern "C" {
    int Gen_Report(void);
}

int main( int argc, char *argv[])
{
    int cmd;
    if (argc < 2 )
    {
        printf("ERROR - program takes at least one parm");
    }
    else
    {
        cmd=argv[1][0];
        cmd=toupper(cmd);
        switch (cmd)
        {
            case 'R':
            {
                Gen_Report();
                break;
            }
            default:
            {
                printf("%d is an invalid option.\n");
            }
        }
    }
}

Figure 215. C++ Calling a C Program That Accesses QMF
```
/* this example shows how C++ can access QMF by way of a C program */
/* part 2 of 2-this file is called from C */
/* other file is CCNGQM2 */

#include <string.h>
#include <stdlib.h>
#include <DSQCOMMC.H> /* QMF header file */

int Gen_Report(void)
{
  struct dsqcomm communication_area; /* found in DSQCOMM */

  /*********************************************************************/
  /* Query interface command length and commands */
  /*********************************************************************/
  signed long command_length;
  static char start_query_interface[] = "START";
  static char set_global_variables[] = "SET GLOBAL";
  static char run_query[] = "RUN QUERY Q1";
  static char print_report[] = "PRINT REPORT (FORM=F1)";
  static char end_query_interface[] = "EXIT";

  /*********************************************************************/
  /* Query command extension, number of parameters and lengths */
  /*********************************************************************/
  signed long number_of_parameters;
  signed long keyword_lengths[10];
  signed long data_lengths[10];

  /*********************************************************************/
  /* Variable data type constants */
  /*********************************************************************/
  static char char_data_type[] = DSQ_VARIABLE_CHAR;
  static char int_data_type[] = DSQ_VARIABLE_FINT;

  /*********************************************************************/
  /* Keyword parameter and value for START command */
  /*********************************************************************/
  static char start_keywords[] = "DSQSCMD";
  static char start_keyword_values[] = "USERCMD1";

  /*********************************************************************/
  /* Keyword parameter and value for SET command */
  /*********************************************************************/
  #define SIZE_VAL 8
  char set_keywords[3][SIZE_VAL];
  signed long set_values[3];

Figure 216. C Program That Accesses QMF (Part 1 of 3)
/* Start a Query Interface Session */

number_of_parameters = 1;
command_length = sizeof(start_query_interface);
keyword_lengths[0] = sizeof(start_keywords);
data_lengths[0] = sizeof(start_keyword_values);
dsqcice(&communication_area,
   &command_length,
   &start_query_interface[0],
   &number_of_parameters,
   &keyword_lengths[0],
   &start_keywords[0],
   &data_lengths[0],
   &start_keyword_values[0],
   &char_data_type[0]);

/* Set numeric values into query using SET command */

number_of_parameters = 3;
command_length = sizeof(set_global_variables);
strcpy(set_keywords[0], "MYVAR01");
strcpy(set_keywords[1], "SHORT");
strcpy(set_keywords[2], "MYVAR03");
keyword_lengths[0] = SIZE_VAL;
keyword_lengths[1] = SIZE_VAL;
keyword_lengths[2] = SIZE_VAL;
data_lengths[0] = sizeof(long);
data_lengths[1] = sizeof(long);
data_lengths[2] = sizeof(long);
set_values[0] = 20;
set_values[1] = 40;
set_values[2] = 84;
dsqcice(&communication_area,
   &command_length,
   &set_global_variables[0],
   &number_of_parameters,
   &keyword_lengths[0],
   &set_keywords[0],
   &data_lengths[0],
   &set_values[0],
   &int_data_type[0]);

Figure 216. C Program That Accesses QMF (Part 2 of 3)
Figure 216. C Program That Accesses QMF (Part 3 of 3)
This part includes the following topics related to Locales and Character Sets:

- Chapter 46, “Introduction to Locale” on page 671
- Chapter 47, “Building a Locale” on page 675
- Chapter 48, “Customizing a Locale” on page 723
- Chapter 49, “Customizing a Time Zone” on page 729
- Chapter 50, “Definition of S370 C, SAA C, and POSIX C Locales” on page 731
- Chapter 51, “Code Set Conversion Utilities” on page 739
- Chapter 52, “Coded Character Set Considerations with Locale Functions” on page 773
Chapter 46. Introduction to Locale

Internationalization in Programming Languages

Internationalization in programming languages is a concept that comprises externally stored cultural data, a set of programming tools to create such cultural data, a set of programming interfaces to access this data, and a set of programming methods that enable you to use provided interfaces to write programs that do not make any assumptions about the cultural environments they run in. Such programs modify their behavior according to the user’s cultural environment, specified during the program’s execution.

Elements of Internationalization

The typical elements of cultural environment are as follows:

Native language
The text that the executing program uses to communicate with a user or environment, that is, the natural language of the end user.

Character sets and coded character sets
Map an alphabet, the characters used in a particular language, onto the set of hexadecimal values (code points) that uniquely identify each character. This mapping creates the coded character set, which is uniquely identified by the character set it encodes, the set of code point values, and the mapping between these two.

For example IBM-273, also known as the German Code Page, and IBM-297, also known as the French Code Page, are two coded character sets which assign different EBCDIC encodings in the hexadecimal range 40 to FE to the same Latin Alphabet Number 1. IBM S/390 systems in Germany and France both use this Latin 1 alphabet, which is specified by International Standard ISO/IEC 8859-1. However, systems in Germany are configured for encodings of this alphabet given by IBM-273; whereas, systems in France are configured for encodings of this alphabet given by IBM-297.

IBM-1027, Japanese Latin Code Page, is another example of a coded character set. It assigns EBCDIC encodings in the hexadecimal range 40 to FE to characters specified by Japanese Industrial Standard JIS X 201-1978 plus encodings for a few more Latin characters selected by IBM. The resulting alphabet defined by IBM-1027 consists of some characters found in Latin Alphabet Number 1 and some Katakana characters. IBM S/390 systems in Japan are configured for encodings of this alphabet assigned by IBM-1027.

Collating and ordering
The relative ordering of characters used for sorting.

Character classification
Determines the type of character (alphabetic, numeric, and so forth) represented by a code point.

Character case conversion
Defines the mapping between uppercase and lowercase characters within a single character set.
Date and time format
Defines the way date and time data are formatted (names of weekdays and months; order of month, day, and year, and so forth).

Format of numeric and non-numeric numbers
Define the way numbers and monetary units are formatted with commas, decimal points, and so forth.

z/OS C/C++ Support for Internationalization
The z/OS C/C++ compiler and library support of internationalization is based on the IEEE POSIX P1003.2 and X/Open Portability Guide standards for global locales and coded character set conversion. See Chapter 47, “Building a Locale” on page 675 for more information about locales.

Locales and Localization
A locale is a collection of data that encodes information about the cultural environment. Localization is an action that establishes the cultural environment for an application by selecting the active locale. Only one locale can be active at one time, but a program can change the active locale at any time during its execution. The active locale affects the behavior of the locale-sensitive interfaces for the entire program. This is called the global locale model.

Locale-Sensitive Interfaces
The z/OS C/C++ run-time library provides many interfaces to manipulate and access locales. You can use these interfaces to write internationalized C programs.

This list summarizes all the z/OS C/C++ library functions which affect or are affected by the current locale.

Selecting locale
Changing the characteristics of the user’s cultural environment by changing the current locale: setlocale()

Querying locale
Retrieving the locale information that characterizes the user’s cultural environment:

Monetary and numeric formatting conventions:
localeconv()  
Date and time formatting conventions:
localtconv()  
User-specified information:
nl_langinfo()  
Encoding of the variant part of the portable character set:
getsyntax()  
Character set identifier:
csid(), wcsid()  
Classification of characters:
isspace(), isalpha(), isdigit(), isgraph(), islower(), isupper(), isxdigit()
Wide characters:
iswalnum(), iswalpha(), iswblank(), iswcntrl(), iswdigit(),
iswgraph(), iswlower(), iswpunct(), iswspace(),
iswupper(), iswxdigit(), wctype(), iswctype()

Character case mapping:

Single-byte characters:
tolower(), toupper()

Wide characters:
towlower(), towupper()

Multibyte character and multibyte string conversion:
mblen(), mbclen(), mbtowc(), mbtowc(), wctomb(), wcrtnb(), mbstowcs(),
mbrtowcs(), wcstombs(), wcstombs(), mbsinit(), wctob()

String conversions to arithmetic:
strtod(), wcstod(), strtol(), wcstol(), strtoul(), wcstoul(), atof(),
atoi(), atoi()

String collating:
strcoll(), strxfrm(), wccoll(), wcsxfrm()

Character display width:
wcwidth(), wcwidth()

Date, time, and monetary formatting:
strftime(), strptime(), wcsftime(), mktime(), ctime(), gmtime(),
localtime() strftime()

Formatted input/output:
printf() (and family of functions), scanf() (and family of functions),
_vswprintf(), swprintf(), swscanf()

Processing regular expressions:
regcomp(), regexec()

Wide character unformatted input/output:
fgetwc(), fgetws(), fputwc(), fputws(), getwc(), gettext(),
putwchar(), ungetwc()

Response matching:
rpmatch()

Collating elements:
ismccollel(), strtocoll(), colltostr(), collequiv(), collrange(),
collorder(), cclass(), maxcoll(), getmccoll(), getmccoll()
Chapter 47. Building a Locale

Cultural information is encoded in the locale source file using the locale definition language. One locale source file characterizes one cultural environment. See Appendix D, “Locales Supplied with z/OS C/C++” on page 815 for a list of the locale source and object files supplied with the z/OS C/C++ compiler.

The locale source file is processed by the locale compilation tool, called the localedef tool.

To enhance portability of the locale source files, certain information related to the character sets can be encoded using the symbolic names of characters. The mapping between the symbolic names and the characters they represent and its associated hexadecimal value is defined in the character set description file or charmap file. See Appendix E, “Charmap Files Supplied with z/OS C/C++” on page 833 for a list of the charmap files shipped with your product.

The conceptual model of the locale build process is presented below:

Limitations of Enhanced ASCII

This section explains under what conditions you can use Enhanced ASCII.

- A subset of C headers and functions is provided in ASCII. For more information, see z/OS 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 applications 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 conversion of ASCII to EBCDIC, and EBCDIC to ASCII. 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 another 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 your NATLANG run-time option is not UEN or ENU, messages directed to the Language Environment message file are converted to ASCII. These messages would cause problems during automatic conversion to EBCDIC.

### Using the charmap File

The `charmap` file defines a mapping between the symbolic names of characters and the hexadecimal values associated with the character in a given coded character set. Optionally, it can provide the alternate symbolic names for characters. Characters in the locale source file can be referred to by their symbolic names or alternate symbolic names, thereby allowing for writing generic locale source files independent of the encoding of the character set they represent.

Each `charmap` file must contain at least the definition of the portable character set and the character symbolic names associated with each character. The characters in the portable character set and the corresponding symbolic names, and optional alternate symbolic names, are defined in Table 73.

#### Table 73. Characters in Portable Character Set and Corresponding Symbolic Names

<table>
<thead>
<tr>
<th>Symbolic Name</th>
<th>Alternate Name</th>
<th>Character</th>
<th>Hex Value (EBCDIC)</th>
<th>Hex Value (ASCII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;NUL&gt;</td>
<td></td>
<td></td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>&lt;tab&gt;</td>
<td>&lt;SE10&gt;</td>
<td></td>
<td>05</td>
<td>09</td>
</tr>
<tr>
<td>&lt;vertical-tab&gt;</td>
<td>&lt;SE12&gt;</td>
<td></td>
<td>0b</td>
<td>0b</td>
</tr>
<tr>
<td>&lt;form-feed&gt;</td>
<td>&lt;SE13&gt;</td>
<td></td>
<td>0c</td>
<td>0c</td>
</tr>
<tr>
<td>&lt;carriage-return&gt;</td>
<td>&lt;SE14&gt;</td>
<td></td>
<td>0d</td>
<td>0d</td>
</tr>
<tr>
<td>&lt;newline&gt;</td>
<td>&lt;SE11&gt;</td>
<td></td>
<td>15</td>
<td>0a</td>
</tr>
<tr>
<td>&lt;backspace&gt;</td>
<td>&lt;SE09&gt;</td>
<td></td>
<td>16</td>
<td>08</td>
</tr>
<tr>
<td>&lt;alert&gt;</td>
<td>&lt;SE08&gt;</td>
<td></td>
<td>2f</td>
<td>07</td>
</tr>
<tr>
<td>&lt;space&gt;</td>
<td>&lt;SP01&gt;</td>
<td></td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>&lt;period&gt;</td>
<td>&lt;SP11&gt;</td>
<td>.</td>
<td>4b</td>
<td>2e</td>
</tr>
<tr>
<td>&lt;less-than-sign&gt;</td>
<td>&lt;SA03&gt;</td>
<td>&lt;</td>
<td>4c</td>
<td>3c</td>
</tr>
<tr>
<td>&lt;left-parenthesis&gt;</td>
<td>&lt;SP06&gt;</td>
<td>(</td>
<td>4d</td>
<td>28</td>
</tr>
</tbody>
</table>
### Table 73. Characters in Portable Character Set and Corresponding Symbolic Names (continued)

<table>
<thead>
<tr>
<th>Symbolic Name</th>
<th>Alternate Name</th>
<th>Character</th>
<th>Hex Value (EBCDIC)</th>
<th>Hex Value (ASCII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;plus-sign&gt;</td>
<td>&lt;SA01&gt;</td>
<td>+</td>
<td>4e 2b</td>
<td>2b</td>
</tr>
<tr>
<td>&lt;ampersand&gt;</td>
<td>&lt;SM03&gt;</td>
<td>&amp;</td>
<td>50</td>
<td>26</td>
</tr>
<tr>
<td>&lt;right-parenthesis&gt;</td>
<td>&lt;SP07&gt;</td>
<td>)</td>
<td>5d 29</td>
<td></td>
</tr>
<tr>
<td>&lt;semicolon&gt;</td>
<td>&lt;SP14&gt;</td>
<td>;</td>
<td>5e 3b</td>
<td></td>
</tr>
<tr>
<td>&lt;hyphen&gt;</td>
<td>&lt;SP10&gt;</td>
<td>-</td>
<td>60</td>
<td>2d</td>
</tr>
<tr>
<td>&lt;hyphen-minus&gt;</td>
<td>&lt;SP10&gt;</td>
<td>-</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>&lt;slash&gt;</td>
<td>&lt;SP12&gt;</td>
<td>/</td>
<td>61 2f</td>
<td></td>
</tr>
<tr>
<td>&lt;solidus&gt;</td>
<td>&lt;SP12&gt;</td>
<td>/</td>
<td>61</td>
<td>2f</td>
</tr>
<tr>
<td>&lt;comma&gt;</td>
<td>&lt;SP08&gt;</td>
<td>,</td>
<td>6b 2c</td>
<td></td>
</tr>
<tr>
<td>&lt;percent-sign&gt;</td>
<td>&lt;SM02&gt;</td>
<td>%</td>
<td>6c 25</td>
<td></td>
</tr>
<tr>
<td>&lt;underscore&gt;</td>
<td>&lt;SP09&gt;</td>
<td>_</td>
<td>6d 5f</td>
<td></td>
</tr>
<tr>
<td>&lt;low-line&gt;</td>
<td>&lt;SP09&gt;</td>
<td>_</td>
<td>6d 5f</td>
<td></td>
</tr>
<tr>
<td>&lt;greater-than-sign&gt;</td>
<td>&lt;SA05&gt;</td>
<td>&gt;</td>
<td>6e 3e</td>
<td></td>
</tr>
<tr>
<td>&lt;question-mark&gt;</td>
<td>&lt;SP15&gt;</td>
<td>?</td>
<td>6f 3f</td>
<td></td>
</tr>
<tr>
<td>&lt;colon&gt;</td>
<td>&lt;SP13&gt;</td>
<td>:</td>
<td>7a 3a</td>
<td></td>
</tr>
<tr>
<td>&lt;apostrophe&gt;</td>
<td>&lt;SP05&gt;</td>
<td>'</td>
<td>7d 27</td>
<td></td>
</tr>
<tr>
<td>&lt;equals-sign&gt;</td>
<td>&lt;SA04&gt;</td>
<td>=</td>
<td>7e 3d</td>
<td></td>
</tr>
<tr>
<td>&lt;quotation-mark&gt;</td>
<td>&lt;SP04&gt;</td>
<td>&quot;</td>
<td>7f 22</td>
<td></td>
</tr>
<tr>
<td>&lt;a&gt;</td>
<td>&lt;LA01&gt;</td>
<td>a</td>
<td>81 61</td>
<td></td>
</tr>
<tr>
<td>&lt;b&gt;</td>
<td>&lt;LB01&gt;</td>
<td>b</td>
<td>82 62</td>
<td></td>
</tr>
<tr>
<td>&lt;c&gt;</td>
<td>&lt;LC01&gt;</td>
<td>c</td>
<td>83 63</td>
<td></td>
</tr>
<tr>
<td>&lt;d&gt;</td>
<td>&lt;LD01&gt;</td>
<td>d</td>
<td>84 64</td>
<td></td>
</tr>
<tr>
<td>&lt;e&gt;</td>
<td>&lt;LE01&gt;</td>
<td>e</td>
<td>85 65</td>
<td></td>
</tr>
<tr>
<td>&lt;f&gt;</td>
<td>&lt;LF01&gt;</td>
<td>f</td>
<td>86 66</td>
<td></td>
</tr>
<tr>
<td>&lt;g&gt;</td>
<td>&lt;LG01&gt;</td>
<td>g</td>
<td>87 67</td>
<td></td>
</tr>
<tr>
<td>&lt;h&gt;</td>
<td>&lt;LH01&gt;</td>
<td>h</td>
<td>88 68</td>
<td></td>
</tr>
<tr>
<td>&lt;i&gt;</td>
<td>&lt;LI01&gt;</td>
<td>i</td>
<td>89 69</td>
<td></td>
</tr>
<tr>
<td>&lt;j&gt;</td>
<td>&lt;LJ01&gt;</td>
<td>j</td>
<td>91 6a</td>
<td></td>
</tr>
<tr>
<td>&lt;k&gt;</td>
<td>&lt;LK01&gt;</td>
<td>k</td>
<td>92 6b</td>
<td></td>
</tr>
<tr>
<td>&lt;l&gt;</td>
<td>&lt;LL01&gt;</td>
<td>l</td>
<td>93 6c</td>
<td></td>
</tr>
<tr>
<td>&lt;m&gt;</td>
<td>&lt;LM01&gt;</td>
<td>m</td>
<td>94 6d</td>
<td></td>
</tr>
<tr>
<td>&lt;n&gt;</td>
<td>&lt;LN01&gt;</td>
<td>n</td>
<td>95 6e</td>
<td></td>
</tr>
<tr>
<td>&lt;o&gt;</td>
<td>&lt;LO01&gt;</td>
<td>o</td>
<td>96 6f</td>
<td></td>
</tr>
<tr>
<td>&lt;p&gt;</td>
<td>&lt;LP01&gt;</td>
<td>p</td>
<td>97 70</td>
<td></td>
</tr>
<tr>
<td>&lt;q&gt;</td>
<td>&lt;LQ01&gt;</td>
<td>q</td>
<td>98 71</td>
<td></td>
</tr>
<tr>
<td>&lt;r&gt;</td>
<td>&lt;LR01&gt;</td>
<td>r</td>
<td>99 72</td>
<td></td>
</tr>
<tr>
<td>&lt;s&gt;</td>
<td>&lt;LS01&gt;</td>
<td>s</td>
<td>a2 73</td>
<td></td>
</tr>
<tr>
<td>&lt;t&gt;</td>
<td>&lt;LT01&gt;</td>
<td>t</td>
<td>a3 74</td>
<td></td>
</tr>
</tbody>
</table>
Table 73. Characters in Portable Character Set and Corresponding Symbolic Names (continued)

<table>
<thead>
<tr>
<th>Symbolic Name</th>
<th>Alternate Name</th>
<th>Character</th>
<th>Hex Value (EBCDIC)</th>
<th>Hex Value (ASCII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;u&gt;</td>
<td>&lt;LU01&gt;</td>
<td>u</td>
<td>a4 75</td>
<td></td>
</tr>
<tr>
<td>&lt;v&gt;</td>
<td>&lt;LU01&gt;</td>
<td>v</td>
<td>a5 76</td>
<td></td>
</tr>
<tr>
<td>&lt;w&gt;</td>
<td>&lt;LW01&gt;</td>
<td>w</td>
<td>a6 77</td>
<td></td>
</tr>
<tr>
<td>&lt;x&gt;</td>
<td>&lt;LX01&gt;</td>
<td>x</td>
<td>a7 78</td>
<td></td>
</tr>
<tr>
<td>&lt;y&gt;</td>
<td>&lt;LY01&gt;</td>
<td>y</td>
<td>a8 79</td>
<td></td>
</tr>
<tr>
<td>&lt;z&gt;</td>
<td>&lt;LZ01&gt;</td>
<td>z</td>
<td>a9 7a</td>
<td></td>
</tr>
<tr>
<td>&lt;A&gt;</td>
<td>&lt;LA02&gt;</td>
<td>A</td>
<td>c1 41</td>
<td></td>
</tr>
<tr>
<td>&lt;B&gt;</td>
<td>&lt;LB02&gt;</td>
<td>B</td>
<td>c2 42</td>
<td></td>
</tr>
<tr>
<td>&lt;C&gt;</td>
<td>&lt;LC02&gt;</td>
<td>C</td>
<td>c3 43</td>
<td></td>
</tr>
<tr>
<td>&lt;D&gt;</td>
<td>&lt;LD02&gt;</td>
<td>D</td>
<td>c4 44</td>
<td></td>
</tr>
<tr>
<td>&lt;E&gt;</td>
<td>&lt;LE02&gt;</td>
<td>E</td>
<td>c5 45</td>
<td></td>
</tr>
<tr>
<td>&lt;F&gt;</td>
<td>&lt;LF02&gt;</td>
<td>F</td>
<td>c6 46</td>
<td></td>
</tr>
<tr>
<td>&lt;G&gt;</td>
<td>&lt;LG02&gt;</td>
<td>G</td>
<td>c7 47</td>
<td></td>
</tr>
<tr>
<td>&lt;H&gt;</td>
<td>&lt;LH02&gt;</td>
<td>H</td>
<td>c8 48</td>
<td></td>
</tr>
<tr>
<td>&lt;I&gt;</td>
<td>&lt;LI02&gt;</td>
<td>I</td>
<td>c9 49</td>
<td></td>
</tr>
<tr>
<td>&lt;J&gt;</td>
<td>&lt;LJ02&gt;</td>
<td>J</td>
<td>d1 4a</td>
<td></td>
</tr>
<tr>
<td>&lt;K&gt;</td>
<td>&lt;LK02&gt;</td>
<td>K</td>
<td>d2 4b</td>
<td></td>
</tr>
<tr>
<td>&lt;L&gt;</td>
<td>&lt;LL02&gt;</td>
<td>L</td>
<td>d3 4c</td>
<td></td>
</tr>
<tr>
<td>&lt;M&gt;</td>
<td>&lt;SM02&gt;</td>
<td>M</td>
<td>d4 4d</td>
<td></td>
</tr>
<tr>
<td>&lt;N&gt;</td>
<td>&lt;LN02&gt;</td>
<td>N</td>
<td>d5 4e</td>
<td></td>
</tr>
<tr>
<td>&lt;O&gt;</td>
<td>&lt;LO02&gt;</td>
<td>O</td>
<td>d6 4f</td>
<td></td>
</tr>
<tr>
<td>&lt;P&gt;</td>
<td>&lt;LP02&gt;</td>
<td>P</td>
<td>d7 50</td>
<td></td>
</tr>
<tr>
<td>&lt;Q&gt;</td>
<td>&lt;LQ02&gt;</td>
<td>Q</td>
<td>d8 51</td>
<td></td>
</tr>
<tr>
<td>&lt;R&gt;</td>
<td>&lt;LR02&gt;</td>
<td>R</td>
<td>d9 52</td>
<td></td>
</tr>
<tr>
<td>&lt;S&gt;</td>
<td>&lt;LS02&gt;</td>
<td>S</td>
<td>e2 53</td>
<td></td>
</tr>
<tr>
<td>&lt;T&gt;</td>
<td>&lt;LT02&gt;</td>
<td>T</td>
<td>e3 54</td>
<td></td>
</tr>
<tr>
<td>&lt;U&gt;</td>
<td>&lt;LU02&gt;</td>
<td>U</td>
<td>e4 55</td>
<td></td>
</tr>
<tr>
<td>&lt;V&gt;</td>
<td>&lt;LV02&gt;</td>
<td>V</td>
<td>e5 56</td>
<td></td>
</tr>
<tr>
<td>&lt;W&gt;</td>
<td>&lt;LM02&gt;</td>
<td>W</td>
<td>e6 57</td>
<td></td>
</tr>
<tr>
<td>&lt;X&gt;</td>
<td>&lt;LX02&gt;</td>
<td>X</td>
<td>e7 58</td>
<td></td>
</tr>
<tr>
<td>&lt;Y&gt;</td>
<td>&lt;LY02&gt;</td>
<td>Y</td>
<td>e8 59</td>
<td></td>
</tr>
<tr>
<td>&lt;Z&gt;</td>
<td>&lt;LZ02&gt;</td>
<td>Z</td>
<td>e9 5a</td>
<td></td>
</tr>
<tr>
<td>&lt;zero&gt;</td>
<td>&lt;ND10&gt;</td>
<td>0</td>
<td>f0 30</td>
<td></td>
</tr>
<tr>
<td>&lt;one&gt;</td>
<td>&lt;ND01&gt;</td>
<td>1</td>
<td>f1 31</td>
<td></td>
</tr>
<tr>
<td>&lt;two&gt;</td>
<td>&lt;ND02&gt;</td>
<td>2</td>
<td>f2 32</td>
<td></td>
</tr>
<tr>
<td>&lt;three&gt;</td>
<td>&lt;ND03&gt;</td>
<td>3</td>
<td>f3 33</td>
<td></td>
</tr>
<tr>
<td>&lt;four&gt;</td>
<td>&lt;ND04&gt;</td>
<td>4</td>
<td>f4 34</td>
<td></td>
</tr>
<tr>
<td>&lt;five&gt;</td>
<td>&lt;ND05&gt;</td>
<td>5</td>
<td>f5 35</td>
<td></td>
</tr>
</tbody>
</table>
**Table 73. Characters in Portable Character Set and Corresponding Symbolic Names (continued)**

<table>
<thead>
<tr>
<th>Symbolic Name</th>
<th>Alternate Name</th>
<th>Character</th>
<th>Hex Value (EBCDIC)</th>
<th>Hex Value (ASCII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;six&gt;</td>
<td>&lt;ND06&gt;</td>
<td>6</td>
<td>f6</td>
<td>36</td>
</tr>
<tr>
<td>&lt;seven&gt;</td>
<td>&lt;ND07&gt;</td>
<td>7</td>
<td>f7</td>
<td>37</td>
</tr>
<tr>
<td>&lt;eight&gt;</td>
<td>&lt;ND08&gt;</td>
<td>8</td>
<td>f8</td>
<td>38</td>
</tr>
<tr>
<td>&lt;nine&gt;</td>
<td>&lt;ND09&gt;</td>
<td>9</td>
<td>f9</td>
<td>39</td>
</tr>
<tr>
<td>&lt;vertical-line&gt;</td>
<td>&lt;SM13&gt;</td>
<td></td>
<td></td>
<td>(4f)</td>
</tr>
<tr>
<td>&lt;exclamation-mark&gt;</td>
<td>&lt;SP02&gt;</td>
<td>!</td>
<td>(5a)</td>
<td>21</td>
</tr>
<tr>
<td>&lt;dollar-sign&gt;</td>
<td>&lt;SC03&gt;</td>
<td>$</td>
<td>(5b)</td>
<td>24</td>
</tr>
<tr>
<td>&lt;circumflex&gt;</td>
<td>&lt;SD15&gt;</td>
<td>^</td>
<td>(5f)</td>
<td>5e</td>
</tr>
<tr>
<td>&lt;circumflex-accent&gt;</td>
<td>&lt;SD15&gt;</td>
<td>^</td>
<td>(5f)</td>
<td>5e</td>
</tr>
<tr>
<td>&lt;grave-accent&gt;</td>
<td>&lt;SD13&gt;</td>
<td>#</td>
<td>(79)</td>
<td>60</td>
</tr>
<tr>
<td>&lt;number-sign&gt;</td>
<td>&lt;SM01&gt;</td>
<td>#</td>
<td>(7b)</td>
<td>23</td>
</tr>
<tr>
<td>&lt;commercial-at&gt;</td>
<td>&lt;SM05&gt;</td>
<td>@</td>
<td>(7c)</td>
<td>40</td>
</tr>
<tr>
<td>&lt;tilde&gt;</td>
<td>&lt;SD19&gt;</td>
<td>(a1)</td>
<td>(7d)</td>
<td>5e</td>
</tr>
<tr>
<td>&lt;left-square-bracket&gt;</td>
<td>&lt;SM06&gt;</td>
<td>[</td>
<td>(ad)</td>
<td>5b</td>
</tr>
<tr>
<td>&lt;right-square-bracket&gt;</td>
<td>&lt;SM08&gt;</td>
<td>]</td>
<td>(bd)</td>
<td>5d</td>
</tr>
<tr>
<td>&lt;left-brace&gt;</td>
<td>&lt;SM11&gt;</td>
<td>{</td>
<td>(c0)</td>
<td>7b</td>
</tr>
<tr>
<td>&lt;left-curly-bracket&gt;</td>
<td>&lt;SM11&gt;</td>
<td>{</td>
<td>(c0)</td>
<td>7b</td>
</tr>
<tr>
<td>&lt;right-brace&gt;</td>
<td>&lt;SM14&gt;</td>
<td>}</td>
<td>(d0)</td>
<td>7d</td>
</tr>
<tr>
<td>&lt;right-curly-bracket&gt;</td>
<td>&lt;SM14&gt;</td>
<td>}</td>
<td>(d0)</td>
<td>7d</td>
</tr>
<tr>
<td>&lt;backslash&gt;</td>
<td>&lt;SM07&gt;</td>
<td>\</td>
<td>(e0)</td>
<td>5c</td>
</tr>
<tr>
<td>&lt;reverse-solidus&gt;</td>
<td>&lt;SM07&gt;</td>
<td>\</td>
<td>(e0)</td>
<td>5c</td>
</tr>
</tbody>
</table>

The portable character set is the basis for the syntactic and semantic processing of the localedef tool, and for most of the utilities and functions that access the locale object files. Therefore the portable character set must always be defined. It is conceptually divided into two parts:

**Invariant**

Characters for which encoding must be constant among all charmap files. The required encoded values are specified in Table 73 on page 676. If any of these values change, the behavior of any utilities and functions on z/OS C/C++ is unpredictable.

For example, if you are using charmaps such as Turkish IBM-1026 or Japanese IBM-290, where the characters encoded vary from the encoding in Table 73 on page 676, you may get unpredictable results with the utilities and functions.

**Variant**

Characters for which encoding may vary from one EBCDIC charmap file to another. Only the following characters are allowed in this group:
The default EBCDIC encoding of each variant character is shown by a hexadecimal value in parentheses. It is equivalent to the encoding in code page 1047.

The charmap file is divided into two main sections:
1. the charmap section, or CHARMAP
2. the character set identifier section, or CHARSETID

The following definitions can precede the two sections listed above. Each consists of the symbol shown in the following list, starting in column 1, including the surrounding brackets, followed by one or more <blank>s, followed by the value to be assigned to the symbol.

<code_set_name>
The string literal containing the name of the coded character set name (IBM-1047, IBM-273, etc.)

<mb_cur_max>
the maximum number of bytes in a multibyte character which can be set to a value between 1 and 4. EBCDIC locales have \mb\_cur\_max\ settings of either 1 or 4. ASCII locales have \mb\_cur\_max\ settings of 1, 2 or 3.

If it is 1, each character in the character set defined in this charmap is encoded by a one-byte value. If it is 4, each character in the character set defined in this charmap is encoded by a one-, two-, three-, or four-byte value. If it is not specified, the default value of 1 is assumed. If a value of other than 1 or 4 is specified for an EBCDIC locale, a warning message is issued and the default value of 1 is assumed.

For ASCII locales \mb\_cur\_max\ is defined as 1, 2 or 3. The value 1 means the same as for EBCDIC locales, while the values 2 and 3 mean 2 and 3 bytes per character respectively.

<mb_cur_min>
The minimum number of bytes in a multibyte character. Can be set to 1 only. If a value of other than 1 is specified, a warning message is issued and the default value of 1 is assumed.

<escape_char>
Specifies the escape character that is used to specify hexadecimal or octal notation for numeric values. It defaults to the hexadecimal value 0xe0, which represents the \ character in the coded character set IBM-1047.

For portability among the EBCDIC based systems, the escape character has been redefined to the / or <slash> character in all IBM-supplied charmap files, with the following statement:

<escape_char> /
Denotes the character chosen to indicate a comment within a charmap file. It defaults to the hexadecimal value 0x7b, which represents the # character in the coded character set IBM-1047.

For portability among the EBCDIC based systems, the comment character has been redefined to the % or <percent-sign> character in all IBM-supplied charmap files, with the following statement:

```<comment_char> %```

Specifies the value of the shift-out control character that indicates the start of a string of double-byte characters. If specified, it must be the value of the EBCDIC shift-out (SO) character (hexadecimal value 0x0e). It is ignored if the `<mb_cur_max>` value is 1.

Specifies the value of the shift-in control character that indicates the end of a string of double-byte characters. If specified, it must be the value of the EBCDIC shift-in (SI) character (hexadecimal value 0x0f). It is ignored if the `<mb_cur_max>` value is 1.

The CHARMAP Section

The CHARMAP section defines the values for the symbolic names representing characters in the coded character set. Each charmap file must define at least the portable character set. The character symbolic names or alternate symbolic names (or both) must be used to define the portable character set. These are shown in Table 73 on page 676.

Additional characters can be defined by the user with symbolic character names.

The CHARMAP section starts with the line containing the keyword CHARMAP, and ends with the line containing the keywords END CHARMAP. CHARMAP and END CHARMAP must both start in column one.

The character set mapping definitions are all the lines between the first and last lines of the CHARMAP section.

The formats of the character set mappings for this section are as follows:

```
"%s %s %s\n", <symbolic-name>, <encoding>, <comments>
"%s...%s %s %s\n", <symbolic-name>, <symbolic-name>, <encoding>, <comments>
```

The first format defines a single symbolic name and a corresponding encoding. A symbolic name is one or more characters with visible glyphs, enclosed between angle brackets.

For reasons of portability, a symbolic name should include only the characters from the invariant part of the portable character set. If you use variant characters or decimal or hexadecimal notation in a symbolic name, the symbolic name will not be portable. A character following an escape character is interpreted as itself; for example, the sequence `\` represents the symbolic name \ enclosed within angle brackets, where the backslash \ is the escape character. If / is the escape character, the sequence `/` represents the symbolic name /. In the supplied charmap files, the escape character has been redefined to the forward slash /.
The second format defines a group of symbolic names associated with a range of values. The two symbolic names are comprised of two parts, a prefix and suffix. The prefix consists of zero or more non-numeric invariant visible glyph characters and is the same for both symbolic names. The suffix consists of a positive decimal integer. The suffix of the first symbolic name must be less than or equal to the suffix of the second symbolic name. As an example, `<j0101>...<j0104>` is interpreted as the symbolic names `<j0101>, <j0102>, <j0103>, <j0104>`. The common prefix is `'j'` and the suffixes are `'0101'` and `'0104'`.

The encoding part can be written in one of two forms:

```
<escape-char><number> (single byte value)
<escape-char><number><escape-char><number> (double byte value)
```

The number can be written using octal, decimal, or hexadecimal notation. Decimal numbers are written as a `'d'` followed by 2 or 3 decimal digits. Hexadecimal numbers are written as an `'x'` followed by 2 hexadecimal digits. An octal number is written with 2 or 3 octal digits. As an example, the single byte value `x1F` could be written as `'\37'`, `'\x1F'`, or `'\d31'`.

The double byte value of `0x1A1F` could be written as `'\32\37'`, `'\x1Ax1F'`, or `'\d26\d31'`.

In lines defining ranges of symbolic names, the encoded value is the value for the first symbolic name in the range (the symbolic name preceding the ellipsis). Subsequent names defined by the range have encoding values in increasing order.

When constants are concatenated for multibyte character values, they must be of the same type, and are interpreted in byte order from first to last with the least significant byte of the multibyte character specified by the last constant. Each value is then prepended by the byte value of `<shift_out>` and appended with the byte value of `<shift_in>`. Such a string represents one EBCDIC multibyte character. For example:

```
<escape_char> /<comment_char> %
<mb_cur_max> 4
<mb_cur_min> 1
<shift-out> /x0e
<shift-in> /x0f
CHARMAP
% many definition lines
<j0101>...<j0104> /d129/d254
%many definition lines
END CHARMAP
```

is interpreted as:

```
<j0101> /d129/d254
<j0102> /d129/d255
<j0103> /d130/d0
<j0104> /d130/d1
```

It produces four 4-byte long multibyte EBCDIC characters:

```
<j0101> x0Ex81xFEx0F
<j0102> x0Ex81xFFx0F
<j0103> x0Ex82x00x0F
<j0104> x0Ex82x01x0F
```
The CHARSETID Section

The character set identifier section of the charmap file maps the symbolic names defined in the CHARMAP section to a character set identifier.

Note: The two functions csid() and wcsid() query the locales and return the character set identifier for a given character. This information is not currently used by any other library function.

The CHARSETID section starts with a line containing the keyword CHARSETID, and ends with the line containing the keywords END CHARSETID. Both CHARSETID and END CHARSETID must begin in column 1. The lines between the first and last lines of the CHARSETID section define the character set identifier for the defined coded character set.

The character set identifier mappings are defined as follows:

"%s %c", <symbolic-name>, <value>
"%c %c", <value>, <value>
"%s...%s %c", <symbolic-name>, <symbolic-name>, <value>
"%c...%c %c", <value>, <value>, <value>
"%s...%c %c", <symbolic-name>, <value>, <value>
"%c...%s %c", <value>, <symbolic-name>, <value>

The individual characters are specified by the symbolic name or the value. The group of characters are specified by two symbolic names or by two numeric values (or combination) separated by an ellipsis (...). The interpretation of ranges of values is the same as specified in the CHARMAP section. The character set identifier is specified by a numeric value.

For example:

```
<comment_char> %
<escape_char> /
<code_set_name> "IBM-930"
<mb_cur_max> 4
<mb_cur_min> 1
<shift_out> /x0e
<shift_in> /x0f
%
% CHARMAP
%
CHARMAP
...
<j0110> /x42/x5a
<j0111>...<j0112> /x43/xbe
<judc2001>...<judc2094> /x72/x8d
...
END CHARMAP
%
% CHARSETID
%
CHARSETID
...
<j0110> 1
<j0111>...<j0112> 1
<judc2001>...<judc2094> 3
...
END CHARSETID
```
Locale Source Files

Locales are defined through the specification of a locale definition file. The locale definition contains one or more distinct locale category source definitions and not more than one definition of any category. Each category controls specific aspects of the cultural environment. A category source definition is either the explicit definition of a category or the copy directive, which indicates that the category definition should be copied from another locale definition file.

ASCII locales must be specified using only the characters from the portable character set, and all character references must be symbolic names, not explicit code point values.

The definition file is composed of an optional definition section for the escape and comment characters to be used, followed by the category source definitions. Comment lines and blank lines can appear anywhere in the locale definition file. If the escape and comment characters are not defined, default code points are used (xE0 for the escape character and x7B for the comment character, respectively). The definition section consists of the following optional lines:

```
escape_char <character>
comment_char <character>
```

where `<character>` in both cases is a single-byte character to be used, for example:

```
escape_char /
```

defines the escape character in this file to be `/' (the `<slash>` character).

Locale definition files passed to the localedef utility are assumed to be in coded character set IBM-1047.

To ensure portability among EBCDIC systems, you should redefine these characters to characters from the invariant part of the portable character set. The suggested redefinition is:

```
escape_char /
comment_char %
```

This suggested redefinition is used in all locale definition files supplied by IBM. For reasons of portability, you should use the suggested redefinition in all your customized locale definition files. See Chapter 48, “Customizing a Locale” on page 723 for information about customizing locales. These two redefinitions should be placed in the first lines of the locale definition source file, before any of the redefined characters are used.

Each category source definition consists of a category header, a category body, and a category trailer, in that order.

**category header**

consists of the keyword naming the category. Each category name starts with the characters LC_. The following category names are supported: LC_CTYPE, LC_COLLATE, LC_NUMERIC, LC_MONETARY, LC_TIME, LC_MESSAGES, LC_TOD, and LC_SYNTAX.

The LC_TOD and LC_SYNTAX categories, if present, must be the last two categories in the locale definition file.
category body
consists of one or more lines describing the components of the category. Each component line has the following format:

\(<\text{identifier}>\ <\text{operand}\>\)
\(<\text{identifier}>\ <\text{operand1}>;\ <\text{operand2}>;\ldots;\ <\text{operandN}>\)

\(<\text{identifier}>\) is a keyword that identifies a locale element, or a symbolic name that identifies a collating element. \(<\text{operand}>\) is a character, collating element, or string literal. Escape sequences can be specified in a string literal using the \(<\text{escape_character}>\). If multiple operands are specified, they must be separated by semicolons. White space can be before and after the semicolons.

category trailer
consists of the keyword END followed by one or more \(<\text{blank}>\)s and the category name of the corresponding category header.

Here is an example of locale source containing the header, body, and trailer:

```plaintext
escape_char  /
comment_char  %
% Here is a simple locale definition file consisting of one
% category source definition, LC_CTYPE.
%  
LC_CTYPE
upper <A>; ...; <Z>
END LC_CTYPE
```

You do not have to define each category. Where category definitions are absent from the locale source, default definitions are used.

In each category, the keyword copy followed by a string specifies the name of an existing locale to be used as the source for the definition of this category.

If the locale is not found, an error is reported and no locale output is created.

For MVS, the name must be the member name of a partitioned data set allocated to the EDCLOCL DD statement.

You can continue a line in a locale definition file by placing an escape character as the last character on the line. This continuation character is discarded from the input. Even though there is no limitation on the length of each line, for portability reasons it is suggested that each line be no longer than 2048 characters (bytes). There is no limit on the accumulated length of a continued line. You cannot continue comment lines on a subsequent line by using an escaped <newline>.

Individual characters, characters in strings, and collating elements are represented using symbolic names, as defined below. Characters can also be represented as the characters themselves, or as octal, hexadecimal, or decimal constants. If you use non-symbolic notation, the resultant locale definition file may not be portable among systems and environments. The left angle bracket (<) is a reserved symbol, denoting the start of a symbolic name; if you use it to represent itself, you must precede it with the escape character.

The following rules apply to the character representation:
1. A character can be represented by a symbolic name, enclosed within angle brackets. The symbolic name, including the angle brackets, must exactly match
a symbolic name defined in the charmap file. The symbolic name is replaced by the character value determined from the value associated with the symbolic name in the charmap file.

The use of a symbolic name not found in the charmap file constitutes an error, unless the name is in the category LC_CTYPE or LC_COLLATE, in which case it constitutes a warning. Use of the escape character or right angle bracket within a symbolic name is invalid unless the character is preceded by the escape character. For example:

```
<c>;<c-cedilla>
```

specifies two characters whose symbolic names are "c" and "c-cedilla"

```
"<$><a><y>"
```

specifies a 3-character string composed of letters represented by symbolic names "M", "a", and "y"

```
"<a><\>"
```

specifies a 2-character string composed of letters represented by symbolic names "a" and ">" (assuming the escape character is \)

If the character represented by the symbolic name is a multibyte character defined by 2 byte values in the charmap file, and the shift-out and shift-in characters are defined, the value is enclosed within shift-out and shift-in characters before the localedef utility processes it any further.

2. A character can represent itself. Within a string, the double quotation mark, the escape character, and the left angle bracket must be escaped (preceded by the escape character) to be interpreted as the characters themselves. For example:

```
c    'c' character represented by itself

"may" represents a 3-character string, each character within the string represented by itself

"%>%>" represents the three character long string "%>%>", where the escape character is defined as \\n```

3. A character can be represented as an octal constant. An octal constant is specified as the escape character followed by two or more octal digits. Each constant represents a byte value. For example:

```
131 "\212\129\168" \16\66\193\17
```

4. A character can be represented as a hexadecimal constant. A hexadecimal constant is specified as the escape character, followed by an \x, followed by two or more hexadecimal digits. Each constant represents a byte value. For example:

```
\x83 "\xD4\x81\xA8"
```

5. A character can be represented as a decimal constant. A decimal constant is specified as the escape character followed by a \d followed by two or more decimal digits. Each constant represents a byte value. For example:

```
\d131 "\d212\d129\d168" \d14\d66\d193\d15
```

For multibyte characters, the entire encoding sequence, including the shift-out and shift-in characters, must be present. Otherwise, the sequence of bytes not enclosed between the shift-out and shift-in characters are interpreted as a sequence of single byte characters.
Multibyte characters can be represented by concatenating constants specified in byte order with the last constant specifying the least significant byte of the character. If the sequence of octal, hexadecimal, or decimal constants is to represent a multibyte character, it must be enclosed in shift-out and shift-in constants.

For example: \x0e\x42\xC1\x0f

**LC_CTYPE Category**

This category defines character classification, case conversion, and other character attributes. In this category, you can represent a series of characters by using three adjacent periods as an ellipsis symbol (…). An ellipsis is interpreted as including all characters with an encoded value higher than the encoded value of the character preceding the ellipsis and lower than the encoded value following the ellipsis.

An ellipsis is valid within a single encoded character set.

For example, \x30;...;\x39; includes in the character class all characters with encoded values from X'30' to X'39'.

The keywords recognized in the LC_CTYPE category are listed below. In the descriptions, the term "automatically included" means that it is not an error either to include or omit any of the referenced characters; they are assumed by default even if the entire keyword is missing and accepted if present. If a keyword is specified without any arguments, the default characters are assumed.

When a character is automatically included, it has an encoded value dependent on the charmap file in effect. If no charmap file is specified, the encoding of the encoded character set IBM-1047 is assumed.

**copy** Specifies the name of an existing locale to be used as the source for the definition of this category. If this keyword is specified, no other keywords are present in this category. If the locale is not found, an error is reported and no locale output is created. The copy keyword cannot specify a locale that also specifies the copy keyword for the same category.

**charclass** Defines one or more locale-specific character class names as strings separated by semicolons. Each named character class can then be defined subsequently in the LC_CTYPE definition. A character class name consists of at least one and at most `{CHARCLASS_NAME_MAX}` bytes of alphanumeric characters from the portable filename character set. The first character of a character class name cannot be a digit. The name cannot match any of the LC_CTYPE keywords defined in this document.

**upper** Defines characters to be classified as uppercase letters. No character defined for the keywords cntrl, digit, punct, or space can be specified. The uppercase letters A through Z are automatically included in this class.

The isupper() and iswupper() functions test for any character and wide character, respectively, included in this class.

**lower** Defines characters to be classified as lowercase letters. No character defined for the keywords cntrl, digit, punct, or space can be specified. The lowercase letters a through z are automatically included in this class.
alpha  Defines characters to be classified as letters. No character defined for the keywords  
cntrl, digit, punct, or space can be specified. Characters classified as either upper or lower  
are automatically included in this class.

digit  Defines characters to be classified as numeric digits. Only the digits 0, 1,  
2, 3, 4, 5, 6, 7, 8, 9 can be specified. If they are, they must be in contiguous ascending  
sequence by numerical value. The digits 0 through 9 are automatically included in this  
class.

space  Defines characters to be classified as whitespace characters. No character  
defined for the keywords upper, lower, alpha, digit, or xdigit can be specified for space.  
The characters <space>, <form-feed>, <newline>, <carriage-return>, <horizontal-tab>, and  
<vertical-tab>, and any characters defined in the class blank are automatically included in  
this class.

cntrl  Defines characters to be classified as control characters. No character  
defined for the keywords upper, lower, alpha, digit, punct, graph, print, or xdigit can  
be specified for cntrl.

punct  Defines characters to be classified as punctuation characters. No character  
defined for the keywords upper, lower, alpha, digit, cntrl, or xdigit, or as the <space>  
character, can be specified.

graph  Defines characters to be classified as printing characters, not including the  
<space> character. Characters specified for the keywords upper, lower, alpha, digit,  
xdigit, and punct are automatically included. No character specified in the keyword  
ecntrl can be specified for graph.

print  Defines characters to be classified as printing characters, including the  
<space> character. Characters specified for the keywords upper, lower, alpha, digit,  
xdigit, punct, and the <space> character are automatically included. No character  
specified in the keyword cntrl can be specified for print.

xdigit  Defines characters to be classified as hexadecimal digits. Only the  
characters defined for the class digit can be specified, in contiguous ascending  
sequence by numerical value, followed by one or more sets of six characters  
representing the hexadecimal digits 10 through 15, with each
set in ascending order (for example, A, B, C, D, E, F, a, b, c, d, e, f). The digits 0 through 9, the uppercase letters A through F, and the lowercase letters a through f are automatically included in this class.

The functions isxdigit() and iswxdigit() test for any character or wide character, respectively, included in this class.

**blank** Defines characters to be classified as blank characters. The characters <space> and <tab> are automatically included in this class.

The functions isblank() and iswblank() test for any character or wide character, respectively, included in this class.

**toupper** Defines the mapping of lowercase letters to uppercase letters. The operand consists of character pairs, separated by semicolons. The characters in each character pair are separated by a comma; the pair is enclosed in parentheses. The first character in each pair is the lowercase letter, and the second is the corresponding uppercase letter. Only characters specified for the keywords lower and upper can be specified for toupper. The lowercase letters a through z, their corresponding uppercase letters A through Z, are automatically included in this mapping, but only when the toupper keyword is omitted from the locale definition.

It affects the behavior of the toupper() and towupper() functions for mapping characters and wide characters, respectively.

**tolower** Defines the mapping of uppercase letters to lowercase letters. The operand consists of character pairs, separated by semicolons. The characters in each character pair are separated by a comma; the pair is enclosed by parentheses. The first character in each pair is the uppercase letter, and the second is its corresponding lowercase letter. Only characters specified for the keywords lower and upper can be specified. If the tolower keyword is omitted from the locale definition, the mapping is the reverse mapping of the one specified for the toupper.

The tolower keyword affects the behavior of the tolower() and towlower() functions for mapping characters and wide characters, respectively.

You may define additional character classes using your own keywords. A maximum of 31 classes are supported in total: the 12 standard classes, and up to 19 user-defined classes.

The defined classes affect the behavior of wctype() and iswctype() functions.

Here is an example of the definition of the LC_CTYPE category:
A collation sequence definition defines the relative order between collating elements (characters and multicharacter collating elements) in the locale. This order is expressed in terms of collation values. It assigns each element one or more collation values (also known as collation weights). The collation sequence definition is used by regular expressions, pattern matching, and sorting and collating functions. The following capabilities are provided:

1. **Multicharacter collating elements.** Specification of multicharacter collating elements (sequences of two or more characters to be collated as an entity).

2. **User-defined ordering of collating elements.** Each collating element is assigned a collation value defining its order in the character (or basic) collation sequence. This ordering is used by regular expressions and pattern matching, and unless collation weights are explicitly specified, also as the collation weight to be used in sorting.

3. **Multiple weights and equivalence classes.** Collating elements can be assigned 1 to 6 collating weights for use in sorting. The first weight is referred to as the primary weight.

4. **One-to-many mapping.** A single character is mapped into a string of collating elements.

5. **Many-to-many substitution.** A string of one or more characters are mapped to another string (or an empty string). The character or characters are ignored for collation purposes.

**Note:** This is an IBM extension; therefore, locales that use it may not be portable to localedef tools developed by other vendors.
6. **Equivalence class definition.** Two or more collating elements have the same collation value (primary weight).

7. **Ordering by weights.** When two strings are compared to determine their relative order, the two strings are first broken up into a series of collating elements. Each successive pair of elements is compared according to the relative primary weights for the elements. If they are equal, and more than one weight is assigned, then the pairs of collating elements are compared again according to the relative subsequent weights, until either two collating elements are not equal or the weights are exhausted.

### Collating Rules

Collation rules consist of an ordered list of collating order statements, ordered from lowest to highest. The `<NULL>` character is considered lower than any other character. The ellipsis symbol ("...") is a special collation order statement. It specifies that a sequence of characters collate according to their encoded character values. It causes all characters with values higher than the value of the `<collating identifier>` in the preceding line, and lower than the value for the `<collating identifier>` on the following line, to be placed in the character collation order between the previous and the following collation order statements in ascending order according to their encoded character values.

The use of the ellipsis symbol ties the definition to a specific coded character set and may preclude the definition from being portable among implementations.

The ellipsis symbol can precede or succeed the ellipsis symbol and may also have weights on the same line.

A collating order statement describes how a collating identifier is weighted.

Each `<collating-identifier>` consists of a character, `<collating-element>`, `<collating-symbol>`, or the special symbol UNDEFINED. The order in which collating elements are specified determines the character order sequence, such that each collating element is considered lower than the elements following it. The `<NULL>` character is considered lower than any other character. Weights are expressed as characters, `<collating-symbol>s`, `<collating-element>s`, or the special symbol IGNORE. A single character, a `<collating-symbol>`, or a `<collating-element>` represents the relative position in the character collating sequence of the character or symbol, rather than the character or characters themselves. Thus rather than assigning absolute values to weights, a particular weight is expressed using the relative "order value" assigned to a collating element based on its order in the character collation sequence.

A `<collating-element>` specifies multicharacter collating elements, and indicates that the character sequence specified by the `<collating-element>` is to be collated as a unit and in the relative order specified by its place.

A `<collating-symbol>` can define a position in the relative order for use in weights.

The `<collating-symbol>` UNDEFINED is interpreted as including all characters not specified explicitly. Such characters are inserted in the character collation order at the point indicated by the symbol, and in ascending order according to their encoded character values. If no UNDEFINED symbol is specified, and the current coded character set contains characters not specified in this clause, the localedef utility issues a warning and places such characters at the end of the character collation order.
The syntax for a collation order statement is:
<collating-identifier> <weight1>;<weight2>;...;<weightn>

Collation of two collating identifiers is done by comparing their relative primary weights. This process is repeated for successive weight levels until the two identifiers are different, or the weight levels are exhausted. The operands for each collating identifier define the primary, secondary, and subsequent relative weights for the collating identifier. Two or more collating elements can be assigned the same weight. If two collating identifiers have the same primary weight, they belong to the same equivalence class.

The special symbol IGNORE as a weight indicates that when strings are compared using the weights at the level where IGNORE is specified, the collating element should be ignored, as if the string did not contain the collating element. In regular expressions and pattern matching, all characters that are IGNOREd in their primary weight form an equivalence class.

All characters specified by an ellipsis are assigned unique weights, equal to the relative order of the characters. Characters specified by an explicit or implicit UNDEFINED special symbol are assigned the same primary weight (they belong to the same equivalence class).

One-to-many mapping is indicated by specifying two or more concatenated characters or symbolic names. For example, if the character "<ezset>" is given the string '"ss"' as a weight, comparisons are performed as if all occurrences of the character <ezset> are replaced by <s><s> (assuming <s> has the collating weight <s>). If it is desirable to define <ezset> and <s><s> as an equivalence class, then a collating element must be defined for the string "ss".

If no weight is specified, the collating identifier is interpreted as itself.

For example, the order statement

\[<a> \quad <a>\]

is equivalent to

\[<a>\]

**Collating Keywords**

The following keywords are recognized in a collation sequence definition.

- **copy** Specifies the name of an existing locale to be used as the source for the definition of this category. If this keyword is specified, no other keyword shall be present in this category. If the locale is not found, an error is reported and no locale output is created. The `copy` keyword cannot specify a locale that also specifies the `copy` keyword for the same category.

- **collating-element**
  Defines a collating-element symbol representing a multicharacter collating element. This keyword is optional.
  
  In addition to the collating elements in the character set, the `collating-element` keyword can be used to define multicharacter collating elements. The syntax is:
  
  "collating-element %s from \%s\"", <collating-element>, <string>

  The `<collating-element>` should be a symbolic name enclosed between angle brackets (< and >), and should not duplicate any symbolic name in
the current charmap file (if any), or any other symbolic name defined in this collation definition. The string operand is a string of two or more characters that collate as an entity. A <collating-element> defined with this keyword is only recognized within the LC_COLLATE category.

For example:
collating-element <ch> from "<c><h>"
collating-element <e-acute> from "<acute><e>"
collating-element <ll> from "ll"

**collating-symbol**
Defines a collating symbol for use in collation order statements.

The **collating-symbol** keyword defines a symbolic name that can be associated with a relative position in the character order sequence. While such a symbolic name does not represent any collating element, it can be used as a weight. This keyword is optional.

This construct can define symbols for use in collation sequence statements, between the order_start and order_end keywords.

The syntax is:
"collating-symbol \%s", <collating-symbol>

The <collating-symbol> must be a symbolic name, enclosed between angle brackets (< and >), and should not duplicate any symbolic name in the current charmap file (if any), or any other symbolic name defined in this collation definition. A <collating-symbol> defined with this keyword is only recognized within the LC_COLLATE category.

For example:
collating-symbol <UPPER_CASE>
collating-symbol <HIGH>

**substitute**
The substitute keyword defines a substring substitution in a string to be collated. This keyword is optional. The following operands are supported with the substitute keyword:
"substitute \%s with \%s", <regular-expr>, <replacement>

The first operand is treated as a basic regular expression. The replacement operand consists of zero or more characters and regular expression back-references (for example, \1 through \9). The back-references consist of the backslash followed by a digit from 1 to 9. If the backslash is followed by two or three digits, it is interpreted as an octal constant.

When strings are collated according to a collation definition containing substitute statements, the collation behaves as if occurrences of substrings matching the basic regular expression are replaced by the replacement string, before the strings are compared based on the specified collation sequence. Ranges in the regular expression are interpreted according to the current character collation sequence and character classes according to the character classification specified by the LC_CTYPE environment variable at collation time. If more than one substitute statement is present in the collation definition, the collation process behaves as if the substitute statements are applied to the strings in the order they occur in the source definition. The substitution for the substitute statements are processed
before any substitutions for one-to-many mappings. The support of the
"substitute" keyword is an IBM z/OS C/C++ extension to the POSIX
standard.

Note: This is an IBM extension; therefore, locales that use it may not be
portable to localedef tools developed by other vendors.

order_start
Define collating rules. This statement is followed by one or more collation
order statements, assigning character collation values and collation weights
to collating elements.

The order_start keyword must precede collation order entries. It defines
the number of weights for this collation sequence definition and other
collation rules.

The syntax of the order_start keyword is:

order_start <sort-rule1>;<sort-rule1>;...;<sort-rule n>

The operands of the order_start keyword are optional. If present, the
operands define rules to be applied when strings are compared. The
number of operands define how many weights each element is assigned; if
no operands are present, one forward operand is assumed. If any is
present, the first operand defines rules to be applied when comparing
strings using the first (primary) weight; the second when comparing strings
using the second weight, and so on. Operands are separated by
semicolons (;). Each operand consists of one or more collation directives
separated by commas (,). If the number of operands exceeds the limit of 6,
the localedef utility issues a warning message.

The following directives are supported:

forward
specifies that comparison operations for the weight level proceed
from the start of the string towards its end.

backward
specifies that comparison operations for the weight level proceed
from the end of the string toward its beginning.

no-substitute
no substitution is performed, such that the comparison is based on
collation values for collating elements before any substitution
operations are performed.

Notes:
1. This is an IBM extension; therefore, locales that use it may not be
portable to localedef tools developed by other vendors.
2. When the no-substitute keyword is specified, one-to-many
mappings are ignored.

position
specifies that comparison operations for the weight level must
consider the relative position of non-IGNOREd elements in the
strings. The string containing a non-IGNOREd element after the
fewest IGNOREd collating elements from the start of the comparison
collates first. If both strings contain a non-IGNOREd character in the
same relative position, the collating values assigned to the
elements determine the order. If the strings are equal, subsequent non-IGNOREd characters are considered in the same manner.

The collating order entries are terminated with an order_end keyword.

Here is an example of an LC_COLLATE category:

```plaintext
LC_COLLATE
% ARTIFICIAL COLLATE CATEGORY
% collating elements
   collating-element <ch> from "<c><h>"
   collating-element <Ch> from "<C><h>"
   collating-element <eszet> from "<s><z>"
% collating symbols for relative order definition
   collating-symbol <LOW>
   collating-symbol <UPPER-CASE>
   collating-symbol <LOWER-CASE>
   collating-symbol <NONE>

order_start forward;backward;forward
   <NONE>
   <LOW>
   <UPPER-CASE>
   <LOWER-CASE>

UNDEFINED IGNORE;IGNORE;IGNORE

<space>
......
<quotation-mark>
   <a>
   <a-acute>
   <a-grave>
   <A>
   <A-acute>
   <A-grave>
   <ch>
   <Ch>
   <s>
   <eszet>
   <z>

order_end
```

The example is interpreted as follows:

1. collating elements
   - character `<c>` followed by `<h>` collate as one entity named `<ch>`
   - character `<c>` followed by `<h>` collate as one entity named `<Ch>`
   - character `<s>` followed by `<z>` collate as one entity named `<eszet>`
2. collating symbols `<LOW>`, `<UPPER-CASE>`, `<LOWER-CASE>` and `<NONE>` are defined to be used in relative order definition
3. up to 3 string comparisons are defined:
   - first pass starts from the beginning of the strings
   - second pass starts from the end of the strings, and
   - third pass starts from the beginning of the strings
4. the collating weights are defined such that
• <LOW> collates before <UPPER-CASE>,
• <UPPER-CASE> collates before <LOWER-CASE>,
• <LOWER-CASE> collates before <NONE>;
5. all characters for which collation is not specified here are ordered after <NONE>, and before <space> in ascending order according to their encoded values
6. all characters with an encoded value larger than the encoded value of <space> and lower than the encoded value of <quotation-mark> in the current encoded character set, collate in ascending order according to their values;
7. <a> has a:
   • primary weight of <a>,
   • secondary weight <NONE>,
   • tertiary weight of <LOWER-CASE>,
8. <A> has a:
   • primary weight of <a>,
   • secondary weight of <NONE>,
   • tertiary weight of <UPPER-CASE>,
9. the weights of <s> and <z> are determined in a similar fashion to <a> and <A>.
10. <a-acute> has a:
    • primary weight of <a>,
    • secondary weight of <a-acute> itself,
    • tertiary weight of <LOWER-CASE>,
11. the weights of <a-grave>, <A-acute>, <A-grave>, <ch> and <Ch> are determined in a similar fashion to <a-acute>.
12. <eszet> has a:
    • primary weight determined by replacing each occurrence of <eszet> with the sequence of two <s>'s and using the weight of <s>,
    • secondary weight determined by replacing each occurrence of <eszet> with the sequence of <eszet> and <s> and using their weights,
    • tertiary weight is the relative position of <LOWER-CASE>.

Comparison of Strings
Compare the strings s1="aAch" and s2="AaCh" using the above LC_COLLATE definition:
1. s1=> "aA<ch>", and s2=> "Aa<Ch>"
2. first pass:
   a. substitute the elements of the strings with their primary weights: s1=> "<a><a><ch>", s2=> "<a><a><ch>"
   b. compare the two strings starting with the first element — they are equal.
3. second pass:
   a. substitute the elements of the strings with their secondary weights: s1=> "<NONE><NONE><NONE>", s2=> "<NONE><NONE><NONE>"
   b. compare the two strings from the last element to the first — they are equal.
4. third pass:
   a. substitute the elements of the strings with their third level weights:
      s1=> "<LOWER-CASE><UPPER-CASE><LOWER-CASE>",
      s2=> "<UPPER-CASE><LOWER-CASE><UPPER-CASE>",
   b. compare the two strings starting from the beginning of the strings: s2 compares lower than s1, because <UPPER-CASE> is before <LOWER-CASE>.
Compare the strings s1="áß" and s2="àss":
1. s1= "á<eszet>" and s2= "àss";
2. first pass:
   a. substitute the elements of the strings with their primary weights: s1=> "<a><s><s>", s2=> "<a><s><s>
   b. compare the two strings starting with the first element — they are equal.
3. second pass:
   a. substitute the elements of the strings with their secondary weights: s1= "<a-acute><eszet><s>", s2= "<a-grave><s><s>
   b. compare the two strings from the last element to the first — <s> is before <ezset>.

**LC_MONETARY Category**

This category defines the rules and symbols used to format monetary quantities. The operands are strings or integers. The following keywords are supported:

**copy**
Specifies the name of an existing locale to be used as the source for the definition of this category. If this keyword is specified, no other keyword should be present in this category. If the locale is not found, an error is reported and no locale output is created. The copy keyword cannot specify a locale that also specifies the copy keyword for the same category.

**int_curr_symbol**
Specifies the international currency symbol. The operand is a four-character string, with the first three characters containing the alphabetic international currency symbol in accordance with those specified in ISO4217 Codes for the Representation of Currency and Funds. The fourth character is the character used to separate the international currency symbol from the monetary quantity.

The following value may also be specified, though it is not if not defined, it defaults to the empty string (""").

**currency_symbol**
Specifies the string used as the local currency symbol. If not defined, it defaults to the empty string (""").

**mon_decimal_point**
The string used as a decimal delimiter to format monetary quantities. If not defined it defaults to the empty string (""").

**mon_thousands_sep**
Specifies the string used as a separator for groups of digits to the left of the decimal delimiter in formatted monetary quantities. If not defined, it defaults to the empty string (""").

**mon_grouping**
Defines the size of each group of digits in formatted monetary quantities. The operand is a sequence of integers separated by semicolons. Also, for compatibility, it may be a string of integers separated by semicolons. Each integer specifies the number of digits in each group, with the initial integer defining the size of the group immediately preceding the decimal delimiter, and the following integers defining the preceding groups. If the last integer is not −1, then the size of the previous group (if any) is used repeatedly for the rest of the digits. If the last integer is −1, then no further grouping is performed. If not defined, mon_grouping defaults to −1 which indicates that no grouping. An empty string is interpreted as −1.
positive_sign
A string used to indicate a formatted monetary quantity with a non-negative value. If not defined, it defaults to the empty string ("").

negative_sign
Specifies a string used to indicate a formatted monetary quantity with a negative value. If not defined, it defaults to the empty string ("").

int_frac_digits
Specifies an integer representing the number of fractional digits (those to the right of the decimal delimiter) to be displayed in a formatted monetary quantity using int_curr_symbol. If not defined, it defaults to −1.

frac_digits
Specifies an integer representing the number of fractional digits (those to the right of the decimal delimiter) to be displayed in a formatted monetary quantity using currency_symbol. If not defined, it defaults to −1.

p_cs_precedes
Specifies an integer set to 1 if the currency_symbol or int_curr_symbol precedes the value for a non-negative formatted monetary quantity, and set to 0 if the symbol succeeds the value. If not defined, it defaults to −1.

p_sep_by_space
Specifies an integer set to 0 if no space separates the currency_symbol or int_curr_symbol from the value for a non-negative formatted monetary quantity, set to 1 if a space separates the symbol from the value, and set to 2 if a space separates the symbol and the string sign, if adjacent. If not defined, it defaults to −1.

n_cs_precedes
An integer set to 1 if the currency_symbol or int_curr_symbol precedes the value for a negative formatted monetary quantity, and set to 0 if the symbol succeeds the value. If not defined, it defaults to −1.

n_sep_by_space
An integer set to 0 if no space separates the currency_symbol or int_curr_symbol from the value for a negative formatted monetary quantity, set to 1 if a space separates the symbol from the value, and set to 2 if a space separates the symbol and the string sign, if adjacent. If not defined, it defaults to −1.

p_sign_posn
An integer set to a value indicating the positioning of the positive_sign for a non-negative formatted monetary quantity. The following integer values are recognized:

0 Parentheses surround the quantity and the currency_symbol or int_curr_symbol.
1 The sign string precedes the quantity and the currency_symbol or int_curr_symbol.
2 The sign string succeeds the quantity and the currency_symbol or int_curr_symbol.
3 The sign string immediately precedes the currency_symbol or int_curr_symbol.
4 The sign string immediately succeeds the currency_symbol or int_curr_symbol.
part of the POSIX standard.

5 Use debit-sign or credit-sign for p_sign_posn or n_sign_posn.

If not defined, it defaults to –1.

**n_sign_posn**
An integer set to a value indicating the positioning of the negative_sign for a negative formatted monetary quantity. The recognized values are the same as for p_sign_posn. If not defined, it defaults to –1.

**left_parenthesis**
The symbol of the locale’s equivalent of ( to form a negative-valued formatted monetary quantity together with right_parenthesis. If not defined, it defaults to the empty string (""").

**Note:** This is an IBM-specific extension.

**right_parenthesis**
The symbol of the locale’s equivalent of ) to form a negative-valued formatted monetary quantity together with left_parenthesis. If not defined, it defaults to the empty string ("");

**Note:** This is an IBM-specific extension.

**debit_sign**
The symbol of locale’s equivalent of DB to indicate a non-negative-valued formatted monetary quantity. If not defined, it defaults to the empty string (""");

**Note:** This is an IBM-specific extension.

**credit_sign**
The symbol of locale’s equivalent of CR to indicate a negative-valued formatted monetary quantity. If not defined, it defaults to the empty string (""");

**Note:** This is an IBM-specific extension.

Here is an example of the definition of the LC_MONETARY category:
LC_NUMERIC Category

This category defines the rules and symbols used to format non-monetary numeric information. The operands are strings. The following keywords are recognized:

**copy**
Specifies the name of an existing locale to be used as the source for the definition of this category. If this keyword is specified, no other keyword should be present in this category. If the locale is not found, an error is reported and no locale output is created. The *copy* keyword cannot specify a locale that also specifies the *copy* keyword for the same category.

**decimal_point**
Specifies a string used as the decimal delimiter in numeric, non-monetary formatted quantities. This keyword cannot be omitted and cannot be set to the empty string.

**thousands_sep**
Specifies a string containing the symbol that is used as a separator for groups of digits to the left of the decimal delimiter in numeric, non-monetary, formatted quantities.

**grouping**
Defines the size of each group of digits in formatted non-monetary quantities. The operand is a sequence of integers separated by semicolons. Also, for compatibility, it may be a string of integers separated by semicolons. Each integer specifies the number of digits in each group, with the initial integer defining the size of the group immediately preceding the decimal delimiter, and the following integers defining the preceding groups. If the last integer is not −1, then the size of the previous group (if any) is used repeatedly for the rest of the digits. If the last integer is −1, then no further grouping is performed. An empty string is interpreted as −1.
Here is an example of how to specify the LC_NUMERIC category:

```
escape_char /
comment_char %

%%%%%%%%%%%%%%%%%%%%%
LC_NUMERIC
%%%%%%%%%%%%%%%%%%%%%
decimal_point "<comma>
thousands_sep "<space>
grouping 3

END LC_NUMERIC
```

**LC_TIME Category**

The LC_TIME category defines the interpretation of the field descriptors used for parsing, then formatting, the date and time. The descriptors identify the replacement portion of the string, while the rest of a string is constant. The definition of descriptors is included in [z/OS C/C++ Run-Time Library Reference](#). All these descriptors can be used in the format specifier in the time formatting functions `strftime()`.

The following keywords are supported:

- **copy** Specifies the name of an existing locale to be used as the source for the definition of this category. If this keyword is specified, no other keyword should be present in this category.
  
  If the locale is not found, an error is reported and no locale output is created. The `copy` keyword cannot specify a locale that also specifies the `copy` keyword for the same category.

- **abday** Defines the abbreviated weekday names, corresponding to the `%a` field descriptor. The operand consists of seven semicolon-separated strings. The first string is the abbreviated name corresponding to Sunday, the second string corresponds to Monday, and so forth.

- **day** Defines the full weekday names, corresponding to the `%A` field descriptor. The operand consists of seven semicolon-separated strings. The first string is the full name corresponding to Sunday, the second string to Monday, and so forth.

- **abmon** Defines the abbreviated month names, corresponding to the `%b` field descriptor. The operand consists of twelve strings separated by semicolons. The first string is an abbreviated name that corresponds to January, the second corresponds to February, and so forth.

- **mon** Defines the full month names, corresponding to the `%B` field descriptor. The operand consists of twelve strings separated by semicolons. The first string is an abbreviated name that corresponds to January, the second corresponds to February, and so forth.

- **d_t_fmt** Defines the appropriate date and time representation, corresponding to the `%c` field descriptor. The operand consists of a string, which may contain any combination of characters and field descriptors.

- **d_fmt** Defines the appropriate date representation, corresponding to the `%x` field descriptor. The operand consists of a string, and may contain any combination of characters and field descriptors.
t_fmt  Defines the appropriate time representation, corresponding to the \%X field descriptor. The operand consists of a string, which may contain any combination of characters and field descriptors.

am_pm  Defines the appropriate representation of the ante meridian and post meridian strings, corresponding to the \%p field descriptor. The operand consists of two strings, separated by a semicolon. The first string represents the ante meridian designation, the last string the post meridian designation.

t_fmt_ampm  Defines the appropriate time representation in the 12-hour clock format with am_pm, corresponding to the \%r field descriptor. The operand consists of a string and can contain any combination of characters and field descriptors.

era  Defines how the years are counted and displayed for each era (or emperor's reign) in a locale.

No era is needed if the \%E field descriptor modifier is not used for the locale. See the description of the strftime() function in Run-Time Library Reference for information about this field descriptor.

For each era, there must be one string in the following format:

direction:offset:start_date:end_date:name:format

where

direction  Either a + or − character. The + character indicates the time axis should be such that the years count in the positive direction when moving from the starting date towards the ending date. The − character indicates the time axis should be such that the years count in the negative direction when moving from the starting date towards the ending date.

offset  A number of the first year of the era.

start_date  A date in the form yyyy/mm/dd where yyyy, mm and dd are the year, month and day numbers, respectively, of the start of the era. Years prior to the year AD 0 are represented as negative numbers. For example, an era beginning March 5th in the year 100 BC would be represented as -100/3/5.

end_date  The ending date of the era in the same form as the start_date above or one of the two special values −* or +*. A value of −* indicates the ending date of the era extends to the beginning of time while +* indicates it extends to the end of time. The ending date may be either before or after the starting date of an era. For example, the strings for the Christian eras AD and BC would be:

+0:0000/01/01:+*:AD:%EC %Ey
+:+0001/12/31:+*:BC:%EC %Ey

name  A string representing the name of the era which is substituted for the \%EC field descriptor.

format  A string for formatting the \%Ey field descriptor. This string is usually a function of the \%EC and \%Ey field descriptors.

The operand consists of one string for each era. If there is more than one era, strings are separated by semicolons.
era_year
  Defines the format of the year in alternate era format, corresponding to the 
  %EY field descriptor.

era_d_fmt
  Defines the format of the date in alternate era notation, corresponding to 
  the %Ex field descriptor.

era_t_fmt
  Defines the locale's appropriate alternative time format, corresponding to 
  the %Ex field descriptor.

era_d_t_fmt
  Defines the locale's appropriate alternative date and time format, 
  corresponding to the %Ec field descriptor.

alt_digits
  Defines alternate symbols for digits, corresponding to the %0 field descriptor 
  modifier. The operand consists of semicolon-separated strings. The first 
  string is the alternate symbol corresponding to zero, the second string the 
  symbol corresponding to one, and so forth. A maximum of 100 alternate 
  strings may be specified. The %0 modifier indicates that the string 
  corresponding to the value specified by the field descriptor is used instead 
  of the value.

For the definitions of the time formatting descriptors, see the description of the 
strftime() function in z/OS C/C++ Run-Time Library Reference.

LC_MESSAGES Category

The LC_MESSAGES category defines the format and values for positive and negative 
responses.

The following keywords are recognized:

copy
  Specifies the name of an existing locale to be used as the source for the 
definition of this category. If you specify this keyword, no other keyword 
should be present in this category.

  If the locale is not found, an error is reported and no locale output is 
created. The copy keyword cannot specify a locale that also specifies the 
copy keyword for the same category.

yesexpr
  The operand consists of an extended regular expression that describes the 
acceptable affirmative response to a question that expects an affirmative 
or negative response.

noexpr
  The operand consists of an extended regular expression that describes the 
acceptable negative response to a question that expects an affirmative or 
negative response.

yestr
  The operand consists of a fixed string (not a regular expression) that can 
be used by an application for composition of a message that lists an 
acceptable affirmative response, such as in a prompt.

nostr
  The operand consists of a fixed string that can be used by an application 
for composition of a message that lists an acceptable negative response.

Here is an example that shows how to define the LC_MESSAGES category:
The LC_TOD category defines the rules used to define the beginning, end, and duration of daylight savings time, and the difference between local time and Greenwich Mean time. This is an IBM extension.

Note: LC_TOD and LC_SYNTAX are not supported for ASCII locales (a locale specification can not contain a definition for these categories). However, for consistency with EBCDIC locales, localedef generates default values for these categories in ASCII locale objects (the values generated for the C locale but with ASCII code points).

The following keywords are recognized:

**copy**
Specifies the name of an existing locale to be used as the source for the definition of this category. If this keyword is specified, no other keyword should be present in this category.

If the locale is not found, an error is reported and no locale output is created. The copy keyword cannot specify a locale that also specifies the copy keyword for the same category.

Note: If you specify this keyword, no other keyword should be present in this category.

**timezone_difference**
An integer specifying the time zone difference expressed in minutes. If the local time zone is west of the Greenwich Meridian, this value must be positive. If the local time zone is east of the Greenwich Meridian, this value must be negative. An absolute value greater than 1440 (the number of minutes in a day) for this keyword indicates that z/OS Language Environment is to get the time zone difference from the system.

**timezone_name**
A string specifying the time zone name such as "PST" (Pacific Standard Time) specified within quotation marks. The default for this field is a NULL string.

**daylight_name**
A string specifying the Daylight Saving Time zone name, such as "PDT" (Pacific Daylight Time), if there is one available. The string must be
specified within quotation marks. If DST information is not available, this is set to NULL, which is also the default. This field must be filled in if DST information as provided by the other fields is to be taken into account by the `mktime()` and `localtime()` functions. These functions ignore DST if this field is NULL.

**start_month**
An integer specifying the month of the year when Daylight Saving Time comes into effect. This value ranges from 1 through 12 inclusive, with 1 corresponding to January and 12 corresponding to December. If DST is not applicable to a locale, `start_month` is set to 0, which is also the default.

**end_month**
An integer specifying the month of the year when Daylight Saving Time ceases to be in effect. The specifications are similar to those for `start_month`.

**start_week**
An integer specifying the week of the month when DST comes into effect. Acceptable values range from -4 to +4. A value of 4 means the fourth week of the month, while a value of -4 means fourth week of the month, counting from the end of the month. Sunday is considered to be the start of the week. If DST is not applicable to a locale, `start_week` is set to 0, which is also the default.

**end_week**
An integer specifying the week of the month when DST ceases to be in effect. The specifications are similar to those for `start_week`.

**Note:** The `start_week` and `end_week` need not be used. The `start_day` and `end_day` fields can specify either the day of the week or the day of the month. If day of month is specified, `start_week` and `end_week` become redundant.

**start_day**
An integer specifying the day of the week or the day of the month when DST comes into effect. The value depends on the value of `start_week`. If `start_week` is not equal to 0, this is the day of the week when DST comes into effect. It ranges from 0 through 6 inclusive, with 0 corresponding to Sunday and 6 corresponding to Saturday. If `start_week` equals 0, `start_day` is the day of the month (for the current year) when DST comes into effect. It ranges from 1 through to the last day of the month inclusive. The last day of the month is 31 for January, March, May, July, August, October, and December. It is 30 for April, June, September, and November. For February, it is 28 on non-leap years and 29 on leap years. If DST is not applicable to a locale, `start_day` is set to 0, which is also the default.

**end_day**
An integer specifying the day of the week or the day of the month when DST ceases to be in effect. The specifications are similar to those for `start_day`.

**start_time**
An integer specifying the number of seconds after 12:00 midnight, local standard time, when DST comes into effect. For example, if DST is to start at 2:00 am, `start_time` is assigned the value 7200; for 12:00 am (midnight), `start_time` is 0; for 1:00 am, it is 3600.
**end_time**

An integer specifying the number of seconds after 12 midnight, local standard time, when DST ceases to be in effect. The specifications are similar to those for `start_time`.

**shift**

An integer specifying the DST time shift, expressed in seconds. The default is 3600, for 1 hour.

**uctname**

A string specifying the name to be used for Coordinated Universal Time. If this keyword is not specified, the uctname will default to "UTC".

Here is an example of how to define the `LC_TOD` category:

```plaintext
escape_char  /
comment-char  %

LC_TOD
% the time zone difference is 8hrs; the name of the daylight saving time is PDT, and it starts on the first Sunday of April at 2&00AM and ends on the second Sunday of October at 2&00AM
timezone_difference +480
timezone_name "<P><S><T>"
daylight_name "<P><D><T>"
start_month  4
end_month    10
start_week   1
end_week     2
start_day    1
end_day      30
start_time   7200
end_time     3600
shift        3600
END LC_TOD
```

**LC_SYNTAX Category**

The `LC_SYNTAX` category defines the variant characters from the portable character set. `LC_SYNTAX` is an IBM-specific extension. This category can be queried by the C library function `getsyntx()` to determine the encoding of a variant character if needed.

**Attention:** Customizing the `LC_SYNTAX` category is not recommended. You should use the `LC_SYNTAX` values obtained from the charmap file when you use the localedef utility.

The operands for the characters in the `LC_SYNTAX` category accept the single byte character specification in the form of a symbolic name, the character itself, or the decimal, octal, or hexadecimal constant. The characters must be specified in the `LC_CTYPE` category as a `punct` character. The values for the `LC_SYNTAX` characters must be unique. If symbolic names are used to define the encoding, only the symbolic names listed for each character should be used.

The code points for the `LC_SYNTAX` characters are set to the code points specified. Otherwise, they default to the code points for the respective characters from the charmap file, if the file is present, or to the code points of the respective characters in the IBM-1047 code page.
Note: LC_TOD and LC_SYNTAX are not supported for ASCII locales (a locale specification can not contain a definition for these categories). However, for consistency with EBCDIC locales, localedef generates default values for these categories in ASCII locale objects (the values generated for the C locale but with ASCII code points).

The following keywords are recognized:

- **copy**
  Specifies the name of an existing locale to be used as the source for the definition of this category. If you specify this keyword, no other keyword should be present.
  If the locale is not found, an error is reported and no locale output is created. The `copy` keyword cannot specify a locale that also specifies the `copy` keyword for the same category.

- **backslash**
  Specifies a string that defines the value used to represent the backslash character. If this keyword is not specified, the value from the charmap file for the character `<backslash>`, `<reverse-solidus>`, or `<SM07>` is used, if it is present.

- **right_brace**
  Specifies a string that defines the value used to represent the right brace character. If this keyword is not specified, the value from the charmap file for the character `<right-brace>`, `<right-curlly-bracket>`, or `<SM14>` is used, if it is present.

- **left_brace**
  Specifies a string that defines the value used to represent the left brace character. If this keyword is not specified, the value from the charmap file for the character `<left-brace>`, `<left-curlly-bracket>`, or `<SM11>` is used, if it is present.

- **right_bracket**
  Specifies a string that defines the value used to represent the right bracket character. If this keyword is not specified, the value from the charmap file for the character `<right-square-bracket>`, or `<SM08>` is used, if it is present.

- **left_bracket**
  Specifies a string that defines the value used to represent the left bracket character. If this keyword is not specified, the value from the charmap file for the character `<left-square-bracket>`, or `<SM06>` is used, if it is present.

- **circumflex**
  Specifies a string that defines the value used to represent the circumflex character. If this keyword is not specified, the value from the charmap file for the character `<circumflex>`, `<circumflex-accent>`, or `<SD15>` is used, if it is present.

- **tilde**
  Specifies a string that defines the value used to represent the tilde character. If this keyword is not specified, the value from the charmap file for the character `<tilde>`, or `<SD19>` is used, if it is present.

- **exclamation_mark**
  Specifies a string that defines the value used to represent the exclamation mark character. If this keyword is not specified, the value from the charmap file for the character `<exclamation-mark>`, or `<SP02>` is used, if it is present.

- **number_sign**
  Specifies a string that defines the value used to represent the number sign
character. If this keyword is not specified, the value from the charmap file for the character `<number-sign>`, or `<SM01>` is used, if it is present.

**vertical_line**
Specifies a string that defines the value used to represent the vertical line character. If this keyword is not specified, the value from the charmap file for the character `<vertical-line>`, or `<SM13>` is used, if it is present.

**dollar_sign**
Specifies a string that defines the value used to represent the dollar sign character. If this keyword is not specified, the value from the charmap file for the character `<dollar-sign>`, or `<SC03>` is used, if it is present.

**commercial_at**
Specifies a string that defines the value used to represent the commercial at character. If this keyword is not specified, the value from the charmap file for the character `<commercial-at>`, or `<SM05>` is used, if it is present.

**grave_accent**
Specifies a string that defines the value used to represent the grave accent character. If this keyword is not specified, the value from the charmap file for the character `<grave-accent>`, or `<SD13>` is used, if it is present.

Here is an example of how the LC_SYNTAX category is defined:

```
escape_char  /
comment-char  %

%%%%%%
LC_SYNTAX
%%%%%%
backslash     "<backslash>"
right_brace   "<right-brace>"
left_brace    "<left-brace>"
right_bracket "<right-square-bracket>"
left_bracket  "<left-square-bracket>"
circumflex    "<circumflex>"
tilde         "<tilde>"
exclamation_mark "<exclamation-mark>"
umber_sign    "<number-sign>"
vertical_line "<vertical-line>"
dollar_sign   "<dollar-sign>"
commercial_at "<commercial-at>"
grave_accent  "<grave-accent>"

END LC_SYNTAX
```

### Method Files

Method files can be used when creating ASCII locales. They specify the method functions used by the C run-time's locale-sensitive interfaces when the ASCII locale is activated.

IBM ships the method files used to build its ASCII locales in the `/usr/lib/nls/method` directory. These method files support various ASCII Latin 1 and non-Latin 1 single byte encodings, ASCII SJIS and EUC multibyte encodings and UTF-8 multibyte encodings.

By replacing the CHARMAP related method functions in a method file, users can create a locale which supports a user-defined code page. For each replaced
method, the method file supplies the user-written method function name, and optionally indicates where the method function code is to be found (.o file, archive library or DLL). The method source file maps method names to the National Language Support (NLS) subroutines that implement those methods. The method file also specifies the object libraries or DLL side decks where the implementing subroutines are stored. The methods correspond to those subroutines that require direct access to the data structures representing locale data.

Each user provided method must follow the standard interface defined for the API it implements and add an argument of type _LC_charmap_objhdl_t as the first argument. The _LC_charmap_objhdl_t is defined in the localdef.h header file.

Users can provide these CHARMAP methods via a DLL side deck, an archive library or an object file. The user-written method functions are used both by the locale-sensitive APIs they represent, and also by the localedef utility itself while generating the method-file based ASCII locale object. This second use by localedef itself causes a temporary DLL to be created while processing the CHARMAP file supplied on the -f parameter. The name of the file containing method objects or side deck information is passed by the localedef utility as a parameter on the c89 command line, so the standard archive/object/side deck suffix naming conventions apply (i.e. .a, .o, .x).

The following is the expected grammar for a method file:

```
method_def : "METHODS"
    method_assign_list "END METHODS"
;
method_assign_list : method_assign_list method_assign
method_assign_list
method_assign
;

method_assign : "csid" meth_name meth_lib_path
    "fnmatch" meth_name meth_lib_path
    "is_wctype" meth_name meth_lib_path
    "mblen" meth_name meth_lib_path
    "mbstowcs" meth_name meth_lib_path
    "mbtowc" meth_name meth_lib_path
    "regcomp" meth_name meth_lib_path
    "regerror" meth_name meth_lib_path
    "regexec" meth_name meth_lib_path
    "regfree" meth_name meth_lib_path
    "rpmatch" meth_name meth_lib_path
    "strcoll" meth_name meth_lib_path
    "strfmon" meth_name meth_lib_path
    "strftime" meth_name meth_lib_path
    "strptime" meth_name meth_lib_path
    "strxfrm" meth_name meth_lib_path
    "towlower" meth_name meth_lib_path
    "towupper" meth_name meth_lib_path
    "wcscoll" meth_name meth_lib_path
    "wcsftime" meth_name meth_lib_path
    "wcsid" meth_name meth_lib_path
    "wcscmp" meth_name meth_lib_path
    "wcstombs" meth_name meth_lib_path
    "wcswidth" meth_name meth_lib_path
    "wcsxfrm" meth_name meth_lib_path
    "wctomb" meth_name meth_lib_path
    "wcwidth" meth_name meth_lib_path
;

meth_name: global_name
    cfunc_name
;```
global_name: CSID_STD
FNMATCH_C
FNMATCH_STD
GET_WCTYPE_STD
IS_WCTYPE_SB
IS_WCTYPE_STD
LOCALCONV_STD
MBLEN_932
MBLEN_EUCJP
MBLEN_SB
MBSTOWCS_932
MBSTOWCS_EUCJP
MBSTOWCS_SB
MBOCW_932
MBTOCW_EUCJP
MBTOCW_SB
REGCOMP_STD
REGERROR_STD
REGEXEC_STD
REGFREE_STD
RPMATCH_C
RPMATCH_STD
STRCOLL_C
STRCOLL_SB
STRCOLL_STD
STRFMON_STD
STRTIME_STD
STRTIME_STD
STRXFRM_C
STRXFRM_SB
STRXFRM_STD
TOWLOWER_STD
TOWUPPER_STD
WCSCOLL_C
WCSCOLL_STD
WCSTIME_STD
WCSTID_STD
WSTOMBS_932
WSTOMBS_EUCJP
WSTOMBS_SB
WCWID_932
WCWID_EUCJP
WCWID_LATIN
WCXFRM_C
WCXFRM_STD
WCTOMB_932
WCTOMB_EUCJP
WCTOMB_SB
WCWID_932
WCWID_EUCJP
WCWID_LATIN
;

Where cfunc_name is the name of a user supplied subroutine, and meth_lib_path is an optional path name for the file containing the compiled subroutine or a side-deck for the DLL containing the subroutine.

The localedef command parses this information to determine the methods to be used for this locale. The following subroutines must be specified in the method file:

mblen  mbstowcs
mbtowc  mbstowcs
wctomb  wcstombs
wcswidth wcstombs
wcwidth  wctomb
The following additional subroutines are mandatory in AIX method files, but are not supported on z/OS and if specified are ignored:

mbtopc
mbstopcs
pctomb
pcstombs

Any other method not specified in the method file retains the default. Mixing of user-written method function names (represented as cfunc_name in the grammar) and IBM-provided method function names (represented by global_name in the grammar) is not allowed. A method file should not include both. If the localedef command encounters both cfunc_name values and global_name values in a method file, an error is generated and the locale is not created.

It is not mandatory that the METHODS section specify the meth_lib_path name for all methods. The following is an example of how to specify the meth_lib_path and what the localedef passes on the c89 command invoking the binder when linking the method-based ASCII locale object:

METHODS

mblen "__mblen_myuni"
mbstowcs "__mbstowcs_myuni" "/u/my/libmyuni.a"
mbtowc "__mbtowc_myuni"
wctombs "__wctombs_myuni" "/u/gen/libgenuni.a"
wcswidth "__wcswidth_myuni"
wctomb "__wctomb_myuni"
wctowidth "__wctowidth_myuni" ./wcwidth.o

In the example, libmyuni.a contains functions __mbstowcs_myuni and __mbtowc_myuni. Similarly, libgenuni.a contains functions __wctombs_myuni, __wcswidth_myuni and __wctomb_myuni. The function __wcswidth_myuni is contained in the file wcwidth.o. If the function __mblen_myuni is not defined in either of the three files indicated, a locale object will not be created. For this example the localedef utility would invoke the binder using the following c89 command line:

c89 -o myuni.locale -Wl,xplink ./localefBGgfFcGAo ./localeEgaBGaahA.o /u/my/libmyuni.a /u/gen/libgenuni.a ./wcwidth.o

It is also possible to use the -L localedef option to specify the c89 -L library flags and only reference the library names in the method file following the liblibname.a convention.

If an individual method does not specify a meth_lib_path name, the method inherits the most recently specified meth_lib_path name. If no meth_lib_path name is specified in the METHODS section, the default run-time library side-deck is assumed. The files indicated by meth_lib_path names of all methods in the method file are used when linking the locale object. A concatenated list of all meth_lib_path names is specified on the link step. If multiple object libraries or side decks are specified, the same routine should not be defined in more than one of them. Unexpected results may occur if the method functions appear in more than one file, particularly if the duplicate copies are not identical. The binder could resolve a method function from a file different from the one given in the method file itself.

The method for the mbtowc and wcwidth subroutines should avoid calling other methods where possible.
Using the localedef Utility

The locale objects or locales are generated using the localedef utility. The localedef utility:
1. Reads the locale definition file
2. Resolves all the character symbolic names to the values of characters defined in the specified character set definition file, (CHARMAP)
3. Produces a z/OS C source file.
4. Compiles the source file using the z/OS C compiler and link-edits the produced text module to produce a locale object. localedef produces ASCII locales as XPLINK DLL’s exclusively, while EBCDIC locales can be non-XPLINK objects or XPLINK DLL’s.

The locale DLL can be loaded by the setlocale() function and then accessed by the z/OS C/C++ functions that are sensitive to the cultural information, or that can query the locales. For a list of all the library functions sensitive to locale, see "Locale-Sensitive Interfaces" on page 672. For detailed information on how to invoke the localedef utility, see z/OS C/C++ User’s Guide.

The locale DLL created by localedef must adhere to certain naming conventions so that the locale can be used by the system. These conventions are outlined in "Locale Naming Conventions".

XPLINK applications require XPLINK locale objects, and non-XPLINK applications require non-XPLINK locale objects. localedef creates non-XPLINK locales by default. The option XPLINK causes the TSO version of localedef to produce an XPLINK locale object. The EDCXLDEF proc causes the BATCH version of localedef to produce an XPLINK locale object. The -X parameter causes the HFS version of localedef to generate an XPLINK locale object.

The TSO version of localedef and EDCXLDEF proc cannot be used to generate ASCII locales. ASCII locales are generated by specifying the -A localedef option on the command line. Either user-provided or IBM-provided method functions can be indicated by the -m method_file option on the command line.

The POSIX shell (/bin/sh) is an example of a non-XPLINK application that uses locales. It needs non-XPLINK locales. If the shell invokes an XPLINK application that uses locales, the application will need an XPLINK version of the same locale. Usually, both XPLINK and non-XPLINK versions of a locale are needed whenever an XPLINK application is invoked from the shell, or when an XPLINK application invokes the shell or any other non-XPLINK application. The locale object naming conventions ensure that the run-time library loads the appropriate version of the locale.

Locale Naming Conventions

The setlocale() library function that selects the active locale maps the descriptive locale name into the name of the locale object before loading the locale and making it accessible.

In z/OS C/C++ programs, the locale modules are referred to by descriptive locale names. The locale names themselves are not case sensitive. They follow these conventions:

<Language>-<Territory>,<Codeset>
Where:

**Language**

is a two-letter uppercase abbreviation for the language name. The abbreviations come from the ISO 639 standard.

**Territory**

is a two-letter uppercase abbreviation for the territory name. The abbreviation comes from the ISO 3166 standard.

**Codeset**

is the name registered by the MIT X Consortium that identifies the registration authority that owns the specific encoding.

A modifier may be added to the registered name but is not required. The modifier is of the form `@codeset modifier` and identifies the coded character set as defined by that registration authority.

The Codeset parts are optional. If they are not specified, Codeset defaults to `IBM-nnn`, where `nnn` is the default code page, which for EBCDIC locales is shown in Table 74 on page 714 and for ASCII locales in Table 75 on page 716 (The modifier portion defaults to nothing.)

For PDS resident locales, the mapping between the descriptive locale name and the eight-character name of the locale object is performed as follows:

1. The Language-Territory part is mapped into a two-letter LT code.
2. The Codeset part is mapped into a two-letter CC code.
3. If the @euro modifier is not specified, the object name is built from the prefix `EDC$` for non-XPLINK locales, `CEH$` for EBCDIC XPLINK locales, or `CEJ$` for ASCII XPLINK locales, the two-letter LT code, and the two-letter CC code.
4. If the @euro modifier is specified, the object name is built from the prefix `EDC@` for non-XPLINK locales or `CEH@` for XPLINK locales, the two-letter LT code and the two-letter CC code.

For example:

- **Non-XPLINK**
  
  `Fr_BE.IBM-1148` maps to `EDC$FBHO`
  
  `Fr_BE.IBM-1148@euro` maps to `EDC@FBHO`

- **XPLINK**
  
  `Fr_BE.IBM-1148` maps to `CEH$FBHO`
  
  `Fr_BE.IBM-1148@euro` maps to `CEH@FBHO`

- **ASCII**
  
  `Fr_BE.ISO8859-1` maps to `CEJ$FBII`
  
  `Fr_BE.UTF-8` maps to `CEJ$FBUB`

For HFS resident locales, the mapping between the descriptive locale name and the HFS file name is performed as follows:

1. The locale object file name starts out the same as the descriptive name.
2. If the locale object is XPLINK, add a suffix of ".xplink" to the end of the object file name.

For example:

- **Non-XPLINK**

---

8. The @-sign in the PDS and HFS locale names always has Latin-1/Open Systems encoding. See IBM-1047 CHARMAP.
Fr_BE.IBM-1148 maps to Fr_BE.IBM-1148
Fr_BE.IBM-1148@euro maps to Fr_BE.IBM-1148@euro

- XPLINK
Fr_BE.IBM-1148 maps to Fr_BE.IBM-1148.xplink
Fr_BE.IBM-1148@euro maps to Fr_BE.IBM-1148@euro.xplink

- ASCII
Fr_BE.ISO8859-1 maps to Fr_BE.ISO8859-1.xplink
Fr_BE.UTF-8 maps to Fr_BE.UTF-8.xplink

The mapping between Language-Territory and the two-letter LT code is defined in the LT conversion table EDC$LCNM, built with assembler macros as follows:

EDC$LCNM TITLE 'LOCALE NAME CONVERSION TABLE'
EDC$LCNM CSECT
  EDCLOCNM TYPE=ENTRY,LOCALE='DA_DK',CODESET='IBM-1047',CODE='DA'
  EDCLOCNM TYPE=ENTRY,LOCALE='DE_BE',CODESET='IBM-1047',CODE='DB'
  EDCLOCNM TYPE=ENTRY,LOCALE='DE_CH',CODESET='IBM-1047',CODE='DC'
  EDCLOCNM TYPE=ENTRY,LOCALE='DE_DE',CODESET='IBM-1047',CODE='DD'
  EDCLOCNM TYPE=ENTRY,LOCALE='JA_3P',CODESET='IBM-939',CODE='E3'

EDCLOCNM TYPE=END
END EDC$LCNM

LOCALE specifies the name of Language-Territory, while CODE specifies the respective LT code.

You can customize this table by adding new LOCALE name mappings. z/OS C/C++ reserves alphabetic LT codes, but you can use codes containing numeric values for your own customized names.

The following Language-Territory names and their mappings into LT codes are provided:

Table 74. Supported Language-Territory Names and LT Codes for EBCDIC Locales

<table>
<thead>
<tr>
<th>Locale Name</th>
<th>Language</th>
<th>Country/Territory</th>
<th>EBCDIC Codeset</th>
<th>2-Byte LT Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ar_AA</td>
<td>Arabic</td>
<td>Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, U.A.E., Yemen</td>
<td>IBM-425</td>
<td>AR</td>
</tr>
<tr>
<td>Be_BY</td>
<td>Byelorussian</td>
<td>Belarus</td>
<td>IBM-1025</td>
<td>BB</td>
</tr>
<tr>
<td>Bg_BG</td>
<td>Bulgarian</td>
<td>Bulgaria</td>
<td>IBM-1025</td>
<td>BG</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>IBM-1047</td>
<td></td>
<td>CC</td>
</tr>
<tr>
<td>Ca_ES</td>
<td>Catalan</td>
<td>Spain</td>
<td>IBM-924</td>
<td>CS</td>
</tr>
<tr>
<td>Cs_CZ</td>
<td>Czech</td>
<td>Czech Republic</td>
<td>IBM-870</td>
<td>CZ</td>
</tr>
<tr>
<td>Da_DK</td>
<td>Danish</td>
<td>Denmark</td>
<td>IBM-1047</td>
<td>DA</td>
</tr>
<tr>
<td>De_AT</td>
<td>German</td>
<td>Austria</td>
<td>IBM-924</td>
<td>DT</td>
</tr>
<tr>
<td>De_CH</td>
<td>German</td>
<td>Switzerland</td>
<td>IBM-1047</td>
<td>DC</td>
</tr>
<tr>
<td>De_DE</td>
<td>German</td>
<td>Germany</td>
<td>IBM-1047</td>
<td>DD</td>
</tr>
<tr>
<td>De_LU</td>
<td>German</td>
<td>Luxembourg</td>
<td>IBM-924</td>
<td>DL</td>
</tr>
<tr>
<td>El_GR</td>
<td>Greek</td>
<td>Greece</td>
<td>IBM-875</td>
<td>EL</td>
</tr>
<tr>
<td>En_BE</td>
<td>English</td>
<td>Belgium</td>
<td>IBM-924</td>
<td>EB</td>
</tr>
<tr>
<td>Locale Name</td>
<td>Language</td>
<td>Country/Territory</td>
<td>EBCDIC Codeset</td>
<td>2-Byte LT Code</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td>-------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>En_CA</td>
<td>English</td>
<td>Canada</td>
<td>IBM-1047</td>
<td>EC</td>
</tr>
<tr>
<td>En_GB</td>
<td>English</td>
<td>United Kingdom</td>
<td>IBM-1047</td>
<td>EK</td>
</tr>
<tr>
<td>En_IE</td>
<td>English</td>
<td>Ireland</td>
<td>IBM-924</td>
<td>EI</td>
</tr>
<tr>
<td>En_JP</td>
<td>English</td>
<td>Japan</td>
<td>IBM-1027</td>
<td>EJ</td>
</tr>
<tr>
<td>En_US</td>
<td>English</td>
<td>United States</td>
<td>IBM-1047</td>
<td>EU</td>
</tr>
<tr>
<td>En_ZA</td>
<td>English</td>
<td>South Africa</td>
<td>IBM-1047</td>
<td>EZ</td>
</tr>
<tr>
<td>Es_AR</td>
<td>Spanish</td>
<td>Argentina</td>
<td>IBM-1047</td>
<td>EA</td>
</tr>
<tr>
<td>Es_BO</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>IBM-1047</td>
<td>EO</td>
</tr>
<tr>
<td>Es_CL</td>
<td>Spanish</td>
<td>Chile</td>
<td>IBM-1047</td>
<td>EH</td>
</tr>
<tr>
<td>Es_CO</td>
<td>Spanish</td>
<td>Colombia</td>
<td>IBM-1047</td>
<td>FG</td>
</tr>
<tr>
<td>Es_CR</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>IBM-1047</td>
<td>ER</td>
</tr>
<tr>
<td>Es_DO</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>IBM-1047</td>
<td>ED</td>
</tr>
<tr>
<td>Es_EC</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>IBM-1047</td>
<td>EQ</td>
</tr>
<tr>
<td>Es_ES</td>
<td>Spanish</td>
<td>Spain</td>
<td>IBM-1047</td>
<td>ES</td>
</tr>
<tr>
<td>Es_GT</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>IBM-1047</td>
<td>EG</td>
</tr>
<tr>
<td>Es_HN</td>
<td>Spanish</td>
<td>Honduras</td>
<td>IBM-1047</td>
<td>FE</td>
</tr>
<tr>
<td>Es_MX</td>
<td>Spanish</td>
<td>Mexico</td>
<td>IBM-1047</td>
<td>EM</td>
</tr>
<tr>
<td>Es_NI</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>IBM-1047</td>
<td>FA</td>
</tr>
<tr>
<td>Es_PA</td>
<td>Spanish</td>
<td>Panama</td>
<td>IBM-1047</td>
<td>EP</td>
</tr>
<tr>
<td>Es_PE</td>
<td>Spanish</td>
<td>Peru</td>
<td>IBM-1047</td>
<td>EW</td>
</tr>
<tr>
<td>Es_PR</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>IBM-1047</td>
<td>EX</td>
</tr>
<tr>
<td>Es_PY</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>IBM-1047</td>
<td>EY</td>
</tr>
<tr>
<td>Es_SV</td>
<td>Spanish</td>
<td>El Salvador</td>
<td>IBM-1047</td>
<td>EV</td>
</tr>
<tr>
<td>Es_US</td>
<td>Spanish</td>
<td>United States</td>
<td>IBM-1047</td>
<td>ET</td>
</tr>
<tr>
<td>Es_UY</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>IBM-1047</td>
<td>FD</td>
</tr>
<tr>
<td>Es_VE</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>IBM-1047</td>
<td>EF</td>
</tr>
<tr>
<td>Et_RU</td>
<td>Estonian</td>
<td>Estonia</td>
<td>IBM-1122</td>
<td>EE</td>
</tr>
<tr>
<td>Fi_FI</td>
<td>Finnish</td>
<td>Finland</td>
<td>IBM-1047</td>
<td>FI</td>
</tr>
<tr>
<td>Fr_BE</td>
<td>French</td>
<td>Belgium</td>
<td>IBM-1047</td>
<td>FB</td>
</tr>
<tr>
<td>Fr_CA</td>
<td>French</td>
<td>Canada</td>
<td>IBM-1047</td>
<td>FC</td>
</tr>
<tr>
<td>Fr_CH</td>
<td>French</td>
<td>Switzerland</td>
<td>IBM-1047</td>
<td>FS</td>
</tr>
<tr>
<td>Fr_FR</td>
<td>French</td>
<td>France</td>
<td>IBM-1047</td>
<td>FF</td>
</tr>
<tr>
<td>Fr_LU</td>
<td>French</td>
<td>Luxembourg</td>
<td>IBM-924</td>
<td>FL</td>
</tr>
<tr>
<td>He_IL</td>
<td>Hebrew</td>
<td>Israel</td>
<td>IBM-424</td>
<td>IL</td>
</tr>
<tr>
<td>Hr_HR</td>
<td>Croatian</td>
<td>Croatia</td>
<td>IBM-870</td>
<td>HR</td>
</tr>
<tr>
<td>Hu_HU</td>
<td>Hungarian</td>
<td>Hungary</td>
<td>IBM-870</td>
<td>HU</td>
</tr>
<tr>
<td>It_CH</td>
<td>Italian</td>
<td>Switzerland</td>
<td>IBM-1047</td>
<td>IC</td>
</tr>
<tr>
<td>Is_IS</td>
<td>Icelandic</td>
<td>Iceland</td>
<td>IBM-871</td>
<td>IS</td>
</tr>
</tbody>
</table>
Table 74. Supported Language-Territory Names and LT Codes for EBCDIC Locales (continued)

<table>
<thead>
<tr>
<th>Locale Name</th>
<th>Language</th>
<th>Country/Territory</th>
<th>EBCDIC Codeset</th>
<th>2-Byte LT Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>It_IT</td>
<td>Italian</td>
<td>Italy</td>
<td>IBM-1047</td>
<td>IT</td>
</tr>
<tr>
<td>Ja_JP</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-939</td>
<td>JA</td>
</tr>
<tr>
<td>Ko_KR</td>
<td>Korean</td>
<td>Korea</td>
<td>IBM-933</td>
<td>KR</td>
</tr>
<tr>
<td>Iw_IL</td>
<td>Hebrew</td>
<td>Israel</td>
<td>IBM-424</td>
<td>IL</td>
</tr>
<tr>
<td>Lt_LT</td>
<td>Lithuanian</td>
<td>Lithuania</td>
<td>IBM-1112</td>
<td>LT</td>
</tr>
<tr>
<td>Lv_LV</td>
<td>Latvian</td>
<td>Latvia</td>
<td>IBM-1112</td>
<td>LL</td>
</tr>
<tr>
<td>Mk_MK</td>
<td>Macedonian</td>
<td>Macedonia</td>
<td>IBM-1025</td>
<td>MM</td>
</tr>
<tr>
<td>Ni_BE</td>
<td>Dutch</td>
<td>Belgium</td>
<td>IBM-1047</td>
<td>NB</td>
</tr>
<tr>
<td>Ni_NL</td>
<td>Dutch</td>
<td>The Netherlands</td>
<td>IBM-1047</td>
<td>NN</td>
</tr>
<tr>
<td>No_NO</td>
<td>Norwegian</td>
<td>Norway</td>
<td>IBM-1047</td>
<td>NO</td>
</tr>
<tr>
<td>Pl_PL</td>
<td>Polish</td>
<td>Poland</td>
<td>IBM-870</td>
<td>PL</td>
</tr>
<tr>
<td>Pt_BR</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>IBM-1047</td>
<td>BR</td>
</tr>
<tr>
<td>Pt_PT</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>IBM-1047</td>
<td>PT</td>
</tr>
<tr>
<td>Ro_RO</td>
<td>Romanian</td>
<td>Romania</td>
<td>IBM-870</td>
<td>RO</td>
</tr>
<tr>
<td>Ru_RU</td>
<td>Russian</td>
<td>Russia</td>
<td>IBM-1025</td>
<td>RU</td>
</tr>
<tr>
<td>Sh_SP</td>
<td>Serbian</td>
<td>Serbia</td>
<td>IBM-870</td>
<td>SL</td>
</tr>
<tr>
<td>Sk_SK</td>
<td>Slovak</td>
<td>Slovakia</td>
<td>IBM-870</td>
<td>SK</td>
</tr>
<tr>
<td>Sl_SI</td>
<td>Slovene</td>
<td>Slovenia</td>
<td>IBM-870</td>
<td>SI</td>
</tr>
<tr>
<td>Sq_AL</td>
<td>Albanian</td>
<td>Albania</td>
<td>IBM-500</td>
<td>SA</td>
</tr>
<tr>
<td>Sr_SP</td>
<td>Serbian (Cyrillic)</td>
<td>Serbia</td>
<td>IBM-1025</td>
<td>SC</td>
</tr>
<tr>
<td>Sv_SE</td>
<td>Swedish</td>
<td>Sweden</td>
<td>IBM-1047</td>
<td>SV</td>
</tr>
<tr>
<td>Th_TH</td>
<td>Thai</td>
<td>Thailand</td>
<td>IBM-838</td>
<td>TH</td>
</tr>
<tr>
<td>Tr_TR</td>
<td>Turkish</td>
<td>Turkey</td>
<td>IBM-1026</td>
<td>TR</td>
</tr>
<tr>
<td>Zh_CN</td>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>IBM-935</td>
<td>ZC</td>
</tr>
<tr>
<td>Zh_TW</td>
<td>Traditional Chinese</td>
<td>Taiwan</td>
<td>IBM-937</td>
<td>ZT</td>
</tr>
</tbody>
</table>

Table 75. Supported Language-Territory Names and LT Codes for ASCII Locales

<table>
<thead>
<tr>
<th>Locale Name</th>
<th>Language</th>
<th>Country/Territory</th>
<th>ASCII Codeset</th>
<th>2-Byte LT Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>be_BY</td>
<td>Byelorussian</td>
<td>Belarus</td>
<td>ISO8859-5</td>
<td>BB</td>
</tr>
<tr>
<td>en_CA</td>
<td>English</td>
<td>Canada</td>
<td>ISO8859-1</td>
<td>EC</td>
</tr>
<tr>
<td>cs_CZ</td>
<td>Czech</td>
<td>Czech Republic</td>
<td>ISO8859-2</td>
<td>CZ</td>
</tr>
<tr>
<td>en_ZA</td>
<td>English</td>
<td>South Africa</td>
<td>ISO8859-1</td>
<td>EZ</td>
</tr>
<tr>
<td>da_DK</td>
<td>Danish</td>
<td>Denmark</td>
<td>ISO8859-1</td>
<td>DA</td>
</tr>
<tr>
<td>de_CH</td>
<td>German</td>
<td>Switzerland</td>
<td>ISO8859-1</td>
<td>DC</td>
</tr>
<tr>
<td>de_DE</td>
<td>German</td>
<td>Germany</td>
<td>ISO8859-1</td>
<td>DD</td>
</tr>
<tr>
<td>el_GR</td>
<td>Greek</td>
<td>Greece</td>
<td>ISO8859-7</td>
<td>EL</td>
</tr>
<tr>
<td>Locale Name</td>
<td>Language</td>
<td>Country/Territory</td>
<td>ASCII Codeset</td>
<td>2-Byte LT Code</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>------------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>en_GB</td>
<td>English</td>
<td>United Kingdom</td>
<td>ISO8859-1</td>
<td>EK</td>
</tr>
<tr>
<td>en_US</td>
<td>English</td>
<td>United States</td>
<td>ISO8859-1</td>
<td>EU</td>
</tr>
<tr>
<td>es_AR</td>
<td>Spanish</td>
<td>Argentina</td>
<td>ISO8859-1</td>
<td>EA</td>
</tr>
<tr>
<td>es_BO</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>ISO8859-1</td>
<td>EO</td>
</tr>
<tr>
<td>es_CL</td>
<td>Spanish</td>
<td>Chile</td>
<td>ISO8859-1</td>
<td>EH</td>
</tr>
<tr>
<td>es_CO</td>
<td>Spanish</td>
<td>Colombia</td>
<td>ISO8859-1</td>
<td>FG</td>
</tr>
<tr>
<td>es_CR</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>ISO8859-1</td>
<td>ER</td>
</tr>
<tr>
<td>es_DO</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>ISO8859-1</td>
<td>ED</td>
</tr>
<tr>
<td>es_EC</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>ISO8859-1</td>
<td>EQ</td>
</tr>
<tr>
<td>es_ES</td>
<td>Spanish</td>
<td>Spain</td>
<td>ISO8859-1</td>
<td>ES</td>
</tr>
<tr>
<td>es_GT</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>ISO8859-1</td>
<td>EG</td>
</tr>
<tr>
<td>es_HN</td>
<td>Spanish</td>
<td>Honduras</td>
<td>ISO8859-1</td>
<td>FE</td>
</tr>
<tr>
<td>es_MX</td>
<td>Spanish</td>
<td>Mexico</td>
<td>ISO8859-1</td>
<td>EM</td>
</tr>
<tr>
<td>es_NI</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>ISO8859-1</td>
<td>FA</td>
</tr>
<tr>
<td>es_PA</td>
<td>Spanish</td>
<td>Panama</td>
<td>ISO8859-1</td>
<td>EP</td>
</tr>
<tr>
<td>es_PE</td>
<td>Spanish</td>
<td>Peru</td>
<td>ISO8859-1</td>
<td>EW</td>
</tr>
<tr>
<td>es_PR</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>ISO8859-1</td>
<td>EX</td>
</tr>
<tr>
<td>es_PY</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>ISO8859-1</td>
<td>EY</td>
</tr>
<tr>
<td>es_SV</td>
<td>Spanish</td>
<td>El Salvador</td>
<td>ISO8859-1</td>
<td>EV</td>
</tr>
<tr>
<td>es_US</td>
<td>Spanish</td>
<td>United States</td>
<td>ISO8859-1</td>
<td>ET</td>
</tr>
<tr>
<td>es_UY</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>ISO8859-1</td>
<td>FD</td>
</tr>
<tr>
<td>es_VE</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>ISO8859-1</td>
<td>EF</td>
</tr>
<tr>
<td>fi_FI</td>
<td>Finnish</td>
<td>Finland</td>
<td>ISO8859-1</td>
<td>FI</td>
</tr>
<tr>
<td>fr_BE</td>
<td>French</td>
<td>Belgium</td>
<td>ISO8859-1</td>
<td>FB</td>
</tr>
<tr>
<td>fr_CA</td>
<td>French</td>
<td>Canada</td>
<td>ISO8859-1</td>
<td>FC</td>
</tr>
<tr>
<td>fr_CH</td>
<td>French</td>
<td>Switzerland</td>
<td>ISO8859-1</td>
<td>FS</td>
</tr>
<tr>
<td>fr_FR</td>
<td>French</td>
<td>France</td>
<td>ISO8859-1</td>
<td>FF</td>
</tr>
<tr>
<td>he_IL</td>
<td>Hebrew</td>
<td>Israel</td>
<td>ISO8859-8</td>
<td>IL</td>
</tr>
<tr>
<td>hr_HR</td>
<td>Croatian</td>
<td>Croatia</td>
<td>ISO8859-2</td>
<td>HR</td>
</tr>
<tr>
<td>hu_HU</td>
<td>Hungarian</td>
<td>Hungary</td>
<td>ISO8859-2</td>
<td>HU</td>
</tr>
<tr>
<td>it_CH</td>
<td>Italian</td>
<td>Switzerland</td>
<td>ISO8859-1</td>
<td>IC</td>
</tr>
<tr>
<td>it_IT</td>
<td>Italian</td>
<td>Italy</td>
<td>ISO8859-1</td>
<td>IT</td>
</tr>
<tr>
<td>iw_IL</td>
<td>Hebrew</td>
<td>Israel</td>
<td>ISO8859-8</td>
<td>IL</td>
</tr>
<tr>
<td>ja_JP</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-943</td>
<td>JA</td>
</tr>
<tr>
<td>nl_NL</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>ISO8859-1</td>
<td>NN</td>
</tr>
<tr>
<td>no_NO</td>
<td>Norwegian</td>
<td>Norway</td>
<td>ISO8859-1</td>
<td>NO</td>
</tr>
<tr>
<td>pl_PL</td>
<td>Polish</td>
<td>Poland</td>
<td>ISO8859-2</td>
<td>PL</td>
</tr>
</tbody>
</table>
Table 75. Supported Language-Territory Names and LT Codes for ASCII Locales (continued)

<table>
<thead>
<tr>
<th>Locale Name⁹</th>
<th>Language</th>
<th>Country/Territory</th>
<th>ASCII Codeset</th>
<th>2-Byte LT Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>pt_BR</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>ISO8859-1</td>
<td>BR</td>
</tr>
<tr>
<td>pt_PT</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>ISO8859-1</td>
<td>PT</td>
</tr>
<tr>
<td>ro_RO</td>
<td>Romanian</td>
<td>Romania</td>
<td>ISO8859-2</td>
<td>RO</td>
</tr>
<tr>
<td>ru_RU</td>
<td>Russian</td>
<td>Russia</td>
<td>ISO8859-5</td>
<td>RU</td>
</tr>
<tr>
<td>sk_SK</td>
<td>Slovak</td>
<td>Slovakia</td>
<td>ISO8859-2</td>
<td>SK</td>
</tr>
<tr>
<td>sl_SI</td>
<td>Slovene</td>
<td>Slovenia</td>
<td>ISO8859-2</td>
<td>SI</td>
</tr>
<tr>
<td>sv_SE</td>
<td>Swedish</td>
<td>Sweden</td>
<td>ISO8859-1</td>
<td>SV</td>
</tr>
<tr>
<td>th_TH</td>
<td>Thai</td>
<td>Thailand</td>
<td>TIS-620</td>
<td>TH</td>
</tr>
<tr>
<td>tr_TR</td>
<td>Turkish</td>
<td>Turkey</td>
<td>ISO8859-9</td>
<td>TR</td>
</tr>
<tr>
<td>zh_CN</td>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>IBM-eucCN</td>
<td>ZC</td>
</tr>
<tr>
<td>zh_HKS</td>
<td>Simplified Chinese</td>
<td>China (Hong Kong S.A.R. of China)</td>
<td>UTF-8</td>
<td>ZG</td>
</tr>
<tr>
<td>zh_HKT</td>
<td>Traditional Chinese</td>
<td>China (Hong Kong S.A.R. of China)</td>
<td>UTF-8</td>
<td>ZU</td>
</tr>
<tr>
<td>zh_SGS</td>
<td>Simplified Chinese</td>
<td>Singapore</td>
<td>UTF-8</td>
<td>ZS</td>
</tr>
<tr>
<td>zh_TW</td>
<td>Simplified Chinese</td>
<td>Taiwan</td>
<td>BIG5</td>
<td>ZT</td>
</tr>
</tbody>
</table>

The mapping between Codeset and the two-letter CC code is defined in the CC conversion table EDCUCSNM. This table is built with assembler macros as follows:

```
EDCUCSNM TITLE 'CODE SET NAME CONVERSION TABLE'
EDCUCSNM CSECT
EDCCSNAM TYPE=ENTRY, CODESET='IBM-037', CODE='EA'
EDCCSNAM TYPE=ENTRY, CODESET='IBM-273', CODE='EB'
EDCCSNAM TYPE=ENTRY, CODESET='IBM-274', CODE='EC'
EDCCSNAM TYPE=ENTRY, CODESET='IBM-277', CODE='ED'
EDCCSNAM TYPE=ENTRY, CODESET='IBM-278', CODE='EE'
```

CODESET specifies the name Codeset; CODE specifies the respective CC code.

You can customize this table by adding new CODESET names. The alphabetic codes in the first byte of each CC name are reserved by IBM for future use, but you can use codes starting with numeric values for your own customized names.

---

⁹ ASCII locale names can also be coded <uppercase><lowercase>_<uppercase><uppercase>. For example, both en_US and En_US are valid ASCII locale names.
The following Codeset names and their mappings into CC codes are provided:

<table>
<thead>
<tr>
<th>Codesets</th>
<th>Primary Country or Territory</th>
<th>2-Byte CC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big5</td>
<td>Taiwan</td>
<td>BT</td>
</tr>
<tr>
<td>IBM-037</td>
<td>USA, Canada, Brazil</td>
<td>EA</td>
</tr>
<tr>
<td>IBM-273</td>
<td>Germany, Austria</td>
<td>EB</td>
</tr>
<tr>
<td>IBM-274</td>
<td>Belgium</td>
<td>EC</td>
</tr>
<tr>
<td>IBM-277</td>
<td>Denmark, Norway</td>
<td>EE</td>
</tr>
<tr>
<td>IBM-278</td>
<td>Finland, Sweden</td>
<td>EF</td>
</tr>
<tr>
<td>IBM-280</td>
<td>Italy</td>
<td>EG</td>
</tr>
<tr>
<td>IBM-282</td>
<td>Portugal</td>
<td>EI</td>
</tr>
<tr>
<td>IBM-284</td>
<td>Spain, Latin America</td>
<td>EJ</td>
</tr>
<tr>
<td>IBM-285</td>
<td>United Kingdom</td>
<td>EK</td>
</tr>
<tr>
<td>IBM-290</td>
<td>Japan (Katakana)</td>
<td>EL</td>
</tr>
<tr>
<td>IBM-297</td>
<td>France</td>
<td>EM</td>
</tr>
<tr>
<td>IBM-300</td>
<td>Japanese DBCS</td>
<td>EN</td>
</tr>
<tr>
<td>IBM-420</td>
<td>Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, U.A.E., Yemen</td>
<td>FF</td>
</tr>
<tr>
<td>IBM-424</td>
<td>Israel</td>
<td>FB</td>
</tr>
<tr>
<td>IBM-425</td>
<td>Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, U.A.E., Yemen</td>
<td>AR</td>
</tr>
<tr>
<td>IBM-500</td>
<td>International</td>
<td>EO</td>
</tr>
<tr>
<td>IBM-838</td>
<td>Thailand</td>
<td>EP</td>
</tr>
<tr>
<td>IBM-848</td>
<td>Ukraine with Euro(Cyrillic)</td>
<td>AS</td>
</tr>
<tr>
<td>IBM-870</td>
<td>Croatia, Czech Republic, Hungary, Poland, Romania, Serbia(Latin), Slovakia, Slovenia</td>
<td>EQ</td>
</tr>
<tr>
<td>IBM-871</td>
<td>Iceland</td>
<td>ER</td>
</tr>
<tr>
<td>IBM-875</td>
<td>Greece</td>
<td>ES</td>
</tr>
<tr>
<td>IBM-880</td>
<td>Cyrillic</td>
<td>ET</td>
</tr>
<tr>
<td>IBM-924</td>
<td>Latin 9/Open Systems</td>
<td>DL</td>
</tr>
<tr>
<td>IBM-930</td>
<td>Japan Katakana Extended (combined with DBCS)</td>
<td>EU</td>
</tr>
<tr>
<td>IBM-933</td>
<td>Korea</td>
<td>GZ</td>
</tr>
<tr>
<td>IBM-935</td>
<td>China(PRC)</td>
<td>GY</td>
</tr>
<tr>
<td>IBM-937</td>
<td>Taiwan</td>
<td>GW</td>
</tr>
<tr>
<td>IBM-943</td>
<td>Japan</td>
<td>JA</td>
</tr>
<tr>
<td>IBM-943</td>
<td>China(PRC)</td>
<td>No</td>
</tr>
<tr>
<td>Codesets</td>
<td>Primary Country or Territory</td>
<td>2-Byte CC code</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>IBM-1025</td>
<td>Bulgaria, Macedonia, Russia, Serbia (Cyrillic)</td>
<td>FE</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>Turkey</td>
<td>EW</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>Japan (Latin) Extended</td>
<td>EX</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>Latin 1/Open Systems</td>
<td>EY</td>
</tr>
<tr>
<td>IBM-1112</td>
<td>Lithuania</td>
<td>GD</td>
</tr>
<tr>
<td>IBM-1122</td>
<td>Estonia</td>
<td>FD</td>
</tr>
<tr>
<td>IBM-1123</td>
<td>Ukraine (Cyrillic)</td>
<td>FH</td>
</tr>
<tr>
<td>IBM-1125</td>
<td>Ukraine (Cyrillic)</td>
<td>AT</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>USA, Canada, Brazil</td>
<td>HA</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>Austria, Germany</td>
<td>HB</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>Denmark, Norway</td>
<td>HE</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>Finland, Sweden</td>
<td>HF</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>Italy</td>
<td>HG</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>Spain, Latin America</td>
<td>HJ</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>United Kingdom</td>
<td>HK</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>France</td>
<td>HM</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>International</td>
<td>HO</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>Iceland</td>
<td>HR</td>
</tr>
<tr>
<td>IBM-1158</td>
<td>Ukraine with Euro (Cyrillic)</td>
<td>FI</td>
</tr>
<tr>
<td>IBM-1165</td>
<td>Latin 2/Open Systems</td>
<td>FG</td>
</tr>
<tr>
<td>IBM-1364</td>
<td>Korea</td>
<td>KZ</td>
</tr>
<tr>
<td>IBM-1371</td>
<td>Taiwan</td>
<td>ZT</td>
</tr>
<tr>
<td>IBM-1388</td>
<td>China (PRC)</td>
<td>GV</td>
</tr>
<tr>
<td>IBM-1390</td>
<td>Japan</td>
<td>HU</td>
</tr>
<tr>
<td>IBM-1399</td>
<td>Japan</td>
<td>HV</td>
</tr>
<tr>
<td>IBM-4971</td>
<td>Greece</td>
<td>HS</td>
</tr>
<tr>
<td>IBMEUCCN</td>
<td>China (PRC)</td>
<td>BY</td>
</tr>
<tr>
<td>IBMEUCKR</td>
<td>Korea</td>
<td>BZ</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>All Latin 1 Countries</td>
<td>I1</td>
</tr>
<tr>
<td>ISO8859-2</td>
<td>Croatia, Czech Republic, Hungary, Poland, Romania, Serbia (Latin), Slovakia, Slovenia</td>
<td>I2</td>
</tr>
<tr>
<td>ISO8859-5</td>
<td>Bulgaria, Macedonia, Russia, Serbia (Cyrillic)</td>
<td>I5</td>
</tr>
<tr>
<td>ISO8859-7</td>
<td>Greece</td>
<td>I7</td>
</tr>
<tr>
<td>ISO8859-8</td>
<td>Israel</td>
<td>I8</td>
</tr>
<tr>
<td>ISO8859-9</td>
<td>Turkey</td>
<td>I9</td>
</tr>
<tr>
<td>TIS–620</td>
<td>Thailand</td>
<td>BU</td>
</tr>
<tr>
<td>UTF-8</td>
<td>All Countries</td>
<td>F8</td>
</tr>
</tbody>
</table>
The exceptions to the rule above are the following special locale names, which are already recognized:

- C (EBCDIC and ASCII)
- POSIX (EBCDIC and ASCII)
- SAA (EBCDIC only)
- S370 (EBCDIC only)

The special names C, POSIX, SAA, and S370 always refer to the built-in locales, which cannot be modified.

- GERM (EBCDIC only)
- FRAN (EBCDIC only)
- UK (EBCDIC only)
- ITAL (EBCDIC only)
- SPAI (EBCDIC only)
- USA (EBCDIC only)

These names are for locales in the old format, created with assembler macros rather than with the localedef utility.

You can use the following macros, defined in the locale.h header file, as synonyms for the special locale names above. These macros can only be used for EBCDIC locales. The <prefix> in the Compiled locale column is EDC for non-XPLINK locales and CEH for XPLINK locales.

<table>
<thead>
<tr>
<th>Macro</th>
<th>Locale</th>
<th>Compiled locale</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC_C</td>
<td>C</td>
<td>Not applicable</td>
</tr>
<tr>
<td>LC_POSIX</td>
<td>POSIX</td>
<td>Not applicable</td>
</tr>
<tr>
<td>LC_C_GERMANY</td>
<td>&quot;GERM&quot;</td>
<td>&lt;prefix&gt;$GERM</td>
</tr>
<tr>
<td>LC_C_FRANCE</td>
<td>&quot;FRAN&quot;</td>
<td>&lt;prefix&gt;$FRAN</td>
</tr>
<tr>
<td>LC_C_UK</td>
<td>&quot;UK&quot;</td>
<td>&lt;prefix&gt;$UK</td>
</tr>
<tr>
<td>LC_C_ITALY</td>
<td>&quot;ITAL&quot;</td>
<td>&lt;prefix&gt;$ITAL</td>
</tr>
<tr>
<td>LC_C_SPAIN</td>
<td>&quot;SPAI&quot;</td>
<td>&lt;prefix&gt;$SPAI</td>
</tr>
<tr>
<td>LC_C_USA</td>
<td>&quot;USA&quot;</td>
<td>&lt;prefix&gt;$USA</td>
</tr>
</tbody>
</table>

The predefined name for the built-in locale in the old format is S370.

The rest of the special names refer to the EBCDIC locale objects whose names are built by prepending the letters EDC$ for non-XPLINK locales or CEH$ for XPLINK locales to the special name, as for EDC$FRAN.
Chapter 48. Customizing a Locale

This chapter describes how you can create your own locales, based on the locale definition files supplied by IBM. See Appendix D, “Locales Supplied with z/OS C/C++” on page 815 for more information on the compiled locales and locale source files. The information in this chapter applies to the format of locales based on the localedef utility.

In this example you will build a locale named TEXAN using the charmap file representing the IBM-1047 encoded character set. The locale is derived from the locale representing the English language and the cultural conventions of the United States. We will assume that both non-XPLINK and XPLINK applications will use the TEXAN locale. Both non-XPLINK and XPLINK versions of the TEXAN locale will be generated.

1. See “Locale Source Files” on page 828 to determine the source of the locale you are going to use. In this case, it is the English language in the United States locale, the source for which is the member EDC$EUEY of the PDS CEE.SCEELOCX.

2. Copy the member EDC$EUEY from PDS CEE.SCEELOCX to the data set hlq.LOCALE.SOURCE which has been pre-allocated with the same attributes as CEE.SCEELOCX.

3. In your new file, change the locale variables to the desired values. For example, change
   
   d_t_fmt "%a %b %e %H:%M:%S %Z %Y"

   to
   
   d_t_fmt "Howdy Pardner %a %b %e %H:%M:%S %Z %Y"

4. This locale’s <Language>-<Territory> value is TEXAN. The <Codeset> value is IBM-1047. TEXAN is not a valid PDS resident locale name in the run-time library, because it does not appear in the run-time Locale Name Table. You must modify the table to include the TEXAN locale. Here are the steps to follow.

   a. Copy the member EDC$LCNM from PDS CEE.SCEEASAMP to the data set hlq.LOCALE.TABLE which has been pre-allocated with the same attributes as CEE.SCEEASAMP. The z/OS C/C++ Library uses this table to map locale code registry prefixes into two-character codes.
   
   b. For this example, insert a new line into the assembler table before the last EDCLOCNM TYPE=END entry:

   EDCLOCNM TYPE=ENTRY,LOCALE='TEXAN',CODESET='IBM-1047',CODE='1T'

5. Now that your locale name table has been modified, you must make it available to the system. Assemble the EDC$LCNM member and link-edit it into the hlq.LOCALE.LOADLIB load library with the member name EDC$LCNM. For our example, this is done as follows:

   //HLASM EXEC PGM=ASMA90
   //SYSPRINT DD SYSOUT=*  
   //SYSLIB DD DSN=SYS1.MACLIB,DISP=SHR
   // DD DSN=CEE.SCEEMAC,DISP=SHR
   //SYSLIB1 DD DSN=VIO,DISP=(NEW,DELETE),SPACE=(32000,(30,30))
   //SYSLIB2 DD DSN=VIO,DISP=(NEW,DELETE),SPACE=(32000,(30,30))
   //SYSLIB3 DD DSN=VIO,DISP=(NEW,DELETE),SPACE=(32000,(30,30))
   //SYSPUNCH DD DUMMY
   //SYSLIB1 DD DSN=<hlq>.LOCALE.OBJECT(EDC$LCNM),DISP=SHR
   //SYSLIB1 DD DSN=<hlq>.LOCALE.TABLE(EDC$LCNM),DISP=SHR

© Copyright IBM Corp. 1996, 2002
6. Generate the non-XPLINK and XPLINK locale objects into a load library. Note that XPLINK locale objects must be placed in a PDSE, while non-XPLINK locale objects may be in either a PDS or PDSE load library.

a. Determine the correct locale object names, using the locale naming Conventions outlined in "Locale Naming Conventions" on page 712. PDS resident locale object names are of the form <prefix><LT><CC>. For this non-XPLINK locale the <prefix> is EDC$, the <LT> code for TEXAN is 1T and the <CC> code for IBM-1047 is EY. The non-XPLINK object name is therefore EDC$1TEY.

For this XPLINK locale the <prefix> is CEH$. The <LT> and <CC> codes remain the same. The XPLINK object name is therefore CEH$1TEY.

b. Use localedef to generate the locale objects.

• For non-XPLINK:

```
//GENLOCNX EXEC PROC=EDCLDEF,
  // INFILE='hlq.LOCALE.SOURCE(TEXAN)',
  // OUTFILE='hlq.LOCALE.LOADLIB(EDC$1TEY),DISP=SHR',
  // LOPT='CHARMAP(IBM-1047)'
```

• For XPLINK:

```
//GENLOCX EXEC PROC=EDCXLDEF,
  // INFILE='hlq.LOCALE.SOURCE(TEXAN)',
  // OUTFILE='hlq.LOCALE.PDSE.LOADLIB(CEH$1TEY),DISP=SHR',
  // LOPT='CHARMAP(IBM-1047)'
```

See z/OS C/C++ User's Guide for detailed information about the syntax of the localedef utility.

Note: The TEXAN locale uses one of the IBM supplied CHARMAPs. If you need to customize a CHARMAP, then you must define its two-letter <CC> code in the Codeset Name table EDCUCSNM. This is similar to defining the locale TEXAN in EDC$LCNM. The two-letter CHARMAP codes beginning with a number are reserved for customer use. This is the same as the convention for customer-supplied Locale Name <LT> codes in the Locale Name table. The <CC> portion of your locale object names would then change to be the new <CC> value you added to the Codeset Name table.

Using the Customized Locale

Your locale objects must be made available to your program before they can be used. For PDS and PDSE resident locales, your load library must be included in your program search order. For HFS resident locales, do one of the following:

• Copy your locales into the system default locale object directory /usr/lib/nls/locale.

• Update your LOCPATH environment variable to include the directory containing your locales.

For example, assume that the CCNGCL1 program has been compiled with XPLINK into an HFS executable called getlocname. Further assume that you have generated non-XPLINK and XPLINK HFS resident versions of the TEXAN locale into your current directory. The following commands make TEXAN available to non-XPLINK and XPLINK applications:
If \texttt{getlocname} was compiled non-XPLINK then the output would look like the following:

\begin{verbatim}
$ getlocname
Default NULL locale = C
Default "" locale = /u/marcw/TEXAN.IBM-1047
$ 
\end{verbatim}

The customized locale is now ready to be used in these ways:

- Explicitly referenced by name in z/OS C/C++ application code that uses \texttt{setlocale()} calls referring to the locale descriptive name (recommended) such as:
  \begin{verbatim}
  setlocale(LC_ALL, "TEXAN.IBM-1047");
  \end{verbatim}
  or by a short internal name (not recommended) such as:
  \begin{verbatim}
  setlocale(LC_ALL, "ITEY");
  \end{verbatim}

- Explicitly referenced in the z/OS C/C++ initialization exit, using customized setup code in CEEBINT.

- Implicitly specified in each user environment with environment variables.

\textbf{Note:} You cannot customize the built-in locales, C, POSIX, SAA, or S370. The locale source files \texttt{EDC$POSX} and \texttt{EDC$SAA} are provided for reference only.

\section*{Referring Explicitly to a Customized Locale}

Here is a non-XPLINK program with an explicit reference to the TEXAN locale.
/* this example shows how to get the local time formatted by the */
/* current locale */

#include <stdio.h>
#include <time.h>
#include <locale.h>

int main(void)
{
    char dest[80];
    int ch;
    time_t temp;
    struct tm *timeptr;
    temp = time(NULL);
    timeptr = localtime(&temp);
    /* Fetch default locale name */
    printf("Default empty_str locale is %s\n",setlocale(LC_ALL,""));
    ch = strftime(dest,sizeof(dest)-1,
                 "Local C datetime is %c", timeptr);
    printf("%s\n", dest);
    /* Set new Texan locale name */
    printf("New locale is %s\n", setlocale(LC_ALL,"Texan.IBM-1047"));
    ch = strftime(dest,sizeof(dest)-1,
                 "Texan datetime is %c ", timeptr);
    printf("%s\n", dest);

    return(0);
}

Figure 217. Referring Explicitly to a Customized Locale

Compile the above program. Before you execute it, ensure the load library
containing the non-XPLINK version of the TEXAN locale and updated table is
available. If you compile your program XPLINK, ensure the load library containing
the XPLINK version of the TEXAN locale and updated Locale Name table is
available.

The output should be similar to:
Default locale is S370
Local C datetime is Fri Aug 20 14:58:12 1993
New locale is TEXAN
Texan datetime is Howdy Pardner Fri Aug 20 14:58:12 1993

Note that if the second operand to setlocale() had been NULL, rather than ",", the
default locale name returned would have been C.

setlocale(LC_ALL,"") returns "S370"
setlocale(LC_ALL,NULL) returns "C"

Note: For setlocale(LC_ALL,""), "S370" is returned unless the locale-related
environment variables are set. See Chapter 50, "Definition of S370 C, SAA
C, and POSIX C Locales" on page 731 for more information about the
definition of the S370 locale.
Referring Implicitly to a Customized Locale

An installation may require that a global mechanism should be used for all C programs. The exit CEEBINT may be used for this purpose. Users can insert a setlocale() call inside the routines referencing the locale required. Here is an example:

CCNGCL2

/* this example refers implicitly to a customized locale */

#ifdef __cplusplus
extern "C"{
#else
#pragma linkage(CEEBINT,OS)
#endif

void CEEBINT(int, int, int, int, void**, int, void**);
#pragma map(CEEBINT,"CEEBINT")

#endif

#include <locale.h>
#include <stdio.h>

int main(void){
    printf("Default NULL locale = %s\n", setlocale(LC_ALL,NULL));
    printf("Default "\ locale = %s\n", setlocale(LC_ALL,""));
}

void CEEBINT(int number, int retcode, int rsncode, int fnccode, void **a_main, int userwd, void **a_exits){ /* user code goes here */
    printf("CEEBINT entry. number = %i\n", number);
    printf("Locale = %s\n", setlocale(LC_ALL,"Texan.IBM-1047"));
}

Figure 218. Referring Implicitly to a Customized Locale

If the above example is compiled and executed with the TEXAN locale, the results are as follows:

CEEBINT entry. number = 7
Locale = TEXAN.IBM-1047
Default NULL locale = TEXAN.IBM-1047
Default "" locale = S370

The exit CEEBINT may provide a uniform way of restricting the use of customized locales across an installation. To do this, a system programmer can compile CEEBINT separately, and link it with the application program that will use it. The disadvantage to this approach is that CEEBINT must be link-edited into each user module explicitly. See Chapter 36, “Using Run-Time User Exits” on page 549 for more information about user exits.
If you run this program above as is without calling `setenv()`, you can expect the following result:

```
Default NULL locale = C
Default "" locale = S370
```

On the other hand, if you issue the above `setenv()` call after `main()` but before the first `printf()` statement, the `LC_ALL` variable will be set to "TEXAN.IBM-1047" and you can expect this result instead:

```
Default NULL locale = C
Default "" locale = TEXAN.IBM-1047
```

In the example above, the default NULL locale returns C because the value of `LC_ALL` does not affect the current locale until the next `setlocale(LC_ALL,"")` is done. When this call is made, the `LC_ALL` environment variable will be used and the locale will be set to `TEXAN.IBM-1047`.

For more information about setting environment variables, see Chapter 33, “Using Environment Variables” on page 479.

The names of the environment variables match the names of the locale categories:

- `LC_ALL`
- `LC_COLLATE`
- `LC_CTYPE`
- `LC_MONETARY`
- `LC_NUMERIC`
- `LC_TIME`
- `LC_TOD`
- `LC_SYNTAX`

See `z/OS C/C++ Run-Time Library Reference` for information about `setlocale()`.

Customizing Your Installation: When z/OS C/C++ initializes its environment, it uses the C locale as its default locale. The only values that may be customized when z/OS Language Environment is installed are those associated with the `LC_TOD` category. Details on this customization are provided in `z/OS Language Environment Customization`.

---

```c
/* this example can be used with setenv() to specify the name of a */
/* locale *=/

#include <locale.h>
#include <stdio.h>

int main(void){
    printf("Default NULL locale = %s\n", setlocale(LC_ALL,NULL));
    printf("Default "" locale = %s\n", setlocale(LC_ALL,""));

    return(0);
}
```

---

Figure 219. Using Environment Variables to Select a Locale
Chapter 49. Customizing a Time Zone

You can customize time zone information using the following:

- LC_TOD category of a locale
  You can customize the LC_TOD category in a locale to a particular time zone. The LC_TOD category binds each C/C++ locale to one time zone. For more information on customizing the LC_TOD category, see “LC_TOD Category” on page 704 and Chapter 48, “Customizing a Locale” on page 723.

- TZ or _TZ environment variable
  In a distributed environment, you might have users in several time zones. You can use the TZ or _TZ environment variable to set each time zone. The user of your application can use the ENVAR run-time option with the TZ or _TZ environment variable to select the appropriate time zone.
  For POSIX(ON) programs the TZ environment variable is used. For POSIX(OFF) programs the _TZ environment variable is used. If neither TZ nor _TZ are defined, time zone information is obtained from the LC_TOD category of the current locale.

Using the TZ or _TZ Environment Variable to Specify Time Zone

The C/C++ run-time library assumes times returned by the operating system are stored using Greenwich Mean Time (GMT) or Universal Time Coordinated (UTC). This time is referred to as the universal reference time. You can use the TZ or _TZ environment variable to specify information at run time. The C/C++ run-time library uses this information to map universal reference times to local times.

The format of the TZ or _TZ environment variable is:

```
TZ=standardHH[:MM[:SS]]
[daylight[HH[:MM[:SS:]]]
[,startdate[/starttime],enddate[/endtime]]]
```

The value of the TZ or _TZ environment variable has the following five fields (two required and three optional):

- **standard**
  An alphabetic abbreviation for the local standard time zone (for example, GMT, EST, MSEZ).

- **HH[:MM[:SS]]**
  The time offset westward from the universal reference time. A leading minus sign (-) means that the local time zone is east of the universal reference time. An offset of this form must follow standard and can also optionally follow daylight. An optional colon (:) separates hours from optional minutes and seconds.
  If daylight is specified without a daylight offset, daylight savings time is assumed to be one hour ahead of the standard time.

- **[daylight]**
  The abbreviation for your local daylight savings time zone. If the first and third fields are identical, or if the third field is missing, daylight savings time conversion is disabled. The number of hours, minutes, and seconds your local daylight savings time is offset from UTC when daylight savings time is in effect. If the daylight savings time abbreviation is specified and the offset omitted, the offset of one hour is assumed.
A rule that identifies the start and end of daylight savings time, specifying when daylight savings time should be in effect. Both the *startdate* and *enddate* must be present and must either take the form Jn, n, or Mm.n.d where:

- Jn is the Julian day \( n \) \((1 \leq n \leq 365)\) and does not account for leap days.
- n is the zero-based Julian day \((0 \leq n \leq 365)\). Leap days are counted; therefore, you can refer to February 29th.
- For Mm.n.d, \((0 \leq n \leq 6)\) of week \( n \) of month \( m \) of the year \((1 \leq n \leq 5, 1 \leq m \leq 12)\) where week 5 is the last \( d \) day in month \( m \), which may occur in either the fourth or fifth week. Week 1 is the first week in which the \( d \) day occurs, and day zero is Sunday.

Neither *starttime* nor *endtime* are required, and when omitted, their values default to 02:00:00. If this daylight savings time rule is omitted altogether, the values in the rule default to the standard American daylight savings time rules starting at 02:00:00 the first Sunday in April and ending at 02:00:00 the last Sunday in October.

**Relationship Between TZ or _TZ and LC_TOD**

The C/C++ run-time library uses time zone information specified by the TZ or _TZ environment variable to convert universal reference times to local times. When neither the TZ nor _TZ variable are defined, the C/C++ run-time library uses time zone information specified by the LC_TOD category of the current locale to map universal reference times to local times. If LC_TOD in the current locale has not been customized, the C/C++ run-time library uses the time zone of the system on which C/C++ is installed. See Chapter 48, “Customizing a Locale” on page 723 for information about customizing LC_TOD.

**Note:** The time zone external variables, tzname, timezone, and daylight, declarations remain feature test protected in time.h. Definition of these external variables are only known to the C/C++ run-time library if the z/OS UNIX System Services C/C++ signature CSECT is link edited with your C/C++ application.
Chapter 50. Definition of S370 C, SAA C, and POSIX C Locales

The default C locales for POSIX SAA, and S370 are pre-built into the run-time library. The SAA C locale provides compatibility with previous releases of C/370. The POSIX C locale provides consistency with POSIX requirements and supports the z/OS UNIX environment.

The POSIX definition of the C locale is described below, with the IBM extensions LC_SYNTAX and LC_TOD showing their default values.

The SAA and S370 definitions of the C locale are different from the POSIX definition; consistency with previous releases of z/OS C/C++ is provided for migration compatibility. The differences are described in "Differences between SAA C and POSIX C Locales" on page 737.

The relationship between the POSIX C and SAA C locales is as follows. If you are running with the run-time option POSIX(OFF):

1. The SAA C locale definition is the default. "C", "SAA", and "S370" are synonyms for the SAA C locale definition, which is prebuilt into the library.

   The source file EDC$SAAC LOCALE is provided for reference, but cannot be used to alter the definition of this prebuilt locale.

2. Issuing setlocale(category, ") has the following effect:
   - Locale-related environment variables are checked to find the name of locales to use to set the category specified. Querying the locale with setlocale(category, NULL) returns the name of the locales specified by the appropriate environment variables.
   - If no non-null environment variable is present, then it is the equivalent of having issued setlocale(category, "S370"). That is, the locale chosen is the SAA C locale definition, and querying the locale with setlocale(category, NULL) returns "S370" as the locale name.

3. If no setlocale() function is issued, or setlocale(LC_ALL, "C"), then the locale chosen is the pre-built SAA C locale, and querying the locale with setlocale(category, NULL) returns "C" as the locale name.

4. For setlocale(LC_ALL, "SAA"), the locale chosen is the pre-built SAA C locale, and querying the locale with setlocale(category, NULL) returns "SAA" as the locale name.

5. For setlocale(LC_ALL, "S370"), the locale chosen is the pre-built SAA C locale, and querying the locale with setlocale(category, NULL) returns "S370" as the locale name.

6. For setlocale(LC_ALL, "POSIX"), the locale chosen is the pre-built POSIX C locale, and querying the locale with setlocale(category, NULL) returns "POSIX" as the locale name.

If you are running with the run-time option POSIX(ON):

1. The POSIX C locale definition is the default. "C" and "POSIX" are synonyms for the POSIX C locale definition, which is prebuilt into the library.

   The source file EDC$POSX LOCALE is provided for reference, but cannot be used to alter the definition of this prebuilt locale.

2. Issuing setlocale(category, ") has the following effect:
Locale-related environment variables are checked to find the name of locales that can set the category specified. Querying the locale with `setlocale(category, NULL)` returns the name of the locale specified by the appropriate environment variables.

- If no non-null environment variable is present, then the result is equivalent to having issued `setlocale(category, "C")`. That is, the locale chosen is the POSIX C locale definition, and querying the locale with `setlocale(category, NULL)` returns "C" as the locale name.

3. If no `setlocale()` function is issued, or if `setlocale(LC_ALL, "C")` is used, then the locale chosen is the pre-built POSIX C locale. Querying the locale with `setlocale(category, NULL)` returns "C" as the locale name.

4. For `setlocale(LC_ALL, "POSIX")`, the locale chosen is the pre-built POSIX C locale, and querying the locale with `setlocale(category, NULL)` returns "POSIX" as the locale name.

5. For `setlocale(LC_ALL, "SAA")`, the locale chosen is the pre-built SAA C locale. Querying the locale with `setlocale(category, NULL)` returns "SAA" as the locale name.

6. For `setlocale(LC_ALL, "S370")`, the locale chosen is the pre-built SAA C locale. Querying the locale with `setlocale(category, NULL)` returns "S370" as the locale name.

The `setlocale()` function supports locales built using the localedef utility, as well as locales built using the assembler source and produced by the EDCLOC macro.

The `LC_TOD` category for the SAA C and POSIX C locales can be customized during installation of the library by your system programmer. See "Customizing Your Installation" on page 728 for more information. The supplied default will obtain the time zone difference from the operating system. However, it will not define the daylight savings time.

The `LC_SYNTAX` category for the SAA C and POSIX C locales is set to the IBM-1047 definition of the variant characters.

The other locale categories for the POSIX C locale are as follows.

```
escape_char /
comment_char %

LC_CTYPE

% "alpha" is by default "upper" and "lower"
% "alnum" is by definition "alpha" and "digit"
% "print" is by default "alnum", "punct" and <space> character
% "punct" is by default "alnum" and "punct"

upper <A>;<B>;<C>;<D>;<E>;<F>;<G>;<H>;<I>;<J>;<K>;<L>;<M>;/<N>;<O>;<P>;<Q>;<R>;<S>;<T>;<U>;<V>;<W>;<X>;<Y>;<Z>
lower <a>;<b>;<c>;<d>;<e>;<f>;<g>;<h>;<i>;<j>;<k>;<l>;<m>;/<n>;<o>;<p>;<q>;<r>;<s>;<t>;<u>;<v>;<w>;<x>;<y>;<z>
digit <zero>;<one>;<two>;<three>;<four>;/<five>;<six>;<seven>;<eight>;<nine>
space <tab>;<newline>;<vertical-tab>;<form-feed>;/<carriage-return>;<space>
```
Chapter 50. Definition of S370 C, SAA C, and POSIX C Locales

END LC_CTYPE

LC_COLLATE

order_start

% ASCII Control characters

<NUL>

<SOH>

<STX>

<ETX>

<ENQ>

<EOT>

<ACK>

<SYN>

<ETB>

<alert>

<backspace>

<tab>

<newline>

<form-feed>

<carriage-return>

<S0>

<S1>

<DLE>

<DC1>

<DC2>

<DC3>

<DC4>

<NAK>

<SYM>

<ETB>

<punct>

<exclamation-mark>

<quotation-mark>

<number-sign>

<dollar-sign>

<percent-sign>

<ampersand>

<apostrophe>

<left-parenthesis>

<right-parenthesis>

<asterisk>

<plus-sign>

<comma>

<hyphen>

<period>

<slash>

<colon>

<semicolon>

<less-than-sign>

<equals-sign>

<greater-than-sign>

<question-mark>

<commercial-at>

<left-square-bracket>

<backslash>

<right-square-bracket>

<circumflex>

<underscore>

<grave-accent>

<left-curly-bracket>

<vertical-line>

<right-curly-bracket>

<tilde>

<xdigit>

<zero>

<one>

<two>

<three>

<four>

<five>

<six>

<seven>

<eight>

<nine>

<A>

<B>

<C>

<D>

<E>

<F>

<G>

<H>

<I>

<J>

<K>

<L>

<M>

<N>

<O>

<P>

<Q>

<R>

<S>

<T>

<U>

<V>

<W>

<X>

<Y>

<Z>

<blank>

<space>

<tab>

<toupper>

(a, A);

(b, B);

(c, C);

(d, D);

(e, E);

(f, F);

(g, G);

(h, H);

(i, I);

(j, J);

(k, K);

(l, L);

(m, M);

(n, N);

(o, O);

(p, P);

(q, Q);

(r, R);

(s, S);

(t, T);

(u, U);

(v, V);

(w, W);

(x, X);

(y, Y);

(z, Z);

<tolower>

(A, a);

(B, b);

(C, c);

(D, d);

(E, e);

(F, f);

(G, g);

(H, h);

(I, i);

(J, j);

(K, k);

(L, l);

(M, m);

(N, n);

(O, o);

(P, p);

(Q, q);

(R, r);

(S, s);

(T, t);

(U, u);

(V, v);

(W, w);

(X, x);

(Y, y);

(Z, z)

END LC_CTYPE

%%%%%%

LC_COLLATE

%%%%%%
<CAN>
<EM>
<SUB>
<ESC>
<IS4>
<IS3>
<IS2>
<IS1>
<space>
<exclamation-mark>
<quotation-mark>
<number-sign>
<dollar-sign>
<percent-sign>
<ampersand>
<apostrophe>
<left-parenthesis>
<right-parenthesis>
<asterisk>
<plus-sign>
<comma>
<hyphen>
<period>
<slash>
<zero>
<one>
<two>
<three>
<four>
<five>
<six>
<seven>
<eight>
<nine>
<colon>
<semicolon>
<less-than-sign>
<equals-sign>
<greater-than-sign>
<question-mark>
<commercial-at>
<A>
<B>
<C>
<D>
<E>
<F>
<G>
<H>
<I>
<J>
<K>
<L>
<M>
<N>
<O>
<P>
<Q>
<R>
<S>
<T>
<U>
<V>
<W>
<X>
<Y>
<Z>
Chapter 50. Definition of S370 C, SAA C, and POSIX C Locales

END LC_COLLATE

LC_MONETARY

int_curr_symbol ""
currency_symbol ""
mon_decimal_point ""
mon_thousands_sep ""
mon_grouping ""
positive_sign ""
negative_sign ""
int_frac_digits -1
frac_digits -1
p_cs_precedes -1
p_sep_by_space -1
n_cs_precedes -1
n_sep_by_space -1
p_sign_posn -1
n_sign_posn -1

END LC_MONETARY

LC_NUMERIC

decimal_point "<period>"
thousands_sep ""
grouping ""

END LC_NUMERIC

LC_TIME

abday "<S><u><n>";
"<m><o><n>";
"<t><u><e>";
"<w><e><d>";
"<t><h><u>";
"<f><r><y>";
"<s><a><t>"

day "<s><u><n><d><a><y>";
"<m><o><n><d><a><y>";
"<t><u><e><s><d><a><y>";
"<w><e><d><n><e><s><d><a><y>";
"<t><h><u><r><s><d><a><y>";
"<f><r><i><d><a><y>";
"<s><a><t><u><r><d><a><y>"

abmon "<j><a><n>";
"<f><e><b>";
"<m><a><r>";
"<a><p><r>";
"<m><a><y>";
"<j><u><n>";
"<j><u><l>";
"<a><u><g>";
"<s><e><p>";
"<o><c><t>";
"<n><o><v>";
"<d><e><c>"

mon "<j><a><n><u><a><r><y>";
"<f><e><b><r><u><a><r><y>";
"<m><a><r><c><h>";
"<a><p><r><i><l>";
"<m><a><y>";
"<j><u><n><e>";
"<j><u><l><y>";
"<a><u><g><u><s><t>";
"<s><e><p><t><e><m><b><e><r>";
"<o><c><t><o><b><e><r>";
"<n><o><v><e><m><b><e><r>";
"<d><e><c><e><m><b><e><r>""

% equivalent of AM/PM (%p)

am_pm "<a><m>";
"<p><m>"

% appropriate date and time representation (%c) "%a %b %e %H:%M:%S %Y"
d_t_fmt "<percent-sign><a><space><percent-sign><b><space><percent-sign><e><space><percent-sign><h><colon><percent-sign><m><colon><percent-sign><s><space><percent-sign><y>

d_f_fmt "<percent-sign><m><slash><percent-sign><d><slash><percent-sign><y>"

t_f_fmt "<percent-sign><h><colon><percent-sign><m><colon><percent-sign><s>"

t_f_fmt_ampm "<percent-sign><I><colon><percent-sign><M><colon><percent-sign><S>"
Differences between SAA C and POSIX C Locales

In fact, there are three built-in locales, S370 C, SAA C, and POSIX C. The default locale at your site depends on the system that is running the application. Issuing `setlocale(LC_ALL,"")` sets the default, based on the current environment. Issuing `setlocale(LC_ALL,"SAA")` sets the SAA C locale, even when you are running with the POSIX(ON) run-time option. Likewise, `setlocale(LC_ALL,"POSIX")` sets the POSIX locale.

If you are running in a C locale, one way you can determine whether the SAA C or the POSIX locale is in effect is to check whether the cent sign (¢ at X'4A') is defined as a punctuation character. Under the default POSIX support, the cent sign is not part of the POSIX portable character set. The following code illustrates how to perform this test:

```c
/* this example shows how to determine whether the SAA C or POSIX */
/* locale is in effect */

#include <stdio.h>
#include <ctype.h>

int main(void)
{
    if (ispunct(0x4A)) {
        printf(" cent sign is punct\n");
        printf(" current locale is SAA- or S370-like\n");
    }
    else {
        printf(" cent sign is not punct\n");
        printf(" default locale is POSIX-like\n");
    }
    return(0);
}
```

Figure 220. Determining Which Locale is in Effect

the uppercase letters, whereas under the POSIX definition, the lowercase letters collate after the uppercase letters. The locale "" is the same locale as the one obtained from `setlocale(LC_ALL,"")`. For more detail on these special environment variables, see Chapter 33, "Using Environment Variables" on page 479.

Other differences between the SAA C locale and the POSIX C locale are as follows:

- `<mb_cur_max>` The SAA C locale is built using coded character set IBM-1047, with `<mb_cur_max>` as 1.
  The POSIX C locale is built using coded character set IBM-1047, with `<mb_cur_max>` as 4.
The cent sign

In the default POSIX support, the cent sign (¢) is not part of the POSIX portable character set, but in the SAA locale it is defined as a punctuation character.

Collation weight by case

In the POSIX definition, the lowercase letters collate after the uppercase letters, whereas in the SAA or System/370 default locales, the lowercase letters collate before the uppercase letters.

LC_CTYPE category

The SAA C locale has all the EBCDIC control characters defined in the 'cntrl' class. The POSIX C locale has only the ASCII control characters in the 'cntrl' class.

The SAA C locale includes ¢ (the cent character) and \ (the broken vertical line) as 'punct' characters. The POSIX C locale does not group these characters as 'punct' characters.

LC_COLLATE category

The default collation for the SAA C locale is the EBCDIC sequence. The POSIX C locale uses the ASCII collation sequence; the first 128 ASCII characters are defined in the collation sequence, and the remaining EBCDIC characters are at the end of the collating sequence.

LC_TIME category

The SAA C locale uses the date and time format (d_t_fmt) as "%Y/%M/%D %X", whereas the POSIX C locale uses "%a %b %d %H/%M/%S %Y".

The SAA C locale uses the strings "am" and "pm", whereas the POSIX C locale uses "AM" and "PM".
Chapter 51. Code Set Conversion Utilities

This chapter describes the code set conversion utilities supported by the z/OS C/C++ compiler. These utilities are as follows:

**genxlt utility**
Generates a translation table for use by the `iconv` utility and `iconv()` functions.

**iconv utility**
Converts a file from one code set encoding to another.

**iconv() functions**
Perform code set translation. These functions are `iconv_open()`, `iconv()`, and `iconv_close()`. They are used by the `iconv` utility and may be called from any z/OS C/C++ program requiring code set translation.

See [z/OS C/C++ User’s Guide](#) for descriptions of the genxlt and iconv utilities, and [z/OS C/C++ Run-Time Library Reference](#) for descriptions of the `iconv()` functions.

The genxlt Utility

The genxlt utility reads a source translation file from `InputFile`, writes the compiled version to `OutputFile`, and then generates the translation load module. The source translation file provides the conversion specification from `fromCodeSet` to `toCodeSet`.

The source translation file contains directives that are acted upon by the genxlt utility to produce the compiled version of the translation table.

The name of the conversion programs have the following naming conventions:

- The name starts with a four letter prefix. For non-XPLINK converters, the prefix is EDCU. For XPLINK converters, the prefix is CEHU.
- The prefix is followed by the two-letter `CC` code that corresponds to the `CodesetRegistry.CodesetEncoding` name of the `fromCodeSet` defined in the Table 76 on page 719.
- The first `CC` code is followed by the two-letter `CC` code than corresponds to the `CodesetRegistry.CodesetEncoding` name of the `toCodeSet` defined in the Table 76 on page 719.

To generate your own conversions, you must modify the codeset name table EDCUCSNM with the macros described in "Locale Naming Conventions" on page 712. For descriptions of the genxlt and iconv utilities, refer to [z/OS C/C++ User’s Guide](#).

The iconv Utility

The iconv utility reads characters from the input file, converts them from `fromCodeSet` encoding to `toCodeSet` encoding, and writes them to the output file.

The conversion is performed by the code conversion functions of the run-time library. They are described in "Code Conversion Functions" on page 740. The tables used are determined by the `CC` codes of the `fromCodeSet` and `toCodeSet` appended to the four-character prefix. The prefix is EDCU for non-XPLINK converters, and CEHU for XPLINK converters. See [z/OS C/C++ User’s Guide](#) for descriptions of the genxlt and iconv utilities. For a description of iconv as a shell command refer to [z/OS UNIX System Services Command Reference](#).
The iconv utility can also perform bidirectional layout transformation (such as shaping and reordering) while converting from fromCodeSet to toCodeSet according to the value of an environment variable called _BIDION. The value of this variable is either set to TRUE to activate the BiDi layout transformation or FALSE to prevent the bidirectional layout transformation. If this variable is not defined in the environment it defaults to FALSE. The _BIDIATTR environment variable can be used to contain the bidirectional attributes (for information on bidirectional layout transformation see Chapter 53, “Bidirectional Language Support” on page 791) which will determine the way the bidirectional transformation takes place. These two environment variables are described in Chapter 33, “Using Environment Variables” on page 479.

---

**Code Conversion Functions**

The iconv_open(), iconv(), and iconv_close() library functions can be called from C or C++ source to initialize and perform the characters conversions from one character set encoding to another.

---

**Code Set Converters Supplied**

There is a set of code set converters that are provided in the National Language Resources component of z/OS Language Environment. Consult your system programmer to see whether this component has been installed on your system.

The converters are as follows:

- **Round Trip Conversions (RTC)** or Customized
- **Round Trip Conversions (C-RTC)**, which means round trip with exceptions.

Conversions:
- Latin-1 EBCDIC to/from Latin-1 EBCDIC: RTC
- Non-Latin-1 EBCDIC to/from Latin-1 EBCDIC: RTC
- Latin-1 ASCII to/from Latin-1 EBCDIC: C-RTC
- Non_latin-1 ASCII to/from Latin-1 EBCDIC: C-RTC

Example of Customized Round Trip Conversions (C-RTC) is IBM-850 to/from IBM-1047 conversion.

**Customized Round Trip Conversion**

<table>
<thead>
<tr>
<th>Code Point</th>
<th>Code Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>0A</td>
<td>15</td>
</tr>
<tr>
<td>DA</td>
<td>3F</td>
</tr>
<tr>
<td>0A</td>
<td>25</td>
</tr>
</tbody>
</table>

The code set converters provided as programs are shown in Table 77 on page 741. The GENXLT source for the code set converters are shipped in the CEE.SCEEGXLT data set.

**Notes:**

1. The <prefix> in the Program Name column is EDCU for non-XPLINK converters and CEHU for XPLINK converters.
2. Specify IBM-932C or IBM-eucJC as the iconv_open() source or target code set name to set up for conversion of POSIX data encoded by IBM-932 or IBM-eucJP to or from a host code set encoding of the data such as IBM-930 or IBM-939.

Examples of POSIX data are C/C++ source and shell scripts. The data includes characters from the POSIX character set. The names IBM-932C and IBM-eucJC
indicate that the `<yen>` and `<overline>` characters in POSIX data encoded by IBM-932 or IBM-eucJP map to the `<backslash>` and `<tilde>` characters, respectively, when the data is converted to or from host encodings.

### Table 77. Coded Character Set Conversion Tables

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-037</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EAEO</td>
</tr>
<tr>
<td>IBM-037</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EAAA</td>
</tr>
<tr>
<td>IBM-037</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EAEZ</td>
</tr>
<tr>
<td>IBM-037</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EAEY</td>
</tr>
<tr>
<td>IBM-037</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EA11</td>
</tr>
<tr>
<td>IBM-037</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EAU2</td>
</tr>
<tr>
<td>IBM-037</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EAF8</td>
</tr>
<tr>
<td>IBM-273</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EBEO</td>
</tr>
<tr>
<td>IBM-273</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EBAA</td>
</tr>
<tr>
<td>IBM-273</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EBEZ</td>
</tr>
<tr>
<td>IBM-273</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EBEY</td>
</tr>
<tr>
<td>IBM-273</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EBI1</td>
</tr>
<tr>
<td>IBM-273</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EBU2</td>
</tr>
<tr>
<td>IBM-273</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EBF8</td>
</tr>
<tr>
<td>IBM-274</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;ECEO</td>
</tr>
<tr>
<td>IBM-274</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;ECEY</td>
</tr>
<tr>
<td>IBM-274</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;ECHO</td>
</tr>
<tr>
<td>IBM-274</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;ECI1</td>
</tr>
<tr>
<td>IBM-274</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ECU2</td>
</tr>
<tr>
<td>IBM-274</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ECF8</td>
</tr>
<tr>
<td>IBM-275</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EDEO</td>
</tr>
<tr>
<td>IBM-275</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EDEY</td>
</tr>
<tr>
<td>IBM-275</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;EDHO</td>
</tr>
<tr>
<td>IBM-275</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EDI1</td>
</tr>
<tr>
<td>IBM-275</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EDU2</td>
</tr>
<tr>
<td>IBM-275</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EDF8</td>
</tr>
<tr>
<td>IBM-277</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EEEEO</td>
</tr>
<tr>
<td>IBM-277</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EEAA</td>
</tr>
<tr>
<td>IBM-277</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EEYE</td>
</tr>
<tr>
<td>IBM-277</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EEI1</td>
</tr>
<tr>
<td>IBM-277</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EEU2</td>
</tr>
<tr>
<td>IBM-277</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EEF8</td>
</tr>
<tr>
<td>IBM-278</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EFE0</td>
</tr>
<tr>
<td>IBM-278</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EFAA</td>
</tr>
<tr>
<td>IBM-278</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EFEE</td>
</tr>
<tr>
<td>IBM-278</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EFEY</td>
</tr>
<tr>
<td>IBM-278</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EFI1</td>
</tr>
</tbody>
</table>
Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-278</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EFU2</td>
</tr>
<tr>
<td>IBM-278</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EFF8</td>
</tr>
<tr>
<td>IBM-280</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EGEO</td>
</tr>
<tr>
<td>IBM-280</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EGAA</td>
</tr>
<tr>
<td>IBM-280</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EGEZ</td>
</tr>
<tr>
<td>IBM-280</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EGEY</td>
</tr>
<tr>
<td>IBM-280</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EGI1</td>
</tr>
<tr>
<td>IBM-280</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EGU2</td>
</tr>
<tr>
<td>IBM-280</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EGF8</td>
</tr>
<tr>
<td>IBM-281</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EHEO</td>
</tr>
<tr>
<td>IBM-281</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EHEY</td>
</tr>
<tr>
<td>IBM-281</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;EHHO</td>
</tr>
<tr>
<td>IBM-281</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EHI1</td>
</tr>
<tr>
<td>IBM-282</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EIEO</td>
</tr>
<tr>
<td>IBM-282</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EIEY</td>
</tr>
<tr>
<td>IBM-282</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;EHO</td>
</tr>
<tr>
<td>IBM-282</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EII1</td>
</tr>
<tr>
<td>IBM-282</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EJU2</td>
</tr>
<tr>
<td>IBM-282</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EJF8</td>
</tr>
<tr>
<td>IBM-284</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EJEO</td>
</tr>
<tr>
<td>IBM-284</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EJAA</td>
</tr>
<tr>
<td>IBM-284</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EJEZ</td>
</tr>
<tr>
<td>IBM-284</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EJI1</td>
</tr>
<tr>
<td>IBM-284</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EJU2</td>
</tr>
<tr>
<td>IBM-284</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EJF8</td>
</tr>
<tr>
<td>IBM-285</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EKEO</td>
</tr>
<tr>
<td>IBM-285</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EKAA</td>
</tr>
<tr>
<td>IBM-285</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EKEZ</td>
</tr>
<tr>
<td>IBM-285</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EKEY</td>
</tr>
<tr>
<td>IBM-285</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELI1</td>
</tr>
<tr>
<td>IBM-285</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EKU2</td>
</tr>
<tr>
<td>IBM-285</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ELF8</td>
</tr>
<tr>
<td>IBM-290</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELEO</td>
</tr>
<tr>
<td>IBM-290</td>
<td>IBM-932</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELAB</td>
</tr>
<tr>
<td>IBM-290</td>
<td>IBM-932C</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELAG</td>
</tr>
<tr>
<td>IBM-290</td>
<td>IBM-1027</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELEX</td>
</tr>
<tr>
<td>IBM-290</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELEY</td>
</tr>
<tr>
<td>IBM-290</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELHO</td>
</tr>
<tr>
<td>IBM-290</td>
<td>IBM-eucJC</td>
<td>No</td>
<td>&lt;prefix&gt;ELAH</td>
</tr>
</tbody>
</table>
Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-290</td>
<td>IBM-eucJP</td>
<td>No</td>
<td>&lt;prefix&gt;ELAC</td>
</tr>
<tr>
<td>IBM-290</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;ELI1</td>
</tr>
<tr>
<td>IBM-290</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ELU2</td>
</tr>
<tr>
<td>IBM-290</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ELF8</td>
</tr>
<tr>
<td>IBM-297</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EMEO</td>
</tr>
<tr>
<td>IBM-297</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EMAA</td>
</tr>
<tr>
<td>IBM-297</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EMEZ</td>
</tr>
<tr>
<td>IBM-297</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EMEY</td>
</tr>
<tr>
<td>IBM-297</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EMI1</td>
</tr>
<tr>
<td>IBM-297</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EMU2</td>
</tr>
<tr>
<td>IBM-297</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EMF8</td>
</tr>
<tr>
<td>IBM-300</td>
<td>IBM-eucJP</td>
<td>No</td>
<td>&lt;prefix&gt;ENAC</td>
</tr>
<tr>
<td>IBM-300</td>
<td>IBM-eucJC</td>
<td>No</td>
<td>&lt;prefix&gt;ENAH</td>
</tr>
<tr>
<td>IBM-300</td>
<td>IBM-932</td>
<td>No</td>
<td>&lt;prefix&gt;ENAB</td>
</tr>
<tr>
<td>IBM-300</td>
<td>IBM-932C</td>
<td>No</td>
<td>&lt;prefix&gt;ENAG</td>
</tr>
<tr>
<td>IBM-300</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ENU2</td>
</tr>
<tr>
<td>IBM-300</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ENF8</td>
</tr>
<tr>
<td>IBM-420</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;FFU2</td>
</tr>
<tr>
<td>IBM-420</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;FFF8</td>
</tr>
<tr>
<td>IBM-424</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;FBU2</td>
</tr>
<tr>
<td>IBM-424</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;FBF8</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-037</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEA</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-273</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEB</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-274</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEC</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-275</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOED</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-277</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEE</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-278</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOFB</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-280</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOF8</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-281</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEA</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-282</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEB</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-284</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEC</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-285</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOED</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-290</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEE</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-297</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOFB</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEA</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-871</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEB</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEC</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1027</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOED</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEE</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1140</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOEA</td>
</tr>
</tbody>
</table>
Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-500</td>
<td>IBM-1141</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHB</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1142</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHE</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1143</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHF</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1144</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHG</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1145</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHJ</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1146</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHK</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1147</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHM</td>
</tr>
<tr>
<td>IBM-500</td>
<td>IBM-1149</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOHR</td>
</tr>
<tr>
<td>IBM-500</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EOI1</td>
</tr>
<tr>
<td>IBM-500</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EOU2</td>
</tr>
<tr>
<td>IBM-500</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GPF8</td>
</tr>
<tr>
<td>IBM-808</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GQF8</td>
</tr>
<tr>
<td>IBM-808</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GLU2</td>
</tr>
<tr>
<td>IBM-813</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GMU2</td>
</tr>
<tr>
<td>IBM-813</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GLF8</td>
</tr>
<tr>
<td>IBM-819</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GEOF</td>
</tr>
<tr>
<td>IBM-819</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GQEO</td>
</tr>
<tr>
<td>IBM-833</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;GPEY</td>
</tr>
<tr>
<td>IBM-833</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GPEY</td>
</tr>
<tr>
<td>IBM-833</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GPU2</td>
</tr>
<tr>
<td>IBM-834</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GPFR</td>
</tr>
<tr>
<td>IBM-834</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GUI2</td>
</tr>
<tr>
<td>IBM-835</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GGUI</td>
</tr>
<tr>
<td>IBM-835</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GGUI</td>
</tr>
<tr>
<td>IBM-836</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;GLEY</td>
</tr>
<tr>
<td>IBM-836</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GUI2</td>
</tr>
<tr>
<td>IBM-836</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GLF8</td>
</tr>
<tr>
<td>IBM-837</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GEOF</td>
</tr>
<tr>
<td>IBM-837</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GQEO</td>
</tr>
<tr>
<td>IBM-838</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GPEY</td>
</tr>
<tr>
<td>IBM-838</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GPEY</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-037</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-273</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-277</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-278</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-280</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-284</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-285</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-297</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAB</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-871</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAER</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAEY</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1140</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHA</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1141</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHB</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1142</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHE</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1143</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHF</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1144</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHG</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1145</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHJ</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1146</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHK</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1147</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHM</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHO</td>
</tr>
<tr>
<td>IBM-850</td>
<td>IBM-1149</td>
<td>Yes</td>
<td>&lt;prefix&gt;AAHR</td>
</tr>
<tr>
<td>IBM-850</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;AAU2</td>
</tr>
<tr>
<td>IBM-850</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;AAF8</td>
</tr>
<tr>
<td>IBM-852</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CBU2</td>
</tr>
<tr>
<td>IBM-852</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CBF8</td>
</tr>
<tr>
<td>IBM-855</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CEU2</td>
</tr>
<tr>
<td>IBM-855</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CEF8</td>
</tr>
<tr>
<td>IBM-856</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CHU2</td>
</tr>
<tr>
<td>IBM-856</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CHF8</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIYEY</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1140</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHA</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1141</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHB</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1142</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHE</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1143</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHF</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1144</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHG</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1145</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHJ</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1146</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHK</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1147</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHM</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHO</td>
</tr>
<tr>
<td>IBM-858</td>
<td>IBM-1149</td>
<td>Yes</td>
<td>&lt;prefix&gt;AIHR</td>
</tr>
<tr>
<td>IBM-858</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;AIU2</td>
</tr>
<tr>
<td>IBM-858</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;AIF8</td>
</tr>
<tr>
<td>IBM-861</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CAU2</td>
</tr>
<tr>
<td>IBM-861</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CAF8</td>
</tr>
<tr>
<td>IBM-862</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;BHU2</td>
</tr>
<tr>
<td>IBM-862</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;BHF8</td>
</tr>
<tr>
<td>IBM-864</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CFU2</td>
</tr>
<tr>
<td>IBM-864</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CFF8</td>
</tr>
<tr>
<td>IBM-866</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;BEU2</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-866</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;BETF8</td>
</tr>
<tr>
<td>IBM-867</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;LJU2</td>
</tr>
<tr>
<td>IBM-869</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CGU2</td>
</tr>
<tr>
<td>IBM-869</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CGF8</td>
</tr>
<tr>
<td>IBM-870</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EQU2</td>
</tr>
<tr>
<td>IBM-870</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EQUF8</td>
</tr>
<tr>
<td>IBM-871</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EREEO</td>
</tr>
<tr>
<td>IBM-871</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;ERAA</td>
</tr>
<tr>
<td>IBM-871</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EREY</td>
</tr>
<tr>
<td>IBM-871</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;ERI1</td>
</tr>
<tr>
<td>IBM-871</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ERU2</td>
</tr>
<tr>
<td>IBM-872</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;LEU2</td>
</tr>
<tr>
<td>IBM-872</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;LEF8</td>
</tr>
<tr>
<td>IBM-874</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;BUU2</td>
</tr>
<tr>
<td>IBM-874</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;BUF8</td>
</tr>
<tr>
<td>IBM-875</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;ESEY</td>
</tr>
<tr>
<td>IBM-875</td>
<td>ISO8859-7</td>
<td>Yes</td>
<td>&lt;prefix&gt;ESI7</td>
</tr>
<tr>
<td>IBM-875</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ESU2</td>
</tr>
<tr>
<td>IBM-875</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ESF8</td>
</tr>
<tr>
<td>IBM-880</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ETU2</td>
</tr>
<tr>
<td>IBM-880</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ETF8</td>
</tr>
<tr>
<td>IBM-901</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;LHUE2</td>
</tr>
<tr>
<td>IBM-901</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;LHF8</td>
</tr>
<tr>
<td>IBM-902</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;LDU2</td>
</tr>
<tr>
<td>IBM-902</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;LDF8</td>
</tr>
<tr>
<td>IBM-904</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CNU2</td>
</tr>
<tr>
<td>IBM-904</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CNF8</td>
</tr>
<tr>
<td>IBM-912</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;L2U2</td>
</tr>
<tr>
<td>IBM-912</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;L2F8</td>
</tr>
<tr>
<td>IBM-914</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;L4U2</td>
</tr>
<tr>
<td>IBM-914</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;L4F8</td>
</tr>
<tr>
<td>IBM-915</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;L5U2</td>
</tr>
<tr>
<td>IBM-915</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;L5F8</td>
</tr>
<tr>
<td>IBM-916</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;L8U2</td>
</tr>
<tr>
<td>IBM-916</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;L8F8</td>
</tr>
<tr>
<td>IBM-920</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;L9U2</td>
</tr>
<tr>
<td>IBM-920</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;L9F8</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-921</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;BDU2</td>
</tr>
<tr>
<td>IBM-921</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;BDF8</td>
</tr>
<tr>
<td>IBM-922</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ADU2</td>
</tr>
<tr>
<td>IBM-922</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ADF8</td>
</tr>
<tr>
<td>IBM-923</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;IFEZ</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-037</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEA</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-273</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEB</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-278</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEF</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-280</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEG</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-284</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEJ</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-285</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEK</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-297</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEM</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEO</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-871</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZER</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-923</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZIF</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZEY</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1140</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHA</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1141</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHB</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1142</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHE</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1143</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHF</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1144</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHG</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1145</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHI</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1146</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHK</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1147</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHM</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHO</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-1149</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHR</td>
</tr>
<tr>
<td>IBM-924</td>
<td>IBM-4971</td>
<td>Yes</td>
<td>&lt;prefix&gt;EZHS</td>
</tr>
<tr>
<td>IBM-927</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;COU2</td>
</tr>
<tr>
<td>IBM-927</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;COF8</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-932</td>
<td>No</td>
<td>&lt;prefix&gt;EUAB</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-932C</td>
<td>No</td>
<td>&lt;prefix&gt;EUAG</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-956</td>
<td>No</td>
<td>&lt;prefix&gt;EUJB</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-957</td>
<td>No</td>
<td>&lt;prefix&gt;EUJC</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-958</td>
<td>No</td>
<td>&lt;prefix&gt;EUJD</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-959</td>
<td>No</td>
<td>&lt;prefix&gt;EUJE</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EUJY</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-2022-JP</td>
<td>No</td>
<td>&lt;prefix&gt;EUJA</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-5052</td>
<td>No</td>
<td>&lt;prefix&gt;EUJF</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-5053</td>
<td>No</td>
<td>&lt;prefix&gt;EUJG</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-5054</td>
<td>No</td>
<td>&lt;prefix&gt;EUJH</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-5055</td>
<td>No</td>
<td>&lt;prefix&gt;EUJI</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-eucJP</td>
<td>No</td>
<td>&lt;prefix&gt;EUAC</td>
</tr>
<tr>
<td>IBM-930</td>
<td>IBM-eucJC</td>
<td>No</td>
<td>&lt;prefix&gt;EUAH</td>
</tr>
<tr>
<td>IBM-930</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EUU2</td>
</tr>
<tr>
<td>IBM-930</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EUF8</td>
</tr>
<tr>
<td>IBM-932</td>
<td>IBM-290</td>
<td>Yes</td>
<td>&lt;prefix&gt;ABEL</td>
</tr>
<tr>
<td>IBM-932</td>
<td>IBM-300</td>
<td>No</td>
<td>&lt;prefix&gt;ABEN</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>IBM-300</td>
<td>No</td>
<td>&lt;prefix&gt;AGEN</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;ABEU</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;ABEV</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;AGEV</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>IBM-290</td>
<td>Yes</td>
<td>&lt;prefix&gt;AGEL</td>
</tr>
<tr>
<td>IBM-932</td>
<td>IBM-1027</td>
<td>Yes</td>
<td>&lt;prefix&gt;ABEX</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>IBM-1027</td>
<td>Yes</td>
<td>&lt;prefix&gt;AGEX</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;AGEY</td>
</tr>
<tr>
<td>IBM-933</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;GZEY</td>
</tr>
<tr>
<td>IBM-933</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;GZI1</td>
</tr>
<tr>
<td>IBM-933</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GZU2</td>
</tr>
<tr>
<td>IBM-933</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GZF8</td>
</tr>
<tr>
<td>IBM-935</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;GYEY</td>
</tr>
<tr>
<td>IBM-935</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GYU2</td>
</tr>
<tr>
<td>IBM-935</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GYF8</td>
</tr>
<tr>
<td>IBM-937</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;GWEY</td>
</tr>
<tr>
<td>IBM-937</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GWU2</td>
</tr>
<tr>
<td>IBM-937</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GWF8</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-932</td>
<td>No</td>
<td>&lt;prefix&gt;EVAB</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-932C</td>
<td>Yes</td>
<td>&lt;prefix&gt;EVAG</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-956</td>
<td>No</td>
<td>&lt;prefix&gt;EVJB</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-957</td>
<td>No</td>
<td>&lt;prefix&gt;EVJC</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-958</td>
<td>No</td>
<td>&lt;prefix&gt;EVJD</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-959</td>
<td>No</td>
<td>&lt;prefix&gt;EVJE</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EVEY</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-2022-JP</td>
<td>No</td>
<td>&lt;prefix&gt;EVJA</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-5052</td>
<td>No</td>
<td>&lt;prefix&gt;EVJF</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-5053</td>
<td>No</td>
<td>&lt;prefix&gt;EVJG</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-5054</td>
<td>No</td>
<td>&lt;prefix&gt;EVJH</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-5055</td>
<td>No</td>
<td>&lt;prefix&gt;EVJL</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-eucJP</td>
<td>No</td>
<td>&lt;prefix&gt;EVAC</td>
</tr>
<tr>
<td>IBM-939</td>
<td>IBM-eucJC</td>
<td>No</td>
<td>&lt;prefix&gt;EVAH</td>
</tr>
</tbody>
</table>
Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-939</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EVU2</td>
</tr>
<tr>
<td>IBM-939</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EVF8</td>
</tr>
<tr>
<td>IBM-942</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ABU2</td>
</tr>
<tr>
<td>IBM-942</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ABF8</td>
</tr>
<tr>
<td>IBM-943</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;AJU2</td>
</tr>
<tr>
<td>IBM-943</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;AJF8</td>
</tr>
<tr>
<td>IBM-946</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DYU2</td>
</tr>
<tr>
<td>IBM-946</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DYF8</td>
</tr>
<tr>
<td>IBM-948</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CWU2</td>
</tr>
<tr>
<td>IBM-948</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CWF8</td>
</tr>
<tr>
<td>IBM-949</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CZU2</td>
</tr>
<tr>
<td>IBM-949</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CZF8</td>
</tr>
<tr>
<td>IBM-950</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DWU2</td>
</tr>
<tr>
<td>IBM-950</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DWF8</td>
</tr>
<tr>
<td>IBM-951</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CQU2</td>
</tr>
<tr>
<td>IBM-951</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CQF8</td>
</tr>
<tr>
<td>IBM-956</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JBEU</td>
</tr>
<tr>
<td>IBM-956</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JBEV</td>
</tr>
<tr>
<td>IBM-957</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JCEU</td>
</tr>
<tr>
<td>IBM-957</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JCEV</td>
</tr>
<tr>
<td>IBM-958</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JDEU</td>
</tr>
<tr>
<td>IBM-958</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JDEV</td>
</tr>
<tr>
<td>IBM-959</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JEEEU</td>
</tr>
<tr>
<td>IBM-959</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JEEV</td>
</tr>
<tr>
<td>IBM-964</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;BWU2</td>
</tr>
<tr>
<td>IBM-964</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;BWF8</td>
</tr>
<tr>
<td>IBM-970</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;BZU2</td>
</tr>
<tr>
<td>IBM-970</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;BZF8</td>
</tr>
<tr>
<td>IBM-1025</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;FEU2</td>
</tr>
<tr>
<td>IBM-1025</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;FEF8</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EWEY</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>IBM-1254</td>
<td>Yes</td>
<td>&lt;prefix&gt;EWDI</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>ISO8859-9</td>
<td>Yes</td>
<td>&lt;prefix&gt;EWI9</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EWU2</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EWF8</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-290</td>
<td>Yes</td>
<td>&lt;prefix&gt;EXEL</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EXEO</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-932</td>
<td>Yes</td>
<td>&lt;prefix&gt;EXAB</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-932C</td>
<td>Yes</td>
<td>&lt;prefix&gt;EXAG</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;EXEY</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;EXHO</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-eucJC</td>
<td>No</td>
<td>&lt;prefix&gt;EXAH</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>IBM-eucJP</td>
<td>No</td>
<td>&lt;prefix&gt;EXAC</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EXI1</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EXU2</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EXF8</td>
</tr>
<tr>
<td>IBM-1046</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;AFU2</td>
</tr>
<tr>
<td>IBM-1046</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;AFF8</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-037</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEA</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-273</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEB</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-274</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEC</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-275</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYED</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-277</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEE</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-278</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEF</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-280</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEG</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-281</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEH</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-282</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEI</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-284</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEJ</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-285</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEK</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-290</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEL</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-297</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEM</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEO</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-833</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYGP</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-836</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYGL</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYAA</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYAI</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-871</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYER</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-875</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYES</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEZ</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-930</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEU</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-933</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYGZ</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-935</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYGY</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-937</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYGW</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-939</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEV</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1026</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEW</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1027</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYEX</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1140</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHA</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1141</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHB</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1142</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHE</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1143</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHF</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1144</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHG</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1145</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHJ</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1146</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHK</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1147</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHM</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHO</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>IBM-1149</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYHR</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;EYI1</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;EYU2</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;EYF8</td>
</tr>
<tr>
<td>IBM-1088</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CPF8</td>
</tr>
<tr>
<td>IBM-1088</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GDF8</td>
</tr>
<tr>
<td>IBM-1112</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GDU2</td>
</tr>
<tr>
<td>IBM-1112</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CLU2</td>
</tr>
<tr>
<td>IBM-1115</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CLK8</td>
</tr>
<tr>
<td>IBM-1115</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;FDU2</td>
</tr>
<tr>
<td>IBM-1122</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;FDF8</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HAEO</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HAAA</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HAEZ</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HAYE</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HAI1</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HBU2</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HFEO</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HBAE</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HBAI</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HBEZ</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HBEY</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HBHO</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HBl1</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HBU2</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HBF8</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HEEO</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HEAA</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HEAI</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HEEZ</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HEEY</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HEHO</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HEI1</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HEU2</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HEF8</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HFE0</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HFAA</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HFEZ</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HFEY</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HFEY</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HFI0</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HFU2</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HFF8</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HGEO</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HGAA</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HGAI</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HGEZ</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HGEY</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HGEO</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HGIA</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HGU2</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HGF8</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HJEO</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HJAA</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HJAI</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HJEZ</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HJEO</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HJIA</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HJIA</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HJU2</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HJF8</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HKE0</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HKAA</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HKAI</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HKEZ</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HKEY</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HKH0</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HKII</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HKU2</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HKF8</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HMEO</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HMAA</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HMEZ</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HMEY</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HMHO</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HMI1</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HMU2</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HMF8</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-274</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOEC</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-275</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOED</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-281</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOEH</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-282</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOEI</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-290</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOEL</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOAA</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOAI</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOEZ</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1027</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOEX</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOEY</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1140</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHA</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1141</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHB</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1142</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHE</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1143</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHF</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1144</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHG</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1145</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHJ</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1146</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHK</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1147</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHM</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>IBM-1149</td>
<td>Yes</td>
<td>&lt;prefix&gt;HOHR</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HRI1</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HOU2</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HOF8</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>IBM-500</td>
<td>Yes</td>
<td>&lt;prefix&gt;HREO</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>IBM-850</td>
<td>Yes</td>
<td>&lt;prefix&gt;HRAA</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>IBM-858</td>
<td>Yes</td>
<td>&lt;prefix&gt;HRAI</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HREZ</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>&lt;prefix&gt;HREY</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;HRHO</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>ISO8859-1</td>
<td>Yes</td>
<td>&lt;prefix&gt;HRI1</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HRU2</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HRF8</td>
</tr>
<tr>
<td>IBM-1153</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;MBU2</td>
</tr>
<tr>
<td>IBM-1153</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;MBF8</td>
</tr>
<tr>
<td>IBM-1154</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HTU2</td>
</tr>
<tr>
<td>IBM-1154</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HTF8</td>
</tr>
<tr>
<td>IBM-1155</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HUWU2</td>
</tr>
<tr>
<td>IBM-1155</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HWF8</td>
</tr>
<tr>
<td>IBM-1156</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HUZU2</td>
</tr>
<tr>
<td>IBM-1156</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HZF8</td>
</tr>
<tr>
<td>IBM-1157</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HDU2</td>
</tr>
<tr>
<td>IBM-1157</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HDF8</td>
</tr>
<tr>
<td>IBM-1160</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HPF8</td>
</tr>
<tr>
<td>IBM-1160</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;LUU2</td>
</tr>
<tr>
<td>IBM-1161</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;LUF8</td>
</tr>
<tr>
<td>IBM-1250</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DBU2</td>
</tr>
<tr>
<td>IBM-1250</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DBF8</td>
</tr>
<tr>
<td>IBM-1251</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DEU2</td>
</tr>
<tr>
<td>IBM-1251</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DEF8</td>
</tr>
<tr>
<td>IBM-1252</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DAU2</td>
</tr>
<tr>
<td>IBM-1252</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DAF8</td>
</tr>
<tr>
<td>IBM-1253</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DGU2</td>
</tr>
<tr>
<td>IBM-1253</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DGF8</td>
</tr>
<tr>
<td>IBM-1254</td>
<td>IBM-1026</td>
<td>Yes</td>
<td>&lt;prefix&gt;DIEW</td>
</tr>
<tr>
<td>IBM-1254</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DIU2</td>
</tr>
<tr>
<td>IBM-1254</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DIF8</td>
</tr>
<tr>
<td>IBM-1255</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DHU2</td>
</tr>
<tr>
<td>IBM-1255</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DHF8</td>
</tr>
<tr>
<td>IBM-1256</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;DFU2</td>
</tr>
<tr>
<td>IBM-1256</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;DFF8</td>
</tr>
<tr>
<td>IBM12712</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HHU2</td>
</tr>
<tr>
<td>IBM12712</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HHF8</td>
</tr>
<tr>
<td>IBM-1363</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;LZU2</td>
</tr>
<tr>
<td>IBM-1363</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;LZF8</td>
</tr>
<tr>
<td>IBM-1364</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;KZU2</td>
</tr>
<tr>
<td>IBM-1364</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;KZF8</td>
</tr>
<tr>
<td>IBM-1380</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CMU2</td>
</tr>
<tr>
<td>IBM-1380</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CMF8</td>
</tr>
<tr>
<td>IBM-1381</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CYU2</td>
</tr>
</tbody>
</table>
Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-1381</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CYF8</td>
</tr>
<tr>
<td>IBM-1383</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;BYU2</td>
</tr>
<tr>
<td>IBM-1383</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;BYF8</td>
</tr>
<tr>
<td>IBM-1386</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;CVU2</td>
</tr>
<tr>
<td>IBM-1386</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;CVF8</td>
</tr>
<tr>
<td>IBM-1388</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;GVU2</td>
</tr>
<tr>
<td>IBM-1388</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;GVF8</td>
</tr>
<tr>
<td>IBM-1390</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HUU2</td>
</tr>
<tr>
<td>IBM-1390</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HUF8</td>
</tr>
<tr>
<td>IBM-1399</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HVU2</td>
</tr>
<tr>
<td>IBM-1399</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HVF8</td>
</tr>
<tr>
<td>IBM16804</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;HCU2</td>
</tr>
<tr>
<td>IBM16804</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;HCF8</td>
</tr>
<tr>
<td>IBM17248</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;NJU2</td>
</tr>
<tr>
<td>IBM17248</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;NJF8</td>
</tr>
<tr>
<td>IBM-2022-JP</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JAEU</td>
</tr>
<tr>
<td>IBM-2022-JP</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JAEV</td>
</tr>
<tr>
<td>IBM33722</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;ACU2</td>
</tr>
<tr>
<td>IBM33722</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;ACF8</td>
</tr>
<tr>
<td>IBM-4909</td>
<td>IBM-4971</td>
<td>Yes</td>
<td>&lt;prefix&gt;IAHS</td>
</tr>
<tr>
<td>IBM-4971</td>
<td>IBM-924</td>
<td>Yes</td>
<td>&lt;prefix&gt;HSEZ</td>
</tr>
<tr>
<td>IBM-4971</td>
<td>IBM-4909</td>
<td>Yes</td>
<td>&lt;prefix&gt;HSIA</td>
</tr>
<tr>
<td>IBM-5052</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JFEU</td>
</tr>
<tr>
<td>IBM-5052</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JFEV</td>
</tr>
<tr>
<td>IBM-5053</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JGEU</td>
</tr>
<tr>
<td>IBM-5053</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JGEV</td>
</tr>
<tr>
<td>IBM-5054</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JHEU</td>
</tr>
<tr>
<td>IBM-5054</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JHEV</td>
</tr>
<tr>
<td>IBM-5055</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;JIEU</td>
</tr>
<tr>
<td>IBM-5055</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;JIEV</td>
</tr>
<tr>
<td>IBM-5346</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;NBU2</td>
</tr>
<tr>
<td>IBM-5346</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;NBF8</td>
</tr>
<tr>
<td>IBM-5347</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;NEU2</td>
</tr>
<tr>
<td>IBM-5347</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;NEF8</td>
</tr>
<tr>
<td>IBM-5350</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;NIU2</td>
</tr>
<tr>
<td>IBM-5350</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;NIF8</td>
</tr>
<tr>
<td>IBM-5351</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;NHU2</td>
</tr>
<tr>
<td>IBM-5351</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;NHF8</td>
</tr>
<tr>
<td>IBM-5352</td>
<td>UCS-2</td>
<td>No</td>
<td>&lt;prefix&gt;NFU2</td>
</tr>
<tr>
<td>IBM-5352</td>
<td>UTF-8</td>
<td>No</td>
<td>&lt;prefix&gt;NFF8</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-9044</td>
<td>UCS-2</td>
<td>No</td>
<td>${prefix}NGU2</td>
</tr>
<tr>
<td>IBM-9044</td>
<td>UTF-8</td>
<td>No</td>
<td>${prefix}NGF8</td>
</tr>
<tr>
<td>IBM-9061</td>
<td>UCS-2</td>
<td>No</td>
<td>${prefix}LGU2</td>
</tr>
<tr>
<td>IBM-9061</td>
<td>UTF-8</td>
<td>No</td>
<td>${prefix}LGF8</td>
</tr>
<tr>
<td>IBM-9238</td>
<td>UCS-2</td>
<td>No</td>
<td>${prefix}LIU2</td>
</tr>
<tr>
<td>IBM-9238</td>
<td>UTF-8</td>
<td>No</td>
<td>${prefix}LIF8</td>
</tr>
<tr>
<td>IBM-eucJC</td>
<td>IBM-290</td>
<td>Yes</td>
<td>${prefix}AHEL</td>
</tr>
<tr>
<td>IBM-eucJC</td>
<td>IBM-1027</td>
<td>No</td>
<td>${prefix}AHEX</td>
</tr>
<tr>
<td>IBM-eucJP</td>
<td>IBM-290</td>
<td>No</td>
<td>${prefix}ACEL</td>
</tr>
<tr>
<td>IBM-eucJC</td>
<td>IBM-300</td>
<td>No</td>
<td>${prefix}ACEN</td>
</tr>
<tr>
<td>IBM-eucJP</td>
<td>IBM-300</td>
<td>No</td>
<td>${prefix}ACEN</td>
</tr>
<tr>
<td>IBM-eucJC</td>
<td>IBM-930</td>
<td>No</td>
<td>${prefix}ACEU</td>
</tr>
<tr>
<td>IBM-eucJP</td>
<td>IBM-939</td>
<td>No</td>
<td>${prefix}ACEV</td>
</tr>
<tr>
<td>IBM-eucJC</td>
<td>IBM-939</td>
<td>No</td>
<td>${prefix}AHEV</td>
</tr>
<tr>
<td>IBM-eucJP</td>
<td>IBM-1027</td>
<td>No</td>
<td>${prefix}ACEX</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-037</td>
<td>Yes</td>
<td>${prefix}I1EA</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-273</td>
<td>Yes</td>
<td>${prefix}I1EB</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-274</td>
<td>Yes</td>
<td>${prefix}I1EC</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-275</td>
<td>Yes</td>
<td>${prefix}I1ED</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-277</td>
<td>Yes</td>
<td>${prefix}I1EE</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-278</td>
<td>Yes</td>
<td>${prefix}I1EF</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-280</td>
<td>Yes</td>
<td>${prefix}I1EG</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-281</td>
<td>Yes</td>
<td>${prefix}I1EH</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-282</td>
<td>Yes</td>
<td>${prefix}I1EI</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-284</td>
<td>Yes</td>
<td>${prefix}I1EJ</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-285</td>
<td>Yes</td>
<td>${prefix}I1EK</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-290</td>
<td>Yes</td>
<td>${prefix}I1EL</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-297</td>
<td>Yes</td>
<td>${prefix}I1EM</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-500</td>
<td>Yes</td>
<td>${prefix}I1EO</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-871</td>
<td>Yes</td>
<td>${prefix}I1ER</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-933</td>
<td>Yes</td>
<td>${prefix}I1GZ</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1027</td>
<td>Yes</td>
<td>${prefix}I1EX</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1047</td>
<td>Yes</td>
<td>${prefix}I1EY</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1140</td>
<td>Yes</td>
<td>${prefix}I1HA</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1141</td>
<td>Yes</td>
<td>${prefix}I1HB</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1142</td>
<td>Yes</td>
<td>${prefix}I1HE</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1143</td>
<td>Yes</td>
<td>${prefix}I1HF</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1144</td>
<td>Yes</td>
<td>${prefix}I1HG</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1145</td>
<td>Yes</td>
<td>${prefix}I1HJ</td>
</tr>
</tbody>
</table>
## Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO8859-1</td>
<td>IBM-1146</td>
<td>Yes</td>
<td>&lt;prefix&gt;I1HK</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1147</td>
<td>Yes</td>
<td>&lt;prefix&gt;I1HM</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1148</td>
<td>Yes</td>
<td>&lt;prefix&gt;I1HO</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>IBM-1149</td>
<td>Yes</td>
<td>&lt;prefix&gt;I1HR</td>
</tr>
<tr>
<td>ISO8859-7</td>
<td>IBM-875</td>
<td>Yes</td>
<td>&lt;prefix&gt;I7ES</td>
</tr>
<tr>
<td>ISO8859-9</td>
<td>IBM-1026</td>
<td>Yes</td>
<td>&lt;prefix&gt;I9EW</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-037</td>
<td>No</td>
<td>&lt;prefix&gt;U2EA</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-273</td>
<td>No</td>
<td>&lt;prefix&gt;U2EB</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-274</td>
<td>No</td>
<td>&lt;prefix&gt;U2EC</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-275</td>
<td>No</td>
<td>&lt;prefix&gt;U2ED</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-277</td>
<td>No</td>
<td>&lt;prefix&gt;U2EE</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-278</td>
<td>No</td>
<td>&lt;prefix&gt;U2EF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-280</td>
<td>No</td>
<td>&lt;prefix&gt;U2EG</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-282</td>
<td>No</td>
<td>&lt;prefix&gt;U2EI</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-284</td>
<td>No</td>
<td>&lt;prefix&gt;U2EJ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-285</td>
<td>No</td>
<td>&lt;prefix&gt;U2EK</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-290</td>
<td>No</td>
<td>&lt;prefix&gt;U2EL</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-297</td>
<td>No</td>
<td>&lt;prefix&gt;U2EM</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-300</td>
<td>No</td>
<td>&lt;prefix&gt;U2EN</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-420</td>
<td>No</td>
<td>&lt;prefix&gt;U2FF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-424</td>
<td>No</td>
<td>&lt;prefix&gt;U2FB</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-500</td>
<td>No</td>
<td>&lt;prefix&gt;U2EO</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-808</td>
<td>No</td>
<td>&lt;prefix&gt;U2LF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-813</td>
<td>No</td>
<td>&lt;prefix&gt;U2I7</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-819</td>
<td>No</td>
<td>&lt;prefix&gt;U2I1</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-833</td>
<td>No</td>
<td>&lt;prefix&gt;U2GP</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-834</td>
<td>No</td>
<td>&lt;prefix&gt;U2GQ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-835</td>
<td>No</td>
<td>&lt;prefix&gt;U2GO</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-836</td>
<td>No</td>
<td>&lt;prefix&gt;U2GL</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-837</td>
<td>No</td>
<td>&lt;prefix&gt;U2GM</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-838</td>
<td>No</td>
<td>&lt;prefix&gt;U2EP</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-850</td>
<td>No</td>
<td>&lt;prefix&gt;U2AA</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-852</td>
<td>No</td>
<td>&lt;prefix&gt;U2CB</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-855</td>
<td>No</td>
<td>&lt;prefix&gt;U2CE</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-856</td>
<td>No</td>
<td>&lt;prefix&gt;U2CH</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-858</td>
<td>No</td>
<td>&lt;prefix&gt;U2AI</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-861</td>
<td>No</td>
<td>&lt;prefix&gt;U2CA</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-862</td>
<td>No</td>
<td>&lt;prefix&gt;U2BH</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-864</td>
<td>No</td>
<td>&lt;prefix&gt;U2CF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-866</td>
<td>No</td>
<td>&lt;prefix&gt;U2BE</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-869</td>
<td>No</td>
<td>&lt;prefix&gt;U2CG</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-870</td>
<td>No</td>
<td>&lt;prefix&gt;U2EQ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-871</td>
<td>No</td>
<td>&lt;prefix&gt;U2ER</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-872</td>
<td>No</td>
<td>&lt;prefix&gt;U2LE</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-874</td>
<td>No</td>
<td>&lt;prefix&gt;U2BU</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-875</td>
<td>No</td>
<td>&lt;prefix&gt;U2ES</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-867</td>
<td>No</td>
<td>&lt;prefix&gt;U2LJ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-880</td>
<td>No</td>
<td>&lt;prefix&gt;U2ET</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-901</td>
<td>No</td>
<td>&lt;prefix&gt;U2LH</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-902</td>
<td>No</td>
<td>&lt;prefix&gt;U2LD</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-904</td>
<td>No</td>
<td>&lt;prefix&gt;U2CN</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-912</td>
<td>No</td>
<td>&lt;prefix&gt;U2I2</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-914</td>
<td>No</td>
<td>&lt;prefix&gt;U2I4</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-915</td>
<td>No</td>
<td>&lt;prefix&gt;U2I5</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-916</td>
<td>No</td>
<td>&lt;prefix&gt;U2I8</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-920</td>
<td>No</td>
<td>&lt;prefix&gt;U2I9</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-921</td>
<td>No</td>
<td>&lt;prefix&gt;U2BD</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-922</td>
<td>No</td>
<td>&lt;prefix&gt;U2AD</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-927</td>
<td>No</td>
<td>&lt;prefix&gt;U2CO</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;U2EU</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-933</td>
<td>No</td>
<td>&lt;prefix&gt;U2EZ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-935</td>
<td>No</td>
<td>&lt;prefix&gt;U2EM</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-937</td>
<td>No</td>
<td>&lt;prefix&gt;U2EW</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-942</td>
<td>No</td>
<td>&lt;prefix&gt;U2EX</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-943</td>
<td>No</td>
<td>&lt;prefix&gt;U2FW</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-946</td>
<td>No</td>
<td>&lt;prefix&gt;U2FY</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-948</td>
<td>No</td>
<td>&lt;prefix&gt;U2FZ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-949</td>
<td>No</td>
<td>&lt;prefix&gt;U2GZ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-950</td>
<td>No</td>
<td>&lt;prefix&gt;U2GD</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-951</td>
<td>No</td>
<td>&lt;prefix&gt;U2GE</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-964</td>
<td>No</td>
<td>&lt;prefix&gt;U2GF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-970</td>
<td>No</td>
<td>&lt;prefix&gt;U2GG</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1025</td>
<td>No</td>
<td>&lt;prefix&gt;U2GH</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1026</td>
<td>No</td>
<td>&lt;prefix&gt;U2GI</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1027</td>
<td>No</td>
<td>&lt;prefix&gt;U2GJ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1046</td>
<td>No</td>
<td>&lt;prefix&gt;U2GK</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1047</td>
<td>No</td>
<td>&lt;prefix&gt;U2GL</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1088</td>
<td>No</td>
<td>&lt;prefix&gt;U2GM</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1089</td>
<td>No</td>
<td>&lt;prefix&gt;U2GN</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1112</td>
<td>No</td>
<td>&lt;prefix&gt;U2GD</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1115</td>
<td>No</td>
<td>&lt;prefix&gt;U2CL</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1122</td>
<td>No</td>
<td>&lt;prefix&gt;U2FD</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1140</td>
<td>No</td>
<td>&lt;prefix&gt;U2HA</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1141</td>
<td>No</td>
<td>&lt;prefix&gt;U2HB</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1142</td>
<td>No</td>
<td>&lt;prefix&gt;U2HE</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1143</td>
<td>No</td>
<td>&lt;prefix&gt;U2HF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1144</td>
<td>No</td>
<td>&lt;prefix&gt;U2HG</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1145</td>
<td>No</td>
<td>&lt;prefix&gt;U2HJ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1146</td>
<td>No</td>
<td>&lt;prefix&gt;U2HK</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1147</td>
<td>No</td>
<td>&lt;prefix&gt;U2HM</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1148</td>
<td>No</td>
<td>&lt;prefix&gt;U2HO</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1149</td>
<td>No</td>
<td>&lt;prefix&gt;U2HR</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1153</td>
<td>No</td>
<td>&lt;prefix&gt;U2MB</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1154</td>
<td>No</td>
<td>&lt;prefix&gt;U2HT</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1155</td>
<td>No</td>
<td>&lt;prefix&gt;U2HW</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1156</td>
<td>No</td>
<td>&lt;prefix&gt;U2HZ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1157</td>
<td>No</td>
<td>&lt;prefix&gt;U2HD</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1160</td>
<td>No</td>
<td>&lt;prefix&gt;U2HP</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1161</td>
<td>No</td>
<td>&lt;prefix&gt;U2LU</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1250</td>
<td>No</td>
<td>&lt;prefix&gt;U2DB</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1251</td>
<td>No</td>
<td>&lt;prefix&gt;U2DE</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1252</td>
<td>No</td>
<td>&lt;prefix&gt;U2DA</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1253</td>
<td>No</td>
<td>&lt;prefix&gt;U2DG</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1254</td>
<td>No</td>
<td>&lt;prefix&gt;U2DI</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1255</td>
<td>No</td>
<td>&lt;prefix&gt;U2DH</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1256</td>
<td>No</td>
<td>&lt;prefix&gt;U2DF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM12712</td>
<td>No</td>
<td>&lt;prefix&gt;U2HH</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1363</td>
<td>No</td>
<td>&lt;prefix&gt;U2LZ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1364</td>
<td>No</td>
<td>&lt;prefix&gt;U2KZ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1380</td>
<td>No</td>
<td>&lt;prefix&gt;U2CM</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1381</td>
<td>No</td>
<td>&lt;prefix&gt;U2CY</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1383</td>
<td>No</td>
<td>&lt;prefix&gt;U2BY</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1386</td>
<td>No</td>
<td>&lt;prefix&gt;U2CV</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1388</td>
<td>No</td>
<td>&lt;prefix&gt;U2GV</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1390</td>
<td>No</td>
<td>&lt;prefix&gt;U2HU</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-1399</td>
<td>No</td>
<td>&lt;prefix&gt;U2HV</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM16804</td>
<td>No</td>
<td>&lt;prefix&gt;U2HC</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM17248</td>
<td>No</td>
<td>&lt;prefix&gt;U2NJ</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM33722</td>
<td>No</td>
<td>&lt;prefix&gt;U2AC</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-5346</td>
<td>No</td>
<td>&lt;prefix&gt;U2NB</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-5347</td>
<td>No</td>
<td>&lt;prefix&gt;U2NE</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-5350</td>
<td>No</td>
<td>&lt;prefix&gt;U2NI</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-5351</td>
<td>No</td>
<td>&lt;prefix&gt;U2NH</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-5352</td>
<td>No</td>
<td>&lt;prefix&gt;U2NF</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-9044</td>
<td>No</td>
<td>&lt;prefix&gt;U2NG</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-9061</td>
<td>No</td>
<td>&lt;prefix&gt;U2LG</td>
</tr>
<tr>
<td>UCS-2</td>
<td>IBM-9238</td>
<td>No</td>
<td>&lt;prefix&gt;U2LI</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-037</td>
<td>No</td>
<td>&lt;prefix&gt;F8EA</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-273</td>
<td>No</td>
<td>&lt;prefix&gt;F8EB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-274</td>
<td>No</td>
<td>&lt;prefix&gt;F8EC</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-275</td>
<td>No</td>
<td>&lt;prefix&gt;F8ED</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-277</td>
<td>No</td>
<td>&lt;prefix&gt;F8EE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-278</td>
<td>No</td>
<td>&lt;prefix&gt;F8EF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-280</td>
<td>No</td>
<td>&lt;prefix&gt;F8EG</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-282</td>
<td>No</td>
<td>&lt;prefix&gt;F8EI</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-284</td>
<td>No</td>
<td>&lt;prefix&gt;F8EJ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-285</td>
<td>No</td>
<td>&lt;prefix&gt;F8EK</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-290</td>
<td>No</td>
<td>&lt;prefix&gt;F8EL</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-297</td>
<td>No</td>
<td>&lt;prefix&gt;F8EM</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-300</td>
<td>No</td>
<td>&lt;prefix&gt;F8EN</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-420</td>
<td>No</td>
<td>&lt;prefix&gt;F8FF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-424</td>
<td>No</td>
<td>&lt;prefix&gt;F8FB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-500</td>
<td>No</td>
<td>&lt;prefix&gt;F8EO</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-808</td>
<td>No</td>
<td>&lt;prefix&gt;F8LF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-813</td>
<td>No</td>
<td>&lt;prefix&gt;F8LF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-819</td>
<td>No</td>
<td>&lt;prefix&gt;F8LI</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-833</td>
<td>No</td>
<td>&lt;prefix&gt;F8GP</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-834</td>
<td>No</td>
<td>&lt;prefix&gt;F8GQ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-835</td>
<td>No</td>
<td>&lt;prefix&gt;F8GO</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-836</td>
<td>No</td>
<td>&lt;prefix&gt;F8GL</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-837</td>
<td>No</td>
<td>&lt;prefix&gt;F8GM</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-838</td>
<td>No</td>
<td>&lt;prefix&gt;F8EP</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-850</td>
<td>No</td>
<td>&lt;prefix&gt;F8AA</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-852</td>
<td>No</td>
<td>&lt;prefix&gt;F8CB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-855</td>
<td>No</td>
<td>&lt;prefix&gt;F8CE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-856</td>
<td>No</td>
<td>&lt;prefix&gt;F8CH</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-858</td>
<td>No</td>
<td>&lt;prefix&gt;F8AI</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-861</td>
<td>No</td>
<td>&lt;prefix&gt;F8CA</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-862</td>
<td>No</td>
<td>&lt;prefix&gt;F8BH</td>
</tr>
<tr>
<td>FromCode</td>
<td>ToCode</td>
<td>GENXLT source</td>
<td>Program Name</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-864</td>
<td>No</td>
<td>&lt;prefix&gt;F8CF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-866</td>
<td>No</td>
<td>&lt;prefix&gt;F8BE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-867</td>
<td>No</td>
<td>&lt;prefix&gt;F8LJ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-869</td>
<td>No</td>
<td>&lt;prefix&gt;F8CG</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-870</td>
<td>No</td>
<td>&lt;prefix&gt;F8EQ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-871</td>
<td>No</td>
<td>&lt;prefix&gt;F8ER</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-872</td>
<td>No</td>
<td>&lt;prefix&gt;F8LE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-874</td>
<td>No</td>
<td>&lt;prefix&gt;F8BU</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-875</td>
<td>No</td>
<td>&lt;prefix&gt;F8ES</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-880</td>
<td>No</td>
<td>&lt;prefix&gt;F8ET</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-901</td>
<td>No</td>
<td>&lt;prefix&gt;F8LH</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-902</td>
<td>No</td>
<td>&lt;prefix&gt;F8LD</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-904</td>
<td>No</td>
<td>&lt;prefix&gt;F8CN</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-912</td>
<td>No</td>
<td>&lt;prefix&gt;F8I2</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-914</td>
<td>No</td>
<td>&lt;prefix&gt;F8I4</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-915</td>
<td>No</td>
<td>&lt;prefix&gt;F8I5</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-916</td>
<td>No</td>
<td>&lt;prefix&gt;F8I8</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-920</td>
<td>No</td>
<td>&lt;prefix&gt;F8I9</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-921</td>
<td>No</td>
<td>&lt;prefix&gt;F8BD</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-922</td>
<td>No</td>
<td>&lt;prefix&gt;F8AD</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-927</td>
<td>No</td>
<td>&lt;prefix&gt;F8CO</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-930</td>
<td>No</td>
<td>&lt;prefix&gt;F8EU</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-933</td>
<td>No</td>
<td>&lt;prefix&gt;F8GZ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-935</td>
<td>No</td>
<td>&lt;prefix&gt;F8GY</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-937</td>
<td>No</td>
<td>&lt;prefix&gt;F8GW</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-939</td>
<td>No</td>
<td>&lt;prefix&gt;F8EV</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-942</td>
<td>No</td>
<td>&lt;prefix&gt;F8AB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-943</td>
<td>No</td>
<td>&lt;prefix&gt;F8AJ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-946</td>
<td>No</td>
<td>&lt;prefix&gt;F8DY</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-948</td>
<td>No</td>
<td>&lt;prefix&gt;F8CW</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-949</td>
<td>No</td>
<td>&lt;prefix&gt;F8CZ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-950</td>
<td>No</td>
<td>&lt;prefix&gt;F8DW</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-951</td>
<td>No</td>
<td>&lt;prefix&gt;F8CQ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-964</td>
<td>No</td>
<td>&lt;prefix&gt;F8QX</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-970</td>
<td>No</td>
<td>&lt;prefix&gt;F8BZ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1025</td>
<td>No</td>
<td>&lt;prefix&gt;F8FE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1026</td>
<td>No</td>
<td>&lt;prefix&gt;F8EW</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1027</td>
<td>No</td>
<td>&lt;prefix&gt;F8EX</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1046</td>
<td>No</td>
<td>&lt;prefix&gt;F8AF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1047</td>
<td>No</td>
<td>&lt;prefix&gt;F8EY</td>
</tr>
</tbody>
</table>
Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTF-8</td>
<td>IBM-1088</td>
<td>No</td>
<td>&lt;prefix&gt;F8CP</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1089</td>
<td>No</td>
<td>&lt;prefix&gt;F8I6</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1112</td>
<td>No</td>
<td>&lt;prefix&gt;F8GD</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1115</td>
<td>No</td>
<td>&lt;prefix&gt;F8CL</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1122</td>
<td>No</td>
<td>&lt;prefix&gt;F8FD</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1140</td>
<td>No</td>
<td>&lt;prefix&gt;F8HA</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1141</td>
<td>No</td>
<td>&lt;prefix&gt;F8HB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1142</td>
<td>No</td>
<td>&lt;prefix&gt;F8HE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1143</td>
<td>No</td>
<td>&lt;prefix&gt;F8HF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1144</td>
<td>No</td>
<td>&lt;prefix&gt;F8HG</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1145</td>
<td>No</td>
<td>&lt;prefix&gt;F8HJ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1146</td>
<td>No</td>
<td>&lt;prefix&gt;F8HK</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1147</td>
<td>No</td>
<td>&lt;prefix&gt;F8HM</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1148</td>
<td>No</td>
<td>&lt;prefix&gt;F8HO</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1149</td>
<td>No</td>
<td>&lt;prefix&gt;F8HR</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1153</td>
<td>No</td>
<td>&lt;prefix&gt;F8MB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1154</td>
<td>No</td>
<td>&lt;prefix&gt;F8HT</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1155</td>
<td>No</td>
<td>&lt;prefix&gt;F8HW</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1156</td>
<td>No</td>
<td>&lt;prefix&gt;F8HZ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1157</td>
<td>No</td>
<td>&lt;prefix&gt;F8HD</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1160</td>
<td>No</td>
<td>&lt;prefix&gt;F8HP</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1161</td>
<td>No</td>
<td>&lt;prefix&gt;F8LU</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1250</td>
<td>No</td>
<td>&lt;prefix&gt;F8DB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1251</td>
<td>No</td>
<td>&lt;prefix&gt;F8DE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1252</td>
<td>No</td>
<td>&lt;prefix&gt;F8DA</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1253</td>
<td>No</td>
<td>&lt;prefix&gt;F8DG</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1254</td>
<td>No</td>
<td>&lt;prefix&gt;F8DI</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1255</td>
<td>No</td>
<td>&lt;prefix&gt;F8DH</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1256</td>
<td>No</td>
<td>&lt;prefix&gt;F8DF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM12712</td>
<td>No</td>
<td>&lt;prefix&gt;F8HH</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1363</td>
<td>No</td>
<td>&lt;prefix&gt;F8LZ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1364</td>
<td>No</td>
<td>&lt;prefix&gt;F8KZ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1380</td>
<td>No</td>
<td>&lt;prefix&gt;F8CM</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1381</td>
<td>No</td>
<td>&lt;prefix&gt;F8CY</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1383</td>
<td>No</td>
<td>&lt;prefix&gt;F8BY</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1386</td>
<td>No</td>
<td>&lt;prefix&gt;F8CV</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1388</td>
<td>No</td>
<td>&lt;prefix&gt;F8GV</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1390</td>
<td>No</td>
<td>&lt;prefix&gt;F8HU</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-1399</td>
<td>No</td>
<td>&lt;prefix&gt;F8HV</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM16804</td>
<td>No</td>
<td>&lt;prefix&gt;F8HC</td>
</tr>
</tbody>
</table>
Table 77. Coded Character Set Conversion Tables (continued)

<table>
<thead>
<tr>
<th>FromCode</th>
<th>ToCode</th>
<th>GENXLT source</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTF-8</td>
<td>IBM17248</td>
<td>No</td>
<td>&lt;prefix&gt;F8NJ</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM33722</td>
<td>No</td>
<td>&lt;prefix&gt;F8AC</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-5346</td>
<td>No</td>
<td>&lt;prefix&gt;F8NB</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-5347</td>
<td>No</td>
<td>&lt;prefix&gt;F8NE</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-5350</td>
<td>No</td>
<td>&lt;prefix&gt;F8NI</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-5351</td>
<td>No</td>
<td>&lt;prefix&gt;F8NH</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-5352</td>
<td>No</td>
<td>&lt;prefix&gt;F8NF</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-9044</td>
<td>No</td>
<td>&lt;prefix&gt;F8NG</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-9061</td>
<td>No</td>
<td>&lt;prefix&gt;F8LG</td>
</tr>
<tr>
<td>UTF-8</td>
<td>IBM-9238</td>
<td>No</td>
<td>&lt;prefix&gt;F8LI</td>
</tr>
</tbody>
</table>

Universal Coded Character Set Converters

You can use the name UCS-2 to request setup for conversion to and from the Universal Two-Octet Coded Character Set, UCS-2, specified in ISO/IEC International Standard 10646–1. For example, iconv_open("UCS-2", "IBM-1047") requests setup for conversion from IBM-1047 character encoding to UCS-2 character encoding.

You can also use the name UTF-8 to request setup for conversion to and from Transform Format 8, UTF-8, specified in Unicode Standard, Version 2.1, Appendices A-7 and A-8. For example, iconv_open("UTF-8", "IBM-1047") requests setup for conversion from IBM-1047 character encoding to UTF-8 character encoding.

Source for UCS-2 converters resides in a data set named installation-prefix.SCEEUMAP, where the installation prefix for z/OS C/C++ data sets defaults to CEE. UCS-2 source is also installed in the hierarchical file system (HFS) directory /usr/lib/nls/locale/ucmap.

The uconvdef command, which is documented in z/OS UNIX System Services Command Reference, produces uconvTable binary files required by uconv_open() from UCS-2 source files. Table 78 on page 764 lists coded character sets for which z/OS C/C++ provides UCS-2 source and uconvTable binaries. The uconvTable binaries reside in a data set named installation-prefix.SCEEUTBL. The same as for the UCS-2 source dat aset, the default value of the installation-prefix is CEE.

Notes:

1. If your installation uses an installation-prefix different from CEE for z/OS C/C++ data sets, you must use the environment variable _ICONV_UCS2_PREFIX to specify the value of your installation-prefix before using iconv_open() to set up UCS-2 converters. Otherwise, iconv_open() cannot find your z/OS C/C++ uconvTable binary data set. One way to do this is to use the ENVAR run-time option when you start your application. For example, ENVAR(..., _ICONV_UCS2_PREFIX=OUR.PREFIX, ...) has iconv_open() search for uconvTable binaries it requires in the data set OUR.PREFIX.SCEEUTBL.
2. The uconvTable binaries are also installed in the HFS directory named /usr/lib/nls/locale/uconvTable. The iconv_open() function searches for uconvTable binaries in the HFS before looking in the z/OS C/C++ UCS-2 data set.

3. You can use the LOCPATH environment variable to give iconv_open() a colon-separated list of pathname prefixes to use instead of /usr/lib/nls/locale/ to find uconvTable directories in your HFS.

4. UCS-2 source and binaries found in installation-prefix.SCEEUMAP and installation-prefix.SCEEUTBL data sets (or corresponding HFS directories), respectively, pertain to conversions to and from UTF-8 as well as UCS-2.

Members in the z/OS C/C++ UCS-2 source and uconvTable binary data sets have names of the form EDCCUccU; where cc is the CC-id associated with a particular coded character set name. Table 78 shows the CC-id and member name associated with each coded character set name for which z/OS C/C++ provides source and a uconvTable binary in UCS-2 data sets.

Table 78. UCS-2 Converters

<table>
<thead>
<tr>
<th>Codeset Name</th>
<th>CC-id</th>
<th>UCS-2 source</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-850</td>
<td>AA</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-4946</td>
<td>AA</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-301</td>
<td>AB</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-932</td>
<td>AB</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-942</td>
<td>AB</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>EUCJP</td>
<td>AC</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-EUCJP</td>
<td>AC</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM33722</td>
<td>AC</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-922</td>
<td>AD</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-1046</td>
<td>AF</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-932C</td>
<td>AG</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-EUCJC</td>
<td>AH</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-858</td>
<td>AI</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-943</td>
<td>AJ</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-859</td>
<td>AK</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-425</td>
<td>AR</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-921</td>
<td>BD</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-866</td>
<td>BE</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-862</td>
<td>BH</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>GBK</td>
<td>BS</td>
<td>EDCUUAACU</td>
</tr>
<tr>
<td>IBM-874</td>
<td>BU</td>
<td>EDCUUBBUU</td>
</tr>
<tr>
<td>TIS-620</td>
<td>BU</td>
<td>EDCUUBBUU</td>
</tr>
<tr>
<td>EUCTW-1993</td>
<td>BW</td>
<td>EDCUUBBUU</td>
</tr>
<tr>
<td>IBM-EUCTW</td>
<td>BW</td>
<td>EDCUUBBUU</td>
</tr>
<tr>
<td>IBM-964</td>
<td>BW</td>
<td>EDCUUBBUU</td>
</tr>
<tr>
<td>IBM-1383</td>
<td>BY</td>
<td>EDCUUBBUU</td>
</tr>
<tr>
<td>EUCKR</td>
<td>BZ</td>
<td>EDCUUBBUU</td>
</tr>
</tbody>
</table>
Table 78. UCS-2 Converters (continued)

<table>
<thead>
<tr>
<th>Codeset Name</th>
<th>CC-id</th>
<th>UCS-2 source</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-EUCKR</td>
<td>BZ</td>
<td>EDCUUUBZU</td>
</tr>
<tr>
<td>IBM-970</td>
<td>BZ</td>
<td>EDCUUUBZU</td>
</tr>
<tr>
<td>IBM-861</td>
<td>CA</td>
<td>EDCUUCAU</td>
</tr>
<tr>
<td>IBM-852</td>
<td>CB</td>
<td>EDCUU CBU</td>
</tr>
<tr>
<td>IBM-855</td>
<td>CE</td>
<td>EDCUU CEU</td>
</tr>
<tr>
<td>IBM-864</td>
<td>CF</td>
<td>EDCUU CFU</td>
</tr>
<tr>
<td>IBM-869</td>
<td>CG</td>
<td>EDCUU CGU</td>
</tr>
<tr>
<td>IBM-856</td>
<td>CH</td>
<td>EDCUU CHU</td>
</tr>
<tr>
<td>IBM-1115</td>
<td>CL</td>
<td>EDCUU CLU</td>
</tr>
<tr>
<td>IBM-1380</td>
<td>CM</td>
<td>EDCUU CMU</td>
</tr>
<tr>
<td>IBM-904</td>
<td>CN</td>
<td>EDCUU CNU</td>
</tr>
<tr>
<td>IBM-927</td>
<td>CO</td>
<td>EDCUU COU</td>
</tr>
<tr>
<td>IBM-1088</td>
<td>CP</td>
<td>EDCUU CPU</td>
</tr>
<tr>
<td>IBM-951</td>
<td>CQ</td>
<td>EDCUU CQU</td>
</tr>
<tr>
<td>IBM-942</td>
<td>CR</td>
<td>EDCUU CRU</td>
</tr>
<tr>
<td>IBM-1386</td>
<td>CV</td>
<td>EDCUU CVU</td>
</tr>
<tr>
<td>IBM-938</td>
<td>CW</td>
<td>EDCUU CWU</td>
</tr>
<tr>
<td>IBM-948</td>
<td>CW</td>
<td>EDCUU CWU</td>
</tr>
<tr>
<td>IBM-1381</td>
<td>CY</td>
<td>EDCUU CYU</td>
</tr>
<tr>
<td>IBM-949</td>
<td>CZ</td>
<td>EDCUU CZU</td>
</tr>
<tr>
<td>IBM-1252</td>
<td>DA</td>
<td>EDCUU DAU</td>
</tr>
<tr>
<td>IBM-1250</td>
<td>DB</td>
<td>EDCUU DBU</td>
</tr>
<tr>
<td>IBM-1251</td>
<td>DE</td>
<td>EDCUU DEU</td>
</tr>
<tr>
<td>IBM-1256</td>
<td>DF</td>
<td>EDCUU DFU</td>
</tr>
<tr>
<td>IBM-1253</td>
<td>DG</td>
<td>EDCUU DGU</td>
</tr>
<tr>
<td>IBM-1255</td>
<td>DH</td>
<td>EDCUU DHU</td>
</tr>
<tr>
<td>IBM-1254</td>
<td>DI</td>
<td>EDCUU DIU</td>
</tr>
<tr>
<td>IBM-5348</td>
<td>DJ</td>
<td>EDCUU DJU</td>
</tr>
<tr>
<td>IBM-5349</td>
<td>DK</td>
<td>EDCUU DKU</td>
</tr>
<tr>
<td>IBM-5488</td>
<td>DL</td>
<td>EDCUU DLU</td>
</tr>
<tr>
<td>BIG5</td>
<td>DW</td>
<td>EDCUU DWU</td>
</tr>
<tr>
<td>IBM-947</td>
<td>DW</td>
<td>EDCUU DWU</td>
</tr>
<tr>
<td>IBM-950</td>
<td>DW</td>
<td>EDCUU DWU</td>
</tr>
<tr>
<td>IBM-928</td>
<td>DY</td>
<td>EDCUU DYU</td>
</tr>
<tr>
<td>IBM-936</td>
<td>DY</td>
<td>EDCUU DYU</td>
</tr>
<tr>
<td>IBM-946</td>
<td>DY</td>
<td>EDCUU DYU</td>
</tr>
<tr>
<td>IBM-037</td>
<td>EA</td>
<td>EDCUU EAU</td>
</tr>
<tr>
<td>IBM-28709</td>
<td>EA</td>
<td>EDCUU EAU</td>
</tr>
<tr>
<td>IBM-273</td>
<td>EB</td>
<td>EDCUU EBU</td>
</tr>
<tr>
<td>IBM-274</td>
<td>EC</td>
<td>EDCUU ECU</td>
</tr>
</tbody>
</table>
Table 78. UCS-2 Converters (continued)

<table>
<thead>
<tr>
<th>Codeset Name</th>
<th>CC-id</th>
<th>UCS-2 source</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-275</td>
<td>ED</td>
<td>EDCUUEDU</td>
</tr>
<tr>
<td>IBM-277</td>
<td>EE</td>
<td>EDCUUEEU</td>
</tr>
<tr>
<td>IBM-278</td>
<td>EF</td>
<td>EDCUUEFU</td>
</tr>
<tr>
<td>IBM-280</td>
<td>EG</td>
<td>EDCUUEGU</td>
</tr>
<tr>
<td>IBM-281</td>
<td>EH</td>
<td>EDCUUEHU</td>
</tr>
<tr>
<td>IBM-282</td>
<td>EI</td>
<td>EDCUUEIU</td>
</tr>
<tr>
<td>IBM-284</td>
<td>EJ</td>
<td>EDCUUEJU</td>
</tr>
<tr>
<td>IBM-285</td>
<td>EK</td>
<td>EDCUUEKU</td>
</tr>
<tr>
<td>IBM-290</td>
<td>EL</td>
<td>EDCUUELU</td>
</tr>
<tr>
<td>IBM-297</td>
<td>EM</td>
<td>EDCUUEMU</td>
</tr>
<tr>
<td>IBM-300</td>
<td>EN</td>
<td>EDCUUENU</td>
</tr>
<tr>
<td>IBM-4396</td>
<td>EN</td>
<td>EDCUENU</td>
</tr>
<tr>
<td>IBM-500</td>
<td>EO</td>
<td>EDCUUEOU</td>
</tr>
<tr>
<td>IBM-838</td>
<td>EP</td>
<td>EDCUUEPU</td>
</tr>
<tr>
<td>IBM-870</td>
<td>EQ</td>
<td>EDCUUEQU</td>
</tr>
<tr>
<td>IBM-871</td>
<td>ER</td>
<td>EDCUUERU</td>
</tr>
<tr>
<td>IBM-875</td>
<td>ES</td>
<td>EDCUUESU</td>
</tr>
<tr>
<td>IBM-880</td>
<td>ET</td>
<td>EDCUUETU</td>
</tr>
<tr>
<td>IBM-930</td>
<td>EU</td>
<td>EDCUUEUU</td>
</tr>
<tr>
<td>IBM-5026</td>
<td>EU</td>
<td>EDCUUEUU</td>
</tr>
<tr>
<td>IBM-939</td>
<td>EV</td>
<td>EDCUUEVU</td>
</tr>
<tr>
<td>IBM-5035</td>
<td>EV</td>
<td>EDCUUEVU</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>EW</td>
<td>EDCUUEWU</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>EX</td>
<td>EDCUUEXU</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>EY</td>
<td>EDCUUEYU</td>
</tr>
<tr>
<td>IBM-924</td>
<td>EZ</td>
<td>EDCUUEZU</td>
</tr>
<tr>
<td>UTF-8</td>
<td>F8</td>
<td>EDCUUUF8U</td>
</tr>
<tr>
<td>IBM-424</td>
<td>FB</td>
<td>EDCUUFBU</td>
</tr>
<tr>
<td>IBM-1122</td>
<td>FD</td>
<td>EDCUUFDU</td>
</tr>
<tr>
<td>IBM-1025</td>
<td>FE</td>
<td>EDCUUEFU</td>
</tr>
<tr>
<td>IBM-420</td>
<td>FF</td>
<td>EDCUUFFU</td>
</tr>
<tr>
<td>IBM-1112</td>
<td>GD</td>
<td>EDCUUGDU</td>
</tr>
<tr>
<td>IBM-836</td>
<td>GL</td>
<td>EDCUUGLU</td>
</tr>
<tr>
<td>IBM-837</td>
<td>GM</td>
<td>EDCUUGMU</td>
</tr>
<tr>
<td>IBM-835</td>
<td>GO</td>
<td>EDCUUGOU</td>
</tr>
<tr>
<td>IBM-833</td>
<td>GP</td>
<td>EDCUUGPU</td>
</tr>
<tr>
<td>IBM-834</td>
<td>GQ</td>
<td>EDCUUGQU</td>
</tr>
<tr>
<td>IBM-1388</td>
<td>GV</td>
<td>EDCUUBUGU</td>
</tr>
<tr>
<td>IBM-937</td>
<td>GW</td>
<td>EDCUUUGWU</td>
</tr>
<tr>
<td>IBM-935</td>
<td>GY</td>
<td>EDCUUUGYU</td>
</tr>
</tbody>
</table>
Table 78. UCS-2 Converters (continued)

<table>
<thead>
<tr>
<th>Codeset Name</th>
<th>CC-id</th>
<th>UCS-2 source</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-5031</td>
<td>GY</td>
<td>EDCUUUGYU</td>
</tr>
<tr>
<td>IBM-933</td>
<td>GZ</td>
<td>EDCUUUGZU</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>HA</td>
<td>EDCUUHAU</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>HB</td>
<td>EDCUUHBU</td>
</tr>
<tr>
<td>IBM16804</td>
<td>HC</td>
<td>EDCUUHCU</td>
</tr>
<tr>
<td>IBM-1157</td>
<td>HD</td>
<td>EDCUUHDU</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>HE</td>
<td>EDCUUHEU</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>HF</td>
<td>EDCUUHFU</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>HG</td>
<td>EDCUUHGU</td>
</tr>
<tr>
<td>IBM12712</td>
<td>HH</td>
<td>EDCUUHHU</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>HJ</td>
<td>EDCUUHJU</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>HK</td>
<td>EDCUUHKU</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>HM</td>
<td>EDCUUHMU</td>
</tr>
<tr>
<td>IBM-16684</td>
<td>HN</td>
<td>EDCUUHNU</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>HO</td>
<td>EDCUHUOU</td>
</tr>
<tr>
<td>IBM-1160</td>
<td>HP</td>
<td>EDCUUHPU</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>HR</td>
<td>EDCUUHRU</td>
</tr>
<tr>
<td>IBM-4971</td>
<td>HS</td>
<td>EDCUUHSU</td>
</tr>
<tr>
<td>IBM-1154</td>
<td>HT</td>
<td>EDCUUHTU</td>
</tr>
<tr>
<td>IBM-1390</td>
<td>HU</td>
<td>EDCUUHUU</td>
</tr>
<tr>
<td>IBM-1399</td>
<td>HV</td>
<td>EDCUUHVU</td>
</tr>
<tr>
<td>IBM-1155</td>
<td>HW</td>
<td>EDCUUHWU</td>
</tr>
<tr>
<td>IBM-5123</td>
<td>HX</td>
<td>EDCUHXU</td>
</tr>
<tr>
<td>IBM-1156</td>
<td>HZ</td>
<td>EDCUHZU</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>I1</td>
<td>EDCUI1U</td>
</tr>
<tr>
<td>IBM-819</td>
<td>I1</td>
<td>EDCUI1U</td>
</tr>
<tr>
<td>ISO8859-2</td>
<td>I2</td>
<td>EDCUI2U</td>
</tr>
<tr>
<td>IBM-912</td>
<td>I2</td>
<td>EDCUI2U</td>
</tr>
<tr>
<td>ISO8859-4</td>
<td>I4</td>
<td>EDCUI4U</td>
</tr>
<tr>
<td>IBM-914</td>
<td>I4</td>
<td>EDCUI4U</td>
</tr>
<tr>
<td>ISO8859-5</td>
<td>I5</td>
<td>EDCUI5U</td>
</tr>
<tr>
<td>IBM-915</td>
<td>I5</td>
<td>EDCUI5U</td>
</tr>
<tr>
<td>ISO8859-6</td>
<td>I6</td>
<td>EDCUI6U</td>
</tr>
<tr>
<td>IBM-1089</td>
<td>I6</td>
<td>EDCUI6U</td>
</tr>
<tr>
<td>ISO8859-7</td>
<td>I7</td>
<td>EDCUI7U</td>
</tr>
<tr>
<td>IBM-813</td>
<td>I7</td>
<td>EDCUI7U</td>
</tr>
<tr>
<td>ISO8859-8</td>
<td>I8</td>
<td>EDCUI8U</td>
</tr>
<tr>
<td>IBM-916</td>
<td>I8</td>
<td>EDCUI8U</td>
</tr>
<tr>
<td>ISO8859-9</td>
<td>I9</td>
<td>EDCUI9U</td>
</tr>
<tr>
<td>IBM-920</td>
<td>I9</td>
<td>EDCUI9U</td>
</tr>
<tr>
<td>Codeset Name</td>
<td>CC-id</td>
<td>UCS-2 source</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
<td>--------------</td>
</tr>
<tr>
<td>IBM-4909</td>
<td>IA</td>
<td>EDCUUJIAU</td>
</tr>
<tr>
<td>IBM-923</td>
<td>IF</td>
<td>EDCUUJIFU</td>
</tr>
<tr>
<td>ISO8859–15</td>
<td>IF</td>
<td>EDCUUJIFU</td>
</tr>
<tr>
<td>ISO-2022–JP</td>
<td>JA</td>
<td>EDCUUJIAU</td>
</tr>
<tr>
<td>IBM-956</td>
<td>JB</td>
<td>EDCUUJBU</td>
</tr>
<tr>
<td>IBM-957</td>
<td>JC</td>
<td>EDCUUJCU</td>
</tr>
<tr>
<td>IBM-956C</td>
<td>JD</td>
<td>EDCUUJDU</td>
</tr>
<tr>
<td>IBM-958</td>
<td>JD</td>
<td>EDCUUJDU</td>
</tr>
<tr>
<td>IBM-957C</td>
<td>JE</td>
<td>EDCUUJEU</td>
</tr>
<tr>
<td>IBM-959</td>
<td>JE</td>
<td>EDCUUJEU</td>
</tr>
<tr>
<td>IBM-5052</td>
<td>JF</td>
<td>EDCUUJFU</td>
</tr>
<tr>
<td>IBM-5053</td>
<td>JG</td>
<td>EDCUUJGU</td>
</tr>
<tr>
<td>IBM-5052C</td>
<td>JH</td>
<td>EDCUUJHU</td>
</tr>
<tr>
<td>IBM-5054</td>
<td>JH</td>
<td>EDCUUJHU</td>
</tr>
<tr>
<td>IBM-5053C</td>
<td>JI</td>
<td>EDCUUJIIU</td>
</tr>
<tr>
<td>IBM-5055</td>
<td>JI</td>
<td>EDCUUJIIU</td>
</tr>
<tr>
<td>IBM-1371</td>
<td>KA</td>
<td>EDCUUKAU</td>
</tr>
<tr>
<td>IBM-1364</td>
<td>KZ</td>
<td>EDCUUKZU</td>
</tr>
<tr>
<td>IBM-1370</td>
<td>LA</td>
<td>EDCUULAU</td>
</tr>
<tr>
<td>IBM-902</td>
<td>LD</td>
<td>EDCUULDU</td>
</tr>
<tr>
<td>IBM-872</td>
<td>LE</td>
<td>EDCUULEU</td>
</tr>
<tr>
<td>IBM-808</td>
<td>LF</td>
<td>EDCUULFU</td>
</tr>
<tr>
<td>IBM-9061</td>
<td>LG</td>
<td>EDCUULGU</td>
</tr>
<tr>
<td>IBM-901</td>
<td>LH</td>
<td>EDCUULHU</td>
</tr>
<tr>
<td>IBM-9238</td>
<td>LI</td>
<td>EDCUULIU</td>
</tr>
<tr>
<td>IBM-867</td>
<td>LJ</td>
<td>EDCUULIU</td>
</tr>
<tr>
<td>IBM-1161</td>
<td>LU</td>
<td>EDCUULUU</td>
</tr>
<tr>
<td>IBM-1363</td>
<td>LZ</td>
<td>EDCUULZU</td>
</tr>
<tr>
<td>IBM-1153</td>
<td>MB</td>
<td>EDCUUMBU</td>
</tr>
<tr>
<td>IBM-5346</td>
<td>NB</td>
<td>EDCUUNBU</td>
</tr>
<tr>
<td>IBM-5347</td>
<td>NE</td>
<td>EDCUUNEU</td>
</tr>
<tr>
<td>IBM-5352</td>
<td>NF</td>
<td>EDCUUNFU</td>
</tr>
<tr>
<td>IBM-9044</td>
<td>NG</td>
<td>EDCUUNGU</td>
</tr>
<tr>
<td>IBM-5351</td>
<td>NH</td>
<td>EDCUUNHU</td>
</tr>
<tr>
<td>IBM-5350</td>
<td>NI</td>
<td>EDCUUNIU</td>
</tr>
<tr>
<td>IBM17248</td>
<td>NJ</td>
<td>EDCUUNJU</td>
</tr>
<tr>
<td>UCS-2</td>
<td>U2</td>
<td>EDCUUU2U</td>
</tr>
</tbody>
</table>
Codeset Conversion Using UCS-2

z/OS C/C++ icnv supports use of UCS-2 as an intermediate code set for conversion of characters encoded in one code set to another. The _ICONV_UCS2 environment variable instructs icnv_open("Y", "X") whether or not to set up indirect conversion from code set X to code set Y using UCS-2 as an intermediate code set. Values icnv_open() recognizes for _ICONV_UCS2 are:

1  Set up indirect conversion using UCS-2 first. The indirect conversions will use direct unicode converters if available, if not, icnv_open() will fopen/fread uconvTable binaries. If set up of indirect conversion fails, icnv_open() will try to set up direct conversion.

2  Set up direct conversion first. If this fails, try to set up indirect conversion using UCS-2. The indirect conversions will use direct unicode converters if available, if not, icnv_open() will fopen/fread uconvTable binaries. This is the default.

3  Set up direct conversion first. If this fails, try to set up indirect conversion using UCS-2. The indirect conversions will use direct unicode converters, if direct unicode converters are unavailable, the icnv_open() request fails.

N  Never set up indirect conversion using UCS-2. If a direct converter cannot be found, the icnv_open() request fails.

D  Never set up indirect conversion using UCS-2. If a direct converter cannot be found, the icnv_open() request fails.

O  Only set up indirect conversion using UCS-2. icnv_open() will fopen/fread uconvTable binaries. Direct unicode converters will not be used. If required uconvTable binaries cannot be found, the icnv_open() request fails.

U  Only set up indirect conversion using UCS-2. The indirect conversions will use direct unicode converters if available, if not, icnv_open() will fopen/fread uconvTable binaries.

Notes:

1. If the value of the _ICONV_UCS2 environment variable allows icnv_open("Y", "X") to use UCS-2 as an intermediate code set when it cannot find a direct converter from X to Y, icnv_open() will attempt to do so even if X and Y are not compatible code sets. That is, even if character sets encoded by X and Y are not the same, icnv_open() will set up conversion from X to UCS-2 to Y.

2. The application must specify compatible source and target code set names on various icnv_open() requests. For example, this can be accomplished by using a code set registry such as is used by DCE to prevent icnv setup for conversion from incompatible code sets.

UCMAP Source Format

A UCMAP source file defines UCS-2 (Unicode) conversion mappings for input to the uconvdef command. Conversion mapping values are defined using UCS-2 symbolic character names followed by character encoding (code point) values for the multibyte code set. For example:

<U0020>
\x20 represents the mapping between the <U0020> UCS-2 symbolic character name for the space character and the \x20 hexadecimal code point for the space character in ASCII.

In addition to the code set mappings, directives are interpreted by the uconvdef command to produce the compiled table. These directives must precede the code
set mapping section. They consist of the following keywords surrounded by <> (angle brackets), starting in column 1, followed by white space and the value to be assigned to the symbol:

<comment_char>
Character used to denote start of escape sequence. Default escape character is <number_sign> (#). In cmap, source shipped by C/370 <percent_sign> (%) is specified for <comment_char>.

<escape_char>
Character used to denote start of escape sequence. Default escape character is <backslash> (\). In cmap source shipped by C/370 <slash> (/) is specified for <escape_char>.

<code_set_name>
The name of the coded character set, enclosed in quotation marks(""), for which the character set description file is defined.

<mb_cur_max>
The maximum number of bytes in a multibyte character. The default value is 1.

<mb_cur_min>
An unsigned positive integer value that defines the minimum number of bytes in a character for the encoded character set. The value is less than or equal to <mb_cur_max>. If not specified, the minimum number is equal to <mb_cur_max>.

<char_name_mask>
A quoted string consisting of format specifiers for the UCS-2 symbolic names. This must be a value of AXXXX, indicating an alphabetic character followed by 4 hexadecimal digits. Also, the alphabetic character must be a U, and the hexadecimal digits must represent the UCS-2 code point for the character. An example of a symbolic character name based on this mask is <U0020> Unicode space character.

<uconv_class>
Specifies the type of the code set. It must be one of the following:

**SBCS**  Single-byte encoding

**DBCS**  Stateless double-byte, single-byte, or mixed encodings

**EBCDIC_STATEFUL**  Stateful double-byte, single-byte, or mixed encodings

**MBCS**  Stateless multibyte encoding

This type is used to direct uconvdef on the type of table to build. It is also stored in the table to indicate the type of processing algorithm in the UCS conversion methods.

<locale>
Specifies the default locale name to be used if locale information is needed.

<subchar>
Specifies the encoding of the default substitute character in the multibyte code set.
The mapping definition section consists of a sequence of mapping definition lines preceded by a CHARMAP declaration and terminated by an END CHARMAP declaration. Empty lines and lines containing <comment_char> in the first column are ignored.

Symbolic character names in mapping lines must follow the pattern specified in the <char_name_mask>, except for the reserved symbolic name, <unassigned>, that indicates the associated code points are unassigned.

Each noncomment line of the character set mapping definition must be in one of the following formats:

1. "%s%s%s%s/n", <symbolic_name>, <encoding>, <comments>
   <U3004> \x81\x57
   This format defines a single symbolic character name and a corresponding encoding.
   The encoding part is expressed as one or more concatenated decimal, hexadecimal, or octal constants in the following formats:
   - "%cd%d",<escape_char>, <decimal byte value>
   - "%cx%x",<escape_char>,<hexadecimal byte value>
   - "%c%o",<escape_char>,<octal byte value>
   Decimal constants are represented by two or more decimal digits preceded by the escape character and the lowercase letter d, as in \d97 or \d143.
   Hexadecimal constants are represented by two or more hexadecimal digits preceded by an escape character and the lowercase letter x, as in \x61 or \x8f.
   Octal constants are represented by two or more octal digits preceded by an escape character.
   Each constant represents a single—byte value. When constants are concatenated for multibyte character values, the last value specifies the least significant octet and preceding constants specify successively more significant octets.

2. "%s...%s %s %s%n",<symbolic_name>,<symbolic_name>,<encoding><comments>
   For example:
   <U3003><U3006> \x81\x56
   This format defines a range of symbolic character names and corresponding encodings. The range is interpreted as a series of symbolic names formed from the alphabetic prefix and all the values in the range defined by the numeric suffixes.
   The listed encoding value is assigned to the first symbolic name, and subsequent symbolic names in the range are assigned corresponding incremental values. For example, the line:
   <U3003>...<U3006> \x81\x56
   is interpreted as:
   <U3003> \x81\x56
   <U3004> \x81\x57
   <U3005> \x81\x58
   <U3006> \x81\x59

3. "<unassigned>%s...%s %s%n",<encoding>,<comments>
   This format defines a range of one or more unassigned encodings. For example, the line
<unassigned> \x9b...\x9c

is interpreted as:
<unassigned> \x9b <unassigned> \x9c
Chapter 52. Coded Character Set Considerations with Locale

Functions

Each EBCDIC coded character set consists of a mapping of all the available glyphs to their respective hex encodings and unique Graphic Character Global Identifiers (GCGIDs). GCGIDs are unique identifiers assigned to each character in the Unicode standard. A glyph is the printed appearance of a character. Each coded character set serves one linguistic environment.

There is wide variation among coded character sets; many glyphs do not appear in all coded character sets, and hexadecimal encodings for some glyphs differ from one coded character set to another. You may encounter problems when exporting a file from a system running in one coded character set, to a system running in another. For example, a left bracket (I) entered under the APL-293 or Open Systems IBM-1047 coded character set will appear as the capitalized Y-acute (Ý). This occurs in such common coded character sets as International 500, France 297, Germany 273, and US or Canada 037.

z/OS C/C++ contains the following extensions to prevent such problems:

- The `#pragma filetag` directive allows you to specify the coded character set that was used when entering the source files. See "The pragma filetag Directive" on page 779 for details on this pragma.
- The `LOCALE` compiler option enables you to tell the compiler what locale to use at compile time. See "Converting Coded Character Sets at Compile Time" on page 782 for details on this compiler option.
- The `CONVLIT` compiler option enables you to change the assumed code page for string literals. See "CONVLIT Compiler Option" on page 782 for details on this compiler option.

These facilities cause the compiler to respect your code page. Thus, you can enter source code with what appears to you to be the correct characters, and the compiler will recognize those characters.

The rest of this chapter discusses other ways to work efficiently in different locales.

Variant Character Detail

The POSIX Portable Character Set (PPCS) identifies the core set of 128 characters that are needed to write code and to run applications. Of these, 13 characters are variant among the EBCDIC coded character sets.

"Mappings of 13 PPCS Variant Characters" on page 774 lists these 13 characters. It also displays their appearance when the Open Systems coded character set IBM-1047 hexadecimal values are entered on systems where different Country Extended Coded Character Sets are installed. These hex values are the ones expected by z/OS C/C++, and are consistent with the use of the APL-293 coded character set. Table 80 on page 774 lists the hexadecimal values assigned across some of the EBCDIC coded character sets for the 13 variant characters from the PPCS. Appendix C, "z/OS C/C++ Code Point Mappings" on page 813 gives more information about the mapping of glyphs. Appendix A, "POSIX Character Set" on page 803 lists the full PPCS.
Mappings of 13 PPCS Variant Characters

Table 79. Mappings of 13 PPCS Variant Characters

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>left bracket</td>
<td>AD</td>
<td>[</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>right bracket</td>
<td>BD</td>
<td>)</td>
<td>ü</td>
<td>~</td>
<td>ü</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td>left brace</td>
<td>C0</td>
<td>{</td>
<td>(</td>
<td>é</td>
<td>â</td>
<td>(</td>
<td>)</td>
</tr>
<tr>
<td>right brace</td>
<td>D0</td>
<td>}</td>
<td>)</td>
<td>è</td>
<td>ü</td>
<td>)</td>
<td>)</td>
</tr>
<tr>
<td>backslash</td>
<td>E0</td>
<td>\</td>
<td>\</td>
<td>ç</td>
<td>Ø</td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td>circumflex</td>
<td>5F</td>
<td>^</td>
<td>^</td>
<td>^</td>
<td>^</td>
<td>^</td>
<td>~</td>
</tr>
<tr>
<td>tide</td>
<td>A1</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>ü</td>
<td>ß</td>
<td>~</td>
</tr>
<tr>
<td>exclamation mark</td>
<td>5A</td>
<td>!</td>
<td>!</td>
<td>§</td>
<td>Ü</td>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>pound (number) sign</td>
<td>7B</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>£</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>vertical bar</td>
<td>4F</td>
<td>\</td>
<td>\</td>
<td>\</td>
<td>\</td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td>accent grave</td>
<td>79</td>
<td>\</td>
<td>\</td>
<td>\</td>
<td>µ</td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td>dollar sign</td>
<td>5B</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>commercial “at”</td>
<td>7C</td>
<td>@</td>
<td>@</td>
<td>@</td>
<td>á</td>
<td>$</td>
<td>@</td>
</tr>
</tbody>
</table>

Two tables are available to show the full code—point mappings for Open Systems coded character set IBM-1047 (Figure 230 on page 813) and for the APL coded character set IBM-293 (Figure 231 on page 814). Upon examination of these coded character sets, you will notice that coded character set 1047 is a “Latinized” coded character set IBM-293. All the APL code points have been replaced by Latin 1 code points, allowing a one-to-one mapping among coded character set IBM-1047 and all other coded character sets in the Latin 1 group.

Although the official current coded character set for z/OS C/C++ is now coded character set IBM-1047 (Open Systems), the coded character set IBM-293 syntax points are still valid. Those points are the ones with syntactic relevance to the z/OS C/C++ compiler. Refer to “Mappings of 13 PPCS Variant Characters” and “Mappings of Hex Encoding of 13 PPCS Variant Characters” for more information.

Mappings of Hex Encoding of 13 PPCS Variant Characters

Table 80. Mappings of Hex Encoding of 13 PPCS Variant Characters

<table>
<thead>
<tr>
<th>Character Name</th>
<th>Glyph</th>
<th>GCGID</th>
<th>Open Systems IBM-1047 view</th>
<th>APL IBM-293 view</th>
<th>International 500 view</th>
<th>France 297 view</th>
<th>Germany 273 view</th>
<th>US/Can 037 view</th>
</tr>
</thead>
<tbody>
<tr>
<td>left bracket</td>
<td>[</td>
<td>SM060000</td>
<td>AD</td>
<td>AD</td>
<td>4A</td>
<td>90</td>
<td>63</td>
<td>BA</td>
</tr>
<tr>
<td>right bracket</td>
<td>)</td>
<td>SM080000</td>
<td>BD</td>
<td>BD</td>
<td>5A</td>
<td>B5</td>
<td>FC</td>
<td>BB</td>
</tr>
<tr>
<td>left brace</td>
<td>{</td>
<td>SM110000</td>
<td>C0</td>
<td>C0</td>
<td>C0</td>
<td>51</td>
<td>43</td>
<td>C0</td>
</tr>
<tr>
<td>right brace</td>
<td>)</td>
<td>SM140000</td>
<td>D0</td>
<td>D0</td>
<td>D0</td>
<td>54</td>
<td>DC</td>
<td>D0</td>
</tr>
<tr>
<td>backslash</td>
<td>\</td>
<td>SM070000</td>
<td>E0</td>
<td>E0</td>
<td>E0</td>
<td>48</td>
<td>EC</td>
<td>E0</td>
</tr>
<tr>
<td>circumflex</td>
<td>^</td>
<td>SD150000</td>
<td>5F</td>
<td>5F</td>
<td>5F</td>
<td>5F</td>
<td>5F</td>
<td>B0</td>
</tr>
</tbody>
</table>
Table 80. Mappings of Hex Encoding of 13 PPCS Variant Characters (continued)

<table>
<thead>
<tr>
<th>Character Name</th>
<th>Glyph</th>
<th>GCGID</th>
<th>Open Systems IBM-1047 view</th>
<th>APL IBM-293 view</th>
<th>International 500 view</th>
<th>France 297 view</th>
<th>Germany 273 view</th>
<th>US/Can 037 view</th>
</tr>
</thead>
<tbody>
<tr>
<td>tilda</td>
<td>~</td>
<td>SD190000</td>
<td>A1</td>
<td>A1</td>
<td>A1</td>
<td>BD</td>
<td>59</td>
<td>A1</td>
</tr>
<tr>
<td>exclamation mark</td>
<td>!</td>
<td>SP020000</td>
<td>5A</td>
<td>5A</td>
<td>4F</td>
<td>4F</td>
<td>4F</td>
<td>5A</td>
</tr>
<tr>
<td>pound (number) sign</td>
<td>#</td>
<td>SM010000</td>
<td>7B</td>
<td>7B</td>
<td>7B</td>
<td>B1</td>
<td>7B</td>
<td>7B</td>
</tr>
<tr>
<td>vertical bar</td>
<td></td>
<td>SM130000</td>
<td>4F</td>
<td>4F</td>
<td>BB</td>
<td>BB</td>
<td>BB</td>
<td>4F</td>
</tr>
<tr>
<td>accent grave</td>
<td>`</td>
<td>SD130000</td>
<td>79</td>
<td>79</td>
<td>79</td>
<td>A0</td>
<td>79</td>
<td>79</td>
</tr>
<tr>
<td>dollar sign</td>
<td>$</td>
<td>SC030000</td>
<td>5B</td>
<td>5B</td>
<td>5B</td>
<td>5B</td>
<td>5B</td>
<td>5B</td>
</tr>
<tr>
<td>commercial “at”</td>
<td>@</td>
<td>SM050000</td>
<td>7C</td>
<td>7C</td>
<td>7C</td>
<td>44</td>
<td>B5</td>
<td>7C</td>
</tr>
</tbody>
</table>

Alternate Code Points

All syntactic code points that were supported in previous versions of z/OS C/C++ will continue to be supported if you are compiling with the NOLOCALE option.

To be compatible, the vertical bar character is represented by the following two encodings, provided you are not using the LOCALE compiler option or the NOLOCALE option:

- X'4F'
- X'6A'

If you do specify the LOCALE compiler option, each of these characters is represented by a unique value specified in the LC_SYNTAX category of the selected locale.

Coding without Locale Support by Using a Hybrid Coded Character Set

To avoid using the locale of the compiler, you may use a hybrid coded character set. A hybrid piece of code is in the local coded character set but the syntax is written as if it were in coded character set IBM-1047.

You can continue coding in the local coded character set, writing the syntax as if it were in coded character set IBM-1047. This solution uses the existing behavior of the compiler, but this method is not ideal for the following reasons:

- The code can be difficult to read and may not even look like C code anymore.
- There may be ambiguities in the code.
- Exporting code to another site can be difficult because the mapping between the hybrid characters used and the target coded character set may not be exact.

The following example illustrates these difficulties.
The code points in 'CCNGCC1', which have different glyphs in character code set IBM-273 and APL-293, appear in 'CCNGCC1' and are described below:

1. This is the code point for the { character. In coded character set 273, this is the character ä.
This is the code point for the [ character. In coded character set 273, this is the character Ý.

This is the code point for the ] character. In coded character set 273, this is the character .

This is the code point for the } character. In coded character set 273, this is the character ü.

This is the code point for the \ character. In coded character set 273, this is the character Ő.

This is the code point for the ! character. In coded character set 273, this is the character Ü.

This is the code point for the | character. In coded character set 273, this is the character !. This particular code point mapping is unfortunate because the | character and the ! character are both valid C syntax characters. Note that the ! character used in the printf() call at will appear as ! on a terminal displaying in coded character set 273.

Writing Code Using a Hybrid Coded Character Set

“CCNGCC1” on page 776 illustrates some of the problems with hybrid files. The following steps were done when writing this code:

1. Look up each variant character in coded character set IBM-1047 to find out what the compiler expects. For example, z/OS C/C++ expects the character [ to have a byte value of X'AD'.
2. Determine which glyph is at X'AD' in the local coded character set, then use this in the code.
3. Always use the appropriate substitution. For example, to obtain a needed [ in Germany, one would look up X'AD' in the German IBM-273 coded character set, and find the character Ý.

Converting Hybrid Code

Existing code that was written in a hybrid coded character set will continue to be supported.

Appendix G, “Converting Code from Coded Character Set IBM-1047” on page 851 shows you a program you can use to convert the hybrid code to another coded character set.

Coded Character Set Independence in Developing Applications

To work effectively with the locale functionality, you may need to use functions, macros, and tools. The following summary of the compile-edit work flow shows what functions to use and where you can use them.
The highlighted numbers refer to the following functions:

1 **Setup.** The `localedef` information (see overview in Chapter 48, “Customizing a Locale” on page 723 and details in “Locale Source Files” on page 684).

2 **Coded character set of source code, header files, and data.**
   The compiler must support the coded character set used to create a source file so that it will recognize the variant C syntax characters correctly.
   - The `#pragma filetag` directive identifies the coded character set of the source file as well as the library or user’s `include` files (for an overview see “The pragma filetag Directive” on page 779).
   - Predefined macros `__LOCALE__`, `__FILETAG__`, and `__CODESET__` (for an overview see “Using Predefined Macros” on page 780).
   - The function `setlocale()`
   - The `pragma convlit` directive

3 **Coded character set conversion utilities and functions.** The coded character set of a file, or a stream of data, can be converted to another coded character set using the utilities `genxlt` and `iconv` (for an overview see Chapter 51, “Code Set Conversion Utilities” on page 739) for details see the z/OS C/C++ User’s Guide, as well as the functions in the run-time library.

4 **Coded character set conversion at compile time** is determined by the compile-time locale and supported by the compiler options, `LOCALE` and `NLOCALE` (for an overview see “Converting Coded Character Sets at Compile Time” on page 782) for details see the z/OS C/C++ User’s Guide.

---

**Figure 222. Compile-Edit, Related to Locale Function**

The highlighted numbers refer to the following functions:

1 **Setup.** The `localedef` information (see overview in Chapter 48, “Customizing a Locale” on page 723 and details in “Locale Source Files” on page 684).

2 **Coded character set of source code, header files, and data.**
   The compiler must support the coded character set used to create a source file so that it will recognize the variant C syntax characters correctly.
   - The `#pragma filetag` directive identifies the coded character set of the source file as well as the library or user’s `include` files (for an overview see “The pragma filetag Directive” on page 779).
   - Predefined macros `__LOCALE__`, `__FILETAG__`, and `__CODESET__` (for an overview see “Using Predefined Macros” on page 780).
   - The function `setlocale()`
   - The `pragma convlit` directive

3 **Coded character set conversion utilities and functions.** The coded character set of a file, or a stream of data, can be converted to another coded character set using the utilities `genxlt` and `iconv` (for an overview see Chapter 51, “Code Set Conversion Utilities” on page 739) for details see the z/OS C/C++ User’s Guide, as well as the functions in the run-time library.

4 **Coded character set conversion at compile time** is determined by the compile-time locale and supported by the compiler options, `LOCALE` and `NLOCALE` (for an overview see “Converting Coded Character Sets at Compile Time” on page 782) for details see the z/OS C/C++ User’s Guide.
Run-time environment. During run time, the setlocale() function has an effect on run-time functions, such as printf(), scanf(), and regcomp(), which use variant characters.

Listings and output files. The coded character set used to create or to convert source files may affect listings, preprocessed source code, object modules, and SYSEVENT files (for an overview see "Object Modules and Output Listings" on page 784). Your application can, however, include logic using the following to minimize the impact:

- __LOCALE__, __FILETAG__, and __CODESET__ macros
- Locale functions such as setlocale()

Coded Character Set in Source Code and Header Files

There are four types of locale-related changes that you can make in your source code:

- You can tag your source code and other associated files with the #pragma filetag directive to specify the coded character set that was used while entering the file. You can then compile these to ensure that all variant characters in your files are correct.
- You can use the three macros: __LOCALE__, __FILETAG__, and __CODESET__. These z/OS C/C++ macros expand to provide information about the #pragma filetag directive of the current source, and the locale and target coded character set used by the compiler at compile time. See the chapter “Predefined Macros" in [C/C++ Language Reference] for more information.
- You can use the setlocale() function to set the run-time locale to be the same as the locale used to compile the application. This can be used when your application contains dependencies on the coded character set, as it would when comparing constants with external data. Using the macros forces the run-time locale to be the same as the one used to compile your code.
- You can use the #pragma convlit suspend and resume to exclude portions of your code from string literal conversion. See [z/OS C/C++ User's Guide] for more details on the CONVLIT compiler option and [C/C++ Language Reference] for more information on this pragma.

The pragma filetag Directive

By using the #pragma filetag directive, you may write your programs in any convenient supported coded character set (see Appendix D, “Locales Supplied with z/OS C/C++" on page 815 for a list of coded character set names). The #pragma filetag directive instructs the z/OS C/C++ compiler how to “read" the source. Tagging the source files, the header files, and all data files (including messages) with the #pragma filetag directive enables you to keep the information about the coded character set used to create each source file, within the source file itself. This information can be helpful when moving source files to systems with different coded character sets. See [C/C++ Language Reference] for the syntax and details of this pragma.

The following example tag uses the German coded character set IBM-273:

```c
??=pragma filetag("IBM-273")
```

Because the # character is variant in different coded character sets, you must use the trigraph ??= for the #pragma filetag directive.

The #pragma filetag directive specifies the coded character set in which the source or data was entered. The coded character set specified in the #pragma
filetag directive is in effect for the entire source file, but not for any other source file. This also applies to header files and data files.

The #pragma filetag directive can only appear once in each file, and it must appear before the first statement in a program. If encountered elsewhere, a warning appears and the directive does not change. If a comment contains variant characters and appears before the directive, the comment does not translate.

**Attention:** If you wish to use the iconv utility on a file that is tagged with the ??= #pragma filetag directive, you must update the file manually to change the filetag to the correct converted coded character set. iconv does not update the pragma in source files.

**Using Predefined Macros**
There are three macros for z/OS C/C++ that relate to locale.

**__LOCALE__**
This macro expands to a string literal representing the locale of the LOCALE compiler option. This macro can be used to set the run-time locale to be the same as the compiled locale:

```c
main() {
    setlocale(LC_ALL, __LOCALE__);
    ...
}
```

The value of this macro is defined per compilation. If NOLOCALE compiler option is supplied, the macro is undefined.

**__FILETAG__**
This macro expands to a string literal representing the character coded character set of the #pragma filetag directive associated with the current file. For example, to convert to the coded character set specified by the LOCALE option from the coded character set specified by the #pragma filetag directive, you would use the iconv_open() function:

```c
iconv_open(__FILETAG__, variable);
```

The value of this macro is defined per source file. If no #pragma filetag directive is present, the macro is undefined.

**__CODESET__**
This macro expands to a string literal representing the character coded character set of the LOCALE compiler option. The value of this macro is defined per compilation. If a value is not supplied, the macro is undefined.
The following illustration shows the values that these macros will take on, emphasizing that for __FILETAG__, a value is assigned for each source file, but for __LOCALE__ and __CODESET__, a value is assigned for a compilation.

```c
#include <iconv.h>
#include <string.h>
#include <stdio.h>

/* The following function could be in a header file */
#if defined __CODESET__
    static int convstr(iconv_t convInfo, char *in, int inSize, char *out, int outSize) {
        return(iconv(convInfo, in, inSize, out, outSize))
    }
#else
    static int convstr(iconv_t convInfo, char *in, int inSize, char *out, int outSize) {
        memcpy(out, in, outSize > inSize ? inSize : outSize);
        return(outSize > inSize ? -1 :: 0);
    }
#endif

iconv_t convInfo;

int main() {
#if defined __CODESET__
    char *run-timeCodeSet;
    setlocale(LC_ALL, ""); /* set locale to default locale */
    run-timeCodeSet = nl_langinfo(CODESET);
    convInfo = iconv_open(run-timeCodeSet, __CODESET__);
#else
    char intro[] = "Welcome to my variant world!\n";
    char nlIntro[sizeof(intro)];
    convstr(convInfo, intro, sizeof(intro), nlIntro, sizeof(nlIntro));
    puts(nlIntro); /* string will print appropriately */
#endif
    iconv_close(convInfo);

    return(0);
}
```

Figure 223. Example of __CODESET__ macro
Using setlocale()
You can change the run-time locale to any one of the other predefined locales listed in Table 81 on page 815. To use a defined locale, refer to it by its setlocale() parameter.

To define a new locale, copy the source file provided, edit it, then assemble it (see Chapter 48, “Customizing a Locale” on page 723).

Converting Coded Character Sets at Compile Time

CONVLIT Compiler Option
You can control the conversion of string literals in your code by using the CONVLIT compiler option. CONVLIT provides a means for changing the assumed code page for character string literals by supplying a codepage value. See z/OS C/C++ User’s Guide for the syntax and details of this compiler option.

For example, if you used an ASCII client machine to write code that uses string literals, and then upload this to an EBCDIC server such as MVS, your string literals would be converted to EBCDIC. However, if you specified “CONVLIT(ISO8859-1)” when you compiled your code, your string literals would have been converted to an ASCII code page.
Consider the following program:

/* header.h */
char *text="Hello World";

/* test.c */
#pragma convlit(suspend)
#pragma comment (user, "A user comment")
#include <stdio.h>
#include "header.h"
#pragma convlit(resume)

main()
{
    char *text2 ="Hi There!";
}

When this program is compiled with the CONVLIT(IS08859-1) option, the string "Hi There!" will be converted to an ASCII string, but the string "Hello World" will not be converted.

**LOCALE Compiler Option**

The LOCALE compiler option enables you to instruct the compiler to use a specific locale at compile time, which then generates the output in the same coded character set.

The input files that are affected are:

- The primary source file
- Library header files
- User header files

The output files that are affected are:

- Object Modules
- Preprocessed source code
- Listings

To use the LOCALE option, you must supply a locale name value. The locale name is a string that represents the locale you want to compile source with; this will determine the characteristics of output, including the coded character set used for variant characters in the source. Usually, a locale name is of the format *territory name.coded character set*. For example, the German locale for coded character set 273 is De_DE.IBM-273. The *territory name* is De_DE and the *coded character set* is IBM-273. To determine the coded character set of the current locale, use the function `nl_langinfo(CODESET)`.

The special locale name "" gives you the default locale, which can be set using environment variables. The locale name "C" specifies the C default locale. Full details about the C locale are found in Chapter 50, “Definition of S370 C, SAA C, and POSIX C Locales” on page 731.

The default option setting is NOLOCALE. It instructs the compiler to do no conversion of text for input or for output.

You can create your own locales by using the `localedef` utility. See “Locale Source Files” on page 684 for details.

**Examples:** To compile a sample file, userid.SORTNAME.C, enter:
The compiler recognizes "De_DE.IBM-273" as a valid locale and automatically converts the source code to coded character set IBM-273, for its own use. The compiler would then generate listings in the German coded character set 273.

To generate a preprocessed file that can be sent to other sites, that use different coded character sets, enter:

```
CC 'userid.SORTNAME.C' (LOCALE("De_DE.IBM-273") PPONLY)
```

The compiler will insert the `#pragma filetag` directive at the start of the preprocessed file, using the coded character set specified in the LOCALE option. In this example, `?#pragma filetag("IBM-273")` is inserted.

Since the preprocessed file has been tagged, it can be compiled using the z/OS C/C++ compiler at any site, regardless of the locale used.

**Summary of Usage for LOCALE, NOLOCALE, and pragma filetag directive:**

The following list shows the results from different combinations of the `#pragma filetag` directive and the LOCALE compiler option.

**Using LOCALE compiler option**

In this case, the compiler does the following:

- Converts the source code from the coded character set specified with the `#pragma filetag` directive to the code set specified by the LOCALE compiler option.
- If no `#pragma filetag` directive is specified, the compiler assumes the source is in the same coded character set as specified by the locale, and does not perform any conversion.
- Converts compiler error messages from coded character set IBM-1047 to the coded character set specified in the LOCALE compiler option.
- Generates compiler output in the same coded character set as that of the locale specified in the LOCALE compiler option.
- If PPONLY was specified, the compiler inserts the `#pragma filetag` directive at the beginning of the preprocessor file, using the coded character set specified in the locale option.

**Using NOLOCALE compiler option**

In this case, the compiler does the following:

- Does not convert text in the input or output file, and uses the default coded character set IBM-1047 to interpret syntactic characters.
- If a `#pragma filetag` directive is specified, the compiler suppresses the `#pragma filetag` directive in the preprocessor file. The compiler issues warnings if the `#pragma filetag` directive specifies a coded character set other than IBM-1047, and uses IBM-1047 anyway.

**Object Modules and Output Listings:** The compiler respects the locale specified by the LOCALE compiler option in generating the listing. If the locale option is specified, the object module is generated in the coded character set of your current locale. Otherwise, the object module is generated in the coded character set IBM-1047.

Code will run correctly if the run-time locale is the same as the locale of the object module.
If the object was generated with a different locale from the one you run under, you must ensure that your code can run under different locales. Refer to Chapter 48, "Customizing a Locale" on page 723 for more information.

For information about exporting code to other sites, see "Exporting Source Code to Other Sites" on page 787.

You can use the LOCALE compiler option to ensure that listings are sensitive to a specified locale. For example, here is the result from compiling the source file hello273.c with:

```
c89 -o hello273 -Wc,so,locale("De_DE.IBM-273"),xplink,goff -Wl,xplink hello273.c
```
In the listing above, notice the locale-specific information:

1. The date at the top right. The format of the date in the listing is that specified by the locale.
2. The name of the locale and the code set.
3. Code points for the }, /, and { characters.
Writing Source Code in Coded Character Set IBM-1047

There are two reasons why you would want to write source in coded character set IBM-1047.

First, even though z/OS C/C++ provides support for multiple coded character sets, other tools may not do so. Tools such as CICS and DB2 may not support source code in any coded character set other than the default coded character set, IBM-1047. If you are using these tools, and you write your code in a code page other than IBM-1047, you will need to use the z/OS C/C++ iconv utility to convert your code to coded character set IBM-1047 before you can use the tool.

Second, older versions of the C/370 product do not support source in coded character sets other than IBM-1047. This makes it difficult to share code with a site using an older compiler.

Exporting Source Code to Other Sites

This section deals with the exporting of code from one Latin-1 coded character set to another; that is, writing code that can be run in a locale that uses a different coded character set than the one used to write the source.

To export code, use the `iconv()` utility to convert each source file, header file, and data file to the target coded character set. You can then send all files to the target location for compilation.

**Note:** You must ensure that your code runs in the same locale that it was compiled under before running it with any other locales.

1. Use the `#pragma filetag` directive to tag each source file, header file, and data file.
2. Use message files for all external strings, such as prompts, help screens, and error messages. To write truly portable code, convert these strings to the run-time coded character set in your application code.
3. Use the `setlocale()` function so that the library functions are sensitive to the run-time coded character set.

   Ensure that locale-sensitive information, such as decimal points, are displayed appropriately. Use either `nl_langinfo()` or `localeconv()` to obtain this information.

   The `setlocale()` function does not change the CEE callable services under the z/OS Language Environment in such areas as date, time, currency, and time zones. Internationalization is specific to z/OS C/C++ applications. Also, the z/OS Language Environment CEE callable services do not change the z/OS C/C++ locales. For a list of these callable services, see the z/OS Language Environment Programming Guide.

4. Compile with the locale specifying coded character set IBM-1047.

If you specify `locale("locale-name")`, your code will run correctly with libraries running in the same coded character set. However, if you compile with a different locale than you run under, you have to ensure that your code has no internal data, and also that all libraries you use are run-time locale sensitive. Consider the following code fragment:
int main() {
    setlocale(LC_ALL, "");
    :
    rc = scanf("%[1234567890abcdefABCDEF]", hexNum);
    :
}

For example, if you compile with `locale("De_DE.IBM-273")`, the square brackets are converted to the hex values `X'63'` and `X'FC'`. If the default locale you then run under is not "De_DE.IBM-273", but instead "En_US.IBM-1047", and you have not used `setlocale()`, the square brackets will be interpreted as Å and Ü, and the call to `scanf()` will not do what you intended.

If you only need to run your code locally or export it to a site that has your locale environment, you can solve this problem by coding:

```c
int main() {
    setlocale(LC_ALL, __LOCALE__);
    :
    rc = scanf("%[1234567890abcdefABCDEF]", hexNum);
    :
}
```

This ensures that your code runs with the same locale it was compiled under. Library functions such as `printf()`, `scanf()`, `strftime()`, and `regcomp()` are sensitive to the current coded character set. The `__LOCALE__` macro is described in "Using Predefined Macros" on page 780.

If you are generating code to export to a site that may not have your locale environment, you should write your code in IBM-1047.

---

## Converting Existing Work

This section describes some conversion issues and presents some conversion scenarios. It is assumed that existing source code and libraries cannot be quickly converted from mixed coded character sets into a common coded character set; thus a staged approach is recommended.

- Code your new source in one coded character set, preferably IBM-1047. Tag all new source files to make them more portable by putting the `#pragma filetag` directive at the top of each one.

- If you need to interact with existing code, compile your new code using the locale in which the existing code was written.

- If you want to write code in a coded character set that does not have a one-to-one mapping to coded character set IBM-1047 (that is, a coded character set that is not Latin-1), create your own conversion table and compile it with the `genxlt` utility. Use your own conversion table with the `iconv` utility to convert your source code to coded character set IBM-1047.
Considerations With Other Products and Tools

Note: Any software tool that scans source code or compiler listings is affected by the introduction of the locale functionality. Tools that read or generate source code now need to recognize the #pragma filetag directive. Tools that read listings need to recognize the coded character set in the title header.

Since the following tools scan source code, they may be affected:

- The Debug Tool does not support code written in any coded character set other than IBM-1047.
- Translators such as CICS and DB2 read source files and generate new source files. If they do not, then follow these steps:
  1. Convert the source file to coded character set IBM-1047 using the iconv utility.
  2. Remove the #pragma filetag directive from the source file, or change it to ??=pragma filetag("IBM-1047"). Run the source that is in the IBM-1047 coded character set through the appropriate translator, if needed.
Chapter 53. Bidirectional Language Support

This chapter describes the characteristics of bidirectional languages, and provides an overview of the layout functions for bidirectional languages. For more information on the layout functions see [z/OS C/C++ Run-Time Library Reference] and X/Open Portable Layout Services: Context-dependent and Directional Text.

Bidirectional Languages

Bidirectional languages are languages such as Arabic and Hebrew, that are written and read mainly from right to left, but some portions of the text, such as numbers and embedded Latin languages (e.g. English) are written and read left to right. Additional characteristics of bidirectional languages include:

- visual order versus logical order
- symmetric swapping
- number formats
- cursive (shaping) versus non-cursive

In bidirectional text it is important to note the difference between the logical order in which the text is processed or read, and the visual order in which the text is displayed. Bidirectional text is usually stored in logical order. For example, assume that the following text is Arabic, then the logical storage would contain:

maple street 25 entrance b

and the visual display would be (if read from right to left):

b ecnartne 25 teerts elpam

Some characters, such as the greater-than sign, have an implied directional meaning and have a complementary symmetric character with an opposite directional meaning (the less-than sign.) When used within a segment that is presented right-to-left but is inverted (left-to-right) when stored for processing, such a character might have to be replaced by its symmetric sibling to ensure that the correct meaning of the text is preserved. The replacement of such a character by its complement during the transformation of BiDi text is called “symmetrical swapping”. Other graphic characters that need symmetrical swapping include the parentheses, square brackets, braces, and so on. Although symmetrical swapping is a characteristic of BiDi languages, it is not always mandatory for the software functions that transform different BiDi language text layouts. Sometimes this function is performed automatically by the workstation hardware or micro code.

Arabic numerals (Latin digits) are those numerals used with Latin text, while Hindi numerals are used within Arabic text, in some of the Arabian countries, like Egypt. However, the Implicit algorithm states the number storage should use Arabic numerals (Latin digit), and be displayed according to the user’s settings.

Note that even though the text in the example is displayed right to left, the number “25” is still written left to right. That is because Arabic/Hebrew numbers are written and read left to right.

Arabic is a cursive language. Arabic characters are connected together, and each character has different shapes depending on its location within the word: initial, middle, final or isolated. Cursive languages are suited to handwriting rather than printing. Arabic is always cursive, whether in books, newspapers, signs or
workstation displays. English can be handwritten in a cursive style, and it is often used that way in personal communications, but English is seldom published or displayed in a cursive style. Thus, English is not considered a cursive language.

To simplify processing, characters are usually stored in an unshaped form. (The unshaped form is also referred to as the abstract or basic form.) Shaping takes into account the character being shaped and the characters in its vicinity, and replaces the unshaped, abstract form with the proper shape. For example, in Arabic, the unshaped character would be replaced with the initial, middle, final or isolated shaped character, depending on the context.

Note that Hebrew letters do not use shaping, and numbers used with Hebrew text are always displayed with the same digits as used for English.

Legacy operating systems like MVS used to store Arabic and Hebrew data in their visual format. Sometimes for specific needs, data might be stored in a specific shape, for example initial shape. Currently, most applications store text in its unshaped form in logical order. Reordering and shaping are done at display time. Storing text in its unshaped form in logical order makes it easier to process the data (sorting, comparison).

Overview of the Layout Functions
The layout functions are used to handle bidirectional languages correctly, to transform text from a format readable for the user to a format suitable for processing, and vice-versa. The layout functions include the following:

- **m_create_layout()** — called at the beginning of the application to create the layout object that will be used by the other layout functions.
- **m_setvalues_layout()** — sets the values that will be used inside the transform. **m_setvalues_layout()** must be called before calling **m_transform_layout** or **m_wtransform_layout**. This function is optional. Use this function if you need to change the values for the bidirectional attributes. You can eliminate it from the application, and use a modifier instead.
- **m_getvalues_layout()** — queries the current layout values within a layout object.
- **m_transform_layout()** — does the actual processing to convert the text format between different bidirectional layouts, according to the settings of the **LayoutObject**. Nothing will change if this function (or its wide character equivalent) is not called inside the application.
- **m_wtransform_layout()** — works the same as **m_transform_layout()**, except that it handles Unicode wide characters (wchar_t).
- **m_destroy_layout()** — called at the end of the application to destroy the layout object, and free up the allocated memory used by the layout object.

Those functions can be used to convert text from logical (implicit) unshaped forms to visual (display) shaped forms and vice versa. The layout functions also handle conversion of numerals.

**m_create_layout( )**

```
#include <sys/layout.h>
LayoutObject m_create_layout(const AttrObject attrobj,const char* modifier);
```

This function creates a **LayoutObject** associated with the locale identified by **attrobj**. The **LayoutObject** is an opaque object containing all the data and methods necessary to perform the layout operations on context-dependent or directional characters of the locale identified by the **attrobj**. The memory for the **LayoutObject** is allocated by **m_create_layout( )**. The **LayoutObject** created has default layout...
values. (If the modifier argument is not NULL, the layout values specified by the modifier overwrite the default layout values associated with the locale).

attrobj argument
Is or may be an amalgam of many opaque objects. A locale object is just one example of the type of object that can be attached to an attribute object. The attrobj argument specifies a name that is usually associated with a locale category.

modifier argument
Can be used to announce a set of layout values when the LayoutObject is created.

m_setvalues_layout()
#include <sys/layout.h>
int m_setvalues_layout(LayoutObject layout_object, const LayoutValues values,
int *index_returned);

This function is used to change the layout values of a LayoutObject.

layout_object argument
Specifies a LayoutObject returned by the m_create_layout() function.

values argument
Specifies the list of layout values that are to be changed. The values are written into the LayoutObject and may affect the behavior of subsequent layout functions.

m_getvalues_layout()
#include <sys/layout.h>
int m_getvalues_layout(const LayoutObject layout_object, LayoutValues values,
int *index_returned);

This function is used to query the current settings of the layout values within a Layout Object.

layout_object argument
Specifies a Layout Object returned by the m_create_layout() function.

values argument
Specifies the list of layout values that are to be queried. Each value element of a LayoutValueRec must point to a location where the layout value is stored. That is, if the layout value is of type T, the argument must be of type *T. The values are queried from the Layout Object and represent its current setting. It is the user’s responsibility to manage the memory allocation for the layout values queried. If the layout value name has QueryValueSize ORed to it, instead of the setting of the layout value, only its size is returned. This option can be used by the caller to determine the amount of memory needed to be allocated for the layout values queried.

m_transform_layout()
#include <sys/layout.h>
int m_transform_layout(LayoutObject layout_object,
const char *InpBuf,
const size_t InpSize,
void *OutBuf,
size_t *Outsize,
size_t *InpToOut,
size_t *OutToInp,
unsigned char *Property,
size_t *InpBufIndex);
This function performs layout transformations (reordering and shaping), or it may provide additional information needed for layout transformation (such as the expected size of the transformed layout, the nesting level of different segments in the text and cross references between the locations of the corresponding elements before and after the layout transformation). Both the input text and output text are character strings. The m_transform_layout() function transforms the input text in InpBuf according to the current layout values in layout_object. Any layout value whose value type is LayoutTextDescriptor describes the attributes of the InpBuf and OutBuf arguments. If the attributes are the same for both InpBuf and OutBuf, a null transformation is performed with respect to that specific layout value. The InpBuf argument specifies the source text to be processed. The InpSize argument specifies the number of bytes within InpBuf to be processed by the transformation. Its value will not change after return from the transformation.

**LayoutObject argument**
- Specifies the Layout Object returned by m_create_layout().

**InpBuf argument**
- Corresponds to the input string that the layout functions will process.

**InpSize argument**
- Gives the input size of the input string specified by the InpBuf argument.

**OutBuf argument**
- Any transformed data is stored here. This buffer will contain the data after converting it to the specified layout values and output code page.

**Outsize argument**
- Gives the number of bytes in the Output Buffer.

**InpToOut Mapping argument**
- A cross-reference from each InpBuf code element to the transformed data. The cross-reference relates to the data in InpBuf starting with the first element that InpBufIndex points to (and not necessarily starting from the beginning of the InpBuf).

**OutToInp Mapping argument**
- A cross-reference to each InpBuf code element from the transformed data. The cross-reference relates to the data in InpBuf starting with the first element that InpBufIndex points to (and not necessarily starting from the beginning of the InpBuf).

**Property argument**
- A weighted value that represents peculiar input string transformation properties with different connotations. If this argument is not a NULL pointer, it represents an array of values with the same number of elements as the source sub string text before the transformation. Each byte will contain relevant "property" information of the corresponding element in InpBuf starting from the element pointed by InpBufIndex.

**InpBufIndex argument**
- InpBufIndex is an offset value to the location of the transformed text. When m_transform_layout() is called, InpBufIndex contains the offset to the element in InpBuf that will be transformed first. (Note that this is not necessarily the first element in InpBuf). At the return from the transformation, InpBufIndex contains the offset to the first element in the InpBuf that has not been transformed. If the entire sub string has been transformed successfully, InpBufIndex will be incremented by the amount defined by InpSize.
The m_wtransform_layout is the same as m_transform_layout, except that it takes Unicode (wchar_t *) as an input buffer.

m_destroy_layout( )
#include <sys/layout.h>
int m_destroy_layout(const LayoutObject layoutobject);

This function destroys the layout object and frees up the allocated memory used by the layout object.

Using the Layout Functions

Perform the following steps to use the layout functions:

1. Include the sys/layout.h header file to define the values and function prototypes.
   Example:
   #include <sys/layout.h>

2. Declare the program variables.
   Example:
   LayoutObject plh;
   int error = 0, index;
   size_t insize = 9, outsize;
   LayoutValues layout;
   LayoutTextDescriptor set_desc;
   char *inbuffer;
   char *outbuffer;
   char *inShape;
   char *outShape;
   char *myModifier = "@lstypeoftext=implicit:visual,shaping=nominal:shaped,orientation=ltr:rtl";

   In the first line declare a LayoutObject called "plh", this is the layout object that m_create_layout() creates later when invoked. index is the index of the returned error. insize is the size of the input buffer, and outsize is the size of the output buffer. The four integer variables in the second and third lines will be used later in the call of m_setvalues_layout() and m_transform_layout(). In the fourth line declare a LayoutValues variable called "layout" and in the fifth line declare a LayoutTextDescriptor called "set_desc". These two variables are very important. They will be used with m_setvalues_layout() in the form of input/output pairs to specify new input and output values for each one of the specified attributes. The next two lines add four strings (char *), that will be used as the input buffer, output buffer, input code page and finally the output code page. The last line adds a string that specifies the modifier to be used as specified earlier in the m_create_layout() function to create the layout object.
3. Allocate memory to the declared strings, layout values, layout text descriptor, and write the contents of the input buffer.

Example:

```c
inbuffer = (char *)malloc(insize*sizeof(char));
outbuffer = (char *)malloc(outsize*sizeof(char));
layout = (LayoutValues)malloc(6*sizeof(LayoutValueRec));
set_desc = (LayoutTextDescriptor)malloc(3*sizeof(LayoutTextDescriptorRec));
inShape = (char*) malloc(20 * sizeof(char));
outShape = (char*) malloc(20 * sizeof(char));
inbuffer[0] = 0xB0;
inbuffer[1] = 0xB1;
inbuffer[2] = 0xB2;
inbuffer[3] = 0xBF;
inbuffer[4] = 0x40;
inbuffer[5] = 0x9A;
inbuffer[6] = 0x75;
inbuffer[7] = 0x58;
inbuffer[8] = 0xDC;
```

The values of the input buffer are added one by one as an array of characters, but several alternatives could be used. For example, you can read the input buffer as a string from a file, or get it from another application.

4. Call the m_create_layout() function to create a layout object "plh".

Example:

```c
plh = m_create_layout("Ar_AA",myModifier);
```

The layout object "plh" is created with the locale Ar-AA with the modifier myModifier.

5. At this point of the program there are two options, either call m_setvalues_layout() or just call the m_transform_layout() (or m_wtransform_layout()) directly.

Specify the input/output layout values. The first two lines below specify the two strings used as the input and output code pages. These two strings will be used by the other functions to specify the input code page for the input buffer and the output code page for the output buffer.

Example:

```c
strcpy(outShape,"ibm-420");
strcpy(inShape,"ibm-425");
```

Add the input/output layout text descriptor pairs. These pairs are in the form of input descriptor and output descriptor, for example the first statement specifies that the input orientation will be "orientation-left-to-right" and the second statement specifies that the output orientation will be also "orientation-left-to-right". All the above pairs follow the same rule to define the input/output pairs.
Example:

```c
layout[0].name = ShapeCharset;
layout[0].value = (char *)outShape;
layout[1].name = InputCharset;
layout[1].value = (char *)inShape;
layout[2].name = Orientation;
layout[2].value = (LayoutTextDescriptor *)&set_desc[0];
layout[3].name = TypeOfText;
layout[3].value = (LayoutTextDescriptor *)&set_desc[1];
layout[4].name = TextShaping;
layout[4].value = (LayoutTextDescriptor *)&set_desc[2];
layout[5].name = 0;
```

In the above lines "set_desc" pairs create the new layout values attributes. Each one of these statements will be in the form of attribute_name/attribute_value pairs, for example in the fifth and sixth statements "Orientation" is the attribute name and set_desc[0] (as defined above) is the attribute value. The first two statements are used to declare the output code page and the following two lines are used to specify the input code page.

Call the m_setvalues_layout() function.

Example:

```c
if((error = m_setvalues_layout(plh, layout, &index)))
    printf("An error %d occurred in setting the value number %d\n", error, index);
```

Invoke m_setvalues_layout() using the layout object "plh", the layout values "layout" and an integer "index". If m_setvalues_layout() could not set any one of the layout values attributes, it will return -1 in the integer variable called "error", and also return the index of the layout value that caused the problem.

6. Call the m_transform_layout() function. The m_transform_layout() and m_wtransform_layout() functions are the same, except that m_wtransform_layout() is used for wide character (wchar_t). Both functions will do the actual reordering and shaping of the input buffer using the layout object (plh) created in step 4.

Example:

```c
m_transform_layout(plh, inbuffer, insize, outbuffer, &outsize, NULL, NULL, NULL, NULL);
```

*plh*  The Layout Object returned by m_create_layout().

*inbuffer*  Corresponds to the input string to the function that the layout functions will process.

*insize*  Gives the input size of the input string specified by the Input Buffer argument.

*outbuffer*  Any transformed data is stored here. This buffer will contain the data after converting it to the specified output code page.
**outsize**

Gives the number of bytes in the Output Buffer.

The last four parameters are given here as NULL and they represent Input To Output Mapping, Output To Input Mapping, Property and Input Buffer Index as described above in the Overview of the Layout Functions. Each of these output arguments may be NULL to specify that no output is desired for the specific argument.

---

7. Call the `m_destroy_layout()` function. This function must be called at the end of the program to destroy the layout object or to free up the allocated memory used by the layout object.

**Example:**

```
m_destroy_layout(plh);
```
CCNGBID1

/*******************************************************************************
/* This is a simple program that explains how the layout API’s are used */
/* This program will convert a simple implicit unshaped Arabic string */
/* to a visual shaped Arabic string. */
#include <sys/layout.h>
#include <stdio.h>

void main(int argc,char** argv)
{
    LayoutObject plh;
    int error = 0;
    LayoutValues layout;
    LayoutTextDescriptor set_desc;
    size_t insize = 9,outsize = 9;
    
    char *inbuffer= NULL;
    char *outbuffer= NULL;
    char *inShape= NULL;
    char *outShape= NULL;
    char *myModifier = "@lstypeoftext=implicit:visual,shaping=nominal:shaped,orientation=ltr:rtl";

    inbuffer = (char*) malloc((insize+1)*sizeof(char) ) ;
    outbuffer = (char*) malloc((outsize+1)*sizeof(char) ) ;
    layout = (LayoutValues)malloc(6*sizeof(LayoutValueRec));
    set_desc = (LayoutTextDescriptor)malloc(3*sizeof(LayoutTextDescriptorRec));
    inShape = (char*) malloc(8 * sizeof(char));
    outShape = (char*) malloc(8 * sizeof(char));

    inbuffer[0] = 0xB0; /* These are the HEX code for Arabic characters in the IBM-425 codepage */
    inbuffer[1] = 0xB1;
    inbuffer[2] = 0xB2;
    inbuffer[3] = 0xBF;
    inbuffer[4] = 0x40;
    inbuffer[5] = 0x9A;
    inbuffer[6] = 0x75;
    inbuffer[7] = 0x58;
    inbuffer[8] = 0xDC;

    Figure 226. Example of bidirectional layout API’s (Part 1 of 2)
plh = m_create_layout("Ar_AA",myModifier);
strcpy(outShape,"ibm-420");
strcpy(inShape,"ibm-425");

set_desc[0].inp = ORIENTATION_LTR;
set_desc[0].out = ORIENTATION_LTR;

set_desc[1].inp = TEXT_IMPLICIT;
set_desc[1].out = TEXT_VISUAL;

set_desc[2].inp = TEXT_NOMINAL;
set_desc[2].out = TEXT_SHAPED;

layout[0].name = ShapeCharset;
layout[0].value = (char *)outShape;

layout[1].name = InputCharset;
layout[1].value = (char *)inShape;

layout[2].name = Orientation;
layout[2].value = (LayoutTextDescriptor)&set_desc[0];

layout[3].name = TypeOfText;
layout[3].value = (LayoutTextDescriptor)&set_desc[1];

layout[4].name = TextShaping;
layout[4].value = (LayoutTextDescriptor)&set_desc[2];

layout[5].name = 0;

if( error=m_setvalues_layout(plh,layout,&index))
  printf("An error %d occurred in setting the value number %d\n",error,index);

m_transform_layout(plh,inbuffer,insize,outbuffer,&outsize,NULL,NULL,NULL,NULL);

m_destroy_layout(plh);

if(inbuffer)
  free(inbuffer);
if(outbuffer)
  free(outbuffer);
if(set_desc)
  free(set_desc);
if(layout)
  free(layout);
if(inShape)
  free(inShape);
if(outShape)
  free(outShape);
}

Figure 226. Example of bidirectional layout API's (Part 2 of 2)
Appendix A. POSIX Character Set

POSIX 1003.2, section 2.4, specifies the characters that are in the portable character set. The following table lists the characters in the portable character set with their symbolic name, the GCGID, and the graphic symbol for the character. Some of the characters (the hyphen, for example) also have alternate symbolic names.

The input files for the localedef utility, the charmap file and the locale definition file, are coded using the characters in the portable character set.

<table>
<thead>
<tr>
<th>Symbolic Name</th>
<th>Alternate Name</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;NUL&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;alert&gt;</td>
<td>&lt;SE08&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;backspace&gt;</td>
<td>&lt;SE09&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;tab&gt;</td>
<td>&lt;SE10&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;newline&gt;</td>
<td>&lt;SE11&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;vertical-tab&gt;</td>
<td>&lt;SE12&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;form-feed&gt;</td>
<td>&lt;SE13&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;carriage-return&gt;</td>
<td>&lt;SE14&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;space&gt;</td>
<td>&lt;SP01&gt;</td>
<td></td>
</tr>
<tr>
<td>&lt;exclamation-mark&gt;</td>
<td>&lt;SP02&gt;</td>
<td>!</td>
</tr>
<tr>
<td>&lt;quotation-mark&gt;</td>
<td>&lt;SP04&gt;</td>
<td>&quot;</td>
</tr>
<tr>
<td>&lt;number-sign&gt;</td>
<td>&lt;SM01&gt;</td>
<td>#</td>
</tr>
<tr>
<td>&lt;dollar-sign&gt;</td>
<td>&lt;SC03&gt;</td>
<td>$</td>
</tr>
<tr>
<td>&lt;percent-sign&gt;</td>
<td>&lt;SM02&gt;</td>
<td>%</td>
</tr>
<tr>
<td>&lt;ampersand&gt;</td>
<td>&lt;SM03&gt;</td>
<td>&amp;</td>
</tr>
<tr>
<td>&lt;apostrophe&gt;</td>
<td>&lt;SP05&gt;</td>
<td>’</td>
</tr>
<tr>
<td>&lt;left-parenthesis&gt;</td>
<td>&lt;SP06&gt;</td>
<td>(</td>
</tr>
<tr>
<td>&lt;right-parenthesis&gt;</td>
<td>&lt;SP07&gt;</td>
<td>)</td>
</tr>
<tr>
<td>&lt;asterisk&gt;</td>
<td>&lt;SM04&gt;</td>
<td>*</td>
</tr>
<tr>
<td>&lt;plus-sign&gt;</td>
<td>&lt;SA01&gt;</td>
<td>+</td>
</tr>
<tr>
<td>&lt;comma&gt;</td>
<td>&lt;SP08&gt;</td>
<td>,</td>
</tr>
<tr>
<td>&lt;hyphen&gt;</td>
<td>&lt;SP10&gt;</td>
<td>-</td>
</tr>
<tr>
<td>&lt;hyphen-minus&gt;</td>
<td>&lt;SP10&gt;</td>
<td>-</td>
</tr>
<tr>
<td>&lt;period&gt;</td>
<td>&lt;SP11&gt;</td>
<td>.</td>
</tr>
<tr>
<td>&lt;slash&gt;</td>
<td>&lt;SP12&gt;</td>
<td>/</td>
</tr>
<tr>
<td>&lt;zero&gt;</td>
<td>&lt;ND10&gt;</td>
<td>0</td>
</tr>
<tr>
<td>&lt;one&gt;</td>
<td>&lt;ND01&gt;</td>
<td>1</td>
</tr>
<tr>
<td>&lt;two&gt;</td>
<td>&lt;ND02&gt;</td>
<td>2</td>
</tr>
<tr>
<td>&lt;three&gt;</td>
<td>&lt;ND03&gt;</td>
<td>3</td>
</tr>
<tr>
<td>&lt;four&gt;</td>
<td>&lt;ND04&gt;</td>
<td>4</td>
</tr>
<tr>
<td>&lt;five&gt;</td>
<td>&lt;ND05&gt;</td>
<td>5</td>
</tr>
<tr>
<td>&lt;six&gt;</td>
<td>&lt;ND06&gt;</td>
<td>6</td>
</tr>
<tr>
<td>Symbolic Name</td>
<td>Alternate Name</td>
<td>Character</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------</td>
<td>-----------</td>
</tr>
<tr>
<td>&lt;seven&gt;</td>
<td>&lt;ND07&gt;</td>
<td>7</td>
</tr>
<tr>
<td>&lt;eight&gt;</td>
<td>&lt;ND08&gt;</td>
<td>8</td>
</tr>
<tr>
<td>&lt;nine&gt;</td>
<td>&lt;ND09&gt;</td>
<td>9</td>
</tr>
<tr>
<td>&lt;colon&gt;</td>
<td>&lt;SP13&gt;</td>
<td>:</td>
</tr>
<tr>
<td>&lt;semicolon&gt;</td>
<td>&lt;SP14&gt;</td>
<td>;</td>
</tr>
<tr>
<td>&lt;less-than-sign&gt;</td>
<td>&lt;SA03&gt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>&lt;equals-sign&gt;</td>
<td>&lt;SA04&gt;</td>
<td>=</td>
</tr>
<tr>
<td>&lt;greater-than-sign&gt;</td>
<td>&lt;SA05&gt;</td>
<td>&gt;</td>
</tr>
<tr>
<td>&lt;question-mark&gt;</td>
<td>&lt;SP15&gt;</td>
<td>?</td>
</tr>
<tr>
<td>&lt;commercial-at&gt;</td>
<td>&lt;SM05&gt;</td>
<td>@</td>
</tr>
<tr>
<td>&lt;A&gt;</td>
<td>&lt;LA02&gt;</td>
<td>A</td>
</tr>
<tr>
<td>&lt;B&gt;</td>
<td>&lt;LB02&gt;</td>
<td>B</td>
</tr>
<tr>
<td>&lt;C&gt;</td>
<td>&lt;LC02&gt;</td>
<td>C</td>
</tr>
<tr>
<td>&lt;D&gt;</td>
<td>&lt;LD02&gt;</td>
<td>D</td>
</tr>
<tr>
<td>&lt;E&gt;</td>
<td>&lt;LE02&gt;</td>
<td>E</td>
</tr>
<tr>
<td>&lt;F&gt;</td>
<td>&lt;LF02&gt;</td>
<td>F</td>
</tr>
<tr>
<td>&lt;G&gt;</td>
<td>&lt;LG02&gt;</td>
<td>G</td>
</tr>
<tr>
<td>&lt;H&gt;</td>
<td>&lt;LH02&gt;</td>
<td>H</td>
</tr>
<tr>
<td>&lt;I&gt;</td>
<td>&lt;LI02&gt;</td>
<td>I</td>
</tr>
<tr>
<td>&lt;J&gt;</td>
<td>&lt;LJ02&gt;</td>
<td>J</td>
</tr>
<tr>
<td>&lt;K&gt;</td>
<td>&lt;LK02&gt;</td>
<td>K</td>
</tr>
<tr>
<td>&lt;L&gt;</td>
<td>&lt;LL02&gt;</td>
<td>L</td>
</tr>
<tr>
<td>&lt;M&gt;</td>
<td>&lt;SM02&gt;</td>
<td>M</td>
</tr>
<tr>
<td>&lt;N&gt;</td>
<td>&lt;LN02&gt;</td>
<td>N</td>
</tr>
<tr>
<td>&lt;O&gt;</td>
<td>&lt;LO02&gt;</td>
<td>O</td>
</tr>
<tr>
<td>&lt;P&gt;</td>
<td>&lt;LP02&gt;</td>
<td>P</td>
</tr>
<tr>
<td>&lt;Q&gt;</td>
<td>&lt;LQ02&gt;</td>
<td>Q</td>
</tr>
<tr>
<td>&lt;R&gt;</td>
<td>&lt;LR02&gt;</td>
<td>R</td>
</tr>
<tr>
<td>&lt;S&gt;</td>
<td>&lt;LS02&gt;</td>
<td>S</td>
</tr>
<tr>
<td>&lt;T&gt;</td>
<td>&lt;LT02&gt;</td>
<td>T</td>
</tr>
<tr>
<td>&lt;U&gt;</td>
<td>&lt;LU02&gt;</td>
<td>U</td>
</tr>
<tr>
<td>&lt;V&gt;</td>
<td>&lt;LV02&gt;</td>
<td>V</td>
</tr>
<tr>
<td>&lt;W&gt;</td>
<td>&lt;LW02&gt;</td>
<td>W</td>
</tr>
<tr>
<td>&lt;X&gt;</td>
<td>&lt;LX02&gt;</td>
<td>X</td>
</tr>
<tr>
<td>&lt;Y&gt;</td>
<td>&lt;LY02&gt;</td>
<td>Y</td>
</tr>
<tr>
<td>&lt;Z&gt;</td>
<td>&lt;LZ02&gt;</td>
<td>Z</td>
</tr>
<tr>
<td>&lt;left-square-bracket&gt;</td>
<td>&lt;SM06&gt;</td>
<td>[</td>
</tr>
<tr>
<td>&lt;backslash&gt;</td>
<td>&lt;SM07&gt;</td>
<td>\</td>
</tr>
<tr>
<td>&lt;reverse-solidus&gt;</td>
<td>&lt;SM07&gt;</td>
<td>\</td>
</tr>
<tr>
<td>&lt;right-square-bracket&gt;</td>
<td>&lt;SM08&gt;</td>
<td>]</td>
</tr>
<tr>
<td>&lt;circumflex&gt;</td>
<td>&lt;SD15&gt;</td>
<td>^</td>
</tr>
<tr>
<td>Symbolic Name</td>
<td>Alternate Name</td>
<td>Character</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------</td>
<td>-----------</td>
</tr>
<tr>
<td><code>&lt;circumflex-accent&gt;</code></td>
<td><code>&lt;SD15&gt;</code></td>
<td>^</td>
</tr>
<tr>
<td><code>&lt;underscore&gt;</code></td>
<td><code>&lt;SP09&gt;</code></td>
<td>_</td>
</tr>
<tr>
<td><code>&lt;low-line&gt;</code></td>
<td><code>&lt;SP09&gt;</code></td>
<td>_</td>
</tr>
<tr>
<td><code>&lt;grave-accent&gt;</code></td>
<td><code>&lt;SD13&gt;</code></td>
<td><code>\</code></td>
</tr>
<tr>
<td><code>&lt;a&gt;</code></td>
<td><code>&lt;LA01&gt;</code></td>
<td>a</td>
</tr>
<tr>
<td><code>&lt;b&gt;</code></td>
<td><code>&lt;LB01&gt;</code></td>
<td>b</td>
</tr>
<tr>
<td><code>&lt;c&gt;</code></td>
<td><code>&lt;LC01&gt;</code></td>
<td>c</td>
</tr>
<tr>
<td><code>&lt;d&gt;</code></td>
<td><code>&lt;LD01&gt;</code></td>
<td>d</td>
</tr>
<tr>
<td><code>&lt;e&gt;</code></td>
<td><code>&lt;LE01&gt;</code></td>
<td>e</td>
</tr>
<tr>
<td><code>&lt;f&gt;</code></td>
<td><code>&lt;LF01&gt;</code></td>
<td>f</td>
</tr>
<tr>
<td><code>&lt;g&gt;</code></td>
<td><code>&lt;LG01&gt;</code></td>
<td>g</td>
</tr>
<tr>
<td><code>&lt;h&gt;</code></td>
<td><code>&lt;LH01&gt;</code></td>
<td>h</td>
</tr>
<tr>
<td><code>&lt;i&gt;</code></td>
<td><code>&lt;LI01&gt;</code></td>
<td>i</td>
</tr>
<tr>
<td><code>&lt;j&gt;</code></td>
<td><code>&lt;LJ01&gt;</code></td>
<td>j</td>
</tr>
<tr>
<td><code>&lt;k&gt;</code></td>
<td><code>&lt;LK01&gt;</code></td>
<td>k</td>
</tr>
<tr>
<td><code>&lt;l&gt;</code></td>
<td><code>&lt;LL01&gt;</code></td>
<td>l</td>
</tr>
<tr>
<td><code>&lt;m&gt;</code></td>
<td><code>&lt;LM01&gt;</code></td>
<td>m</td>
</tr>
<tr>
<td><code>&lt;n&gt;</code></td>
<td><code>&lt;LN01&gt;</code></td>
<td>n</td>
</tr>
<tr>
<td><code>&lt;o&gt;</code></td>
<td><code>&lt;LO01&gt;</code></td>
<td>o</td>
</tr>
<tr>
<td><code>&lt;p&gt;</code></td>
<td><code>&lt;LP01&gt;</code></td>
<td>p</td>
</tr>
<tr>
<td><code>&lt;q&gt;</code></td>
<td><code>&lt;LQ01&gt;</code></td>
<td>q</td>
</tr>
<tr>
<td><code>&lt;r&gt;</code></td>
<td><code>&lt;LR01&gt;</code></td>
<td>r</td>
</tr>
<tr>
<td><code>&lt;s&gt;</code></td>
<td><code>&lt;LS01&gt;</code></td>
<td>s</td>
</tr>
<tr>
<td><code>&lt;t&gt;</code></td>
<td><code>&lt;LT01&gt;</code></td>
<td>t</td>
</tr>
<tr>
<td><code>&lt;u&gt;</code></td>
<td><code>&lt;LU01&gt;</code></td>
<td>u</td>
</tr>
<tr>
<td><code>&lt;v&gt;</code></td>
<td><code>&lt;LU01&gt;</code></td>
<td>v</td>
</tr>
<tr>
<td><code>&lt;w&gt;</code></td>
<td><code>&lt;LW01&gt;</code></td>
<td>w</td>
</tr>
<tr>
<td><code>&lt;x&gt;</code></td>
<td><code>&lt;LX01&gt;</code></td>
<td>x</td>
</tr>
<tr>
<td><code>&lt;y&gt;</code></td>
<td><code>&lt;LY01&gt;</code></td>
<td>y</td>
</tr>
<tr>
<td><code>&lt;z&gt;</code></td>
<td><code>&lt;LZ01&gt;</code></td>
<td>z</td>
</tr>
<tr>
<td><code>&lt;left-brace&gt;</code></td>
<td><code>&lt;SM11&gt;</code></td>
<td>{</td>
</tr>
<tr>
<td><code>&lt;left-curly-bracket&gt;</code></td>
<td><code>&lt;SM11&gt;</code></td>
<td>{</td>
</tr>
<tr>
<td><code>&lt;vertical-line&gt;</code></td>
<td><code>&lt;SM13&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;right-brace&gt;</code></td>
<td><code>&lt;SM14&gt;</code></td>
<td>)</td>
</tr>
<tr>
<td><code>&lt;right-curly-bracket&gt;</code></td>
<td><code>&lt;SM14&gt;</code></td>
<td>)</td>
</tr>
<tr>
<td><code>&lt;tilde&gt;</code></td>
<td><code>&lt;SD19&gt;</code></td>
<td>~</td>
</tr>
</tbody>
</table>

With z/OS C/C++, the localedef utility uses code page IBM-1047 as the definition of the code points for the characters in the Portable Character Set. Therefore the default values for the escape-char and comment-char are the code points from the IBM-1047 code page.
There are some coded character sets, such as the Japanese Katakana coded character set 290, that have code points for the lowercase characters different from the code points for the lowercase characters in the set IBM-1047. A charmap file or locale definition file cannot be coded using these coded character sets.
Appendix B. Mapping Variant Characters for z/OS C/C++

This appendix describes how you can enter and display the variant characters. These characters include square brackets ([ ]) and the caret character (^) for the host environment. If you use a programmable workstation or a 3270 terminal, you can follow the documented procedures to map the keys on your keyboard. Remapping will send the correct variant character hexadecimal values to the host system for the z/OS C/C++ compiler.

Compile and run sample program in Displaying Hexadecimal Values. View hexadecimal values for the variant characters.

Keyed in hex values match those used by the compiler. YES Done

NO

Apply one of the following:

Use iconv() to convert your source coded character set to IBM-1047 which the compiler recognizes by default. 1

Use EDIT session to correct variant characters. 2

Figure 227. Variant Characters

1 See the z/OS C/C++ User’s Guide for more information on this utility.

2 See “Displaying Square Brackets When Using ISPF” on page 810 for more information on variant characters.

Note: If you are running a programmable workstation by using host emulation software, apply your host emulation software’s keyboard by remapping first. If this allows correct hexadecimal values for the variant characters sent to the host, then you have completed the task.

Displaying Hexadecimal Values

To ensure that your current keys generate correct hexadecimal values for the z/OS C/C++ compiler and its library, use the following program to show the hexadecimal values on the display. This program displays the hexadecimal values for the variant characters that your current setup uses, and the values that the compiler and library expect.

Note: See the appropriate section of the z/OS C/C++ User’s Guide for information on the LOCALE|NOLOCALE option and the list of IBM-supported locales available for use at compile time or run time. The default C locale is encoded in code page IBM-1047; therefore the default encoding of variant characters is as in IBM-1047.
Example

The sample program reads the ten characters from the input file MYFILE.DAT and displays the character values in hexadecimal notation. The program also queries the current compile time locale for the character values that compiler would expect. These ten variant characters are selected because they are syntactically important to the z/OS C/C++ compiler. You must type them in MYFILE.DAT in this order on a single line, without spaces between them:

- backslash \
- right square bracket ]
- left square bracket [
- right brace }
- left brace {
- circumflex ^
- tilde ~
- exclamation mark !
- number sign #
- vertical line |

You can use the sample program to display the character values and then reset your environment. This will generate the codes as shown in the column EXPECTED BY COMPILER. After re-editing your input file, you can run this program again. Consult your system programmer for the coded character set that your installation uses. If you are running under TSO, the data file containing the ten variant characters is TSOid.myfile.dat. Assign this file to SYSIN and run the program.

CCNGMV1

/* this example will display hexadecimal values for the variant */
/* characters */

#include <stdio.h>
#include <locale.h>
#include <variant.h>
#include <stdlib.h>

Figure 228. Example of Displaying Hexadecimal Values (Part 1 of 2)
void read_user_data(char *, int);

void main() {
    char *user_char, *compiler_char;

    struct variant *compiler_var_char;
    int num_var_char, index;
    char *code_set;
    char *char_names[]={"backslash",
                        "right bracket",
                        "left bracket",
                        "right brace",
                        "left brace",
                        "circumflex",
                        "tilde",
                        "exclamation mark",
                        "number sign",
                        "vertical line"};

    num_var_char=sizeof(char_names)/sizeof(char *);
    if ((user_char=(char*)calloc(num_var_char, 1)) == NULL)
    {
        printf("Error: Unable to allocate the storage\n");
        exit(99);
    }
    read_user_data(user_char, num_var_char);
    /* managed to read the users' characters from the file */

    code_set="default IBM-1047";
    compiler_char="\xe0\xbd\xd0\xc0\x5f\xa1\x5a\x7b\x4f";
    /* standard compiler code page */

    printf("Compiler and library code page is : %s\n", code_set);
    printf("Variant character values:\n");
    printf("%16s expected by compiler your current\n", "");
    for (index=0; index<num_var_char; index++)
    {
        printf("%16s : %X %X\n", char_names[index], compiler_char[index], user_char[index]);
    }
    exit(0);
}

void read_user_data(char* char_array, int num_var_char)
{
    FILE *stream;
    int num;

    if (stream = fopen ("myfile.dat", "rb"))
    { // !!!!
        if(!((num = fread(char_array, 1, num_var_char, stream))))
        {
            printf("Error: Unable to read from the file\n");
            exit(99);
        }
    }
    else { ; }
    else
    {
        printf("Error: Unable to open the file\n");
        exit(99);
    } // !!!!
    fclose(stream);
    return;
}

Figure 228. Example of Displaying Hexadecimal Values (Part 2 of 2)
After executing this program, use the procedures described above to ensure that your special characters on the keyboard generate the hexadecimal values expected by the z/OS C/C++ compiler.

---

**Using pragma Filetag To Specify Code Page in C**

Add the following `#pragma filetag` in the source and header file to specify that the code page encodes the file:

```c
ifdef __COMPILER_VER__
   pragma filetag ("codepage")
endif
```

`codepage` is the codepage in which the source code is written.

*Note:* If you are running standard 3270 emulation in the U.S., your workstation software most likely uses code page 37. You can then use this alternative by specifying IBM-037 as `codepage`.

---

**Displaying Square Brackets When Using ISPF**

When your workstation is sending correct hexadecimal values for the square brackets to the host system, you may still find that they are not correctly displayed by the ISPF editor when you key them in. The following sample ISPF macro can be used to view the [ and ] characters in text, trigraph, or hex form. You can then toggle between the three settings. Include this macro in a regular CLIST library that is concatenated to the ddname SYSPROC.
**Using The CCNGMV2 Macro**

Follow these steps to use the CCNGMV2 macro:

1. Remap your host emulation software keyboard. If this does not enable correct display of [ and ] on ISPF, try this macro.
2. Start ISPF to edit the C or C++ source file.

---

### Appendix B. Mapping Variant Characters for z/OS C/C++

811
3. Run the CCNGMV2 macro before editing to convert the compiler recognizable hexadecimal values of the square brackets to trigraphs.
4. Run the CCNGMV2 macro again to convert the trigraphs to displayable characters.
5. Edit your C or C++ source code.
6. Run the CCNGMV2 macro again to convert the displayable characters back to original hexadecimal values.
7. Save and File the C source file.

Procedure for Mapping on 3279

Follow this procedure if you are using a 3279-S3G-1 with ISPF, z/OS batch, or TSO. You should have the APL keys on your keyboards.

- Go to ISPF 0.1 and set the terminal type to 3278A.
- Edit the file which has the square brackets.

When you want to enter brackets [ or ], press ALT APLon, enter the square brackets and then ALT APLoff. You get = X'AD', and = X'BD', which is what z/OS C/C++ expects for square brackets.
Appendix C. z/OS C/C++ Code Point Mappings

The tables below show the code point mappings for Latin-1/Open Systems coded character set 1047 [Figure 230] and for the APL coded character set 293 [Figure 231 on page 814].

<table>
<thead>
<tr>
<th>Code Page 01047</th>
<th>4-</th>
<th>5-</th>
<th>6-</th>
<th>7-</th>
<th>8-</th>
<th>9-</th>
<th>A-</th>
<th>B-</th>
<th>C-</th>
<th>D-</th>
<th>E-</th>
<th>F-</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>001</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>002</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>003</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>004</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>005</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>006</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>007</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>008</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>009</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

© Copyright IBM Corp. 1996, 2002

813
Figure 231. Coded Character Set for APL
Appendix D. Locales Supplied with z/OS C/C++

The following tables list the compiled locales and locale source files supported by default with the z/OS C/C++ product. All of these locale files are provided with the National Language Resources feature of z/OS Language Environment.

Starting with OS/390 V1R3, the compiled locales are built using the locale source files stored in the CEE.SCEELOCX partitioned data set. The CEE.SCEELOCX locale source files were created in support of the XPG4 standard. The previous locale source files (pre-XPG4) are in the CEE.SCEELOC partitioned data set. We include the pre-XPG4 source for customers who want to run in a non-POSIX locale environment.

Note: In the HFS, the locale source files are in /usr/lib/nls/localedef and the binaries are in /usr/lib/nls/locale (we do not ship the pre-XPG4 source or binaries in the HFS).

Compiled Locales

The following table lists each setlocale() parameter and its corresponding language, country/territory, codeset, and actual program name. The S370 C, POSIX C and SAA C locales do not have locale modules associated with them. They are built-in locales that cannot be modified, and are always present. Their names cannot be changed. These locales are based on the coded character set IBM-1047. The new versions of the POSIX C and SAA C locales can be provided, but to refer to them, you must specify the full name of the requested locale, including the CodesetRegistry-CodesetEncoding names. For example, "SAA.IBM-037"

refers to the SAA C locale built from the coded character set IBM-037.

Note: Not all locales listed in the following table are fully enabled. The compiler cannot compile source that is coded in Ja_JP.IBM-290, Ja_JP.IBM-930, Ja_JP.IBM-1390, or Tr_TR.IBM-1026.

The <prefix> in the Load module name column is EDC for non-XPLINK EBCDIC locales and CEH for XPLINK EBCDIC locales.

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ar_AA.IBM-425</td>
<td>Arabic</td>
<td>Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, U.A.E., Yemen</td>
<td>IBM-425</td>
<td>&lt;prefix&gt;$AAAR</td>
</tr>
<tr>
<td>Be_BY.IBM-1025</td>
<td>Byelorussian</td>
<td>Belarus</td>
<td>IBM-1025</td>
<td>&lt;prefix&gt;$BBFE</td>
</tr>
</tbody>
</table>

© Copyright IBM Corp. 1996, 2002
Table 81. Compiled EBCDIC locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be_BY.IBM-1154</td>
<td>Byelorussuan</td>
<td>Belarus</td>
<td>IBM-1154</td>
<td>&lt;prefix&gt;$BBHT</td>
</tr>
<tr>
<td>Bg_BG.IBM-1025</td>
<td>Bulgarian</td>
<td>Bulgaria</td>
<td>IBM-1025</td>
<td>&lt;prefix&gt;$BGFE</td>
</tr>
<tr>
<td>Bg_BG.IBM-1154</td>
<td>Bulgarian</td>
<td>Bulgaria</td>
<td>IBM-1154</td>
<td>&lt;prefix&gt;$BGHT</td>
</tr>
<tr>
<td>Ca_ES.IBM-924</td>
<td>Catalan</td>
<td>Spain</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$CSEZ</td>
</tr>
<tr>
<td>Ca_ES.IBM-924@euro</td>
<td>Catalan</td>
<td>Spain</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@CSEZ</td>
</tr>
<tr>
<td>Cs_CZ.IBM-870</td>
<td>Czech</td>
<td>Czech Republic</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$CZEQ</td>
</tr>
<tr>
<td>Cs_CZ.IBM-1153</td>
<td>Czech</td>
<td>Czech Republic</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$CZMB</td>
</tr>
<tr>
<td>Cs_CZ.IBM-1165</td>
<td>Czech</td>
<td>Czech Republic</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$CZFG</td>
</tr>
<tr>
<td>Da_DK.IBM-277</td>
<td>Danish</td>
<td>Denmark</td>
<td>IBM-277</td>
<td>&lt;prefix&gt;$DAEE</td>
</tr>
<tr>
<td>Da_DK.IBM-924</td>
<td>Danish</td>
<td>Denmark</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$DAEZ</td>
</tr>
<tr>
<td>Da_DK.IBM-924@euro</td>
<td>Danish</td>
<td>Denmark</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@DAEZ</td>
</tr>
<tr>
<td>Da_DK.IBM-1047</td>
<td>Danish</td>
<td>Denmark</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$DAEY</td>
</tr>
<tr>
<td>Da_DK.IBM-1142</td>
<td>Danish</td>
<td>Denmark</td>
<td>IBM-1142</td>
<td>&lt;prefix&gt;$DAHE</td>
</tr>
<tr>
<td>Da_DK.IBM-1142@euro</td>
<td>Danish</td>
<td>Denmark</td>
<td>IBM-1142</td>
<td>&lt;prefix&gt;@DAHE</td>
</tr>
<tr>
<td>De_AT.IBM-924</td>
<td>German</td>
<td>Austria</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$DTEZ</td>
</tr>
<tr>
<td>De_AT.IBM-924@euro</td>
<td>German</td>
<td>Austria</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@DTEZ</td>
</tr>
<tr>
<td>De_CH.IBM-500</td>
<td>German</td>
<td>Switzerland</td>
<td>IBM-500</td>
<td>&lt;prefix&gt;$DCEO</td>
</tr>
<tr>
<td>De_CH.IBM-1047</td>
<td>German</td>
<td>Switzerland</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$DCEY</td>
</tr>
<tr>
<td>De_CH.IBM-1148</td>
<td>German</td>
<td>Switzerland</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;$DCHO</td>
</tr>
<tr>
<td>De_CH.IBM-1148@euro</td>
<td>German</td>
<td>Switzerland</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;@DCHO</td>
</tr>
<tr>
<td>De_DE.IBM-273</td>
<td>German</td>
<td>Germany</td>
<td>IBM-273</td>
<td>&lt;prefix&gt;$DDEB</td>
</tr>
<tr>
<td>De_DE.IBM-924</td>
<td>German</td>
<td>Germany</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$DDEZ</td>
</tr>
<tr>
<td>De_DE.IBM-924@euro</td>
<td>German</td>
<td>Germany</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@DDEZ</td>
</tr>
<tr>
<td>De_DE.IBM-1047</td>
<td>German</td>
<td>Germany</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$DDEY</td>
</tr>
<tr>
<td>De_DE.IBM-1141</td>
<td>German</td>
<td>Germany</td>
<td>IBM-1141</td>
<td>&lt;prefix&gt;$DDBH</td>
</tr>
<tr>
<td>De_DE.IBM-1141@euro</td>
<td>German</td>
<td>Germany</td>
<td>IBM-1141</td>
<td>&lt;prefix&gt;@DDHB</td>
</tr>
<tr>
<td>De_LU.IBM-924</td>
<td>German</td>
<td>Luxembourg</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$DLEZ</td>
</tr>
<tr>
<td>De_LU.IBM-924@euro</td>
<td>German</td>
<td>Luxembourg</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@DLEZ</td>
</tr>
<tr>
<td>El_GR.IBM-875</td>
<td>Greek</td>
<td>Greece</td>
<td>IBM-875</td>
<td>&lt;prefix&gt;$ELES</td>
</tr>
<tr>
<td>El_GR.IBM-4971</td>
<td>Greek</td>
<td>Greece</td>
<td>IBM-4971</td>
<td>&lt;prefix&gt;$ELHS</td>
</tr>
<tr>
<td>El_GR.IBM-4971@euro</td>
<td>Greek</td>
<td>Greece</td>
<td>IBM-4971</td>
<td>&lt;prefix&gt;@ELHS</td>
</tr>
<tr>
<td>En_BE.IBM-924</td>
<td>English</td>
<td>Belgium</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EBEZ</td>
</tr>
<tr>
<td>En_BE.IBM-924@euro</td>
<td>English</td>
<td>Belgium</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@EBEZ</td>
</tr>
<tr>
<td>En_CA.IBM-037</td>
<td>English</td>
<td>Canada</td>
<td>IBM-37</td>
<td>&lt;prefix&gt;$ECEA</td>
</tr>
<tr>
<td>En_CA.IBM-924</td>
<td>English</td>
<td>Canada</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$ECEZ</td>
</tr>
<tr>
<td>En_CA.IBM-1047</td>
<td>English</td>
<td>Canada</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$ECEY</td>
</tr>
<tr>
<td>En_CA.IBM-1140</td>
<td>English</td>
<td>Canada</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;$ECHA</td>
</tr>
</tbody>
</table>
### Table 81. Compiled EBCDIC locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in <code>setlocale()</code> argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>En_GB.IBM-285</td>
<td>English</td>
<td>United Kingdom</td>
<td>IBM-285</td>
<td>&lt;prefix&gt;$EKEK</td>
</tr>
<tr>
<td>En_GB.IBM-924</td>
<td>English</td>
<td>Great Britain</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EKEZ</td>
</tr>
<tr>
<td>En_GB.IBM-924@euro</td>
<td>English</td>
<td>Great Britain</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@EKEZ</td>
</tr>
<tr>
<td>En_GB.IBM-1047</td>
<td>English</td>
<td>United Kingdom</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EKEY</td>
</tr>
<tr>
<td>En_GB.IBM-1146</td>
<td>English</td>
<td>United Kingdom</td>
<td>IBM-1146</td>
<td>&lt;prefix&gt;$EKHK</td>
</tr>
<tr>
<td>En_GB.IBM-1146@euro</td>
<td>English</td>
<td>United Kingdom</td>
<td>IBM-1146</td>
<td>&lt;prefix&gt;@EKHK</td>
</tr>
<tr>
<td>En_IE.IBM-924</td>
<td>English</td>
<td>Ireland</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EIEZ</td>
</tr>
<tr>
<td>En_IE.IBM-924@euro</td>
<td>English</td>
<td>Ireland</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@EIEZ</td>
</tr>
<tr>
<td>En_JP.IBM-1027</td>
<td>English</td>
<td>Japan</td>
<td>IBM-1027</td>
<td>&lt;prefix&gt;$EJEX</td>
</tr>
<tr>
<td>En_JP.IBM-5123</td>
<td>English</td>
<td>Japan</td>
<td>IBM-5123</td>
<td>&lt;prefix&gt;$EJHX</td>
</tr>
<tr>
<td>En_US.IBM-037</td>
<td>English</td>
<td>United States</td>
<td>IBM-037</td>
<td>&lt;prefix&gt;$EUEA</td>
</tr>
<tr>
<td>En_US.IBM-1047</td>
<td>English</td>
<td>United States</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EUEY</td>
</tr>
<tr>
<td>En_US.IBM-1140</td>
<td>English</td>
<td>United States</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;$EUHA</td>
</tr>
<tr>
<td>En_US.IBM-1140@euro</td>
<td>English</td>
<td>United States</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;@EUHA</td>
</tr>
<tr>
<td>En_ZA.IBM-037</td>
<td>English</td>
<td>South Africa</td>
<td>IBM-37</td>
<td>&lt;prefix&gt;$EZEA</td>
</tr>
<tr>
<td>En_ZA.IBM-924</td>
<td>English</td>
<td>South Africa</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EZEA</td>
</tr>
<tr>
<td>En_ZA.IBM-1047</td>
<td>English</td>
<td>South Africa</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EZEY</td>
</tr>
<tr>
<td>En_ZA.IBM-1140</td>
<td>English</td>
<td>South Africa</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;$EZHA</td>
</tr>
<tr>
<td>Es_AR.IBM-284</td>
<td>Spanish</td>
<td>Argentina</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EADE</td>
</tr>
<tr>
<td>Es_AR.IBM-924</td>
<td>Spanish</td>
<td>Argentina</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EADE</td>
</tr>
<tr>
<td>Es_AR.IBM-1047</td>
<td>Spanish</td>
<td>Argentina</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EADE</td>
</tr>
<tr>
<td>Es_AR.IBM-1145</td>
<td>Spanish</td>
<td>Argentina</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$EADE</td>
</tr>
<tr>
<td>Es_BO.IBM-284</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EOEJ</td>
</tr>
<tr>
<td>Es_BO.IBM-924</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EOEJ</td>
</tr>
<tr>
<td>Es_BO.IBM-1047</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EOEJ</td>
</tr>
<tr>
<td>Es_BO.IBM-1145</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$EOEJ</td>
</tr>
<tr>
<td>Es_CL.IBM-284</td>
<td>Spanish</td>
<td>Chile</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EHEJ</td>
</tr>
<tr>
<td>Es_CL.IBM-924</td>
<td>Spanish</td>
<td>Chile</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EHEJ</td>
</tr>
<tr>
<td>Es_CL.IBM-1047</td>
<td>Spanish</td>
<td>Chile</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EHEJ</td>
</tr>
<tr>
<td>Es_CL.IBM-1145</td>
<td>Spanish</td>
<td>Chile</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$EHEJ</td>
</tr>
<tr>
<td>Es_CO.IBM-284</td>
<td>Spanish</td>
<td>Colombia</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$FGEDE</td>
</tr>
<tr>
<td>Es_CO.IBM-924</td>
<td>Spanish</td>
<td>Colombia</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$FGEDE</td>
</tr>
<tr>
<td>Es_CO.IBM-1047</td>
<td>Spanish</td>
<td>Colombia</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FGEDE</td>
</tr>
<tr>
<td>Es_CO.IBM-1145</td>
<td>Spanish</td>
<td>Colombia</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$FGEJ</td>
</tr>
<tr>
<td>Es_CR.IBM-284</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EREJ</td>
</tr>
<tr>
<td>Es_CR.IBM-924</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EREJ</td>
</tr>
<tr>
<td>Locale name as in <code>setlocale()</code> argument</td>
<td>Language</td>
<td>Country / Territory</td>
<td>Codeset</td>
<td>Load module name</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>----------</td>
<td>---------------------</td>
<td>---------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Es_CR.IBM-1047</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>IBM-1047</td>
<td>$EREY</td>
</tr>
<tr>
<td>Es_CR.IBM-1145</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>IBM-1145</td>
<td>$ERHJ</td>
</tr>
<tr>
<td>Es_DO.IBM-284</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>IBM-284</td>
<td>$EDEJ</td>
</tr>
<tr>
<td>Es_DO.IBM-924</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>IBM-924</td>
<td>$EDEZ</td>
</tr>
<tr>
<td>Es_DO.IBM-1047</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>IBM-1047</td>
<td>$EDEY</td>
</tr>
<tr>
<td>Es_DO.IBM-1145</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>IBM-1145</td>
<td>$EDHJ</td>
</tr>
<tr>
<td>Es_EC.IBM-284</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>IBM-284</td>
<td>$EQEJ</td>
</tr>
<tr>
<td>Es_EC.IBM-924</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>IBM-924</td>
<td>$EQEZ</td>
</tr>
<tr>
<td>Es_EC.IBM-1047</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>IBM-1047</td>
<td>$EQUEY</td>
</tr>
<tr>
<td>Es_EC.IBM-1145</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>IBM-1145</td>
<td>$EQHJ</td>
</tr>
<tr>
<td>Es_ES.IBM-284</td>
<td>Spanish</td>
<td>Spain</td>
<td>IBM-284</td>
<td>$ESEJ</td>
</tr>
<tr>
<td>Es_ES.IBM-924</td>
<td>Spanish</td>
<td>Spain</td>
<td>IBM-924</td>
<td>$SEZ</td>
</tr>
<tr>
<td>Es_ES.IBM-924@euro</td>
<td>Spanish</td>
<td>Spain</td>
<td>IBM-924</td>
<td>$ESEZ</td>
</tr>
<tr>
<td>Es_ES.IBM-1047</td>
<td>Spanish</td>
<td>Spain</td>
<td>IBM-1047</td>
<td>$SEEHJ</td>
</tr>
<tr>
<td>Es_ES.IBM-1145</td>
<td>Spanish</td>
<td>Spain</td>
<td>IBM-1145</td>
<td>$ESHJ</td>
</tr>
<tr>
<td>Es_ES.IBM-1145@euro</td>
<td>Spanish</td>
<td>Spain</td>
<td>IBM-1145</td>
<td>$ESHJ</td>
</tr>
<tr>
<td>Es_GT.IBM-284</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>IBM-284</td>
<td>$EGEJ</td>
</tr>
<tr>
<td>Es_GT.IBM-924</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>IBM-924</td>
<td>$EGEZ</td>
</tr>
<tr>
<td>Es_GT.IBM-1047</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>IBM-1047</td>
<td>$EGEY</td>
</tr>
<tr>
<td>Es_GT.IBM-1145</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>IBM-1145</td>
<td>$EGHJ</td>
</tr>
<tr>
<td>Es_HN.IBM-284</td>
<td>Spanish</td>
<td>Honduras</td>
<td>IBM-284</td>
<td>$FEEJ</td>
</tr>
<tr>
<td>Es_HN.IBM-924</td>
<td>Spanish</td>
<td>Honduras</td>
<td>IBM-924</td>
<td>$FEEZ</td>
</tr>
<tr>
<td>Es_HN.IBM-1047</td>
<td>Spanish</td>
<td>Honduras</td>
<td>IBM-1047</td>
<td>$FEHEJ</td>
</tr>
<tr>
<td>Es_HN.IBM-1145</td>
<td>Spanish</td>
<td>Honduras</td>
<td>IBM-1145</td>
<td>$FEHJ</td>
</tr>
<tr>
<td>Es_MX.IBM-284</td>
<td>Spanish</td>
<td>Mexico</td>
<td>IBM-284</td>
<td>$EMEJ</td>
</tr>
<tr>
<td>Es_MX.IBM-924</td>
<td>Spanish</td>
<td>Mexico</td>
<td>IBM-924</td>
<td>$EMEZ</td>
</tr>
<tr>
<td>Es_MX.IBM-1047</td>
<td>Spanish</td>
<td>Mexico</td>
<td>IBM-1047</td>
<td>$EMEY</td>
</tr>
<tr>
<td>Es_MX.IBM-1145</td>
<td>Spanish</td>
<td>Mexico</td>
<td>IBM-1145</td>
<td>$EMHJ</td>
</tr>
<tr>
<td>Es_NI.IBM-284</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>IBM-284</td>
<td>$FAEJ</td>
</tr>
<tr>
<td>Es_NI.IBM-924</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>IBM-924</td>
<td>$FAEZ</td>
</tr>
<tr>
<td>Es_NI.IBM-1047</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>IBM-1047</td>
<td>$FAEY</td>
</tr>
<tr>
<td>Es_NI.IBM-1145</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>IBM-1145</td>
<td>$FAHY</td>
</tr>
<tr>
<td>Es_PA.IBM-284</td>
<td>Spanish</td>
<td>Panama</td>
<td>IBM-284</td>
<td>$SEPEJ</td>
</tr>
<tr>
<td>Es_PA.IBM-924</td>
<td>Spanish</td>
<td>Panama</td>
<td>IBM-924</td>
<td>$SEPEZ</td>
</tr>
<tr>
<td>Es_PA.IBM-1047</td>
<td>Spanish</td>
<td>Panama</td>
<td>IBM-1047</td>
<td>$SEPEY</td>
</tr>
<tr>
<td>Es_PA.IBM-1145</td>
<td>Spanish</td>
<td>Panama</td>
<td>IBM-1145</td>
<td>$SEPHJ</td>
</tr>
</tbody>
</table>
Table 81. Compiled EBCDIC locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Es_PE.IBM-284</td>
<td>Spanish</td>
<td>Peru</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EWEJ</td>
</tr>
<tr>
<td>Es_PE.IBM-924</td>
<td>Spanish</td>
<td>Peru</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EWEZ</td>
</tr>
<tr>
<td>Es_PE.IBM-1047</td>
<td>Spanish</td>
<td>Peru</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EWEY</td>
</tr>
<tr>
<td>Es_PR.IBM-284</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EWEJ</td>
</tr>
<tr>
<td>Es_PR.IBM-924</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EWEZ</td>
</tr>
<tr>
<td>Es_PR.IBM-1047</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EWEY</td>
</tr>
<tr>
<td>Es_PR.IBM-1145</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$EXHJ</td>
</tr>
<tr>
<td>Es_PY.IBM-284</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EYEJ</td>
</tr>
<tr>
<td>Es_PY.IBM-924</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EYEZ</td>
</tr>
<tr>
<td>Es_PY.IBM-1047</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EYEY</td>
</tr>
<tr>
<td>Es_PY.IBM-1145</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$EYHJ</td>
</tr>
<tr>
<td>Es_SV.IBM-284</td>
<td>Spanish</td>
<td>El Salvador</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EVEJ</td>
</tr>
<tr>
<td>Es_SV.IBM-924</td>
<td>Spanish</td>
<td>El Salvador</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EVEZ</td>
</tr>
<tr>
<td>Es_SV.IBM-1047</td>
<td>Spanish</td>
<td>El Salvador</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EVEY</td>
</tr>
<tr>
<td>Es_SV.IBM-1145</td>
<td>Spanish</td>
<td>El Salvador</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$EVHJ</td>
</tr>
<tr>
<td>Es_US.IBM-284</td>
<td>Spanish</td>
<td>United States</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$EETE</td>
</tr>
<tr>
<td>Es_US.IBM-924</td>
<td>Spanish</td>
<td>United States</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$EEZE</td>
</tr>
<tr>
<td>Es_US.IBM-1047</td>
<td>Spanish</td>
<td>United States</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$EETY</td>
</tr>
<tr>
<td>Es_US.IBM-1145</td>
<td>Spanish</td>
<td>United States</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$EETH</td>
</tr>
<tr>
<td>Es_UY.IBM-284</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$FDJE</td>
</tr>
<tr>
<td>Es_UY.IBM-924</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$FDFD</td>
</tr>
<tr>
<td>Es_UY.IBM-1047</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FDDE</td>
</tr>
<tr>
<td>Es_UY.IBM-1145</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$FDHY</td>
</tr>
<tr>
<td>Es_VE.IBM-284</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>IBM-284</td>
<td>&lt;prefix&gt;$FEEJ</td>
</tr>
<tr>
<td>Es_VE.IBM-924</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$FEEZ</td>
</tr>
<tr>
<td>Es_VE.IBM-1047</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FEEY</td>
</tr>
<tr>
<td>Es_VE.IBM-1145</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>IBM-1145</td>
<td>&lt;prefix&gt;$FEHY</td>
</tr>
<tr>
<td>Et_EE.IBM-1122</td>
<td>Estonian</td>
<td>Estonia</td>
<td>IBM-1122</td>
<td>&lt;prefix&gt;$EEFD</td>
</tr>
<tr>
<td>Et_EE.IBM-1157</td>
<td>Estonian</td>
<td>Estonia</td>
<td>IBM-1157</td>
<td>&lt;prefix&gt;$EFEH</td>
</tr>
<tr>
<td>Fi_FI.IBM-278</td>
<td>Finnish</td>
<td>Finland</td>
<td>IBM-278</td>
<td>&lt;prefix&gt;$FIEF</td>
</tr>
<tr>
<td>Fi_FI.IBM-924</td>
<td>Finnish</td>
<td>Finland</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$FIEZ</td>
</tr>
<tr>
<td>Fi_FI.IBM-924@euro</td>
<td>Finnish</td>
<td>Finland</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@FIEZ</td>
</tr>
<tr>
<td>Fi_FI.IBM-1047</td>
<td>Finnish</td>
<td>Finland</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FIEY</td>
</tr>
<tr>
<td>Fi_FI.IBM-1143</td>
<td>Finnish</td>
<td>Finland</td>
<td>IBM-1143</td>
<td>&lt;prefix&gt;$FIFE</td>
</tr>
<tr>
<td>Fi_FI.IBM-1143@euro</td>
<td>Finnish</td>
<td>Finland</td>
<td>IBM-1143</td>
<td>&lt;prefix&gt;@FIFE</td>
</tr>
<tr>
<td>Fr_BE.IBM-500</td>
<td>French</td>
<td>Belgium</td>
<td>IBM-500</td>
<td>&lt;prefix&gt;$FBEO</td>
</tr>
<tr>
<td>Fr_BE.IBM-924</td>
<td>French</td>
<td>Belgium</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$FBEZ</td>
</tr>
<tr>
<td>Fr_BE.IBM-924@euro</td>
<td>French</td>
<td>Belgium</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@FBEZ</td>
</tr>
</tbody>
</table>
Table 81. Compiled EBCDIC locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in <code>setlocale()</code> argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fr_BE.IBM-1047</td>
<td>French</td>
<td>Belgium</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FBYE</td>
</tr>
<tr>
<td>Fr_BE.IBM-1148</td>
<td>French</td>
<td>Belgium</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;$FBHO</td>
</tr>
<tr>
<td>Fr_BE.IBM-1148@euro</td>
<td>French</td>
<td>Belgium</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;@FBHO</td>
</tr>
<tr>
<td>Fr_CA.IBM-037</td>
<td>French</td>
<td>Canada</td>
<td>IBM-037</td>
<td>&lt;prefix&gt;$FCEA</td>
</tr>
<tr>
<td>Fr_CA.IBM-1047</td>
<td>French</td>
<td>Canada</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FCEY</td>
</tr>
<tr>
<td>Fr_CA.IBM-1140</td>
<td>French</td>
<td>Canada</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;$FCHA</td>
</tr>
<tr>
<td>Fr_CA.IBM-1140@euro</td>
<td>French</td>
<td>Canada</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;@FCHA</td>
</tr>
<tr>
<td>Fr_CH.IBM-500</td>
<td>French</td>
<td>Switzerland</td>
<td>IBM-500</td>
<td>&lt;prefix&gt;$FSKO</td>
</tr>
<tr>
<td>Fr_CH.IBM-1047</td>
<td>French</td>
<td>Switzerland</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FSEO</td>
</tr>
<tr>
<td>Fr_CH.IBM-1148</td>
<td>French</td>
<td>Switzerland</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;$FSEA</td>
</tr>
<tr>
<td>Fr_CH.IBM-1148@euro</td>
<td>French</td>
<td>Switzerland</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;@FSEA</td>
</tr>
<tr>
<td>Fr_FR.IBM-297</td>
<td>French</td>
<td>France</td>
<td>IBM-297</td>
<td>&lt;prefix&gt;$FFEM</td>
</tr>
<tr>
<td>Fr_FR.IBM-924</td>
<td>French</td>
<td>France</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$FFEZ</td>
</tr>
<tr>
<td>Fr_FR.IBM-924@euro</td>
<td>French</td>
<td>France</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@FFEZ</td>
</tr>
<tr>
<td>Fr_FR.IBM-1047</td>
<td>French</td>
<td>France</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$FFEY</td>
</tr>
<tr>
<td>Fr.FR.IBM-1147</td>
<td>French</td>
<td>France</td>
<td>IBM-1147</td>
<td>&lt;prefix&gt;$FFHM</td>
</tr>
<tr>
<td>Fr.FR.IBM-1147@euro</td>
<td>French</td>
<td>France</td>
<td>IBM-1147</td>
<td>&lt;prefix&gt;@FFHM</td>
</tr>
<tr>
<td>Fr_LU.IBM-924</td>
<td>French</td>
<td>Luxembourg</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$FLEZ</td>
</tr>
<tr>
<td>Fr_LU.IBM-924@euro</td>
<td>French</td>
<td>Luxembourg</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@FLEZ</td>
</tr>
<tr>
<td>Hr_HR.IBM-870</td>
<td>Croatian</td>
<td>Croatia</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$SHRE</td>
</tr>
<tr>
<td>Hr_HR.IBM-1153</td>
<td>Croatian</td>
<td>Croatia</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$HRMB</td>
</tr>
<tr>
<td>Hr_HR.IBM-1165</td>
<td>Croatian</td>
<td>Croatia</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$HRFG</td>
</tr>
<tr>
<td>Hu_HU.IBM-870</td>
<td>Hungarian</td>
<td>Hungary</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$HUEQ</td>
</tr>
<tr>
<td>Hu_HU.IBM-1153</td>
<td>Hungarian</td>
<td>Hungary</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$HUMB</td>
</tr>
<tr>
<td>Hu_HU.IBM-1165</td>
<td>Hungarian</td>
<td>Hungary</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$HUFG</td>
</tr>
<tr>
<td>Is.IS.IBM-871</td>
<td>Icelandic</td>
<td>Iceland</td>
<td>IBM-871</td>
<td>&lt;prefix&gt;$ISER</td>
</tr>
<tr>
<td>Is.IS.IBM-1047</td>
<td>Icelandic</td>
<td>Iceland</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$ISEY</td>
</tr>
<tr>
<td>Is.IS.IBM-1149</td>
<td>Icelandic</td>
<td>Iceland</td>
<td>IBM-1149</td>
<td>&lt;prefix&gt;$ISHR</td>
</tr>
<tr>
<td>Is.IS.IBM-1149@euro</td>
<td>Icelandic</td>
<td>Iceland</td>
<td>IBM-1149</td>
<td>&lt;prefix&gt;@ISHR</td>
</tr>
<tr>
<td>It_CH.IBM-500</td>
<td>Italian</td>
<td>Switzerland</td>
<td>IBM-500</td>
<td>&lt;prefix&gt;$SICEO</td>
</tr>
<tr>
<td>It_CH.IBM-924</td>
<td>Italian</td>
<td>Switzerland</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$SICEZ</td>
</tr>
<tr>
<td>It_CH.IBM-1047</td>
<td>Italian</td>
<td>Switzerland</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$SICEY</td>
</tr>
<tr>
<td>It_CH.IBM-1148</td>
<td>Italian</td>
<td>Switzerland</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;$SCHO</td>
</tr>
<tr>
<td>It_IT.IBM-280</td>
<td>Italian</td>
<td>Italy</td>
<td>IBM-280</td>
<td>&lt;prefix&gt;$SITEG</td>
</tr>
<tr>
<td>It_IT.IBM-924</td>
<td>Italian</td>
<td>Italy</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$SITEZ</td>
</tr>
<tr>
<td>It_IT.IBM-924@euro</td>
<td>Italian</td>
<td>Italy</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@ITEZ</td>
</tr>
<tr>
<td>It_IT.IBM-1047</td>
<td>Italian</td>
<td>Italy</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$SITEY</td>
</tr>
<tr>
<td>It_IT.IBM-1144</td>
<td>Italian</td>
<td>Italy</td>
<td>IBM-1144</td>
<td>&lt;prefix&gt;$SITHG</td>
</tr>
<tr>
<td>It_IT.IBM-1144@euro</td>
<td>Italian</td>
<td>Italy</td>
<td>IBM-1144</td>
<td>&lt;prefix&gt;@ITHG</td>
</tr>
</tbody>
</table>
### Table 81. Compiled EBCDIC locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in <code>setlocale()</code> argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iw_IL.IBM-424</td>
<td>Hebrew</td>
<td>Israel</td>
<td>IBM-424</td>
<td>&lt;prefix&gt;$ILFB</td>
</tr>
<tr>
<td>Iw_IL.IBM-12712</td>
<td>Hebrew</td>
<td>Israel</td>
<td>IBM12712</td>
<td>&lt;prefix&gt;$ILHH</td>
</tr>
<tr>
<td>Ja_JP.IBM-290</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-290</td>
<td>&lt;prefix&gt;$JAEL</td>
</tr>
<tr>
<td>Ja_JP.IBM-930</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-930</td>
<td>&lt;prefix&gt;$JAEL</td>
</tr>
<tr>
<td>Ja_JP.IBM-939</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-939</td>
<td>&lt;prefix&gt;$JAEL</td>
</tr>
<tr>
<td>Ja_JP.IBM-1027</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-1027</td>
<td>&lt;prefix&gt;$JAEX</td>
</tr>
<tr>
<td>Ja_JP.IBM-1390</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-1390</td>
<td>&lt;prefix&gt;$JAHU</td>
</tr>
<tr>
<td>Ja_JP.IBM-1399</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-1399</td>
<td>&lt;prefix&gt;$JAHV</td>
</tr>
<tr>
<td>Ja_JP.IBM-5123</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-5123</td>
<td>&lt;prefix&gt;$JAHX</td>
</tr>
<tr>
<td>Ja_JP.IBM-8482</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-8482</td>
<td>&lt;prefix&gt;$JAHL</td>
</tr>
<tr>
<td>Ko_KR.IBM-933</td>
<td>Korean</td>
<td>Korea</td>
<td>IBM-933</td>
<td>&lt;prefix&gt;$KRGZ</td>
</tr>
<tr>
<td>Ko_KR.IBM-1364</td>
<td>Korean</td>
<td>Korea</td>
<td>IBM-1364</td>
<td>&lt;prefix&gt;$KRKZ</td>
</tr>
<tr>
<td>Lt_LT.IBM-1112</td>
<td>Lithuanian</td>
<td>Lithuania</td>
<td>IBM-1112</td>
<td>&lt;prefix&gt;$LTGD</td>
</tr>
<tr>
<td>Lt_LT.IBM-1156</td>
<td>Lithuanian</td>
<td>Lithuania</td>
<td>IBM-1156</td>
<td>&lt;prefix&gt;$LTHZ</td>
</tr>
<tr>
<td>Lv_LV.IBM-1112</td>
<td>Latvian</td>
<td>Latvia</td>
<td>IBM-1112</td>
<td>&lt;prefix&gt;$LLGD</td>
</tr>
<tr>
<td>Lv_LV.IBM-1156</td>
<td>Latvian</td>
<td>Latvia</td>
<td>IBM-1156</td>
<td>&lt;prefix&gt;$LLHZ</td>
</tr>
<tr>
<td>Mk_MK.IBM-1025</td>
<td>Macedonian</td>
<td>Macedonia</td>
<td>IBM-1025</td>
<td>&lt;prefix&gt;$MMFE</td>
</tr>
<tr>
<td>Mk_MK.IBM-1154</td>
<td>Macedonian</td>
<td>Macedonia</td>
<td>IBM-1154</td>
<td>&lt;prefix&gt;$MMHT</td>
</tr>
<tr>
<td>Ni_BE.IBM-500</td>
<td>Dutch</td>
<td>Belgium</td>
<td>IBM-500</td>
<td>&lt;prefix&gt;$NBEO</td>
</tr>
<tr>
<td>Ni_BE.IBM-924</td>
<td>Dutch</td>
<td>Belgium</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$NBEZ</td>
</tr>
<tr>
<td>Ni_BE.IBM-924@euro</td>
<td>Dutch</td>
<td>Belgium</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@NBEZ</td>
</tr>
<tr>
<td>Ni_BE.IBM-1047</td>
<td>Dutch</td>
<td>Belgium</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$NBEO</td>
</tr>
<tr>
<td>Ni_BE.IBM-1148</td>
<td>Dutch</td>
<td>Belgium</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;$NBHO</td>
</tr>
<tr>
<td>Ni_BE.IBM-1148@euro</td>
<td>Dutch</td>
<td>Belgium</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;@NBHO</td>
</tr>
<tr>
<td>Ni_NL.IBM-037</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>IBM-037</td>
<td>&lt;prefix&gt;$NNEA</td>
</tr>
<tr>
<td>Ni_NL.IBM-924</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$NNEZ</td>
</tr>
<tr>
<td>Ni_NL.IBM-924@euro</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@NNEZ</td>
</tr>
<tr>
<td>Ni_NL.IBM-1047</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$NNEY</td>
</tr>
<tr>
<td>Ni_NL.IBM-1140</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;$NNHA</td>
</tr>
<tr>
<td>Ni_NL.IBM-1140@euro</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;@NNHA</td>
</tr>
<tr>
<td>No_NO.IBM-277</td>
<td>Norwegian</td>
<td>Norway</td>
<td>IBM-277</td>
<td>&lt;prefix&gt;$NOEE</td>
</tr>
<tr>
<td>No_NO.IBM-1047</td>
<td>Norwegian</td>
<td>Norway</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$NOEY</td>
</tr>
<tr>
<td>No_NO.IBM-1142</td>
<td>Norwegian</td>
<td>Norway</td>
<td>IBM-1142</td>
<td>&lt;prefix&gt;$NOHE</td>
</tr>
<tr>
<td>No_NO.IBM-1142@euro</td>
<td>Norwegian</td>
<td>Norway</td>
<td>IBM-1142</td>
<td>&lt;prefix&gt;@NOHE</td>
</tr>
<tr>
<td>Pi_PL.IBM-870</td>
<td>Polish</td>
<td>Poland</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$PLEQ</td>
</tr>
<tr>
<td>Pi_PL.IBM-1153</td>
<td>Polish</td>
<td>Poland</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$PLMB</td>
</tr>
<tr>
<td>Pi_PL.IBM-1165</td>
<td>Polish</td>
<td>Poland</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$PLFG</td>
</tr>
<tr>
<td>Pt_BR.IBM-037</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>IBM-037</td>
<td>&lt;prefix&gt;$BREA</td>
</tr>
<tr>
<td>Pt_BR.IBM-1047</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$BREY</td>
</tr>
</tbody>
</table>
Table 81. Compiled EBCDIC locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt_BR.IBM-1140</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;$BRHA</td>
</tr>
<tr>
<td>Pt_BR.IBM-1140@euro</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;@BRHA</td>
</tr>
<tr>
<td>Pt_PT.IBM-037</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$PTEA</td>
</tr>
<tr>
<td>Pt_PT.IBM-924</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@PTEZ</td>
</tr>
<tr>
<td>Pt_PT.IBM-1047</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$PTEY</td>
</tr>
<tr>
<td>Pt_PT.IBM-1140</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>IBM-1140</td>
<td>&lt;prefix&gt;@PTHA</td>
</tr>
<tr>
<td>Ro_RO.IBM-870</td>
<td>Romanian</td>
<td>Romania</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$ROEQ</td>
</tr>
<tr>
<td>Ro_RO.IBM-1153</td>
<td>Romanian</td>
<td>Romania</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$ROMB</td>
</tr>
<tr>
<td>Ro_RO.IBM-1165</td>
<td>Romanian</td>
<td>Romania</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$ROFG</td>
</tr>
<tr>
<td>Ru_RU.IBM-1025</td>
<td>Russian</td>
<td>Russia</td>
<td>IBM-1025</td>
<td>&lt;prefix&gt;$RUFE</td>
</tr>
<tr>
<td>Ru_RU.IBM-1154</td>
<td>Russian</td>
<td>Russia</td>
<td>IBM-1154</td>
<td>&lt;prefix&gt;$RUHT</td>
</tr>
<tr>
<td>Sh_SP.IBM-870</td>
<td>Serbian (Latin)</td>
<td>Serbia</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$SLEQ</td>
</tr>
<tr>
<td>Sh_SP.IBM-1153</td>
<td>Serbian (Latin)</td>
<td>Serbia</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$SLMB</td>
</tr>
<tr>
<td>Sh_SP.IBM-1165</td>
<td>Serbian (Latin)</td>
<td>Serbia</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$SLFG</td>
</tr>
<tr>
<td>Sk_SK.IBM-870</td>
<td>Slovak</td>
<td>Slovakia</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$SKEQ</td>
</tr>
<tr>
<td>Sk_SK.IBM-1153</td>
<td>Slovak</td>
<td>Slovakia</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$SKMB</td>
</tr>
<tr>
<td>Sk_SK.IBM-1165</td>
<td>Slovak</td>
<td>Slovakia</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$SKFG</td>
</tr>
<tr>
<td>Sl_SI.IBM-870</td>
<td>Slovene</td>
<td>Slovenia</td>
<td>IBM-870</td>
<td>&lt;prefix&gt;$SIEQ</td>
</tr>
<tr>
<td>Sl_SI.IBM-1153</td>
<td>Slovene</td>
<td>Slovenia</td>
<td>IBM-1153</td>
<td>&lt;prefix&gt;$SIMB</td>
</tr>
<tr>
<td>Sl_SI.IBM-1165</td>
<td>Slovene</td>
<td>Slovenia</td>
<td>IBM-1165</td>
<td>&lt;prefix&gt;$SIFG</td>
</tr>
<tr>
<td>Sq_AL.IBM-500</td>
<td>Albanian</td>
<td>Albania</td>
<td>IBM-500</td>
<td>&lt;prefix&gt;$SAEO</td>
</tr>
<tr>
<td>Sq_AL.IBM-1047</td>
<td>Albanian</td>
<td>Albania</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$SAEY</td>
</tr>
<tr>
<td>Sq_AL.IBM-1148</td>
<td>Albanian</td>
<td>Albania</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;$SAHO</td>
</tr>
<tr>
<td>Sq_AL.IBM-1148@euro</td>
<td>Albanian</td>
<td>Albania</td>
<td>IBM-1148</td>
<td>&lt;prefix&gt;@SAHO</td>
</tr>
<tr>
<td>Sr_SP.IBM-1025</td>
<td>Serbian</td>
<td>Serbia</td>
<td>IBM-1025</td>
<td>&lt;prefix&gt;$SCFE</td>
</tr>
<tr>
<td>Sr_SP.IBM-1154</td>
<td>Serbian</td>
<td>Serbia</td>
<td>IBM-1154</td>
<td>&lt;prefix&gt;$SCHT</td>
</tr>
<tr>
<td>Sv_SE.IBM-278</td>
<td>Swedish</td>
<td>Sweden</td>
<td>IBM-278</td>
<td>&lt;prefix&gt;$SVEF</td>
</tr>
<tr>
<td>Sv_SE.IBM-924</td>
<td>Swedish</td>
<td>Sweden</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;$SVEZ</td>
</tr>
<tr>
<td>Sv_SE.IBM-924@euro</td>
<td>Swedish</td>
<td>Sweden</td>
<td>IBM-924</td>
<td>&lt;prefix&gt;@SVEZ</td>
</tr>
<tr>
<td>Sv_SE.IBM-1047</td>
<td>Swedish</td>
<td>Sweden</td>
<td>IBM-1047</td>
<td>&lt;prefix&gt;$SVEY</td>
</tr>
<tr>
<td>Sv_SE.IBM-1143</td>
<td>Swedish</td>
<td>Sweden</td>
<td>IBM-1143</td>
<td>&lt;prefix&gt;$SVHF</td>
</tr>
<tr>
<td>Sv_SE.IBM-1143@euro</td>
<td>Swedish</td>
<td>Sweden</td>
<td>IBM-1143</td>
<td>&lt;prefix&gt;@SVHF</td>
</tr>
<tr>
<td>th_TH.IBM-838</td>
<td>Thai</td>
<td>Thailand</td>
<td>IBM-838</td>
<td>&lt;prefix&gt;$STHEP</td>
</tr>
<tr>
<td>th_TH.IBM-1160</td>
<td>Thai</td>
<td>Thailand</td>
<td>IBM-1160</td>
<td>&lt;prefix&gt;$THHP</td>
</tr>
<tr>
<td>Tr_TR.IBM-1026</td>
<td>Turkish</td>
<td>Turkey</td>
<td>IBM-1026</td>
<td>&lt;prefix&gt;$STREW</td>
</tr>
<tr>
<td>Tr_TR.IBM-1155</td>
<td>Turkish</td>
<td>Turkey</td>
<td>IBM-1155</td>
<td>&lt;prefix&gt;$TRHW</td>
</tr>
</tbody>
</table>
Table 81. Compiled EBCDIC locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zh_CN.IBM-935</td>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>IBM-935</td>
<td>&lt;prefix&gt;$ZCGY</td>
</tr>
<tr>
<td>Zh_CN.IBM-1388</td>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>IBM-1388</td>
<td>&lt;prefix&gt;$ZCGV</td>
</tr>
<tr>
<td>Zh_TW.IBM-937</td>
<td>Traditional Chinese</td>
<td>Taiwan</td>
<td>IBM-937</td>
<td>&lt;prefix&gt;$ZTGW</td>
</tr>
<tr>
<td>Zh_TW.IBM-1371</td>
<td>Traditional Chinese</td>
<td>Taiwan</td>
<td>IBM-1371</td>
<td>&lt;prefix&gt;$ZTKA</td>
</tr>
</tbody>
</table>

Table 82. Compiled ASCII locales supplied with z/OS C/C++

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>be_BY.ISO8859-5</td>
<td>Byelorussian</td>
<td>Belarus</td>
<td>ISO8859-5</td>
<td>CEJ$BBI5</td>
</tr>
<tr>
<td>cs_CZ.ISO8859-2</td>
<td>Czech</td>
<td>Czech Republic</td>
<td>ISO8859-2</td>
<td>CEJ$SCZI2</td>
</tr>
<tr>
<td>cs_CZ.UTF-8</td>
<td>Czech</td>
<td>Czech Republic</td>
<td>UTF-8</td>
<td>CEJ$SCZF8</td>
</tr>
<tr>
<td>da_DK.ISO8859-1</td>
<td>Danish</td>
<td>Denmark</td>
<td>ISO8859-1</td>
<td>CEJ$SDAI1</td>
</tr>
<tr>
<td>da_DK.UTF-8</td>
<td>Danish</td>
<td>Denmark</td>
<td>UTF-8</td>
<td>CEJ$DAF8</td>
</tr>
<tr>
<td>de_CH.ISO8859-1</td>
<td>German</td>
<td>Switzerland</td>
<td>ISO8859-1</td>
<td>CEJ$SDCI1</td>
</tr>
<tr>
<td>de_CH.UTF-8</td>
<td>German</td>
<td>Switzerland</td>
<td>UTF-8</td>
<td>CEJ$DCF8</td>
</tr>
<tr>
<td>de_DE.ISO8859-1</td>
<td>German</td>
<td>Germany</td>
<td>ISO8859-1</td>
<td>CEJ$SDDI1</td>
</tr>
<tr>
<td>de_DE.UTF-8</td>
<td>German</td>
<td>Germany</td>
<td>UTF-8</td>
<td>CEJ$DDF8</td>
</tr>
<tr>
<td>el_GR.ISO8859-7</td>
<td>Greek</td>
<td>Greece</td>
<td>ISO8859-7</td>
<td>CEJ$ELI7</td>
</tr>
<tr>
<td>el_GR.UTF-8</td>
<td>Greek</td>
<td>Greece</td>
<td>UTF-8</td>
<td>CEJ$ELF8</td>
</tr>
<tr>
<td>en_CA.ISO8859-1</td>
<td>English</td>
<td>Canada</td>
<td>ISO8859-1</td>
<td>CEJ$SEC1</td>
</tr>
<tr>
<td>en_CA.ISO8859-15</td>
<td>English</td>
<td>Canada</td>
<td>ISO8859-15</td>
<td>CEJ$SEC1F</td>
</tr>
<tr>
<td>en_GB.ISO8859-1</td>
<td>English</td>
<td>United Kingdom</td>
<td>ISO8859-1</td>
<td>CEJ$SEK1</td>
</tr>
<tr>
<td>en_GB.UTF-8</td>
<td>English</td>
<td>United Kingdom</td>
<td>UTF-8</td>
<td>CEJ$SEKF8</td>
</tr>
<tr>
<td>en_US.ISO8859-1</td>
<td>English</td>
<td>United States</td>
<td>ISO8859-1</td>
<td>CEJ$SEU1</td>
</tr>
<tr>
<td>en_US.UTF-8</td>
<td>English</td>
<td>United States</td>
<td>UTF-8</td>
<td>CEJ$EUF8</td>
</tr>
<tr>
<td>es_ES.ISO8859-1</td>
<td>Spanish</td>
<td>Spain</td>
<td>ISO8859-1</td>
<td>CEJ$SES1</td>
</tr>
<tr>
<td>es_ES.UTF-8</td>
<td>Spanish</td>
<td>Spain</td>
<td>UTF-8</td>
<td>CEJ$ESF8</td>
</tr>
<tr>
<td>en_ZA.ISO8859-1</td>
<td>English</td>
<td>South Africa</td>
<td>ISO8859-1</td>
<td>CEJ$EZ1</td>
</tr>
<tr>
<td>en_ZA.ISO8859-15</td>
<td>English</td>
<td>South Africa</td>
<td>ISO8859-15</td>
<td>CEJ$EZ1F</td>
</tr>
<tr>
<td>es_AR.ISO8859-1</td>
<td>Spanish</td>
<td>Argentina</td>
<td>ISO8859-1</td>
<td>CEJ$SEA1</td>
</tr>
<tr>
<td>es_AR.ISO8859-15</td>
<td>Spanish</td>
<td>Argentina</td>
<td>ISO8859-15</td>
<td>CEJ$SEA1F</td>
</tr>
<tr>
<td>es_BO.ISO8859-1</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>ISO8859-1</td>
<td>CEJ$SEO1</td>
</tr>
<tr>
<td>es_BO.ISO8859-15</td>
<td>Spanish</td>
<td>Bolivia</td>
<td>ISO8859-15</td>
<td>CEJ$SEO1F</td>
</tr>
<tr>
<td>es_CL.ISO8859-1</td>
<td>Spanish</td>
<td>Chile</td>
<td>ISO8859-1</td>
<td>CEJ$SEH1</td>
</tr>
<tr>
<td>es_CL.ISO8859-15</td>
<td>Spanish</td>
<td>Chile</td>
<td>ISO8859-15</td>
<td>CEJ$SEH1F</td>
</tr>
<tr>
<td>es_CO.ISO8859-1</td>
<td>Spanish</td>
<td>Colombia</td>
<td>ISO8859-1</td>
<td>CEJ$FGL1</td>
</tr>
</tbody>
</table>
Table 82. Compiled ASCII locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>es_CO.ISO8859-15</td>
<td>Spanish</td>
<td>Colombia</td>
<td>ISO8859-15</td>
<td>CEJ$FGIF</td>
</tr>
<tr>
<td>es_CR.ISO8859-1</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>ISO8859-1</td>
<td>CEJ$SERI1</td>
</tr>
<tr>
<td>es_CR.ISO8859-15</td>
<td>Spanish</td>
<td>Costa Rica</td>
<td>ISO8859-15</td>
<td>CEJ$SERIF</td>
</tr>
<tr>
<td>es_DO.ISO8859-1</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>ISO8859-1</td>
<td>CEJ$EDI1</td>
</tr>
<tr>
<td>es_DO.ISO8859-15</td>
<td>Spanish</td>
<td>Dominican Republic</td>
<td>ISO8859-15</td>
<td>CEJ$EDIF</td>
</tr>
<tr>
<td>es_EC.ISO8859-1</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>ISO8859-1</td>
<td>CEJ$EQI1</td>
</tr>
<tr>
<td>es_EC.ISO8859-15</td>
<td>Spanish</td>
<td>Ecuador</td>
<td>ISO8859-15</td>
<td>CEJ$EQIF</td>
</tr>
<tr>
<td>es_GT.ISO8859-1</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>ISO8859-1</td>
<td>CEJ$EGI1</td>
</tr>
<tr>
<td>es_GT.ISO8859-15</td>
<td>Spanish</td>
<td>Guatemala</td>
<td>ISO8859-15</td>
<td>CEJ$EGIF</td>
</tr>
<tr>
<td>es_HN.ISO8859-1</td>
<td>Spanish</td>
<td>Honduras</td>
<td>ISO8859-1</td>
<td>CEJ$FEI1</td>
</tr>
<tr>
<td>es_HN.ISO8859-15</td>
<td>Spanish</td>
<td>Honduras</td>
<td>ISO8859-15</td>
<td>CEJ$FEIF</td>
</tr>
<tr>
<td>es_MX.ISO8859-1</td>
<td>Spanish</td>
<td>Mexico</td>
<td>ISO8859-1</td>
<td>CEJ$EMI1</td>
</tr>
<tr>
<td>es_MX.ISO8859-15</td>
<td>Spanish</td>
<td>Mexico</td>
<td>ISO8859-15</td>
<td>CEJ$EMIF</td>
</tr>
<tr>
<td>es_NI.ISO8859-1</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>ISO8859-1</td>
<td>CEJ$FAI1</td>
</tr>
<tr>
<td>es_NI.ISO8859-15</td>
<td>Spanish</td>
<td>Nicaragua</td>
<td>ISO8859-15</td>
<td>CEJ$FAIF</td>
</tr>
<tr>
<td>es_PA.ISO8859-1</td>
<td>Spanish</td>
<td>Panama</td>
<td>ISO8859-1</td>
<td>CEJ$EPI1</td>
</tr>
<tr>
<td>es_PA.ISO8859-15</td>
<td>Spanish</td>
<td>Panama</td>
<td>ISO8859-15</td>
<td>CEJ$EPIF</td>
</tr>
<tr>
<td>es_PE.ISO8859-1</td>
<td>Spanish</td>
<td>Peru</td>
<td>ISO8859-1</td>
<td>CEJ$EWI1</td>
</tr>
<tr>
<td>es_PE.ISO8859-15</td>
<td>Spanish</td>
<td>Peru</td>
<td>ISO8859-15</td>
<td>CEJ$EWIF</td>
</tr>
<tr>
<td>es_PR.ISO8859-1</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>ISO8859-1</td>
<td>CEJ$EXI1</td>
</tr>
<tr>
<td>es_PR.ISO8859-15</td>
<td>Spanish</td>
<td>Puerto Rico</td>
<td>ISO8859-15</td>
<td>CEJ$EXIF</td>
</tr>
<tr>
<td>es_PY.ISO8859-1</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>ISO8859-1</td>
<td>CEJ$EYI1</td>
</tr>
<tr>
<td>es_PY.ISO8859-15</td>
<td>Spanish</td>
<td>Paraguay</td>
<td>ISO8859-15</td>
<td>CEJ$EYIF</td>
</tr>
<tr>
<td>es_SV.ISO8859-1</td>
<td>Spanish</td>
<td>El Salvador</td>
<td>ISO8859-1</td>
<td>CEJ$EVI1</td>
</tr>
<tr>
<td>es_US.ISO8859-1</td>
<td>Spanish</td>
<td>United States</td>
<td>ISO8859-1</td>
<td>CEJ$ETI1</td>
</tr>
<tr>
<td>es_US.ISO8859-15</td>
<td>Spanish</td>
<td>United States</td>
<td>ISO8859-15</td>
<td>CEJ$ETIF</td>
</tr>
<tr>
<td>es_UY.ISO8859-1</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>ISO8859-1</td>
<td>CEJ$FDI1</td>
</tr>
<tr>
<td>es_UY.ISO8859-15</td>
<td>Spanish</td>
<td>Uruguay</td>
<td>ISO8859-15</td>
<td>CEJ$FDIF</td>
</tr>
<tr>
<td>es_VE.ISO8859-1</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>ISO8859-1</td>
<td>CEJ$EFI1</td>
</tr>
<tr>
<td>es_VE.ISO8859-15</td>
<td>Spanish</td>
<td>Venezuela</td>
<td>ISO8859-15</td>
<td>CEJ$EFIF</td>
</tr>
<tr>
<td>fi_FI.ISO8859-1</td>
<td>Finnish</td>
<td>Finland</td>
<td>ISO8859-1</td>
<td>CEJ$FI1</td>
</tr>
<tr>
<td>fi_FI.UTF-8</td>
<td>Finnish</td>
<td>Finland</td>
<td>UTF-8</td>
<td>CEJ$FIF8</td>
</tr>
<tr>
<td>fr_BE.ISO8859-1</td>
<td>French</td>
<td>Belgium</td>
<td>ISO8859-1</td>
<td>CEJ$FB1</td>
</tr>
<tr>
<td>fr_BE.UTF-8</td>
<td>French</td>
<td>Belgium</td>
<td>UTF-8</td>
<td>CEJ$FBF8</td>
</tr>
<tr>
<td>fr_CA.ISO8859-1</td>
<td>French</td>
<td>Canada</td>
<td>ISO8859-1</td>
<td>CEJ$FC1</td>
</tr>
<tr>
<td>fr_CA.UTF-8</td>
<td>French</td>
<td>Canada</td>
<td>UTF-8</td>
<td>CEJ$FCF8</td>
</tr>
<tr>
<td>Locale name as in setlocale() argument</td>
<td>Language</td>
<td>Country / Territory</td>
<td>Codeset</td>
<td>Load module name</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-----------</td>
<td>---------------------</td>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>fr_CH.ISO8859-1</td>
<td>French</td>
<td>Switzerland</td>
<td>ISO8859-1</td>
<td>CEJ$FSI1</td>
</tr>
<tr>
<td>fr_CH.UTF-8</td>
<td>French</td>
<td>Switzerland</td>
<td>UTF-8</td>
<td>CEJ$FSF8</td>
</tr>
<tr>
<td>fr_FR.ISO8859-1</td>
<td>French</td>
<td>France</td>
<td>ISO8859-1</td>
<td>CEJ$FFI1</td>
</tr>
<tr>
<td>fr_FR.UTF-8</td>
<td>French</td>
<td>France</td>
<td>UTF-8</td>
<td>CEJ$FFF8</td>
</tr>
<tr>
<td>he_IL.ISO8859-8</td>
<td>Hebrew</td>
<td>Israel</td>
<td>ISO8859-8</td>
<td>CEJ$ILF8</td>
</tr>
<tr>
<td>he_IL.UTF-8</td>
<td>Hebrew</td>
<td>Israel</td>
<td>UTF-8</td>
<td>CEJ$ILF8</td>
</tr>
<tr>
<td>hr_HR.ISO8859-2</td>
<td>Croatian</td>
<td>Croatia</td>
<td>ISO8859-2</td>
<td>CEJ$HRI2</td>
</tr>
<tr>
<td>hr_HR.UTF-8</td>
<td>Croatian</td>
<td>Croatia</td>
<td>UTF-8</td>
<td>CEJ$HRF8</td>
</tr>
<tr>
<td>hu_HU.ISO8859-2</td>
<td>Hungarian</td>
<td>Hungary</td>
<td>ISO8859-2</td>
<td>CEJ$HU12</td>
</tr>
<tr>
<td>hu_HU.UTF-8</td>
<td>Hungarian</td>
<td>Hungary</td>
<td>UTF-8</td>
<td>CEJ$HUF8</td>
</tr>
<tr>
<td>it_CH.ISO8859-1</td>
<td>Italian</td>
<td>Switzerland</td>
<td>ISO8859-1</td>
<td>CEJ$ICI1</td>
</tr>
<tr>
<td>it_CH.ISO8859-15</td>
<td>Italian</td>
<td>Switzerland</td>
<td>ISO8859-15</td>
<td>CEJ$ICIF</td>
</tr>
<tr>
<td>it_IT.ISO8859-1</td>
<td>Italian</td>
<td>Italy</td>
<td>ISO8859-1</td>
<td>CEJ$ITI1</td>
</tr>
<tr>
<td>it_IT.UTF-8</td>
<td>Italian</td>
<td>Italy</td>
<td>UTF-8</td>
<td>CEJ$ITF8</td>
</tr>
<tr>
<td>iw_IL.ISO8859-8</td>
<td>Hebrew</td>
<td>Israel</td>
<td>ISO8859-8</td>
<td>CEJ$ILF8</td>
</tr>
<tr>
<td>iw_IL.UTF-8</td>
<td>Hebrew</td>
<td>Israel</td>
<td>UTF-8</td>
<td>CEJ$ILF8</td>
</tr>
<tr>
<td>ja_JP.IBM-943</td>
<td>Japanese</td>
<td>Japan</td>
<td>IBM-943</td>
<td>CEJ$JAAJ</td>
</tr>
<tr>
<td>ja_JP.UTF-8</td>
<td>Japanese</td>
<td>Japan</td>
<td>UTF-8</td>
<td>CEJ$JAF8</td>
</tr>
<tr>
<td>ko_KR.UTF-8</td>
<td>Korean</td>
<td>Korea</td>
<td>UTF-8</td>
<td>CEJ$KRF8</td>
</tr>
<tr>
<td>lv_LV.IBM-901</td>
<td>Latvian</td>
<td>Latvia</td>
<td>901</td>
<td>CEJ$LLLH</td>
</tr>
<tr>
<td>lv_LV.IBM-921</td>
<td>Latvian</td>
<td>Latvia</td>
<td>921</td>
<td>CEJ$LLBD</td>
</tr>
<tr>
<td>nl_NL.ISO8859-1</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>ISO8859-1</td>
<td>CEJ$SNN1</td>
</tr>
<tr>
<td>nl_NL.UTF-8</td>
<td>Dutch</td>
<td>Netherlands</td>
<td>UTF-8</td>
<td>CEJ$SNF8</td>
</tr>
<tr>
<td>no_NO.ISO8859-1</td>
<td>Norwegian</td>
<td>Norway</td>
<td>ISO8859-1</td>
<td>CEJ$SON01</td>
</tr>
<tr>
<td>no_NO.UTF-8</td>
<td>Norwegian</td>
<td>Norway</td>
<td>UTF-8</td>
<td>CEJ$SNOF8</td>
</tr>
<tr>
<td>pl_PL.ISO8859-2</td>
<td>Polish</td>
<td>Poland</td>
<td>ISO8859-2</td>
<td>CEJ$SPLI2</td>
</tr>
<tr>
<td>pl_PL.UTF-8</td>
<td>Polish</td>
<td>Poland</td>
<td>UTF-8</td>
<td>CEJ$SPLF8</td>
</tr>
<tr>
<td>pt_BR.ISO8859-1</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>ISO8859-1</td>
<td>CEJ$BRI1</td>
</tr>
<tr>
<td>pt_BR.UTF-8</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>UTF-8</td>
<td>CEJ$BRF8</td>
</tr>
<tr>
<td>pt_PT.ISO8859-1</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>ISO8859-1</td>
<td>CEJ$PTI1</td>
</tr>
<tr>
<td>pt_PT.UTF-8</td>
<td>Portuguese</td>
<td>Portugal</td>
<td>UTF-8</td>
<td>CEJ$PTF8</td>
</tr>
<tr>
<td>ro_RO.ISO8859-2</td>
<td>Romanian</td>
<td>Romania</td>
<td>ISO8859-2</td>
<td>CEJ$RO12</td>
</tr>
<tr>
<td>ro_RO.UTF-8</td>
<td>Romanian</td>
<td>Romania</td>
<td>UTF-8</td>
<td>CEJ$ROF8</td>
</tr>
<tr>
<td>ru_RU.ISO8859-5</td>
<td>Russian</td>
<td>Russia</td>
<td>ISO8859-5</td>
<td>CEJ$RUI5</td>
</tr>
<tr>
<td>ru_RU.UTF-8</td>
<td>Russian</td>
<td>Russia</td>
<td>UTF-8</td>
<td>CEJ$RUF8</td>
</tr>
<tr>
<td>sk.SK.ISO8859-2</td>
<td>Slovak</td>
<td>Slovakia</td>
<td>ISO8859-2</td>
<td>CEJ$SK12</td>
</tr>
<tr>
<td>sk_SK.UTF-8</td>
<td>Slovak</td>
<td>Slovakia</td>
<td>UTF-8</td>
<td>CEJ$SKF8</td>
</tr>
</tbody>
</table>
Table 82. Compiled ASCII locales supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Locale name as in setlocale() argument</th>
<th>Language</th>
<th>Country / Territory</th>
<th>Codeset</th>
<th>Load module name</th>
</tr>
</thead>
<tbody>
<tr>
<td>sl_SI.ISO8859-2</td>
<td>Slovene</td>
<td>Slovenia</td>
<td>ISO8859-2</td>
<td>CEJ$SII2</td>
</tr>
<tr>
<td>sl_SI.UTF-8</td>
<td>Slovene</td>
<td>Slovenia</td>
<td>UTF-8</td>
<td>CEJ$SIF8</td>
</tr>
<tr>
<td>sv_SE.ISO8859-1</td>
<td>Swedish</td>
<td>Sweden</td>
<td>ISO8859-1</td>
<td>CEJ$SVI1</td>
</tr>
<tr>
<td>sv_SE.UTF-8</td>
<td>Swedish</td>
<td>Sweden</td>
<td>UTF-8</td>
<td>CEJ$SVF8</td>
</tr>
<tr>
<td>th_TH.TIS-620</td>
<td>Thai</td>
<td>Thailand</td>
<td>TIS-620</td>
<td>CEJ$THBU</td>
</tr>
<tr>
<td>th_TH.UTF-8</td>
<td>Thai</td>
<td>Thailand</td>
<td>UTF-8</td>
<td>CEJ$THF8</td>
</tr>
<tr>
<td>tr_TR.ISO8859-9</td>
<td>Turkish</td>
<td>Turkey</td>
<td>ISO8859-9</td>
<td>CEJ$TRI9</td>
</tr>
<tr>
<td>tr_TR.UTF-8</td>
<td>Turkish</td>
<td>Turkey</td>
<td>UTF-8</td>
<td>CEJ$TRF8</td>
</tr>
<tr>
<td>zh_CN.IBM-eucCN</td>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>IBM-eucCN</td>
<td>CEJ$ZCBY</td>
</tr>
<tr>
<td>zh_CN.UTF-8</td>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>UTF-8</td>
<td>CEJ$ZCF8</td>
</tr>
<tr>
<td>zh_HKS.UTF-8</td>
<td>Simplified Chinese</td>
<td>China (Hong Kong S.A.R. of China)</td>
<td>UTF-8</td>
<td>CEJ$ZGF8</td>
</tr>
<tr>
<td>zh_HKT.UTF-8</td>
<td>Traditional Chinese</td>
<td>China (Hong Kong S.A.R. of China)</td>
<td>UTF-8</td>
<td>CEJ$ZUF8</td>
</tr>
<tr>
<td>zh_SGS.UTF-8</td>
<td>Simplified Chinese</td>
<td>Singapore</td>
<td>UTF-8</td>
<td>CEJ$ZSF8</td>
</tr>
<tr>
<td>zh_TW.BIG5</td>
<td>Simplified Chinese</td>
<td>Taiwan</td>
<td>BIG5</td>
<td>CEJ$ZTBT</td>
</tr>
<tr>
<td>zh_TW.UTF-8</td>
<td>Simplified Chinese</td>
<td>Taiwan</td>
<td>UTF-8</td>
<td>CEJ$ZTF8</td>
</tr>
</tbody>
</table>

Table 83. ASCII HFS locale object names and method files

<table>
<thead>
<tr>
<th>HFS Locale Object Name</th>
<th>Method File</th>
</tr>
</thead>
<tbody>
<tr>
<td>cs_CZ.ISO8859-2.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>cs_CZ.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>da_DK.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>da_DK.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>de_CH.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>de_CH.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>de_DE.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>de_DE.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>el_GR.ISO8859-7.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>el_GR.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>en_GB.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>en_GB.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>en_US.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>en_US.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>es_ES.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>es_ES.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
</tbody>
</table>
Table 83. ASCII HFS locale object names and method files (continued)

<table>
<thead>
<tr>
<th>HFS Locale Object Name</th>
<th>Method File</th>
</tr>
</thead>
<tbody>
<tr>
<td>fi_Fl.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>fi_Fl.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>fr_BE.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>fr_BE.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>fr_CA.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>fr_CA.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>fr_CH.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>fr_CH.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>fr_FR.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>fr_FR.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>he_IL.ISO8859-8.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>he_IL.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>hr_HR.ISO8859-2.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>hr_HR.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>hu_HU.ISO8859-2.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>hu_HU.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>it_IT.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>it_IT.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>ja_JP.IBM-943.xplink</td>
<td>stdmeth.m</td>
</tr>
<tr>
<td>ja_JP.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>ko_KR.IBM-eucKR.xplink</td>
<td>stdmeth.m</td>
</tr>
<tr>
<td>ko_KR.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>nl_NL.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>nl_NL.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>no_NO.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>no_NO.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>pl_PL.ISO8859-2.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>pl_PL.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>pt_BR.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>pt_BR.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>pt_PT.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>pt_PT.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>ro_RO.ISO8859-2.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>ro_RO.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>ru_RU.ISO8859-5.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>ru_RU.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>sk_SK.ISO8859-2.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>sk_SK.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>sl_SI.ISO8859-2.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>sl_SI.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
</tbody>
</table>
### Table 83. ASCII HFS locale object names and method files (continued)

<table>
<thead>
<tr>
<th>HFS Locale Object Name</th>
<th>Method File</th>
</tr>
</thead>
<tbody>
<tr>
<td>sv_SE.ISO8859-1.xplink</td>
<td>iso1meth.m</td>
</tr>
<tr>
<td>sv_SE.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>th_TH.TIS-620.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>th_TH.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>tr_TR.ISO8859-9.xplink</td>
<td>sbmeth.m</td>
</tr>
<tr>
<td>tr_TR.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
<tr>
<td>zh_CN.IBM-eucCN.xplink</td>
<td>stdmeth.m</td>
</tr>
<tr>
<td>zh_CN.UTF-8.xplink</td>
<td>utf_asia.m</td>
</tr>
<tr>
<td>zh_TW.BIG5.xplink</td>
<td>stdmeth.m</td>
</tr>
<tr>
<td>zh_TW.UTF-8.xplink</td>
<td>utfmeth.m</td>
</tr>
</tbody>
</table>

### Locale Source Files

The locale source files are supplied to enable you to build locales in coded character sets other than those supplied. The locale sources supplied are listed in the following table.

The “Applicable Codesets” column indicates which **chrmapi** files can be used with the source files to build the locales. The values in this column indicate the following:

- **All** The locale source contains only the portable character set and can be used to build a locale with any of the supplied **chrmapi** files.
- **Latin-1** The locale source contains characters from the Latin-1 character set, and can be used to build a locale from any of the supplied Latin-1 **chrmapi** files. See Appendix E, “Charmap Files Supplied with z/OS C/C++” on page 833 for a list of Latin-1 **chrmapi** files.
- **Other** The locale source is specific to the specified coded character set, and can only be used to build a locale with the specified **chrmapi** file.

### Table 84. Locale source files supplied with z/OS C/C++

<table>
<thead>
<tr>
<th>Language</th>
<th>Country / Territory</th>
<th>Source name</th>
<th>Applicable Codesets</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSIX (built-in)</td>
<td></td>
<td>EDC$POSX</td>
<td>All</td>
</tr>
<tr>
<td>SAA (built-in)</td>
<td></td>
<td>EDC$SAAC</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Arabic</td>
<td>Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, U.A.E., Yemen</td>
<td>EDC$AAAR</td>
<td>IBM-425</td>
</tr>
<tr>
<td>Bulgarian</td>
<td>Bulgaria</td>
<td>EDC$BGFE</td>
<td>IBM-1025</td>
</tr>
<tr>
<td>Bulgarian</td>
<td>Bulgaria</td>
<td>EDC$BGHT</td>
<td>IBM-1154</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Brazil</td>
<td>EDC$BREY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Brazil</td>
<td>EDC$BRHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>Language</td>
<td>Country / Territory</td>
<td>Source name</td>
<td>Applicable Codesets</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------</td>
<td>-------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Brazil</td>
<td>EDC@BRHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>Catalan</td>
<td>Spain</td>
<td>EDC$CSEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Catalan</td>
<td>Spain</td>
<td>EDC@CSEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Czech</td>
<td>Czech Republic</td>
<td>EDC$CZEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Czech</td>
<td>Czech Republic</td>
<td>EDC$CZMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Danish</td>
<td>Denmark</td>
<td>EDC$DAEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Danish</td>
<td>Denmark</td>
<td>EDC$DAEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Danish</td>
<td>Denmark</td>
<td>EDC$DAHE</td>
<td>IBM-1142</td>
</tr>
<tr>
<td>Danish</td>
<td>Denmark</td>
<td>EDC$DAHE</td>
<td>IBM-1142</td>
</tr>
<tr>
<td>Danish</td>
<td>Denmark</td>
<td>EDC$DAEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Danish</td>
<td>Denmark</td>
<td>EDC$DAHE</td>
<td>IBM-1142</td>
</tr>
<tr>
<td>German</td>
<td>Switzerland</td>
<td>EDC$DCEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>German</td>
<td>Switzerland</td>
<td>EDC$DCHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>German</td>
<td>Switzerland</td>
<td>EDC$DCHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>German</td>
<td>Germany</td>
<td>EDC$DDEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>German</td>
<td>Germany</td>
<td>EDC$DDEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>German</td>
<td>Germany</td>
<td>EDC$DDEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>German</td>
<td>Germany</td>
<td>EDC$DDHB</td>
<td>IBM-1141</td>
</tr>
<tr>
<td>German</td>
<td>Germany</td>
<td>EDC$DDHB</td>
<td>IBM-1141</td>
</tr>
<tr>
<td>German</td>
<td>Luxembourg</td>
<td>EDC$DLEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>German</td>
<td>Luxembourg</td>
<td>EDC$DLEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>German</td>
<td>Austria</td>
<td>EDC$DTEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>German</td>
<td>Austria</td>
<td>EDC$DTEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Estonian</td>
<td>Estonia</td>
<td>EDC$EEFD</td>
<td>IBM-1122</td>
</tr>
<tr>
<td>Estonian</td>
<td>Estonia</td>
<td>EDC$EEHD</td>
<td>IBM-1157</td>
</tr>
<tr>
<td>English</td>
<td>Belgium</td>
<td>EDC$EBEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>English</td>
<td>Belgium</td>
<td>EDC$EBEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>English</td>
<td>Ireland</td>
<td>EDC$EIEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>English</td>
<td>Ireland</td>
<td>EDC$EIEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>English</td>
<td>Japan</td>
<td>EDC$EJHE</td>
<td>IBM-1027</td>
</tr>
<tr>
<td>English</td>
<td>Japan</td>
<td>EDC$EJHX</td>
<td>IBM-5123</td>
</tr>
<tr>
<td>English</td>
<td>United Kingdom</td>
<td>EDC$EKEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>English</td>
<td>Great Britain</td>
<td>EDC$EKEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>English</td>
<td>Great Britain</td>
<td>EDC$EKEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>English</td>
<td>United Kingdom</td>
<td>EDC$EKHK</td>
<td>IBM-1146</td>
</tr>
<tr>
<td>English</td>
<td>United Kingdom</td>
<td>EDC$EKHK</td>
<td>IBM-1146</td>
</tr>
<tr>
<td>Greek</td>
<td>Greece</td>
<td>EDC$ELHS</td>
<td>IBM-4971</td>
</tr>
<tr>
<td>Greek</td>
<td>Greece</td>
<td>EDC$ELHS</td>
<td>IBM-4971</td>
</tr>
<tr>
<td>Greek</td>
<td>Greece</td>
<td>EDC$ELES</td>
<td>IBM-875</td>
</tr>
<tr>
<td>Spanish</td>
<td>Spain</td>
<td>EDC$ESEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Language</td>
<td>Country / Territory</td>
<td>Source name</td>
<td>Applicable Codesets</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>-------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Spanish</td>
<td>Spain</td>
<td>EDC$ESEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Spanish</td>
<td>Spain</td>
<td>EDC@ESEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Spanish</td>
<td>Spain</td>
<td>EDC$ESHJ</td>
<td>IBM-1145</td>
</tr>
<tr>
<td>Spanish</td>
<td>Spain</td>
<td>EDC@ESHJ</td>
<td>IBM-1145</td>
</tr>
<tr>
<td>English</td>
<td>United States</td>
<td>EDC$EUEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>English</td>
<td>United States</td>
<td>EDC$EUHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>English</td>
<td>United States</td>
<td>EDC@EUHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>French</td>
<td>Belgium</td>
<td>EDC$FBYEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>French</td>
<td>Belgium</td>
<td>EDC$FBEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>French</td>
<td>Belgium</td>
<td>EDC@FBEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>French</td>
<td>Belgium</td>
<td>EDC$FBHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>French</td>
<td>Belgium</td>
<td>EDC@FBHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>French</td>
<td>Canada</td>
<td>EDC$FCEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>French</td>
<td>Canada</td>
<td>EDC$FCHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>French</td>
<td>Canada</td>
<td>EDC@FCHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>French</td>
<td>France</td>
<td>EDC$FFEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>French</td>
<td>France</td>
<td>EDC$FFEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>French</td>
<td>France</td>
<td>EDC@FFEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>French</td>
<td>France</td>
<td>EDC$FFHM</td>
<td>IBM-1147</td>
</tr>
<tr>
<td>French</td>
<td>France</td>
<td>EDC@FFHM</td>
<td>IBM-1147</td>
</tr>
<tr>
<td>Finnish</td>
<td>Finland</td>
<td>EDC$FIEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Finnish</td>
<td>Finland</td>
<td>EDC$FIEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Finnish</td>
<td>Finland</td>
<td>EDC@FIEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Finnish</td>
<td>Finland</td>
<td>EDC$FIHF</td>
<td>IBM-1143</td>
</tr>
<tr>
<td>Finnish</td>
<td>Finland</td>
<td>EDC@FIHF</td>
<td>IBM-1143</td>
</tr>
<tr>
<td>French</td>
<td>Luxembourg</td>
<td>EDC$FLEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>French</td>
<td>Luxembourg</td>
<td>EDC@FLEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>French</td>
<td>Switzerland</td>
<td>EDC$FSEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>French</td>
<td>Switzerland</td>
<td>EDC$FSHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>French</td>
<td>Switzerland</td>
<td>EDC@FSHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>Croatian</td>
<td>Croatia</td>
<td>EDC$HRSEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Croatian</td>
<td>Croatia</td>
<td>EDC$HRMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Hungarian</td>
<td>Hungary</td>
<td>EDC$HUEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Hungarian</td>
<td>Hungary</td>
<td>EDC$HUMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Hebrew</td>
<td>Israel</td>
<td>EDC$ILFB</td>
<td>IBM-424</td>
</tr>
<tr>
<td>Hebrew</td>
<td>Israel</td>
<td>EDC$ILHH</td>
<td>IBM12712</td>
</tr>
<tr>
<td>Icelandic</td>
<td>Iceland</td>
<td>EDC$ISEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Icelandic</td>
<td>Iceland</td>
<td>EDC$ISHR</td>
<td>IBM-1149</td>
</tr>
<tr>
<td>Icelandic</td>
<td>Iceland</td>
<td>EDC@ISHR</td>
<td>IBM-1149</td>
</tr>
<tr>
<td>Language</td>
<td>Country / Territory</td>
<td>Source name</td>
<td>Applicable Codesets</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------</td>
<td>-------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Italian</td>
<td>Italy</td>
<td>EDC$ITEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Italian</td>
<td>Italy</td>
<td>EDC$ITEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Italian</td>
<td>Italy</td>
<td>EDC@ITEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Italian</td>
<td>Italy</td>
<td>EDC$ITHG</td>
<td>IBM-1144</td>
</tr>
<tr>
<td>Italian</td>
<td>Italy</td>
<td>EDC@ITHG</td>
<td>IBM-1144</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japan</td>
<td>EDC$JAEL</td>
<td>IBM-290</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japan</td>
<td>EDC$JAEU</td>
<td>IBM-930</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japan</td>
<td>EDC$JAEX</td>
<td>IBM-1027</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japan</td>
<td>EDC$JAHL</td>
<td>IBM-8482</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japan</td>
<td>EDC$JAHU</td>
<td>IBM-1390</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japan</td>
<td>EDC$JAHV</td>
<td>IBM-1399</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japan</td>
<td>EDC$JAHX</td>
<td>IBM-5123</td>
</tr>
<tr>
<td>Korean</td>
<td>Korea</td>
<td>EDC$KRGZ</td>
<td>IBM-933</td>
</tr>
<tr>
<td>Korean</td>
<td>Korea</td>
<td>EDC$KRKZ</td>
<td>IBM-1364</td>
</tr>
<tr>
<td>Lithuanian</td>
<td>Lithuania</td>
<td>EDC$LTDG</td>
<td>IBM-1112</td>
</tr>
<tr>
<td>Lithuanian</td>
<td>Lithuania</td>
<td>EDC$LTHZ</td>
<td>IBM-1156</td>
</tr>
<tr>
<td>Macedonian</td>
<td>Macedonia</td>
<td>EDC$MMFE</td>
<td>IBM-1025</td>
</tr>
<tr>
<td>Macedonian</td>
<td>Macedonia</td>
<td>EDC$MMHT</td>
<td>IBM-1154</td>
</tr>
<tr>
<td>Dutch</td>
<td>Belgium</td>
<td>EDC$NBBEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Dutch</td>
<td>Belgium</td>
<td>EDC$NBEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Dutch</td>
<td>Belgium</td>
<td>EDC@NBEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Dutch</td>
<td>Belgium</td>
<td>EDC$NBHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>Dutch</td>
<td>Belgium</td>
<td>EDC@NBHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>Dutch</td>
<td>Netherlands</td>
<td>EDC$NNBEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Dutch</td>
<td>Netherlands</td>
<td>EDC$NNEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Dutch</td>
<td>Netherlands</td>
<td>EDC@NNEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Dutch</td>
<td>Netherlands</td>
<td>EDC$NNHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>Dutch</td>
<td>Netherlands</td>
<td>EDC@NNHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>Norwegian</td>
<td>Norway</td>
<td>EDC$NOEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Norwegian</td>
<td>Norway</td>
<td>EDC$NOHE</td>
<td>IBM-1142</td>
</tr>
<tr>
<td>Norwegian</td>
<td>Norway</td>
<td>EDC@NOHE</td>
<td>IBM-1142</td>
</tr>
<tr>
<td>Polish</td>
<td>Poland</td>
<td>EDC$PLEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Polish</td>
<td>Poland</td>
<td>EDC$PLMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Portugal</td>
<td>EDC$PTBEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Portugal</td>
<td>EDC$PTEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Portugal</td>
<td>EDC@PTEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Portugal</td>
<td>EDC$PTHA</td>
<td>IBM-1140</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Portugal</td>
<td>EDC@PTHA</td>
<td>IBM-1140</td>
</tr>
</tbody>
</table>
Table 84. Locale source files supplied with z/OS C/C++ (continued)

<table>
<thead>
<tr>
<th>Language</th>
<th>Country / Territory</th>
<th>Source name</th>
<th>Applicable Codesets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romanian</td>
<td>Romania</td>
<td>EDC$ROEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Romanian</td>
<td>Romania</td>
<td>EDC$ROMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Russian</td>
<td>Russia</td>
<td>EDC$RUFE</td>
<td>IBM-1025</td>
</tr>
<tr>
<td>Russian</td>
<td>Russia</td>
<td>EDC$RUHT</td>
<td>IBM-1154</td>
</tr>
<tr>
<td>Albanian</td>
<td>Albania</td>
<td>EDC$SAEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Albanian</td>
<td>Albania</td>
<td>EDC$SAHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>Albanian</td>
<td>Albania</td>
<td>EDC@SAHO</td>
<td>IBM-1148</td>
</tr>
<tr>
<td>Serbian (Cyrillic)</td>
<td>Serbia</td>
<td>EDC$SCFE</td>
<td>IBM-1025</td>
</tr>
<tr>
<td>Serbian (Cyrillic)</td>
<td>Serbia</td>
<td>EDC$SCHT</td>
<td>IBM-1154</td>
</tr>
<tr>
<td>Slovene</td>
<td>Slovenia</td>
<td>EDC$SIEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Slovene</td>
<td>Slovenia</td>
<td>EDC$SIMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Slovak</td>
<td>Slovakia</td>
<td>EDC$SKEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Slovak</td>
<td>Slovakia</td>
<td>EDC$SKMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Serbian (Latin)</td>
<td>Serbia</td>
<td>EDC$SLEQ</td>
<td>IBM-870</td>
</tr>
<tr>
<td>Serbian (Latin)</td>
<td>Serbia</td>
<td>EDC$SLMB</td>
<td>IBM-1153</td>
</tr>
<tr>
<td>Swedish</td>
<td>Sweden</td>
<td>EDC$SVEY</td>
<td>Latin-1</td>
</tr>
<tr>
<td>Swedish</td>
<td>Sweden</td>
<td>EDC$SVEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Swedish</td>
<td>Sweden</td>
<td>EDC@SVEZ</td>
<td>IBM-924</td>
</tr>
<tr>
<td>Swedish</td>
<td>Sweden</td>
<td>EDC$SVHF</td>
<td>IBM-1143</td>
</tr>
<tr>
<td>Swedish</td>
<td>Sweden</td>
<td>EDC@SVHF</td>
<td>IBM-1143</td>
</tr>
<tr>
<td>Thai</td>
<td>Thailand</td>
<td>EDC$THEP</td>
<td>IBM-838</td>
</tr>
<tr>
<td>Thai</td>
<td>Thailand</td>
<td>EDC$THHP</td>
<td>IBM-1160</td>
</tr>
<tr>
<td>Turkish</td>
<td>Turkey</td>
<td>EDC$TREW</td>
<td>IBM-1026</td>
</tr>
<tr>
<td>Turkish</td>
<td>Turkey</td>
<td>EDC$TRHW</td>
<td>IBM-1155</td>
</tr>
<tr>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>EDC$ZCGY</td>
<td>IBM-935</td>
</tr>
<tr>
<td>Simplified Chinese</td>
<td>China (PRC)</td>
<td>EDC$ZCGV</td>
<td>IBM-1388</td>
</tr>
<tr>
<td>Traditional Chinese</td>
<td>Taiwan</td>
<td>EDC$ZTGW</td>
<td>IBM-937</td>
</tr>
<tr>
<td>Traditional Chinese</td>
<td>Taiwan</td>
<td>EDC$ZTKA</td>
<td>IBM-1371</td>
</tr>
</tbody>
</table>
Appendix E. Charmap Files Supplied with z/OS C/C++

All the locales supplied were built using the appropriate charmap file that represents the coded character sets described by the CodesetRegistry-CodesetEncoding element of the locale name.

All of these charmap files are provided with the National Language Resources feature of z/OS Language Environment. Consult your system programmer to determine whether they have been installed.

Under MVS, the charmap files are provided in a separate partitioned data set, CEE.SCEECMAP. The − sign is converted to the @ character.

The following table lists the coded character set name, which is the same as the name of the corresponding charmap file, and the national language each code set represents.

The column marked Latin-1 indicates whether the charmap file is for a coded character set that contains the Latin-1 character set.

Table 85. Coded character set names and corresponding primary country/territory

<table>
<thead>
<tr>
<th>Codeset</th>
<th>Primary Country/Territory</th>
<th>Latin-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big5</td>
<td>Taiwan</td>
<td>No</td>
</tr>
<tr>
<td>IBM-037</td>
<td>USA, Canada, Brazil</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-273</td>
<td>Germany, Austria</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-274</td>
<td>Belgium</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-277</td>
<td>Denmark, Norway</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-278</td>
<td>Finland, Sweden</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-280</td>
<td>Italy</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-281</td>
<td>Japan (Latin-1)</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-282</td>
<td>Portugal</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-284</td>
<td>Spain, Latin America</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-285</td>
<td>United Kingdom</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-290</td>
<td>Japan (Katakana)</td>
<td>No</td>
</tr>
<tr>
<td>IBM-297</td>
<td>France</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-424</td>
<td>Israel</td>
<td>No</td>
</tr>
<tr>
<td>IBM-425</td>
<td>Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait,</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Lebanon, Libya, Morocco, Oman, Qatar, Saudi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arabia, Syria, Tunisia, U.A.E., Yemen</td>
<td></td>
</tr>
<tr>
<td>IBM-500</td>
<td>International</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-838</td>
<td>Thailand</td>
<td>No</td>
</tr>
<tr>
<td>IBM-870</td>
<td>Croatia, Czech Republic, Hungary, Poland,</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Romania, Serbia (Latin), Slovakia, Slovenia</td>
<td></td>
</tr>
<tr>
<td>IBM-871</td>
<td>Iceland</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-875</td>
<td>Greece</td>
<td>No</td>
</tr>
<tr>
<td>IBM–901</td>
<td>Estonia, Latvia, Lithuania</td>
<td>No</td>
</tr>
<tr>
<td>IBM–921</td>
<td>Estonia, Latvia, Lithuania</td>
<td>No</td>
</tr>
<tr>
<td>Codeset</td>
<td>Primary Country/Territory</td>
<td>Latin-1</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>IBM-923</td>
<td>Multinational</td>
<td>No</td>
</tr>
<tr>
<td>IBM-924</td>
<td>Latin 9/Open Systems</td>
<td>No</td>
</tr>
<tr>
<td>IBM-930</td>
<td>Japan (Katakana, combined with DBCS)</td>
<td>No</td>
</tr>
<tr>
<td>IBM-933</td>
<td>Korea</td>
<td>No</td>
</tr>
<tr>
<td>IBM-935</td>
<td>China (PRC)</td>
<td>No</td>
</tr>
<tr>
<td>IBM-937</td>
<td>Taiwan</td>
<td>No</td>
</tr>
<tr>
<td>IBM-939</td>
<td>Japan (Latin, combined with DBCS)</td>
<td>No</td>
</tr>
<tr>
<td>IBM-943</td>
<td>Japan</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1025</td>
<td>Bulgaria, Macedonia, Russia, Serbia (Cyrillic)</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1026</td>
<td>Turkey</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1027</td>
<td>Japan (Latin) extended</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1047</td>
<td>Latin 1/Open Systems</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1112</td>
<td>Lithuania</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1122</td>
<td>Estonia</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1140</td>
<td>USA, Canada, Brazil</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1141</td>
<td>Germany, Austria</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1142</td>
<td>Denmark, Norway</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1143</td>
<td>Finland, Sweden</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1144</td>
<td>Italy</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1145</td>
<td>Spain, Latin America</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1146</td>
<td>United Kingdom</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1147</td>
<td>France</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1148</td>
<td>International</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1149</td>
<td>Iceland</td>
<td>Yes</td>
</tr>
<tr>
<td>IBM-1153</td>
<td>Croatia, Czech Republic, Hungary, Poland, Romania, Serbia (Latin), Slovakia, Slovenia</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1154</td>
<td>Bulgaria, Macedonia, Russia, Serbia (Cyrillic)</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1155</td>
<td>Turkey</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1156</td>
<td>Lithuania</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1157</td>
<td>Estonia</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1160</td>
<td>Thailand</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1165</td>
<td>Multinational</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1364</td>
<td>Korea</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1371</td>
<td>Taiwan</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1388</td>
<td>China (PRC)</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1390</td>
<td>Japan</td>
<td>No</td>
</tr>
<tr>
<td>IBM-1399</td>
<td>Japan</td>
<td>No</td>
</tr>
<tr>
<td>IBM-4971</td>
<td>Greece</td>
<td>No</td>
</tr>
<tr>
<td>IBM-5123</td>
<td>Japan</td>
<td>No</td>
</tr>
</tbody>
</table>
Table 85. Coded character set names and corresponding primary country/territory (continued)

<table>
<thead>
<tr>
<th>Codeset</th>
<th>Primary Country/Territory</th>
<th>Latin-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM-8482</td>
<td>Japan</td>
<td>No</td>
</tr>
<tr>
<td>IBM12712</td>
<td>Israel</td>
<td>No</td>
</tr>
<tr>
<td>IBMEUCCN</td>
<td>China (PRC)</td>
<td>No</td>
</tr>
<tr>
<td>IBMEUCKR</td>
<td>Korea</td>
<td>No</td>
</tr>
<tr>
<td>ISO8859-1</td>
<td>All Latin 1 Countries</td>
<td>Yes</td>
</tr>
<tr>
<td>ISO8859-2</td>
<td>Croatia, Czech Republic, Hungary, Poland, Romania, Serbia (Latin), Slovakia, Slovenia</td>
<td>No</td>
</tr>
<tr>
<td>ISO8859-5</td>
<td>Bulgaria, Macedonia, Russia, Serbia (Cyrillic)</td>
<td>No</td>
</tr>
<tr>
<td>ISO8859-7</td>
<td>Greece</td>
<td>No</td>
</tr>
<tr>
<td>ISO8859-8</td>
<td>Israel</td>
<td>No</td>
</tr>
<tr>
<td>ISO8859-9</td>
<td>Turkey</td>
<td>No</td>
</tr>
<tr>
<td>TIS–620</td>
<td>Thailand</td>
<td>No</td>
</tr>
<tr>
<td>UTF-8</td>
<td>All Countries</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Only the charmap files for IBM-930, IBM-933, IBM-935, IBM-937, IBM-939 and IBM-1388 specify `<mb_cur_max>` as 4 and include the definition of the double-byte characters.

**Note:** The SAA C locale is built with the charmap IBM-1047, but has `<mb_cur_max>` set to 4 to maintain compatibility with old releases of C/370.

Any of these charmaps that represent the same character set, even though they represent different encoding of the same character sets, can be used with any locale source that uses the same character set, to build a new locale and charmap combination. See Chapter 47, “Building a Locale” on page 675 for information about building your own locales.
Appendix F. Examples of Charmap and Locale Definition Source

Following are examples of the charmap source and locale definition source files.

Charmap File

This example shows the charmap file for the encoded character set IBM-1047.

Charmap File

```xml
<code_set_name> "IBM-1047"
<mb_cur_max> 1
<mb_cur_min> 1
<escape_char> /
<comment_char> %

CHARMAP
<NUL> /x00
<SOH> /x01
<STX> /x02
<ETX> /x03
<SEL> /x04
<tab> /x05
<VT> /x05
<RNL> /x06
<DEL> /x07
<GE> /x08
<SPS> /x09
<RPT> /x0a
<vertical-tab> /x0b
<VT> /x0b
<form-feed> /x0c
<FF> /x0c
<carriage-return> /x0d
<CR> /x0d
<SD> /x0e
<SI> /x0f
<DLE> /x10
<DC1> /x11
<DC2> /x12
<DC3> /x13
<RES> /x14
<newline> /x15
<backspace> /x16
<BS> /x16
<P0C> /x17
<CAN> /x18
<EM> /x19
<UBS> /x1a
<CU1> /x1b
<IFS> /x1c  % file separator
<IS4> /x1c
<FS> /x1c
<IGS> /x1d  % group separator
<IS3> /x1d
<GS> /x1d
<IIRS> /x1e  % record separator
<IS2> /x1e
<RS> /x1e
<IUS> /x1f  % unit separator
<IS1> /x1f
<US> /x1f
<ITB> /x1f
```
<DS>  /x20
<SOS> /x21
<FS>  /x22  % field separator
<WUS> /x23
<BYP> /x24
<LF>  /x25
<ETB> /x26
<ESC> /x27
<SA>  /x28
<SFE> /x29
<SM>  /x2a
<CSP> /x2b
<MFA> /x2c
<ENQ> /x2d
<ACK> /x2e
>alert> /x2f
<BEL> /x2f
<SYN> /x32
<IR>  /x33
<PP>  /x34
<TRN> /x35
<NBS> /x36
<EOT> /x37
<SBS> /x38
<IT>  /x39
<RFF> /x3a
<CU3> /x3b
<DC4> /x3c
<NAK> /x3d
<SUB> /x3f
<space> /x40
<SP01> /x40
<RSP> /x41
<SP30> /x41
<a-circumflex> /x42
<LA15> /x42
<a-diaeresis> /x43
<LA17> /x43
<a-grave> /x44
<LA13> /x44
<a-acute> /x45
<LA11> /x45
<a-tilde> /x46
<LA19> /x46
<a-ring> /x47
<LA27> /x47
<c-cedilla> /x48
<LC41> /x48
<n-tilde> /x49
<LN19> /x49
<cent>  /x4a
<SC04> /x4a
<period> /x4b
<SP11> /x4b
<less-than-sign> /x4c
<SA03> /x4c
<left-parenthesis> /x4d
<SP06> /x4d
<plus-sign> /x4e
<SA01> /x4e
<vertical-line> /x4f
<SM13> /x4f
<ampersand> /x50
<SM03> /x50
<e-acute> /x51
<LE11> /x51
<e-circumflex> /x52
Appendix F. Examples of Charmap and Locale Definition Source
Appendix F. Examples of Charmap and Locale Definition Source
z/OS V1R4.0 C/C++ Programming Guide
Appendix F. Examples of Charmap and Locale Definition Source 843
Locale Definition Source File

This example shows the typical locale definition file representing the cultural and language conventions in the United States of America. For this example (LC_COLLATE), please note the following:

- The digits (0...9) sort before the letters.
- Upper case and lowercase letters have the same primary sorting weight.
- For each letter, the uppercase letter sorts before the equivalent lowercase letter.

Locale Definition File

escape_char / comment-char %

% % % % % % % % % % % % % % % % % % % % %
LC_CTYPE
% % % % % % % % % % % % % % % % % % % % %
upper <A>;<B>;<C>;<D>;<E>;<F>;<G>;<H>;<I>;<J>;<K>;<L>;<M>;/
  <N>;<O>;<P>;<Q>;<R>;<S>;<T>;<U>;<V>;<W>;<X>;<Y>;<Z>
lower <a>;<b>;<c>;<d>;<e>;<f>;<g>;<h>;<i>;<j>;<k>;<l>;<m>;/
  <n>;<o>;<p>;<q>;<r>;<s>;<t>;<u>;<v>;<w>;<x>;<y>;<z>
space <tab>;<newline>;<vertical-tab>;<form-feed>;/
  <carriage-return>;<space>
cntrl <alert>;<backspace>;<tab>;<newline>;<vertical-tab>;/
  <form-feed>;<carriage-return>;<NULL>;<SOH>;<STX>;/
  <ETX>;<ESC>;<SEL>;<DEL>;<BS>;<FS>;<CR>;<LF>;<ESC>;<FS>;<CR>;<LF>;<ESC>;<FS>;<CR>;<LF>;
  <SYNC>;<SUB>;<SUP>;<UNDERLINE>;<OVERLINE>;<SPECIAL>;
  <exclamation-mark>;<quotation-mark>;<number-sign>;<dollar-sign>;/
  <percent-sign>;<ampersand>;<apostrophe>;<left-parenthesis>;/
Appendix F. Examples of Charmap and Locale Definition Source
END LC_COLLATE

%%%%%%%%%%%%%%%%
LC_MONETARY
%%%%%%%%%%%%%%%%

int_curr_symbol "<$><$><space>"
currency_symbol "<$><$>"
mon_decimal_point "<period>"
mon_thousands_sep "<comma>"
mon_grouping "3;0"
positive_sign ""
negative_sign "<hyphen-minus>"
int_frac_digits 2
frac_digits 2
p_cs_precedes 1
p_sep_by_space 0
n_cs_precedes 1
n_sep_by_space 0
p_sign_posn 2
n_sign_posn 2
debit_sign "<D><B>"
credit_sign "<C><R>
left_parenthesis "<left-parenthesis>"
right_parenthesis "<right-parenthesis>"

END LC_MONETARY

%%%%%%%%%%%%%%%%
LC_NUMERIC
%%%%%%%%%%%%%%%%
decimal_point "<period>"
thousands_sep "<comma>"
grouping "3;0"

END LC_NUMERIC

%%%%%%%%%%%%%%%%
LC_TIME
%%%%%%%%%%%%%%%%
abday "<S><u><n>;/
 "<M><o><n>;/
 "<T><u><e>;/
 "<W><e><d>;/
 "<T><h><u>;/
 "<F><r><i>;/
 "<S><a><t>

day "<S><u><n><a><y>;/
 "<M><o><n><a><y>;/
 "<T><u><e><s><a><y>;/
 "<W><e><d><n><a><y>;/
 "<T><h><u><r><a><y>;/
 "<F><r><i><a><y>;/
 "<S><a><t>

abmon "<J><a><n>;/
 "<F><e><b>;/
 "<M><a><r>;/
 "<A><p><r>;/
 "<M><a><y>;/
 "<J><u><n>;/
 "<J><u><l>;/
 "<A><u><g>;/
 "<S><e><p>;/
 "<O><c><t>;/
 "<N><o><v>;/
 "<D><e><c>

mon "<J><a><n><u><a><r><y>;/
 "<F><e><b><r><u><a><r><y>;/
 "<M><a><r><c><h>;/
 "<A><p><r><i><l>;/
 "<M><a><y>;/
 "<J><u><n><e>;/
 "<J><u><l><y>;/
 "<A><u><g><u><s><t>;/
 "<S><e><p><t><e><m><b><e><r>;/
 "<O><c><t><o><b><e><r>;/
 "<N><o><v><e><m><b><e><r>;/
 "<D><e><c><e><m><b><e><r>;

 d_t_fmt "%a %b %e %H:%M:%S %Z %Y"
d_fmt  "%m/%d/%y"

T_FMT  "%H:%M:%S"

am_pm  "<A><M>;""<P><M>"

END LC_TIME

%%%%%%%%%%%%%%%% LC_MESSAGES %%%%%%%%%%%%%%%%%

yesexpr  "<circumflex><left-parenthesis><left-square-bracket><y><Y>/<right-square-bracket><left-square-bracket><e><E><right-square-bracket>/<left-square-bracket><s><S><right-square-bracket>/<left-square-bracket><y><Y><right-parenthesis>"

noexpr  "<circumflex><left-parenthesis><left-square-bracket><n><N>/<right-square-bracket><left-square-bracket><o><O><right-square-bracket>/vertical-line/<left-square-bracket><n><N>/<right-parenthesis>"

END LC_MESSAGES

%%%%%%%%%%%%%%%% LC_SYNTAX %%%%%%%%%%%%%%%%%

backslash  "<backslash>"

right_brace  "<right-brace>"

left_brace  "<left-brace>"

right_bracket  "<right-square-bracket>"

left_bracket  "<left-square-bracket>"

circumflex  "<circumflex>"

tilde  "<tilde>"

exclamation_mark  "<exclamation-mark>"

number_sign  "<number-sign>"

vertical_line  "<vertical-line>"

dollar_sign  "<dollar-sign>"

commercial_at  "<commercial-at>"

grave_accent  "<grave-accent>"

END LC_SYNTAX

%%%%%%%%%%%%%%%% LC_TOD %%%%%%%%%%%%%%%%%

timezone_difference  +480

timezone_name  "<P><S><T>"

daylight_name  "<P><D><T>"

start_month  0

end_month  0

start_week  0

end_week  0

start_day  0

end_day  0

start_time  0

end_time  0

shift  3600

END LC_TOD
The method source file maps method names to the National Language Support (NLS) subroutines that implement those methods. The method file also specifies the object libraries or DLL side-decks where the implementing subroutines are stored. The methods correspond to those subroutines that require direct access to the data structures representing locale data. The following example shows a typical locale method source file.

Locale Method Source File

locale_method /
comment_char %
%******************************************************************
%*Licensed Materials - Property of IBM *
%* "Restricted Materials of IBM" *
%* 5694-A01 5688-198 *
%* (C) Copyright IBM Corp. 2001 *
%* Status = HLE7705 *
%* *
%* method file for ISO1 ASCII locales *
%* ******************************************************************
% IBM_PROLOG_BEGIN_TAG
% This is an automatically generated prolog.
% bos430 src/bos/usr/lib/nls/loc/locale/iso1meth.m 1.1
% Licensed Materials - Property of IBM
% Restricted Materials of IBM
% (C) COPYRIGHT International Business Machines Corp. 1997
% All Rights Reserved
% US Government Users Restricted Rights - Use, duplication or
% disclosure restricted by GSA ADP Schedule Contract with IBM Corp.
% IBM_PROLOG_END_TAG
METHODS
mblen "__mblen_sb_a"
mbtowc "__mbtowc_isol"
mbstowcs "__mbstowcs_std_a"
wctomb "__wctomb_isol"
wctombs "__wctombs_std_a"
wcswidth "__wcswidth_std_a"
wcswidth "__wcswidth_std_a"
csid "__csid_std_a"
towupper "__towupper_std_a"
towlower "__towlower_std_a"
get_wctype "__get_wctype_std_a"
is_wctype "__is_wctype_std_a"
strcoll "__strcoll_std_a"
strxfrm "__strxfrm_std_a"
wcscoll "__wcscoll_std_a"
wcsxfrm "__wcsxfrm_std_a"
regcomp "__regcomp_std_a"
regexec "__regexec_std_a"
regfree "__regfree_std_a"
regerror "__regerror_std_a"
strfmon "__strfmon_std_a"
END METHODS
Appendix G. Converting Code from Coded Character Set IBM-1047

The following program shows you how to convert hybrid code to a specified code page. Hybrid code is code in which the data is in the local coded character set but the syntax uses IBM-1047 code.

CCNGHC1

/* CCNGHC1: Sample code to convert all C syntax from code page 1047 to the coded character set the user specifies.
   Comments, string literals and character constants are left alone. The escape character in an escape sequence is changed, since it is variant.
   Usage: CCNGHC1 <coded character set>
   The input file is read from stdin and the output is written to stdout.
   Example: If you want to convert all C syntax, written in coded character set 1047, in a file (test1047 c a) to coded character set 500, you can use CCNGHC1 by issuing the following command.
   ccnghc1 <test1047.c.a >test1047.gen.a IBM-500
   The result will store in "test500 gen a" file.
*/

#include <stdio.h>
#include <stdlib.h>
#include <iconv.h>
#include <errno.h>

enum boolean { false=0, False=0, FALSE=0, true=1, True=1, TRUE=1 };

/* CharState - state that the FSM is in. Initial State is CodeState */
enum CharState { CodeState, SQuoteState, DQuoteState, CommentState, DBCSSState, EscState, EOFState };

/* CharVal - characters that can change the state of the FSM */
enum CharVal { SlashChar='/', SQuoteChar='\', DQuoteChar='"', StarChar='*', SOChar='OE', SIChar='OF', BSlashChar='\', EOFChar= -1 };

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 1 of 10)
/*
 * XlateTable - type of translation table
 */
typedef iconv_t XlateTable;

static char *Initialize(int argc, char *argv[]);
static int Convert(char *codeset);
static int InitConv(char **inBuff, char **outBuff, int *maxRecSize,
                   char *codeSet, XlateTable *xlateTable);
static void ConvBuff(int start, int end,
                     char *buff, XlateTable xlateTable);
static enum CharVal LookAhead(char *inBuff, char *outBuff,
                               int *recSize, int *curPos,
                               int maxRecSize, int *codeStartPos,
                               enum CharState state,
                               XlateTable xlateTable);
static enum CharVal GetNextChar(char *inBuff, char *outBuff,
                               int *recSize, int maxRecSize,
                               int *curPos, int *codeStartPos,
                               enum CharState state,
                               XlateTable xlateTable);
static int UpdateAndRead(char *inBuff, char *outBuff,
                           int *recSize, int codeStartPos, enum CharState state,
                           XlateTable xlateTable);
static int ReadAndCopy(char *inBuff, char *outBuff, int maxRecSize);

#pragma inline(LAST_POS)
#pragma inline(NEXT_TO_LAST_POS)
#pragma inline(LookAhead)
#pragma inline(GetNextChar)
#pragma inline(ConvBuff)

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 2 of 10)
*/
* Initialize the environment, and if everything is ok, convert input
*/
main(int argc, char *argv[]) {
char *codeset = Initialize(argc, argv);
if (codeset == NULL) {
    return(8);
}
return(Convert(codeset));
}

/*
* Check that 1 parameter was specified - the coded character set to convert the
* the syntax to.
* Re-open stdin and stdout as binary files for record I/O.
* Return the code set if everything is ok, NULL otherwise
*/
static char *Initialize(int argc, char *argv[]) {
    if (argc != 2) {
        fprintf(stderr, "Expected %d argument but got %d
", 1, argc-1);
        return(NULL);
    }
    stdin = freopen("", "rb,type=record", stdin);
    stdout= freopen("", "wb,type=record", stdout);
    if (stdin == NULL || stdout == NULL) {
        fprintf(stderr, "Could not re-open standard streams
");
        return(NULL);
    }
    return(argv[1]);
}

/*
* Return the last position in a record
*/
static int LAST_POS(int recSize) {
    return(recSize-1);
}

/*
* Return the next to last position in a record
*/
static int NEXT_TO_LAST_POS(int recSize) {
    return(recSize-2);
}

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 3 of 10)
/*
* Convert the stdin file using codeset and write to stdout.
* Set up the translation table.
* Read the first record and copy it into the output buffer.
* Go through the FSM, starting in the Code State and leaving
* when EOFState is reached (End Of File).
* Close the translation table.
*/

static int Convert(char *codeset) {
  enum CharVal  c;
  int           recSize;
  enum CharState prvState;
  int           rc;

  int codeStartPos = 0;
  int curPos = 0;
  enum boolean  high = FALSE;
  enum CharState state = CodeState;

  char * inBuff;
  char * outBuff;
  int    maxRecSize;
  XlateTable xlateTable;

  rc = InitConv(&inBuff, &outBuff, &maxRecSize, codeset, &xlateTable);
  if (rc) {
    if (inBuff) free(inBuff);
    if (outBuff) free(outBuff);
    return(rc);
  }

  recSize = ReadAndCopy(inBuff, outBuff, maxRecSize);

  while (state != EOFState) {
    c = GetNextChar(inBuff, outBuff, &recSize, maxRecSize,
                    &curPos, &codeStartPos, state, xlateTable);
    if (c == EOFChar) {
      state = EOFState;
    }
  }

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 4 of 10)
switch(state) {
    case CodeState:
        switch (c) {
        case BSlashChar:
            curPos = LAST_POS(recSize);
            break;
        case SlashChar:
            if (LookAhead(inBuff, outBuff, &recSize,
                        &curPos, maxRecSize, &codeStartPos,
                        state, xlateTable)
                == StarChar) {
                state = CommentState;
            }
            break;
        case SQuoteChar:
            state = SQuoteState;
            break;
        case DQuoteChar:
            state = DQuoteState;
            break;
        }
        if (state != CodeState || curPos == NEXT_TO_LAST_POS(recSize)) {
            if (curPos == NEXT_TO_LAST_POS(recSize)) {
                ++curPos;
            } else {
                ConvBuff(codeStartPos, curPos, outBuff, xlateTable);
            }
        }
        break;
    case CommentState:
        switch(c) {
        case BSlashChar:
            curPos = LAST_POS(recSize);
            break;
        case StarChar:
            if (LookAhead(inBuff, outBuff, &recSize,
                            &curPos, maxRecSize, &codeStartPos,
                            state, xlateTable)
                == SlashChar) {
                state = CodeState;
                codeStartPos = curPos;
            }
            break;
        }
        break;
}

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 5 of 10)
case DQuoteState:
    switch(c) {
    case DQuoteChar:
        state = CodeState;
        codeStartPos = curPos;
        break;
    case SOChar:
        prvState = state;
        state = DBCSState;
        break;
    case BSlashChar:
        ConvBuff(curPos, curPos, outBuff, xlateTable);
        if (curPos != LAST_POS(recSize)) {
            prvState = state;
            state = EscState;
        }
        break;
    }
    break;

    case SQuoteState:
    switch(c) {
    case SQuoteChar:
        state = CodeState;
        codeStartPos = curPos;
        break;
    case SOChar:
        prvState = state;
        state = DBCSState;
        break;
    case BSlashChar:
        ConvBuff(curPos, curPos, outBuff, xlateTable);
        if (curPos != LAST_POS(recSize)) {
            prvState = state;
            state = EscState;
        }
        break;
    }
    break;

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 6 of 10)
case DBCSState:
    high = !high; /* TRUE -> FALSE or FALSE -> TRUE */
    if (high && (c == SIChar)) {
        state = prvState;
        high = FALSE;
    }
    break;

case EscState:
    state = prvState; /* really, this is ok */
    break;

case EOFState:
    break;

default:
    fprintf(stderr, "Internal error - ended up in state %d\n", state);
    return (16);
    } /* end of switch statement */

rc = TermConv(inBuff, outBuff, xlateTable);
return(0);

/*
 * Initialize the translation table and allocate the input and
 * output buffers to use.
 * Return 0 if successful.
 */
static int InitConv(char **inBuff, char **outBuff, int *maxRecSize,
                     char *codeset, XlateTable* xlateTable) {

    static char fileNameBuff[FILENAME_MAX+1];
    fldata_t info;
    int rc;

    *outBuff = *inBuff = NULL;

    rc = fldata(stdin, fileNameBuff, &info);
    if (rc) {
        return(rc);
    }

    *maxRecSize = info.__maxreclen;
    *inBuff = malloc(*maxRecSize);
    *outBuff = malloc(*maxRecSize);

    if (((xlateTable = iconv_open("IBM-1047",codeset)) != (iconv_t)(-1)) {  
        fprintf(stderr,"Cannot open convertor from %s to IBM-1047",codeset);
        return (8);
    }

    return(!inBuff || !outBuff);
}

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 7 of 10)
/ Convert the buffer from start to end using the translation table
*/
static void ConvBuff(int start, int end,
        char *buff, XlateTable xlateTable) {
    int rc;
    size_t inleft, outleft, org;
    char *inp, *outptr;

    outleft = inleft = end-start+1;
    inp = outptr = &buff[start];

    while (1) {
        rc = iconv(xlateTable, &inp, &inleft, &outptr, &outleft);

        if (rc == -1) {
            switch (errno) {
                case EILSEQ: if (--inleft == 0) return;
                    ++inp;
                    ++outptr;
                    --outleft;
                    break;
                default: fprintf(stderr, "iconv() fails with errno = %d\n", errno);
                    exit(8);
            }
        } else
            return;
    }

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 8 of 10)
Look ahead to the next character. If the current position
is the last character of the input record, write the current
output record and read in the next record.
Return the 'character' read, which may be EOF if the end of
the file was reached.

LookAhead(char *inBuff, char *outBuff,
int *recSize, int *curPos,
int maxRecSize, int *codeStartPos,
enum CharState state,
XlateTable xlateTable) {
    if (*curPos == LAST_POS(*recSize)) {
        if (UpdateAndRead(inBuff, outBuff, recSize, maxRecSize,
            *codeStartPos, state, xlateTable)) {
            return(EOFChar);
        }
        *curPos = 0;
        *codeStartPos = 0;
    }
    else {
        (*curPos)++;
        return(inBuff[*curPos]);
    }
}

Similar to LookAhead(), but return the current character

GetNextChar(char *inBuff, char *outBuff,
int *recSize, int maxRecSize,
int *curPos, int *codeStartPos,
enum CharState state,
XlateTable xlateTable) {
    if (*curPos > LAST_POS(*recSize)) {
        if (UpdateAndRead(inBuff, outBuff, recSize, maxRecSize,
            *codeStartPos, state, xlateTable)) {
            return(EOFChar);
        }
        *curPos = 0;
        *codeStartPos = 0;
    }
    return(inBuff[*curPos]);
}

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 9 of 10)
/*
* If the current state is the code state, translate the remaining
* part of the record.
* Write out the record to stdout
* Read in the next record and copy it to the output buffer.
*/
static int UpdateAndRead(char *inBuff, char *outBuff,
                          int *recSize, int maxRecSize,
                          int codeStartPos, enum CharState state,
                          XlateTable xlateTable) {

    if (state == CodeState) {
        ConvBuff(codeStartPos, LAST_POS(*recSize), outBuff, xlateTable);
    }
    fwrite(outBuff, 1, *recSize, stdout);
    *recSize = ReadAndCopy(inBuff, outBuff, maxRecSize);
    return((*recSize == 0)?1:0);
}

/*
* Read in a record from stdin and copy it to the output buffer.
* Return the number of bytes read.
*/
static int ReadAndCopy(char *inBuff, char *outBuff,
                        int maxRecSize) {
    int recSize;

    recSize = fread(inBuff, 1, maxRecSize, stdin);
    if (feof(stdin) && recSize == 0) {
        return(0);
    }
    else {
        memcpy(outBuff, inBuff, recSize);
        return(recSize);
    }
}

/*
* Free allocated storage and close the translation table.
*/
static int TermConv(char *inBuff,
                     char *outBuff, XlateTable xlateTable) {
    iconv_close(xlateTable);
    free(inBuff);
    free(outBuff);
    return(0);
}

Figure 232. Converting Hybrid Code to a Specific Character Set (Part 10 of 10)
Appendix H. Additional Examples

This chapter contains additional examples that you might find useful when you are writing a C or C++ program.

Memory Management

If you have ever received an error from overwriting storage created with the malloc() function, the following code may be of interest. It shows how to use debuggable versions of malloc()/calloc()/realloc() and free(). You can tailor the following macros.

CCNGM1

/* debuggable malloc()/calloc()/realloc()/free() example */
/* part 1 of 2-other file is CCNGM2 */
#ifndef __STORAGE__
#define __STORAGE__
#define PADDING_SIZE 4 /* amount of padding around */
    /* allocated storage */
#define PADDING_BYTE 0xFE /* special value to initialize */
    /* padding to */
#define HEAP_INIT_SIZE 4096 /* get 4K to start with */
#define HEAP_INCR_SIZE 4096 /* get 4K increments */
#define HEAP_OPTS 72 /* HEAP,,,ANYWHERE,FREE */
extern int heapVerbose; /* If 0, heap allocation and */
    /* free messages will be */
    /* suppressed, otherwise, they */
    /* will be displayed */
#endif

Figure 233. Debuggable malloc()/calloc()/realloc()/free() example

Main routine follows:
/* debuggable malloc()/calloc()/realloc()/free() example */
/* part 2 of 2-other file is CCNGMI1 */
/*
 * STORAGE:
 *
 * EXTERNALS:
 *
 * This file contains code for the following functions:
 * -malloc......allocate storage from a Language Environment heap
 * -calloc......allocate storage from a Language Environment heap
 * and initialize it to 0.
 * file.
 * this file. If a NULL pointer is passed instead of a
 * directly.
 *
 * USAGE:
 *
 * You do not need to compile this code with any special options.
 * The TEST option is useful, however, as the traceback will provide
 * additional information. Line number information and the type and
 * values of variables will be dumped in a traceback for all
 * files compiled with TEST.
 *
 * Prelink,link, or bind this object module with your other object modules.
 * malloc(), free(), and realloc().
 *
 * INTERNALS:
 *
 * General Algorithm:
 *
 * When storage is allocated, extra 'padding' is allocated at the
 * start and end of the actual storage allocated for you.
 * This padding is then initialized to a special pad value. If your
 * code is functioning correctly, the padding should not
 * have been changed when it comes time to free the storage. If the
 * free() routine finds that the padding does not have the correct
 * value, the storage about to be freed is dumped and a traceback
 * is issued. The storage is then dumped, as usual.
 * The padding size and padding byte value can be modified to suit
 * your needs. Update the include file "ccngmi2.h" if you want
 * to modify these values.
 * Here is a diagram of how storage is allocated (assume that the
 * pad value is xFE, the padding size is 4 bytes and 8 bytes of
 * storage were requested):
 *
 Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 1 of 10)
This method is fairly effective in tracking down storage allocation problems. Also, code does not have to be recompiled to use these routines - it just has to be relinked. Note that this method is not guaranteed to find all storage allocation errors - if you overwrite the padding with the same value it had before, or you overwrite more storage than you had padding for, you will still have problems.

This code uses the Language Environment heap services to allocate, reallocate, and free storage. A User Heap is used instead of the library heap so that if the heap gets corrupted, the standard library services that use the heap will not be affected. For example, if the user heap is damaged, a call to a library function such as printf should still succeed.

Notes of interest:
- The run-time option STORAGE is very useful for tracking down random pointer problems - it initializes heap or stack frame storage to a particular value.
- The run-time option RPTSTG(ON) is useful for improving heap and stack frame allocation - it generates a report indicating how stack and heap storage was managed for a given program.

```
#include "storage.h"
#include <leawi.h>
#include <stdio.h>
```

Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 2 of 10)
/*
  * heapVerbose: external variable that controls whether heap
  * allocation and free messages are displayed.
  */
int heapVerbose=1;

/*
  * mallocHeapID: static variable that is the Heap ID used for allocating
  * storage via malloc(). On the first call to malloc(),
  * a Heap will be created and this Heap ID will be set.
  * All subsequent calls to malloc will use this Heap ID.
  */
static _INT4 mallocHeapID=0;

/*
  * CHARS_PER_LINE/BYTES_PER_LINE: Used by dump() and DumpLine()
  * to control the width of a storage dump.
  */
#define CHARS_PER_LINE 40
#define BYTES_PER_LINE 16

/*
  * align: Given a value and the alignment desired (in bits), round
  * the value to the next largest alignment, unless it is
  * already aligned, in which case, just return the value passed.
  */
#pragma inline(align)
static int align(int value, int shift) {
    int alignment = (0x1 << shift);
    if (value % alignment) {
        return(((value >> shift) << shift) + alignment);
    } else {
        return(value);
    }
}

/*
  * padding: given a buffer (address and length), return 1 if the
  * entire buffer consists of the pad character specified,
  * otherwise return 0.
  */
#pragma inline(padding)
static int padding(const char* buffer, long size, int pad) {
    int i;
    for (i=0;i<size;++i) {
        if (buffer[i] != pad) return(0);
    }
    return(1);
}

Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 3 of 10)
/ * CEECmp: Given two feedback codes, return 0 if they have the same 
 * message number and facility id, otherwise return 1. 
 */ 
#pragma inline(CEECmp) 
static int CEECmp(_FEEDBACK* fc1, _FEEDBACK* fc2) { 
    if (fc1->tok_msgno == fc2->tok_msgno && 
        memcmp(fc1->tok_facid, fc2->tok_facid, 
               sizeof(fc1->tok_facid))) { 
        return(0); 
    } else { 
        return(1); 
    } 
} 

/* 
 * CEEOk: Given a feedback code, return 1 if it compares the same to
 * condition code CEE000. 
 */ 
#pragma inline(CEEOk) 
static int CEEOk(_FEEDBACK* fc) { 
    _FEEDBACK CEE000 = { 0, 0, 0, 0, 0, {0,0,0}, 0 }; 
    return(CEECmp(fc, &CEE000) == 0); 
} 

/* 
 * CEEErr: Given a title string and a feedback code, print the
 * title to stderr, then print the message associated
 * with the feedback code. If the feedback code message can not
 * be printed out, print out the message number and severity. 
 */ 
static void CEEErr(const char* title, _FEEDBACK* fc) { 
    _FEEDBACK msgFC; 
    _INT4 dest = 2; 
    fprintf(stderr, "\n%s\n", title); 
    CEEMSG(fc, &dest, &msgFC); 
    if (!CEEOk(&msgFC)); { 
        fprintf(stderr, "Message number: %d with severity %d occurred\n", 
                fc->tok_msgno, fc->tok_sev); 
    } 
} 

Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 4 of 10)
/*
 * DumpLine: Dump out a buffer (address and length) to stderr.
 */
static void DumpLine(char* address, int length) {
  int i, c, charCount=0;

  if (length % 4) length += 4;

  fprintf(stderr, "%.8p: ", address);
  for (i=0; i < length/4; ++i) {
    fprintf(stderr, "%.8X ", ((int*)address)[i]);
    charCount += 9;
  }
  for (i=charCount; i < CHARS_PER_LINE; ++i) {
    putc(' ', stderr);
  }
  fprintf(stderr, "| ");
  for (i=0; i < length; ++i) {
    c = address[i];
    c = (isprint(c) ? c : '.');
    fprintf(stderr, "%c", c);
  }
  fprintf(stderr, "\n");
}

/*
 * dump: dump out a buffer (address and length) to stderr by dumping out
 * a line at a time (DumpLine), until the buffer is written out.
 */
static void dump(void* generalAddress, int length) {
  int curr = 0;
  char* address = (char*) generalAddress;

  while (&address[curr] < &address[length-BYTES_PER_LINE]) {
    DumpLine(&address[curr], BYTES_PER_LINE);
    curr += BYTES_PER_LINE;
  }
  if (curr < length) {
    DumpLine(&address[curr], length-curr);
  }
}

Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 5 of 10)
void* malloc(long initSize) {
  FEEDBACK fc;
  _POINTER address=0;
  long totSize;
  long* lenPtr;
  char* msg;
  char* start;
  char* end;

  /* malloc: Create a heap if necessary by calling CEECRHP. This only
     needs to be done on the first call to malloc(). Verify
     that the heap creation was ok. If it was not, issue an
     error message and return a NULL pointer.
     Write a message to stderr indicating how many bytes
     are about to be allocated.
     Call CEEGST to allocate the storage requested plus
     additional padding to be placed at the start and end
     of the allocated storage. Verify that the storage allocation
     was successful. If it was not, issue an error message and
     return a NULL pointer.
     Write a message to stderr indicating the address of the
     allocated storage.
     Initialize the padding to the value of PADDING_BYTE, so that
     free() will be able to test that the padding was not changed.
     Return the address of the allocated storage (starting after
     the padding bytes).
     */

  Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 6 of 10)
if (!mallocHeapID) {
    _INT4 heapSize = HEAP_INIT_SIZE;
    _INT4 heapInc = HEAP_INCR_SIZE;
    _INT4 opts = HEAP_OPTS;

    CEECRHP(&mallocHeapID, &heapSize, &heapInc, &opts, &fc);
    if (!CEEOk(&fc)) {
        CEEErr("Heap creation failed", &fc);
        return(0);
    }
}

if (heapVerbose) {
    fprintf(stderr, "Allocate %d bytes", initSize);
}

/*
 * Add the padding size to the total size, then round up to the
 * nearest double word
 */
    totSize = initSize + (PADDING_SIZE*2) + sizeof(long);
    totSize = align(totSize, 3);

    CEEGTST(&mallocHeapID, &totSize, &address, &fc);
    if (!CEEOk(&fc)) {
        msg = "Storage request failed";
        CEEEerr(msg, &fc);
        __ctrace(msg);
        return(0);
    }

    lenPtr = (long*) address;
    *lenPtr= initSize;
    start = ((char*) address) + sizeof(long);
    end = start + initSize + PADDING_SIZE;

    memset(start, PADDING_BYTE, PADDING_SIZE);
    memset(end, PADDING_BYTE, PADDING_SIZE);

    if (heapVerbose) {
        fprintf(stderr, " starting at address %p\n", address);
    }

    return(start + PADDING_SIZE);


Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 7 of 10)
/*
 * calloc: Call malloc() to allocate the requested amount of storage.
 * If the allocation was successful, initialize the allocated
 * storage to 0.
 * Return the address of the allocated storage (or a NULL
 * pointer if malloc returned a NULL pointer).
 */

void* calloc(long initSize) {
    void* ptr;

    ptr = malloc(initSize);
    if (ptr) {
        memset(ptr, 0, initSize);
    }
    return(ptr);
}

/*
 * realloc: If a NULL pointer is passed, call malloc() directly.
 * Call CECZST to reallocate the storage requested plus
 * additional padding to be placed at the start and end
 * of the allocated storage.
 * Verify that the storage re-allocation was ok. If it was not,
 * issue an error message, dump the storage, and return a NULL
 * pointer.
 * Write a message to stderr indicating the address of the
 * reallocated storage.
 * Initialize the padding to the value of PADDING_BYTE, so
 * that free() will be able to test that the padding was not
 * changed. Note that the padding at the start of the storage
 * does not need to be allocated, since it was already
 * initialized by an earlier call to malloc().
 * Return the address of the reallocated storage (starting
 * after the padding bytes).
 */

void* realloc(char* ptr, long initSize) {
    FEEDBACK fc;
    _POINTER address = (ptr - sizeof(long) - PADDING_SIZE);
    long oldSize;
    long* lenPtr;
    char* start;
    char* end;
    char* msg;
    long newSize = initSize;

    Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 8 of 10)
if (ptr == 0) {
    return(malloc(newSize));
}

oldSize = *((long*) address);

if (heapVerbose) {
    fprintf(stderr, "Re-allocate %d bytes from address %p to ",
            newSize, address);
}

newSize += (PADDING_SIZE*2) + sizeof(long);
newSize = align(newSize, 3);
CEECZST(&address, &newSize, &fc);
if (!CEEOk(&fc)) {
    msg = "Storage re-allocation failed";
    CEEErr(msg, &fc);
    dump(address, oldSize + (PADDING_SIZE*2) + sizeof(long));
    __ctrace(msg);
    return(0);
}

lenPtr = (long*) address;
*lenPtr= initSize;
start = ((char*) address) + sizeof(long);
end = start + initSize + PADDING_SIZE;
memset(end, PADDING_BYTE, PADDING_SIZE);
if (heapVerbose) {
    fprintf(stderr, "address %p
", address);
}

return(start + PADDING_SIZE);

Figure 234. Debuggable malloc()/calloc()/realloc()/free() example (Part 9 of 10)
Calling MVS WTO routines from C

The following sample code calls a function that will perform a Write To Operator (WTO) call. You can tailor it as you wish. The C code performs an ILC to an assembler routine to do a dynamic WTO call.

Assemble CCNGWT1, compile CCNGWT2, link the two together, and run CCNGWT2. Information is written to the job log.

Note: This example runs only in the TSO BATCH environment.
* WRITE TO OPERATOR EXAMPLE *
* PART 1 OF 2-OTHER FILE IS CCNGWT2 *
WTO CSECT
WTO AMODE 31
WTO RMODE ANY

********
* R1->ADDRESS OF INTEGER -> LENGTH OF STRING
* ->CHARACTER STRING

EDCPRLG DSALN=DLEN
USING DSA,13

********
* RANGE CHECK LENGTH
* IGNORE A SINGLE TRAILING NULL CHARACTER

L 5,0(,1)  POINT TO LENGTH
LA 15,4  RETURN CODE FOR INVALID LENGTH
ICM 5,'1111',0(5)  LENGTH OF MESSAGE
BNP RETURN  NOT >0?  RETURN
L 6,4(,1)  POINT TO MESSAGE
LA 8,0(5,6)  POINT TO CHAR AFTER MESSAGE
BCTR 8,0  POINT TO LAST CHARACTER
CLI 0(8),0  IS IT A NULL CHARACTER?
BNE NOENDINGNULL
BCT 5,NOENDINGNULL  IGNORE IT:  USER SAID WTO(SIZEOF S,S)
B RETURN  UNLESS LENGTH WAS DROPPED TO ZERO

NOENDINGNULL DS 0H
LA 7,0  LENGTH OK SO FAR
LA 8,L'BUFFER  MAXIMUM LENGTH
CR 5,8  CHECK LENGTH
BNH LENOK
LR 5,8  SHOW ONLY WHAT FITS INTO BUFFER
LA 7,4  REMEMBER SPECIFIED STRING WAS TOO LONG
LENOK DS 0H

********
* BUILD WTO BUFFER
* COPY LIST FORM OF WTO TO DSA
* EXECUTE WTO

STH 5,PREFIX  LENGTH SHOWN GOES INTO PREFIX
BCTR 5,0  REDUCE LENGTH FOR EXECUTE
EX 5,MSG  MOVE MESSAGE TEXT
LA 6,PREFIX  POINT TO PREFIX OF COPIED MESSAGE
MVC WTOD,WTOL  MOVE LIST FORM OF MACRO TO DSA
WTO TEXT=(6),MF=(E,WTOD)

Figure 235. Performing a Write To Operator (Part 1 of 2)
Listing Partitioned Data Set Members

The following example shows a way to create a list of all members in a Partitioned Data Set (PDS).

**Note:** This information is included to aid you in such a task and is not programming interface information.

---

**Listing Partitioned Data Set Members**

The following example shows a way to create a list of all members in a Partitioned Data Set (PDS).

**Note:** This information is included to aid you in such a task and is not programming interface information.

---

Figure 235. Performing a Write To Operator (Part 2 of 2)

---

Figure 236. Performing a Write To Operator

---

Listing Partitioned Data Set Members

The following example shows a way to create a list of all members in a Partitioned Data Set (PDS).

**Note:** This information is included to aid you in such a task and is not programming interface information.
/* this example shows how to create a list of members of a PDS */
/* part 1 of 2-other file is CCNGIP2 */

/* NODE_PTR pds_mem(const char *pds):
 * pds must be a fully qualified pds name, for example,
 * ID.PDS.DATASET  * returns a * pointer to a linked list of
 * nodes. Each node contains a member of the * pds and a
 * pointer to the next node. If no members exist, the pointer
 * is NULL.
 *
 * Note: Behavior is undefined if pds is the name of a sequential file.
 */

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include "ccngip2.h"

/* RECORD: each record of a pds will be read into one of these structures.
 * The first 2 bytes is the record length, which is put into 'count',
 * the remaining 254 bytes are put into rest. Each record is 256 bytes long.
 */
#define RECLEN 254

typedef struct {
    unsigned short int count;
    char rest[RECLEN];
} RECORD;

/* Local function prototypes */
static int gen_node(NODE_PTR *node, RECORD *rec, NODE_PTR *last_ptr);
static char *add_name(NODE_PTR *node, char *name, NODE_PTR *last_ptr);

Figure 237. Example of Listing All Members of a PDS (Part 1 of 5)
NODE_PTR pds_mem(const char *pds) {

    FILE *fp;
    int bytes;
    NODE_PTR node, last_ptr;
    RECORD rec;
    int list_end;
    char *qual_pds;
    node = NULL;
    last_ptr = NULL;
    /*
    * Allocate a new variable, qual_pds, which will be the same as pds, except
    * with single quotes around it, i.e. ID.PDS.DATASET ==> 'ID.PDS.DATASET'
    */

    qual_pds = (char *)malloc(strlen(pds) + 3);
    if (qual_pds == NULL) {
        fprintf(stderr,"malloc failed for %d bytes\n",strlen(pds) + 3);
        exit(-1);
    }
    sprintf(qual_pds,"'\%s'",pds);
    /*
    * Open the pds in binary read mode. The PDS directory will be read one
    * record at a time until either the end of the directory or end-of-file
    * is detected. Call up gen_node() with every record read, to add member
    * names to the linked list
    */

    fp = fopen(qual_pds,"rb");
    if (fp == NULL)
        return(NULL);
    do {
        bytes = fread(&rec, 1, sizeof(rec), fp);
        if (((bytes != sizeof(rec)) && !feof(fp)) { 
            perror("FREAD:");
            fprintf(stderr,"Failed in \%s, line \%d\n"
                    "Expected to read \%d bytes but read \%d bytes\n",
                    __FILE__,__LINE__,sizeof(rec), bytes);
            exit(-1);
        }
        list_end = gen_node(&node,&rec, &last_ptr);
    } while (!feof(fp) && !list_end);
    fclose(fp);
    free(qual_pds);
    return(node);
}

Figure 237. Example of Listing All Members of a PDS (Part 2 of 5)
/*
 * GEN_NODE() processes the record passed. The main loop scans through the
 * record until it has read at least rec->count bytes, or a directory end
 * marker is detected.
 *
 * Each record has the form:
 *
 * +------------+------+------+------+------+----------------+
 * + # of bytes |Member|Member|......|Member| Unused +
 * + in record | 1    | 2    |......| n    | +
 * +------------+------+------+------+------+----------------+
 * |--count--|-------------------rest------------------------|
 * (Note that the number stored in count includes its own
 * two bytes)
 *
 * And, each member has the form:
 *
 * +--------+-------+----+-----------------------------------+
 * + Member |TTR    |info| +
 * + Name   |byte   | User Data TTRN's (halfwords) +
 * + 8 bytes|3 bytes| +
 * +--------+-------+----+-----------------------------------+
 */

#define TTRLEN 3 /* The TTR's are 3 bytes long */
/*
 * bit 0 of the info-byte is '1' if the member is an alias,
 * 0 otherwise. ALIAS_MASK is used to extract this information
 */
#define ALIAS_MASK ((unsigned int) 0x80)
/*
 * The number of user data half-words is in bits 3-7 of the info byte.
 * SKIP_MASK is used to extract this information. Since this number is
 * in half-words, it needs to be double to obtain the number of bytes.
 */
#define SKIP_MASK ((unsigned int) 0x1F)
/*
 * 8 hex FF's mark the end of the directory

Figure 237. Example of Listing All Members of a PDS (Part 3 of 5)
/*
char *endmark = "\xFF\xFF\xFF\xFF\xFF\xFF\xFF\xFF\xFF\xFF"
static int gen_node(NODE_PTR *node, RECORD *rec, NODE_PTR *last_ptr) {

    char *ptr, *name;
    int skip, count = 2;
    unsigned int info_byte, alias, ttrn;
    char ttr[TTRLEN];
    int list_end = 0;

    ptr = rec->rest;

    while(count < rec->count) {
        if (!memcmp(ptr,endmark,NAMELEN)) {
            list_end = 1;
            break;
        }

        /* member name */
        name = ptr;
        ptr += NAMELEN;

        /* ttr */
        memcpy(ttr,ptr,TTRLEN);
        ptr += TTRLEN;

        /* info_byte */
        info_byte = (unsigned int)(*ptr);
        alias = info_byte & ALIAS_MASK;
        if (!alias) add_name(node,name,last_ptr);
        skip = (info_byte & SKIP_MASK)*2+1;
        ptr += skip;
        count += (TTRLEN + NAMELEN + skip);
    }

    return(list_end);
}

Figure 237. Example of Listing All Members of a PDS (Part 4 of 5)
/* ADD_NAME: Add a new member name to the linked node. The new member is
* added to the end so that the original ordering is maintained.
*/

static char *add_name(NODE_PTR *node, char *name, NODE_PTR *last_ptr) {
    NODE_PTR newnode;

    /* malloc space for the new node */
    newnode = (NODE_PTR)malloc(sizeof(NODE));
    if (newnode == NULL) {
        fprintf(stderr,"malloc failed for %d bytes\n",sizeof(NODE));
        exit(-1);
    }

    /* copy the name into the node and NULL terminate it */
    memcpy(newnode->name,name,NAMELEN);
    newnode->name[NAMELEN] = '\0';
    newnode->next = NULL;

    /* add the new node to the linked list */
    if (*last_ptr != NULL) {
        (*last_ptr)->next = newnode;
        *last_ptr = newnode;
    } else {
        *node = newnode;
        *last_ptr = newnode;
    }
    return(newnode->name);
}

/* FREE_MEM: This function is not used by pds_mem(), but it should be used
* as soon as you are finished using the linked list. It frees the storage
* allocated by the linked list. */

void free_mem(NODE_PTR node) {
    NODE_PTR next_node=node;

    while (next_node != NULL) {
        next_node = node->next;
        free(node);
        node = next_node;
    }
    return;
}

Figure 237. Example of Listing All Members of a PDS (Part 5 of 5)
CCNGIP2

/* this example shows how to create a list of members of a PDS */
/* part 2 of 2-other file is CCNGIP1 */
/*
 * NODE: a pointer to this structure is returned from the call to pds_mem().
 * It is a linked list of character arrays - each array contains a member
 * name. Each next pointer points * to the next member, except the last
 * next member which points to NULL.
 */
#define NAMELEN 8    /* Length of a MVS member name */
typedef struct node {
    struct node *next;
    char name[NAMELEN+1];
} NODE, *NODE_PTR;

NODE_PTR pds_mem(const char *pds);
void free_mem(NODE_PTR list);

Figure 238. ccngip2.h Header file
Appendix I. Using Built-In Functions

The following built-in functions are components of the z/OS C/C++ compiler. The compiler generates inline code for these functions at compile time when the appropriate Standard header file (as listed below) is included in the source file.
Built-in functions do not correspond to inline functions that result from the use of the compile-time option INLINE and the #pragma inline directive in C. Refer to z/OS C/C++ Run-Time Library Reference for more information.

<table>
<thead>
<tr>
<th>Built-In Function</th>
<th>Header File</th>
</tr>
</thead>
<tbody>
<tr>
<td>abs()</td>
<td>stdlib.h</td>
</tr>
<tr>
<td>alloca()</td>
<td>stdlib.h</td>
</tr>
<tr>
<td>cds()</td>
<td>stdlib.h</td>
</tr>
<tr>
<td>__cds1 (void*, void*, void*);</td>
<td>stdlib.h</td>
</tr>
<tr>
<td>__cs1 (void*, void*, void*);</td>
<td>stdlib.h</td>
</tr>
</tbody>
</table>

**Note:** __cds1 and __cs1 correspond to __cds and __cs respectively. The former functions do not explicitly specify the type to be swapped in the prototype, making them easier to use and avoiding type casting when the argument type does not match. The “cds” and “cs” names are masking macros expanded to “__cds” and “__cs” by the system header. It is advisable to use the underscored names explicitly whenever possible.

<table>
<thead>
<tr>
<th>Built-In Function</th>
<th>Header File</th>
</tr>
</thead>
<tbody>
<tr>
<td>__clcl (void*, void*, unsigned int*, unsigned int*, unsigned char);</td>
<td>builtins.h</td>
</tr>
<tr>
<td>decabs()</td>
<td>decimal.h</td>
</tr>
<tr>
<td>decchk()</td>
<td>decimal.h</td>
</tr>
<tr>
<td>decfix()</td>
<td>decimal.h</td>
</tr>
<tr>
<td>fortrc()</td>
<td>stdlib.h</td>
</tr>
<tr>
<td>memchr()</td>
<td>string.h</td>
</tr>
<tr>
<td>memcpy()</td>
<td>string.h</td>
</tr>
<tr>
<td>memcmp()</td>
<td>string.h</td>
</tr>
<tr>
<td>memset()</td>
<td>string.h</td>
</tr>
<tr>
<td>__stck (unsigned long long *);</td>
<td>builtins.h</td>
</tr>
<tr>
<td>__stcke (void*);</td>
<td>builtins.h</td>
</tr>
<tr>
<td>strcat()</td>
<td>string.h</td>
</tr>
<tr>
<td>strchr()</td>
<td>string.h</td>
</tr>
<tr>
<td>strcmp()</td>
<td>string.h</td>
</tr>
<tr>
<td>strcpy()</td>
<td>string.h</td>
</tr>
<tr>
<td>strlen()</td>
<td>string.h</td>
</tr>
<tr>
<td>strncat()</td>
<td>string.h</td>
</tr>
<tr>
<td>strncmp()</td>
<td>string.h</td>
</tr>
<tr>
<td>strncpy()</td>
<td>string.h</td>
</tr>
<tr>
<td>strrchr()</td>
<td>string.h</td>
</tr>
<tr>
<td>tsched()</td>
<td>mtf.h</td>
</tr>
</tbody>
</table>

**Note:** tsched() is valid only under C.
z/OS V1R2 C/C++ supports floating-point built-in functions which provide access to specific hardware instructions, as shown in the next four tables below. These functions are declared in the header builtins.h, which is included by stdlib.h. In the header, the function names are guarded by the macro _MI_BUILTIN, which is predefined by the compiler if the option LANGLEVEL(LIBEXT) or LANGLEVEL(EXTENDED) is used. (Refer to the LANGLEVEL option in z/OS C/C++ User's Guide for details.) If necessary, you can undefine this macro in the program to protect the namespace. You can also define the macro if you are not using LANGLEVEL(EXTENDED) or LANGLEVEL(LIBEXT).

These functions are not portable. Consider limiting their use to restricted parts of the program, or defining your own masking macros so that substitutions can be made easily when needed.

The built-ins expand into machine instructions, which are described in detail in z/Architecture Principles of Operation.

Notes:
1. If the instruction changes the condition code, the function returns the value of the condition code. If there is also an output operand, for example Oper1, it is prototyped as pointer in the parameter list.
2. If the instruction does not change the condition code, the function will return the value of the output operand if there is one.

To use the next set of built-in functions, one of the following set of options must be in effect:
- FLOAT(IEEE) and ARCH >= 3
- FLOAT(IEEE) and TARGET(OSV2R6) or higher

<table>
<thead>
<tr>
<th>Built-In Function Prototype</th>
<th>Hardware Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>int __cfebr(int* Oper1, int M31, float Oper2);</td>
<td>CFEBR CONVERT TO FIXED</td>
</tr>
<tr>
<td>int __cfdbr(int* Oper1, int M31, double Oper2);</td>
<td>CFDBR CONVERT TO FIXED</td>
</tr>
<tr>
<td>int __cfxhr(int* Oper1, int M31, long double Oper2);</td>
<td>CFXBR CONVERT TO FIXED</td>
</tr>
<tr>
<td>int __diebr(float* Oper1, float* Oper3, float Oper2, float M41);</td>
<td>DIEBR DIVIDE TO INTEGER</td>
</tr>
<tr>
<td>int __didbr(double* Oper1, double* Oper3, double Oper2, double M41);</td>
<td>DIDBR DIVIDE TO INTEGER</td>
</tr>
<tr>
<td>int __efpc(void);</td>
<td>EFPC EXTRACT FPC</td>
</tr>
<tr>
<td>float __fiebr(int M31, float Oper2);</td>
<td>FIEBR LOAD FP INTEGER</td>
</tr>
<tr>
<td>double __fidbr(int M31, double Oper2);</td>
<td>FIDBR LOAD FP INTEGER</td>
</tr>
<tr>
<td>long double __fixbr(int M31, long double Oper2);</td>
<td>FIXBR LOAD FP INTEGER</td>
</tr>
<tr>
<td>int __lnebr(float* Oper1, float Oper2);</td>
<td>LNEBR LOAD NEGATIVE</td>
</tr>
<tr>
<td>int __lndbr(double* Oper1, double Oper2);</td>
<td>LNDBR LOAD NEGATIVE</td>
</tr>
<tr>
<td>int __lnxbr(long double* Oper1, long double Oper2);</td>
<td>LNXBR LOAD NEGATIVE</td>
</tr>
<tr>
<td>int __lpebr(float* Oper1, float Oper2);</td>
<td>LPEBR LOAD POSITIVE</td>
</tr>
<tr>
<td>int __lpdbr(double* Oper1, double Oper2);</td>
<td>LPDBR LOAD POSITIVE</td>
</tr>
<tr>
<td>int __lpxbr(long double* Oper1, long double Oper2);</td>
<td>LPXBR LOAD POSITIVE</td>
</tr>
</tbody>
</table>
### Built-In Function Prototype

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Instruction Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAEBR</td>
<td>MULTIPLY AND ADD</td>
</tr>
<tr>
<td>MADBR</td>
<td>MULTIPLY AND ADD</td>
</tr>
<tr>
<td>MSEBR</td>
<td>MULTIPLY AND SUBTRACT</td>
</tr>
<tr>
<td>MSDBR</td>
<td>MULTIPLY AND SUBTRACT</td>
</tr>
<tr>
<td>SFPC</td>
<td>SET FPC</td>
</tr>
<tr>
<td>SRNM</td>
<td>SET ROUNING MODE</td>
</tr>
<tr>
<td>SQEBR</td>
<td>SQUARE ROOT</td>
</tr>
<tr>
<td>SQDBR</td>
<td>SQUARE ROOT</td>
</tr>
<tr>
<td>SQXBR</td>
<td>SQUARE ROOT</td>
</tr>
<tr>
<td>CFER</td>
<td>CONVERT TO FIXED</td>
</tr>
<tr>
<td>CFDR</td>
<td>CONVERT TO FIXED</td>
</tr>
<tr>
<td>CFRX</td>
<td>CONVERT TO FIXED</td>
</tr>
<tr>
<td>FIER</td>
<td>LOAD FP INTEGER</td>
</tr>
<tr>
<td>FIDR</td>
<td>LOAD FP INTEGER</td>
</tr>
</tbody>
</table>

1M3 and M4 are modifiers specifying a rounding method. See the particular instruction in z/Architecture Principles of Operation for details.

To use the next set of built-in functions, the FLOAT(HEX) option must be in effect.

### Built-In Function Prototype

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Instruction Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNER</td>
<td>LOAD NEGATIVE</td>
</tr>
<tr>
<td>LNDR</td>
<td>LOAD NEGATIVE</td>
</tr>
<tr>
<td>LPER</td>
<td>LOAD POSITIVE</td>
</tr>
<tr>
<td>LPDR</td>
<td>LOAD POSITIVE</td>
</tr>
<tr>
<td>SQER</td>
<td>SQUARE ROOT</td>
</tr>
<tr>
<td>SQDR</td>
<td>SQUARE ROOT</td>
</tr>
</tbody>
</table>

To use the next set of built-in functions, one of the following set of options must be in effect:
- FLOAT(HEX) and ARCH >= 3
- FLOAT(HEX) and TARGET(OSV2R6) or higher
### Built-In Function Prototype

<table>
<thead>
<tr>
<th>Hardware Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mnemonic</strong></td>
</tr>
<tr>
<td>FIXR</td>
</tr>
<tr>
<td>LNXR</td>
</tr>
<tr>
<td>LPXR</td>
</tr>
<tr>
<td>SQXR</td>
</tr>
</tbody>
</table>

1 M3 is a modifier specifying a rounding method. See the particular instruction in *z/Architecture Principles of Operation* for details.

To use the next set of built-in functions, one of the following options must be in effect:

- ARCH >= 3
- TARGET(OSV2R6) or higher

### Built-In Function Prototype

<table>
<thead>
<tr>
<th>Hardware Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mnemonic</strong></td>
</tr>
<tr>
<td>THDER</td>
</tr>
<tr>
<td>THDR</td>
</tr>
<tr>
<td>TBDR</td>
</tr>
<tr>
<td>TBEDR</td>
</tr>
</tbody>
</table>

1 M3 is a modifier specifying a rounding method. See the particular instruction in *z/Architecture Principles of Operation* for details.
Appendix J. Application Considerations for z/OS UNIX C/C++

This appendix briefly describes the extent of z/OS C/C++ support available for traditional MVS programming environments when you are using z/OS UNIX.

Relationship to DB2 Universal Database

No explicit support for DB2 programs exists for POSIX.1 implementation. DB2 z/OS C/C++ programs must be processed by a DB2 precompile step to replace Structured Query Language (SQL) statements with z/OS C/C++ functions. The precompilation step accepts only MVS data set I/O. Therefore, a DB2 database cannot reside in a hierarchical file system (HFS).

It is possible that an existing DB2 z/OS C/C++ application program can be changed to add POSIX.1-defined I/O functions to access data in HFS files. IBM, however, does not explicitly support this access. It is also possible that you can write a new POSIX.1-conforming z/OS C/C++ application program that access DB2 data by calling non-POSIX.1-conforming DB2 programs. IBM, however, does not explicitly support this either.

Application Programming Environments Not Supported

The following MVS programming environments are not supported for use when developing POSIX.1 z/OS C/C++ application programs:

- CICS
- IMS file system

Application programs that attempt to take advantage of these environments will not work as intended.

Support for the Curses Library

The Curses library provides a set of functions that enable you to manipulate a terminal's display regardless of the terminal type. Using this structure, you can manipulate data on a terminal's display. You can instruct curses to treat the entire terminal display as one large window or you can create multiple windows on the display. The windows can be different sizes and can overlap one another.

Each window on a terminal's display has its own window data structure. This structure keeps state information about the window such as its size and where it is located on the display. Curses uses the window data structure to obtain relevant information it needs to carry out your instructions.

The Curses archive file resides in /usr/lib. The non-XPLINK version is named libcurses.a, and the XPLINK version is named libcursesxp.a. The following is an example of compiling test.c with the Curses XPLINK archive:

c89 -o test -Wc,xplink -Wl,xplink test.c -lcursesxp

For more information about curses, refer to the z/OS C Curses manual.
Appendix K. External Variables

The POSIX 1003.1 and X/Open CAE Specification 4.2 (XPG4.2) require that the C system header files define certain external variables. Additional variables are defined for use with POSIX or XPG4.2 functions. If you define one of the POSIX or XPG4 feature test macros and include one of these headers, the external variables will be defined in your program. These external variables are treated differently than other global variables in a multithreaded environment (values are thread-specific) and across a call to a fetched module (values are propagated). To access the global variable values (not thread specific), either C with the RENT compiler option or C++ must be used, and the SCEEOBJ autocall library must be specified during the z/OS bind. The SCEEOBJ library must be specified before the SCEELKEX and the SCEELKED libraries. If the SCEEOBJ library is not specified first, then Language Environment cannot find the external variables. Although there are no linker/binder errors or warnings, run-time errors can occur. Functions to access the thread-specific values of these variables are provided for use in a multithreaded environment.

For a dynamically called DLL module to share access to the POSIX external variables with its caller, the DLL module must define the _SHARE_EXT_VARS feature test macro. This is implemented in the current Language Environment run-time. For more information, see the section on feature test macros in z/OS C/C++ Run-Time Library Reference.

When compiling code with the XPLINK compiler option, all access to these external variables is resolved by dynamic linkage, using IMPORT control statements in the CELHS003 member of the SCEELIB library. The SCEEOBJ library cannot be used when binding XPLINK executable modules. Because of this, the _SHARE_EXT_VARS (and subordinate) feature test macros need not be used with XPLINK (they will be ignored). All references to these external variables are as if _SHARE_EXT_VARS was defined, without the need to access them through the thread-specific functions.

For more information on the header files referred to in the following sections, see z/OS C/C++ Run-Time Library Reference.

errno

When a run-time library function is not successful, the function may do any of the following to identify the error:

• Set errno to a documented value.
• Set errno to a value that is not documented. You can use strerror() or perror() to get the message associated with the errno.
• Not set errno.
• Clear errno.

See also errno.h.

daylight

The daylight savings time flag set by tzset(). Note that other time zone sensitive functions such as ctime(), localtime(), mktime(), and strftime() implicitly call tzset(). For non-XPLINK code, use the __dlight() function to access the thread-specific value of daylight. See also time.h.
getdate_err

The variable is set to the following value when an error occurs in the getdate() function.

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The DATEMASK environment variable is null or undefined.</td>
</tr>
<tr>
<td>2</td>
<td>The template file cannot be opened for reading.</td>
</tr>
<tr>
<td>3</td>
<td>Failed to get file status information.</td>
</tr>
<tr>
<td>4</td>
<td>The template file is not a regular file.</td>
</tr>
<tr>
<td>5</td>
<td>An error is encountered while reading the template file.</td>
</tr>
<tr>
<td>6</td>
<td>Memory allocation is not successful.</td>
</tr>
<tr>
<td>7</td>
<td>There is no line in the template that matches the input.</td>
</tr>
<tr>
<td>8</td>
<td>There is no line in the template that matches the input.</td>
</tr>
</tbody>
</table>

Any changes to errno are unspecified. For non-XPLINK code, use the __gderr() function to access the thread-specific value of getdate_err. See also time.h.

h_errno

An integer that holds the specific error code when the network nameserver encounters an error. The network nameserver is used by the gethostbyname() and gethostbyaddr() functions. For non-XPLINK code, use the __h_errno() function to access the thread-specific value of h_errno. See also netdb.h.

__loc1

A global character pointer that is set by the regex() function to point to the first matched character in the input string. For non-XPLINK code, use the __loc1() function to access the thread-specific value of __loc1. See also libgen.h.

loc1

A pointer to characters matched by regular expressions used by step(). The value is not propagated across a call to a fetched module. See also regexp.h.

loc2

A pointer to characters matched by regular expressions used by step(). The value is not propagated across a call to a fetched module. See also regexp.h.

locs

Used by advance() to stop regular expression matching in a string. The value is not propagated across a call to a fetched module. See also regexp.h.

optarg

Character pointer used by getopt() for options parsing variables. For non-XPLINK code, use the __optarg() function to access the thread-specific value of optarg. See also stdio.h and unistd.h.
opterr
Error value used by getopt(). For non-XPLINK code, use the __operrf() function
to access the thread-specific value of opterr. See also stdio.h and unistd.h.

optind
Integer pointer used by getopt() for options parsing variables. For non-XPLINK
code, use the __opindf() function to access the thread-specific value of optind.
See also stdio.h and unistd.h.

optopt
Integer pointer used by getopt() for options parsing variables. For non-XPLINK
code, use the __opoptf() function to access the thread-specific value of optopt.
See also stdio.h and unistd.h.

signgam
Storage for sign of lgamma(). This function defaults to thread specific. See also
math.h.

stdin
Standard Input stream. The external variable will be initialized to point to the
enclave-level stream pointer for the standard input file. There is no multithreaded
function. See also stdio.h.

stderr
Standard Error stream. The external variable will be initialized to point to the
enclave-level stream pointer for the standard error file. There is no multithreaded
function. See also stdio.h.

stdout
Standard Output stream. The external variable will be initialized to point to the
enclave-level stream pointer for the standard output file. There is no multithreaded
function. See also stdio.h.

t_errno
An integer that holds the specific error code when a failure occurs in one of the
X/Open Transport Interface (XTI) functions. For non-XPLINK code, use the
__t_errno() function to access the thread-specific value of t_errno. See also xti.h.

timezone
Long integer difference from UTC and standard time as set by tzset(). Note that
other time zone sensitive functions such as, ctime(), localtime(), mktime(), and
strftime() implicitly call tzset(). For non-XPLINK code, use the __tzone() function to access the thread-specific value of timezone. See also time.h.
**tzname**

Character pointer to unsized array of timezone strings used by `tzset()` and `ctime()`. The `*tzname` variable contains the Standard and Daylight Savings time zone names. If the TZ environment variable is present and correct, tzname is set from TZ. Otherwise tzname is set from the LC_TOD locale category. See the `tzset()` function for a description. There is no multithreaded function. See also `time.h`.
Appendix L. 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 it 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 Volume 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.
This information was developed for products and services offered in the U.S.A.

IBM may not offer the products, services, or features discussed in this document in other countries. Consult your local IBM representative for information on the products and services currently available in your area. Any reference to an IBM product, program, or service is not intended to state or imply that only that IBM product, program, or service may be used. Any functionally equivalent product, program, or service that does not infringe any IBM intellectual property right may be used instead. However, it is the user’s responsibility to evaluate and verify the operation of any non-IBM product, program, or service.

IBM may have patents or pending patent applications covering subject matter described in this document. The furnishing of this document does not give you any license to these patents. You can send license inquiries, in writing, to:

IBM Director of Licensing
IBM Corporation
North Castle Drive
Armonk, NY 10504-1785
U.S.A.

For license inquiries regarding double-byte (DBCS) information, contact the IBM Intellectual Property Department in your country or send inquiries, in writing, to:

IBM World Trade Asia Corporation
Licensing
2-31 Roppongi 3-chome, Minato-ku
Tokyo 106, Japan

The following paragraph does not apply to the United Kingdom or any other country where such provisions are inconsistent with local law:

INTERNATIONAL BUSINESS MACHINES CORPORATION PROVIDES THIS PUBLICATION “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OR CONDITIONS OF NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Some states do not allow disclaimer of express or implied warranties in certain transactions, therefore, this statement may not apply to you.

This information could include technical inaccuracies or typographical errors. Changes are periodically made to the information herein; these changes will be incorporated in new editions of the publication. IBM may make improvements and/or changes in the product(s) and/or the program(s) described in this publication at any time without notice.

Any references in this information to non-IBM Web sites are provided for convenience only and do not in any manner serve as an endorsement of those Web sites. The materials at those Web sites are not part of the materials for this IBM product and use of those Web sites is at your own risk.

IBM may use or distribute any of the information you supply in any way it believes appropriate without incurring any obligation to you.
Licensees of this program who wish to have information about it for the purpose of enabling: (i) the exchange of information between independently created programs and other programs (including this one) and (ii) the mutual use of the information which has been exchanged, should contact:

IBM Corporation
Mail Station P300
2455 South Road
Poughkeepsie, NY 12601-5400
U.S.A

Such information may be available, subject to appropriate terms and conditions, including in some cases, payment of a fee.

The licensed program described in this information and all licensed material available for it are provided by IBM under terms of the IBM Customer Agreement, IBM International Program License Agreement, or any equivalent agreement between us.

This information contains examples of data and reports used in daily business operations. To illustrate them as completely as possible, the examples may include the names of individuals, companies, brands, and products. All of these names are fictitious and any similarity to the names and addresses used by an actual business enterprise is entirely coincidental.

COPYRIGHT LICENSE:

This information contains sample application programs in source language, which illustrates programming techniques on the z/OS operating platforms. You may copy, modify, and distribute these sample programs in any form without payment to IBM, for the purposes of developing, using, marketing or distributing application programs conforming to the application programming interface for the operating platform for which the sample programs are written. These examples have not been thoroughly tested under all conditions. IBM, therefore, cannot guarantee or imply reliability, serviceability, or function of these programs. You may copy, modify, and distribute these sample programs in any form without payment to IBM for the purposes of developing, using, marketing, or distributing application programs conforming to IBM’s application programming interfaces.

If you are viewing this information softcopy, the photographs and color illustrations may not appear.

Programming interface information

This publication documents intended Programming Interfaces that allow the customer to write z/OS C/C++ programs.

Trademarks

The following terms are trademarks of International Business Machines Corporation in the United States or other countries or both:

- AIX
- C/370
- DB2
- GDDM
- IMS
- BookManager
- CICS
- DB2 Universal Database
- Hiperspace
- IMS/ESA
- BookMaster
- CICS/ESA
- DFSMS/MVS
- IBM
- Language Environment

894  z/OS V1R4.0 C/C++ Programming Guide
Microsoft, Windows, and Windows NT are trademarks of Microsoft Corporation in the U.S. and/or other countries.

UNIX is a registered trademark of The Open Group in the U.S. and/or other countries.

Java and all Java-based trademarks are trademarks of Sun Microsystems, Inc. in the U.S. and/or other countries.

Other company, product, and service names may be trademarks or service marks of others.

Standards

Extracts are reprinted from IEEE Std 1003.1—1990, IEEE Standard Information Technology—Portable Operating System Interface (POSIX)—Part 1: System Application Program Interface (API) [C language], copyright 1990 by the Institute of Electrical and Electronic Engineers, Inc.

Extracts are reprinted from IEEE P1003.1a Draft 6 July 1991, Draft Revision to Information Technology—Portable Operating System Interface (POSIX), Part 1: System Application Program Interface (API) [C Language], copyright 1992 by the Institute of Electrical and Electronic Engineers, Inc.


For more information on IEEE, visit their web site at http://www.ieee.org/.

Extracts from ISO/IEC 9899:1990 have been reproduced with the permission of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). The complete standard can be obtained from any ISO or IEC member or from the ISO or IEC Central Offices, Case postale 56, CH - 1211 Geneva 20, Switzerland. Copyright remains ISO and IEC. For more information on ISO, visit their web site at http://www.iso.ch/.

Extracts from X/Open Specification, Programming Languages, Issue 4 Release 2, copyright 1988, 1989, February 1992, by the X/Open Company Limited, have been reproduced with the permission of X/Open Company Limited. No further reproduction of this material is permitted without the written notice from the X/Open Company Ltd, UK. For more information, visit http://www.opengroup.org/.
Glossary

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

This glossary includes terms and definitions from:
- IBM Dictionary of Computing, SC20-1699. These definitions are indicated by the registered trademark IBM after the definition.
- X/Open CAE Specification, Commands and Utilities, Issue 4, July, 1992. These definitions are indicated by the symbol X/Open after the definition.
- ISO/IEC 9945-1:1990/IEEE POSIX 1003.1-1990. These definitions are indicated by the symbol ISO.1 after the definition.
- The Information Technology Vocabulary, developed by Subcommittee 1, Joint Technical Committee 1, of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC1/SC1). Definitions of published parts of this vocabulary are identified by the symbol ISO-JTC1 after the definition; definitions taken from draft international standards, committee drafts, and working papers being developed by ISO/IEC JTC1/SC1 are identified by the symbol ISO Draft after the definition, indicating that final agreement has not yet been reached among the participating National Bodies of SC1.

A

abstract class. (1) A class with at least one pure virtual function that is used as a base class for other classes. The abstract class represents a concept; classes derived from it represent implementations of the concept. You cannot create a direct object of an abstract class, but you can create references and pointers to an abstract class and set them to refer to objects of classes derived from the abstract class. See also base class. (2) A class that allows polymorphism. There can be no objects of an abstract class; they are only used to derive new classes.

abstract code unit. See ACU.

abstract data type. A mathematical model that includes a structure for storing data and operations that can be performed on that data. Common abstract data types include sets, trees, and heaps.

abstraction (data). A data type with a private representation and a public set of operations (functions or operators) which restrict access to that data type to that set of operations. The C++ language uses the concept of classes to implement data abstraction.

access. An attribute that determines whether or not a class member is accessible in an expression or declaration.

access declaration. A declaration used to restore access to members of a base class.

access mode. (1) A technique that is used to obtain a particular logical record from, or to place a particular logical record into, a file assigned to a mass storage device. ANSI/ISO. (2) The manner in which files are referred to by a computer. Access can be sequential (records are referred to one after another in the order in which they appear on the file), access can be random (individual records can be referred to in a nonsequential manner), or access can be dynamic (records can be accessed sequentially or randomly, depending on the form of the input/output request). IBM. (3) A particular form of access permitted to a file. X/Open.

access resolution. The process by which the accessibility of a particular class member is determined.

access specifier. One of the C++ keywords: public, private, and protected, used to define the access to a member.

ACU (abstract code unit). A measurement used by the z/OS C/C++ compiler for judging the size of a function. The number of ACUs that comprise a function is proportional to its size and complexity.

addressing mode. See AMODE.

address space. (1) The range of addresses available to a computer program. ANSI/ISO. (2) The complete range of addresses that are available to a programmer. See also virtual address space. (3) The area of virtual storage available for a particular job. (4) The memory locations that can be referenced by a process. X/Open. ISO.1.
aggregate. (1) An array or a structure. (2) A compile-time option to show the layout of a structure or union in the listing. (3) In programming languages, a structured collection of data items that form a data type. ISO JTC1. (4) In C++, an array or a class with no user-declared constructors, no private or protected non-static data members, no base classes, and no virtual functions.

alert. (1) A message sent to a management services focal point in a network to identify a problem or an impending problem. IBM. (2) To cause the user's terminal to give some audible or visual indication that an error or some other event has occurred. When the standard output is directed to a terminal device, the method for alerting the terminal user is unspecified. When the standard output is not directed to a terminal device, the alert is accomplished by writing the alert character to standard output (unless the utility description indicates that the use of standard output produces undefined results in this case). X/Open.

alert character. A character that in the output stream should cause a terminal to alert its user via a visual or audible notification. The alert character is the character designated by a `\'a` in the C and C++ languages. It is unspecified whether this character is the exact sequence transmitted to an output device by the system to accomplish the alert function. X/Open.

This character is named <alert> in the portable character set.

alias. (1) An alternate label; for example, a label and one or more aliases may be used to refer to the same data element or point in a computer program. ANSI/ISO. (2) An alternate name for a member of a partitioned data set. IBM. (3) An alternate name used for a network. Synonymous with nickname. IBM.

alias name. (1) A word consisting solely of underscores, digits, and alphabets from the portable file name character set, and any of the following characters: ! % ^ & \ ' (space). Implementations may allow other characters within alias names as an extension. X/Open. (2) An alternate name. IBM. (3) A name that is defined in one network to represent a logical unit name in another interconnected network. The alias name does not have to be the same as the real name; if these names are not the same, translation is required. IBM.

alignment. The storing of data in relation to certain machine-dependent boundaries. IBM.

alternate code point. A syntactic code point that permits a substitute code point to be used. For example, the left brace (\{) can be represented by \X'B0\ and also by \X'C0\.

American National Standard Code for Information Interchange (ASCII). The standard code, using a coded character set consisting of 7-bit coded characters (8 bits including parity check), that is used for information interchange among data processing systems, data communication systems, and associated equipment. The ASCII set consists of control characters and graphic characters. IBM.

Note: IBM has defined an extension to ASCII code (characters 128–255).

American National Standards Institute (ANSI/ISO). An organization consisting of producers, consumers, and general interest groups, that establishes the procedures by which accredited organizations create and maintain voluntary industry standards in the United States. ANSI/ISO.

AMODE (addressing mode). In z/OS, a program attribute that refers to the address length that a program is prepared to handle upon entry. In z/OS, addresses may be 24 or 31 bits in length. IBM.

angle brackets. The characters < (left angle bracket) and > (right angle bracket). When used in the phrase "enclosed in angle brackets", the symbol < immediately precedes the object to be enclosed, and > immediately follows it. When describing these characters in the portable character set, the names <less-than-sign> and <greater-than-sign> are used. X/Open.

anonymous union. A union that is declared within a structure or class and does not have a name. It must not be followed by a declarator.

ANSI/ISO. See American National Standards Institute.

API (application program interface). A functional interface supplied by the operating system or by a separately orderable licensed program that allows an application program written in a high-level language to use specific data or functions of the operating system or the licensed program. IBM.

application. (1) The use to which an information processing system is put; for example, a payroll application, an airline reservation application, a network application. IBM. (2) A collection of software components used to perform specific types of user-oriented work on a computer. IBM.

application generator. An application development tool that creates applications, application components (panels, data, databases, logic, interfaces to system services), or complete application systems from design specifications.

application program. A program written for or by a user that applies to the user's work, such as a program that does inventory control or payroll. IBM.

archive libraries. The archive library file, when created for application program object files, has a special symbol table for members that are object files.
argument.  (1) A parameter passed between a calling program and a called program. IBM.  (2) In a function call, an expression that represents a value that the calling function passes to the function specified in the call.  (3) In the shell, a parameter passed to a utility as the equivalent of a single string in the argv array created by one of the exec functions. An argument is one of the options, option-arguments, or operands following the command name. X/Open.

argument declaration. See parameter declaration.

arithmetic object.  (1) A bit field, or an integral, floating-point, or packed decimal (IBM extension) object.  (2) A real object or objects having the type float, double, or long double.

array.  In programming languages, an aggregate that consists of data objects with identical attributes, each of which may be uniquely referenced by subcripting. ISO-JTC1.

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

ASCII. See American National Standard Code for Information Interchange.

Assembler H.  An IBM licensed program. Translates symbolic assembler language into binary machine language.

assembler language.  A source language that includes symbolic language statements in which there is a one-to-one correspondence with the instruction formats and data formats of the computer. IBM.

assembler user exit.  In the z/OS Language Environment a routine to tailor the characteristics of an enclave prior to its establishment.

assignment expression.  An expression that assigns the value of the right operand expression to the left operand variable and has as its value the value of the right operand. IBM.

atexit list.  A list of actions specified in the z/OS C/C++ atexit() function that occur at normal program termination.

auto storage class specifier.  A specifier that enables the programmer to define a variable with automatic storage; its scope restricted to the current block.

automatic call library.  Contains modules that are used as secondary input to the binder to resolve external symbols left undefined after all the primary input has been processed. The automatic call library can contain:

* Object modules, with or without binder control statements
* Load modules
* z/OS C/C++ run-time routines (SCEELKED)

automatic library call.  The process in which control sections are processed by the binder or loader to resolve references to members of partitioned data sets. IBM.

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.

B

background process.  (1) A process that does not require operator intervention but can be run by the computer while the workstation is used to do other work. IBM.  (2) A mode of program execution in which the shell does not wait for program completion before prompting the user for another command. IBM.  (3) A process that is a member of a background process group. X/Open. ISO.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. X/Open. ISO.1.

backslash.  The character \. This character is named <backslash> in the portable character set.

base class.  A class from which other classes are derived. A base class may itself be derived from another base class. See also abstract class.

based on.  The use of existing classes for implementing new classes.

binary expression.  An expression containing two operands and one operator.

binary stream.  (1) An ordered sequence of untranslated characters.  (2) A sequence of characters that corresponds on a one-to-one basis with the characters in the file. No character translation is performed on binary streams. IBM.

bind.  (1) To combine one or more control sections or program modules into a single program module, resolving references between them.  (2) To assign virtual storage addresses to external symbols.

binder.  The DFSMS/MVS program that processes the output of 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, OS/390, or z/OS operating system.

bit field.  A member of a structure or union that contains a specified number of bits. IBM.

bitwise operator.  An operator that manipulates the value of an object at the bit level.
blank character. (1) A graphic representation of the space character. ANSI/ISO. (2) A character that represents an empty position in a graphic character string. ISO Draft. (3) One of the characters that belong to the blank character class as defined via the LC_CTYPE category in the current locale. In the POSIX locale, a blank character is either a tab or a space character. X/Open.

block. (1) In programming languages, a compound statement that coincides with the scope of at least one of the declarations contained within it. A block may also specify storage allocation or segment programs for other purposes. ISO-JTC1. (2) A string of data elements recorded or transmitted as a unit. The elements may be characters, words or physical records. ISO Draft. (3) The unit of data transmitted to and from a device. Each block contains one record, part of a record, or several records.

block statement. In the C or C++ languages, a group of data definitions, declarations, and statements appearing between a left brace and a right brace that are processed as a unit. The block statement is considered to be a single C or C++ statement. IBM.

boundary alignment. The position in main storage of a fixed-length field, such as a halfword or doubleword, on a byte-level boundary for that unit of information. IBM.

braces. The characters { (left brace) and } (right brace), also known as curly braces. When used in the phrase "enclosed in (curly) braces" the symbol { immediately precedes the object to be enclosed, and } immediately follows it. When describing these characters in the portable character set, the names <left-brace> and <right-brace> are used. X/Open.

brackets. The characters [ (left bracket) and ] (right bracket), also known as square brackets. When used in the phrase enclosed in (square) brackets the symbol [ immediately precedes the object to be enclosed, and ] immediately follows it. When describing these characters in the portable character set, the names <left-bracket> and <right-bracket> are used. X/Open.

break statement. A C or C++ control statement that contains the keyword "break" and a semicolon. IBM. It is used to end an iterative or a switch statement by exiting from it at any point other than the logical end. Control is passed to the first statement after the iteration or switch statement.

built-in. (1) A function that the compiler will automatically inline instead of making the function call, unless the programmer specifies not to inline. (2) In programming languages, pertaining to a language object that is declared by the definition of the programming language; for example, the built-in function SIN in PL/I, the predefined data type INTEGER in FORTRAN. ISO-JTC1. Synonymous with predefined. IBM.

byte-oriented stream. See orientation of a stream.

C

c library. A system library that contains common C language subroutines for file access, string operators, character operations, memory allocation, and other functions. IBM.

C or C++ language statement. A C or C++ language statement contains zero or more expressions. A block statement begins with a { (left brace) symbol, ends with a } (right brace) symbol, and contains any number of statements.

All C or C++ language statements, except block statements, end with a ; (semicolon) symbol.

c89 utility. A utility used to compile and bind an application program from the z/OS shell.

C++ class library. A collection of C++ classes.

C++ library. A system library that contains common C++ language subroutines for file access, memory allocation, and other functions.

callable services. A set of services that can be invoked by z/OS Language Environment-conforming high level languages using the conventional z/OS Language Environment-defined call interface, and usable by all programs sharing the z/OS 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.

call chain. A trace of all active functions.

caller. A function that calls another function.

cancelability point. A specific point within the current thread that is enabled to solicit cancel requests. This is accomplished using the pthread_testcancel() function.

carryage-return character. A character that in the output stream indicates that printing should start at the beginning of the same physical line in which the carriage-return character occurred. The carriage-return is the character designated by 'r' in the C and C++ languages. It is unspecified whether this character is the exact sequence transmitted to an output device by the system to accomplish the movement to the beginning of the line. X/Open.

case clause. In a C or C++ switch statement, a CASE label followed by any number of statements.
case label. The word case followed by a constant integral expression and a colon. When the selector evaluates the value of the constant expression, the statements following the case label are processed.

cast expression. An expression that converts or reinterprets its operand.

cast operator. The cast operator is used for explicit type conversions.

cataloged procedures. A set of control statements placed in a library and retrievable by name. IBM.

catch block. A block associated with a try block that receives control when an exception matching its argument is thrown.

c char specifier. A char is a built-in data type. In the C++ language, char, signed char, and unsigned char are all distinct data types.

c character. (1) 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. ANSI/ISO. (2) A sequence of one or more bytes representing a single graphic symbol or control code. This term corresponds to the ISO C standard term multibyte character (multibyte character), where a single-byte character is a special case of the multibyte character. Unlike the usage in the ISO C standard, character here has no necessary relationship with storage space, and byte is used when storage space is discussed. X/Open. ISO.1.

c character array. An array of type char. X/Open.

c character class. A named set of characters sharing an attribute associated with the name of the class. The classes and the characters that they contain are dependent on the value of the LC_CTYPE category in the current locale. X/Open.

c character constant. A string of any of the characters that can be represented, usually enclosed in quotes.

c character set. (1) A finite set of different characters that is complete for a given purpose; for example, the character set in ISO Standard 646, 7-bit Coded Character Set for Information Processing Interchange. ISO Draft. (2) All the valid characters for a programming language or for a computer system. IBM. (3) A group of characters used for a specific reason; for example, the set of characters a printer can print. IBM. (4) See also portable character set.

c character special file. (1) A special file that provides access to an input or output device. The character interface is used for devices that do not use block I/O. IBM. (2) A file that refers to a device. One specific type of character special file is a terminal device file. X/Open. ISO.1.

c character string. A contiguous sequence of characters terminated by and including the first null byte. X/Open.

c child. A node that is subordinate to another node in a tree structure. Only the root node is not a child.

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

CICS (Customer Information Control System). Pertaining to an IBM licensed program that enables transactions entered at remote terminals to be processed concurrently by user-written application programs. It includes facilities for building, using, and maintaining databases. IBM.

CICS destination control table. See DCT.

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.

class. (1) A C++ aggregate that may contain functions, types, and user-defined operators in addition to data. A class may be derived from another class, inheriting the properties of its parent class. A class may restrict access to its members. (2) A user-defined data type. A class data type can contain both data representations (data members) and functions (member functions).

class key. One of the C++ keywords: class, struct and union.

class library. A collection of classes.

class member operator. An operator used to access class members through class objects or pointers to class objects. The class member operators are: ., ->, *, *-

class name. A unique identifier that names a class type.

class scope. An indication that a name of a class can be used only in a member function of that class.

class tag. Synonym for class name.

class template. A blueprint describing how a set of related classes can be constructed.

class template declaration. A class template declaration introduces the name of a class template and specifies its template parameter list. A class template declaration may optionally include a class template definition.

class template definition. A class template definition describes various characteristics of the class types that are its specializations. These characteristics include the
client program. A program that uses a class. The program is said to be a client of the class.

CLIST. A programming language that typically executes a list of TSO commands.

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

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. See CLLE.

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

coded character set. (1) A set of graphic characters and their code point assignments. The set may contain fewer characters than the total number of possible characters: some code points may be unassigned. IBM. (2) A coded set whose elements are single characters; for example, all characters of an alphabet. ISO Draft. (3) Loosely, a code. ANSI/ISO.

code element set. (1) The result of applying a code to all elements of a coded set, for example, all the three-letter international representations of airport names. ISO Draft. (2) The result of applying rules that map a numeric code value to each element of a character set. An element of a character set may be related to more than one numeric code value but the reverse is not true. However, for state-dependent encodings the relationship between numeric code values to elements of a character set may be further controlled by state information. The character set may contain fewer elements than the total number of possible numeric code values; that is, some code values may be unassigned. X/Open. (3) Synonym for codeset.

code page. (1) An assignment of graphic characters and control function meanings to all code points; for example, assignment of characters and meanings to 256 code points for an 8-bit code, assignment of characters and meanings to 128 code points for a 7-bit code. (2) A particular assignment of hexadecimal identifiers to graphic characters.

code point. (1) A representation of a unique character. For example, in a single-byte character set each of 256 possible characters is represented by a one-byte code point. (2) An identifier in an alert description that represents a short unit of text. The code point is replaced with the text by an alert display program.

codeset. Synonym for code element set. IBM.

collating element. The smallest entity used to determine the logical ordering of character or wide-character strings. A collating element consists of either a single character, or two or more characters collating as a single entity. The value of the LC_COLLATE category in the current locale determines the current set of collating elements. X/Open.

collating sequence. (1) A specified arrangement used in sequencing. ISO-JTC1. ANSI/ISO. (2) An ordering assigned to a set of items, such that any two sets in that assigned order can be collated. ANSI/ISO. (3) The relative ordering of collating elements as determined by the setting of the LC_COLLATE category in the current locale. The character order, as defined for the LC_COLLATE category in the current locale, defines the relative order of all collating elements, such that each element occupies a unique position in the order. This is the order used in ranges of characters and collating elements in regular expressions and pattern matching. In addition, the definition of the collating weights of characters and collating elements uses collating elements to represent their respective positions within the collation sequence.

collation. The logical ordering of character or wide-character strings according to defined precedence rules. These rules identify a collation sequence between the collating elements, and such additional rules that can be used to order strings consisting or multiple collating elements. X/Open.

collection. (1) An abstract class without any ordering, element properties, or key properties. (2) In a general sense, an implementation of an abstract data type for storing elements.

Collection Class Library. A set of classes that provide basic functions for collections, and can be used as base classes.

column position. A unit of horizontal measure related to characters in a line.

It is assumed that each character in a character set has an intrinsic column width independent of any output device. Each printable character in the portable character set has a column width of one. The standard utilities, when used as described in this document set, assume that all characters have integral column widths. The column width of a character is not necessarily related to the internal representation of the character (numbers of bits or bytes).

The column position of a character in a line is defined as one plus the sum of the column widths of the preceding characters in the line. Column positions are numbered starting from 1. X/Open.
**comma expression.** An expression (not a function argument list) that contains two or more operands separated by commas. The compiler evaluates all operands in the order specified, discarding all but the last (rightmost). The value of the expression is the value of the rightmost operand. Typically this is done to produce side effects.

**command.** A request to perform an operation or run a program. When parameters, arguments, flags, or other operands are associated with a command, the resulting character string is a single command.

**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 Business-Oriented Language.** See COBOL.

**common expression elimination.** Duplicated expressions are eliminated by using the result of the previous expression. This includes intermediate expressions within expressions.

**compilation unit.** (1) A portion of a computer program sufficiently complete to be compiled correctly. IBM. (2) A single compiled file and all its associated include files. (3) An independently compilable sequence of high-level language statements. Each high-level language product has different rules for what makes up a compilation unit.

**complete class name.** The complete qualification of a nested class name including all enclosing class names.

**Complex Mathematics library.** A C++ class library that provides the facilities to manipulate complex numbers and perform standard mathematical operations on them.

**computational independence.** No data modified by either a main task program or a parallel function is examined or modified by a parallel function that might be running simultaneously.

**concrete class.** (1) A class that is not abstract. (2) A class defining objects that can be created.

**condition.** (1) A relational expression that can be evaluated to a value of either true or false. IBM. (2) An exception that has been enabled, or recognized, by the z/OS Language Environment and thus is eligible to activate user and language condition handlers. Any alteration to the normal programmed flow of an application. 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.

**conditional expression.** A compound expression that contains a condition (the first expression), an expression to be evaluated if the condition has a nonzero value (the second expression), and an expression to be evaluated if the condition has the value zero (the third expression).

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

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

**condition token.** In the z/OS Language Environment, a data type consisting of 12 bytes (96 bits). 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.

**const.** (1) An attribute of a data object that declares the object cannot be changed. (2) A keyword that allows you to define a variable whose value does not change. (3) A keyword that allows you to define a parameter that is not changed by the function. (4) A keyword that allows you to define a member function that does not modify the state of the class for which it is defined.

**constant.** (1) In programming languages, a language object that takes only one specific value. ISO-JTC1. (2) A data item with a value that does not change. IBM.

**constant expression.** An expression having a value that can be determined during compilation and that does not change during the running of the program. IBM.

**constant propagation.** An optimization technique where constants used in an expression are combined and new ones are generated. Mode conversions are done to allow some intrinsic functions to be evaluated at compile time.

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

**constructor.** A special C++ class member function that has the same name as the class and is used to create an object of that class.

**control character.** (1) A character whose occurrence in a particular context specifies a control function. ISO Draft. (2) Synonymous with non-printing character. IBM. (3) A character, other than a graphic character, that affects the recording, processing, transmission, or interpretation of text. X/Open.
control statement. (1) A statement that is used to alter the continuous sequential execution of statements; a control statement may be a conditional statement, such as if, or an imperative statement, such as return. (2) A statement that changes the path of execution.

controlling process. The session leader that establishes the connection to the controlling terminal. If the terminal ceases to be a controlling terminal for this session, the session leader ceases to be the controlling process. X/Open. ISO.1.

controlling terminal. A terminal that is associated with a session. Each session may have at most one controlling terminal associated with it, and a controlling terminal is associated with exactly one session. Certain input sequences from the controlling terminal cause signals to be sent to all processes in the process group associated with the controlling terminal. X/Open. ISO.1.

conversion. (1) In programming languages, the transformation between values that represent the same data item but belong to different data types. Information may be lost because of conversion since accuracy of data representation varies among different data types. ISO-JTC1. (2) The process of changing from one method of data processing to another or from one data processing system to another. IBM. (3) The process of changing from one form of representation to another; for example to change from decimal representation to binary representation. IBM. (4) A change in the type of a value. For example, when you add values having different data types, the compiler converts both values to a common form before adding the values.

conversion descriptor. A per-process unique value used to identify an open codeset conversion. X/Open.

cursor. A reference to an element at a specific position in a data structure.

Customer Information Control System. See CICS.

D

data abstraction. A data type with a private representation and a public set of operations (functions or operators) which restrict access to that data type to that set of operations. The C++ language uses the concept of classes to implement data abstraction.

data definition (DD). (1) In the C and C++ languages, a definition that describes a data object, reserves storage for a data object, and can provide an initial value for a data object. A data definition appears outside a function or at the beginning of a block statement. IBM. (2) A program statement that describes the features of, specifies relationships of, or establishes context of, data. ANSI/ISO. (3) A statement that is stored in the environment and that externally identifies a file and the attributes with which it should be opened.

data definition name. See ddname.

data definition statement. See DD statement.

data member. The smallest possible piece of complete data. Elements are composed of data members.

data object. (1) A storage area used to hold a value. (2) Anything that exists in storage and on which operations can be performed, such as files, programs, classes, or arrays. (3) In a program, an element of data structure, such as a file, array, or operand, that is needed for the execution of a program and that is named or otherwise specified by the allowable character set of the language in which a program is coded. IBM.

data set. Under z/OS, a named collection of related data records that is stored and retrieved by an assigned name.
**data stream.** A continuous stream of data elements being transmitted, or intended for transmission, in character or binary-digit form, using a defined format. *IBM.*

**data structure.** The internal data representation of an implementation.

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

**Data Window Services (DWS).** Services provided as part of the Callable Services Library that allow manipulation of data objects such as VSAM linear data sets and temporary data objects known as TEMPSPACE.

**DBCS (double-byte character set).** A set of characters in which each character is represented by 2 bytes. Languages such as Japanese, Chinese, and Korean, which contain more symbols than can be represented by 256 code points, require double-byte character sets. Because each character requires 2 bytes, the typing, display, and printing of DBCS characters requires hardware and programs that support DBCS. *IBM.*

**DCT (destination control table).** 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.

**ddname (data definition name).** (1) 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. (2) The part of the data definition before the equal sign. It is the name used in a call to fopen or freopen to refer to the data definition stored in the environment.

**DD statement (data definition statement).** (1) In z/OS, serves as the connection between the logical name of a file and the physical name of the file. (2) A job control statement that defines a file to the operating system, and is a request to the operating system for the allocation of input/output resources.

**dead code elimination.** A process that eliminates code that exists for calculations that are not necessary. Code may be designated as dead by other optimization techniques.

**dead store elimination.** A process that eliminates unnecessary storage use in code. A store is deemed unnecessary if the value stored is never referenced again in the code.

**decimal constant.** (1) A numerical data type used in standard arithmetic operations. (2) A number containing any of the digits 0 through 9. *IBM.*

**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.

**declaration.** (1) In the C and C++ languages, a description that makes an external object or function available to a function or a block statement. *IBM.* (2) Establishes the names and characteristics of data objects and functions used in a program.

**declarator.** Designates a data object or function declared. Initializations can be performed in a declarator.

**default argument.** An argument that is declared with a default value in a function prototype or declaration. If a call to the function omits this argument, the default value is used. Arguments with default values must be the trailing arguments in a function prototype argument list.

**default clause.** In the C or C++ languages, within a switch statement, the keyword default followed by a colon, and one or more statements. When the conditions of the specified case labels in the switch statement do not hold, the default clause is chosen. *IBM.*

**default constructor.** A constructor that takes no arguments, or, if it takes arguments, all its arguments have default values.

**default initialization.** The initial value assigned to a data object by the compiler if no initial value is specified by the programmer.

**default locale.** (1) The C locale, which is always used when no selection of locale is performed. (2) A system default locale, named by locale-related environmental variables.

**define directive.** A preprocessor directive that directs the preprocessor to replace an identifier or macro invocation with special code.

**definition.** (1) A data description that reserves storage and may provide an initial value. (2) A declaration that allocates storage, and may initialize a data object or specify the body of a function.

**degree.** The number of children of a node.

**delete.** (1) A C++ keyword that identifies a free storage deallocation operator. (2) A C++ operator used to destroy objects created by new.

**demangling.** The conversion of mangled names back to their original source code names. During C++
compilation, identifiers such as function and static class member names are mangled (encoded) with type and scoping information to ensure type-safe linkage. These mangled names appear in the object file and the final executable file. Demangling (decoding) converts these names back to their original names to make program debugging easier. See also mangling.

deque. A queue that can have elements added and removed at both ends. A double-ended queue.

dequeue. An operation that removes the first element of a queue.

dereference. In the C and C++ languages, the application of the unary operator * to a pointer to access the object the pointer points to. Also known as indirection.

derivation. In the C++ language, to derive a class, called a derived class, from an existing class, called a base class.

derived class. A class that inherits from a base class. All members of the base class become members of the derived class. You can add additional data members and member functions to the derived class. A derived class object can be manipulated as if it is a base class object. The derived class can override virtual functions of the base class.

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.

destination control table. See DCT.

destructor. A special member function that has the same name as its class, preceded by a tilde (~), and that "cleans up" after an object of that class, for example, freeing storage that was allocated when the object was created. A destructor has no arguments and no return type.

detach state attribute. An attribute associated with a thread attribute object. This attribute has two possible values:

0 Undetached. An undetached thread keeps its resources after termination of the thread.

1 Detached. A detached thread has its resources freed by the system after termination.

device. A computer peripheral or an object that appears to the application as such. X/Open. ISO.1.

difference. For two sets A and B, the difference (A-B) is the set of all elements in A but not in B. For bags, there is an additional rule for duplicates: If bag P contains an element m times and bag Q contains the same element n times, then, if m>n, the difference contains that element m-n times. If m<n, the difference contains that element zero times.

digraph. A combination of two keystrokes used to represent unavailable characters in a C or C++ source program. Digraphs are read as tokens during the preprocessor phase.

directory. (1) In a hierarchical file system, a container for files or other directories. IBM. (2) The part of a partitioned data set that describes the members in the data set.

disabled signal. Synonym for enabled signal.

display. To direct the output to the user's terminal. If the output is not directed to the terminal, the results are undefined. X/Open.

DLL. See dynamic link library.

do statement. In the C and C++ compilers, a looping statement that contains the keyword "do", followed by a statement (the action), the keyword "while", and an expression in parentheses (the condition). IBM.

dot. The file name consisting of a single dot character (.). X/Open. ISO.1.

double-byte character set. See DBCS.

double-precision. Pertaining to the use of two computer words to represent a number in accordance with the required precision. ISO-JTC1. ANSI/ISO.

double-quote. The character ", also known as quotation mark. X/Open.

This character is named <quotation-mark> in the portable character set.

doubleword. A contiguous sequence of bytes or characters that comprises two computer words and is capable of being addressed as a unit. IBM.

dynamic. Pertaining to an operation that occurs at the time it is needed rather than at a predetermined or fixed time. IBM.

dynamic allocation. Assignment of system resources to a program when the program is executed rather than when it is loaded into main storage. IBM.

dynamic binding. The act of resolving references to external variables and functions at run time. In C++, dynamic binding is supported by using virtual functions.

dynamic link library (DLL). A file containing executable code and data bound to a program at run time. The code and data in a dynamic link library can be shared by several applications simultaneously. Compiling code with the DLL option does not mean that
the produced executable will be a DLL. To create a DLL, use
#pragma export or the EXPORTALL compiler option.

**DSA (dynamic storage area).** 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 known as a stack
frame.

dynamic storage. Synonym for automatic storage.

**dynamic storage area .** See DSA

**E**

**EBCDIC.** See extended binary-coded decimal
interchange code.

effective group ID.** An attribute of a process that is
used in determining various permissions, including file
access permissions. This value is subject to change
during the process lifetime, as described in the exec
family of functions and setgid(). X/Open. ISO.1.

effective user ID.** (1) The user ID associated with the
last authenticated user or the last setuid() program. It
is equal to either the real or the saved user ID. (2) The
current user ID, but not necessarily the user’s login ID;
for example, a user logged in under a login ID may
change to another user’s ID. The ID to which the user
changes becomes the effective user ID until the user
switches back to the original login ID. All discretionary
access decisions are based on the effective user ID.
IBM. (3) An attribute of a process that is used in
determining various permissions, including file access
permissions. This value is subject to change during the
process lifetime, as described in exec and setuid().
X/Open. ISO.1.

element.** The component of an array, subrange,
enumeration, or set.

element equality.** A relation that determines if two
elements are equal.

element occurrence.** A single instance of an element
in a collection. In a unique collection, element
occurrence is synonymous with element value.

element value.** All the instances of an element with a
particular value in a collection. In a nonunique
collection, an element value may have more than one
occurrence. In a unique collection, element value is
synonymous with element occurrence.

else clause.** The part of an if statement that contains
the word else, followed by a statement. The else clause
provides an action that is started when the if condition
evaluates to a value of zero (false). IBM.

**empty line.** A line consisting of only a new-line
character. X/Open.

**empty string.** (1) A string whose first byte is a null
byte. Synonymous with null string. X/Open. (2) A
character array whose first element is a null character.
ISO.1.

**enabled signal.** The occurrence of an enabled signal
results in the default system response or the execution
of an established signal handler. If disabled, the
occurrence of the signal is ignored.

**encapsulation.** Hiding the internal representation of
data objects and implementation details of functions
from the client program. This enables the end user to
focus on the use of data objects and functions without
having to know about their representation or
implementation.

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

**enqueue.** (1) An operation that adds an element as
the last element to a queue. (2) Request control of a
serially reusable resource.

**entry point.** The address or label of the first
instruction that is executed when a routine is entered for
execution.

**enumeration constant.** In the C or C++ language, an
identifier, with an associated integer value, defined in an
enumerator. An enumeration constant may be used
anywhere an integer constant is allowed. IBM.

**enumeration data type.** (1) In the Fortran, C, and
C++ language, a data type that represents a set of
values that a user defines. IBM. (2) A type that
represents integers and a set of enumeration constants.
Each enumeration constant has an associated integer
value.

**enumeration tag.** In the C and C++ language, the
identifier that names an enumeration data type. IBM.

**enumeration type.** An enumeration type defines a set
of enumeration constants. In the C++ language, an
enumeration type is a distinct data type that is not an
integral type.

**enumerator.** In the C and C++ language, an
enumeration constant and its associated value. IBM.
equivalence class. (1) A grouping of characters that are considered equal for the purpose of collation; for example, many languages place an uppercase character in the same equivalence class as its lowercase form, but some languages distinguish between accented and unaccented character forms for the purpose of collation. IBM. (2) A set of collating elements with the same primary collation weight. Elements in an equivalence class are typically elements that naturally group together, such as all accented letters based on the same base letter. The collation order of elements within an equivalence class is determined by the weights assigned on any subsequent levels after the primary weight. X/Open.

escape sequence. (1) A representation of a character. An escape sequence contains the \ symbol followed by one of the characters: a, b, f, n, r, t, v, ' ', "", x, \, or followed by one or more octal or hexadecimal digits. (2) A sequence of characters that represent, for example, non-printing characters, or the exact code point value to be used to represent variant and nonvariant characters regardless of code page. (3) In the C and C++ language, an escape character followed by one or more characters. The escape character indicates that a different code, or a different coded character set, is used to interpret the characters that follow. Any member of the character set used at run time can be represented using an escape sequence. (4) A character that is preceded by a backslash character and is interpreted to have a special meaning to the operating system. (5) A sequence sent to a terminal to perform actions such as moving the cursor, changing from normal to reverse video, and clearing the screen. Synonymous with multibyte control. IBM.

exception. (1) Any user, logic, or system error detected by a function that does not itself deal with the error but passes the error on to a handling routine (also called throwing the exception). (2) In programming languages, an abnormal situation that may arise during execution, that may cause a deviation from the normal execution sequence, and for which facilities exist in a programming language to define, raise, recognize, ignore, and handle it; for example, (ON-) condition in PL/I, exception in ADA. ISO-JTC1.

executable. A load module or program object which has yet to be loaded into memory for execution.

executable file. A regular file acceptable as a new process image file by the equivalent of the exec family of functions, and thus usable as one form of a utility. The standard utilities described as compilers can produce executable files, but other unspecified methods of producing executable files may also be provided. The internal format of an executable file is unspecified, but a conforming application cannot assume an executable file is a text file. X/Open.

dependency handler. (1) Exception handlers are catch blocks in C++ applications. Catch blocks catch exceptions when they are thrown from a function enclosed in a try block. Try blocks, catch blocks, and throw expressions are the constructs used to implement formal exception handling in C++ applications. (2) A set of routines used to detect deadlock conditions or to process abnormal condition processing. An exception handler allows the normal running of processes to be interrupted and resumed. IBM.

eexecutable file. A regular file acceptable as a new process image file by the equivalent of the exec family of functions, and thus usable as one form of a utility. The standard utilities described as compilers can produce executable files, but other unspecified methods of producing executable files may also be provided. The internal format of an executable file is unspecified, but a conforming application cannot assume an executable file is a text file. X/Open.

eexecutable program. A program that has been link-edited and therefore can be run in a processor. IBM.

extended binary-coded data interchange code (EBCDIC). A coded character set of 256 8-bit characters. IBM.

extended-precision. Pertaining to the use of more than two computer words to represent a floating point number in accordance with the required precision. In z/OS four computer words are used for an extended-precision number.

token. (1) An element or function not included in the standard language. (2) File name extension.

eexternal data definition. A description of a variable appearing outside a function. It causes the system to allocate storage for that variable and makes that variable accessible to all functions that follow the definition and are located in the same file as the definition. IBM.

eextern storage class specifier. A specifier that enables the programmer to declare objects and functions that several source files can use.

F

feature test macro (FTM). A macro (#define) used to determine whether a particular set of features will be included from a header. X/Open. ISO.1.

FIFO special file. A type of file with the property that data written to such a file is read on a first-in-first-out basis. Other characteristics of FIFOs are described in open(), read(), write(), and lseek(). X/Open. ISO.1.

file access permissions. The standard file access control mechanism uses the file permission bits. The
bits are set at the time of file creation by functions such as `open()`, `creat()`, `mkdir()`, and `mkfifo()` and can be changed by `chmod()`. The bits are read by `stat()` or `fstat()`. X/Open.

**file descriptor.** (1) A positive integer that the system uses instead of the file name to identify an open file. (2) A per-process unique, non-negative integer used to identify an open file for the purpose of file access. ISO.1.

The value of a file descriptor is from zero to `{OPEN_MAX}`—which is defined in `<limits.h>`. A process can have no more than `{OPEN_MAX}` file descriptors open simultaneously. File descriptors may also be used to implement directory streams. X/Open.

**file mode.** An object containing the `file mode bits` and file type of a file, as described in `<sys/stat.h>`. X/Open.

**file mode bits.** A file's file permission bits, set-user-ID-on-execution bit (S_ISUID) and set-group-ID-on-execution bit (S_ISGID). X/Open.

**file permission bits.** Information about a file that is used, along with other information, to determine if a process has read, write, or execute/search permission to a file. The bits are divided into three parts: owner, group, and other. Each part is used with the corresponding file class of process. These bits are contained in the file mode, as described in `<sys/stat.h>`. The detailed usage of the file permission bits is described in `file access permissions`. X/Open. ISO.1.

**file scope.** A name declared outside all blocks, classes, and function declarations has file scope and can be used after the point of declaration in a source file.

**filter.** A command whose operation consists of reading data from standard input or a list of input files and writing data to standard output. Typically, its function is to perform some transformation on the data stream. X/Open.

**first element.** The element visited first in an iteration over a collection. Each collection has its own definition for first element. For example, the first element of a sorted set is the element with the smallest value.

**flat collection.** A collection that has no hierarchical structure.

**float constant.** (1) A constant representing a nonintegral number. (2) A number containing a decimal point, an exponent, or both a decimal point and an exponent. The exponent contains an e or E, an optional sign (+ or -), and one or more digits (0 through 9). IBM.

**for statement.** A looping statement that contains the word `for` followed by a for-initializing-statement, an optional condition, a semicolon, and an optional expression, all enclosed in parentheses.

**foreground process.** (1) A process that must run to completion before another command is issued. The foreground process is in the foreground process group, which is the group that receives the signals generated by a terminal. IBM. (2) A process that is a member of a foreground process group. X/Open. ISO.1.

**foreground process group.** (1) The group that receives the signals generated by a terminal. IBM. (2) A process group whose member processes have certain privileges, denied to processes in background process groups, when accessing their controlling terminal. Each session that has established a connection with a controlling terminal has exactly one process group of the session as the foreground process group of that controlling terminal. X/Open. ISO.1.

**foreground process group ID.** The process group ID of the foreground process group. X/Open. ISO.1.

**form-feed character.** A character in the output stream that indicates that printing should start on the next page of an output device. The formfeed is the character designated by ‘\f’ in the C and C++ language. If the formfeed is not the first character of an output line, the result is unspecified. It is unspecified whether this character is the exact sequence transmitted to an output device by the system to accomplish the movement to the next page. X/Open.

**forward declaration.** A declaration of a class or function made earlier in a compilation unit, so that the declared class or function can be used before it has been defined.

**freestanding application.** (1) An application that is created to run without the run-time environment or library with which it was developed. (2) An z/OS C/C++ application that does not use the services of the dynamic z/OS C/C++ run-time library or of the Language Environment. Under z/OS C support, this ability is a feature of the System Programming C support.

**free store.** Dynamically allocated memory. New and delete are used to allocate and deallocate free store.

**friend class.** A class in which all the member functions are granted access to the private and protected members of another class. It is named in the declaration of another class and uses the keyword friend as a prefix to the class. For example, the following source code makes all the functions and data in class `you` friends of class `me`:

```cpp
class me {
    friend class you;
    // ...
};
```

**friend function.** A function that is granted access to the private and protected parts of a class. It is named in the declaration of the other class with the prefix friend.
function. A named group of statements that can be called and evaluated and can return a value to the calling statement. IBM.

function call. An expression that moves the path of execution from the current function to a specified function and evaluates to the return value provided by the called function. A function call contains the name of the function to which control moves and a parenthesized list of values. IBM.

function declarator. The part of a function definition that names the function, provides additional information about the return value of the function, and lists the function parameters. IBM.

function definition. The complete description of a function. A function definition contains a sequence of specifiers (storage class, optional type, inline, virtual, optional friend), a function declarator, optional constructor-initializers, parameter declarations, optional const, and the block statement. Inline, virtual, friend, and const are not available with C.

function prototype. A function declaration that provides type information for each parameter. It is the first line of the function (header) followed by a semicolon (;). The declaration is required by the compiler at the time that the function is declared, so that the compiler can check the type.

function scope. Labels that are declared in a function have function scope and can be used anywhere in that function after their declaration.

function template. Provides a blueprint describing how a set of related individual functions can be constructed.

G

Generalization. Refers to a class, function, or static data member which derives its definition from a template. An instantiation of a template function would be a generalization.

Generalized Object File Format (GOFF). It is the strategic object module format for S/390. It extends the capabilities of object modules to contain more information than current object modules. It removes the limitations of the previous object module format and supports future enhancements. It is required for XPLINK.

generic class. Synonym for class templates.

global. Pertaining to information available to more than one program or subroutine. IBM.

global scope. Synonym for file scope.

global variable. A symbol defined in one program module that is used in other independently compiled program modules.

GMT (Greenwich Mean Time). The solar time at the meridian of Greenwich, formerly used as the prime basis of standard time throughout the world. GMT has been superseded by coordinated universal time (UTC).

graphic character. (1) A visual representation of a character, other than a control character, that is normally produced by writing, printing, or displaying. ISO Draft. (2) A character that can be displayed or printed. IBM.

Graphical Data Display Manager (GDDM). Pertaining to an IBM licensed program that provides a group of routines that allows pictures to be defined and displayed procedurally through function routines that correspond to graphic primitives. IBM.

Greenwich Mean Time. See GMT.

group ID. (1) A non-negative integer that is used to identify a group of system users. Each system user is a member of at least one group. When the identity of a group is associated with a process, a group ID value is referred to as a real group ID, an effective group ID, one of the supplementary group IDs or a saved set-group-ID. X/Open. (2) A non-negative integer, which can be contained in an object of type gid_t, that is used to identify a group of system users. ISO.1.

H

halfword. A contiguous sequence of bytes or characters that constitutes half a computer word and can be addressed as a unit. IBM.

hash function. A function that determines which category, or bucket, to put an element in. A hash function is needed when implementing a hash table.

hash table. (1) A data structure that divides all elements into (preferably) equal-sized categories, or buckets, to allow quick access to the elements. The hash function determines which bucket an element belongs in. (2) A table of information that is accessed by way of a shortened search key (that hash value). Using a hash table minimizes average search time.

header file. A text file that contains declarations used by a group of functions, programs, or users.

heap storage. 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.

hexadecimal constant. A constant, usually starting with special characters, that contains only hexadecimal
digits. Three examples for the hexadecimal constant with value 0 would be 'x00', '0x0', or '0X00'.

**High Level Assembler.** An IBM licensed program. Translates symbolic assembler language into binary machine language.

**Hiperspace memory file.** An IBM file used under z/OS to deal with memory files as large as 2 gigabytes. *IBM.*

**hooks.** Instructions inserted into a program by a compiler at compile-time. Using hooks, you can set break-points to instruct the Debug Tool to gain control of the program at selected points during its execution.

**hybrid code.** Program statements that have not been internationalized with respect to code page, especially where data constants contain variant characters. Such statements can be found in applications written in older implementations of MVS, which required syntax statements to be written using code page IBM-1047 exclusively. Such applications cannot be converted from one code page to another using `iconv()`.

**I18N.** Abbreviation for internationalization.

**identifier.** (1) One or more characters used to identify or name a data element and possibly to indicate certain properties of that data element. *ANSI/ISO.* (2) In programming languages, a token that names a data object such as a variable, an array, a record, a subprogram, or a function. *ANSI/ISO.* (3) A sequence of letters, digits, and underscores used to identify a data object or function. *IBM.*

**if statement.** A conditional statement that contains the keyword if, followed by an expression in parentheses (the condition), a statement (the action), and an optional else clause (the alternative action). *IBM.*

**ILC (interlanguage call).** A function call made by one language to a function coded in another language. Interlanguage calls are used to communicate between programs written in different languages.

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

**implementation-defined behavior.** Application behavior that is not defined by the standards. The implementing compiler and library defines this behavior when a program contains correct program constructs or uses correct data. Programs that rely on implementation-defined behavior may behave differently on different C or C++ implementations. Refer to the *z/OS C/C++ books that are listed in "z/OS C/C++ and related publications" on page 6* for information about implementation-defined behavior in the z/OS C/C++ environment. Contrast with *unspecified behavior* and *undefined behavior.*

**IMS (Information Management System).** Pertaining to an IBM database/data communication (DB/DC) system that can manage complex databases and networks. *IBM.*

**include directive.** A preprocessor directive that causes the preprocessor to replace the statement with the contents of a specified file.

**include file.** See *header file.*

**incomplete class declaration.** A class declaration that does not define any members of a class. Until a class is fully declared, or defined, you can only use the class name where the size of the class is not required. Typically an incomplete class declaration is used as a forward declaration.

**incomplete type.** A type that has no value or meaning when it is first declared. There are three incomplete types: void, arrays of unknown size and structures and unions of unspecified content. A void type can never be completed. Arrays of unknown size and structures or unions of unspecified content can be completed in further declarations.

**indirection.** (1) A mechanism for connecting objects by storing, in one object, a reference to another object. (2) In the C and C++ languages, the application of the unary operator * to a pointer to access the object to which the pointer points.

**indirection class.** Synonym for *reference class.*

**induction variable.** It is a controlling variable of a loop.

**inheritance.** A technique that allows the use of an existing class as the base for creating other classes.

**initial heap.** The z/OS C/C++ heap controlled by the *HEAP run-time option and designated by a heap_id of 0.* The initial heap contains dynamically allocated user data.

**initializer.** An expression used to initialize data objects. The C++ language, supports the following types of initializers:

- An expression followed by an assignment operator that is used to initialize fundamental data type objects or class objects that contain copy constructors.
- A parenthesized expression list that is used to initialize base classes and members that use constructors.

Both the C and C++ languages support an expression enclosed in braces (\{\}) that used to initialize aggregates.
inlined function. A function whose actual code replaces a function call. A function that is both declared and defined in a class definition is an example of an inlined function. Another example is one which you explicitly declared inline by using the keyword `inline`. Both member and non-member functions can be inlined.

input stream. A sequence of control statements and data submitted to a system from an input unit. Synonymous with input job stream, job input stream. IBM.

instance. An object-oriented programming term synonymous with object. An instance is a particular instantiation of a data type. It is simply a region of storage that contains a value or group of values. For example, if a class `box` is previously defined, two instances of a class `box` could be instantiated with the declaration: `box box1, box2;`

instantiate. To create or generate a particular instance or object of a data type. For example, an instance `box1` of class `box` could be instantiated with the declaration: `box box1;`

instruction. A program statement that specifies an operation to be performed by the computer, along with the values or locations of operands. This statement represents the programmer's request to the processor to perform a specific operation.

instruction scheduling. An optimization technique that reorders instructions in code to minimize execution time.

integer constant. A decimal, octal, or hexadecimal constant.

integral object. A character object, an object having an enumeration type, an object having variations of the type `int`, or an object that is a bit field.

Interactive System Productivity Facility. See ISPF.

interlanguage call. See ILC (interlanguage call).

interlanguage communication. See ILC (interlanguage communication).

internationalization. The capability of a computer program to adapt to the requirements of different native languages, local customs, and coded character sets. X/Open.

Synonymous with `I18N`.

interoperability. The capability to communicate, execute programs, or transfer data among various functional units in a way that requires the user to have little or no knowledge of the unique characteristics of those units.

Interprocedural Analysis. See IPA.

interprocess communication. (1) The exchange of information between processes or threads through semaphores, queues, and shared memory. (2) The process by which programs communicate data to each other to synchronize their activities. Semaphores, signals, and internal message queues are common methods of inter-process communication.

I/O stream library. A class library that provides the facilities to deal with many varieties of input and output.

IPA (Interprocedural Analysis). A process for performing optimizations across compilation units.

ISPF (Interactive System Productivity Facility). An IBM licensed program that serves as a full-screen editor and dialogue manager. Used for writing application programs, it provides a means of generating standard screen panels and interactive dialogues between the application programmer and terminal user. (ISPF)

iteration. The process of repeatedly applying a function to a series of elements in a collection until some condition is satisfied.

J

JCL (job control language). A control language used to identify a job to an operating system and to describe the job's requirement. IBM.

K

keyword. (1) A predefined word reserved for the C and C++ languages, that may not be used as an identifier. (2) A symbol that identifies a parameter in JCL.

kind attribute. An attribute for a mutex attribute object. This attribute's value determines whether the mutex can be locked once or more than once for a thread and whether state changes to the mutex will be reported to the debug interface.

L

label. An identifier within or attached to a set of data elements. ISO Draft.

Language Environment. Abbreviated form of z/OS Language Environment. Pertaining to an IBM software product that provides a common run-time environment and run-time services to applications compiled by Language Environment-conforming compilers.

last element. The element visited last in an iteration over a collection. Each collection has its own definition for last element. For example, the last element of a sorted set is the element with the largest value.
late binding. Allowing the system to determine the specific class of the object and invoke the appropriate function implementations at run time. Late binding or dynamic binding hides the differences between a group of related classes from the application program.


lexically. Relating to the left-to-right order of units.

library. (1) A collection of functions, calls, subroutines, or other data. IBM. (2) A set of object modules that can be specified in a link command.

linkage editor. Synonym for linker. The linkage editor has been replaced by the binder for the MVS/ESA, OS/390, or z/OS operating systems. See binder.

Linkage. Refers to the binding between a reference and a definition. A function has internal linkage if the function is defined inline as part of the class, is declared with the inline keyword, or is a non-member function declared with the static keyword. All other functions have external linkage.

linker. A computer program for creating load modules from one or more object modules by resolving cross references among the modules and, if necessary, adjusting addresses. IBM.

link pack area (LPA). In z/OS, an area of storage containing re-enterable routines from system libraries. Their presence in main storage saves loading time.

literal. (1) In programming languages, a lexical unit that directly represents a value; for example, 14 represents the integer fourteen, “APRIL” represents the string of characters APRIL, 3.0005E2 represents the number 300.05. ISO-JTC1. (2) A symbol or a quantity in a source program that is itself data, rather than a reference to data. IBM. (3) A character string whose value is given by the characters themselves; for example, the numeric literal 7 has the value 7, and the character literal CHARACTERS has the value CHARACTERS. IBM.

loader. A routine, commonly a computer program, that reads data into main storage. ANSI/ISO.

load module. All or part of a computer program in a form suitable for loading into main storage for execution. A load module is usually the output of a linkage editor. ISO Draft.

local. (1) In programming languages, pertaining to the relationship between a language object and a block such that the language object has a scope contained in that block. ISO-JTC1. (2) Pertaining to that which is defined and used only in one subdivision of a computer program. ANSI/ISO.

local customs. The conventions of a geographical area or territory for such things as date, time, and currency formats. X/Open.

locale. The definition of the subset of a user's environment that depends on language and cultural conventions. X/Open.

localization. The process of establishing information within a computer system specific to the operation of particular native languages, local customs, and coded character sets. X/Open.

local scope. A name declared in a block has scope within the block, and can therefore only be used in that block.

Long name. An external name C++ name in an object module, or and external name in an object module created by the C compiler when the LONGNAME option is used. Long names are up to 1024 characters long and may contain both upper-case and lower-case characters.

lvalue. An expression that represents a data object that can be both examined and altered.

M

macro. An identifier followed by arguments (may be a parenthesized list of arguments) that the preprocessor replaces with the replacement code located in a preprocessor #define directive.

macro call. Synonym for macro.

macro instruction. Synonym for macro.

main function. An external function with the identifier main that is the first user function—aside from exit routines and C++ static object constructors—to get control when program execution begins. Each C and C++ program must have exactly one function named main.

makefile. A text file containing a list of your application's parts. The make utility uses makefiles to maintain application parts and dependencies.

make utility. Maintains all of the parts and dependencies for your application. The make utility uses a makefile to keep the parts of your program synchronized. If one part of your application changes, the make utility updates all other files that depend on the changed part. This utility is available under the z/OS shell and by default, uses the c89 utility to recompile and bind your application.

mangling. The encoding during compilation of identifiers such as function and variable names to include type and scope information. These mangled names ensure type-safe linkage. See also demangling.
**manipulator.** A value that can be inserted into streams or extracted from streams to affect or query the behavior of the stream.

**member.** A data object or function in a structure, union, or class. Members can also be classes, enumerations, bit fields, and type names.

**member function.** (1) An operator or function that is declared as a member of a class. A member function has access to the private and protected data members and member functions of objects of its class. Member functions are also called methods. (2) A function that performs operations on a class.

**method.** In the C++ language, a synonym for *member function.*

**method file.** (1) A file that allows users to indicate to the localedef utility where to look for user-provided methods for processing user-designed codepages. (2) For ASCII locales, a file that defines the method functions to be used by C runtime locale-sensitive interfaces. A method file also identifies where the method functions can be found. IBM supplies several method files used to create its standard set of ASCII locales. Other method files can be created to support customized or user-created codepages. Such customized method files replace IBM-supplied charmap method functions with user-written functions.

**migrate.** To move to a changed operating environment, usually to a new release or version of a system. *IBM.*

**module.** A program unit that usually performs a particular function or related functions, and that is distinct and identifiable with respect to compiling, combining with other units, and loading.

**multibyte character.** A mixture of single-byte characters from a single-byte character set and double-byte characters from a double-byte character set.

**multicharacter collating element.** A sequence of two or more characters that collate as an entity. For example, in some coded character sets, an accented character is represented by a non-spacing accent, followed by the letter. Other examples are the Spanish elements ch and ll. *X/Open.*

**multiple inheritance.** An object-oriented programming technique implemented in the C++ language through derivation, in which the derived class inherits members from more than one base class.

**multitasking.** A mode of operation that allows concurrent performance, or interleaved execution of two or more tasks. *ISO-JTC1. ANSI/ISO.*

**mutex.** A flag used by a semaphore to protect shared resources. The mutex is locked and unlocked by threads in a program. A mutex can only be locked by one thread at a time and can only be unlocked by the same thread that locked it. The current owner of a mutex is the thread that it is currently locked by. An unlocked mutex has no current owner.

**mutex attribute object.** Allows the user to manage the characteristics of mutexes in their application by defining a set of values to be used for the mutex during its creation. A mutex attribute object allows the user to create many mutexes with the same set of characteristics without redefining the same set of characteristics for each mutex created.

**mutex object.** Used to identify a mutex.

**namespace.** A category used to group similar types of identifiers.

**named pipe.** A FIFO file. Named pipes allow transfer of data between processes in a FIFO manner and synchronization of process execution. Allows processes to communicate even though they do not know what processes are on the other end of the pipe.

**natural reentrancy.** A program that contains no writable static and requires no additional processing to make it reentrant is considered naturally reentrant.

**nested class.** A class defined within the scope of another class.

**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.*

**newline character.** A character that in the output stream indicates that printing should start at the beginning of the next line. The newline character is designated by ‘\n’ in the C and C++ language. It is unspecified whether this character is the exact sequence transmitted to an output device by the system to accomplish the movement to the next line. *X/Open.*

**nickname.** Synonym for alias.

**non-printing character.** See *control character.*

**null character (NUL).** The ASCII or EBCDIC character ‘\0’ with the hex value 00, all bits turned off. It is used to represent the absence of a printed or displayed character. This character is named <NUL> in the portable character set.

**null pointer.** The value that is obtained by converting the number 0 into a pointer; for example, (*void *) 0. The C and C++ languages guarantee that this value will not match that of any legitimate pointer, so it is used by many functions that return pointers to indicate an error. *X/Open.*
null statement. A C or C++ statement that consists solely of a semicolon.

null string. (1) A string whose first byte is a null byte. Synonymous with empty string. X/Open. (2) A character array whose first element is a null character. ISO.1.

null value. A parameter position for which no value is specified. IBM.

null wide-character code. A wide-character code with all bits set to zero. X/Open.

number sign. The character #, also known as pound sign and hash sign. This character is named <number-sign> in the portable character set.

object. (1) A region of storage. An object is created when a variable is defined. An object is destroyed when it goes out of scope. (See also instance.) (2) In object-oriented design or programming, an abstraction consisting of data and the operations associated with that data. See also class. IBM. (3) An instance of a class.

object code. Machine-executable instructions, usually generated by a compiler from source code written in a higher level language (such as the C++ language). For programs that must be linked, object code consists of relocatable machine code.

object module. (1) All or part of an object program sufficiently complete for linking. Assemblers and compilers usually produce object modules. ISO Draft. (2) A set of instructions in machine language produced by a compiler from a source program. IBM.

object-oriented programming. A programming approach based on the concepts of data abstraction and inheritance. Unlike procedural programming techniques, object-oriented programming concentrates not on how something is accomplished, but on what data objects comprise the problem and how they are manipulated.

octal constant. The digit 0 (zero) followed by any digits 0 through 7.

open file. A file that is currently associated with a file descriptor. X/Open. ISO.1.

operand. An entity on which an operation is performed. ISO-JTC1. ANSI/ISO.

operating system (OS). Software that controls functions such as resource allocation, scheduling, input/output control, and data management.

operator function. An overloaded operator that is either a member of a class or that takes at least one argument that is a class type or a reference to a class type.

operator precedence. In programming languages, an order relation defining the sequence of the application of operators within an expression. ISO-JTC1.

orientation of a stream. After application of an input or output function to a stream, it becomes either byte-oriented or wide-oriented. A byte-oriented stream is a stream that had a byte input or output function applied to it when it had no orientation. A wide-oriented stream is a stream that had a wide character input or output function applied to it when it had no orientation. A stream has no orientation when it has been associated with an external file but has not had any operations performed on it.

overflow. (1) A condition that occurs when a portion of the result of an operation exceeds the capacity of the intended unit of storage. (2) That portion of an operation that exceeds the capacity of the intended unit of storage. IBM.

overlay. The technique of repeatedly using the same areas of internal storage during different stages of a program. ANSI/ISO. Unions are used to accomplish this in C and C++.

overloading. An object-oriented programming technique that allows you to redefine functions and most standard C++ operators when the functions and operators are used with class types.

parameter. (1) In the C and C++ languages, an object declared as part of a function declaration or definition that acquires a value on entry to the function, or an identifier following the macro name in a function-like macro definition. X/Open. (2) Data passed between programs or procedures. IBM.

parameter declaration. A description of a value that a function receives. A parameter declaration determines the storage class and the data type of the value.

parent enclave. The enclave that issues a call to system services or language constructs to create a nested or child enclave. See also child enclave and nested enclave.

parent process. (1) The program that originates the creation of other processes by means of spawn or exec function calls. See also child process. (2) A process that creates other processes.

parent process ID. (1) An attribute of a new process identifying the parent of the process. The parent process ID of a process is the process ID of its creator,
for the lifetime of the creator. After the creator’s lifetime has ended, the parent process ID is the process ID of an implementation-dependent system process. X/Open.

(2) An attribute of a new process after it is created by a currently active process. ISO.1.

partitioned concatenation. Specifying multiple PDSs or PDSEs under one ddname. The concatenated data sets act as one big PDS or PDSE and access can be made to any member with a unique name. An attempted access to a member whose name occurs more than once in the concatenated data sets, returns the first member with that name found in the entire concatenation.

partitioned data set (PDS). A data set in direct access storage that is divided into partitions, called members, each of which can contain a program, part of a program, or data. IBM.

partitioned data set extended (PDSE). Similar to partitioned data set, but with extended capabilities.

path name. (1) A string that is used to identify a file. A path name consists of, at most, (PATH_MAX) bytes, including the terminating null character. It has an optional beginning slash, followed by zero or more file names separated by slashes. If the path name refers to a directory, it may also have one or more trailing slashes. Multiple successive slashes are treated as one slash. A path name that begins with two successive slashes may be interpreted in an implementation-dependent manner, although more than two leading slashes are treated as a single slash. The interpretation of the path name is described in path name resolution. ISO.1. (2) A file name specifying all directories leading to the file.

path name resolution. Path name resolution is performed for a process to resolve a path name to a particular file in a file hierarchy. There may be multiple path names that resolve to the same file. X/Open.

pattern. A sequence of characters used either with regular expression notation or for path name expansion, as a means of selecting various characters strings or path names, respectively. The syntaxes of the two patterns are similar, but not identical. X/Open.

period. The character (.). The term period is contrasted against dot, which is used to describe a specific directory entry. This character is named <period> in the portable character set.

permissions. Codes that determine how a file can be used by any users who work on the system. See also file access permissions. IBM.

persistent environment. A program can explicitly establish a persistent environment, direct functions to it, and explicitly terminate it.

pointer. In the C and C++ languages, a variable that holds the address of a data object or a function. IBM.

pointer class. A class that implements pointers.

pointer to member. An operator used to access the address of non-static members of a class.

polymorphism. The technique of taking an abstract view of an object or function and using any concrete objects or arguments that are derived from this abstract view.

portable character set. The set of characters specified in POSIX 1003.2, section 2.4:

```c
<NUL>
>alert>
<backspace>
<tab>
<newline>
<vertical-tab>
<form-feed>
<carriage-return>
<space>
<exclamation-mark> !
<quotation-mark> "
<number-sign> #
<dollar-sign> $
<percent-sign> %
<ampersand> &
<apostrophe> '
<left-parenthesis> ( 
<right-parenthesis> )
<asterisk> *
<plus-sign> +
<comma> ,
<hyphen> –
<hyphen-minus> –
<period> .
<slash> /
<zero> 0
<one> 1
<two> 2
<three> 3
<four> 4
<five> 5
<six> 6
<seven> 7
<eight> 8
<nine> 9
<colon> :
<semicolon> ;
<less-than-sign> <
<equals-sign> =
<greater-than-sign> >
<question-mark> ?
<commercial-at> @
<A> A
<B> B
<C> C
<D> D
<E> E
<F> F
<G> G
<H> H
<I> I
```
portable file name character set. The set of characters from which portable file names are constructed. For a file name to be portable across implementations conforming to the ISO POSIX-1 standard and to ISO/IEC 9945, it must consists only of the following characters:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
0 1 2 3 4 5 6 7 8 9 . _ -

Figure 239.

The last three characters are the period, underscore, and hyphen characters, respectively. The hyphen must not be used as the first character of a portable file name. Upper- and lower-case letters retain their unique identities between conforming implementations. In the case of a portable path name, the slash character may also be used. X/Open. ISO.1.

portability. The ability of a programming language to compile successfully on different operating systems without requiring changes to the source code.

positional parameter. A parameter that must appear in a specified location relative to other positional parameters. IBM.

precedence. The priority system for grouping different types of operators with their operands.

predefined macros. Frequently used routines provided by an application or language for the programmer.

preinitialization. A process by which an environment or library is initialized once and can then be used repeatedly to avoid the inefficiency of initializing the environment or library each time it is needed.

prelinker. A utility provided with z/OS Language Environment that you can use to process application programs that require DLL support, or contain either constructed reentrancy or external symbol names that are longer than 8 characters. You require the prelinker, or its equivalent function which is provided by the binder, to process all C++ applications, or C applications that are compiled with the RENT, DLL, LONGNAME or IPA options. As of Version 2 Release 4, the prelinker was superseded by the binder. See also binder.

preprocessor. A phase of the compiler that examines the source program for preprocessor statements that are then executed, resulting in the alteration of the source program.
preprocessor statement. In the C and C++ languages, a statement that begins with the symbol # and is interpreted by the preprocessor during compilation. IBM.

primary expression. (1) An identifier, parenthesized expression, function call, array element specification, structure member specification, or union member specification. IBM. (2) Literals, names, and names qualified by the :: (scope resolution) operator.

printable character. One of the characters included in the print character classification of the LC_CTYPE category in the current locale. X/Open.

private. Pertaining to a class member that is only accessible to member functions and friends of that class.

process. (1) An instance of an executing application and the resources it uses. (2) 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 the fork() function is known as the parent process, and the new process created by the fork() function is known as the child process. X/Open. ISO.1.

process group. A collection of processes that permits the signaling of related processes. Each process in the system is a member of a process group that is identified by the process group ID. A newly created process joins the process group of its creator. IBM. X/Open. ISO.1.

process group ID. The unique identifier representing a process group during its lifetime. A process group ID is a positive integer. (Under ISO only, it is a positive integer that can be contained in a pid_t) A process group ID will not be reused by the system until the process group lifetime ends. X/Open. ISO.1.

process group lifetime. A period of time that begins when a process group is created and ends when the last remaining process in the group leaves the group, because either it is the end of the last process' lifetime or the last remaining process is calling the setsid() or setpgid() functions. X/Open. ISO.1.

process ID. The unique identifier representing a process. A process ID is a positive integer. (Under ISO only, it is a positive integer that can be contained in a pid_t) A process ID will not be reused by the system until the process lifetime ends. In addition, if there exists a process group whose process group ID is equal to that process ID, the process ID will not be reused by the system until the process group lifetime ends. A process that is not a system process will not have a process ID of 1. X/Open. ISO.1.

process lifetime. The period of time that begins when a process is created and ends when the process ID is returned to the system. After a process is created with a fork() function, it is considered active. Its thread of control and address space exist until it terminates. It then enters an inactive state where certain resources may be returned to the system, although some resources, such as the process ID, are still in use. When another process executes a wait() or waitpid() function for an inactive process, the remaining resources are returned to the system. The last resource to be returned to the system is the process ID. At this time, the lifetime of the process ends. X/Open. ISO.1.

program object. All or part of a computer program in a format suitable for loading into main storage for execution. A program object is the output of the z/OS Binder and is a newer more flexible format (e.g. longer external names) than a load module.

protected. Pertaining to a class member that is only accessible to member functions and friends of that class, or to member functions and friends of classes derived from that class.

prototype. A function declaration or definition that includes both the return type of the function and the types of its parameters. See function prototype.

public. Pertaining to a class member that is accessible to all functions.

pure virtual function. A virtual function that has a function definition of = 0; See also abstract classes.

qualified class name. Any class name or class name qualified with one or more :: (scope resolution) operators.

qualified name. Used to qualify a non-class type name such as a member by its class name.

qualified type name. Used to reduce complex class name syntax by using typedefs to represent qualified class names.

Query Management Facility (QMF). Pertaining to an IBM query and report writing facility that enables a variety of tasks such as data entry, query building, administration, and report analysis. IBM.

queue. A sequence with restricted access in which elements can only be added at the back end (or bottom) and removed from the front end (or top). A queue is characterized by first-in, first-out behavior and chronological order.

quotation marks. The characters " and ' also known as double-quote and single-quote respectively. X/Open.
R

radix character. The character that separates the integer part of a number from the fractional part. X/Open.

real group ID. The attribute of a process that, at the time of process creating, identifies the group of the user who created the process. This value is subject to change during the process lifetime, as described in setgid(). X/Open. ISO.1.

real user ID. The attribute of a process that, at the time of process creation, identifies the user who created the process. This value is subject to change during the process lifetime, as described in setuid(). X/Open. ISO.1.

reason code. A code that identifies the reason for a detected error. IBM.

reassociation. An optimization technique that rearranges the sequence of calculations in a subscript expression producing more candidates for common expression elimination.

redirection. In the shell, a method of associating files with the input or output of commands. X/Open.

reentrant. The attribute of a program or routine that allows the same copy of a program or routine to be used concurrently by two or more tasks.

reference class. A class that links a concrete class to an abstract class. Reference classes make polymorphism possible with the Collection Classes. Synonymous with indirection class.

refresh. To ensure that the information on the user’s terminal screen is up-to-date. X/Open.

register storage class specifier. A specifier that indicates to the compiler within a block scope data definition, or a parameter declaration, that the object being described will be heavily used.

register variable. A variable defined with the register storage class specifier. Register variables have automatic storage.

regular expression. (1) A mechanism to select specific strings from a set of character strings. (2) A set of characters, meta-characters, and operators that define a string or group of strings in a search pattern. (3) A string containing wildcard characters and operations that define a set of one or more possible strings.

regular file. A file that is a randomly accessible sequence of bytes, with no further structure imposed by the system. X/Open. ISO.1.

relation. An unordered flat collection class that uses keys, allows for duplicate elements, and has element equality.

relative path name. The name of a directory or file expressed as a sequence of directories followed by a file name, beginning from the current directory. See path name resolution. IBM.

reserved word. (1) In programming languages, a keyword that may not be used as an identifier. ISO-JTC1. (2) A word used in a source program to describe an action to be taken by the program or compiler. It must not appear in the program as a user-defined name or a system name. IBM.

RMODE (residency mode). In z/OS, a program attribute that refers to where a module is prepared to run. RMODE can be 24 or ANY. ANY refers to the fact that the module can be loaded either above or below the 16M line. RMODE 24 means the module expects to be loaded below the 16M line.

RTTI. Use the RTTI option to generate run-time type identification (RTTI) information for the typeid operator and the dynamic_cast operator.

run-time library. A compiled collection of functions whose members can be referred to by an application program during run-time execution. Typically used to refer to a dynamic library that is provided in object code, such that references to the library are resolved during the linking step. The run-time library itself is not statically bound into the application modules.

S

saved set-group-ID. An attribute of a process that allows some flexibility in the assignment of the effective group ID attribute, as described in the exec() family of functions and setgid(). X/Open. ISO.1.

saved set-user-ID. An attribute of a process that allows some flexibility in the assignment of the effective user ID attribute, as described in exec() and setuid(). X/Open. ISO.1.

scalar. An arithmetic object, or a pointer to an object of any type.

scope. (1) That part of a source program in which a variable is visible. (2) That part of a source program in which an object is defined and recognized.

scope operator (::). An operator that defines the scope for the argument on the right. If the left argument is blank, the scope is global; if the left argument is a class name, the scope is within that class. Synonymous with scope resolution operator.

scope resolution operator (::). Synonym for scope operator.
semaphore. An object used by multi-threaded applications for signalling purposes and for controlling access to serially reusable resources. Processes can be locked to a resource with semaphores if the processes follow certain programming conventions.

sequence. A sequentially ordered flat collection.

sequential concatenation. Multiple sequential data sets or partitioned data-set members are treated as one long sequential data set. In the case of sequential data sets, you can access or update the data sets in order. In the case of partitioned data-set members, you can access or update the members in order. Repositioning is possible if all of the data sets in the concatenation support repositioning.

sequential data set. A data set whose records are organized on the basis of their successive physical positions, such as on magnetic tape. IBM.

session. A collection of process groups established for job control purposes. Each process group is a member of a session. A process is a member of the session of which its process group is a member. A newly created process joins the session of its creator. A process can alter its session membership; see setsid(). There can be multiple process groups in the same session. X/Open. ISO.1.

shell. A program that interprets sequences of text input as commands. It may operate on an input stream or it may interactively prompt and read commands from a terminal. X/Open. This feature is provided as part of the z/OS Shell and Utilities feature licensed program.

Short name. An external non-C++ name in an object module produced by compiling with the NOLONGNAME option. Such a name is up to 8 characters long and single case.

signal. (1) A condition that may or may not be reported during program execution. For example, SIGFPE is the signal used to represent erroneous arithmetic operations such as a division by zero. (2) 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. X/Open. ISO.1. (3) A method of interprocess communication that simulates software interrupts. IBM.

signal handler. A function to be called when the signal is reported.

single-byte character set (SBCS). A set of characters in which each character is represented by a one-byte code. IBM.

single-precision. Pertaining to the use of one computer word to represent a number in accordance with the required precision. ISO-JTC1. ANSI/ISO.

single-quote. The character ', also known as apostrophe. This character is named <quotation-mark> in the portable character set.

slash. The character /, also known as solidus. This character is named <slash> in the portable character set.

socket. (1) A unique host identifier created by the concatenation of a port identifier with a transmission control protocol/Internet protocol (TCP/IP) address. (2) A port identifier. (3) A 16-bit port-identifier. (4) A port on a specific host; a communications end point that is accessible though a protocol family's addressing mechanism. A socket is identified by a socket address. IBM.

sorted map. A sorted flat collection with key and element equality.

sorted relation. A sorted flat collection that uses keys, has element equality, and allows duplicate elements.

sorted set. A sorted flat collection with element equality.

source module. A file that contains source statements for such items as high-level language programs and data description specifications. IBM.

source program. A set of instructions written in a programming language that must be translated to machine language before the program can be run. IBM.

space character. The character defined in the portable character set as <space>. The space character is a member of the space character class of the current locale, but represents the single character, and not all of the possible members of the class. X/Open.

spanned record. A logical record contained in more than one block. IBM.

specialization. A user-supplied definition which replaces a corresponding template instantiation.

specifiers. Used in declarations to indicate storage class, fundamental data type and other properties of the object or function being declared.

spill area. A storage area used to save the contents of registers. IBM.

SQL (Structured Query Language). A language designed to create, access, update and free data tables.

square brackets. The characters [ (left bracket) and ] (right bracket). Also see brackets.
stack frame. The physical representation of the activation of a routine. The stack frame is 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 storage. Synonym for automatic storage.

standard error. An output stream usually intended to be used for diagnostic messages. X/Open.

standard input. (1) An input stream usually intended to be used for primary data input. X/Open. (2) The primary source of data entered into a command. Standard input comes from the keyboard unless redirection or piping is used, in which case standard input can be from a file or the output from another command. IBM.

standard output. (1) An output stream usually intended to be used for primary data output. X/Open. (2) The primary destination of data coming from a command. Standard output goes to the display unless redirection or piping is used, in which case standard output can go to a file or to another command. IBM.

statement. An instruction that ends with the character ; (semicolon) or several instructions that are surrounded by the characters { and }.

static. A keyword used for defining the scope and linkage of variables and functions. For internal variables, the variable has block scope and retains its value between function calls. For external values, the variable has file scope and retains its value within the source file. For class variables, the variable is shared by all objects of the class and retains its value within the entire program.

static binding. The act of resolving references to external variables and functions before run time.

storage class specifier. One of the terms used to specify a storage class, such as auto, register, static, or extern.

stream. (1) A continuous stream of data elements being transmitted, or intended for transmission, in character or binary-digit form, using a defined format. (2) A file access object that allows access to an ordered sequence of characters, as described by the ISO C standard. Such objects can be created by the fopen() or fdopen() functions, and are associated with a file descriptor. A stream provides the additional services of user-selectable buffering and formatted input and output. X/Open.

string. A contiguous sequence of bytes terminated by and including the first null byte. X/Open.

string constant. Zero or more characters enclosed in double quotation marks.

string literal. Zero or more characters enclosed in double quotation marks.

striped data set. A special data set organization that spreads a data set over a specified number of volumes so that I/O parallelism can be exploited. Record n in a striped data set is found on a volume separate from the volume containing record n - p, where n > p.

struct. An aggregate of elements having arbitrary types.

structure. A construct (a class data type) that contains an ordered group of data objects. Unlike an array, the data objects within a structure can have varied data types. A structure can be used in all places a class is used. The initial projection is public.

structure tag. The identifier that names a structure data type.

Structured Query Language. See SQL.

stub routine. A routine, within a run-time library, that contains the minimum lines of code required to locate a given routine at run time.

subprogram. In the IPA Link version of the Inline Report listing section, an equivalent term for 'function'.

subscript. One or more expressions, each enclosed in brackets, that follow an array name. A subscript refers to an element in an array.

subsystem. A secondary or subordinate system, usually capable of operating independently of or asynchronously with, a controlling system. ISO Draft.

subtree. A tree structure created by arbitrarily denoting a node to be the root node in a tree. A subtree is always part of a whole tree.

superset. Given two sets A and B, A is a superset of B if and only if all elements of B are also elements of A. That is, A is a superset of B if B is a subset of A.

support. In system development, to provide the necessary resources for the correct operation of a functional unit. IBM.

switch expression. The controlling expression of a switch statement.

switch statement. A C or C++ language statement that causes control to be transferred to one of several statements depending on the value of an expression.

system default. A default value defined in the system profile. IBM.

system process. (1) An implementation-dependent object, other than a process executing an application, that has a process ID. X/Open. (2) An object, other than
a process executing an application, that is defined by the system, and has a process ID. ISO.1.

**T**

**tab character.** A character that in the output stream indicates that printing or displaying should start at the next horizontal tabulation position on the current line. The tab is the character designated by \'\t\' in the C language. If the current position is at or past the last defined horizontal tabulation position, the behavior is unspecified. It is unspecified whether the character is the exact sequence transmitted to an output device by the system to accomplish the tabulation. X/Open.

This character is named <tab> in the portable character set.

**task library.** A class library that provides the facilities to write programs that are made up of tasks.

**template.** A family of classes or functions with variable types.

**template class.** A class instance generated by a class template.

**template function.** A function generated by a function template.

**template instantiation.** The act of creating a new definition of a function, class, or member of a class from a template declaration and one or more template arguments.

**terminals.** Synonym for leaves.

**text file.** A file that contains characters organized into one or more lines. The lines must not contain NUL characters and none can exceed (LINE_MAX)—which is defined in limits.h—bytes in length, including the new-line character. The term text file does not prevent the inclusion of control or other unprintable characters (other than NUL). X/Open.

**thread.** The smallest unit of operation to be performed within a process. IBM.

**throw expression.** An argument to the C++ exception being thrown.

**tilde.** The character ~. This character is named <tilde> in the portable character set.

**token.** The smallest independent unit of meaning of a program as defined either by a parser or a lexical analyzer. A token can contain data, a language keyword, an identifier, or other parts of language syntax. IBM.

**traceback.** A section of a dump that provides information about the stack frame, the program unit address, the entry point of the routine, the statement number, and the status of the routines on the call-chain at the time the traceback was produced.

**trigraph sequence.** An alternative spelling of some characters to allow the implementation of C in character sets that do not provide a sufficient number of non-alphabetic graphics. ANSI/ISO.

Before preprocessing, each trigraph sequence in a string or literal is replaced by the single character that it represents.

**truncate.** To shorten a value to a specified length.

**try block.** A block in which a known C++ exception is passed to a handler.

**type definition.** A definition of a name for a data type. IBM.

**type specifier.** Used to indicate the data type of an object or function being declared.

**U**

**ultimate consumer.** The target of data in an I/O operation. An ultimate consumer can be a file, a device, or an array of bytes in memory.

**ultimate producer.** The source of data in an I/O operation. An ultimate producer can be a file, a device, or an array of bytes in memory.

**unary expression.** An expression that contains one operand. IBM.

**undefined behavior.** Action by the compiler and library when the program uses erroneous constructs or contains erroneous data. Permissible undefined behavior includes ignoring the situation completely with unpredictable results. It also includes behaving in a documented manner that is characteristic of the environment, during translation or program execution, with or without issuing a diagnostic message. It can also include terminating a translation or execution, while issuing a diagnostic message. Contrast with unspecified behavior and implementation-defined behavior.

**underflow.** (1) A condition that occurs when the result of an operation is less than the smallest possible nonzero number. (2) Synonym for arithmetic underflow, monadic operation. IBM.

**union.** (1) In the C or C++ language, a variable that can hold any one of several data types, but only one data type at a time. IBM. (2) For bags, there is an additional rule for duplicates: If bag P contains an element m times and bag Q contains the same element n times, then the union of P and Q contains that element m + n times.

**union tag.** The identifier that names a union data type.
unnamed pipe. A pipe that is accessible only by the process that created the pipe and its child processes. 
An unnamed pipe does not have to be opened before it can be used. It is a temporary file that lasts only until the last file descriptor that uses it is closed.

unique collection. A collection in which the value of an element only occurs once; that is, there are no duplicate elements.

unrecoverable error. An error for which recovery is impossible without use of recovery techniques external to the computer program or run.

unspecified behavior. Action by the compiler and library when the program uses correct constructs or data, for which the standards impose no specific requirements. Such action should not cause compiler or application failure. You should not, however, write any programs to rely on such behavior as they may not be portable to other systems. Contrast with implementation-defined behavior and undefined behavior.

user-defined data type. (1) A mathematical model that includes a structure for storing data and operations that can be performed on that data. Common abstract data types include sets, trees, and heaps. (2) See also abstract data type.

user ID. A nonnegative integer that is used to identify a system user. (Under ISO only, a nonnegative integer, which can be contained in an object of type uid_t.) When the identity of a user is associated with a process, a user ID value is referred to as a real user ID, an effective user ID, or (under ISO only, and there optionally) a saved set-user ID. X/Open. ISO.1

user name. A string that is used to identify a user. ISO.1.

user prefix. In the z/OS environment, the user prefix is typically the user's logon user identification.

V

value numbering. An optimization technique that involves local constant propagation, local expression elimination, and folding several instructions into a single instruction.

variable. In programming languages, a language object that may take different values, one at a time. The values of a variable are usually restricted to a certain data type. ISO-JTC1.

variant character. A character whose hexadecimal value differs between different character sets. On EBCDIC systems, such as S/390, these 13 characters are an exception to the portability of the portable character set.

vertical-tab character. A character that in the output stream indicates that printing should start at the next vertical tabulation position. The vertical-tab is the character designated by ‘\v’ in the C or C++ languages. If the current position is at or past the last defined vertical tabulation position, the behavior is unspecified. It is unspecified whether this character is the exact sequence transmitted to an output device by the system to accomplish the tabulation. X/Open. This character is named <vertical-tab> in the portable character set.

virtual address space. In virtual storage systems, the virtual storage assigned to a batched or terminal job, a system task, or a task initiated by a command.

virtual function. A function of a class that is declared with the keyword virtual. The implementation that is executed when you make a call to a virtual function depends on the type of the object for which it is called, which is determined at run time.

Virtual Storage Access Method (VSAM). An access method for direct or sequential processing of fixed and variable length records on direct access devices. The records in a VSAM data set or file can be organized in logical sequence by a key field (key sequence), in the physical sequence in which they are written on the data set or file (entry-sequence), or by relative-record number.

visible. Visibility of identifiers is based on scoping rules and is independent of access.

volatile attribute. (1) In the C or C++ language, the keyword volatile, used in a definition, declaration, or cast. It causes the compiler to place the value of the data object in storage and to reload this value at each reference to the data object. IBM. (2) An attribute of a data object that indicates the object is changeable. Any expression referring to a volatile object is evaluated immediately (for example, assignments).

W

while statement. A looping statement that contains the keyword while followed by an expression in parentheses (the condition) and a statement (the action). IBM.
white space. (1) Space characters, tab characters, form-feed characters, and new-line characters. (2) A sequence of one or more characters that belong to the space character class as defined via the LC_CTYPE category in the current locale. In the POSIX locale, white space consists of one or more blank characters (space and tab characters), new-line characters, carriage-return characters, form-feed characters, and vertical-tab characters. X/Open.

wide-character. A character whose range of values can represent distinct codes for all members of the largest extended character set specified among the supporting locales.

wide-character code. An integral value corresponding to a single graphic symbol or control code. X/Open.

wide-character string. A contiguous sequence of wide-character codes terminated by and including the first null wide-character code. X/Open.

wide-oriented stream. See orientation of a stream.

word. A character string considered as a unit for a given purpose. In z/OS, a word is 32 bits or 4 bytes.

working directory. Synonym for current working directory.

writable static area. See WSA.

write. (1) To output characters to a file, such as standard output or standard error. Unless otherwise stated, standard output is the default output destination for all uses of the term write. X/Open. (2) To make a permanent or transient recording of data in a storage device or on a data medium. ISO-JTC1. ANSI/ISO.

WSA (writable static area). An area of memory in the program that is modifiable during program execution. Typically, this area contains global variables and function and variable descriptors for DLLs.

X

XPLINK (Extra Performance Linkage). A new call linkage between functions that has the potential for a significant performance increase when used in an environment of frequent calls between small functions. XPLINK makes subroutine calls more efficient by removing nonessential instructions from the main path. When all functions are compiled with the XPLINK option, pointers can be used without restriction, which makes it easier to port new applications to z/OS.

Z

Bibliography

This bibliography lists the publications for IBM products that are related to the z/OS C/C++ product. It includes publications covering the application programming task. The bibliography is not a comprehensive list of the publications for these products, however, it should be adequate for most z/OS C/C++ users. Refer to z/OS Information Roadmap, SA22-7500 for a complete list of publications belonging to the z/OS product.

Related publications not listed in this section can be found on the IBM Online Library Omnibus Edition MVS Collection, SK2T-0710, the z/OS Collection, SK3T-4269, or on a tape available with z/OS.

z/OS

- z/OS Introduction and Release Guide, GA22-7502
- z/OS and z/OS.e Planning for Installation, GA22-7504
- z/OS Summary of Message Changes, SA22-7505
- z/OS Information Roadmap, SA22-7500

z/OS C/C++

- z/OS C/C++ Programming Guide, SC09-4765
- z/OS C/C++ User’s Guide, SC09-4767
- C/C++ Language Reference, SC09-4815
- z/OS C/C++ Messages, GC09-4819
- z/OS C/C++ Run-Time Library Reference, SA22-7821
- z/OS C Curses, SA22-7820
- z/OS C/C++ Compiler and Run-Time Migration Guide, GC09-4913
- IBM Open Class Library User’s Guide, SC09-4811
- IBM Open Class Library Reference, Vol. 1, SC09-4812
- Debug Tool User’s Guide and Reference, SC09-2137
- Standard C++ Library Reference, which is available at: http://www.ibm.com/software/ad/c390/czos/czosdocs.html

z/OS Language Environment

- z/OS Language Environment Concepts Guide, SA22-7567
- z/OS Language Environment Customization, SA22-7564
- z/OS Language Environment Debugging Guide, GA22-7560
- z/OS Language Environment Programming Guide, SA22-7561
- z/OS Language Environment Programming Reference, SA22-7562
- z/OS Language Environment Run-Time Migration Guide, GA22-7565
- z/OS Language Environment Writing Interlanguage Communication Applications, SA22-7563
- z/OS Language Environment Run-Time Messages, SA22-7566
Assembler

- HLASM Language Reference, SC26-4940
- HLASM Programmer’s Guide, SC26-4941

COBOL

- COBOL for OS/390 & VM Compiler and Run-Time Migration Guide, GC26-4764
- COBOL for OS/390 & VM Programming Guide, SC26-9049
- COBOL for OS/390 & VM Language Reference, SC26-9046
- COBOL for OS/390 & VM Diagnosis Guide, GC26-9047
- COBOL for OS/390 & VM Licensed Program Specifications, GC26-9044
- COBOL for OS/390 & VM Millenium Language Extensions Guide, GC26-9266

PL/I

- VisualAge PL/I Language Reference, SC26-9476
- PL/I for MVS & VM Language Reference, SC26-3114
- PL/I for MVS & VM Programming Guide, SC26-3113
- PL/I for MVS & VM Compiler and Run-Time Migration Guide, SC26-3118

VS FORTRAN

- Language and Library Reference, SC26-4221
- Programming Guide, SC26-4222

CICS

- CICS Application Programming Guide, SC34-5993
- CICS Application Programming Reference, SC34-5994
- CICS Distributed Transaction Programming Guide, SC34-5998
- CICS Front End Programming Interface User’s Guide, SC34-5996
- CICS Messages and Codes, GC34-6003
- CICS Resource Definition Guide, SC34-5990
- CICS System Definition Guide, SC34-5988
- CICS System Programming Reference, SC34-5995
- CICS User’s Handbook, SC34-5986
- CICS Family: Client/Server Programming, SC33-1435
- CICS Transaction Server for OS/390 Migration Guide, GC34-5984
- CICS Transaction Server for OS/390 Installation Guide, GC34-5985

DB2

- DB2 Administration Guide, SC26-9931
- DB2 Application Programming and SQL Guide, SC26-9933
- DB2 ODBC Guide and Reference, GC26-9941
- DB2 Command Reference, SC26-9934
- DB2 Data Sharing: Planning and Administration, SC26-9935
- **DB2 Installation Guide**, GC26-9936
- **DB2 Messages and Codes**, GC26-9940
- **DB2 Reference for Remote DRDA Requesters and Servers**, SC26-9942
- **DB2 SQL Reference**, SC26-9944
- **DB2 Utility Guide and Reference**, SC26-9945

### IMS/ESA

- **IMS/ESA Application Programming: Design Guide**, SC26-8728
- **IMS/ESA Application Programming: Transaction Manager**, SC26-8729
- **IMS/ESA Application Programming: Database Manager**, SC26-8727
- **IMS/ESA Application Programming: EXEC DLI Commands for CICS and IMS**, SC26-8726

### QMF

- **Introducing QMF**, GC26-9576
- **Using QMF**, SC26-9578
- **Developing QMF Applications**, SC26-9579
- **Reference**, SC26-9577
- **Installing and Managing QMF on MVS**, SC26-9575
- **Messages and Codes**, SC26-9580

### DFSMS

- **z/OS DFSMS Introduction**, SC26-7397
- **z/OS DFSMS: Managing Catalogs**, SC26-7409
- **z/OS DFSMS: Using Data Sets**, SC26-7410
- **z/OS DFSMS Macro Instructions for Data Sets**, SC26-7408
- **z/OS DFSMS Access Method Services for Catalogs**, SC26-7394
- **z/OS MVS Program Management: User’s Guide and Reference**, SA22-7643
- **z/OS MVS Program Management: Advanced Facilities**, SA22-7644
INDEX

Special characters
__abendcode macro, using for debugging 234
__amrc structure
  debugging I/O programs 233
  example 235
  using with VSAM 170, 192
__amrc2 structure
  usage 236
__csplist() library function 617
__last_op codes for __amrc 237
__rsncode macro 234, 392
_24malc() library function 547
_4kmalc() library function 547
_EDC_ERRNO_DIAG environment variable 491
_EDC_GLOBAL_STREAMS environment variable 491
_EDC_IP_CACHE_ENTRIES environment variable 492
_EDC_RRDS_HIDE_KEY environment variable 179
_ICONV_UCS2 environment variable 769
_ICONV_UCS2_PREFIX environment variable 763
_TZ environment variable 729
_xhotc() library function 543
_xhotl() library function 544
_xhott() library function 544
_xhotu() library function 545
_xregs() library function 545
_xsacc() library function 546
_xsrvc() library function 546
_xusr() library function 547
_xusr2() library function 547
! (exclamation mark) 808
// (double slash), part of MVS data set name 108, 173
/* (EOF sequence for text terminal) 207
\a (alarm) 130
\b (backspace) 130
\f (form feed) 130
\n (newline) 130
\r (carriage return) 130
\t (horizontal tab) 130
\v (vertical tab) 130
\x0E (DBCS shift out) 130
\x0F (DBCS shift in) 130
] (right square bracket) and [ (left square bracket) 807
| (vertical bar) 808
& (ampersand)
  using to specify temporary data set names 108
# (number sign) 808
( (left brace) 808
) (right brace) 808
^ (caret) 807
~ (tilde) 808

Numerics
24malc() library function 547
4kmalc() library function 547
64 bit offsets 159

A
abend
  CICS and assembler user exit 557
codes
    CEEBXITA, CEEAUE RETC field 555
    specifying those to be percolated 558
dumps, CEEAUEDUMP 557
generating 535
percolating 553, 558
requesting dump 557
system 553, 558
TRAP run-time option 554
user 553, 558
absolute value, decimal type 364
acc parameter for fopen()
  memory file I/O 218
terminal I/O 207
VSAM data sets 175
z/OS OS I/O 123
accept(), network example 443
access control list (ACL) 164
accessibility 891
ACL (access control list) 164
additive operators, decimal 354
addressing
  within AF_INET domain 440
  within AF_INET6 domain 441
  within AF_UNIX domain 442
  within sockets 439
AF_INET domain
  addressing 440
  defined 440
AF_INET6 domain
  addressing 441
AF_UNIX domain
  addressing 442
  defined 442
alarm escape sequence \a 130
alloca() library function 408
alternate code point support 775
AMODE processing option
  for CEEBXITA user exit 554
AMODE/RMODE under CICS 593, 614
ANSLALIAS compiler option 415
application service routines 517
application, network 447
ARCHITECTURE compiler option 415
argc under CICS 600
ARGPARSE run-time option 267
argv under CICS 600
arithmetic
  constructions 405
  operators, decimal data type
    additive 354
    conditional 356
    equality 355
    multiplicative 354
buffers (continued)
no buffering (continued)
memory files 73
OS I/O 123
terminal I/O 207
using 73
BUFNO subparameter, multiple buffering 124
built-in library functions
list of 881
optimizing code 407
byte order, network 440
bytesseek parameter in fopen()
effects on OS files 137
memory file I/O 218
terminal I/O 207
VSAM data sets 176
z/OS OS I/O 123

C
C locale
comparing with POSIX and SAA locales 737
defined 731
C or C++ interlanguage calls
with assembler 251
with C++ 245
with COBOL 245
with FORTRAN 245
with PL/I 245
CALL
command 617
token for preinitialization 264
calling
assembler from C or C++ 251
C from C++ 245
C or C++ from assembler 251
C++ from C 245
COBOL from C or C++ 245
FORTRAN from C or C++ 245
functions repeatedly 262
PL/I from C or C++ 245
card
punch output 119
reader input 119
carriage return escape sequence \r 130
cast operator, decimal 358
catalogued procedure 459
changes for sockets 457, 459
EDCC sample 459
EDCCB sample 457
link edit 457
catch 379
CCSID (coded character set id) 163
cds() library function 407
cdump() library function 601
CEE.SCEEMAC 255
CEEAUE_parameters 553
CEEBINT HLL user exit
customizing 551
invoking 550
using default version 551

B
backspace escape sequence \b 130
BDAM data sets, restriction 107
BDW (block descriptor word) 121
bidirectional languages 791
binary files
byte stream behavior 46
fixed behavior 39
undefined format behavior 45
using fseek() and ftell(), OS I/O 137
variable behavior 43
binary I/O, description 36
bind(), network example 443
bit fields 407
blksize parameter
defaults 60
memory file I/O 218
specifying 60
terminal I/O 206
VSAM data sets 175
z/OS OS I/O 121
blocked records 38
BookManager documents 11
buffers
full buffering 73
line buffering 73
multiple 124
no buffering
HFS files 73
CEEBXITA assembler user exit
abends 553
customizing for your installation 551
during enclave termination 552
during process termination 553
effects of run-time options 553
error handling 554
invoking 550, 552
using default version 551
CEEESTART
creating modules without 503
using with MTF 585
cerr
C++ standard error stream 87
predefined stream, usage 49
CSE, CICS data queue 229
CESO, CICS data queue 229
Character Set
hexadecimal values 813
POSIX 803
character shaping 792
character special files (HFS)
creating 144
I/O rules 156
using 143
charmap file
example 837
input 803
restriction, Japanese Katakana 805
charmap section 681
CHARSETID section 683
CICS (Customer Information Control System)
AMODE/RMODE considerations 593, 614
arguments to C or C++ main() 600
cdump() library function 601
CESE data queue 229
CESO data queue 229
clock() library function 601
compile 608, 613
Cross System Product (CSP) 617
CSD considerations 616
csnapi() library function 601
ctdli() library function 601
ctrace() library function 601
define and run the program 615
designing and coding a program 594
developing a C or C++ program 593
DLL 601
dump functions 601
dynamic allocation 600
EXEC CICS LINK 601
EXEC CICS XCTL 601
fetch() library function 601
floating point arithmetic 601
input and output 58, 229
interlanguage support 602
iscics() library function 601
JCL to translate and compile 613
link considerations 615
link load module 614
linking for reentrancy 614
CICS (Customer Information Control System) (continued)
locale support 600, 789
memory file support 599
MTF support 600
overview 593
packed decimal support 600
POSIX support 600
prelinking 614
preparing for use with z/OS Language Environment 593
program processing 615
program termination 601
redirecting standard streams 98
reentrancy 615
release() library function 601
requirements 593
run-time options 600
SP C support 600
standard stream support 598
storage management 602
svc99() library function 600
system() library function 601
translate 608
using with IMS 601
z/OS C/C++ library support 600
z/OS UNIX 885
cin
C++ standard input stream 87
predefined stream, usage 49
CINET 452
clearenv() library function 485
clearing memory 408
client perspective 444
client/server
allocation with socket() 442
conversation 442
exchanging data 442
server perspective 442
clock() library function 601
clog
C++ standard error stream 87
predefined stream, usage 49
closing
HFS files 150
memory files 225
OS I/O files 139
terminal files 212
VSAM data sets 191
z/OS Language Environment message file 232
clrmemt() library function
memory I/O files 226
COBOL
assembler user exit 552
using linkage specifications 245
code
independence 575
motion 411
point mapping 813
coded character set
CICS character set
INDEX 931
coded character set (continued)
considerations with locale 773
conversion during compile 783
conversion utilities 739
converters supplied 740
IBM-1047
converting code from 851
converting code to 777
IBM-1047 vs. IBM-293 774
independence 777
related to compile-edit cycle 777
converted coded character set id 163
collating sequence difference, SAA and POSIX 737
command
syntax diagrams 3
common expression elimination 411
Common INET 452
Common Programming Interface (CPI) 661
communication, network basics 436
communications, interprocess asynchronous signal delivery 387
TCP/IP for MVS considerations 455
COMPACT compiler option 415
compile-edit cycle related to coded character set 777
compiling 454
for a locale 783
include files 456
linking 453
procedures 453
sockets programs 453
under batch
for Berkeley Sockets 457
for X/Open Sockets 458
with X Windows 458
using c89
for Berkeley Sockets 458
with X Windows 458
COMPRESS compiler option 415
computational independence 568, 575
concatenation
compatibility rules 116
in-stream data sets 117
sequential and partitioned 115
condition variable 330
conditional operators, decimal 356
configuration file access, TCP/IP for MVS 456
constant
fixed-point decimal 352
propagation 411
constants defined in idecimal.hpp 371
control characters
ASA text files 75
OS I/O text files 130
terminal I/O files 210
z/OS C/C++-recognized by text files 35
conversation 442
conversions
code set 739
decimal objects 376
decimal types
decimal to decimal 358
conversions (continued)
decimal types (continued)
decimal to float 361
decimal to integer 360
float to decimal 361
integer to decimal 360
hybrid code from IBM-1047 851
hybrid code to IBM-1047 777
IBinaryCodedDecimal objects 372, 377
converters, locale code set 740
cout
C++ standard output stream 87
predefined stream, usage 49
CPI (Common Programming Interface) 661
creat() library function 144
csi() library function 407
CSECT (control section)
CEESTART 503
csid() library function 672
csnap() library function 601
CSP (Cross System Product) 617
CSP/AD (Cross System Product/Application Development) 617
CSP/AE (Cross System Product/Application Execution) 617
cspplist library function
passing parameters 617
cstdll() library function 601
ctrace() library function 601
cursive languages 791
CVFT compiler option 415
CXIT control block 553

D

DASD (Direct-Access Storage Device)
input and output 107
multivolume data sets, input and output 118
sequential and partitioned concatenation 115
striped data sets, input and output 119
data independence 568, 575
data sets
in-stream 117
multivolume 118
name
opening a memory file 216
opening an MVS data set 173
opening z/OS OS files 107
sequential vs. partitioned concatenation 115
striped 119
temporary 108
datagram
definition 436
sockets 439
DB2
application programming environment, z/OS UNIX 885
locale support 789
with z/OS C/C++ 633
DBCS (Double-Byte Character Support)
input and output functions 79
DBCS (Double-Byte Character Support) (continued)
    reading  80
    shift in character  130
    shift out character  130
    writing  81
dbx  25
DCB (Data Control Block)
    OS I/O  125
    parameter on a DD statement  110
    parameters, optimizing code  399
ddname
    creating
        description  62
        in source code  63
        under MVS batch  62
        under TSO  62
        opening an HFS I/O file under MVS  147
        opening an OS I/O file under z/OS  109
        restriction  63
defad code elimination  412
dead store elimination  411
Debug Tool  19
    CEEBINT and  563
debugging
    dbx  25
    Debug Tool  19
debugging I/O programs  233
DEC_DIG decimal constant
    numerical limit  353
    range of values  351, 374
DEC_EPSILON decimal constant  353
DEC_MAX decimal constant  353
DEC_MIN decimal constant  353
DEC_PRECISION decimal constant
    numerical limit  353
    range of values  351, 374
decchk() library function  368
decimal class  374
    arithmetic operators  375
    input and output  375
    representation  374
decimal data type
    absolute value  364
    assignments  353
    constants  352
    constructing  374
    conversions  358
    declarations  351
    error messages  369
    exception handling  367, 377
    fixing sign of  363
    operators  353
    printing with library functions  362
    SPC restriction  368
    validating  363
    variables  352
    viewing with library functions  362
decimal object (continued)
    precision of  377
    declarations
        decimal  351, 374
        extern, using for linkage to other languages  245
        using optimization  406
default
    C locales for POSIX, SAA, and S370  731
    DCB attributes for SYSOUT data set  118
    fopen()  60
    locales  731, 737
    LRECL, fopen()  60
    RECFM  60
definition side-deck  295
delete
    HFS files  151
    named module from storage  539
    pipes with HFS  153
    VSAM records  181
delimiter in JCL statements  117
delivery, signals
    ANSI C rules  385
    asynchronous  387
    POSIX rules  385
differences among C, POSIX, and SAA locales  737
digitsof operator  357
direct processing  179
directories (HFS)
    creating  144
    deleting  151
    using  143
disability  891
    disabled signals  389
disjoint pragma  409
DISP=MOD specification, DD statement
    DDnames  63
    OS I/O, fopen() modes  109
displaying variant characters  807
DL/I (Data Language I)  645
DLL code  303
DLL Rename Utility  285
DLLs (Dynamic Link Libraries)
    applications  286
    binding a DLL  295
    binding a DLL application  295
    C example  312, 318, 319
    C or C++ example  288
    C++ example  316
    calling explicitly  288
    calling implicitly  287
    CICS  601
    compatibility with non-DLL  307
Complex
    assigning pointers  309
    compatibility issues  307
    creating  303
    guidelines  305
    modifying source  304
    creating  292
    C  292
    description  292
DLLs (Dynamic Link Libraries) (continued)
creating (continued)
  export pragma 293
  exporting functions 293
  guidelines 305
DLL Rename Utility 285
entry point 298
example 297
freeing 292
load-on-call 287
loading 290
managing the use of 290
performance 300
restrictions 298
sharing among application executable files 292
using 296
documents, licensed 12
domain
AF_INET 440
AF_UNIX 442
DSQCOMMC.H header file 661
DUMMY data set output 119
dumps
  requesting in the CEEBXITA assembler user exit 553, 557
duplicate alternate index keys
  retrieval sequence 178
  under VSAM 176
DWS (Data Window Services) 631
DXFR, transfer control 617
dynamic memory 417

E
EDCCB 457, 459
  cataloged procedure 457, 459
  changes for sockets 457, 459
  sample 457, 459
EDCDPLNK macro 348
EDCDSAD macro 255, 257
EDCDXD macro 348
EDCEPIL macro 255, 256
EDCLA macro 348
EDCPRLG macro 255
EDCPROL macro 255
EDCRCINT routine 508
EDCX4KGT routine 537
EDCXABND routine 535
EDCXABRT module
  using during link edit 505
EDCXABRT routine 508, 512
EDCXENV module 512
EDCXENVL module 512
EDCXEPLG 255
EDCXEPLG macro 257
EDCXEXIT module
  exit(), system programming version 512, 517, 535
  in freestanding applications 508
EDCXFREE routine 538
EDCXGET routine 536
EDCXHOTC library function 543
EDCXHOTC routine 517
EDCXHOTL library function 544
EDCXHOTL routine 517
EDCXHOTT library function 544
EDCXHOTT routine 517
EDCXHOTU library function 545
EDCXHOTU routine 517
EDCXISA module
  entry point 505
  in freestanding applications 508
EDCXLANE module 540
EDCXLANK module 540
EDCXLANU module 540
EDCXLOAD routine 539
EDCXMEM module
  freestanding applications 508
  persistent environment 517
  system programming memory management 512, 535
EDCXPRILG 255
EDCXPRILG macro 256
EDCXREGS library function 546
EDCXSACC routine
EDCXSACC routine
EDCXSAC2 routine
EDCXSAC2 routine
EDCXSPRT module
  in freestanding applications 508
  sprintf(), system programming version 517
  sprintf(), system programming version of 512
  System programming version of sprintf() 535
EDCXSRC routine
  xsrv library function 546
EDCXSRVC routine 534
EDCXSRVN routine
  initiating a server request 533
EDCXSTRL module
  in freestanding applications 508
  usage 504
EDCXSTRT module
  in freestanding applications 508
  usage 503
EDCXSTRX module
  in freestanding applications 508
  usage 504
EDCXUNLD routine 539
EDCXUSR library function 547
EDCXUSR2 library function 547
ELPA (Extended Link Pack Area) 344
empty records
  _EDC_ZERO_RECLEN 44, 493
enabled signals 389
enclave
  terminating with CEEAUE_ABND 557
encoded offset 137
ENGLISH run-time messages 540
Enhanced ASCII
  limitations of 675
environment variables
  _BPXK_AUTOCVTS 479
  _BPXK_CCSIDS 480
  _BPXK_SIGDANGER 481
environment variables  (continued)  examples  (continued)
  _CEE_DMPTARG  487  ccngcp7  628
  _CEE_ENVFILE  488  ccngdb1  633
  _CEE_HEAP_MANAGER  488  ccngdc1  354
  _CEE_RUNOPTS  489  ccngdc2  355
  _EDC_ADD_ERRNO2  489  ccngdc3  365
  _EDC_ANSI_OPEN_DEFAULT  125, 489  ccngdc4  367
  _EDC_BYTE_SEEK  123, 137, 489  ccngdi1  235
  _EDC_CLEAR_SCREEN  210, 490  ccngdi2  240
  _EDC_COMPAT  490  ccngdi1  737
  _EDC_ERRNO_DIAG  491  ccngdw1  632
  _EDC_GLOBAL_STREAMS  491  ccngdw2  631
  _EDC_IP_CACHE_ENTRIES  492  ccngec1  398
  _EDC_RRDS_HIDE_KEY  493  ccngev1  494
  _EDC_STOR_INCREMENT  493  ccngev2  495
  _EDC_STOR_INITIAL  493  ccnggd1  640
  _EDC_ZERO_RECLEN  493  ccnggd2  642
  _ICONV_UCS2  769  ccnghc1  851
  _ICONV_UCS2_PREFIX  763  ccnghf1  152
  BIDIATTR  479  ccnghf2  154
  BIDION  479  ccnghf3  157
  locale  483  ccnghf4  160
  naming conventions  486  ccngim1  648
  using  485  ccngim2  650
  EOF (end of file)  ccngim3  652
  resetting terminal I/O  207  ccngip1  874
  equality operators  ccngip2  879
  decimal in C  355  ccngis1  656
  decimal in C++  376  ccngis2  656
  IBinaryCodedDecimal in C++  372  ccngis3  657
  ERRCOUNT run-time option  385  ccngis4  657
  errno values  887  ccngis5  658
  errors, debugging  392  ccngis6  658
  ESCON channels, striped data sets  119  ccngis7  659
  ESDS (Entry-Sequenced Data Set)  ccngis8  659
  alternate index keys  170  ccngis9  659
  use of  167  ccngisa  660
  established signals  388  ccngisb  660
  examples  ccngmf1  221
  ccngas1  75  ccngmf2  222
  ccngbid1  799  ccngmf3  227
  ccngca1  260  ccngmf4  228
  ccngca2  259, 260  ccngmi1  861
  ccngca3  261  ccngmi2  862
  ccngca5  259  ccngmt1  582
  ccngca6  268  ccngmt2  583
  ccngca7  271  ccngmt3  584
  ccngcc2  781  ccngmv1  808
  ccngch1  381  ccngmv2  811
  ccngch2  383  ccngof1  57
  ccngci1  595  ccngop1  412
  ccngci3  609  ccngop2  413
  ccngcl1  726  ccngop3  405
  ccngcl2  727  ccngos1  112
  ccngcl3  728  ccngos2  113
  ccngcp1  618  ccngos3  134
  ccngcp2  620  ccngqm1  661
  ccngcp3  622  ccngqm2  664
  ccngcp4  623  ccngqm3  665
  ccngcp5  626  ccngre1  346
  ccngcp6  627  ccngre2  347

INDEX  935
examples (continued)
ccngre3 348
ccngre4 349
ccngsp1 505
ccngsp2 506
ccngsp3 510
ccngsp4 514
ccngsp5 515
ccngsp6 519
ccngsp7 520
ccngsp8 525
ccngsp9 527
cnsgspa 536
cnsgspb 537
cnsgspc 538
cnsgspd 528
cnsgspe 530
cnsgspf 532
cnngth1 335
cngve1 171
cngve2 193
cngve3 198
cngve4 201
cngwt1 872
cngwt2 873
cnngc02 605
machine-readable 11
naming of 11
softcopy 11
exception handling
C exceptions under C++ 379
C-IMS 645
C++-IMS 645
CEEBXITA assembler user exit 554
decimal type 367, 377
description 379
hardware exceptions under C++ 380
EXEC CICS commands
FREEMAIN 602
GETMAIN 602
how to use 594
LINK 601
RETURN 601
WRITEQ TD 237
XCTL 601
exec family of functions
data definition considerations 147
described 401
EXECUTE extended parameter list request 265
EXH compiler option 415
export pragma 409
EXPORTALL compiler option 415
exporting functions 286
exporting source to other sites 787
expressions, optimizing 404
extended parameter list 262
extern declaration
using for linkage to other languages 245
external
static 344
variables 404, 407
F
F-format records 38
families
address 439
socket 438
fclose() library function
_EDC_COMPAT environment variable 490
fcntl() library function 144
fdelrec() library function
using to delete records 172, 181
fetch() library function
and writable statics 340
calling other z/OS C/C++ modules in C 402
system programming C environment 501
under CICS 601
fflush() library function
_EDC_COMPAT environment variable 490
optimizing code 401
fgetpos() library function
_EDC_COMPAT environment variable 490
optimizing code 401
fgets() library function
optimizing code 400
fgetwc() library function 80
fgetws() library function 80
FIFO
mkfifo() 151, 153
special files
creating 144
using 143, 152
files
conversion 163
large support 159
memory
closing 225
extending 225
flushing 224
opening 216
positioning 225
reading 223
repositioning 225
writing 224
named pipe 152
origin of OS attributes 125
OS
flushing 133
opening 107
reading from 127
removing 140
renaming 140
repositioning 136, 139
writing to 129
tagging 163
VSAM
closing 191
deleting a record 181
flushing 183
locating a record 181
reading a record 178
repositioning 181
updating a record 180
INDEX 937

fopen() library function (continued)
under MTF 588
VSAM data sets 173
warning 62
fseek() library function
_EDC_COMPAT environment variable 490
optimizing code 400
fsetpos() library function
optimizing code 401
fseek() library function
_EDC_COMPAT environment variable 490
full buffering 73
functions
arguments 404
descriptors 285
exported 286
imported 286
fwrite() library function
_EDC_COMPAT environment variable 490
optimizing code 400, 401
fwrite() library function
_EDC_COMPAT environment variable 490
optimizing code 400, 401

G
GDDM (Graphical Data Display Manager)
interface 639
with z/OS C/C++ 639
GDG (Generation Data Group)
C example 112
C++ example 113
input and output 110
genxlt utility 739
getenv() library function 485
getsyntx() library function 672
getwc() library function 80
getwchar() library function 80
global assembler user exit 551
global variables 403
graph coloring register allocation 412
graphics support 639

H
hard-coding 775
hardware signals 389
HEAP run-time option
system programming C environment 501
HFS (Hierarchical File System)
character special 144
closing files 150
creating files 143
deleting 151
directory 144
eample 157, 160
FIFO 144
file types 143
flushing records 150
I/O functions, example program 156
I/O stream library 143
I/O, description 56
input and output 143
HFS (Hierarchical File System) (continued)
  link 144
  naming files 144
  reading streams and files 149
  record I/O rules 148
  regular 143
  setting positions within files 150
  writing to streams and files 149
high-level language user exits
  CEEBINT 550
qualifier
  defaults 109, 217
  running without RACF 109, 216
  setting the user prefix under TSO 109, 217
hiperspace memory files
  I/O, description 57
  input and output 215
  POSIX restrictions 58
  specifying buffer size, setvbuf() 215
  thread affinity restrictions 339
horizontal tab escape sequence \t 130
hybrid coded character set, using 775

I/O (continued)
  restrictions in multithreaded applications 339
  striped data sets 119
  summary table 55
  sysout data set 117
  tapes 118
  terminal 205
  text stream 35
  wide characters 79
  z/OS Language Environment message file 231
I/O Stream Library 87
I/O Streams File I/O 49
IBinaryCodedDecimal 371
  arithmetic operators 372
  constants 371
  constructing objects 372
  exceptions 374
  input and output 372
IBinaryCodedDecimal class representation 371
IBinaryCodedDecimal object
digitsof 373
precisionof 374
IBM-1047 coded character set
  converting code from 851
  converting code to 777
iconv utility
  converting code sets 739
  preparing source code for exporting 787
iconv() library function 740
idecimal.hpp header file 371, 374
IEBGENER utility (TSO)
  tape files 118
if statement 406
ifstream class 50
IGNERRNO compiler option 416
IMS (Information Management System)
  default high-level qualifier 109, 217
  error handling 645
  opening files 109, 217
  other considerations 646
  redirecting standard streams 98
  using with CICS 601
  with z/OS C/C++ 645
  z/OS UNIX 885
in-stream data sets
  delimiter for data 117
  input 117
  noseek parameter 117
include files
  with z/OS UNIX sockets 456
INCLUDE statement, MVS 551
INIT token preinitialization 264
initialization
  nested enclave
    CEEBXITA's function code for 555
  using CEEBXITA 552
inlining
  optimization 412
  suggestions 413
under IPA 415
installation-wide assembler user exit 551
locale (continued)
  compiler option examples 783
  converting existing work 788
  customizing 723
  environment variables 483
  generating an object module 784
  hybrid coded character set, using 775
library functions
  localdconv() 672
  localeconv() 672
  setlocale() 672
LOCALE compiler option 783
localeconv() library function 684
macros 780
overview of z/OS C/C++ support 672
predefined 782
source-code functions summary 779
summary of support in compiler 784
tests for SAA or POSIX 737
TZ or _TZ environment variable 729
using with CICS 600
LOCALE compiler option 783
localeconv() library function 672
localedef utility
  example 837
loop statements, optimizing 405
low-level z/OS UNIX I/O 156
LPA (Link Pack Area) 344
LRECL (logical record length) parameter
defaults 60
  fopen() library function
    memory file I/O 218
    terminal I/O 206
    VSAM data sets 175
  z/OS OS I/O 121
  lrecl=X, OS I/O 122

M
m_create_layout() library function 792
m_destroy_layout() library function 795
m_getvalues_layout() library function 793
m_setvalues_layout() library function 793
m_transform_layout() library function 794
m_wtransform_layout() library function 795
machine print-control codes 38
macros
  EDCDSAD 255
  EDEPIL 255
  EDCPRILG 255
  EDCPROL 255
  EDCXEPILG 255
  EDCXPRLG 255
  use with locale 780
main task for MTF 567
malloc() library function
  system programming C environment 512, 517, 535
mapping variant characters 807
MB_CUR_MAX, effect on DBCS 79
member, PDS and PDSE 114
memcmp library function 408
memory files
  automatic name generation 219
  closing 225
  example 57, 227
  example program 227
  extending 225
  flushing 224
  I/O, description 57
  in hipersepace 215
  input and output 215
  opening 216
  positioning within 225
  reading from 223
  repositioning within 225
  return values for fldata() 226
  simulated partitioned data sets
    description 220
    example 221, 222
    specifying asterisk as file name 219
  support under CICS 599
  text mode treated as binary 219
  ungetc() considerations 224
  using to optimize code 403
  writing to 224
memset library function 408
method files 708, 826, 827, 828
mkdir() library function 144
mkfifo() library function
  with HFS files 144, 151, 153
mknod() library function 144, 153
MSGCLASS, matching for SYSOUT data sets 118
MSGFILE (z/OS Language Environment)
closing 232
  default destination SYSOUT 96
  flushing buffers 232
  opening files 231
output 231
  reading from 231
repositioning within 232
writing to 231
MTF (multitasking facility)
coding for 575
compiling 584
  concepts illustrated 570
  DD statements 587
designing for 575
dynamic commons 581
EDCMTFS 585
examples 579
  independence requirement 575
  introduction to 567
  Job Control Language (JCL) 585, 587
link-editing considerations 586
linking 584
load modules 584
  modifying run-time options 586
multithreading 341
passing data 577
restrictions 587
rules 575
running under 586
MTF (multitasking facility) (continued)
  tasks 567
  with z/OS C++ 497
multibyte characters 79
  effect of MB_CUR_MAX 79
  reading 80
  writing 81
multiple buffering 124
multiple invocations, preinitialized program 262
multiple threads 329
multiplicative operators, decimal 354
multivolume data sets, opening 118
mutex 330
MVS (Multiple Virtual System)
  alternative initialization routine 503
  building freestanding applications 505
  Data Window Services (DWS) 631
  file names 107
  file names for memory files 216
  listing PDS members 873
  reentrant modules 506

N
named pipes
  example 154
  using 152
naming environment variables 486
natural reentrancy 343
NCP subparameter
  multiple buffering 124
network byte order 440
network communication basics 436
network, application example 447
newline escape sequence \n 130
nl_langinfo() library function 672
NOARGPARSE run-time option 267
non-DASD devices, I/O 119
nonoverrideable run-time options in the user exit 557
NOSEEK parameter
  in-stream data sets 117
  memory file I/O 218
  sequential concatenations 116
  terminal I/O 207
  VSAM data sets 176
z/OS OS I/O 123
Notices 893

O
object-oriented model for I/O 49
OBJECTMODEL compiler option 416
ofstream class 50
Open Socket 435
open() library function
  for low-level z/OS UNIX files 144
  HFS files 144
  with pipes 153
opening
  CICS data queues 58
  determining type of file to open 55
opening (continued)
  files for I/O, overview 53
  HFS files 56, 145
  memory files
    description 57
    example 57
  memory I/O files 216
  multibyte character files 80
  OS files 56
  terminal files 205
  terminal I/O files 56
  VSAM data sets 56, 173
z/OS Language Environment message files 58, 231
operators, decimal
  arithmetic 354
  assignment 357
  cast 358
  summary 358
  unary 357
optica/reader input 119
optimization
  additional compiler options 415
  arithmetic constructions 405
  code motion 411
  common expression elimination 411
  constant propagation 411
  control constructs 405
  conversions 405
  dead code elimination 412
  dead store elimination 411
  declarations 406
  dynamic memory 417
  expressions 404
  fixed standard format records 38
  function arguments 404
  graph coloring register allocation 412
  inlining 412, 413
  inlining under IPA 415
  input/output 399
  instruction scheduling 411
  levels 399
  library extensions 402
  library functions 407
  loop statements 405
  noseek parameter for OS I/O 123
  pointers 404
  programming recommendations 38, 403
  straightening 411
  strength reduction 411
  techniques 410
  value numbering 411
  variables 403
  XPLINK 417
option_override 409
order, network byte 440
OS I/O
  acc= parameter 123
  asis parameter 123
  asynchronous reads 123, 124
  asynchronous writes 123, 124
  buffering 123
OS I/O (continued)
byteseek parameter 123
closing files 139
description 56
fgetpos() and ftell() values 137
flushing records
description 133
example 134
I/O stream library 107
in-stream data sets 117
lrecl=X 122
multivolume data sets 118
opening files 107
overview 107
password= parameter 123
PDS and PDSE considerations
BLKSIZE values 122
LRECL values 122
overview 114
RECFM values 121
reading from files 127
repositioning within files 136
space= parameter 122
striped data sets 119
tapes 118
type= parameter 122
ungetc() considerations 135, 136
writing to files 129
OS linkage 245, 252, 261
os parameter, fopen()
memory file I/O 218
terminal I/O 207
VSAM I/O 176
z/OS OS I/O 123
overlapped I/O 124
overrideable run-time options in the user exit 557

P
packed decimal
assignments 353
constructing 374
conversions 358
declarations 351
operators 353
using with CICS 600
variables 352
parallel functions 568
parameter list, OS 252
partitioned concatenation
compatibility rules 116
data sets 115
passing parameters
CSP 617
OS 252
passing streams across system calls 98
password= parameter
memory file I/O 218
VSAM data sets 176
z/OS OS I/O 123
PATH, under VSAM 170

pathname, under POSIX.1 145
PDF documents 11
PDS (partitioned data set)
input and output 114
listing members 873
memory files simulation
description 220
example 221, 222
opening 121
OS I/O, restriction on opening 114
PDSE (partitioned data set extended)
input and output 114
opening 121
OS I/O, restriction on opening 114
performance
impact from BYTESEEK mode for OS files 137
improvements by using fixed standard format
records 38
memory files 215
noseek parameter for OS I/O 123
opening memory files 219
specifying FBS format 122
persistent C environments 512
pipe() library function 144
pipes
creating 144
I/O 151
named 152
unnamed 151
description 144
example 152
PL/I
using linkage specifications 245
PLIST
system programming environment 501
plotters, Graphical Data Display Manager (GDDM) 639
pointers 309
assigning in DLLs 309
optimization 404
portability
VM/CMS and z/OS filenames 109
portable character set 773
ports
description 440
locating 446
positioning
HFS files 150
memory files 225
OS I/O files 136
terminal files 212
z/OS Language Environment message file 232
POSIX
character set 803
locale, defined 731
POSIX C locale and SAA C locale differences 737
pragmas
disjoint 409
environment 508, 511
export 409
filetag
??=pragma filetag directive 779
pragmas (continued)
inline 409, 881
isolated_call 409
leaves 409
linkage 505
noinline 409
option_override 409
reachable 409
runopts
description 540, 541
heap 586
IMS 645
plist 501
stack 586
strings 410
variable 410
NORENT 343
RENT 343
precision of operator 357
predefined locale 782
preinitialization
ARGPARSE run-time option 266
CALL token 264
example 267
INIT token 264
TERM token 265
z/OS 272
presentation interface 639
printer output
Graphical Data Display Manager (GDDM) 639
protocols, transport 436
putc() library function
optimizing code 400
putwc() library function 81
putwchar() library function 81

Q
QMF (Query Management Facility)
with has SAA callable interface 661

R
RACF (Resource Access Control Facility)
no hyphens in names for 108
qualifier required in data set name 109
raise() library function
error handling 384
RBA (Random Byte Address)
in VSAM 170
RDW (record descriptor word) 121
reachable pragma 409
read-write lock 330
read() library function
HFS files 149
with pipes 153
reading
from HFS files 149
from memory files 223
from OS I/O files 127
from terminal files 208

reading (continued)
from the z/OS Language Environment message
file 231
from VSAM data sets 178
multibyte characters 80
using recfm=U 121
realloc() library function
system programming C environment 517, 535
reason codes
in user exits 556
RECFM (record format)
F (fixed-format) 38
memory file I/O 218
overview 37
RECFM defaults 60
recfm=* extension 59, 121
recfm=A extension 121
restrictions 62
S (fixed standard) 38
S (variable spanned) 42
specifying 59
terminal I/O 206
U (undefined format)
overview 44
reading OS files 121
V (variable format)
overview 41
VSAM data sets 175
z/OS OS I/O 121
record
empty
_EDC_ZERO_RECLEN 44, 493
files, using fseek() and ftell() 139
fixed standard format 38
HFS I/O rules 148
I/O
byte stream behavior 46
fixed-format behavior 41
introduction 36
restriction 80
undefined-format behavior 46
variable-format behavior 44
spanned 42
specifying length 59
undefined-length 44
variable-length 41
zero-byte
_EDC_ZERO_RECLEN 44, 493
redirection
standard streams 87
introduction 96
to fully qualified data sets 96
using DD statements 96
using freopen() 96
using PARM 96
standard streams in a system programming C
environment 501
stdout, with z/OS Language Environment MSGFILE
option 94
stream, using assignment 94
streams under CICS 98
redirection (continued)
    streams under IMS 98
    streams under TSO
        from the command line 97
        introduction 97
    streams, using freopen() 94
    symbols 93
reentrancy
    in z/OS C/C++ 343
    limitations 344
    modified CEEBXITA must be reentrant 554
register
    allocation 412
    conventions 261
    variables 404
regular HFS files 143
relational operators
    decimal in C 355
    decimal in C++ 376
    IBinaryCodedDecimal in C++ 372
relative byte offset 137
remove() library function
    memory I/O files 226
    OS I/O files 140
rename() library function
    OS I/O files 140
RENT compiler option 343
repositioning
    binary streams, wide character I/O 85
    HFS files 150
    memory files 225
    OS I/O files 136
    terminal files 212
    text streams, wide character I/O 85
    VSAM records 181
    z/OS Language Environment message file 232
restrictions, compiler 454
retaining for multiple invocations
    assembler to C repeatedly 262
    preinitialized program 262
return codes
    __amrc structure 192
    CEEAUE_RETC field of CEEBXITA and 555
    in user exits 555
    value under CICS 601
RMODE processing option
    for CEEBXITA user exit 554
ROCONST compiler option 416
controlling external static 344
ROSTRING compiler option 416
controlling writable strings 345
RPC (Remote Procedure Call) 455
RRDS (Relative Record Data Set)
    choosing whether key and data are contiguous 178
    choosing whether key is returned with data on read 179
    key structure 177
    related environment variable 492
    use of 167
RRN (Relative Record Number)
    under VSAM 171
run-time messages
    EDCXLANE 540
    EDCXLANK 540
    UENGLISH 540
options
    in the user exit 552, 557
    TRAP 553, 554, 557
    user exits 549
S
S370 locale 731
SAA (Systems Application Architecture)
    applications using QMF callable interface 661
    differences between C and POSIX locales 737
    locale 731
screen layouts 639
SEEK_CUR macro
    effects of ungetc() 137
    effects of ungetwc() 86
seeking
    OS I/O files 136
    terminal files 212
    within HFS files 150
    within memory files 225
    z/OS Language Environment message file 232
select(), network example 443
sequential concatenation
    compatibility rules 116
    data sets 115
    nosseek parameter 116
    processing 178, 179
server
    allocation with socket() 442
    locating the port 446
    perspective 442
service routines 517
session
    typical TCP socket 444
    typical UDP socket 445
setenv() library function
    setting environment variables 485
setlocale() library function
    description 672
    not thread-safe 340
setvbuf() library function
    hiperspace memory files 73, 216
    specifying size of buffer for hiperspace 215
    usage 401
severity of a condition
    CEEBXITA assembler user exit and 556
shaping characters 792
shared programs 343
shareoptions specification, VSAM
    deleting records 180
    opening a data set 174
shift-in character (DBCS) 130
shift-out character (DBCS) 130
shortcut keys 891
SIGABND signal 389
SIGABRT signal 389
SIGFPE signal
  error condition 389
  under decimal 357
SIGILL signal 389
SIGINT signal 389
SIGIOERR signal 240, 389
signal
  actions, defaults 392
  delivery
    ANSI C rules 385
    asynchronous 387
    POSIX rules 385
handling
  default 392
  disabled 389
  enabled 389
  established 388
  hardware 389
  raise 384
  software 389
  with signal() and raise() 384
  with z/OS Language Environment 384
SIGSEGV signal 389
SIGTERM signal 389
SIGUSR1 signal 389
SIGUSR2 signal 389
sizeof operator 357
socket
  address 440
  address families 439
  addressing within 439
  AF_INET domain 440
  AF_UNIX domain 442
  client perspective 444
  compiling 453
  data sets 456
  datagram 439
  defined 435, 437
  domains 439
  families 438
  include files 456
  Internet 435
  linking 453
  local 435
  TCP/IP for MVS 455
types
  datagram 438
  guidelines for using 439
  stream 438
  typical TCP session 444
  typical UDP session 445
  using over TCP/IP 435
  z/OS UNIX specific 438
software signals 389
space= parameter (continued)
  VSAM data sets 175
  z/OS OS I/O 122
spanned records 42
SPILL compiler option 416
spool data sets 490
sprintf() library function
  in freestanding routines 506
  system programming C environment 512, 517, 535
square brackets ([ and ])
  displaying on workstation or 3270 807
  displaying square brackets 810
  square brackets 810
sscanf() library function
  character to integer conversions 408
stand-alone modules 502
standard
  records 38
  stream
    association with ddnames 97
    buffering 73
    cerr 49
    cin 49
    clog 49
    cout 49
    default open modes 88
    direct assignment 94
    global behavior 102, 491
    interleaving 89
    interleaving without sync_with_stdio() 90
    passing across a system() call 98
    redirecting 87
    redirection to fully qualified data sets 96
    redirection under MVS 96
    restrictions in threaded applications 339
    stderr 87
    stdin 87
    stdout 87
    support under CICS 598
    using 87
  standard error, redirecting 87
  standard in, redirecting 87
  standard out, redirecting 87
static variables 403
STDERR
  redirecting with z/OS Language Environment
    MSGFILE option 94
stdin, C standard input stream 87
stdout, C standard output stream 87
STEPLIB DD statement 586
storage
  allocating with the system programming C
    environment 500
  freeing with EDCXFREE 538
  getting with EDCXGET 536
  page-aligned, getting with EDCX4KGT 537
  under CICS 602
straightening 411
strcat() library function 408
stream sockets 438
streambuf class 49
<table>
<thead>
<tr>
<th>Concept</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streams, orientation</td>
<td>79</td>
</tr>
<tr>
<td>Strength reduction</td>
<td>411</td>
</tr>
<tr>
<td>STRICT_INDUCTION compiler option</td>
<td>417</td>
</tr>
<tr>
<td>Strings</td>
<td></td>
</tr>
<tr>
<td>Comparisons</td>
<td>408</td>
</tr>
<tr>
<td>Pragma</td>
<td>410</td>
</tr>
<tr>
<td>Processing</td>
<td>408</td>
</tr>
<tr>
<td>Striped data sets</td>
<td>119</td>
</tr>
<tr>
<td>strlen library function</td>
<td>408</td>
</tr>
<tr>
<td>Structure comparison</td>
<td>408</td>
</tr>
<tr>
<td>Stub routines</td>
<td></td>
</tr>
<tr>
<td>In a user-server environment</td>
<td>534</td>
</tr>
<tr>
<td>svc99() library function</td>
<td>600</td>
</tr>
<tr>
<td>swprintf() library function</td>
<td>81</td>
</tr>
<tr>
<td>swscanf() library function</td>
<td>81</td>
</tr>
<tr>
<td>Symbolic link (HFS) files, creating</td>
<td>144</td>
</tr>
<tr>
<td>symlink() library function</td>
<td>144</td>
</tr>
<tr>
<td>Syntax diagrams</td>
<td></td>
</tr>
<tr>
<td>How to read</td>
<td>3</td>
</tr>
<tr>
<td>SYSERR data set</td>
<td></td>
</tr>
<tr>
<td>With stdout</td>
<td>88, 96</td>
</tr>
<tr>
<td>SYSIN data set for stdin</td>
<td></td>
</tr>
<tr>
<td>Description of</td>
<td>88, 96</td>
</tr>
<tr>
<td>SYSOUT data set</td>
<td></td>
</tr>
<tr>
<td>DCB attributes, defaults</td>
<td>118</td>
</tr>
<tr>
<td>Default destination for z/OS Language Environment</td>
<td></td>
</tr>
<tr>
<td>MSGFILE</td>
<td>96</td>
</tr>
<tr>
<td>Output</td>
<td>117</td>
</tr>
<tr>
<td>SYSPRINT data set</td>
<td></td>
</tr>
<tr>
<td>With stdout</td>
<td>88, 96</td>
</tr>
<tr>
<td>System</td>
<td></td>
</tr>
<tr>
<td>Exit routines</td>
<td>508</td>
</tr>
<tr>
<td>Functions</td>
<td></td>
</tr>
<tr>
<td>Built-in</td>
<td>500</td>
</tr>
<tr>
<td>Memory management</td>
<td>500</td>
</tr>
<tr>
<td>Programming facilities</td>
<td></td>
</tr>
<tr>
<td>Additional library routines</td>
<td>541</td>
</tr>
<tr>
<td>Building persistent C environments</td>
<td>512, 513</td>
</tr>
<tr>
<td>Building system exit routines</td>
<td>509</td>
</tr>
<tr>
<td>Building user-server environments</td>
<td>534</td>
</tr>
<tr>
<td>Freestanding applications</td>
<td>502</td>
</tr>
<tr>
<td>Run-time messages</td>
<td>540</td>
</tr>
<tr>
<td>Tailoring the environment</td>
<td>535</td>
</tr>
<tr>
<td>With z/OS C++</td>
<td>497</td>
</tr>
<tr>
<td>System() library function</td>
<td></td>
</tr>
<tr>
<td>CICS</td>
<td>601</td>
</tr>
<tr>
<td>Library extension</td>
<td>403</td>
</tr>
<tr>
<td>Programming C environment</td>
<td>501</td>
</tr>
<tr>
<td>SYSPRINT data set</td>
<td></td>
</tr>
<tr>
<td>With stdout</td>
<td>88, 96</td>
</tr>
<tr>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Tab, horizontal</td>
<td>130</td>
</tr>
<tr>
<td>Tab, vertical</td>
<td>130</td>
</tr>
<tr>
<td>Tapes</td>
<td></td>
</tr>
<tr>
<td>Input and output</td>
<td>118</td>
</tr>
<tr>
<td>Multivolume data sets</td>
<td>118</td>
</tr>
<tr>
<td>TARGET compiler option (C++)</td>
<td></td>
</tr>
<tr>
<td>IMS</td>
<td>645</td>
</tr>
<tr>
<td>Tasks, using MTF</td>
<td>567</td>
</tr>
<tr>
<td>TCP socket session</td>
<td>444</td>
</tr>
<tr>
<td>TCP/IP for MVS</td>
<td></td>
</tr>
<tr>
<td>Child process creation restrictions</td>
<td>456</td>
</tr>
<tr>
<td>Configuration file access</td>
<td>456</td>
</tr>
<tr>
<td>Header file restrictions</td>
<td>455</td>
</tr>
<tr>
<td>Interprocess communication</td>
<td>455</td>
</tr>
<tr>
<td>Socket API restrictions</td>
<td>455</td>
</tr>
<tr>
<td>Templates</td>
<td></td>
</tr>
<tr>
<td>NOTEMPINC</td>
<td></td>
</tr>
<tr>
<td>Example source code</td>
<td>475</td>
</tr>
<tr>
<td>Programs without automatic template generation</td>
<td>474</td>
</tr>
<tr>
<td>Source code organization</td>
<td>475</td>
</tr>
<tr>
<td>TEMPINC</td>
<td></td>
</tr>
<tr>
<td>Contents of the template-instantiation file</td>
<td>474</td>
</tr>
<tr>
<td>Example</td>
<td>470</td>
</tr>
<tr>
<td>Examples of source files</td>
<td>472</td>
</tr>
<tr>
<td>JCL to compile examples</td>
<td>473</td>
</tr>
<tr>
<td>Regenerating the template-instantiation file</td>
<td>473</td>
</tr>
<tr>
<td>Source code organization</td>
<td>471</td>
</tr>
<tr>
<td>TEMPLATEREGISTRY</td>
<td></td>
</tr>
<tr>
<td>Changing and recompiling parts of program</td>
<td>478</td>
</tr>
<tr>
<td>Instantiation with template registry</td>
<td>477</td>
</tr>
<tr>
<td>Terms</td>
<td></td>
</tr>
<tr>
<td>Declaration</td>
<td>468</td>
</tr>
<tr>
<td>Definition</td>
<td>468</td>
</tr>
<tr>
<td>Function instantiation</td>
<td>471</td>
</tr>
<tr>
<td>Instantiation</td>
<td>468</td>
</tr>
<tr>
<td>Linkage</td>
<td>468</td>
</tr>
<tr>
<td>Specialization</td>
<td>468</td>
</tr>
<tr>
<td>Using TEMPINC or NOTEMPINC</td>
<td></td>
</tr>
<tr>
<td>Example of multipurpose header file</td>
<td>475</td>
</tr>
<tr>
<td>Example source code</td>
<td>476</td>
</tr>
<tr>
<td>Multipurpose header file</td>
<td>475</td>
</tr>
<tr>
<td>Temporary data sets (MVS)</td>
<td></td>
</tr>
<tr>
<td>Using &amp; names</td>
<td>108</td>
</tr>
<tr>
<td>Temporary files</td>
<td>215</td>
</tr>
<tr>
<td>TERM token preinitialization</td>
<td>265</td>
</tr>
<tr>
<td>Terminals</td>
<td></td>
</tr>
<tr>
<td>Closing</td>
<td>212</td>
</tr>
<tr>
<td>Flushing</td>
<td>211</td>
</tr>
<tr>
<td>Graphical Data Display Manager (GDDM)</td>
<td>639</td>
</tr>
<tr>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>56</td>
</tr>
<tr>
<td>Overview</td>
<td>205</td>
</tr>
<tr>
<td>Reading from files</td>
<td>208</td>
</tr>
<tr>
<td>Writing to files</td>
<td>209</td>
</tr>
<tr>
<td>Opening I/O files</td>
<td>205</td>
</tr>
<tr>
<td>Positioning within</td>
<td>212</td>
</tr>
<tr>
<td>Responses to fldata()</td>
<td>212</td>
</tr>
<tr>
<td>Termination</td>
<td></td>
</tr>
<tr>
<td>As indicated in CEEAUE_ABND field of CEEAUE_FLAGS</td>
<td>557</td>
</tr>
<tr>
<td>As indicated in CEEAUE_ABTERM field of CEEAUE_FLAGS</td>
<td>556</td>
</tr>
<tr>
<td>CEEBXITA's behavior during</td>
<td>552</td>
</tr>
<tr>
<td>CEEBXITA's function codes for</td>
<td>555</td>
</tr>
<tr>
<td>Process</td>
<td>553, 555</td>
</tr>
<tr>
<td>Text files</td>
<td></td>
</tr>
<tr>
<td>ASA RECFM fixed-format behavior</td>
<td>41</td>
</tr>
</tbody>
</table>
text files (continued)
ASA RECFM undefined-format behavior 45
ASA RECFM variable-format behavior 44
non-ASA RECFM fixed-format behavior 39
non-ASA RECFM undefined-format behavior 45
non-ASA RECFM variable-format behavior 44
RECFM byte stream behavior 46
using fseek() and ftell() 138

text I/O 35

threads
cancel 337
cleanup 338
condition variable 330
create 329
functions 329
low-level z/OS UNIX I/O 156
management 329
mutex 330
read-write lock 330
signals 335
thread-specific data 334
using in z/OS UNIX applications 329
using with MVS files 339

throw 379
time zone
customizing 729
specifying 684
tolower() macro 407
toupper() macro 407
traceback 380
translation tables 739
transport protocols 436

TRAP run-time option
CEEEXITA assembler user exit and 553
how CEEAUE ABND is affected by 557
IMS considerations 646

try 379

TSO (Time Sharing Option)
default high-level qualifier 109, 217
opening files 109, 217
redirecting standard streams 97
setting the user prefix 109, 217
variant characters 808

TUNE compiler option 415
type= parameter
memory file I/O 218
terminal I/O 207
VSAM data sets 175
z/OS OS I/O 122
types, sockets 439
TZ environment variable 729

tzset() library function
not thread-safe 340

U
UDP socket session 445

unary operators, decimal data type
digitsOf 357
precisionOf 357
sizeof 357

unbuffered I/O
setvbuf() function 124

undefined format records 44

ungetc() library function
_EDC_COMPAT environment variable 490
memory file I/O, effect on fflush() 224
OS I/O, effect on fflush() 135
OS I/O, effect on fgetpos() and ftell() 136
SEEK_CUR 137
ungetwc() library function
effect on fflush(), wide character I/O 84
effect on fgetpos(), ftell() and fseek() 85
seek_cur 86

universal reference time 729
unlink() library function
using with named pipes 153
with HFS files 151

unnamed pipes
creating 144
example 152
using 151

updating VSAM records 180

user exit
for initialization 552
for termination 551, 552, 553
run-time options 557
under CICS 555, 557

user words 547
user-server stub routines 534

USL 18

V

V-format records 41
value numbering 411
variable pragma 410
variable-format records 41

variables
decimal 352
environment 479
exported 286
external 404
global 403
local 403
locale 483
register 404
static 403

variant characters
detail 773
mapping keyboard 807
mappings 774
use of 773

VB-format records 41
VBS-format records 41
vertical tab escape sequence \v 130
VS-format records 41

VSAM (Virtual Storage Access Method)
__amrc structure 192
closing a data set 191
down example programs 192
KSDS 192
VSAM (Virtual Storage Access Method) (continued)

example programs (continued)

RRDS 200

example showing how to access __amrc structure 171

I/O operations

deleting a record 181

loading a data set 179

locating a record 181

opening a file 56

overview 167

reading a record 178

repositioning 181

specifying access mode 174

summary of binary I/O operations 190

summary of operations 171

summary of record I/O operations 184

summary of text I/O operations 189

updating a record 180

using fopen() 173

using freopen() 173

writing a record 179

I/O stream library 167

delimiters 170

KSDS example 193

linear data sets 168

naming MVS data sets 173

organization of data sets 167

Record Level Sharing 184

Relative Byte Addresses (RBA) 170

Relative Record Numbers (RRN) 171

return codes 192

RLS 184

RSDS example 201

types and advantages of data sets 169

vswprintf() library function 81

writing (continued)

to terminal files 209

to the z/OS Language Environment message file 231

VSAM data sets 179

X

X Windows, TCP/IP for MVS 455

X/Open Socket 435

X/Open Transport Interface (XTI) concepts 460

transport endpoints 460

transport providers 460

XFER, transfer control 617

xhotc library function 543

xhotl library function 544

xhot library function 544

xhotu library function 545

XITPTR, CIXT control block 554

XPLINK

assembler macros 253

register conventions 254

when to use 417

xregs library function 545

xsacc library function 546

xusr() library function 547

xusr2() library function 547

Z

z/OS Language Environment

message file I/O, description 58

message file output 231

z/OS UNIX

application programming environment 885

I/O, low-level 156

zero-byte records, _EDC_ZERO_RECLEN 44, 493

W

wcsid() library function 672

wide characters

effect of MB_CUR_MAX 79

input and output functions 79

reading streams and files 80

ungetwc() considerations 84

writing streams and files 81

windowing 639

writable static

assembler code 347

in reentrant programs 343

write() library function

HFS I/O 150

with pipes 153

writing

binary streams, wide character I/O 83

in coded character set IBM-1047 787

multibyte characters 81

text streams, wide character I/O 82

to HFS files 149

to memory files 224

to OS I/O files 129

948 z/OS V1R4.0 C/C++ Programming Guide