

IBM XL C/C++ for Linux on z Systems, V1.2



# Getting Started with XL C/C++

*Version 1.2*



IBM XL C/C++ for Linux on z Systems, V1.2



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*Version 1.2*

**Note**

Before using this information and the product it supports, read the information in "Notices" on page 27.

**First edition**

This edition applies to IBM XL C/C++ for Linux on z Systems, V1.2 (Program 5725-N01) and to all subsequent releases and modifications until otherwise indicated in new editions. Make sure you are using the correct edition for the level of the product.

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## About this document

This document contains overview and basic usage information for the IBM® XL C/C++ for Linux on z Systems™, V1.2 compiler.

### Who should read this document

This document is intended for C and C++ developers who are looking for introductory overview and usage information for XL C/C++. It assumes that you have some familiarity with command-line compilers, basic knowledge of the C and C++ programming languages, and basic knowledge of operating system commands. Programmers new to XL C/C++ can use this document to find information about the capabilities and features unique to XL C/C++.

### How to use this document

Unless indicated otherwise, all of the text in this reference pertains to both C and C++ languages. Where there are differences between languages, these are indicated through qualifying text and icons, as described in “Conventions.”

Throughout this document, the `xlc` and `xlC` compiler invocations are used to describe the behavior of the compiler. You can, however, substitute other forms of the compiler invocation command if your particular environment requires it, and compiler option usage remains the same unless otherwise specified.

While this document covers information such as configuring the compiler environment, and compiling and linking C or C++ applications using the XL C/C++ compiler, it does not include the following topics:

- Compiler installation: see the *XL C/C++ Installation Guide*.
- Compiler options: see the *XL C/C++ Compiler Reference* for detailed information about the syntax and usage of compiler options.
- The C or C++ programming language: see the *XL C/C++ Language Reference* for information about the syntax, semantics, and IBM implementation of the C or C++ IBM extension features. See C/C++ standards for the details of standard features.
- Programming topics: see the *XL C/C++ Optimization and Programming Guide* for detailed information about developing applications with XL C/C++, with a focus on program portability and optimization.

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## Conventions

### Typographical conventions

The following table shows the typographical conventions used in the IBM XL C/C++ for Linux on z Systems, V1.2 information.

Table 1. *Typographical conventions*

Typeface	Indicates	Example
<b>bold</b>	Lowercase commands, executable names, compiler options, and directives.	The compiler provides basic invocation commands, <code>xlc</code> and <code>xlc</code> ( <code>xlc++</code> ), along with several other compiler invocation commands to support various C/C++ language levels and compilation environments.
<i>italics</i>	Parameters or variables whose actual names or values are to be supplied by the user. Italics are also used to introduce new terms.	Make sure that you update the <i>size</i> parameter if you return more than the <i>size</i> requested.
<u>underlining</u>	The default setting of a parameter of a compiler option or directive.	<code>nomaf</code>   <u><code>maf</code></u>
monospace	Programming keywords and library functions, compiler builtins, examples of program code, command strings, or user-defined names.	To compile and optimize <code>myprogram.c</code> , enter: <code>xlc myprogram.c -O3</code> .

## Qualifying elements (icons)

Most features described in this information apply to both C and C++ languages. In descriptions of language elements where a feature is exclusive to one language, or where functionality differs between languages, this information uses icons to delineate segments of text as follows:

Table 2. *Qualifying elements*













Qualifier/Icon	Meaning
C only begins   C only ends	The text describes a feature that is supported in the C language only; or describes behavior that is specific to the C language.
C++ only begins   C++ only ends	The text describes a feature that is supported in the C++ language only; or describes behavior that is specific to the C++ language.
IBM extension begins   IBM extension ends	The text describes a feature that is an IBM extension to the standard language specifications.









Table 2. Qualifying elements (continued)

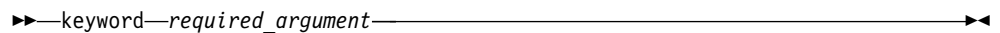
Qualifier/Icon	Meaning
C11 begins   C11 ends	The text describes a feature that is introduced into standard C as part of C11.
C++11 begins   C++11 ends	The text describes a feature that is introduced into standard C++ as part of C++11.
C++14 begins   C++14 ends	The text describes a feature that is introduced into standard C++ as part of C++14.

## Syntax diagrams

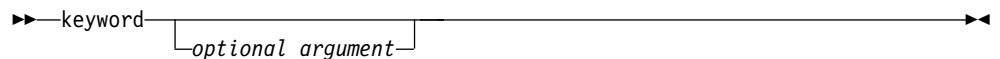
Throughout this information, diagrams illustrate XL C/C++ syntax. This section helps you to interpret and use those diagrams.

- Read the syntax diagrams from left to right, from top to bottom, following the path of the line.
  - The  symbol indicates the beginning of a command, directive, or statement.
  - The  symbol indicates that the command, directive, or statement syntax is continued on the next line.
  - The  symbol indicates that a command, directive, or statement is continued from the previous line.
  - The  symbol indicates the end of a command, directive, or statement.
  - Fragments, which are diagrams of syntactical units other than complete commands, directives, or statements, start with the  symbol and end with the  symbol.

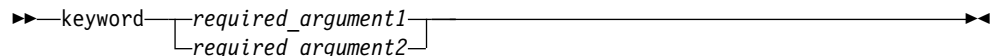
- Required items are shown on the horizontal line (the main path):



- Optional items are shown below the main path:



- If you can choose from two or more items, they are shown vertically, in a stack. If you *must* choose one of the items, one item of the stack is shown on the main path.



If choosing one of the items is optional, the entire stack is shown below the main path.



- An arrow returning to the left above the main line (a repeat arrow) indicates that you can make more than one choice from the stacked items or repeat an item. The separator character, if it is other than a blank, is also indicated:



- The item that is the default is shown above the main path.



- Keywords are shown in nonitalic letters and should be entered exactly as shown.
- Variables are shown in italicized lowercase letters. They represent user-supplied names or values.
- If punctuation marks, parentheses, arithmetic operators, or other such symbols are shown, you must enter them as part of the syntax.

### Example of a syntax statement

EXAMPLE *char\_constant* {*a|b*}[*c|d*]*e*[,*e*]*... name\_list*{*name\_list*}*...*

The following list explains the syntax statement:

- Enter the keyword EXAMPLE.
- Enter a value for *char\_constant*.
- Enter a value for *a* or *b*, but not for both.
- Optionally, enter a value for *c* or *d*.
- Enter at least one value for *e*. If you enter more than one value, you must put a comma between each.
- Optionally, enter the value of at least one *name* for *name\_list*. If you enter more than one value, you must put a comma between each *name*.

**Note:** The same example is used in both the syntax-statement and syntax-diagram representations.

### Examples in this information

The examples in this information, except where otherwise noted, are coded in a simple style that does not try to conserve storage, check for errors, achieve fast performance, or demonstrate all possible methods to achieve a specific result.

The examples for installation information are labelled as either *Example* or *Basic example*. *Basic examples* are intended to document a procedure as it would be performed during a basic, or default, installation; these need little or no modification.

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## Related information

The following sections provide related information for XL C/C++:

### IBM XL C/C++ information

XL C/C++ provides product information in the following formats:

- Quick Start Guide

The Quick Start Guide (`quickstart.pdf`) is intended to get you started with IBM XL C/C++ for Linux on z Systems, V1.2. It is located by default in the XL C/C++ directory and in the `\quickstart` directory of the installation DVD.

- README files

README files contain late-breaking information, including changes and corrections to the product information. README files are located by default in the XL C/C++ directory, and in the root directory and subdirectories of the installation DVD.

- Installable man pages

Man pages are provided for the compiler invocations and all command-line utilities provided with the product. Instructions for installing and accessing the man pages are provided in the *IBM XL C/C++ for Linux on z Systems, V1.2 Installation Guide*.

- Online product documentation

The fully searchable HTML-based documentation is viewable in IBM Knowledge Center at [http://www.ibm.com/support/knowledgecenter/SSVUN6\\_1.2.0/com.ibm.compilers.loz.doc/welcome.html](http://www.ibm.com/support/knowledgecenter/SSVUN6_1.2.0/com.ibm.compilers.loz.doc/welcome.html).

- PDF documents

PDF documents are available on the web at <http://www.ibm.com/support/docview.wss?uid=swg27044043>.

The following files comprise the full set of XL C/C++ product information:

*Table 3. XL C/C++ PDF files*

Document title	PDF file name	Description
<i>IBM XL C/C++ for Linux on z Systems, V1.2 Installation Guide, GC27-5995-01</i>	<code>install.pdf</code>	Contains information for installing XL C/C++ and configuring your environment for basic compilation and program execution.
<i>Getting Started with IBM XL C/C++ for Linux on z Systems, V1.2, GI13-2865-01</i>	<code>getstart.pdf</code>	Contains an introduction to the XL C/C++ product, with information about setting up and configuring your environment, compiling and linking programs, and troubleshooting compilation errors.
<i>IBM XL C/C++ for Linux on z Systems, V1.2 Compiler Reference, SC27-5998-01</i>	<code>compiler.pdf</code>	Contains information about the various compiler options, pragmas, macros, environment variables, and built-in functions.
<i>IBM XL C/C++ for Linux on z Systems, V1.2 Language Reference, SC27-5996-01</i>	<code>langref.pdf</code>	Contains information about language extensions for portability and conformance to nonproprietary standards.

Table 3. XL C/C++ PDF files (continued)

Document title	PDF file name	Description
<i>IBM XL C/C++ for Linux on z Systems, V1.2 Optimization and Programming Guide, SC27-5997-01</i>	proguide.pdf	Contains information about advanced programming topics, such as application porting, library development, application optimization, and the XL C/C++ high-performance libraries.

To read a PDF file, use Adobe Reader. If you do not have Adobe Reader, you can download it (subject to license terms) from the Adobe website at <http://www.adobe.com>.

More information related to XL C/C++, including IBM Redbooks® publications, white papers, and other articles, is available on the web at <http://www.ibm.com/support/docview.wss?uid=swg27044043>.

For more information about C/C++, see the C/C++ café at <https://www.ibm.com/developerworks/community/groups/service/html/communityview?communityUuid=5894415f-be62-4bc0-81c5-3956e82276f3>.

## Standards and specifications

XL C/C++ is designed to support the following standards and specifications. You can refer to these standards and specifications for precise definitions of some of the features found in this information.

- *Information Technology - Programming languages - C, ISO/IEC 9899:1990*, also known as C89.
- *Information Technology - Programming languages - C, ISO/IEC 9899:1999*, also known as C99.
- *Information Technology - Programming languages - C, ISO/IEC 9899:2011*, also known as C11.
- *Information Technology - Programming languages - C++, ISO/IEC 14882:1998*, also known as C++98.
- *Information Technology - Programming languages - C++, ISO/IEC 14882:2003*, also known as C++03.
- *Information Technology - Programming languages - C++, ISO/IEC 14882:2011*, also known as C++11 (Partial support).
- *Information Technology - Programming languages - C++, ISO/IEC 14882:2014*, also known as C++14 (Partial support).
- *ANSI/IEEE Standard for Binary Floating-Point Arithmetic, ANSI/IEEE Std 754-1985*.

## Other information

- *Using the GNU Compiler Collection* available at <http://gcc.gnu.org/onlinedocs>

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## Technical support

Additional technical support is available from the XL C/C++ Support page at [http://www.ibm.com/support/entry/portal/product/rational/xl\\_c/c++\\_for\\_linux\\_on\\_z\\_systems](http://www.ibm.com/support/entry/portal/product/rational/xl_c/c++_for_linux_on_z_systems). This page provides a portal with search capabilities to a large selection of Technotes and other support information.

If you cannot find what you need, you can send an email to [compinfo@ca.ibm.com](mailto:compinfo@ca.ibm.com).

For the latest information about XL C/C++, visit the product information site at <http://www.ibm.com/software/products/en/xlcpp-loz>.

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## **How to send your comments**

Your feedback is important in helping us to provide accurate and high-quality information. If you have any comments about this information or any other XL C/C++ information, send your comments to [compinfo@ca.ibm.com](mailto:compinfo@ca.ibm.com).

Be sure to include the name of the manual, the part number of the manual, the version of XL C/C++, and, if applicable, the specific location of the text you are commenting on (for example, a page number or table number).



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## Chapter 1. Introducing XL C/C++

IBM XL C/C++ for Linux on z Systems, V1.2 is an advanced, high-performance compiler that can be used for developing complex, computationally intensive C/C++ programs.

This section contains information about the features of the XL C/C++ compiler at a high level. It is intended for people who are evaluating the compiler and for new users who want to find out more about the product.

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### Commonality with other IBM compilers

IBM XL C/C++ for Linux on z Systems, V1.2 is part of a larger family of IBM C, C++, and Fortran compilers.

These compilers are derived from a common code base that shares compiler function and optimization technologies for a variety of platforms and programming languages. Programming environments include IBM AIX®, IBM Blue Gene®/Q, IBM i, selected Linux distributions, IBM z/OS®, and IBM z/VM®. The common code base, along with compliance with international programming language standards, helps support consistent compiler performance and ease of code portability across multiple operating systems and hardware platforms.

IBM XL C/C++ for Linux on z Systems combines the Clang front end infrastructure with the advanced optimization technology in the IBM compiler back end. Clang is a component of the LLVM open source compiler and toolchain project and provides the C and C++ language family front end for LLVM. XL C/C++ combines the Clang front-end infrastructure with the advanced optimization technology from IBM. For additional information about Clang, see the LLVM web site at: <http://clang.llvm.org/>

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### Operating system and hardware support

This section describes the operating systems and hardware that IBM XL C/C++ for Linux on z Systems, V1.2 supports.

IBM XL C/C++ for Linux on z Systems, V1.2 supports the following operating systems:

- Red Hat Enterprise Linux for IBM System z® 6.3 (RHEL 6.3)
- Red Hat Enterprise Linux for IBM System z 7 (RHEL 7.0)
- Red Hat Enterprise Linux for IBM System z 7.1 (RHEL 7.1)
- Red Hat Enterprise Linux for IBM System z 7.2 (RHEL 7.2)
- SUSE Linux Enterprise Server for System z 11 SP3 (SLES 11 SP3)
- SUSE Linux Enterprise Server for System z 12 (SLES 12)
- SUSE Linux Enterprise Server for System z 12 Service Pack 1 (SLES 12 SP1)

See the README file and "Before installing XL C/C++" in the *XL C/C++ Installation Guide* for a complete list of requirements.

The compiler, its libraries, and its generated object programs run on the following IBM z Systems servers:

- IBM z13™ (z13)
- IBM zEnterprise® EC12 (zEC12) or IBM zEnterprise BC12 (zBC12)
- IBM zEnterprise 196 (z196) or IBM zEnterprise 114 (z114)
- IBM System z10® Enterprise Class (z10™ EC) or IBM System z10 Business Class (z10 BC)

To exploit the various supported hardware configurations, the compiler provides options to tune the performance of applications according to the hardware type that runs the compiled applications.

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## A highly configurable compiler

You can use a variety of compiler invocation commands and options to tailor the compiler to your unique compilation requirements.

### Compiler invocation commands

XL C/C++ provides several commands to invoke the compiler, for example, `xlc`, `xlc++`, and `xlc`. Compiler invocation commands are provided to support most standardized C/C++ language levels and many popular language extensions.

All the invocation commands allow for thread-safe compilations. You can use them to link programs that use multithreading.

For more information about XL C/C++ compiler invocation commands, see "Invoking the compiler" in the *XL C/C++ Compiler Reference*.

### Compiler options

You can choose from a large selection of compiler options to control compiler behavior. You can benefit from using different options for the following tasks:

- Debugging your applications
- Optimizing and tuning application performance
- Selecting language levels and extensions for compatibility with nonstandard features and behaviors that are supported by other C or C++ compilers
- Performing many other common tasks that would otherwise require changing the source code

You can specify compiler options through a combination of environment variables, compiler configuration files, command line options, and compiler directive statements embedded in your program source.

For more information about XL C/C++ compiler options, see "Compiler options reference" in the *XL C/C++ Compiler Reference*.

### Custom compiler configuration files

The installation process creates a default compiler configuration file containing stanzas that define compiler option default settings.

If you frequently specify compiler option settings other than the default settings of XL C/C++, you can use makefiles to define your settings. Alternatively, you can create custom configuration files to define your own frequently used option settings.



For more information about using custom compiler configuration files, see “Using custom compiler configuration files” on page 19.

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## Language standard compliance

This topic describes the C/C++ programming language specifications that IBM XL C/C++ for Linux on z Systems, V1.2 supports.

### C language specifications

- ISO/IEC 9899:2011 (referred to as C11)
- ISO/IEC 9899:1999 (referred to as C99)
- ISO/IEC 9899:1990 (referred to as C89)

### C++ language specifications

- Partial support for ISO/IEC 14882:2014 (referred to as C++14)
- Partial support for ISO/IEC 14882:2011 (referred to as C++11)
- ISO/IEC 14882:2003 (referred to as C++03)
- ISO/IEC 14882:1998, the first official specification of the C++ language (referred to as C++98)

In addition to the standard language levels, XL C/C++ supports the following language extensions:

- A subset of GNU C and C++ language extensions

See "Language levels and language extensions" in the *XL C/C++ Language Reference* for more information about C/C++ language specifications and extensions.

## Compatibility with GNU

XL C/C++ supports a subset of the GNU compiler command options to facilitate porting applications that are developed with the `gcc` and `g++` compilers.

IBM XL C/C++ for Linux on z Systems, V1.2 provides a greater level of GNU source compatibility. It supports the use of `gcc` and `g++` compiler options and therefore the `gxc` and `gxc++` invocation commands are not required or included.

XL C/C++ uses GNU C and GNU C++ header files together with the GNU C and C++ runtime libraries to produce code that is binary-compatible with that produced by GCC. Portions of an application can be built with XL C/C++ and combined with portions built with GCC to produce an application that behaves as if it had been built solely with GCC.

To achieve binary compatibility with GCC-compiled code, a program compiled with XL C/C++ includes the same headers as those used by a GNU compiler residing on the same system. To ensure that the proper versions of headers and runtime libraries are present on the system, you must install the prerequisite GCC compiler before you install XL C/C++.

**Note:** Some additional noteworthy points about this relationship are as follows:

- IBM built-in functions coexist with GNU C built-ins.
- Compilation of C and C++ programs uses the GNU C and GNU C++ header files.
- Compilation uses the GNU assembler for assembler input files.


- Compiled C code is linked to the GNU C runtime libraries.
- Compiled C++ code is linked to the GNU C and GNU C++ runtime libraries.
- Code compiled with XL C/C++ can be debugged with the GNU debugger, **gdb**.

## Source-code migration and conformance checking

XL C/C++ provides compiler invocation commands that instruct the compiler to compile your application code to a specific language level.

You can also use the **-std(-qlanglvl)** compiler option to specify a language level. If the language or language extension elements in your program source do not conform to the specified language level, the compiler issues diagnostic messages.

### Related information

 **-std (-qlanglvl)**

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## Libraries

XL C/C++ includes a runtime environment that contains a number of libraries.

### Mathematical Acceleration Subsystem library

The Mathematical Acceleration Subsystem (MASS) library consists of scalar mathematical built-in functions tuned specifically for optimum performance on supported processor architectures. You can choose a MASS library to support high-performance computing on a broad range of processors, or you can select a library tuned to support a specific processor family.

The MASS library functions support both 31-bit and 64-bit compilation modes and offer improved performance over the default `libm` math library routines. These libraries are threadsafe. You can also make explicit calls to MASS library functions, whether optimization options are in effect or not.

For more information, see "Using the Mathematical Acceleration Subsystem" in the *XL C/C++ Optimization and Programming Guide*.

### Automatically Tuned Linear Algebra Software libraries

XL C/C++ is shipped with a set of Automatically Tuned Linear Algebra Software (ATLAS) libraries for high-performance computing. The ATLAS libraries contain all the Basic Linear Algebra Subprograms (BLAS) and a subset of the Linear Algebra PACKage (LAPACK) routines. For details, see "Using the Automatically Tuned Linear Algebra Software (ATLAS) libraries" in the *XL C/C++ Optimization and Programming Guide*.

### XL C++ Runtime Library

The following library is also shipped with XL C/C++:

- XL C++ Runtime Library contains support routines needed by the compiler.

### Support for Boost libraries

IBM XL C/C++ for Linux on z Systems, V1.2 provides partial support for the Boost V1.55.0 libraries. A patch file is available that modifies the Boost V1.55.0 libraries

so that they can be built and used with XL C/C++ applications. The patch or modification file does not extend nor provide additional functionality to the Boost libraries.

To access the patch file for building the Boost libraries, go to Boost Library Regression Test Summaries and select download required Boost modification file for your compiler release and platform.

You can download the latest Boost libraries at <http://www.boost.org/>.

For more information about support for libraries, search on the XL C/C++ Compiler support page at [http://www.ibm.com/support/entry/portal/product/rational/xl\\_c/c++\\_for\\_linux\\_on\\_z\\_systems](http://www.ibm.com/support/entry/portal/product/rational/xl_c/c++_for_linux_on_z_systems).

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## Utilities and commands

This topic introduces the main utilities and commands that are included with XL C/C++. It does not contain all compiler utilities and commands.

### Utilities

**install** The **install** utility installs and configures IBM XL C/C++ for Linux on z Systems, V1.2 for use on your system.

### Commands

#### Profile-directed feedback (PDF) related commands

##### **cleanpdf** command

The **cleanpdf** command removes all the PDF files or the specified PDF files from the directory to which profile-directed feedback data is written.

##### **mergepdf** command

The **mergepdf** command provides the ability to weigh the importance of two or more PDF records when combining them into a single record. The PDF records must be derived from the same executable.

##### **showpdf** command

The **showpdf** command displays the following types of profiling information for all the procedures executed in a PDF run (compilation under the **-qpdf1** option):

- Block-counter profiling
- Call-counter profiling
- Value profiling

For more information, see **-qpdf1**, **-qpdf2** in the *XL C/C++ Compiler Reference*.

---

## Program optimization

XL C/C++ provides several compiler options that can help you control the optimization and performance of your programs.

With these options, you can perform the following tasks:

- Select different levels of compiler optimizations.
- Control optimizations for loops, floating point, and other types of operations.

- Optimize a program for a particular class of machines or for a very specific machine configuration, depending on where the program will run.

Optimizing transformations can give your application better overall execution performance. XL C/C++ provides a portfolio of optimizing transformations tailored to various supported hardware. These transformations offer the following benefits:

- Reducing the number of instructions executed for critical operations
- Restructuring generated object code to make optimal use of the z/Architecture<sup>®</sup> processors
- Improving the usage of the memory subsystem

#### Related information



Optimizing your applications



Optimization and tuning



Compiler built-in functions

---

## 64-bit object capability

The 64-bit object capability of the XL C/C++ compiler addresses increasing demand for larger storage requirements and greater processing power.

The Linux operating system provides an environment that allows you to develop and execute programs that exploit 64-bit processors through the use of 64-bit address spaces.

To support larger executables that can fit within a 64-bit address space, a separate 64-bit object format is used. The linker binds these objects to create 64-bit executables. Objects that are bound together must all be of the same object format. The following scenarios are not permitted and will fail to load, execute, or both:

- A 64-bit object or executable that has references to symbols from a 31-bit library or shared library
- A 31-bit object or executable that has references to symbols from a 64-bit library or shared library
- A 64-bit executable that explicitly attempts to load a 31-bit module
- A 31-bit executable that explicitly attempts to load a 64-bit module

For more information, see "Using 31-bit and 64-bit modes" in the *XL C/C++ Optimization and Programming Guide*.

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## Diagnostic reports

The compiler listings provide important information to help you develop and debug your applications more efficiently.

For more information about the applicable compiler options and the listing itself, see "Compiler messages and listings" in the *XL C/C++ Compiler Reference*.

---

## Symbolic debugger support

You can instruct XL C/C++ to include debugging information in your compiled objects by using different levels of the `-g` compiler option.

The debugging information can be examined by **`gdb`** or any symbolic debugger that supports the DWARF debug format on Linux to help you debug your programs.

#### **Related information**





---

## Chapter 2. What's new for IBM XL C/C++ for Linux on z Systems, V1.2

This section describes features and enhancements added to IBM XL C/C++ for Linux on z Systems, V1.2.

---

### C++14 features

C++14 is a new C++ programming language standard. This topic lists the C++14 features that are introduced in this release of XL C/C++.

**Note:** IBM supports selected features of C++14 standard. IBM will continue to develop and implement the features of this standard. The implementation of the language level is based on IBM's interpretation of the standard. Until IBM's implementation of all the C++14 features is complete, including the support of a new C++14 standard library, the implementation might change from release to release. IBM makes no attempt to maintain compatibility, in source, binary, or listings and other compiler interfaces, with earlier releases of IBM's implementation of the new C++14 features.

- Polymorphic lambda expressions
- Variable templates

#### Related information

- Standard features in the *XL C/C++ Language Reference*

---

### C++11 features

In addition to existing C++11 features, this topic lists the C++11 features that are introduced in this release of XL C/C++.

**Note:** IBM supports the majority of C++11 features and will continue to develop and implement the features of this standard.

- Alignment support
- `constexpr`
- Explicit overrides and `final`
- Generalized attributes
- Inheriting constructors
- Local and unnamed types as template arguments
- Monomorphic lambda expressions
- New character types
- New definitions of POD types
- `noexcept`
- Non-static data member initializers
- Range-based `for`
- Raw string literals
- `ref-qualifiers`
- Template aliases
- `thread_local`

- Unicode names (UCN) and unicode literals
- Uniform initialization
- Unrestricted unions
- User-defined literals

**Note:** Compiler support for language features that have runtime library requirements is dependent on the GCC runtime library on the Linux distribution.

### Related information

- Standard features in the *XL C/C++ Language Reference*

## C11 features

In addition to existing C11 features, this topic lists the C11 features that are introduced in this release of XL C/C++.

- `_Thread_local`
- Alignment
- Complex type initializations
- Composite types for variable length arrays
- Conversions between pointers and floating types
- Generic selection
- Temporary lifetime extensions
- typedef redeclarations
- Unicode and UTF-8 literals

### Related information

- Standard features in the *XL C/C++ Language Reference*

## Built-in functions

This section describes the major categories of built-in functions that are new for IBM XL C/C++ for Linux on z Systems, V1.2.

- `__cp`** This function compares two signed packed decimal integers.
- `__cvb`** This function converts an 8-byte, signed packed decimal integer to a signed binary integer.
- `__cvbg`**  
This function converts a packed decimal integer to a 64-bit signed binary integer.
- `__cvd`** This function converts a signed binary integer to a packed decimal integer.
- `__cvdg`**  
This function converts a 64-bit signed binary integer to a packed decimal integer.
- `__dp`** This function performs a divide operation on signed packed-decimal integers.
- `__fidbr`**  
This function rounds a long binary-floating-point number to an integer value in the same floating-point format using the specified rounding mode.



- \_\_fiebr** This function rounds a short binary-floating-point number to an integer value in the same floating-point format using the specified rounding mode.
- \_\_fixbr** This function rounds an extended binary-floating-point number to an integer value in the same floating-point format using the specified rounding mode.
- \_\_lcbb** This function counts the number of bytes from a given address without crossing the specified block boundary.
- \_\_mp** This function performs a multiply operation on signed packed-decimal integers.
- \_\_srp** This function shifts a signed packed decimal integer with or without rounding.
- \_\_zap** This function places a signed packed decimal integer at a given address.

#### Vector built-in functions

You can use vector built-in functions to access and manipulate individual elements of vectors. For detailed information about each built-in function, see the topic collection about vector programming support in the *XL C/C++ Optimization and Programming Guide*.

---

## Commands

This section lists commands that are introduced in this release.

#### **cleanpdf command**

The **cleanpdf** command removes all the PDF files or the specified PDF files from the directory to which profile-directed feedback data is written.

#### **mergepdf command**

The **mergepdf** command provides the ability to weigh the importance of two or more PDF records when combining them into a single record. The PDF records must be derived from the same executable.

#### **showpdf command**

The **showpdf** command displays the following types of profiling information for all the procedures executed in a PDF run (compilation under the **-qpdf1** option):

- Block-counter profiling
- Call-counter profiling
- Value profiling

For more information, see **-qpdf1**, **-qpdf2** in the *XL C/C++ Compiler Reference*.

---

## Compiler options and pragma directives

This section describes new compiler options and pragma directives that are added in this version.

You can specify compiler options on the command line. You can also modify compiler behavior through pragma directives embedded in your application source files. For detailed descriptions and usage information for XL C/C++ compiler options, see the *XL C/C++ Compiler Reference*.

## Compiler options

### **-ftree-vectorize (-qsimd)**

The **-ftree-vectorize (-qsimd)** option is added to control whether the compiler can automatically take advantage of vector instructions for processors that support them.

### **-gdwarf (-qdbgfmt)**

The **-gdwarf (-qdbgfmt)** option is added to control the format for the debugging information in object files.

### **-mzvector**

The **-mzvector** option is added to enable the compiler support for vector programming including the `vector` and `__vector` keywords and vector built-in functions. Note that **-mzvector** takes effect only on the Linux distributions that have vector support and run on the IBM z13™ models.

### **-qasm\_as**

This option is added to specify the path and flags that is used to invoke the assembler to handle assembler code in an `asm` assembly statement.

### **-qfuncsect**

This option is added to place instructions for each function in a separate section. Placing each function in its own section might reduce the size of your program because the linker can collect garbage per function rather than per object file.

### **-finline-functions (-qinline)**

The **level** suboption is added to indicate the relative degree of inlining. In addition, the **-qinline+<function\_name>** and **-qinline-<function\_name>** options are added to control whether the named functions must be inlined or must not be inlined.

### **-qpdf1, -qpdf2**

These options are added to tunes optimizations through profile-directed feedback (PDF). With this feature, sample program execution are used to improve optimization near conditional branches and in frequently executed code sections.

### **-qpriority (C++ only)**

This option is added to specify the priority level for the initialization of static objects.

### **-qshowpdf**

This option is added in this release. When **-qshowpdf** is specified with **-qpdf1** and a minimum optimization level of **-O2** at compile and link steps, the compiler creates a PDF map file that contains additional profiling information for all procedures in your application.

### **-std (-qlanglvl)**

The following suboptions are added to **-qlanglvl**:

#### **C++14 extended1y**

Compilation is based on the C++14 standard, invoking most of the C++11 features and all the currently supported C++14 features.

#### **C11 stdc11**

Compilation conforms strictly to the ISO C11 standard.

The following suboptions are added to **-std**:

► C++14 **c++1y**

Compilation is based on the C++14 standard, invoking most of the C++11 features and all the currently supported C++14 features.

► C++11 **c++11 | c++0x**

Compilation conforms strictly to the ISO C++ standard plus amendments, also known as ISO C++11.

► C++11 **gnu++11 | gnu++0x**

Compilation is based on the ISO C++ standard, with some differences to accommodate extended language features.

► C++ **gnu++03**

Compilation is based on the ISO C++98 standard, with some differences to accommodate extended language features.

► C11 **c11 | c1x | iso9899:2011**

Compilation conforms strictly to the ISO C11 standard.

► C11 **gnu11**

Compilation is based on the ISO C11 standard, with some differences to accommodate extended language features.

## Pragma directives

### `#pragma nosimd`

The `#pragma nosimd` pragma is added to disable automatic generation of vector instructions.

---

## Performance and optimization

More features and enhancements assist with performance tuning and application optimization.

### MASS libraries tuned for IBM z13

IBM XL C/C++ for Linux on z Systems, V1.2 provides the MASS libraries that are tuned for the IBM z13 models in addition to the IBM zEnterprise EC12 (zEC12) and IBM zEnterprise BC12 (zBC12) models.

### New ATLAS libraries






In addition to the static version of the ATLAS libraries tuned for the IBM zEnterprise® EC12 (zEC12) and IBM zEnterprise BC12 (zBC12) models, IBM XL C/C++ for Linux on z Systems, V1.2 provides the static version of the ATLAS main library, the CBLAS library, the LAPACK library, and the Fortran BLAS library that are tuned for the IBM z13 models.

IBM XL C/C++ for Linux on z Systems, V1.2 also provides the shared version of the aggregate ATLAS libraries that are tuned for the IBM zEC12, IBM zBC12, and IBM z13 models.

### Vector programming support

In IBM XL C/C++ for Linux on z Systems, V1.2, the Vector Facility for z/Architecture is available on the Linux distributions that have vector support and run on the IBM z13 models. The provided vector programming support includes vector data types, expressions, operators, and vector built-in functions.

## Related information in the XL C/C++ Optimization and Programming Guide

-  [Optimizing your applications](#)
-  [Coding your application to improve performance](#)
-  [Using the Mathematical Acceleration Subsystem \(MASS\) libraries](#)
-  [Using the Automatically Tuned Linear Algebra Software \(ATLAS\) libraries](#)
-  [Using vector programming support](#)

---

## Chapter 3. Migration of your applications

This section lists important considerations when you migrate your applications that were compiled with other versions of XL C/C++.

---

### Migrating applications that use transactional memory built-in functions

Starting from IBM XL C/C++ for Linux on z Systems, V1.2, to use transactional memory built-in functions, you must include a header file in the source code. In addition, if you used numeric return values of the transaction begin and end built-in functions, you must replace numeric return values with macro return values that are provided by IBM XL C/C++ for Linux on z Systems, V1.2.

#### New header file needed for transactional memory built-in functions

You must include the `htmxlintrin.h` file in the source code if you use any of the transactional memory built-in functions.

#### Changed return values of the transaction begin and end built-in functions

The return values of the transaction begin and end built-in functions are no longer numeric. You must update your program using the following return values:

##### `__TM_begin`

This function returns `_HTM_TBEGIN_STARTED` if successful; otherwise, it returns a different value.

##### `__TM_end`

This function returns `_HTM_TBEGIN_STARTED` if the thread is in the transactional state before the instruction starts; otherwise, it returns a different value.

##### `__TM_simple_begin`

This function returns `_HTM_TBEGIN_STARTED` if successful; otherwise, it returns a different value.

#### Related information

Transactional memory built-in functions



Transactional memory built-in functions

---

### Mixing object files compiled with different compilers


Most object files that were compiled with different compilers can be linked together. However, under some circumstances, object files are not compatible and must be recompiled.

Note the following restrictions:

- There is no binary compatibility among AIX, Linux for big endian distributions, and Linux for little endian distributions.
- Do not mix object files that were compiled with the big endian compiler and object files that were compiled with the little endian compiler.

- Do not mix object and library files that were compiled with different versions of a compiler if the **-qipa** option was used during the compilation. The **-qipa** option instructs the compiler to perform an IPA link for these object and library files. An IPA link might not be able to handle mismatched versions.

**Related information:**

 -qipa

---

## Chapter 4. Features added in earlier releases

This section describes features added in earlier releases. These features also apply to the current release.

---

### Features added in Version 1.1

In IBM XL C/C++ for Linux on z Systems, V1.1, XL C/C++ combines the Clang front-end infrastructure with the advanced optimization technology in the IBM compiler back end. This section describes features added in IBM XL C/C++ for Linux on z Systems, V1.1. These features and enhancements apply to later releases as well.

#### Compiler options

IBM XL C/C++ for Linux on z Systems, V1.1 introduces support for many of the options supported by GCC.


For a complete list of options that are supported by IBM XL C/C++ for Linux on z Systems, V1.1, see "Compiler options reference" in the *XL C/C++ Compiler Reference*.

**Note:** Some compiler options are not available if you have makefiles for programs that were previously compiled with XL C/C++ for other platforms.

#### Template model

IBM XL C/C++ for Linux on z Systems, V1.1 supports *Greedy instantiation*. The compiler generates a template instantiation in each compilation unit that uses it. The linker discards the duplicates.

##### Related information

 The C++ template model

#### Compiler predefined macro support

The macros that are supported by IBM XL C/C++ for Linux on z Systems, V1.1 are different from the macros that are supported by other versions of the XL C/C++ compiler. Some macros that are supported by other versions of XL C/C++ for various platforms might be undefined in IBM XL C/C++ for Linux on z Systems, V1.1.

You can specify the **-Wunsupported-xl-macro** option to check whether any unsupported macro is used. If an unsupported macro is used in your code, the compiler issues a warning message. For a complete list of supported macros, see "Compiler predefined macros" in the *XL C/C++ Compiler Reference*.

#### Compiler pragmas

IBM XL C/C++ for Linux on z Systems, V1.1 introduces support for many of the pragmas supported by GCC.

##### Supported GCC pragmas

The following GCC pragmas are supported in IBM XL C/C++ for Linux on z Systems, V1.1. For details about these pragmas, see the GNU Compiler Collection online documentation at <http://gcc.gnu.org/onlinedocs/>.

- #pragma GCC dependency
- #pragma GCC diagnostic *kind option*
- #pragma GCC diagnostic push
- #pragma GCC diagnostic pop
- #pragma GCC error *string*
- #pragma GCC poison
- #pragma GCC system\_header
- #pragma GCC visibility push(*visibility*)
- #pragma GCC visibility pop
- #pragma GCC warning *string*
- #pragma message *string*
- #pragma once
- #pragma pop\_macro("*macro\_name*")
- #pragma push\_macro("*macro\_name*")
- #pragma redefine\_extname *oldname newname*
- #pragma unused

### **Supported IBM pragmas**

- #pragma disjoint
- #pragma execution\_frequency
- #pragma option\_override
- #pragma pack
- #pragma reachable
- #pragma nounroll



---

## Chapter 5. Setting up and customizing XL C/C++

This section describes how to set up and customize the compiler according to your own requirements.

For complete prerequisite and installation information for XL C/C++, see "Before installing XL C/C++" in the *XL C/C++ Installation Guide*.

---

### Using custom compiler configuration files

You can customize compiler settings and options by modifying the default configuration file or creating your own configuration file.

You have the following options to customize compiler settings:

- The XL C/C++ compiler installation process creates a default compiler configuration file. You can directly modify this configuration file to add default options for specific needs. However, if you later apply updates to the compiler, you must reapply all of your modifications to the newly installed configuration file.
- You can create your own custom configuration file that either overrides or complements the default configuration file. The compiler can recognize and resolve compiler settings that you specify in your custom configuration files with compiler settings that are specified in the default configuration file. Compiler updates that might later affect settings in the default configuration file do not affect the settings in your custom configuration files.

#### Related information

 [Using custom compiler configuration files](#)



---

## Chapter 6. Developing applications with XL C/C++

C/C++ application development consists of repeating cycles of editing, compiling, linking, and running. By default, compiling and linking are combined into a single step.

### Notes:

- Before you use the compiler, ensure that XL C/C++ is properly installed and configured. For more information, see the *XL C/C++ Installation Guide*.
- To learn about writing C/C++ programs, refer to the *XL C/C++ Language Reference* and the C and C++ language standards.

---

### The compiler phases

A typical compiler invocation executes some or all of these activities in sequence. For link time optimizations, some activities are executed more than once during a compilation. As each compilation component runs, the results are sent to the next step in the sequence.

1. Preprocessing of source files
2. Compilation, which might consist of the following phases, depending on what compiler options are specified:
  - a. Front-end parsing and semantic analysis
  - b. High-level optimization
  - c. Low-level optimization
  - d. Register allocation
  - e. Final assembly
3. Assembling the assembly (.s) files and the unpreprocessed assembler (.S) files after they are preprocessed
4. Object linking to create an executable application

To see the compiler step through these phases, specify the `-v` compiler option when you compile your application. To see the amount of time the compiler spends in each phase, specify `-ftime-report(-qphsinfo)`.

---

### Editing C/C++ source files

To create C/C++ source programs, you can use any text editor available on your system.

Source programs must be saved using a recognized file name suffix. See “XL C/C++ input and output files” on page 23 for a list of suffixes recognized by XL C/C++.

For a C or C++ source program to be a valid program, it must conform to the language definitions specified in the *XL C/C++ Language Reference* and the C and C++ language standards.

---

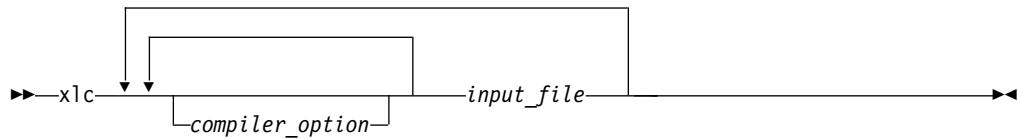
## Compiling with XL C/C++

XL C/C++ is a command-line compiler. Invocation commands and options can be selected according to the needs of a particular C/C++ application.

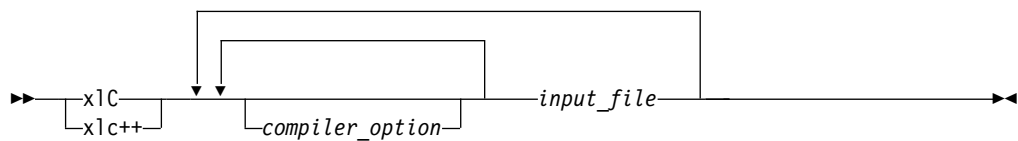
### Invoking the compiler

The compiler invocation commands perform all necessary steps to compile C/C++ source files or preprocessed files (.i or .ii), assemble any .s and .S files, and link the object files and libraries into an executable program.

To compile a C source program, use the following basic invocation syntax:



To compile a C++ source program, use the following basic invocation syntax:



For most applications, compile with `xlc` or `xlC`. You can use `xlC` to compile either C or C++ program source, but compiling C++ files with `xlc` might result in link or runtime errors because libraries required for C++ code are not specified when the linker is called by the C compiler. The compiler invocation commands produce threadsafe code.

More invocation commands are available to meet specialized compilation needs, primarily to provide explicit compilation support for different levels and extensions of the C or C++ language. For more information about available compiler invocation commands, see "Invoking the compiler" in the *XL C/C++ Compiler Reference*.

### Specifying compiler options

Compiler options perform a variety of functions, such as setting compiler characteristics, describing the object code to be produced, controlling the diagnostic messages emitted, and performing some preprocessor functions.

You can specify compiler options in one or any combination of the following ways:

- On the command line
- In your source code using directive statements
- In a makefile
- In the stanzas found in a compiler configuration file

You can also pass options to the linker, assembler, and preprocessor.

## Priority sequence of compiler options


Option conflicts and incompatibilities might occur when multiple compiler options are specified. To resolve these conflicts in a consistent manner, the compiler applies the following general priority sequence to most options:

1. Directive statements in your source file override command line settings.
2. Compiler option settings on the command line override configuration file settings.
3. Configuration file settings override default settings.

Generally, if the same compiler option is specified more than once on the command line when the compiler is invoked, the last option specified prevails.

**Note:** Some compiler options, such as the **-I** option, do not follow the priority sequence described above. The compiler searches any directories specified with **-I** in the `xl.cfg` file before it searches the directories specified with **-I** on the command line. The **-I** option is cumulative rather than preemptive. Other options with cumulative behavior are **-R** and **-l** (lowercase L).

### Related information

 [Compiler options reference](#)

## XL C/C++ input and output files

The topic describes the file types that are recognized by XL C/C++.

For detailed information about these and additional file types used by the compiler, see "Types of input files" in the *XL C/C++ Compiler Reference* and "Types of output files" in the *XL C/C++ Compiler Reference*.

Table 4. Input file types

Filename extension	Description
.c	C source files
.C, .cc, .cp, .cpp, .cxx, .c++	C++ source files
.i	Preprocessed source files
.ii	Preprocessed C++ source files
.o	Object files
.s	Assembler files
.S	Unpreprocessed assembler files
.so	Shared object or library files

Table 5. Output file types

Filename extension	Description
a.out	Default name for executable file created by the compiler
.d	Make dependency file
.i	Preprocessed source files
.lst	Listing files
.o	Object files
.s	Assembler files
.so	Shared object or library files

---

## Linking your compiled applications with XL C/C++

By default, you do not need to do anything special to link an XL C/C++ program. The compiler invocation commands automatically call the linker to produce an executable output file.

For example, you can use `xlc++` to compile `file1.C` and `file3.C` to produce object files `file1.o` and `file3.o`; after that, all object files, including `file2.o`, are submitted to the linker to produce one executable.

```
xlc++ file1.C file2.o file3.C
```

### Compiling and linking in separate steps

To produce object files that can be linked later, use the `-c` option.

```
xlc++ -c file1.C           # Produce one object file (file1.o)
xlc++ -c file2.C file3.C  # Or multiple object files (file1.o, file3.o)
xlc++ file1.o file2.o file3.o # Link object files with default libraries
```

#### Related information



Linking



Constructing a library

## Dynamic and static linking

You can use XL C/C++ to take advantage of the operating system facilities for both dynamic and static linking.

Dynamic linking means that the code for some external routines is located and loaded when the program is first run. When you compile a program that uses shared libraries, the shared libraries are dynamically linked to your program by default. Dynamically linked programs take up less disk space and less virtual memory if more than one program uses the routines in the shared libraries. During linking, they do not require any special precautions to avoid naming conflicts with library routines. They might perform better than statically linked programs if several programs use the same shared routines at the same time. By using dynamic linking, you can upgrade the routines in the shared libraries without relinking. This form of linking is the default and no additional options are needed.

Static linking means that the code for all routines called by your program becomes part of the executable file. Statically linked programs can be moved to run on systems without the XL C/C++ runtime libraries. They might perform better than dynamically linked programs if they make many calls to library routines or call many small routines. They do require some precautions in choosing names for data objects and routines in the program if you want to avoid naming conflicts with library routines.

**Note:** Dynamically and statically linked programs might not work if you compile them on one level of the operating system and run them on a different level of the operating system.

---

## Running your compiled application

After a program is compiled and linked, you can run the generated executable file on the command line.

The default file name for the program executable file produced by the XL C/C++ compiler is **a.out**. You can select a different name with the **-o** compiler option.

You should avoid giving your program executable file the same name as system or shell commands, such as `test` or `cp`, as you could accidentally execute the wrong command. If you do decide to name your program executable file with the same name as a system or shell command, you should execute your program by specifying the path name to the directory in which your executable file resides, such as `./test`.

To run a program, enter the name of the program executable file with runtime arguments on the command line.

### Canceling execution

To suspend a running program, press **Ctrl+Z** while the program is in the foreground. Use the **fg** command to resume running.

To cancel a running program, press **Ctrl+C** while the program is in the foreground.

### Setting runtime options

You can use environment variable settings to control certain runtime options and behaviors of applications created with the XL C/C++ compiler. Some environment variables do not control actual runtime behavior, but they can have an impact on how your applications run.

For more information about environment variables and how they can affect your applications at run time, see the *XL C/C++ Installation Guide*.

### Running compiled applications on other systems

If you want to run an application developed with the XL C/C++ compiler on another system that does not have the compiler installed, you need to install a runtime environment on that system or link your application statically.

You can obtain the latest XL C/C++ Runtime Environment images, together with licensing and usage information, from the [XL C/C++ for Linux support page](#).

---

## XL C/C++ compiler diagnostic aids

XL C/C++ issues diagnostic messages when it encounters problems compiling your application. You can use these messages and other information provided in compiler output listings to help identify and correct such problems.

For more information about listing, diagnostics, and related compiler options that can help you resolve problems with your application, see the following topics in the *XL C/C++ Compiler Reference*:

- "Compiler messages and listings"
- "Error checking and debugging options"

- "Listings, messages, and compiler information options"

## Debugging compiled applications

You can use a symbolic debugger to debug applications compiled with XL C/C++.

At compile time, you can use the **-g** or **-qlinedebug** option to instruct the XL C/C++ compiler to include debugging information in compiled output. For **-g**, you can also use different levels to balance between debug capability and compiler optimization. For more information about the debugging options, see "Error checking and debugging" in the *XL C/C++ Compiler Reference*.

You can then use **gdb** or any symbolic debugger that supports the DWARF debug format on Linux to step through and inspect the behavior of your compiled application.

Optimized applications pose special challenges when you debug your applications. For more information about debugging your optimized code, see "Debugging optimized code" in the *XL C/C++ Optimization and Programming Guide*.

## Determining which level of XL C/C++ is being used

To display the version and release level of XL C/C++ that you are using, invoke the compiler with the **--version** (**-qversion**) compiler option.

For example, to obtain detailed version information, enter the following command:

```
xlc++ --version
```



---

## Notices

Programming interfaces: Intended programming interfaces allow the customer to write programs to obtain the services of IBM XL C/C++ for Linux on z Systems.

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