

IBM XL C/C++ for AIX, V11.1



# Getting Started with XL C/C++

*Version 11.1*



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*Version 11.1*

**Note**

Before using this information and the product it supports, read the information in “Notices” on page 47.

**First edition**

This edition applies to IBM XL C/C++ for AIX, V11.1 (Program 5724-X13) 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 AIX®, V11.1 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, a 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 on 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 actions of the compiler. You can, however, substitute other forms of the compiler invocation command if your particular environment requires it, and compiler option usage will remain the same unless otherwise specified.

While this document covers information on 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* for information on installing XL C/C++.
- Compiler options: see the *XL C/C++ Compiler Reference* for detailed information on the syntax and usage of compiler options.
- The C or C++ programming languages: see the *XL C/C++ Language Reference* for information on the syntax, semantics, and IBM implementation of the C or C++ programming languages.
- Programming topics: see the *XL C/C++ Optimization and Programming Guide* for detailed information on developing applications with XL C/C++, with a focus on program portability and optimization.

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## Conventions

### Typographical conventions

The following table explains the typographical conventions used in the IBM XL C/C++ for AIX, V11.1 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, <b>xlc</b> and <b>xlc</b> ( <b>xlc++</b> ), 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.	nomaf   <u>maf</u>
monospace	Programming keywords and library functions, compiler builtins, examples of program code, command strings, or user-defined names.	To compile and optimize myprogram.c, enter: xlc myprogram.c -O3.

## 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, or 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, or 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
C++0x, or C++0x begins   C++0x ends	The text describes a feature that is introduced into standard C++ as part of C++0x.

## Syntax diagrams

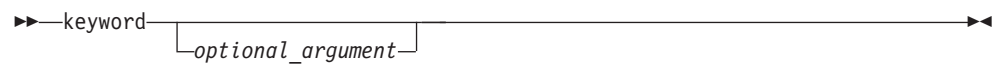
Throughout this information, diagrams illustrate XL C/C++ syntax. This section will help you to interpret and use those diagrams.

- 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.

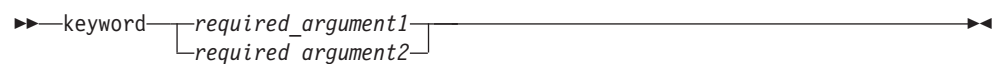
- Required items are shown on the horizontal line (the main path):



- 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:



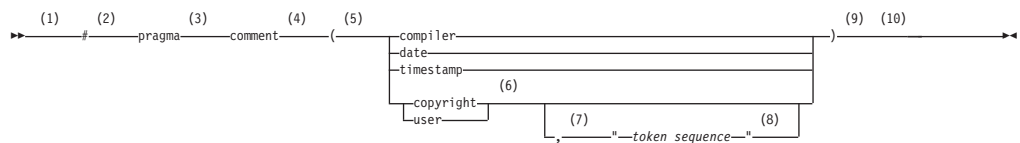
- The item that is the default is shown above the main path.



- 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.

### Sample syntax diagram

The following syntax diagram example shows the syntax for the **#pragma comment** directive.



#### Notes:

- 1 This is the start of the syntax diagram.
- 2 The symbol # must appear first.
- 3 The keyword pragma must appear following the # symbol.
- 4 The name of the pragma comment must appear following the keyword pragma.
- 5 An opening parenthesis must be present.
- 6 The comment type must be entered only as one of the types indicated: compiler, date, timestamp, copyright, or user.
- 7 A comma must appear between the comment type copyright or user, and an optional character string.
- 8 A character string must follow the comma. The character string must be enclosed in double quotation marks.
- 9 A closing parenthesis is required.
- 10 This is the end of the syntax diagram.

The following examples of the **#pragma comment** directive are syntactically correct according to the diagram shown above:

```

#pragma comment(date)
#pragma comment(user)
#pragma comment(copyright,"This text will appear in the module")
  
```

## 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:

- 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 of the installation CD.

- 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 AIX, V11.1 Installation Guide*.

- Information center

The information center of searchable HTML files can be launched on a network and accessed remotely or locally. Instructions for installing and accessing the online information center are provided in the *IBM XL C/C++ for AIX, V11.1 Installation Guide*.

The information center is viewable on the Web at <http://publib.boulder.ibm.com/infocenter/comphelp/v111v131/index.jsp>.

- PDF documents

PDF documents are located by default in the `/usr/vacpp/doc/LANG/pdf/` directory, where *LANG* is one of `en_US`, `zh_CN`, or `ja_JP`. The PDF files are also available on the Web at <http://www.ibm.com/software/awdtools/xlcpp/aix/library/>.

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 AIX, V11.1 Installation Guide, GC27-2480-00</i>	install.pdf	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 AIX, V11.1, GI11-9417-00</i>	getstart.pdf	Contains an introduction to the XL C/C++ product, with information on setting up and configuring your environment, compiling and linking programs, and troubleshooting compilation errors.

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

Document title	PDF file name	Description
<i>IBM XL C/C++ for AIX, V11.1 Compiler Reference, SC27-2479-00</i>	compiler.pdf	Contains information about the various compiler options, pragmas, macros, environment variables, and built-in functions, including those used for parallel processing.
<i>IBM XL C/C++ for AIX, V11.1 Language Reference, SC27-2481-00</i>	langref.pdf	Contains information about the C and C++ programming languages, as supported by IBM, including language extensions for portability and conformance to nonproprietary standards.
<i>IBM XL C/C++ for AIX, V11.1 Optimization and Programming Guide, SC27-2482-00</i>	progguide.pdf	Contains information on advanced programming topics, such as application porting, interlanguage calls with Fortran code, library development, application optimization and parallelization, and the XL C/C++ high-performance libraries.
<i>Standard C++ Library Reference, SC27-2483-00</i>	stdlib.pdf	Contains reference information about the standard C++ runtime libraries and headers.
<i>C/C++ Legacy Class Libraries Reference, SC09-7652-00</i>	legacy.pdf	Contains reference information about the USL I/O Stream Library and the Complex Mathematics Library.

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

More information related to XL C/C++ including IBM Redbooks® publications, white papers, tutorials, and other articles, is available on the Web at:

<http://www.ibm.com/software/awdtools/xlcpp/aix/library/>

For more information about boosting performance, productivity, and portability, see the C/C++ café at <http://www-949.ibm.com/software/rational/cafe/community/ccpp>.

## Standards and specifications

XL C/C++ is designed to support the following standards and specifications. You can refer to these standards 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 14882:1998*, also known as C++98.
- *Information Technology - Programming languages - C++, ISO/IEC 14882:2003(E)*, also known as *Standard C++*.
- *Information Technology - Programming languages - Extensions for the programming language C to support new character data types, ISO/IEC DTR 19769*. This draft technical report has been accepted by the C standards committee, and is available at <http://www.open-std.org/JTC1/SC22/WG14/www/docs/n1040.pdf>.

- *Draft Technical Report on C++ Library Extensions, ISO/IEC DTR 19768*. This draft technical report has been submitted to the C++ standards committee, and is available at <http://www.open-std.org/JTC1/SC22/WG21/docs/papers/2005/n1836.pdf>.
- *Altivec Technology Programming Interface Manual*, Motorola Inc. This specification for vector data types, to support vector processing technology, is available at [http://www.freescale.com/files/32bit/doc/ref\\_manual/ALTIVECPIM.pdf](http://www.freescale.com/files/32bit/doc/ref_manual/ALTIVECPIM.pdf).
- *Information Technology - Programming Languages - Extension for the programming language C to support decimal floating-point arithmetic, ISO/IEC WDTR 24732*. This draft technical report has been submitted to the C standards committee, and is available at <http://www.open-std.org/JTC1/SC22/WG14/www/docs/n1176.pdf>.
- *Decimal Types for C++: Draft 4* <http://www.open-std.org/jtc1/sc22/wg21/docs/papers/2006/n1977.html>
- *ANSI/IEEE Standard for Binary Floating-Point Arithmetic, ANSI/IEEE Std 754-1985*.
- *OpenMP Application Program Interface Version 3.0*, available at <http://www.openmp.org>

## Other IBM information

- *Parallel Environment for AIX: Operation and Use*
- The IBM Systems Information Center, at <http://publib.boulder.ibm.com/infocenter/systems/index.jsp?topic=/com.ibm.aix.doc/doc/base/aixparent.htm> is a resource for AIX information.  
You can find the following books for your specific AIX system:
  - *AIX Commands Reference, Volumes 1 - 6*
  - *Technical Reference: Base Operating System and Extensions, Volumes 1 & 2*
  - *AIX National Language Support Guide and Reference*
  - *AIX General Programming Concepts: Writing and Debugging Programs*
  - *AIX Assembler Language Reference*
- *ESSL for AIX V4.4 - ESSL for Linux on POWER V4.4 Guide and Reference* available at the Engineering and Scientific Subroutine Library (ESSL) and Parallel ESSL Web page.

## 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/software/awdtools/xlcpp/aix/support/>. 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 e-mail 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/awdtools/xlcpp/aix/>.

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## How to send your comments

Your feedback is important in helping 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 by e-mail to [compinfo@ca.ibm.com](mailto:compinfo@ca.ibm.com).

Be sure to include the name of the information, the part number of the information, 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 AIX, V11.1 is an advanced, high-performance compiler that can be used for developing complex, computationally intensive programs, including interlanguage calls with C and Fortran programs.

This section discusses 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 AIX, V11.1 is part of a larger family of IBM C, C++, and Fortran compilers.

XL C/C++, together with XL C and XL Fortran, comprise the family of XL 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<sup>®</sup>/L<sup>™</sup>, IBM Blue Gene<sup>®</sup>/P<sup>™</sup>, the Cell Broadband Engine<sup>™</sup> architecture, IBM i, selected Linux<sup>®</sup> distributions, IBM z/OS<sup>®</sup>, and IBM z/VM<sup>®</sup>. The common code base, along with compliance with international programming language standards, helps support consistent compiler performance and ease of program portability across multiple operating systems and hardware platforms.

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### Hardware and operating system support

IBM XL C/C++ for AIX, V11.1 supports AIX 5L<sup>™</sup> for POWER<sup>®</sup> Version 5.3 and AIX Version 6.1. 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 will run on systems with the required software and disk space.

To take maximum advantage of the various supported hardware configurations, the compiler provides options to tune the performance of applications specific to the type of hardware that will be used to execute 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 different commands that you can use to invoke the compiler, for example, **xlC**, **xlC++**, and **xlC**. Each invocation command is unique in that it instructs the compiler to tailor compilation output to meet a specific language level specification. Compiler invocation commands are provided to support all standardized C/C++ language levels, and many popular language extensions as well.

The compiler also provides corresponding "\_r" versions of most invocation commands, for example, `xlcr` and `xlC_r`. The "\_r" invocations instruct the compiler to link and bind object files to thread safe components and libraries, and produce thread safe object code for compiler-created data and procedures.

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. Different categories of options help you to debug your applications, optimize and tune application performance, select language levels and extensions for compatibility with non-standard features and behaviors supported by other C or C++ compilers, and perform many other common tasks that would otherwise require changing the source code.

XL C/C++ lets you 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 plain text compiler configuration file containing stanzas that define compiler option default settings.

Your compilation needs may frequently call for specifying compiler option settings other than the default settings provided by XL C/C++. If so, you can use makefiles to define your compiler option settings, or alternatively, you can create custom configuration files to define your own sets of frequently used compiler option settings.

For more information about using custom compiler configuration files, see "Using custom compiler configuration files" on page 37.

### **Utilization tracking configuration file**

The utilization tracking and reporting feature of the compiler has its own configuration file. The main compiler configuration file contains an entry that points to this file. The different installations of the compiler product can use a single utilization tracking configuration file to centrally manage the functionality of the utilization tracking and reporting feature. This utilization and reporting tool can be used to detect whether your organization's use of the compiler exceeds your license entitlements. For detailed information about the utilization tracking and reporting feature, see "Tracking and reporting compiler usage" in the *XL C/C++ Compiler Reference*.

---

## **Language standards compliance**

The compiler supports the following programming language specifications for C/C++:

- ISO/IEC 9899:1999 (C99)
- ISO/IEC 9899:1990 (referred to as C89)
- ISO/IEC 14882:2003 (referred to as Standard C++)
- ISO/IEC 14882:1998, the first official specification of the language (referred to as C++98)



In addition to the standardized language levels, XL C/C++ supports language extensions, including:

- OpenMP V3.0 to support portable parallelized programming
- Language extensions to support vector programming
- A subset of GNU C and C++ language extensions
- C++0x

See C++0x in the *Getting Started with IBM XL C/C++ for AIX, V11.1* for more details.

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 developed with **gcc** and **g++** compilers.

This support is available when the **gxlc** or **gxlc++** invocation command is used together with select GNU compiler options. Where possible, the compiler maps GNU options to their XL C/C++ compiler option counterparts before invoking the compiler.

These invocation commands use a plain text configuration file to control GNU-to-XL C/C++ option mappings and defaults. You can customize this configuration file to better meet the needs of any unique compilation requirements you may have. See "Reusing GNU C/C++ compiler options with **gxlc** and **gxlc++**" in the *XL C/C++ Compiler Reference* for more information.

## Source-code migration and conformance checking

XL C/C++ helps protect your investment in your existing C/C++ source code by providing compiler invocation commands that instruct the compiler to compile your application code to a specific language level.

You can also use the **-qlanglvl** compiler option to specify a given language level, and the compiler will issue warnings, errors, and severe error messages if language or language extension elements in your program source do not conform to that language level.

See "qlanglvl" in the *XL C/C++ Compiler Reference* for more information.

---

## Libraries

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

### Standard C++ library

XL C/C++ ships a modified version of the Dinkum C++ Library, a conforming implementation of the Standard C++ Library. The Standard C++ Library consists of 51 headers, including 13 headers which constitute the Standard Template Library (STL). In addition, the Standard C++ Library works in conjunction with the 18 headers from the Standard C Library. The functions in these headers perform essential services such as input and output. They also provide efficient implementations of frequently used operations.

For more information, see the *Standard C++ Library Reference*.

## C++ library extensions

In addition to the Standard C++ Library, XL C/C++ V11.1 supports extensive extensions to the C++ language as defined by the Draft Technical Report on C++ Library Extensions (TR1).

For more information on these language extensions, see Draft Technical Report on C++ Library Extensions (TR1).

## Mathematical Acceleration Subsystem library

The Mathematical Acceleration Subsystem (MASS) library consists of scalar and vector mathematical intrinsic 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 32-bit and 64-bit compilation modes, are thread-safe, and offer improved performance over the default libm math library routines. They are called automatically when you request specific levels of optimization for your application. You can also make explicit calls to MASS library functions regardless of whether optimization options are in effect or not.

See "Using the Mathematical Acceleration Subsystem" in the *XL C/C++ Optimization and Programming Guide* for more information.

## Basic Linear Algebra Subprograms

The Basic Linear Algebra Subprograms (BLAS) set of high-performance algebraic functions are shipped in the libxlopt library. These functions let you:

- Compute the matrix-vector product for a general matrix or its transpose.
- Perform combined matrix multiplication and addition for general matrices or their transposes.

For more information about using the BLAS functions, see "Using the Basic Linear Algebra Subprograms" in the *XL C/C++ Optimization and Programming Guide*.

## Other libraries

The following are also shipped with XL C/C++:

- The SMP runtime library supports both explicit and automated parallel processing. See "SMP Runtime Library" in the *XL C/C++ Optimization and Programming Guide*.
- The memory debug runtime library is used for diagnosing memory leaks. See "Using memory heaps" in the *XL C/C++ Optimization and Programming Guide*.
- XL C++ Runtime Library contains support routines needed by the compiler.
- UNIX® System Laboratories (USL) contains stream classes for input and output capabilities for C++. This library is provided for use by old applications. For new applications, you should use the Standard C++ Library. See *C/C++ Legacy Class Libraries Reference* for more information.
- USL contains classes for manipulating complex numbers. This library is provided for use by old applications. For new applications, you should use the Standard C++ Library. See *C/C++ Legacy Class Libraries Reference* for more information.

-  The demangler library provides routines and classes for demangling linkage names created by the C++ compiler.

## Support for Boost libraries

XL C/C++ for AIX, V11.1 partially supports the Boost V1.40.0 libraries. A patch file is available that modifies the Boost 1.40.0 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.

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

For more information on support for libraries, search on the XL C/C++ Compilers support page at <http://www.ibm.com/software/awdtools/xlcpp/aix/support/>.

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## Tools and utilities

There are many tools and utilities that are included with XL C/C++.

### **vacppndi**

This is a script you can use to install XL C/C++ to a non-default directory location.

### **IBM Debugger for AIX**

The IBM Debugger for AIX can help you detect and diagnose errors in programs that are running locally or remotely. You can control the execution of your programs by setting compiled language-specific breakpoints, suspending execution, stepping through your code, and examining and changing the contents of variables.

The debugger contains views and functionality specific to a given programming language. With the compiled language views, you can monitor variables, expressions, registers, memory, and application modules of the application you are debugging.

### **CreateExportList command**

Creates a file that contains a list of all the global symbols found in a given set of object files.



### **c++filt Name demangling utility**

When XL C/C++ compiles a C++ program, it encodes all function names and certain other identifiers to include type and scoping information. This encoding process is called mangling. This utility converts the mangled names to their original source code names.



### **linkxlc command**

Links C++ .o and .a files. This command is used for linking on systems without XL C/C++ compiler installed.



### **makeC++SharedLib command**

Permits the creation of C++ shared libraries on systems on which the XL C/C++ compiler is not installed.

### **cleanpdf command**

A command related to profile-directed feedback (PDF), **cleanpdf** removes all profiling information from the directory to which profile-directed feedback data is written.

**mergepdf command**

A command related to profile-directed feedback (PDF), **mergepdf** 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.

**resetpdf command**

The current behavior of the **cleanpdf** command is the same as the **resetpdf** command, and is retained for compatibility with earlier releases on other platforms.

**showpdf command**

The **showpdf** command displays the call and block counts for all procedures executed in a profile-directed feedback training run (compilation under the options **-qpdf1** and **-qshowpdf**).

**gxc and gxc++ utilities**

The **gxc** and **gxc++** invocations translate GNU C or GNU C++ invocation commands into corresponding **xlc** or **xlc++** commands before invoking the IBM XL C/C++ for AIX, V11.1 compiler. The purpose of these utilities is to minimize the number of changes to makefiles used for existing applications built with the GNU compilers and to facilitate the transition to IBM XL C/C++ for AIX, V11.1.

**Utilization reporting tool**

The utilization reporting tool generates a report describing your organization's utilization of the compiler. These reports can be used to monitor compliance with your compiler license entitlements. You can use the **urt** command to control how the report is generated. For more information about this tool, see "Tracking and reporting compiler usage" in the *XL C/C++ Compiler Reference*.

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## Program optimization

XL C/C++ provides several compiler options that can help you control the optimization or 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. 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 POWER architecture
- Improving the usage of the memory subsystem
- Exploiting the ability of the architecture to handle large amounts of shared memory parallelization

For more information, see these related topics:

- "Optimizing your applications" in the *XL C/C++ Optimization and Programming Guide*
- "Optimizing and tuning options" in the *XL C/C++ Compiler Reference*
- "Compiler built-in functions" in the *XL C/C++ Compiler Reference*

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## 64-bit object capability

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

The AIX 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 be fit within a 64-bit address space, a separate 64-bit object form is used. The binder 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, or execute, or both:

- A 64-bit object or executable that has references to symbols from a 32-bit library or shared library
- A 32-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 32-bit module
- A 32-bit executable that explicitly attempts to load a 64-bit module
- Attempts to run 64-bit applications on 32-bit platforms

On both 64-bit and 32-bit platforms, 32-bit executables will continue to run as they currently do on a 32-bit platform.

XL C/C++ supports 64-bit mode mainly through the use of the **-q64** and **-qarch** compiler options. This combination determines the bit mode and instruction set for the target architecture.

For more information, see "Using 32-bit and 64-bit modes" in the *XL C/C++ Optimization and Programming Guide*.

---

## Shared memory parallelization

XL C/C++ supports application development for multiprocessor system architectures.

You can use any of the following methods to develop your parallelized applications with XL C/C++:

- Directive-based shared memory parallelization (OpenMP, SMP)
- Instructing the compiler to automatically generate shared memory parallelization
- Message passing based shared or distributed memory parallelization (MPI)
- POSIX threads (Pthreads) parallelization
- Low-level UNIX parallelization using `fork()` and `exec()`

The parallel programming facilities of the AIX operating system are based on the concept of threads. Parallel programming exploits the advantages of multiprocessor systems, while maintaining a full binary compatibility with existing uniprocessor

systems. This means that a multithreaded program that works on a uniprocessor system can take advantage of a multiprocessor system without recompiling.

For more information, see "Parallelizing your programs" in the *XL C/C++ Optimization and Programming Guide*.

## OpenMP directives

OpenMP directives are a set of API-based commands supported by XL C/C++ and many other IBM and non-IBM C, C++, and Fortran compilers.

You can use OpenMP directives to instruct the compiler how to parallelize a particular loop. The existence of the directives in the source removes the need for the compiler to perform any parallel analysis on the parallel code. OpenMP directives require the presence of Pthread libraries to provide the necessary infrastructure for parallelization.

OpenMP directives address three important issues of parallelizing an application:

1. Clauses and directives are available for scoping variables. Frequently, variables should not be shared; that is, each processor should have its own copy of the variable.
2. Work sharing directives specify how the work contained in a parallel region of code should be distributed across the processors.
3. Directives are available to control synchronization between the processors.

As of XL C/C++ for AIX, V10.1, XL C/C++ supports the OpenMP API Version 3.0 specification. See "OpenMP 3.0" on page 27 for an overview of the changes introduced by this feature.

For more information about program performance optimization, see:

- "Optimizing your applications" in the *XL C/C++ Optimization and Programming Guide*
- [www.openmp.org](http://www.openmp.org)

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## Diagnostic listings

The compiler output listing and XML reports can provide important information to help you develop and debug your applications more efficiently.

Listing information is organized into optional sections that you can include or omit. For more information about the applicable compiler options and the listing itself, refer to "Compiler messages and listings" in the *XL C/C++ Compiler Reference*.

It is also possible to get information from the compiler in XML 1.0 format about some of the optimizations that the compiler was able to perform and also which optimization opportunities were missed. This information can be used to improve programmer productivity when tuning applications, especially high performance applications. The report is defined by an XML schema and easily consumable by tools that you can create to read and analyze the results. For detailed information about this report and how to use it, see "Using reports to diagnose optimization opportunities" in the *XL C/C++ Optimization and Programming Guide*.

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## Symbolic debugger support

You can instruct XL C/C++ to include debugging information in your compiled objects. That information can be examined by **dbx**, the IBM Debugger for AIX, or any other symbolic debugger that supports the AIX XCOFF executable format to help you debug your programs.





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## Chapter 2. What's new for IBM XL C/C++ for AIX, V11.1

This section describes features and enhancements added to the compiler in IBM XL C/C++ for AIX, V11.1.

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### Support for POWER7 processors

IBM XL C/C++ for AIX, V11.1 supports POWER7™ processors. New features are introduced in support of POWER7 processors.

The new features and enhancements for POWER7 processors fall into four categories:

- vector scalar extension data types and intrinsic functions
- MASS libraries for POWER7 processors
- built-in functions for POWER7 processors
- compiler options for POWER7 processors

#### Vector scalar extension data types and intrinsic functions

This release of the compiler supports the Vector Scalar eXtension (VSX) instruction set in the POWER7 processors. New data types and intrinsic functions are introduced to support the VSX instructions. With the VSX intrinsic functions and the original Vector Multimedia eXtension (VMX) intrinsic functions, you can efficiently manipulate vector operations in your application.

For more information about the VSX data types and intrinsic functions, see Vector types in the *XL C/C++ Language Reference* and Vector built-in functions in the *XL C/C++ Compiler Reference*.

#### Mathematical Acceleration Subsystem (MASS) libraries for POWER7 processors

##### Vector libraries

The vector MASS library **libmassvp7.a** contains vector functions that have been tuned for the POWER7 architecture. The functions can be used in either 32-bit mode or 64-bit mode.

Functions supporting previous POWER processors, either single-precision or double-precision, are included for POWER7 processors.

The following new functions are added, in both single-precision and double-precision function groups:

- exp2
- exp2m1
- log21p
- log2

For more information about the vector libraries, see Using the vector libraries in the *XL C/C++ Optimization and Programming Guide*.

##### SIMD libraries

The MASS SIMD library `libmass_simdp7.a` contains an accelerated set of frequently used math intrinsic functions that provide improved performance over the corresponding standard system library functions.

For more information about the SIMD libraries, see *Using the SIMD library for POWER7 in the XL C/C++ Optimization and Programming Guide*.

## POWER7 hardware intrinsics

New hardware intrinsics are added to support the following POWER7 processor features:

- new POWER7 prefetch extensions and cache control
- new POWER7 hardware instructions

For more information, see “Built-in functions new for this release” on page 23.

## New compiler option for POWER7 processors

### New arch and tune compiler options

The `-qarch` compiler option specifies the processor architecture for which code is generated. The `-qtune` compiler option tunes instruction selection, scheduling, and other architecture-dependent performance enhancements to run best on a specific hardware architecture.

`-qarch=pwr7` produces object code containing instructions that will run on the POWER7 hardware platforms. With `-qtune=pwr7`, optimizations are tuned for the POWER7 hardware platforms.

For more information, see `-qarch` in the *XL C/C++ Compiler Reference* and `-qtune` in the *XL C/C++ Compiler Reference*.

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## C++0x

C++0x is the working draft of the new C++ programming language standard. Additional C++0x features are supported in this release of XL C/C++.

**Note:** C++0x is a new version of the C++ programming language standard. This is a draft standard and has not been officially adopted in its entirety. The implementation of C++0x is based on IBM's interpretation of the draft C++0x standard and is subject to change at any time without notice. IBM makes no attempt to maintain compatibility with earlier releases and therefore the C++0x language extension should not be relied on as a stable programming interface.

The following features are introduced in XL C/C++ V11.1:

- Auto type deduction
- C99 `long long`
- C99 preprocessor features adopted in C++0x
- `decltype`
- Delegating constructors
- Explicit instantiation declarations
- Extended friend declarations
- Inline namespace definitions
- Static assertion
- Variadic templates

## Auto type deduction

With the auto type deduction feature, you no longer need to specify a type while declaring a variable. This is because auto type deduction delegates the task of deducing the type of an auto variable to the compiler from the type of its initializer expression.


You can use the individual suboption **-qclanglvl=autotypededuction** or the group option **-qclanglvl=extended0x** to enable this feature.

For more information, see "The auto type specifier (C++0x)" in the *XL C/C++ Language Reference*.

## C99 long long

The C++ compiler can use the C99 long long feature, which improves source compatibility between the C and C++ languages.

You can use the individual suboption **-qclanglvl=c99longlong** or the group option **-qclanglvl=extended0x** to enable the C99 long long feature.

 After this feature is enabled, if a decimal integer literal that does not have a suffix containing u or U cannot be represented by the long long int type, you can decide whether to use the unsigned long long int type to represent the literal or not by specifying the **-qclanglvl=[no]extendedintegersafe** option.

For more information, see "Integer literals" in the *XL C/C++ Language Reference*.

## C99 preprocessor features adopted in C++0x

With several C99 preprocessor features adopted in C++0x, C and C++ compilers provide a more common preprocessor interface, which can ease porting C source files to the C++ compiler, eliminate semantic differences between the C and C++ preprocessors, and avoid preprocessor compatibility issues or diverging preprocessor behaviors.

You can use the individual suboption **-qclanglvl=c99preprocessor** or the group option **-qclanglvl=extended0x** to enable this feature.

For more information, see "C99 preprocessor features adopted in C++0x)" in the *XL C/C++ Language Reference*.

## Decltype

With the decltype feature, you can get a type that is based on the resultant type of a possibly type-dependent expression.

You can use the individual suboption **-qclanglvl=decltype** or the group option **-qclanglvl=extended0x** to enable this feature.

For more information, see "The decltype(expression) type specifier (C++0x)" in the *XL C/C++ Language Reference*.

## Delegating constructors

With the delegating constructors feature, you can concentrate common initializations in one constructor, which makes programs more readable and maintainable.

You can use the individual suboption **-qlanglvl=delegatingctors** or the group option **-qlanglvl=extended0x** to enable this feature.

For more information, see "Delegating constructors (C++0x)" in the *XL C/C++ Language Reference*.

## Explicit instantiation declarations

With the explicit instantiation declarations feature, you can suppress the implicit instantiation of a template specialization or its members.

You can use the individual suboption **-qlanglvl=externtemplate** or the group options **-qlanglvl=extended** and **-qlanglvl=extended0x** to enable this feature.

For more information, see "Explicit instantiation (C++ only)" in the *XL C/C++ Language Reference*.

## Extended friend declarations

The extended friend declarations feature relaxes the syntax rules governing friend declarations as follows:

- Template parameters, typedef names, and basic types can be declared as friends.
- The class-key in the context for friend declarations is no longer necessary in C++0x.

You can enable this feature with the individual suboption **-qlanglvl=extendedfriend** or the group option **-qlanglvl=extended0x**.

For more information, see "Friends (C++ only)" in the *XL C/C++ Language Reference*.

## Inline namespace definitions

Inline namespace definitions are namespace definitions with an initial `inline` keyword. You can define or specialize the members of an inline namespace as if they belong to the enclosing namespace that contains the inline namespace.

You can enable this feature with the individual suboption **-qlanglvl=inlinenamespace** or the group option **-qlanglvl=extended0x**.

For more information, see "Inline namespace definitions (C++0x)" in the *XL C/C++ Language Reference*.

## Static assertion

The static assertion feature provides you with the following benefits:

- Libraries can detect common usage errors at compile time.
- Implementations of the C++ Standard Library can detect and diagnose common usage errors, thus improving usability.

You can use a `static_assert` declaration to check important program invariants at compile time.

You can enable the static assertion feature with the individual suboption **-qlanglvl=static\_assert** or the group option **-qlanglvl=extended0x**.

For more information, see "static\_assert declaration (C++0x)" in the *XL C/C++ Language Reference*.

## Variadic templates

With the variadic templates feature, you can define class or function templates that have any number (including zero) of parameters.

You can use the individual suboption **-qlanglvl=variadic[templates]** or the group option **-qlanglvl=extended0x** to enable this feature.

For more information, see "Variadic templates (C++0x)" in the *XL C/C++ Language Reference*.

**Related information in the *XL C/C++ Compiler Reference***



**-qlanglvl**

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## Performance and optimization

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

### Enhancements to -qpdf

The use of the **-qpdf** option consists of two steps. First, compile your program with **-qpdf1** and run it with a typical set of data to generate the profiling data. Second, compile your program again with **-qpdf2** to optimize the program based on the profiling data.

In previous releases, if you modified the source file and compiled with the **-qpdf** option, the compilation would stop with an error. As of IBM XL C/C++ for AIX, V11.1, you can use profiling data after you modify your source files. To do this, compile your application using the stale profiling data at the second stage of the PDF process.

Three new suboptions are added to the **-qpdf** option. These new suboptions allow more fine-grained control over performance improvement and extend **-qpdf** to support multiple pass profiling, cache miss profiling, block counter profiling, call counter profiling, and extended value profiling.

The three new **-qpdf** suboptions are:

**level** Supports multiple-pass profiling, cache miss profiling, block counter profiling, call counter profiling, and extended value profiling. You can compile your application with **-qpdf1=level=0|1|2** to generate profiling data with different levels of optimization.

**Note:** Both **-qpdf1=level=0** and **-qpdf1=level=1** support single-pass profiling, whereas **-qpdf1=level=2** supports multiple-pass profiling.

**exename**

Generates the name of the PDF file you specify with the **-o** parameter.

**defname**

Reverts the PDF file to its default file name.

For detailed information about these suboptions, see **-qpdf1**, **-qpdf2** in the *XL C/C++ Compiler Reference*.

## Reports about compiler optimizations

There have been a number of enhancements to the listing reports to give you more information on how the compiler optimized your code. You can use this information to get further benefits from the compiler's optimization capabilities. For more details about these enhanced reports, see "New diagnostic reports" on page 17.

## Performance-related compiler options and directives

The entries in the following table describe new or changed compiler options and directives.

Information presented here is a brief overview. For detailed information about these and other performance-related compiler options, see "Optimization and tuning options" in the *XL C/C++ Compiler Reference*.

*Table 4. Performance-related compiler options and directives*

<b>-qfuncsect</b>	An enhancement added to <b>-qfuncsect</b> is to improve linker garbage collection of functions with XL C/C++ programs. <b>-qfuncsect</b> places instructions for each function in a separate object file control section or CSECT which may reduce the size of your program. Placing each function in its own CSECT enables the linker to perform garbage collection on a per function basis rather than per object file. For details, see the <b>-qfuncsect</b> section in the <i>XL C/C++ Compiler Reference</i> .
<b>-qhot</b>	Two suboptions <b>-qhot=fastmath</b> and <b>-qhot=nofastmath</b> are added to <b>-qhot</b> , to tune your applications to use the fast scalar versions of the math routines or to use the default versions. <b>-qhot=level=2</b> is also added for loop transformation analysis of nested loops. For details, see the <b>-qhot</b> section in the <i>XL C/C++ Compiler Reference</i> .
<b>-qinline=level=number</b>	A new option is added to <b>-qinline</b> to provide guidance to the compiler about the relative value of inlining in relation to the default value of 5. <i>number</i> is a range of integer values between 0 and 10 that indicates the level of inlining you want to use. For details, see <b>-qinline</b> in the <i>XL C/C++ Compiler Reference</i> .

Table 4. Performance-related compiler options and directives (continued)

<b>-qipa</b>	<p>A new enhancement added to <b>-qipa</b> is <b>-r -qipa=relink</b>. You can generate relinkable objects while preserving IPA information by specifying <b>-r -qipa=relink</b>. This creates a nonexecutable package that contains all object files. By using this suboption, you can postpone linking until the very last stage.</p> <p><b>-qipa=clonearch</b> is no longer supported. Consider using <b>-qtune=balanced</b>.</p> <p>For detailed information, see <b>-qipa</b> section in the <i>XL C/C++ Compiler Reference</i>.</p>
<b>-qpdf</b>	<p><b>-qpdf</b> provides suboptions to give you more control flexibility in controlling different PDF optimizations. For more information, see the <b>-qpdf1</b>, <b>-qpdf2</b> section in the <i>XL C/C++ Compiler Reference</i>.</p>
<b>-qprefetch</b>	<p>A new enhancement added to <b>-qprefetch</b> is <b>-qprefetch=assistthread</b>. <b>-qprefetch</b> inserts prefetch instructions automatically where there are opportunities to improve code performance. For details, see <b>-qprefetch</b> in the <i>XL C/C++ Compiler Reference</i>.</p>

For additional information about performance tuning and program optimization, see "Optimizing your applications" in the *XL C/C++ Optimization and Programming Guide*.

## New diagnostic reports

The new diagnostic reports can help you to identify opportunities to improve performance of code.

### Compiler reports in XML format

It is now possible to get information in XML format about some of the optimizations that the compiler was able to perform and also which optimization opportunities were missed. This information can be used to improve programmer productivity when tuning applications, especially high performance applications.

The information from the compiler is produced in XML 1.0 format. The report is defined by an XML schema and is easily consumable by tools that you can create to read and analyze the results. A stylesheet, `xlstyle.xsl`, is provided to render the report into a human readable format that can be read by anyone with a browser which supports XSLT.

In this release, there are four optimization categories in the report, one for inlining, one for loop transformations, one for data reorganizations, and one for profile-directed feedback information. The new **-qlistfmt** option and its associated suboptions generate the new XML 1.0 report.

For detailed information about this report and how to use it, see "Using reports to diagnose optimization opportunities" in the *XL C/C++ Optimization and Programming Guide*.

## Enhancements to profiling reports

Additional sections of the listing report have been added to help you understand your programs. When using the **-qreport** option with the **-qpdf2** option, you can get the following additional sections added to your listing file in the section entitled PDF Report:

### Loop iteration count

The most frequent loop iteration count and the average iteration count, for a given set of input data, is calculated for most loops in a program. This information is only available when the program is compiled at optimization level -O5.

### Block and call count

This section of the report covers the call structure of the program and the respective execution count for each called function. It also includes block information for each function. For non-user defined functions, only execution count is given. The total block and call coverage, and a list of the user functions ordered by decreasing execution count are printed in the end of this report section. In addition, the block count information is printed at the beginning of each block of the pseudo-code in the listing files.

### Cache miss

This section of the report is printed in a single table. It reports the number of cache misses for certain functions, with additional information about the functions such as: cache level, cache miss ratio, line number, file name, and memory reference.

**Note:** You must use the **-qpdf1=level=2** option to get this report. You can also select the level of cache to profile using the **PDF\_PM\_EVENT** environment variable during run time.

For detailed information about the profile-directed feedback, see "Using profile-directed feedback" in the *XL C/C++ Optimization and Programming Guide*.

For additional information about the listing files, see "Compiler listings" in the *XL C/C++ Compiler Reference*

## Report of data reorganization

The compiler can generate the following information in the listing files:

- Data reorganizations (a summary of useful information about how program variable data gets reorganized by the compiler)
- The location of data prefetch instructions inserted by the compiler

To generate data reorganization information, specify the optimization level **-qipa=level=2** or **-O5** together with **-qreport**. The data reorganization messages for program variable data are added to the data reorganization section of the listing file with the label DATA REORGANIZATION SECTION during the IPA link pass.

Reorganizations include:

- array splitting
- array transposing
- memory allocation merging
- array interleaving
- array coalescing



To generate information about data prefetch insertion locations, use the optimization level of **-qhot**, or any other option that implies **-qhot** together with **-qreport**. This information appears in the LOOP TRANSFORMATION SECTION of the listing file.

## Additional loop analysis

A new suboption has been added to **-qhot** to add some more aggressive loop analysis. **-qhot=level=2** together with **-qsmp** and **-qreport** add information about loop nests on which the aggressive loop analysis was performed to the LOOP TRANSFORMATION SECTION of the listing file. This information can also appear in the XML listing file created with the **-qlistfmt** option.

## New and enhanced diagnostic options

The entries in the following table describe new or changed compiler options and directives that give you control over compiler listings.

Information presented here is a brief overview. For detailed information about these and other performance-related compiler options, see "Listings, messages and compiler information" in the *XL C/C++ Compiler Reference*.

Table 5. Listings-related compiler options and directives

Option/directive	Description
<b>-qlistfmt</b>	Generates a report in an XML 1.0 format containing information about optimizations performed by the compiler and missed optimization opportunities. The report contains information about inlining, loop transformations, data reorganization and profile-directed feedback.
<b>-qreport</b>	The listing now contains a PDF report section when used with <b>-qpdf2</b> . Another new section in the listing files is a DATA REORGANIZATION section when used with <b>-qipa=level=2</b> or <b>-O5</b> .
<b>-qskipsrc</b>	Determines whether the source statements skipped by the compiler are shown in the SOURCE section of the listing file.

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## Utilization tracking and reporting

The utilization tracking and reporting feature is a lightweight and simple mechanism for tracking the compiler utilization within your organization. It is disabled by default. You can use this feature to detect whether your organization's use of the compiler exceeds your compiler license entitlements.

When utilization tracking is enabled, each invocation of the compiler is recorded in a compiler utilization file. You can run the utilization reporting tool to generate a report from one or more of these files to get a picture of the overall usage of the compiler within your organization. The **urt** command can be used to control how the report is generated. In particular, the report indicates whether the compiler usage complies with the number of Concurrent User licenses that you have purchased.

The utilization tracking and reporting feature is easy to set up and manage, and utilization tracking does not impact the usage or performance of the compiler.

For detailed information about the utilization tracking and reporting feature, see "Tracking and reporting compiler usage" in the *XL C/C++ Compiler Reference*.

## New or changed compiler options and directives

New and changed compiler options and directives are described in this section.

Compiler options can be specified on the command line or through directives embedded in your application source files. See the *XL C/C++ Compiler Reference* for detailed descriptions and usage information for these and other compiler options.

Table 6. New or changed compiler options and directives

Option/directive	Description
<b>-qarch</b>	A new suboption has been added to <b>-qarch</b> , specifying <b>-qarch=pwr7</b> produces object code that contains instructions that run on the POWER7 hardware platforms.
<b>-qassert</b>	<b>-qassert</b> is a new option for XL C/C++. It is used to provide information about the characteristics of the files that can help to fine-tune optimizations.
<b>-qconcurrentupdate</b>	If you are building kernel extensions, you must use <b>-qconcurrentupdate</b> to enable hot patching. For details, see <b>-qconcurrentupdate</b> in the <i>XL C/C++ Compiler Reference</i> .
<b>-qfuncsect</b>	In previous releases, <b>-qfuncsect</b> had minimal size reductions for C++ programs. You can see a significant improvement in the current release.
<b>-qfunctrace</b>	You can use <b>-qfunctrace</b> to trace the entry and exit points of functions in a compilation unit or only a specific list of functions.
<b>-qhot</b>	<p>A new suboption has been added for <b>-qhot</b>. The <b>-qhot</b> compiler option is a powerful alternative to hand tuning that provides opportunities to optimize loops and array language.</p> <p>The <b>-qhot=fastmath</b> option enables the replacement of math routines with available math routines from the XLOPT library only if <b>-qstrict=nolib</b> is enabled. <b>-qhot=nofastmath</b> disables the replacement of math routines by the XLOPT library. <b>-qhot=fastmath</b> is enabled by default if <b>-qhot</b> is specified regardless of the hot level.</p>
<b>-qinline</b>	Attempts to inline functions instead of generating calls to those functions, for improved performance.
<b>-qipa</b>	You can generate relinkable objects while preserving IPA information by specifying <b>-r -qipa=relink</b> .
<b>-qkeepinlines</b>	A new suboption <b>exports</b> has been added to the <b>-qkeepinlines</b> option. You can use <b>-qkeepinlines=exports</b> to make sure that the compiler keeps the list of symbols and their definitions from the shared object file compiled with an earlier version of the compiler.

Table 6. New or changed compiler options and directives (continued)



Option/directive	Description
<b>-qlanglvl</b>	<p> <b>C++0x</b> New suboptions have been added to <b>-qlanglvl</b>:</p> <ul style="list-style-type: none"> <li>• <b>-qlanglvl=autotypededuction</b>: Controls whether the auto type deduction feature is enabled. This feature can be used to delegate the task of type deduction of an auto variable to the compiler from the type of its initializer expression.</li> <li>• <b>-qlanglvl=c99longlong</b>: Controls whether the C99 long long feature is enabled. This feature improves source compatibility between the C and C++ languages.</li> <li>• <b>-qlanglvl=c99preprocessor</b>: Controls whether the C99 preprocessor features adopted in C++0x are enabled. This feature can be used to provide a more common preprocessor interface for C and C++ compilers.</li> <li>• <b>-qlanglvl=decltype</b>: Controls whether the decltype feature is enabled. This feature can be used to get a type that is based on the resultant type of a possibly type-dependent expression.</li> <li>• <b>-qlanglvl=delegatingctors</b>: Controls whether the delegating constructors feature is enabled. This feature can be used to concentrate common initializations in one constructor.</li> <li>• <b>-qlanglvl=extendedfriend</b>: Controls whether the extended friend declarations feature is enabled. This feature can be used to accept additional forms of non-function friend declarations.</li> <li>•  <b>IBM</b> <b>-qlanglvl=extendedintegersafe</b>: Controls whether or not unsigned long long int can be used as the type for decimal integer literals that do not have a suffix containing u or U and cannot be represented by the long long int type. This option takes effect only when the <b>-qlanglvl=c99longlong</b> option is specified.</li> <li>• <b>-qlanglvl=externtemplate</b>: Controls whether the explicit instantiation declarations feature is enabled. This feature can be used to suppress the implicit instantiation of a template specialization or its members.</li> <li>• <b>-qlanglvl=inlinenamespace</b>: Controls whether the inline namespace definitions feature is enabled. This feature can be used to define and specialize members of an inline namespace as if they were also members of the enclosing namespace.</li> <li>• <b>-qlanglvl=static_assert</b>: Controls whether the static assertions feature is enabled. This feature can be used to produce compile-time assertions for which a severe error message is issued on failure.</li> <li>• <b>-qlanglvl=variadic[templates]</b>: Controls whether the variadic templates feature is enabled. This feature can be used to define class or function templates that have any number (including zero) of parameters.</li> </ul>

Table 6. New or changed compiler options and directives (continued)

Option/directive	Description
<b>-qlibmpi</b>	You can use <b>-qlibmpi</b> to tune code based on the known behavior of the Message Passing Interface (MPI) functions.
<b>-qlistfmt</b>	Generates a report in an XML 1.0 format containing information about some optimizations performed by the compiler and some missed optimization opportunities for inlining, loop transformations, data reorganization and profile-directed feedback.
<b>-qnamemangling</b>	There is a new namemangling scheme for this release.
<b>-qpdf1,-qpdf2</b>	New options have been added to <b>-qpdf1,-qpdf2</b> .
<b>-qprefetch</b>	A new suboption has been added to <b>-qprefetch</b> . When you work with applications that generate a high cache-miss rate, you can use <b>-qprefetch=assistthread</b> to exploit assist threads for data prefetching.
<b>-qsaveopt -qnosaveopt</b>	The existing <b>-qsaveopt</b> option is enhanced to also include the user's configuration file name and the options specified in the configuration files.
<b>-qsimd</b>	Controls whether the compiler can automatically take advantage of vector instructions for processors that support them.
<b>-qskipsrc</b>	When a listing file is generated using the <b>-qsource</b> option, you can use <b>-qskipsrc</b> to control whether the source statements skipped by the compiler are shown in the source section of the listing file. Alternatively, you can use the <b>-qskipsrc=hide</b> option to hide the source statements skipped by the compiler.
<b>-qstackprotect</b>	You can use <b>-qstackprotect</b> to protect your applications against malicious code or programming errors that overwrite or corrupt the stack.
<b>-qstrict</b>	A new suboption has been added to the <b>-qstrict</b> option to allow more control over optimizations and transformations that violate strict program semantics.  <b>-qstrict=vectorprecision</b> disables vectorization in loops where it might produce different results in vectorized iterations than in nonvectorized ones.
<b>-qtune</b>	A new suboption has been added to <b>-qtune</b> . If you specify <b>-qtune=pwr7</b> , optimizations are tuned for the POWER7 hardware platforms.

Table 7. Deprecated directives and options

Option/directive	Description
<b>#pragma ibm critical</b>	This directive is deprecated and might be removed in a future release. You can use the OpenMP equivalent.
<b>#pragma ibm parallel_loop</b>	This directive is deprecated and might be removed in a future release. You can use the OpenMP equivalent.
<b>#pragma ibm schedule</b>	This directive is deprecated and might be removed in a future release. You can use the OpenMP equivalent.

Table 7. Deprecated directives and options (continued)

Option/directive	Description
<b>-Q</b>	This option is deprecated and replaced with <b>-qinline</b> .
<b>-qenablevmx</b>	This option is deprecated and replaced with the <b>-qsimd=auto</b> option.
<b>-qhot=simd   nosimd</b>	<b>-qhot=simd   nosimd</b> are deprecated and might be removed in a future release. You can use <b>-qsimd</b> .
<b>-qinfo=private</b>	<b>-qinfo=private</b> is deprecated and replaced with <b>-qreport</b> .
<b>-qinfo=reduction</b>	<b>-qinfo=reduction</b> is deprecated and replaced with <b>-qreport</b> .
<b>-qipa=inline   noinline</b>	<b>-qipa=inline   noinline</b> are deprecated and might be removed in a future release. You can use <b>-qinline</b> .
<b>-qipa=clonearch   noclonearch</b>	<b>-qipa=clonearch   noclonearch</b> is no longer supported. You can use <b>-qtune=balanced</b> .
<b>-qipa=clonearch   noclonearch</b>	<b>-qipa=cloneproc   nocloneproc</b> is no longer supported. You can use <b>-qtune=balanced</b> .

## Built-in functions new for this release

This section lists built-in functions that are new for this release.

For more information about built-in functions provided by XL C/C++, see Compiler built-in functions in the *XL C/C++ Compiler Reference*.

### VSX built-in functions

Vector Scalar eXtension (VSX) is newly added for POWER7 processors.

For more information about VSX built-in functions, see Vector built-in functions.

### POWER7 prefetch extensions and cache control

The POWER7 processor has cache control and stream prefetch extensions that support store stream prefetch and prefetch depth control. XL C/C++ provides the following new built-in functions to provide direct programmer access to these instructions:

- `__protected_stream_stride`
- `__transient_protected_stream_count_depth`
- `__unlimited_protected_stream_depth`
- `__transient_unlimited_protected_stream_depth`
- `__partial_dcbt`
- `__dcbtt`
- `__dcbtstt`
- `__dcbflp`

The compiler can insert the built-in functions automatically when it optimizes the code. You can disable automatic use of these instructions with **-qnoprefetch**.

For more information about the directives, see built-in functions in the *XL C/C++ Compiler Reference*.

## POWER7 hardware built-in functions

New XL C/C++ built-in functions corresponding to each new POWER7 hardware instruction are added in this release. With these functions, you can directly manipulate specific hardware instructions in your code, which can improve the performance of your application.

- `__bpermd`
- `__cbcdtd`
- `__cdtbcd`
- `__load8r`
- `__store8r`
- `__divde`
- `__divdeu`
- `__cmpb`
- `__divwe`
- `__divweu`
- `__addg6s`

## Conversion functions

These new functions convert between Declets and Binary Coded Decimal.

- `__cbcdtd`
- `__cdtbcd`

## Comparison functions

This new function compares bytes.

- `__cmpb`

## Decimal floating-point functions

This new function adds and generates sixes.

- `__addg6s`

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## Compatibility of redistributable library libxlopt.a

Starting from this release, compatibility of the redistributable library, `libxlopt.a`, will be maintained. The `libxlopt.a` library will be compatible with compiler XL C/C++ for AIX, V11.1 or later.

Previously, the version of the redistributable library had to be the same as the version of the compiler with which the application was compiled.

You can download and use the latest redistributable library for multiple applications compiled with XL C/C++ V11.1, or later, on supported platforms.

For more information about the redistributable libraries, see Redistributable libraries in the *XL C/C++ Compiler Reference*.

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## Chapter 3. Enhancements added in previous versions

This section lists the enhancements added to the compiler in the previous releases.

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### Enhancements added in Version 10.1

This section describes features and enhancements added to the compiler in Version 10.1.

#### Operating system support

IBM XL C++ for AIX, V10.1 supports AIX V6.1 and AIX V5.3.

This version of the compiler does not support AIX V5.2.

#### C++0x

This release introduces support for a new version of the standard for the C++ programming language - specifically C++0x. This standard has not yet been officially adopted but we are beginning to support some of its features.

**Note:** C++0x is a new version of the C++ programming language standard. This is a draft standard and has not been officially adopted in its entirety. The implementation of C++0x is based on IBM's interpretation of the draft C++0x standard and is subject to change at any time without notice. IBM makes no attempt to maintain compatibility with earlier releases and therefore the C++0x language extension should not be relied on as a stable programming interface.

Specifically, in this release:

- we add a new language level
- we introduce new integer promotion rules for arithmetic conversions with long long data types
- the C++ preprocessor now supports C99 features

#### New language level - extended0x

The default **-qlanglvl** compiler option remains **extended** when invoking the C++ compiler.

A new suboption has been added to the **-qlanglvl** option in this release. **-qlanglvl=extended0x** is used to allow users to try out early implementations of any features of C++0x that are currently supported by XL C/C++.

#### C99 long long under C++

With this release of XL C/C++ V11.1, compiler behavior changes when performing certain arithmetic operations with integral literal data types. Specifically, the integer promotion rules have changed.

Previously, in C++ (and as an extension to C89), when compiling with **-qlonglong**, an unsuffixed integral literal would be promoted to the first type in this list into which it fitted:

int

```
long int
unsigned long int
long long int
unsigned long long
```

Starting with this release and when compiling with **-qlanglvl=extended0x**, the compiler now promotes unsuffixed integral literal to the first type in this list into which it fits:

```
int
long int
long long int
unsigned long long
```

**Note:** Like our implementation of the C99 Standard in the C compiler, C++ will allow promotions from long long to unsigned long long if a value cannot fit into a long long type, but can fit in an unsigned long long. In this case, a message will be generated.

The macro `__C99_LLONG` has been added for compatibility with C99. This macro is defined to 1 with **-qlanglvl=extended0x** and is otherwise undefined.

For more information, see "Integral and floating-point promotions" in the *XL C/C++ Language Reference*.

## Preprocessor changes

The following changes to the C++ preprocessor make it easier to port code from C to C++:

- Regular string literals can now be concatenated with wide-string literals.
- The `#line <integer>` preprocessor directive has a larger upper limit. It has been increased from 32767 to 2147483647 for C++.
- C++ now supports `_Pragma` operator.
- These macros now apply to C++ as well as C:
  - `__C99_MACRO_WITH_VA_ARGS` (also available with **-qlanglvl=extended**)
  - `__C99_MAX_LINE_NUMBER` (also available with **-qlanglvl=extended**)
  - `__C99_PRAGMA_OPERATOR`
  - `__C99_MIXED_STRING_CONCAT`

**Note:** Except as noted, these C++ preprocessor changes are only available when compiling with **-qlanglvl=extended0x**.

For additional information about the language standards supported by XL C/C++, see "Language levels and extensions" in the *XL C/C++ Language Reference*.

## Other XL C/C++ language-related updates

### Vector data types

Vector data types can now use some of the operators that can be used with base data types such as:

- unary operators
- binary operators



- relational operators

## Thread local storage

The thread local storage support has been enhanced to include `__attribute__((tls-model("string")))` where *string* is one of `local-exec`, `initial-exec`, `local-dynamic`, or `global-dynamic`.

## OpenMP 3.0

In IBM XL C++ for AIX, V10.1, XL C/C++ supports the OpenMP API Version 3.0 specification. The XL C/C++ implementation is based on IBM's interpretation of the OpenMP Application Program Interface Draft 3.0 Public Comment.

The main differences between Version 2.5 and Version 3.0 are:

- Addition of task level parallelization. The new OpenMP constructs `TASK` and `TASKWAIT` give users the ability to parallelize irregular algorithms, such as pointer chasing or recursive algorithms for which the existing OpenMP constructs were not adequate.
- for loops can now contain *var* values of unsigned int and pointer type as well as signed int.
- Stack size control. You can now control the size of the stack for threads created by the OMP runtime library using the new environment variable `OMP_STACKSIZE`.
- Users can give hints to the desired behavior of waiting threads using new environment variables `OMP_WAIT_POLICY` and `OMP_SET_POLICY`.
- Storage reuse. Some restrictions on the `PRIVATE` clause have been removed. A list item that appears in the reduction clause of a parallel construct can now also appear in a private clause on a work-sharing construct.
- Scheduling. A new `SCHEDULE` attribute, `auto`, allows the compiler and runtime system to control scheduling.
- Consecutive loop constructs with `STATIC` schedule can now use `nowait`.
- Nesting support - a `COLLAPSE` clause has been added to the `DO`, `FOR`, `PARALLEL FOR`, and `PARALLEL DO` directives to allow parallelization of perfect loop nests. This means that multiple loops in a nest can be parallelized.
- `THREADPRIVATE` directives can now apply to variables at class scope in addition to file and block scope.
- Parallelization of iterator loops of canonical form including those with random access iterators.

For more information, see:

- "Using OpenMP directives" in the *XL C/C++ Optimization and Programming Guide*
- [www.openmp.org](http://www.openmp.org)

## Performance and optimization

Some features and enhancements can assist with performance tuning and optimization of your application.

### Enhancements to `-qstrict`

Many suboptions have been added to the `-qstrict` option to allow more fine-grained control over optimizations and transformations that violate strict program semantics. In previous releases, the `-qstrict` option disabled all transformations that violate strict program semantics. This is still the behavior if

you use **-qstrict** without suboptions. Likewise, in previous releases **-qnostrict** allowed transformations that could change program semantics. Because a higher level of optimizations might require relaxing strict program semantics, the addition of the suboptions relaxes selected rules to get specific benefits of faster code without turning off all semantic verifications.

You can use 16 new suboptions separately or use a suboption group. Here is a list of suboption groups:

**all** Disables all semantics-changing transformations, including those controlled by the other suboptions.

**ieeefp** Controls whether individual operations conform to IEEE 754 semantics.

**order** Controls whether individual operations can be reordered in a way that violate program language semantics.

**precision** Controls optimizations and transformations that can affect the precision of program results.

**exceptions** Controls optimizations and transformations that can affect the runtime exceptions generated by the program.

For detailed information about these suboptions, see "-qstrict" in the *XL C/C++ Compiler Reference*.

## Performance-related compiler options and directives

The entries in the following table describe new or changed compiler options and directives.

Information presented here is a brief overview. For detailed information about these and other performance-related compiler options, see "Optimization and tuning options" in the *XL C/C++ Compiler Reference*.

*Table 8. Performance-related compiler options and directives*

Option/directive	Description
<b>-qstrict</b>	Many new suboptions have been added to give you more control over the relaxation of program semantic rules in order to gain some performance benefits.
<b>-qreport</b>	The listing now contains information about how many streams are created for each loop and which loops cannot be SIMD vectorized due to non-stride-one references. You can use this information to improve the performance of your applications.
<b>-qsmp</b>	When <b>-qsmp=omp</b> is in effect, the additional functionality of OpenMP API 3.0 is now available. For more information, see "OpenMP 3.0" on page 27.

For additional information about performance tuning and program optimization, see "Optimizing your applications" in the *XL C/C++ Optimization and Programming Guide*.

## New or changed compiler options and directives

Compiler options can be specified on the command line or through directives embedded in your application source files. See the *XL C/C++ Compiler Reference* for detailed descriptions and usage information for these and other compiler options.

Table 9. New or changed compiler options and directives

Option/directive	Description
<b>-qstrict</b>	Many suboptions have been added to the <b>-qstrict</b> option to allow more control over optimizations and transformations that violate strict program semantics. See “Performance and optimization” on page 15 for more information.
<b>-qshowmacros</b>	When used in conjunction with the <b>-E</b> option, the <b>-qshowmacros</b> option replaces preprocessed output with macro definitions. There are suboptions provided to control the emissions of predefined and user-defined macros more precisely.
<b>-qreport</b>	When used together with compiler options that enable automatic parallelization or vectorization, the <b>-qreport</b> option now reports the number of streams in a loop and produces information when loops cannot be SIMD vectorized due to non-stride-one references.
<b>-qnamemangling</b>	There is a new namemangling scheme for this release.
<b>-qsmp</b>	When <b>-qsmp=omp</b> is in effect, the additional functionality of OpenMP API 3.0 is now available. For more information, see “OpenMP 3.0” on page 27.
<b>#pragma init</b> and <b>#pragma fini</b>	Programmers can use <b>#pragma init</b> and <b>#pragma fini</b> to specify a list of functions to run before or after main() or when shared libraries are loaded or unloaded. These functions can be used to do initialization and cleanup. <b>Note:</b> A C++ invocation, such as <b>xlC</b> or the redistributable tools <b>linkxlC</b> or <b>makeC++SharedLib</b> must be used at link time.
<b>-qtimestamps</b>	This option can be used to remove timestamps from generated binaries.
<b>-qtls</b>	The thread local storage support has been enhanced to include <code>__attribute__((tls-model("string")))</code> where <i>string</i> is one of <i>local-exec</i> , <i>initial-exec</i> , <i>local-dynamic</i> , or <i>global-dynamic</i> .
<b>-qinfo</b>	The suboptions <b>als</b> and <b>noals</b> have been added to the <b>qinfo</b> option to report (or not report) possible violations of the ANSI aliasing rule.
<b>-qunique</b>	<b>-qunique</b> now applies to both C and C++.

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## Enhancements added in Version 9.0

This section describes features and enhancements added to the compiler in Version 9.0.

### C/C++ language-related updates

The default language level for C compilations changed, and new support for extensions to the C and C++ programming languages was introduced.

## Default language level changed for C - extc99

The default **-qlanglvl** compiler option setting is **extc99** when invoking the C compiler with the **xlC** invocation. This change allows you to use C99 features and headers without having to explicitly specify the **extc99** suboption.

You might encounter issues with the following when compiling with the new default **-qlanglvl=extc99** setting:

- Pointers can be qualified with **restrict** in C99, so **restrict** can not be used as an identifier.
- C99 treatment of long long data differs from the way long long data is handled in C89.
- C99 header files define new macros: **LLONG\_MAX** in **limits.h**, and **va\_copy** in **stdarg.h**.
- The value of macro **\_\_STDC\_VERSION\_\_** changes from 199409 to 19990.

To revert to previous **xlC** behavior, specify **-qlanglvl=extc89** when invoking the compiler.

## Decimal floating point support for C and C++

Decimal floating point arithmetic offers greater computational performance and precision in business and financial applications where numeric data I/O is usually performed in decimal form. Data conversions from decimal type to binary floating point type and back are avoided, as are inherent rounding errors accumulated during data conversions.

XL C/C++ adds support for decimal floating point arithmetic with the following new compiler options:

Table 10. Decimal floating point compiler options

Option/directive	Description
<b>-qdfp</b>   <b>-qnodfp</b>	Specifying <b>-qdfp</b> enables compiler support for decimal floating-point data types and literals. If you specify <b>-qdfp</b> when compiling for an architecture that does not support decimal floating-point computation, the compiler will assume <b>-qfloat=dfpemulate</b> and enable software emulation of decimal floating-point computations.
<b>-qfloat=dfpemulate</b>   <b>nodfpemulate</b>	Specifying <b>-qfloat=dfpemulate</b> instructs the compiler to use software emulation when handling decimal floating point computations. This option can be used with any architecture supported by XL C/C++.
<b>-y</b>	There are suboptions specific to decimal floating-point arithmetic for the <b>-y</b> option to control rounding of constant expressions.

**Note:** Compiler support for decimal floating point operations requires AIX 5L for POWER version 5.3 with the 5300-06 Technology Level or higher.

For more information, see Extension for the programming language C to support decimal floating-point arithmetic: TR 24732 and Decimal Types for C++: Draft 4.

## TR1 library extensions for C++

XL C/C++ Version 9.0 introduced support for numerous extensions to the C++ language as defined by the Draft Technical Report on C++ Library Extensions (TR1).

For more information on these language extensions, see Draft Technical Report on C++ Library Extensions (TR1).

## Architecture and processor support

The **-qarch** and **-qtune** compiler options control the code generated by the compiler. These compiler options adjust the instructions, scheduling, and other optimizations to give the best performance for a specified target processor or range of processors.

### New default settings for **-qarch**, **-qtune**

The new default **-qarch** and **-qtune** settings are:

- **-qarch=ppc**
- **-qtune=balanced**

The **-qtune=balanced** suboption is new for this release, and becomes the default **-qtune** setting when certain **-qarch** settings are specified. Using **-qtune=balanced** instructs the compiler to tune generated code for optimal performance across a range of recent processor architectures, including POWER6®.

**Important:** The change to the **-qarch** default suboption setting can affect the results of floating-point short arithmetic computations in your programs. The **-qarch=com** default used in the previous release of the compiler caused such computations to be performed using double precision instructions followed by rounding. The new **-qarch=ppc** default instructs the compiler to generate code that uses short floating point instructions. The difference in computational method can affect the precision of computational results. To achieve the behavior of the previous **-qarch=com** default, specify the new **-qfloat=nosingle** compiler option when compiling your application.

### New support for POWER6 processors

XL C/C++ Version 9.0 expanded the list of **-qarch** and **-qtune** suboptions to support the newly-available POWER6 processors.

The following **-qarch** and **-qtune** options are now available:

- **-qarch=pwr6**
- **-qarch=pwr6e**
- **-qtune=pwr6**

### Support removed for selected processors

XL C/C++ Version 9.0 removed support for processor architectures not supported by AIX V5.2, such as POWER, POWER2™, and PowerPC® 601. As a result, the following **-qarch** and **-qtune** suboption settings are no longer supported.

- **-qarch= com | pwr | pwr2 | pwr2s | p2sc | 601 | 602 | 603**
- **-qtune= pwr | pwr2 | pwr2s | pwr6 | pwr6e | pwr6x | p2sc | 601 | 602 | 603**

The compiler continues to recognize these suboption settings, and will still generate code for their corresponding architectures. However, in some cases the behavior of that code might differ from code generated by previous versions of the compiler. Also, code generated for these unsupported architectures may not even execute at all on supported AIX systems because of differences in architecture.

Use caution if you will still be using these unsupported **-qarch** and **-qtune** suboption settings.

## Performance and optimization

Many enhancements were made to assist with performance tuning and program optimization.

### Performance-related compiler options and directives

The entries in the following table describes new or changed compiler options and directives.

Information presented here is just a brief overview. For more information about these and other performance-related compiler options, refer to "Optimization and tuning options" in the *XL C/C++ Compiler Reference*.

Table 11. Performance-related compiler options and directives

Option/directive	Description
<b>-qalias= global   noglobal</b>	These new <b>-qalias</b> suboptions enable or disable the application of language-specific aliasing rules across compilation units during link time optimization.
<b>-qalias= restrict   norestrict</b>	These new <b>-qalias</b> suboptions enable or disable optimization for restrict qualified pointers. Specifying <b>-qalias=restrict</b> will usually improve performance for code that uses restrict qualified pointers. You can use <b>-qalias=norestrict</b> to preserve compatibility with code compiled with versions of the compiler previous to V9.0.
<b>-qfloat= fenv   nofenv</b>	These new <b>-qfloat</b> suboptions inform the compiler if code has a dependency on the floating-point hardware environment, such as explicitly reading or writing the floating-point status and control register. Specifying <b>-qfloat=nofenv</b> indicates that there is no dependency on the hardware environment, allowing the compiler to perform aggressive optimizations.
<b>-qfloat= hscmplx   nohscmplx</b>	Specifying <b>-qfloat=hscmplx</b> improves optimization of operations involving complex division and complex absolute values.
<b>-qfloat= rngchk   norngchk</b>	Specifying <b>-qfloat=rngchk</b> enables range checking on input arguments for software divide and inlined sqrt operations. Specifying <b>-qfloat=norngchk</b> instructs the compiler to skip range checking, allowing for better performance in certain circumstances. Specifying the <b>-qnostrict</b> compiler option sets <b>-qfloat=norngchk</b> .

Table 11. Performance-related compiler options and directives (continued)

Option/directive	Description
<b>-qfloat= single   nosingle</b>	Specifying <b>-qfloat=single</b> instructs the compiler to compute single-precision floating-point values using single-precision arithmetic instructions supported by all current PowerPC processors. Use <b>-qfloat=nosingle</b> if you need to preserve the computational behavior in applications originally compiled for earlier processors, such as POWER and POWER2 processors. You may also need to specify <b>-qfloat=norndsnl</b> to obtain the same computational results.
<b>-qipa=threads=[auto   noauto   number]</b>	This new <b>-qipa</b> suboption lets you specify how many threads the compiler will assign to code generation during the second IPA pass.
<b>-qminimaltoc   -qnominimaltoc</b>	Specifying <b>-qminimaltoc</b> helps avoid toc overflow conditions in 64-bit compilations by placing toc entries into a separate data section for each object file.
<b>-qpdf</b>	The <b>-qpdf</b> option can now be used to provide profile-directed feedback on specific objects. See "Object level profile-directed feedback" in the <i>XL C/C++ Optimization and Programming Guide</i> for more information.
<b>-qsmp= threshold=n</b>	When <b>-qsmp=auto</b> is in effect, this new suboption lets you specify the amount of work required in a loop before the compiler will consider it for automatic parallelization.
<b>-qspeculateabsolutes   -qnospeculateabsolutes</b>	During program optimization, <b>-qnospeculateabsolutes</b> works with <b>-qtocmerge -bI:file</b> for non-IPA links and <b>-bI:file</b> for IPA links to disable speculation of variables at absolute addresses.
<b>#pragma expected_value(param, value)</b>	Use the <b>#pragma expected_value</b> directive to specify a value that a parameter passed in a function call is most likely to take at run time. The compiler can use this information to perform certain optimizations, such as function cloning and inlining.

## Built-in functions in Version 9.0

Some built-in functions were added in Version 9.0.

For more information on built-in functions provided by XL C/C++, see "Compiler built-in functions" in the *XL C/C++ Compiler Reference*.

## PowerPC cache control

The PowerPC architecture specifies the **dcbst** and **dcbf** cache copy instructions. The following new built-in functions provide direct programmer access to these instructions.

- `void __dcbst(const void* addr);` /\* Data Cache Block Store \*/
- `void __dcbf(const void* addr);` /\* Data Cache Block Flush \*/



## POWER6 prefetch extensions and cache control

The POWER6 processor has cache control and stream prefetch extensions with support for store stream prefetch and prefetch depth control. XL C/C++ provides the following new built-in functions to provide direct programmer access to these instructions.

- `void __dcbfl(const void* addr);` /\* pwr6 - Data Cache Block Flush from L1 data cache only \*/
- `void __protected_unlimited_stream_set(unsigned int direction, const void* addr, unsigned int ID);` /\* Supported by pwr5 and pwr6 \*/
- `void __protected_unlimited_store_stream_set(unsigned int direction, const void* addr, unsigned int ID);` /\* Supported by pwr6 \*/
- `void __protected_store_stream_set(unsigned int direction, const void* addr, unsigned int ID);` /\* Supported by pwr6 \*/
- `void __protected_stream_count_depth(unsigned int unit_cnt, unsigned int prefetch_depth, unsigned int ID);` /\* Supported by pwr6 \*/

## Other new or changed compiler options

Compiler options can be specified on the command line or through directives embedded in your application source files. See the *XL C/C++ Compiler Reference* for detailed descriptions and usage information for these and other compiler options.

Table 12. Other new or changed compiler options

Option/directive	Description
<b>-C!</b>	Specifying the <b>-C!</b> compiler option removes comments from preprocessed output.
<b>-qoptdebug</b>   <b>-qnootdebug</b>	When used with optimization levels of <b>-O3</b> or higher, the new <b>-qoptdebug</b> option instructs the compiler to produce optimized pseudocode that can be read by a symbolic debugger.
<b>-qreport</b>	When used together with compiler options that enable automatic parallelization or vectorization, the <b>-qreport</b> option produces a pseudo-code listing showing how program loops are parallelized and vectorized. The report also provides diagnostic information if the compiler is not able to parallelize or vectorize a given loop.
<b>-qsaveopt</b>   <b>-qnosaveopt</b>	In previous releases, the <b>-qsaveopt</b> option stored the command line options used to compile a file into the resulting object file. In Version 9.0, the information stored in the object file expanded to also include version and level information for each compiler component invoked during compilation.
<b>-qsmp=stackcheck</b>	This new <b>-qsmp</b> suboption instructs the compiler to check for stack overflow by slave threads at run time, and issue a warning if the remaining stack size is less than the number of bytes specified by the <b>stackcheck</b> option of the <b>XL SMP OPTS</b> environment variable.
<b>-qtemplatedepth=number</b>	<b>-qtemplatedepth</b> specifies the maximum number of recursively-instantiated template specializations that the compiler will process.



Table 12. Other new or changed compiler options (continued)

Option/directive	Description
<b>-qversion=verbose</b>	The <b>-qversion</b> option adds a new <b>verbose</b> suboption. Specifying <b>-qversion=verbose</b> instructs the compiler to display the version and level information for each compiler component invoked during compilation.



---

## Chapter 4. Setting up and customizing XL C/C++

For complete prerequisite and installation information for XL C/C++, refer to "Before installing" 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 by creating your own.

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 you specify in your custom configuration files together with compiler settings specified in the default configuration file. Compiler updates that might later affect settings in the default configuration file does not affect the settings in your custom configuration files.

For more information, see "Using custom compiler configuration files" in the *XL C/C++ Compiler Reference*.

---

### Configuring compiler utilization tracking and reporting

In addition to the compiler configuration file, there is a separate configuration file for the utilization tracking and reporting feature. Utilization tracking is disabled by default, but you can enable it by modifying an entry in this configuration file. Various other aspects of utilization tracking can also be configured using this file.

Although the compiler configuration file is separate from the utilization tracking configuration file, it contains an entry that specifies the location of the utilization tracking configuration file so that the compiler can find this file.

For more information about how to configure the utilization tracking and reporting feature, see Tracking and reporting compiler usage in the *XL C/C++ Compiler Reference*.



---

## Chapter 5. Developing applications with XL C/C++

C/C++ application development consists of repeating cycles of editing, compiling and linking (by default a single step combined with compiling), and running.

### Notes:

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

---

### The compiler phases

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

1. Preprocessing of source files
2. Compilation, which may 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. Assemble 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 **-qphsinfo**.

---

### Editing C/C++ source files

To create C/C++ source programs, you can use any text editor available to your system, such as **vi** or **emacs**.

Source programs must be saved using a recognized file name suffix. See the “XL C/C++ input and output files” on page 42 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*.

---

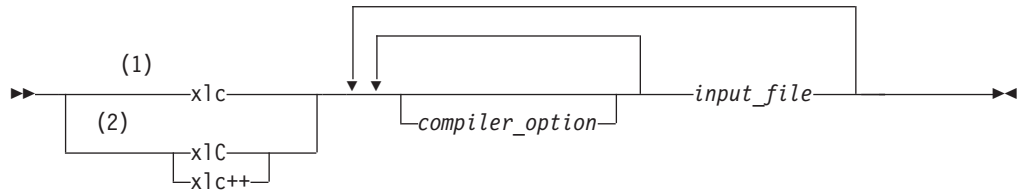
### Compiling with XL C/C++

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 or C++ source files, assemble any `.s` and `.S` files, and link the object files and libraries into an executable program.

To compile a source program, use the basic invocation syntax shown below:



### Notes:

- 1 Basic invocation to compile C source code
- 2 Basic invocations to compile C++ source code

For most applications, you should compile with `xlc`, `xlc++`, or a thread safe counterpart. You can use `xlc++` to compile either C or C++ program source, but compiling C++ files with `xlc` may result in link or run time errors because libraries required for C++ code are not specified when the linker is called by the C compiler.

Additional 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. See "Invoking the compiler" in the *XL C/C++ Compiler Reference* for more information about compiler invocation commands available to you, including special invocations intended to assist developers migrating from a GNU compilation environment to XL C/C++.

## Compiling parallelized XL C/C++ applications

XL C/C++ provides thread-safe compiler invocation commands that you can use when compiling parallelized applications for use in multiprocessor environments.

These invocations are similar to their corresponding base compiler invocations, except that they link and bind compiled objects to thread-safe components and libraries. The generic XL C/C++ thread-safe compiler invocations include:

- `xlc_r`, `xlc_r7`, `xlc128_r`, `xlc128_r7`
- `xlc++_r`, `xlc++_r7`, `xlc++128_r`, `xlc++128_r7`
- `xlc_r`, `xlc_r7`, `xlc128_r`, `xlc128_r7`

XL C/C++ provides additional thread-safe invocations to meet specific compilation requirements. See "Invoking the compiler" in the *XL C/C++ Compiler Reference* for more information.

**Note:** Using any of these commands alone does not imply parallelization. For the compiler to recognize SMP or OpenMP directives and activate parallelization, you must also specify `-qsmp` compiler option. In turn, you should specify the `-qsmp` option only in conjunction with one of these thread-safe invocation commands. When you specify `-qsmp`, the driver links in the libraries specified on the `smp libraries` line in the active stanza of the configuration file.

For more information on parallelized applications see "Parallelizing your programs" in the *XL C/C++ Optimization and Programming Guide*.

## 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:

- On the command-line with command-line compiler options
- In your source code using directive statements
- In a makefile
- In the stanzas found in a compiler configuration file
- Or by using any combination of these techniques

It is possible for option conflicts and incompatibilities to occur when multiple compiler options are specified. To resolve these conflicts in a consistent fashion, the compiler usually applies the following general priority sequence to most options:

1. Directive statements in your source file *override* command-line settings
2. Command-line compiler option settings *override* configuration file settings
3. Configuration file settings *override* default settings

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

**Note:** Some compiler options do not follow the priority sequence described above.

For example, the **-I** compiler option is a special case. The compiler searches any directories specified with **-I** in the `vac.cfg` file before it searches the directories specified with **-I** on the command-line. The option is cumulative rather than preemptive.

See the *XL C/C++ Compiler Reference* for more information about compiler options and their usage.

You can also pass compiler options to the linker, assembler, and preprocessor. See "Compiler options reference" in the *XL C/C++ Compiler Reference* for more information about compiler options and how to specify them.

### Reusing GNU C/C++ compiler options with `gxc` and `gxc++`

XL C/C++ includes various features to help you transition from GNU C/C++ compilers to XL C/C++ including `gxc` and `gxc++` commands.

Each of the `gxc` and `gxc++` utilities accepts GNU C or C++ compiler options and translates them into comparable XL C/C++ options. Both utilities use the XL C/C++ options to create an `xlc` or `xlc++` invocation command, which is then used to invoke the compiler. These utilities are provided to help you reuse makefiles created for applications previously developed with GNU C/C++. However, to fully exploit the capabilities of XL C/C++, you should use the XL C/C++ invocation commands and their associated options.

The actions of `gxc` and `gxc++` are controlled by the configuration file `gxlc.cfg`. The GNU C/C++ options that have an XL C/C++ counterpart are shown in this

file. Not every GNU option has a corresponding XL C/C++ option. `gxc` and `gxc++` return warnings for input options that were not translated.

The `gxc` and `gxc++` option mappings are modifiable. For information on using the `gxc` or `gxc++` configuration file, see "Reusing GNU C/C++ compiler options with `gxc` and `gxc++`" in the *XL C/C++ Compiler Reference* .

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

These file types 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 13. Input file types

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

Table 14. Output file types

Filename extension	Description
a.out	Default name for executable file created by the compiler
.d	Target file suitable for inclusion in a makefile
.i	Preprocessed source files
.lst	Listing files
.o	Object files
.s	Assembler files
.so	Shared object files
.u	Make dependency 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, running the following command:

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

compiles `file1.C` and `file3.C` to produce the object files `file1.o` and `file3.o`, then all object files (including `file2.o`) are submitted to the linker to produce one executable.



## 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
```

For more information about compiling and linking your programs, see:

- "Linking" in the *XL C/C++ Compiler Reference*
- "Constructing a library" in the *XL C/C++ Optimization and Programming Guide*

## Relinking an existing executable file

The linker accepts executable files as input, so you can link an existing executable file with updated object files.

You cannot, however, relink executable files that were previously linked using the `-qipa` option.

If you have a program consisting of several source files and only make localized changes to some of the source files, you do not necessarily have to compile each file again. Instead, you can include the executable file as the last input file when compiling the changed files:

```
xlc -omansion front_door.c entry_hall.c parlor.c sitting_room.c \
    master_bath.c kitchen.c dining_room.c pantry.c utility_room.c

vi kitchen.c # Fix problem in OVEN function

xlc -o newmansion kitchen.c mansion
```

Limiting the number of files to compile and link the second time reduces the compile time, disk activity, and memory use.

**Note:** You should avoid this type of linking unless you are experienced with linking. If done incorrectly, it can result in interface errors and other problems. If you do encounter problems, compiling with the `-qextchk` compiler option can help you diagnose problems with linking.

## Dynamic and static linking

XL C/C++ allows your programs 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 may perform better than statically linked programs if several programs use the same shared routines at the same time. They also allow you to upgrade the routines in the shared libraries without relinking.

Because this form of linking is the default, you need no additional options to turn it on.

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 and run on systems without the XL C/C++ runtime libraries. They may 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. They also may 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

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.

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

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`.

### Canceling execution

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

To cancel a running program, press the **Ctrl+C** key 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. Other environment variables do not control actual runtime behavior, but can have an impact on how your applications will run.

For more information on 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

In general, applications linked on a system using an earlier version of AIX will run with more recent versions of AIX. However, applications linked on a system using a newer version of AIX will not necessarily run with earlier versions of AIX.

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 will need to install a runtime environment on that system.

You can obtain the latest XL C/C++ Runtime Environment PTF images, together with licensing and usage information, from the XL C/C++ Support page at:

## 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++.

Specifying the **-g** or **-qlinedebug** compiler options at compile time instructs the XL C/C++ compiler to include debugging information in compiled output. For more information debugging options, see "Error checking and debugging" in the *XL C/C++ Compiler Reference*.

You can then use **dbx**, the IBM Debugger for AIX, or any other symbolic debugger that supports the AIX XCOFF executable format to step through and inspect the behavior of your compiled application.

Optimized applications pose special challenges when debugging. When debugging highly optimized applications, you should consider using the **-qoptdebug** compiler option. For more information about optimizing your code, see "Optimizing your applications" in the *XL C/C++ Optimization and Programming Guide*.

## Determining what level of XL C/C++ is installed

If contacting software support for assistance, you will need to know what level of XL C/C++ is installed on a particular machine.

To display the version and release level of the compiler you have installed on your system, invoke the compiler with the **-qversion** compiler option.

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

```
xlc++ -qversion=verbose
```



---

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Program Number: 5724-X13

Printed in USA

GI11-9417-00

