

# Oracle® Developer Studio 12.5: C++ User's Guide

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## Examples

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## Using This Documentation

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- **Overview** – Describes the Oracle Developer Studio 12.5 C++ Compiler
- **Audience** – Application developers, system developers, architects, support engineers
- **Required knowledge** – Programming experience, software development testing, aptitude to build and compile software products

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**PART I**

## **C++ Compiler**



# The C++ Compiler

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This chapter provides general information about the current Oracle Developer Studio C++ compiler.

## 1.1 New Features and Functionality of the Oracle Developer Studio 12.5 C++ 5.14 Compiler

This section provides a summary list of the new features and changed functionality introduced in the Oracle Developer Studio 12.5 C++ 5.14 Compiler release.

- Support for SPARC M6, M7, and T7 processors.
- Support for the Intel Broadwell/avx2\_i processor.
- Support for x86 dataspace profiling.
- The default compilation mode on Oracle Solaris is `-compat=5` with `-library=Cstd` (C++03 mode with the Sun ABI and `libcstd` library). The default compilation mode on Oracle Linux is `-std=c++03` (C++03 mode with the g++ ABI and runtime libraries).
- In `-compat=5` mode on all platforms, correct name mangling is now the default. Previously, bugs in name mangling were the default on SPARC, and on x86 with `-m32`.
- New compiler options:
  - `-abiopt=[mangle5|mangle6]` is available only in `-compat=5` mode. The default is `mangle6`, correct name mangling. On Oracle Solaris SPARC, and on Oracle Solaris x86 with `-m32`, you can specify `mangle5` for compatibility with possibly buggy name mangling of older compilers.
  - `-features=[no%]mergestrings` causes the compiler to put string literals and other suitable `const` or read-only data into a special section of the binary where the linker removes duplicate strings. This option is available only on SPARC.
  - `-pedantic` emits warnings or errors for code that is accepted by default but does not conform to the C++ Standard.
  - `-xatomic` specifies which atomics support runtime library is linked.

- `-xcheck=noreturn` informs the compiler to add code to cause a runtime error if a routine which has been described as "do not return" returns.
- `-xsecure_code_analysis` enables compiler secure code analysis to find and display possible memory safety violations at compile time.

## 1.1.1 C++11 Standard

Oracle Developer Studio 12.5 provides full support for C++11.

The `g++ 4.8.2` library provided with Oracle Solaris Studio 12.4 did not follow all of the requirements of C++11. The standard string and list classes in particular required changes that would break binary compatibility.

The `g++ 5.1` release provides a choice of compatibility with `g++ 4.x` or conformance to the C++ standard. The choices are mutually incompatible. More detailed information about using `g++` is available in the article [GCC5 and the C++11 ABI \(http://developerblog.redhat.com/2015/02/05/gcc5-and-the-c11-abi\)](http://developerblog.redhat.com/2015/02/05/gcc5-and-the-c11-abi).

Oracle Developer Studio 12.5 in `-std=c++11` or `-std=c++14` modes provides compatibility with Oracle Solaris Studio 12.4 and `g++ 4.8.2`. Oracle Developer Studio 12.5 does not provide the incompatible standard-conforming option.

If you want to combine `g++ 5.1` binaries with Oracle Developer Studio binaries, the `g++` binaries must all be compiled using the `-D_GLIBCXX_USE_CXX11_ABI=0` option on every `g++` command line.

## 1.1.2 C++14 Standard

Oracle Developer Studio 12.5 provides limited support for the C++14 Standard. The following features are supported:

- Binary literals
- Sized deallocation
- deprecated attribute
- Single-quote digit separator
- Member initialization and aggregates



## 1.1.3 Support for Atomics

Atomics is a new language feature in the C++ 2011 standard. The atomics feature is available only with the `-std=c++11` and `-std=c++14` options. For information about the functions and types supported, see the C++ Language Standard and the [atomic\\_fence\(3A\)](#), [atomic\\_flag\(3A\)](#), and [stdatomic.h\(3A\)](#) man pages.

The atomics feature requires runtime support. For more information about the runtime library, see “[11.2.3 Bundled Atomics Library](#)” on page 126.

## 1.1.4 Enforcement of C++ Rules

The Oracle Developer Studio 12.5 C++ 5.14 compiler enforces some C++ rules more strictly than past compilers. The incorrect rule enforcement caused earlier compilers to treat some valid code incorrectly. This section explains the stricter enforcement, provides examples of offending code, and shows how to fix the code. In all cases, you can change your code and it should still work with old and new compilers.

### 1.1.4.1 Template definition parsing

Previous compilers did not parse template definitions until the template was instantiated, with the following consequences:

1. Previous compilers would allow use of names not declared until after the template definition. Invalid code could be accepted, valid code could be rejected due to an apparent conflict, or the wrong declaration could be used.
2. Unconditional errors in templates that were not instantiated would not be diagnosed.
3. Names in a the definition of template T that do not depend on template parameters would not be instantiated until T was instantiated. They should be instantiated implicitly at the point where T is defined.

Example 1:

```
template< class T > int f(int i = j) // j is not visible
{ return i; }
int j = 2;
int main()
{
    return f<int>();
}
```

```
}
```

Older compilers accepted this code because template *f* was not parsed until after *j* was defined.

Solution: Move the declaration of *j* ahead of the template.

Example 2:

```
#include <stdio.h>
void f(double d) { printf("f(double)\n"); }
template< class C > struct B {
    B() { f(1); } // f is not dependent on template parameter
};
void f(int d) { printf("f(int)\n"); }
int main()
{
    B<int> b; // should print "f(double)"
}
```

Solution: Be sure any declarations that the template should depend on occur before the template definition.

### 1.1.4.2 Dependent base lookup

When looking up an unqualified name in a template definition, base classes that depend on a template parameter should not be examined. Previous compilers did incorrect name lookup.

Example:

```
template <typename T> struct Base { };

template <typename T> struct Derived : Base <T>
{
    Derived() : Base() { } // unqualified Base should not be found
};
Derived <int> x;

template <typename T> struct Derived2 : Base <T>
{
    Derived2() : Base<T>() { } // OK
};
Derived2<int> x2;

int main() { }
```

In class *Derived*, the use of unqualified *Base* without template arguments is not valid.

Solution: In class `Derived2`, the usage is correct.

### 1.1.4.3 Re-declaring template parameters

You can no longer re-declare the name of a template parameter.

Example:

```
template <typename T> class A { typedef int T; }; // re-declare T
```

Solution: Pick a different name for the template parameter or for the local name.

### 1.1.4.4 Forward template declarations

Forward template declarations are no longer supported.

Example:

```
$ cat x.cc
template <> struct A<int>;
.
$ CC x.cc
"x.cc", line 1: Error: A class template name was expected instead of A<int>.
```

Previous releases of Oracle Developer Studio C++ would silently accept this as explicit specialization of implicitly declared template by the name "A" with one type parameter.

Solution: Declare the primary template before any explicit specializations.

```
template<class T> struct A;
template <> struct A<int>;
```

### 1.1.4.5 Old-style explicit instantiations

The pre-1998 style of declaring an explicit specialization without `template<>` is no longer allowed.

Example:

```
template <typename T> class A { static T m; };
template <> class A<int> { static int m; };
```

```
int A<int>::m = 0; // now an error
```

Solution:

```
template<> int A<int>::m = 0;
```

### 1.1.4.6 Stricter `-template=extdef`

Refer to [“5.2.2 Template Definitions Separate” on page 76](#). The "template definitions separate" compilation model is now more strict. When creating the `X.cc` file that has the definitions of templates declared in header `X.h`, you must be especially careful not to have anything else (that is, other than items directly associated with the definitions) in that file. You are now more likely to get "multiple definition" errors if you violate the rule.

Example:

```
% cat extdef.h
template <typename T> T foo(T);
% cat extdef.cc
#include "extdef.h"
int main() {
    foo(1);
}
% CC extdef.cc -template=extdef
"extdef.cc", line 3: Error: main() already had a body defined.
1 Error(s) detected.
```

Solution: Remove everything from the `X.cc` file that is not needed for the template definitions. Recall that the `X.cc` file is not supposed to be explicitly compiled, because it is automatically included whenever the `X.h` file is included.

If extensive changes are needed, you might consider compiling with the `-template=no%extdef` option. That behavior is the default for other compilers, and is now the default in this release.

### 1.1.4.7 Implicit `int`

An implicit declaration of type `int` was never allowed in C++, but earlier compilers sometimes allowed it with a warning. Due to the way it interferes with proper template handling, the compiler no longer assumes you meant to declare something type `int`.

Example:

```
static i = 0; // now an error
```

Solution: Provide the type explicitly in the declaration.

### 1.1.4.8 Friend declarations

When a friend declaration in class C for a function or class T was the first declaration of T, previous compilers incorrectly inserted the declaration of T into the surrounding scope. The Oracle Developer Studio 12.5 C++ 5.14 compiler no longer does so, because it can lead to incorrect interpretation of valid programs.

Example:

```
class A
{
    friend class B;    // not previously declared
    friend void foo(); // not previously declared

    B* bar() // Error: B is not defined.
    {
        foo(); // Error: The function "foo" must have a prototype.
        return 0;
    }
};
```

Solution: Declare the friend function or class in a scope outside the class before the class declaration that declares it a friend

```
class B;
void foo();
class A
{
    friend class B;    // refers to prior declaration
    friend void foo(); // refers to prior declaration

    B* bar() // OK
    {
        foo(); // OK
        return 0;
    }
};
```

A friend declaration that specifies a default argument must also be the function definition.

Example:

```
class C {
    friend int f1(int i = 0); // Error
```

```
    friend int f2(int i = 0) { return i; } // OK
}
```

Prior releases of the C++ compiler did not enforce this rule. Allowing default arguments in friend declarations interferes with proper template handling, and so is no longer allowed.

### 1.1.4.9 Static functions and name lookup in templates

1. When looking up names in a dependent function call, previous compilers incorrectly ignored static functions that were in scope. The Oracle Developer Studio 12.5 C++ 5.14 compiler now treats static and extern functions the same way.

Example:

```
// previous compilers ignored this bar() in dependent name lookup
static int bar(int)
{
    return 1;
}
int bar(long)
{
    return 0;
}
template <typename T>
int foo(T t)
{
    // function call depends on template argument
    return bar(t);
}
int main()
{
    return foo(0);
}
```

Compiled with previous compilers, the program would return 0. With the Oracle Developer Studio 12.5 C++ 5.14 compiler, the program returns 1.

2. When only a static function was found in name lookup, previous compilers would issue an error like

```
"Reference to static bar(int) not allowed in template foo(int),
try using -features=tmplrefstatic."
```

See the previous example, with extern function `bar(long)` removed. The compiler now issues only a warning in `-compat=5` mode because the code is technically an extension to

the C++03 standard. In C++11 mode, the code is silently accepted because it is valid C++11.

3. The option `-features=no%tmplrefstatic` is still accepted, but has no net effect because references to static objects from templates are always allowed.

### 1.1.4.10 **const correctness**

Prior compilers did not enforce all the rules that preserve the properties of the keyword `const`.

Example:

```
void f1(int**) { printf("f1(int**)\n"); }
void f2(int**) { printf("Error: f2(int**)\n"); }
void f2(...) { printf("OK: f1(...)\n"); }
int main()
{
    int* const p = 0;
    f1(&p);          // #1 Should be an error
    f2(&p);          // #2 Should choose f2(...)
}
```

Earlier compilers incorrectly accepted #1, and for #2 incorrectly called `f2(int**)`. As line #2 shows, the wrong overloaded function, or an incorrect template specialization, could be selected due to the compiler's incorrect behavior.

Line #1 can be fixed either by declaring

```
int* p = 0;
```

or by changing the definition of `f1` or adding the overload

```
void f1(int * const*);
```

If you prefer that existing invalid code continue to compile, you can add the undocumented option

```
-W0, -xconstcheck=false [note: W-zero, not W-oh]
```

to CC command lines that now produce complaints about `const` correctness.

## 1.2 Special x86 Notes

Be aware of some important issues when compiling for x86 platforms.

- Programs compiled with `-xarch` set to `sse`, `sse2`, `sse2a`, `sse3`, or beyond must be run only on platforms that provide these extensions and features.
- With Oracle Developer Studio 12.5, the default instruction set and the meaning of `-xarch=generic` has changed to `sse2`. Now, compiling without specifying a target platform option results in an `sse2` binary incompatible with older Pentium III or earlier systems.
- If you compile and link in separate steps, always link using the compiler and with the same `-xarch` setting to ensure that the correct startup routine is linked.
- Numerical results on x86 might differ from results on SPARC due to the x86 80-bit floating-point registers. To minimize these differences, use the `-fstore` option or compile with `-xarch=sse2` if the hardware supports SSE2.
- Numerical results can also differ between Oracle Solaris and Oracle Linux because the intrinsic math libraries (for example, `sin(x)`) are not the same.

## 1.3 Compiling for 64–Bit Platforms

Use the `-m32` option to compile for the ILP32 32–bit model. Use the `-m64` option to compile for the LP64 64–bit model.

The ILP32 model specifies that C-language `int`, `long`, and `pointer` data types are each 32-bits wide. The LP64 model specifies that `long` and `pointer` data types are each 64-bits wide and `int` is 32-bits wide. The Oracle Solaris and Oracle Linux OS also support large files and large arrays under the LP64 data type model.

## 1.4 Binary Compatibility Verification

On Oracle Solaris systems, program binaries compiled with the Oracle Developer Studio compilers are marked with architecture hardware flags indicating the instruction sets assumed by the compiled binary. At runtime these marker flags are checked to verify that the binary can run on the hardware it is attempting to execute on.

If a program does not contain these architecture hardware flags, or if the platform does not enable the appropriate features or instruction set extensions, running the program could result in segmentation faults or incorrect results without any explicit warning messages.



On Oracle Linux, however, there is no such verification check. Running binary objects compiled by Oracle Developer Studio compilers on older hardware platforms could result in runtime failures; on Oracle Linux it is the user's responsibility to deploy these binaries on suitable hardware platforms.

This warning extends also to programs that employ `.i1` inline assembly language functions or `__asm()` assembler code that utilize SSE, SSE2, SSE2a, and SSE3 and newer instructions and extensions.

## 1.5 Standards Conformance

The C++ compiler (CC) supports the ISO International Standard for C++, ISO IS 14882:2011, Programming Language—C++. The 2011 standard replaced the 2003 standard, but the compiler recognizes the new features added in C++11 only when the option `-std=c++11` is in effect.

The C++ compiler (CC) supports the ISO International Standard for C++, ISO IS 14882:2014, Programming Language—C++. The 2014 standard replaced the 2011 standard, which in turn replaced the 2003 standard. The compiler recognizes the new features added in C++11 only when the option `-std=c++11` is in effect, and recognizes the new features added in C++14 only when the option `-std=c++14` is in effect.

On SPARC platforms, the compiler provides support for the optimization-exploiting features of SPARC V8 and SPARC V9, including the UltraSPARC implementation. These features are defined in the SPARC Architecture Manuals, Version 8 (ISBN 0-13-825001-4), and Version 9 (ISBN 0-13-099227-5), published by Prentice-Hall for SPARC International.

In this document, “Standard” means conforming to the versions of the standards listed above. “Nonstandard” or “Extension” refers to features that go beyond these versions of these standards.

The responsible standards bodies may revise these standards from time to time. The versions of the applicable standards to which the C++ compiler conforms may be revised or replaced, resulting in features in future releases of the Oracle Developer Studio C++ compiler that create incompatibilities with earlier releases.

## 1.6 Release Information

The [What's New in the Oracle Developer Studio 12.5 Release](#) guide highlights important information relevant to this release of the compiler, and includes:

- Information discovered after the manuals were printed
- New and changed features
- Software corrections
- Problems and workarounds
- Limitations and incompatibilities
- Shippable libraries
- Standards not implemented

## 1.7 Man Pages

Online manual (`man`) pages provide immediate documentation about a command, function, subroutine, or collection of such things.

You can display a man page by running the command:

```
example% man topic
```

Throughout the C++ documentation, man page references appear with the topic name and man section number: `CC(1)` is accessed with `man CC`. Sections other than 1 (`ieee_flags(3M)` for example) would be accessed with the `-s` option on the `man` command as follows:

```
example% man -s 3M ieee_flags
```

## 1.8 Native-Language Support

This release of C++ supports the development of applications in languages other than English, including most European languages, Chinese, and Japanese. As a result, you can easily switch your application from one native language to another. This feature is known as *internationalization*.

In general, the C++ compiler implements internationalization as follows:

- C++ recognizes ASCII characters from international keyboards (in other words, it has keyboard independence and is 8-bit clean).
- C++ allows the printing of some messages in the native language.
- C++ allows native-language characters in comments, strings, and data.
- C++ supports only Extended UNIX Character (EUC) compliant character sets in which every null byte in a string is the null character and every byte in the string with the ASCII value of `/` is the `/` character.

Variable names cannot be internationalized and must be in the English character set.

You can change your application from one native language to another by setting the locale. For information on this and other native-language support features, see the operating system documentation.



## Using the C++ Compiler

---

This chapter describes how to use the C++ compiler.

The principal use of any compiler is to transform a program written in a high-level language like C++ into a data file that is executable by the target computer hardware. You can use the C++ compiler to do the following:

- Transform source files into relocatable binary (.o) files, to be linked later into an executable file, a static (archive) library (.a) file (using `-xar`), or a dynamic (shared) library (.so) file
- Link or relink object files or library files (or both) into an executable file
- Compile an executable file with runtime debugging enabled (`-g`)
- Compile an executable file with runtime statement or procedure-level profiling (`-pg`)

### 2.1 Getting Started

This section gives you a brief overview of how to use the C++ compiler to compile and run C++ programs. See [Appendix A, “C++ Compiler Options”](#) for a full reference to the command-line options.

---

**Note** - The command-line examples in this chapter show CC usages. Printed output might be slightly different.

---

The basic steps for building and running a C++ program involve the following tasks:

1. Using an editor to create a C++ source file with one of the valid suffixes listed in [Table 1, “File Name Suffixes Recognized by the C++ Compiler,”](#) on page 31
2. Invoking the compiler to produce an executable file
3. Launching the program into execution by typing the name of the executable file

The following program displays a message on the screen:

```
example% cat greetings.cc
#include <iostream>
int main() {
    std::cout << "Real programmers write C++!" << std::endl;
    return 0;
}
example% CC greetings.cc
example% ./a.out
Real programmers write C++!
example%
```

In this example, `CC` compiles the source file `greetings.cc` and, by default, compiles the executable program onto the file, `a.out`. To launch the program, type the name of the executable file, `a.out`, at the command prompt.

Traditionally, UNIX compilers name the executable file `a.out`. It can be awkward to have each compilation write to the same file. Moreover, if such a file already exists, it will be overwritten the next time you run the compiler. Instead, use the `-o` compiler option to specify the name of the executable output file, as in the following example:

```
example% CC -o greetings greetings.cc
```

In this example, the `-o` option tells the compiler to write the executable code to the file `greetings`. (Common practice is to give a program consisting of a single source file the name of the source file without the suffix.)

Alternatively, you could rename the default `a.out` file using the `mv` command after each compilation. Either way, run the program by typing the name of the executable file:

```
example% ./greetings
Real programmers write C++!
example%
```

## 2.2 Invoking the Compiler

The remainder of this chapter discusses the conventions used by the `CC` command, compiler source line directives, and other issues concerning the use of the compiler.

### 2.2.1 Command Syntax

The general syntax of a compiler command line is as follows:

`CC [options] [source-files] [object-files] [libraries]`

An *option* is an option keyword prefixed by either a dash (–) or a plus sign (+). Some options take arguments.

In general, the processing of the compiler options is from left to right, allowing selective overriding of macro options (options that include other options). In most cases, if you specify the same option more than once, the rightmost assignment overrides and there is no accumulation. Note the following exceptions:

- All linker options and the `-features`, `-I`, `-l`, `-L`, `-library`, `-pti`, `-R`, `-staticlib`, `-U`, `-verbose`, `-xdumpmacros`, and `-xprefetch` options accumulate, they do not override.
- All `-U` options are processed after all `-D` options.

Source files, object files, and libraries are compiled and linked in the order in which they appear on the command line.

In the following example, `CC` is used to compile two source files (`growth.C` and `fft.C`) to produce an executable file named `growth` with runtime debugging enabled:

```
example% CC -g -o growth growth.C fft.C
```

## 2.2.2 File Name Conventions

The suffix attached to a file name appearing on the command line determines how the compiler processes the file. A file name with a suffix other than those listed in the following table, or without a suffix, is passed to the linker.

**TABLE 1** File Name Suffixes Recognized by the C++ Compiler

Suffix	Language	Action
<code>.c</code>	C++	Compile as C++ source files, put object files in current directory; default name of object file is that of the source but with an <code>.o</code> suffix.
<code>.C</code>	C++	Same action as <code>.c</code> suffix.
<code>.cc</code>	C++	Same action as <code>.c</code> suffix.
<code>.cpp</code>	C++	Same action as <code>.c</code> suffix.
<code>.cxx</code>	C++	Same action as <code>.c</code> suffix.
<code>.c++</code>	C++	Same action as <code>.c</code> suffix.
<code>.i</code>	C++	Preprocessor output file treated as C++ source file. Same action as <code>.c</code> suffix.

Suffix	Language	Action
.s	Assembler	Assemble source files using the assembler.
.S	Assembler	Assemble source files using both the C language preprocessor and the assembler.
.il	Inline expansion	Process assembly inline-template files for inline expansion. The compiler will use templates to expand inline calls to selected routines. (Inline-template files are special assembler files. See the <code>inline(1)</code> man page.)
.o	Object files	Pass object files through to the linker.
.a	Static (archive) library	Pass object library names to the linker.
.so	Dynamic (shared) library	Pass names of shared objects to the linker.
.so.n		

### 2.2.3 Using Multiple Source Files

The C++ compiler accepts multiple source files on the command line. A single source file compiled by the compiler, together with any files that it directly or indirectly includes, is referred to as a *compilation unit*. C++ treats each source as a separate compilation unit.

## 2.3 Template Cache Considerations

This compiler does not use a template cache (repository) by default. It only uses the cache if you specify `-instances=extern`. If the compiler makes use of the cache, it checks the cache directory's version and issues error messages whenever it encounters cache version problems. Future C++ compilers will also check cache versions. For example, a future compiler that has a different template cache version identification and that processes a cache directory produced by this release of the compiler might issue an error that is similar to the following message:

```
Template Database at ./SunWS_cache is incompatible with
this compiler
```

Similarly, the compiler issues an error if it encounters a cache directory that was produced by a later version of the compiler.

When you upgrade your compiler, cleaning the cache is always a good practice. Run `CCadmin -clean` on every directory that contains a template cache directory. In most cases, a template cache directory is named `SunWS_cache`. Alternatively, you can use `rm -rf SunWS_cache`.



## 2.4 Compiling and Linking

This section describes some aspects of compiling and linking programs. In the following example, `CC` is used to compile three source files and to link the object files to produce an executable file named `prgrm`.

```
example% CC file1.cc file2.cc file3.cc -o prgrm
```

### 2.4.1 Compile-Link Sequence

In the previous example, the compiler automatically generates the loader object files (`file1.o`, `file2.o`, and `file3.o`) and then invokes the system linker to create the executable program for the file `prgrm`.

After compilation, the object files (`file1.o`, `file2.o`, and `file3.o`) remain. This convention enables you to easily relink and recompile your files.

---

**Note** - If only one source file is compiled and a program is linked in the same operation, the corresponding `.o` file is deleted automatically. To preserve all `.o` files, do not compile and link in the same operation unless more than one source file gets compiled.

---

If the compilation fails, you will receive a message for each error. No `.o` files are generated for those source files with errors, and no executable program is written.

### 2.4.2 Separate Compiling and Linking

You can compile and link in separate steps. The `-c` option compiles source files and generates `.o` object files, but does not create an executable. Without the `-c` option, the compiler invokes the linker. By splitting the compile and link steps, a complete recompilation is not needed just to fix one file. The following example shows how to compile one file and link with others in separate steps:

```
example% CC -c file1.cc           Make new object file
example% CC -o prgrm file1.o file2.o file3.o   Make executable file
```

Be sure that the link step lists *all* the object files needed to make the complete program. If any object files are missing from this step, the link will fail with “undefined external reference” errors (missing routines).

## 2.4.3 Consistent Compiling and Linking

If you compile and link in separate steps, consistent compiling and linking is critical when using the compiler options listed in [“3.4.3 Compile-Time and Link-Time Options”](#) on page 46.

If you compile a subprogram using any of these options, you must link using the same option as well:

- If you compile with the `-library` or `-m64/-m32` options, you must include these same options on all CC commands.
- If you compile with `-compat` or `-std` options, you must include the same or equivalent options on all CC commands. For example, `-compat=5` and `-std=sun03` are equivalent.
- With `-p`, `-xpg`, and `-xprofile`, including the option in one phase and excluding it from the other phase will not affect the correctness of the program, but you will not be able to do profiling.
- With `-g[n]` and `-xdebuginfo`, including the option in one phase and excluding it from the other phase will not affect the correctness of the program, but it will affect the ability to debug the program. Any module that is not compiled with either of these options but is linked with `-g[n]` or `-xdebuginfo` will not be prepared properly for debugging. Note that compiling the module that contains the function `main` with the `-g[n]` option or the `-xdebuginfo` option is usually necessary for debugging.

In the following example, the programs are compiled using the `-library=stlport4` compiler option.

```
example% CC -library=stlport4 sbr.cc -c
example% CC -library=stlport4 main.cc -c
example% CC -library=stlport4 sbr.o main.o -o myprogram
```

If you do not use `-library=stlport4` consistently, some parts of the program will use the default `libCstd`, and others will use the optional replacement STLport library. The resulting program might not link, and would not in any case run correctly.

If the program uses templates, some templates might get instantiated at link time. In that case, the command-line options from the last line (the link line) will be used to compile the instantiated templates.

## 2.4.4 Compiler Command-Line Diagnostics

The `-V` option displays the name and version number of each program invoked by CC. The `-v` option displays the full command lines invoked by CC.

The `-verbose=all` displays additional information about the compiler.

Any arguments on the command line that the compiler does not recognize are interpreted as linker options, object program file names, or library names.

The basic distinctions are:

- Unrecognized *options*, which are preceded by a dash (-) or a plus sign (+), generate warnings.
- Unrecognized *nooptions*, which are not preceded by a dash or a plus sign, generate no warnings. However, they are passed to the linker. If the linker does not recognize them, they generate linker error messages.

In the following example, note that `-bit` is not recognized by `CC` and the option is passed on to the linker (`ld`), which tries to interpret it. Because single letter `ld` options can be strung together, the linker sees `-bit` as `-b -i -t`, all of which are legitimate `ld` options. This result might not be what you intend or expect:

```
example% CC -bit move.cc           -bit is not a recognized compiler option
CC: Warning: Option -bit passed to ld, if ld is invoked, ignored otherwise
```

In the next example, the user intended to type the `CC` option `-fast` but omitted the leading dash. The compiler again passes the argument to the linker, which in turn interprets it as a file name:

```
example% CC fast move.cc           < - The user meant to type -fast
move.CC:
ld: fatal: file fast: cannot open file; errno=2
ld: fatal: File processing errors. No output written to a.out
```

## 2.4.5 Understanding the Compiler Organization

The C++ compiler package consists of a front end, optimizer, code generator, assembler, template prelinker, and link editor. The `CC` command invokes each of these components automatically unless you use command-line options to specify otherwise.

Because any of these components may generate an error, and the components perform different tasks, identifying the component that generates an error might be helpful. Use the `-v` and `-dryrun` options to display more detail during compiler execution.

As shown in the following table, input files to the various compiler components have different file name suffixes. The suffix establishes the kind of compilation that is done. Refer to [Table 1, “File Name Suffixes Recognized by the C++ Compiler,” on page 31](#) for the meanings of the file suffixes.

**TABLE 2** Components of the C++ Compilation System

Component	Description	Notes on Use
ccfe	Front end (compiler preprocessor and compiler)	
iropt	Code optimizer	-x0[2-5], -fast
inline	(SPARC) Inline expansion of assembly language templates	.il file specified
fbe	Assembler	
cg	(SPARC) Code generator, inliner, assembler	-x0[1-5], -fast, -std=c++11
ube	(x86) Code generator	-x0[1-5], -fast, -std=c++11
CCLink	Template prelinker	Used only with the -instances=extern option
ld	link editor	

## 2.5 Preprocessing Directives and Names

This section discusses information about preprocessing directives that is specific to the C++ compiler.

### 2.5.1 Pragmas

The preprocessor directive `pragma` is part of the C++ standard but the form, content, and meaning of pragmas is different for every compiler. See [Appendix B, “Pragmas”](#) for details on the pragmas that the C++ compiler recognizes.

Oracle Developer Studio C++ also supports the C99 keyword `_Pragma`. The following two invocations are equivalent:

```
#pragma dumpmacros(defs)
_Pragma("dumpmacros(defs)")
```

To use `_Pragma` instead of `#pragma`, write the `pragma` text as a literal string enclosed in parentheses as the one argument of the `_Pragma` keyword.

### 2.5.2 Macros With a Variable Number of Arguments

The C++ compiler accepts `#define` preprocessor directives of the following form.

```
#define identifier (...) replacement-list
#define identifier (identifier-list, ...) replacement-list
```

If the macro parameter list ends with an ellipsis, an invocation of the macro is allowed to have more arguments than there are macro parameters. The additional arguments are collected into a single string, including commas, that can be referenced by the name `__VA_ARGS__` in the macro replacement list.

The following example demonstrates how to use a variable-argument-list macro.

```
#define debug(...) fprintf(stderr, __VA_ARGS__)
#define showlist(...) puts(#__VA_ARGS__)
#define report(test, ...) ((test)?puts(#test):\
                          printf(__VA_ARGS__))

debug("Flag");
debug("X = %d\n",x);
showlist(The first, second, and third items.);
report(x>y, "x is %d but y is %d", x, y);
```

which results in the following:

```
fprintf(stderr, "Flag");
fprintf(stderr, "X = %d\n", x);
puts("The first, second, and third items.");
((x>y)?puts("x>y"):printf("x is %d but y is %d", x, y));
```

## 2.5.3 Predefined Names

[“A.2.9 –Dname\[=def\]” on page 181](#) in the appendix shows the predefined macros. You can use these values in such preprocessor conditionals as `#ifdef`. The `+p` option prevents the automatic definition of the `sun`, `unix`, `sparc`, and `i386` predefined macros.

## 2.5.4 Warnings and Errors

The `#error` and `#warning` preprocessor directives can be used to generate compile-time diagnostics.

<code>#error <i>token-string</i></code>	Issue error diagnostic <i>token-string</i> and terminate compilation
<code>#warning <i>token-string</i></code>	Issue warning diagnostic <i>token-string</i> and continue compilation.

## 2.6 Memory Requirements

The amount of memory a compilation requires depends on several parameters, including:

- Size of each procedure
- Level of optimization
- Limits set for virtual memory
- Size of the disk swap file

On the SPARC platform, if the optimizer runs out of memory, it tries to recover by retrying the current procedure at a lower level of optimization. The optimizer then resumes subsequent routines at the original level specified in the `-x0level` option on the command line.

If you compile a single source file that contains many routines, the compiler might run out of memory or swap space. Try reducing the level of optimization. Alternatively, split the largest procedures into separate files of their own.

### 2.6.1 Swap Space Size

The `swap -s` command displays available swap space. See the `swap(1M)` man page for more information.

The following example demonstrates the use of the `swap` command:

```
example% swap -s
total: 40236k bytes allocated + 7280k reserved = 47516k used, 1058708k available
```

### 2.6.2 Increasing Swap Space

Use `mkfile(1M)` and `swap (1M)` to increase the size of the swap space on a workstation. (You must become superuser to do this.) The `mkfile` command creates a file of a specific size, and `swap -a` adds the file to the system swap space:

```
example# mkfile -v 90m /home/swapfile
/home/swapfile 94317840 bytes
example# /usr/sbin/swap -a /home/swapfile
```

## 2.6.3 Control of Virtual Memory

Compiling very large routines (thousands of lines of code in a single procedure) at `-xO3` or higher can require a large amount of memory. In such cases, performance of the system might degrade. You can control memory footprint by limiting the amount of virtual memory available to a single process.

To limit virtual memory in an `sh` shell, use the `ulimit` command. See the `sh(1)` man page for more information.

The following example shows how to limit virtual memory to 4 Gbytes:

```
example$ ulimit -d 4000000
```

In a `csh` shell, use the `limit` command to limit virtual memory. See the `csh(1)` man page for more information.

The next example also shows how to limit virtual memory to 4 Gbytes:

```
example% limit datasize 4G
```

Each of these examples causes the optimizer to try to recover at 4 Gbytes of data space.

The limit on virtual memory cannot be greater than the system's total available swap space and, in practice, must be small enough to permit normal use of the system while a large compilation is in progress.

Be sure that no compilation consumes more than half the swap space.

With 8 Gbytes of swap space, use the following commands:

In an `sh` shell:

```
example$ ulimit -d 4000000
```

In a `csh` shell:

```
example% limit datasize 4G
```

The best setting depends on the degree of optimization requested and the amount of real memory and virtual memory available.

## 2.6.4 Memory Requirements

A workstation should have at least 2 gigabytes of memory. See the product release notes for detailed requirements.

## 2.7 Using the strip Command with C++ Objects

The UNIX `strip` command should not be used with C++ object files, as it can render those object files unusable.

## 2.8 Simplifying Commands

You can simplify complicated compiler commands by defining special shell aliases by using the `CCFLAGS` environment variable, or by using `make`.

### 2.8.1 Using Aliases Within the C Shell

The following example defines an alias for a command with frequently used options.

```
example% alias CCfx "CC -fast -xnoLibmIL"
```

The next example uses the alias `CCfx`.

```
example% CCfx any.C
```

The command `CCfx` is now the same as the following command:

```
example% CC -fast -xnoLibmIL any.C
```

### 2.8.2 Using CCFLAGS to Specify Compile Options

You can specify options by setting the `CCFLAGS` variable.

The `CCFLAGS` variable can be used explicitly in the command line. The following example shows how to set `CCFLAGS` (C Shell):

```
example% setenv CCFLAGS '-x02 -m64'
```

The next example uses `CCFLAGS` explicitly.

```
example% CC $CCFLAGS any.cc
```



When you use `make`, if the `CCFLAGS` variable is set as in the preceding example and the makefile's compilation rules are implicit, then invoking `make` will result in a compilation equivalent to the following command:

```
CC -x02 -m64 files...
```

## 2.8.3 Using `make`

The `make` utility is a very powerful program development tool that you can easily use with all Oracle Developer Studio compilers. See the `make(1S)` man page for additional information.

### 2.8.3.1 Using `CCFLAGS` Within `make`

When you are using the *implicit* compilation rules of the makefile (that is, there is no `C++` compile line), the `make` program uses `CCFLAGS` automatically.



# ◆◆◆ CHAPTER 3

## Using the C++ Compiler Options

---

This chapter explains how to use the command-line C++ compiler options and then summarizes their use by function. Detailed explanations of the options are provided in [“A.2 Option Reference” on page 176](#).

### 3.1 Syntax Overview

The following table shows examples of typical option syntax formats that are used in this book.

**TABLE 3** Option Syntax Format Examples

Syntax Format	Example
-option	-E
-optionvalue	-Ipathname
-option=value	-xunroll=4
-option value	-o filename

Parentheses, braces, brackets, pipe characters, and ellipses are *metacharacters* used in the descriptions of the options and are not part of the options themselves. See the typographical conventions in the Preface to this manual for a detailed explanation of the usage syntax.

### 3.2 General Guidelines

Some general guidelines for the C++ compiler options are:

- The `-llib` option links with library `llib.a` (or `llib.so`). It is always safer to put `-llib` after the source and object files to ensure the order in which libraries are searched.

- In general, processing of the compiler options is from left to right (with the exception that -U options are processed after all -D options), allowing selective overriding of macro options (options that include other options). This rule does not apply to linker options.
- The -features, -I -l, -L, -library, -pti, -R, -staticlib, -U, -verbose, and -xprefetch options accumulate, they do not override.
- The -D option accumulates. However, multiple -D options for the same name override each other.

Source files, object files, and libraries are compiled and linked in the order in which they appear on the command line.

## 3.3 Platform-specific Option Defaults

Some C++ compiler options which affect binary compatibility have default behavior that matches the platform where the compiler is running.

Oracle Linux 6	-m64 -std=c++03 -library=stdcpp
Oracle Linux 7	-m64 -std=c++03 -library=stdcpp
Solaris 10	-m32 -std=sun03 -library=Cstd
Oracle Solaris 11	-m32 -std=sun03 -library=Cstd

## 3.4 Options Summarized by Function

In this section, the compiler options are grouped by function to provide a quick reference. For a detailed description of each option, refer to [Appendix A, “C++ Compiler Options”](#).

The options apply to all platforms except as noted; features that are unique to the Oracle Solaris OS on SPARC-based systems are identified as (SPARC), and the features that are unique to the Oracle Solaris OS on x86-based systems are identified as (x86).

## 3.4.1 Code Generation Options

**TABLE 4** Code Generation Options

Option	Action
-compat	Sets the e compatibility mode of the compiler.
-g	Compiles for use with the debugger.
-KPIC	Produces position-independent code.
-Kpic	Produces position-independent code.
-mt	Compiles and links for multithreaded code.
-xaddr32	Restricts code to a 32-bit address space (x86/x64)
-xarch	Specifies the target architecture.
-xcode= <i>a</i>	(SPARC) Specifies the code address space.
-xlinker	Specify linker options.
-xMerge	(SPARC) Merges the data segment with the text segment.
-xtarget	Specifies the target system.
-xmodel	Modifies the form of 64-bit objects for the x86 platforms
+w	Identifies code that might have unintended consequences.
+w2	Emits all the warnings emitted by +w plus warnings about technical violations that are probably harmless but that might reduce the maximum portability of your program.
-xregs	The compiler can generate faster code if it has more registers available for temporary storage (scratch registers). This option makes available additional scratch registers that might not always be appropriate.
-xsegment_align	Cause the driver to include a special mapfile on the link line.
-z <i>arg</i>	Linker option.

## 3.4.2 Compile-Time Performance Options

**TABLE 5** Compile-Time Performance Options

Option	Action
-instlib	Inhibits the generation of template instances that are already present in the designated library.
-m32 -m64	Specifies the data type model for the compiled binary object.
-xinstrument	Compiles and instruments your program for analysis by the Thread Analyzer.
-xjobs	Sets the number of processes the compiler can create to complete its work.

Option	Action
-xpch	Might reduce compile time for applications whose source files share a common set of include files.
-xpchstop	Specifies the last include file to be considered in creating a precompiled header file with -xpch.
-xprofile_ircache	(SPARC) Reuses compilation data saved during -xprofile=collect.
-xprofile_pathmap	(SPARC) Support for multiple programs or shared libraries in a single profile directory.

### 3.4.3 Compile-Time and Link-Time Options

The following table lists the options that must be specified both at link-time and at compile-time.

**TABLE 6** Compile-Time and Link-Time Options

Option	Action
-fast	Selects the optimum combination of compilation options for speed of executable code.
-fopenmp	Equivalent to -xopenmp=parallel.
-m32 -m64	Specifies the data type model for the compiled binary object.
-mt	Macro option that expands to -D_REENTRANT -lthread.
-std	Specify C++ language version and compatibility mode.
-xarch	Specifies the instruction set architecture.
-xautopar	Turns on automatic parallelization for multiple processors.
-xhwcpuf	Enables compiler support for hardware counter-based profiling.
-xipo	Performs whole-program optimizations by invoking an interprocedural analysis component.
-xipo_build	Reduce compile time by avoiding optimizations during the initial pass through the compiler, optimizing only at link time.
-xlinker	Specify linker options
-xlinkopt	Performs link-time optimizations on relocatable object files.
-xmemalign	(SPARC) Specifies the maximum assumed memory alignment and behavior of misaligned data accesses.
-xopenmp	Supports the OpenMP interface for explicit parallelization including a set of source code directives, runtime library routines, and environment variables
-xpagesize	Sets the preferred page size for the stack and the heap.
-xpagesize_heap	Sets the preferred page size for the heap.

Option	Action
-xpagesize_stack	Sets the preferred page size for the stack.
-xpatchpadding	Reserve an area of memory before the start of each function.
-xpg	Prepares the object code to collect data for profiling with <code>gprof(1)</code> .
-xprofile	Collects data for a profile or uses a profile to optimize.
-xs	(Solaris) Link debug information from object files into executable.
-xvector=lib	Enables automatic generation of calls to the vector library functions.

## 3.4.4 Debugging Options

TABLE 7 Debugging Options

Option	Action
-###	Equivalent to <code>-dryrun</code>
+d	Does not expand C++ inline functions.
-dryrun	Shows shows all commands that the driver would issue to all components of the compilation.
-E	Runs only the preprocessor on the C++ source files and sends the result to <code>stdout</code> . Does not compile.
-g	Compiles for use with the debugger.
-g0	Compiles for debugging but does not disable inlining.
-H	Prints path names of included files.
-keepmp	Retains temporary files created during compilation.
-P	Only preprocesses source; outputs to <code>.i</code> file.
-preserve_argvalues	(x86) Save copies of register-based function arguments in the stack.
-Qoption	Passes an option directly to a compilation phase.
-s	Strips the symbol table out of the executable file, thus preventing the ability to debug code.
-temp	Defines the directory for temporary files.
-verbose	Controls compiler verbosity.
-xanalyze	Produce a static analysis of the source code that can be viewed using the Code Analyzer.
-xcheck	Adds a runtime check for stack overflow.
-xdebuginfo	Compiles for use with the debugger, specifying how much debug detail to emit.

### 3.4 Options Summarized by Function

Option	Action
-xdumpmacros	Prints information about macros such as definition, location defined and undefined, and locations used.
-xe	Only checks for syntax and semantic errors.
-xglobalize	Control globalization of file static variables but not functions.
-xhelp=flags	Displays a summary list of compiler options.
-xkeep_unref	Keep definitions of unreferenced functions and variables.
-xpatchpadding	Reserve an area of memory before the start of each function.
-xprewise	Produce a static analysis of the source code that can be viewed using the Code Analyzer.
-xport64	Warns against common problems during a port from a 32-bit architecture to a 64-bit architecture.
-xs	(Solaris) Link debug information from object files into executable.

## 3.4.5 Floating-Point Options

TABLE 8 Floating-Point Options

Option	Action
-fma	Enables automatic generation of floating-point fused multiply-add instructions.
-fns[={no yes}]	(SPARC) Disables or enables the SPARC nonstandard floating-point mode.
-fprecision= <i>p</i>	<i>x86</i> : Sets floating-point precision mode.
-fround= <i>r</i>	Sets IEEE rounding mode in effect at startup.
-fsimple= <i>n</i>	Sets floating-point optimization preferences.
-fstore	<i>x86</i> : Forces precision of floating-point expressions.
-ftrap= <i>t st</i>	Sets the IEEE trapping mode in effect at startup.
-nofstore	<i>x86</i> : Disables forced precision of expression.
-xlibieee	Causes <code>libm</code> to return IEEE 754 values for math routines in exceptional cases.

## 3.4.6 Language Options

TABLE 9 Language Options

Option	Action
-compat	Sets the major release compatibility mode of the compiler.
-features= <i>alst</i>	Enables or disables various C++ language features.
-std	Specify C++ language version.



Option	Action
-xchar	Eases the migration of code from systems where the char type is defined as unsigned.
-xldscope	Controls the default linker scope of variable and function definitions to create faster and safer shared libraries.
-xthreadvar	(SPARC) Changes the default thread-local storage access mode.
-xtrigraphs	Enables recognition of trigraph sequences.
-xustr	Enables recognition of string literals composed of sixteen-bit characters.

## 3.4.7 Library Options

TABLE 10 Library Options

Option	Action
-Bbinding	Requests symbolic, dynamic, or static library linking.
-d{y n}	Allows or disallows dynamic libraries for the entire executable.
-G	Builds a dynamic shared library instead of an executable file.
-hname	Assigns an internal name to the generated dynamic shared library.
-i	Tells ld(1) to ignore any LD_LIBRARY_PATH setting.
-Ldir	Adds dir to the list of directories to be searched for libraries.
-llib	Adds liblib.a or liblib.so to the linker's library search list.
-library=llst	Forces inclusion of specific libraries and associated files into compilation and linking.
-mt	Compiles and links for multithreaded code.
-norunpath	Does not build the path for libraries into the executable file.
-Rplst	Builds dynamic library search paths into the executable file.
-staticlib=llst	Indicates which C++ libraries are to be linked statically.
-xar	Creates archive libraries.
-xbuiltin[=opt]	Enables or disables better optimization of standard library calls
-xia	(Solaris) Links the appropriate interval arithmetic libraries and sets a suitable floating-point environment.
-xlang=[,l]	Includes the appropriate runtime libraries and ensures the proper runtime environment for the specified language.
-xlibieee	Causes libm to return IEEE 754 values for math routines in exceptional cases.
-xlibmil	Inlines selected libm library routines for optimization.
-xlibmopt	Uses a library of optimized math routines.
-xno lib	Disables linking with default system libraries.

Option	Action
-xnolibmil	Cancels <code>xlibmil</code> on the command line.
-xnolibmopt	Does not use the math routine library.

## 3.4.8 Obsolete Options

**Note** - The following options are either currently obsolete and so no longer accepted by the compiler, or are likely to be removed in a future release.

**TABLE 11** Obsolete Options

Option	Action
-features=[%all %none]	Obsolete suboptions <code>%all</code> and <code>%none</code> .
-library=%all	Obsolete suboption that is likely to be removed in a future release.
-migration	This option is no longer recognized.
-xanalyze	Obsolete, use <code>-prewise</code> instead.
-xarch=v7, v8, v8a	Obsolete.
-xlic_lib=sunperf	Use <code>-library=sunperf</code> to link to the Sun Performance Library.
-xlicinfo	Deprecated.
-xnativeconnect	Obsolete, there is no alternative option.
-xprefetch=yes	Use <code>-xprefetch=auto,explicit</code> instead.
-xprefetch=no	Use <code>-xprefetch=no%auto,no%explicit</code> instead.
-xvector=yes	Use <code>-xvector=lib</code> instead.
-xvector=no	Use <code>-xvector=none</code> instead.

## 3.4.9 Output Options

**TABLE 12** Output Options

Option	Action
-c	Compiles only; produces object ( <code>.o</code> ) files, but suppresses linking.
-dryrun	Shows all the command lines that would be issued by the driver, but does not run any of them.
-E	Runs only the preprocessor on the C++ source files and sends the result to <code>stdout</code> . Does not compile.
-eroff	Suppresses compiler warning messages.
-errtags	Displays the message tag for each warning message.

Option	Action
-errwarn	If the indicated warning message is issued, compiler exits with a failure status.
-filt	Suppresses the filtering that the compiler applies to linker error messages.
-G	Builds a dynamic shared library instead of an executable file.
-H	Prints the path names of included files.
-o <i>filename</i>	Sets name of the output or executable file to <i>filename</i> .
-P	Only preprocesses source; outputs to .i file.
-Qproduce <i>sourcetype</i>	Causes the CC driver to produce output of the type <i>sourcetype</i> .
-s	Strips the symbol table out of the executable file.
-verbose= <i>vlst</i>	Controls compiler verbosity.
+w	Prints extra warnings where necessary.
+w2	Prints still more warnings where appropriate.
-w	Suppresses warning messages.
-xdumpmacros	Prints information about macros such as definition, location defined and undefined, and locations used.
-xe	Performs only syntax and semantic checking on the source file but does not produce any object or executable code.
-xhelp=flags	Displays a summary list of compiler options
-xM	Outputs makefile dependency information.
-xM1	Generates dependency information, but excludes /usr/include
-xtime	Reports execution time for each compilation phase.
-xwe	Converts all warnings to errors.
-z <i>arg</i>	Linker option.

### 3.4.10 Run-Time Performance Options

**TABLE 13** Run-Time Performance Options

Option	Action
-fast	Selects a combination of compilation options for optimum execution speed for some programs.
-fma	Enables automatic generation of floating-point fused multiply-add instructions.
-g	Instructs both the compiler and the linker to prepare the program for performance analysis (and for debugging).
-s	Strips the symbol table out of the executable.
-m32 -m64	Specifies the data type model for the compiled binary object.
-xalias_level	Enables the compiler to perform type-based alias analysis and optimizations.

### 3.4 Options Summarized by Function

Option	Action
-xarch= <i>isa</i>	Specifies target architecture instruction set.
-xbinopt	Prepares the binary for later optimizations, transformations, and analysis.
-xbuiltin[= <i>opt</i> ]	Enables or disables better optimization of standard library calls
-xcache= <i>c</i>	(SPARC) Defines target cache properties for the optimizer.
-xchip= <i>c</i>	Specifies target processor chip.
-xdebuginfo	Instructs both the compiler and the linker to prepare the program for performance analysis (and for debugging).
-xF	Enables linker reordering of functions and variables.
-xinline= <i>flst</i>	Specifies which user-written routines can be inlined by the optimizer
-xinline_param	Manually change the heuristics used by the compiler for deciding when to inline a function call.
-xinline_report	Generate a report written to standard output on the inlining of functions by the compiler.
-xipo	Performs interprocedural optimizations.
-xipo_build	Reduce compile time by avoiding optimizations during the initial pass through the compiler, optimizing only at link time.
-xlibmil	Inlines selected libm library routines for optimization.
-xlibmopt	Uses a library of optimized math routines.
-xlinkopt	Performs link-time optimization on the resulting executable or dynamic library in addition to any optimizations in the object files.
-xmalign= <i>ab</i>	(SPARC) Specifies maximum assumed memory alignment and behavior of misaligned data accesses.
-xnolibmil	Cancels- xlibmil on the command line.
-xnolibmopt	Does not use the math routine library.
-x0level	Specifies optimization level to <i>level</i> .
-xpagesize	Sets the preferred page size for the stack and the heap.
-xpagesize_heap	Sets the preferred page size for the heap.
-xpagesize_stack	Sets the preferred page size for the stack.
-xprefetch[= <i>lst</i> ]	Enables prefetch instructions on architectures that support prefetch.
-xprefetch_level	Control the aggressiveness of automatic insertion of prefetch instructions as set by -xprefetch=auto
-xprofile	Collects or optimizes using runtime profiling data.
-xregs= <i>rlst</i>	Controls scratch register use.
-xsafe=mem	(SPARC) Allows no memory-based traps.
-xsegment_align	Cause the driver to include a special mapfile on the link line.
-xspace	(SPARC) Does not allow optimizations that increase code size.
-xtarget= <i>t</i>	Specifies a target instruction set and optimization system.

Option	Action
-xthreadvar	Changes the default thread-local storage access mode.
-xthroughput	Specify that the application will be run in situations where many processes are simultaneously running on the system.
-xunboundsym	Specify whether the program contains references to dynamically bound symbols.
-xunroll= <i>n</i>	Enables unrolling of loops where possible.
-xvis	(SPARC) Enables compiler recognition of the assembly-language templates defined in the VIS™ instruction set

### 3.4.11 Preprocessor Options

TABLE 14 Preprocessor Options

Option	Action
-D <i>name</i> [= <i>def</i> ]	Defines symbol <i>name</i> to the preprocessor.
-E	Runs only the preprocessor on the C++ source files and sends the result to <code>stdout</code> . Includes information about the the source of the preprocessed lines. Does not compile.
-H	Prints the path names of included files.
-P	Only preprocesses source; outputs to <code>.i</code> file.
-U <i>name</i>	Deletes initial definition of preprocessor symbol <i>name</i> .
-xM	Outputs makefile dependency information.
-xM1	Generates dependency information but excludes <code>/usr/include</code> .

### 3.4.12 Profiling Options

TABLE 15 Profiling Options

Option	Action
-p	Prepares the object code to collect data for profiling using <code>prof</code> .
-xpg	Compiles for profiling with the <code>gprof</code> profiler.
-xprofile	Collects or optimizes using runtime profiling data.

## 3.4.13 Reference Options

**TABLE 16** Reference Options

Option	Action
-xhelp=flags	Displays a summary list of compiler options.

## 3.4.14 Source Options

**TABLE 17** Source Options

Option	Action
-H	Prints the path names of included files.
-Ipathname	Adds <i>pathname</i> to the <code>include</code> file search path.
-I-	Changes the include-file search rules
-xM	Outputs makefile dependency information.
-xM1	Generates dependency information but excludes <code>/usr/include</code> .

## 3.4.15 Template Options

**TABLE 18** Template Options

Option	Action
-instances= <i>a</i>	Controls the placement and linkage of template instances.
-template= <i>wlst</i>	Enables or disables various template options.

## 3.4.16 Thread Options

**TABLE 19** Thread Options

Option	Action
-mt	Compiles and links for multithreaded code.
-xsafe=mem	(SPARC) Allows no memory-based traps.
-xthreadvar	(SPARC) Changes the default thread-local storage access mode.

## 3.5 User-Supplied Default Options File

The default compiler options file enables the user to specify a set of default options that are applied to all compiles, unless otherwise overridden. For example, the file could specify that all compiles default at `-x02`, or automatically include the file `setup.il`.

At startup, the compiler searches for a default options file listing default options it should include for all compiles. The environment variable `SPRO_DEFAULTS_PATH` specifies a colon separated list of directories to search for the defaults file.

If the environment variable is not set, a standard set of defaults is used. If the environment variable is set but is empty, no defaults are used.

The defaults file name must be of the form `compiler.defaults`, where `compiler` is one of the following: `cc`, `c89`, `c99`, `CC`, `ftn`, or `lint`. For example, the defaults for the C++ compiler would be `CC.defaults`

If a defaults file for the compiler is found in the directories listed in `SPRO_DEFAULTS_PATH`, the compiler will read the file and process the options prior to processing the options on the command line. The first defaults file found will be used and the search terminated.

System administrators may create system-wide default files in `Studio-install-path/lib/compilers/etc/config`. If the environment variable is set, the installed defaults file will not be read.

The format of a defaults file is similar to the command line. Each line of the file may contain one or more compiler options separated by white space. Shell expansions, such as wild cards and substitutions, will not be applied to the options in the defaults file.

The value of the `SPRO_DEFAULTS_PATH` and the fully expanded command line will be displayed in the verbose output produced by options `-#`, `-###`, and `-dryrun`.

Options specified by the user on the command line will usually override options read from the defaults file. For example, if the defaults file specifies compiling with `-x04` and the user specifies `-x02` on the command line, `-x02` will be used.

Some options appearing in the default options file will be appended after the options specified on the command line. These are the preprocessor option `-I`, linker options `-B`, `-L`, `-R`, and `-l`, and all file arguments, such as source files, object files, archives, and shared objects.

The following is an example of how a user-supplied default compiler option startup file might be used.

```
demo% cat /project/defaults/CC.defaults
```

```
-I/project/src/hdrs -L/project/libs -llibproj -xvpara  
demo% setenv SPRO_DEFAULTS_PATH /project/defaults  
demo% CC -c -I/local/hdrs -L/local/libs -lliblocal tst.c
```

This command is now equivalent to:

```
CC -fast -xvpara -c -I/local/hdrs -L/local/libs -lliblocal tst.c \  
-I/project/src/hdrs -L/project/libs -llibproj
```

While the compiler defaults file provides a convenient way to set the defaults for an entire project, it can become the cause of hard to diagnose problems. Set the environment variable `SPRO_DEFAULTS_PATH` to an absolute path rather than the current directory to avoid such problems.

The interface stability of the default options file is uncommitted. The order of option processing is subject to change in a future release.



**PART II**

## **Writing C++ Programs**



## Language Extensions

---

This chapter documents the language extensions specific to this compiler. The compiler does not recognize some of the features described in this chapter unless you specify certain compiler options on the command line. The relevant compiler options are listed in each section as appropriate.

The `-features=extensions` option enables you to compile nonstandard code that is commonly accepted by other C++ compilers. You can use this option when you must compile invalid code and you are not permitted to modify the code to make it valid.

This chapter describes the language extensions that the compiler supports when you use the `-features=extensions` options.

---

**Note** - You can easily turn each supported instance of invalid code into valid code that all compilers will accept. If you are allowed to make the code valid, you should do so instead of using this option. Using the `-features=extensions` option perpetuates invalid code that will be rejected by some compilers.

---

### 4.1 Linker Scoping

Use the following declaration specifiers to help constrain declarations and definitions of extern symbols. The scoping restraints you specify for a static archive or an object file will not take effect until the file is linked into a shared library or an executable. Despite this, the compiler can still perform some optimization given the presence of the linker scoping specifiers.

By using these specifiers, you no longer need to use mapfiles for linker scoping. You can also control the default setting for variable scoping by specifying `-xldscope` on the command line.

For more information, see [“A.2.142 -xldscope={v}” on page 286](#).

**TABLE 20** Linker Scoping Declaration Specifiers

Value	Meaning
<code>__global</code>	Symbol definitions have global linker scoping and is the least restrictive linker scoping. All references to the symbol bind to the definition in the first dynamic load module that defines the symbol. This linker scoping is the current linker scoping for extern symbols.
<code>__symbolic</code>	Symbol definitions have symbolic linker scoping, which is more restrictive than global linker scoping. All references to the symbol from within the dynamic load module being linked bind to the symbol defined within the module. Outside of the module, the symbol appears as though it were global. This linker scoping corresponds to the linker option <code>-Bsymbolic</code> . Although you cannot use <code>-Bsymbolic</code> with C++ libraries, you can use the <code>__symbolic</code> specifier without causing problems. See the <code>ld(1)</code> man page for more information on the linker.
<code>__hidden</code>	Symbol definitions have hidden linker scoping. Hidden linker scoping is more restrictive than symbolic and global linker scoping. All references within a dynamic load module bind to a definition within that module. The symbol will not be visible outside of the module.

A symbol definition may be redeclared with a more restrictive specifier, but may not be redeclared with a less restrictive specifier. A symbol may not be declared with a different specifier once the symbol has been defined.

`__global` is the least restrictive scoping, `__symbolic` is more restrictive, and `__hidden` is the most restrictive scoping.

All virtual functions must be visible to all compilation units that include the class definition because the declaration of virtual functions affects the construction and interpretation of virtual tables.

You can apply the linker scoping specifiers to `struct`, `class`, and `union` declarations and definitions because C++ classes may require generation of implicit information, such as virtual tables and runtime type information. The specifier, in this case, follows the `struct`, `class`, or `union` keyword. Such an application implies the same linker scoping for all its implicit members.

### 4.1.1 Compatibility with Microsoft Windows

For compatibility with similar scoping features in Microsoft Visual C++ (MSVC++) for dynamic libraries, the following syntax is also supported:

`__declspec(dllexport)` is equivalent to `__symbolic`

`__declspec(dllimport)` is equivalent to `__global`

When taking advantage of this syntax with Oracle Developer Studio C++, you should add the option `-xldscope=hidden` to CC command lines. The result will be comparable to the results using MSVC++. With MSVC++, `__declspec(dllimport)` is supposed to be used only on declarations of external symbols, not on definitions. Example:

```
__declspec(dllimport) int foo(); // OK
__declspec(dllimport) int bar() { ... } // not OK
```

MSVC++ is lax about allowing `dllimport` on definitions, and the results using Oracle Developer Studio C++ will be different. In particular, using `dllimport` on a definition using Oracle Developer Studio C++ results in the symbol having global linkage instead of symbolic linkage. Dynamic libraries on Microsoft Windows do not support global linkage of symbols. If you run into this problem, you can change the source code to use `dlexport` instead of `dllimport` on definitions. You will then get the same results with MSVC++ and Oracle Developer Studio C++.

## 4.2 Thread-Local Storage

Take advantage of thread-local storage by declaring thread-local variables. A thread-local variable declaration consists of a normal variable declaration with the addition of the declaration specifier `__thread`. For more information, see [“A.2.191 - xthreadvar\[=o\]” on page 333](#).

The `__thread` keyword is recognized without the `-features=extensions` option. In C++11 mode, the `__thread` keyword is equivalent to the C++11 `thread_local` keyword.

You must include the `__thread` specifier in the first declaration of the thread variable. Variables that you declare with the `__thread` specifier are bound as they would be without the `__thread` specifier.

In C++03 or `-compat=5` mode, you can declare variables only of static duration with the `__thread` specifier. Variables with static duration include file global, file static, function local static, and class static member. You should not declare variables with dynamic or automatic duration with the `__thread` specifier. A thread variable can have a static initializer, but it cannot have a dynamic initializer or destructors. For example, `__thread int x = 4;` is permitted, but `__thread int x = f();` is not. A thread variable should not have a type with non-trivial constructors and destructors. In particular, a thread variable may not have type `std::string`.

In C++11 mode, you can declare variables of automatic duration with the `__thread` or `thread_local` specifier. Dynamic initialization of thread-local variables is supported.

The address-of operator (&) for a thread variable is evaluated at runtime and returns the address of the current thread's variable. Therefore, the address of a thread variable is not a constant.

The address of a thread variable is stable for the lifetime of the corresponding thread. Any thread in the process can freely use the address of a thread variable during the variable's lifetime. You cannot use a thread variable's address after its thread terminates. All addresses of a thread's variables are invalid after the thread's termination.

## 4.3 Overriding With Less Restrictive Virtual Functions

The C++ standard says that an overriding virtual function must not be less restrictive in the exceptions it allows than any function it overrides. It can have the same restrictions or be more restrictive. Note that the absence of an exception specification allows any exception.

Suppose, for example, that you call a function through a pointer to a base class. If the function has an exception specification, you can count on no other exceptions being thrown. If the overriding function has a less-restrictive specification, an unexpected exception could be thrown, which can result in unexpected program behavior followed by a program abort.

When you use `-features=extensions`, the compiler will allow overriding functions with less-restrictive exception specifications.

## 4.4 Making Forward Declarations of enum Types and Variables

When you use `-features=extensions`, the compiler allows the forward declaration of enum types and variables. In addition, the compiler allows the declaration of a variable with an incomplete enum type. The compiler will always assume an incomplete enum type to have the same size and range as type `int` on the current platform.

The following two lines show an example of invalid code that will compile when you use the `-features=extensions` option.

```
enum E; // invalid: forward declaration of enum not allowed
E e;   // invalid: type E is incomplete
```

Because enum definitions cannot reference one another, and no enum definition can cross-reference another type, the forward declaration of an enumeration type is never necessary. To make the code valid, you can always provide the full definition of the enum before it is used.

---

**Note** - On 64-bit architectures, enum can require a size that is larger than type `int`. If that is the case, and if the forward declaration and the definition are visible in the same compilation, the compiler will emit an error. If the actual size is not the assumed size and the compiler does not see the discrepancy, the code will compile and link, but might not run properly. Unexpected program behavior can occur, particularly if an 8-byte value is stored in a 4-byte variable.

---

---

**Note** - C++11 allows forward declaration of enum types with additional syntax.

---

## 4.5 Using Incomplete enum Types

When you use `-features=extensions`, incomplete enum types are taken as forward declarations. For example, the following invalid code will compile when you use the `-features=extensions` option.

```
typedef enum E F; // invalid, E is incomplete
```

As noted previously, you can always include the definition of an enum type before it is used.

---

**Note** - C++11 allows forward declaration of enum types with additional syntax.

---

## 4.6 Using an enum Name as a Scope Qualifier

Because an enum declaration does not introduce a scope, an enum name cannot be used as a scope qualifier. For example, the following code is invalid.

```
enum E {e1, e2, e3};  
int i = E::e1; // invalid: E is not a scope name
```

To compile this invalid code, use the `-features=extensions` option. The `-features=extensions` option instructs the compiler to ignore a scope qualifier if it is the name of an enum type.

To make the code valid, remove the invalid qualifier `E::`.

---

**Note** - Use of this option increases the possibility of typographical errors yielding incorrect programs that compile without error messages.

---

---

**Note** - C++11 allows declaration of "class enum", creating an enum type with its own scope.

---

## 4.7 Using Anonymous struct Declarations

An anonymous struct declaration is a declaration that declares neither a tag for the struct, nor an object or typedef name. Anonymous structs are not allowed in C++.

The `-features=extensions` option allows the use of an anonymous struct declaration but only as member of a union.

The following code is an example of an invalid anonymous struct declaration that compiles when you use the `-features=extensions` option.

```
union U {
    struct {
        int a;
        double b;
    }; // invalid: anonymous struct
    struct {
        char* c;
        unsigned d;
    }; // invalid: anonymous struct
};
```

The names of the struct members are visible without qualification by a struct member name. Given the definition of U in this code example, you can write:

```
U u;
u.a = 1;
```

Anonymous structs are subject to the same limitations as anonymous unions.

Note that you can make the code valid by giving a name to each struct, for example:

```
union U {
    struct {
        int a;
        double b;
    } A;
    struct {
        char* c;
        unsigned d;
    } B;
};
```



```
};  
U u;
```

## 4.8 Passing the Address of an Anonymous Class Instance

You are not allowed to take the address of a temporary variable. For example, the following code is invalid because it takes the address of a variable created by a constructor call. However, the compiler accepts this invalid code when you use the `-features=extensions` option.

```
class C {  
    public:  
        C(int);  
    ...  
};  
void f1(C*);  
int main()  
{  
    f1(&C(2)); // invalid  
}
```

Note that you can make this code valid by using an explicit variable.

```
C c(2);  
f1(&c);
```

The temporary object is destroyed when the function returns. Ensuring that the address of the temporary variable is not retained is the programmer's responsibility. In addition, the data that is stored in the temporary variable (for example, by `f1`) is lost when the temporary variable is destroyed.

## 4.9 Declaring a Static Namespace-Scope Function as a Class Friend

The following code is invalid.

```
class A {  
    friend static void foo(<args>);  
    ...  
}
```

```
};
```

Because a class name has external linkage and all definitions must be identical, friend functions must also have external linkage. However, when you use the `-features=extensions` option, the compiler to accepts this code.

Presumably the programmer's intent with this invalid code was to provide a nonmember "helper" function in the implementation file for class A. You can get the same effect by making `foo` a static member function. You can make it private if you do not want clients to call the function.

---

**Note** - If you use this extension, your class can be "hijacked" by any client. Any client can include the class header, then define its own static function `foo`, which will automatically be a friend of the class. The effect will be as if you made all members of the class public.

---

## 4.10 Using the Predefined `__func__` Symbol for Function Name

The compiler implicitly declares the identifier `__func__` in each function as a static array of `const char`. If the program uses the identifier, the compiler also provides the following definition where *function-name* is the unadorned name of the function. Class membership, namespaces, and overloading are not reflected in the name.

```
static const char __func__[] = "function-name";
```

For example, consider the following code fragment.

```
#include <stdio.h>
void myfunc(void)
{
    printf("%s\n", __func__);
}
```

Each time the function is called, it will print the following to the standard output stream.

```
myfunc
```

The identifier `__FUNCTION__` is also defined and is equivalent to `__func__`.

---

**Note** - In C++11, `__func__` is a standard symbol.

---

## 4.11 Supported Attributes

The following are supported attributes: The following attributes, invoked by `__attribute__((keyword))`, or alternatively by `[[keyword]]`, are implemented by the compiler for compatibility. Spelling the attribute keyword within double underscores, `__keyword__`, is also accepted.

<code>aligned</code>	Roughly equivalent to <code>#pragma align</code> . Generates a warning and is ignored if used on variable length arrays.
<code>always_inline</code>	Equivalent to <code>#pragma inline</code> and <code>-xinline</code>
<code>const</code>	Equivalent to <code>#pragma no_side_effect</code>
<code>constructor</code>	Equivalent to <code>#pragma init</code>
<code>deprecated(msg)</code>	Results in a warning if the type, variable, or function is used in the source file. The optional argument <code>msg</code> must be a string literal and will be included in the warning message.
<code>destructor</code>	Equivalent to <code>#pragma fini</code>
<code>malloc</code>	Equivalent to <code>#pragma returns_new_memory</code>
<code>mode</code>	(No equivalent)
<code>noinline</code>	Equivalent to <code>#pragma no_inline</code> and <code>-xinline</code>
<code>noreturn</code>	Equivalent to <code>#pragma does_not_return</code>
<code>pure</code>	Equivalent to <code>#pragma does_not_write_global_data</code>
<code>packed</code>	Equivalent to <code>#pragma pack()</code> . See details below.
<code>returns_twice</code>	Equivalent to <code>#pragma unknown_control_flow</code>
<code>strong</code>	Accepted for compatibility with g++, but has no effect. The g++ documentation recommends not using this attribute.
<code>tls_model</code>	Sets the thread-local storage model. The <code>tls_model</code> argument should be one of <code>global-dynamic</code> , <code>local-dynamic</code> , <code>initial-exec</code> , or <code>local-exec</code> .

<code>vector_size</code>	Indicates that a variable or a type name (created using typedef) represents a vector.						
<code>visibility</code>	Provides linker scoping. (See “A.2.142 <code>-xldscope={v}</code> ” on page 286) Syntax is: <code>__attribute__((visibility("visibility-type")))</code> , where <i>visibility-type</i> is one of:  <table><tr><td><code>default</code></td><td>Same as <code>__global</code> linker scoping</td></tr><tr><td><code>hidden</code></td><td>Same as <code>__hidden</code> linker scoping</td></tr><tr><td><code>internal</code></td><td>Same as <code>__symbolic</code> linker scoping</td></tr></table>	<code>default</code>	Same as <code>__global</code> linker scoping	<code>hidden</code>	Same as <code>__hidden</code> linker scoping	<code>internal</code>	Same as <code>__symbolic</code> linker scoping
<code>default</code>	Same as <code>__global</code> linker scoping						
<code>hidden</code>	Same as <code>__hidden</code> linker scoping						
<code>internal</code>	Same as <code>__symbolic</code> linker scoping						
<code>weak</code>	Equivalent to <code>#pragma weak</code>						

### 4.11.1 `__has_attribute` function-like macro

The predefined function-like macro

```
__has_attribute(attr)
```

evaluates to 1 if *attr* is a supported attribute. It evaluates to 0 otherwise. Example usage:

```
#ifndef __has_attribute // if we don't have __has_attribute, ignore it
    #define __has_attribute(x) 0
#endif
#if __has_attribute(deprecated)
    #define DEPRECATED __attribute__((deprecated))
#else
    #define DEPRECATED // attribute "deprecated" not available
#endif
void DEPRECATED old_func(int); // use the attribute if available
```

### 4.11.2 `__packed__` Attribute Details

This attribute, attached to struct or union type definition, specifies that each member (other than zero-width bit-fields) of the structure or union is placed to minimize the memory required. When attached to an enum definition, `__packed__` indicates that the smallest integral type should be used.

Specifying this attribute for struct and union types is equivalent to specifying the packed attribute on each of the structure or union members.

In the following example, struct `my_packed_struct`'s members are packed closely together but the internal layout of its `s` member is not packed. To do that, struct `my_unpacked_struct` would also need to be packed.

```
struct my_unpacked_struct
{
    char c;
    int i;
};

struct __attribute__((packed)) my_packed_struct
{
    char c;
    int i;
    struct my_unpacked_struct s;
};
```

You may only specify this attribute on the definition of an enum, struct, or union, and not on a typedef that does not also define the enumerated type, structure, or union.

## 4.12 Compiler Support for Intel MMX and Extended x86 Platform Intrinsics

Prototypes declared in the `mmintrin.h` header file support the Intel MMX intrinsics, and are provided for compatibility.

Specific header files provide prototypes for additional extended platform intrinsics, as shown in the following table. The location of these headers depends on where the compiler is installed. For example, if the compiler is located in `/opt/Solarisstudio12.3/bin`, the headers will be in `/opt/Solarisstudio12.3/lib/compilers/include/cc/sys`.

**TABLE 21** Header Files

x86 Platform	Header File
SSE	<code>mmintrin.h</code>
SSE2	<code>xmmintrin.h</code>
SSE3	<code>pmmintrin.h</code>
SSSE3	<code>tmmintrin.h</code>
SSE4A	<code>ammintrin.h</code>
SSE4.1	<code>smmintrin.h</code>
SSE4.2	<code>nmmintrin.h</code>

x86 Platform	Header File
AES encryption and PCLMULQDQ	wmmmintrin.h
AVX, CORE-AVX-I, AVX2	immintrin.h

Each header file includes the prototypes before it in the table. For example, on an SSE4.1 platform, including `smmintrin.h` in the user program declares the intrinsic names supporting SSE4.1, SSSE3, SSE3, SSE2, SSE, and MMX platforms because `smmintrin.h` includes `tmmintrin.h`, which includes `pmmintrin.h`, and so on down to `mmintrin.h`.

Note that `ammintrin.h` is published by AMD and is not included in any of the Intel intrinsic headers. `ammintrin.h` includes `pmmintrin.h`, so by including `ammintrin.h`, all AMD SSE4A as well as Intel SSE3, SSE2, SSE and MMX functions are declared.

Alternatively, the single Oracle Developer Studio header file `sunmedia_intrin.h` includes declarations from all the Intel header files, but does not include the AMD header file `ammintrin.h`.

Be aware that code deployed on a host platform (for example, SSE3) that calls any super-set intrinsic function (for example, for AVX) will not load on Oracle Solaris platforms and could fail with undefined behavior or incorrect results on Oracle Linux platforms. Deploy programs that call these platform-specific intrinsics only on the platforms that support them.

These are system header files and should appear in your program as shown in this example:

```
#include <nmmintrin.h>
```

Refer to the latest Intel C++ compiler reference guides for details.

## 4.13 `__atomic` built-ins

The Oracle Developer Studio C++ compiler implements the GCC `__atomic` built-in functions for memory model aware atomic operations. Refer to latest GCC manual for details.

## 4.14 `restrict` keyword

C99 introduced the keyword `restrict` as a type qualifier for function parameters that are pointers. The qualifier means that all accesses to the object pointed to by the argument are made through that pointer. The compiler can make optimizations based on the knowledge that the object is modified only by code that dereferences that pointer.

This C++ language extension is based on the gcc extension described at <https://gcc.gnu.org/onlinedocs/gcc-5.1.0/gcc/Restricted-Pointers.html>. The keywords `__restrict` and `__restrict__` (but not `restrict`) are recognized as type qualifiers for function parameters that have pointer or reference type. The qualifier can also be used on a non-static class member function to indicate that the class object is not accessed other than by the "this" pointer.

Any number of function parameters can be declared restricted.

The keywords are recognized in all compiler modes. Use of these keywords other than as described here are errors.

Examples:

```
int f1(int* __restrict p1, int* __restrict p2);
struct S {
    int f2() __restrict;
};
```

In the first example, the programmer promises that `p1` and `p2` point to distinct objects that are not referenced by the function in any other way. In the second example, the "this" pointer is declared restricted, and the programmer promises that the object associated with the function is not accessed other than with "this".

If the program does not in fact honor the promises implied by the `__restrict` qualifier, the program results are unpredictable.

The `-xrestrict` command-line option is still honored. Using the `__restrict` keyword in source code is more flexible, and may be preferred to the command-line option.

See also: [“A.2.183 `-xrestrict\[=f\]`” on page 325](#)





## Program Organization

---

The file organization of a C++ program requires more care than is typical for a C program. This chapter describes how to set up your header files and your template definitions.

### 5.1 Header Files

Creating an effective header file can be difficult. Often your header file must adapt to different versions of both C and C++. To accommodate templates, make sure your header file is tolerant of multiple inclusions (idempotent).

#### 5.1.1 Language-Adaptable Header Files

You might need to develop header files for inclusion in both C and C++ programs. However, Kernighan and Ritchie C (K&R C), also known as “classic C,” ANSI C, *Annotated Reference Manual C++* (ARM C++), and ISO C++ sometimes require different declarations or definitions for the same program element within a single header file. (See the *C++ Migration Guide* for additional information on the variations between languages and versions.) To make header files acceptable to all these standards, you might need to use conditional compilation based on the existence or value of the preprocessor macros `__STDC__` and `__cplusplus`.

The macro `__STDC__` is not defined in K&R C, but is defined in both ANSI C and C++. Use this macro to separate K&R C code from ANSI C or C++ code. This macro is most useful for separating prototyped from nonprototyped function definitions.

```
#ifdef __STDC__
int function(char*,...);    // C++ & ANSI C declaration
#else
int function();            // K&R C
#endif
```

The macro `__cplusplus` is not defined in C, but is defined in C++.

---

**Note** - Early versions of C++ defined the macro `cplusplus` instead of `__cplusplus`. The macro `cplusplus` is no longer defined.

---

Use the definition of the `__cplusplus` macro to separate C and C++. This macro is most useful in guarding the specification of an extern “C” interface for function declarations, as shown in the following example. To prevent inconsistent specification of extern “C”, never place an `#include` directive within the scope of an extern “C” linkage specification.

```
#include "header.h"
...           // ... other include files...
#ifdef __cplusplus
extern "C" {
#endif
    int g1();
    int g2();
    int g3()
#ifdef __cplusplus
}
#endif
```

In pre-standard (ARM) C++, the `__cplusplus` macro had a value of 1. In ISO C++, the macro has a value reflecting the version of the C++ standard the compiler is following. The value is the date of adoption of the standard, as follows:

```
C++ 1998/2003: 199711L
C++ 2011: 201103L
C++ 2014: 201402L (But see Notes)
```

Notes for Oracle Developer Studio 12.5:

1. Pre-standard C++ is not supported, so the macro never has the value 1.
2. C++14 is only partially supported, so the macro has the C++11 value, 201103L, in C++14 mode. A future release might support C++14.

You can use the value of this macro to determine whether constructs introduced in a newer version of the standard are available in the current compilation mode.

For example, suppose you want to use the “final” qualifier on a class or virtual function, but the code might be compiled in C++03 mode where the feature is not available. You can write this:

```
#if __cplusplus >= 201103L
#define FINAL final
#else
#define FINAL
```

```
#endif
class A FINAL
{
    // ...
};
```

## 5.1.2 Idempotent Header Files

Your header files should be idempotent, that is, the effect of including a header file many times should be exactly the same as including the header file only once. This property is especially important for templates. You can best accomplish idempotency by setting preprocessor conditions that prevent the body of your header file from appearing more than once.

```
#ifndef HEADER_H
#define HEADER_H
/* contents of header file */
#endif
```

## 5.2 Template Definitions

You can organize your template definitions in two ways: with definitions included and with definitions separated. The definitions-included organization allows greater control over template compilation.

### 5.2.1 Template Definitions Included

When you put the declarations and definitions for a template within the file that uses the template, the organization is *definitions-included*. For example:

```
main.cc

template <class Number> Number twice(Number original);
template <class Number> Number twice(Number original )
    { return original + original; }
int main()
    { return twice<int>(-3); }
```

When a file using a template includes a file that contains both the template's declaration and the template's definition, the file that uses the template also has the definitions-included organization. For example:

```
twice.h

#ifndef TWICE_H
#define TWICE_H
template <class Number>
Number twice(Number original);
template <class Number> Number twice( Number original )
    { return original + original; }
#endif

main.cc

#include "twice.h"
int main()
    { return twice(-3); }
```

---

**Note** - Making your template headers idempotent is very important. (See [“5.1.2 Idempotent Header Files” on page 75.](#))

---

## 5.2.2 Template Definitions Separate

Another way to organize template definitions is to keep the definitions in template definition files, as shown in the following example.

```
twice.h

#ifndef TWICE_H
#define TWICE_H
template <class Number>
Number twice(Number original);
#endif TWICE_H

twice.cc

template <class Number>
Number twice( Number original )
    { return original + original; }

main.cc

#include "twice.h"
int main( )
    { return twice<int>( -3 ); }
```

Template definition files *must not* include any non-idempotent header files and often need not include any header files at all. (See [“5.1.2 Idempotent Header Files” on page 75.](#)) Note that not all compilers support the definitions-separate model for templates.

Because a separate definitions file is a header file, it might be included implicitly in many files. It therefore should not contain any function or variable definitions unless they are part of a template definition. A separate definitions file can include type definitions, including typedefs.

---

**Note** - Although source-file extensions for template definition files are commonly used (that is, .c, .C, .cc, .cpp, .cxx, or .c++), template definition files are header files. The compiler includes them automatically if necessary. Template definition files should *not* be compiled independently.

---

If you place template declarations in one file and template definitions in another file, be very careful how you construct the definition file, what you name it, and where you put it. You might also need to identify explicitly to the compiler the location of the definitions. Refer to [“7.5 Template Definition Searching” on page 102](#) for information about the template definition search rules.

When generating preprocessor output with the -E or -P options, the definitions-separate file organization does not allow the template definitions to be included in the .i file. Compiling the .i file can fail due to missing definitions. By conditionally including the template definition file in the template declaration header (see the code example below), you can ensure the template definitions are available by using -template=no%extdef on the command line. The libCtd and STLport libraries are implemented in this way.

```
// template declaration file
template <class T> class foo { ... };
#ifdef _TEMPLATE_NO_EXTDEF
#include "foo.cc" //template definition file
#endif
```

However, do not attempt to define the macro \_TEMPLATE\_NO\_EXTDEF yourself. When defined without the -template=no%extdef option, compilation failures can occur due to multiple inclusion of template definition files.



## Creating and Using Templates

---

Templates enable you to write a single body of code that applies to a wide range of types in a type-safe manner. This chapter introduces template concepts and terminology in the context of function templates, discusses the more complicated (and more powerful) class templates, and describes the composition of templates. Also discussed are template instantiation, default template parameters, and template specialization. The chapter concludes with a discussion of potential problem areas for templates.

### 6.1 Function Templates

A function template describes a set of related functions that differ only by the types of their arguments or return values.

#### 6.1.1 Function Template Declaration

You must declare a template before you can use it. A *declaration*, as in the following example, provides enough information to use the template but not enough information to implement the template.

```
template <class Number> Number twice( Number original );
```

In this example, *Number* is a *template parameter*; it specifies the range of functions that the template describes. More specifically, *Number* is a *template type parameter*, and its use within the template definition stands for a type determined at the location where the template is used.

## 6.1.2 Function Template Definition

If you declare a template, you must also define it. A *definition* provides enough information to implement the template. The following example defines the template declared in the previous example.

```
template <class Number> Number twice( Number original )
    { return original + original; }
```

Because template definitions often appear in header files, a template definition might be repeated in several compilation units. All definitions, however, must be the same. This restriction is called the *One-Definition Rule*.

## 6.1.3 Function Template Use

Once declared, templates can be used like any other function. Their *use* consists of naming the template and providing function arguments. The compiler can infer the template type arguments from the function argument types. For example, you can use the previously declared template as follows:

```
double twicedouble( double item )
    { return twice( item ); }
```

If a template argument cannot be inferred from the function argument types, it must be supplied where the function is called. For example:

```
template<class T> T func(); // no function arguments
int k = func<int>(); // template argument supplied explicitly
```

## 6.2 Class Templates

A class template describes a set of related classes or data types that differ only by types, by integral values, by pointers or references to variables with global linkage, or by a combination thereof. Class templates are particularly useful in describing generic but type-safe data structures.



## 6.2.1 Class Template Declaration

A class template declaration provides only the name of the class and its template arguments. Such a declaration is an *incomplete class template*.

The following example is a template declaration for a class named `Array` that takes any type as an argument.

```
template <class Elem> class Array;
```

This template is for a class named `String` that takes an unsigned `int` as an argument.

```
template <unsigned Size> class String;
```

## 6.2.2 Class Template Definition

A class template definition must declare the class data and function members, as in the following examples.

```
template <class Elem> class Array {
    Elem* data;
    int size;
public:
    Array( int sz );
    int GetSize();
    Elem& operator[]( int idx );
};
```

```
template <unsigned Size> class String {
    char data[Size];
    static int overflows;
public:
    String( char *initial );
    int length();
};
```

Unlike function templates, class templates can have both type parameters (such as `class Elem`) and expression parameters (such as `unsigned Size`). An expression parameter can be:

- A value that has an integral type or enumeration
- A pointer or a reference to an object
- A pointer or a reference to a function

- A pointer to a class member function

## 6.2.3 Class Template Member Definitions

The full definition of a class template requires definitions for its function members and static data members. Dynamic (nonstatic) data members are sufficiently defined by the class template declaration.

### 6.2.3.1 Function Member Definitions

The definition of a template function member consists of the template parameter specification followed by a function definition. The function identifier is qualified by the class template's class name and the template arguments. The following example shows definitions of two function members of the `Array` class template, which has a template parameter specification of `template <class Elem>`. Each function identifier is qualified by the template class name and the template argument `Array<Elem>`.

```
template <class Elem> Array<Elem>::Array( int sz )
    {size = sz; data = new Elem[size];}

template <class Elem> int Array<Elem>::GetSize()
    { return size; }
```

This example shows definitions of function members of the `String` class template.

```
#include <string.h>
template <unsigned Size> int String<Size>::length( )
    {int len = 0;
     while (len < Size && data[len] != '\0') len++;
     return len;}

template <unsigned Size> String<Size>::String(char *initial)
    {strncpy(data, initial, Size);
     if (length( ) == Size) overflows++;}
```

### 6.2.3.2 Static Data Member Definitions

The definition of a template static data member consists of the template parameter specification followed by a variable definition, where the variable identifier is qualified by the class template name and its template actual arguments.

```
template <unsigned Size> int String<Size>::overflows = 0;
```

## 6.2.4 Class Template Use

A template class can be used wherever a type can be used. Specifying a template class consists of providing the values for the template name and arguments. The declaration in the following example creates the variable `int_array` based upon the `Array` template. The variable's class declaration and its set of methods are just like those in the `Array` template except that `Elem` is replaced with `int`. See [“6.3 Template Instantiation” on page 83](#).

```
Array<int> int_array(100);
```

The declaration in this example creates the `short_string` variable using the `String` template.

```
String<8> short_string("hello");
```

You can use template class member functions as you would any other member function

```
int x = int_array.GetSize( );
```

```
int x = short_string.length( );
```

```
.
```

## 6.3 Template Instantiation

Template *instantiation* involves generating a concrete class or function (*instance*) for a particular combination of template arguments. For example, the compiler generates a class for `Array<int>` and a different class for `Array<double>`. The new classes are defined by substituting the template arguments for the template parameters in the definition of the template class. In the `Array<int>` example shown in [“6.2 Class Templates” on page 80](#), the compiler substitutes `int` wherever `Elem` appears.

### 6.3.1 Implicit Template Instantiation

The use of a template function or template class introduces the need for an instance. If that instance does not already exist, the compiler implicitly instantiates the template for that combination of template arguments.

## 6.3.2 Explicit Template Instantiation

The compiler implicitly instantiates templates only for those combinations of template arguments that are actually used. This approach may be inappropriate for the construction of libraries that provide templates. C++ provides a facility to explicitly instantiate templates, as seen in the following examples.

### 6.3.2.1 Explicit Instantiation of Template Functions

To instantiate a template function explicitly, follow the `template` keyword by a declaration (not definition) for the function, with the function identifier followed by the template arguments.

```
template float twice<float>(float original);
```

Template arguments may be omitted when the compiler can infer them.

```
template int twice(int original);
```

### 6.3.2.2 Explicit Instantiation of Template Classes

To instantiate a template class explicitly, follow the `template` keyword by a declaration (not definition) for the class, with the class identifier followed by the template arguments.

```
template class Array<char>;
```

```
template class String<19>;
```

When you explicitly instantiate a class, all of its members are also instantiated.

### 6.3.2.3 Explicit Instantiation of Template Class Function Members

To explicitly instantiate a template class function member, follow the `template` keyword by a declaration (not definition) for the function, with the function identifier qualified by the template class, followed by the template arguments.

```
template int Array<char>::GetSize();
```

```
template int String<19>::length();
```

### 6.3.2.4 Explicit Instantiation of Template Class Static Data Members

To explicitly instantiate a template class static data member, follow the `template` keyword by a declaration (not definition) for the member, with the member identifier qualified by the template class, followed by the template argument.

```
template int String<19>::overflows;
```

## 6.4 Template Composition

You can use templates in a nested manner. This is particularly useful when defining generic functions over generic data structures, as in the standard C++ library. For example, a template sort function may be declared over a template array class:

```
template <class Elem> void sort(Array<Elem>);
```

and defined as:

```
template <class Elem> void sort(Array<Elem> store)
{int num_elems = store.GetSize();
  for (int i = 0; i < num_elems-1; i++)
    for (int j = i+1; j < num_elems; j++)
      if (store[j-1] > store[j])
        {Elem temp = store[j];
         store[j] = store[j-1];
         store[j-1] = temp;}}
```

The preceding example defines a sort function over the predeclared `Array` class template objects. The next example shows the actual use of the sort function.

```
Array<int> int_array(100); // construct an array of ints
sort(int_array);         // sort it
```

## 6.5 Default Template Parameters

You can give default values to template parameters for class templates (but not function templates).

```
template <class Elem = int> class Array;
template <unsigned Size = 100> class String;
```

If a template parameter has a default value, all parameters after it must also have default values. A template parameter can have only one default value.

## 6.6 Template Specialization

Treating some combinations of template arguments as a special case might provide some performance gains, as in the examples for `twice` in this section. Alternatively, a template description might fail to work for a set of its possible arguments, as in the examples for `sort` in this section. Template specialization allows you to define alternative implementations for a given combination of actual template arguments. The template specialization overrides the default instantiation.

### 6.6.1 Template Specialization Declaration

You must declare a specialization before any use of that combination of template arguments. The following examples declare specialized implementations of `twice` and `sort`.

```
template <> unsigned twice<unsigned>( unsigned original );  
template <> sort<char*>(Array<char*> store);
```

You can omit the template arguments if the compiler can unambiguously determine them. For example:

```
template <> unsigned twice(unsigned original);  
template <> sort(Array<char*> store);
```

### 6.6.2 Template Specialization Definition

You must define all template specializations that you declare. The following examples define the functions declared in the preceding section.

```
template <> unsigned twice<unsigned>(unsigned original)  
    {return original << 1;}  
  
#include <string.h>  
template <> void sort<char*>(Array<char*> store)  
    {int num_elems = store.GetSize();  
    for (int i = 0; i < num_elems-1; i++)  
        for (int j = i+1; j < num_elems; j++)
```

```

if (strcmp(store[j-1], store[j]) > 0)
    {char *temp = store[j];
      store[j] = store[j-1];
      store[j-1] = temp;}}

```

### 6.6.3 Template Specialization Use and Instantiation

A specialization is used and instantiated just as any other template, except that the definition of a completely specialized template is also an instantiation.

### 6.6.4 Partial Specialization

In the previous examples, the templates are fully specialized. That is, they define an implementation for specific template arguments. A template can also be partially specialized, meaning that only some of the template parameters are specified, or that one or more parameters are limited to certain categories of type. The resulting partial specialization is itself still a template. For example, the following code sample shows a primary template and a full specialization of that template.

```

template<class T, class U> class A {...}; //primary template
template<> class A<int, double> {...}; //specialization

```

The following code shows examples of partial specialization of the primary template.

```

template<class U> class A<int> {...}; // Example 1
template<class T, class U> class A<T*> {...}; // Example 2
template<class T> class A<T**, char> {...}; // Example 3

```

- Example 1 provides a special template definition for cases when the first template parameter is type `int`.
- Example 2 provides a special template definition for cases when the first template parameter is any pointer type.
- Example 3 provides a special template definition for cases when the first template parameter is pointer-to-pointer of any type, and the second template parameter is type `char`.

## 6.7 Template Problem Areas

This section describes problems you might encounter when using templates.

## 6.7.1 Nonlocal Name Resolution and Instantiation

Sometimes a template definition uses names that are not defined by the template arguments or within the template itself. If so, the compiler resolves the name from the scope enclosing the template, which could be the context at the point of definition, or at the point of instantiation. A name can have different meanings in different places, yielding different resolutions.

Name resolution is complex. Consequently, you should not rely on nonlocal names except those provided in a pervasive global environment. That is, use only nonlocal names that are declared and defined the same way everywhere. In the following example, the template function `converter` uses the nonlocal names `intermediary` and `temporary`. These names have different definitions in `use1.cc` and `use2.cc`, and will probably yield different results under different compilers. For templates to work reliably, all nonlocal names (`intermediary` and `temporary` in this case) must have the same definition everywhere.

```
use_common.h
// Common template definition
template <class Source, class Target>
Target converter(Source source)
    {temporary = (intermediary)source;
    return (Target)temporary;}
use1.cc
typedef int intermediary;
int temporary;

#include "use_common.h"
use2.cc
typedef double intermediary;
unsigned int temporary;

#include "use_common.h"
```

A common use of nonlocal names is the use of the `cin` and `cout` streams within a template. Few programmers really want to pass the stream as a template parameter, so they refer to a global variable. However, `cin` and `cout` must have the same definition everywhere.

## 6.7.2 Local Types as Template Arguments

The template instantiation system relies on type-name equivalence to determine which templates need to be instantiated or reinstantiated. Thus local types can cause serious problems when used as template arguments. Beware of creating similar problems in your code.



**EXAMPLE 1** Example of Local Type as Template Argument Problem

```

array.h
template <class Type> class Array {
    Type* data;
    int size;
public:
    Array(int sz);
    int GetSize();
};

array.cc
template <class Type> Array<Type>::Array(int sz)
    {size = sz; data = new Type[size];}
template <class Type> int Array<Type>::GetSize()
    {return size;}

file1.cc
#include "array.h"
struct Foo {int data;};
Array<Foo> File1Data(10);

file2.cc
#include "array.h"
struct Foo {double data;};
Array<Foo> File2Data(20);

```

The Foo type registered in file1.cc is not the same as the Foo type registered in file2.cc. Using local types in this way could lead to errors and unexpected results.

## 6.7.3 Friend Declarations of Template Functions

Templates must be declared before they are used. A friend declaration constitutes a use of the template, not a declaration of the template. A true template declaration must precede the friend declaration. For example, when the compilation system attempts to link the produced object file for the following example, it generates an undefined error for the operator<< function, which is *not* instantiated.

**EXAMPLE 2** Example of Friend Declaration Problem

```

array.h
// generates undefined error for the operator<< function
#ifndef ARRAY_H
#define ARRAY_H

```

```
#include <iosfwd>

template<class T> class array {
    int size;
public:
    array();
    friend std::ostream&
        operator<<(std::ostream&, const array<T>&);
};
#endif

array.cc
#include <stdlib.h>
#include <iostream>

template<class T> array<T>::array() {size = 1024;}

template<class T>
std::ostream&
operator<<(std::ostream& out, const array<T>& rhs)
    {return out <<'[' << rhs.size <<']';}

main.cc
#include <iostream>
#include "array.h"

int main()
{
    std::cout
        << "creating an array of int... " << std::flush;
    array<int> foo;
    std::cout << "done\n";
    std::cout << foo << std::endl;
    return 0;
}
```

Note that no error message is issued during compilation because the compiler reads the following line as the declaration of a normal function that is a friend of the array class.

```
friend ostream& operator<<(ostream&, const array<T>&);
```

Because `operator<<` is really a template function, you need to supply a template declaration for it prior to the declaration of `template class array`. However, because `operator<<` has a parameter of type `array<T>`, you must precede the function declaration with a declaration of `array<T>`. The file `array.h` must look like this example:

```
#ifndef ARRAY_H
#define ARRAY_H
```

```

#include <iosfwd>

// the next two lines declare operator<< as a template function
template<class T> class array;
template<class T>
    std::ostream& operator<<(std::ostream&, const array<T>&);

template<class T> class array {
    int size;
public:
    array();
    friend std::ostream&
        operator<< <T> (std::ostream&, const array<T>&);
};
#endif

```

## 6.7.4 Using Qualified Names Within Template Definitions

The C++ standard requires types with qualified names that depend upon template arguments to be explicitly noted as type names with the `typename` keyword. This requirement applies even if the compiler can deduce that it should be a type. The comments in the following example show the types with qualified names that require the `typename` keyword.

```

struct simple {
    typedef int a_type;
    static int a_datum;
};
int simple::a_datum = 0; // not a type
template <class T> struct parametric {
    typedef T a_type;
    static T a_datum;
};
template <class T> T parametric<T>::a_datum = 0; // not a type
template <class T> struct example {
    static typename T::a_type variable1; // dependent
    static typename parametric<T>::a_type variable2; // dependent
    static simple::a_type variable3; // not dependent
};
template <class T> typename T::a_type // dependent
    example<T>::variable1 = 0; // not a type
template <class T> typename parametric<T>::a_type // dependent
    example<T>::variable2 = 0; // not a type
template <class T> simple::a_type // not dependent

```

```
example<T>::variable3 = 0;           // not a type
```

## 6.7.5 Nesting Template Names

Because the “>” character sequence is interpreted as the right-shift operator, you must be careful when you use one template name inside another. Make sure you separate adjacent “>” characters with at least one blank space.

For example, the following ill-formed statement:

```
Array<String<10>> short_string_array(100); // >> = right-shift
```

is interpreted as:

```
Array<String<10 >> short_string_array(100);
```

The correct syntax is:

```
Array<String<10> > short_string_array(100);
```

## 6.7.6 Referencing Static Variables and Static Functions

Within a template definition, the compiler does not support referencing an object or function that is declared static at global scope or in a namespace. If multiple instances are generated, the One-Definition Rule (C++ standard section 3.2) is violated because each instance refers to a different object. The usual failure indication is missing symbols at link time.

If you want a single object to be shared by all template instantiations, then make the object a nonstatic member of a named namespace. If you want a different object for each instantiation of a template class, then make the object a static member of the template class. If you want a different object for each instantiation of a template function, then make the object local to the function.

## 6.7.7 Building Multiple Programs Using Templates in the Same Directory

If you do not use the option `-instances=extern`, there are no restrictions on building multiple programs in the same directory.

If you are building more than one program or library by specifying `-instances=extern`, build them in separate directories. If you want to build in the same directory, clean the repository between the different builds. This practice avoids any unpredictable errors. For more information, see [“7.4.4 Sharing Template Repositories” on page 101](#).

Consider the following example with makefiles `a.cc`, `b.cc`, `x.h`, and `x.cc`. Note that this example is meaningful only if you specify `-instances=extern`:

```

.....
Makefile
.....
CCC = CC

all: a b

a:
    $(CCC) -I. -instances=extern -c a.cc
    $(CCC) -instances=extern -o a a.o

b:
    $(CCC) -I. -instances=extern -c b.cc
    $(CCC) -instances=extern -o b b.o

clean:
    /bin/rm -rf SunWS_cache *.o a b

...
x.h
...
template <class T> class X {
public:
    int open();
    int create();
    static int variable;
};

...
x.cc
...
template <class T> int X<T>::create() {
    return variable;
}

template <class T> int X<T>::open() {
    return variable;
}

template <class T> int X<T>::variable = 1;

```

```
...
a.cc
...
#include "x.h"

int main()
{
    X<int> templ;

    templ.open();
    templ.create();
}

...
b.cc
...
#include "x.h"

int main()
{
    X<int> templ;

    templ.create();
}
```

If you build both a and b, add a `make clean` command between the two builds. The following commands result in an error:

```
example% make a
example% make b
```

The following commands will not produce any error:

```
example% make a
example% make clean
example% make b
```

## Compiling Templates

---

Template compilation requires the C++ compiler to do more than traditional UNIX compilers have done. The C++ compiler must generate object code for template instances on an as-needed basis. It might share template instances among separate compilations using a template repository. It might accept some template compilation options. It must locate template definitions in separate source files and maintain consistency between template instances and mainline code.

### 7.1 Verbose Compilation

When given the flag `-verbose=template`, the C++ compiler notifies you of significant events during template compilation. Conversely, the compiler does not notify you when given the default, `-verbose=no%template`. The `+w` option might give other indications of potential problems when template instantiation occurs.

### 7.2 Repository Administration

The `CCadmin(1)` command administers the template repository (used only with the option `-instances=extern`). For example, changes in your program can render some instantiations superfluous, thus wasting storage space. The `CCadmin- clean` command (formerly `ptclean`) clears out all instantiations and associated data. Instantiations are re-created only when needed.

#### 7.2.1 Generated Instances

The compiler treats inline template functions as inline functions for the purposes of template instance generation. The compiler manages them as it does other inline functions, and the descriptions in this chapter do not apply to template inline functions.

## 7.2.2 Whole-Class Instantiation

The compiler usually instantiates members of template classes independently of other members, so that the compiler instantiates only members that are used within the program. Methods written solely for use through a debugger will therefore not normally be instantiated.

Use two strategies to ensure that debugging members are available to the debugger.

- First, write a non-template function that uses the template class instance members that are otherwise unused. This function need not be called.
- Second, use the `-template=wholeclass` compiler option, which instructs the compiler to instantiate all non-template non-inline members of a template class if any of those same members are instantiated.

The ISO C++ Standard permits developers to write template classes for which all members might not be legal with a given template argument. As long as the illegal members are not instantiated, the program is still well formed. The ISO C++ Standard Library uses this technique. However, the `-template=wholeclass` option instantiates all members, and hence cannot be used with such template classes when instantiated with the problematic template arguments.

## 7.2.3 Compile-Time Instantiation

Instantiation is the process by which a C++ compiler creates a usable function or object from a template. The C++ compiler uses compile-time instantiation, which forces instantiations to occur when the reference to the template is being compiled.

The advantages of compile-time instantiation are:

- Debugging is much easier. Error messages occur in context, allowing the compiler to give a complete traceback to the point of reference.
- Template instantiations are always up-to-date.
- The overall compilation time, including the link phase, is reduced.

Templates can be instantiated multiple times if source files reside in different directories or if you use libraries with template symbols.



## 7.2.4 Template Instance Placement and Linkage

By default, instances go into special address sections, and the linker recognizes and discards duplicates. You can instruct the compiler to use one of five instance placement and linkage methods: external, static, global, explicit, and semi-explicit.

- External instances perform best when the following is true:
  - The set of instances in the program is small but each compilation unit references a large subset of the instances.
  - Few instances are referenced in more than one or two compilation units.

Static instances are deprecated.

- Global instances, the default, are suitable for all development, and perform best when objects reference a variety of instances.
- Explicit instances are suitable for some carefully controlled application compilation environments.
- Semi-explicit instances require slightly less controlled compilation environments but produce larger object files and have restricted uses.

This section discusses the five instance placement and linkage methods. Additional information about generating instances can be found in [“6.3 Template Instantiation” on page 83](#).

## 7.3 External Instances

With the external instances method, all instances are placed within the template repository. The compiler ensures that exactly one consistent template instance exists; instances are neither undefined nor multiply defined. Templates are reinstantiated only when necessary. For non-debug code, the total size of all object files (including any within the template cache) may be smaller with `-instances=extern` than with `-instances=global`.

Template instances receive global linkage in the repository. Instances are referenced from the current compilation unit with external linkage.

---

**Note** - If you are compiling and linking in separate steps and you specify `-instance=extern` for the compilation step, you must also specify it for the link step.

---

The disadvantage of this method is that the cache must be cleared whenever you change programs or make significant program changes. The cache is a bottleneck for parallel compilation, as when using `dmake` because access to the cache must be restricted to one compilation at a time. Also, you can build only one program within a directory.

Determining whether a valid template instance is already in the cache can take longer than just creating the instance in the main object file and discarding it later if needed.

Specify external linkage with the `-instances=extern` option.

Because instances are stored within the template repository, you must use the `CC` command to link C++ objects that use external instances into programs.

If you wish to create a library that contains all the template instances that it uses, compile with the `-xar` option. Do *not* use the `ar` command. For example:

```
example% CC -xar -instances=extern -o libmain.a a.o b.o c.o
```

### 7.3.1 Possible Cache Conflicts

Do not run different compiler versions in the same directory due to possible cache conflicts when you specify `-instance=extern`. Consider the following when you compile with the `-instances=extern` template model:

- Do not create unrelated binaries in the same directory. Any binaries (`.o`, `.a`, `.so`, executable programs) created in the same directory should be related, in that names of all objects, functions, and types common to two or more object files have identical definitions.
- It is safe to run multiple compilations simultaneously in the same directory, such as when using `dmake`. It is not safe to run any compilations or link steps at the same time as another link step. A *link step* is any operation that creates a library or executable program. Be sure that dependencies in a makefile do not allow any commands to run in parallel with a link step.

### 7.3.2 Static Instances

---

**Note** - The `-instances=static` option is deprecated because `-instances=global` now gives you all the advantages of `static` without the disadvantages. This option was provided in earlier compilers to overcome problems that no longer exist.

---

With the static instances method, all instances are placed within the current compilation unit. As a consequence, templates are instantiated during each recompilation; instances are not saved to the template repository.

The disadvantage of this method is that it does not follow language semantics and makes substantially larger objects and executables.

Instances receive static linkage. These instances will not be visible or usable outside the current compilation unit. As a result, templates might have identical instantiations in several object files. Because multiple instances produce unnecessarily large programs, static instance linkage is suitable only for small programs where templates are unlikely to be multiply instantiated.

Compilation is potentially faster with static instances, so this method might also be suitable during Fix-and-Continue debugging. (See *Debugging a Program With dbx.*)

---

**Note** - If your program depends on sharing template instances (such as static data members of template classes or template functions) across compilation units, do not use the static instances method. Your program will not work properly.

---

Specify static instance linkage with the `-instances=static` compiler option.

### 7.3.3 Global Instances

Unlike with early compiler releases, you do not have to guard against multiple copies of a global instance.

The advantage of this method is that incorrect source code commonly accepted by other compilers is now also accepted in this mode. In particular, references to static variables from within a template instances are not legal but are commonly accepted.

The disadvantage of this method is that individual object files may be larger due to copies of template instances in multiple files. If you compile some object files for debug using the `-g` option and some without, it is hard to predict whether you will get a debug or non-debug version of a template instance linked into the program.

Template instances receive global linkage. These instances are visible and usable outside the current compilation unit.

Specify global instances with the `-instances=global` option (the default).

### 7.3.4 Explicit Instances

In the explicit instances method, instances are generated only for templates that are explicitly instantiated. Implicit instantiations are not satisfied. Instances are placed within the current compilation unit.

The advantage of this method is that you have the least amount of template compilation and smallest object sizes.

The disadvantage is that you must perform all instantiation manually.

Template instances receive global linkage. These instances are visible and usable outside the current compilation unit. The linker recognizes and discards duplicates.

Specify explicit instances with the `-instances=explicit` option.

### 7.3.5 Semi-Explicit Instances

When you use the semi-explicit instances method, instances are generated only for templates that are explicitly instantiated or implicitly instantiated within the body of a template. Instances required by explicitly created instances are generated automatically. Implicit instantiations in the mainline code are not satisfied. Instances are placed within the current compilation unit. As a consequence, templates are reinstantiated during each recompilation; instances receive global linkage and they are not saved to the template repository.

Specify semi-explicit instances with the `-instances=semiexplicit` option.

## 7.4 Template Repository

The template repository stores template instances between separate compilations so that template instances are compiled only when necessary. The template repository contains all nonsource files needed for template instantiation when using the `-instances=extern` option. The repository is not used for other kinds of instances.

### 7.4.1 Repository Structure

The template repository is contained, by default, within a cache directory called `SunWS_cache`.

The cache directory is contained within the directory in which the object files are placed. You can change the name of the cache directory by setting the `SUNWS_CACHE_NAME` environment variable. Note that the value of the `SUNWS_CACHE_NAME` variable must be a directory name and not a path name. The compiler automatically places the template cache directory under the object file directory so the compiler already has a path.

## 7.4.2 Writing to the Template Repository

When the compiler must store template instances, it stores them within the template repository corresponding to the output file. For example, the following command writes the object file to `./sub/a.o` and writes template instances into the repository contained within `./sub/SunWS_cache`. If the cache directory does not exist and the compiler needs to instantiate a template, the compiler will create the directory.

```
example% CC -o sub/a.o a.cc
```

## 7.4.3 Reading From Multiple Template Repositories

The compiler reads from the template repositories corresponding to the object files that it reads. For example, the following command reads from `./sub1/SunWS_cache` and `./sub2/SunWS_cache`, and, if necessary, writes to `./SunWS_cache`.

```
example% CC sub1/a.o sub2/b.o
```

## 7.4.4 Sharing Template Repositories

Templates that are within a repository must not violate the one-definition rule of the ISO C++ standard. That is, a template must have the same source in all uses of the template. Violating this rule produces undefined behavior.

The simplest, though most conservative, way to ensure that the rule is not violated is to build only one program or library within any one directory. Two unrelated programs might use the same type name or external name to mean different things. If the programs share a template repository, template definitions could conflict, thus yielding unpredictable results.

## 7.4.5 Template Instance Automatic Consistency With `-instances=extern`

The template repository manager ensures that the states of the instances in the repository are consistent and up-to-date with your source files when you specify `-instances=extern`.

For example, if your source files are compiled with the `-g` option (debugging on), the files you need from the database are also compiled with `-g`.

In addition, the template repository tracks changes in your compilation. For example, if you have the `-DDEBUG` flag set to define the name `DEBUG`, the database tracks this. If you omit this flag on a subsequent compile, the compiler reinstantiates those templates on which this dependency is set.

---

**Note** - If you remove the source code of a template or stop using a template, instances of the template remain in the cache. If you change the signature of a function template, instances using the old signature remain in the cache. If you run into unexpected behavior at compile or link time due to these issues, clear the template cache and rebuild the program.

---

## 7.5 Template Definition Searching

When you use the definitions-separate template organization, template definitions are not available in the current compilation unit, and the compiler must search for the definition. This section describes how the compiler locates the definition.

Definition searching is somewhat complex and prone to error. Therefore, you should use the definitions-included template file organization if possible. Doing so helps you avoid definition searching altogether. See [“5.2.1 Template Definitions Included” on page 75](#).

---

**Note** - If you use the `-template=no%extdef` option, the compiler will not search for separate source files.

---

### 7.5.1 Source File Location Conventions

Without the specific directions provided with an options file, the compiler uses a Cfront-style method to locate template definition files. This method requires that the template definition file contain the same base name as the template declaration file. This method also requires the template definition file to be on the current `include` path. For example, if the template function `foo()` is located in `foo.h`, the matching template definition file should be named `foo.cc` or some other recognizable source-file extension (`.C`, `.c`, `.cc`, `.cpp`, `.cxx`, or `.c++`). The template definition file must be located in one of the normal `include` directories or in the same directory as its matching header file.

## 7.5.2 Definitions Search Path

As an alternative to the normal search path set with `-I`, you can specify a search directory for template definition files with the option `-ptidirectory`. Multiple `-pti` flags define multiple search directories, that is, a search path. If you use `-ptidirectory`, the compiler looks for template definition files on this path and ignores the `-I` flag. Because the `-ptidirectory` flag complicates the search rules for source files, use the `-I` option instead of the `-ptidirectory` option.

## 7.5.3 Troubleshooting a Problematic Search

Sometimes the compiler generates confusing warnings or error messages because it is looking for a file that you don't intend to compile. Usually, the problem is that a file, for example `foo.h`, contains template declarations and another file, such as `foo.cc`, gets implicitly included.

If a header file, `foo.h`, has template declarations, the compiler searches for a file called `foo` with a C++ file extension (`.C`, `.c`, `.cc`, `.cpp`, `.cxx`, or `.c++`) by default. If the compiler finds such a file, it includes the file automatically. See [“7.5 Template Definition Searching” on page 102](#) for more information on such searches.

If you have a file `foo.cc` that you don't intend to be treated this way, you have two options:

- Change the name of the `.h` or the `.cc` file to eliminate the name match.
- Disable the automatic search for template definition files by specifying the `-template=no%extdef` option. You must then include all template definitions explicitly in your code and will not be able to use the “definitions separate” model.





## Exception Handling

---

This chapter discusses the C++ compiler's implementation of exception handling. Additional information can be found in [“10.2 Using Exceptions in a Multithreaded Program” on page 116](#). For more information on exception handling, see *The C++ Programming Language*, Third Edition, by Bjarne Stroustrup (Addison-Wesley, 1997).

### 8.1 Synchronous and Asynchronous Exceptions

Exception handling is intended to support only synchronous exceptions, such as array range checks. The term *synchronous exception* means that exceptions can be originated only from throw expressions.

The C++ standard supports synchronous exception handling with a termination model. *Termination* means that once an exception is thrown, control never returns to the throw point.

Exception handling is not intended to directly handle asynchronous exceptions such as keyboard interrupts. However, you can make exception handling work in the presence of asynchronous events if you are careful. For instance, to make exception handling work with signals, you can write a signal handler that sets a global variable, and create another routine that polls the value of that variable at regular intervals and throws an exception when the value changes. You cannot throw an exception from a signal handler.

### 8.2 Specifying Runtime Errors

Five runtime error messages are associated with exceptions:

- No handler for the exception
- Unexpected exception thrown
- An exception can only be re-thrown in a handler
- During stack unwinding, a destructor must handle its own exception

- Out of memory

When errors are detected at runtime, the error message displays the type of the current exception and one of the five error messages. By default, the predefined function `terminate()` is called, which then calls `abort()`.

The compiler uses the information provided in the exception specification to optimize code production. For example, table entries for functions that do not throw exceptions are suppressed, and runtime checking for exception specifications of functions is eliminated wherever possible.

## 8.3 Disabling Exceptions

If you know that exceptions are not used in a program, you can use the compiler option `features=noexcept` to suppress generation of code that supports exception handling. The use of the option results in slightly smaller code size and faster code execution. However, when files compiled with exceptions disabled are linked to files using exceptions, some local objects in the files compiled with exceptions disabled are not destroyed when exceptions occur. By default, the compiler generates code to support exception handling. Unless the time and space overhead is significant, leaving exceptions enabled is usually better.

---

**Note** - The C++ standard library, the `dynamic_cast` operator, and the default operator `new` require exceptions, so you should not turn off exceptions if you use any of these facilities.

---

## 8.4 Using Runtime Functions and Predefined Exceptions

The standard header `<exception>` provides the classes and exception-related functions specified in the C++ standard. You can access this header only when compiling in `-compat=5` mode. The following excerpt shows the `<exception>` header file declarations.

```
// standard header <exception>
namespace std {
    class exception {
        exception() throw();
        exception(const exception&) throw();
        exception& operator=(const exception&) throw();
        virtual ~exception() throw();
        virtual const char* what() const throw();
    };
};
```

```

};
class bad_exception: public exception {...};
// Unexpected exception handling
typedef void (*unexpected_handler)();
unexpected_handler
    set_unexpected(unexpected_handler) throw();
void unexpected();
// Termination handling
typedef void (*terminate_handler)();
terminate_handler set_terminate(terminate_handler) throw();
void terminate();
bool uncaught_exception() throw();
}

```

The standard class `exception` is the base class for all exceptions thrown by selected language constructs or by the C++ standard library. An object of type `exception` can be constructed, copied, and destroyed without generating an exception. The virtual member function `what()` returns a character string that describes the exception.

For compatibility with exceptions as used in C++ release 4.2, the header `<exception.h>` is also provided for use in `-compat=5` mode. This header allows for a transition to standard C++ code and contains declarations that are not part of standard C++. Update your code to follow the C++ standard (using `<exception>` instead of `<exception.h>`) as development schedules permit.

```

// header <exception.h>, used for transition
#include <exception>
#include <new>
using std::exception;
using std::bad_exception;
using std::set_unexpected;
using std::unexpected;
using std::set_terminate;
using std::terminate;
typedef std::exception xmsg;
typedef std::bad_exception xunexpected;
typedef std::bad_alloc xalloc;

```

## 8.5 Mixing Exceptions With Signals and Setjmp/Longjmp

You can use the `setjmp/longjmp` functions in a program where exceptions can occur as long as they do not interact.

All the rules for using exceptions and `setjmp/longjmp` separately apply. In addition, a `longjmp` from point A to point B is valid only if an exception thrown at A and caught at B would have

the same effect. In particular, you must not `longjmp` into or out of a try-block or catch-block (directly or indirectly), or `longjmp` past the initialization or non-trivial destruction of auto variables or temporary variables.

You cannot throw an exception from a signal handler.

## 8.6 Building Shared Libraries That Have Exceptions

Never use `-Bsymbolic` with programs containing C++ code. Use linker map files instead or linker scoping options. See [“4.1 Linker Scoping” on page 59](#). With `-Bsymbolic`, references in different modules can bind to different copies of what is supposed to be one global object.

The exception mechanism relies on comparing addresses. If you have two copies of something, their addresses won't compare equal, and the exception mechanism can fail because the exception mechanism relies on comparing what are supposed to be unique addresses.

## Improving Program Performance

---

You can improve the performance of C++ functions by writing those functions in a manner that helps the compiler do a better job of optimizing them. Many books have been written on software performance in general and C++ in particular. Rather than repeat such valuable information, this chapter discusses only those performance strategies that strongly affect the C++ compiler.

### 9.1 Avoiding Temporary Objects

C++ functions often produce implicit temporary objects, each of which must be created and destroyed. For non-trivial classes, the creation and destruction of temporary objects can be expensive in terms of processing time and memory usage. The C++ compiler does eliminate some temporary objects, but it cannot eliminate all of them.

Write functions to minimize the number of temporary objects while ensuring that your programs remain comprehensible. Techniques include using explicit variables rather than implicit temporary objects and using reference parameters rather than value parameters. Another technique is to implement and use operations such as += rather than implementing and using only + and =. For example, the first line below introduces a temporary object for the result of a + b, while the second line does not.

```
T x = a + b;  
T x(a); x += b;
```

### 9.2 Using Inline Functions

Calls to small and quick functions can be smaller and quicker when expanded inline than when called normally. Conversely, calls to large or slow functions can be larger and slower when expanded inline than when branched to. Furthermore, all calls to an inline function must be

recompiled whenever the function definition changes. Consequently, the decision to use inline functions requires considerable care.

Do not use inline functions when you anticipate changes to the function definition *and* recompiling all callers is expensive. Otherwise, use inline functions when the code to expand the function inline is smaller than the code to call the function *or* the application performs significantly faster with the function inline.

The compiler cannot inline all function calls, so making the most effective use of function inlining may require some source changes. Use the `+w` option to learn when function inlining does not occur. In the following situations, the compiler will *not* inline the function:

- The function contains difficult control constructs, such as loops, switch statements, and try/catch statements. Many times these functions execute the difficult control constructs infrequently. To inline such a function, split the function into two parts: an inner part that contains the difficult control constructs and an outer part that decides when to call the inner part. This technique of separating the infrequent part from the frequent part of a function can improve performance even when the compiler can inline the full function.
- The inline function body is large or complicated. Apparently simple function bodies may be complicated because of calls to other inline functions within the body, or because of implicit constructor and destructor calls (as often occurs in constructors and destructors for derived classes). For such functions, inline expansion rarely provides significant performance improvement, and the function is best left unlined.
- The arguments to an inline function call are large or complicated. The compiler is particularly sensitive when the object for an inline member function call is itself the result of an inline function call. To inline functions with complicated arguments, simply compute the function arguments into local variables and then pass the variables to the function.

## 9.3 Using Default Operators

If a class definition does not declare a parameterless constructor, a copy constructor, a copy assignment operator, or a destructor, the compiler will implicitly declare them. These are called default operators. A C-like `struct` has these default operators. When the compiler builds a default operator, it knows a great deal about the work that needs to be done and can produce very good code. This code is often much faster than user-written code because the compiler can take advantage of assembly-level facilities while the programmer usually cannot. So, when the default operators do what is needed, the program should not declare user-defined versions of these operators.

Default operators are inline functions, so do not use default operators when inline functions are inappropriate (see the previous section). Otherwise, default operators are appropriate in the following situations:

- The user-written parameterless constructor would call only parameterless constructors for its base objects and member variables. Primitive types effectively have “do nothing” parameterless constructors.
- The user-written copy constructor would simply copy all base objects and member variables.
- The user-written copy assignment operator would simply copy all base objects and member variables.
- The user-written destructor would be empty.

Some C++ programming texts suggest that class programmers always define all operators so that any reader of the code will know that the class programmer did not forget to consider the semantics of the default operators. Obviously, this advice interferes with the optimization discussed above. The resolution of the conflict is to place a comment in the code stating that the class is using the default operator. C++11 allows you to declare the above special functions as default, showing that you did not forget about them, but without incurring any overhead.

## 9.4 Using Value Classes

C++ classes, including structures and unions, are passed and returned by value. For Plain-Old-Data (POD) classes, the C++ compiler is required to pass the `struct` as would the C compiler. Objects of these classes are passed *directly*. For objects of classes with user-defined copy constructors, the compiler is effectively required to construct a copy of the object, pass a pointer to the copy, and destruct the copy after the return. Objects of these classes are passed *indirectly*. For classes that fall between these two requirements, the compiler can choose. However, this choice affects binary compatibility, so the compiler must choose consistently for every class.

For most compilers, passing objects directly can result in faster execution. This execution improvement is particularly noticeable with small value classes, such as complex numbers or probability values. You can sometimes improve program efficiency by designing classes that are more likely to be passed directly than indirectly.

A class is passed indirectly if it has any one of the following characteristics:

- A user-defined copy constructor
- A user-defined destructor
- A base that is passed indirectly
- A non-static data member that is passed indirectly

Otherwise, the class is passed directly.

## 9.4.1 Choosing to Pass Classes Directly

To maximize the chance that a class will be passed directly:

- Use default constructors, especially the default copy constructor, where possible.
- Use the default destructor where possible. Because the default destructor is not virtual, a class with a default destructor should generally not be a base class.
- Avoid virtual functions and virtual bases.

## 9.4.2 Passing Classes Directly on Various Processors

Classes and unions that are passed directly by the C++ compiler are passed exactly as the C compiler would pass a struct or union. However, C++ structs and unions are passed differently on different architectures.

**TABLE 22** Passing of Structs and Unions by Architecture

Architecture	Description
SPARC V7/V8	Structs and unions are passed and returned by allocating storage within the caller and passing a pointer to that storage. (That is, all structs and unions are passed by reference.)
SPARC V9	Structs with a size no greater than 16 bytes (32 bytes) are passed (returned) in registers. Unions and all other structs are passed and returned by allocating storage within the caller and passing a pointer to that storage. (That is, small structs are passed in registers; unions and large structs are passed by reference.) As a consequence, small value classes are passed as efficiently as primitive types.
x86 platforms	Structs and unions are passed by allocating space on the stack and copying the argument onto the stack. Structs and unions are returned by allocating a temporary object in the caller's frame and passing the address of the temporary object as an implicit first parameter.

## 9.5 Cache Member Variables

Accessing member variables is a common operation in C++ member functions.

The compiler must often load member variables from memory through the `this` pointer. Because values are being loaded through a pointer, the compiler sometimes cannot determine when a second load must be performed or whether the value loaded before is still valid. In these



cases, the compiler must choose the safe, but slow, approach and reload the member variable each time it is accessed.

You can avoid unnecessary memory reloads by explicitly caching the values of member variables in local variables, as follows:

- Declare a local variable and initialize it with the value of the member variable.
- Use the local variable in place of the member variable throughout the function.
- If the local variable changes, assign the final value of the local variable to the member variable. However, this optimization may yield undesired results if the member function calls another member function on that object.

This optimization is most productive when the values can reside in registers, as is the case with primitive types. The optimization may also be productive for memory-based values because the reduced aliasing gives the compiler more opportunity to optimize.

This optimization may be counter productive if the member variable is often passed by reference, either explicitly or implicitly.

On occasion, the desired semantics of a class requires explicit caching of member variables, for instance when there is a potential alias between the current object and one of the member function's arguments. For example:

```
complex& operator*= (complex& left, complex& right)
{
    left.real = left.real * right.real + left.imag * right.imag;
    left.imag = left.real * right.imag + left.image * right.real;
}
```

will yield unintended results when called with:

```
x*=x;
```



## Building Multithreaded Programs

---

This chapter explains how to build multithreaded programs. It also discusses the use of exceptions, explains how to share C++ Standard Library objects across threads, and describes how to use classic (old) iostreams in a multithreading environment.

For more information about multithreading, see the Oracle Solaris [Multithreaded Programming Guide](#).

See also the [Oracle Developer Studio 12.5: OpenMP API User's Guide](#) for information on using OpenMP shared memory parallelization directives to create multithreaded programs.

### 10.1 Building Multithreaded Programs

All libraries shipped with the C++ compiler are multithreading safe. If you want to build a multithreaded application, or if you want to link your application to a multithreaded library, you must compile and link your program with the `-mt` option. This option passes `-D_REENTRANT` to the preprocessor and passes `-lthread` in the correct order to `ld`. By default, the `-mt` option ensures that `libthread` is linked before `libCrun`. Use of `-mt` is recommended as a simpler and less error-prone alternative to specifying the macro and library.

#### 10.1.1 Indicating Multithreaded Compilation

You can check whether an application is linked to `libthread` by using the `ldd` command:

```
example% CC -mt myprog.cc
example% ldd a.out
libm.so.1 => /usr/lib/libm.so.1
libCrun.so.1 => /usr/lib/libCrun.so.1
libthread.so.1 => /usr/lib/libthread.so.1
```

```
libc.so.1 => /usr/lib/libc.so.1
libdl.so.1 => /usr/lib/libdl.so.1
```

## 10.1.2 Using C++ Support Libraries With Threads and Signals

The C++ support libraries, `libCrun`, `libiostream`, and `libCstd` are multithread safe but are not async safe. Therefore, in a multithreaded application, functions available in the support libraries should not be used in signal handlers. Doing so can result in a deadlock situation.

It is not safe to use the following features in a signal handler in a multithreaded application:

- Iostreams
- new and delete expressions
- Exceptions

## 10.2 Using Exceptions in a Multithreaded Program

The current exception-handling implementation is safe for multithreading because exceptions in one thread do not interfere with exceptions in other threads. However, you cannot use exceptions to communicate across threads because an exception thrown from one thread cannot be caught in another.

Each thread can set its own `terminate()` or `unexpected()` function. Calling `set_terminate()` or `set_unexpected()` in one thread affects only the exceptions in that thread. The default function for `terminate()` is `abort()` for any thread (see [“8.2 Specifying Runtime Errors” on page 105](#)).

### 10.2.1 Thread Cancellation

Thread cancellation through a call to `pthread_cancel(3T)` results in the destruction of automatic (local nonstatic) objects on the stack except when you specify `-noex` or `-features=no%except`.

`pthread_cancel(3T)` uses the same mechanism as exceptions. When a thread is cancelled, the execution of local destructors is interleaved with the execution of cleanup routines that the user

has registered with `pthread_cleanup_push()`. The local objects for functions called after a particular cleanup routine is registered are destroyed before that routine is executed.

## 10.3 Sharing C++ Standard Library Objects Between Threads

The C++ Standard Library (`libc++` - `library=C++`) is MT-safe with the exception of some locales. It ensures that the internals of the library work properly in a multithreaded environment. You still need to place locks around any library objects that you yourself share between threads. See the man pages for `setlocale(3C)` and `attributes(5)`.

For example, if you instantiate a string, then create a new thread and pass that string to the thread by reference, then you must add locks around write accesses to that string because you are explicitly sharing the one string object between threads. (The facilities provided by the library to accomplish this task are described below.)

On the other hand, if you pass the string to the new thread by value, you do not need to worry about locking even if the library uses a reference-counted implementation. The library handles that locking automatically. You are only required to lock when making an object available to multiple threads explicitly, either by passing references between threads or by using global or static objects.

The locking (synchronization) mechanism used internally in the C++ Standard Library to ensure correct behavior in the presence of multiple threads can be described as follows:

Two synchronization classes provide mechanisms for achieving multithreaded safety; `_RWSTMutex` and `_RWSTGuard`.

The `_RWSTMutex` class provides a platform-independent locking mechanism through the following member functions:

- `void acquire()`—Acquires a lock on self, or blocks until such a lock can be obtained.
- `void release()`—Releases a lock on self.

```
class _RWSTMutex
{
public:
    _RWSTMutex ();
    ~_RWSTMutex ();
    void acquire ();
    void release ();
};
```

The `_RWSTDGuard` class is a convenience wrapper class that encapsulates an object of `_RWSTMutex` class. An `_RWSTDGuard` object attempts to acquire the encapsulated mutex in its constructor (throwing an exception of type `::thread_error`, derived from `std::exception` on error), and releases the mutex in its destructor (the destructor never throws an exception).

```
class _RWSTDGuard
{
public:
    _RWSTDGuard (_RWSTMutex&);
    ~_RWSTDGuard ();
};
```

Additionally, you can use the macro `_RWSTD_MT_GUARD(mutex)` (formerly `_STDGUARD`) to conditionally create an object of the `_RWSTDGuard` class in multithread builds. The object guards the remainder of the code block in which it is defined from being executed by multiple threads simultaneously. In single-threaded builds, the macro expands into an empty expression.

The following example illustrates the use of these mechanisms.

```
#include <rw/stdmutex.h>

//
// An integer shared among multiple threads.
//
int I;

//
// A mutex used to synchronize updates to I.
//
_RWSTMutex I_mutex;

//
// Increment I by one. Uses an _RWSTMutex directly.
//

void increment_I ()
{
    I_mutex.acquire(); // Lock the mutex.
    I++;
    I_mutex.release(); // Unlock the mutex.
}

//
// Decrement I by one. Uses an _RWSTDGuard.
//

void decrement_I ()
{
```

```

    _RWSTDGuard guard(I_mutex); // Acquire the lock on I_mutex.
    --I;
    //
    // The lock on I is released when destructor is called on guard.
    //
}

```

## 10.4 Memory Barrier Ininsics

The compiler provides the header file `mbarrier.h`, which defines various memory barrier intrinsics for SPARC and x86 processors. These intrinsics may be of use for developers writing multithreaded code using their own synchronization primitives. Refer to the appropriate processor documentation to determine when and if these intrinsics are necessary for their particular situation.

Memory ordering intrinsics supported by `mbarrier.h` include the following:

- `__machine_r_barrier()` - This is a *read* barrier. It ensures that all the load operations before the barrier will be completed before all the load operations after the barrier.
- `__machine_w_barrier()` - This is a *write* barrier. It ensures that all the store operations before the barrier will be completed before all the store operations after the barrier.
- `__machine_rw_barrier()` - This is a *read—write* barrier. It ensures that all the load and store operations before the barrier will be completed before all the load and store operations after the barrier.
- `__machine_acq_barrier()` - This is a barrier with *acquire* semantics. It ensures that all the load operations before the barrier will be completed before all the load and store operations after the barrier.
- `__machine_rel_barrier()` - This is a barrier with *release* semantics. It ensures that all the load and store operations before the barrier will be completed before all the store operations after the barrier.
- `__compiler_barrier()` - Prevents the compiler from moving memory accesses across the barrier.

All the barrier intrinsics with the exception of the `__compiler_barrier()` intrinsic generate memory ordering instructions on x86, these are `mfence`, `sfence`, or `lfence` instructions. On SPARC platforms these are `membar` instructions.

The `__compiler_barrier()` intrinsic generates no instructions and instead informs the compiler that all previous memory operations must be completed before any future memory operations are initiated. The practical result is that all non-local variables and local variables

with the `static` storage class specifier will be stored back to memory before the barrier, and reloaded after the barrier, and the compiler will not mix memory operations from before the barrier with those after the barrier. All other barriers implicitly include the behavior of the `__compiler_barrier()` intrinsic.

For example, in the following code the presence of the `__compiler_barrier()` intrinsic stops the compiler from merging the two loops:

```
#include "mbarrier.h"
int thread_start[16];
void start_work()
{
    /* Start all threads */
    for (int i=0; i<8; i++)
    {
        thread_start[i]=1;
    }
    __compiler_barrier();
    /* Wait for all threads to complete */
    for (int i=0; i<8; i++)
    {
        while (thread_start[i]==1){}
    }
}
```



**PART III**

**Libraries**



# ◆◆◆ CHAPTER 11

## Using Libraries

---

Libraries provide a way to share code among several applications and to reduce the complexity of very large applications. The C++ compiler gives you access to a variety of libraries. This chapter explains how to use these libraries.

### 11.1 C Libraries

The Oracle Solaris operating system comes with several libraries installed in `/usr/lib`. Most of these libraries have a C interface. Of these, the `libc` and `libm`, libraries are linked by the `CC` driver by default. The library `libthread` is linked if you use the `-mt` option. To link any other system library, use the appropriate `-l` option at link time. For example, to link the `libdemangle` library, pass `-ldemangle` on the `CC` command line at link time:

```
example% CC text.c -ldemangle
```

---

**Note** - `libatomic` is available on certain versions of Oracle Solaris and Oracle Linux in `/usr/lib`. Note that `-latomic` does not link the system library `libatomic`. See [“A.2.111 -xatomic=a” on page 249](#) and *Oracle Developer Studio 12.5: Release Notes* for more information.

---

The C++ compiler has its own runtime support libraries. All C++ applications are linked to these libraries by the `CC` driver. The C++ compiler also comes with several other useful libraries, as explained in the following section.

### 11.2 Libraries Provided With the C++ Compiler

Several libraries are shipped with the C++ compiler.

The following table lists the libraries that are shipped with the C++ compiler and the modes in which they are available.

**TABLE 23** Libraries Shipped With the C++ Compiler

Library	Description
libstlport	STLport implementation of the standard library for -compat=5 or -std=sun03 mode
libstlport_dbg	STLport library for debug mode for -compat=5 or -std=sun03 mode
libCrun	C++ runtime for -compat=5 or -std=sun03 mode
libCstd	C++ standard library for -compat=5 or -std=sun03 mode
libiostream	Classic iostreams for -compat=5 or -std=sun03 mode
libcsunimath	Supports the -xia option for -compat=5 or -std=sun03 mode.
libgc	Garbage collection
libdemangle	Demangling
libstdc++	C++ standard library for -std=c++03, -std=c++11, and -std=c++14 modes
libgcc_s	Runtime support for -std=c++03, -std=c++11, and -std=c++14 modes
libCrunG3	Additional runtime support for -std=c++03, -std=c++11, and -std=c++14 modes
libstatomic	Atomics runtime support for -std=c++03, -std=c++11 and -std=c++14 modes

**Note** - Do not redefine or modify any of the configuration macros for STLport or Oracle Developer Studio C++ libraries. The libraries are configured and built in a way that works with the C++ compiler. Modifying the configuration macros results in programs that will not compile, will not link, or do not run properly.

## 11.2.1 C++ Library Descriptions

This section provides a brief description of each of the C++ libraries.

- `libCrun` – Contains the runtime support needed by the compiler in `-compat=5` mode. It provides support for `new/delete`, exceptions, and RTTI.
- `libCstd` – The C++ standard library. In particular, this library includes `iostreams`. This library is the default in `-compat=5` mode on Oracle Solaris. On Oracle Linux, use `-library=Cstd` to get this library. If you have existing sources that use the classic `iostreams` and you want to make use of the standard `iostreams`, you have to modify your sources to conform to the new interface.

- `libiostream` – The classic iostreams library built with `-compat=5`. If you have existing sources that use the classic iostreams and you want to compile these sources with `-compat=5`, you can use `libiostream` without modifying your sources. Use `-library=iostream` to get this library.

---

**Note** - Much of the standard library depends on using standard iostreams. Using classic iostreams in the same program can cause problems.

---

- `libstlport` – The STLport implementation of the C++ standard library. You can use this library instead of the default `libCstd` by specifying the option `-library=stlport4`. However, you cannot use `libstlport` and `libCstd` in the same program. You must compile and link everything, including imported libraries, using one library or the other exclusively.
- `libstdcxx` – The Apache `stdcxx` implementation of the C++ standard library. You can use this library instead of the default `libCstd` by specifying the option `-library=stdcxx4`. However, you cannot use `libstdcxx` and `libCstd` in the same program. You must compile and link everything, including imported libraries, using one library or the other exclusively.
- `libgc` – Used in deployment mode or garbage collection mode. Simply linking with the `libgc` library automatically and permanently fixes a program's memory leaks. When you link your program with the `libgc` library, you can program without calling `free` or `delete` while otherwise programming normally. The garbage collection library has a dependency on the dynamic load library so specify `-lgc` and `-ldl` when you link your program.  
Additional information can be found in the `gcFixPrematureFrees(3)` and `gcInitialize(3)` man pages.
- `libdemangle` – Used for demangling C++ mangled names.
- `libstdc++` – The gcc implementation of the C++ standard library, used in `-std=c++03`, `-std=c++11`, and `-std=c++14` modes.
- `libgcc_s` – Contains runtime support for code used in `libstdc++`.
- `libCrunG3` – Contains the runtime support needed by the compiler in the `-std=c++03`, `-std=c++11`, and `-std=c++14` modes. It provides support for new/delete, exceptions, and RTTI.
- `libstatomic` – Contains the runtime support functions needed by atomic operations. The library is used in `c++11` and `c++14` modes for user code and in `c++03` mode for some runtime library code. Users can control the link of this library with the `-xatomic` option.

## 11.2.2 Default C++ Libraries

The C++ libraries are linked by default when building an executable program, but not when building a shared library (.so). When building a shared library, all needed libraries must be listed explicitly. The `-zdefs` option will cause the linker to complain if a needed library is omitted, and is the default when building an executable program. In default `-compat=5` mode, the following libraries are linked by default by the CC driver:

```
-lcstd -lCrun -lm -lc
```

In `-std=c++03`, `-std=c++11`, and `-std=c++14` modes, the following libraries are linked by default by the CC driver:

```
-lstdc++ -lgcc_s -lCrunG3 -lm -lc
```

See [“A.2.51 `-library=\[,l...\]`” on page 215](#) for more information.

## 11.2.3 Bundled Atomics Library

Atomics is a new language feature in the C11 and C++11 standards that requires runtime support from the operating system. For more information about using the atomics features, see the [atomic\\_fence\(3A\)](#), [atomic\\_flag\(3A\)](#), and [stdatomic.h\(3A\)](#) man pages.

Because there is not yet a standard interface for this runtime support, there are slight differences between the gcc atomics library and the Oracle Developer Studio atomics library.

GCC supports atomics with a runtime library called `libatomic.so` that is included in `/usr/lib` on Oracle Solaris 11.3 and Oracle Linux 7.x.

Oracle Developer Studio 12.5 compilers support atomics with a new runtime library called `libstdatomic.so`. This library is bundled with the Oracle Developer Studio release, and is not included in Oracle Solaris or Oracle Linux. This is an interim solution until the GCC and Oracle Developer Studio libraries can be merged and incorporated into Oracle Solaris and until the Oracle Linux-bundled library conforms to a standard interface.

The `libstdatomic.so` library has been tested and is compatible with the GCC 4.8, 4.9, and 5.1 releases of `libstdatomic.so` with a few exceptions discussed in [“11.2.3.2 Compatibility with GCC Atomics Library `libatomic`” on page 128](#).

A new compiler option `-xatomic` enables you to specify whether to use the GCC `libatomic` library or the Oracle Developer Studio `libstdatomic` library when linking your programs and libraries.

### 11.2.3.1 Selecting an Atomics Library

You can choose to use either the Oracle Developer Studio atomics library (`libstatomic.so`) or the GCC atomics library (`libatomic.so`), but it is important to make this consistent among executables and libraries that are linked together. Only one atomics library should be used in a running process.

---

**Note** - If you do not need to be compatible with gcc-built libraries that use atomics, you should use `libstatomic.so` with the Oracle Developer Studio compilers.

---

To control which library is used at link time, use the `-xatomic` option. To link to Oracle Developer Studio's library `libstatomic`, use `-xatomic=studio` and to link to GCC's library `libatomic`, use `-xatomic=gcc`. To prevent linking with a library, use `-xatomic=none`.

As an aid to porting existing Makefiles or source code that uses GCC compilers, if `-latomic` is passed to the compiler, the option is converted to `-xatomic=studio`.

For C++ programs, the atomic support library is linked by default, when needed.

---

**Note** - The `-xatomic=none` option ensures that the application does not have the Oracle Developer Studio `libstatomic` installation directory as a run path. In order to build the application that calls the library functions with `-xatomic=none`, `libstatomic.so` should be linked explicitly at build time.

---

## ▼ Deploying Applications that use `libstatomic.so`

The bundled atomics library `libstatomic.so` is fully supported as a part of the Oracle Developer Studio product. You can deploy an application that uses the library, but you need to include the library unless the application will run on a system where Oracle Developer Studio is installed.

1. **Determine the run-time path from your executable to `libstatomic.so`.**

For example:

```
./lib
```

2. **Determine the build-time path to `libstatomic.so`.**

For example:

```
build-path/import/libstatomic.so
```

3. **Add `-xatomic=none` to your linking step.**

#### 4. Add new link time options.

For example:

```
-R runtime-path build-path-to-atomics/libstatomic.so.1
```

#### 5. Copy the libstatomic library into your own product installation tree.

### Example 3 Including libstatomic.so With a myprog Executable

The following example deploys an application on a 64-bit SPARC platform that does not have Oracle Developer Studio installed.

Before the application is built on the build machine, decide where libstatomic will be located relative to the executable. For example, if your application is located at app\_root, and the libstatomic library is in app\_root/lib, the relative directory of the library is ./lib.

```
bash-4.1$ ls app_root/  
lib      myprog  
bash-4.1$ ls app_root/lib/  
libstatomic.so  libstatomic.so.1
```

On the build machine, determine where libstatomic.so is located. For example, if Oracle Developer Studio is installed in install-dir/, then libstatomic.so is located at install-dir/lib/compilers/atomic/sparcv9/libstatomic.so.

Compile the program, using the following command:

```
$ install-dir/bin/CC -m64 [compiler-options] -xatomic=none myprog.cc -o myprog -R'$ORIGIN' /  
lib install-dir/lib/compilers/atomic/sparcv9/libstatomic.so
```

On the deployment machine, create the package directories.

Then copy the 64-bit libstatomic.so library to app\_root/lib.

```
$ cp install-dir/lib/compilers/atomic/sparcv9/libstatomic.so app_root/lib
```

Copy the resulting executable for myprog to the app\_root directory. This enables the runtime linker to find libstatomic.so under ./lib when myprog is executed.

```
$ cp myprog.out app_root
```

### 11.2.3.2 Compatibility with GCC Atomics Library libatomic

If your application or library uses atomics and it needs to interoperate with executables and libraries which use the GCC version of libatomic, then you must link your Oracle Developer



Studio program with the GCC version of `libatomic`. You must be careful to have only one version of the atomics runtime library in your program.

To link your Oracle Developer Studio C and C++ programs with the GCC version of `libatomic`, use the compiler option `-xatomic=gcc`.

If you are linking and running on an older system that does not have the GCC version of `libatomic` in `/usr/lib`, then you do not have to worry about incompatible atomic support. In that circumstance, you can use `libstatomic` in combination with GCC binaries on that system, because no other atomics library will be in use.

The Oracle Developer Studio compiler works best with the `libstatomic` library, but is compatible with GCC's `libatomic` version 1.1, with the known issues listed below:

- **GCC 4.8 includes `libatomic 1.0.0`.** - This version of `libatomic` supports C11 and C++11 atomics, if you avoid using floating point atomics in C 11 programs. The GCC 4.8 compiler itself does not support C11 until a later release.
- **GCC 4.9 and 5.1 include `libatomic 1.1`.** - This version includes the floating-point atomics for C11, and the GCC compilers with these versions support the C11 atomics keyword.

---

**Note** - Your C11 program might take the address of an atomic function, which is legal only for non-generic functions. This will not work correctly with `libatomic 1.0.0` or with `libatomic 1.1`, because the library assumes all the atomic functions will always be inlined by the compiler and don't need code in the library. You can see the list of these functions in the atomic man pages. You should use `libstatomic` if you need to get function pointers for these.

---

Oracle Linux 7.x and Oracle Solaris 11.3 include GCC 4.8 with `libatomic 1.0.0`.

### 11.2.3.3 Implementation Notes

When multiple components such as executables or shared libraries require an atomic runtime, you should dynamically link each component with the appropriate `-xatomic` option to create a correct dynamic dependency. You should not produce a shared library that requires an atomic option to be supplied when the library is linked.

It is not recommend to use both runtime libraries in the same process, for the following reasons:

- Some atomic types require calls to the runtime support library to perform synchronization. The two runtime systems have different internal data structures, so the two libraries cannot synchronize the same object.

- The Oracle Developer Studio library `libstatomic` uses the same global symbol names for functions as `libatomic`. If both libraries are used in the same process, an executable or library could call functions in an unexpected library.

Programs that attempt to use both runtime libraries might seem to work at first, but are likely to fail and cannot be supported.

---

**Note** - Using `-latomic` to link will not result in linking with `/usr/lib/libatomic.so.1`. That library is the GCC implementation and primarily intended to be used with GCC until a compatible library is released in Oracle Solaris and Oracle Linux.

---

Because many of the atomic operations are inlined, your application might be able to use the atomics feature without depending on the atomics runtime library. The behavior is implementation specific, so the results might change if you upgrade compilers. If your application uses only scalar atomic types (flags, char, int, long, or pointers) and builds on an x86 platform, then your resulting binary might not need `libstatomic`. You can try compiling such an application or library with the `-xatomic=none` option and check if it links and runs correctly.

## 11.3 Related Library Options

The CC driver provides several options to help you use libraries.

- Use the `-l` option to specify a library to be linked.
- Use the `-L` option to specify a directory to be searched for the library.
- Use the `-mt` option compile and link multithreaded code.
- Use the `-xia` option to link the interval arithmetic libraries.
- Use the `-xlang` option to link Fortran or C99 runtime libraries.
- Use the `-xatomic=[studio|gcc|none]` option to specify which atomics support library is linked.
- Use the `-library` option to specify the following libraries that are shipped with the Oracle Developer Studio C++ compiler:

```
libCrun
libCstd
libiostream
libC
libcomplex
libstlport, libstlport_dbg
```

```
libgc
libsunperf
libstdcxx (distributed as part of the Oracle Solaris OS)
```

A library that is specified using both `-library` and `-staticlib` options will be linked statically if a static version of the library is available. Some examples:

The following command links the `libgc` library statically.

```
example% CC test.cc -library=gc -staticlib=gc
```

The following command excludes the libraries `libCrun` and `libCstd`, which would otherwise be included by default.

```
example% CC test.cc -library=no%Crun,no%Cstd
```

By default, `CC` links various sets of system libraries depending on the command line options. If you specify `-xnoLib` (or `-noLib`), `CC` links only those libraries that are specified explicitly with the `-l` option on the command line. (When `-xnoLib` or `-noLib` is used, the `-library` option is ignored, if present.)

The `-R` option allows you to build dynamic library search paths into the executable file. At execution time, the runtime linker searches these paths for the shared libraries needed by the application. The `CC` driver passes one or more `-R` options pointing into `<install-directory>/lib` to `ld` by default if the compiler is installed in the standard location. You can use `-norunpath` to disable building the default path for shared libraries into the executable.

The linker searches `/lib` and `/usr/lib` by default. Do not specify these directories or any compiler installation directories in `-L` options.

Programs built for deployment should be built with `-norunpath` or an `-R` option that avoids looking in the compiler directory for libraries. See [“11.6 Using Shared Libraries” on page 134](#).

## 11.4 Using Class Libraries

Generally, two steps are involved in using a class library:

1. Include the appropriate header in your source code.
2. Link your program with the object library.

## 11.4.1 `iostream` Library

The C++ compiler provides two implementations of `iostreams`:

- **Classic `iostreams`.** This term refers to the `iostreams` library shipped with the C++ 4.0, 4.0.1, 4.1, and 4.2 compilers, and earlier with the `cfront`-based 3.0.1 compiler. There is no standard for this library. It is available in `libiostream`.
- **Standard `iostreams`.** This is part of the version of the standard C++ library you use—`libcstd`, `libstlport`, `libstdcxx`, or the `g++` runtime library. The standard version of `iostreams` is neither binary-compatible nor entirely source-compatible with the classic `iostreams` library.

If you have existing C++ sources, your code might look like the following example, which uses classic `iostreams`.

```
// file prog1.cc
#include <iostream.h>

int main() {
    cout << "Hello, world!" << endl;
    return 0;
}
```

The following example uses standard `iostreams`.

```
// file prog2.cc
#include <iostream>

int main() {
    std::cout << "Hello, world!" << std::endl;
    return 0;
}
```

The following command compiles and links `prog2.cc` into an executable program called `prog2`. The program is compiled in `-compat=5` mode. `libcstd`, which includes the standard `iostream` library, is linked by default.

```
example% CC -compat=5 prog2.cc -o prog2
```

### 11.4.1.1 Note About Classic `iostreams`

The so-called “Classic” `iostreams` is the original 1986 version of `iostreams`, which was replaced in the C++ standard. It is selected through the `-library=iostream` option. No two

implementations of “classic” iostreams are the same, so apart from being obsolete, code using it is not portable. Note that this library and option will be discontinued in future Oracle Developer Studio releases.

## 11.4.2 Linking C++ Libraries

The following table shows the compiler options for linking the C++ libraries. See [“A.2.51 – library=l\[,l...\]” on page 215](#) for more information.

**TABLE 24** Compiler Options for Linking C++ Libraries

Library	Option
Classic iostream	-library=iostream
Garbage collection	-library=gc
STLport version 4	-library=stlport4
STLport version 4 debug	-library=stlport4_dbg
Apache stdc++ version 4	-library=stdc++4
Sun Performance Library	-library=sunperf

**Note** - In `-std=c++03`, `-std=c++11`, and `-std=c++14` modes, only the `gc` and `sunperf` libraries can be added. There are no options for different versions of the C++ standard library.

## 11.5 Statically Linking Standard Libraries

The CC driver links in shared versions of several libraries by default, including `libc` and `libm`, by passing a `-llib` option for each of the default libraries to the linker. (See [“11.2.2 Default C++ Libraries” on page 126](#) for the list of default libraries.)

If you want any of these default libraries to be linked statically, you can use the `-library` option along with the `-staticlib` option. For example:

```
example% CC test.c -staticlib=Crun
```

In this example, the `-library` option is not explicitly included in the command. In this case, the `-library` option is not necessary because the default setting for `-library` is `Cstd,Crun` in standard `-compat=5` mode.

Alternately, you can use the `-xnoLib` compiler option. With the `-xnoLib` option, the driver does not pass any `-l` options to `ld`; you must pass these options yourself. The following example shows how you would link statically with `libCrun`, and dynamically with `libm`, and `libc`:

```
example% CC test.c -xnoLib -lCstd -Bstatic -lCrun -Bdynamic -lm -lc
```

The order of the `-l` options is important. The `-lCstd`, `-lCrun`, and `-lm` options appear before `-lc`.

---

**Note** - Linking the `libCrun` and `libCstd` statically is not recommended. The dynamic versions in `/usr/lib` are built to work with the version of Oracle Solaris where they are installed.

---

Some CC options link to other libraries. These library links are also suppressed by `-xnoLib`. For example, using the `-mt` option causes the CC driver to pass `-pthread` to `ld`. However, if you use both `-mt` and `-xnoLib`, the CC driver does not pass `-pthread` to `ld`. See “[A.2.159 – xnoLib](#)” on page 296 for more information. See *Oracle Solaris 11.3 Linkers and Libraries Guide* for more information about `ld`.

---

**Note** - Static versions of Oracle Solaris libraries in `/lib` and `/usr/lib` are no longer available. For example, this attempt to link `libc` statically will fail:

```
CC hello.cc -xnoLib -lCrun -lCstd -Bstatic -lc
```

---

## 11.6 Using Shared Libraries

The following C++ runtime shared libraries are shipped as part of the C++ compiler:

- `libCCEXCEPT.so.1` (SPARC only)
- `libstlport.so.1`
- `libstdc++.so.6`
- `libgcc_s.so.1`
- `libCrunG3.so.1`
- `libstatomic.so.1`

On Oracle Linux, these additional libraries are shipped as part of the C++ compiler:

- `libCrun.so.1`
- `libCstd.so.1`

- `libdemangle.so`
- `libiostream.so.1`

On the latest Oracle Solaris releases, these additional libraries, along with some others, are installed as part of the Oracle Solaris C++ runtime library package, `SUNWlibC`.

If your application uses any of the shared libraries that are shipped as part of the C++ compiler, the CC driver arranges for a *runpath* (refer to the `-R` option) pointing to the location of the library to be built into the executable. If the executable is later deployed to a different computer where the same compiler version is not installed in the same location, the required shared library will not be found. Refer to the *Oracle Developer Studio 12.5: Release Notes* for information regarding the deployment of applications using `libstatomic`.

At program start time, the library might not be found at all, or the wrong version of the library might be used, leading to incorrect program behavior. In such a case, you should ship the required libraries along with the executable, and build with *runpath* pointing to where they will be installed.

The article *Using and Redistributing Solaris Studio Libraries in an Application* contains a full discussion of this topic, along with examples. It is available on the Oracle Developer Studio product site (<http://www.oracle.com/technetwork/server-storage/solarisstudio/>).

## 11.7 Replacing the C++ Standard Library

Replacing the standard library that is distributed with the compiler is risky, and good results are not guaranteed. The basic operation is to disable the standard headers and library supplied with the compiler and to specify the directories where the new header files and library are found, as well as the name of the library itself.

The compiler supports the STLport and Apache `stdcxx` implementations of the standard library. See “12.1 STLport” on page 142 and “12.2 Apache `stdcxx` Standard Library” on page 143 for more information.

This discussion of replacing the C++ standard library applies only to the default `-compat=5` mode.

### 11.7.1 What Can Be Replaced

You can replace most of the standard library and its associated headers. The replaced library is `libcstd`, and the associated headers are the following:

```
<algorithm> <bitset> <complex> <deque> <fstream <functional> <iomanip> <ios>
<iosfwd> <iostream> <istream> <iterator> <limits> <list> <locale> <map> <memory>
<numeric> <ostream> <queue> <set> <sstream> <stack> <stdexcept> <streambuf>
<string> <stringstream> <utility> <valarray> <vector>
```

The replaceable part of the library consists of what is loosely known as “STL”, plus the string classes, the iostream classes, and their helper classes. Because these classes and headers are interdependent, replacing just a portion of them is unlikely to work. You should replace all of the headers and all of `libCstd` if you replace any part.

## 11.7.2 What Cannot Be Replaced

The standard headers `<exception>`, `<new>`, and `<typeinfo>` are tied tightly to the compiler itself and to `libCrun`, and cannot reliably be replaced. The library `libCrun` contains many “helper” functions that the compiler depends on, and cannot be replaced.

The 17 standard headers inherited from C (`<stdlib.h>`, `<stdio.h>`, `<string.h>`, and so forth) are tied tightly to the Oracle Solaris operating system and the basic Oracle Solaris runtime library `libc`, and cannot reliably be replaced. The C++ versions of those headers (`<cstdlib>`, `<cstdio>`, `<cstring>`, and so forth) are tied tightly to the basic C versions and cannot reliably be replaced.

## 11.7.3 Installing the Replacement Library

To install the replacement library, you must first decide on the locations for the replacement headers and on the replacement for `libCstd`. For purposes of discussion, assume the headers are placed in `/opt/mycstd/include` and the library is placed in `/opt/mycstd/lib`. Assume the library is called `libmyCstd.a`. (Usually library names start with “lib”.)

## 11.7.4 Using the Replacement Library

On each compilation, use the `-I` option to point to the location where the headers are installed. In addition, use the `-library=no%Cstd` option to prevent finding the compiler’s own versions of the `libCstd` headers. For example:

```
example% CC -I/opt/mycstd/include -library=no%Cstd... (compile)
```

During compiling, the `-library=no%Cstd` option prevents searching the directory where the compiler’s own version of these headers is located.



On each program or library link, use the `-library=no%Cstd` option to prevent finding the compiler's own `libCstd`, the `-L` option to point to the directory where the replacement library is, and the `-l` option to specify the replacement library. For example:

```
example% CC -library=no%Cstd -L/opt/mycstd/lib -lmyCstd... (link)
```

Alternatively, you can use the full path name of the library directly, and omit using the `-L` and `-l` options. For example:

```
example% CC -library=no%Cstd /opt/mycstd/lib/libmyCstd.a... (link)
```

During linking, the `-library=no%Cstd` option prevents linking the compiler's own version of `libCstd`.

## 11.7.5 Standard Header Implementation

C has 17 standard headers (`<stdio.h>`, `<string.h>`, `<stdlib.h>`, and others). These headers are delivered as part of the Oracle Solaris operating system in the directory `/usr/include`. C++ has those same headers, with the added requirement that the various declared names appear in both the global namespace and in namespace `std`.

C++ also has a second version of each of the C standard headers (`<cstdio>`, `<cstring>`, and `<cstdlib>`, and others) with the various declared names appearing only in namespace `std`. Finally, C++ adds 32 of its own standard headers (`<string>`, `<utility>`, `<iostream>`, and others).

The obvious implementation of the standard headers would use the name found in C++ source code as the name of a text file to be included. For example, the standard headers `<string>` (or `<string.h>`) would refer to a file named `string` (or `string.h`) in some directory. That obvious implementation has the following drawbacks:

- You cannot search for just header files or create a `makefile` rule for the header files if they do not have file name suffixes.
- If you have a directory or executable program named `string`, it might erroneously be found instead of the standard header file.

To solve these problems, the compiler `include` directory contains a file with the same name as the header, along with a symbolic link to it that has the unique suffix `.SUNWCCh` (`SUNW` is the prefix for all compiler-related packages, `CC` is the C++ compiler, and `h` is the usual suffix for header files). When you specify `<string>`, the compiler rewrites it to `<string.SUNWCCh>` and searches for that name. The suffixed name will be found only in the compiler's own `include` directory. If the file so found is a symbolic link (which it normally is), the compiler

dereferences the link exactly once and uses the result (`string` in this case) as the file name for error messages and debugger references. The compiler uses the suffixed name when emitting file dependency information.

The name rewriting occurs only for the two forms of the 17 standard C headers and the 32 standard C++ headers, only when they appear in angle brackets and without any path specified. If you use quotes instead of angle brackets, specify any path components, or specify some other header, no rewriting occurs.

The following table illustrates common situations.

**TABLE 25** Header Search Examples

Source Code	Compiler Searches For	Comments
<code>&lt;string&gt;</code>	<code>string.SUNWCCh</code>	C++ string templates
<code>&lt;cstring&gt;</code>	<code>cstring.SUNWCCh</code>	C++ version of C <code>string.h</code>
<code>&lt;string.h&gt;</code>	<code>string.h.SUNWCCh</code>	C <code>string.h</code>
<code>&lt;fcntl.h&gt;</code>	<code>fcntl.h</code>	Not a standard C or C++ header
<code>"string"</code>	<code>string</code>	Double-quotation marks, not angle brackets
<code>&lt;../string&gt;</code>	<code>../string</code>	Path specified

If the compiler does not find `header.SUNWCCh`, the compiler restarts the search looking for the name as provided in the `#include` directive. For example, given the directive `#include <string>`, the compiler attempts to find a file named `string.SUNWCCh`. If that search fails, the compiler looks for a file named `string`.

### 11.7.5.1 Replacing Standard C++ Headers

Because of the search algorithm described in [“11.7.5 Standard Header Implementation” on page 137](#), you do not need to supply `SUNWCCh` versions of the replacement headers described in [“11.7.3 Installing the Replacement Library” on page 136](#). However, if you run into some of the described problems, the recommended solution is to add symbolic links having the suffix `.SUNWCCh` for each of the unsuffixed headers. That is, for file `utility`, you would run the following command:

```
example% ln -s utility utility.SUNWCCh
```

When the compiler looks first for `utility.SUNWCCh`, it will find it, and not be confused by any other file or directory called `utility`.

## 11.7.5.2 Replacing Standard C Headers

Replacing the standard C headers is not supported. If you nevertheless want to provide your own versions of standard headers, the recommended procedure is as follows:

- Put all the replacement headers in one directory.
- Create a `.SUNWCCh` symbolic link to each of the replacement headers in that directory.
- Cause the directory that contains the replacement headers to be searched by using the `-I` directives on each invocation of the compiler.

For example, suppose you have replacements for `<stdio.h>` and `<cstdio>`. Put the files `stdio.h` and `cstdio` in directory `/myproject/myhdr`. In that directory, run the following commands:

```
example% ln -s stdio.h stdio.h.SUNWCCh
example% ln -s cstdio cstdio.SUNWCCh
```

Use the option `-I/myproject/mydir` on every compilation.

### Caveats:

- If you replace any C headers, you must replace them in pairs. For example, if you replace `<time.h>`, you should also replace `<ctime>`.
- Replacement headers must have the same effects as the versions being replaced. That is, the various runtime libraries such as `libCrun`, `libC`, `libCstd`, and `libc`, are built using the definitions in the standard headers. If your replacements do not match, your program is unlikely to work.



## Using the C++ Standard Library

---

The compiler has access to the complete library specified by the C++ standard. The library components include what is informally known as the Standard Template Library (STL), as well as the following components:

- String classes
- Numeric classes
- Standard stream I/O classes
- Basic memory allocation
- Exception classes
- Runtime type information

The term STL does not have a formal definition, but it is usually understood to include containers, iterators, and algorithms.

In `-compat=5` mode:

- The C++ standard library (`libCstd`) is based on the RogueWave™ Standard C++ Library, Version 2. This library is the default.
- The C++ compiler also supports STLport's Standard Library implementation version 4.5.3. `libCstd` is still the default library, but STLport's product is available as an alternative. See [“12.1 STLport” on page 142](#) for more information.
- the C++ compiler also supports the Apache `stdcxx` library that is available on Oracle Solaris as an alternative to `libCstd` and STLport. See [“12.2 Apache stdcxx Standard Library” on page 143](#) for more information.
- If you need to use your own version of the C++ standard library instead of one of the versions that is supplied with the compiler, you can do so by specifying the `-library=no%std` option. Replacing the standard library that is distributed with the compiler is risky, and good results are not guaranteed. For more information, see [“11.7 Replacing the C++ Standard Library” on page 135](#).

## 12.1 STLport

You can use the STLport implementation of the standard library if you wish to use an alternative standard library to `libCstd`. You can issue the following compiler option to turn off `libCstd` and use the STLport library instead:

- `-library=stlport4`

See “[A.2.51 `-library=I\[,I...\]`” on page 215](#) for more information.

This release includes both a static archive called `libstlport.a` and a dynamic library called `libstlport.so`.

Consider the following information before deciding to use the STLport implementation:

- STLport is an open source product and does not guarantee compatibility across different releases. In other words, compiling with a future version of STLport may break applications compiled with STLport 4.5.3. It also might not be possible to link binaries compiled using STLport 4.5.3 with binaries compiled using a future version of STLport.
- The `stlport4` and `iostream` libraries provide their own implementation of I/O streams. Specifying more than one of these with the `-library` option can result in undefined program behavior.
- Future releases of the compiler might not include STLport4. They might include only a later version of STLport. The compiler option `-library=stlport4` might not be available in future releases, but could be replaced by an option referring to a later STLport version.
- `Tools.h++` is not supported with STLport.
- STLport does not provide support for locales, which are used for internationalization and localization of text I/O.
- STLport is binary incompatible with the default `libCstd`. If you use the STLport implementation of the standard library, then you must compile and link all files, including third-party libraries, with the option `-library=stlport4`. This means, for example, that you cannot use the STLport implementation and the C++ interval math library `libCsunimath` together. The reason for this is that `libCsunimath` was compiled with the default library headers, not with STLport.
- If you decide to use the STLport implementation, be certain to include header files that your code implicitly references. The standard headers are allowed, but not required, to include one another as part of the implementation. STLport tends to have fewer instances of headers including one another than other implementations.

The following test case does not compile with STLport because the code in the test case makes unportable assumptions about the library implementation. In particular, it assumes that either `<vector>` or `<iostream>` automatically include `<iterator>`, which is not a valid assumption.

```

#include <vector>
#include <iostream>

using namespace std;

int main ()
{
    vector <int> v1 (10);
    vector <int> v3 (v1.size());
    for (int i = 0; i < v1.size (); i++)
        {v1[i] = i; v3[i] = i;}
    vector <int> v2(v1.size ());
    copy_backward (v1.begin (), v1.end (), v2.end ());
    ostream_iterator<int> iter (cout, " ");
    copy (v2.begin (), v2.end (), iter);
    cout << endl;
    return 0;
}

```

To fix the problem, include `<iterator>` in the source.

### 12.1.1 Redistribution and Supported STLport Libraries

See the Distribution README file for a list of libraries and object files that you can redistribute with your executables or libraries under the terms of the End User Object Code License. The C++ section of this README file lists which version of the STLport .so this release of the compiler supports. This README file can be found on the legal page for this release of Oracle Developer Studio software, at <http://www.oracle.com/technetwork/server-storage/solarisstudio/overview/index.html>

## 12.2 Apache stdcxx Standard Library

Use the Apache `stdcxx` version 4 C++ standard library in Oracle Solaris, instead of the default `libcstd` by compiling with `-library=stdcxx4`. This option also sets the `-mt` option implicitly. The `stdcxx` library requires multithreading mode. This option must be used consistently on every compilation and link command in the entire application. Code compiled with `-library=stdcxx4` cannot be used in the same program as code compiled with the default `-library=Cstd` or the optional `-library=stlport4`.

Keep in mind the following when using the Apache `stdcxx` library:

- The `stdcxx` and `iostream` libraries provide their own implementation of I/O streams. Specifying more than one of these with the `-library` option can result in undefined program behavior.
- `Tools.h++` is not supported with `stdcxx`.
- The C++ Interval Math library (`LibCsunimath`) is not supported with `stdcxx`.
- The `stdcxx` library is binary incompatible with the default `libCstd` and with `STLport`. If you use the `stdcxx` implementation of the standard library, then you must compile and link all files, including third-party libraries, with the option `-library=stdcxx4`.
- The `stdcxx` library is delivered as part of Oracle Solaris, not Oracle Developer Studio. You can build and deploy programs using `stdcxx` only on Oracle Solaris systems where the library is installed.

## 12.3 g++ Standard Library

In the compilation modes `-compat=g`, `-std=c++03`, `-std=c++11`, and `-std=c++14`, the C++ compiler supports only the g++ 5.1.0 headers and standard library that are delivered with the compiler.

### 12.3.1 Redistribution and Supported g++ Libraries.

See the Distribution README file for a list of libraries and object files that you can redistribute with your executables or libraries under the terms of the End User Object Code License. The C++ section of this README file lists the version of the g++ runtime libraries this release of the compiler supports. This README file can be found on the legal page for this release of Oracle Developer Studio software, at <http://www.oracle.com/technetwork/server-storage/solarisstudio/overview/index.html>.



## Using the Classic `iostream` Library

---

C++, like C, has no built-in input or output statements. Instead, I/O facilities are provided by a library. The C++ compiler provides both the classic implementation and the ISO standard implementation of the `iostream` classes.

- By default, the classic `iostream` classes are contained in `libiostream`. Use `libiostream` when you have source code that uses the classic `iostream` classes and you want to compile the source in `-compat=5` mode. To use the classic `iostream` facilities in `-compat=5` mode, include the `iostream.h` header file and compile using the `-library=iostream` option.
- The standard `iostream` classes are available and are part of each of the standard C++ libraries supported by the compiler.

This chapter provides an introduction to the classic `iostream` library and provides examples of its use. This chapter does not provide a complete description of the `iostream` library. See the `iostream` library man pages for more details. To access the classic `iostream` man pages type the command: `man -s 3CC4 name`

See “[11.4.1.1 Note About Classic iostreams](#)” on page 132.

### 13.1 Predefined `iostreams`

There are four predefined `iostreams`:

- `cin`, connected to standard input
- `cout`, connected to standard output
- `cerr`, connected to standard error
- `clog`, connected to standard error

The predefined `iostreams` are fully buffered, except for `cerr`. See “[13.3.1 Output Using `iostream`](#)” on page 147 and “[13.3.2 Input Using `iostream`](#)” on page 150.

## 13.2 Basic Structure of `iostream` Interaction

By including the `iostream` library, a program can use any number of input or output streams. Each stream has some source or sink, which may be one of the following:

- Standard input
- Standard output
- Standard error
- A file
- An array of characters

A stream can be restricted to input or output, or a single stream can allow both input and output. The `iostream` library implements these streams using two processing layers.

- The lower layer implements sequences, which are simply streams of characters. These sequences are implemented by the `streambuf` class, or by classes derived from it.
- The upper layer performs formatting operations on sequences. These formatting operations are implemented by the `istream` and `ostream` classes, which have as a member an object of a type derived from class `streambuf`. An additional class, `iostream`, is for streams on which both input and output can be performed.

Standard input, output, and error are handled by special class objects derived from class `istream` or `ostream`.

The `ifstream`, `ofstream`, and `fstream` classes, which are derived from `istream`, `ostream`, and `iostream` respectively, handle input and output with files.

The `istrstream`, `ostrstream`, and `strstream` classes, which are derived from `istream`, `ostream`, and `iostream` respectively, handle input and output to and from arrays of characters.

When you open an input or output stream, you create an object of one of these types, and associate the `streambuf` member of the stream with a device or file. You generally do this association through the stream constructor, so you don't work with the `streambuf` directly. The `iostream` library predefines stream objects for the standard input, standard output, and error output, so you don't have to create your own objects for those streams.

You use operators or `iostream` member functions to insert data into a stream (output) or extract data from a stream (input), and to control the format of data that you insert or extract.

When you want to insert and extract a new data type—one of your classes—you generally overload the insertion and extraction operators.

## 13.3 Using the Classic `iostream` Library

To use routines from the classic `iostream` library, you must include the header files for the part of the library you need. The header files are described in the following table.

**TABLE 26** `iostream` Routine Header Files

Header File	Description
<code>iostream.h</code>	Declares basic features of <code>iostream</code> library.
<code>fstream.h</code>	Declares <code>istream</code> s and <code>streambuf</code> s specialized to files. Includes <code>iostream.h</code> .
<code>strstream.h</code>	(Obsolete) Declares <code>istream</code> s and <code>streambuf</code> s specialized to character arrays. Includes <code>iostream.h</code> .
<code>iomanip.h</code>	Declares manipulators: values you insert into or extract from <code>istream</code> s to have different effects. Includes <code>iostream.h</code> .
<code>stdiostream.h</code>	(obsolete) Declares <code>istream</code> s and <code>streambuf</code> s specialized to use <code>stdio</code> <code>FILE</code> s. Includes <code>iostream.h</code> .
<code>stream.h</code>	(obsolete) Includes <code>iostream.h</code> , <code>fstream.h</code> , <code>iomanip.h</code> , and <code>stdiostream.h</code> . For compatibility with older style streams from C++ version 1.2.

You usually do not need all of these header files in your program. Include only the ones that contain the declarations you need. By default, `libiostream` contains the classic `iostream` library.

### 13.3.1 Output Using `iostream`

Output using `iostream` usually relies on the overloaded left-shift operator (`<<`) which, in the context of `iostream`, is called the insertion operator. To output a value to standard output, you insert the value in the predefined output stream `cout`. For example, given a value `someValue`, you send it to standard output with a statement like:

```
cout << someValue;
```

The insertion operator is overloaded for all built-in types, and the value represented by `someValue` is converted to its proper output representation. If, for example, `someValue` is a `float` value, the `<<` operator converts the value to the proper sequence of digits with a decimal point. Where it inserts `float` values on the output stream, `<<` is called the float inserter. In general, given a type `X`, `<<` is called the `X` inserter. The format of output and how you can control it is discussed in the `ios(3CC4)` man page.

The `iostream` library does not support user-defined types. If you define types that you want to output in your own way, you must define an inserter (that is, overload the `<<` operator) to handle them correctly.

The `<<` operator can be applied repetitively. To insert two values on `cout`, you can use a statement like the one in the following example:

```
cout << someValue << anotherValue;
```

The output from the above example will show no space between the two values. So you may want to write the code this way:

```
cout << someValue << " " << anotherValue;
```

The `<<` operator has the precedence of the left shift operator (its built-in meaning). As with other operators, you can always use parentheses to specify the order of action. When necessary, use parentheses to avoid problems of precedence. Of the following four statements, the first two are equivalent, but the last two are not.

```
cout << a+b;           // + has higher precedence than <<
cout << (a+b);
cout << (a&y);        // << has precedence higher than &
cout << a&y;          // probably an error: (cout << a) & y
```

### 13.3.1.1 Defining Your Own Insertion Operator

The following example defines a `string` class:

```
#include <stdlib.h>
#include <iostream.h>

class string {
private:
    char* data;
    size_t size;

public:
    // (functions not relevant here)

    friend ostream& operator<<(ostream&, const string&);
    friend istream& operator>>(istream&, string&);
};
```

The insertion and extraction operators must in this case be defined as friends because the data part of the `string` class is private.

```
ostream& operator<< (ostream& ostr, const string& output)
{    return ostr << output.data;}
```

The following example shows the definition of `operator<<` overloaded for use with strings.

```
cout << string1 << string2;
```

`operator<<` takes `ostream&` (that is, a reference to an `ostream`) as its first argument and returns the same `ostream`, making it possible to combine insertions in one statement.

### 13.3.1.2 Handling Output Errors

Generally, you don't have to check for errors when you overload `operator<<` because the `iostream` library is arranged to propagate errors.

When an error occurs, the `iostream` where it occurred enters an error state. Bits in the `iostream`'s state are set according to the general category of the error. The inserters defined in `iostream` ignore attempts to insert data into any stream that is in an error state, so such attempts do not change the `iostream`'s state.

In general, the recommended way to handle errors is to periodically check the state of the output stream in some central place. If an error exists, you should handle it in some way. This chapter assumes that you define a function `error`, which takes a string and aborts the program. `error` is not a predefined function. See [“13.3.9 Handling Input Errors” on page 153](#) for an example of an error function. You can examine the state of an `iostream` with the operator `!`, which returns a nonzero value if the `iostream` is in an error state. For example:

```
if (!cout) error("output error");
```

There is another way to test for errors. The `ios` class defines `operator void *()`, so it returns a `NULL` pointer when an error occurs. You can use a statement like the following example:

```
if (cout << x) return; // return if successful
```

You can also use the function `good`, a member of `ios`:

```
if (cout.good()) return; // return if successful
```

The error bits are declared in the enum:

```
enum io_state {goodbit=0, eofbit=1, failbit=2,
badbit=4, hardfail=0x80};
```

For details on the error functions, see the `iostream` man pages.

### 13.3.1.3 Flushing

As with most I/O libraries, `iostream` often accumulates output and sends it on in larger and generally more efficient chunks. If you want to flush the buffer, insert the special value `flush`. For example:

```
cout << "This needs to get out immediately." << flush;
```

`flush` is an example of a kind of object known as a *manipulator*, which is a value that can be inserted into an `iostream` to have some effect other than causing output of its value. These values are really functions that take an `ostream&` or `istream&` argument and return its argument after performing some actions on it (see [“13.7 Manipulators” on page 158](#)).

### 13.3.1.4 Binary Output

To obtain output in the raw binary form of a value, use the member function `write` as shown in the following example. This example shows the output in the raw binary form of `x`.

```
cout.write((char*)&x, sizeof(x));
```

The previous example violates type discipline by converting `&x` to `char*`. Doing so is normally harmless but if the type of `x` is a class with pointers or virtual member functions, or one that requires nontrivial constructor actions, the value written by the above example cannot be read back in properly.

## 13.3.2 Input Using `istream`

Input using `istream` is similar to output. You use the extraction operator `>>` and can string together extractions the way you can with insertions. For example:

```
cin >> a >> b;
```

This statement gets two values from standard input. As with other overloaded operators, the extractors used depend on the types of `a` and `b`. Two different extractors are used if `a` and `b` have

different types. The format of input and how you can control it is discussed in some detail in the `ios(3CC4)` man page. In general, leading whitespace characters (spaces, newlines, tabs, form-feeds, and so on) are ignored.

### 13.3.3 Defining Your Own Extraction Operators

When you want input for a new type, you overload the extraction operator for it, just as you overload the insertion operator for output.

Class `string` defines its extraction operator in the following code example:

**EXAMPLE 4**     `string` Extraction Operator

```
istream& operator>> (istream& istr, string& input)
{
    const int maxline = 256;
    char holder[maxline];
    istr.get(holder, maxline, "\n");
    input = holder;
    return istr;
}
```

The `get` function reads characters from the input stream `istr` and stores them in `holder` until `maxline-1` characters have been read, a new line is encountered, or EOF, whichever happens first. The data in `holder` is then null-terminated. Finally, the characters in `holder` are copied into the target string.

By convention, an extractor converts characters from its first argument (in this case, `istream& istr`), stores them in its second argument, which is always a reference, and returns its first argument. The second argument must be a reference because an extractor is meant to store the input value in its second argument.

### 13.3.4 Using the `char*` Extractor

Be careful when using this predefined extractor, which can cause problems. Use this extractor as follows:

```
char x[50];
cin >> x;
```

This extractor skips leading whitespace, extracts characters, and copies them to `x` until it reaches another whitespace character. It then completes the string with a terminating null (0) character. Use this extractor carefully because input can overflow the given array.

You must also be sure the pointer points to allocated storage. The following example shows a common error:

```
char * p; // not initialized
cin >> p;
```

Because the location where the input data will be stored is unclear, your program might abort.

## 13.3.5 Reading Any Single Character

In addition to using the `char` extractor, you can get a single character with either form of the `get` member function. For example:

```
char c;
cin.get(c); // leaves c unchanged if input fails

int b;
b = cin.get(); // sets b to EOF if input fails
```

---

**Note** - Unlike the other extractors, the `char` extractor does not skip leading whitespace.

---

The following example shows a way to skip only blanks, stopping on a tab, newline, or any other character:

```
int a;
do {
    a = cin.get();
}
while(a == ' ');
```

## 13.3.6 Binary Input

If you need to read binary values (such as those written with the member function `write`), you can use the `read` member function. The following example shows how to input the raw binary form of `x` using the `read` member function, and is the inverse of the earlier example that uses `write`.



```
cin.read((char*)&x, sizeof(x));
```

### 13.3.7 Peeking at Input

You can use the `peek` member function to look at the next character in the stream without extracting it. For example:

```
if (cin.peek() != c) return 0;
```

### 13.3.8 Extracting Whitespace

By default, the `iostream` extractors skip leading whitespace. The following example turns off whitespace skipping from `cin`, then turns it back on:

```
cin.unsetf(ios::skipws); // turn off whitespace skipping
...
cin.setf(ios::skipws); // turn it on again
```

You can use the `iostream` manipulator `ws` to remove leading whitespace from the `iostream` regardless of whether skipping is enabled. The following example shows how to remove the leading whitespace from `iostream` `istr`:

```
istr >> ws;
```

### 13.3.9 Handling Input Errors

By convention, an extractor whose first argument has a nonzero error state should not extract anything from the input stream and should not clear any error bits. An extractor that fails should set at least one error bit.

As with output errors, you should check the error state periodically and take some action, such as aborting, when you find a nonzero state. The `!` operator tests the error state of an `iostream`. For example, the following code produces an input error if you type alphabetic characters for input:

```
#include <stdlib.h>
#include <iostream.h>
void error (const char* message) {
    cerr << message << "\n";
}
```

```
        exit(1);
    }
    int main() {
        cout << "Enter some characters: ";
        int bad;
        cin >> bad;
        if (!cin) error("aborted due to input error");
        cout << "If you see this, not an error." << "\n";
        return 0;
    }
```

Class `ios` has member functions that you can use for error handling. See the man pages for details.

### 13.3.10 Using `iostreams` With `stdio`

You can use `stdio` with C++ programs, but problems can occur when you mix `iostreams` and `stdio` in the same standard stream within a program. For example, if you write to both `stdout` and `cout`, independent buffering occurs and produces unexpected results. The problem is worse if you input from both `stdin` and `cin` because independent buffering could render the input unusable.

To eliminate this problem with standard input, standard output, and standard error, use the following instruction before performing any input or output. It connects all the predefined `iostreams` with the corresponding predefined `stdio` FILES.

```
ios::sync_with_stdio();
```

This type of a connection is not the default because a significant performance penalty occurs when the predefined streams are made unbuffered as part of the connection. You can use both `stdio` and `iostreams` in the same program applied to different files, that is, you can write to `stdout` using `stdio` routines and write to other files attached to `iostreams`. You can open `stdio` FILES for input and also read from `cin` so long as you don't also try to read from `stdin`.

## 13.4 Creating `iostreams`

To read or write a stream other than the predefined `iostreams`, you need to create your own `iostream`. In general, that means creating objects of types defined in the `iostream` library. This section discusses the various types available.

## 13.4.1 Dealing With Files Using Class `fstream`

Dealing with files is similar to dealing with standard input and standard output; classes `ifstream`, `ofstream`, and `fstream` are derived from classes `istream`, `ostream`, and `iostream`, respectively. As derived classes, they inherit the insertion and extraction operations (along with the other member functions) and also have members and constructors for use with files.

Include the file `fstream.h` to use any of the `fstreams`. Use an `ifstream` when you only want to perform input, an `ofstream` for output only, and an `fstream` for a stream on which you want to perform both input and output. Use the name of the file as the constructor argument.

For example, copy the file `thisFile` to the file `thatFile` as in the following example:

```
ifstream fromFile("thisFile");
if (!fromFile)
    error("unable to open 'thisFile' for input");
ofstream toFile ("thatFile");
if (!toFile)
    error("unable to open 'thatFile' for output");
char c;
while (toFile && fromFile.get(c)) toFile.put(c);
```

This code does the following:

- Creates an `ifstream` object called `fromFile` with a default mode of `ios::in` and connects it to `thisFile`. It opens `thisFile`.
- Checks the error state of the new `ifstream` object and if it is in a failed state, calls the error function, which must be defined elsewhere in the program.
- Creates an `ofstream` object called `toFile` with a default mode of `ios::out` and connects it to `thatFile`.
- Checks the error state of `toFile` as above.
- Creates a `char` variable to hold the data while it is passed.
- Copies the contents of `fromFile` to `toFile` one character at a time.

---

**Note** - Copying a file this way, one character at a time, is, of course, undesirable. This code is provided merely as an example of using `fstreams`. You should instead insert the `streambuf` associated with the input stream into the output stream. See [“13.10 Working With `streambuf` Streams” on page 162](#), and the `sbufpub(3CC4)` man page.

---

### 13.4.1.1 Open Mode

The mode is constructed by OR-ing together bits from the enumerated type `open_mode`, which is a public type of class `ios` and has the following definition:

```
enum open_mode {binary=0, in=1, out=2, ate=4, app=8, trunc=0x10,
               nocreate=0x20, noreplace=0x40};
```

---

**Note** - The binary flag is not needed on UNIX but is provided for compatibility with systems that do need it. Portable code should use the binary flag when opening binary files.

---

You can open a file for both input and output. For example, the following code opens file `someName` for both input and output, attaching it to the `fstream` variable `inoutFile`.

```
fstream inoutFile("someName", ios::in|ios::out);
```

### 13.4.1.2 Declaring an `fstream` Without Specifying a File

You can declare an `fstream` without specifying a file and open the file later. The following example creates the `ofstream` `toFile` for writing.

```
ofstream toFile;
toFile.open(argv[1], ios::out);
```

### 13.4.1.3 Opening and Closing Files

You can close the `fstream` and then open it with another file. For example, to process a list of files provided on the command line:

```
ifstream infile;
for (char** f = &argv[1]; *f; ++f) {
    infile.open(*f, ios::in);
    ...;
    infile.close();
}
```

### 13.4.1.4 Opening a File Using a File Descriptor

If you know a file descriptor, such as the integer 1 for standard output, you can open it as follows:

```
ofstream outfile;
outfile.attach(1);
```

When you open a file by providing its name to one of the `fstream` constructors or by using the `open` function, the file is automatically closed when the `fstream` is destroyed by a `delete` or when it goes out of scope. When you attach a file to an `fstream`, it is not automatically closed.

### 13.4.1.5 Repositioning Within a File

You can alter the reading and writing position in a file. Several tools are supplied for this purpose.

- `streampos` is a type that can record a position in an `iostream`.
- `tellg` (`tellp`) is an `istream` (`ostream`) member function that reports the file position. Because `istream` and `ostream` are the parent classes of `fstream`, `tellg` and `tellp` can also be invoked as a member function of the `fstream` class.
- `seekg` (`seekp`) is an `istream` (`ostream`) member function that finds a given position.
- The `seek_dir` enum specifies relative positions for use with `seek`.

```
enum seek_dir {beg=0, cur=1, end=2};
```

For example, given an `fstream` `aFile`:

```
streampos original = aFile.tellp();    //save current position
aFile.seekp(0, ios::end); //reposition to end of file
aFile << x;                          //write a value to file
aFile.seekp(original); //return to original position
```

`seekg` (`seekp`) can take one or two parameters. When it has two parameters, the first is a position relative to the position indicated by the `seek_dir` value given as the second parameter. For example:

```
aFile.seekp(-10, ios::end);
```

moves to 10 bytes from the end while

```
aFile.seekp(10, ios::cur);
```

moves to 10 bytes forward from the current position.

---

**Note** - Arbitrary seeks on text streams are not portable, but you can always return to a previously saved `streampos` value.

---

## 13.5 Assignment of `iostreams`

`iostreams` does not allow assignment of one stream to another.

The problem with copying a stream object is that two versions of the state information now exist, such as a pointer to the current write position within an output file, which can be changed independently. Problems could occur as a result.

## 13.6 Format Control

Format control is discussed in detail in the `ios(3CC4)` man page.

## 13.7 Manipulators

Manipulators are values that you can insert into or extract from `iostreams` to have special effects.

Parameterized manipulators are manipulators that take one or more parameters.

Because manipulators are ordinary identifiers and therefore use up possible names, `iostream` does not define them for every possible function. A number of manipulators are discussed with member functions in other parts of this chapter.

The 13 predefined manipulators are described in the following table. This table assumes the following:

- `i` has type `long`.
- `n` has type `int`.
- `c` has type `char`.
- `istr` is an input stream.
- `ostr` is an output stream.

**TABLE 27** `iostream` Predefined Manipulators

	Predefined Manipulator	Description
1	<code>ostr &lt;&lt; dec, istr &gt;&gt; dec</code>	Makes the integer conversion base 10.

	Predefined Manipulator	Description
2	<code>ostr &lt;&lt; endl</code>	Inserts a newline character ( <code>'\n'</code> ) and invokes <code>ostream::flush()</code> .
3	<code>ostr &lt;&lt; ends</code>	Inserts a null ( <code>0</code> ) character. Useful when dealing with <code>stringstream</code> .
4	<code>ostr &lt;&lt; flush</code>	Invokes <code>ostream::flush()</code> .
5	<code>ostr &lt;&lt; hex, istr &gt;&gt; hex</code>	Makes the integer conversion base 16.
6	<code>ostr &lt;&lt; oct, istr &gt;&gt; oct</code>	Make the integer conversion base 8.
7	<code>istr &gt;&gt; ws</code>	Extracts whitespace characters (skips whitespace) until a non-whitespace character is found (which is left in <code>istr</code> ).
8	<code>ostr &lt;&lt; setbase(n), istr &gt;&gt; setbase(n)</code>	Sets the conversion base to <code>n</code> ( <code>0</code> , <code>8</code> , <code>10</code> , <code>16</code> only).
9	<code>ostr &lt;&lt; setw(n), istr &gt;&gt; setw(n)</code>	Invokes <code>ios::width(n)</code> . Sets the field width to <code>n</code> .
10	<code>ostr &lt;&lt; resetiosflags(i), istr &gt;&gt; resetiosflags(i)</code>	Clears the flags bitvector according to the bits set in <code>i</code> .
11	<code>ostr &lt;&lt; setiosflags(i), istr &gt;&gt; setiosflags(i)</code>	Sets the flags bitvector according to the bits set in <code>i</code> .
12	<code>ostr &lt;&lt; setfill(c), istr &gt;&gt; setfill(c)</code>	Sets the fill character (for padding a field) to <code>c</code> .
13	<code>ostr &lt;&lt; setprecision(n), istr &gt;&gt; setprecision(n)</code>	Sets the floating-point precision to <code>n</code> digits.

To use predefined manipulators, you must include the file `omanip.h` in your program.

You can define your own manipulators. The two basic types of manipulators are:

- Plain manipulator – Takes an `istream&`, `ostream&`, or `ios&` argument, operates on the stream, and then returns its argument.
- Parameterized manipulator – Takes an `istream&`, `ostream&`, or `ios&` argument, one additional argument (the parameter), operates on the stream, and then returns its stream argument.

## 13.7.1 Using Plain Manipulators

A plain manipulator is a function that performs the following actions:

- Takes a reference to a stream

- Operates on the stream in some way
- Returns its argument

The shift operators taking a pointer to such a function are predefined for `ostream`s so the function can be put in a sequence of input or output operators. The shift operator calls the function rather than trying to read or write a value. The following example shows a tab manipulator that inserts a tab in an `ostream` is:

```
ostream& tab(ostream& os) {
    return os << '\t';
}
...
cout << x << tab << y;
```

This example is an elaborate way to achieve the following code:

```
const char tab = '\t';
...
cout << x << tab << y;
```

The following code is another example, which cannot be accomplished with a simple constant. Suppose you want to turn whitespace skipping on and off for an input stream. You can use separate calls to `ios::setf` and `ios::unsetf` to turn the `skipws` flag on and off, or you could define two manipulators.

```
#include <iostream.h>
#include <iomanip.h>
istream& skipon(istream &is) {
    is.setf(ios::skipws, ios::skipws);
    return is;
}
istream& skipoff(istream& is) {
    is.unsetf(ios::skipws);
    return is;
}
...
int main ()
{
    int x,y;
    cin >> skipon >> x >> skipoff >> y;
    return 1;
}
```



## 13.7.2 Parameterized Manipulators

One of the parameterized manipulators that is included in `iomanip.h` is `setfill`. `setfill` sets the character that is used to fill out field widths. This manipulator is implemented as shown in the following example:

```
//file setfill.cc
#include<iostream.h>
#include<iomanip.h>

//the private manipulator
static ios& sfill(ios& i, int f) {
    i.fill(f);
    return i;
}
//the public applicator
smanip_int setfill(int f) {
    return smanip_int(sfill, f);
}
```

A parameterized manipulator is implemented in two parts:

- The *manipulator*. It takes an extra parameter. In the previous code example, it takes an extra `int` parameter. You cannot place this manipulator function in a sequence of input or output operations, because no shift operator is defined for it. Instead, you must use an auxiliary function, the applicator.
- The *applicator*. It calls the manipulator. The applicator is a global function, and you make a prototype for it available in a header file. Usually the manipulator is a static function in the file containing the source code for the applicator. The manipulator is called only by the applicator. If you make it static, you keep its name out of the global address space.

Several classes are defined in the header file `iomanip.h`. Each class holds the address of a manipulator function and the value of one parameter. The `iomanip` classes are described in the `manip(3CC4)` man page. The previous example uses the `smanip_int` class, which works with an `ios`. Because it works with an `ios`, it also works with an `istream` and an `ostream`. The previous example also uses a second parameter of type `int`.

The applicator creates and returns a class object. In the previous code example the class object is an `smanip_int`, and it contains the manipulator and the `int` argument to the applicator. The `iomanip.h` header file defines the shift operators for this class. When the applicator function `setfill` appears in a sequence of input or output operations, the applicator function is called, and it returns a class. The shift operator acts on the class to call the manipulator function with its parameter value, which is stored in the class.

In the following example, the manipulator `print_hex` performs the following actions:

- Puts the output stream into the hex mode
- Inserts a long value into the stream
- Restores the conversion mode of the stream

The class `omanip_long` is used because this code example is for output only. It operates on a long rather than an `int`:

```
#include <iostream.h>
#include <iomanip.h>
static ostream& xfield(ostream& os, long v) {
    long save = os.setf(ios::hex, ios::basefield);
    os << v;
    os.setf(save, ios::basefield);
    return os;
}
omanip_long print_hex(long v) {
    return omanip_long(xfield, v);
}
```

## 13.8 `stringstream`: `ostreams` for Arrays

See the `stringstream(3CC4)` man page.

## 13.9 `stdiobuf`: `ostreams` for `stdio` Files

See the `stdiobuf(3CC4)` man page.

## 13.10 Working With `streambuf` Streams

`ostreams` are the formatting part of a two-part (input or output) system. The other part of the system is made up of `streambuf` streams, which work with input or output of unformatted streams of characters.

You usually use `streambuf` streams through `ostreams`, so you don't have to be familiar with them in detail. You can use `streambuf` streams directly if you choose to, for example,

if you need to improve efficiency or to get around the error handling or formatting built into `istream`s.

### 13.10.1 `streambuf` Pointer Types

A `streambuf` consists of a stream or sequence of characters and one or two pointers into that sequence. Each pointer points between two characters. (Pointers cannot actually point between characters, but thinking of them that way can be helpful.) There are two kinds of `streambuf` pointers:

- A *put* pointer, which points just before the position where the next character will be stored
- A *get* pointer, which points just before the next character to be fetched

A `streambuf` can have one or both of these pointers.

The positions of the pointers and the contents of the sequences can be manipulated in various ways. Whether or not both pointers move when manipulated depends on the kind of `streambuf` used. Generally, with queue-like `streambuf` streams, the `get` and `put` pointers move independently. With file-like `streambuf` streams the `get` and `put` pointers always move together. A `strstream` is an example of a queue-like stream; an `fstream` is an example of a file-like stream.

### 13.10.2 Using `streambuf` Objects

You never create an actual `streambuf` object, but only objects of classes derived from class `streambuf`. Examples are `filebuf` and `strstreambuf`, which are described in the `filebuf(3CC4)` and `sdbuf(3)` man pages. Advanced users may want to derive their own classes from `streambuf` to provide an interface to a special device or to provide other than basic buffering. The `sdbufpub(3CC4)` and `sdbufprot` man pages (3CC4) discuss how to do this.

Apart from creating your own special kind of `streambuf`, you might want to access the `streambuf` associated with an `istream` to access the public member functions, as described in the man pages. In addition, each `istream` has a defined inserter and extractor which takes a `streambuf` pointer. When a `streambuf` is inserted or extracted, the entire stream is copied.

The following example shows another way to do the file copy discussed earlier, with the error checking omitted for clarity:

```
ifstream fromFile("thisFile");
ofstream toFile ("thatFile");
toFile << fromFile.rdbuf();
```

The input and output files are opened as before. Every `iostream` class has a member function `rdbuf` that returns a pointer to the `streambuf` object associated with it. In the case of an `fstream`, the `streambuf` object is type `filebuf`. The entire file associated with `fromFile` is copied (inserted into) the file associated with `toFile`. The last line could also be written as follows:

```
fromFile >> toFile.rdbuf();
```

The source file is then extracted into the destination. The two methods are entirely equivalent.

## 13.11 iostream Man Pages

A number of C++ man pages give details of the `iostream` library. The following table gives an overview of what is in each man page.

To access a classic `iostream` library man page, type:

```
example% man -s 3CC4 name
```

**TABLE 28** `iostream` Man Pages Overview

Man Page	Overview
<code>filebuf</code>	Details the public interface for the class <code>filebuf</code> , which is derived from <code>streambuf</code> and is specialized for use with files. See the <code>sbufpub(3CC4)</code> and <code>sbufprot(3CC4)</code> man pages for details of features inherited from class <code>streambuf</code> . Use the <code>filebuf</code> class through class <code>fstream</code> .
<code>fstream</code>	Details specialized member functions of classes <code>ifstream</code> , <code>ofstream</code> , and <code>fstream</code> , which are specialized versions of <code>istream</code> , <code>ostream</code> , and <code>iostream</code> for use with files.
<code>ios</code>	Details parts of class <code>ios</code> , which functions as a base class for <code>istream</code> s. It contains state data common to all streams.
<code>ios.intro</code>	Gives an introduction to and overview of <code>istream</code> s.
<code>istream</code>	Details the following: <ul style="list-style-type: none"> <li>■ Member functions for class <code>istream</code>, which supports interpretation of characters fetched from a <code>streambuf</code></li> <li>■ Input formatting</li> <li>■ Positioning functions described as part of class <code>ostream</code>.</li> <li>■ Some related functions</li> <li>■ Related manipulators</li> </ul>
<code>manip</code>	Describes the input and output manipulators defined in the <code>iostream</code> library.

Man Page	Overview
<code>ostream</code>	<p>Details the following:</p> <ul style="list-style-type: none"> <li>■ Member functions for class <code>ostream</code>, which supports interpretation of characters written to a <code>streambuf</code></li> <li>■ Output formatting</li> <li>■ Positioning functions described as part of class <code>ostream</code></li> <li>■ Some related functions</li> <li>■ Related manipulators</li> </ul>
<code>sbufprot</code>	Describes the interface needed by programmers who are coding a class derived from class <code>streambuf</code> . Also refer to the <code>sbufpub(3CC4)</code> man page because some public functions are not discussed in the <code>sbufprot(3CC4)</code> man page.
<code>sbufpub</code>	Details the public interface of class <code>streambuf</code> , in particular, the public member functions of <code>streambuf</code> . This man page contains the information needed to manipulate a <code>streambuf</code> -type object directly, or to find out about functions that classes derived from <code>streambuf</code> inherit from it. If you want to derive a class from <code>streambuf</code> , also see the <code>sbufprot(3CC4)</code> man page.
<code>ssbuf</code>	Details the specialized public interface of class <code>strstreambuf</code> , which is derived from <code>streambuf</code> and specialized for dealing with arrays of characters. See the <code>sbufpub(3CC4)</code> man page for details of features inherited from class <code>streambuf</code> .
<code>stdiobuf</code>	Contains a minimal description of class <code>stdiobuf</code> , which is derived from <code>streambuf</code> and specialized for dealing with <code>stdio</code> FILES. See the <code>sbufpub(3CC4)</code> man page for details of features inherited from class <code>streambuf</code> .
<code>strstream</code>	Details the specialized member functions of <code>strstreams</code> , which are implemented by a set of classes derived from the <code>iostream</code> classes and specialized for dealing with arrays of characters.

## 13.12 `iostream` Terminology

The `iostream` library descriptions often use terms similar to terms from general programming but with specialized meanings. The following table defines these terms as they are used in discussing the `iostream` library.

**TABLE 29** `iostream` Terminology

<code>iostream</code> Term	Definition
Buffer	A word with two meanings, one specific to the <code>iostream</code> package and one more generally applied to input and output.

<b>iostream Term</b>	<b>Definition</b>
	<p>When referring specifically to the <code>iostream</code> library, a buffer is an object of the type defined by the class <code>streambuf</code>.</p> <p>A buffer, generally, is a block of memory used to make efficient transfer of characters for input or output. With buffered I/O, the actual transfer of characters is delayed until the buffer is full or forcibly flushed.</p> <p>An unbuffered buffer refers to a <code>streambuf</code> where there is no buffer in the general sense defined above. This chapter avoids use of the term <code>buffer</code> to refer to <code>streambufs</code>. However, the man pages and other C++ documentation do use the term <code>buffer</code> to mean <code>streambufs</code>.</p>
Extraction	The process of taking input from an <code>iostream</code> .
<code>Fstream</code>	An input or output stream specialized for use with files. Refers specifically to a class derived from class <code>iostream</code> when printed in monospace font.
Insertion	The process of sending output into an <code>iostream</code> .
<code>iostream</code>	Generally, an input or output stream.
<code>iostream</code> library	Refers to a library implemented by the include files <code>iostream.h</code> , <code>fstream.h</code> , <code>sstream.h</code> , <code>iomanip.h</code> , and <code>stdiostream.h</code> . Because <code>iostream</code> is an object-oriented library, you should extend it.
Stream	An <code>iostream</code> , <code>fstream</code> , <code>sstream</code> , or user-defined stream in general.
<code>streambuf</code>	A buffer that contains a sequence of characters with a put or get pointer, or both. When printed in monospace font, it means the particular class. Otherwise, it refers generally to any object of class <code>streambuf</code> or a class derived from <code>streambuf</code> . Any stream object contains an object, or a pointer to an object, of a type derived from <code>streambuf</code> .
<code>stringstream</code>	An <code>iostream</code> specialized for use with character arrays. It refers to the specific class when printed in monospace font.

## Building Libraries

---

This chapter explains how to build your own libraries.

### 14.1 Understanding Libraries

Libraries provide two benefits. First, they provide a way to share code among several applications. If you have such code, you can create a library with it and link the library with any application that needs it. Second, libraries provide a way to reduce the complexity of very large applications. Such applications can build and maintain relatively independent portions as libraries and so reduce the burden on programmers working on other portions.

Building a library simply means creating `.o` files (by compiling your code with the `-c` option) and combining the `.o` files into a library using the `CC` command. You can build two kinds of libraries: static (archive) libraries and dynamic (shared) libraries.

With static (archive) libraries, objects within the library are linked into the program's executable file at link time. Only those `.o` files from the library that are needed by the application are linked into the executable. The name of a static (archive) library generally ends with a `.a` suffix.

With dynamic (shared) libraries, objects within the library are not linked into the program's executable file. Instead, the linker notes in the executable that the program depends on the library. When the program is executed, the system loads the dynamic libraries that the program requires. If two programs that use the same dynamic library execute at the same time, the operating system shares the library among the programs. The name of a dynamic (shared) library ends with an `.so` suffix.

Linking dynamically with shared libraries has several advantages over linking statically with archive libraries:

- The size of the executable is smaller.
- Significant portions of code can be shared among programs at runtime, reducing the amount of memory use.

- The library can be replaced at runtime without relinking with the application. (This is the primary mechanism that enables programs to take advantage of many improvements in the Oracle Solaris operating system without requiring relinking and redistribution of programs.)
- The shared library can be loaded at runtime using the `dlopen()` function call.

However, dynamic libraries have some disadvantages:

- Runtime linking has an execution-time cost.
- Distributing a program that uses dynamic libraries might require simultaneous distribution of the libraries it uses.
- Moving a shared library to a different location can prevent the system from finding the library and executing the program. (The environment variable `LD_LIBRARY_PATH` helps overcome this problem.)

## 14.2 Building Static (Archive) Libraries

The mechanism for building static (archive) libraries is similar to that of building an executable. A collection of object (`.o`) files can be combined into a single library using the `-xar` option of `CC`.

If your program uses a template cache, you should build static (archive) libraries using `CC -xar` instead of using the `ar` command directly. The C++ language generally requires that the compiler maintain more information than can be accommodated with traditional `.o` files, particularly template instances. The `-xar` option ensures that all necessary information, including template instances, is included in the library. You might not be able to accomplish this in a normal programming environment because `make` might not be able to determine which template files are actually created and referenced. Without `CC -xar`, referenced template instances might not be included in the library, as required. For example:

```
% CC -c foo.cc # Compile main file, templates objects are created.
% CC -xar -o foo.a foo.o # Gather all objects into a library.
```

The `-xar` flag causes `CC` to create a static (archive) library. The `-o` directive is required to name the newly created library. The compiler examines the object files on the command line, cross-references the object files with those known to the template repository, and adds those templates required by the user's object files (along with the main object files themselves) to the archive.

---

**Note** - Use the `-xar` flag for creating or updating an existing archive only. Do not use it to maintain an archive. The `-xar` option is equivalent to `ar -cr`.

---

Put only one function in each `.o` file. If you are linking with an archive, an entire `.o` file from the archive is linked into your application when a symbol is needed from that particular `.o` file.



With one function in each `.o` file, only those symbols needed by the application will be linked from the archive.

## 14.3 Building Dynamic (Shared) Libraries

Dynamic (shared) libraries are built the same way as static (archive) libraries, except that you use `-G` instead of `-xar` on the command line.

You should not use `ld` directly. As with static libraries, the `CC` command ensures that all the necessary template instances from the template repository are included in the library if you are using templates. All static constructors in a dynamic library that is linked to an application are called *before* `main()` is executed and all static destructors are called *after* `main()` exits. If a shared library is opened using `dlopen()`, all static constructors are executed at `dlopen()` and all static destructors are executed at `dclose()`.

You should use `CC -G` to build a dynamic library. When you use `ld` (the link-editor) or `cc` (the C compiler) to build a dynamic library, exceptions might not work and the global variables that are defined in the library are not initialized.

To build a dynamic (shared) library, you must create relocatable object files by compiling each object with the `-Kpic` or `-KPIC` option of `CC`. You can then build a dynamic library with these relocatable object files. If you get any unexpected link failures, you might have forgotten to compile some objects with `-Kpic` or `-KPIC`.

To build a C++ dynamic library named `libfoo.so` that contains objects from source files `lsrc1.cc` and `lsrc2.cc`, type:

```
% CC -G -o libfoo.so -h libfoo.so -Kpic lsrc1.cc lsrc2.cc
```

The `-G` option specifies the construction of a dynamic library. The `-o` option specifies the file name for the library. The `-h` option specifies an internal name for the shared library. The `-Kpic` option specifies that the object files are to be position-independent.

The `CC -G` command does not pass any `-l` options to the linker, `ld`. To ensure proper initialization order, a shared library must have an explicit dependency on each other shared library it needs. To create the dependencies, use a `-l` option for each such library. Typical C++ shared libraries will use one of the following sets of options:

```
-lcstd -lCrun -lc
-library=stlport4 -lCrun -lc
-library=stdcxx4 -lCrun -lc
-lstdc++ -lgcc_s -lCrunG3 -lc
```

The first three sets can be used only in the default `-compat=5` mode. The fourth set can be used only in the `-std=c++03`, `-std=c++11`, or `-std=c++14` modes. For each option set, list the options in the order given after all other libraries.

To be sure you have listed all needed dependencies, build the library with the `-zdefs` option. The linker will issue an error message for each missing symbol definition. To provide the missing definitions, add a `-l` option for those libraries.

To find out if you have included unneeded dependencies, use the following commands

```
ldd -u -r mylib.so
ldd -U -r mylib.so
```

You can then rebuild `mylib.so` without the unneeded dependencies.

## 14.4 Building Shared Libraries That Contain Exceptions

Never use `-Bsymbolic` with programs containing C++ code. Use linker map files instead. With `-Bsymbolic`, references in different modules can bind to different copies of what is supposed to be one global object.

The exception mechanism relies on comparing addresses. If you have two copies of an object, their addresses won't compare equal, and the exception mechanism can fail because the exception mechanism relies on comparing what are supposed to be unique addresses.

## 14.5 Building Libraries for Private Use

When an organization builds a library for internal use only, the library can be built with options that are not advised for more general use. In particular, the library need not comply with the system's application binary interface (ABI). For example, the library can be compiled with the `-fast` option to improve its performance on a known architecture. Likewise, it can be compiled with the `-xregs=float` option to improve performance.

## 14.6 Building Libraries for Public Use

When an organization builds a library for use by other organizations, the management of the libraries, platform generality, and other issues become significant. A simple test for whether a

library is public is to ask if the application programmer can recompile the library easily. Public libraries should be built in conformance with the system's application binary interface (ABI). In general, this means that any processor-specific options should be avoided. (For example, do not use `-fast` or `-xtarget`.)

The SPARC ABI reserves some registers exclusively for applications. For SPARC V7 and V8, these registers are `%g2`, `%g3`, and `%g4`. For SPARC V9, these registers are `%g2` and `%g3`. Because most compilations are for applications, the C++ compiler, by default, uses these registers for scratch registers, improving program performance. However, use of these registers in a public library is generally not compliant with the SPARC ABI. When building a library for public use, compile all objects with the `-xregs=no%appl` option to ensure that the application registers are not used.

## 14.7 Building a Library That Has a C API

If you want to build a library that is written in C++ but that can be used with a C program, the library must have a C API (application programming interface). This means that all the exported functions are declared `extern "C"`. Note that you can do so only for ordinary functions and data, not for class members. In addition, all types used in the interface must be types that can be declared in C.

If a C-interface library needs C++ runtime support (for example, you use class types or C++ library functions internally) and you are linking with the C compiler `cc`, you must also link with the appropriate C++ runtime libraries, as described below.

You should create a dynamic (shared) library instead of a static (archive) library. A dynamic library will be self-contained with its own references to the C++ runtime libraries it depends on. If you create a static library, users of your library will need to link the C++ runtime libraries into their program, and will need to either use `CC` (not `cc`) to link the program or duplicate the `ld` command line that `CC` would generate.

When you create your dynamic library, list the C++ runtime libraries associated with the compilation mode (`-compat=x`, `-std=x`) you are using. These libraries are listed in [“14.3 Building Dynamic \(Shared\) Libraries” on page 169](#).

It may be possible to build your library without a dependency on any of the C++ runtime libraries. At a minimum, you would need to follow these guidelines:

- Do not use the array forms of `new` or `delete`.
- Do not use single-object forms of `new` or `delete`, unless you provide your own versions of `operator new` and `operator delete`.

- Do not use exceptions. (Compile with `-noex.`)
- Do not use runtime type information (RTTI). (Compile with `-features=no%rtti.`)
- Do not use `dynamic_cast`.
- Do not use any of the standard C++ headers.

## 14.8 Using dlopen to Access a C++ Library From a C Program

If you want to use `dlopen()` to open a C++ shared library from a C program, make sure that the shared library has a dependency on the appropriate C++ runtime (`libCrun.so.1` for `-compat=5`).

To do this, add `-lCrun` for `-compat=5` to the command line when building the shared library. For example:

```
example% CC -G -compat=5... -lCrun
```

When using `-compat=g`, `-std=c++03`, `-std=c++11`, or `-std=c++14` options, you need to link the g++ support libraries instead:

```
example% CC -G -std=c++11 ... -lstdc++ -lgcc_s -lCrunG3
```

If the shared library uses exceptions and does not have a dependency on the C++ runtime library, your C program might behave erratically.

**PART IV**

**Appendixes**



## C++ Compiler Options

---

This appendix details the command-line options for the C++ compiler. The features described apply to all platforms except as noted; features that are unique to the Oracle Solaris OS on SPARC-based systems are identified as (SPARC), and the features that are unique to the Oracle Solaris and Oracle Linux OS on x86-based systems are identified as (x86). Features limited to the Oracle Solaris OS only are marked (Solaris); features limited only to Oracle Linux OS are marked (Linux).

The typographical conventions that are listed in the Preface are used in this section of the manual to describe individual options.

Parentheses, braces, brackets, pipe characters, and ellipses are *metacharacters* used in the descriptions of the options and are not part of the options themselves.

### A.1 How Option Information Is Organized

To help you find information, compiler option descriptions are separated into the following subsections. If the option is one that is replaced by or identical to some other option, see the description of the other option for full details.

**TABLE 30** Option Subsections

Subsection	Contents
Option Definition	A short definition immediately follows each option. (There is no heading for this category.)
Values	If the option has one or more values, this section defines each value.
Defaults	<p>If the option has a primary or secondary default value, it is stated here.</p> <p>The primary default is the option value in effect if the option is not specified. For example, if <code>-compat</code> is not specified, the default is <code>-compat=5</code>.</p> <p>The secondary default is the option in effect if the option is specified, but no value is given. For example, if <code>-compat</code> is specified without a value, the default is <code>-compat=5</code>.</p>

Subsection	Contents
Expansions	If the option has a macro expansion, it is shown in this section.
Examples	If an example is needed to illustrate the option, it is given here.
Interactions	If the option interacts with other options, the relationship is discussed here.
Warnings	Cautions regarding use of the option are noted here, as are actions that might cause unexpected behavior.
See also	This section contains references to further information in other options or documents.
“Replace with” “Same as”	<p>If an option has become obsolete and has been replaced by another option, the replacement option is noted here. Options described this way might not be supported in future releases.</p> <p>If two options have the same general meaning and purpose, the preferred option is referenced here. For example, “Same as -x0” indicates that -x0 is the preferred option.</p>

## A.2 Option Reference

The following section alphabetically lists all the C++ compiler options and indicates any platform restrictions.

### A.2.1 **-#**

Turns on verbose mode, showing how command options expand. Shows each component as it is invoked.

### A.2.2 **-###**

Shows each component as it would be invoked, but does not actually execute it. Also shows how command options would expand.

### A.2.3 **-abiopt=[mangle5|mangle6]**

This option is allowed only in -compat=5 (or -std=sun03) mode. It is an error in all other modes.



The `mangle6` sub-option is allowed on all platforms. It selects correct name mangling that might not be compatible with prior compiler releases on SPARC and on x86 with the `-m32` option.

The `mangle5` sub-option is allowed only on SPARC with `-m32` or `-m64` and x86 only with `-m32`. It selects name mangling compatible with prior compiler releases. It is the default on SPARC and on x86 with the `-m32` option.

The name mangling performed in prior releases of Oracle Developer Studio in `-compat=5` mode had errors. Fixing the errors would have created binary incompatibilities. The errors were found and corrected prior to Oracle Developer Studio releases on x86 with `-m64` and on Oracle Linux, but remained on the other platforms.

## A.2.4 `-Bbinding`

Specifies whether a library binding for linking is symbolic, dynamic (shared), or static (nonshared).

You can use the `-B` option several times on a command line. This option is passed to the linker, `ld`.

### A.2.4.1 Values

*binding* must be one of the values listed in the following table:

Value	Meaning
<code>dynamic</code>	Directs the link editor to look for <code>liblib.so</code> (shared) files, and if they are not found, to look for <code>liblib.a</code> (static, nonshared) files. Use this option if you want shared library bindings for linking.
<code>static</code>	Directs the link editor to look only for <code>liblib.a</code> (static, nonshared) files. Use this option if you want nonshared library bindings for linking.
<code>symbolic</code>	Forces symbols to be resolved within a shared library if possible, even when a symbol is already defined elsewhere.  See the <code>ld(1)</code> man page.

(No space is allowed between `-B` and the *binding* value.)

### Defaults

If `-B` is not specified, `-Bdynamic` is assumed.

## Interactions

To link the C++ default libraries statically, use the `-staticlib` option.

The `-Bstatic` and `-Bdynamic` options affect the linking of the libraries that are provided by default. To ensure that the default libraries are linked dynamically, the last use of `-B` should be `-Bdynamic`.

## Examples

The following compiler command links `libfoo.a` even if `libfoo.so` exists; all other libraries are linked dynamically:

```
example% CC a.o -Bstatic -lfoo -Bdynamic
```

## Warnings

Never use `-Bsymbolic` with programs containing C++ code, use linker map files instead.

With `-Bsymbolic`, references in different modules can bind to different copies of what is supposed to be one global object.

The exception mechanism relies on comparing addresses. If you have two copies of something, their addresses won't compare equal, and the exception mechanism can fail because the exception mechanism relies on comparing what are supposed to be unique addresses.

If you compile and link in separate steps and are using the `-Bbinding` option, you must include the option in the link step.

## See Also

`-nolib`, `-staticlib`, `ld(1)` man page, [“11.5 Statically Linking Standard Libraries” on page 133, Oracle Solaris 11.3 Linkers and Libraries Guide](#)

## A.2.5 `-c`

Compile only; produce object `.o` files, but suppress linking.

This option directs the CC driver to suppress linking with `ld` and produce a `.o` file for each source file. If you specify only one source file on the command line, then you can explicitly name the object file with the `-o` option.

### A.2.5.1 Examples

If you enter `cc -c x.cc`, the `x.o` object file is generated.

If you enter `cc -c x.cc -o y.o`, the `y.o` object file is generated.

#### Warnings

When the compiler produces object code for an input file (`.c`, `.i`), the compiler always produces a `.o` file in the working directory. If you suppress the linking step, the `.o` files are not removed.

#### See Also

`-o filename`, `-xe`

### A.2.6 `-cg{89|92}`

(SPARC) Obsolete, do not use this option. Current Oracle Solaris operating system software no longer supports SPARC V7 architecture. Compiling with this option generates code that runs slower on current SPARC platforms. Use `-x0` instead and take advantage of compiler defaults for `-xarch`, `-xchip`, and `-xcache`.

### A.2.7 `-compat={5|g}`

Sets the compatibility mode of the compiler. The new `-std` option is preferred and provides more choices. See [“A.2.88 `-std=v`” on page 230](#).

*Compatibility Mode* (`-compat=4`), which accepted the semantics and language defined by the 4.2 compiler in previous releases, was removed in Oracle Solaris Studio 12.3.

#### A.2.7.1 Defaults

The `-compat` option has a default value that depends on the platform. It is intended to match C++ libraries bundled with the operating system. See [“3.3 Platform-specific Option Defaults” on page 44](#).

## A.2.8 +d

Does not expand C++ inline functions.

Under the C++ language rules, a C++ inline function is a function for which one of the following statements is true:

- The function is defined using the `inline` keyword,
- The function is defined, not just declared, inside a class definition
- The function is a compiler-generated class member function

Under the C++ language rules, the compiler can choose whether actually to inline a call to an inline function. The C++ compiler inlines calls to an inline function unless one of the following is true:

- The function is too complex
- The `+d` option is selected
- The `-g` option is selected without a `-x0n` optimization level specified

### A.2.8.1 Examples

By default, the compiler may inline the functions `f()` and `mf2()` in the following code example. In addition, the class has a default compiler-generated constructor and destructor that the compiler may inline. When you use `+d`, the compiler will not inline `f()` and `C::mf2()`, the constructor, and the destructor.

```
inline int f() {return 0;} // may be inlined
class C {
    int mf1(); // not inlined unless inline definition comes later
    int mf2() {return 0;} // may be inlined
};
```

#### Interactions

This option is automatically turned on when you specify `-g`, the debugging option, unless an optimization level is also specified (`-O` or `-x0`).

The `-g0` debugging option does not turn on `+d`.

The `+d` option has no effect on the automatic inlining that is performed when you use `-x04` or `-x05`.

**See Also**

`-g0`, `-g`

**A.2.9**    **`-Dname[=def]`**

Define a macro with optional arguments as if the macro is defined by a `#define` preprocessing directive.5 mode

If no `=expansion` is specified, the compiler assumes 1.

See the CC(1) man page for a list of compiler predefined macros.

**A.2.10**    **`-d{y|n}`**

Allows or disallows dynamic libraries for the entire executable.

This option is passed to `ld`.

This option can appear only once on the command line.

**A.2.10.1**    **Values**

Value	Meaning
<code>-dy</code>	Specifies dynamic linking in the link editor.
<code>-dn</code>	Specifies static linking in the link editor.

**Defaults**

If no `-d` option is specified, `-dy` is assumed.

**Warnings**

This option causes fatal errors if you use it in combination with dynamic libraries. Most system libraries are only available as dynamic libraries.

### See Also

ld(1) man page, [Oracle Solaris 11.3 Linkers and Libraries Guide](#)

## A.2.11 `-dalign`

(SPARC) Obsolete — Do not use. Use `-xmemalign=8s`. See “[A.2.157 -xmemalign=ab](#)” on page 293 for more information.

This option is silently ignored on x86 platforms.

## A.2.12 `-dryrun`

Shows the subcommands built by driver, but does not compile.

This option directs the CC driver to show, but not execute, the subcommands constructed by the compilation driver.

## A.2.13 `-E`

Runs the preprocessor on source files; does not compile.

Directs the CC driver to run only the preprocessor on C++ source files, and to send the result to `stdout` (standard output). No compilation is done; no `.o` files are generated.

This option causes preprocessor-type line number information to be included in the output.

To compile the output of the `-E` option when the source code involves templates, you might need to use the `-template=no%extdef` option with the `-E` option. If application code uses the definitions separate template source code model, the output of the `-E` option might still not compile. Refer to the chapters on templates for more information.

When compiling in any of `-compat=g`, `-std=c++03`, `-std=c++11`, or `-std=c++14` modes, the compiler silently includes a private header `builtins.h`. If you then compile the preprocessed output, the header will be included again, resulting in many complaints about multiple declarations. To compile the the preprocessed file, you must first delete the lines associated with the `builtins.h` header.

## A.2.13.1 Examples

This option is useful for determining the changes made by the preprocessor. For example, the following program, `foo.cc`, generates the output shown in [“A.2.13.1 Examples” on page 183](#)

**EXAMPLE 5** Preprocessor Example Program `foo.cc`

```
#if __cplusplus < 199711L
int power(int, int);
#else
template <> int power(int, int);
#endif

int main () {
    int x;
    x=power(2, 10);
}
.
```

**EXAMPLE 6** Preprocessor Output of `foo.cc` Using `-E` Option

```
example% CC -E foo.cc
#4 "foo.cc"
template < > int power (int, int);

int main () {
int x;
x = power (2, 10);
}
```

### Warnings

The output of this option might not be usable as input to a C++ compilation if the code contains templates under the definitions-separate model.

### See Also

–P

## A.2.14 `-erroff[=t]`

This command suppresses C++ compiler warning messages and has no effect on error messages. This option applies to all warning messages regardless of whether they have been designated by `-errwarn` to cause a non-zero exit status.

### A.2.14.1 Values

*t* is a comma-separated list that consists of one or more of the following: *tag*, `no%tag`, `%all`, `%none`. Order is important; for example, `%all,no%tag` suppresses all warning messages except *tag*. The following table lists the `-erroff` values.

**TABLE 31** `-erroff` Values

Value	Meaning
<i>tag</i>	Suppresses the warning message specified by this <i>tag</i> . You can display the tag for a message by using the <code>-errtags=yes</code> option.
<code>no%tag</code>	Enables the warning message specified by this <i>tag</i> .
<code>%all</code>	Suppresses all warning messages.
<code>%none</code>	Enables all warning messages (default).

### Defaults

The default is `-erroff=%none`. Specifying `-erroff` is equivalent to specifying `-erroff=%all`.

### Examples

For example, `-erroff=tag` suppresses the warning message specified by this tag. On the other hand, `-erroff=%all,no%tag` suppresses all warning messages except the messages identified by *tag*.

You can display the tag for a warning message by using the `-errtags=yes` option.

### Warnings

Only warning messages from the C++ compiler that display a tag when the `-errtags` option is used can be suppressed with the `-erroff` option.



**See Also**

-errtags, -errwarn

**A.2.15 -errtags[=*a*]**

Displays the message tag for each warning message of the C++ compiler that can be suppressed with the -erroff option or made a fatal warning with the -errwarn option.

In previous C++ compilers, the -errtags option caused a tag to be printed as part of the message for both warnings and errors. The C++ compiler behavior is now the same as the C compiler, emitting tags only for warning messages.

**A.2.15.1 Values and Defaults**

*a* can be either yes or no. The default is -errtags=no. Specifying -errtags is equivalent to specifying -errtags=yes.

**Warnings**

Messages from the C++ compiler driver and other components of the compilation system do not have error tags. Therefore they cannot be suppressed with -erroff or made fatal with -errwarn.

**See Also**

-erroff, -errwarn

**A.2.16 -errwarn[=*t*]**

Use -errwarn to cause the C++ compiler to exit with a failure status for the given warning messages.

## A.2.16.1 Values

*t* is a comma-separated list that consists of one or more of the following: *tag*, *no%tag*, *%all*, *%none*. Order is important; for example *%all, no%tag* causes *cc* to exit with a fatal status if any warning except *tag* is issued.

The following table details the `-errwarn` values.

**TABLE 32** `-errwarn` Values

Value	Meaning
<i>tag</i>	Cause CC to exit with a fatal status if the message specified by this <i>tag</i> is issued as a warning message. Has no effect if <i>tag</i> is not issued.
<i>no%tag</i>	Prevent CC from exiting with a fatal status if the message specified by <i>tag</i> is issued only as a warning message. Has no effect if the message specified by <i>tag</i> is not issued. Use this option to revert a warning message that was previously specified by this option with <i>tag</i> or <i>%all</i> from causing <i>cc</i> to exit with a fatal status when issued as a warning message.
<i>%all</i>	Cause CC to exit with a fatal status if any warning messages are issued. <i>%all</i> can be followed by <i>no %tag</i> to exempt specific warning messages from this behavior.
<i>%none</i>	Prevents any warning message from causing CC to exit with a fatal status should any warning message be issued.

### Defaults

The default is `-errwarn=%none`. Specifying `-errwarn` alone is equivalent to `-errwarn=%all`.

### Warnings

Only warning messages from the C++ compiler that display a tag when the `-errtags` option is used can be specified with the `-errwarn` option to cause the compiler to exit with a failure status.

The warning messages generated by the C++ compiler change from release to release as the compiler error checking improves and features are added. Code that compiles using `-errwarn=%all` without error may not compile without error in the next release of the compiler.

### See Also

`-erroff`, `-errtags`, `-xwe`

## A.2.17 `-fast`

This option is a macro that can be effectively used as a starting point for tuning an executable for maximum runtime performance. `-fast` is a macro that can change from one release of the compiler to the next and expands to options that are target platform specific. Use the `-dryrun` or `-xdryrun` option to examine the expansion of `-fast`, and incorporate the appropriate options of `-fast` into the ongoing process of tuning the executable.

This option is a macro that selects a combination of compilation options for optimum execution speed on the machine upon which the code is compiled.

### A.2.17.1 Expansions

This option provides near maximum performance for many applications by expanding to the following compilation options.

**TABLE 33** `-fast` Expansion

Option	SPARC	x86
<code>-fma=fused</code>	X	X
<code>-fns</code>	X	X
<code>-fsimple=2</code>	X	X
<code>-nofstore</code>	-	X
<code>-xbuiltin=%all</code>	X	X
<code>-xlibmil</code>	X	X
<code>-xlibmopt</code>	X	X
<code>-xmemalign</code>	X	-
<code>-x05</code>	X	X
<code>-xregs=frameptr</code>	-	X
<code>-xtarget=native</code>	X	X

### Interactions

See the description for each option to determine possible interactions.

The code generation option, the optimization level, the optimization of built-in functions, and the use of inline template files can be overridden by subsequent options (see examples). The optimization level that you specify overrides a previously set optimization level.

The `-fast` option includes `-fns -ft rap=%none`; that is, this option turns off all trapping.

On x86 the `-fast` option includes `-xregs=frameptr`. See the discussion of this option for details, especially when compiling mixed C, Fortran, and C++ source codes.

## Examples

The following compiler command results in an optimization level of `-x03`.

```
example% CC -fast -x03
```

The following compiler command results in an optimization level of `-x05`.

```
example% CC -x03 -fast
```

## Warnings

If you compile and link in separate steps, the `-fast` option must appear in both the compile command and the link command.

Object binaries compiled with the `-fast` option are not portable. For example, using the following command on a SPARC T3 system generates a binary that will not execute on a SPARC T4 system.

```
example% CC -fast test.cc
```

Do not use this option for programs that depend on IEEE standard floating-point arithmetic. Different numerical results, premature program termination, or unexpected SIGFPE signals can occur.

The expansion of `-fast` includes `-D_MATHERR_ERRNO_DONTCARE`.

With `-fast`, the compiler is free to replace calls to floating-point functions with equivalent optimized code that does not set the `errno` variable. Further, `-fast` also defines the macro `__MATHERR_ERRNO_DONTCARE`, which allows the compiler to ignore ensuring the validity of `errno` and floating-point exceptions raised after a floating-point function call. As a result, user code that relies on the value of `errno` or an appropriate floating-point exception raised after a floating-point function call could produce inconsistent results.

One way around this problem is to avoid compiling such codes with `-fast`. However, if `-fast` optimization is required and the code depends on the value of `errno` being set properly or a floating-point exception being raised after floating-point library calls, you should compile with the following options after `-fast` on the command line to inhibit the compiler from optimizing out such library calls:

```
-xbuiltin=%none -U__MATHERR_ERRNO_DONTCARE -xnolibmopt -xnolibmil
```

To display the expansion of `-fast` on any platform, run the command `CC -dryrun -fast` as shown in the following example.

```
>CC -dryrun -fast |& grep ###
###      command line files and options (expanded):

### -dryrun -xO5 -xchip=T4 -xcache=16/32/4/8:128/32/8/8:4096/64/16/64
-xarch=sparc4 -xdepend=yes -xmemalign=8s -fma=fused -fsimple=2 -fns=yes
-ftrap=%none -xlibmil -xlibmopt -xbuiltin=%all -D__MATHERR_ERRNO_DONTCARE
```

### See Also

`-fns`, `-fsimple`, `-fttrap=%none`, `-xlibmil`, `-nofstore`, `-xO5`, `-xlibmopt`, `-xtarget=native`

## A.2.18 `-features=a[,a...]`

Enables/disables various C++ language features named in a comma-separated list.

### A.2.18.1 Values

Keyword *a* can have the values shown in the following table. The `no%` prefix disables the associated option.

**TABLE 34** `-features` Values

Value	Meaning
[no%]altspell	Recognize alternative token spellings (for example, “and” for “&&”). The default is <code>altspell</code> .
[no%]anachronisms	Allow anachronistic constructs. When disabled (that is, <code>-features=no%anachronisms</code> ), no anachronistic constructs are allowed. The default is <code>anachronisms</code> .
[no%]bool	Allow the <code>bool</code> type and literals. When enabled, the macro <code>_BOOL=1</code> . When not enabled, the macro is not defined. The default is <code>bool</code> .
[no%]conststrings	Put literal strings in read-only memory. The default is <code>conststrings</code> .
<code>cplusplus_redef</code>	Allows the normally predefined macro <code>__cplusplus</code> to be redefined by a <code>-D</code> option on the command line. Attempting to redefine <code>__cplusplus</code> with a <code>#define</code> directive in source code is not allowed. Example:  <code>CC -features=cplusplus_redef -D__cplusplus=1...</code>

Value	Meaning
	<p>Old versions of g++ predefined the <code>__cplusplus</code> macro to 1, and some source code might depend on this non-standard value.</p> <p>Do not use this option unless you need to redefine <code>__cplusplus</code> to 1 to compile code intended for g++.</p>
<code>[no]except</code>	<p>Allow C++ exceptions. When C++ exceptions are disabled (that is, <code>-features=noexcept</code>), a throw-specification on a function is accepted but ignored; the compiler does not generate exception code. Note that the keywords <code>try</code>, <code>throw</code>, and <code>catch</code> are always reserved. See <a href="#">“8.3 Disabling Exceptions” on page 106</a>. The default is <code>except</code>.</p>
<code>explicit</code>	<p>Recognize the keyword <code>explicit</code>. The option <code>noexplicit</code> is not allowed.</p>
<code>[no]export</code>	<p>Recognize the keyword <code>export</code>. The default is <code>export</code>.</p>
<code>[no]extensions</code>	<p>Allow nonstandard code that is commonly accepted by other C++ compilers. The default is <code>noextensions</code>.</p>
<code>[no]iddollar</code>	<p>Allow a <code>\$</code> symbol as a noninitial identifier character. The default is <code>noiddollar</code>.</p>
<code>[no]localfor</code>	<p>Use standard-conforming local-scope rules for the <code>for</code> statement. The default is <code>localfor</code>.</p>
<code>[no]mergestrings</code>	<p>(SPARC) Causes the compiler to put string literals and other suitable <code>const</code> or read-only data into a special section of the binary where the linker removes duplicate strings.</p> <p>The default is <code>-features=nomergestrings</code>, and duplicate strings are not removed.</p> <p><code>-features=mergestrings</code> is only effective when <code>-features=conststrings</code> is also in effect.</p>
<code>[no]mutable</code>	<p>Recognize the keyword <code>mutable</code>. The default is <code>mutable</code>.</p>
<code>namespace</code>	<p>Recognize the keyword <code>namespace</code>. The option <code>nonamespace</code> is not allowed.</p>
<code>[no]nestedaccess</code>	<p>Allow nested classes to access private members of the enclosing class. Default: <code>-features=nestedaccess</code></p>
<code>[no]rtti</code>	<p>Issue runtime type identification (RTTI) data in the compiled program. The default is <code>-features=rtti</code>. Specifying <code>-features=no<code>rtti</code></code> disables generation of RTTI data. RTTI data can be large, so if you don't need RTTI the program uses less data space. Some C++ language features depend on RTTI and will not work if <code>no<code>rtti</code></code> is in effect. The compiler issues error messages if you use a feature that is disabled by <code>no<code>rtti</code></code>.</p>
<code>[no]rvaluref</code>	<p>Allow binding a non-<code>const</code> reference to an <i>rvalue</i> or temporary. Default: <code>-features=no<code>rvaluref</code></code></p> <p>The C++ compiler, by default, enforces the rule that a non-<code>const</code> reference cannot be bound to a temporary or <i>rvalue</i>. To override this rule, use the option <code>-features=<code>rvaluref</code></code>.</p>
<code>[no]split_init</code>	<p>Put initializers for nonlocal static objects into individual functions. When you use <code>-features=no<code>split_init</code></code>, the compiler puts all the initializers in</p>

Value	Meaning
	one function. Using <code>-features=no%split_init</code> minimizes code size at the possible expense of compile time. The default is <code>split_init</code> .
<code>[no%]transitions</code>	<p>Allow ARM language constructs that are problematic in standard C++ and that may cause the program to behave differently than expected or that may be rejected by future compilers. When you use <code>-features=no%transitions</code>, the compiler treats these as errors. When you use <code>-features=transitions</code>, the compiler issues warnings about these constructs instead of error messages.</p> <p>The following constructs are considered to be transition errors: redefining a template after it was used, omitting the <code>typename</code> directive when it is needed in a template definition, and implicitly declaring type <code>int</code>. The set of transition errors may change in a future release. The default is <code>transitions</code>.</p>
<code>[no%]strictdestrorder</code>	Follow the requirements specified by the C++ standard regarding the order of the destruction of objects with static storage duration. The default is <code>strictdestrorder</code> .
<code>[no%]tmplrefstatic</code>	Allow function templates to refer to dependent static functions or static function templates. The default is <code>-features=tmplrefstatic</code> and <code>no%tmplrefstatic</code> has no effect.
<code>[no%]tmplife</code>	Clean up the temporary objects that are created by an expression at the end of the full expression, as defined in the ANSI/ISO C++ Standard. (When <code>-features=no%tmplife</code> is in effect, most temporary objects are cleaned up at the end of their block.) The default is <code>tmplife</code> .
<code>[no%]zla</code>	<p>Allow an array to be declared with a size of 0, which is otherwise not allowed in C++. For example,</p> <pre>struct S {     int a[0]; // allowed only with -features=zla }; int b[0];    // allowed only with -features=zla</pre>

## Interactions

This option accumulates instead of overrides.

Use of the following is not compatible with the standard libraries and headers:

- `no%bool`
- `no%except`
- `no%mutable`

`no%bool` is not compatible with any gcc compatibility compiler modes: `-compat=g` or `-std=[c++03|c++11|c++14]`.

## Warnings

Do not use `-features=%all` or `-features=%none`. These sub-options are no longer allowed.

The behavior of a program might change when you use the `-features=tmplife` option. Testing whether the program works both with and without the `-features=tmplife` option is one way to test the program's portability.

## See Also

[Table 19, "Thread Options," on page 54](#) and the *C++ Migration Guide*

## A.2.19 `-fexceptions|fno-exceptions`

`-fexceptions` is equivalent to `-features=except`.

`-fno-exceptions` is equivalent to `-features=no%except` (and thus to `-noex`).

## A.2.20 `-filt[=filter[,filter...]]`

Controls the filtering that the compiler normally applies to linker and compiler error messages.

### A.2.20.1 Values

*filter* must be one of the values listed in the following table. The `%no` prefix disables the associated suboption.

**TABLE 35** `-filt` Values

Value	Meaning
<code>[no%]errors</code>	Show the C++ explanations of the linker error messages. The suppression of the explanations is useful when the linker diagnostics are provided directly to another tool.
<code>[no%]names</code>	Demangle the C++ mangled linker names.
<code>[no%]returns</code>	Demangle the return types of functions. Suppression of this type of demangling helps you to identify function names more quickly, but note that in the case of covariant returns, some functions differ only in the return type.
<code>[no%]stdlib</code>	Simplify names from the standard library in both the linker and compiler error messages and provide an easier way to recognize the names of standard library template types.



Value	Meaning
%all	Equivalent to <code>-filt=errors,names,returns,stdlib</code> . This is the default behavior.
%none	Equivalent to <code>-filt=no%errors,no%names,no%returns,no%stdlib</code> .

## Defaults

If you do not specify the `-filt` option or if you specify `-filt` without any values, then the compiler assumes `-filt=%all`.

## Examples

The following examples show the effects of compiling this code with the `-filt` option.

```
// filt_demo.cc
class type {
public:
    virtual ~type(); // no definition provided
};

int main()
{
    type t;
}
```

When you compile the code without the `-filt` option, the compiler assumes `-filt=errors,names,returns,stdlib` and displays the standard output.

```
example% CC filt_demo.cc
Undefined          first referenced
 symbol            in file
type::~~type()     filt_demo.o
type::~__vtbl      filt_demo.o
[Hint: try checking whether the first non-inlined, /
non-pure virtual function of class type is defined]

ld: fatal: Symbol referencing errors. No output written to a.out
```

The following command suppresses the demangling of the of the C++ mangled linker names and suppresses the C++ explanations of linker errors.

```
example% CC -filt=no%names,no%errors filt_demo.cc
Undefined          first referenced
 symbol            in file
__1cEtype2T6M_v_   filt_demo.o
```

```
__1cEtypeG__vtbl_          filt_demo.o
ld: fatal: Symbol referencing errors. No output written to a.out
```

Now consider this code:

```
#include <string>
#include <list>
int main()
{
    std::list<int> l;
    std::string s(l); // error here
}
```

Specifying `-filt=no%stdlib` results in the following output:

```
Error: Cannot use std::list<int, std::allocator<int>> to initialize
std::basic_string<char, std::char_traits<char>,
std::allocator<char>>.
```

Specifying `-filt=stdlib` results in the following output:

```
Error: Cannot use std::list<int> to initialize std::string .
```

## Interactions

When you specify `no%names`, neither `returns` nor `no%returns` has an effect. That is, the following options are equivalent:

- `-filt=no%names`
- `-filt=no%names,no%returns`
- `-filt=no%names,returns`

### A.2.21 `-flags`

Same as `-xhelp=flags`.

### A.2.22 `-fma[={none|fused}]`

Enables automatic generation of floating-point fused multiply-add instructions. `-fma=none` disables generation of these instructions. `-fma=fused` allows the compiler to attempt to find

opportunities to improve the performance of the code by using floating-point fused multiply-add instructions.

The default is `-fma=none`.

The minimum requirement is `-xarch=sparcfmaf` on SPARC and `-xarch=avx2` on x86 to generate fused multiply-add instructions. The compiler marks the binary program if fused multiply-add instructions are generated in order to prevent the program from executing on platforms that do not support fused multiply-add instructions. When the minimum architecture is not used, then `-fma=fused` has no effect.

Fused multiply-add instructions eliminate the intermediate rounding step between the multiply and add. Consequently, programs may produce different results when compiled with `-fma=fused`, although precision will tend to increase rather than decrease.

### A.2.23 `-fnonstd`

This is a macro that expands to `-fttrap=common` on x86, and `-fns -fttrap=common` on SPARC.

See `-fns` and `-fttrap=common` for more information.

### A.2.24 `-fns[={yes|no}]`

- (SPARC) Enables/disables the SPARC nonstandard floating-point mode.  
`-fns=yes` (or `-fns`) causes the nonstandard floating point mode to be enabled when a program begins execution.

This option provides a way of toggling the use of nonstandard or standard floating-point mode following some other macro option that includes `-fns`, such as `-fast`.

On some SPARC architectures, the nonstandard floating-point mode disables “gradual underflow,” causing tiny results to be flushed to zero rather than to produce subnormal numbers. It also causes subnormal operands to be silently replaced by zero.

On those SPARC architectures that do not support gradual underflow and subnormal numbers in hardware, `-fns=yes` (or `-fns`) can significantly improve the performance of some programs.

- (x86) Selects/deselects SSE flush-to-zero mode and, where available, denormals-are-zero mode.

This option causes subnormal results to be flushed to zero. Where available, this option also causes subnormal operands to be treated as zero.

This option has no effect on traditional x86 floating-point operations that do not utilize the SSE or SSE2 instruction set.

## A.2.24.1 Values

The `-fns` option can have the values listed in the following table.

**TABLE 36** `-fns` Values

Value	Meaning
yes	Selects nonstandard floating-point mode
no	Selects standard floating-point mode

### Defaults

If `-fns` is not specified, the nonstandard floating point mode is not enabled automatically. Standard IEEE 754 floating-point computation takes place, that is, underflows are gradual.

If only `-fns` is specified, `-fns=yes` is assumed.

### Examples

In the following example, `-fast` expands to several options, one of which is `-fns=yes` which selects nonstandard floating-point mode. The subsequent `-fns=no` option overrides the initial setting and selects floating-point mode.

```
example% CC foo.cc -fast -fns=no
```

### Warnings

When nonstandard mode is enabled, floating-point arithmetic can produce results that do not conform to the requirements of the IEEE 754 standard.

If you compile one routine with the `-fns` option you should compile all routines of the program with the `-fns` option. Otherwise, you might get unexpected results.

This option is effective only when compiling the main program.

Use of the `-fns=yes` (or `-fns`) option might generate warning messages if your program encounters a floating-point error normally managed by the IEEE floating-point trap handlers.

**See Also**

[Oracle Developer Studio 12.5: Numerical Computation Guide](#), `ieee_sun(3M)` man page

**A.2.25 -fopenmp**

Same as `-xopenmp=parallel`.

**A.2.26 -fprecision=*p***

(x86) Sets the non-default floating-point precision mode.

The `-fprecision` option sets the rounding precision mode bits in the floating-point control word (FPCW). These bits control the precision to which the results of basic arithmetic operations (add, subtract, multiply, divide, and square root) are rounded.

**A.2.26.1 Values**

*p* must be one of the values listed in the following table.

**TABLE 37** `-fprecision` Values

Value	Meaning
<code>single</code>	Rounds to an IEEE single-precision value.
<code>double</code>	Rounds to an IEEE double-precision value.
<code>extended</code>	Rounds to the maximum precision available.

If *p* is `single` or `double`, this option causes the rounding precision mode to be set to `single` or `double` precision, respectively, when a program begins execution. If *p* is `extended` or the `-fprecision` option is not used, the rounding precision mode remains at the extended precision.

The `single` precision rounding mode causes results to be rounded to 24 significant bits, and `double` precision rounding mode causes results to be rounded to 53 significant bits. In the default `extended` precision mode, results are rounded to 64 significant bits. This mode controls only the precision to which results in registers are rounded, and it does not affect the range. All results in register are rounded using the full range of the extended double format. Results that

are stored in memory are rounded to both the range and precision of the destination format, however.

The nominal precision of the `float` type is `single`. The nominal precision of the `long double` type is `extended`.

### Defaults

When the `-fprecision` option is not specified, the rounding precision mode defaults to `extended`.

### Warnings

This option is effective only on x86 systems and only if used when compiling the main program, but is ignored if compiling for 64-bit (`-m64`) or SSE2-enabled (`-xarch=sse2`) processors. It is also ignored on SPARC systems.

## A.2.27 `-fround=r`

Sets the IEEE rounding mode in effect at startup.

This option sets the IEEE 754 rounding mode that can be used by the compiler in evaluating constant expressions. The rounding mode is established at runtime during the program initialization.

The meanings are the same as those for the `ieee_flags` subroutine, which can be used to change the mode at runtime.

### A.2.27.1 Values

`r` must be one of the values listed in the following table.

**TABLE 38** `-fround` Values

Value	Meaning
<code>nearest</code>	Rounds towards the nearest number and breaks ties to even numbers.
<code>tozero</code>	Rounds to zero.
<code>negative</code>	Rounds to negative infinity.

Value	Meaning
positive	Rounds to positive infinity.

## Defaults

When the `-fround` option is not specified, the rounding mode defaults to `-fround=nearest`.

## Warnings

If you compile one routine with `-fround=r`, you must compile all routines of the program with the same `-fround=r` option. Otherwise, you might get unexpected results.

This option is effective only if used when compiling the main program.

Note that compiling with `-xvector` or `-xlibmopt` require default rounding. Programs that link with libraries compiled with either `-xvector` or `-xlibmopt` or both must ensure that default rounding is in effect.

## A.2.28 `-fsimple[=n]`

Selects floating-point optimization preferences.

This option enables the optimizer to make simplifying assumptions concerning floating-point arithmetic.

### A.2.28.1 Values

If  $n$  is present, it must be 0, 1, or 2.

**TABLE 39** `-fsimple` Values

Value	Meaning
0	Permit no simplifying assumptions. Preserve strict IEEE 754 conformance.
1	<p>Allow conservative simplification. The resulting code does not strictly conform to IEEE 754.</p> <p>With <code>-fsimple=1</code>, the optimizer can assume the following:</p> <ul style="list-style-type: none"> <li>■ IEEE754 default rounding/trapping modes do not change after process initialization.</li> <li>■ Computation producing no visible result other than potential floating-point exceptions can be deleted.</li> </ul>

Value	Meaning
	<ul style="list-style-type: none"> <li>■ Computation with infinities or NaNs as operands needs to propagate NaNs to their results; that is, <math>x*0</math> can be replaced by 0.</li> <li>■ Computations do not depend on sign of zero.</li> </ul> <p>With <code>-fsimple=1</code>, the optimizer is not allowed to optimize completely without regard to roundoff or exceptions. In particular, a floating-point computation cannot be replaced by one that produces different results when rounding modes are held constant at runtime.</p>
2	Includes all the functionality of <code>-fsimple=1</code> and also permits aggressive floating-point optimization that can cause many programs to produce different numeric results due to changes in rounding. For example, permit the optimizer to replace all computations of $x/y$ in a given loop with $x*z$ , where $x/y$ is guaranteed to be evaluated at least once in the loop $z=1/y$ , and the values of $y$ and $z$ are known to have constant values during execution of the loop.

## Defaults

If `-fsimple` is not designated, the compiler uses `-fsimple=0`.

If `-fsimple` is designated but no value is given for  $n$ , the compiler uses `-fsimple=1`.

## Interactions

`-fast` implies `-fsimple=2`.

## Warnings

This option can break IEEE 754 conformance.

## See Also

`-fast`

## A.2.29 `-fstore`

(x86) Forces precision of floating-point expressions.

This option causes the compiler to convert the value of a floating-point expression or function to the type on the left side of an assignment rather than leave the value in a register when the following is true:



- The expression or function is assigned to a variable.
- The expression is cast to a shorter floating-point type.

To turn off this option, use the `-nofstore` option. Both `-fstore` and `-nofstore` are ignored with a warning on SPARC platforms.

### A.2.29.1 Warnings

Due to roundoffs and truncation, the results can be different from those that are generated from the register values.

#### See Also

`-nofstore`

## A.2.30 `-ftrap=t[,t...]`

Sets the IEEE trapping mode in effect at startup but does not install a SIGFPE handler. You can use `ieee_handler(3M)` or `fex_set_handling(3M)` to simultaneously enable traps and install a SIGFPE handler. If you specify more than one value, the list is processed sequentially from left to right.

### A.2.30.1 Values

`t` can be one of the values listed in the following table.

**TABLE 40** The `-ftrap` Values

Value	Meaning
<code>[no%]division</code>	Trap on division by zero.
<code>[no%]inexact</code>	Trap on inexact result.
<code>[no%]invalid</code>	Trap on invalid operation.
<code>[no%]overflow</code>	Trap on overflow.
<code>[no%]underflow</code>	Trap on underflow.
<code>%all</code>	Trap on all of the above.
<code>%none</code>	Trap on none of the above.

Value	Meaning
common	Trap on invalid, division by zero, and overflow.

Note that the [no%] form of the option is used only to modify the meaning of the %all and common values, and must be used with one of these values, as shown in the example. The [no%] form of the option by itself does not explicitly cause a particular trap to be disabled.

### Defaults

If you do not specify `-fttrap`, the compiler assumes `-fttrap=%none`.

### Examples

`-fttrap=%all,no%inexact` means to set all traps except `inexact`.

### Warnings

If you compile one routine with `-fttrap=t`, you should compile all routines of the program with the same `-fttrap=t` option. Otherwise, you might get unexpected results.

Use the `-fttrap=inexact` trap with caution. Use of `-fttrap=inexact` results in the trap being issued whenever a floating-point value cannot be represented exactly. For example, the following statement generates this condition:

```
x = 1.0 / 3.0;
```

This option is effective only if used when compiling the main program. Be cautious when using this option. If you want to enable the IEEE traps, use `-fttrap=common`.

### See Also

`ieee_handler(3M)` and `fex_set_handling(3M)` man pages.

## A.2.31 `-G`

Build a dynamic shared library instead of an executable file.

All source files specified in the command line are compiled with `-xcode=pic13` by default.

When building a shared library from files that involve templates and were compiled with the `-instances=extern` option, any template instances referenced by the `.o` files will be included from the template cache automatically.

If you are creating a shared object by specifying `-G` along with other compiler options that must be specified at both compile time and link time, make sure that those same options are also specified at both compile time and link time when you link with the resulting shared object.

When you create a shared object, all the object files compiled for 64-bit SPARC architectures must also be compiled with an explicit `-xcode` value as recommended in [“A.2.119 – `xcode=a`” on page 259](#).

### A.2.31.1 Interactions

The following options are passed to the linker if `-c` (the compile-only option) is not specified:

- `-dy`
- `-G`
- `-R`

#### Warnings

Do not use `ld -G` to build shared libraries; use `CC -G`. The CC driver automatically passes several options to `ld` that are needed for C++.

When you use the `-G` option, the compiler does not pass any default `-l` options to `ld`. If you want the shared library to have a dependency on another shared library, you must pass the necessary `-l` or `-library` option on the command line. For example, if you want the shared library to be dependent upon `libCrun`, you must pass `-lCrun` or `-library=Crun` on the command line.

#### See Also

`-dy`, `-xcode=pic13`, `-ztext`, `ld(1)` man page, [“14.3 Building Dynamic \(Shared\) Libraries” on page 169](#).

### A.2.32 `-g`

See `-g[n]`.

## A.2.33 `-g[n]`

Produces additional symbol table information for debugging with `dbx(1)` or the Debugger and for analysis with the Performance Analyzer `analyzer(1)`.

Instructs both the compiler and the linker to prepare the file or program for debugging and for performance analysis.

The tasks include:

- Producing detailed debug information in the symbol table of the object files and the executable
- Producing helper functions that the debugger can call to implement some of its features
- Disabling the inline generation of functions if no optimization level is specified; that is, using this option implies the `+d` option if no optimization level is also specified. `-g` with any `-O` or `-xO` level does not disable inlining.
- Disabling certain levels of optimization

`-g` is implemented as a macro that expands to various other, more primitive, options. See `-xdebuginfo` for the details of the expansions.

<code>-g</code>	Produce standard debugging information.
<code>-gnone</code>	Do not produce any debugging information. This is the default.
<code>-g1</code>	Produce file and line number as well as simple parameter information that is considered crucial during post-mortem debugging.
<code>-g2</code>	Same as <code>-g</code> .
<code>-g3</code>	Produce additional debugging information, which currently consists only of macro definition information. This added information can result in an increase in the size of the debug information in the resulting <code>.o</code> and executable when compared to using only <code>-g</code> .
<code>-g0</code>	<p>Instructs the compiler to prepare the file or program for debugging, but not to disable inlining. This option is the same as <code>-g</code>, except that <code>+d</code> is disabled and <code>dbx</code> cannot step into inlined functions.</p> <p>If you specify <code>-g0</code> and the optimization level is <code>-xO3</code> or lower, the compiler provides best-effort symbolic information with almost full optimization. Tail-call optimization and back-end inlining are disabled.</p>

### A.2.33.1 Interactions

If you use this option with `-x0level` (or its equivalent options, such as `-0`), you will get limited debugging information. For more information, see [“A.2.163 -x0level” on page 298](#).

If you use this option and the optimization level is `-x04` or higher, the compiler provides best-effort symbolic information with full optimization. If you use `-g` without an optimization level specified, inlining of function calls will be disabled. (Inlining is enabled when an optimization level is specified with `-g`.)

When you specify this option, the `+d` option is specified automatically unless you also specify `-0` or `-x0`.

To use the full capabilities of the Performance Analyzer, compile with the `-g` option. While some performance analysis features do not require `-g`, you must compile with `-g` to view annotated source, some function level information, and compiler commentary messages. See the `analyzer(1)` man page and the *Performance Analyzer* manual for more information.

The commentary messages that are generated with `-g` describe the optimizations and transformations that the compiler made while compiling your program. Use the `er_src(1)` command to display the messages, which are interleaved with the source code.

#### Warnings

If you compile and link your program in separate steps, then including the `-g` option in one step and excluding it from the other step will not affect the correctness of the program, but it will affect the ability to debug the program. Any module that is not compiled with `-g` (or `-g0`), but is linked with `-g` (or `-g0`) will not be prepared properly for debugging. Note that compiling the module that contains the function `main` with the `-g` option (or the `-g0` option) is usually necessary for debugging.

#### See Also

`+d`, `-xs`, `analyzer(1)` man page, `er_src(1)` man page, `ld(1)` man page, [Oracle Developer Studio 12.5: Debugging a Program with dbx](#) (for details about stabs), and [Oracle Developer Studio 12.5: Performance Analyzer](#).

### A.2.34 -H

Prints path names of included files.

On the standard error output (`stderr`), this option prints, one per line, the path name of each `#include` file contained in the current compilation.

## A.2.35 `-h[ ]name`

Assigns the name *name* to the generated dynamic shared library.

This is a linker option passed to `ld`. In general, the name after `-h` should be exactly the same as the one after `-o`. A space between the `-h` and *name* is optional.

The compile-time loader assigns the specified name to the shared dynamic library you are creating. It records the name in the library file as the intrinsic name of the library. If there is no `-hname` option, then no intrinsic name is recorded in the library file.

Every executable file has a list of shared library files that are needed. When the runtime linker links the library into an executable file, the linker copies the intrinsic name from the library into that list of needed shared library files. If there is no intrinsic name of a shared library, then the linker copies the path of the shared library file instead.

When a shared library is built without the `-h` option, the runtime loader looks only for the file name of the library. You can replace the library with a different library with the same file name. If the shared library has an intrinsic name, the loader checks the intrinsic name when loading the file. If the intrinsic name does not match, the loader will not use the replacement file.

### A.2.35.1 Examples

```
example% CC -G -o libx.so.1 -h libx.so.1 a.o b.o c.o
```

## A.2.36 `-help`

This option is deprecated and will be removed in a future release. Use `-xhelp=flags` instead.

## A.2.37 `-Ipathname`

Add *pathname* to the `#include` file search path.

This option adds *pathname* to the list of directories that are searched for `#include` files with relative file names (those that do not begin with a slash).

The compiler searches for quote-included files (of the form `#include "foo.h"`) in this order:

1. In the directory containing the source
2. In the directories named with `-I` options, if any
3. In the `include` directories for compiler-provided C++ header files, ANSI C header files, and special-purpose files
4. In the `/usr/include` directory

The compiler searches for bracket-included files (of the form `#include <foo.h>`) in this order:

1. In the directories named with `-I` options, if any
2. In the `include` directories for compiler-provided C++ header files, ANSI C header files, and special-purpose files
3. In the `/usr/include` directory

---

**Note** - If the spelling matches the name of a standard header file, also refer to [“11.7.5 Standard Header Implementation”](#) on page 137.

---

### A.2.37.1 Interactions

The `-I-` option allows you to override the default search rules.

If you specify `-library=no%Cstd`, then the compiler does not include in its search path the compiler-provided header files that are associated with the C++ standard libraries. See [“11.7 Replacing the C++ Standard Library”](#) on page 135.

If `-ptipath` is not used, the compiler looks for template files in `-Ipathname`.

Use `-Ipathname` instead of `-ptipath`.

This option accumulates instead of overrides.

#### Warnings

Never specify the compiler installation area, `/usr/include`, `/lib`, or `/usr/lib`, as search directories.

#### See Also

`-I-`

## A.2.38 -I-

Change the include-file search rules.

For include files of the form `#include "foo.h"`, search the directories in the following order:

1. The directories named with `-I` options (both before and after `-I-`)
2. The directories for compiler-provided C++ header files, ANSI C header files, and special-purpose files
3. The `/usr/include` directory

For include files of the form `#include <foo.h>`, search the directories in the following order:

1. The directories named in the `-I` options that appear after `-I-`
2. The directories for compiler-provided C++ header files, ANSI C header files, and special-purpose files
3. The `/usr/include` directory

---

**Note** - If the name of the include file matches the name of a standard header, also refer to [“11.7.5 Standard Header Implementation” on page 137](#).

---

### A.2.38.1 Examples

The following example shows the results of using `-I-` when compiling `prog.cc`.

```
prog.cc
#include "a.h"
#include <b.h>
#include "c.h"
c.h
#ifdef _C_H_1
#define _C_H_1
int c1;
#endif
inc/a.h
#ifdef _A_H
#define _A_H
#include "c.h"
int a;
```



```

#endif
inc/b.h
#ifndef _B_H
#define _B_H
#include <c.h>
int b;
#endif
inc/c.h
#ifndef _C_H_2
#define _C_H_2
int c2;
#endif

```

The following command shows the default behavior of searching the current directory (the directory of the including file) for include statements of the form `#include "foo.h"`. When processing the `#include "c.h"` statement in `inc/a.h`, the compiler includes the `c.h` header file from the `inc` subdirectory. When processing the `#include "c.h"` statement in `prog.cc`, the compiler includes the `c.h` file from the directory containing `prog.cc`. Note that the `-H` option instructs the compiler to print the paths of the included files.

```

example% CC -c -Iinc -H prog.cc
inc/a.h
        inc/c.h
inc/b.h
        inc/c.h
c.h

```

The next command shows the effect of the `-I-` option. The compiler does not look in the including directory first when it processes statements of the form `#include "foo.h"`. Instead, it searches the directories named by the `-I` options in the order that they appear in the command line. When processing the `#include "c.h"` statement in `inc/a.h`, the compiler includes the `./c.h` header file instead of the `inc/c.h` header file.

```

example% CC -c -I. -I- -Iinc -H prog.cc
inc/a.h
        ./c.h
inc/b.h
        inc/c.h
./c.h

```

## Interactions

When `-I-` appears in the command line, the compiler never searches the current directory unless the directory is listed explicitly in a `-I` directive. This effect applies even for include statements of the form `#include "foo.h"`.

## Warnings

Only the first `-I-` in a command line causes the described behavior.

Never specify the compiler installation area, `/usr/include`, `/lib`, or `/usr/lib`, as search directories.

### A.2.39 `-i`

Tells the linker, `ld`, to ignore any `LD_LIBRARY_PATH` and `LD_LIBRARY_PATH_64` settings.

### A.2.40 `-include filename`

This option causes the compiler to treat *filename* as if it appears in the first line of a primary source file as a `#include` preprocessor directive. Consider the source file `t.c`:

```
int main()
{
    ...
}
```

If you compile `t.c` with the command `cc -include t.h t.c`, the compilation proceeds as if the source file contains the following:

```
#include "t.h"
int main()
{
    ...
}
```

The first directory the compiler searches for *filename* is the current working directory and not the directory containing the main source file, as is the case when a file is explicitly included. For example, the following directory structure contains two header files with the same name, but at different locations:

```
foo/
  t.c
  t.h
bar/
  u.c
  t.h
```

If your working directory is `foo/bar` and you compile with the command `cc ../t.c -include t.h`, the compiler includes `t.h` from `foo/bar`, not `foo/` as would be the case with a `#include` directive from within the source file `t.c`.

If the compiler cannot find the file specified with `-include` in the current working directory, it searches the normal directory paths for the file. If you specify multiple `-include` options, the files are included in the order they appear on the command line.

## A.2.41 `-inline`

This option is deprecated and will be removed in a future release. Use `-xinline` instead.

## A.2.42 `-instances=a`

Controls the placement and linkage of template instances.

### A.2.42.1 Values

`a` must be one of the values listed in the following table.

TABLE 41 `-instances` Values

Value	Meaning
<code>extern</code>	Places all needed instances into the template repository within linker <i>comdat</i> sections and gives them global linkage. (If an instance in the repository is out of date, it is reinstantiated.)  <b>Note:</b> If you are compiling and linking in separate steps and you specify <code>-instance=extern</code> for the compilation step, you must also specify it for the link step.
<code>explicit</code>	Places explicitly instantiated instances into the current object file and gives them global linkage. Does not generate any other needed instances.
<code>global</code>	Places all needed instances into the current object file and gives them global linkage.
<code>semiexplicit</code>	Places explicitly instantiated instances into the current object file and gives them global linkage. Places all instances needed by the explicit instances into the current object file and gives them global linkage. Does not generate any other needed instances.
<code>static</code>	<b>Note:</b> <code>-instances=static</code> is deprecated. You no longer need to use <code>-instances=static</code> because <code>-instances=global</code> now gives you all the advantages of static without the disadvantages. This option was provided in earlier compilers to overcome problems that do not exist in this version of the compiler.  Places all needed instances into the current object file and gives them static linkage.

## Defaults

If `-instances` is not specified, `-instances=global` is assumed.

## See Also

[“7.2.4 Template Instance Placement and Linkage” on page 97](#)

## A.2.43 `-instlib=filename`

Use this option to inhibit the generation of template instances that are duplicated in a library, either shared or static, and the current object. In general, if your program shares large numbers of instances with libraries, try `-instlib=filename` and see whether compilation time improves.

### A.2.43.1 Values

Use the *filename* argument to specify a library that contains template instances that could be generated by the current compilation. The filename argument must contain a forward slash `'/'` character. For paths relative to the current directory, use dot-slash `'./'`.

## Defaults

The `-instlib=filename` option has no default and is only used if you specify it. This option can be specified multiple times and accumulates.

## Example

Assume that the `libfoo.a` and `libbar.so` libraries instantiate many template instances that are shared with your source file `a.cc`. Adding `-instlib=filename` and specifying the libraries helps reduce compile time by avoiding the redundancy.

```
example% CC -c -instlib=./libfoo.a -instlib=./libbar.so a.cc
```

## Interactions

When you compile with `-g`, if the library specified with `-instlib=file` is not compiled with `-g`, those template instances will not be debuggable. The workaround is to avoid `-instlib=file` when you use `-g`.

**Warning**

If you specify a library with `-instlib`, you must link with that library.

**See Also**

`-template`, `-instances`, `-pti`

**A.2.44 -KPIC**

(SPARC) (Obsolete) Same as `-xcode=pic32`.

(x86) Same as `-Kpic`.

Use this option to compile source files when building a shared library. Each reference to a global datum is generated as a dereference of a pointer in the global offset table. Each function call is generated in program counter (PC)-relative addressing mode through a procedure linkage table.

**A.2.45 -Kpic**

(SPARC) (Obsolete) Same as `-xcode=pic13`.

(x86) Compiles with position-independent code.

Use this option to compile source files when building a shared library. Each reference to a global datum is generated as a dereference of a pointer in the global offset table. Each function call is generated in program counter (PC)-relative addressing mode through a procedure linkage table.

**A.2.46 -keeptmp**

Retains temporary files created during compilation.

Along with `-verbose=diags`, this option is useful for debugging.

### A.2.46.1 See Also

`-v`, `-verbose`

## A.2.47 `-Lpath`

Adds *path* to the list of directories to search for libraries.

This option is passed to `ld`. The directory that is named by *path* is searched before compiler-provided directories.

### A.2.47.1 Interactions

This option accumulates instead of overrides.

#### Warnings

Never specify the compiler installation area, `/usr/include`, `/lib`, or `/usr/lib`, as search directories.

## A.2.48 `-llib`

Adds library `llib.a` or `llib.so` to the linker's list of search libraries.

This option is passed to `ld`. Libraries generally have names such as `llib.a` or `llib.so`, where the `lib` and `.a` or `.so` parts are required. You should specify the *lib* part with this option. You can put as many libraries as you want on a single command line. Libraries are searched in the order specified with `-Ldir`.

Use this option after your object file name.

### A.2.48.1 Interactions

This option accumulates instead of overrides.

Put `-lx` after the list of sources and objects to ensure that libraries are searched in the correct order.

## Warnings

If you are building a multithreaded application, you must compile and link your program with the `-mt` option. See `-mt`.

## See Also

`-Ldir` and `-mt`

### A.2.49 `-libmieee`

This option is deprecated and will be removed in a future release. Use `-xlibmieee` instead.

### A.2.50 `-libmil`

This option is deprecated and will be removed in a future release. Use `-xlibmil` instead.

### A.2.51 `-library=l[,l...]`

Incorporates specified CC-provided libraries into compilation and linking.

#### A.2.51.1 Values

Keyword `l` must be one of the values in the following table. The `no%` prefix disables the associated option.

**TABLE 42** `-library` Values

Value	Meaning
<code>[no%]f77</code>	Deprecated. Use <code>-xlang=f95</code> instead.
<code>[no%]f90</code>	Deprecated. Use <code>-xlang=f90</code> instead.
<code>[no%]f95</code>	Deprecated. Use <code>-xlang=f95</code> instead.
<code>[no%]interval</code>	Deprecated. Do not use. Use <code>-xia</code> .
<code>[no%]iostream</code>	Use <code>libiostream</code> , the classic <code>iostreams</code> library.

Value	Meaning
[no%]Cstd	Use libCstd, a C++ runtime library compatible with all C++5.x releases. Available only in -compat=5 mode.
[no%]Crun	Use libCrun, the C++ compiler support library only for -compat=5 mode.
[no%]CrunG3	Use libCrunG3, the C++ compiler support library for modes -compat=g, -std=c++03, -std=c++11, and -std=c++14. Not available with -compat=5 mode.
[no%]gc	Use libgc garbage collection.
[no%]stlport4	Use the STLport implementation of the standard library instead of the default library. Code compiled with -library=stlport4 cannot be used in the same program as code compiled with -library=Cstd or -library=stdcxx4. Available only in -compat=5 mode.
[no%]stlport4_dbg	Use STLport's debug-enabled library. Available only in -compat=5 mode.
[no%]sunperf	Use the Sun Performance Library™.
[no%]stdcxx4	Use the Apache stdcxx version 4 library installed as part of Oracle Solaris. This option also sets the -mt option implicitly. The stdcxx library requires multi-threading mode. Code compiled with -library=stdcxx4 cannot be used in the same program as code compiled with -library=Cstd or -library=stlport4. Available only in -compat=5 mode.
[no%]stdcpp	Use libstdc++, the C++ runtime library for modes -compat=g, -std=c++03, -std=c++11, and -std=c++14. Not available with -compat=5 mode.
%none	In -compat=5 or -std=sun03 mode, use no libraries except libCrun. In gcc compatibility modes (any of -compat=g or -std=[c++03 c++11 c++14]) use no libraries other than libCrunG3. libCrunG3 has a dependency on the g++ runtime libraries libgcc_s and libstdc++. The option -library=%none in gcc compatibility modes will not work unless you add noCrunG3. The libCrunG3 library provides support for operator new, dynamic_cast, RTTI, exceptions, and initializing arrays of objects. Most programs require this library.

### A.2.51.2 Defaults

- **-compat=5 mode**
  - The libCstd library is always included unless it is specifically excluded using -library=%none or -library=noCstd, -library=stdcxx4 or -library=stlport4.
  - The libCrun library is always included unless it is specifically excluded using -library=noCrun.

The libm library is always included, even if you specify -library=%none.



For other values of `-std`, `-library=stdcpp` is the default.

The `-std` and `-library` options have default values that depend on the platform. They are intended to match C++ libraries bundled with the operating system. See [“3.3 Platform-specific Option Defaults” on page 44](#).

### A.2.51.3 Examples

To link in `-compat=5` mode without any C++ libraries (except `libCrun`):

```
example% CC -library=%none
```

### A.2.51.4 Interactions

If a library is specified with `-library`, the proper `-I` paths are set during compilation. The proper `-L`, `-Y P`, `-R` paths and `-l` options are set during linking.

This option accumulates instead of overrides.

When you use the interval arithmetic libraries, you must include one of the following libraries: `libCstd` or `libiostream`.

The specified libraries are linked before the system support libraries are linked.

For `-library=stdcxx4`, the Apache `stdcxx` library must be installed in `/usr/include` and `/usr/lib` on Oracle Solaris platforms.

You cannot use `-library=sunperf` and `-xlic_lib=sunperf` on the same command line.

You can use at most only one of `-library=stlport4`, `-library=stdcxx4`, or `-library=Cstd` options on any command line.

If you include both `libCstd` and `libiostream`, you must be careful to not use the old and new forms of iostreams within a program to access the same file (for example, `cout` and `std::cout`). Mixing standard iostreams and classic iostreams in the same program is likely to cause problems if the same file is accessed from both classic and standard iostream code.

If `-xnoLib` is specified, `-library` is ignored.

### A.2.51.5 Warnings

If you compile and link in separate steps, the set of `-library` options that appear in the compile command must appear in the link command.

The set of libraries is not stable and might change from release to release.

### A.2.51.6 See Also

See [“11.4.1.1 Note About Classic iostreams”](#) on page 132.

`-I`, `-l`, `-R`, `-staticlib`, `-xia`, `-xlang`, `-xnoib`, [“Caveats:”](#) on page 139, [“12.1.1 Redistribution and Supported STLport Libraries”](#) on page 143.

For information about using the `-library=no%csd` option to enable use of your own C++ standard library, see [“11.7 Replacing the C++ Standard Library”](#) on page 135.

## A.2.52 `-m32|-m64`

Specifies the data type model for the compiled binary object.

Use `-m32` to create 32-bit executables and shared libraries. Use `-m64` to create 64-bit executables and shared libraries.

Object files or libraries compiled with `-m32` cannot be linked with object files or libraries compiled with `-m64`.

When compiling applications with large amounts of static data using `-m64`, `-xmodel=medium` may also be required. Be aware that some Oracle Linux platforms do not support the medium model.

Modules that are compiled with `-m32|-m64` must also be linked with `-m32|-m64`. For a complete list of compiler options that must be specified at both compile time and link time, see [“3.4.3 Compile-Time and Link-Time Options”](#) on page 46.

The default behavior depends on the platform. The behavior is intended to match C++ libraries bundled with the operating system. See [“3.3 Platform-specific Option Defaults”](#) on page 44.

### A.2.52.1 See Also

`-xarch`.

## A.2.53 `-mc`

Removes duplicate strings from the ELF `.comment` section of the object file. When you use the `-mc` option, the `mcs -c` command is invoked. See the `mcs(1)` man page for details.

## A.2.54 `-misalign`

(SPARC) Obsolete. This option should not be used. Use `-xmemalign=2i` instead..

## A.2.55 `-mr[,string]`

Removes all strings from the `.comment` section of the object file and, if *string* is supplied, places *string* in that section. If the string contains blanks, the string must be enclosed in quotation marks. When you use this option, the command `mcs -d [-a string]` is invoked.

## A.2.56 `-mt[={yes|no}]`

Use this option to compile and link multithreaded code.

This option passes `-D_REENTRANT` to the preprocessor.

`-mt=yes` is the default behavior of the compiler. `-mt` is equivalent to `-mt=yes`. If this behavior is not desired use the option `-mt=no`.

The `-xopenmp` option (for using the OpenMP shared-memory parallelization API) includes `-mt=yes` automatically.

Use this option consistently. If you compile and link one translation unit with `-mt`, you must compile and link all units of the program with `-mt`.

To determine which system support libraries will be linked by default, compile with the `-dryrun` option.

### A.2.56.1 See Also

`-xno1ib`, and the Oracle Solaris [Multithreaded Programming Guide](#) and [Oracle Solaris 11.3 Linkers and Libraries Guide](#)

## A.2.57 `-native`

Same as `-xtarget=native`.

## **A.2.58    -noex**

Same as `-features=no%except`.

## **A.2.59    -nofstore**

(x86) Cancel `-fstore` on command line.

Cancels forcing expressions to have the precision of the destination variable invoked by `-fstore`. `-nofstore` is invoked by `-fast`. `-fstore` is the usual default.

### **A.2.59.1    See Also**

`-fstore`

## **A.2.60    -nolib**

This option is deprecated and will be removed in a future release. Use `-xnolib` instead.

## **A.2.61    -nolibmil**

This option is deprecated and will be removed in a future release. Use `-xnolibmil` instead.

## **A.2.62    -norunpath**

Does not build a runtime search path for shared libraries into the executable.

If an executable file uses shared libraries, then the compiler normally builds in a path that points the runtime linker to those shared libraries. To do so, the compiler passes the `-R` option to `ld`. The path depends on the directory where you have installed the compiler.

This option is recommended for building executables that will be shipped to customers who might use a different path for the shared libraries that are referenced by the program. Refer to [“11.6 Using Shared Libraries” on page 134](#)

### A.2.62.1 Interactions

If you use any shared libraries under the compiler installed area and you also use `-norunpath`, then you should either use the `-R` option at link time or set the environment variable `LD_LIBRARY_PATH` at runtime to specify the location of the shared libraries. Doing so enables the runtime linker to find the shared libraries.

### A.2.63 `-O`

The `-O` macro expands to `-xO3`. (Some previous releases expanded `-O` to `-xO2`).

The change in default yields higher runtime performance. However, `-xO3` may be inappropriate for programs that rely on all variables being automatically considered volatile. Typical programs that might have this assumption are device drivers and older multithreaded applications that implement their own synchronization primitives. The workaround is to compile with `-xO2` instead of `-O`.

### A.2.64 `-Olevel`

Same as `-xOlevel`.

### A.2.65 `-o filename`

Sets the name of the output file or the executable file to *filename*.

#### A.2.65.1 Interactions

This interaction discussion applies only when using `instances=extern`, which is not the default.

When the compiler must store template instances, it stores them in the template repository in the output file's directory. For example, the following command writes the object file to `./sub/a.o` and writes template instances into the repository contained within `./sub/SunWS_cache`.

```
example% CC -instances=extern -o sub/a.o a.cc
```

The compiler reads from the template repositories corresponding to the object files that it reads. For example, the following command reads from `./sub1/SunWS_Cache` and `./sub2/SunWS_cache`, and, if necessary, writes to `./SunWS_cache`.

```
example% CC -instances=extern sub1/a.o sub2/b.o
```

For more information, see [“7.4 Template Repository” on page 100](#).

## Warnings

The *filename* must have the appropriate suffix for the type of file to be produced by the compilation. When used with `-c`, *filename* specifies the target `.o` object file; with `-G` it specifies the target `.so` library file. This option and its argument are passed to `ld`.

*filename* cannot be the same file as the source file because the CC driver does not overwrite the source file.

## A.2.66 +p

Ignore nonstandard preprocessor asserts.

### A.2.66.1 Defaults

If `+p` is not present, the compiler recognizes nonstandard preprocessor asserts.

### Interactions

If `+p` is used, the following macros are not defined:

- `sun`
- `unix`
- `sparc`
- `i386`

## A.2.67 -P

Only preprocesses source; does not compile. (Outputs a file with a `.i` suffix.)

This option does not include preprocessor-type line number information in the output.

### A.2.67.1 See Also

-E

### A.2.68 -p

Obsolete, see “[A.2.172 -xpg](#)” on page 311.

### A.2.69 -pedantic{=[yes|no]}

When enabled, emits warnings or errors for code that is accepted by default, but which does not conform to the C++ Standard. The Standard that is in effect is determined by the `-compat` and `-std` options:

C++ 2003                    `-compat=[5|g]` or `-std=[c++03|sun03]`

C++ 2011                    `-std=c++11`

C++ 2014                    `-std=c++14`

The option `-pedantic` is equivalent to `-pedantic=yes`.

`-pedantic=no` is the default when no `-pedantic` option is specified.

The option does not interact with the `+w` or `-w` options.

If `-pedantic` appears more than once, the right-most option takes precedence.

### A.2.70 -pentium

(x86) Replace with `-xtarget=pentium`.

### A.2.71 -pg

This option is deprecated and will be removed in a future release. Use `-xpg` instead.

### **A.2.72    **-PIC****

(SPARC) Same as `-xcode=pic32`.

(x86) Same as `-Kpic`.

### **A.2.73    **-pic****

(SPARC) Same as `-xcode=pic13`.

(x86) Same as `-Kpic`.

### **A.2.74    **-preserve\_argvalues[=simple|none]****

(x86) Saves copies of register-based function arguments in the stack.

When `none` is specified or if the `-preserve_argvalues` option is not specified on the command line, the compiler behaves as usual.

When `simple` is specified, up to six integer arguments are saved.

The values are not updated during the function lifetime on assignments to formal parameters.

### **A.2.75    **-pta****

Same as `-template=wholeclass`.

### **A.2.76    **-ptipath****

Specifies an additional search directory for template source.

This option is an alternative to the normal search path set by `-Ipathname`. If the `-ptipath` option is used, the compiler looks for template definition files on this path and ignores the `-Ipathname` option.

Using the `-Ipathname` option instead of `-ptipath` produces less confusion.



### A.2.76.1 Interactions

This option accumulates instead of overrides.

### A.2.76.2 See Also

`-Ipathname`, and [“7.5.2 Definitions Search Path” on page 103](#)

### A.2.77 `-pto`

Same as `-instances=static`.

### A.2.78 `-ptv`

Same as `-verbose=template`.

### A.2.79 `-Qoption phase option[,option...]`

Passes *option* to the compilation *phase*.

To pass multiple options, specify them in order as a comma-separated list. Options that are passed to components with `-Qoption` might be reordered. Options that the driver recognizes are kept in the correct order. Do not use `-Qoption` for options that the driver already recognizes. For example, the C++ compiler recognizes the `-z` option for the linker (`ld`). If you issue a command like the following example, the `-z` options are passed in order to the linker.

```
CC -G -zallextract mylib.a -zdefaultextract ... // correct
```

But if you specify the command like as in the following example, the `-z` options can be reordered, giving incorrect results.

```
CC -G -Qoption ld -zallextract mylib.a -Qoption ld -zdefaultextract ... // error
```

#### A.2.79.1 Values

*phase* must have one of the values listed in the following table.

**TABLE 43** -Qoption Values

SPARC	x86
ccfe	ccfe
prewise	prewise
iropt	iropt
cg	ube
CCLink	CCLink
ld	ld

### A.2.79.2 Examples

In the following command, when `ld` is invoked by the CC driver, `-Qoption` passes the `-i` and `-m` options to `ld`.

```
example% CC -Qoption ld -i,-m test.c
```

### A.2.79.3 Warnings

Be careful to avoid unintended effects. For example, the following sequence of options:

```
-Qoption ccfe -features=bool,iddollar
```

are interpreted as:

```
-Qoption ccfe -features=bool -Qoption ccfe iddollar
```

The correct usage is

```
-Qoption ccfe -features=bool,-features=iddollar
```

These features do not require `-Qoption`, and are used only as an example.

### A.2.79.4 See also

[“A.2.99 -Wc, arg” on page 237](#)

## A.2.80 `-qoption` *phase option*

Same as `-Qoption`.

**A.2.81**    **-qp**

Same as -p.

**A.2.82**    **-Qproduce *sourcetype***

Causes the CC driver to produce output of the type *sourcetype*.

*sourcetype* types are defined in the following table:

**TABLE 44**    -Qproduce Values

Type	Meaning
.i	Preprocessed C++ source from ccfe.
.o	Generated object code.
.s	Assembler source from cg.

**A.2.83**    **-qproduce *sourcetype***

Same as -Qproduce.

**A.2.84**    **-Rpathname[:pathname...]**

Builds dynamic library search paths into the executable file.

This option is passed to ld.

**A.2.84.1**    **Defaults**

If the -R option is not present, the library search path that is recorded in the output object and passed to the runtime linker depends upon various compilation options that are in effect. These include -compat/-std, -m32/-m64, -library, and -xarch.

Examine the output from `-dryrun` and the `-R` option passed to the linker, `ld`, to see the default paths assumed by the compiler.

### A.2.84.2 Interactions

This option accumulates instead of overrides.

If the `LD_RUN_PATH` environment variable is defined and the `-R` option is specified, then the path from `-R` is scanned and the path from `LD_RUN_PATH` is ignored.

### A.2.84.3 See Also

`-norunpath`, [Oracle Solaris 11.3 Linkers and Libraries Guide](#)

### A.2.85 `-s`

Compiles and generates only assembly code.

This option causes the CC driver to compile the program and output an assembly source file, without assembling the program. The assembly source file is named with a `.s` suffix.

### A.2.86 `-s`

Strips the symbol table from the executable file.

This option removes all symbol information from output executable files. This option is passed to `ld`.

### A.2.87 `-staticlib=[[,l...]`

Indicates which C++ libraries are to be linked statically, as specified by the `-library` option (including its defaults), by the `-xlang` option, and by the `-xia` option.

## A.2.87.1 Values

*l* must be one of the values listed in the following table.

**TABLE 45** -staticlib Values

Value	Meaning
[no%] <i>library</i>	Link <i>library</i> statically. The valid values for <i>library</i> are all the valid values for -library (except %all and %none), all the valid values for -xlang, and interval (to be used in conjunction with -xia).
%all	Statically link all the libraries specified in the -library option, all the libraries specified in the -xlang option, and, if -xia is specified in the command line, the interval libraries.
%none	Link no libraries specified in the -library option and the -xlang option statically. If -xia is specified in the command line, link no interval libraries statically.

## A.2.87.2 Defaults

If -staticlib is not specified, -staticlib=%none is assumed.

## A.2.87.3 Examples

The following command links libCrun statically because Crun is a default value for -library:

```
example% CC -staticlib=Crun test.cc (correct)
```

However, the following command does not link libgc because libgc is not linked unless explicitly specified with the -library option:

```
example% CC -staticlib=gc test.cc (incorrect)
```

```
example% example% CC -library=gc -staticlib=gc test.cc (correct)
```

To link libgc statically, use the following command:

```
example% CC -library=gc -staticlib=gc (correct)
```

The following command will link the Sun Performance Libraries dynamically because -library=sunperf must be used in conjunction with -staticlib=sunperf in order for the -staticlib option to have an effect on the linking of these libraries:

```
example% CC -xlic_lib=sunperf -staticlib=sunperf (incorrect)
```

This command links the Sun Performance Libraries statically:

```
example% CC -library=sunperf -staticlib=sunperf (correct)
```

#### A.2.87.4 Interactions

This option accumulates instead of overrides.

The `-staticlib` option only works for the C++ libraries that are selected explicitly with the `-xia` option, the `-xlang` option, and the `-library` option, in addition to the C++ libraries that are selected implicitly by default. `Cstd` and `Crun` are selected by default.

#### A.2.87.5 Warnings

The set of allowable values for *library* is not stable and might change from release to release.

On Oracle Solaris platforms, system libraries are not available as static libraries.

You should link the support libraries dynamically unless you have a specific need to link them statically. In some cases, static linking can prevent a program from working correctly.

#### A.2.87.6 See Also

`-library`, [“11.5 Statically Linking Standard Libraries” on page 133](#)

#### A.2.88 `-std=v`

Sets the compatibility mode of the compiler. The mode specified by *v* is required and is one of the following:

<code>c++03</code> (zero-3, not oh-3)	Equivalent to the <code>-compat=g</code> option. It selects C++ 03 dialect and g++ ABI; it is binary compatible with g++ on Oracle Solaris and Oracle Linux. It sets the <code>__SUNPRO_CC_COMPAT</code> preprocessor macro to 'G'.
<code>c++11</code>	Selects C++ 11 dialect and g++ binary compatibility. It sets the <code>__SUNPRO_CC_COMPAT</code> preprocessor macro to 'G'.

<code>c++14</code>	Select C++ 14 dialect and <code>g++</code> binary compatibility. It sets the <code>__SUNPRO_CC_COMPAT</code> preprocessor macro to 'G'.
<code>c++0x</code> (zero-x, not oh-x)	Equivalent to <code>c++11</code> .
<code>sun03</code> (zero-3, not oh-3)	Equivalent to the <code>-compat=5</code> option. It selects C++ 03 dialect and Sun ABI; it is binary compatible with C++ 5.x. It sets the <code>__SUNPRO_CC_COMPAT</code> preprocessor macro to '5'.

If more than one `-std` option appears on the command line, only the last one (right-most) has an effect.

The `-std=c++03` provides compatibility with the `gcc/g++` compiler on all Oracle Solaris and Oracle Linux platforms.

With `-std=c++03`, binary compatibility extends only to shared (dynamic or `.so`) libraries, not to individual `.o` files or archive (`.a`) libraries. The `gcc` headers and libraries used are those provided with the compiler, rather than the version of `gcc` installed on the system.

The following example shows linking a `g++` shared library to an Oracle Developer Studio C++ main program:

```
% g++ -shared -o libfoo.so -fpic a.cc b.cc c.cc
% CC -std=c++03 main.cc -L. -lfoo
```

The following example shows linking an Oracle Developer Studio C++ shared library to a `g++` main program:

```
% CC -std=c++03 -G -o libfoo.so -Kpic a.cc b.cc c.cc
% g++ main.cc -L. -lfoo
```

### A.2.88.1 Defaults:

The `-std` and `-library` options have default values that depend on the platform. They are intended to match C++ libraries bundled with the operating system. See [“3.3 Platform-specific Option Defaults” on page 44](#).

### A.2.88.2 Interactions:

The `-compat` and `-std` options cannot appear on the same command line.

When `-std` other than `-std=sun03` is specified, none of the following `-library` sub-options can be used: `Cstd`, `Crun`, `iostream`, `stlport4`, `stdcxx4`.

You can use `discover(1)` only in limited feature mode (option `-l`) when compiling with `-std=c++11` or `-std=c++14`.

### A.2.88.3 Notes:

The C++11 and C++14 dialects are not available with `-compat=5` binary compatibility.

## A.2.89 `-sync_stdio=[yes|no]`

Use this option when your runtime performance is degraded due to the synchronization between C++ `iostreams` and C `stdio`. Synchronization is needed only when you use `iostreams` to write to `cout` and `stdio` to write to `stdout` in the same program. The C++ standard requires synchronization so the C++ compiler turns it on by default. However, application performance is often much better without synchronization. If your program does not write to both `cout` and `stdout`, you can use the option `-sync_stdio=no` to turn off synchronization.

### A.2.89.1 Defaults

If you do not specify `-sync_stdio`, the compiler sets it to `-sync_stdio=yes`.

### A.2.89.2 Examples

Consider the following example:

```
#include <stdio.h>
#include <iostream>
int main()
{
    std::cout << "Hello ";
    printf("beautiful ");
    std::cout << "world!";
    printf("\n");
}
```

With synchronization, the program prints on a line by itself

```
Hello beautiful world!
```



:

Without synchronization, the output gets scrambled.

### A.2.89.3 Warnings

This option is only effective for linking of executables, not for libraries.

## A.2.90 `-temp=path`

Defines the directory for temporary files.

This option sets the path name of the directory for storing the temporary files which are generated during the compilation process. The compiler gives precedence to the value set by `-temp` over the value of `TMPDIR`.

### A.2.90.1 See Also

`-keeptmp`

## A.2.91 `-template=opt[,opt...]`

Enables/disables various template options.

### A.2.91.1 Values

*opt* must be one of the values listed in the following table.

TABLE 46 `-template` Values

Value	Meaning
<code>[no%]extdef</code>	Search for template definitions in separate source files. With <code>no%extdef</code> , the compiler predefines <code>_TEMPLATE_NO_EXTDEF</code>
<code>[no%]geninlinefuncs</code>	Generate unreferenced inline member functions for explicitly instantiated class templates.
<code>[no%]wholeclass</code>	Instantiate a whole template class, rather than only those functions that are used. You must reference at least one member of the class.

Value	Meaning
	Otherwise, the compiler does not instantiate any members for the class.

### A.2.91.2 Defaults

If the `-template` option is not specified, `-template=no%wholeclass,no%extdef` is assumed.

### A.2.91.3 Examples

Consider the following code:

```
example% cat Example.cc
    template <class T> struct S {
        void imf() {}
        static void smf() {}
    };

    template class S <int>;

    int main() {
    }
example%
```

When you specify `-template=geninlinefuncs`, even though the two member functions of `S` are not called in the program, they are generated in the object file.

```
example% CC -c -template=geninlinefuncs Example.cc
example% nm -C Example.o
```

Example.o:

```
[Index] Value Size Type Bind Other Shndx Name
[5]      0  0  NOTY GLOB  0  ABS  __fsr_init_value
[1]      0  0  FILE LOCL  0  ABS  b.c
[4]     16 32  FUNC GLOB  0  2   main
[3]    104 24  FUNC LOCL  0  2   void S<int>::imf()
      [__1cBS4Ci_Dimf6M_v_]
[2]     64 20  FUNC LOCL  0  2   void S<int>::smf()
      [__1cBS4Ci_Dsmf6F_v_]

```

### A.2.91.4 See Also

[“7.2.2 Whole-Class Instantiation”](#) on page 96, [“7.5 Template Definition Searching”](#) on page 102

## A.2.92 `-time`

This option is deprecated and will be removed in a future release. Use `-xtime` instead.

## A.2.93 `-ttraceback[={%none|common|signals_list}]`

Issue a stack trace if a severe error occurs in execution.

The `-ttraceback` option causes the executable to issue a stack trace to `stderr`, dump core, and exit if certain signals are generated by the program. If multiple threads generate a signal, a stack trace will only be produced for the first one.

To use traceback, add the `-ttraceback` option to the compiler command line when linking. The option is also accepted at compile-time but is ignored unless an executable binary is generated. Do not use `-ttraceback` with `-G` to create a shared library.

**TABLE 47** `-ttraceback` Options

Option	Meaning
<code>common</code>	Specifies that a stack trace should be issued if any of a set of common signals occurs: <code>sigill</code> , <code>sigfpe</code> , <code>sigbus</code> , <code>sigsegv</code> , or <code>sigabrt</code> .
<code>signals_list</code>	Specifies a comma-separated list of names of signals that should generate a stack trace, in lowercase. The following signals (those that cause the generation of a core file) can be caught: <code>sigquit</code> , <code>sigill</code> , <code>sigtrap</code> , <code>sigabrt</code> , <code>sigemt</code> , <code>sigfpe</code> , <code>sigbus</code> , <code>sigsegv</code> , <code>sigsys</code> , <code>sigxcpu</code> , <code>sigxfsz</code> .  Any of these signals can be preceded with <code>no%</code> to disable catching the signal.  For example: <code>-ttraceback=sigsegv,sigfpe</code> will produce a stack trace and core dump if either <code>sigsegv</code> or <code>sigfpe</code> occurs.
<code>%none</code> or <code>none</code>	disables traceback

If the option is not specified, the default is `-ttraceback=%none`

`-ttraceback` alone, without an `=` sign, implies `-ttraceback=common`

Note: If the core dump is not wanted, you may set the core dump size limit to zero using the following command:

```
% limit coredumpsize 0
```

The `-ttraceback` option has no effect on runtime performance.

## A.2.94 **-Uname**

Deletes initial definition of the preprocessor symbol *name*.

This option removes any initial definition of the macro symbol *name* created by `-D` on the command line including those implicitly placed there by the CC driver. This option has no effect on any other predefined macros, nor on macro definitions in source files.

To see the `-D` options that are placed on the command line by the CC driver, add the `-dryrun` option to your command line.

### A.2.94.1 **Examples**

The following command undefines the predefined symbol `__sun`. Preprocessor statements in `foo.cc` such as `#ifdef(__sun)` will sense that the symbol is undefined.

```
example% CC -U__sun foo.cc
```

### A.2.94.2 **Interactions**

You can specify multiple `-U` options on the command line.

All `-U` options are processed after any `-D` options that are present. That is, if the same *name* is specified for both `-D` and `-U` on the command line, *name* is undefined, regardless of the order the options appear.

### A.2.94.3 **See Also**

`-D`

## A.2.95 **-unroll=n**

This option is deprecated and will be removed in a future release. Use `-xunroll=n` instead.

## A.2.96 **-v**

Same as `-verbose=version`.

**A.2.97** `-v`

Same as `-verbose=diags`.

**A.2.98** `-verbose=v[, v...]`

Controls compiler verbosity.

**A.2.98.1** **Values**

`v` must be one of the values listed in the following table. The `no%` prefix disables the associated option.

**TABLE 48** `-verbose` Values

Value	Meaning
<code>[no%]diags</code>	Print the command line for each compilation pass.
<code>[no%]template</code>	Turn on the template instantiation verbose mode (sometimes called the “verify” mode). The verbose mode displays each phase of instantiation as it occurs during compilation.
<code>[no%]version</code>	Direct the CC driver to print the names and version numbers of the programs it invokes.
<code>%all</code>	Invokes all of the other options.
<code>%none</code>	<code>-verbose=%none</code> is the same as <code>-verbose=no%template,no%diags,no%version</code> .

**Defaults**

If `-verbose` is not specified, `-verbose=%none` is assumed.

**Interactions**

This option accumulates instead of overrides.

**A.2.99** `-Wc, arg`

Passes the argument `arg` to a specified component `c`.

Arguments must be separated from the preceding only by a comma. All `-w` arguments are passed after the rest of the command-line arguments. To include a comma as part of an argument, use the escape character `\` (backslash) immediately before the comma.

For example, `-wa, -o,objfile` passes `-o` and `objfile` to the assembler in that order. Also, `-wl, -l,name` causes the linking phase to override the default name of the dynamic linker, `/usr/lib/ld.so.1`.

The order in which the arguments are passed to a tool with respect to the other specified command line options might change an subsequent compiler releases.

The possible values for `c` are listed in the following table.

**TABLE 49** `-w` Flags

Flag	Meaning
a	Assembler: (fbc); (gas)
c	C++ code generator: (cg) (SPARC); (ube) (Intel)
d	CC driver
l	Link editor (ld)
m	mcs
O (Capital o)	Interprocedural optimizer
o (Lowercase o)	Postoptimizer
p	Preprocessor (cpp)
0 (Zero)	Compiler (ccfe)
2	Optimizer: (iropt)
3	Static error checking: (previs)

Note: You cannot use `-wd` to pass CC options to the C++ compiler. However, `-wa` can be used to pass options to `ccfe`.

### A.2.99.1 See also

`-Ooption phase option[,option...]`

### A.2.100 +w

Identifies code that might have unintended consequences. The `+w` option no longer generates a warning if a function is too large to inline or if a declared program element is unused. These

warnings do not identify real problems in the source, and were thus inappropriate to some development environments. Removing these warnings from `+w` enables more aggressive use of `+w` in those environments. These warnings are still available with the `+w2` option.

This option generates additional warnings about constructs that are questionable in the following ways:

- Nonportable
- Likely to be mistakes
- Inefficient

### **A.2.100.1 Defaults**

If `+w` is not specified, the compiler warns about constructs that are almost certainly problems.

### **A.2.100.2 See Also**

`-w`, `+w2`

## **A.2.101 +w2**

Emits all the warnings emitted by `+w` plus warnings about technical violations that are probably harmless but that might reduce the maximum portability of your program.

The `+w2` option no longer warns about the use of implementation-dependent constructs in the system header files. Because the system header files are the implementation, the warning was inappropriate. Removing these warnings from `+w2` enables more aggressive use of the option.

### **A.2.101.1 See Also**

`+w`

## **A.2.102 -w**

Suppresses most warning messages.

This option causes the compiler *not* to print warning messages. However, some warnings, particularly warnings regarding serious anachronisms, cannot be suppressed.

### A.2.102.1 See Also

+w

### A.2.103 `-xlinker arg`

Pass *arg* to linker `ld(1)`.

### A.2.104 `-Xm`

Same as `-features=iddollar`.

### A.2.105 `-xaddr32`

(Solaris x86/x64) The `-xaddr32=yes` compilation flag restricts the resulting executable or shared object to a 32-bit address space.

An executable that is compiled in this manner results in the creation of a process that is restricted to a 32-bit address space.

When `-xaddr32=no` is specified, a normal 64 bit binary is produced.

If the `-xaddr32` option is not specified, `-xaddr32=no` is assumed.

If only `-xaddr32` is specified `-xaddr32=yes` is assumed.

This option is only applicable to `-m64` compilations and only on Oracle Solaris platforms supporting `SF1_SUNW_ADDR32` software capability. Because Oracle Linux kernels do not support address space limitation, this option is not available on Oracle Linux.

When linking, if a single object file was compiled with `-xaddr32=yes`, the whole output file is assumed to be compiled with `-xaddr32=yes`.



A shared object that is restricted to a 32-bit address space must be loaded by a process that executes within a restricted 32-bit mode address space.

For more information, refer to the SF1\_SUNW\_ADDR32 software capabilities definition described in the *Oracle Solaris 11.3 Linkers and Libraries Guide*.

## A.2.106 `-xalias_level[=n]`

The C++ compiler can perform type-based alias-analysis and optimizations when you specify the following commands:

```
-xalias_level[=n]
```

where *n* is any, simple, or compatible.

### A.2.106.1 `-xalias_level=any`

At this level of analysis, the compiler assumes that any type may alias any other type. However, despite this assumption, some optimization is possible.

### A.2.106.2 `-xalias_level=simple`

The compiler assumes that simple types are not aliased. Storage objects must have a dynamic type that is one of the following simple types:

char, signed char, unsigned char wchar\_t, data pointer types  
short int, unsigned short int, int unsigned int, function pointer types  
long int, unsigned long int, long long int, unsigned long long int, data member pointer types  
float, double long double, enumeration types, function member pointer types

The storage object should only be accessed through lvalues of the following types:

- The dynamic type of the object
- A constant or volatile qualified version of the dynamic type of the object, a type that is the signed or unsigned type which corresponds to the dynamic type of the object
- A type that is the signed or unsigned type which corresponds to the constant or volatile qualified version of the dynamic type of the object
- An aggregate or union type that includes one of the aforementioned types among its members (including, recursively, a member of a subaggregate or contained union)

- A `char` or `unsigned char` type.

### A.2.106.3 `-xalias_level=compatible`

The compiler assumes that layout-incompatible types are not aliased. A storage object is only accessed through lvalues of the following types:

- The dynamic type of the object
- A `constant` or `volatile` qualified version of the dynamic type of the object, a type that is the signed or unsigned type which corresponds to the dynamic type of the object
- A type that is the signed or unsigned type which corresponds to the `constant` or `volatile` qualified version of the dynamic type of the object
- An aggregate or union type that includes one of the aforementioned types among its members (including, recursively, a member of a subaggregate or contained union)
- A type that is (possibly `constant` or `volatile` qualified) base class type of the dynamic type of the object
- A `char` or `unsigned char` type.

The compiler assumes that the types of all references are layout-compatible with the dynamic type of the corresponding storage object. Two types are layout-compatible under the following conditions:

- If two types are the same type
- If two types differ only in `constant` or `volatile` qualification
- If for each of the signed integer types a corresponding (but different) unsigned integer type exists, these corresponding types are layout compatible.
- Two enumeration types are layout-compatible if they have the same underlying type.
- Two plain old data (POD) `struct` types are layout compatible if they have the same number of members, and corresponding members (in order) have layout compatible types.
- Two POD union types are layout compatible if they have the same number of members, and corresponding members (in any order) have layout compatible types.

References may be non-layout-compatible with the dynamic type of the storage object under limited circumstances:

- If a POD union contains two or more POD `structs` that share a common initial sequence, and if the POD union object currently contains one of those POD `structs`, it is permitted to inspect the common initial part of any of them. Two POD `structs` share a common initial sequence if corresponding members have layout compatible types and, as applicable to bit fields, the same widths, for a sequence of one or more initial members.
- A pointer to a POD `struct` object, suitably converted using a `reinterpret_cast`, points to its initial member, or if that member is a bit field, to the unit in which it resides.

### A.2.106.4 Defaults

If you do not specify `-xalias_level`, the compiler sets the option to `-xalias_level=any`. If you specify `-xalias_level` but do not provide a value, the compiler sets the option to `-xalias_level=compatible`.

### A.2.106.5 Interactions

The compiler does not perform type-based alias analysis at optimization level `-xO2` and below.

### A.2.106.6 Warning

If you are using `reinterpret_cast` or an equivalent old-style cast, the program may violate the assumptions of the analysis. Also, *union type punning*, as shown in the following example, violates the assumptions of the analysis.

```
union bitbucket{
    int i;
    float f;
};

int bitsof(float f){
    bitbucket var;
    var.f=3.6;
    return var.i;
}
```

## A.2.107 `-xanalyze={code|none}`

(Obsolete) This option will be removed in a future release. Use `-xprewise` instead.

Produce a static analysis of the source code that can be viewed using the Oracle Developer Studio Code Analyzer.

When compiling with `-xanalyze=code` and linking in a separate step, include `-xanalyze=code` also on the link step.

The default is `-xanalyze=none`.

On Oracle Linux, `-xanalyze=code` needs to be specified along with `-xannotate`.

See the Oracle Developer Studio Code Analyzer documentation for more information.

## A.2.108 **-xannotate[=yes|no]**

Create binaries that can later be used by the optimization and observability tools `binopt(1)`, `code-analyzer(1)`, `discover(1)`, `collect(1)`, and `uncover(1)`.

The default on Oracle Solaris is `-xannotate=yes`. The default on Oracle Linux is `-xannotate=no`. Specifying `-xannotate` without a value is equivalent to `-xannotate=yes`.

For optimal use of the optimization and observability tools, `-xannotate=yes` must be in effect at both compile and link time. Compile and link with `-xannotate=no` to produce slightly smaller binaries and libraries when optimization and observability tools will not be used.

## A.2.109 **-xar**

Creates archive libraries.

When building a C++ archive that uses templates, include in the archive those template functions that are instantiated in the template repository. The template repository is used only when at least one object file was compiled using the `-instances=extern` option. Compiling with `-xar` automatically adds those templates to the archive as needed.

However, since the compiler default is not to use a template cache, the `-xar` option is often not needed. You can use the plain `ar(1)` command to create archives (`.a` files) of C++ code unless some code was compiled with `-instances=extern`. In that case, or if you are not sure, use `CC -xar` instead of the `ar` command.

### A.2.109.1 **Values**

Specify `-xar` to invokes `ar -c -r` and create an archive from scratch.

#### **Examples**

The following command line archives the template functions contained in the library and object files.

```
example% CC -xar -o libmain.a a.o b.o c.o
```

## Warnings

Do not add `.o` files from the template database on the command line.

Do not use the `ar` command directly for building archives. Use `CC -xar` to ensure that template instantiations are automatically included in the archive.

## See Also

`ar(1)` man page

### A.2.110 `-xarch=isa`

Specifies the target instruction set architecture (ISA).

This option limits the code generated by the compiler to the instructions of the specified instruction set architecture. This option does not guarantee use of any target-specific instructions. However, use of this option may affect the portability of a binary program.

---

**Note** - Use the `-m64` or `-m32` option to specify the intended data type model, LP64 (64-bits) or ILP32 (32-bits) respectively. The `-xarch` option no longer indicates the data type model except for compatibility with previous releases, as indicated below.

---

Code using `_asm` statements or inline templates (`.i1` files) that use architecture-specific instructions might require compiling with the appropriate `-xarch` value to avoid compilation errors.

If you compile and link in separate steps, make sure you specify the same value for `-xarch` in both steps. For complete list of all compiler options that must be specified at both compile time and at link time, see [“3.4.3 Compile-Time and Link-Time Options” on page 46](#).

#### A.2.110.1 `-xarch` Flags for SPARC and x86

The following table lists the `-xarch` keywords common to both SPARC and x86 platforms.

**TABLE 50** `-xarch` Flags for SPARC and x86

Flag	Meaning
<code>generic</code>	Uses the instruction set common to most processors. This is the default.
<code>native</code>	Compile for good performance on this system. The compiler chooses the appropriate setting for the current system processor it is running on.

## A.2.110.2 -xarch Flags for SPARC

The following table gives the details for each of the -xarch keywords on SPARC platforms.

**TABLE 51** -xarch Flags for SPARC Platforms

Flag	Meaning
sparc	Compile for the SPARC-V9 ISA but without the Visual Instruction Set (VIS) and without other implementation-specific ISA extensions. This option enables the compiler to generate code for good performance on the V9 ISA.
sparcvis	Compile for SPARC-V9 plus the Visual Instruction Set (VIS) version 1.0, and with UltraSPARC extensions. This option enables the compiler to generate code for good performance on the UltraSPARC architecture.
sparcvis2	Enables the compiler to generate object code for the UltraSPARC architecture, plus the Visual Instruction Set (VIS) version 2.0, and with UltraSPARC III extensions.
sparcvis3	Compile for the SPARC VIS version 3 of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set plus the UltraSPARC extensions including the Visual Instruction Set (VIS) version 1.0, the UltraSPARC-III extensions, including the Visual Instruction Set (VIS) version 2.0, the fused multiply-add instructions, and the Visual Instruction Set (VIS) version 3.0
sparcfmaf	Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the UltraSPARC extensions, including the Visual Instruction Set (VIS) version 1.0, the UltraSPARC-III extensions, including the Visual Instruction Set (VIS) version 2.0, and the SPARC64 VI extensions for floating-point multiply-add.  You must use -xarch=sparcfmaf in conjunction with fma=fused and some optimization level to get the compiler to attempt to find opportunities to use the multiply-add instructions automatically.
sparcace	Compile for the sparcace version of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the UltraSPARC extensions, including the Visual Instruction Set (VIS) version 1.0, the UltraSPARC-III extensions, including the Visual Instruction Set (VIS) version 2.0, the SPARC64 VI extensions for floating-point multiply-add, the SPARC64 VII extensions for integer multiply-add, and the SPARC64 X extensions for ACE floating-point.
sparcaceplus	Compile for the sparcaceplus version of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the UltraSPARC extensions, including the Visual Instruction Set (VIS) version 1.0, the UltraSPARC-III extensions, including the Visual Instruction Set (VIS) version 2.0, the SPARC64 VI extensions for floating-point multiply-add, the SPARC64 VII extensions for integer multiply-add, the SPARC64 X extensions for SPARCACE floating-point, and the SPARC64 X+ extensions for SPARCACE floating-point.
sparcima	Compile for the SPARC IMA version of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the UltraSPARC extensions, including the Visual Instruction Set (VIS) version 1.0, the UltraSPARC-III extensions, including the Visual Instruction Set (VIS) version 2.0, the SPARC64 VI extensions for floating-point multiply-add, and the SPARC64 VII extensions for integer multiply-add.
sparc4	Compile for the SPARC4 version of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the extensions, which includes

Flag	Meaning
	VIS 1.0, the UltraSPARC-III extensions, which includes VIS2.0, the fused floating-point multiply-add instructions, VIS 3.0, and SPARC4 instructions.
<code>sparc4b</code>	Compile for the SPARC4B version of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the UltraSPARC extensions, which includes VIS 1.0, the UltraSPARC-III extensions, which includes VIS2.0, the SPARC64 VI extensions for floating-point multiply-add, the SPARC64 VII extensions for integer multiply-add, and the PAUSE and CBCOND instructions from the SPARC T4 extensions.
<code>sparc4c</code>	Compile for the SPARC4C version of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the UltraSPARC extensions, which includes VIS 1.0, the UltraSPARC-III extensions, which includes VIS2.0, the SPARC64 VI extensions for floating-point multiply-add, the SPARC64 VII extensions for integer multiply-add, the VIS3B subset of the VIS 3.0 instructions a subset of the SPARC T3 extensions, called the VIS3B subset of VIS 3.0, and the PAUSE and CBCOND instructions from the SPARC T4 extensions.
<code>sparc5</code>	Compile for the SPARC5 version of the SPARC-V9 ISA. Enables the compiler to use instructions from the SPARC-V9 instruction set, plus the extensions, which includes VIS 1.0, the Ultra SPARC-III extensions, which includes VIS2.0, the fused floating-point multiply-add instructions, VIS 3.0, SPARC4, and SPARC5 instructions.
<code>v9</code>	Equivalent to <code>-m64 -xarch=sparc</code> . Legacy makefiles and scripts that use <code>-xarch=v9</code> to obtain the 64-bit data type model need only use <code>-m64</code> .
<code>v9a</code>	Equivalent to <code>-m64 -xarch=sparcvis</code> and provided for compatibility with earlier releases.
<code>v9b</code>	Equivalent to <code>-m64 -xarch=sparcvis2</code> and provided for compatibility with earlier releases.

Also note the following:

- Object binary files (`.o`) compiled with `generic`, `sparc`, `sparcvis2`, `sparcvis3`, `sparcfmaf`, `sparcima` can be linked and can execute together, but can only run on a processor supporting all the instruction sets linked.
- For any particular choice, the generated executable might not run or run much more slowly on legacy architectures. Also, because quad-precision (`long double`) floating-point instructions are not implemented in any of these instruction set architectures, the compiler does not use these instructions in the code it generates.

### A.2.110.3 -xarch Flags for x86

The following table lists the `-xarch` flags on x86 platforms.

**TABLE 52** -xarch Flags on x86

Flag	Meaning
<code>pentium_pro</code>	Limits the instruction set to the 32-bit Pentium Pro architecture.

Flag	Meaning
pentium_proa	Adds the AMD extensions (3DNow!, 3DNow! extensions, and MMX extensions) to the 32-bit Pentium Pro architecture.
sse	Adds the SSE instruction set to the Pentium Pro architecture.
ssea	Adds the AMD extensions (3DNow!, 3DNow! extensions, and MMX extensions) to the 32-bit SSE architecture.
sse2	Adds the SSE2 instruction set to the Pentium Pro architecture.
sse2a	Adds the AMD extensions (3DNow!, 3DNow! extensions, and MMX extensions) to the 32-bit SSE2 architecture.
sse3	Adds the SSE3 instruction set to SSE2 instruction set.
sse3a	Adds the AMD extended instructions including 3dnow to the SSE3 instruction set.
ssse3	Supplements the Pentium Pro, SSE, SSE2, and SSE3 instruction sets with the SSSE3 instruction set.
sse4_1	Supplements the Pentium Pro, SSE, SSE2, SSE3, and SSSE3 instruction sets with the SSE4.1 instruction set.
sse4_2	Supplements the Pentium Pro, SSE, SSE2, SSE3, SSSE3, and SSE4.1 instruction sets with the SSE4.2 instruction set.
amdsse4a	Uses the AMD SSE4a Instruction set.
aes	Uses Intel Advanced Encryption Standard instruction set.
avx	Uses Intel Advanced Vector Extensions instruction set.
avx_i	Uses Intel Advanced Vector Extensions instruction set with the RDRND, FSGSBASE and F16C instruction sets.
avx2	Uses Intel Advanced Vector Extensions 2 instruction set.
avx2_i	Supplements the pentium_pro, SSE, SSE2, SSE3, SSSE3, SSE4.1, SSE4.2, AVX, AVX2 instruction sets with Broadwell instructions (ADOX, ADCX, MULX, RDSEED, PREFETCHWT1).

If any part of a program is compiled or linked on an x86 platform with `-m64`, then all parts of the program must be compiled with one of these options as well. For details on the various Intel instruction set architectures (SSE, SSE2, SSE3, SSSE3, and so on) refer to the *Intel 64 and IA-32 Architectures Software Developer Manuals* at <http://www.intel.com>.

See also “1.2 Special x86 Notes” on page 24 and “1.4 Binary Compatibility Verification” on page 24.

## A.2.110.4 Interactions

Although this option can be used alone, it is part of the expansion of the `-xtarget` option and may be used to override the `--xarch` value that is set by a specific `-xtarget` option. For example, `-xtarget=T3` expands to `-xarch=sparcv3 -xchip=T3 -xcache=8/16/4:6144/64/24`.



In the following command `-xarch=sparc4` overrides the `-xarch=sparcv3` that is set by the expansion of `-xtarget=T3`.

```
example% CC -xtarget=T3 -xarch=sparc4 foo.cc
```

### A.2.110.5 Warnings

If you use this option with optimization, the appropriate choice can provide good performance of the executable on the specified architecture. An inappropriate choice, however, might result in serious degradation of performance or in a binary program that is not executable on the intended target platform.

If you compile and link in separate steps, make sure you specify the same value for `-xarch` in both steps.

### A.2.111 `-xatomic=a`

Specify which atomics support runtime library is linked.

`a` must be one of the following:

<code>studio</code>	Link with the <code>libstatomic</code> library bundled with Oracle Developer Studio.
<code>gcc</code>	Link with the <code>libatomic</code> library in <code>/usr/lib</code> .
<code>none</code>	Do not link with any atomics support library.

The option `-xatomic=studio` is the default when neither `-latomic` nor `-xatomic` is specified, and the compiler is compiling in `-std={c++03|c++11|c++14}` mode.

`-latomic` will be automatically translated to `-xatomic=studio`.

An explicit `-xatomic` option overrides the presence of `-latomic` regardless of the order on the command line. A warning message will be emitted if the setting of `-xatomic` is conflict with `-latomic`.

See also [“A.2.7 `-compat={5|g}`”](#) on page 179, [“A.2.88 `-std=v`”](#) on page 230, and [“A.2.159 `-xno1ib`”](#) on page 296 and the [“11.2.3 Bundled Atomics Library”](#) on page 126 for

the GCC compatibility impact, the application deployment impact, and some notes about the `-xatomic` option.

## A.2.112 `-xautopar`

Enables automatic parallelization for multiple processors. Does dependence analysis (analyze loops for inter-iteration data dependence) and loop restructuring. If optimization is not at `-xO3` or higher, optimization is raised to `-xO3` and a warning is issued.

Avoid `-xautopar` if you do your own thread management.

To achieve faster execution, this option requires a multi-processor system. On a single-processor system, the resulting binary usually runs slower.

Use the `OMP_NUM_THREADS` environment variable to specify the number of threads to use when running a program automatically parallelized by the `-xautopar` compiler option. If `OMP_NUM_THREADS` is not set, the default number of threads used is a multiple of the number of cores per socket (that is, cores per processor chip), which is less than or equal to the total number of cores or 32, whichever is less. For best performance, the number of threads used should not exceed the number of hardware threads (or virtual processors) available on the machine. On Oracle Solaris systems, this number can be determined by using the `psrinfo(1M)` command. On Oracle Linux systems, this number can be determined by inspecting the file `/proc/cpuinfo`. See the [Oracle Developer Studio 12.5: OpenMP API User's Guide](#) for more information.

In addition to `OMP_NUM_THREADS`, other environment variables that apply to an OpenMP programs may be used with a program automatically parallelized by the `-xautopar` compiler option. See the [Oracle Developer Studio 12.5: OpenMP API User's Guide](#) for descriptions of the environment variables.

If you use `-xautopar` and compile and link in one step, then linking automatically includes the microtasking library and the threads-safe C runtime library. If you use `-xautopar` and compile and link in separate steps, then you must also link with `-xautopar`.

Use the `-xreduction` option in conjunction with `-xautopar` to recognize reduction operations in loops.

Use the `-xloopinfo` option to show which loops are parallelized.

### A.2.112.1 See Also

[“A.2.164 `-xopenmp\[={parallel|noopt|none}\]`” on page 302](#)

## A.2.113 `-xbinopt={prepare|off}`

(SPARC) *This option is now obsolete and will be removed in a future release of the compiler. See “A.2.108 `-xannotate[=yes|no]`” on page 244*

Instructs the compiler to prepare the binary for later optimizations, transformations and analysis. See the `binopt(1)` man page. This option may be used for building executables or shared objects. If you compile in separate steps, `-xbinopt` must appear on both compile and link steps:

```
example% cc -c -xO1 -xbinopt=prepare a.c b.c
example% cc -o myprog -xbinopt=prepare a.o
```

If some source code is not available for compilation, this option may still be used to compile the remainder of the code. It should then be used in the link step that creates the final binary. In such a situation, only the code compiled with this option can be optimized, transformed or analyzed.

### A.2.113.1 Defaults

The default is `-xbinopt=off`.

#### Interactions

This option must be used with optimization level `-xO1` or higher to be effective. There is a modest increase in size of the binary when built with this option.

Compiling with `-xbinopt=prepare` and `-g` increases the size of the executable by including debugging information.

## A.2.114 `-xbuiltin[={%all|%default|%none}]`

Enables or disables better optimization of standard library calls.

Use the `-xbuiltin` option to improve the optimization of code that calls standard library functions. This option lets the compiler substitute intrinsic functions or inline system functions where profitable for performance. See the `er_src(1)` man page to learn how to read compiler commentary output to determine which functions were substituted by the compiler.

With `-xbuiltin=%all`, substitutions can cause the setting of `errno` to become unreliable. If your program depends on the value of `errno`, avoid this option.

`-xbuiltin=%default` only inlines functions that do not set `errno`. The value of `errno` is always correct at any optimization level, and can be checked reliably. With `-xbuiltin=%default` at `-xO3` or lower, the compiler will determine which calls are profitable to inline, and not inline others.

The `-xbuiltin=%none` option results in the default compiler behavior, and the compiler does not do any special optimizations for built-in functions.

### A.2.114.1 Defaults

If you do not specify `-xbuiltin`, the default is `-xbuiltin=%default` when compiling with an optimization level `-xO1` and higher, and `-xbuiltin=%none` at `-xO0`. If you specify `-xbuiltin` without an argument, the default is `-xbuiltin=%all` and the compiler substitutes intrinsics or inlines standard library functions much more aggressively.

Note that the `-xbuiltin` option only inlines global functions defined in system header files, never static functions defined by the user. User code that attempts to interpose on global functions may result in undefined behavior.

#### Interactions

The expansion of the macro `-fast` includes `-xbuiltin=%all`.

#### Examples

The following compiler command requests special handling of the standard library calls.

```
example% CC -xbuiltin -c foo.cc
```

The following compiler command requests that there be no special handling of the standard library calls. Note that the expansion of the macro `-fast` includes `-xbuiltin=%all`.

```
example% CC -fast -xbuiltin=%none -c foo.cc
```

### A.2.115 `-xcache=C`

Defines cache properties for use by the optimizer. This option does not guarantee that any particular cache property is used.

---

**Note** - Although this option can be used alone, it is part of the expansion of the `-xtarget` option. Its primary use is to override a value supplied by the `-xtarget` option.

---

The optional property `[/ti]` sets the number of threads that can share the cache.

## A.2.115.1 Values

`c` must be one of the values listed in the following table.

**TABLE 53** `-xcache` Values

Value	Meaning
generic	Directs the compiler to use cache properties for good performance on most x86 and SPARC processors, without major performance degradation on any of them. (The default)  With each new release, these best timing properties will be adjusted, if appropriate.
native	Set the parameters for the best performance on the host environment.
<code>s1/l1/a1[/t1]</code>	Defines level 1 cache properties
<code>s1/l1/a1[/t1]:s2/l2/a2[/t2]</code>	Defines level 1 and 2 cache properties
<code>s1/l1/a1[/t1]:s2/l2/a2[/t2]:s3/l3/a3[/t3]</code>	Defines level 1, 2, and 3 cache properties

The definitions of the cache properties `si/li/ai/ti` are described in the following table:

Property	Definition
<code>si</code>	The <i>size</i> of the data cache at level <i>i</i> , in kilobytes
<code>li</code>	The <i>line size</i> of the data cache at level <i>i</i> , in bytes
<code>ai</code>	The <i>associativity</i> of the data cache at level <i>i</i>
<code>ti</code>	The number of hardware threads sharing the cache at level <i>i</i>

For example, `i=1` designates level 1 cache properties, `s1/l1/a1`.

## Defaults

If `-xcache` is not specified, the default `-xcache=generic` is assumed. This value directs the compiler to use cache properties for good performance on most SPARC processors without major performance degradation on any of them.

If you do not specify a value for `t`, the default is 1.

## Examples

`-xcache=16/32/4:1024/32/1` specifies the following values:

Level 1 Cache            16 Kbytes, 32 bytes line size, four-way associativity

Level 2 Cache            1024 Kbytes, 32 bytes line size, direct mapping associativity

## See Also

`-xtarget=t`

## A.2.116 `-xchar[=o]`

The option is provided solely for the purpose of easing the migration of code from systems where the `char` type is defined as unsigned. Unless you are migrating from such a system, do not use this option. Only code that relies on the sign of a `char` type needs to be rewritten to explicitly specify signed or unsigned.

### A.2.116.1 Values

You can substitute one of the values in the following table for `o`.

**TABLE 54**     The `-xchar` Values

Value	Meaning
signed	Treat character constants and variables declared as <code>char</code> as signed. This option affects the behavior of compiled code, but does not affect the behavior of library routines.
s	Equivalent to <code>signed</code>
unsigned	Treat character constants and variables declared as <code>char</code> as unsigned. This option affects the behavior of compiled code, but does not affect the behavior of library routines.

Value	Meaning
u	Equivalent to <code>unsigned</code>

## Defaults

If you do not specify `-xchar`, the compiler assumes `-xchar=s`.

If you specify `-xchar`, but do not specify a value, the compiler assumes `-xchar=s`.

## Interactions

The `-xchar` option changes the range of values for the type `char` only for code compiled with `-xchar`. This option does not change the range of values for type `char` in any system routine or header file. In particular, the values of `CHAR_MAX` and `CHAR_MIN`, as defined by `limits.h`, do not change when this option is specified. Therefore, `CHAR_MAX` and `CHAR_MIN` no longer represent the range of values encodable in a plain `char`.

## Warnings

If you use `-xchar=unsigned`, be particularly careful when you compare a `char` against a predefined system macro because the value in the macro may be signed. This situation is most common for any routine that returns an error code which is accessed through a macro. Error codes are typically negative values so when you compare a `char` against the value from such a macro, the result is always false. A negative number can never be equal to any value of an unsigned type.

Never use `-xchar` to compile routines for any interface exported through a library. The Oracle Solaris ABI specifies type `char` as signed, and system libraries behave accordingly. The effect of making `char` unsigned has not been extensively tested with system libraries. Instead of using this option, modify your code so that it does not depend on whether type `char` is signed or unsigned. The sign variety of type `char` varies among compilers and operating systems.

### A.2.117 `-xcheck[=i[,i]]`

Compiling with `-xcheck=stkovf` adds a runtime check for stack overflow of the main thread in a single-threaded program as well as slave-thread stacks in a multithreaded program. If a stack overflow is detected, a `SIGSEGV` is generated. See the `sigaltstack(2)` man page for information

on how to handle a SIGSEGV caused by a stack overflow differently than other address-space violations.

## A.2.117.1 Values

*i* must be one of the values listed in the following table.

**TABLE 55** -xcheck Values

Value	Meaning
%all	Perform all checks.
%none	Perform no checks.
stkovf[ <i>action</i> ]	<p>Generate code to detect stack overflow errors at runtime, optionally specifying an action to be taken when a stack overflow error is detected.</p> <p>A stack overflow error occurs when a thread's stack pointer is set beyond the thread's allocated stack bounds. The error may not be detected if the new top of stack address is writable.</p> <p>A stack overflow error is detected if a memory access violation occurs as a direct result of the error, raising an associated signal (usually SIGSEGV). The signal thus raised is said to be associated with the error.</p> <p>If -xcheck=stkovf[<i>action</i>] is specified, the compiler generates code to detect stack overflow errors in cases involving stack frames larger than the system page size. The code includes a library call to force a memory access violation instead of setting the stack pointer to an invalid but potentially mapped address (see <code>_stack_grow(3C)</code>).</p> <p>The optional <i>action</i>, if specified, must be either <code>:detect</code> or <code>:diagnose</code>.</p> <p>If <i>action</i> is <code>:detect</code>, a detected stack overflow error is handled by executing the signal handler normally associated with the error.</p> <p>On SPARC, -xcheck=stkovf:detect is enabled by default. This prevents silent corruption of the stack due to stack overflow. It can be disabled by specifying -xcheck=no%stkovf.</p> <p>If <i>action</i> is <code>:diagnose</code>, a detected stack overflow error is handled by catching the associated signal and calling <code>stack_violation(3C)</code> to diagnose the error. This is the default behavior if no action is specified.</p> <p>If a memory access violation is diagnosed as a stack overflow error, the following message is printed to <code>stderr</code>:</p> <pre>ERROR: stack overflow detected: pc=&lt;inst_addr&gt;, sp=&lt;sp_addr&gt;</pre> <p>where <code>&lt;inst_addr&gt;</code> is the address of the instruction where the error was detected, and <code>&lt;sp_addr&gt;</code> is the value of the stack pointer at the time that the error was detected. After checking for stack overflow and printing the above message if appropriate, control passes to the signal handler normally associated with the error.</p>



Value	Meaning
	<p><code>-xcheck=stkovf:detect</code> adds a stack bounds check on entry to routines with stack frames larger than system page size (see <code>_stack_grow(3C)</code>). The relative cost of the additional bounds check should be negligible in most applications.</p> <p><code>-xcheck=stkovf:diagnose</code> adds a system call to thread creation (see <code>sigaltstack(2)</code>). The relative cost of the additional system call depends on how frequently the application creates and destroys new threads.</p> <p><code>-xcheck=stkovf</code> is supported only on Oracle Solaris. The C runtime library on Oracle Linux does not support stack overflow detection.</p>
<code>no%stkovf</code>	Turns off stack-overflow checking.
<code>init_local</code>	<p>Initialize local variables. See the <a href="#">Oracle Developer Studio 12.5: C User's Guide</a> for details.</p> <p>Exercise caution when using <code>-xcheck</code> with a large amount of local data, such as arrays with more than 10,000 elements. This can cause the compiler's internal representation of the program to become very large when that local data is initialized, which can result in significantly longer compilation times, especially when combined with optimization levels greater than <code>-O2</code>.</p>
<code>no%init_local</code>	Do not initialize local variables.
<code>noreturn</code>	<p>Inform the compiler to add code to cause a runtime error if a routine which has been described as "do not return" returns.</p> <p>A routine can be described as "do not return" by any of the following:</p> <ul style="list-style-type: none"> <li>■ <code>__attribute__((noreturn))</code></li> <li>■ <code>#pragma does_not_return</code></li> <li>■ using the C11 qualifier <code>_Noreturn</code></li> </ul> <p>Undefined behaviour will result if a routine returns after being described as not returning. The <code>-xcheck=noreturn</code> flag tells the compiler to add an illegal instruction after every call to a function marked as does not return to force the target application to abort if that function returns.</p>

## Defaults

If you do not specify `-xcheck`, the compiler defaults to `-xcheck=noreturn`. If you specify `-xcheck` without any arguments, the compiler defaults to `-xcheck=all`, unless you are on an Oracle Solaris system for SPARC, in which case the compiler defaults to `-xcheck=stkovf:detect` for both cases.

The `-xcheck` option does not accumulate on the command line. The compiler sets the flag in accordance with the last occurrence of the command.

## A.2.118 `-xchip=C`

Specifies target processor for use by the optimizer.

The `-xchip` option specifies timing properties by specifying the target processor. This option affects the following properties:

- The ordering of instructions—that is, scheduling
- The way the compiler uses branches
- The instructions to use in cases where semantically equivalent alternatives are available

---

**Note** - Although this option can be used alone, it is part of the expansion of the `-xtarget` option. Its primary use is to override a value supplied by the `-xtarget` option.

---

### A.2.118.1 Values

`c` must be one of the values listed in the following two tables.

**TABLE 56** `-xchip` Values for SPARC Processors

<code>generic</code>	Good performance on most SPARC processors
<code>native</code>	Good performance on the host SPARC system on which the compiler is running
<code>sparc64vi</code>	SPARC64 VI processor
<code>sparc64vii</code>	SPARC64 VII processor
<code>sparc64viplus</code>	SPARC64 VII+ processor
<code>sparc64x</code>	SPARC64 X processor
<code>sparc64xplus</code>	SPARC64 X+ processor
<code>ultraT1</code>	UltraSPARC T1 processor.
<code>ultraT2</code>	UltraSPARC T2 processor.
<code>ultraT2plus</code>	UltraSPARC T2+ processor.
<code>T3</code>	SPARC T3 processor.
<code>T4</code>	SPARC T4 processor.
<code>T5</code>	Uses the timing properties of the SPARC T5 processor.
<code>T7</code>	Uses the timing properties of the SPARC T7 processor.
<code>M5</code>	Uses the timing properties of the SPARC M5 processor.
<code>M6</code>	Uses the timing properties of the SPARC M6 processor.
<code>M7</code>	Uses the timing properties of the SPARC M7 processor.

**TABLE 57** -xchip Values for x86/x64 Processors

generic	Good performance on most x86 processors
native	Good performance on the host x86 system on which the compiler is running
core2	Intel Core2 processor
nehalem	Intel Nehalem processor
opteron	AMD Opteron processor
penryn	Intel Penryn processor
pentium	Intel Pentium processor
pentium_pro	Intel Pentium Pro processor
pentium3	Intel Pentium 3 style processor
pentium4	Intel Pentium 4 style processor
amdfam10	AMD AMDFAM10 processor
sandybridge	Intel Sandy Bridge processor
ivybridge	Intel Ivy Bridge processor
haswell	Intel Haswell processor
westmere	Intel Westmere processor
broadwell	Intel Broadwell processor

## Defaults

On most processors, `generic` is the default value that directs the compiler to use the best timing properties for good performance without major performance degradation on any of the processors.

## A.2.119 `-xcode=a`

(SPARC) Specifies the code address space.

---

**Note** - You should build shared objects by specifying `-xcode=pic13` or `-xcode=pic32`. Shared objects built without `pic13` or `pic32` will not work correctly, and might not build at all.

---

### A.2.119.1 Values

`a` must be one of the values listed in the following table.

**TABLE 58** -xcode Values

Value	Meaning
abs32	Generates 32-bit absolute addresses, which are fast but have limited range. Code + data + bss size is limited to 2**32 bytes.
abs44	(SPARC) Generates 44-bit absolute addresses, which have moderate speed and moderate range. Code + data + bss size is limited to 2**44 bytes. Available only on 64-bit architectures. Do not use this value with dynamic (shared) libraries.
abs64	(SPARC) Generates 64-bit absolute addresses, which are slow but have full range. Available only on 64-bit architectures.
pic13	Generates position-independent code (small model), which is fast but has limited range. Equivalent to -Kpic. Permits references to at most 2**11 unique external symbols on 32-bit architectures; 2**10 on 64-bit.
pic32	Generates position-independent code (large model), which might not be as fast as pic13, but has full range. Equivalent to -KPIC. Permits references to at most 2**30 unique external symbols on 32-bit architectures; 2**29 on 64-bit.

To determine whether to use `-xcode=pic13` or `-xcode=pic32`, check the size of the Global Offset Table (GOT) by using `elfdump -c` and look for the section header `sh_name: .got`. The `sh_size` value is the size of the GOT. If the GOT is less than 8,192 bytes, specify `-xcode=pic13`, otherwise specify `-xcode=pic32`. See the `elfdump(1)` man page for more information.

In general, use the following guidelines to determine how you should use `-xcode`:

- If you are building an executable you should not use `-xcode=pic13` or `-xcode=pic32`.
- If you are building an archive library only for linking into executables you should not use `-xcode=pic13` or `-xcode=pic32`.
- If you are building a shared library, start with `-xcode=pic13`. Once the GOT size exceeds 8,192 bytes, use `-xcode=pic32`.
- If you are building an archive library for linking into shared libraries you should only use `-xcode=pic32`.

## Defaults

The default is `-xcode=abs32` for 32-bit architectures. The default for 64-bit architectures is `-xcode=abs44`.

When building shared dynamic libraries, the default `-xcode` values of `abs44` and `abs32` will not work with 64-bit architectures. Specify `-xcode=pic13` or `-xcode=pic32` instead. There are two nominal performance costs with `-xcode=pic13` and `-xcode=pic32` on SPARC:

- A routine compiled with either `-xcode=pic13` or `-xcode=pic32` executes a few extra instructions upon entry to set a register to point at a table (`_GLOBAL_OFFSET_TABLE_`) used for accessing a shared library's global or static variables.
- Each access to a global or static variable involves an extra indirect memory reference through `_GLOBAL_OFFSET_TABLE_`. If the compile is done with `-xcode=pic32`, there are two additional instructions per global and static memory reference.

When considering the above costs, remember that the use of `-xcode=pic13` and `-xcode=pic32` can significantly reduce system memory requirements due to the effect of library code sharing. Every page of code in a shared library compiled `-xcode=pic13` or `-xcode=pic32` can be shared by every process that uses the library. If a page of code in a shared library contains even a single non-pic (that is, absolute) memory reference, the page becomes nonsharable, and a copy of the page must be created each time a program using the library is executed.

The easiest way to tell whether a `.o` file has been compiled with `-xcode=pic13` or `-xcode=pic32` is with the `nm` command:

```
% nm file.o | grep _GLOBAL_OFFSET_TABLE_ U _GLOBAL_OFFSET_TABLE_
```

A `.o` file containing position-independent code contains an unresolved external reference to `_GLOBAL_OFFSET_TABLE_`, as indicated by the letter `U`.

To determine whether to use `-xcode=pic13` or `-xcode=pic32`, use `nm` to identify the number of distinct global and static variables used or defined in the library. If the size of `_GLOBAL_OFFSET_TABLE_` is under 8,192 bytes, you can use `-Kpic`. Otherwise, you must use `-xcode=pic32`.

## A.2.120 `-xdebugformat=[stabs|dwarf]`

Use this option to control the format of debugger information emitted by the compiler. Debugger information is emitted when a debugging option such as `-g` is used. A small amount of debugger information is emitted even without a debugging option.

### A.2.120.1 Values

TABLE 59 `-xdebugformat` Flags

Value	Meaning
<code>stabs</code>	<code>-xdebugformat=stabs</code> generates debugging information using the <code>stabs</code> format. The <code>stabs</code> format is obsolete and is no longer supported.

Value	Meaning
dwarf	-xdebugformat=dwarf generates debugging information using the standard dwarf format.

## Defaults

The `-xdebugformat` option requires an argument.

If you do not specify `-xdebugformat`, the compiler assumes `-xdebugformat=dwarf`.

## Interactions

The stabs format is not available when using the g++ ABI (binary format). You cannot specify `-xdebugformat=stabs` with any of the options `-compat=g` or `-std=c++[03/11/14]`.

## Notes

The detailed format of individual fields in stabs or dwarf format may evolve over time.

See also the man pages for `dumpstabs(1)` and `dwarfdump(1)`.

## A.2.121 `-xdebuginfo=a[,a...]`

Control how much debugging and observability information is emitted.

The term *tagtype* refers to tagged types: structs, unions, enums, and classes.

The following list contains the possible values for suboptions *a*. The prefix `no%` applied to a suboption disables that suboption. The default is `-xdebuginfo=%none`. Specifying `-xdebuginfo` without a suboption is forbidden.

<code>%none</code>	No debugging information is generated. This is the default.
<code>[no%]line</code>	Emit line number and file information.
<code>[no%]param</code>	Emit location list info for parameters. Emit full type information for scalar values (for example, <code>int</code> , <code>char *</code> ) and type names but not full definitions of tagtypes.
<code>[no%]variable</code>	Emit location list information for lexically global and local variables, including file and function statics but excluding class statics and externs.

---

	Emit full type information for scalar values such as <code>int</code> and <code>char *</code> and type names but not full definitions of tagtypes.
<code>[no%]decl</code>	Emit information for function and variable declarations, member functions, and static data members in class declarations.
<code>[no%]tagtype</code>	Emit full type definitions of tagtypes referenced from <code>param</code> and <code>variable</code> datasets, as well as template definitions.
<code>[no%]macro</code>	Emit macro information.
<code>[no%]codetag</code>	Emit DWARF codetags (also known as Stabs <code>N_PATCH</code> ). This is information regarding bitfields, structure copy, and spills used by RTC and discover.
<code>[no%]hwcp</code>	Generate information critical to hardware counter profiling. This information includes <code>ldst_map</code> , a mapping from <code>ld/st</code> instructions to the symbol table entry being referenced, and <code>branch_target</code> table of branch-target addresses used to verify that backtracking did not cross a branch-target. See <code>-xhwcp</code> for more information.

---

**Note** - `ldst_map` requires the presence of tagtype information. The driver will issue an error if this requirement is not met.

---

These are macros which expand to combinations of `-xdebuginfo` and other options as follows:

```
-g = -g2
-gnone =
    -xdebuginfo=%none
    -xglobalize=no
    -xpatchpadding=fix
    -xkeep_unref=no%funcs,no%vars
-g0 =
    -xdebuginfo=line,param,decl,variable,tagtype
    -xglobalize=yes
    -xpatchpadding=fix
    -xkeep_unref=funcs,vars
-g1 =
    -xdebuginfo=line,param,codetag
    -xglobalize=no
    -xpatchpadding=fix
    -xkeep_unref=no%funcs,no%vars
```

```
-g2 =  
  -xdebuginfo=line,param,decl,variable,tagtype,codetag  
  -xglobalize=yes  
  -xpatchpadding=fix  
  -xkeep_unref=funcs,vars  
  
-g3 =  
  -xdebuginfo=line,param,decl,variable,tagtype,codetag,macro  
  -xglobalize=yes  
  -xpatchpadding=fix  
  -xkeep_unref=funcs,vars
```

## A.2.122 **-xdepend=[yes|no]**

Analyzes loops for inter-iteration data dependencies and does loop restructuring, including loop interchange, loop fusion, scalar replacement, and elimination of “dead array” assignments.

The `-xdepend` option defaults to `-xdepend=yes` for all optimization levels `-xO3` and above. Otherwise `-xdepend` defaults to `-xdepend=no`. Specifying an explicit setting of `-xdepend` overrides any default setting.

Specifying `-xdepend` without an argument is equivalent to `-xdepend=yes`.

Dependency analysis is included in `-xautopar`. Dependency analysis is done at compile time.

Dependency analysis may help on single-processor systems. However, if you use `-xdepend` on single-processor systems, you should not also specify `-xautopar` because the `-xdepend` optimization will be done for a multiprocessor system.

### A.2.122.1 **See Also**

`-xprefetch_auto_type`

## A.2.123 **-xdumpmacros[=*value*[, *value*...]]**

Use this option when you want to see how macros are behaving in your program. This option provides information such as macro defines, undefines, and instances of usage. It prints output to the standard error (`stderr`), based on the order in which macros are processed. The `-xdumpmacros` option is in effect through the end of the file or until it is overridden by the `dumpmacros` or `end_dumpmacros` pragma. See [“B.2.5 #pragma dumpmacros” on page 346](#).



## A.2.123.1 Values

The following table lists the valid arguments for *value*. The prefix `no%` disables the associated value.

**TABLE 60** -xdumpmacros Values

Value	Meaning
[no%]defs	Print all macro defines.
[no%]undefs	Print all macro undefines.
[no%]use	Print information about macros used.
[no%]loc	Print location (path name and line number) also for defs, undefs, and use.
[no%]conds	Print use information for macros used in conditional directives.
[no%]sys	Print all macros defines, undefines, and use information for macros in system header files.
%all	Sets the option to <code>-xdumpmacros=defs,undefs,use,loc,conds,sys</code> . A good way to use this argument is in conjunction with the <code>[no%]</code> form of the other arguments. For example, <code>-xdumpmacros=%all,no%sys</code> would exclude system header macros from the output but still provide information for all other macros.
%none	Do not print any macro information.

The option values accumulate, so specifying `-xdumpmacros=sys -xdumpmacros=undefs` has the same effect as `-xdumpmacros=undefs,sys`.

---

**Note** - The sub-options `loc`, `conds`, and `sys` are qualifiers for `defs`, `undefs` and `use` options. By themselves, `loc`, `conds`, and `sys` have no effect. For example, `-xdumpmacros=loc,conds,sys` has no effect.

---

### Defaults

Specifying `-xdumpmacros` without any arguments defaults to `-xdumpmacros=defs,undefs,sys`. The default when not specifying `-xdumpmacros` is `-xdumpmacros=%none`.

### Examples

If you use the option `-xdumpmacros=use,no%loc`, the name of each macro that is used is printed only once. However, if you want more detail, use the option `-xdumpmacros=use,loc` so the location and macro name is printed every time a macro is used.

Consider the following file `t.c`:

```
example% cat t.c
#ifdef FOO
#undef FOO
#define COMPUTE(a, b) a+b
#else
#define COMPUTE(a,b) a-b
#endif
int n = COMPUTE(5,2);
int j = COMPUTE(7,1);
#if COMPUTE(8,3) + NN + MM
int k = 0;
#endif
```

The following examples show the output for file `t.c` based on the defs, undefs, sys, and loc arguments.

```
example% CC -c -xdumpmacros -DFOO t.c
#define __SunOS_5_9 1
#define __SUNPRO_CC 0x5140
#define unix 1
#define sun 1
#define sparc 1
#define __sparc 1
#define __unix 1
#define __sun 1
#define __BUILTIN_VA_ARG_INCR 1
#define __SVR4 1
#define __SUNPRO_CC_COMPAT 5
#define __SUN_PREFETCH 1
#define FOO 1
#undef FOO
#define COMPUTE(a, b) a + b
```

```
example% CC -c -xdumpmacros=defs,undefs,loc -DFOO -UBAR t.c
command line: #define __SunOS_5_9 1
command line: #define __SUNPRO_CC 0x5140
command line: #define unix 1
command line: #define sun 1
command line: #define sparc 1
command line: #define __sparc 1
command line: #define __unix 1
command line: #define __sun 1
command line: #define __BUILTIN_VA_ARG_INCR 1
command line: #define __SVR4 1
command line: #define __SUNPRO_CC_COMPAT 5
command line: #define __SUN_PREFETCH 1
command line: #define FOO 1
```

```
command line: #undef BAR
t.c, line 2: #undef FOO
t.c, line 3: #define COMPUTE(a, b) a + b
```

The following examples show how the `use`, `loc`, and `conds` arguments report macro behavior in file `t.c`:

```
example% CC -c -xdumpmacros=use t.c
used macro COMPUTE
```

```
example% CC -c -xdumpmacros=use,loc t.c
t.c, line 7: used macro COMPUTE
t.c, line 8: used macro COMPUTE
```

```
example% CC -c -xdumpmacros=use,conds t.c
used macro FOO
used macro COMPUTE
used macro NN
used macro MM
```

```
example% CC -c -xdumpmacros=use,conds,loc t.c
t.c, line 1: used macro FOO
t.c, line 7: used macro COMPUTE
t.c, line 8: used macro COMPUTE
t.c, line 9: used macro COMPUTE
t.c, line 9: used macro NN
t.c, line 9: used macro MM
```

Consider the file `y.c`:

```
example% cat y.c
#define X 1
#define Y X
#define Z Y
int a = Z;
```

The following example shows the output from `-xdumpmacros=use,loc` based on the macros in `y.c`:

```
example% CC -c -xdumpmacros=use,loc y.c
y.c, line 4: used macro Z
y.c, line 4: used macro Y
y.c, line 4: used macro X
```

## See Also

Pragma `dumpmacros/end_dumpmacros` overrides the scope of the `-xdumpmacros` command-line option.

## A.2.124 -xe

Checks only for syntax and semantic errors. When you specify `-xe`, the compiler does not produce any object code. The output for `-xe` is directed to `stderr`.

Use the `-xe` option if you do not need the object files produced by compilation. For example, if you are trying to isolate the cause of an error message by deleting sections of code, you can speed the edit and compile cycle by using `-xe`.

### A.2.124.1 See Also

`-c`

## A.2.125 -xF[=v[,v...]]

Enables optimal reordering of functions and variables by the linker.

This option instructs the compiler to place functions or data variables into separate section fragments, which enables the linker to reorder these sections to optimize program performance using directions in a mapfile specified by the linker's `-M` option. Generally, this optimization is only effective when page fault time constitutes a significant fraction of program run time.

Reordering of variables can help solve the following problems which negatively impact runtime performance:

- Cache and page contention caused by unrelated variables that are near each other in memory
- Unnecessarily large work-set size as a result of related variables which are not near each other in memory
- Unnecessarily large work-set size as a result of unused copies of weak variables that decrease the effective data density

Reordering variables and functions for optimal performance requires the following operations:

1. Compiling and linking with `-xF`.
2. Following the instructions in the [Oracle Developer Studio 12.5: Performance Analyzer](#) regarding how to generate a mapfile for functions or following the instructions in the [Oracle Solaris 11.3 Linkers and Libraries Guide](#) regarding how to generate a mapfile for data.
3. Relinking with the new mapfile by using the linker's `-M` option.
4. Re-executing under the Analyzer to verify improvement.

### A.2.125.1 Values

`v` can be one or more of the values listed in the following table. The `no%` prefix disables the associated value.

**TABLE 61** `-xF` Values

Value	Meaning
<code>[no%]func</code>	Fragment functions into separate sections.
<code>[no%]globdata</code>	Fragment global data (variables with external linkage) into separate sections.
<code>[no%]lclldata</code>	Fragment local data (variables with internal linkage) into separate sections.
<code>%all</code>	Fragment functions, global data, and local data.
<code>%none</code>	Fragment nothing.

#### Defaults

If you do not specify `-xF`, the default is `-xF=%none`. If you specify `-xF` without any arguments, the default is `-xF=%none, func`.

#### Interactions

Using `-xF=lclldata` inhibits some address calculation optimizations, so you should only use this flag when it is experimentally justified.

#### See Also

The `analyzer(1)` and `ld(1)` man pages

### A.2.126 `-xglobalize[={yes|no}]`

Control globalization of function-level or file-level static variables.

Globalization is a technique needed by `fix` and `continue` functionality in the debugger whereby function-level or file-level static symbols are promoted to globals while a prefix is added to the name to keep identically named symbols distinct.

The default is `-xglobalize=no`. Specifying `-xglobalize` is equivalent to specifying `-xglobalize=yes`.

### **A.2.126.1 Interactions**

See `-xpatchpadding`.

### **A.2.127 `-xhelp=flags`**

Displays a brief description of each compiler option.

### **A.2.128 `-xhwcprof`**

Enables compiler support for hardware counter-based profiling.

When `-xhwcprof` is enabled, the compiler generates information that helps tools associate profiled load and store instructions with the data-types and structure members (in conjunction with symbolic information produced with `-g` to which they refer. It associates profile data with the data space of the target, rather than the instruction space. This option provides insight into behavior that is not easily obtained from instruction profiling alone.

You can compile a specified set of object files with `-xhwcprof`. However, `-xhwcprof` is most useful when applied to all object files in the application, providing complete coverage to identify and correlate all memory references distributed in the application's object files.

If you are compiling and linking in separate steps, use `-xhwcprof` at link time as well. Future extensions to `-xhwcprof` may require its use at link time.

An instance of `-xhwcprof=enable` or `-xhwcprof=disable` overrides all previous instances of `-xhwcprof` in the same command line.

`-xhwcprof` is disabled by default. Specifying `-xhwcprof` without any arguments is the equivalent to `-xhwcprof=enable`.

`-xhwcprof` requires that optimization is turned on and that the DWARF debug data format is selected. Note that DWARF format (`-xdebugformat=dwarf`) is now the default with current Oracle Developer Studio compilers. The occurrence of `-xhwcprof` and `-xdebugformat=stabs` on the same command line is not permitted.

`-xhwcprof` uses `-xdebuginfo` to automatically enable the minimum amount of debugging information it needs, so `-g` is not required.

The combination of `-xhwcprof` and `-g` increases compiler temporary file storage requirements by more than the sum of the increases resulting from either `-xhwcprof` and `-g` alone.

`-xhwcprof` is implemented as a macro that expands to various other, more primitive, options as follows:

```
-xhwcprof
    -xdebuginfo=hwcprof,tagtype,line
-xhwcprof=enable
    -xdebuginfo=hwcprof,tagtype,line
-xhwcprof=disable
    -xdebuginfo=no%hwcprof,no%tagtype,no%line
```

The following command compiles `example.cc` and specifies support for hardware counter profiling and symbolic analysis of data types and structure members using DWARF symbols:

```
example% CC -c -O -xhwcprof -g -xdebugformat=dwarf example.cc
```

For more information about hardware counter-based profiling, see the *Performance Analyzer* manual.

## A.2.129 `-xia`

Links the appropriate interval arithmetic libraries and sets a suitable floating-point environment.

---

**Note** - The C++ interval arithmetic library is compatible with interval arithmetic as implemented in the Fortran compiler.

---

On x86 platforms, this option requires support of SSE2 instruction set.

### A.2.129.1 Expansions

The `-xia` option is a macro that expands to `-fsimple=0 -ftrap=%none -fns=no -library=interval`. If you use intervals and override what is set by `-xia` by specifying a different flag for `-fsimple`, `-ftrap`, `-fns` or `-library`, you may cause the compiler to exhibit incorrect behavior.

### A.2.129.2 Interactions

To use the interval arithmetic libraries, include `<suninterval.h>`.

When you use the interval arithmetic libraries, you must include one of the following libraries: `Cstd`, or `iostreams`. See `-library` for information about including these libraries.

### A.2.129.3 Warnings

If you use intervals and you specify different values for `-fsimple`, `-ftrap`, or `-fns`, then your program may exhibit incorrect behavior.

C++ interval arithmetic is experimental and evolving. The specifics might change from release to release.

### A.2.129.4 See Also

`-library`

## A.2.130 `-xinline[=func-spec[,func-spec...]]`

Specifies which user-written routines can be inlined by the optimizer at `-x03` levels or higher.

### A.2.130.1 Values

*func-spec* must be one of the values listed in the following table.

**TABLE 62** `-xinline` Values

Value	Meaning
<code>%auto</code>	Enable automatic inlining at optimization levels <code>-x04</code> or higher. This argument tells the optimizer that it can inline functions of its choosing. Note that without the <code>%auto</code> specification, automatic inlining is normally turned off when explicit inlining is specified on the command line by <code>-xinline=[no%]<i>func-name</i>...</code>
<i>func_name</i>	Strongly request that the optimizer inline the function. If the function is not declared as <code>extern "C"</code> , the value of <i>func_name</i> must be mangled. You can use the <code>nm</code> command on the executable file to find the mangled function names. For functions declared as <code>extern "C"</code> , the names are not mangled by the compiler.
<code>no%<i>func_name</i></code>	When you prefix the name of a routine on the list with <code>no%</code> , the inlining of that routine is inhibited. The rule about mangled names for <i>func-name</i> applies to <code>no%<i>func-name</i></code> as well.



Only routines in the file being compiled are considered for inlining unless you use `-xipo[=1|2]`. The optimizer decides which of these routines are appropriate for inlining.

## A.2.130.2 Defaults

If the `-xinline` option is not specified, the compiler assumes `-xinline=%auto`.

If `-xinline=` is specified with no arguments, no functions are inlined regardless of the optimization level.

## A.2.130.3 Examples

To enable automatic inlining while disabling inlining of the function declared `int foo()`, use the following command:

```
example% CC -x05 -xinline=%auto,no__1cDfoo6F_i_ -c a.cc
```

To strongly request the inlining of the function declared as `int foo()`, and to make all other functions as the candidates for inlining, use the following command:

```
example% CC -x05 -xinline=%auto,__1cDfoo6F_i_ -c a.cc
```

To strongly request the inlining of the function declared as `int foo()`, and to not allow inlining of any other functions, use the following command:

```
example% CC -x05 -xinline=__1cDfoo6F_i_ -c a.cc
```

## A.2.130.4 Interactions

The `-xinline` option has no effect for optimization levels below `-x03`. At `-x04` and higher, the optimizer decides which functions should be inlined, and does so without the `-xinline` option being specified. At `-x04` and higher, the compiler also attempts to determine which functions will improve performance if they are inlined.

A routine is inlined if any of the following conditions apply.

- Optimization is `-x03` or greater
- Inlining is judged to be profitable and safe
- The function is in the file being compiled, or the function is in a file that was compiled with `-xipo[=1|2]`

### A.2.130.5 Warnings

If you force the inlining of a function with `-xinline`, you might actually diminish performance.

### A.2.130.6 See Also

[“A.2.142 `-xldscope={v}`” on page 286](#)

## A.2.131 `-xinline_param=a[,a[,a]...]`

Use this option to manually change the heuristics used by the compiler for deciding when to inline a function call.

This option only has an effect at `-O3` or higher. The following sub-options have an effect only at `-O4` or higher when automatic inlining is on.

In the following sub-options *n* must be a positive integer; *a* can be one of the following:

**TABLE 63** `-xinline_param` Sub-options

Sub-option	Meaning
default	Set the values of all the sub-options to their default values.
<code>max_inst_hard[:n]</code>	<p>Automatic inlining only considers functions smaller than <i>n</i> pseudo instructions (counted in compiler's internal representation) as possible inline candidates.</p> <p>Under no circumstances will a function larger than this be considered for inlining.</p>
<code>max_inst_soft[:n]</code>	<p>Set inlined function's size limit to <i>n</i> pseudo instructions (counted in compiler's internal representation).</p> <p>Functions of greater size than this may sometimes be inlined.</p> <p>When interacting with <code>max_inst_hard</code>, the value of <code>max_inst_soft</code> should be equal to or smaller than the value of <code>max_inst_hard</code>, i.e., <code>max_inst_soft &lt;= max_inst_hard</code>.</p> <p>In general, the compiler's automatic inliner only inlines calls whose called function's size is smaller than the value of <code>max_inst_soft</code>. In some cases a function may be inlined when its size is larger than the value of <code>max_inst_soft</code> but smaller than that of <code>max_inst_hard</code>. An example of this would be if the parameters passed into a function were constants.</p>

Sub-option	Meaning
	When deciding whether to change the value of <code>max_inst_hard</code> or <code>max_inst_soft</code> for inlining one specific call site to a function, use <code>-xinline_report=2</code> to report detailed inlining message and follow the suggestion in the inlining message.
<code>max_function_inst[:n]</code>	Allow functions to increase due to automatic inlining by up to <i>n</i> pseudo instructions (counted in compiler's internal representation).
<code>max_growth[:n]</code>	The automatic inliner is allowed to increase the size of the program by up to <i>n</i> % where the size is measured in pseudo instructions.
<code>min_counter[:n]</code>	The minimum call site frequency counter as measured by profiling feedback ( <code>-xprofile</code> ) in order to consider a function for automatic inlining.  This option is valid only when the application is compiled with profiling feedback ( <code>-xprofile=use</code> ).
<code>level[:n]</code>	Use this suboption to control the degree of automatic inlining that is applied. The compiler will inline more functions with higher settings for <code>-xinline_param=level</code> .  <i>n</i> must be one of 1, 2, or 3.  The default value of <i>n</i> is 2 when this option is not specified, or when the options is specified without <code>:n</code> .  Specify the <code>level</code> of automatic inline:  <pre>level:1  basic inlining level:2  medium inlining (default) level:3  aggressive inlining</pre> The <code>level</code> decides the specified values for the combination of the following inlining parameters:  <pre>max_growth + max_function_inst + max_inst + max_inst_call</pre> When <code>level = 1</code> , all the parameters are half the values of the default.  When <code>level = 2</code> , all the parameters are the default value.  When <code>level = 3</code> , all the parameters are double the values of the default.
<code>max_recursive_depth[:n]</code>	When a function calls itself either directly or indirectly, it is said to be making a recursive call.  This suboption allows a recursive call to be automatically inlined up to <i>n</i> levels.
<code>max_recursive_inst[:n]</code>	Specifies the maximum number of pseudo instructions (counted in compiler's internal representation) the caller of a recursive function can grow to by performing automatic recursive inlining.

Sub-option	Meaning
	When interactions between <code>max_recursive_inst</code> and <code>max_recursive_depth</code> occur, recursive function calls will be inlined until either the <code>max_recursive_depth</code> number of recursive calls, or until the size of the function being inlined into exceeds <code>max_recursive_inst</code> . The settings of these two parameters control the degree of inlining of small recursive functions.

If `-xinline_param=default` is specified, the compiler will set all the values of the suboptions to the default values.

If the option is not specified, the default is `-xinline_param=default`.

The list of values and options accumulate from left to right. So for a specification of `-xinline_param=max_inst_hard:30,..,max_inst_hard:50`, the value `max_inst_hard:50` will be passed to the compiler.

If multiple `-xinline_param` options are specified on the command line, the list of sub-options likewise accumulate from left to right. For example, the effect of

```
-xinline_param=max_inst_hard:50,min_counter:70 ...
-xinline_param=max_growth:100,max_inst_hard:100
```

will be the same as that of

```
-xinline_param=max_inst_hard:100,min_counter:70,max_growth:100
```

### A.2.132 `-xinline_report[=n]`

This option generates a report written to standard output on the inlining of functions by the compiler. The type of report depends on the value of *n*, which must be 0, 1, or 2.

- 0 No report is generated.
- 1 A summary report of default values of inlining parameters is generated.
- 2 A detailed report of inlining messages is generated, showing which callsites are inlined and which are not, with a short reason for not inlining a callsite. In some cases, this report will include suggested values for `-xinline_param` that can be used to inline a callsite that is not inlined.

When `-xinline_report` is not specified, the default value for *n* is 0. When `-xinline_report` is specified without `=n`, the default value is 1.

When `-xlinkopt` is present, the inlining messages about the callsites that are not inlined might not be accurate.

The report is limited to inlining performed by the compiler that is subject to the heuristics controllable by the `-xinline_param` option. Callsites inlined by the compiler for other reasons may not be reported.

### A.2.133 `-xinstrument=[no%]datarace`

Specify this option to compile and instrument your program for analysis by the Thread Analyzer. For more information on the Thread Analyzer, see the `tha(1)` man page for details.

You can then use the Performance Analyzer to run the instrumented program with `collect -r races` to create a data-race-detection experiment. You can run the instrumented code stand-alone but it runs more slowly.

You can specify `-xinstrument=no%datarace` to turn off preparation of source code for the thread analyzer. This is the default.

You cannot specify `-xinstrument` without an argument.

If you compile and link in separate steps, you must specify `-xinstrument=datarace` in both the compilation and linking steps.

This option defines the preprocessor token `__THA_NOTIFY`. You can specify `#ifdef __THA_NOTIFY` to guard calls to `libtha(3)` routines.

This option also sets `-g`.

`-xinstrument` cannot be used together with `-xlinkopt`.

### A.2.134 `-xipo[={0|1|2}]`

Performs interprocedural optimizations.

The `-xipo` option performs partial-program optimizations by invoking an interprocedural analysis pass. It performs optimizations across all object files in the link step, and the optimizations are not limited to just the source files on the compile command. However, whole-program optimizations performed with `-xipo` do not include assembly (`.s`) source files.

The `-xipo` option is particularly useful when compiling and linking large multifile applications. Object files compiled with this flag have analysis information compiled within them that enables interprocedural analysis across source and precompiled program files. However, analysis and optimization is limited to the object files compiled with `-xipo`, and does not extend to object files or libraries.

### A.2.134.1 Values

The `-xipo` option can have the values listed in the following table.

**TABLE 64** The `-xipo` Values

Value	Meaning
0	Do not perform interprocedural optimizations
1	Perform interprocedural optimizations
2	Perform interprocedural aliasing analysis as well as optimizations of memory allocation and layout to improve cache performance

### A.2.134.2 Defaults

If `-xipo` is not specified, `-xipo=0` is assumed.

If only `-xipo` is specified, `-xipo=1` is assumed.

### A.2.134.3 Examples

The following example compiles and links in the same step.

```
example% CC -xipo -x04 -o prog part1.cc part2.cc part3.cc
```

The optimizer performs crossfile inlining across all three source files in the final link step. The compilation of the source files need not all take place in a single compilation and could be accomplished over a number of separate compilations, each specifying the `-xipo` option.

The following example compiles and links in separate steps.

```
example% CC -xipo -x04 -c part1.cc part2.cc
example% CC -xipo -x04 -c part3.cc
example% CC -xipo -x04 -o prog part1.o part2.o part3.o
```

The object files created in the compile steps have additional analysis information compiled within them to permit crossfile optimizations to take place at the link step.

#### A.2.134.4 When Not To Use `-xipo` Interprocedural Analysis

The compiler tries to perform whole-program analysis and optimizations as it works with the set of object files in the link step. The compiler makes the following two assumptions for any function or subroutine `foo()` defined in this set of object files:

- `foo()` is not called explicitly by another routine that is defined outside this set of object files at runtime.
- The calls to `foo()` from any routine in the set of object files are not interposed upon by a different version of `foo()` defined outside this set of object files.

Do not compile with `-xipo=2`, if the first assumption is not true for the given application.

Do not compile with either `-xipo=1` or `-xipo=2`, if the second assumption is not true.

As an example, consider interposing on the function `malloc()` with your own version and compiling with `-xipo=2`. All the functions in any library that reference `malloc()` that are linked with your code have to be compiled with `-xipo=2` also and their object files need to participate in the link step. Because this strategy might not be possible for system libraries, do not compile your version of `malloc()` with `-xipo=2`.

As another example, suppose that you build a shared library with two external calls, `foo()` and `bar()` inside two different source files. Furthermore, suppose that `bar()` calls `foo()`. If `foo()` could be interposed at runtime, do not compile the source file for `foo()` or for `bar()` with `-xipo=1` or `-xipo=2`. Otherwise, `foo()` could be inlined into `bar()`, which could cause incorrect results.

#### A.2.134.5 Interactions

The `-xipo` option requires at least optimization level `-xO4`.

#### A.2.134.6 Warnings

When compiling and linking are performed in separate steps, `-xipo` must be specified in both steps to be effective.

Objects that are compiled without `-xipo` can be linked freely with objects that are compiled with `-xipo`.

Libraries do not participate in crossfile interprocedural analysis, even when they are compiled with `-xipo`, as shown in the following example.

```
example% CC -xipo -xO4 one.cc two.cc three.cc
example% CC -xar -o mylib.a one.o two.o three.o
...
example% CC -xipo -xO4 -o myprog main.cc four.cc mylib.a
```

In this example, interprocedural optimizations will be performed between `one.cc`, `two.cc` and `three.cc`, and between `main.cc` and `four.cc`, but not between `main.cc` or `four.cc` and the routines in `mylib.a`. (The first compilation may generate warnings about undefined symbols, but the interprocedural optimizations will be performed because it is a compile and link step.)

The `-xipo` option generates significantly larger object files due to the additional information needed to perform optimizations across files. However, this additional information does not become part of the final executable binary file. Any increase in the size of the executable program will be due to the additional optimizations performed.

If you have `.o` files compiled with the `-xipo` option from different compiler versions, mixing these files can result in failure with an error message about "IR version mismatch". When using the `-xipo` option, all the files should be compiled with the same version of the compiler.

## A.2.134.7 See Also

`-xjobs`

## A.2.135 `-xipo_archive=[a]`

The `-xipo_archive` option enables the compiler to optimize object files that are passed to the linker with object files that were compiled with `-xipo` and that reside in the archive library (`.a`) before producing an executable. Any object files contained in the library that were optimized during the compilation are replaced with their optimized version.

The following table lists possible values for `a`.

**TABLE 65** `-xipo_archive` Flags

Value	Meaning
<code>writeback</code>	The compiler optimizes object files passed to the linker with object files compiled with <code>-xipo</code> that reside in the archive library ( <code>.a</code> ) before producing an executable. Any object files contained in the library that were optimized during the compilation are replaced with an optimized version.



Value	Meaning
	For parallel links that use a common set of archive libraries, each link should create its own copy of archive libraries to be optimized before linking.
readonly	<p>The compiler optimizes object files passed to the linker with object files compiled with <code>-xipo</code> that reside in the archive library (.a) before producing an executable.</p> <p>The option <code>-xipo_archive=readonly</code> enables cross-module inlining and interprocedural data flow analysis of object files in an archive library specified at link time. However, it does not enable cross-module optimization of the archive library's code except for code that has been inserted into other modules by cross-module inlining.</p> <p>To apply cross-module optimization to code within an archive library, <code>-xipo_archive=writeback</code> is required. Note that this setting modifies the contents of the archive library from which the code was extracted.</p>
none	This is the default. There is no processing of archive files. The compiler does not apply cross-module inlining or other cross-module optimizations to object files compiled using <code>-xipo</code> and extracted from an archive library at link time. To do that, both <code>-xipo</code> and either <code>-xipo_archive=readonly</code> or <code>-xipo_archive=writeback</code> must be specified at link time.

If you do not specify a setting for `-xipo_archive`, the compiler sets it to `-xipo_archive=none`.

You cannot specify `-xipo_archive` without a flag.

## A.2.136 `-xipo_build=[yes|no]`

Building `-xipo` without `-xipo_build` involves two passes through the compiler—once when producing the object files, and then again later at link time when performing the cross file optimization. Setting `-xipo_build` reduces compile time by avoiding optimizations during the initial pass and optimizing only at link time. Optimization is not needed for the object files, as with `-xipo` it will be performed at link time. If unoptimized object files built with `-xipo_build` are linked without including `-xipo` to perform optimization, the application will fail to link with an unresolved symbol error.

### A.2.136.1 `-xipo_build` Examples

The following example performs a fast build of .o files, followed by crossfile optimization at link time:

```
% cc -O -xipo -xipo_build -o code1.o -c code1.c
% cc -O -xipo -xipo_build -o code2.o -c code2.c
% cc -O -xipo -o a.out code1.o code2.o
```

The `-xipo_build` will turn off `-O` when creating the `.o` files, to build these quickly. Full `-O` optimization will be performed at link time as part of `-xipo` crossfile optimization.

The following example links without using `-xipo`.

```
% cc -O -o a.out code1.o code2.o
```

If either `code1.o` or `code2.o` were generated with `-xipo_build`, the result will be a link-time failure indicating the symbol `__unoptimized_object_file` is unresolved.

When building `.o` files separately, the default behavior is `-xipo_build=no`. However, when the executable or library is built in a single pass from source files, `-xipo_build` will be implicitly enabled. For example:

```
% cc -fast -xipo a.c b.c c.c
```

will implicitly enable `-xipo_build=yes` for the first passes that generate `a.o`, `b.o`, and `c.o`. Include the option `-xipo_build=no` to disable this behavior.

## A.2.137 `-xivdep[=p]`

Disable or set interpretation of `#pragma ivdep` pragmas (*ignore vector dependencies*).

The `ivdep` pragmas tell a compiler to ignore some or all loop-carried dependences on array references that it finds in a loop for purposes of optimization. This enables a compiler to perform various loop optimizations such as microvectorization, distribution, software pipelining, and so on, which would not be otherwise possible. It is used in cases where the user knows either that the dependences do not matter or that they never occur in practice.

The interpretation of `#pragma ivdep` directives depend upon the value of the `-xivdep` option.

The following list gives the values for `p` and their meaning.

<code>loop</code>	ignore assumed loop-carried vector dependences
<code>loop_any</code>	ignore all loop-carried vector dependences
<code>back</code>	ignore assumed backward loop-carried vector dependences
<code>back_any</code>	ignore all backward loop-carried vector dependences
<code>none</code>	do not ignore any dependences (disables <code>ivdep</code> pragmas)

These interpretations are provided for compatibility with other vendor's interpretations of the `ivdep` pragma.

## A.2.138 `-xjobs{=n|auto}`

Compile with multiple processes. If this flag is not specified, the default behavior is `-xjobs=auto`.

Specify the `-xjobs` option to set how many processes the compiler creates to complete its work. This option can reduce the build time on a multi-cpu machine. Currently, `-xjobs` works only with the `-xipo` option. When you specify `-xjobs=n`, the interprocedural optimizer uses  $n$  as the maximum number of code generator instances it can invoke to compile different files.

Generally, a safe value for  $n$  is 1.5 multiplied by the number of available processors. Using a value that is many times the number of available processors can degrade performance because of context switching overheads among spawned jobs. Also, using a very high number can exhaust the limits of system resources such as swap space.

When `-xjobs=auto` is specified, the compiler will automatically choose the appropriate number of parallel jobs.

You must always specify `-xjobs` with a value. Otherwise, an error diagnostic is issued and compilation aborts.

If `-xjobs` is not specified, the default behavior is `-xjobs=auto`. This can be overridden by adding `-xjobs=n` to the command line. Multiple instances of `-xjobs` on the command line override each other until the right-most instance is reached.

### A.2.138.1 `-xjobs` Examples

The following example links with up to three parallel processes for `-xipo`:

```
% cc -xipo -x04 -xjobs=3 t1.o t2.o t3.o
```

The following example links serially with a single process for `-xipo`:

```
% cc -xipo -x04 -xjobs=1 t1.o t2.o t3.o
```

The following example links in parallel, with the compiler choosing the number of jobs for `-xipo`:

```
% cc -xipo -x04 t1.o t2.o t3.o
```

Note that this is exactly the same behavior as when explicitly specifying `-xjobs=auto`:

```
% cc -xipo -x04 -xjobs=auto t1.o t2.o t3.o
```

### A.2.139 `-xkeep_unref=[{[no%]funcs,[no%]vars}]`

Keep definitions of unreferenced functions and variables. The `no%` prefix allows the compiler to potentially remove the definitions.

The default is `no%funcs,no%vars`. Specifying `-xkeep_unref` is equivalent to specifying `-xkeep_unref=funcs,vars`, meaning that `-keep_unref` keeps everything.

### A.2.140 `-xkeepframe=[[%all,%none,name,no%name]]`

Prohibit stack related optimizations for the named functions (*name*).

`%all` Prohibit stack related optimizations for all the code.

`%none` Allow stack related optimizations for all the code.

This option is accumulative and can appear multiple times on the command line. For example, `-xkeepframe=%all -xkeepframe=no%func1` indicates that the stack frame should be kept for all functions except `func1`. Also, `-xkeepframe` overrides `-xregs=frameptr`. For example, `-xkeepframe=%all -xregs=frameptr` indicates that the stack should be kept for all functions, but the optimizations for `-xregs=frameptr` would be ignored.

If not specified on the command line, the compiler assumes `-xkeepframe=%none` as the default. If specified but without a value, the compiler assumes `-xkeepframe=%all`.

### A.2.141 `-xlang=language[,language]`

Includes the appropriate runtime libraries and ensures the proper runtime environment for the specified language.

#### A.2.141.1 Values

*language* must be either `f90`, `f95`, or `c99`.

The `f90` and `f95` arguments are equivalent. The `c99` argument invokes ISO 9899:1999 C programming language behavior for objects that were compiled with `cc -std=c99` or `cc -xc99=%all` and are being linked with `CC`.

## A.2.141.2 Interactions

The `-xlang=f90` and `-xlang=f95` options imply `-library=f90`. However, the `-library=f90` option is not sufficient for mixed-language linking because only the `-xlang` option insures the proper runtime environment.

To determine which driver to use for mixed-language linking, use the following language hierarchy:

C++	Use the <code>CC</code> command.
Fortran 95 (or Fortran 90)	Use the <code>f95</code> command. See the <a href="#">Oracle Developer Studio 12.5: Fortran User's Guide</a> for details.
C	Use the <code>cc</code> command. See the <a href="#">Oracle Developer Studio 12.5: C User's Guide</a> for details.

When linking Fortran 95, Fortran 77, and C++ object files together, use the driver of the highest language. For example, use the following C++ compiler command to link C++ and Fortran 95 object files:

```
example% CC -xlang=f95...
```

You cannot use the `-xlang` option and the `-xlic_lib` option in the same compiler command. If you are using `-xlang` and you need to link in the Sun Performance Libraries, use `-library=sunperf` instead.

## A.2.141.3 Warnings

Do not use `-xnoLib` with `-xlang`.

If you are mixing parallel Fortran objects with C++ objects, the link line must specify the `-mt` flag.

## A.2.141.4 See Also

`-library`, `-staticlib`

## A.2.142 `-xldscope={v}`

Specify the `-xldscope` option to change the default linker scoping for the definition of extern symbols. Changing the default can result in faster and safer shared libraries and executables because the implementation are better hidden.

### A.2.142.1 Values

The following table lists the possible values for `v`.

**TABLE 66** The `-xldscope` Values

Value	Meaning
global	Global linker scoping is the least restrictive linker scoping. All references to the symbol bind to the definition in the first dynamic load module that defines the symbol. This linker scoping is the current linker scoping for extern symbols.
symbolic	Symbolic linker scoping is more restrictive than global linker scoping. All references to the symbol from within the dynamic load module being linked bind to the symbol defined within the module. Outside of the module, the symbol appears as though it is global. This linker scoping corresponds to the linker option <code>-Bsymbolic</code> . Although you cannot use <code>-Bsymbolic</code> with C++ libraries, you can use the <code>-xldscope=symbolic</code> without causing problems. See the <code>ld(1)</code> man page for more information on the linker.
hidden	Hidden linker scoping is more restrictive than symbolic and global linker scoping. All references within a dynamic load module bind to a definition within that module. The symbol will not be visible outside of the module.

### A.2.142.2 Defaults

If you do not specify `-xldscope`, the compiler assumes `-xldscope=global`. If you specify `-xldscope` without any values, the compiler issues an error. Multiple instances of this option on the command line override each other until the right-most instance is reached.

### A.2.142.3 Warning

If you intend to allow a client to override a function in a library, you must be sure that the function is not generated inline during the library build. The compiler inlines a function in the following situations:

- The function name is specified with `-xinline`.
- If you compile at `-x04` or higher, in which case inlining is automatic.
- If you use the inline specifier or cross-file optimization.

For example, suppose library ABC has a default allocator function that can be used by library clients, and is also used internally in the library:

```
void* ABC_allocator(size_t size) { return malloc(size); }
```

If you build the library at `-xO4` or higher, the compiler inlines calls to `ABC_allocator` that occur in library components. If a library client wants to replace `ABC_allocator` with a customized version, the replacement will not occur in library components that called `ABC_allocator`. The final program will include different versions of the function.

Library functions declared with the `__hidden` or `__symbolic` specifiers can be generated inline when building the library. These specifiers are not supposed to be overridden by clients. See [“4.1 Linker Scoping” on page 59](#).

Library functions declared with the `__global` specifier, should not be declared inline, and should be protected from inlining by use of the `-xinline` compiler option.

#### A.2.142.4 See Also

`-xinline`, `-xO`

#### A.2.143 `-xlibmieee`

Causes `libm` to return IEEE 754 values for math routines in exceptional cases.

The default behavior of `libm` is XPG-compliant.

#### A.2.143.1 See Also

[Oracle Developer Studio 12.5: Numerical Computation Guide](#)

#### A.2.144 `-xlibmil`

Inlines selected `libm` math library routines for optimization.

---

**Note** - This option does not affect C++ inline functions.

---

This option selects inline templates for `libm` routines that produce the fastest executables for the floating-point option and platform currently being used.

### A.2.144.1 Interactions

This option is implied by the `-fast` option.

#### See Also

`-fast`, [Oracle Developer Studio 12.5: Numerical Computation Guide](#)

## A.2.145 `-xlibmopt`

Uses a library of optimized math routines. You must use default rounding mode by specifying `-fround=nearest` when you use this option.

This option uses a math routine library optimized for performance and usually generates faster code. The results might be slightly different from those produced by the normal math library; if so, they usually differ in the last bit.

The order on the command line for this library option is not significant.

### A.2.145.1 Interactions

This option is implied by the `-fast` option.

### A.2.145.2 See Also

`-fast`, `-xno libmopt`, `-fround`

## A.2.146 `-xlic_lib=sunperf`

Deprecated, do not use. Specify `-library=sunperf` instead. See [“A.2.51 – library=l\[,l...\]” on page 215](#) for more information.



## A.2.147 `-xlicinfo`

This option is silently ignored by the compiler.

## A.2.148 `-xlinkopt[=level]`

(Solaris) Instructs the compiler to perform link-time optimization on the resulting executable or dynamic library over and above any optimizations in the object files. These optimizations are performed at link time by analyzing the object binary code. The object files are not rewritten but the resulting executable code may differ from the original object codes.

You must use `-xlinkopt` on at least some of the compilation commands for `-xlinkopt` to be useful at link time. The optimizer can still perform some limited optimizations on object binaries that are not compiled with `-xlinkopt`.

`-xlinkopt` optimizes code coming from static libraries that appear on the compiler command line, but does not optimize code coming from shared (dynamic) libraries that appear on the command line. You can also use `-xlinkopt` when you build shared libraries (compiling with `-G`).

### A.2.148.1 Values

*level* sets the level of optimizations performed, and must be 0, 1, or 2. The optimization levels are listed in the following table.:

**TABLE 67** The `-xlinkopt` Values

Value	Meaning
0	The link optimizer is disabled (the default).
1	Perform optimizations based on control flow analysis, including instruction cache coloring and branch optimizations, at link time.
2	Perform additional data flow analysis, including dead-code elimination and address computation simplification, at link time.

If you compile in separate steps, `-xlinkopt` must appear on both compile and link steps:

```
example% cc -c -xlinkopt a.c b.c
```

```
example% cc -o myprog -xlinkopt=2 a.o
```

Note that the level parameter is used only when the compiler is linking. In the example, the link optimizer level is 2 even though the object binaries are compiled with an implied level of 1.

### A.2.148.2 Defaults

Specifying `-xlinkopt` without a level parameter implies `-xlinkopt=1`.

### A.2.148.3 Interactions

The `-xlinkopt` option requires profile feedback (`-xprofile`) in order to optimize the program. Profiling reveals the most- and least-used parts of the code, which enables the optimizer to focus its effort accordingly. Link-time optimization is particularly important with large applications where optimal placement of code can substantially reduce instruction cache misses. Additionally, `-xlinkopt` is most effective when used to compile the whole program. Use this option as follows:

```
example% cc -o prog -xO5 -xprofile=collect:prog file.c
example% prog
example% cc -o prog -xO5 -xprofile=use:prog -xlinkopt file.c
```

`-xlinkopt` cannot be used together with `-xinstrument`.

For details on using profile feedback, see [“A.2.178 `-xprofile=p`” on page 319](#).

### A.2.148.4 Warnings

Do not use the `-zcombreloc` linker option when you compile with `-xlinkopt`.

Note that compiling with this option increases link time slightly. Object file sizes also increase, but the size of the executable remains the same. Compiling with `-xlinkopt` and `-g` increases the size of the executable by including debugging information.

## A.2.149 `-xloopinfo`

This option shows which loops are parallelized and is normally for use with the `-xautopar` option.

## A.2.150 `-xM`

Runs only the C++ preprocessor on the named C++ programs, requesting that the preprocessor generate makefile dependencies and send the result to the standard output. See the `make(1)` man page for details about make files and dependencies.

However, `-xM` only reports dependencies of the included headers and not the associated template definition files. You can use the `.KEEP_STATE` feature in your makefile to generate all the dependencies in the `.make.state` file which the make utility creates.

### A.2.150.1 Examples

The following example:

```
#include <unistd.h>
void main(void)
{}
```

generates this output:

```
e.o: e.c
e.o: /usr/include/unistd.h
e.o: /usr/include/sys/types.h
e.o: /usr/include/sys/machtypes.h
e.o: /usr/include/sys/select.h
e.o: /usr/include/sys/time.h
e.o: /usr/include/sys/types.h
e.o: /usr/include/sys/time.h
e.o: /usr/include/sys/unistd.h
```

### A.2.150.2 Interactions

If you specify `-xM` and `-xMF`, the compiler writes all makefile dependency information to the file specified with `-xMF`. This file is overwritten each time the preprocessor writes to it.

### A.2.150.3 See Also

The `make(1S)` man page for details about makefiles and dependencies.

### A.2.151 -xM1

Generates makefile dependencies like `-xM` except that it does not report dependencies for the `/usr/include` header files and it does not report dependencies for compiler-supplied header files.

If you specify `-xM1` and `-xMF`, the compiler writes all makefile dependency information to the file specified with `-xMF`. This file is overwritten each time the preprocessor writes to it.

### A.2.152 -xMD

Generates makefile dependencies like `-xM` but compilation continues. `-xMD` generates an output file for the makefile-dependency information derived from the `-o` output filename, if specified, or the input source filename, replacing (or adding) the filename suffix with `.d`. If you specify `-xMD` and `-xMF`, the preprocessor writes all makefile-dependency information to the file specified with `-xMF`. Compiling with `-xMD -xMF` or `-xMD -o filename` with more than one source file is not allowed and generates an error. The dependency file is overwritten if it already exists.

### A.2.153 -xMF

Use this option to specify a file for the makefile-dependency output. You cannot specify individual filenames for multiple input files with `-xMF` on one command line. Compiling with `-xMD -xMF` or `-xMMD -xMF` with more than one source file is not allowed and generates an error. The dependency file is overwritten if it already exists.

This option cannot be used with `-xM` or `-xM1`.

### A.2.154 -xMMD

Use this option to generate makefile dependencies excluding system header files. This option provides the same functionality as `-xM1`, but compilation continues. `-xMMD` generates an output file for the makefile-dependency information derived from the `-o` output filename, if specified, or the input source filename, replacing (or adding) the filename suffix with `.d`. If you specify

-xMF, the compiler uses the filename you provide instead. Compiling with -xMMD -xMF or -xMMD -o *filename* with more than one source file is not allowed and generates an error. The dependency file is overwritten if it already exists.

## A.2.155 **-xMerge**

(SPARC) Merges the data segment with the text segment.

The data in the object file is read-only and is shared between processes unless you link with `ld -N`.

The three options `-xMerge` `-ztext` `-xprofile=collect` should not be used together. While `-xMerge` forces statically initialized data into read-only storage, `-ztext` prohibits position-dependent symbol relocations in read-only storage, and `-xprofile=collect` generates statically initialized, position-dependent symbol relocations in writable storage.

### A.2.155.1 **See Also**

`ld(1)` man page

## A.2.156 **-xmaxopt[=v]**

This option limits the level of `pragma opt` to the level specified. `v` is one of `off`, `1`, `2`, `3`, `4`, `5`. The default value is `-xmaxopt=off` which causes `pragma opt` to be ignored. The default when specifying `-xmaxopt` without supplying an argument is `-xmaxopt=5`.

If you specify both `-x0` and `-xmaxopt`, the optimization level set with `-x0` must not exceed the `-xmaxopt` value.

## A.2.157 **-xmema1ign=ab**

(SPARC) Use the `-xmema1ign` option to control the assumptions the compiler makes about the alignment of data. By controlling the code generated for potentially misaligned memory accesses and by controlling program behavior in the event of a misaligned access, you can more easily port your code to SPARC.

Specify the maximum assumed memory alignment and behavior of misaligned data accesses. You must provide a value for both *a* (alignment) and *b* (behavior). *a* specifies the maximum assumed memory alignment and *b* specifies the behavior for misaligned memory accesses.

For memory accesses where the alignment is determinable at compile time, the compiler generates the appropriate load/store instruction sequence for that alignment of data.

For memory accesses where the alignment cannot be determined at compile time, the compiler must assume an alignment to generate the needed load/store sequence.

If actual data alignment at runtime is less than the specified alignment, the misaligned access attempt (a memory read or write) generates a trap. The two possible responses to the trap are:

- The OS converts the trap to a SIGBUS signal. If the program does not catch the signal, the program aborts. Even if the program catches the signal, the misaligned access attempt will not have succeeded.
- The OS handles the trap by interpreting the misaligned access and returning control to the program as if the access had succeeded normally.

### A.2.157.1 Values

The following lists the alignment and behavior values for `-xmemalign`

Values for *a*:

1	Assume at most 1–byte alignment.
2	Assume at most 2–byte alignment.
4	Assume at most 4–byte alignment.
8	Assume at most 8–byte alignment.
16	Assume at most 16–byte alignment.

Values for *b*:

<i>i</i>	Interpret access and continue execution.
<i>s</i>	Raise signal SIGBUS
<i>f</i>	For 64–bit SPARC architectures: Raise signal SIGBUS for alignments less or equal to 4. Otherwise interpret access and continue execution. For all other architectures, the flag is equivalent to <i>i</i> .

You must specify `-xmemalign` whenever you want to link to an object file that was compiled with the value of `b` set to either `i` or `f`. For a complete list of all compiler options that must be specified at both compile time and at link time, see “[3.4.3 Compile-Time and Link-Time Options](#)” on page 46.

### A.2.157.2 Defaults

The following default values only apply when no `-xmemalign` option is present:

- `-xmemalign=8i` for all 32-bit SPARC architectures (`-m32`)
- `-xmemalign=8s` for all 64-bit SPARC architectures (`-m64`)

The following default value when the `-xmemalign` option is present but no value is given is:

- `-xmemalign=1i` for all architectures.

### A.2.157.3 Examples

The following shows how you can use `-xmemalign` to handle different alignment situations.

<code>-xmemalign=1s</code>	All memory accesses are misaligned so trap handling is too slow.
<code>-xmemalign=8i</code>	Occasional, intentional, misaligned accesses can occur in code that is otherwise correct.
<code>-xmemalign=8s</code>	No misaligned accesses occur in the program.
<code>-xmemalign=2s</code>	You want to check for possible odd-byte accesses.
<code>-xmemalign=2i</code>	You want to check for possible odd-byte access and you want the program to work.

## A.2.158 `-xmodel=[a]`

(x86) The `-xmodel` option enables the compiler to modify the form of 64-bit objects for the x86 platforms and should be specified only for the compilation of such objects.

This option is invalid when specified with `-m32`.

The following table lists the possible values for `a`.

**TABLE 68** The `-xmodel` Flags

Value	Meaning
<code>small</code>	This option generates code for the small model in which the virtual address of code executed is known at link time and all symbols are known to be located in the virtual addresses in the range from 0 to $2^{31} - 2^{24} - 1$ .
<code>kernel</code>	Generates code for the kernel model in which all symbols are defined to be in the range from $2^{64} - 2^{31}$ to $2^{64} - 2^{24}$ .
<code>medium</code>	Generates code for the medium model in which no assumptions are made about the range of symbolic references to data sections. The size and address of the text section have the same limits as the small code model. Applications with large amounts of static data might require <code>-xmodel=medium</code> when compiling with <code>-m64</code> .

This option is not cumulative so the compiler sets the model value according to the right-most instance of `-xmodel` on the command-line.

If you do not specify `-xmodel`, the compiler assumes `-xmodel=small`. Specifying `-xmodel` without an argument is an error.

You do not need to compile all translation units with this option. You can compile select files as long as you ensure the object you are accessing is within reach.

Be aware that not all Oracle Linux system support the medium model.

## A.2.159 `-xnoLib`

Disables linking with default system libraries.

Without this option, the C++ compiler links with several system support libraries to support C++ programs. With this option, the `-lLib` options to link the default system support libraries are not passed to `ld`.

Normally, the compiler links with the system support libraries in the following order:

For `-compat=5` on Oracle Solaris, the libraries are:

```
-lxxx -lCrun -lm -lc
```

where `-lxxx` is one of the following: `Cstd`, `stlport`, or `stdcxx`.

For `-compat=5` on Oracle Linux, the libraries are:

```
-lxxx -lCrun -lm -lc
```

where `-lxxx` is one of the following: `Cstd` or `stlport`.



For `-compat=g`, `-std=c++03`, `-std=c++11`, and `-std=c++14` on all platforms, the libraries are:

```
-lstdc++ -lgcc_s -lCrunG3 -lm -lc
```

On Oracle Solaris, `-compat=5 -library=stdc++4` is the default.

On Oracle Linux, `-std=c++03` is the default.

The order of the `-l` options is significant. The `-lm` option must appear before `-lc`.

To determine which system support libraries will be linked by default, compile with the `-dryrun` option. For example, the output from the following command on Oracle Solaris:

```
example% CC foo.cc -m64 -dryrun
```

shows the following in the output:

```
-lstdc++4 -lCrun -lm -lc
```

### A.2.159.1 Examples

For minimal compilation to meet the C application binary interface (that is, a C++ program with only C support required), use the following command:

```
example% CC -xnoLib test.cc -lc
```

### A.2.159.2 Interactions

If you specify `-xnoLib`, you must manually link all required system support libraries in the given order. You must link the system support libraries last.

If `-xnoLib` is specified, `-library` is ignored.

`libatomic` and `libatomic` are affected by the `-xnoLib` option. You can explicitly link `libatomic` by either `-xatomic=studio` or `-latomic` and explicitly link `libatomic` by `-xatomic=gcc`.

### A.2.159.3 Warnings

Many C++ language features require the use of `libCrun` (`-compat=5` mode) or `libCrunG3` (g++ compatibility modes).

This set of system support libraries is not stable and might change from release to release.

Many C++ language features require the use of the Oracle Developer Studio C++ library `libstatomic` or system library `libatomic` (`-std=c++03|c++11|c++14` mode).

#### **A.2.159.4 See Also**

[“A.2.48 `-lib`” on page 214](#), [“A.2.51 `-library=l\[,l...\]`” on page 215](#), [“A.2.87 `-staticlib=l\[,l...\]`” on page 228](#), [“A.2.111 `-xatomic=a`” on page 249](#)

#### **A.2.160 `-xnoibmil`**

Cancels `-xlibmil` on the command line.

Use this option with `-fast` to override linking with the optimized math library.

#### **A.2.161 `-xnoibmopt`**

Does not use the math routine library.

##### **A.2.161.1 Examples**

Use this option after the `-fast` option on the command line, as in this example:

```
example% CC -fast -xnoibmopt
```

#### **A.2.162 `-xnorunpath`**

Same as [“A.2.62 `-norunpath`” on page 220](#)

#### **A.2.163 `-xOlevel`**

Specifies optimization level; note the uppercase letter O followed by the digit 1, 2, 3, 4, or 5. In general, program execution speed depends on the level of optimization. The higher the level of optimization, the better the runtime performance. However, higher optimization levels can result in increased compilation time and larger executable files.

In a few cases, `-x02` might perform better than the others, and `-x03` might outperform `-x04`. Try compiling with each level to see if you have one of these rare cases.

If the optimizer runs out of memory, it tries to recover by retrying the current procedure at a lower level of optimization. The optimizer resumes subsequent procedures at the original level specified in the `-x0level` option.

The following sections describe how the five `-x0level` optimization levels operate on the SPARC platform and the x86 platform.

### A.2.163.1 Values

#### On the SPARC Platform:

- `-x01` does only the minimum amount of optimization (peephole), which is post-pass, assembly-level optimization. Do not use `-x01` unless using `-x02` or `-x03` results in excessive compilation time, or you are running out of swap space.
- `-x02` does basic local and global optimization, which includes:
  - Induction-variable elimination
  - Local and global common-subexpression elimination
  - Algebraic simplification
  - Copy propagation
  - Constant propagation
  - Loop-invariant optimization
  - Register allocation
  - Basic block merging
  - Tail recursion elimination
  - Dead-code elimination
  - Tail-call elimination
  - Complicated expression expansion

This level does not optimize references or definitions for external or indirect variables.
- `-x03`, in addition to optimizations performed at the `-x02` level, also optimizes references and definitions for external variables. This level does not trace the effects of pointer assignments. When compiling either device drivers that are not properly protected by `volatile` or programs that modify external variables from within signal handlers, use `-x02`. In general, this level results in increased code size unless combined with the `-xspace` option.
- `-x04` does automatic inlining of functions contained in the same file in addition to performing `-x03` optimizations. This automatic inlining usually improves execution speed

but sometimes makes it worse. In general, this level results in increased code size unless combined with the `-xspace` option.

- `-x05` generates the highest level of optimization. It is suitable only for the small fraction of a program that uses the largest fraction of computer time. This level uses optimization algorithms that take more compilation time or that do not have as high a certainty of improving execution time. Optimization at this level is more likely to improve performance if it is done with profile feedback. See “[A.2.178 `-xprofile=p`” on page 319](#).

#### **On the x86 Platform:**

- `-x01` does basic optimization. This includes algebraic simplification, register allocation, basic block merging, dead code and store elimination, and peephole optimization.
- `-x02` performs local common subexpression elimination, local copy and constant propagation, and tail recursion elimination, as well as the optimization done by level 1.
- `-x03` performs global common subexpression elimination, global copy and constant propagation, loop strength reduction, induction variable elimination, and loop-variant optimization, as well as the optimization done by level 2.
- `-x04` does automatic inlining of functions contained in the same file as well as the optimization done by level 3. This automatic inlining usually improves execution speed but sometimes makes it worse. This level also frees the frame pointer registration (ebp) for general purpose use. In general, this level results in increased code size.
- `-x05` generates the highest level of optimization. It uses optimization algorithms that take more compilation time or that do not have as high a certainty of improving execution time.

### **A.2.163.2 Interactions**

If you use `-g` or `-g0` and the optimization level is `-x03` or lower, the compiler provides best-effort symbolic information with almost full optimization.

If you use `-g` or `-g0` and the optimization level is `-x04` or higher, the compiler provides best-effort symbolic information with full optimization.

Debugging with `-g` does not suppress `-x0level`, but `-x0level` limits `-g` in certain ways. For example, the `-x0level` options reduce the utility of debugging so that you cannot display variables from `dbx`, but you can still use the `dbx where` command to get a symbolic traceback. For more information, see *Debugging a Program With dbx*.

The `-xipo` option is effective only if it is used with `-x04` or `-x05`.

The `-xinline` option has no effect for optimization levels below `-x03`. At `-x04`, the optimizer decides which functions should be inlined, and does so regardless of whether you specify the `-xinline` option. At `-x04`, the compiler also attempts to determine which functions will improve

performance if they are inlined. If you force the inlining of a function with `-xinline`, you might actually diminish performance.

### A.2.163.3 Defaults

The default is no optimization. However, this is only possible if you do not specify an optimization level. If you specify an optimization level, there is no option for turning optimization off.

If you are trying to avoid setting an optimization level, be sure not to specify any option that implies an optimization level. For example, `-fast` is a macro option that sets optimization at `-x05`. All other options that imply an optimization level issue a warning message that optimization has been set. The only way to compile without any optimization is to delete all options from the command line or make file that specify an optimization level.

### A.2.163.4 Warnings

If you optimize at `-x03` or `-x04` with very large procedures (thousands of lines of code in a single procedure), the optimizer might require an unreasonable amount of memory. In such cases, machine performance can be degraded.

To prevent this degradation from taking place, use the `limit` command to limit the amount of virtual memory available to a single process. See the `cs(1)` man page. For example, to limit virtual memory to 4 gigabytes:

```
example% limit datasize 4G
```

This command causes the optimizer to try to recover if it reaches 4 gigabytes of data space.

The limit cannot be greater than the total available swap space of the machine, and should be small enough to permit normal use of the machine while a large compilation is in progress.

The best setting for data size depends on the degree of optimization requested, the amount of real memory, and virtual memory available.

To find the actual swap space, type `swap- l`

To find the actual real memory, type `dmesg | grep mem`

### A.2.163.5 See Also

`-xldscope -fast, -xprofile=p, cs(1)` man page

## A.2.164 -xopenmp[={parallel|noopt|none}]

Enable explicit parallelization with OpenMP directives.

### A.2.164.1 Values

The following table details the -xopenmp values:

**TABLE 69** -xopenmp Values

Values	Meaning
parallel	<p>Enables recognition of OpenMP pragmas. The optimization level under -xopenmp=parallel is -xO3. The compiler raises the optimization to -xO3 if necessary and issues a warning.</p> <p>This flag also defines the preprocessor macro <code>_OPENMP</code>. The <code>_OPENMP</code> macro is defined to have the decimal value <code>yyyymm</code> where <code>yyyy</code> and <code>mm</code> are the year and month designations of the version of the OpenMP API that the implementation supports. Refer to the <a href="#">Oracle Developer Studio 12.5: OpenMP API User's Guide</a> for the value of the <code>_OPENMP</code> macro for a particular release.</p>
noopt	<p>Enables recognition of OpenMP pragmas. The compiler does not raise the optimization level if it is lower than -O3.</p> <p>If you explicitly set the optimization lower than -O3, as in <code>CC -O2 -xopenmp=noopt</code>, the compiler issues an error. If you do not specify an optimization level with -xopenmp=noopt, the OpenMP pragmas are recognized, the program is parallelized accordingly, but no optimization is done.</p> <p>This flag also defines the preprocessor macro <code>_OPENMP</code>.</p>
none	<p>Does not enable recognition of OpenMP pragmas, makes no change to the optimization level of your program, and does not define any preprocessor macros. This is the default when -xopenmp is not specified.</p>

### A.2.164.2 Defaults

If you specify -xopenmp but do not specify a value, the compiler assumes -xopenmp=parallel. If you do not specify -xopenmp at all, the compiler assumes -xopenmp=none.

### A.2.164.3 Interactions

If you are debugging an OpenMP program with dbx, compile with -g -xopenmp=noopt so you can breakpoint within parallel regions and display the contents of variables.

Use the `OMP_NUM_THREADS` environment variable to specify the number of threads to use when running an OpenMP program. If `OMP_NUM_THREADS` is not set, the default number of threads used is a multiple of the number of cores per socket (that is, cores per processor chip), which is less than or equal to the total number of cores or 32, whichever is less. You can specify a different number of threads by setting the `OMP_NUM_THREADS` environment variable, or by calling the `omp_set_num_threads()` OpenMP runtime routine, or by using the `num_threads` clause on the parallel region directive. For best performance, the number of threads used to execute a parallel region should not exceed the number of hardware threads (or virtual processors) available on the machine. On Oracle Solaris systems, this number can be determined by using the `psrinfo(1M)` command. On Oracle Linux systems, this number can be determined by inspecting the file `/proc/cpuinfo`. See the [Oracle Developer Studio 12.5: OpenMP API User's Guide](#) for more information.

Nested parallelism is disabled by default. To enable nested parallelism, you must set the `OMP_NESTED` environment variable to `TRUE`. See the [Oracle Developer Studio 12.5: OpenMP API User's Guide](#) for details.

#### A.2.164.4 Warnings

The default for `-xopenmp` might change in a future release. You can avoid warning messages by explicitly specifying an appropriate optimization level.

If you compile and link in separate steps, specify `-xopenmp` in both the compilation step and the link step. When used with the link step, the `-xopenmp` option will link with the OpenMP runtime support library, `libmtnsk.so`.

For up-to-date functionality and performance, make sure that the latest patch of the OpenMP runtime library, `libmtnsk.so`, is installed on the system.

#### A.2.164.5 See Also

For more information about the OpenMP Fortran 95, C, and C++ application program interface (API) for building multithreaded applications, see the [Oracle Developer Studio 12.5: OpenMP API User's Guide](#).

#### A.2.165 `-xpagesize=n`

Sets the preferred page size for the stack and the heap.

### A.2.165.1 Values

The following values are valid for SPARC: 4k, 8K, 64K, 512K, 2M, 4M, 32M, 256M, 2G, 16G, or default.

The following values are valid on x86/x64: 4K, 2M, 4M, 1G, or default.

You must specify a valid page size for the target platform. If you do not specify a valid page size, the request is silently ignored at runtime.

Use the `pagesize(1)` Oracle Solaris command to determine the number of bytes in a page. The operating system offers no guarantee that the page size request will be honored. However, appropriate segment alignment can be used to increase the likelihood of obtaining the requested page size. See the `-xsegment_align` option on how to set the segment alignment. You can use `pmap(1)` or `meminfo(2)` to determine page size of the target platform.

---

**Note** - Compiling with this option has the same effect as setting the `LD_PRELOAD` environment variable to `mpss.so.1` with the equivalent options, or running the Oracle Solaris command `ppgsz(1)` with the equivalent options before running the program. See the Oracle Solaris man pages for details.

---

---

**Note** - The `libhugetlbf`s library is required for `-xpagesize` to work on Oracle Linux. See the Oracle Linux `libhugetlbf(7)` man page for more information.

---

### A.2.165.2 Defaults

If you specify `-xpagesize=default`, the Oracle Solaris operating system sets the page size.

### A.2.165.3 Expansions

This option is a macro for `-xpagesize_heap` and `-xpagesize_stack`. These two options accept the same arguments as `-xpagesize`: 4k, 8K, 64K, 512K, 2M, 4M, 32M, 256M, 2G, 16G, or default. You can set them both with the same value by specifying `-xpagesize` or you can specify them individually with different values.



## A.2.165.4 Warnings

The `-xpagesize` option has no effect unless you use it at compile time and at link time. See [“3.4.3 Compile-Time and Link-Time Options” on page 46](#) for a complete list of options that must be specified at both compile time and link time.

## A.2.166 `-xpagesize_heap=n`

Set the page size in memory for the heap.

### A.2.166.1 Values

`n` can be 4k, 8K, 64K, 512K, 2M, 4M, 32M, 256M, 2G, 16G, or `default`. You must specify a valid page size for the target platform. If you do not specify a valid page size, the request is silently ignored at runtime.

Use the `getpagesize(3C)` command on the Oracle Solaris operating system to determine the number of bytes in a page. The Oracle Solaris operating system offers no guarantee that the page size request will be honored. You can use `pmmap(1)` or `meminfo(2)` to determine the page size of the target platform.

---

**Note** - Compiling with this option has the same effect as setting the `LD_PRELOAD` environment variable to `mpss.so.1` with the equivalent options, or running the Oracle Solaris command `ppgsz(1)` with the equivalent options before running the program. See the Oracle Solaris man pages for details.

---

### A.2.166.2 Defaults

If you specify `-xpagesize_heap=default`, the Oracle Solaris operating system sets the page size.

### A.2.166.3 Warnings

The `-xpagesize_heap` option has no effect unless you use it at compile time and at link time.

## A.2.167 **-xpagesize\_stack=*n***

Set the page size in memory for the stack.

### A.2.167.1 **Values**

*n* can be 4k, 8K, 64K, 512K, 2M, 4M, 32M, 256M, 2G, 16G, or default. You must specify a valid page size for the target platform. If you do not specify a valid page size, the request is silently ignored at runtime.

Use the `getpagesize(3C)` command on the Oracle Solaris operating system to determine the number of bytes in a page. The Oracle Solaris operating system offers no guarantee that the page size request will be honored. You can use `pmap(1)` or `meminfo(2)` to determine the page size of the target platform.

---

**Note** - Compiling with this option has the same effect as setting the `LD_PRELOAD` environment variable to `mpss.so.1` with the equivalent options, or running the Oracle Solaris command `ppgsz(1)` with the equivalent options before running the program. See the Oracle Solaris man pages for details.

---

### A.2.167.2 **Defaults**

If you specify `-xpagesize_stack=default`, the Oracle Solaris operating system sets the page size.

### A.2.167.3 **Warnings**

The `-xpagesize_stack` option has no effect unless you use it at compile time and at link time.

## A.2.168 **-xpatchpadding[={*fix*|*patch*|*size*}]**

Reserve an area of memory before the start of each function. If `fix` is specified, the compiler will reserve the amount of space required by `fix` and continue. This is the first default. If either `patch` or no value is specified, the compiler will reserve a platform-specific default value. A value of `-xpatchpadding=0` will reserve 0 bytes of space. The maximum value for `size` on x86 is 127 bytes and on SPARC is 2048 bytes.

## A.2.169 -xpch=v

This compiler option activates the precompiled-header feature. The precompiled-header feature might reduce compile time for applications whose source files share a common set of include files containing a large amount of source code. The compiler collects information about a sequence of header files from one source file, and then uses that information when recompiling that source file, and when compiling other source files that have the same sequence of headers. The information that the compiler collects is stored in a precompiled-header file. You can take advantage of this feature through the `-xpch` and `-xpchstop` options in combination with the `#pragma hdrstop` directive.

### A.2.169.1 Creating a Precompiled-Header File

When you specify `-xpch=v`, `v` can be `collect:pch-filename` or `use:pch-filename`. The first time you use `-xpch`, you must specify the `collect` mode. The compilation command that specifies `-xpch=collect` must only specify one source file. In the following example, the `-xpch` option creates a precompiled-header file called `myheader.Cpch` based on the source file `a.cc`:

```
CC -xpch=collect:myheader a.cc
```

A valid precompiled-header filename always has the suffix `.Cpch`. When you specify `pch-filename`, you can add the suffix or let the compiler add it for you. For example, if you specify `cc -xpch=collect:foo a.cc`, the precompiled-header file is called `foo.Cpch`.

When you create a precompiled-header file, pick a source file that contains the common sequence of include files across all the source files with which the precompiled-header file is to be used. The common sequence of include files must be identical across these source files. Remember, only one source filename value is legal in `collect` mode. For example, `CC -xpch=collect:foo bar.cc` is valid, whereas `CC -xpch=collect:foo bar.cc foobar.cc` is invalid because it specifies two source files.

### Using a Precompiled-Header File

Specify `-xpch=use:pch-filename` to use a precompiled-header file. You can specify any number of source files with the same sequence of include files as the source file that was used to create the precompiled-header file. For example, your command in `use` mode could look like this: `CC -xpch=use:foo.Cpch foo.c bar.cc foobar.cc`.

You should only use an existing precompiled-header file if the following situations are true. If any are not true, you should recreate the precompiled-header file:

- The compiler that you are using to access the precompiled-header file is the same as the compiler that created the precompiled-header file. A precompiled-header file created by one version of the compiler might not be usable by another version of the compiler, including differences caused by installed patches.
- Except for the `-xpch` option, the compiler options you specify with `-xpch=use` must match the options that were specified when the precompiled-header file was created.
- The set of included headers you specify with `-xpch=use` is identical to the set of headers that were specified when the precompile header was created.
- The contents of the included headers that you specify with `-xpch=use` is identical to the contents of the included headers that were specified when the precompiled header was created.
- The current directory (that is, the directory in which the compilation is occurring and attempting to use a given precompiled-header file) is the same as the directory in which the precompiled-header file was created.
- The initial sequence of preprocessing directives, including `#include` directives, in the file you specify with `-xpch=collect` are the same as the sequence of preprocessing directives in the files you specify with `-xpch=use`.

In order to share a precompiled-header file across multiple source files, those source files must share a common set of include files as their initial sequence of tokens. This initial sequence of tokens is known as the *viable prefix*. The viable prefix must be interpreted consistently across all the source files that use the same precompiled-header file.

The viable prefix of a source file can only be comprised of comments and any of the following preprocessor directives:

```
#include
#if/ifdef/ifndef/else/elif/endif
#define/undef
#ident (if identical, passed through as is)
#pragma (if identical)
```

Any of these directives may reference macros. The `#else`, `#elif`, and `#endif` directives must match within the viable prefix.

Within the viable prefix of each file that shares a precompiled-header file, each corresponding `#define` and `#undef` directive must reference the same symbol. In the case of `#define`, each one must reference the same value. Their order of appearance within each viable prefix must be the same as well. Each corresponding `pragma` must also be the same and appear in the same order across all the files sharing a precompiled header.

A header file that is incorporated into a precompiled-header file must not violate the following constraints. The results of compiling a program that violates any of these constraints is undefined.

- The header file must not contain function and variable definitions.
- The header file must not use `__DATE__` and `__TIME__`. Use of these preprocessor macros can generate unpredictable results.
- The header file must not contain `#pragma hdrstop`.
- The header file must not use `__LINE__` and `__FILE__` in the viable prefix. You can use `__LINE__` and `__FILE__` in included headers.

## How to Modify Makefiles

This section describes possible approaches to modifying your makefiles in order to incorporate `-xpch` into your builds.

- You can use the implicit make rules by using an auxiliary `CCFLAGS` variable and the `KEEP_STATE` facility of both `make` and `dmake`. The precompiled header is produced as a separate independent step.

```
.KEEP_STATE:
CCFLAGS_AUX = -O etc
CCFLAGS = -xpch=use:shared $(CCFLAGS_AUX)
shared.Cpch: foo.cc
    $(CCC) -xpch=collect:shared $(CCFLAGS_AUX) foo.cc
a.out: foo.o ping.o pong.o
    $(CCC) foo.o ping.o pong.o
```

You can also define your own compilation rule instead of trying to use an auxiliary `CCFLAGS`.

```
.KEEP_STATE:
.SUFFIXES: .o .cc
%.o:%.cc shared.Cpch
    $(CCC) -xpch=use:shared $(CCFLAGS) -c $<
shared.Cpch: foo.cc
    $(CCC) -xpch=collect:shared $(CCFLAGS) foo.cc -xe
a.out: foo.o ping.o pong.o
    $(CCC) foo.o ping.o pong.o
```

- You can produce the precompiled header as a side effect of regular compilation and without using `KEEP_STATE`, but this approach requires explicit compilation commands.

```
shared.Cpch + foo.o: foo.cc bar.h
    $(CCC) -xpch=collect:shared foo.cc $(CCFLAGS) -c
ping.o: ping.cc shared.Cpch bar.h
    $(CCC) -xpch=use:shared ping.cc $(CCFLAGS) -c
pong.o: pong.cc shared.Cpch bar.h
    $(CCC) -xpch=use:shared pong.cc $(CCFLAGS) -c
a.out: foo.o ping.o pong.o
    $(CCC) foo.o ping.o pong.o
```

## A.2.169.2 See Also

- [“A.2.170 -xpchstop=file” on page 310](#)
- [“B.2.9 #pragma hdrstop” on page 349](#)

## A.2.170 -xpchstop=file

Use the `-xpchstop=file` option to specify the last include file to be considered in creating the precompiled header file with the `-xpch` option. Using `-xpchstop` on the command line is equivalent to placing a `hdrstop` pragma after the first include-directive that references file in each of the source files that you specify with the `cc` command.

In the following example, the `-xpchstop` option specifies that the viable prefix for the precompiled header file ends with the include of `projectheader.h`. Therefore, `privateheader.h` is not a part of the viable prefix.

```
example% cat a.cc
#include <stdio.h>
#include <strings.h>
#include "projectheader.h"
#include "privateheader.h"
.
.
.
example% CC -xpch=collect:foo.Cpch a.cc -xpchstop=projectheader.h -c
```

## A.2.170.1 See Also

`-xpch`, `pragma hdrstop`

## A.2.171 -xpec [= {yes | no}]

(Solaris) Generates a Portable Executable Code (PEC) binary. This option puts the program intermediate representations in the object file and the binary. This binary may be used later for tuning and troubleshooting.

A binary that is built with `-xpecis` usually five to ten times larger than if it is built without `-xpec`.

---

If you do not specify `-xpec`, the compiler sets it to `-xpec=no`. If you specify `-xpec`, but do not supply a flag, the compiler sets it to `-xpec=yes`.

## A.2.172 `-xpg`

Compiles for profiling with the `gprof` profiler.

The `-xpg` option compiles self-profiling code to collect data for profiling with `gprof`. This option invokes a runtime recording mechanism that produces a `gmon.out` file when the program normally terminates.

---

**Note** - `-xprofile` does not benefit if you specify `-xpg`. The two do not prepare or use data provided by the other.

---

Profiles are generated by using `prof(1)` or `gprof(1)` on 64-bit Oracle Solaris platforms or just `gprof` on 32-bit Oracle Solaris platforms and include approximate user CPU times. These times are derived from PC sample data for routines in the main executable and routines in shared libraries specified as linker arguments when the executable is linked. Other shared libraries (libraries opened after process startup using `dlopen(3C)`) are not profiled.

On 32-bit Oracle Solaris systems, profiles generated using `prof(1)` are limited to routines in the executable. 32-bit shared libraries can be profiled by linking the executable with `-xpg` and using `gprof(1)`.

On x86 systems, `-xpg` is incompatible with `-xregs=frameptr`, and these two options should not be used together. Note also that `-xregs=frameptr` is included in `-fast`.

The Solaris 10 software does not include system libraries compiled with `-p`. As a result, profiles collected on Oracle Solaris 10 platforms do not include call counts for system library routines.

### A.2.172.1 Warnings

If you compile and link separately and you compile with `-xpg`, be sure to link with `-xpg`. See [“3.4.3 Compile-Time and Link-Time Options” on page 46](#) for a complete list of options that must be specified at both compile time and link time.

Binaries compiled with `-xpg` for `gprof` profiling should not be used with `binopt(1)`, as they are incompatible and can result in internal errors.

## A.2.172.2 See Also

`-xprofile=p`, the `analyzer(1)` man page, and the *Performance Analyzer* manual

## A.2.173 `-xport64[=(v)]`

Use this option to help you debug code you are porting to a 64-bit environment. Specifically, this option warns against problems such as truncation of types (including pointers), sign extension, and changes to bit-packing that are common when code is ported from a 32-bit architecture such as V8 to a 64-bit architecture such as V9.

This option has no effect unless you are also compiling in 64-bit mode, `-m64`.

### A.2.173.1 Values

The following table lists the valid values for `v`.

**TABLE 70** `-xport64` Values

Values	Meaning
<code>no</code>	Generate no warnings related to the porting of code from a 32-bit environment to a 64-bit environment.
<code>implicit</code>	Generate warning only for implicit conversions. Do not generate warnings when an explicit cast is present.
<code>full</code>	Generate all warnings related to the porting of code from a 32-bit environment to a 64-bit environment. This includes warnings for truncation of 64-bit values, sign-extension to 64 bits under ISO value-preserving rules, and changes to the packing of bitfields.

### A.2.173.2 Defaults

If you do not specify `-xport64`, the default is `-xport64=no`. If you specify `-xport64` but do not specify a flag, the default is `-xport64=full`.

### A.2.173.3 Examples

This section provides examples of code that can cause truncation of type, sign extension, and changes to bit-packing.



## Checking for the Truncation of 64-bit Values

When you port to a 64-bit architecture such as SPARC V9, your data may be truncated. The truncation could happen implicitly, by assignment, at initialization, or by an explicit cast. The difference of two pointers is the typedef `ptrdiff_t`, which is a 32-bit integer type in 32-bit mode, and a 64-bit integer type in 64-bit mode. The truncation of a long to a smaller size integral type generates a warning as in the following example.

```
example% cat test1.c
int x[10];

int diff = &x[10] - &x[5]; //warn

example% CC -c -m64 -Qoption ccfe -xport64=full test1.c
"test1.c", line 3: Warning: Conversion of 64-bit type value to "int" causes truncation.
1 Warning(s) detected.
example%
```

Use `-xport64=implicit` to disable truncation warnings in 64-bit compilation mode when an explicit cast is the cause of data truncation.

```
example% CC -c -m64 -Qoption ccfe -xport64=implicit test1.c
"test1.c", line 3: Warning: Conversion of 64-bit type value to "int" causes truncation.
1 Warning(s) detected.
example%
```

Another common issue that arises from porting to a 64-bit architecture is the truncation of a pointer. This is always an error in C++. An operation such as casting a pointer to an `int` which causes such a truncation results in an error diagnostic in 64-bit SPARC architectures when you specify `-xport64`.

```
example% cat test2.c
char* p;
int main() {
    p =(char*) (((unsigned int)p) & 0xFF); // -m64 error
    return 0;
}
example% CC -c -m64 -Qoption ccfe -xport64=full test2.c
"test2.c", line 3: Error: Cannot cast from char* to unsigned.
1 Error(s) detected.
example%
```

## Checking for Sign Extension

You can also use the `-xport64` option to check for situations in which the normal ISO C value-preserving rules allow for the extension of the sign of a signed-integral value in an expression of unsigned-integral type. Such sign extensions can cause subtle run-time bugs.

```
example% cat test3.c
int i= -1;
void promo(unsigned long l) {}

int main() {
    unsigned long l;
    l = i; // warn
    promo(i); // warn
}
example% CC -c -m64 -Qoption ccfe -xport64=full test3.c
"test3.c", line 6: Warning: Sign extension from "int" to 64-bit integer.
"test3.c", line 7: Warning: Sign extension from "int" to 64-bit integer.
2 Warning(s) detected.
```

## Checking for Changes to the Packing of Bitfields

Use `-xport64` to generate warnings against long bitfields. In the presence of such bitfields, packing of the bitfields might drastically change. Any program which relies on assumptions regarding the way bitfields are packed needs to be reviewed before a successful port can take place to a 64-bit architecture.

```
example% cat test4.c
#include <stdio.h>

union U {
    struct S {
        unsigned long b1:20;
        unsigned long b2:20;
    } s;

    long buf[2];
} u;

int main() {
    u.s.b1 = 0XFFFFFF;
    u.s.b2 = 0XFFFFFF;
    printf(" u.buf[0] = %lx u.buf[1] = %lx\n", u.buf[0], u.buf[1]);
    return 0;
}
example%
```

Output on 64-bit SPARC systems (-m64):

```
example% u.buf[0] = ffffffff000000 u.buf[1] = 0
```

### A.2.173.4 Warnings

Note that warnings are generated only when you compile in 64-bit mode using -m64.

### A.2.173.5 See Also

[“A.2.52 -m32|-m64” on page 218](#)

## A.2.174 -xprefetch[=*a*[, *a*...]]

Enable prefetch instructions on those architectures that support prefetch.

Explicit prefetching should only be used under special circumstances that are supported by measurements.

The following table lists the possible values of *a*.

**TABLE 71** -xprefetch Values

Value	Meaning
auto	Enable automatic generation of prefetch instructions.
no%auto	Disable automatic generation of prefetch instructions.
explicit	Enable explicit prefetch macros.
no%explicit	Disable explicit prefetch macros.
latx: <i>factor</i>	(SPARC) Adjust the compiler’s assumed prefetch-to-load and prefetch-to-store latencies by the specified factor. You can combine this flag only with -xprefetch=auto. The factor must be a positive floating-point or integer number.
yes	Obsolete, do not use. Use -xprefetch=auto,explicit instead.
no	Obsolete, do not use. Use -xprefetch=no%auto,no%explicit instead.

With -xprefetch and -xprefetch=auto the compiler is free to insert prefetch instructions into the code it generates. This may result in a performance improvement on architectures that support prefetch.

If you are running computationally intensive codes on large multiprocessors, using -xprefetch=latx:*factor* could improve performance. This option instructs the code generator

to adjust the default latency time between a prefetch and its associated load or store by the specified factor.

The prefetch latency is the hardware delay between the execution of a prefetch instruction and the time the data being prefetched is available in the cache. The compiler assumes a prefetch latency value when determining how far apart to place a prefetch instruction and the load or store instruction that uses the prefetched data.

---

**Note** - The assumed latency between a prefetch and a load may not be the same as the assumed latency between a prefetch and a store.

---

The compiler tunes the prefetch mechanism for optimal performance across a wide range of machines and applications. This tuning may not always be optimal. For memory-intensive applications, especially applications intended to run on large multiprocessors, you may be able to obtain better performance by increasing the prefetch latency values. To increase the values, use a factor that is greater than 1 (one). A value between .5 and 2.0 will most likely provide the maximum performance.

For applications with data sets that reside entirely within the external cache, you may be able to obtain better performance by decreasing the prefetch latency values. To decrease the values, use a factor that is less than 1 (one).

To use the `-xprefetch=latx:factor` option, start with a factor value near 1.0 and run performance tests against the application. Then increase or decrease the factor, as appropriate, and run the performance tests again. Continue adjusting the factor and running the performance tests until you achieve optimum performance. When you increase or decrease the factor in small steps, you will see no performance difference for a few steps, then a sudden difference, then it will level off again.

## A.2.174.1 Defaults

The default is `-xprefetch=auto,explicit`. This default adversely affects applications that have essentially non-linear memory access patterns. Specify `-xprefetch=no%auto,no%explicit` to override the default.

The default of `auto` is assumed unless explicitly overridden with an argument of `no%auto` or an argument of `no`. For example, `-xprefetch=explicit` is the same as `-xprefetch=explicit,auto`.

The default of `explicit` is assumed unless explicitly overridden with an argument of `no%explicit` or an argument of `no`. For example, `-xprefetch=auto` is the same as `-xprefetch=auto,explicit`.

If only `-xprefetch` is specified, `-xprefetch=auto,explicit` is assumed.

If automatic prefetching is enabled, but a latency factor is not specified, then `-xprefetch=latx:1.0` is assumed.

### A.2.174.2 Interactions

This option accumulates instead of overrides.

The `sun_prefetch.h` header file provides the macros for specifying explicit prefetch instructions. The prefetches will be approximately at the place in the executable that corresponds to where the macros appear.

To use the explicit prefetch instructions, you must be on the correct architecture, include `sun_prefetch.h`, and either exclude `-xprefetch` from the compiler command or use `-xprefetch`, `-xprefetch=auto,explicit` or `-xprefetch=explicit`.

If you call the macros and include the `sun_prefetch.h` header file but specify `-xprefetch=no%explicit`, the explicit prefetches will not appear in your executable.

The use of `latx:factor` is valid only when automatic prefetching is enabled. `latx:factor` is ignored unless you use it in conjunction with `-xprefetch=auto, latx:factor`.

### A.2.174.3 Warnings

Explicit prefetching should be used only under special circumstances that are supported by measurements.

Because the compiler tunes the prefetch mechanism for optimal performance across a wide range of machines and applications, you should use `-xprefetch=latx:factor` only when the performance tests indicate there is a clear benefit. The assumed prefetch latencies might change from release to release. Therefore, retesting the effect of the latency factor on performance whenever switching to a different release is highly recommended.

### A.2.175 `-xprefetch_auto_type=a`

Where `a` is `[no%]indirect_array_access`.

Use this option to determine whether the compiler generates indirect prefetches for the loops indicated by the option `-xprefetch_level` in the same fashion the prefetches for direct memory accesses are generated.

If you do not specify a setting for `-xprefetch_auto_type`, the compiler sets it to `-xprefetch_auto_type=no%indirect_array_access`.

Options such as `-xdepend`, `-xrestrict`, and `-xalias_level` can affect the aggressiveness of computing the indirect prefetch candidates and therefore the aggressiveness of the automatic indirect prefetch insertion due to better memory alias disambiguation information.

## A.2.176 `-xprefetch_level[=i]`

Use the `-xprefetch_level=i` option to control the aggressiveness of the automatic insertion of prefetch instructions as determined with `-xprefetch=auto`. The compiler becomes more aggressive, or, in other words, introduces more prefetches, with each higher level of `-xprefetch_level`.

The appropriate value for `-xprefetch_level` depends on the number of cache misses your application has. Higher `-xprefetch_level` values have the potential to improve the performance of applications with a high number of cache misses.

### A.2.176.1 Values

*i* must be one of 1, 2, or 3, as shown in the following table.

**TABLE 72** `-xprefetch_level` Values

Value	Meaning
1	Enables automatic generation of prefetch instructions.
2	Targets additional loops beyond those targeted at <code>-xprefetch_level=1</code> for prefetch insertion. Additional prefetches could be inserted beyond those at <code>-xprefetch_level=1</code> .
3	Targets additional loops beyond those targeted at <code>-xprefetch_level=2</code> for prefetch insertion. Additional prefetches could be inserted beyond those at <code>-xprefetch_level=2</code> .

### A.2.176.2 Defaults

The default is `-xprefetch_level=1` when you specify `-xprefetch=auto`.

### A.2.176.3 Interactions

This option is effective only when it is compiled with `-xprefetch=auto`, with optimization level 3 or greater (`-xO3`), and on 64-bit platforms that support prefetch (`-m64`).

### A.2.177 `-xprewise={yes|no}`

Compile with this option to produce a static analysis of the source code that can be viewed using the Code Analyzer.

When compiling with `-xprewise=yes` and linking in a separate step, include `-xprewise=yes` also on the link step.

The default is `-xprewise=no`.

On Oracle Linux, `-xprewise=yes` needs to be specified along with `-xannotate`.

See the Oracle Developer Studio Code Analyzer documentation for further information.

### A.2.178 `-xprofile=p`

Collects data for a profile or uses a profile to optimize.

*p* must be `collect[:profdir]`, `use[:profdir]`, or `tcov[:profdir]`.

This option causes execution frequency data to be collected and saved during execution, then the data can be used in subsequent runs to improve performance. Profile collection is safe for multithreaded applications. Profiling a program that does its own multitasking (`-mt`) produces accurate results. This option is only valid when you specify `-xO2` or greater level of optimization. If compilation and linking are performed in separate steps, the same `-xprofile` option must appear on the link step as well as the compile step.

<code>collect[:<i>profdir</i>]</code>	Collects and saves execution frequency for later use by the optimizer with <code>-xprofile=use</code> . The compiler generates code to measure statement execution-frequency.
	<code>-xMerge</code> , <code>-ztext</code> , and <code>-xprofile=collect</code> should not be used together. While <code>-xMerge</code> forces statically initialized data into read-only storage, <code>-ztext</code> prohibits position-dependent symbol relocations in read-only storage, and <code>-xprofile=collect</code> generates statically initialized, position-dependent symbol relocations in writable storage.

The profile directory name *profdir*, if specified, is the pathname of the directory where profile data are to be stored when a program or shared library containing the profiled object code is executed. If the *profdir* pathname is not absolute, it is interpreted relative to the current working directory when the program is compiled with the option `-xprofile=use:profdir`.

If no profile directory name is specified with `-xprofile=collect:prof_dir` or `-xprofile=tcov:prof_dir`, profile data are stored at run time in a directory named *program.profile* where *program* is the basename of the profiled process's main program. In this case, the environment variables `SUN_PROFDATA` and `SUN_PROFDATA_DIR` can be used to control where the profile data are stored at run time. If set, the profile data are written to the directory given by `$SUN_PROFDATA_DIR/$SUN_PROFDATA`. If a profile directory name is specified at compilation time, `SUN_PROFDATA_DIR` and `SUN_PROFDATA` have no effect at run time. These environment variables similarly control the path and names of the profile data files written by `tcov`, as described in the `tcov(1)` man page.

If these environment variables are not set, the profile data is written to the directory *profdir.profile* in the current directory, where *profdir* is the name of the executable or the name specified in the `-xprofile=collect:profdir` flag. `-xprofile` does not append `.profile` to *profdir* if *profdir* already ends in `.profile`. If you run the program several times, the execution frequency data accumulates in the *profdir.profile* directory; that is output from prior executions is not lost.

If you are compiling and linking in separate steps, make sure that any object files compiled with `-xprofile=collect` are also linked with `-xprofile=collect`.

The following example collects and uses profile data in the directory *myprof.profile* located in the same directory where the program is built:

```
demo: CC -xprofile=collect:myprof.profile -xO5 prog.cc -o prog
demo: ./prog
demo: CC -xprofile=use:myprof.profile -xO5 prog.cc -o prog
```

The following example collects profile data in the directory `/bench/myprof.profile` and later uses the collected profile data in a feedback compilation at optimization level `-xO5`:

```
demo: CC -xprofile=collect:/bench/myprof.profile
```



```

\   -xO5 prog.cc -o prog
...run prog from multiple locations..
demo: CC -xprofile=use:/bench/myprof.profile
\   -xO5 prog.cc -o prog

```

use[:*profdir*]

Uses execution frequency data collected from code compiled with `-xprofile=collect[:profdir]` or `-xprofile=tcov[:profdir]` to optimize for the work performed when the profiled code was executed. *profdir* is the pathname of a directory containing profile data collected by running a program that was compiled with `-xprofile=collect[:profdir]` or `-xprofile=tcov[:profdir]`.

To generate data that can be used by both `tcov` and `-xprofile=use[:profdir]`, a profile directory must be specified at compilation time, using the option `-xprofile=tcov[:profdir]`. The same profile directory must be specified in both `-xprofile=tcov:profdir` and `-xprofile=use:profdir`. To minimize confusion, specify *profdir* as an absolute pathname.

The *profdir* pathname is optional. If *profdir* is not specified, the name of the executable binary is used. `a.out` is used if `-o` is not specified. The compiler looks for *profdir*.profile/feedback, or `a.out.profile/feedback` when *profdir* is not specified. For example:

```

demo: CC -xprofile=collect -o myexe prog.cc
demo: CC -xprofile=use:myexe -xO5 -o myexe prog.cc

```

The program is optimized by using the execution frequency data previously generated and saved in the feedback files written by a previous execution of the program compiled with `-xprofile=collect`.

Except for the `-xprofile` option, the source files and other compiler options must be exactly the same as those used for the compilation that created the compiled program that generated the feedback file. The same version of the compiler must be used for both the `collect` build and the `use` build as well.

If compiled with `-xprofile=collect:profdir`, the same profile directory name *profdir* must be used in the optimizing compilation: `-xprofile=use:profdir`.

See also `-xprofile_ircache` for speeding up compilation between `collect` and `use` phases.

tcov[:*profdir*]

Instrument object files for basic block coverage analysis using `tcov(1)`.

If the optional *profdir* argument is specified, the compiler will create a profile directory at the specified location. The data stored in the profile directory can be used either by `tcov(1)` or by the compiler with `-xprofile=use:profdir`. If the optional *profdir* pathname is omitted, a profile directory will be created when the profiled program is executed. The data stored in the profile directory can only be used by `tcov(1)`. The location of the profile directory can be controlled using environment variables `SUN_PROFDATA` and `SUN_PROFDATA_DIR`.

If the location specified by *profdir* is not an absolute pathname, it is interpreted at compilation time relative to the current working directory at the time of compilation. If *profdir* is specified for any object file, the same location must be specified for all object files in the same program. The directory whose location is specified by *profdir* must be accessible from all machines where the profiled program is to be executed. The profile directory should not be deleted until its contents are no longer needed, because data stored there by the compiler cannot be restored except by recompilation.

If object files for one or more programs are compiled with `-xprofile=tcov:/test/profdata`, a directory named `/test/profdata.profile` will be created by the compiler and used to store data describing the profiled object files. The same directory will also be used at execution time to store execution data associated with the profiled object files.

If a program named `myprog` is compiled with `-xprofile=tcov` and executed in the directory `/home/joe`, the directory `/home/joe/myprog.profile` will be created at runtime and used to store runtime profile data.

## A.2.179 `-xprofile_ircache[=path]`

(SPARC) Use `-xprofile_ircache[=path]` with `-xprofile=collect|use` to improve compilation time during the use phase by reusing compilation data saved from the collect phase.

With large programs, compilation time in the use phase can improve significantly because the intermediate data is saved. Note that the saved data could increase disk space requirements considerably.

When you use `-xprofile_ircache[=path]`, *path* overrides the location where the cached files are saved. By default, these files are saved in the same directory as the object file. Specifying

a path is useful when the `collect` and `use` phases happen in two different directories. The following example shows a typical sequence of commands:

```
example% CC -x05 -xprofile=collect -xprofile_ircache t1.cc t2.cc
example% a.out // run collects feedback data
example% CC -x05 -xprofile=use -xprofile_ircache t1.cc t2.cc
```

## A.2.180 `-xprofile_pathmap`

(SPARC) Use the `-xprofile_pathmap=collect-prefix:use-prefix` option when you are also specifying the `-xprofile=use` command. Use `-xprofile_pathmap` when both of the following conditions are true and the compiler is unable to find profile data for an object file that is compiled with `-xprofile=use`.

- You are compiling the object file with `-xprofile=use` in a directory that is different from the directory in which the object file was previously compiled with `-xprofile=collect`.
- Your object files share a common basename in the profile but are distinguished from each other by their location in different directories.

The *collect-prefix* is the prefix of the UNIX path name of a directory tree in which object files were compiled using `-xprofile=collect`.

The *use-prefix* is the prefix of the UNIX path name of a directory tree in which object files are to be compiled using `-xprofile=use`.

If you specify multiple instances of `-xprofile_pathmap`, the compiler processes them in the order of their occurrence. Each *use-prefix* specified by an instance of `-xprofile_pathmap` is compared with the object file path name until either a matching *use-prefix* is identified or the last specified *use-prefix* is found not to match the object file path name.

## A.2.181 `-xreduction`

Analyzes loops for reduction in automatic parallelization. This option is valid only if `-xautopar` is also specified. Otherwise the compiler issues a warning.

When a reduction recognition is enabled, the compiler parallelizes reductions such as dot products and maximum and minimum finding. These reductions yield roundoffs different from those obtained by unparallelized code.

## A.2.182 `-xregs=r[,r...]`

Specifies the usage of registers for the generated code.

*r* is a comma-separated list that consists of one or more of the following suboptions: `appl`, `float`, `frameptr`.

Prefixing a suboption with `no%` disables that suboption. For example: `-xregs=appl,no%float`

Note that `-xregs` suboptions are restricted to specific hardware platforms.

**TABLE 73** `-xregs` Sub-options

Value	Meaning
<code>appl</code>	<p>(SPARC) Allow the compiler to generate code using the application registers as scratch registers. The application registers are:</p> <p>g2, g3, g4 (on 32-bit platforms)</p> <p>g2, g3 (on 64-bit platforms)</p> <p>All system software and libraries should be compiled using <code>-xregs=no%appl</code>. System software (including shared libraries) must preserve these registers' values for the application. Their use is intended to be controlled by the compilation system and must be consistent throughout the application.</p> <p>In the SPARC ABI, these registers are described as <i>application</i> registers. Using these registers can improve performance because fewer load and store instructions are needed. However, such use can conflict with some old library programs written in assembly code.</p>
<code>float</code>	<p>(SPARC) Allow the compiler to generate code by using the floating-point registers as scratch registers for integer values. Use of floating-point values may use these registers regardless of this option. If you want your code to be free of all references to floating-point registers, use <code>-xregs=no%float</code> and also make sure your code does not in any way use floating-point types.</p> <p>(x86) Allow the compiler to generate code by using the floating-point registers as scratch registers. Floating-point values may use these registers regardless of this option. To generate binary code free of all references to floating point registers, use <code>-xregs=no%float</code> and make sure your source code does not in any way use floating point types. During code generation the compilers will attempt to diagnose code that results in the use of floating point, <code>simd</code>, or <code>x87</code> instructions.</p>
<code>frameptr</code>	<p>(x86) Allow the compiler to use the frame-pointer register (<code>%ebp</code> on IA32, <code>%rbp</code> on AMD64) as a general-purpose register.</p> <p>The default is <code>-xregs=no%frameptr</code></p> <p>The C++ compiler ignores <code>-xregs=frameptr</code> unless exceptions are also disabled with <code>-features=no%except</code>. Note that <code>-xregs=frameptr</code> is part of <code>-fast</code> but is ignored by the C++ compiler unless <code>-features=no%except</code> is also specified.</p> <p>With <code>-xregs=frameptr</code> the compiler is free to use the frame-pointer register to improve program performance. However, some features of the debugger and performance measurement tools may be</p>

Value	Meaning
	<p>limited as a result. Stack tracing, debuggers, and performance analyzers cannot report on functions compiled with <code>-xregs=frameptr</code></p> <p>Also, C++ calls to POSIX <code>pthread_cancel()</code> will fail to find cleanup handlers.</p> <p>Mixed C, Fortran, and C++ code should not be compiled with <code>-xregs=frameptr</code> if a C++ function called directly or indirectly from a C or Fortran function can throw an exception. If compiling such mixed source code with <code>-fast</code>, add <code>-xregs=no%frameptr</code> after the <code>-fast</code> option on the command line.</p> <p>With more available registers on 64-bit platforms, compiling with <code>-xregs=frameptr</code> has a better chance of improving 32-bit code performance than 64-bit code.</p> <p>The compiler ignores <code>-xregs=frameptr</code> and issues a warning if you also specify <code>-xpg</code>. Also, <code>-xkeepframe</code> overrides <code>-xregs=frameptr</code>.</p>

The SPARC default is `-xregs=appl, float`.

The x86 default is `-xregs=no%frameptr, float`.

On x86 systems, `-xpg` is incompatible with `-xregs=frameptr`, and these two options should not be used together. Note also that `-xregs=frameptr` is included in `-fast`.

Code intended for shared libraries that will link with applications should be compiled with `-xregs=no%appl, float`. At the very least, the shared library should explicitly document how it uses the application registers so that applications linking with those libraries are aware of these register assignments.

For example, an application using the registers in some global sense (such as using a register to point to some critical data structure) would need to know exactly how a library with code compiled without `-xregs=no%appl` is using the application registers in order to safely link with that library.

## A.2.183 `-xrestrict[=f]`

Treats pointer-valued function parameters as restricted pointers. In addition to pointers, references can also be declared restricted, with the same meaning.

*f* must be one of the values listed in the following table:

**TABLE 74** `-xrestrict` Values

Value	Meaning
<code>%all</code>	All pointer parameters in the entire file are treated as restricted.

Value	Meaning
<code>%none</code>	No pointer parameters in the file are treated as restricted.
<code>%source</code>	Only functions defined within the main source file are restricted. Functions defined within included files are not restricted.
<code>f1[,f2...]</code>	<p>A comma-separated list of one or more function names. If you specify a function list, the compiler treats pointer parameters in the specified functions as restricted; Refer to the following section, “<a href="#">A.2.183.1 Restricted Pointers</a>” on page 327, for more information.</p> <p>Each listed name must be the mangled name (if applicable) of the function. For example:</p> <pre>extern "C++" int foo(int* __restrict a, int* __restrict b) { ... } extern "C"   int bar(int* __restrict a, int* __restrict b) { ... }</pre> <p>Because function <code>bar</code> is declared extern "C", its name is not mangled. The command line option <code>-xrestrict=foo,bar</code> causes function <code>bar</code>'s pointer parameters to be treated as restricted, but not those of function <code>foo</code>. You would need to use the mangled name of <code>foo</code>, which depends on the compilation mode.</p>

This command-line option can be used on its own, but it is best used with optimization.

For example, the following command treats all pointer parameters in the file `prog.c` as restricted pointers.

```
%CC -xO3 -xrestrict=%all prog.cc
```

The following command treats all pointer parameters in the function `agc` in the file `prog.c` as restricted pointers:

```
%CC -xO3 -xrestrict=agc prog.cc
```

The C99 standard for the C programming language introduced the `restrict` keyword, but the keyword is not part of the current C++ standard. Like some other compilers, Oracle Developer Studio C++ recognizes the keywords `__restrict` (and `__restrict__`) as equivalent to the C99 `restrict` keyword. Use of the keyword is generally preferable to the `-xrestrict` command-line option, because the keyword allows finer control over which pointers are declared restricted.

Declaring a pointer restricted (using the command-line option or a keyword) primarily affects optimization opportunities, and limits the arguments that can be passed to a function.

The default is `%none`; specifying `-xrestrict` is equivalent to specifying `-xrestrict=%source`.

### A.2.183.1 Restricted Pointers

In order for a compiler to effectively perform parallel execution of a loop, it needs to determine if certain lvalues designate distinct regions of storage. Aliases are lvalues whose regions of storage are not distinct. Determining if two pointers to objects are aliases is a difficult and time consuming process because it could require analysis of the entire program. Consider the function `vsq()` in the following example:

```
extern "C"
void vsq(int n, double *a, double *b) {
    int i;
    for (i=0; i<n; i++) {
        b[i] = a[i] * a[i];
    }
}
```

The compiler can parallelize the execution of the different iterations of the loops if it knows that pointers `a` and `b` access different objects. If there is an overlap in objects accessed through pointers `a` and `b` then it would be unsafe for the compiler to execute the loops in parallel.

At compile time, the compiler does not know if the objects accessed by `a` and `b` overlap by simply analyzing the function `vsq()`. The compiler may need to analyze the whole program to get this information. You can specify that pointer-valued function parameters be treated as restricted pointers by using the following command line option: `-xrestrict[=func1,...,funcn]` If a function list is specified, pointer parameters in the specified functions are treated as restricted. Otherwise, all pointer parameters in the entire source file are treated as restricted (not recommended). For example, `-xrestrict=vsq` qualifies the pointers `a` and `b` given in the example of the function `vsq()`.

Declaring the pointer arguments as restricted states that the pointers designate distinct objects. The compiler can assume that `a` and `b` point to distinct regions of storage. With this alias information, the compiler is able to parallelize the loop.

Make sure you use `-xrestrict` correctly. If pointers qualified as restricted pointers point to objects that are not distinct, the compiler can incorrectly parallelize loops resulting in undefined behavior. For example, assume that pointers `a` and `b` of function `vsq()` point to objects that overlap such that `b[i]` and `a[i+1]` are the same object. If `a` and `b` are not declared as restricted pointers the loops will be executed serially. If `a` and `b` are incorrectly qualified as restricted pointers, the compiler might parallelize the execution of the loops, which is not safe because `b[i+1]` should only be computed after `b[i]` is computed.

## A.2.184 `-xs[={yes|no}]`

(Solaris) Link debug information from object files into executable.

`-xs` is the same as `-xs=yes`.

The default for `-xdebugformat=dwarf` is the same as `-xs=yes`.

The default for `-xdebugformat=stabs` is the same as `-xs=no`.

This option controls the trade-off of executable size versus the need to retain object files in order to debug. For dwarf, use `-xs=no` to keep the executable small but depend on the object files. For stabs, use `-xs` or `-xs=yes` to avoid dependence on the object files at the cost of a larger executable. This option has almost no effect on dbx performance or the runtime performance of the program.

When the compile command forces linking (that is, `-c` is not specified) there will be no object file(s) and the debug information must be placed in the executable. In this case, `-xs=no` (implicit or explicit) will be ignored.

The feature is implemented by having the compiler adjust the section flags and/or section names in the object file that it emits, which then tells the linker what to do for that object file's debug information. It is therefore a compiler option, not a linker option. It is possible to have an executable with some object files compiled `-xs=yes` and others compiled `-xs=no`.

Oracle Linux compilers accept but ignore `-xs`. Oracle Linux compilers do not accept `-xs={yes|no}`.

## A.2.185 `-xsafe=mem`

(SPARC) Allows the compiler to assume that no memory protection violations occur.

This option allows the compiler to use the non-faulting load instruction in the SPARC V9 architecture.

### A.2.185.1 Interactions

This option takes effect only when used with optimization level `-xO5` and one of the following `-xarch` values: `sparc`, `sparcvis`, `sparcvis2`, or `sparcvis3` for both `-m32` and `-m64`.



## A.2.185.2 Warnings

Because non-faulting loads do not cause a trap when a fault such as address misalignment or segmentation violation occurs, you should use this option only for programs in which such faults cannot occur. Because few programs incur memory-based traps, you can safely use this option for most programs. Do not use this option for programs that explicitly depend on memory-based traps to handle exceptional conditions.

## A.2.186 `-xsecure_code_analysis{=[yes|no]}`

Enable or disable compiler secure code analysis to find and display possible memory safety violations at compile time. Secure code analysis runs in parallel with the compilation process and may result in increased compile time.

If `-xsecure_code_analysis` is not specified or if it is specified without a `yes|no` argument, the default is `-xsecure_code_analysis=yes`.

Use `-xsecure_code_analysis=no` to disable secure code analysis.

## A.2.187 `-xsegment_align=n`

(Solaris) This option causes the driver to include a special mapfile on the link line. The mapfile aligns the text, data, and bss segments to the value specified by *n*. When using very large pages, it is important that the heap and stack segments are aligned on an appropriate boundary. If these segments are not aligned, small pages will be used up to the next boundary, which could cause a performance degradation. The mapfile ensures that the segments are aligned on an appropriate boundary.

The *n* value must be one of the following:

(SPARC) The following values are valid: 8K, 64K, 512K, 2M, 4M, 32M, 256M, 1G, and none.

(x86) The following values are valid: 4K, 8K, 64K, 512K, 2M, 4M, 32M, 256M, 1G, and none.

The default for both SPARC and x86 is none.

Recommended usage is as follows:

SPARC 32-bit compilation: `-xsegment_align=64K`

SPARC 64-bit compilation: `-xsegment_align=4M`

x86 32-bit compilation: `-xsegment_align=8K`

x86 64-bit compilation: `-xsegment_align=4M`

The driver will include the appropriate mapfile. For example, if the user specifies `-xsegment_align=4M`, the driver adds `-M install-directory/lib/compilers/mapfiles/map.4M.align` to the link line, where *install-directory* is the installation directory. The aforementioned segments will then be aligned on a 4M boundary.

## A.2.188 `-xspace`

(SPARC) Does not allow optimizations that increase code size.

## A.2.189 `-xtarget=t`

Specifies the target platform for instruction set and optimization.

The value of *t* must be one of the following: *native*, *generic*, or *system-name*.

Each specific value for `-xtarget` expands into a specific set of values for the `-xarch`, `-xchip`, and `-xcache` options. Use the `-xdryrun` option to determine the expansion of `-xtarget=native` on a running system.

For example, `-xtarget=T3` is equivalent to `-xchip=T3 -xcache=8/16/4:6144/64/24 -xarch=sparcvis3`.

```
cc -dryrun -xtarget=T3 |& grep ###
###      command line files and options (expanded):
### -dryrun -xchip=T3 -xcache=8/16/4:6144/64/24 -xarch=sparcvis3
```

The data type model, either 32-bit or 64-bit, is indicated by the `-m32|-m64` option. To specify the 64-bit data type model, specify the `-m64` option as follows:

```
-xtarget=<value> ... -m64
```

To specify the 32-bit data type model, use the `-m32` option as follows:

```
-xtarget=<value> ... -m32
```

See also the `-m32|-m64` option for a discussion of the default data type model.

---

**Note** - The expansion of `-xtarget` for a specific host system might not expand to the same `-xarch`, `-xchip`, or `-xcache` settings as `-xtarget=native` when compiling on that system.

---

## A.2.189.1 `-xtarget` Values By Platform

This section provides descriptions of the `-xtarget` values by platform. The following table lists the `-xtarget` values for all platforms.

**TABLE 75** `-xtarget` Values for All Platforms

Value	Meaning
<code>native</code>	Equivalent to <code>-m32 -xarch=native -xchip=native -xcache=native</code> to give best performance on the host 32-bit system.
<code>generic</code>	Equivalent to <code>-m32 -xarch=generic -xchip=generic -xcache=generic</code> to give best performance on most 32-bit systems.
<code>system-name</code>	Gets the best performance for the specified platform.  Select a system name from the following lists for which represents the actual system you are targeting.

The performance of some programs may benefit by providing the compiler with an accurate description of the target computer hardware. When program performance is critical, the proper specification of the target hardware could be very important, especially when running on the newer SPARC processors. However, for most programs and older SPARC processors, the performance gain is negligible and a generic specification is sufficient.

### `-xtarget` Values on SPARC Platforms

**TABLE 76** `-xtarget` Expansions on SPARC Architecture

<code>-xtarget=</code>	<code>-xarch</code>	<code>-xchip</code>	<code>-xcache</code>
<code>ultraT1</code>	<code>sparcvis2</code>	<code>ultraT1</code>	<code>8/16/4/4:3072/64/12/32</code>
<code>ultraT2</code>	<code>sparc</code>	<code>ultraT2</code>	<code>8/16/4:4096/64/16</code>

<b>-xtarget=</b>	<b>-xarch</b>	<b>-xchip</b>	<b>-xcache</b>
ultraT2plus	sparcvis2	ultraT2plus	8/16/4:4096/64/16
T3	sparcvis3	T3	8/16/4:6144/64/24
T4	sparc4	T4	16/32/4:128/32/8:4096/64/16
sparc64vi	sparcfmaf	sparc64vi	128/64/2:5120/64/10
sparc64vii	sparcima	sparc64vii	64/64/2:5120/256/10
sparc64viplus	sparcima	sparc64viplus	64/64/2:11264/256/11
sparc64x	sparcace	sparc64x	64/128/4/2:24576/128/24/32
sparc64xplus	sparcaceplus	sparc64xplus	64/128/4/2:24576/128/24/32
T5	sparc4	T5	16/32/4/8:128/32/8/8:8192/64/16/128
T7	sparc5	T7	16/32/4/8:256/64/8/16:8192/64/8/32
M5	sparc4	M5	16/32/4/8:128/32/8/8:49152/64/12/48
M6	sparc4	M6	16/32/4/8:128/32/8/8:49152/64/12/96
M7	sparc5	M7	16/32/4/8:256/64/8/16:8192/64/8/32

### **-xtarget Values on x86 Platforms**

**TABLE 77** -xtarget Values on x86 Platforms

<b>-xtarget=</b>	<b>-xarch</b>	<b>-xchip</b>	<b>-xcache</b>
pentium	386	pentium	generic
pentium_pro	pentium_pro	pentium_pro	generic
pentium3	sse	pentium3	16/32/4:256/32/4
pentium4	sse2	pentium4	8/64/4:256/128/8
opteron	sse2a	opteron	64/64/2:1024/64/16
woodcrest	ssse3	core2	32/64/8:4096/64/16
barcelona	amdsse4a	amdfam10	64/64/2:512/64/16
penryn	sse4_1	penryn	2/64/8:6144/64/24
nehalem	sse4_2	nehalem	32/64/8:256/64/8: 8192/64/16
westmere	aes	westmere	32/64/8:256/64/8:30720/64/24
sandybridge	avx	sandybridge	32/64/8/2:256/64/8/2: 20480/64/20/16
ivybridge	avx_i	ivybridge	32/64/8/2:256/64/8/2: 20480/64/20/16
haswell	avx2	haswell	32/64/8/2:256/64/8/2: 20480/64/20/16

<code>-xtarget=</code>	<code>-xarch</code>	<code>-xchip</code>	<code>-xcache</code>
broadwell	avx2_i	broadwell	32/64/8/2:256/64/8/2: 20480/64/20/16

### A.2.189.2 Defaults

On both SPARC and x86 devices, if `-xtarget` is not specified, `-xtarget=generic` is assumed.

### A.2.189.3 Expansions

The `-xtarget` option is a macro that permits a quick and easy specification of the `-xarch`, `-xchip`, and `-xcache` combinations that occur on commercially purchased platforms. The only meaning of `-xtarget` is in its expansion.

### A.2.189.4 Examples

`-xtarget=T3` is equivalent to `-xchip=T3 -xcache=8/16/4:6144/64/24 -xarch=sparcvis3`.

### A.2.189.5 Warnings

When you compile and link in separate steps, you must use the same `-xtarget` settings in the compile step and the link step.

### A.2.190 `-xtemp=path`

Equivalent to `-temppath`.

### A.2.191 `-xthreadvar[=0]`

Specify `-xthreadvar` to control the implementation of thread local variables. Use this option in conjunction with the `__thread` declaration specifier to take advantage of the compiler's thread-local storage facility. After you declare the thread variables with the `__thread` specifier, specify `-xthreadvar` to enable the use of thread-local storage with position dependent code (non-PIC code) in dynamic (shared) libraries. For more information about how to use `__thread`, see [“4.2 Thread-Local Storage” on page 61](#).

### A.2.191.1 Values

The following table lists the possible values of `o`.

**TABLE 78** `-xthreadvar` Values

Value	Meaning
<code>[no%]dynamic</code>	Compile variables for dynamic loading. Access to thread variables is significantly faster when <code>-xthreadvar=no%dynamic</code> but you cannot use the object file within a dynamic library. That is, you can only use the object file in an executable file.

### A.2.191.2 Defaults

If you do not specify `-xthreadvar`, the default used by the compiler depends upon whether position-independent code is enabled. If position-independent code is enabled, the option is set to `-xthreadvar=dynamic`. If position-independent code is disabled, the option is set to `-xthreadvar=no%dynamic`.

If you specify `-xthreadvar` but do not specify any arguments, the option is set to `-xthreadvar=dynamic`.

### A.2.191.3 Interactions

The `-mt` option must be used when compiling and linking files that use `__thread`.

### A.2.191.4 Warnings

If a dynamic library contains code that is not position-independent, you must specify `-xthreadvar`.

The linker cannot support the thread-variable equivalent of non-PIC code in dynamic libraries. Non-PIC thread variables are significantly faster, and hence should be the default for executables.

### A.2.191.5 See Also

`-xcode`, `-KPIC`, `-Kpic`

## A.2.192 `-xthroughput[={yes|no}]`

The `-xthroughput` option tells the compiler that the application will be run in situations where many processes are simultaneously running on the system

If `-xthroughput=yes`, the compiler will favor optimizations that slightly reduce performance for a single process while improving the amount of work achieved by all the processes on the system. As an example, the compiler might choose to be less aggressive in prefetching data. Such a choice would reduce the memory bandwidth consumed by the process, and as such the process may run slower, but it would also leave more memory bandwidth to be shared among other processes.

The default is `-xthroughput=no`.

## A.2.193 `-xtime`

Causes the CC driver to report execution time for the various compilation passes.

## A.2.194 `-xtrigraphs[={yes|no}]`

Enables or disables recognition of trigraph sequences as defined by the ISO/ANSI C standard.

If your source code has a literal string containing question marks (?) that the compiler is interpreting as a trigraph sequence, you can use the `-xtrigraph=no` suboption to turn off the recognition of trigraph sequences.

### A.2.194.1 Values

The following lists the possible values for `-xtrigraphs`.

**TABLE 79** `-xtrigraphs` Values

Value	Meaning
yes	Enables recognition of trigraph sequences throughout the compilation unit
no	Disables recognition of trigraph sequences throughout the compilation unit

### A.2.194.2 Defaults

When you do not include the `-xtrigraphs` option on the command line, the compiler assumes `-xtrigraphs=yes`.

If only `-xtrigraphs` is specified, the compiler assumes `-xtrigraphs=yes`.

### A.2.194.3 Examples

Consider the following example source file named `trigraphs_demo.cc`.

```
#include <stdio.h>

int main ()
{
    (void) printf("(\\?\\?) in a string appears as (??)\\n");
    return 0;
}
```

The following example shows the output when you compile this code with `-xtrigraphs=yes`.

```
example% CC -xtrigraphs=yes trigraphs_demo.cc
example% a.out
(??) in a string appears as []
```

The following example shows the output when you compile this code with `-xtrigraphs=no`.

```
example% CC -xtrigraphs=no trigraphs_demo.cc
example% a.out
(??) in a string appears as (??)
```

### A.2.194.4 See Also

For information about trigraphs, see [Chapter 7, “Transitioning to ISO C” in \*Oracle Developer Studio 12.5: C User’s Guide\*](#).

## A.2.195 `-xunboundsym={yes|no}`

Specify whether the program contains references to dynamically bound symbols.

`-xunboundsym=yes` means the program contains references dynamically bound symbols.



`-xunboundsym=no` means the program does not contain references to dynamically bound symbols.

The default is `-xunboundsym=no`.

## A.2.196 `-xunroll=n`

This option directs the compiler to optimize loops by unrolling them where possible.

### A.2.196.1 Values

When  $n$  is 1, it is a suggestion to the compiler to not unroll loops.

When  $n$  is an integer greater than 1, `-unroll=n` causes the compiler to unroll loops  $n$  times.

## A.2.197 `-xustr={ascii_utf16_ushort|no}`

Use this option if your code contains string or character literals that you want the compiler to convert to UTF-16 strings in the object file. Without this option, the compiler neither produces nor recognizes 16-bit character string literals. This option enables recognition of the `U"ASCII-string"` string literals as an array of unsigned `short int`.

This Oracle Developer Studio C++ option was introduced long before standard Unicode strings were provided in C++11. The source-code syntax used for this option conflicts with standard C++11, where `U"string"` creates a string of 32-bit Unicode characters. This option is therefore not available when compiling in C++11 or C++14 mode.

Not all files have to be compiled with this option.

### A.2.197.1 Values

Specify `-xustr=ascii_utf16_ushort` if you need to support an internationalized application that uses ISO10646 UTF-16 string literals. You can turn off compiler recognition of `U"ASCII-string"` string or character literals by specifying `-xustr=no`. The right-most instance of this option on the command line overrides all previous instances.

You can specify `-xustr=ascii_ustf16_ushort` without also specifying a `U"ASCII-string"` string literal. To do so is not an error.

## A.2.197.2 Defaults

The default is `-xustr=no`. If you specify `-xustr` without an argument, the compiler won't accept it and instead issues a warning. The default could change if the C or C++ standards define a meaning for the syntax.

## A.2.197.3 Example

The following example shows a string literal in quotes that is prepended by `U`. It also shows a command line that specifies `-xustr`

```
example% cat file.cc
const unsigned short *foo = U"foo";
const unsigned short bar[] = U"bar";
const unsigned short *fun() {return foo;}
example% CC -xustr=ascii_utf16_ushort file.cc -c
```

An 8-bit character literal can be prepended with `U` to form a 16-bit UTF-16 character of type `unsigned short`. For example:

```
const unsigned short x = U'x';
const unsigned short y = U'\x79';
```

## A.2.198 `-xvector[=a]`

Enables automatic generation of calls to the vector library functions or the generation of the SIMD (Single Instruction Multiple Data) instructions on processors that support SIMD. You must use default rounding mode by specifying `-fround=nearest` when you use this option.

The `-xvector` option requires optimization level `-xO3` or greater. The option is silently ignored if the optimization level is lower than `-xO3`.

The possible values for `a` are listed in the following table. The `no%` prefix disables the associated suboption.

**TABLE 80** `-xvector` Sub-options

Value	Meaning
<code>[no%]lib</code>	(Solaris) Enables the compiler to transform math library calls within loops into single calls to the equivalent vector math routines when such transformations are possible.

Value	Meaning
	This could result in a performance improvement for loops with large loop counts. Use <code>no%lib</code> to disable this option.
<code>[no%]simd</code>	<p>(SPARC) For <code>-xarch=sparcace</code> and <code>-xarch=sparcaceplus</code>, directs the compiler to use floating point and integral SIMD instructions to improve the performance of certain loops. Contrary to that of the other SPARC <code>-xarch</code> values under <code>-xarch=sparcace</code> and <code>-xarch=sparcaceplus</code>, <code>-xvector=simd</code> is in effect unless <code>-xvector=none</code> or <code>-xvector=no%simd</code> has been specified. In addition <code>-x04</code> or greater is required for <code>-xvector=simd</code>, otherwise <code>-xvector=simd</code> is ignored.</p> <p>For all other <code>-xarch</code> values, directs the compiler to use the Visual Instruction Set [VIS1, VIS2, ViS3, etc.] SIMD instructions to improve the performance of certain loops. Basically with explicit <code>-xvector=simd</code> option, the compiler will perform loop transformation enabling the generation of special vectorized SIMD instructions to reduce the number of loop iterations. In addition to the optimization level requirement noted below, the <code>-xvector=simd</code> option is effective only if <code>-xarch=sparcvis3</code> and above.</p>
<code>[no%]simd</code>	<p>(x86) Directs the compiler to use the native x86 SSE SIMD instructions to improve performance of certain loops. Streaming extensions are used on x86 by default at optimization level 3 and above where beneficial. Use <code>no%simd</code> to disable this option..</p> <p>The compiler will use SIMD only if streaming extensions exist in the target architecture; that is, if target ISA is at least SSE2. For example, you can specify <code>-xtarget=woodcrest</code>, <code>-xarch=generic</code>, <code>-xarch=sse2</code>, <code>-xarch=sse3</code>, or <code>-fast</code> on a modern platform to use it. If the target ISA has no streaming extensions, the suboption will have no effect.</p>
<code>%none</code>	Disable this option completely.
<code>yes</code>	This option is deprecated; specify <code>-xvector=lib</code> instead.
<code>no</code>	This option is deprecated; specify <code>-xvector=%none</code> instead.

### A.2.198.1 Defaults

On x86, the default is `-xvector=simd`. On SPARC, the default is `-xvector=simd` under `-xarch=sparcace` and `-xarch=sparcaceplus`, and `-xvector=%none` on other SPARC `-xarch` values. If you specify `-xvector` without a suboption, the compiler assumes `-xvector=simd, lib` on x86, `-xvector=lib` on SPARC, and `-xvector=simd` on Oracle Linux platforms.

### A.2.198.2 Interactions

The compiler includes the `libmvec` libraries in the load step.

If you compile and link with separate commands, be sure to use `-xvector` in the linking `CC` command as well.

## A.2.199 `-xvis[={yes|no}]`

(SPARC) Use the `-xvis=[yes|no]` command when you are using the assembly-language templates defined in the VIS™ Software Developers Kit (VSDK), or when using assembler inline code that uses VIS instructions and the `vis.h` header file.

The VIS instruction set is an extension to the SPARC-V9 instruction set. Even though the SPARC processors are 64-bit, there are many cases, especially in multimedia applications, when the data are limited to 8 or 16 bits in size. The VIS instructions can process four words of 16-bit data with one instruction so they greatly improve the performance of applications that handle new media such as imaging, linear algebra, signal processing, audio, video and networking.

### A.2.199.1 Defaults

The default is `-xvis=no`. Specifying `-xvis` is equivalent to specifying `-xvis=yes`.

## A.2.200 `-xvpara`

Issues warnings about potential parallel-programming related problems that might cause incorrect results when using OpenMP. Use with `-xopenmp` and OpenMP API directives.

The compiler issues warnings when it detects the following situations:

- Loops are parallelized using MP directives with data dependencies between different loop iterations
- OpenMP data-sharing attributes-clauses are problematic. For example, declaring a variable "shared" whose accesses in an OpenMP parallel region may cause a data race, or declaring a variable "private" whose value in a parallel region is used after the parallel region.

No warnings appear if all parallelization directives are processed without problems.

---

**Note** - Oracle Developer Studio compilers support OpenMP API parallelization. Consequently, the MP pragmas directives are deprecated and are no longer supported. See the [Oracle Developer Studio 12.5: OpenMP API User's Guide](#) for information on migrating to the OpenMP API.

---

## A.2.201 `-xwe`

Converts all warnings to errors by returning nonzero exit status.

### A.2.201.1 See Also

[“A.2.16 `-errwarn\[=t\]`” on page 185](#)

### A.2.202 `-Yc,path`

Specifies a new path for the location of component *c*.

If the location of a component is specified, then the new path name for the component is *path/component-name*. This option is passed to `ld`.

### A.2.202.1 Values

The following table lists the possible values for *c*.

**TABLE 81** `-Y` Flags

Value	Meaning
P	Changes the default directory for <code>cpp</code> .
0	Changes the default directory for <code>ccfe</code> .
a	Changes the default directory for <code>fbe</code> .
2	Changes the default directory for <code>iropt</code> .
c (SPARC)	Changes the default directory for <code>cg</code> .
O	Changes the default directory for <code>ipo</code> .
k	Changes the default directory for <code>CcLink</code> .
l	Changes the default directory for <code>ld</code> .
f	Changes the default directory for <code>c++filt</code> .
m	Changes the default directory for <code>mcs</code> .
u (x86)	Changes the default directory for <code>ube</code> .
A	Specifies a directory to search for all compiler components. If a component is not found in <i>path</i> , the search reverts to the directory where the compiler is installed.
P	Adds <i>path</i> to the default library search path. This path will be searched before the default library search paths.
S	Changes the default directory for startup object files

### **A.2.202.2 Interactions**

You can have multiple -Y options on a command line. If more than one -Y option is applied to any one component, then the last occurrence holds.

### **A.2.202.3 See Also**

*[Oracle Solaris 11.3 Linkers and Libraries Guide](#)*

### **A.2.203 -z[ ]arg**

Link editor option. For more information, see the `ld(1)` man page and the *[Oracle Solaris 11.3 Linkers and Libraries Guide](#)*.

See also “[A.2.103 -xlinker arg](#)” on page 240

# ◆◆◆ APPENDIX B

## Pragmas

---

This appendix describes the C++ compiler pragmas. A *pragma* is a compiler directive that enables the programmer to provide additional information to the compiler. This information can change compilation details that are not otherwise under your control. For example, the `pack` pragma affects the layout of data within a structure. Compiler pragmas are also called *directives*.

The preprocessor keyword `pragma` is part of the C++ standard, but the form, content, and meaning of pragmas is different for every compiler. No pragmas are defined by the C++ standard.

---

**Note** - Code that depends on pragmas is not portable.

---

### B.1 Pragma Forms

The various forms of a C++ compiler pragma are:

```
#pragma keyword  
#pragma keyword ( a [ , a ] ... ) [ , keyword ( a [ , a ] ... ) ] , ...  
#pragma sun keyword
```

The variable *keyword* identifies the specific directive; *a* indicates an argument.

#### B.1.1 Overloaded Functions as Pragma Arguments

Several pragmas listed in this appendix take function names as arguments. In the event that the function is overloaded, the pragma uses the function declaration immediately preceding the pragma as its argument. Consider the following example:

```
int bar(int);  
int foo(int);
```

```
int foo(double);
#pragma does_not_read_global_data(foo, bar)
```

In this example, `foo` means `foo(double)`, the declaration of `foo` immediately preceding the `pragma`, and `bar` means `bar(int)`, the only declared `bar`. Now, consider this following example in which `foo` is again overloaded:

```
int foo(int);
int foo(double);
int bar(int);
#pragma does_not_read_global_data(foo, bar)
```

In this example, `bar` means `bar(int)`, the only declared `bar`. However, the `pragma` will not know which version of `foo` to use. To correct this problem, you must place the `pragma` immediately following the definition of `foo` that you want the `pragma` to use.

The following `pragmas` use the selection method described in this section:

- `does_not_read_global_data`
- `does_not_return`
- `does_not_write_global_data`
- `no_side_effect`
- `opt`
- `rarely_called`
- `returns_new_memory`

## B.2 Pragma Reference

This section describes the `pragma` keywords that are recognized by the C++ compiler.

### B.2.1 `#pragma align`

```
#pragma align integer(variable[,variable...])
```

Use `align` to make the listed variables memory-aligned to *integer* bytes, overriding the default. The following limitations apply:

- *integer* must be a power of 2 between 1 and 128. Valid values are 1, 2, 4, 8, 16, 32, 64, and 128.



- *variable* is a global or static variable. It cannot be a local variable or a class member variable.
- If the specified alignment is smaller than the default, the default is used.
- The pragma line must appear before the declaration of the variables that it mentions. Otherwise, it is ignored.
- Any variable mentioned on the pragma line but not declared in the code following the pragma line is ignored. Variables in the following example are properly declared.

```
#pragma align 64 (aninteger, astring, astruct)
int aninteger;
static char astring[256];
struct S {int a; char *b;} astruct;
```

When `#pragma align` is used inside a namespace, mangled names must be used. For example, in the following code, the `#pragma align` statement will have no effect. To correct the problem, replace `a`, `b`, and `c` in the `#pragma align` statement with their mangled names.

```
namespace foo {
    #pragma align 8 (a, b, c)
    static char a;
    static char b;
    static char c;
}
```

## B.2.2 `#pragma does_not_read_global_data`

```
#pragma does_not_read_global_data(funcname[, funcname])
```

This pragma asserts that the specified routines do not read global data directly or indirectly, enabling better optimization of code around calls to such routines. In particular, assignment statements or stores could be moved around such calls.

This pragma is permitted only after the prototype for the specified functions are declared. If the assertion about global access is not true, then the behavior of the program is undefined.

For a more detailed explanation of how the pragma treats overloaded function names as arguments, see [“B.1.1 Overloaded Functions as Pragma Arguments”](#) on page 343.

## B.2.3 `#pragma does_not_return`

```
#pragma does_not_return(funcname[, funcname])
```

This pragma is an assertion to the compiler that the calls to the specified routines will not return, enabling the compiler to perform optimizations consistent with that assumption. For example, register life-times terminate at the call sites which in turn enables more optimizations.

If the specified function does return, then the behavior of the program is undefined.

This pragma is permitted only after the prototype for the specified functions are declared, as the following example shows:

```
extern void exit(int);
#pragma does_not_return(exit)

extern void __assert(int);
#pragma does_not_return(__assert)
```

For a more detailed explanation of how the pragma treats overloaded function names as arguments, see [“B.1.1 Overloaded Functions as Pragma Arguments” on page 343](#).

## B.2.4 `#pragma does_not_write_global_data`

```
#pragma does_not_write_global_data(funcname[, funcname])
```

This pragma asserts that the specified list of routines do not write global data directly or indirectly, enabling better optimization of code around calls to such routines. In particular, assignment statements or stores could be moved around such calls.

This pragma is permitted only after the prototype for the specified functions are declared. If the assertion about global access is not true, then the behavior of the program is undefined.

For a more detailed explanation of how the pragma treats overloaded function names as arguments, see [“B.1.1 Overloaded Functions as Pragma Arguments” on page 343](#).

## B.2.5 `#pragma dumpmacros`

```
#pragma dumpmacros (value[,value...])
```

Use this pragma when you want to see how macros are behaving in your program. This pragma provides information such as macro defines, undefines, and instances of usage. It prints output to the standard error (`stderr`) based on the order macros are processed. The `dumpmacros` pragma is in effect through the end of the file or until it reaches a `#pragma end_dumpmacro`. See [“B.2.6 `#pragma end\_dumpmacro`” on page 347](#). The following table lists the possible values for *value*:

Value	Meaning
defs	Print all macro defines
undefs	Print all macro undefines
use	Print information about the macros used
loc	Print location (path name and line number) also for defs, undefs, and use
conds	Print use information for macros used in conditional directives
sys	Print all macros defines, undefines, and use information for macros in system header files

---

**Note** - The suboptions `loc`, `conds`, and `sys` are qualifiers for `defs`, `undefs` and `use` options. By themselves, `loc`, `conds`, and `sys` have no effect. For example, `#pragma dumpmacros(loc, conds, sys)` has no effect.

---

The `dumpmacros` pragma has the same effect as the command-line option, however, the pragma overrides the command-line option. See “[A.2.123 - xdumpmacros\[=value\[, value...\]\]](#)” on page 264.

The `dumpmacros` pragma does not nest so the following lines of code stop printing macro information when the `#pragma end_dumpmacros` is processed:

```
#pragma dumpmacros(defs, undefs)
#pragma dumpmacros(defs, undefs)
...
#pragma end_dumpmacros
```

The effect of the `dumpmacros` pragma is cumulative. The following lines

```
#pragma dumpmacros(defs, undefs)
#pragma dumpmacros(loc)
```

have the same effect as:

```
#pragma dumpmacros(defs, undefs, loc)
```

If you use the option `#pragma dumpmacros(use, no%loc)`, the name of each macro that is used is printed only once. If you use the option `#pragma dumpmacros(use, loc)`, the location and macro name is printed every time a macro is used.

## B.2.6 #pragma end\_dumpmacros

```
#pragma end_dumpmacros
```

This pragma marks the end of a `dumpmacros` pragma and stops printing information about macros. If you do not use an `end_dumpmacros` pragma after a `dumpmacros` pragma, the `dumpmacros` pragma continues to generate output through the end of the file.

## B.2.7 `#pragma error_messages`

`#pragma error_messages (on|off|default, tag... tag)`

The error message pragma provides control within the source program over the messages issued by the compiler. The pragma has an effect on warning messages only. The `-w` command-line option overrides this pragma by suppressing all warning messages.

- `#pragma error_messages (on, tag... tag)`

The `on` option ends the scope of any preceding `#pragma error_messages` option, such as the `off` option, and overrides the effect of the `-erroff` option.

- `#pragma error_messages (off, tag... tag)`

The `off` option prevents the compiler program from issuing the given messages beginning with the token specified in the pragma. The scope of the pragma for any specified error message remains in effect until overridden by another `#pragma error_messages`, or the end of compilation.

- `#pragma error_messages (default, tag... tag)`

The `default` option ends the scope of any preceding `#pragma error_messages` directive for the specified tags.

## B.2.8 `#pragma fini`

`#pragma fini (identifier[, identifier...])`

Use `fini` to mark *identifier* as a finalization function. Such functions are expected to be of type `void`, to accept no arguments, and to be called either when a program terminates under program control or when the containing shared object is removed from memory. As with initialization functions, finalization functions are executed in the order processed by the link editor.

In a source file, the functions specified in `#pragma fini` are executed after the static destructors in that file. You must declare the identifiers before using them in the pragma.

Such functions are called once for every time they appear in a `#pragma fini` directive.

## B.2.9 `#pragma hdrstop`

Embed the `hdrstop` pragma in your source-file headers to identify the end of the viable source prefix. For example, consider the following files:

```
example% cat a.cc
#include "a.h"
#include "b.h"
#include "c.h"
#include <stdio.h>
#include "d.h"
.
.
.
example% cat b.cc
#include "a.h"
#include "b.h"
#include "c.h"
```

The viable source prefix ends at `c.h` so you would insert a `#pragma hdrstop` after `c.h` in each file.

`#pragma hdrstop` must only appear at the end of the viable prefix of a source file that is specified with the `CC` command. Do not specify `#pragma hdrstop` in any include file.

See [“A.2.169 -xpch=v” on page 307](#) and [“A.2.170 -xpchstop=file” on page 310](#).

## B.2.10 `#pragma ident`

```
#pragma ident string
```

Use `ident` to place *string* in the `.comment` section of the executable.

## B.2.11 `#pragma init`

```
#pragma init(identifier[,identifier...])
```

Use `init` to mark *identifier* as an initialization function. Such functions are expected to be of type `void`, to accept no arguments, and to be called while constructing the memory image of the program at the start of execution. Initializers in a shared object are executed during the operation that brings the shared object into memory, either at program start up or during some dynamic loading operation, such as `dlopen()`. The only ordering of calls to initialization functions is the order in which they are processed by the link editors, both static and dynamic.

Within a source file, the functions specified in `#pragma init` are executed after the static constructors in that file. You must declare the identifiers before using them in the pragma.

Such functions are called once for every time they appear in a `#pragma init` directive.

## B.2.12 `#pragma ivdep`

The `ivdep` pragmas tell a compiler to ignore some or all loop-carried dependences on array references that it finds in a loop for purposes of optimization. This enables a compiler to perform various loop optimizations such as microvectorization, distribution, software pipelining, and so on., which would not be otherwise possible. It is used in cases where the user knows either that the dependences do not matter or that they never occur in practice.

The interpretation of `#pragma ivdep` directives depend upon the value of the `-xivdep` option.

## B.2.13 `#pragma must_have_frame`

```
#pragma must_have_frame(funcname[, funcname])
```

This pragma requests that the specified list of functions always be compiled to have a complete stack frame (as defined in the System V ABI). You must declare the prototype for a function before listing that function with this pragma.

```
extern void foo(int);
extern void bar(int);
#pragma must_have_frame(foo, bar)
```

This pragma is permitted only after the prototype for the specified functions is declared. The pragma must precede the end of the function.

```
void foo(int) {
    .
    #pragma must_have_frame(foo)
    .
    return;
}
```

See [“B.1.1 Overloaded Functions as Pragma Arguments” on page 343](#)

## B.2.14 `#pragma no_side_effect`

```
#pragma no_side_effect(name[, name...])
```

Use `no_side_effect` to indicate that a function does not change any persistent state. The pragma declares that the named functions have no side effects of any kind. That is, the functions return result values that depend on the passed arguments only. In addition, the functions and their called descendants behave as follows:

- Do not access for reading or writing any part of the program state visible in the caller at the point of the call.
- Do not perform I/O.
- Do not change any part of the program state not visible at the point of the call.

The compiler can use this information when doing optimizations.

If the function does have side effects, the results of executing a program which calls this function are undefined.

The *name* argument specifies the name of a function within the current translation unit. The pragma must be in the same scope as the function and must appear after the function declaration. The pragma must be before the function definition.

For a more detailed explanation of how the pragma treats overloaded function names as arguments, see [“B.1.1 Overloaded Functions as Pragma Arguments” on page 343](#).

## B.2.15 `#pragma opt`

```
#pragma opt level (funcname[, funcname])
```

*funcname* specifies the name of a function defined within the current translation unit. The value of *level* specifies the optimization level for the named function. You can assign optimization levels 0, 1, 2, 3, 4, 5. You can turn off optimization by setting *level* to 0. The functions must be declared with a prototype or empty parameter list prior to the pragma. The pragma must proceed the definitions of the functions to be optimized.

The level of optimization for any function listed in the pragma is reduced to the value of `-xmaxopt`. The pragma is ignored when `-xmaxopt=off`.

For a more detailed explanation of how the pragma treats overloaded function names as arguments, see [“B.1.1 Overloaded Functions as Pragma Arguments” on page 343](#).

## B.2.16 `#pragma pack(n)`

```
#pragma pack([n])
```

Use `pack` to affect the packing of structure members.

If present,  $n$  must be 0 or a power of 2. A value of other than 0 instructs the compiler to use the smaller of  $n$ -byte alignment and the platform's natural alignment for the data type. For example, the following directive causes the members of all structures defined after the directive (and before subsequent `pack` directives) to be aligned no more strictly than on 2-byte boundaries, even if the normal alignment would be on 4-byte or 8-byte boundaries.

```
#pragma pack(2)
```

When  $n$  is 0 or omitted, the member alignment reverts to the natural alignment values.

If the value of  $n$  is the same as or greater than the strictest alignment on the platform, the directive has the effect of natural alignment. The following table shows the strictest alignment for each platform.

**TABLE 82** Strictest Alignment by Platform

Platform	Strictest Alignment
x86	4
SPARC generic	8
64-bit SPARC V9 (-m64)	16

A `pack` directive applies to all structure definitions which follow it until the next `pack` directive. If the same structure is defined in different translation units with different packing, your program might fail in unpredictable ways. In particular, you should not use a `pack` directive prior to including a header defining the interface of a precompiled library. The recommended usage is to place the `pack` directive in your program code, immediately before the structure to be packed, and to place `#pragma pack()` immediately after the structure.

When using `#pragma pack` on a SPARC platform to pack denser than the type's default alignment, the `-misalign` option must be specified for both the compilation and the linking of the application. The following table shows the storage sizes and default alignments of the integral data types.

**TABLE 83** Storage Sizes and Default Alignments in Bytes

Type	32-bit SPARC Size, Alignment	64-bit SPARC Size, Alignment	x86 Size, Alignment
bool	1, 1	1, 1	1, 1
char	1, 1	1, 1	1, 1
short	2, 2	2, 2	2, 2



Type	32-bit SPARC	64-bit SPARC	x86
	Size, Alignment	Size, Alignment	Size, Alignment
wchar_t	4, 4	4, 4	4, 4
int	4, 4	4, 4	4, 4
long	4, 4	8, 8	4, 4
float	4, 4	4, 4	4, 4
double	8, 8	8, 8	8, 4
long double	16, 8	16, 16	12, 4
Pointer to data	4, 4	8, 8	4, 4
Pointer to function	4, 4	8, 8	4, 4
Pointer to member data	4, 4	8, 8	4, 4
Pointer to member function	8, 4	16, 8	8, 4

## B.2.17 `#pragma rarely_called`

```
#pragms rarely_called(funcname[, funcname])
```

This pragma provides a hint to the compiler that the specified functions are called infrequently, enabling the compiler to perform profile-feedback style optimizations on the call-sites of such routines without the overhead of a profile-collections phase. Since this pragma is a suggestion, the compiler may not perform any optimizations based on this pragma.

The `#pragma rarely_called` preprocessor directive is only permitted after the prototype for the specified functions are declares. The following is an example of `#pragma rarely_called`:

```
extern void error (char *message);
#pragma rarely_called(error)
```

For a more detailed explanation of how the pragma treats overloaded function names as arguments, see [“B.1.1 Overloaded Functions as Pragma Arguments” on page 343](#).

## B.2.18 `#pragma returns_new_memory`

```
#pragma returns_new_memory(name[, name...])
```

This pragma asserts that each named function returns the address of newly allocated memory and that the pointer does not alias with any other pointer. This information allows the optimizer to better track pointer values and to clarify memory location, resulting in improved scheduling and pipelining.

If the assertion is false, the results of executing a program which calls this function are undefined.

The *name* argument specifies the name of a function within the current translation unit. The pragma must be in the same scope as the function and must appear after the function declaration. The pragma must be before the function definition.

For a more detailed explanation of how the pragma treats overloaded function names as arguments, see [“B.1.1 Overloaded Functions as Pragma Arguments” on page 343](#).

## B.2.19 `#pragma unknown_control_flow`

```
#pragma unknown_control_flow(name[, name...])
```

Use `unknown_control_flow` to specify a list of routines that violate the usual control flow properties of procedure calls. For example, the statement following a call to `setjmp()` can be reached from an arbitrary call to any other routine. The statement is reached by a call to `longjmp()`.

Because such routines render standard flowgraph analysis invalid, routines that call them cannot be safely optimized; hence, they are compiled with the optimizer disabled.

If the function name is overloaded, the most recently declared function is chosen.

## B.2.20 `#pragma weak`

```
#pragma weak name1 [= name2]
```

Use `weak` to define a weak global symbol. This pragma is used mainly in source files for building libraries. The linker does not warn you if it cannot resolve a weak symbol.

The weak pragma can specify symbols in one of two forms:

- **String form.** The string must be the mangled name for a C++ variable or function. The behavior for an invalid mangled name reference is unpredictable. The compiler might not produce an error for invalid mangled name references. Regardless of whether it produces an error, the behavior of the compiler when invalid mangled names are used is unpredictable.
- **Identifier form.** The identifier must be an unambiguous identifier for a C++ function that was previously declared in the compilation unit. The identifier form cannot be used for variables. The front end (`ccfe`) will produce an error message if it encounters an invalid identifier reference.

### B.2.20.1 `#pragma weak name`

In the form `#pragma weak name`, the directive makes *name* a weak symbol. The linker will not indicate if it does not find a symbol definition for *name*. It also does not warn about multiple weak definitions of the symbol. The linker simply takes the first one it encounters.

If another compilation unit has a strong definition for the function or variable, *name* will be linked to that. If there is no strong definition for *name*, the linker symbol will have a value of 0.

The following directive defines `ping` to be a weak symbol. No error messages are generated if the linker cannot find a definition for a symbol named `ping`.

```
#pragma weak ping
```

#### `#pragma weak name1 = name2`

In the form `#pragma weak name1 = name2`, the symbol *name1* becomes a weak reference to *name2*. If *name1* is not defined elsewhere, *name1* will have the value *name2*. If *name1* is defined elsewhere, the linker uses that definition and ignores the weak reference to *name2*. The following directive instructs the linker to resolve any references to `bar` if it is defined anywhere in the program, and to `foo` otherwise.

```
#pragma weak bar = foo
```

In the identifier form, *name2* must be declared and defined within the current compilation unit. For example:

```
extern void bar(int) {...}
extern void _bar(int);
#pragma weak _bar=bar
```

When you use the string form, the symbol does not need to be previously declared. If both `_bar` and `bar` in the following example are `extern "C"`, the functions do not need to be declared. However, `bar` must be defined in the same object.

```
extern "C" void bar(int) {...}
#pragma weak "_bar" = "bar"
```

### Overloading Functions

When you use the identifier form, exactly one function with the specified name must be in scope at the pragma location. Attempting to use the identifier form of `#pragma weak` with an overloaded function is an error. For example:

```
int bar(int);
float bar(float);
#pragma weak bar          // error, ambiguous function name
```

To avoid the error, use the string form, as shown in the following example.

```
int bar(int);
float bar(float);
#pragma weak "__1cDbar6Fi_i_" // make float bar(int) weak
```

See the [Oracle Solaris 11.3 Linkers and Libraries Guide](#) for more information.

## Glossary

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<b>ABI</b>	See Application Binary Interface.
<b>abstract class</b>	A class that contains one or more abstract methods, and therefore can never be instantiated. Abstract classes are defined so that other classes can extend them and make them concrete by implementing the abstract methods.
<b>abstract method</b>	A method that has no implementation.
<b>ANSI C</b>	American National Standards Institute's definition of the C programming language. It is the same as the ISO definition. See ISO.
<b>ANSI/ISO C++</b>	The American National Standards Institute and the ISO standard for the C++ programming language. See ISO.
<b>application binary interface</b>	The binary system interface between compiled applications and the operating system on which they run.
<b>array</b>	A data structure that stores a collection of values of a single data type consecutively in memory. Each value is accessed by its position in the array.
<b>base class</b>	See <i>inheritance</i> .
<b>binary compatibility</b>	The ability to link object files that are compiled by one release while using a compiler of a different release.
<b>binding</b>	Associating a function call with a specific function definition. More generally, associating a name with a particular entity.
<b>cfront</b>	A C++ to C compiler program that translates C++ to C source code, which in turn can be compiled by a standard C compiler.
<b>class</b>	A user-defined data type consisting of named data elements (which may be of different types), and a set of operations that can be performed with the data.

<b>class template</b>	A template that describes a set of classes or related data types.
<b>class variable</b>	A data item associated with a particular class as a whole, not with particular instances of the class. Class variables are defined in class definitions. Also called static field. See also instance variable.
<b>compiler option</b>	An instruction to the compiler that changes its behavior. For example, the <code>-g</code> option tells the compiler to generate data for the debugger. Synonyms: <i>flag</i> , <i>switch</i> .
<b>constructor</b>	A special class member function that is automatically called by the compiler whenever a class object is created to ensure the initialization of that object's instance variables. The constructor must always have the same name as the class to which it belongs. See destructor.
<b>data member</b>	An element of a class that is <i>data</i> , as opposed to a function or type definition.
<b>data type</b>	The mechanism that enables the representation of, for example, characters, integers, or floating-point numbers. The type determines the storage that is allocated to a variable and the operations that can be performed on the variable.
<b>derived class</b>	See <i>inheritance</i> .
<b>destructor</b>	A special class member function that is automatically called by the compiler whenever a class object is destroyed or the operator <code>delete</code> is applied to a class pointer. The destructor must always have the same name as the class to which it belongs, preceded by a tilde (~). See <i>constructor</i> .
<b>dynamic binding</b>	Connection of the function call to the function body at runtime. Occurs only with virtual functions. Also called <i>late binding</i> , <i>runtime binding</i> .
<b>dynamic cast</b>	A safe method of converting a pointer or reference from its declared type to any type that is consistent with the dynamic type to which it refers.
<b>dynamic type</b>	The actual type of an object that is accessed by a pointer or reference that might have a different declared type.
<b>early binding</b>	See static binding.
<b>ELF file</b>	Executable and Linking Format file, which is produced by the compiler.
<b>exception</b>	An error occurring in the normal flow of a program that prevents the program from continuing. Some reasons for errors include memory exhaustion or division by zero.
<b>exception handler</b>	Code specifically written to deal with errors that is invoked automatically when an exception occurs for which the handler has been registered.
<b>exception handling</b>	An error recovery process that is designed to intercept and prevent errors. During the execution of a program, if a synchronous error is detected, control of the program returns to an exception

---

	handler that was registered at an earlier point in the execution, and the code containing the error is bypassed.
<b>flag</b>	See compiler option.
<b>function overloading</b>	Giving the same name, but different argument types and numbers, to different functions. Also called <i>functional polymorphism</i> .
<b>function prototype</b>	A declaration that describes the function's interface with the rest of the program.
<b>function template</b>	A mechanism that enables you to write a single function that you can then use as a model, or pattern, for writing related functions.
<b>functional polymorphism</b>	See function overloading.
<b>idempotent</b>	The property of a header file that including it many times in one translation unit has the same effect as including it once.
<b>incremental linker</b>	A linker that creates a new executable file by linking only the changed .o files to the previous executable.
<b>inheritance</b>	A feature of object-oriented programming that allows the programmer to derive new classes (derived classes) from existing ones (base classes). There are three kinds of inheritance: public, protected, and private.
<b>inline function</b>	A function that replaces the function call with the actual function code.
<b>instance variable</b>	Any item of data that is associated with a particular object. Each instance of a class has its own copy of the instance variables defined in the class. Also called field. See also class variable.
<b>instantiation</b>	The process by which a C++ compiler creates a usable function or object (instance) from a template.
<b>ISO</b>	International Organization for Standardization.
<b>K&amp;R C</b>	The de facto C programming language standard that was developed by Brian Kernighan and Dennis Ritchie before ANSI C.
<b>keyword</b>	A word that has unique meaning in a programming language, and that can be used only in a specialized context in that language.
<b>late binding</b>	See dynamic binding.
<b>linker</b>	The tool that connects object code and libraries to form a complete, executable program.

<b>local variable</b>	A data item known within a block, but inaccessible to code outside the block. For example, any variable defined within a method is a local variable and cannot be used outside the method.
<b>locale</b>	A set of conventions that are unique to a geographical area or language, such as date, time, and monetary format.
<b>lvalue</b>	An expression that designates a location in memory at which a variable's data value is stored. Also, the instance of a variable that appears to the left of the assignment operator.
<b>mangle</b>	See name mangling.
<b>member function</b>	An element of a class that is a function as opposed to a data definition or type definition.
<b>method</b>	In some object-oriented languages, another name for a member function.
<b>multiple inheritance</b>	Inheritance of a derived class directly from more than one base class.
<b>multithreading</b>	The software technology that enables the development of parallel applications, whether on single or multi-processor systems.
<b>name mangling</b>	In C++, many functions can share the same name, so name alone is not sufficient to distinguish different functions. The compiler solves this problem by name mangling: creating a unique name for the function that consists of some combination of the function name and its parameters. This strategy enables type-safe linkage. Also called <i>name decoration</i> .
<b>namespace</b>	A mechanism that controls the scope of global names by allowing the global space to be divided into uniquely named scopes.
<b>operator overloading</b>	The ability to use the same operator notation to produce different outcomes. A special form of function overloading.
<b>optimization</b>	The process of improving the efficiency of the object code that is generated by the compiler.
<b>option</b>	See compiler option.
<b>overloading</b>	To give the same name to more than one function or operator.
<b>polymorphism</b>	The ability of a pointer or reference to refer to objects whose dynamic type is different from the declared pointer or reference type.
<b>pragma</b>	A compiler preprocessor directive, or special comment, that instructs the compiler to take a specific action.
<b>runtime binding</b>	See dynamic binding.



---

<b>runtime type identification (RTTI)</b>	A mechanism that provides a standard method for a program to determine an object type during runtime.
<b>rvalue</b>	The variable that is located to the right of an assignment operator. The rvalue can be read but not altered.
<b>scope</b>	The range over which an action or definition applies.
<b>stab</b>	A symbol table entry that is generated in the object code. The same format is used in both a.out files and ELF files to contain debugging information.
<b>stack</b>	A data storage method by which data can be added to or removed from only the top of the stack using a last-in, first-out strategy.
<b>static binding</b>	Connection of a function call to a function body at compile time. Also called <i>early binding</i> .
<b>subroutine</b>	A function. In Fortran, a function that does not return a value.
<b>switch</b>	See compiler option.
<b>symbol</b>	A name or label that denotes some program entity.
<b>symbol table</b>	A list of all identifiers that are present when a program is compiled, their locations in the program, and their attributes. The compiler uses this table to interpret uses of identifiers.
<b>template database</b>	A directory containing all configuration files that are needed to handle and instantiate the templates that are required by a program.
<b>template options file</b>	A user-provided file containing options for the compilation of templates, as well as source location and other information. The template options file is deprecated and should not be used.
<b>template specialization</b>	A specialized instance of a class template member function that overrides the default instantiation when the default cannot handle a given type adequately.
<b>trapping</b>	Interception of an action, such as program execution, in order to take other action. The interception causes the temporary suspension of microprocessor operations and transfers program control to another source.
<b>type</b>	A description of the ways in which a symbol can be used. The basic types are <code>integer</code> and <code>float</code> . All other types are constructed from these basic types by collecting them into arrays or structures, or by adding modifiers such as <code>pointer-to</code> or <code>constant</code> attributes.
<b>variable</b>	An item of data named by an identifier. Each variable has a type, such as <code>int</code> or <code>void</code> , and a scope. See also <code>class variable</code> , <code>instance variable</code> , <code>local variable</code> .
<b>VTABLE</b>	A table that is created by the compiler for each class that contains virtual functions.



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