CodeWarrior Development Studio ColdFire™ Architectures Edition

Build Tools Reference

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1

Introduction

This reference describes how to use CodeWarrior build tools to build programs. CodeWarrior build tools translate source code into object code then organize that object code to create a program that is ready to execute. CodeWarrior build tools often run on a different platform than the programs they generate. Build tools run on the *host* platform to generate software that runs on the *target* platform.

This chapter describes what this reference covers and the processes that CodeWarrior build tools use to create software:

- CodeWarrior Build Tools Versions
- Compiler Architecture
- Linker Architecture

CodeWarrior Build Tools Versions

This reference covers the CodeWarrior compiler version 4.0 and its related linker.

Compiler Architecture

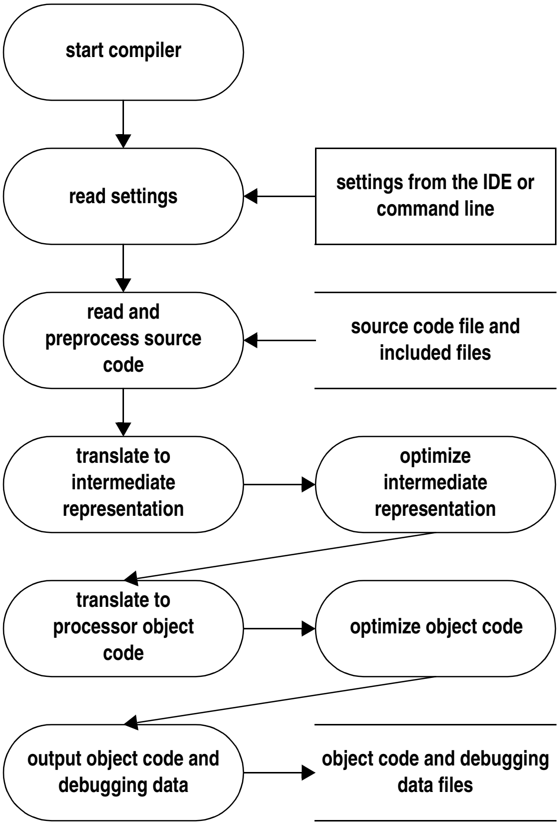
From a programmer's point of view, the CodeWarrior compiler translates source code into object code. Internally, however, the CodeWarrior compiler organizes its work into several steps.

Figure 1.1 shows the steps the compiler takes to coordinate its front-end and back-end to translate source code into object code.

- reading settings: the compiler retrieves your settings from the CodeWarrior IDE or the command line to determine what files to translate and how they should be translated in subsequent steps
- preprocessing: reads your program's source code files then preprocesses them
- front-end translation: translates your program's preprocessed source code into a platform-independent intermediate representation
- front-end optimization: rearranges the intermediate representation to reduce your program's size or improve its performance while preserving its logic

- back-end translation: converts the optimized intermediate representation into native object code, containing data and instructions, for the target processor
- back-end optimization: specific to a target platform, rearranges the native object code to reduce its size or improve performance
- output: writes object code and other data, ready for linking

Figure 1.1 CodeWarrior compiler steps

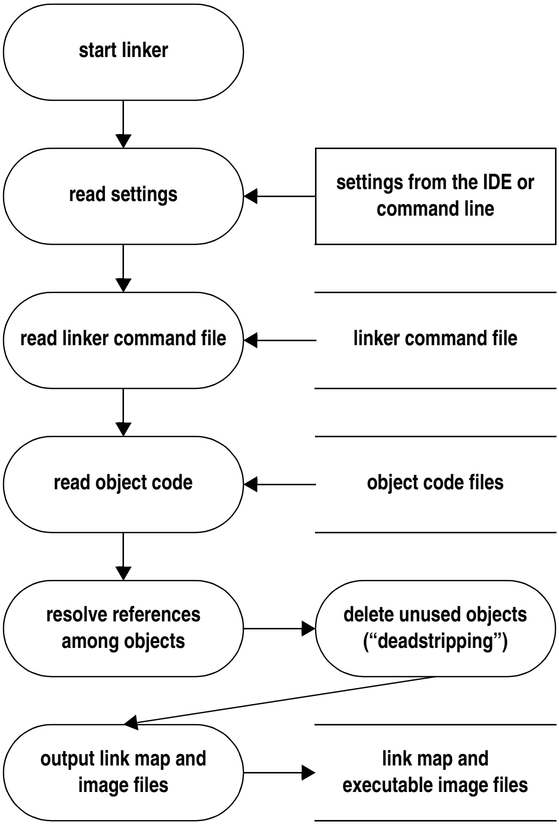

start compiler
read settings
settings from the IDE or command line
read and preprocess source code
source code file and included files
translate to intermediate representation
optimize intermediate representation
translate to processor object code
optimize object code
output object code and debugging data
object code and debugging data files

Linker Architecture

A linker combines and arranges data and instructions from one or more object code files into a single file, or *image*. This image is ready to execute on the target platform. The CodeWarrior linker uses settings from the CodeWarrior IDE or command line to determine how to generate the image file. The linker also uses an optional linker command file. A linker command file allows you to specify precise details of how data and instructions should be arranged in the linker's output file.

Figure 1.2 shows the steps the CodeWarrior linker takes to build an executable image.

Figure 1.2 CodeWarrior linker steps


start linker
read settings
settings from the IDE or command line
read linker command file
linker command file
read object code
object code files
resolve references among objects
delete unused objects ("deadstripping")
output link map and image files
link map and executable image files

2

Using Build Tools with the CodeWarrior IDE

The CodeWarrior Integrated Development Environment (IDE) uses settings in a project's build target to choose which compilers and linkers to invoke, which files those compilers and linkers will process, and which options the compilers and linkers will use.

This chapter describes how to use CodeWarrior compilers and linkers with the CodeWarrior IDE:

- Invoking CodeWarrior Compilers and Linkers
- Specifying File Locations
- IDE Options and Pragmas
- IDE Settings Panels

Invoking CodeWarrior Compilers and Linkers

The IDE uses settings in the **Target Settings** panel of the ***build-target*** **Settings** window, where *build-target* is the name of the current build target, to determine which compilers and linkers to use. The **Linker** option in this settings panel specifies the platform or processor to build for. From this option, the IDE also determines which compilers, pre-linkers, and post-linkers to use.

The IDE uses the settings in the **File Mappings** panel of the ***build-target*** **Settings** window to determine which types of files may be added to a project's build target and which compiler should be invoked to process each file. The menu of compilers in the **Compiler** option of this panel is determined by the **Linker** setting in the **Target Settings** panel.

Specifying File Locations

The IDE uses the settings in a build target's **Access Paths** and **Source Trees** panels to choose the source code and object code files to dispatch to the CodeWarrior build tools. See the *IDE User's Guide* for more information on these panels.

IDE Options and Pragmas

The build tools determine their settings by IDE settings and directives in source code.

The CodeWarrior compiler follows these steps to determine the settings to apply to each file that the compiler translates under the IDE:

- before translating the source code file, the compiler gets option settings from the IDE's settings panels in the current build target
- the compiler updates the settings for pragmas that correspond to panel settings
- the compiler translates the source code in the **Prefix Text** field of the build target's **C/C++ Preprocessor** panel

  The compiler applies pragma directives and updates their settings as pragmas directives are encountered in this source code.
- the compiler translates the source code file and the files that it includes

  The compiler applies pragma settings as it encounters them.

IDE Settings Panels

A build target that uses a CodeWarrior C or C++ compiler has these settings panels to control the compiler:

- C/C++ Language Settings Panel
- C/C++ Preprocessor Panel
- C/C++ Warnings Panel

C/C++ Language Settings Panel

This settings panel controls compiler language features and some object code storage features for the current build target.

- Force C++ Compilation
- ISO C++ Template Parser
- Use Instance Manager
- Enable C++ Exceptions
- Enable RTTI
- Enable bool Support
- Enable wchar_t Support
- EC++ Compatibility Mode

- Inline Depth
- Auto-Inline
- Bottom-up Inlining
- ANSI Strict
- ANSI Keywords Only
- Expand Trigraphs
- Legacy for-scoping
- Require Function Prototypes
- Enable C99 Extensions
- Enable GCC Extensions
- Enums Always Int
- Use Unsigned Chars
- Pool Strings
- Reuse Strings

Force C++ Compilation

When on, translates all C source files as C++ source code. When off, the IDE uses the file name's extension to determine whether to use the C or C++ compiler. The entries in the IDE's **File Mappings** settings panel specify the suffixes that the compiler assigns to each compiler.

This setting corresponds to the pragma `cplusplus` and the command-line option `-lang c++`.

ISO C++ Template Parser

When on, follows the ISO/IEC 14882-1998 standard for C++ to translate templates, enforcing more careful use of the `typename` and `template` keywords. When on, the compiler also follows stricter rules for resolving names during declaration and instantiation. When off, the C+++ compiler does not expect template source code to follow the ISO C++ standard as closely.

This setting corresponds to the `parse_func_templ` pragma. It corresponds to the command-line option `-iso_templates`.

Use Instance Manager

When on, reduces compile time by generating any instance of a C++ template (or non-inlined inline) function only once. When off, generates a new instance of a template or non-inlined function each time it appears in source code.

You can control where the instance database is stored using the `#pragma instmgr_file`. This setting corresponds to the command-line option `-instmgr`.

Enable C++ Exceptions

When on, generates executable code for C++ exceptions. When off, generates smaller, faster executable code.

Enable the **Enable C++ Exceptions** setting if you use the `try`, `throw`, and `catch` statements specified in the ISO/IEC 14882-1998 C++ standard. Otherwise, disable this setting to generate smaller and faster code.

This setting corresponds to the pragma `exceptions` and the command-line option `-cpp_exceptions`.

Enable RTTI

When on, allows the use of the C++ runtime type information (RTTI) capabilities, including the `dynamic_cast` and `typeid` operators. When off, the compiler generates smaller, faster object code but does not allow runtime type information operations.

This setting corresponds to the pragma `RTTI` and the command-line option `-RTTI`.

Enable bool Support

When on, the C++ compiler recognizes the `bool` type and its `true` and `false` values specified in the ISO/IEC 14882-1998 C++ standard. When off, the compiler does not recognize this type or its values.

This setting corresponds to the pragma `bool` and the command-line option `-bool`.

Enable wchar_t Support

When on, the C++ compiler recognizes the `wchar_t` data type specified in the ISO/IEC 14882-1998 C++ standard. When off, the compiler does not recognize this type.

Turn off this option when compiling source code that defines its own `wchar_t` type.

This setting corresponds to the pragma `wchar_type` and the command-line option `-wchar_t`.

EC++ Compatibility Mode

When on, expects C++ source code files to contain Embedded C++ source code. When off, the compiler expects regular C++ source code in C++ source files.

This setting corresponds to the pragma `ecplusplus` and the command-line option `-dialect ec++`.

Inline Depth

Specifies the policy to follow to determine the level of function calls to replace with function bodies. These policies are listed in Table 2.1.

Table 2.1 Settings for the Inline Depth Pop-up Menu

This setting	Does this…
Don’t Inline	Inlines no functions, not even C or C++ functions declared `inline`.
Smart	Inlines small functions to a depth of 2 to 4 inline functions deep.
1 to **8**	Inlines to the depth specified by the numerical selection.

The **Smart** and **1** to **8** items correspond to the `pragma inline_depth` and the command-line option `−inline level=`*n*, where *n* is `1` to `8`. The **Don’t Inline** item corresponds to the pragma `dont_inline` and the command-line option `-inline off`.

Auto-Inline

Lets the compiler choose which functions to inline. Also inlines C++ functions declared `inline` and member functions defined within a class declaration. This setting corresponds to the pragma `auto_inline` and the command-line option `-inline auto`.

Bottom-up Inlining

Inline functions starting at the last function to the first function in a chain of function calls. This setting corresponds to the pragma `inline_bottom_up` and the command-line option `-inline bottomup`.

ANSI Strict

Only recognizes source code that conforms to the ISO/IEC 9899-1990 standard for C. The compiler does not recognize several CodeWarrior extensions to the C language:

- C++-style comments
- unnamed arguments in function definitions
- a # not followed by a macro directive
- using an identifier after a `#endif` directive
- using typecasted pointers as lvalues
- converting points to type of the same size
- arrays of zero length in structures
- the `D` constant suffix
- enumeration constant definitions that cannot be represented as signed integers when the **Enums Always Int** option is on in the IDE's **C/C++ Language** settings panel or the `enumsalwaysint` pragma is on
- a C++ `main()` function that does not return an integer value

You cannot enable individual extensions that are controlled by the **ANSI Strict** setting.

This setting corresponds to the pragma `ANSI_strict` and the command-line option `-ansi strict`.

ANSI Keywords Only

Controls whether the compiler recognizes non-standard keywords.

(ISO/IEC 9899-1990 C, §6.4.1) The CodeWarrior compiler can recognize several additional reserved keywords. If you enable this setting, the compiler generates an error message if it encounters any of the additional keywords that it recognizes. If you must write source code that strictly adheres to the ISO standard, enable the **ANSI Strict** setting.

If you disable this setting, the compiler recognizes the following non-standard keywords: `far`, `inline`, `__inline__`, `__inline`, and `pascal`.

This setting corresponds to the pragma `only_std_keywords` and the command-line option `-stdkeywords`.

Expand Trigraphs

(ISO/IEC 9899-1990 C, §5.2.1.1) The compiler normally ignores trigraph characters. Many common character constants look like trigraph sequences, and this extension lets you use them without including escape characters.

This setting corresponds to the pragma `trigraphs` and the command-line option `-trigraphs`.

Legacy for-scoping

Generates an error message when the compiler encounters a variable scope usage that the ISO/IEC 14882-1998 C++ standard disallows, but is allowed in the C++ language specified in *The Annotated C++ Reference Manual* (“ARM”).

This setting corresponds to the pragma `ARM_scoping` and the command-line option `-for_scoping`.

Require Function Prototypes

Enforces the requirement of function prototypes. If you enable the **Require Function Prototypes** setting, the compiler generates an error message if you define a previously referenced function that does not have a prototype. If you define the function before it is referenced but do not give it a prototype, then enabling the **Require Function Prototypes** setting causes the compiler to issue a warning message.

This setting corresponds to the pragma `require_prototypes` and the command-line option `-requireprotos`.

Enable C99 Extensions

Recognizes ISO/IEC 9899-1999 (“C99”) language features that are supported by the CodeWarrior compiler.

This setting corresponds to the pragma `c99` and the command-line option `-dialect c99`.

Enable GCC Extensions

Lets you use language features of the GCC (Gnu Compiler Collection) C compiler that are supported by CodeWarrior.

This setting corresponds to the pragma `gcc_extensions` and the command-line option `-gcc_extensions`.

Enums Always Int

Uses signed integers to represent enumerated constants. This option corresponds to the `enumsalwaysint` pragma and the command-line option `-enum`.

Use Unsigned Chars

Treats `char` declarations as `unsigned char` declarations. This setting corresponds to the pragma `unsigned_char` and the command-line option `-char unsigned`.

Pool Strings

Controls where the compiler stores character string literals.

If you enable this setting, the compiler collects all string constants into a single data section in the object code it generates. If you disable this setting, the compiler creates a unique section for each string constant.

This option corresponds to the pragma `pool_strings` and the command-line option `-strings pool`.

Reuse Strings

When on, the compiler stores only one copy of identical string literals. When off, the compiler stores each string literal separately.

The **Reuse Strings** setting corresponds to opposite of the pragma `dont_reuse_strings` and the command-line option `-string reuse`.

C/C++ Preprocessor Panel

The C/C++ Preprocessor settings panel controls the operation of the CodeWarrior compiler’s preprocessor.

- Prefix Text
- Source encoding
- Use prefix text in precompiled header
- Emit file changes
- Emit #pragmas
- Show full paths
- Keep comments
- Use #line
- Keep whitespace

Prefix Text

Contains source code that the compiler inserts at the beginning of each translation unit. A translation unit is the combination of a source code file and all the files that it includes.

Source encoding

Allows you to specify the default encoding of source files. The compiler recognizes Multibyte and Unicode source text. To replicate the obsolete option **Multi-Byte Aware**, set this option to **System** or **Autodetect**. Additionally, options that affect the preprocess request appear in this panel.

Use prefix text in precompiled header

Controls whether the compiler inserts the source code in the **Prefix Text** field at the beginning of a precompiled header file.

This option defaults to disabled to correspond with previous versions of the compiler that ignore the prefix file when building precompiled headers. If any pragmas are imported from old C/C++ Language Panel settings, this option is enabled.

Emit file changes

Controls whether notification of file changes (or #line changes) appear in the output.

Emit #pragmas

Controls whether pragmas directives encountered in the source text appear in the preprocessor output.

NOTE This option is essential for producing reproducible test cases for bug reports.

Show full paths

Controls whether file changes show the full path or the base filename of the file.

Keep comments

Controls whether comments are emitted in the output.

Use #line

Controls whether file changes appear in comments (as before) or in #line directives.

Keep whitespace

Controls whether whitespace is stripped out or copied into the output. This is useful for keeping the starting column aligned with the original source, though the compiler attempts to preserve space within the line. This doesn't apply when macros are expanded.

C/C++ Warnings Panel

The **C/C++ Warnings** settings panel contains options that control which warning messages the CodeWarrior C/C++ compiler issues as it translates source code:

- Illegal Pragmas
- Possible Errors
- Extended Error Checking
- Hidden Virtual Functions
- Implicit Arithmetic Conversions
- Float To Integer
- Signed/Unsigned
- Integer To Float
- Pointer/Integral Conversions
- Unused Variables
- Unused Arguments
- Missing 'return' Statements
- Expression Has No Side Effect
- Enable All
- Disable All
- Extra Commas
- Inconsistent 'class'/'struct' Usage
- Empty Declarations
- Include File Capitalization
- Check System Includes
- Pad Bytes Added
- Undefined Macro in #if
- Non-Inlined Functions
- Treat All Warnings As Errors

Illegal Pragmas

Issues a warning message if the compiler encounters an unrecognized pragma.

This setting corresponds to the `warn_illpragma` pragma and the command-line option `-warnings illpragmas`.

Possible Errors

Issues warning messages for common, usually-unintended logical errors:

- in conditional statements, using the assignment (=) operator instead of the equality comparison (==) operator
- in expression statements, using the == operator instead of the = operator
- placing a semicolon (`;`) immediately after a `do`, `while`, `if`, or `for` statement

This setting corresponds to pragma `warn_possunwant` and the command-line option `-warnings possible`.

Extended Error Checking

Issues warning messages for common programming errors:

- mis-matched return type in a function's definition and the return statement in the function's body
- mismatched assignments to variables of enumerated types

This setting corresponds to pragma `extended_errorcheck` and the command-line option `-warnings extended`.

Hidden Virtual Functions

Generates a warning message if you declare a non-virtual member function that prevents a virtual function, that was defined in a superclass, from being called.

This setting corresponds to pragma `warn_hidevirtual` and the command-line option `-warnings hidevirtual`.

Implicit Arithmetic Conversions

Issues a warning message when the compiler applies implicit conversions that may not give results you intend:

- assignments where the destination is not large enough to hold the result of the conversion
- a signed value converted to an unsigned value

- an integer or floating-point value is converted to a floating-point or integer value, respectively

This setting corresponds to the `warn_implicitconv` pragma and the command-line option `-warnings implicitconv`.

Float To Integer

Issues a warning message for implicit conversions from floating point values to integer values.

This setting corresponds to the `warn_impl_f2i_conv` pragma and the command-line option `-warnings impl_float2int`.

Signed/Unsigned

Issues a warning message for implicit conversions from a signed or unsigned integer value to an unsigned or signed value, respectively.

This setting corresponds to the `warn_impl_s2u_conv` pragma and the command-line option `-warnings signedunsigned`.

Integer To Float

Issues a warning message for implicit conversions from integer to floating-point values.

This setting corresponds to the `warn_impl_i2f_conv` pragma and the command-line option `-warnings impl_int2float`.

Pointer/Integral Conversions

Issues a warning message for implicit conversions from pointer values to integer values and from integer values to pointer values.

This setting corresponds to the `warn_any_ptr_int_conv` and `warn_ptr_int_conv` pragmas and the command-line option `-warnings ptrintconv,anyptrinvconv`.

Unused Variables

Issues a warning message for local variables that are not referred to in a function.

This setting corresponds to the `warn_unusedvar` pragma and the command-line option `-warnings unusedvar`.

Unused Arguments

Issues a warning message for function arguments that are not referred to in a function.

This setting corresponds to the `warn_unusedarg` pragma and the command-line option `-warnings unusedarg`.

Missing ‘return’ Statements

Issues a warning message if a function that is defined to return a value has no `return` statement.

This setting corresponds to the `warn_missingreturn` pragma and the command-line option `-warnings missingreturn`.

Expression Has No Side Effect

Issues a warning message if a statement does not change the program’s state.

This setting corresponds to the `warn_no_side_effect` pragma and the command-line option `-warnings unusedexpr`.

Enable All

Turns on all warning options.

Disable All

Turns off all warning options.

Extra Commas

Issues a warning message if a list in an enumeration terminates with a comma. The compiler ignores terminating commas in enumerations when compiling source code that conforms to the ISO/IEC 9899-1999 (“C99”) standard.

This setting corresponds to the `warn_extracomma` pragma and the command-line option `-warnings extracomma`.

Inconsistent ‘class’/’struct’ Usage

Issues a warning message if the class and struct keywords are used interchangeably in the definition and declaration of the same identifier in C++ source code.

This setting corresponds to the `warn_structclass` pragma and the command-line option `-warnings structclass`.

Empty Declarations

Issues a warning message if a declaration has no variable name.

This setting correspongsd to the pragma `warn_emptydecl` and the command-line option `-warnings emptydecl`.

Include File Capitalization

Issues a warning message if the name of the file specified in a `#include "`*`file`*`"` directive uses different letter case from a file on disk.

This setting corresponds to the `warn_filenamecaps` pragma and the command-line option `-warnings filecaps`.

Check System Includes

Issues a warning message if the name of the file specified in a `#include <`*`file`*`>` directive uses different letter case from a file on disk.

This setting corresponds to the `warn_filenamecaps_system` pragma and the command-line option `-warnings sysfilecaps`.

Pad Bytes Added

Issues a warning message when the compiler adjusts the alignment of components in a data structure.

This setting corresponds to the `warn_padding` pragma and the command-line option `-warnings padding`.

Undefined Macro in #if

Issues a warning message if an undefined macro appears in `#if` and `#elif` directives.

This setting corresponds to the `warn_undefmacro` pragma and the command-line option `-warnings undefmacro`.

Non-Inlined Functions

Issues a warning message if a call to a function defined with the `inline`, `__inline__`, or `__inline` keywords could not be replaced with the function body.

This setting corresponds to the `warn_notinlined` pragma and the command-line option `-warnings notinlined`.

Treat All Warnings As Errors

Issues warning messages as error messages.

This setting corresponds to the `warning_errors` pragma and the command-line option `-warnings error`.

3

Using Build Tools on the Command Line

The CodeWarrior command line compilers and assemblers translate source code into object code, storing this object code in files. CodeWarrior command-line linkers then combine one or more of these object code files to produce an executable image ready to load and execute on the target platform.

Each command-line tool has options that you configure when you invoke the tool.

The CodeWarrior IDE (Integrated Development Environment) uses these same compilers and linkers, however CodeWarrior provides versions of these tools that you can directly invoke on the command line. Many command-line options correspond to settings in the IDE's **Target Settings** window.

This chapter contains these topics:

- Configuring Command-Line Tools
- Invoking Command-Line Tools
- Getting Help
- File Name Extensions

Configuring Command-Line Tools

To use the command-line tools, several environment variables must be changed or defined.

If you are using CodeWarrior command-line tools with Microsoft Windows, environment variables may be assigned in the `autoexec.bat` file in Windows 95/98 operating systems or in the **Environment** tab under the **System** control panel in Windows NT/2000/XP operating systems.

The CodeWarrior command-line tools refer to environment variables for configuration information:

- CWFolder Environment Variable
- Setting the PATH Environment Variable

CWFolder Environment Variable

In this example, `CWFolder` refers to the path where you installed your CodeWarrior software. Note that you must not include quote marks when defining environment variables that include spaces. The Windows operating system will not remove the quotes, which leads to warning messages for unknown directories. Use the following syntax if defining variables in batch files or at the command line (Listing 3.1).

Listing 3.1 Example of setting CWFolder.

```
set CWFolder=C:\Program Files\CodeWarrior
```

Setting the PATH Environment Variable

The `PATH` variable should include the paths for your CodeWarrior tools, shown in Listing 3.2. *Toolset* represents the name of the folder that contains the command line tools for your build target.

Listing 3.2 Example of setting PATH

```
%CWFolder%\Bin
%CWFolder%\toolset\Command_Line_Tools
```

The first path in Listing 3.2 contains the FlexLM license manager DLL, and the second path contains the tools.

In order for FlexLM to work properly, you can simply copy the following file into the directory from which you will be using the command line tools:

```
..\CodeWarrior\license.dat
```

Alternately, you can define the variable `LM_LICENSE_FILE` as:

```
%CWFolder%\license.dat
```

This variable points to license information. It may point to alternate versions of this file, as needed.

Invoking Command-Line Tools

To compile, assemble, link, or perform some other programming task with the CodeWarrior command-line tools, you type a command at a command line's prompt. This command specifies the tool you want to run, what options to use while the tool runs, and what files the tool should operate on.

The form of a command to run a command-line tool is

```
tool options files
```

where `tool` is the name of the CodeWarrior command-line tool to invoke, `options` is a list of zero or more options that specify to the tool what operation it should perform and how it should be performed, and `files` is a list of files zero or more files that the tool should operate on.

Which options and files you should specify depend on what operation you want the tool to perform.

The tool then performs the operation on the files you specify. If the tool is successful it simply finishes its operation and a new prompt appears at the command line. If the tool encounters problems it reports these problems as text messages on the command-line before a new prompt appears.

Scripts that automate the process to build a piece of software contain commands to invoke command-line tools. For example, the `make` tool, a common software development tool, uses scripts to manage dependencies among source code files and invoke command-line compilers, assemblers and linkers as needed, much like the CodeWarrior IDE's project manager.

Getting Help

To show short descriptions of a tool's options, type this command at the command line:

```
tool -help
```

where *tool* is the name of the CodeWarrior build tool.

To show only a few lines of help information at a time, pipe the tool's output to a pager program. For example,

```
tool -help | more
```

will use the `more` pager program to display the help information.

Help Guidelines

Enter the following command in a **Command Prompt** window to see a list of specifications that describe how options are formatted:

```
tool -help usage
```

where *tool* is the name of the CodeWarrior build tool.

Parameter Formats

Parameters in an option are formatted as follows:

- A parameter included in brackets "`[]`" is optional.

- Use of the ellipsis "`...`" character indicates that the previous type of parameter may be repeated as a list.

Option Formats

Options are formatted as follows:

- For most options, the option and the parameters are separated by a space as in "`-xxx param`".

  When the option's name is "`-xxx+`", however, the parameter must directly follow the option, without the "+" character (as in "`-xxx45`") and with no space separator.

- An option given as "`-[no]xxx`" may be issued as "`-xxx`" or "`-noxxx`".

  The use of "`-noxxx`" reverses the meaning of the option.

- When an option is specified as "`-xxx | yy[y] | zzz`", then either "`-xxx`", "`-yy`", "`-yyy`", or "`-zzz`" matches the option.
- The symbols "`,`" and "=" separate options and parameters unconditionally; to include one of these symbols in a parameter or filename, escape it (e.g., as "`\,`" in `mwcc file.c\,v)`.

Common Terms

These common terms appear in many option descriptions:

- A "cased" option is considered case-sensitive. By default, no options are case-sensitive.
- "compatibility" indicates that the option is borrowed from another vendor's tool and its behavior may only approximate its counterpart.
- A "global" option has an effect over the entire command line and is parsed before any other options. When several global options are specified, they are interpreted in order.
- A "deprecated" option will be eliminated in the future and should no longer be used. An alternative form is supplied.
- An "ignored" option is accepted by the tool but has no effect.
- A "meaningless" option is accepted by the tool but probably has no meaning for the target operating system.
- An "obsolete" option indicates a deprecated option that is no longer available.
- A "substituted" option has the same effect as another option. This points out a preferred form and prevents confusion when similar options appear in the help.
- Use of "default" in the help text indicates that the given value or variation of an option is used unless otherwise overridden.

This tool calls the linker (unless a compiler option such as `-c` prevents it) and understands linker options – use “`-help tool=other`” to see them. Options marked “passed to linker” are used by the compiler and the linker; options marked “for linker” are used only by the linker. When using the compiler and linker separately, you must pass the common options to both.

File Name Extensions

Files specified on the command line are identified by contents and file extension, as in the CodeWarrior IDE.

The command-line version of the CodeWarrior C/C++ compiler accepts non-standard file extensions as source code but also emits a warning message. By default, the compiler assumes that a file with any extensions besides `.c`, `.h`, `.pch` is C++ source code. The linker ignores all files that it can not identify as object code, libraries, or command files.

Linker command files must end in `.lcf`. They may be simply added to the link line, for example (Listing 3.3).

Listing 3.3 Example of using linker command files

```
mwldtarget file.o lib.a commandfile.lcf
```

For more information on linker command files, refer to the *Targeting* manual for your platform.

4

Command-Line Standard C Conformance

-ansi

Controls the ISO/IEC 9899-1990 (“C89”) conformance options, overriding the given settings.

Syntax

`-ansi` *`keyword`*

The arguments for `keyword` are:

`off`

Turns ISO conformance off. Same as

```
-stdkeywords off -enum min -strict off.
```

`on | relaxed`

Turns ISO conformance on in relaxed mode. Same as

```
-stdkeywords on -enum min -strict on
```

`strict`

Turns ISO conformance on in strict mode. Same as

```
-stdkeywords on -enum int -strict on
```

-stdkeywords

Controls the use of ISO/IEC 9899-1990 (“C89”) keywords.

Syntax

```
-stdkeywords on | off
```

Remarks

Default setting is `off`.

-strict

Controls the use of non-standard ISO/IEC 9899-1990 (“C89”) language features.

Syntax

```
-strict on | off
```

Remarks

If this option is `on`, the compiler generates an error message if it encounters some CodeWarrior extensions to the C language defined by the ISO/IEC 9899-1990 (“C89”) standard:

- C++-style comments
- unnamed arguments in function definitions
- non-standard keywords

The default setting is `off`.

5

Command-Line Standard C++ Conformance

-ARM

Deprecated. Use -for_scoping instead.

-bool

Controls the use of `true` and `false` keywords for the C++ `bool` data type.

Syntax

```
-bool on | off
```

Remarks

When `on`, the compiler recognizes the `true` and `false` keywords in expressions of type `bool`. When off, the compiler does recognizes the keywords, forcing the source code to provide definitions for these names. The default is `on`.

-Cpp_exceptions

Controls the use of C++ exceptions.

Syntax

```
-cpp_exceptions on | off
```

Remarks

When `on`, the compiler recognizes the `try`, `catch`, and `throw` keywords and generates extra executable code and data to handle exception throwing and catching. The default is `on`.

-dialect

Specify the source language.

Syntax

```
-dialect keyword
```

```
-lang keyword
```

The arguments for *`keyword`* are:

`c`

Compiles source code using the language specified by the ISO/IEC 9899-1990 ("C89") standard.

`c99`

Compiles source code using the language specified by the ISO/IEC 9899-1999 ("C99") standard.

`c++ | cplus`

Always treat source as the C++ language.

`ec++`

Generate error messages for use of C++ features outside the Embedded C++ subset. Implies `dialect cplus`.

`objc`

Always treat source as the Objective-C language.

-for_scoping

Controls legacy scope behavior in for loops.

Syntax

```
-for_scoping
```

Remarks

When enabled, variables declared in `for` loops are visible to the enclosing scope; when disabled, such variables are scoped to the loop only. The default is `off`.

-instmgr

Controls whether the instance manager for templates is active.

Syntax

```
-inst[mgr] keyword [,...]
```

The options for *keyword* are:

`off`

Turn off the C++ instance manager. This is the default.

`on`

Turn on the C++ instance manager.

`file=`*`path`*

Specify the path to the database used for the C++ instance manager. Unless specified the default database is `cwinst.db`.

Remarks

This command is global. The default setting is `off`.

-iso_templates

Controls whether the ISO/IEC 14882-1998 standard C++ template parser is active.

Syntax

```
-iso_templates on | off
```

Remarks

Default setting is `off`.

-RTTI

Controls the availability of runtime type information (RTTI).

Syntax

```
-RTTI on | off
```

Remarks

Default setting is `on`.

-som

Obsolete. This option is no longer available.

-som_env_check

Obsolete. This option is no longer available.

-wchar_t

Controls the use of the `wchar_t` data type in C++ source code.

Syntax

```
-wchar_t on | off
```

Remarks

The `−wchar on` option tells the C++ compiler to recognize the `wchar_t` type as a built-in type for wide characters. The `-wchar off` option tells the compiler not to allow this built-in type, forcing the user to provide a definition for this type. Default setting is `on`.

6

Command-Line Language Translation

-char

Controls the default sign of the `char` data type.

Syntax

`-char` *`keyword`*

The arguments for *keyword* are:

`signed`

`char` data items are signed.

`unsigned`

`char` data items are unsigned.

Remarks

The default is `signed`.

-defaults

Controls whether the compiler uses additional environment variables to provide default settings.

Syntax

```
-defaults
```

```
-nodefaults
```

Remarks

This option is global. To tell the command-line compiler to use the same set of default settings as the CodeWarrior IDE, use `-defaults`. For example, in the IDE, all access paths and libraries are explicit. `defaults` is the default setting.

Use `-nodefaults` to disable the use of additional environment variables.

-encoding

Specify the default source encoding used by the compiler.

Syntax

`-enc[oding]` *`keyword`*

The options for *keyword* are:

`ascii`

American Standard Code for Information Interchange (ASCII) format. This is the default.

`autodetect | multibyte | mb`

Scan file for multibyet encoding.

`system`

Uses local system format.

`UTF[8 | -8]`

Unicode Transformation Format (UTF).

`SJIS | Shift-JIS | ShiftJIS`

Shift Japanese Industrial Standard (Shift-JIS) format.f

`EUC[JP | -JP]`

Japanese Extended UNIX Code (EUCJP) format.

`ISO[2022JP | -2022-JP]`

International Organization of Standards (ISO) Japanese format.

Remarks

The compiler automatically detects UTF-8 (Unicode Transformation Format) header or UCS-2/UCS-4 (Uniform Communications Standard) encodings regardless of setting. The default setting is `ascii`.

-flag

Specifies compiler #pragma as either on or off.

Syntax

```
-fl[ag] [no-]pragma
```

Remarks

For example, this option setting

```
-flag require_prototypes
```

is equivalent to

```
#pragma require_prototypes on
```

This option setting

```
-flag no-require_prototypes
```

is the same as

```
#pragma require_prototypes off
```

-gccext

Enables GCC (Gnu Compiler Collection) C language extensions.

Syntax

```
-gcc[ext] on | off
```

Remarks

See "GCC Extensions" on page 142 for a list of language extensions that the compiler recognizes when this option is on.

The default setting is off.

-gcc_extensions

Equivalent to the -gccext option.

Syntax

```
-gcc[_extensions] on | off
```

-M

Scan source files for dependencies and emit a Makefile, without generating object code.

Syntax

```
-M
```

Remarks

This command is global and case-sensitive.

-make

Scan source files for dependencies and emit a Makefile, without generating object code.

Syntax

```
-make
```

Remarks

This command is global.

-mapcr

Swaps the values of the `\n` and `\r` escape characters.

Syntax

```
-mapcr
```

```
-nomapcr
```

Remarks

The `-mapcr` option tells the compiler to treat the `'\n'` character as ASCII 13 and the `'\r'` character as ASCII 10. The `-nomapcr` option tells the compiler to treat these characters as ASCII 10 and 13, respectively.

-MM

Scan source files for dependencies and emit a Makefile, without generating object code or listing system `#include` files.

Syntax

```
-MM
```

Remarks

This command is global and case-sensitive.

-MD

Scan source files for dependencies and emit a Makefile, generate object code, and write a dependency map.

Syntax

```
-MD
```

Remarks

This command is global and case-sensitive.

-MMD

Scan source files for dependencies and emit a Makefile, generate object code, write a dependency map, without listing system `#include` files.

Syntax

```
-MMD
```

Remarks

This command is global and case-sensitive.

-msext

Allows Microsoft Visual C++ extensions.

Syntax

```
-msext on | off
```

Remarks

Turn on this option to allow Microsoft Visual C++ extensions:

- Redefinition of macros
- Allows `XXX::yyy` syntax when declaring method `yyy` of class `XXX`
- Allows extra commas
- Ignores casts to the same type
- Treats function types with equivalent parameter lists but different return types as equal
- Allows pointer-to-integer conversions, and various syntactical differences

-multibyteaware

Allows multi-byte characters encodings in source text.

Syntax

```
-multibyte[aware]
```

```
-nomultibyte[aware]
```

-once

Prevents header files from being processed more than once.

Syntax

```
-once
```

Remarks

You can also add `#pragma once on` in a prefix file.

-pragma

Defines a pragma for the compiler.

Syntax

```
-pragma 'name ["setting"]'
```

The arguments are:

`name`

Name of the new pragma enclosed in single-quotes.

`setting`

Setting for the new pragma. When adding a setting, setting must be enclosed in double-quotes.

-relax_pointers

Relaxes the pointer type-checking rules in C.

Syntax

```
-relaxpointers
```

Remarks

This option is equivalent to

```
#pragma mpwc_relax on
```

-requireprotos

Controls whether or not the compiler should expect function prototypes.

Syntax

```
-r[equireprotos]
```

-search

Globally searches across paths for source files, object code, and libraries specified in the command line.

Syntax

```
-search
```

-trigraphs

Controls the use of trigraph sequences specified by the ISO/IEC standards for C and C++.

Syntax

```
-trigraphs on | off
```

Remarks

Default setting is `off`.

7

Command-Line Diagnostic Messages

-disassemble

Tells the command-line tool to disassemble files and send result to `stdout`.

Syntax

```
-dis[assemble]
```

Remarks

This option is global.

-help

Lists descriptions of the CodeWarrior tool's command-line options.

Syntax

```
-help [keyword [,...]]
```

The options for *keyword* are:

`all`

Show all standard options

`group=`*`keyword`*

Show help for groups whose names contain *keyword* (case-sensitive).

`[no]compatible`

Use `compatible` to show options compatible with this compiler. Use `nocompatible` to show options that do not work with this compiler.

`[no]deprecated`

Shows deprecated options

`[no]ignored`

Shows ignored options

`[no]meaningless`

Shows options meaningless for this target

`[no]normal`

Shows only standard options

`[no]obsolete`

Shows obsolete options

`[no]spaces`

Inserts blank lines between options in printout.

`opt[ion]=name`

Shows help for a given option; for ’name’, maximum length 63 chars

`search=keyword`

Shows help for an option whose name or help contains ’keyword’ (case-sensitive); for ’keyword’, maximum length 63 chars

`tool=keyword[ all | this | other|skipped | both ]`

Categorizes groups of options by tool; default.

- `all`–show all options available in this tool
- `this`–show options executed by this tool; default
- `other`|`skipped`–show options passed to another tool
- `both`–show options used in all tools

`usage`

Displays usage information.

-maxerrors

Specify the maximum number of errors messages to show.

Syntax

```
-maxerrors max
```

`max`

Use `max` to specify the number of error messages. Common values are:

- `0` (zero) – disable maximum count, show all error messages.
- `100` – Default setting.

-maxwarnings

Specify the maximum number of warning messages to show.

Syntax

```
-maxerrors max
```

`max`

Specifies the number of warning messages. Common values are:

- `0` (zero) – Disable maximum count (default).
- *`n`* – Maximum number of warnings to show.

-msgstyle

Controls the style used to show error and warning messages.

Syntax

```
-msgstyle keyword
```

The options for *keyword* are:

`gcc`

Uses the message style that the Gnu Compiler Collection tools use.

`ide`

Uses CodeWarrior's Integrated Development Environment (IDE) message style.

`mpw`

Uses Macintosh Programmer's Workshop (MPW®) message style.

`parseable`

Uses context-free machine parseable message style.

`std`

Uses standard message style. This is the default.

-nofail

Continues processing after getting error messages in earlier files.

Syntax

```
-nofail
```

-progress

Shows progess and version information.

Syntax

```
-progress
```

-S

Disassembles all files and send output to a file. This command is global and case-sensitive.

Syntax

```
-S
```

-stderr

Use the standard error stream to report error and warning messages.

Syntax

```
-stderr
```

```
-nostderr
```

Remarks

The `-stderr` option specifies to the compiler, and other tools that it invokes, that error and warning messages should be sent to the standard error stream.

The `-nostderr` option specifies that error and warning messages should be sent to the standard output stream.

-verbose

Tells the compiler to provide extra, cumulative information in messages.

Syntax

```
-v[erbose]
```

Remarks

This option also gives progress and version information.

-version

Displays version, configuration, and build data.

Syntax

```
-v[ersion]
```

-timing

Shows the amount of time that the tool used to perform an action.

Syntax

```
-timing
```

-warnings

Specify which warning messages the command-line tool issues. This command is global.

Syntax

`-w[arning] keyword [,...]`

The options for `keyword` are:

`off`

Turns off all warning messages. Passed to all tools. Equivalent to

`#pragma warning off`

`on`

Turns on most warning messages. Passed to all tools. Equivalent to

`#pragma warning on`

`[no]cmdline`

Passed to all tools.

`[no]err[or] | [no]iserr[or]`

Treats warnings as errors. Passed to all tools. Equivalent to

`#pragma warning_errors`

`all`

Turns on all warning messages and require prototypes.

`[no]pragmas | [no]illpragmas`

Issues warning messages on illegal pragmas. Equivalent to

`#pragma warn_illpragma`

`[no]empty[decl]`

Issues warning messages on empty declarations. Equivalent to

`#pragma warn_emptydecl`

`[no]possible | [no]unwanted`

Issues warning messages on possible unwanted effects. Equivalent to

`#pragma warn_possunwanted`

`[no]unusedarg`

Issues warning messages on unused arguments. Equivalent to

`#pragma warn_unusedarg`

`[no]unusedvar`

Issues warning messages on unused variables. Equivalent to

`#pragma warn_unusedvar`

`[no]unused`

Same as

`-w [no]unusedarg,[no]unusedvar`

`[no]extracomma | [no]comma`

Issues warning messages on extra commas in enumerations. The compiler ignores terminating commas in enumerations when compiling source code that conforms to the ISO/IEC 9899-1999 (“C99”) standard. Equivalent to

`#pragma warn_extracomma`

`[no]pedantic | [no]extended`

Pedantic error checking.

`[no]hidevirtual | [no]hidden[virtual]`

Issues warning messages on hidden virtual functions. Equivalent to

`#pragma warn_hidevirtual`

`[no]implicit[conv]`

Issues warning messages on implicit arithmetic conversions. Implies

`-warn impl_float2int,impl_signedunsigned`

`[no]impl_int2float`

Issues warning messages on implicit integral to floating conversions. Equivalent to

`#pragma warn_impl_i2f_conv`

`[no]impl_float2int`

Issues warning messages on implicit floating to integral conversions. Equivalent to

`#pragma warn_impl_f2i_conv`

`[no]impl_signedunsigned`

Issues warning messages on implicit signed/unsigned conversions.

`[no]notinlined`

Issues warning messages for functions declared with the `inline` qualifier that are not inlined. Equivalent to

`#pragma warn_notinlined`

`[no]largeargs`

Issues warning messages when passing large arguments to unprototyped functions. Equivalent to

```
#pragma warn_largeargs
```

`[no]structclass`

Issues warning messages on inconsistent use of `class` and `struct`. Equivalent to

```
#pragma warn_structclass
```

`[no]padding`

Issue warning messages when padding is added between `struct` members. Equivalent to

```
#pragma warn_padding
```

`[no]notused`

Issues warning messages when the result of non-void-returning functions are not used. Equivalent to

```
#pragma warn_resultnotused
```

`[no]missingreturn`

Issues warning messages when a return without a value in non-void-returning function occurs. Equivalent to

```
#pragma warn_missingreturn
```

`[no]unusedexpr`

Issues warning messages when encountering the use of expressions as statements without side effects. Equivalent to

```
#pragma warn_no_side_effect
```

`[no]ptrintconv`

Issues warning messages when lossy conversions occur from pointers to integers.

`[no]anyptrintconv`

Issues warning messages on any conversion of pointers to integers. Equivalent to

```
#pragma warn_ptr_int_conv
```

`[no]undef[macro]`

Issues warning messages on the use of undefined macros in `#if` and `#elif` conditionals. Equivalent to

```
#pragma warn_undefmacro
```

`[no]filecaps`

Issues warning messages when `#include ""` directives use incorrect capitalization. Equivalent to

```
#pragma warn_filenamecaps
```

`[no]sysfilecaps`

Issue warning messages when `#include <>` statements use incorrect capitalization. Equivalent to

```
#pragma warn_filenamecaps_system
```

`[no]tokenpasting`

Issue warning messages when token is not formed by the `##` preprocessor operator. Equivalent to

```
#pragma warn_illtokenpasting
```

`display | dump`

Display list of active warnings.

-wraplines

Controls the word wrapping of messages.

Syntax

```
-wraplines
```

```
-nowraplines
```

8

Command-Line Preprocessing and Precompilation

-convertpaths

Instructs the compiler to interpret `#include` file paths specified for a foreign operating system. This command is global.

Syntax

```
-[no]convertpaths
```

Remarks

The CodeWarrior compiler can interpret file paths from several different operating systems. Each operating system uses unique characters as path separaters. These separaters include:

- Mac OS® – colon “`:`” (`:sys:stat.h`)
- UNIX – forward slash “`/`” (`sys/stat.h`)
- Windows® operating systems – backward slash “`\`” (`sys\stat.h`)

When `convertpaths` is enabled, the compiler can correctly interpret and use paths like `<sys/stat.h>` or `<:sys:stat.h>`. However, when enabled, (`/`) and (`:`) separate directories and cannot be used in filenames.

NOTE This is not a problem on Windows since these characters are already disallowed in file names. It is safe to leave this option on.

When `noconvertpaths` is enabled, the compiler can only interpret paths that use the Windows form, like `<\sys\stat.h>`.

-cwd

Controls where a search begins for `#include` files.

Syntax

`-cwd keyword`

The options for *keyword* are:

`explicit`

No implicit directory. Search `-I` or `-ir` paths.

`include`

Begins searching in directory of referencing file.

`proj`

Begins searching in current working directory (default).

`source`

Begins searching in directory that contains the source file.

Remarks

The path represented by *keyword* is searched before searching access paths defined for the build target.

-D+

Same as the `-define` option.

Syntax

`-D+name`

The parameters are:

`name`

The symbol name to define. Symbol is set to 1.

-define

Defines a preprocessor symbol.

Syntax

`-d[efine]`*`name`*`[=`*`value`*`]`

The parameters are:

`name`

The symbol name to define.

`value`

The value to assign to symbol name. If no value is specified, set symbol value equal to 1.

-E

Tells the command-line tool to preprocess source files.

Syntax

```
-E
```

Remarks

This option is global and case sensitive.

-EP

Tells the command-line tool to preprocess source files that are stripped of `#line` directives.

Syntax

```
-EP
```

Remarks

This option is global and case sensitive.

-gccincludes

Controls the compilers use of GCC `#include` semantics.

Syntax

```
-gccinc[ludes]
```

Remarks

Use `-gccinclude` to control the CodeWarrior compiler understanding of Gnu Compiler Collection (GCC) semantics. When enabled, the semantices include:

- Adds `-I-` paths to the systems list if `-I-` is not already specified
- Search referencing file's directory first for `#include` files (same as `-cwd include`) The compiler and IDE only search access paths, and do not take the currently `#include` file into account.

This command is global.

-I-

Changes the build target's search order of access paths to start with the system paths list.

Syntax

```
-I-
```

```
-i-
```

Remarks

The compiler can search `#include` files in several different ways. Use `-I-` to set the search order as follows:

- For include statements of the form `#include "xyz"`, the compiler first searches user paths, then the system paths
- For include statements of the form `#include <xyz>`, the compiler searches only system paths

This command is global.

-I+

Appends a non-recursive access path to the current `#include` list.

Syntax

```
-I+path
```

```
-i path
```

The parameters are:

`path`

The non-recursive access path to append.

Remarks

This command is global and case-sensitive.

-include

Defines the name of the text file or precompiled header file to add to every source file processed.

Syntax

```
-include file
```

`file`

Name of text file or precompiled header file to prefix to all source files.

Remarks

With the command line tool, you can add multiple prefix files all of which are included in a meta-prefix file.

-ir

Appends a recursive access path to the current `#include` list. This command is global.

Syntax

```
-ir path
```

`path`

The recursive access path to append.

-P

Preprocess the source files without generating object code, and send output to file.

Syntax

```
-P
```

Remarks

This option is global and case-sensitive.

-precompile

Precompile a header file from selected source files.

Syntax

`-precompile` *`file`* | *`dir`* | `""`

`file`

If specified, the precompiled header name.

`dir`

If specified, the directory to store the header file.

`""`

If `""` is specified, write header file to location specified in source code. If neither argument is specified, the header file name is derived from the source file name.

Remarks

The driver determines whether to precompile a file based on its extension. The option

`-precompile` *`filesource`*

is equivalent to

`-c -o` *`filesource`*

-preprocess

Preprocess the source files. This command is global .

Syntax

```
-preprocess
```

-ppopt

Specify options affecting the preprocessed output.

Syntax

```
-ppopt keyword [,...]
```

The arguments for *keyword* are:

`[no]break`

Emits file and line breaks. This is the default.

`[no]line`

Controls whether #line directives are emitted or just comments. The default is `line`.

`[no]full[path]`

Controls whether full paths are emitted or just the base filename. The default is `fullpath`.

`[no]pragma`

Controls whether #pragma directives are kept or stripped. The default is `pragma`.

`[no]comment`

Controls whether comments are kept or stripped.

`[no]space`

Controls whether whitespace is kept or stripped. The default is `space`.

Remarks

The default settings is `break`.

-prefix

Add contents a text file or precompiled header as a prefix to all source files.

Syntax

```
-prefix file
```

-noprecompile

Do not precompile any source files based upon the filename extension.

Syntax

```
-noprecompile
```

-nosyspath

Perform searches of both the user and system paths, treating `#include` statements of the form `#include <xyz>` the same as the form `#include "xyz"`.

Syntax

```
-nosyspath
```

Remarks

This command is global.

-stdinc

Use standard system include paths as specified by the environment variable `%MWCIncludes%`.

Syntax

```
-stdinc
```

```
-nostdinc
```

Remarks

Add this option after all system `-I` paths.

-U+

Same as the -undefine option.

Syntax

```
-U+name
```

-undefine

Undefine the specified symbol name.

Syntax

```
-u[ndefine] name
```

```
-U+name
```

```
name
```

The symbol name to undefine.

Remarks

This option is case-sensitive.

9

Command-Line Library and Linking

-keepobjects

Retains or deletes object files after invoking the linker.

Syntax

```
-keepobj[ects]
```

```
-nokeepobj[ects]
```

Remarks

Use `-keepobjects` to retain object files after invoking the linker. Use `-nokeepobjects` to delete object files after linking. This option is global.

NOTE Object files are always kept when compiling.

-nolink

Compile the source files, without linking.

Syntax

```
-nolink
```

Remarks

This command is global.

-o

Specify the output filename or directory for storing object files or text output during compilation, or the the output file if calling the linker.

Syntax

```
-o file | dir
```

`file`

The output file name.

`dir`

The directory to store object files or text output.

10

Command-Line Object Code

-c

Instructs the compiler to compile but not invoke the linker to link the object code.

Syntax

```
-c
```

Remarks

This option is global.

-codegen

Instructs the compiler to compile without generating object code.

Syntax

```
-codegen
-nocodegen
```

Remarks

This option is global.

-enum

Specify the default size for enumeration types.

Syntax

```
-enum keyword
```

The arguments for *keyword* are:

`int`

Uses `int` size for enumerated types.

`min`

Uses minimum size for enumerated types. This is the default.

-min_enum_size

Specifies the size, in bytes, of enumerated types.

Syntax

```
-min_enum_size 1 | 2 | 4
```

Remarks

Specifying this option also invokes the `-enum min` option by default.

-ext

Tells the command-line tool the extension to apply to object files.

Syntax

```
-ext extension
```

`extension`

The extension to apply to object files. Use these rules to specify the extension:

- Limited to a maximum length of 14-characters
- Extensions specified without a leading period (*`extension`*) replace the source file's extension. For example, if `extension` is "o" (without quotes), then `source.cpp` becomes `source.o`.
- Extensions specified with a leading period (`.`*`extension`*) are appended to the object files name. For example, if `extension` is "`.o`" (without quotes), then `source.cpp` becomes `source.cpp.o`.

Remarks

This command is global. The default setting is no extension.

-strings

Controls how string literals are stored and used.

Remarks

```
-str[ings] keyword[, ...]
```

The *keyword* arguments are:

`[no]pool`

All string constants are stored as a single data object so your program needs one data section for all of them.

`[no]reuse`

All equivilent string constants are stored as a single data object so your program can reuse them. This is the default.

`[no]readonly`

Make all string constants read-only. This is the default.

11

Command-Line for Optimization

-inline

Specify inline options. Default settings are `smart`, `noauto`.

Syntax

`-inline` *`keyword`*

The options for *keyword* are:

`off | none`

Turns off inlining.

`on | smart`

Turns on inlining for functions declared with the `inline` qualifier. This is the default.

`auto`

Attempts to inline small functions even if they are declared with `inline`.

`noauto`

Does not auto-inline. This is the default auto-inline setting.

`deferred`

Refrains from inlining until a file has been translated. This allows inlining of functions in both directions.

`level=`*`n`*

Inlines functions up to *n* levels deep. Level 0 is the same as `-inline on`. For *n*, enter 1 to 8 levels. This argument is case-sensitive.

`all`

Turns on aggressive inlining. This option is the same as `-inline on`, `-inline auto`.

-O

Sets optimization settings to `-opt level=2`.

Syntax

```
-O
```

Remarks

Provided for backwards compatibility.

-O+

Controls optimization settings.

Syntax

```
-O+keyword [,...]
```

The *keyword* arguments are:

`0`

Equivalent to `-opt off`.

`1`

Equivalent to `-opt level=1`.

`2`

Equivalent to `-opt level=2`.

`3`

Equivalent to `-opt level=3`.

`4`

Equivalent to `-opt level=4,intrinsics`.

`p`

Equivalent to `-opt speed`.

`s`

Equivalent to `-opt space`.

Remarks

Options can be combined into a single command. Command is case-sensitive.

-opt

Specify code optimization options to apply to object code.

Remarks

`-opt`*`keyword`* `[,...]`

The *keyword* arguments are:

`off | none`

Suppresses all optimizations. This is the default.

`on`

Same as `-opt level=2`

`all | full`

Same as `-opt speed,level=4,intrinsics,noframe`

`l[evel]=`*`num`*

Sets a specific optimization level. The options for *num* are:

- `0` – Global register allocation only for temporary values. Equivalent to `#pragma optimization_level 0`.
- `1` – Adds dead code elimination, branch and arithmetic optimizations, expression simplification, and peephole optimization. Equivalent to `#pragma optimization_level 1`.
- `2` – Adds common subexpression elimination, copy and expression propagation, stack frame compression, stack alignment, and fast floating-point to integer conversions. Equivalent to: `#pragma optimization_level 2`.
- `3` – Adds dead store elimination, live range splitting, loop-invariant code motion, strength reduction, loop transformations, loop unrolling (with `-opt speed` only), loop vectorization, lifetime-based register allocation, and instruction scheduling. Equivalent to `optimization_level 3`.
- `4` – Like level 3, but with more comprehensive optimizations from levels 1 and 2. Equivalent to `#pragma optimization_level 4`.

For `num` options 0 through 4 inclusive, the default is 0.

`[no]space`

Optimizes object code for size. Equivalent to `#pragma optimize_for_size on`.

`[no]speed`

Optimizes object code for speed. Equivalent to `#pragma optimize_for_size off`.

`[no]cse | [no]commonsubs`

Common subexpression elimination. Equivalent to `#pragma opt_common_subs`.

`[no]deadcode`

Removes of dead code. Equivalent to `#pragma opt_dead_code`.

`[no]deadstore`

Removes of dead assignments. Equivalent to `#pragma opt_dead_assignments`.

`[no]lifetimes`

Computation of variable lifetimes. Equivalent to `#pragma opt_lifetimes`.

`[no]loop[invariants]`

Removes of loop invariants. Equivalent to `#pragma opt_loop_invariants`.

`[no]prop[agation]`

Propagation of constant and copy assignments. Equivalent to `#pragma opt_propagation`.

`[no]strength`

Strength reduction. Reducing multiplication by an array index variable to addition. Equivalent to `#pragma opt_strength_reduction`.

`[no]dead`

Same as `-opt [no]deadcode` and `[no]deadstore`. Equivalent to `#pragma opt_dead_code on|off` and `#pragma opt_dead_assignments`.

`[no]peep[hole]`

Peephole optimization. Equivalent to `#pragma peephole`.

`[no]color[ing]`

Register coloring. Equivalent to `#pragma register_coloring`.

`[no]intrinsics`

Inlines intrinsic functions.

`[no]schedule`

Performs instruction scheduling.

`display | dump`

Displays complete list of active optimizations.

12

Linker

The compiler organizes its object code into sections that the linker arranges when it creates its output file.

To generate an output file, the linker reads from input ELF (Executable and Linkable Format) files generated by compiler and other tools. The linker also reads a linker command file to determine how to build its output file. The linker then writes to its output file, an ELF file. This output file is the executable image, ready to load and run on the target platform.

This chapter describes the sections in the object code of and how to arrange them in the linker's output file:

- Speciyfing Link Order in the IDE
- Defining Sections in Source Code
- Using a Linker Command File
- Linker Command File Syntax

Speciyfing Link Order in the IDE

To specify link order, use the **Link Order** page of the CodeWarrior IDE's Project window. (For certain targets, the name of this page is **Segments**.)

Regardless of the order that the **Link Order** page specifies, the linker always processes source code files before it processes relocatable (`.o`) files or archive (`.a`) files. This policy means that the linker prefers using a symbol definition from a source file rather than a library file definition for the same symbol.

There is an exception, however: if the source file defines a weak symbol, the linker uses a global-symbol definition from a library. Use `#pragma overload` to create weak symbols.

Well-constructed projects usually do not have strong link-order dependencies.

The linker ignores executable files of the project. You may find it convenient to keep the executable files in the project folder so that you can disassemble it. If a build is successful, a check mark appears in the touch column on the left side of the project window. This indicates that the new file in the project is out of date. If a build is unsuccessful, the IDE is not be able to find the executable file and it stops the build with an appropriate message.

Defining Sections in Source Code

The compiler defines its own sections to organize the data and executable code it generates. You may also define your own sections directly in your program's source code.

The `section` pragma specifies to the compiler where to place proceeding definitions in source code. Use the `push`, `section`, and `pop` pragmas to enclose source code definitions. Listing 12.1 shows an example that places variables named `red` and `sky` in a section named `.myData`.

Listing 12.1 Using pragma section to specify where to place definitions

```
#pragma push /* Save the compiler's state. */
#pragma section data_type ".myData" ".myData" data_mode=far_abs
int red;
int sky;
#pragma pop /* Restore the compiler's state. */
```

An alternative to using the section pragma is to use `__declspec` to specify where to place a single definition in object code. Listing 12.2 shows an example.

Listing 12.2 Using __declspec to specify where to place definitions

```
__declspec (section ".myData") int red;
__declspec (section ".myData") int sky;
__declspec (section ".myISRSection") ISRType
InterruptVectorTable[256];
```

Using a Linker Command File

A linker command file (`.lcf` file) is a text file that the linker reads to determine how to arrange object code from input files to produce an output file.

Use a linker command file to control dead-stripping, describe the target platform's memory map, define and arrange sections, and control addresses and alignment:

- Dead-Stripping
- Defining the Target's Memory Map
- Defining Sections in the Output File
- Associating Input Sections With Output Sections
- Controlling Alignment
- Specifying Memory Area Locations and Sizes

Dead-Stripping

Normally, the CodeWarrior linker ignores object code that is not referred to by other object code. If the linker detects that an object is not referred to by the rest of the program being linked, the linker will not place that object in its output file. In other words, the linker “dead-strips” objects that are not used.

Dead-stripping ensures the smallest possible output file. Also, dead-stripping relieves you from having to manually exclude unused source code from the compiler and unused object code from the linker.

There are some objects, however, that need to be in the linker’s output file even if these objects are not explicitly referred to by other parts of your program. For example, an executable image might contain an interrupt table that the target platform needs, but this interrupt table is not referred to by the rest of the image.

Use the `FORCEACTIVE` and `FORCEFILES` directives in a linker command file to specify to the linker which objects and files must not be dead-stripped.

Listing 12.3 shows an example from a linker command file that tells the linker not to dead-strip an object named `InterruptVectorTable` and all the objects in an input file named `segfault.o`.

Listing 12.3 FORCEACTIVE and FORCEFILES example

```
FORCEACTIVE { InterruptVectorTable }
FORCEFILES { segfault.o }
```

Defining the Target’s Memory Map

Use the linker command file’s `MEMORY` directive to delineate areas in the target platform’s memory map and associate a name for each of these areas. Names defined in a `MEMORY` directive may be used later in the linker command file to specify where object code should be stored. Listing 12.4 shows an example.

Listing 12.4 MEMORY directive example

```
MEMORY
{
   ISR_table : org = 0x00000000, len = 0x400
   data : org = 0x00000400, len = 0x10000
   flash: org = 0x10000000, len = 0x10000
   text : org = 0x80000000
}
```

This example defines 3 memory areas named ISR_table, data, and text. The org argument specifies the beginning byte address of a memory area. The len argument is optional, It specifies how many bytes of data or executable code the linker may store in an area. The linker issues a warning message if an attempt to store object code in an area exceeds its length.

Defining Sections in the Output File

Use the linker command file's SECTIONS directive to

- define sections in the linker's output file
- to specify in which memory area on the target platform a section in the output file should be loaded at runtime

Use GROUP directives in a SECTIONS directive to organize objects.

The linker will only create a section in the output file if the section is not empty, even if the section is defined in a SECTION or GROUP directive.

Listing 12.5 shows an example.

Listing 12.5 SECTIONS and GROUP example

```
SECTIONS
{
   GROUP :
   {
      .text : {}
      .rodata : {}
   } > text

   GROUP
   {
      .sdata : {}
      .sbss : {}
   } > data

   GROUP
   {
      .sdata2 : {}
      .sbss2 : {}
   } > data
}
```

This example defines the .text and .rodata sections in the output file and specifies that they should be loaded in the memory area named text on the target platform at runtime. The example then defines sections named .sdata and .sbss. These sections will be loaded in the memory named data. The last GROUP directive in the example defines sections named .sdata2, and .sbss2. These sections will also be loaded in the memory area named data, after the sections .sdata and .sbss.

Associating Input Sections With Output Sections

Normally the linker stores sections from input object code in the sections of the linker's output file that have the same name. The linker command file's SECTIONS and GROUP directives allow you to specify other ways to associate input object code with sections in linker output. Listing 12.6 shows an example.

Listing 12.6 Associating object code with sections in linker output

```
SECTIONS
{
   GROUP :
   {
      .myText : { main.o (.text) }
      .text : ( *(.text) }
   } > text
}
```

This example defines a section in the output file named .myText. This section will contain the objects that are in the .text section in the object code taken from the input file named main.o. The example also defines a section in the output file named .text. This section will contain all objects in the .text sections of all input files containing object code. Both these sections in the output file, .myText and .text, will be loaded in the memory area named text on the target platform.

The SECTIONS and GROUP directives also allow you to filter what kinds of object code from input files will be stored in a section in the output file. Table 12.1 shows the kinds of data that may be filtered.

Table 12.1 Filter types for object code in input files

This filter	allows input objects that have these permissions	and contain this kind of object code
TEXT	readable, executable	initialized
CODE	readable, executable	initialized
DATA	readable, writable	initialized
BSS	readable, writable	uninitialized

Table 12.1 Filter types for object code in input files

This filter	allows input objects that have these permissions	and contain this kind of object code
`CONST`	readable	initialized
`MIXED`	readable, writable, executable	initialized

Listing 12.7 shows an example.

Listing 12.7 Filtering objects from input files

```
SECTIONS
{
   .text (TEXT) : { } > text
   .bss (BSS) : { } > data
}
```

This example defines a section in the output file named `.text`. The linker will only store objects from input object code that are readable, executable, and initialized. This example also defines a section in the output file named `.bss`. This section will only contain objects from the linker's input files that are readable, writable, and uninitialized.

Controlling Alignment

Use the `ALIGN` argument in a `SECTIONS` or `GROUP` directive to specify a byte boundary on which to align a section in the output file.

Listing 12.8 shows an example.

Listing 12.8 Example of the ALIGN directive

```
SECTIONS
{
   GROUP:
   {
      .init ALIGN(0x1000) : {}
      .text ALIGN(0x1000) : {}
   } > text
}
```

This example defines two sections named `.init` and `.text`. At runtime, each section will be loaded at the next available address that is evenly divisible by `0x1000` in the memory area named `text` on the target platform.

Specifying Memory Area Locations and Sizes

Normally, the linker stores sections in the output file in sequential order. Each object from the linker's output is stored after the last object in the output file. Use the `BIND`, `ADDR`, and `SIZEOF` keywords in `SECTIONS` and `GROUP` directives to precisely specify where sections in the output file will be loaded.

Listing 12.9 shows an example.

Listing 12.9 BIND, ADDR, and SIZEOF example

```
SECTIONS
{
   .text BIND(0x00010000) : ()
   .rodata : {}
   .data BIND(ADDR(.rodata + SIZEOF(.rodata)) ALIGN(0x010) : {}
}
```

This example defines a section in the output file named `.text`. This section will be loaded at address `0x00010000` on the target platform at runtime. The next section, `.rodata`, will be loaded at the address immediately proceeding the last byte in the `.text` section. The last section, `.data`, will be loaded at the address that is the sum of the beginning of the `.rodata` section's address and the size of the `.rodata` section. This last section will be aligned at the next address that is evenly divisible by `0x10`.

The dot keyword ("`.`"), is a convenient way to set the linker's place in the current output section.

Listing 12.10 shows an example.

Listing 12.10 Skipping areas of memory

```
SECTIONS
{
   GROUP :
   {
      .ISR_Table : {}
      . = 0x2000
   } > flash

   GROUP :
   {
      .paramsection : {}
   } > flash
}
```

This example defines two sections. The first section, `.ISRTable`, will be loaded at beginning of the memory area named `flash` on the target platform at runtime. The second section, `.paramsection`, will be loaded at the address that is `0x2000` bytes past the beginning of the memory area named `flash`.

Linker Command File Syntax

Listing 12.11 shows the syntax for linker command files.

Listing 12.11 Linker Command File Syntax

```
<linker command file> =
   <commands>* <memory>? <commands>* <sections>? <commands>*

<commands> =
   <exclude files> |
   <force active> |
   <force files> |
   <include dwarf> |
   <shorten names for tornado 101 > |
   <cats bss mod> |
   <cats header mod> |
   <data type converts> |
   <entry> |
   <init> |
   <term> |
   <external symbol> |
   <internal symbol> |
   <memory gaps>

<exclude files> =
   "EXCLUDEFILES" "{" <file name> "}"

<force active> =
   "FORCEACTIVE" "{" <identifier> + "}"

<letter> =
   'a'|'b'|'c'|'d'|'e'|'f'|'g'|'h'|'i'|'j'|'k'|'l'|'m'|
   'n'|'o'|'p'|'q'|'r'|'s'|'t'|'u'|'v'|'w'|'x'|'y'|'z'|
   'A'|'B'|'C'|'D'|'E'|'F'|'G'|'H'|'I'|'J'|'K'|'L'|'M'|
   'N'|'O'|'P'|'Q'|'R'|'S'|'T'|'U'|'V'|'W'|'X'|'Y'|'Z'

<file name> =
   (<letter> |"_") (<letter> |<digit> |"_")*
   (".")?(<letter> |<digit> |"_")*
```

```
<object file> =
   (<letter> |"_") (<letter> |<digit> |"_")* (".") ("o"|"O")

<archive file> =
   (<letter> |"_") (<letter> |<digit> |"_")* (".") ("a"|"A")

<force files> =
   "FORCEFILES" "{" ( <object file> | <archive file> )
   "(" object file ")" )+ "}"

<include dwarf>=
   "INCLUDEDWARF" "{" <file name> "}"

<shorten names for tornado 101>=
   "SHORTEN_NAMES_FOR_TOR_101"

<cats bss mod> =
   "CATS_BSS_MOD"

<cats header mod> =
   "CATS_HEADER_MOD"

<data type converts> =
   "DATA_TYPE_CONVERTS"

<entry> =
   "ENTRY" "(" <identifier> ")"

<init> =
   "INIT" "(" <identifier> ")"

<term> =
   "TERM" "(" <identifier> ")"

<external symbol> =
   "EXTERNAL_SYMBOL" "{" <identifier> "}"

<internal symbol> =
   "INTERNAL_SYMBOL" "{" <identifier> "}"

<group>=
   "GROUP" <address modifiers> ":"
   "{" (<section spec> )* "}" ["=" <fill shortnumber> ]
   [ "> " <mem area symbolic name> ]

<hexadigit> =
   '0'|'1'|'2'|'3'|'4'|'5'|'6'|'7'|'8'|'9'|
   'A'|'B'|'C'|'D'|'E'|'a'|'b'|'c'|'d'|'e'
```

```
<digit> =
   '0'|'1'|'2'|'3'|'4'|'5'|'6'|'7'|'8'|'9'

<hexadecimal number> =
   "0"("x"|"X")(<hexadigit> )+

<decimal number> =
   (<digit> )+

<number> =
   <hexadecimal number> | <decimal number>

<binary op> =
   '+'|'-'|'*'|'/'| '%' '==' | '!=' | '>'| '>='| '<'| '<='|
   '&&' | '||'    '>>' | '<<' | '&' | '|' | '' | ''

<unary op> =
   '++' | '--' | '~' | '!'

<postfix unary op> =
   '++' | '--'

<symbol declaration> =
   ( <identifier> "=" <address spec> ) |
   ( "PROVIDE" "("<identifier> "=" <address spec> ")" )

<identifier> =
   (<letter> |"_") (<letter> |"_"|<digit> )*

<operand> =
   <number> |
   ("ADDR" "(" <output section spec> | <address expr> ")" ) |
   ("ROMADDR" "("<output section spec> | <address expr> ")" |
      ("SIZEOF" "("<output section spec> | <address expr> ")" )

<address spec> =
   <number> |
   "." |
   <operand> |
   (<address spec> <binary op> <operand> ) |
   (<unary op> <address spec> ) |
   (<address spec> <postfix unary op> )

<memory spec> =
   <mem area symbolic name> ":" "origin" |
   "org" |
   "o" "=" <number> "," "length"|
   "len" |
   "l" "=" <number>

<memory gaps>=
   "." "=" <address spec>

<memory>=
   "MEMORY" ":" "{" <memory spec> +"}"

<sections>=
   "SECTIONS" "{"
   (<section spec> | <memory gaps> | <symbol declaration> | <group> )*
   "}"

<section spec> =
   <output section name>
   ["(" <input type> ")"]
   [<address modifiers> ] ":" "{"
      [( <input section spec> )*] "}"
   [= fill shortnumber] [ > mem area symbolic name ]

<output section name> =
   <section name>

<input type> =
   [ "TEXT" | "DATA" | "BSS" | "CONST" | "MIXED" | "ZTEXT" | "ZCODE" ]

<address modifiers> =
   ["BIND" "("<address spec> ")" ]
   ["ALIGN" "("<address spec> ")" | "NEXT" "("<address spec> ")"]
   [("LOAD" | "INTERNAL_LOAD") "("<address spec> ")"

<input section spec> =
   (<file name> |
      <file name> "("<section name> ")" |
      "*("<section name>    ")" |
      <symbol declaration> |
      <data write> )+

<data write> =
   ("LONG" | "SHORT" | "BYTE" ) "(" <number> ")"

<fill shortnumber> =
   <number>
```

Commands, Directives, and Keywords

The rest of this chapter consists of explanations of all valid LCF functions, keywords, directives, and commands, in alphabetic order.

Table 12.2 LCF Functions, Keywords, Directives, and Commands

. (location counter)	ADDR	ALIGN
ALIGNALL	EXCEPTION	EXPORTSTRTAB
EXPORTSYMTAB	FORCE_ACTIVE	IMPORTSTRTAB
IMPORTSYMTAB	INCLUDE	KEEP_SECTION
MEMORY	OBJECT	REF_INCLUDE
SECTIONS	SIZEOF	SIZEOF_ROM
WRITEB	WRITEH	WRITEW
WRITES0COMMENT	ZERO_FILL_UNINITIALIZED	

. (location counter)

Denotes the current output location.

Remarks

The period always refers to a location in a sections segment, so is valid only in a sections-section definition. Within such a definition, '.' may appear anywhere a symbol is valid.

Assigning a new, greater value to '.' causes the location counter to advance. But it is not possible to decrease the location-counter value, so it is not possible to assign a new, lesser value to '.' You can use this effect to create empty space in an output section, as the Listing 12.12 example does.

Example

The code of Listing 12.12 moves the location counter to a position 0x10000 bytes past the symbol __start.

Listing 12.12 Moving the Location Counter

```
..data :
```

```
{
      *.(data)
      *.(bss)
      *.(COMMON)
      __start = .;
      . = __start + 0x10000;
      __end = .;
} > DATA
```

ADDR

Returns the address of the named section or memory segment.

ADDR (*sectionName* | *segmentName*)

Parameters

sectionName

Identifier for a file section.

segmentName

Identifier for a memory segment

Example

The code of Listing 12.13 uses the ADDR function to assign the address of ROOT to the symbol __rootbasecode .

Listing 12.13 ADDR() Function

```
MEMORY{
    ROOT   (RWX) : ORIGIN = 0x80000400, LENGTH = 0
}

SECTIONS{
  .code :
  {
  __rootbasecode = ADDR(ROOT);
      *.(text);
  } > ROOT
}
```

ALIGN

Returns the location-counter value, aligned on a specified boundary.

```
ALIGN(alignValue)
```

Parameter

`alignValue`

Alignment-boundary specifier; must be a power of two.

Remarks

The `ALIGN` function does *not* update the location counter; it only performs arithmetic. Updating the location counter requires an assignment such as:

```
. = ALIGN(0x10); #update location counter to
                  16-byte alignment
```

ALIGNALL

Forces minimum alignment for all objects in the current segment to the specified value.

```
ALIGNALL(alignValue);
```

Parameter

`alignValue`

Alignment-value specifier; must be a power of two.

Remarks

`ALIGNALL` is the command version of the `ALIGN` function. It updates the location counter as each object is written to the output.

Example

Listing 12.14 is an example use for `ALIGNALL()` command.

Listing 12.14 ALIGNALL Example

```
.code :
{
    ALIGNALL(16);  // Align code on 16-byte boundary
    *     (.init)
    *    (.text)

    ALIGNALL(64);  //align data on 64-byte boundary
    *    (.rodata)
} > .text
```

EXCEPTION

Creates the exception table index in the output file.

EXCEPTION

Remarks

Only C++ code requires exception tables. To create an exception table, add the EXCEPTION command, with symbols __exception_table_start__ and __exception_table_end__, to the end of your code section segment, just as Listing 12.15 shows. (At runtime, the system knows the values of the two symbols.)

Example

Listing 12.15 shows the code for creating an exception table.

Listing 12.15 Creating an Exception Table

```
  __exception_table_start__ = .;
  EXCEPTION
  __exception_table_end__ = .;
```

EXPORTSTRTAB

Creates a string table from the names of exported symbols.

EXPORTSTRTAB

Remarks

Table 12.3 shows the structure of the export string table. As with an ELF string table, the system zero-terminates the library and symbol names.

Table 12.3 Export String Table Structure

`0x00`	1 byte
library name	varies
symbol1 name	varies
symbol2 name	varies

Example

Listing 12.16 shows the code for creating an export string table.

Listing 12.16 Creating an Export String Table

```
.expstr:
{
 EXPORTSTRTAB
} > EXPSTR
```

EXPORTSYMTAB

Creates a jump table of the exported symbols.

`EXPORTSYMTAB`

Remarks

Table 12.4 shows the structure of the export symbol table. The start of the export symbol table must be aligned on at least a four-byte boundary.

Table 12.4 Export Symbol Table Structure

Size (in bytes) of export table	4 bytes
Index to *library* name in export string table	4 bytes
Index to *symbol1* name in export string table	4 bytes
Address of *symbol1*	4 bytes
A5 value for *symbol1*	4 bytes

Table 12.4 Export Symbol Table Structure (*continued*)

Index to *symbol2* name in export string table	4 *bytes*
Address of *symbolf2*	4 bytes
A5 value for *symbol2*	4 bytes

Example

Listing 12.17 shows the code for creating an export symbol table.

Listing 12.17 Creating an Export Symbol Table

```
.expsym:
{
 EXPORTSYMTAB
} > EXPSYM
```

FORCE_ACTIVE

Starts an optional LCF closure segment that specifies symbols the linker should *not* deadstrip.

`FORCE_ACTIVE{ *symbol*[, *symbol*] }`

Parameter

`symbol`

Any defined symbol.

IMPORTSTRTAB

Creates a string table from the names of imported symbols.

`IMPORTSTRTAB`

Remarks

Table 12.5 shows the structure of the import string table. As with an ELF string table, the system zero-terminates the library and symbol names.

Table 12.5 Import String Table Structure

`0x00`	1 byte
library name	varies
symbol1 name	varies
symbol2 name	varies

Example

Listing 12.18 shows the code for creating an import string table.

Listing 12.18 Creating an Import String Table

```
.impstr:
{
 IMPORTSTRTAB
} > IMPSTR
```

IMPORTSYMTAB

Creates a jump table of the imported symbols.

`IMPORTSYMTAB`

Remarks

Table 12.6 shows the structure of the import symbol table. The start of the import symbol table must be aligned on at least a four-byte boundary.

Table 12.6 Import Symbol Table Structure

Size (in bytes) of import table	4 bytes
Index to *library1* name in import string table	4 bytes
Number of entries in *library1*	4 bytes
Index to *symbol1* name in import string table	4 bytes
Address of *symbol1* vector in export string table	4 bytes
Index to *symbol2* name in import string table	4 bytes

Table 12.6 Import Symbol Table Structure (*continued*)

Address of *symbol2* vector in export string table	4 *bytes*
Index to *library2* name in import string table	4 bytes
Number of entries in *library2*	4 bytes

Example

Listing 12.19 shows the code for creating an import symbol table.

Listing 12.19 Creating an Import Symbol Table

```
.expsym:
{
 IMPORTSYMTAB
} > EXPSYM
```

INCLUDE

Include a specified binary file in the output file.

`INCLUDE` *`filename`*

Parameter

`filename`

Name of a binary file in the project. The File Mappings target settings panel must specify resource file for all files that have the same extension as this file.

KEEP_SECTION

Starts an optional LCF closure segment that specifies sections the linker should *not* deadstrip.

`KEEP_SECTION{` *`sectionType`*`[,` *`sectionType`*`] }`

Parameter

`sectionType`

Identifier for any user-defined or predefined section.

MEMORY

Starts the LCF memory segment, which defines segments of target memory.

```
MEMORY { memory_spec[, memory_spec] }
```

Parameters

`memory_spec`

```
    segmentName (accessFlags) : ORIGIN = address,
     LENGTH = length [> fileName]
```

`segmentName`

Name for a new segment of target memory. Consists of alphanumeric characters; can include the underscore character.

`accessFlags`

ELF-access permission flags — `R` = read, `W` = write, or `X` = execute.

`address`

A memory address, such as 0x80000400, or an `AFTER` command. The format of the `AFTER` command is `AFTER (name[, name]);` this command specifies placement of the new memory segment at the end of the named segments.

`length`

Size of the new memory segment: a value greater than zero. Optionally, the value zero for *autolength*, in which the linker allocates space for all the data and code of the segment. (Autolength cannot increase the amount of target memory, so the feature can lead to overflow.)

`fileName`

Optional, binary-file destination. The linker writes the segment to this binary file on disk, instead of to an ELF program header. The linker puts this binary file in the same folder as the ELF output file. This option has two variants:

- `> fileName:` writes the segment to a new binary file.
- `>> fileName:` appends the segment to an existing binary file.

Remarks

The LCF contains only one `MEMORY` directive, but this directive can define as many memory segments as you wish.

For each memory segment, the `ORIGIN` keyword introduces the starting address, and the `LENGTH` keyword introduces the length value.

There is no overflow checking for the autolength feature. To prevent overflow, you should use the AFTER keyword to specify the segment's starting address.

If an AFTER keyword has multiple parameter values, the linker uses the highest memory address.

Example

Listing 12.20 is an example use of the MEMORY directive.

Listing 12.20 MEMORY Directive Example

```
MEMORY {
    TEXT (RX)   :  ORIGIN = 0x00003000, LENGTH = 0
    DATA (RW)   :  ORIGIN = AFTER(TEXT), LENGTH = 0
    }
```

OBJECT

Sections-segment keyword that specifies a function. Multiple OBJECT keywords control the order of functions in the output file.

OBJECT (*function*, *sourcefile.c*)

Parameters

`function`

Name of a function.

`sourcefile.c`

Name of the C file that contains the function.

Remarks

If an OBJECT keyword tells the linker to write an object to the output file, the linker does not write the same object again, in response to either the GROUP keyword or the '*' wildcard character.

REF_INCLUDE

Starts an optional LCF closure segment that specifies sections the linker should *not* deadstrip, if program code references the files that contain these sections.

```
REF_INCLUDE{ sectionType[, sectionType] }
```

Parameter

`sectionType`

Identifier for any user-defined or predefined section.

Remarks

Useful if you want to include version information from your source file components.

SECTIONS

Starts the LCF sections segment, which defines the contents of target-memory sections. Also defines global symbols to be used in the output file.

```
SECTIONS { section_spec[, section_spec] }
```

Parameters

`section_spec`

```
sectionName : [AT (loadAddress)] {contents}
  > segmentName
```

`sectionName`

Name for the output section, such as `mysection`. Must start with a period.

`AT (loadAddress)`

Optional specifier for the load address of the section. The default value is the relocation address.

`contents`

Statements that assign a value to a symbol or specify section placement, including input sections.

`segmentName`

Predefined memory-segment destination for the contents of the section. The two variants are:

- `> segmentName`: puts section contents at the beginning of memory segment `segmentName`.
- `>> segmentName`: appends section contents to the end of memory segment `segmentName`.

Example

Listing 12.21 is an example sections-segment definition.

Listing 12.21 SECTIONS Directive Example

```
SECTIONS {
  .text : {
            _textSegmentStart = .;
            alpha.c (.text)
            . = ALIGN (0x10);
            beta.c (.text)
            _textSegmentEnd = .;
  }
  .data : { *(.data) }
  .bss  : { *(.bss)
            *(COMMON)
  }
}
```

SIZEOF

Returns the size (in bytes) of the specified segment or section.

`SIZEOF(`*`segmentName`*` | `*`sectionName`*`)`

Parameters

`segmentName`

Name of a segment; must start with a period.

`sectionName`

Name of a section; must start with a period.

SIZEOF_ROM

Returns the size (in bytes) that a segment occupies in ROM.

`SIZEOF_ROM (`*`segmentName`*`)`

Parameter

`segmentName`

Name of a ROM segment; must start with a period.

Remarks

Always returns the value 0 until the ROM is built. Accordingly, you should use `SIZEOF_ROM` only within an expression inside a `WRITEB`, `WRITEH`, `WRITEW`, or `AT` function.

Furthermore, you need `SIZEOF_ROM` only if you use the `COMPRESS` option on the memory segment. Without compression, there is no difference between the return values of `SIZEOF_ROM` and `SIZEOF`.

WRITEB

Inserts a byte of data at the current address of a section.

`WRITEB (`*`expression`*`);`

Parameter

`expression`

Any expression that returns a value `0x00` to `0xFF`.

WRITEH

Inserts a halfword of data at the current address of a section.

`WRITEH (`*`expression`*`);`

Parameter

`expression`

Any expression that returns a value `0x0000` to `0xFFFF`

WRITEW

Inserts a word of data at the current address of a section.

```
WRITEW (expression);
```

Parameter

`expression`

Any expression that returns a value `0x00000000` to `0xFFFFFFFF`.

WRITES0COMMENT

Inserts an S0 comment record into an S-record file.

```
WRITES0COMMENT "comment"
```

Parameter

`comment`

Comment text: a string of alphanumerical characters `0-9`, `A-Z`, and `a-z`, plus space, underscore, and dash characters. Double quotes *must* enclose the comment string. (If you omit the closing double-quote character, the linker tries to put the entire LCF into the `S0` comment.)

Remarks

This command, valid only in an LCF sections segment, creates an S0 record of the form:

```
S0aa0000bbbbbbbbbbbbbbbbdd
```

- `aa` — hexadecimal number of bytes that follow
- `bb` — ASCII equivalent of `comment`
- `dd` — the checksum

This command does not null-terminate the ASCII string.

Within a comment string, do not use these character sequences, which are reserved for LCF comments: `#` `/*` `*/` `//`

Example

This example shows that multi-line `S0` comments are valid:

```
WRITES0COMMENT "Line 1 comment
Line 2 comment"
```

ZERO_FILL_UNINITIALIZED

Forces the linker to put zeroed data into the binary file for uninitialized variables.

```
ZERO_FILL_UNINITIALIZED
```

Remarks

This directive must be between directives `MEMORY` and `SECTIONS`; placing it anywhere else would be a syntax error.

Using linker configuration files and the `define_section` pragma, you can mix uninitialized and initialized data. As the linker does not normally write uninitialized data to the binary file, forcing explicit zeroing of uninitialized data can help with proper placement.

Example

The code of Listing 12.22 tells the linker to write uninitialized data to the binary files as zeros.

Listing 12.22 ZERO_FILL_UNINITIALIZED Example

```
MEMORY {
  TEXT   (RX) :ORIGIN = 0x00030000, LENGTH = 0
  DATA   (RW) :ORIGIN = AFTER(TEXT), LENGTH = 0
}

ZERO_FILL_UNINITIALIZED


SECTIONS {
  .main_application:
  {
    *(.text)
    .=ALIGN(0x8);
    *(.rodata)
    .=ALIGN(0x8);
  } > TEXT
...
}
```

13

ColdFire Linker

This chapter describes how to use the features in the CodeWarrior linker that are specific to ColdFire software development.

You access these functions through commands in the linker command file (LCF). The LCF syntax and structure are similar to those of a programming language; the syntax includes keywords, directives, and expressions.

This chapter consists of these sections:

Deadstripping

As the linker combines object files into one executable file, it recognizes portions of executable code that execution cannot possibly reach. *Deadstripping* is removing such unreachable object code — that is, not including these portions in the executable fie. The CodeWarrior linker performs this deadstripping on a per-function basis.

The CodeWarrior linker deadstrips unused code and data from *only* object files that a CodeWarrior compiler generates. The linker never deadstrips assembler-relocatable files, or object files from a different compiler.

Deadstripping is particularly useful for C++ programs or for linking to large, general-purpose libraries. Libraries (archives) built with the CodeWarrior compiler only contribute the used objects to the linked program. If a library has assembly or other compiler built files, only those files that have at least one referenced object contribute to the linked program. The linker always ignores unreferenced object files.

Well-constructed projects probably do not contain unused data or code. Accordingly, you can reduce the time linking takes by disabling deadstripping:

- To disable deadstripping completely, check the **Disable Deadstripping** checkbox of the **ColdFire Linker** panel.
- To disable deadstripping for particular symbols, enter the symbol names in the **Force Active Symbols** text box of the **ColdFire Linker** Panel.

- To disable deadstripping for individual sections of the linker command file, use the `KEEP_SECTION()` directive. As code does not directly reference interrupt-vector tables, a common use for this directive is disabling deadstripping for these interrupt-vector tables. The subsection Closure Segments provides additional information about the `KEEP_SECTION()` directive.

NOTE To deadstrip files from standalone assembler, you must make each assembly functions start its own section (for example, a new `.text` directive before functions) and using an appropriate directive.

Executable files in Projects

It may be convenient to keep executable files in a project, so that you can disassemble them later. As the linker ignores executable files, the IDE portrays them as out of date — even after a successful build. The IDE out-of-date indicator is a check mark in the *touch* column, at the left side of the project window.

Dragging/dropping the final elf and disassembling it is a useful way to view the absolute code.

S-Record Comments

You can insert one comment at the beginning of an S-Record file via the linker-command-file directive WRITES0COMMENT.

LCF Structure

Linker command files consist of three kinds of segments, which *must* be in this order:

- A *memory* segment, which begins with the `MEMORY{}` directive
- Optional *closure* segments, which begin with the `FORCE_ACTIVE{}`, `KEEP_SECTION{}`, or `REF_INCLUDE{}` directives
- A *sections* segment, which begins with the `SECTIONS{}` directive

Memory Segment

Use the memory segment to divide available memory into segments. Listing 13.1 shows the pattern.

Listing 13.1 Example Memory Segment

```
MEMORY {
    segment_1 (RWX): ORIGIN = 0x80001000, LENGTH = 0x19000
    segment_2 (RWX): ORIGIN = AFTER(segment_1), LENGTH = 0
    segment_x (RWX): ORIGIN = memory address, LENGTH = segment size
     and so on...
}
```

In this pattern:

- The (RWX) portion consists of ELF-access permission flags: R = read, W = write, or X = execute.
- ORIGIN specifies the start address of the memory segment — either an actual memory address or, via the AFTER keyword, the name of the preceding segment.
- LENGTH specifies the size of the memory segment. The value 0 means *unlimited length*.

The segment_2 line of Listing 13.1 shows how to use the AFTER and LENGTH commands to specify a memory segment, even though you do not know the starting address or exact length.

Closure Segments

An important feature of the linker is deadstripping unused code and data. At times, however, an output file should keep symbols even if there are no direct references to the symbols. Linking for interrupt handlers, for example, usually is at special addresses, without any explicit, control-transfer jumps.

Closure segments let you make symbols immune from deadstripping. This closure is *transitive*, so that closing a symbol also forces closure on all other referenced symbols.

For example, suppose that:

- Symbol _abc references symbols _def and _ghi,
- Symbol _def references symbols _jkl and _mno, and
- Symbol _ghi references symbol _pqr

Specifying symbol _abc in a closure segment would force closure on all six of these symbols.

The three closure-segment directives have specific uses:

- FORCE_ACTIVE — Use this directive to make the linker include a symbol that it otherwise would not include.
- KEEP_SECTION — Use this directive to keep a section in the link, particularly a user-defined section.

- REF_INCLUDE — Use this directive to keep a section in the link, provided that there is a reference to the file that contains the section. This is a useful way to include version numbers.

Listing 13.2 shows an example of each directive.

Listing 13.2 Example Closure Sections

```
# 1st closure segment keeps 3 symbols in link
FORCE_ACTIVE {break_handler, interrupt_handler, my_function}

# 2nd closure segment keeps 2 sections in link
KEEP_SECTION {.interrupt1, .interrupt2}

# 3rd closure segment keeps file-dependent section in link
REF_INCLUDE {.version}
```

Sections Segment

Use the sections segment to define the contents of memory sections, and to define any global symbols that you want to use in your output file. Listing 13.3 shows the format of a sections segment.

Listing 13.3 Example Sections Segment

```
SECTIONS {
   .section_name : #The section name, for your reference,
   {               # must begin with a period.
      filename.c  (.text) #Put .text section from filename.c,
      filename2.c (.text) #then put .text section from filename2.c,
      filename.c  (.data) #then put .data section from filename.c,
      filename2.c (.data) #then put .data section from filename2.c,
      filename.c  (.bss)  #then put .bss section from filename.c,
      filename2.c (.bss)  #then put .bss section from filename2.c.
      . = ALIGN (0x10);   #Align next section on 16-byte boundary.
   } > segment_1          #Map these contents to segment_1.
   .next_section_name:
   {
      more content descriptions
   } > segment_x          #End of .next_section_name definition
}                         #End of sections segment
```

LCF Syntax

This section explains LCF commands, including practical ways to use them. Subsections are:

- Variables, Expressions, and Integrals
- Arithmetic, Comment Operators
- Alignment
- Specifying Files and Functions
- Stack and Heap
- Static Initializers
- Exception Tables
- Position-Independent Code and Data
- ROM-RAM Copying
- Writing Data Directly to Memory

Variables, Expressions, and Integrals

In a linker command file, all symbol names must start with the underscore character (_). The other characters can be letters, digits, or underscores. These valid lines for an LCF assign values to two symbols:

```
_dec_num = 99999999;
```

```
_hex_num_ = 0x9011276;
```

Use the standard assignment operator to create global symbols and assign their addresses, according to the pattern:

```
_symbolicname = some_expression;
```

NOTE There must be a semicolon at the end of a symbol assignment statement.
A symbol assignment is valid only at the start of an expression, so a line such as this is not valid:
you cannot use something like this:

```
_sym1 + _sym2 = _sym3;
```

When the system evaluates an expression and assigns it to a variable, the expression receives the type value *absolute* or a *relocatable*:

- Absolute expression — the symbol contains the value that it will have in the output file.

- Relocatable expression — the value expression is a fixed offset from the base of a section.

LCF syntax for expressions is very similar to the syntax of the C programming language:

- All integer types are `long` or `unsigned long`.
- Octal integers begin with a leading zero; other digits are 0 through 7, as these symbol assignments show:

```
_octal_number = 01374522;
_octal_number2 = 032405;
```

- Decimal integers begin with any non-zero digit; other digits are 0 through 9, as these symbol assignments show:

```
_dec_num = 99999999;
_decimal_number = 123245;
_decvalfour = 9011276;
```

- Hexadecimal integers begin with a zero and the letter x; other digits are 0 through f, as these symbol assignments show:

```
_hex_number = 0x999999FF;
_firstfactorspace = 0X123245EE;
_fifthhexval = 0xFFEE;
```

- Negative integers begin with a minus sign:

```
_decimal_number = -123456;
```

Arithmetic, Comment Operators

Use standard C arithmetic and logical operations as you define and use symbols in the LCF. All operators are left-associative. Table 13.1 lists these operators in the order of precedence. For additional information about these operators, refer to the *C Compiler Reference*.

Table 13.1 LCF Arithmetic Operators

Precedence	Operators
1	`- ~ !`
2	`* / %`
3	`+ -`
4	`>> <<`

Table 13.1 LCF Arithmetic Operators (*continued*)

Precedence	Operators
5	== != > < <= >=
6	&
7	|
8	&&
9	||

To add comments to your file, use the pound character, C-style slash and asterisk characters, or C++-style double-slash characters, in any of these formats:

```
#  This is a one-line comment
/* This is a
             multiline comment */
* (.text) // This is a partial-line comment
```

Alignment

To align data on a specific byte boundary, use the ALIGN keyword or the ALIGNALL command. Listing 13.4 and Listing 13.5 are examples for bumping the location counter to the next 16-byte boundary.

Listing 13.4 ALIGN Keyword Example

```
file.c (.text)
. = ALIGN (0x10);
file.c (.data)     # aligned on 16-byte boundary.
```

Listing 13.5 ALIGNALL Command Example

```
file.c (.text)
ALIGNALL (0x10);   #everything past this point aligned
                   # on 16 byte boundary
file.c (.data)
```

NOTE If one segment entry imposes an alignment requirement, that segment's starting address must conform to that requirement. Otherwise, there could be

conflicting section alignment in the code the linker produces.
In general, the instructions for data alignment should be lust before the end of the section.

Specifying Files and Functions

Defining the contents of a sections segment includes specifying the source file of each section. The standard method is merely listing the files, as Listing 13.6 shows.

Listing 13.6 Standard Source-File Specification

```
SECTIONS {
  .example_section :
    {
       main.c  (.text)
       file2.c (.text)
       file3.c (.text)
       # and so forth
```

For a large project, however, such a list can be very long. To shorten it, you can use the asterisk (`*`) wild-card character, which represents the filenames of every file in your project. The line

```
*   (.text)
```

in a section definition tells the system to include the `.text` section from each file.

Furthermore the `*` wildcard does not duplicate sections already specified; you need not replace existing lines of the code. In Listing 13.6, replacing the `# and so forth` comment line with

```
*   (.text)
```

would add the `.text` sections from all other project files, without duplicating the `.text` sections from files `main.c`, `file2.c`, or `file3.c`.

Another possibility as you define a sections segment, is specifying sections from a named group of files. To do so, use the GROUP keyword:

```
GROUP(fileGroup1) (.text)
```

```
GROUP(fileGroup4) (.data)
```

These two lines would specify including the `.text` sections from all `fileGroup1` files, and the `.data` sections from all `fileGroup4` files.

For precise control over function placement within a section, use the OBJECT keyword. For example, to place functions `beta` and `alpha` before anything else in a section, your definition could be like Listing 13.7.

Listing 13.7 Function Placement Example

```
SECTIONS {
  .program_section :
    {
      OBJECT (beta, main.c)    # Function beta is 1st section item
      OBJECT (alpha, main.c)   # Function alpha is 2nd section_item
      * (.text)  # Remaining_items are .text sections from all files
    } > ROOT
```

NOTE For C++, you must specify functions by their mangled names.

If you use the `OBJECT` keyword to specify a function, subsequently using `*` wild-card character does *not* specify that function a second time.

Stack and Heap

Reserving space for the stack requires some arithmetic operations to set the symbol values used at runtime. Listing 13.8 is a sections-segment definition code fragment that shows this arithmetic.

Listing 13.8 Stack Setup Operations

```
_stack_address = __END_BSS;
_stack_address = _stack_address & ~7; /*align top of stack by 8*/
__SP_INIT = _stack_address + 0x4000;  /*set stack to 16KB*/
```

The heap requires a similar space reservation, which Listing 13.9 shows. Note that the bottom address of the stack is the top address of the heap.

Listing 13.9 Heap Setup Operations

```
___heap_addr = __SP_INIT; /* heap grows opposite stack */
___heap_size = 0x50000; /* heap size set to 500KB */
```

Static Initializers

You must invoke static initializers to initialize static data before the start of `main()`. To do so, use the STATICINIT keyword to have the linker generate the static initializer sections.

In your linker command file, use lines similar to these to tell the linker where to put the table of static initializers (relative to the `'.'` location counter):

```
___sinit__ = .;
STATICINIT
```

The program knows the symbol ___sinit__ at runtime. So in startup code, you can use corresponding lines such as these:

```
#ifdef __cplusplus
/* call the c++ static initializers */
__call_static_initializers();
#endif
```

Exception Tables

You need exception tables only for C++ code. To create one, add the EXCEPTION command to the end of your code section — Listing 13.10 is an example.

The program knows the two symbols __exception_table_start__ and __exception_table_end__ at runtime.

Listing 13.10 Creating an Exception Table

```
  __exception_table_start__ = .;
  EXCEPTION
  __exception_table_end__ = .;
```

Position-Independent Code and Data

For position-independent code (PIC) and position-independent data (PID), your LCF must include .picdynrel and .piddynrel sections. These sections specify where to store the PIC and PID dynamic relocation tables.

In addition, your LCF must define these six symbols:

```
__START_PICTABLE   __END_PICTABLE __PICTABLE_SIZE
__START_PIDTABLE __END_PIDTABLE   __PIDTABLE_SIZE
```

Listing 13.11 is an example definition for PIC and PID.

Listing 13.11 PIC, PID Section Definition

```
.pictables :
{
. = ALIGN(0x8);
__START_PICTABLE = .;
*(.picdynrel)__END_PICTABLE = .;
__PICTABLE_SIZE = __END_PICTABLE - __START_PICTABLE;
__START_PIDTABLE = .;
*(.piddynrel)__END_PIDTABLE = .;
__PIDTABLE_SIZE = __END_PIDTABLE - __START_PIDTABLE;
} >> DATA
```

ROM-RAM Copying

In embedded programming, it is common that data or code of a program residing in ROM gets copied into RAM at runtime.

To indicate such data or code, use the LCF to assign it two addresses:

- The memory segment specifies the intended location in RAM
- The sections segment specifies the resident location in ROM, via its AT (address) parameter

For example, suppose that we want to copy all initialized data into RAM at runtime. At runtime, the system loads the `.main_data` section containing the initialized data to RAM address `0x80000`, but until runtime, this section remains in ROM. Listing 13.12 shows part of the corresponding LCF.

Listing 13.12 Partial LCF for ROM-to-RAM Copy

```
# ROM location: address 0x0
# RAM location: address 0x800000
# For clarity, no alignment directives in this listing

MEMORY {
  TEXT (RX) : ORIGIN = 0x0, LENGTH = 0
  DATA (RW) : ORIGIN = 0x800000, LENGTH = 0
}

SECTIONS{
  .main :
  {
    *(.text)
    *(.rodata)
  } > TEXT

# Locate initialized data in ROM area at end of .main.

  .main_data : AT( ADDR(.main) + SIZEOF(.main) )
  {
    *(.data)
    *(.sdata)
    *(.sbss)
  } > DATA
  .uninitialized_data:
  {
    *(SCOMMON)
    *(.bss)
    *(COMMON)
  } >> DATA
```

For program execution to copy the section from ROM to RAM, a copy table such as Listing 13.13 must supply the information that the program needs at runtime. This copy table, which the symbol `__S_romp` identifies, contains a sequence of three word values per entry:

- ROM start address
- RAM start address
- size

The last entry in this table must be all zeros: this is the reason for the three lines `WRITEW(0)` ; before the table closing brace character.

Listing 13.13 LCF Copy Table for Runtime ROM Copy

```
# Locate ROM copy table into ROM after initialized data
_romp_at = _main_ROM + SIZEOF(.main_data);

 .romp : AT (_romp_at)
 {
   __S_romp = _romp_at;
   WRITEW(_main_ROM);           #ROM start address
   WRITEW(ADDR(.main_data));    #RAM start address
   WRITEW(SIZEOF(.main_data)); #size
   WRITEW(0);
   WRITEW(0);
   WRITEW(0);
 }
 __SP_INIT = . + 0x4000;  # set stack to 16kb
 __heap_addr = __SP_INIT; # heap grows opposite stack direction
 __heap_size = 0x10000;   # set heap to 64kb
}                         # end SECTIONS segment
                          # end LCF
```

Writing Data Directly to Memory

To write data directly to memory, use appropriate `WRITEx` keywords in your LCF:

- `WRITEB` writes a byte

- WRITEH writes a two-byte halfword
- WRITEW writes a four-byte word.

The system inserts the data at the section's current address. Listing 13.14 shows an example.

Listing 13.14 Embedding Data Directly into Output

```
.example_data_section :
{
   WRITEB 0x48;  /*  'H'  */
   WRITEB 0x69;  /*  'i'  */
   WRITEB 0x21;  /*  '!'  */
```

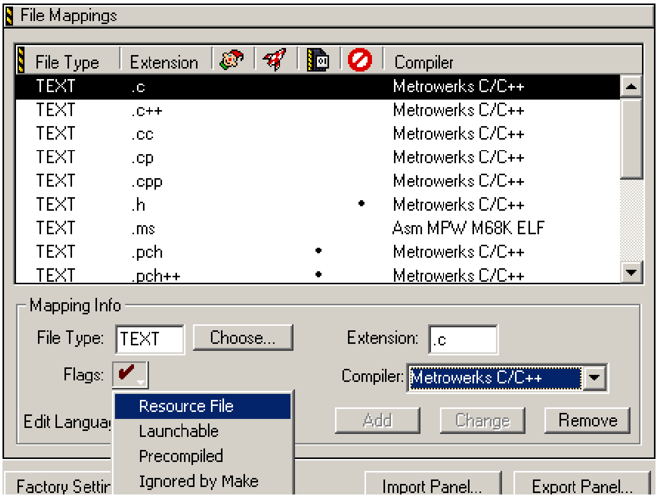
To insert a complete binary file, use the INCLUDE keyword, as Listing 13.15 shows.

Listing 13.15 Embedding a Binary File into Output

```
    _musicStart = .;
    INCLUDE music.mid
    _musicEnd = .;
}  > DATA
```

You must include the binary file in your IDE project. Additionally, the **File Mappings** target settings panel must specify *resource file* for all files that have the same extension as the binary file. Figure 13.1 shows how to make this type designation.

Figure 13.1 Marking a Binary File Type as a Resource File



File Type	Extension					Compiler
TEXT	.c					Metrowerks C/C++
TEXT	.c++					Metrowerks C/C++
TEXT	.cc					Metrowerks C/C++
TEXT	.cp					Metrowerks C/C++
TEXT	.cpp					Metrowerks C/C++
TEXT	.h				•	Metrowerks C/C++
TEXT	.ms					Asm MPW M68K ELF
TEXT	.pch			•		Metrowerks C/C++
TEXT	.pch++			•		Metrowerks C/C++

File Type: TEXT

Extension: .c

Flags: ✓

Compiler: Metrowerks C/C++

14

C Compiler

This chapter describes the CodeWarrior implementation of the C programming language:

- Extensions to Standard C
- C99 Extensions
- GCC Extensions

Extensions to Standard C

The CodeWarrior C compiler adds extra features to the C programming language. These extensions make it easier to port source code from other compilers and offer some programming conveniences. Note that some of these extensions do not conform to the ISO/IEC 9899-199 C standard (“C89”).

- Controlling Standard C Conformance
- C++-style Comments
- Unnamed Arguments
- Extensions to the Preprocessor
- Non-Standard Keywords

Controlling Standard C Conformance

The compiler offers settings that verify how closely your source code conforms to the ISO/IEC 9899-1990 C standard (“C89”). Enable these settings to check for possible errors or improve source code portability.

Some source code is too difficult or time-consuming to change so that it conforms to the ISO/IEC standard. In this case, disable some or all of these settings.

Table 14.5 shows how to control the compiler's features for ISO conformance.

Table 14.1 Controlling conformance to the ISO/IEC 9899-1990 C language

To control this option from here...	use this setting
CodeWarrior IDE	**ANSI Strict** and **ANSI Keywords Only** in the **C/C++ Language Settings** panel

source code	`#pragma ANSI_strict`
	`#pragma only_std_keywords`

command line	`-ansi`

C++-style Comments

When ANSI strictness is off, the C compiler allows C++-style comments. Listing 14.1 shows an example.

Listing 14.1 C++ Comments

```
a = b;     // This is a C++-style comment.
c = d;      /* This is a regular C-style comment. */
```

Unnamed Arguments

When ANSI strictness is off, the C compiler allows unnamed arguments in function definitions. Listing 14.2 shows an example.

Listing 14.2 Unnamed Arguments

```
void f(int ) {}  /* OK if ANSI Strict is disabled. */
void f(int i) {} /* Always OK. */
```

Extensions to the Preprocessor

When ANSI strictness is off, the C compiler allows a `#` to prefix an item that is not a macro argument. It also allows an identifier after an `#endif` directive. Listing 14.3 and Listing 14.4 show examples.

Listing 14.3 Using # in Macro Definitions

```
#define add1(x) #x #1
    /* OK, if ANSI_strict is disabled,
       but probably not what you wanted:
       add1(abc) creates "abc"#1
     */

#define add2(x) #x "2"
    /* Always OK: add2(abc) creates "abc2". */
```

Listing 14.4 Identifiers After #endif

```
#ifdef __MWERKS__
  /* . . . */
#endif __MWERKS__ /* OK if ANSI_strict is disabled. */

#ifdef __MWERKS__
  /* . . . */
#endif /*__MWERKS__*/ /* Always OK. */
```

Non-Standard Keywords

When the ANSI keywords setting is off, the C compiler recognizes non-standard keywords that extend the language.

C99 Extensions

The CodeWarrior C compiler accepts most of the enhancements to the C language specified by the ISO/IEC 9899-1999 standard, commonly referred to as “C99.”

- Controlling C99 Extensions
- Trailing Commas in Enumerations
- Compound Literal Values
- Designated Initializers
- Predefined Symbol __func__
- Implicit Return From main()
- Non-constant Static Data Initialization
- Variable Argument Macros
- Extra C99 Keywords

- C++-Style Comments
- C++-Style Digraphs
- Empty Arrays in Structures
- Hexadecimal Floating-Point Constants
- Variable-Length Arrays
- Unsuffixed Decimal Literal Values

Controlling C99 Extensions

Table 14.2 shows how to control C99 extensions.

Table 14.2 Controlling C99 extensions to the C language

To control this option from here...	use this setting
CodeWarrior IDE	**Enable C99 Extensions** in the **C/C++ Language Settings** panel
source code	`#pragma c99`
command line	`-c99`

Trailing Commas in Enumerations

When the C99 extensions setting is on, the compiler allows a comma after the final item in a list of enumerations. Listing 14.5 shows an example.

Listing 14.5 Trailing comma in enumeration example

```
enum
{
    violet,
    blue
    green,
    yellow,
    orange,
    red, /* OK: accepted if C99 extensions setting is on. */
};
```

Compound Literal Values

When the C99 extensions setting is on, the compiler allows literal values of structures and arrays. Listing 14.6 shows an example.

Listing 14.6 Example of a Compound Literal

```
#pragma c99 on
struct my_struct {
  int i;
  char c[2];
} my_var;

my_var = ((struct my_struct) {x + y, 'a', 0});
```

Designated Initializers

When the C99 extensions setting is on, the compiler allows an extended syntax for specifying which structure or array members to initialize. Listing 14.7 shows an example.

Listing 14.7 Example of Designated Initializers

```
#pragma c99 on

struct X {
    int a,b,c;
} x = { .c = 3, .a = 1, 2 };

union U {
    char a;
    long b;
} u = { .b = 1234567 };

int arr1[6] = { 1,2, [4] = 3,4 };
int arr2[6] = { 1, [1 ... 4] = 3,4 }; /* GCC only, not part of C99. */
```

Predefined Symbol __func__

When the C99 extensions setting is on, the compiler offers the `__func__` predefined variable. Listing 14.8 shows an example.

Listing 14.8 Predefined symbol __func__

```
void abc(void)
{
    puts(__func__); /* Output: "abc" */
}
```

Implicit Return From main()

When the C99 extensions setting is on, the compiler inserts this statement at the end of a program’s main() function if the function does not return a value:

```
return 0;
```

Non-constant Static Data Initialization

When the C99 extensions setting is on, the compiler allows static variables to be initialized with non-constant expressions.

Variable Argument Macros

When the C99 extensions setting is on, the compiler allows macros to have a variable number of arguments. Listing 14.9 shows an example.

Listing 14.9 Variable argument macros example

```
#define MYLOG(...) fprintf(myfile, __VA_ARGS__)
#define MYVERSION 1
#define MYNAME "SockSorter"

int main(void)
{
    MYLOG("%d %s\n", MYVERSION, MYNAME);
    /* Expands to: fprintf(myfile, "%d %s\n", 1, "SockSorter"); */

    return 0;
}
```

Extra C99 Keywords

When the C99 extensions setting is on, the compiler recognizes extra keywords and the language features they represent. Table 14.3 lists these keywords.

Table 14.3 Extra C99 Keywords

This keyword or combination of keywords...	represents this language feature
`_Bool`	boolean data type
`long long`	integer data type
`restrict`	type qualifier
`inline`	function qualifier
`_Complex`	complex number data type
`_Imaginary`	imaginary number data type

C++-Style Comments

When the C99 extensions setting is on, the compiler allows C++-style comments as well as regular C comments. A C++-style comment begins with

```
//
```

and continue until the end of a source code line.

A C-style comment begins with

```
/*
```

ends with

```
*/
```

and may span more than one line.

C++-Style Digraphs

When the C99 extensions setting is on, the compiler recognizes C++-style two-character combinations that represent single-character punctuation. Table 14.4 lists these digraphs.

Table 14.4 C++-Style Digraphs

This digraph	is equivalent to this character
`<:`	`[`
`:>`	`]`
`<%`	`{`
`%>`	`}`
`%:`	`#`
`%:%:`	`##`

Empty Arrays in Structures

When the C99 extensions setting is on, the compiler allows an empty array to be the last member in a structure definition. Listing 14.10 shows an example.

Listing 14.10 Example of an Empty Array as the Last struct Member

```
struct {
  int r;
  char arr[];
} s;
```

Hexadecimal Floating-Point Constants

Precise representations of constants specified in hexadecimal notation to ensure an accurate constant is generated across compilers and on different hosts. The compiler generates a warning message when the mantissa is more precise than the host floating point format. The compiler generates an error message if the exponent is too wide for the host float format.

Examples:

```
0x2f.3a2p3
0xEp1f
0x1.8p0L
```

The standard library supports printing values of type `float` in this format using the “`%a`” and “`%A`” specifiers.

Variable-Length Arrays

Variable length arrays are supported within local or function prototype scope, as required by the ISO/IEC 9899-1999 (“C99”) standard. Listing 14.11 shows an example.

Listing 14.11 Example of C99 Variable Length Array usage

```
#pragma c99 on

void f(int n) {
   int arr[n];
   /* ... */
}
```

While the example shown in Listing 14.12 generates an error message.

Listing 14.12 Bad Example of C99 Variable Length Array usage

```
#pragma c99 on

int n;
int arr[n];
// ERROR: variable length array
// types can only be used in local or
// function prototype scope.
```

A variable length array cannot be used in a function template’s prototype scope or in a local template `typedef`, as shown in Listing 14.13.

Listing 14.13 Bad Example of C99 usage in Function Prototype

```
#pragma c99 on

template<typename T> int f(int n, int A[n][n]);
{
};
// ERROR: variable length arrays
// cannot be used in function template prototypes
// or local template variables
```

Unsuffixed Decimal Literal Values

Listing 14.14 shows an example of specifying decimal literal values without a suffix to specify the literal's type.

Listing 14.14 Examples of C99 Unsuffixed Constants

```
#pragma c99 on  // Note: ULONG_MAX == 4294967295

sizeof(4294967295)  == sizeof(long long)
sizeof(4294967295u) == sizeof(unsigned long)

#pragma c99 off

sizeof(4294967295)  == sizeof(unsigned long)
sizeof(4294967295u) == sizeof(unsigned long)
```

GCC Extensions

The CodeWarrior compiler accepts many of the extensions to the C language that the GCC (Gnu Compiler Collection) tools allow. Source code that uses these extensions does not conform to the ISO/IEC 9899-1990 C ("C89") standard.

- Controlling GCC Extensions
- Initializing Automatic Arrays and Structures
- The sizeof() Operator
- Statements in Expressions
- Redefining Macros
- The typeof() Operator
- Void and Function Pointer Arithmetic
- The __builtin_constant_p() Operator
- Forward Declarations of Static Arrays
- Omitted Operands in Conditional Expressions
- The __builtin_expect() Operator
- Void Return Statements
- Minimum and Maximum Operators

Controlling GCC Extensions

Table 14.5 shows how to turn GCC extensions on or off.

Table 14.5 Controlling GCC extensions to the C language

To control this option from here...	use this setting
CodeWarrior IDE	**Enable GCC Extensions** in the **C/C++ Language Settings** panel
source code	`#pragma gcc_extensions`
command line	`-gcc_extensions`

Initializing Automatic Arrays and Structures

When the GCC extensions setting is on, array and structure variables that are local to a function and have the automatic storage class may be initialized with values that do not need to be constant. Listing 14.15 shows an example.

Listing 14.15 Initializing arrays and structures with non-constant values

```
void f(int i)
{
    int j = i * 10; /* Always OK. */

    /* These initializations are only accepted when GCC extensions
     * are on. */
    struct { int x, y; } s = { i + 1, i + 2 };
    int a[2] = { i, i + 2 };
}
```

The sizeof() Operator

When the GCC extensions setting is on, the `sizeof()` operator computes the size of function and void types. In both cases, the `sizeof()` operator evaluates to 1. The ISO/IEC 9899-1990 C Standard (“C89”) does not specify the size of the `void` type and functions. Listing 14.16 shows an example.

Listing 14.16 Using the sizeof() operator with void and function types

```
int f(int a)
{
    return a * 10;
}

void g(void)
{
    size_t voidsize = sizeof(void); /* voidsize contains 1 */
    size_t funcsize = sizeof(f); /* funcsize contains 1 */
}
```

Statements in Expressions

When the GCC extensions setting is on, expressions in function bodies may contain statements and definitions. To use a statement or declaration in an expression, enclose it within braces. The last item in the brace-enclosed expression gives the expression its value. Listing 14.17 shows an example.

Listing 14.17 Using statements and definitions in expressions

```
#define POW2(n) ({ int i,r; for(r=1,i=n; i>0; --i) r *= 2; r;})

int main()
{
    return POW2(4);
}
```

Redefining Macros

When the GCC extensions setting is on, macros may be redefined with the `#define` directive without first undefining them with the `#undef` directive. Listing 14.18 shows an example.

Listing 14.18 Redefining a macro without undefining first

```
#define SOCK_MAXCOLOR 100
#undef SOCK_MAXCOLOR
#define SOCK_MAXCOLOR 200 /* OK: this macro is previously undefined. */

#define SOCK_MAXCOLOR 300
```

The typeof() Operator

When the GCC extensions setting is on, the compiler recognizes the `typeof()` operator. This compile-time operator returns the type of an expression. You may use the value returned by this operator in any statement or expression where the compiler expects you to specify a type. The compiler evaluates this operator at compile time. The `__typeof()__` operator is the same as this operator. Listing 14.19 shows an example.

Listing 14.19 Using the typeof() operator

```
int *ip;

/* Variables iptr and jptr have the same type. */
typeof(ip) iptr;
int *jptr;

/* Variables i and j have the same type. */
typeof(*ip) i;
int j;
```

Void and Function Pointer Arithmetic

The ISO/IEC 9899-1990 C Standard does not accept arithmetic expressions that use pointers to `void` or functions. With GCC extensions on, the compiler accepts arithmetic manipulation of pointers to `void` and functions.

The __builtin_constant_p() Operator

When the GCC extensions setting is on, the compiler recognizes the `__builtin_constant_p()` operator. This compile-time operator takes a single argument and returns 1 if the argument is a constant expression or 0 if it is not.

Forward Declarations of Static Arrays

When the GCC extensions setting is on, the compiler will not issue an error when you declare a static array without specifying the number of elements in the array if you later declare the array completely. Listing 14.20 shows an example.

Listing 14.20 Forward declaration of an empty array

```
static int a[]; /* Allowed only when GCC extensions are on. */
/* ... */
static int a[10]; /* Complete declaration. */
```

Omitted Operands in Conditional Expressions

When the GCC extensions setting is on, you may skip the second expression in a conditional expression. The default value for this expression is the first expression. Listing 14.21 shows an example.

Listing 14.21 Using the shorter form of the conditional expression

```
void f(int i, int j)
{
    int a = i ? i : j;
    int b = i ?: j; /* Equivalent to int b = i ? i : j; */
    /* Variables a and b are both assigned the same value. */
}
```

The __builtin_expect() Operator

When the GCC extensions setting is on, the compiler recognizes the `__builtin_expect()` operator. Use this compile-time operator in an `if` or `while` statement to specify to the compiler how to generate instructions for branch prediction.

This compile-time operator takes two arguments:

- the first argument must be an integral expression
- the second argument must be a literal value

The second argument is the most likely result of the first argument. Listing 14.22 shows an example.

Listing 14.22 Example for __builtin_expect() operator

```
void search(int *array, int size, int key)
{
    int i;

    for (i = 0; i < size; ++i)
    {
          /* We expect to find the key rarely. */
          if (__builtin_expect(array[i] == key, 0))
         {
             rescue(i);
         }
    }
}
```

Void Return Statements

When the GCC extensions setting is on, the compiler allows you to place expressions of type `void` in a `return` statement. Listing 14.23 shows an example.

Listing 14.23 Returning void

```
void f(int a)
{
    /* ... */
    return; /* Always OK. */
}

void g(int b)
{
    /* ... */
    return f(b); /* Allowed when GCC extensions are on. */
}
```

Minimum and Maximum Operators

The compiler recognizes built-in minimum (`<?`) and maximum (`>?`) operators.

Listing 14.24 Example of minimum and maximum operators

```
int a = 1 <? 2; // 1 is assigned to a.
int b = 1 >? 2; // 2 is assigned to b.
```

15

C++ Compiler

This chapter describes the CodeWarrior implementation of the C++ programming language:

- C++ Compiler Performance
- Extensions to Standard C++
- Implementation-Defined Behavior
- GCC Extensions
- Embedded C++

C++ Compiler Performance

Some options affect the C++ compiler's performance. This section describes how to improve compile times when translating C++ source code:

- Precompiling C++ Source Code
- Using the Instance Manager

Precompiling C++ Source Code

The CodeWarrior C++ compiler has these requirements for precompiling source code:

- C source code may not include precompiled C++ header files and C++ source code may not include precompiled C header files.
- C++ source code can contain inline functions
- C++ source code may contain constant variable declarations
- A C++ source code file that will be automatically precompiled must have a `.pch++` file name extension.

Using the Instance Manager

The instance manager reduces compile time by generating a single instance of some kinds of functions only once:

- template functions

- functions declared with the `inline` qualifier that the compiler was not able to insert in line

The instance manager reduces the size of object code and debug information but does not affect the linker's output file size, though, since the compiler is effectively doing the same task as the linker in this mode.

Table 15.1 shows how to control the C++ instance manager.

Table 15.1 Controlling the C++ instance manager

To control this option from here...	use this setting
CodeWarrior IDE	**Use Instance Manager** in the **C/C++ Language Settings** panel
source code	`#pragma instmgr_file`
command line	`-instmgr`

Extensions to Standard C++

The CodeWarrior C++ compiler has features and capabilities that are not described in the ISO/IEC 14882-1998 C++ standard:

- `__PRETTY_FUNCTION__` Identifier
- Standard and Non-Standard Template Parsing

`__PRETTY_FUNCTION__` Identifier

The `__PRETTY_FUNCTION__` predefined identifier represents the qualified (unmangled) C++ name of the function being compiled.

Standard and Non-Standard Template Parsing

CodeWarrior C++ has options to specify how strictly template declarations and instantiations are translated. When using its strict template parser, the compiler expects the `typename` and `template` keywords to qualify names, preventing the same name in different scopes or overloaded declarations from being inadvertently used. When using its regular template parser, the compiler makes guesses about names in templates, but may guess incorrectly about which name to use.

A qualified name that refers to a type and that depends on a template parameter must begin with `typename` (ISO/IEC 14882-1998 C++, §14.6). Listing 15.1 shows an example.

Listing 15.1 Using the `typename` keyword

```
template <typename T> void f()
{
  T::name *ptr; // ERROR: an attempt to multiply T::name by ptr
  typename T::name *ptr; // OK
}
```

The compiler requires the `template` keyword at the end of "`.`" and "`->`" operators, and for qualified identifiers that depend on a template parameter. Listing 15.2 shows an example.

Listing 15.2 Using the `template` keyword

```
template <typename T> void f(T* ptr)
{
  ptr->f<int>(); // ERROR: f is less than int
  ptr->template f<int>(); // OK
}
```

Names referred to inside a template declaration that are not dependent on the template declaration (that do not rely on template arguments) must be declared before the template's declaration. These names are bound to the template declaration at the point where the template is defined. Bindings are not affected by definitions that are in scope at the point of instantiation. Listing 15.3 shows an example.

Listing 15.3 Binding non-dependent identifiers

```
void f(char);

template <typename T> void tmpl_func()
{
  f(1); // Uses f(char); f(int), below, is not defined yet.
  g(); // ERROR: g() is not defined yet.
}
void g();
void f(int);
```

Names of template arguments that are dependent in base classes must be explicitly qualified (ISO/IEC 14882-1998 C++, §14.6.2). See Listing 15.4.

Listing 15.4 Qualifying template arguments in base classes

```
template <typename T> struct Base
{
  void f();
}
template <typename T> struct Derive: Base<T>
{
  void g()
  {
    f(); // ERROR: Base<T>::f() is not visible.
    Base<T>::f(); // OK
  }
}
```

When a template contains a function call in which at least one of the function's arguments is type-dependent, the compiler uses the name of the function in the context of the template definition (ISO/IEC 14882-1998 C++, §14.6.2.2) and the context of its instantiation (ISO/IEC 14882-1998 C++, §14.6.4.2). Listing 15.5 shows an example.

Listing 15.5 Function call with type-dependent argument

```
void f(char);

template <typename T> void type_dep_func()
{
  f(1); // Uses f(char), above; f(int) is not declared yet.
  f(T()); // f() called with a type-dependent argument.
}

void f(int);
struct A{};
void f(A);

int main()
{
  type_dep_func<int>(); // Calls f(char) twice.
  type_dep_func<A>(); // Calls f(char) and f(A);
  return 0;
}
```

The compiler only uses external names to look up type-dependent arguments in function calls. See Listing 15.6.

Listing 15.6 Function call with type-dependent argument and external names

```
static void f(int); // f() is internal.

template <typename T> void type_dep_fun_ext()
{
  f(T()); // f() called with a type-dependent argument.
}

int main()
{
  type_dep_fun_ext<int>(); // ERROR: f(int) must be external.
160}
```

The compiler does not allow expressions in inline assembly statements that depend on template parameters. See Listing 15.7.

Listing 15.7 Assembly statements cannot depend on template arguments

```
template <typename T> void asm_tmpl()
{
  asm { move #sizeof(T), D0 ); // ERROR: Not supported.
}
```

The compiler also supports the address of template-id rules. See Listing 15.8.

Listing 15.8 Address of Template-id Supported

```
template <typename T> void funcA(T) {}
template <typename T> void funcB(T) {}
...
funcA{ &funcB<int> );     // now accepted
```

Implementation-Defined Behavior

Annex A of the ISO/IEC 14882-1998 C++ Standard lists compiler behaviors that are beyond the scope of the standard, but which must be documented for a compiler implementation. This annex also lists minimum guidelines for these behaviors, although a conforming compiler is not required to meet these minimums.

The CodeWarrior C++ compiler has these implementation quantities listed in Table 15.2, based on the ISO/IEC 14882-1998 C++ Standard, Annex A.

NOTE The term *unlimited* in Table 15.2 means that a behavior is limited only by the processing speed or memory capacity of the computer on which the CodeWarrior C++ compiler is running.

Table 15.2 Implementation Quantities for the C/C++ Compiler (ISO/IEC 14882-1998 C++, §A)

Behavior	Standard Minimum Guideline	CodeWarrior Limit
Nesting levels of compound statements, iteration control structures, and selection control structures	256	Unlimited
Nesting levels of conditional inclusion	256	32
Pointer, array, and function declarators (in any combination) modifying an arithmetic, structure, union, or incomplete type in a declaration	256	Unlimited
Nesting levels of parenthesized expressions within a full expression	256	Unlimited
Number of initial characters in an internal identifier or macro name	1024	Unlimited (255 significant in identifiers)
Number of initial characters in an external identifier	1024	Unlimited (255 significant in identifiers)
External identifiers in one translation unit	65536	Unlimited
Identifiers with block scope declared in one block	1024	Unlimited
Macro identifiers simultaneously defined in one translation unit	65536	Unlimited
Parameters in one function definition	256	Unlimited
Arguments in one function call	256	Unlimited
Parameters in one macro definition	256	128

Table 15.2 Implementation Quantities for the C/C++ Compiler (ISO/IEC 14882-1998 C++, §A) (*continued*)

Behavior	Standard Minimum Guideline	CodeWarrior Limit
Arguments in one macro invocation	256	128
Characters in one logical source line	65536	Unlimited
Characters in a character string literal or wide string literal (after concatenation)	65536	Unlimited
Size of an object	262144	2 GB
Nesting levels for `#include` files	256	32
`Case` labels for a `switch` statement (excluding those for any nested `switch` statements)	16384	Unlimited
Data members in a single class, structure, or union	16384	Unlimited
Enumeration constants in a single enumeration	4096	Unlimited
Levels of nested class, structure, or union definitions in a single struct-declaration-list	256	Unlimited
Functions registered by `atexit()`	32	64
Direct and indirect base classes	16384	Unlimited
Direct base classes for a single class	1024	Unlimited
Members declared in a single class	4096	Unlimited
Final overriding virtual functions in a class, accessible or not	16384	Unlimited
Direct and indirect virtual bases of a class	1024	Unlimited
Static members of a class	1024	Unlimited
Friend declarations in a class	4096	Unlimited
Access control declarations in a class	4096	Unlimited
Member initializers in a constructor definition	6144	Unlimited

Table 15.2 Implementation Quantities for the C/C++ Compiler (ISO/IEC 14882-1998 C++, §A) (*continued*)

Behavior	Standard Minimum Guideline	CodeWarrior Limit
Scope qualifications of one identifier	256	Unlimited
Nested external specifications	1024	Unlimited
Template arguments in a template declaration	1024	Unlimited
Recursively nested template instantiations	17	Unlimited
Handlers per try block	256	Unlimited
Throw specifications on a single function declaration	256	Unlimited

GCC Extensions

The CodeWarrior C++ compiler recognizes some extensions to the ISO/IEC 14882-1998 C++ standard that are also recognized by the GCC (GNU Compiler Collection) C++ compiler.

These extensions are:

- Using the :: Operator in Class Declarations

Using the :: Operator in Class Declarations

The compiler allows the use of the :: operator, of the form `class::member`, in a class declaration.

Listing 15.9 Using the :: operator in class declarations

```
class MyClass {
   int MyClass::getval();
};
```

Embedded C++

Embedded C++ (EC++) is a subset of the ISO/IEC 14882-1998 C++ language that is intended to compile into smaller, faster executable code suitable for embedded systems. Embedded C++ source code is upwardly compatible with ISO/IEC C++ source code.

- Activating EC++
- Differences Between ISO C++ and EC++
- EC++ Specifications

Activating EC++

Table 15.3 shows how to control Embedded C++ conformance.

Table 15.3 Controlling Embedded C++ conformance

To control this option from here...	use this setting
CodeWarrior IDE	**EC++ Compatibility Mode** in the **C/C++ Language Settings** panel
source code	`#pragma ecplusplus`
command line	`-dialect ec++`

To test for EC++ compatibility mode at compile time, use the `__embedded_cplusplus` predefined symbol.

Differences Between ISO C++ and EC++

The EC++ proposal does not support the following ISO/IEC 14882-1998 C++ features:

- Templates
- Libraries
- File Operations
- Localization
- Exception Handling
- Unsupported Language Features

Templates

ISO/IEC C++ specifies templates. The EC++ proposal does not include template support for class or functions.

Libraries

The EC++ proposal supports the `<string>`, `<complex>`, `<ios>`, `<streambuf>`, `<istream>`, and `<ostream>` classes, but only in a non-template form. The EC++ specifications do not support any other ISO/IEC C++ libraries, including the STL-type algorithm libraries.

File Operations

The EC++ proposal does not support any file operations except simple console input and output file types.

Localization

The EC++ proposal does not contain localization libraries because of the excessive memory requirements.

Exception Handling

The EC++ proposal does not support exception handling.

Unsupported Language Features

The EC++ proposal does not support the following language features:

- mutable specified
- RTTI
- namespace
- multiple inheritance
- virtual inheritance

EC++ Specifications

Topics in this section describe how to design software that adhere to the EC++ proposal:

- Language Related Issues
- Library-Related Issues

Language Related Issues

To make sure your source code complies with both ISO/IEC 14882-1998 C++ and EC++ standards, follow these guidelines:

- Do not use RTTI (Run Time Type Identification).
- Do not use exception handling, namespaces, or other unsupported features.
- Do not use multiple or virtual inheritance.

Library-Related Issues

Do not refer to routines, data structures, and classes in the Metrowerks Standard Library (MSL) for C++.

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Tool Performance

Some options for CodeWarrior compilers and linkers affect how much time these tools take. By managing these options so that they are used only when they are needed, you can reduce the time needed to build your software.

Precompiling

Source code files in a project often use many header files. Typically, the same header files are included by each source code file in a project, forcing the compiler to read these header files repeatedly during compilation. To shorten the time spent compiling and recompiling the same header files, CodeWarrior compilers can precompile a header file once instead of preprocessing it several times.

- When to Use Precompiled Files
- What Can be Precompiled
- Using a Precompiled Header File
- Preprocessing and Precompiling
- Pragma Scope in Precompiled Files
- Precompiling a File in the CodeWarrior IDE
- Updating a Precompiled File Automatically

When to Use Precompiled Files

As a convenience, programmers often create a header file that contains commonly-used preprocessor definitions and includes frequently-used header files. This header file is then included by each source code file in a project, saving the programmer some time and effort while writing source code.

This convenience comes at a cost, though. While the programmer saves time typing, the compiler does extra work, preprocessing and compiling this header file each time it compiles a source code file that includes it.

This header file can be precompiled so that, instead of preprocessing files several times, the compiler needs to load just one precompiled header file.

What Can be Precompiled

A file to be precompiled does not have to be a header file (`.h` or `.hpp` files, for example), but it must meet these requirements:

- The file must be a source code file in text format.

  You cannot precompile libraries or other binary files.

- A C source code file that will be automatically precompiled must have `.pch` file name extension.
- Precompiled files must have a `.mch` file name extension.
- The file to be precompiled does not have to be in a CodeWarrior IDE project, although a project must be open to precompile the file.

  The CodeWarrior IDE uses the build target settings to precompile a file.

- The file must not contain any statements that generate data or executable code.

  However, the file may define static data.

- Precompiled header files for different build targets are not interchangeable.
- A source file may include only one precompiled file.
- A file may not define any items before including a precompiled file.

  Typically, a source code file includes a precompiled header file before anything else (except comments).

Using a Precompiled Header File

Although a precompiled file is not a text file, you use it like you would a regular header file. To include a precompiled header file in a source code file, use the `#include` directive.

NOTE Unlike regular header files in text format, a source code file may include only one precompiled file.

TIP Instead of explicitly including a precompiled file in each source code file with the `#include` directive, put the `#include` directive in the **Prefix Text** field of the CodeWarrior IDE's **C/C++ Preprocessor** settings panel and make sure that the **Use prefix in precompiled headers** option is on. If the **Prefix File** field already specifies a file name, include the precompiled file in the prefix file with the `#include` directive.

Listing 16.1 and Listing 16.2 show an example.

Listing 16.1 Header File that Creates a Precompiled Header File for C

```
/* sock_header.pch
 *
 * When compiled or precompiled, this file will generate a
 * precompiled file named "sock_precomp.mch"
 */
#pragma precompile_target "sock_precomp.mch"

#define SOCK_VERSION "SockSorter 2.0"
#include "sock_std.h"
#include "sock_string.h"
#include "sock_sorter.h"
```

Listing 16.2 Using a Precompiled File

```
/* sock_main.c
 *
 * Instead of including all the files included in
 * sock_header.pch, we use sock_precomp.h instead.
 *
 * A precompiled file must be included before anything
 * else.
 */

#include "sock_precomp.mch"

int main(void)
{
  /* ... */
  return 0;
}
```

Preprocessing and Precompiling

When precompiling a header file, the compiler preprocesses the file too. In other words, a precompiled file is preprocessed in the context of its precompilation, not in the context of its later compilation.

The preprocessor also tracks macros used to guard `#include` files to reduce parsing time. Thus, if a file’s contents are surrounded with:

```
#ifndef MYHEADER_H
#define MYHEADER_H
   /* file contents */
#endif
```

the compiler will not load the file twice, saving some time in the process.

Pragma Scope in Precompiled Files

Pragma settings inside a precompiled file affect only the source code within that file. The pragma settings for an item declared in a precompiled header file (such as data or a function) are saved then restored when the precompiled header file is included.

For example, the source code in Listing 16.3 specifies that the variable `xxx` is a `far` variable.

Listing 16.3 Pragma Settings in a Precompiled Header

```
/* my_pch.pch */

/* Generate a precompiled header named pch.mch. */
#pragma precompile_target "my_pch.mch"

#pragma far_data on
extern int xxx;
```

The source code in Listing 16.4 includes the precompiled version of Listing 16.3.

Listing 16.4 Pragma Settings in an Included Precompiled File

```
/* test.c */

/* Far data is disabled. */
#pragma far_data off

/* This precompiled file sets far_data on. */
#include "my_pch.mch"

/* far_data is still off but xxx is still a far variable. */
```

The pragma setting in the precompiled file is active within the precompiled file, even though the source file including the precompiled file has a different setting.

Precompiling a File in the CodeWarrior IDE

To precompile a file in the CodeWarrior IDE, use the **Precompile** command in the **Project** menu:

1. Start the CodeWarrior IDE.
2. Open or create a project.

3. Choose or create a build target in the project.

   The settings in the project's active build target will be used when preprocessing and precompiling the file you want to precompile.

4. Open the source code file to precompile.

   See "What Can be Precompiled" on page 162 for information on what a precompiled file may contain.

5. From the **Project** menu, choose **Precompile**.

   A save dialog box appears.

6. Choose a location and type a name for the new precompiled file.

   The IDE precompiles the file and saves it.

7. Click **Save**.

   The save dialog box closes, and the IDE precompiles the file you opened, saving it in the folder you specified, giving it the name you specified.

You may now include the new precompiled file in source code files.

Updating a Precompiled File Automatically

Use the CodeWarrior IDE's project manager to update a precompiled header automatically. The IDE creates a precompiled file from a source code file during a compile, update, or make operation if the source code file meets these criteria:

- The text file name ends with `.pch` (for C header files).
- The file is in a project's build target.
- The file uses the `precompile_target` pragma.
- The file, or files it depends on, have been modified.

  See the *CodeWarrior IDE User Guide* for information on how the IDE determines that a file must be updated.

The IDE uses the build target's settings to preprocess and precompile files.

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Intermediate Optimizations

After it translates a program's source code into its intermediate representation, the compiler optionally applies optimizations that reduce the program's size, improve its execution speed, or both. The topics in this chapter describes these optimizations and how to apply them:

- Interprocedural Analysis
- Intermediate Optimizations
- Inlining

Interprocedural Analysis

Most compiler optimizations are applied only within a function. The compiler analyzes a function's flow of execution and how the function uses variables. It uses this information to find shortcuts in execution and reduce the number of registers and memory that the function uses. These optimizations are useful and effective but are limited to the scope of a function.

The CodeWarrior compiler has a special optimization that it applies at a greater scope. Widening the scope of an optimization offers the potential to greatly improve performance and reduce memory use. *Interprocedural analysis* examines the flow of execution and data within entire files and programs to improve performance and reduce size.

- Invoking Interprocedural Analysis
- File-Level Optimizations
- Program-Level Optimizations
- Program-Level Requirements

Invoking Interprocedural Analysis

Table 17.1 describes how to control interprocedural analysis.

Table 17.1 Controlling interprocedural analysis

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose an item in the **IPA** option of the **C/ C++ Langauge Settings** settings pane.l
source code	`#pragma ipa off | file | program`
command line	`-ipa off | file | program`

File-Level Optimizations

When interprocedual analysis is set to optimize at the file level, the compiler reads and analyzes an entire file before generating instructions and data.

At this level, the compiler generates more efficient code for inline function calls and C++ exception handling than when interprocedural analysis is off. The compiler also safely removes static functions and variables that are not referred to within the file, which reduces the amount of object code that the linker must process, resulting in better linker performance.

Program-Level Optimizations

When interprocedural analysis is set to optimize at the program level, the compiler reads and analyzes all files in a program before generating instructions and data.

At this level of interprocedural analysis, the compiler generates the most efficient instructions and data for inline function calls and C++ exception handling compared to other levels. The compiler is also able to increase character string reuse and pooling, reducing the size of object code.

Program-Level Requirements

Program-level interprocedural analysis imposes some requirements and limitations on the source code files that the compiler translates:

- Dependencies Among Source Files
- Function and Top-level Variable Declarations
- Type Definitions

- Unnamed Structures and Enumerations in C

Dependencies Among Source Files

A change to even a single source file in a program still requires that the compiler read and analyze all files in the program, even those files that are not dependent on the changed file. This requirement significantly increases compile time.

Function and Top-level Variable Declarations

Because the compiler treats all files that compose a program as if they were a single, large source file. Make sure all non-static declarations for variables or functions with the same name are identical. See Listing 17.1 for an example of declarations that prevent the compiler from applying program-level analysis. Listing 17.2 fixes this problem by renaming the conflicting symbols.

Listing 17.1 Declaration conflicts in program-level interprocedural analysis

```
/* file1.c */
extern int i;
extern int f();
int main(void)
{
   return i + f();
}

/* file2.c */
short i;       /* Conflict with variable i in file1.c. */
extern void f(); /* Conflict with function f() in file1.c */
```

Listing 17.2 Fixing declaration conflicts for program-level interprocedural analysis

```
/* file1.c */
extern int i1;
extern int f1();
int main(void)
{
   return i1 + f1();
}

/* file2.c */
short i2;
extern void f2();
```

Type Definitions

Because the compiler examines all source files for a program, make sure all definitions for a type are the same. See Listing 17.3 for an example of conflicting type definitions. Listing 17.4 and Listing 17.5 show suggested solutions.

Listing 17.3 Type definitions conflicts in program-level interprocedural analysis

```
/* fileA.c */
struct a_rec { int i, j; };
a_rec a;

/* fileB.c */
struct a_rec { char c; }; /* Conflict with a_rec in fileA.c */
a_rec b;
```

Listing 17.4 Fixing type definitions conflicts in C

```
/* fileA.c */
struct a1_rec { int i, j; };
a1_rec a;

/* fileB.c */
struct a2_rec { char c; };
a2_rec b;
```

Listing 17.5 Fixing type definitions conflicts in C++

```
/* fileA.c */
namespace { struct a_rec { int i, j; }; }
a_rec a;

/* fileB.c */
namespace { struct a_rec { char c; }; }
a_rec b;
```

Unnamed Structures and Enumerations in C

The C language allows anonymous `struct` and `enum` definitions in type definitions. Using such definitions prevents the compiler from properly applying program-level interprocedural analysis. Make sure to give names to structures and enumerations in type definitions. Listing 17.6 shows an example of unnamed structures and enumerations and Listing 17.7 shows a suggested solution.

Listing 17.6 Unnamed structures and enumerations in C

```
/* In C, the types x_rec and y_enum each represent a structure
   and an enumeration with no name.

   In C++ these same statements define a type x_rec and y_enum,
   a structure named x_rec and an enumeration named y_enum.
*/
typedef struct { int a, b, c; } x_rec;
typedef enum { Y_FIRST, Y_SECOND, Y_THIRD } y_enum;
```

Listing 17.7 Naming structures and enumerations in C

```
typedef struct x_rec { int a, b, c; } x_rec;
typedef enum y_enum { Y_FIRST, Y_SECOND, Y_THIRD } y_enum;
```

Intermediate Optimizations

After it translates a function into its intermediate representation, the compiler may optionally apply some optimizations. The result of these optimizations on the intermediate representation will either reduce the size of the executable code, improve the executable code's execution speed, or both.

- Dead Code Elimination
- Expression Simplification
- Common Subexpression Elimination
- Copy Propagation
- Dead Store Elimination
- Live Range Splitting
- Loop-Invariant Code Motion
- Strength Reduction
- Loop Unrolling

Dead Code Elimination

The dead code elimination optimization removes expressions that are not accessible or are not referred to. This optimization reduces size and increases execution speed.

Table 17.2 describes how to control the optimization for dead code elimination.

Table 17.2 Controlling dead code elimination

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 1**, **Level 2**, **Level 3**, or **Level 4** in the **Global Optimizations** settings pane.l
source code	`#pragma opt_dead_code on | off | reset`
command line	`-opt [no]deadcode`

In Listing 17.8, the call to `func1()` will never execute because the `if` statement that it is associated with will never be true. Consequently, the compiler can safely eliminate the call to `func1()`, as shown in Listing 17.9.

Listing 17.8 Before dead code elimination

```
void func_from(void)
{
    if (0)
    {
        func1();
    }
    func2();
}
```

Listing 17.9 After dead code elimination

```
void func_to(void)
{
    func2();
}
```

Expression Simplification

The expression simplification optimization attempts to replace arithmetic expressions with simpler expressions. Additionally, the compiler also looks for operations in expressions that can be avoided completely without affecting the final outcome of the expression. This optimization reduces size and increases speed.

Table 17.3 describes how to control the optimization for expression simplification.

Table 17.3 Controlling expression simplification

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 1**, **Level 2**, **Level 3**, or **Level 4** in the **Global Optimizations** settings pane.l
source code	There is no pragma to control this optimization.
command line	`-opt level=1`, `-opt level=2`, `-opt level=3`, `-opt level=4`

For example, Listing 17.10 contains a few assignments to some arithmetic expressions:

- addition to zero
- multiplication by a power of 2
- subtraction of a value from itself
- arithmetic expression with two or more literal values

Listing 17.10 Before expression simplification

```
void func_from(int* result1, int* result2, int* result3, int* result4,
int x)
{
    *result1 = x + 0;
    *result2 = x * 2;
    *result3 = x - x;
    *result4 = 1 + x + 4;
}
```

Listing 17.11 shows source code that is equivalent to expression simplification. The compiler has modified these assignments to:

- remove the addition to zero
- replace the multiplication of a power of 2 with bit-shift operation
- replace a subtraction of x from itself with 0
- consolidate the additions of 1 and 4 into 5

Listing 17.11 After expression simplification

```
void func_to(int* result1, int* result2, int* result3, int* result4,
int x)
```

```
{
    *result1 = x;
    *result2 = x << 1;
    *result3 = 0;
    *result4 = 5 + x;
}
```

Common Subexpression Elimination

Common subexpression elimination replaces multiple instances of the same expression with a single instance. This optimization reduces size and increases execution speed.

Table 17.4 descirbes how to control the optimization for common subexpression elimination.

Table 17.4 Controlling common subexpression elimination

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 2**, **Level 3**, or **Level 4** in the **Global Optimizations** settings pane.l
source code	`#pragma opt_common_subs on | off | reset`
command line	`-opt [no]cse`

For example, in Listing 17.12, the subexpression `x * y` occurs twice.

Listing 17.12 Before common subexepression elimination

```
void func_from(int* vec, int size, int x, int y, int value)
{
    if (x * y < size)
    {
        vec[x * y - 1] = value;
    }
}
```

Listing 17.13 shows equivalent source code after the compiler applies common subexpression elimination. The compiler generates instructions to compute `x * y` and store it in a hidden, temporary variable. The compiler then replaces each instance of the subexpression with this variable.

Listing 17.13 After common subexpression elimination

```
void func_to(int* vec, int size, int x, int y, int value)
{
    int temp = x * y;
    if (temp < size)
    {
        vec[temp - 1] = value;
    }
}
```

Copy Propagation

Copy propagation replaces variables with their original values if the variables do not change. This optimization reduces runtime stack size and improves execution speed.

Table 17.5 describes how to control the optimization for copy propagation.

Table 17.5 Controlling copy propagation

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 2**, **Level 3**, or **Level 4** in the **Global Optimizations** settings pane.l
source code	`#pragma opt_propagation on	off	reset`
command line	`-opt [no]prop[agation]`

For example, in Listing 17.14, the variable `j` is assigned the value of `x`. But `j`'s value is never changed, so the compiler replaces later instances of `j` with `x`, as shown in Listing 17.15.

By propagating `x`, the compiler is able to reduce the number of registers it uses to hold variable values, allowing more variables to be stored in registers instead of slower memory. Also, this optimization reduces the amount of stack memory used during function calls.

Listing 17.14 Before copy propagation

```
void func_from(int* a, int x)
{
    int i;
    int j;
    j = x;
    for (i = 0; i < j; i++)
    {
        a[i] = j;
    }
}
```

Listing 17.15 After copy propagation

```
void func_to(int* a, int x)
{
    int i;
    int j;
    j = x;
    for (i = 0; i < x; i++)
    {
        a[i] = x;
    }
}
```

Dead Store Elimination

Dead store elimination removes unused assignment statements. This optimization reduces size and improves speed.

Table 17.6 describes how to control the optimization for dead store elimination.

Table 17.6 Controlling dead store elimination

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 3** or **Level 4** in the **Global Optimizations** settings pane.l
source code	`#pragma opt_dead_assignments on | off | reset`
command line	`-opt [no]deadstore`

For example, in Listing 17.16 the variable `x` is first assigned the value of `y * y`. However, this result is not used before `x` is assigned the result returned by a call to `getresult()`.

In Listing 17.17 the compiler can safely remove the first assignment to `x` since the result of this assignment is never used.

Listing 17.16 Before dead store elimination

```
void func_from(int x, int y)
{
    x = y * y;
    otherfunc1(y);
    x = getresult();
    otherfunc2(y);
}
```

Listing 17.17 After dead store elimination

```
void func_to(int x, int y)
{
    otherfunc1(y);
    x = getresult();
    otherfunc2(y);
}
```

Live Range Splitting

Live range splitting attempts to reduce the number of variables used in a function. This optimization reduces a function's runtime stack size, requiring fewer instructions to invoke the function. This optimization potentially improves execution speed.

Table 17.7 describes how to control the optimization for live range splitting.

Table 17.7 Controlling live range splitting

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 3** or **Level 4** in the **Global Optimizations** settings pane.l
source code	There is no pragma to control this optimization.
command line	`-opt level=3, -opt level=4`

For example, in Listing 17.18 three variables, `a`, `b`, and `c`, are defined. Although each variable is eventually used, each of their uses is exclusive to the others. In other words, `a` is not referred to in the same expressions as `b` or `c`, `b` is not referred to with `a` or `c`, and `c` is not used with `a` or `b`.

In Listing 17.19, the compiler has replaced a, b, and c, with a single variable. This optimization reduces the number of registers that the object code uses to store variables, allowing more variables to be stored in registers instead of slower memory. This optimization also reduces a function's stack memory.

Listing 17.18 Before live range splitting

```
void func_from(int x, int y)
{
    int a;
    int b;
    int c;

    a = x * y;
    otherfunc(a);

    b = x + y;
    otherfunc(b);

    c = x - y;
    otherfunc(c);
}
```

Listing 17.19 After live range splitting

```
void func_to(int x, int y)
{
    int a_b_or_c;

    a_b_or_c = x * y;
    otherfunc(temp);

    a_b_or_c = x + y;
    otherfunc(temp);

    a_b_or_c = x - y;
    otherfunc(temp);
}
```

Loop-Invariant Code Motion

Loop-invariant code motion moves expressions out of a loop if the expressions are not affected by the loop or the loop does not affect the expression. This optimization improves execution speed.

Table 17.8 describes how to control the optimization for loop-invariant code motion.

Table 17.8 Controlling loop-invariant code motion

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 3** or **Level 4** in the **Global Optimizations** settings pane.l
source code	`#pragma opt_loop_invariants on | off | reset`
command line	`-opt [no]loop[invariants]`

For example, in Listing 17.20, the assignment to the variable `circ` does not refer to the counter variable of the `for` loop, `i`. But the assignment to `circ` will be executed at each loop iteration.

Listing 17.21 shows source code that is equivalent to how the compiler would rearrange instructions after applying this optimization. The compiler has moved the assignment to `circ` outside the `for` loop so that it is only executed once instead of each time the `for` loop iterates.

Listing 17.20 Before loop-invariant code motion

```
void func_from(float* vec, int max, float val)
{
    float circ;
    int i;
    for (i = 0; i < max; ++i)
    {
        circ = val * 2 * PI;
        vec[i] = circ;
    }
}
```

Listing 17.21 After loop-invariant code motion

```
void func_to(float* vec, int max, float val)
{
    float circ;
    int i;
    circ = val * 2 * PI;
    for (i = 0; i < max; ++i)
    {
        vec[i] = circ;
    }
}
```

Strength Reduction

Strength reduction attempts to replace slower multiplication operations with faster addition operations. This optimization improves execution speed but increases code size.

Table 17.9 describes how to control the optimization for strength reduction.

Table 17.9 Controlling strength reduction

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 3** or **Level 4** in the **Global Optimizations** settings pane.l
source code	`#pragma opt_strength_reduction on | off | reset`
command line	`-opt [no]strength`

For example, in Listing 17.22, the assignment to elements of the `vec` array use a multiplication operation that refers to the `for` loop's counter variable, `i`.

In Listing 17.23, the compiler has replaced the multiplication operation with a hidden variable that is increased by an equivalent addition operation. Processors execute addition operations faster than multiplication operations.

Listing 17.22 Before strength reduction

```
void func_from(int* vec, int max, int fac)
{
    int i;
    for (i = 0; i < max; ++i)
    {
        vec[i] = fac * i;
    }
}
```

Listing 17.23 After strength reduction

```
void func_to(int* vec, int max, int fac)
{
    int i;
    int strength_red;
    hidden_strength_red = 0;
    for (i = 0; i < max; ++i)
    {
        vec[i] = hidden_strength_red;
        hidden_strength_red = hidden_strength_red + i;
    }
}
```

Loop Unrolling

Loop unrolling inserts extra copies of a loop's body in a loop to reduce processor time executing a loop's overhead instructions for each iteration of the loop body. In other words, this optimization attempts to reduce the ratio of time that the processor executes a loop's completion test and branching instructions compared to the time the processor executes the loop's body. This optimization improves execution speed but increases code size.

Table 17.10 describes how to control the optimization for loop unrolling.

Table 17.10 Controlling loop unrolling

Turn control this option from here...	use this setting
CodeWarrior IDE	Choose **Level 3** or **Level 4** in the **Global Optimizations** settings pane.l
source code	`#pragma opt_unroll_loops on	off	reset`
command line	`-opt level=3, -opt level=4`

For example, in Listing 17.24, the `for` loop's body is a single call to a function, `otherfunc()`. For each time the loop's completion test executes

`for (i = 0; i < MAX; ++i)`

the function executes the loop body only once.

In Listing 17.25, the compiler has inserted another copy of the loop body and rearranged the loop to ensure that variable `i` is incremented properly. With this arrangement, the loop's completion test executes once for every 2 times that the loop body executes.

Listing 17.24 Before loop unrolling

```
const int MAX = 100;
void func_from(int* vec)
```

```
{
    int i;
    for (i = 0; i < MAX; ++i)
    {
        otherfunc(vec[i]);
    }
}
```

Listing 17.25 After loop unrolling

```
const int MAX = 100;
void func_to(int* vec)
{
    int i;
    for (i = 0; i < MAX;)
    {
        otherfunc(vec[i]);
        ++i;
        otherfunc(vec[i]);
        ++i;
    }
}
```

Inlining

Inlining replaces instructions that call a function and return from it with the actual instructions of the function being called. Inlining functions makes your program faster because it executes the function code immediately without the overhead of a function call and return. However, inlining can also make your program larger because the compiler may insert the function’s instructions many times throughout your program.

The rest of this section describes how to specify which functions to inline and how the compiler performs the inlining:

- Choosing Which Functions to Inline
- Inlining Techniques

Choosing Which Functions to Inline

The compiler offers several methods to specify which functions are elligible for inlining.

To specify that a function is elligible to be inlined, precede its definition with the `inline`, `__inline__`, or `__inline` keyword. To allow these keywords in C source code, turn off **ANSI Keywords Only** in the CodeWarrior IDE’s **C/C++ Language** settings panel or turn off the `only_std_keywords` pragma in your source code.

To verify that an elligible function has been inlined or not, use the **Non-Inlined Functions** option in the IDE’s **C/C++ Warnings** panel or the `warn_notinlined` pragma. Listing 17.26Listing 17.26 shows an example.

Listing 17.26 Specifying to the compiler that a function may be inlined

```
#pragma only_std_keywords off
inline int attempt_to_inline(void)
{
    return 10;
}
```

To specify that a function must never be inlined, follow its definition’s specifier with `__attribute__((never_inline))`. Listing 17.27 shows an example.

Listing 17.27 Specifying to the compiler that a function must never be inlined

```
int never_inline(void) __attribute__((never_inline))
{
   return 20;
}
```

To specify that no functions in a file may be inlined, including those that are defined with the `inline`, `__inline__`, or `__inline` keywords, use the `dont_inline` pragma. Listing 17.28Listing 17.28 shows an example.

Listing 17.28 Specifying that no functions may be inlined

```
#pragma dont_inline on

/* Will not be inlined. */
inline int attempt_to_inline(void)
{
    return 10;
}

/* Will not be inlined. */
int never_inline(void) __attribute__((never_inline))
{
   return 20;
}

#pragma dont_inline off
/* Will be inlined, if possible. */
```

```
inline int also_attempt_to_inline(void)
{
    return 10;
}
```

Some kinds of functions are never inlined:

- functions with variable argument lists
- functions declared with `__attribute__(never_inline)`
- functions compiled with `#pragma optimize_for_size on` or the **Optimize For Size** setting in the IDE's **Global Optimizations** panel
- functions which have their pointers stored in variables

The compiler will not inline these functions, even if they are defined with the `inline`, `__inline__`, or `__inline` keywords.

Inlining Techniques

The depth of inlining describes how many levels of function calls the compiler will inline. The **Inline Depth** setting in the IDE's **C/C++ Language** settings panel and the `inline_depth` pragma control inlining depth.

Normally, the compiler only inlines an elligible function if it has already translated the function's definition. In other words, if an elligible function has not yet been compiled, the compiler has no object code to insert. To overcome this limitation, the compiler allows deferred inlining, which specifies to the compiler to delay a function's compilation until any functions that it calls have been compiled. The **Deferred Inlining** setting in the IDE's **C/C++ Language** settings panel and the `defer_codegen` pragma control this capability.

The compiler normally inlines functions from the first function in a chain of function calls to the last function called. Alternately, the compiler may inline functions from the last function called to the first function in a chain of function calls. The **Bottom-up Inlining** option in the IDE's **C/C++ Language** settings panel and the `inline_bottom_up` and `inline_bottom_up_once` pragmas control this reverse method of inlining.

Some functions that have not been defined with the `inline`, `__inline__`, or `__inline` keywords may still be good candidates to be inlined. Automatic inlining allows the compiler to inline these functions in addition to the functions that you explicitly specify as elligible for inlining. The **Auto-Inline** option in the IDE's **C/C++ Language** panel and the `auto_inline` pragma control this capability.

When inlining, the compiler calculates the complexity of a function by counting the number of statements, operands, and operations in a function to determine whether or not to inline an elligible function. The compiler does not inline functions that exceed a maximum complexity. The compiler uses three settings to control the extent of inlined functions:

- maximum auto-inlining complexity: the threshold for which a function may be auto-inlined
- maximum complexity: the threshold for which any elligible function may be inlined
- maximum total complexity: the threshold for all inlining in a function

The `inline_max_auto_size`, `inline_max_size`, and `inline_max_total_size` pragmas control these thresholds, respectively.

18

Inline Assembly

This chapter explains support for inline assembly language programming. Inline assembly language are assembly language instructions and directives embedded in C and C++ source code. The standalone assembler, different software component, is not a topic of this chapter. For information on the stand-alone assembler, refer to the *Assembler Guide.)*

- Inline Assembly Syntax
- Inline Assembly Directives

Inline Assembly Syntax

Syntax explanation topics are:

- Statements
- Additional Syntax Rules
- Preprocessor Features
- Local Variables and Arguments
- Returning From a Routine

Statements

All internal assembly statements must follow this syntax:

```
[LocalLabel:] (instruction | directive) [operands];
```

Other rules for statements are:

- The assembly instructions are the standard ColdFire instruction mnemonics.
- Each instruction must end with a newline character or a semicolon (`;`).
- Hexadecimal constants must be in C style: `0xABCDEF` is a valid constant, but `$ABCDEF` is not.
- Assembler directives, instructions, and registers are *not* case-sensitive. To the inline assembler, these statements are the same:

```
move.l    b, DO
MOVE.L    b, d0
```

- To specify assembly-language interpretation for a block of code in your file, use the `asm` keyword.

NOTE To make sure that the C/C++ compiler recognizes the `asm` keyword, you must clear the **ANSI Keywords Only** checkbox of the **C/C++ Language** panel.

Listing 18.1 and Listing 18.2 are valid examples of inline assembly code:

Listing 18.1 Function-Level Sample

```
long int b;
struct mystruct {
  long int a;
} ;
static asm long f(void)      // Legal asm qualifier
{
  move.l   struct(mystruct.a)(A0),D0 // Accessing a struct.
  add.l    b,D0   // Using a global variable, put return value
                  // in D0.
  rts             // Return from the function:
                  // result = mystruct.a + b
}
```

Listing 18.2 Statement-Level Sample

```
long square(short a)
{
   asm {
     move.w  a,d0    // fetch function argument ‘a’
     mulu.w  d0,d0   // multiply
     return          // return from function (result is in D0)
   }
}
```

NOTE Regardless of its settings, the compiler never optimizes assembly-language functions. However, to maintain integrity of all registers, the compiler notes which registers inline assembly uses.

Additional Syntax Rules

These rules pertain to labels, comments, structures, and global variables:

- Each label must end with a colon; labels may contain the `@` character. For example, `x1:` and `@x2:` would be valid labels, but `x3` would not — it lacks a colon.
- Comments must use C/ C++ syntax: either starting with double slash characters (`//`) or enclosed by slash and asterisk characters (`/*` ... `*/`).
- To refer to a field in a structure, use the `struct` construct:

  ```
  struct(structTypeName.fieldName) structAddress
  ```

  For example, suppose that `A0` points to structure `WindowRecord`. This instruction moves the structure's `refCon` field to `D0`:

  ```
  move.l  struct(WindowRecord.refCon) (A0), D0
  ```

- To refer to a global variable, merely use its name, as in the statement

  ```
  move.w      x,d0     // Move x into d0
  ```

Preprocessor Features

You can use all preprocessor features, such as comments and macros, in the inline assembler. But when you write a macro definition, remember to:

- End each assembly statement with a semicolon (`;`) — (the preprocessor ignores newline characters).
- Use the `%` character, instead of `#`, to denote `immediate data`, — the preprocessor uses # as a concatenate operator.

Local Variables and Arguments

Handling of local variables and arguments depends on the level of inline assembly. However, *for optimization level 1 or greater*, you can force variables to stay in a register by using the symbol `$`.

Function-Level

The function-level inline assembler lets you refer to local variables and function arguments yourself, handles such references for you.

For *your own* references, you must explicitly save and restore processor registers and local variables when entering and leaving your inline assembly function. You cannot refer to the variables by name, but you can refer to function arguments off the stack pointer. For example, this function moves its argument into `d0`:

```
asm void alpha(short n)
{
  move.w      4(sp),d0 //  n
```

```
      // . . .
    }
```

To let the *inline assembler* handle references, use the directives `fralloc` and `frfree`, according to these steps:

1. Declare your variables as you would in a normal C function.
2. Use the `fralloc` directive. It makes space on the stack for the local stack variables. Additionally, with the statement `link #x,a6`, this directive reserves registers for the local register variables.
3. In your assembly, you can refer to the local variables and variable arguments by name.
4. Finally, use the `frfree` directive to free the stack storage and restore the reserved registers. (It is somewhat easier to use a C wrapper and statement level assembly.)

Listing 18.3 is an example of using local variables and function arguments in function-level inline assembly.

Listing 18.3 Function-level Local Variables, Function Arguments

```
static asm short f(short n)
{
  register short a; // Declaring a as a register variable
  short b;          //  and b as a stack variable
  // Note that you need semicolons after these statements.
  fralloc +         // Allocate space on stack, reserve registers.
  move.w  n,a       // Using an argument and local var.
  add.w   a,a
  move.w  a,D0
  frfree            // Free space that fralloc allocated
  rts
}
```

Statement-Level

Statement-level inline assembly allows full access to local variables and function arguments without using the `fralloc` or `frfree` directives.

Listing 18.4 is an example of using local variables and function arguments in statement-level inline assembly. You may place statement-level assembly code anywhere in a C/C++ program.

Listing 18.4 Statement-Level Local Variables, Function Arguments

```
long square(short a)
{
  long result=0;
  asm {
    move.w  a,d0      // fetch function argument 'a'
    mulu.w  d0,d0     // multiply
    move.l  d0,result // store in local 'result' variable
  }
  return result;
}
```

Returning From a Routine

Every inline assembly function (not statement level) should end with a return statement. Use the `rts` statement for ordinary C functions, as Listing 18.5 shows.

Listing 18.5 Assembly Function Return

```
asm void f(void)
{   add.l     d4, d5}        // Error, no RTS statement

asm void g(void)
{   add.l     d4, d5
    rts}                     // OK
```

For statement-level returns, see “return” on page 196 and “naked” on page 195.

Inline Assembly Directives

Table 18.1 lists special assembler directives that the ColdFire inline assembler accepts. Explanations follow the table.

Table 18.1 Inline Assembly Directives

dc	ds	entry
fralloc	frfree	macine
naked	opword	return

NOTE Except for dc and ds, the inline assembly directives are available only for function/routine level.

dc

Defines blocks of constant expressions as initialized bytes, words, or longwords. (Useful for inventing new opcodes to be implemented via a loop,)

```
dc[.(b|w|l)] constexpr (,constexpr)*
```

Parameters

`b`

Byte specifier, which lets you specify any C (or Pascal) string constant.

`w`

Word specifier (the default), which lets you specify any 16-bit relative offset to a local label.

`l`

Longword specifier.

`constexpr`

Name for block of constant expressions.

Example

```
asm void alpha(void)
{
x1: dc.b  "Hello world!\n" // Creating a string
x2: dc.w  1,2,3,4          // Creating an array
x3: dc.l  3000000000       // Creating a number
}
```

ds

Defines a block of bytes, words, or longwords, initialized with null characters. Pushes labels outside the block.

```
ds[.(b|w|l)] size
```

Parameters

`b`

Byte specifier.

`w`

Word specifier (the default).

`l`

Longword specifier.

`size`

Number of bytes, words, or longwords in the block.

Example

This statement defines a block big enough for the structure `DRVRHeader`:

```
ds.b  sizeof(DRVRHeader)
```

entry

Defines an entry point into the current function. Use the `extern` qualifier to declare a global entry point and use the `static` qualifier to declare a local entry point. If you leave out the qualifier, `extern` is assumed (Listing 18.6).

```
entry [extern|static] name
```

Parameters

`extern`

Specifier for a global entry point (the default).

`static`

Specifier for a local entry point.

`name`

Name for the new entry point.

Example

Listing 18.6 defines the new local entry point `MyEntry` for function `MyFunc`.

Listing 18.6 Entry Directive Example

```
static long MyEntry(void);
static asm long MyFunc(void)
```

```
{
    move.l  a,d0
    bra.s   L1
    entry   static MyEntry
    move.l  b,d0
L1: rts
}
```

fralloc

Lets you declare local variables in an assembly function.

`fralloc [+]`

Parameter

`+`

Optional ColdFire-register control character.

Remarks

This directive makes space on the stack for your local stack variables. It also reserves registers for your local register variables (with the statement `link #`*`x`*`,a6`).

Without the + control character, this directive pushes modified registers onto the stack.

With the + control character, this directive pushes all register arguments into their ColdFire registers.

Counterpart to the `frfree` directive.

frfree

Frees the stack storage area; also restores the registers (with the statement `unlk a6`) that `fralloc` reserved.

`frfree`

machine

Specifies the CPU for which the compiler generates its inline-assembly instructions.

`machine processor`

Parameter

`processor`

`MCF547x`, `MCF5249`, `MCF5272`, `MCF5280`, `MCF5282`, `MCF5307`, `MCF5407`, `MCF5213`, or `MCF5206e`

Remarks

If you use this directive to specify a target processor, additional inline-assembler instructions become available — instructions that pertain only to that processor. For more information, see the Freescale processor user’s manual

naked

Suppresses the compiler-generated stackframe setup, cleanup, and return code.

`naked`

Remarks

Functions with this directive cannot access local variables by name. They should not contain C code that implicitly or explicitly uses local variables or memory.

Counterpart to the `return` directive.

Example

Listing 18.7 is an example use of this directive.

Listing 18.7 Naked Directive Example

```
long square(short)
{
  asm{
    naked               // no stackframe or compiler-generated rts
    move.w  4(sp),d0    // fetch function argument from stack
    mulu.w  d0,d0       // multiply
    rts                 // return from function: result in D0
  }
}
```

opword

Writes machine-instruction constants directly into the executable file, without any error checking.

`opword constant[,constant]`

Parameter

`constant`

Any appropriate machine-code value.

Example

`opword 0x7C0802A6` — which is equivalent to the instruction `mflr r0`.

return

Inserts a compiler-generated sequence of stackframe cleanup and return instructions. Counterpart to the `naked` directive.

`return instruction[, instruction]`

Parameter

`instruction`

Any appropriate C instruction.

19

ColdFire Code Generation

This chapter describes the code generation features and specifications that the CodeWarrior offers.

Code Generation Limits

Special-Edition software compiles assembly and C code, but the object code size must not exceed 128 kilobytes. Standard-Edition software compiles assembly and C code, without any size restriction. Professional-Edition software compiles assembly, C, and C++ code, without any size restriction.

Integer Representation

The ColdFire compiler lets you specify the number of bytes that the compiler allocates for an `int`. Table 19.1 shows the size and range of the integer types available for ColdFire targets.

Table 19.1 ColdFire Integer Types

Type	Option Setting	Size	Range
`bool`	n/a	8 bits	true or false

Table 19.1 ColdFire Integer Types (*continued*)

Type	Option Setting	Size	Range
`char`	**Use Unsigned Chars** is *off* in the C/C++ Language panel	8 bits	-128 to 127
	Use Unsigned Chars is *on* in the C/C++ Language panel	8 bits	0 to 255
`signed char`	n/a	8 bits	-128 to 127
`unsigned char`	n/a	8 bits	0 to 255
`short`	n/a	16 bits	-32,768 to 32,767
`unsigned short`	n/a	16 bits	0 to 65,535
`int`	**4-Byte Integers** is *off* in the ColdFire Processor panel	16 bits	-32,768 to 32,767
	4-Byte Integers is *on* in the ColdFire Processor panel	32 bits	-2,147,483,648 to 2,147,483,647
`unsigned int`	**4-Byte Integers** is *off* in the ColdFire Processor panel	16 bits	0 to 65,535
	4-Byte Integers is *on* in the ColdFire Processor panel	32 bits	0 to 4,294,967,295
`long`	n/a	32 bits	-2,147,483,648 to 2,147,483,647
`unsigned long`	n/a	32 bits	0 to 4,294,967,295
`long long`	n/a	64 bits	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
`unsigned long long`	n/a	64 bits	0 to 18,446,744,073,709,551,615

Calling Conventions

For ColdFire development, the calling conventions are:

- **Standard** — the compiler uses the default amount of memory, expanding everything to `int` size.
- **Compact** — the compiler tries to minimize memory consumption.
- **Register** — the compiler tries to use memory registers, instead of the stack.

NOTE The corresponding levels for the supported calling conventions are `standard_abi` (the default), `compact_abi`, and `register_abi`.

The compiler passes parameters on the stack in reverse order. It passes the return value in different locations, depending on the nature of the value and compiler settings:

- Integer return value: register `D0`.
- Pointer return value: register `A0`.
- Any other return value: temporary storage area. (For any non-integer, non-pointer return type, the calling routine reserves this area in its stack. The calling routine passes a pointer to this area as its last argument. The called function returns its value in this temporary storage area.)

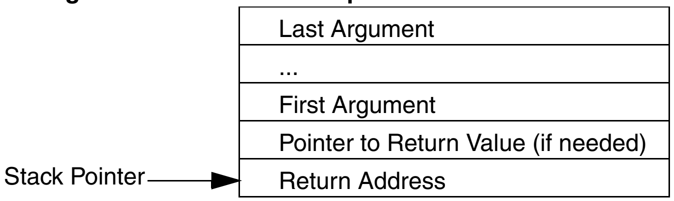
To have the compiler return pointer values in register `D0`, use the pragma `pointers_in_D0`, which the *C Compiler reference guide* explains.

To reset pointer returns, use the pragma `pointers_in_A0`.

NOTE If you use the pragma `pointers_in_A0`, be sure to use correct prototypes. Otherwise, the pragma may not perform reliably.

Figure 19.1 depicts the stack when you use the ColdFire compiler to call a C function.

Figure 19.1 Calling a C Function: Stack Depiction



Variable Allocation

For a ColdFire target, the compiler lets you declare structs and arrays to be any size, but imposes a few limits on how you allocate their space:

- Maximum bitfield size is 32 bits.
- There is no limit to local-variable space for a function. However, access is twice as fast for frames that do not exceed 32 kilobytes. To keep within this limit,
  - Dynamically allocate large variables, or
  - Declare large variables to be `static` (provided that this does not exceed the 32-kilobyte limit on global variables).
- Maximum declaration size for a global variable is 32 kilobytes, unless you use `far` data. You must do one of the following:
  - Dynamically allocate the variable.
  - Use the `far` qualifier when declaring the variable.
  - Select the **Far (32 bit)** option from the **Code** and **Data model** in the **ColdFire Processor settings** panel.

Listing 19.1 shows how to declare a large *struct* or *array*. Keep in mind that declaring large static arrays works only if the device has enough physical memory.

Listing 19.1 Declaring a large structure

```
int i[50000]; // Wrong with ColdFire compiler and the Far Data
              // option in the Processor settings panel is off
far int j[50000]; // ALWAYS OK.
int *k;
k = malloc(50000 * sizeof(int));  // ALWAYS OK.
```

Register Variables

The ColdFire back-end compiler automatically allocates local variables and parameters to registers, according to frequently of use and how many registers are available.

The ColdFire compiler can use these registers for local variables:

- `A2` through `A5` — for pointers
- `D3` through `D7` — for integers and pointers.
- `FP3` through `FP7` — for 64-bit floating-point numbers (provided that you select **Hardware** in the **Floating Point** list box of the **ColdFire Processor** panel).

If you optimize for speed, the compiler gives preference to variables in loops.

The ColdFire back-end compiler gives preference to variables declared `register`, but does not automatically assign them to registers. For example, if the compiler must choose between an inner-loop variable and a variable declared `register`, the compiler places the inner-loop variable in the register.

Position-Independent Code

If you specify position-independent code, the compiler generates code that is the same regardless of its load address. Different processes of your application can share such code.

Listing 19.2 Position Independent Code

```
int relocatableAlpha();
int (*alpha)()=relocatableAlpha;
```

Follow these steps to enable the PIC compiler and runtime support:

1. Add a `.picdynrel` section to the linker command file.
2. Enable PIC generation in the processor settings panel.
3. Customize and recompile the runtime to support your loading routine.

Cryptographic Acceleration Instructions

MCU52235 and related ColdFire-family processors have a cryptography acceleration unit (CAU). This instruction-level coprocessor speeds up software-based encryption/decryption. The CAU enhances these actions for the DES, 3DES, AES, MD5, and SHA-1 encryption algorithms.

Table 19.2 contrasts megabyte-per-second performance of regular software and the CAU for several encryption algorithms, noting the CAU improvement.

Table 19.2 CAU Performance Improvement

Algorithm	Software	CAU	Improvement
DES, 3DES	2	82	41 times
AES-128	9	99	11 times
MD5	47	118	2.5 times
SHA-1	22	55	2.5 times

To access the CAU, you use generic instructions that identify the CAU coprocessor and include appropriate CAU commands.

NOTE Syntax (prototypes) of this text is correct if the CAU is coprocessor 0. For an implementation that includes the CAU as coprocessor 1, you would have to substitute `1` for `0` in the instructions.

Table 19.3 lists the CAU instructions.

Table 19.3 ColdFire CAU Commands

This instruction...	performs this operation
`ADR`	Add to register
`ADRA`	Add register to accumulator
`AESC`	AES column operation
`AESIC`	Inverse AES column operation
`AESIR`	Inverse AES shift rows
`AESIS`	Inverse AES substitution
`AESR`	AES shift rows
`AESS`	AES substitution
`CNOP`	Coprocessor no operation
`DESK`	DES key setup
`DESR`	DES round
`HASH`	Hash function
`ILL`	Illegal command
`LDR`	Load register
`MDS`	Message digest shift
`MVAR`	Move accumulator to register
`MVRA`	Move register to accumulator
`RADR`	Reverse and add to register
`ROTL`	Rotate left

Table 19.3 ColdFire CAU Commands (*continued*)

This instruction...	performs this operation
`SHS`	Secure hash shift
`STR`	Store register
`XOR`	Exclusive or

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ColdFire Runtime Libraries

The CodeWarrior tool chain includes libraries conforming to ISO/IEC-standards for C and C++, runtime libraries, and other code. CodeWarrior tools come with prebuilt configurations of these libraries with variants for:

- integer size
- hardware floating-point operations
- different applications binary interfaces (ABIs)
- UART control
- console input/output support

This chapter explains how to use prebuilt libraries, and how to create reduced working-set libraries. This chapter consists of these sections:

- MSL for ColdFire Development
- Runtime Libraries

NOTE With respect to the Main Standard Libraries (MSL) for C and C++, this chapter is an extension of the *MSL C Reference* and the *MSL C++ Reference.* Consult those manuals for general information.

MSL for ColdFire Development

The Main Standard Library provides the libraries described in the ISO/IEC standards for C and C++. MSL also provides some extensions to the standard libraries.

- Customizing MSL Libraries
- Using MSL for ColdFire
- Serial I/O and UART Libraries
- Reduced Working Set Libraries
- Memory, Heaps, and Other Libraries

Customizing MSL Libraries

Full compliance with the ISO/IEC standards can increase code size — a problem if you must run an application in a small memory, or if you require more efficient memory usage. In such a case, you can discard library files whose functionality you do not need.

In addition to compiled binaries, the CodeWarrior development tools include source code and project files for MSL so that you can customize the libraries.

NOTE The MCF52235 and related processors have smaller memories than many other members of the ColdFire family. Accordingly, C and C++ libraries include special, small library files, appropriate for such limited-memory devices. The names of these small library files include the designation `SZ_`.

Using MSL for ColdFire

Your CodeWarrior installation includes the Main Standard Libraries (MSL), a complete C and C++ library that you can use in your embedded projects. The installation includes all the source files necessary to build MSL as well as project files for different MSL configurations.

NOTE If an MSL version already is on your computer, the CodeWarrior installer installs only the additional MSL files necessary for ColdFire projects.

The names of library files follow this pattern, which Table 20.1 explains:

```
Language IO Int_size CF FPU ABI Position Size MSL.a
```

Table 20.1 MSL Library Name Parameters

Parameter	Value	Specifies
Language	`C_`	C language
	`C++_`	C++ language
IO	`TRK_`	Console IO
Int_size	`2i_`	Code generation with 2-byte integers
	`4i_`	Code generation with 4-byte integers
*CF_*	`CF_`	Code generation for a ColdFire target processor
FPU	`FPU_`	Floating-point support

Table 20.1 MSL Library Name Parameters (*continued*)

Parameter	Value	Specifies
ABI	(nothing)	Code generation with the compact ABI
	RegABI_	Code generation with the register ABI
	StdABI_	Code generation with the standard ABI
Position	PI_	Code generation with position-independent code and data
Size	SZ_	Small libraries working set
MSL.a	MSL.a	Library name constant (do not change)

For example, the name C_4i_CF_MSL.a is the fully compliant, standard C library using 4-byte integers and the compact ABI.

Another example is C++_4i_CF_RegABI_PI_SZ_MSL.a — the reduced working-set C++ library using 4-byte integers, the register ABI, and position-independent code and data.

NOTE 1. As C++ libraries are built over C libraries, a C++ application almost always requires a C library for linking.
2. As C++ relies on low-level C functionality for IO, TRK_ is not part of any C++-library file names.

The factory configuration for all libraries uses:

- far code and data models
- no .sdata section
- no PC-relative strings
- no A6 frames (except for C++ exception handling)
- full optimization with emphasis on reducing code size

Fully compliant, non-FPU libraries use ISA_A instructions; FPU libraries use ISA_B instructions. Library code does not depend on the MAC or EMAC. The startup code (E68k_startup.c) sets the initial values of the SR, A7, and A5 registers. Otherwise, the libraries do not manipulate system registers.

The C and C++ libraries include special, small library files, appropriate for use with MCF52235 and related processors, which have smaller memories than many other members of the ColdFire family. These files, which use ISA_A instructions, include the designation SZ_ in their names.

Table 20.2 lists the MSL C libraries — which are in subdirectory `\E68K_Support\msl\MSL_C\MSL_E68k\Lib` of your CodeWarrior installation directory.

Table 20.3 lists the MSL C++ libraries — which are in subdirectory `\E68K_Support\msl\MSL_C++\MSL_E68k\Lib` of your CodeWarrior installation directory.

Table 20.4 lists MSL EC++ libraries — which are in subdirectory `\E68K_Support\msl\(MSL_EC++)\MSL_E68k\Lib` of your CodeWarrior installation directory.

Table 20.2 C Libraries

Category	Library File	Description
Fully Compliant UART IO	`C_2i_CF_MSL.a`	2-byte integers, compact ABI
	`C_2i_CF_PI_MSL.a`	2-byte integers, compact ABI, position-independent
	`C_2i_CF_RegABI_MSL.a`	2-byte integers, register ABI
	`C_2i_CF_RegABI_PI_MSL.a`	2-byte integers, register ABI, position-independent
	`C_2i_CF_StdABI_MSL.a`	2-byte integers, standard ABI
	`C_2i_CF_StdABI_PI_MSL.a`	2-byte integers, standard ABI, position-independent
	`C_4i_CF_MSL.a`	4-byte integers, compact ABI
	`C_4i_CF_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`C_4i_CF_RegABI_MSL.a`	4-byte integers, register ABI
	`C_4i_CF_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`C_4i_CF_StdABI_MSL.a`	4-byte integers, standard ABI
	`C_4i_CF_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.2 C Libraries (*continued*)

Category	Library File	Description
Fully Compliant Console IO	`C_TRK_2i_CF_MSL.a`	2-byte integers, compact ABI
	`C_TRK_2i_CF_PI_MSL.a`	2-byte integers, compact ABI, position-independent
	`C_TRK_2i_CF_RegABI_MSL.a`	2-byte integers, register ABI
	`C_TRK_2i_CF_RegABI_PI_MSL.a`	2-byte integers, register ABI, position-independent
	`C_TRK_2i_CF_StdABI_MSL.a`	2-byte integers, standard ABI
	`C_TRK_2i_CF_StdABI_PI_MSL.a`	2-byte integers, standard ABI, position-independent
	`C_TRK_4i_CF_MSL.a`	4-byte integers, compact ABI
	`C_TRK_4i_CF_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`C_TRK_4i_CF_RegABI_MSL.a`	4-byte integers, register ABI
	`C_TRK_4i_CF_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`C_TRK_4i_CF_StdABI_MSL.a`	4-byte integers, standard ABI
	`C_TRK_4i_CF_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.2 C Libraries (*continued*)

Category	Library File	Description
Small UART IO	`C_2i_CF_SZ_MSL.a`	2-byte integers, compact ABI
	`C_2i_CF_PI_SZ_MSL.a`	2-byte integers, compact ABI, position-independent
	`C_2i_CF_RegABI_SZ_MSL.a`	2-byte integers, register ABI
	`C_2i_CF_RegABI_PI_SZ_MSL.a`	2-byte integers, register ABI, position-independent
	`C_2i_CF_StdABI_SZ_MSL.a`	2-byte integers, standard ABI
	`C_2i_CF_StdABI_PI_SZ_MSL.a`	2-byte integers, standard ABI, position-independent
	`C_4i_CF_SZ_MSL.a`	4-byte integers, compact ABI
	`C_4i_CF_PI_SZ_MSL.a`	4-byte integers, compact ABI, position-independent
	`C_4i_CF_RegABI_SZ_MSL.a`	4-byte integers, register ABI
	`C_4i_CF_RegABI_PI_SZ_MSL.a`	4-byte integers, register ABI, position-independent
	`C_4i_CF_StdABI_SZ_MSL.a`	4-byte integers, standard ABI
	`C_4i_CF_StdABI_PI_SZ_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.2 C Libraries (*continued*)

Category	Library File	Description
Small Console IO	`C_TRK_2i_CF_SZ_MSL.a`	2-byte integers, compact ABI
	`C_TRK_2i_CF_PI_SZ_MSL.a`	2-byte integers, compact ABI, position-independent
	`C_TRK_2i_CF_RegABI_SZ_MSL.a`	2-byte integers, register ABI
	`C_TRK_2i_CF_RegABI_PI_SZ_MSL.a`	2-byte integers, register ABI, position-independent
	`C_TRK_2i_CF_StdABI_SZ_MSL.a`	2-byte integers, standard ABI
	`C_TRK_2i_CF_StdABI_PI_SZ_MSL.a`	2-byte integers, standard ABI, position-independent
	`C_TRK_4i_CF_SZ_MSL.a`	4-byte integers, compact ABI
	`C_TRK_4i_CF_PI_SZ_MSL.a`	4-byte integers, compact ABI, position-independent
	`C_TRK_4i_CF_RegABI_SZ_MSL.a`	4-byte integers, register ABI
	`C_TRK_4i_CF_RegABI_PI_SZ_MSL.a`	4-byte integers, register ABI, position-independent
	`C_TRK_4i_CF_StdABI_SZ_MSL.a`	4-byte integers, standard ABI
	`C_TRK_4i_CF_StdABI_PI_SZ_MSL.a`	4-byte integers, standard ABI, position-independent
HW Floating-Point UART IO	`C_4i_CF_FPU_MSL.a`	4-byte integers, compact ABI
	`C_4i_CF_FPU_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`C_4i_CF_FPU_RegABI_MSL.a`	4-byte integers, register ABI
	`C_4i_CF_FPU_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`C_4i_CF_FPU_StdABI_MSL.a`	4-byte integers, standard ABI
	`C_4i_CF_FPU_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.2 C Libraries (*continued*)

Category	Library File	Description
HW Floating-Point Console IO	`C_TRK_4i_CF_FPU_MSL.a`	4-byte integers, compact ABI
	`C_TRK_4i_CF_FPU_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`C_TRK_4i_CF_FPU_RegABI_MSL.a`	4-byte integers, register ABI
	`C_TRK_4i_CF_FPU_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`C_TRK_4i_CF_FPU_StdABI_MSL.a`	4-byte integers, standard ABI
	`C_TRK_4i_CF_FPU_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.3 C++ Libraries

Category	Library File	Description
Fully Compliant	`C++_2i_CF_MSL.a`	2-byte integers, compact ABI
	`C++_2i_CF_PI_MSL.a`	2-byte integers, compact ABI, position-independent
	`C++_2i_CF_RegABI_MSL.a`	2-byte integers, register ABI
	`C++_2i_CF_RegABI_PI_MSL.a`	2-byte integers, register ABI, position-independent
	`C++_2i_CF_StdABI_MSL.a`	2-byte integers, standard ABI
	`C++_2i_CF_StdABI_PI_MSL.a`	2-byte integers, standard ABI, position-independent
	`C++_4i_CF_MSL.a`	4-byte integers, compact ABI
	`C++_4i_CF_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`C++_4i_CF_RegABI_MSL.a`	4-byte integers, register ABI
	`C++_4i_CF_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`C++_4i_CF_StdABI_MSL.a`	4-byte integers, standard ABI
	`C++_4i_CF_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.3 C++ Libraries (*continued*)

Category	Library File	Description
Small Working Set	`C++_2i_CF_SZ_MSL.a`	2-byte integers, compact ABI
	`C++_2i_CF_PI_SZ_MSL.a`	2-byte integers, compact ABI, position-independent
	`C++_2i_CF_RegABI_SZ_MSL.a`	2-byte integers, register ABI
	`C++_2i_CF_RegABI_PI_SZ_MSL.a`	2-byte integers, register ABI, position-independent
	`C++_2i_CF_StdABI_SZ_MSL.a`	2-byte integers, standard ABI
	`C++_2i_CF_StdABI_PI_SZ_MSL.a`	2-byte integers, standard ABI, position-independent
	`C++_4i_CF_SZ_MSL.a`	4-byte integers, compact ABI
	`C++_4i_CF_PI_SZ_MSL.a`	4-byte integers, compact ABI, position-independent
	`C++_4i_CF_RegABI_SZ_MSL.a`	4-byte integers, register ABI
	`C++_4i_CF_RegABI_PI_SZ_MSL.a`	4-byte integers, register ABI, position-independent
	`C++_4i_CF_StdABI_SZ_MSL.a`	4-byte integers, standard ABI
	`C++_4i_CF_StdABI_PI_SZ_MSL.a`	4-byte integers, standard ABI, position-independent
HW Floating-Point UART IO	`C_4i_CF_FPU_MSL.a`	4-byte integers, compact ABI
	`C_4i_CF_FPU_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`C_4i_CF_FPU_RegABI_MSL.a`	4-byte integers, register ABI
	`C_4i_CF_FPU_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`C_4i_CF_FPU_StdABI_MSL.a`	4-byte integers, standard ABI
	`C_4i_CF_FPU_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.3 C++ Libraries (*continued*)

Category	Library File	Description
HW Floating-Point	`C++_4i_CF_FPU_MSL.a`	4-byte integers, compact ABI
	`C++_4i_CF_FPU_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`C++_4i_CF_FPU_RegABI_MSL.a`	4-byte integers, register ABI
	`C++_4i_CF_FPU_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`C++_4i_CF_FPU_StdABI_MSL.a`	4-byte integers, standard ABI
	`C++_4i_CF_FPU_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Table 20.4 EC++ Libraries

Category	Library File	Description
Fully Compliant	EC++_2i_CF_MSL.a	2-byte integers, compact ABI
	EC++_2i_CF_PI_MSL.a	2-byte integers, compact ABI, position-independent
	EC++_2i_CF_RegABI_MSL.a	2-byte integers, register ABI
	EC++_2i_CF_RegABI_PI_MSL.a	2-byte integers, register ABI, position-independent
	EC++_2i_CF_StdABI_MSL.a	2-byte integers, standard ABI
	EC++_2i_CF_StdABI_PI_MSL.a	2-byte integers, standard ABI, position-independent
	EC++_4i_CF_MSL.a	4-byte integers, compact ABI
	EC++_4i_CF_PI_MSL.a	4-byte integers, compact ABI, position-independent
	EC++_4i_CF_RegABI_MSL.a	4-byte integers, register ABI
	EC++_4i_CF_RegABI_PI_MSL.a	4-byte integers, register ABI, position-independent
	EC++_4i_CF_StdABI_MSL.a	4-byte integers, standard ABI
	EC++_4i_CF_StdABI_PI_MSL.a	4-byte integers, standard ABI, position-independent
Hardware floating point, UART input/ output	C_4i_CF_FPU_MSL.a	4-byte integers, compact ABI
	C_4i_CF_FPU_PI_MSL.a	4-byte integers, compact ABI, position-independent
	C_4i_CF_FPU_RegABI_MSL.a	4-byte integers, register ABI
	C_4i_CF_FPU_RegABI_PI_MSL.a	4-byte integers, register ABI, position-independent
	C_4i_CF_FPU_StdABI_MSL.a	4-byte integers, standard ABI
	C_4i_CF_FPU_StdABI_PI_MSL.a	4-byte integers, standard ABI, position-independent

Table 20.4 EC++ Libraries (*continued*)

Category	Library File	Description
Hardware floating-point	`EC++_4i_CF_FPU_MSL.a`	4-byte integers, compact ABI
	`EC++_4i_CF_FPU_PI_MSL.a`	4-byte integers, compact ABI, position-independent
	`EC++_4i_CF_FPU_RegABI_MSL.a`	4-byte integers, register ABI
	`EC++_4i_CF_FPU_RegABI_PI_MSL.a`	4-byte integers, register ABI, position-independent
	`EC++_4i_CF_FPU_StdABI_MSL.a`	4-byte integers, standard ABI
	`EC++_4i_CF_FPU_StdABI_PI_MSL.a`	4-byte integers, standard ABI, position-independent

Serial I/O and UART Libraries

The ColdFire Metrowerks Standard Libraries support console I/O through the serial port. This support includes:

- Standard C-library I/O.
- All functions that do not require disk I/O.
- Memory functions `malloc()` and `free()`.

To use C or C++ libraries for console I/O, you must include a special serial UART driver library in your project. These driver library files are in folder `E68K_Tools\MetroTRK\Transport\m68k\`.

Table 20.5 lists target boards and corresponding UART library files.

Table 20.5 Serial I/O UART Libraries

Board	Filename
CF5206e SBC	`mot_sbc_5206e_serial\Bin\UART_SBC_5206e_Aux.a`
CF5206e LITE	`mot_5206e_lite_serial\Bin\UART_5206e_lite_Aux.a`
CF5307 SBC	`mot_sbc_5307_serial\Bin\UART_SBC_5307_Aux.a`
CF5407 SBC	`mot_sbc_5407_serial\Bin\UART_SBC_5407_Aux.a`
CF5249 SBC	`mot_sbc_5249_serial\Bin\UART_SBC_5249_Aux.a`

Reduced Working Set Libraries

Before the current (6.3) software release, specialists defined a reduced-functionality set of files, to reduce library size. This idea became particularly appropriate for MCF52235 and related processors, which have smaller memories than other ColdFire-family devices. When you specify such a target processor — either by selecting it in a settings panel or using it as a `-proc` command-line option — CodeWarrior software automatically specifies this library-file working set as the default.

However, you can control this library specification at the topmost declaration level, such as the preprocessor settings panel or a prefix file. To do so, define `__CF_USE_FULL_LIBS` or `__CF_USE_SMALL_LIBS`. This specification affects available declarations, so you will see its effects at compilation time.

As the reduced working set is a proper subset of the fully compliant library, using the full working set in declarations, but specifying small library files causes:

- Link errors for completely removed functions, or
- Reduced functionality, such as `printf` inability to display floating-point values.

Using the reduced working set in declarations, but specifying fully compliant library files bloats your code.

Table 20.7 summarizes guidance for specifying libraries.

Table 20.6 Specifying Libraries

Base	Processor/Define	Library Set
Processor	MCF5213, MCF5223x, MCF5222x	Reduced working set (`SZ_` in name)
	Other ColdFire	Full compliance set (no `SZ_` in name)
Macro	`#define __CF_USE_SMALL_LIBS`	Reduced working set (`SZ_` in name)
	`#define __CF_USE_FULL_LIBS`	Full compliance set (no `SZ_` in name)

Beyond affecting code size, your library-set specification sets or clears certain configuration flags. In turn, this affects certain functionality. Table 20.7 explains these effects:

- For fully compliant libraries
- For reduced functionality libraries before the 6.3 release
- For reduced functionality libraries beginning with the 6.3 release

Table 20.7 Configuration-Flag Functionality

Flag	Full	<6.3	6.3+	Functionality
`_MSL_THREADSAFE`	off	off	off	no threads on bareboard
`_MSL_C_LOCALE_ONLY`	on	on	on	default, smallest size
`_MSL_CURATE_BUT_LARGE_ANSI_FP`	off	off	off	default
`_MSL_STRERROR_KNOWS_ERROR_NAMES`	off	off	off	default
`_MSL_ASSERT_DISPLAYS_FUNC`	off	off	off	default
`_MSL_C99`	on	on	off	C99 standard compliance
`_MSL_LONGLONG`	on	on	off	int longlong support
`_MSL_WIDE_CHAR`	on	on	off	multi-byte char support
`_MSL_FLOATING_POINT`	on	on	off	floating point operations
`_MSL_FLOATING_POINT_IO`	on	off	off	`printf` knows floating point
`_MSL_NO_WCHART_C_SUPPORT`	off	off	on	C multi-byte char support
`_MSL_NO_WCHART_CPP_SUPPORT`	off	off	on	C++ multi-byte char support
`_MSL_NO_MATH_LIB`	off	off	on	floating point operations
`_MSL_NO_CONDITION`	off	off	on	C++ threading

Memory, Heaps, and Other Libraries

The heap you create in your linker command file becomes the default heap, so it does not need initialization. Additional memory and heap points are:

- To have the system link memory-management code into your code, call `malloc()` or `new()`.
- Initialize multiple memory pools to form a large heap.
- To create each memory pool, call `init_alloc()`. (You do not need to initialize the memory pool for the default heap.)

You may be able to use another standard C library with CodeWarrior projects. You should check the `stdarg.h` file in this other standard library and in your runtime libraries. Additional points are:

- The CodeWarrior ColdFire C/C++ compiler generates correct variable-argument functions only with the header file that the MSL include.

- You may find that other implementations are also compatible.
- You may also need to modify the runtime to support a different standard C library; you must include `__va_arg.c`.
- Other C++ libraries are not compatible.

NOTE If you are working with any kind of embedded OS, you may need to customize MSL to work properly with that OS.

Runtime Libraries

Every ColdFire project must include a runtime library, which provides basic runtime support, basic initialization, system startup, and the jump to the main routine. RAM-based debug is the primary reason behind runtime-library development for ColdFire boards, so you probably must modify a library for your application.

Find your setup in Table 20.8, then include the appropriate runtime library file:

- For a C project, use the file that starts with C_.
- For a C++ project, use the file that starts with Cpp_.
- All these files are in folder `\E68K_Support\Runtime\(Sources)`.

Table 20.8 Runtime Libraries

Category	Library File	Description
C	`C_2i_CF_Runtime.a`	2-byte integers, compact ABI
	`C_2i_CF_PI_Runtime.a`	2-byte integers, compact ABI, position-independent
	`C_2i_CF_RegABI_Runtime.a`	2-byte integers, register ABI
	`C_2i_CF_RegABI_PI_Runtime.a`	2-byte integers, register ABI, position-independent
	`C_2i_CF_StdABI_Runtime.a`	2-byte integers, standard ABI
	`C_2i_CF_StdABI_PI_Runtime.a`	2-byte integers, standard ABI, position-independent
	`C_4i_CF_Runtime.a`	4-byte integers, compact ABI
	`C_4i_CF_PI_Runtime.a`	4-byte integers, compact ABI, position-independent
	`C_4i_CF_RegABI_Runtime.a`	4-byte integers, register ABI
	`C_4i_CF_RegABI_PI_Runtime.a`	4-byte integers, register ABI, position-independent
	`C_4i_CF_StdABI_Runtime.a`	4-byte integers, standard ABI
	`C_4i_CF_StdABI_PI_Runtime.a`	4-byte integers, standard ABI, position-independent

Table 20.8 Runtime Libraries (*continued*)

Category	Library File	Description
C Floating Point	`C_2i_CF_FPU_SZ_Runtime.a`	2-byte integers, compact ABI
	`C_2i_CF_FPU_PI_SZ_Runtime.a`	2-byte integers, compact ABI, position-independent
	`C_2i_CF_FPU_RegABI_SZ_Runtime.a`	2-byte integers, register ABI
	`C_2i_CF_FPU_RegABI_PI_SZ_Runtime.a`	2-byte integers, register ABI, position-independent
	`C_2i_CF_FPU_StdABI_SZ_Runtime.a`	2-byte integers, standard ABI
	`C_2i_CF_FPU_StdABI_PI_SZ_Runtime.a`	2-byte integers, standard ABI, position-independent
	`C_4i_CF_FPU_SZ_Runtime.a`	4-byte integers, compact ABI
	`C_4i_CF_FPU_PI_SZ_Runtime.a`	4-byte integers, compact ABI, position-independent
	`C_4i_CF_FPU_RegABI_SZ_Runtime.a`	4-byte integers, register ABI
	`C_4i_CF_FPU_RegABI_PI_SZ_Runtime.a`	4-byte integers, register ABI, position-independent
	`C_4i_CF_FPU_StdABI_SZ_Runtime.a`	4-byte integers, standard ABI
	`C_4i_CF_FPU_StdABI_PI_SZ_Runtime.a`	4-byte integers, standard ABI, position-independent

Table 20.8 Runtime Libraries (*continued*)

Category	Library File	Description
C++, EC++	`Cpp_2i_CF_Runtime.a`	2-byte integers, compact ABI
	`Cpp_2i_CF_PI_Runtime.a`	2-byte integers, compact ABI, position-independent
	`Cpp_2i_CF_RegABI_Runtime.a`	2-byte integers, register ABI
	`Cpp_2i_CF_RegABI_PI_Runtime.a`	2-byte integers, register ABI, position-independent
	`Cpp_2i_CF_StdABI_Runtime.a`	2-byte integers, standard ABI
	`Cpp_2i_CF_StdABI_PI_Runtime.a`	2-byte integers, standard ABI, position-independent
	`Cpp_4i_CF_Runtime.a`	4-byte integers, compact ABI
	`Cpp_4i_CF_PI_Runtime.a`	4-byte integers, compact ABI, position-independent
	`Cpp_4i_CF_RegABI_Runtime.a`	4-byte integers, register ABI
	`Cpp_4i_CF_RegABI_PI_Runtime.a`	4-byte integers, register ABI, position-independent
	`Cpp_4i_CF_StdABI_Runtime.a`	4-byte integers, standard ABI
	`Cpp_4i_CF_StdABI_PI_Runtime.a`	4-byte integers, standard ABI, position-independent

Table 20.8 Runtime Libraries (*continued*)

Category	Library File	Description
C++, EC++ Floating-Point	`Cpp_2i_CF_FPU_SZ_Runtime.a`	2-byte integers, compact ABI
	`Cpp_2i_CF_FPU_PI_SZ_Runtime.a`	2-byte integers, compact ABI, position-independent
	`Cpp_2i_CF_FPU_RegABI_SZ_Runtime.a`	2-byte integers, register ABI
	`Cpp_2i_CF_FPU_RegABI_PI_SZ_Runtime.a`	2-byte integers, register ABI, position-independent
	`Cpp_2i_CF_FPU_StdABI_SZ_Runtime.a`	2-byte integers, standard ABI
	`Cpp_2i_CF_FPU_StdABI_PI_SZ_Runtime.a`	2-byte integers, standard ABI, position-independent
	`Cpp_4i_CF_FPU_SZ_Runtime.a`	4-byte integers, compact ABI
	`Cpp_4i_CF_FPU_PI_SZ_Runtime.a`	4-byte integers, compact ABI, position-independent
	`Cpp_4i_CF_FPU_RegABI_SZ_Runtime.a`	4-byte integers, register ABI
	`Cpp_4i_CF_FPU_RegABI_PI_SZ_Runtime.a`	4-byte integers, register ABI, position-independent
	`Cpp_4i_CF_FPU_StdABI_SZ_Runtime.a`	4-byte integers, standard ABI
	`Cpp_4i_CF_FPU_StdABI_PI_SZ_Runtime.a`	4-byte integers, standard ABI, position-independent

NOTE ABI corresponds directly to the parameter-passing setting of the **ColdFire Processor Settings** panel (Standard, Compact or Register).

If your target supports floating points, you should use an FPU-enabled runtime library file.

Position-Independent Code

To use position-independent code or position-independent data in your program, you must customize the runtime library. Follow these steps:

1. Load project file `MSL_RuntimeCF.mcp`, from the folder `\E68K_Support\runtime`.
2. Modify runtime functions.
   a. Open file `E68K_startup.c`.
   b. As appropriate for your application, change or remove runtime function `__block_copy_section`. (This function relocates the PIC/PID sections in the absence of an operating system.)
   c. As appropriate for your application, change or remove runtime function `__fix_addr_references`. (This function creates the relocation tables.)
3. Change the prefix file.
   a. Open the C/C++ preference panel for your target.
   b. Make sure this panel specifies prefix file `PICPIDRuntimePrefix.h`.
4. Recompile the runtime library for your target.

Once you complete this procedure, you are ready to use the modified runtime library in your PIC/PID project. Source-file comments and runtime-library release notes may provide additional information.

Board Initialization Code

Your CodeWarrior development tools come with several basic, assembly-language hardware initialization routines, which may be useful in your programs.

You need not include this code when you are debugging, as the debugger or debug kernel already performs the same board initialization.

You should have your program do as much initialization as possible, minimizing the initializations that the configuration file performs. This facilitates the transition from RAM-based debugging to Flash/ROM.

Custom Modifications

As text above shows, specific library files support specific functionality. If target-device memory is particularly small, you may need to delete library files for functionality that your application does not use. Follow this guidance:

- **Configuration settings** — Change them in projects or makefiles. Generally, modifying flags from configuration header `ansi_prefix.CF.size.h` is sufficient to modify the working set. Sometimes, however, you also must modify header `ansi_prefix.e68k.h`.
- **Projects** — The easiest way to create a new project is starting from a copy of a full-compliance project. Turning off such flags as floating point forces you to remove some files from the project file list. But this is appropriate, as your project will not

need those files. Although changing the basic configuration can require editing all targets of all project files, usually modifying the single targets your application uses is sufficient.

- **Makefules** — Makefile targets already are set up to build any library; the `CFLAGS` macro defines the basic configuration. Target `all` does not include all targets, but a commented variation of all these targets is present in every makefile.

21

Predefined Symbols

The compiler preprocessor has prefedined macros and the compiler simulates variable definitions that describe the compile-time environment and properties of the target processor.

This chapter lists the predefined symbols that all CodeWarrior compilers make available.

__cplusplus

Preprocessor macro defined if compiling C++ source code.

Syntax

```
__cplusplus
```

Remarks

The compiler defines this macro when compiling C++ source code. This macro is undefined otherwise.

__DATE__

Preprocessor macro defined as the date of compilation.

Syntax

```
__DATE__
```

Remarks

The compiler defines this macro as a character string representation of the date of compilation. The format of this string is

"*Mmm dd yyyy*"

where *Mmm* is the a three-letter abbrevation of the month, *dd* is the day of the month, and *yyyy* is the year.

__embedded_cplusplus

Defined as 1 when compiling embedded C++ source code, undefined otherwise.

Syntax

```
__embedded_cplusplus
```

Remarks

The compiler defines this macro as 1 when the compiler's settings are configured to restrict the compiler to translate source code that conforms to the Embedded C++ proposed standard. The compiler does not define this macro otherwise.

__FILE__

Preprocessor macro of the name of the source code file being compiled.

Syntax

```
__FILE__
```

Remarks

The compiler defines this macro as a character string literal value of the name of the file being compiled, or the name specified in the last instance of a `#line` directive.

__func__

Predefined variable of the name of the function being compiled.

Prototype

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

Remarks

The compiler implicitly defines this variable at the beginning of each function if the function refers to `__func__`. The character string contained by this array, *function-name*, is the name of the function being compiled.

This implicit variable is undefined outside of a function body. This variable is also undefined when C99 (ISO/IEC 9899-1999) or GCC (GNU Compiler Collection) extension settings are off.

__FUNCTION__

Predefined variable of the name of the function being compiled.

Prototype

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

Remarks

The compiler implicitly defines this variable at the beginning of each function if the function refers to `__FUNCTION__`. The character string contained by this array, *function-name*, is the name of the function being compiled.

This implicit variable is undefined outside of a function body. This variable is also undefined when C99 (ISO/IEC 9899-1999) or GCC (GNU Compiler Collection) extension settings are off.

__ide_target()

Preprocessor operator for querying the IDE about the active build target.

Syntax

```
__ide_target("target_name")
```

`target-name`

The name of a build target in the active project in the CodeWarrior IDE.

Remarks

Expands to `1` if *target_name* is the same as the active build target in the CodeWarrior IDE's active project. Expands to `0` otherwise. The ISO standards do not specify this symbol.

__LINE__

Preprocessor macro of the number of the line of the source code file being compiled.

Syntax

```
__LINE__
```

Remarks

The compiler defines this macro as a integer value of the number of the line of the source code file that the compiler is translating. The `#line` directive also affects the value that this macro expands to.

__MWERKS__

Preprocessor macro defined as the version of the CodeWarrior compiler.

Syntax

```
__MWERKS__
```

Remarks

CodeWarrior compilers issued after 1995 define this macro with the compiler's version. For example, if the compiler version is 4.0, the value of `__MWERKS__` is `0x4000`.

This macro is defined as `1` if the compiler was issued before the CodeWarrior CW7 that was released in 1995.

The ISO standards do not specify this symbol.

__PRETTY_FUNCTION__

Predefined variable containing a character string of the "unmangled" name of the C++ function being compiled.

Syntax

Prototype

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

Remarks

The compiler implicitly defines this variable at the beginning of each function if the function refers to __PRETTY_FUNCTION__. This name, *function-name*, is the same identifer that appears in source code, not the “mangled” identifier that the compiler and linker use. The C++ compiler “mangles” a function name by appending extra characters to the function’s identifier to denote the function’s return type and the types of its parameters.

The ISO/IEC 14882-1998 C++ standard does not specify this symbol. This implicit variable is undefined outside of a function body. This symbol is only defined if the GCC extension setting is on.

__profile__

Preprocessor macro that specifies whether or not the compiler is generating object code for a profiler.

Syntax

```
__profile__
```

Remarks

Defined as 1 when generating object code that works with a profiler. Undefined otherwise. The ISO standards does not specify this symbol.

__STDC__

Defined as 1 when compiling ISO/IEC Standard C source code, undefined otherwise.

Syntax

```
__STDC__
```

Remarks

The compiler defines this macro as 1 when the compiler's settings are configured to restrict the compiler to translate source code that conforms to the ISO/IEC 9899-1990 and ISO/IEC 9899-1999 standards. The compiler does not define this macro otherwise.

__TIME__

Preprocessor macro defined as a character string representation of the time of compilation.

Syntax

```
__TIME__
```

Remarks

The compiler defines this macro as a character string representation of the time of compilation. The format of this string is

"*hh*:*mm*:*ss*"

where *hh* is a 2-digit hour of the day, *mm* is a 2-digit minute of the hour, and *ss* is a 2-digit second of the minute.

22

ColdFire Predefined Symbols

The compiler preprocessor has prefedined macros and the compiler simulates variable definitions that describe the compile-time environment and properties of the target processor.

This chapter lists the predefined symbols made available by the CodeWarrior compiler for ColdFire processors.

__BACKENDVERSION__

Preprocessor macro defined to describe the version of CodeWarrior compiler's back-end.

Syntax

```
#define __BACKENDVERSION__ version
```

Remarks

The compiler defines this macro to be a character string literal containing a numeric value.

__COLDFIRE__

Preprocessor macro defined to describe the target ColdFire processor.

Syntax

```
#define __COLDFIRE__ processor_code
```

Remarks

The compiler defines this macro to describe the ColdFire processor that the compiler is generating object code for. Table 22.1 lists the ColdFire processors that each value of *processor_code* represents.

Table 22.1 ColdFire processor models and compiler codes

When the compiler targets this ColdFire processor...	then the compiler defines `__COLDFIRE__` to this value
MCF5206E	`0x206e`
MCF5208	`0x2008`
MCF521X	`0x2013`
MCF5222X	`0x2022`
MCF5223X	`0x2023`
MCF5249	`0x2049`
MCF5270, MCF5271, MCF5274, MCF5275	`0x2008`
MCF5272	`0x2072`
MCF5280, MCF52801, MCF52802	`0x2082`
MCF5307	`0x3070`
MCF532X	`0x3020`
MCF5407	`0x4070`
MCF547X	`0x4080`
MCF548X	`0x4080`

__STDABI__

Preprocessor macro defined to describe the compiler’s parameter-passing setting.

Syntax

```
#define __STDABI__ 0 | 1
```

Remarks

The compiler defines this macro to be 1 if the compiler is set to use standard parameter-passing code generation, 0 otherwise.

__REGABI__

Preprocessor macro defined to describe the compiler's parameter-passing setting.

Syntax

```
#define __REGABI__ 0 | 1
```

Remarks

The compiler defines this macro to be 1 if the compiler is set to use register-based parameter-passing code generation, 0 otherwise.

23

Using Pragmas

The #pragma preprocessor directive specifies option settings to the compiler to control the compiler and linker's code generation.

- Checking Pragma Settings
- Saving and Restoring Pragma Settings
- Determining Which Settings Are Saved and Restored
- Illegal Pragmas

Checking Pragma Settings

The preprocessor function `__option()` returns the state of pragma settings at compile-time. The syntax is

`__option(`*`setting-name`*`)`

where *setting-name* is the name of a pragma that accepts the `on`, `off`, and `reset` arguments.

If *setting-name* is `on`, `__option(`*`setting-name`*`)` returns 1. If *setting-name* is `off`, `__option(`*`setting-name`*`)` returns 0. If *setting-name* is not the name of a pragma, `__option(`*`setting-name`*`)` returns false. If *setting-name* is the name of a pragma that does not accep the `on`, `off`, and `reset` arguments, the compiler issues a warning message.

Listing 23.1 shows an example.

Listing 23.1 Using the __option() preprocessor function

```
#if __option(ANSI_strict)
#include "portable.h" /* Use the portable declarations. */
#else
#include “custom.h” /* Use the specialized declarations. */
#endif
```

Saving and Restoring Pragma Settings

There are some occasions when you would like to apply pragma settings to a piece of source code independently from the settings in the rest of the source file. For example, a function might require unique optimization settings that should not be used in the rest of the function's source file.

Remembering which pragmas to save and restore is tedious and error-prone. Fortunately, the compiler has mechanisms that save and restore pragma setings at compile time. Pragma settings may be saved and restored at two levels:

- all pragma settings
- some individual pragma settings

Settings may be saved at one point in a compilation unit (a source code file and the files that it includes), changed, then restored later in the same compilation unit. Pragma settings cannot be saved in one source code file then restored in another unless both source code files are included in the same compilation unit.

Pragmas `push` and `pop` save and restore, respectively, most pragma settings in a compilation unit. Pragmas `push` and `pop` may be nested to unlimited depth. Listing 23.2 shows an example.

Listing 23.2 Using push and pop to save and restore pragma settings

```
/* Settings for this file. */
#pragma opt_unroll_loops on
#pragma optimize_for_size off
void fast_func_A(void)
{
/* ... */
}

/* Settings for slow_func(). */
#pragma push /* Save file settings. */
#pragma optimization_size 0
void slow_func(void)
{
/* ... */
}
#pragma pop /* Restore file settings. */

void fast_func_B(void)
{
/* ... */
}
```

Pragmas that accept the reset argument perform the same actions as pragmas push and pop, but apply to a single pragma. A pragma's on and off arguments save the pragma's current setting before changing it to the new setting. A pragma's reset argument restores the pragma's setting. The on, off, and reset arguments may be nested to an unlimited depth. Listing 23.3 shows an example.

Listing 23.3 Using the reset option to save and restore a pragma setting

```
/* Setting for this file. */
#pragma opt_unroll_loops on

void fast_func_A(void)
{
/* ... */
}

/* Setting for smallslowfunc(). */
#pragma opt_unroll_loops off
void small_func(void)
{
/* ... */
}
/* Restore previous setting. */
#pragma opt_unroll_loops reset

void fast_func_B(void)
{
/* ... */
}
```

Determining Which Settings Are Saved and Restored

Not all pragma settings are saved and restored by pragmas push and pop. Pragmas that do not change compiler settings are not affected by push and pop. For example, pragma message cannot be saved and restored.

Listing 23.4 shows an example that checks if the ANSI_strict pragma setting is saved and restored by pragmas push and pop.

Listing 23.4 Testing if pragmas push and pop save and restore a setting

```
/* Preprocess this source code. */
#pragma ANSI_strict on
```

```
#pragma push
#pragma ANSI_strict off
#pragma pop
#if __option(ANSI_strict)
#error "Saved and restored by push and pop."
#else
#error "Not affected by push and pop."
#endif
```

Illegal Pragmas

If you enable the illegal pragmas setting, the compiler issues a warning when it encounters a pragma it does not recognize. For example, the pragma statements in Listing 23.5 generate warnings with the illegal pragmas setting enabled.

Listing 23.5 Illegal Pragmas

```
#pragma silly_data off       // WARNING: silly_data is not a pragma.
#pragma ANSI_strict select  // WARNING: select is not defined
#pragma ANSI_strict on      // OK
```

Table 23.1 shows how to control the recognition of illegal pragmas..

Table 23.1 Controlling illegal pragmas

To control this option from here...	use this setting
CodeWarrior IDE	**Illegal Pragmas** in the **C/C++ Warnings** panel
source code	`#pragma warn_illpragma`
command line	`-warnings illpragmas`

Pragma Scope

The scope of a pragma setting is limited to a compilation unit (a source code file and the files that it includes).

At the beginning of compilation unit, the compiler uses its default settings. The compiler then uses the settings specified by the CodeWarrior IDE’s build target or in command-line options.

The compiler uses the setting in a pragma beginning at the pragma's location in the compilation unit. The compilers continues using this setting:

- until another instance of the same pragma appears later in the source code
- until an instance of pragma `pop` appears later in the source code
- until the compiler finishes translating the compilation unit

24

Pragmas for Standard C Conformance

ANSI_strict

Controls the use of non-standard language features.

Syntax

```
#pragma ANSI_strict on | off | reset
```

Remarks

If you enable the pragma `ANSI_strict`, the compiler generates an error message if it encounters some CodeWarrior extensions to the C language defined by the ISO/IEC 9899-1990 (“C89”) standard:

- C++-style comments
- unnamed arguments in function definitions
- non-standard keywords

This pragma corresponds to the **ANSI Strict** setting in the CodeWarrior IDE’s CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is `off`.

c99

Controls the use of a subset of ISO/IEC 9899-1999 (“C99”) language features.

Syntax

```
#pragma c99 on | off | reset
```

Remarks

If you enable this pragma, the compiler accepts many of the language features described by the ISO/IEC 9899-1999 standard:

- Trailing commas in enumerations
- GCC/C99-style compound literal values.
- Designated initializers.
- `__func__` predefined symbol
- Implicit `return 0;` in `main()`
- Non-`const` static data initializations
- Variable argument macros (`__VA_ARGS__`)
- `bool` and `_Bool` support
- `long long` support (separate switch)
- `restrict` support
- `//` comments
- `inline` support
- Digraphs
- `_Complex` and `_Imaginary` (treated as keywords but not supported)
- Empty arrays as last struct members.
- Designated initializers
- Hexadecimal floating-point constants.
- Variable length arrays are supported within local or function prototype scope (as required by the C99 standard)
- Unsuffixed decimal constant rules
- `++bool--` expressions
- `(T) (int-list)` are handled/parsed as cast-expressions and as literals
- `__STDC_HOSTED__` is `1`

This pragma corresponds to the **Enable C99 Extensions** setting in the CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is disabled.

ignore_oldstyle

Controls the recognition of function declarations that follow the syntax conventions used before ISO/IEC standard C (in other words, “K&R” style).

Syntax

```
#pragma ignore_oldstyle on | off | reset
```

Remarks

If you enable this pragma, the compiler ignores old-style function declarations and lets you prototype a function any way you want. In old-style declarations, you specify the types of arguments on separate lines instead of the function’s argument list. For example, the code in Listing 24.1 defines a prototype for a function with an old-style definition.

Listing 24.1 Mixing Old-style and Prototype Function Declarations

```
int f(char x, short y, float z);

#pragma ignore_oldstyle on

f(x, y, z)
char x;
short y;
float z;
{
  return (int)x+y+z;
}

#pragma ignore_oldstyle reset
```

This pragma does not correspond to any panel setting. By default, this setting is disabled.

only_std_keywords

Controls the use of ISO/IEC keywords.

Syntax

```
#pragma only_std_keywords on | off | reset
```

Remarks

The compiler recognizes additional reserved keywords. If you are writing source code that must follow the ISO/IEC C standards strictly, enable the pragma `only_std_keywords`.

This pragma corresponds to the **ANSI Keywords Only** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is disabled.

require_prototypes

Controls whether or not the compiler should expect function prototypes.

Syntax

```
#pragma require_prototypes on | off | reset
```

Remarks

This pragma only affects non-static functions.

If you enable this pragma, the compiler generates an error message if you use a function that does not have a preceding prototype. Use this pragma to prevent error messages caused by referring to a function before you define it. For example, without a function prototype, you might pass data of the wrong type. As a result, your code might not work as you expect even though it compiles without error.

In Listing 24.2, function `main()` calls `PrintNum()` with an integer argument even though `PrintNum()` takes an argument of type `float`.

Listing 24.2 Unnoticed Type-mismatch

```
#include <stdio.h>

void main(void)
{
  PrintNum(1);  /* PrintNum() tries to interpret the
                   integer as a float. Prints 0.000000. */
}

void PrintNum(float x)
{
    printf("%f\n", x);
}
```

When you run this program, you could get this result:

```
0.000000
```

Although the compiler does not complain about the type mismatch, the function does not give the result you intended. Since `PrintNum()` does not have a prototype, the compiler does not know to generate instructions to convert the integer to a floating-point number before calling `PrintNum()`. Consequently, the function interprets the bits it received as a floating-point number and prints nonsense.

A prototype for `PrintNum()`, as in Listing 24.3, gives the compiler sufficient information about the function to generate instructions to properly convert its argument to a floating-point number. The function prints what you expected.

Listing 24.3 Using a Prototype to Avoid Type-mismatch

```
#include <stdio.h>

void PrintNum(float x); /* Function prototype. */

void main(void)
{
    PrintNum(1);        /*  Compiler converts int to float.
}                           Prints 1.000000. */

void PrintNum(float x)
{
    printf("%f\n", x);
}
```

In other situations where automatic conversion is not possible, the compiler generates an error message if an argument does not match the data type required by a function prototype. Such a mismatched data type error is easier to locate at compile time than at runtime.

This pragma corresponds to the **Require Function Prototypes** setting in the CodeWarrior IDE's **C/C++ Language** settings panel.

25

Pragmas for C++

access_errors

Controls whether or not to change illegal access errors to warnings.

Syntax

```
#pragma access_errors on | off | reset
```

Remarks

If you enable this pragma, the compiler issues an error message instead of a warning when it detects illegal access to protected or private class members.

This pragma does not correspond to any IDE panel setting. By default, this pragma is `on`.

always_inline

Controls the use of inlined functions.

Syntax

```
#pragma always_inline on | off | reset
```

Remarks

This pragma is deprecated. We recommend that you use the `inline_depth()` pragma instead.

arg_dep_lookup

Controls C++ argument-dependent name lookup.

Syntax

```
#pragma arg_dep_lookup on | off | reset
```

Remarks

If you enable this pragma, the C++ compiler uses argument-dependent name lookup.

This pragma does not correspond to any IDE panel setting. By default, this setting is on.

ARM_conform

This pragma is no longer available. Use ARM_scoping instead.

ARM_scoping

Controls the scope of variables declared in the expression parts of if, while, do, and for statements.

Syntax

```
#pragma ARM_scoping on | off | reset
```

Remarks

If you enable this pragma, any variables you define in the conditional expression of an if, while, do, or for statement remain in scope until the end of the block that contains the statement. Otherwise, the variables only remain in scope until the end of that statement. Listing 25.1 shows an example.

This pragma corresponds to the **Legacy for-scoping** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is off.

Listing 25.1 Example of Using Variables Declared in for Statement

```
for(int i=1; i<1000; i++) { /* . . . */ }
return i;  // OK if ARM_scoping is on, error if ARM_scoping is off.
```

array_new_delete

Enables the operator `new[]` and `delete[]` in array allocation and deallocation operations, respectively.

Syntax

```
#pragma array_new_delete on | off | reset
```

Remarks

By default, this pragma is `on`.

auto_inline

Controls which functions to inline.

Syntax

```
#pragma auto_inline on | off | reset
```

Remarks

If you enable this pragma, the compiler automatically chooses functions to inline for you, in addition to functions declared with the `inline` keyword.

Note that if you enable either the **Don't Inline** setting or the `dont_inline` pragma, the compiler ignores the setting of the `auto_inline` pragma and does not inline any functions.

This pragma corresponds to the **Auto-Inline** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is disabled.

bool

Determines whether or not `bool`, `true`, and `false` are treated as keywords in C++ source code.

Syntax

```
#pragma bool on | off | reset
```

Remarks

If you enable this pragma, you can use the standard C++ `bool` type to represent `true` and `false`. Disable this pragma if `bool`, `true`, or `false` are defined in your source code.

Enabling the `bool` data type and its `true` and `false` values is not equivalent to defining them in source code with `typedef`, `enum`, or `#define`. The C++ `bool` type is a distinct type defined by the ISO/IEC 14882-1998 C++ Standard. Source code that does not treat `bool` as a distinct type might not compile properly.

This pragma corresponds to the **Enable bool Support** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this setting is `on`.

cplusplus

Controls whether or not to translate subsequent source code as C or C++ source code.

Syntax

```
#pragma cplusplus on | off | reset
```

Remarks

If you enable this pragma, the compiler translates the source code that follows as C++ code. Otherwise, the compiler uses the suffix of the filename to determine how to compile it. If a file name ends in `.c`, `.h`, or `.pch`, the compiler automatically compiles it as C code, otherwise as C++. Use this pragma only if a file contains both C and C++ code.

NOTE The CodeWarrior C/C++ compilers do not distinguish between uppercase and lowercase letters in file names and file name extensions except on UNIX-based systems.

This pragma corresponds to the **Force C++ Compilation** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is disabled.

cpp_extensions

Controls language extensions to ISO/IEC 14882-1998 C++.

Syntax

```
#pragma cpp_extensions on | off | reset
```

Remarks

If you enable this pragma, you can use the following extensions to the ISO/IEC 14882-1998 C++ standard that would otherwise be illegal:

- Anonymous `struct` & `union` objects. Listing 25.2 shows an example.

Listing 25.2 Example of Anonymous `struct` & `union` Objects

```
#pragma cpp_extensions on
void func()
{
  union {
    long  hilo;
    struct { short hi, lo; }; //  anonymous struct
  };
  hi=0x1234;
  lo=0x5678;  //  hilo==0x12345678
}
```

- Unqualified pointer to a member function. Listing 25.3 shows an example.

Listing 25.3 Example of an Unqualified Pointer to a Member Function

```
#pragma cpp_extensions on
struct RecA { void f(); }
void RecA::f()
{
  void (RecA::*ptmf1)() = &RecA::f; // ALWAYS OK

  void (RecA::*ptmf2)() = f; // OK if you enable cpp_extensions.
}
```

- Inclusion of `const` data in precompiled headers.

This pragma does not correspond to any setting in the CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is disabled.

debuginline

Controls whether the compiler emits debugging information for expanded inline function calls.

Syntax

```
#pragma debuginline on | off | reset
```

Remarks

If the compiler emits debugging information for inline function calls, then the debugger can step to the body of the inlined function. This behavior more closely resembles the debugging experience for un-inlined code.

NOTE Since the actual “call” and “return” instructions are no longer present when stepping through inline code, the debugger will immediately jump to the body of an inlined function and “return” before reaching the return statement for the function. Thus, the debugging experience of inlined functions may not be as smooth as debugging un-inlined code.

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

def_inherited

Controls the use of `inherited`.

Syntax

```
#pragma def_inherited on | off | reset
```

Remarks

The use of this pragma is deprecated. It lets you use the non-standard `inherited` symbol in C++ programming by implicitly adding

```
typedef base inherited;
```

as the first member in classes with a single base class.

NOTE The ISO/IEC 14882-1998 C++ standard does not support the `inherited` symbol. Only the CodeWarrior C++ language implements the `inherited` symbol for single inheritance.

This pragma does not correspond to any setting in the CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is `off`.

defer_codegen

Obsolete pragma. Replaced by interprocedural analysis options. See "Interprocedural Analysis" on page 167.

defer_defarg_parsing

Defers the parsing of default arguments in member functions.

Syntax

```
#pragma defer_defarg_parsing on | off
```

Remarks

To be accepted as valid, some default expressions with template arguments will require additional parenthesis. For example, Listing 25.4 results in an error message.

Listing 25.4 Deferring parsing of default arguments

```
template<typename T,typename U> struct X { T t; U u; };

struct Y {
   // The following line is not accepted, and generates
   // an error message with defer_defarg_parsing on.
   void f(X<int,int> = X<int,int>());
};
```

Listing 25.5 does not generate an error message.

Listing 25.5 Correct default argument deferral

```
template<typename T,typename U> struct X { T t; U u; };

struct Y {
   // The following line is OK if the default
   // argument is parenthesized.
   void f(X<int,int> = (X<int,int>()) );
};
```

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

direct_destruction

This pragma is obsolete. It is no longer available.

direct_to_som

This pragma is obsolete. It is no longer available.

dont_inline

Controls the generation of inline functions.

Syntax

```
#pragma dont_inline on | off | reset
```

Remarks

If you enable this pragma, the compiler does not inline any function calls, even those declared with the `inline` keyword or within a class declaration. Also, it does not automatically inline functions, regardless of the setting of the `auto_inline` pragma, described in "auto_inline" on page 251. If you disable this pragma, the compiler expands all inline function calls, within the limits you set through other inlining-related pragmas.

This pragma corresponds to the **Don't Inline** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is `off`.

ecplusplus

Controls the use of embedded C++ features.

Syntax

```
#pragma ecplusplus on | off | reset
```

Remarks

If you enable this pragma, the C++ compiler disables the non-EC++ features of ISO/IEC 14882-1998 C++ such as templates, multiple inheritance, and so on.

This pragma corresponds to the **EC++ Compatibility Mode** setting in the CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is `off`.

exceptions

Controls the availability of C++ exception handling.

Syntax

```
#pragma exceptions on | off | reset
```

Remarks

If you enable this pragma, you can use the `try` and `catch` statements in C++ to perform exception handling. If your program does not use exception handling, disable this setting to make your program smaller.

You can throw exceptions across any code compiled by the CodeWarrior C/C++ compiler with `#pragma exceptions on`.

You cannot throw exceptions across libraries compiled with `#pragma exceptions off`. If you throw an exception across such a library, the code calls `terminate()` and exits.

This pragma does not correspond to an option in any IDE settings panel. By default, this pragma is `on`.

extended_errorcheck

Controls the issuing of warning messages for possible unintended logical errors.

Syntax

```
#pragma extended_errorcheck on | off | reset
```

Remarks

If you enable this pragma, the C++ compiler generates a warning message for the possible unintended logical errors described in “extended_errorcheck” on page 283.

It also issues a warning message when it encounters a delete operator for a class or structure that has not been defined yet. Listing 25.6 shows an example.

Listing 25.6 Attempting to delete an undefined structure

```
#pragma extended_errorcheck on
struct X;
int func(X *xp)
{
     delete xp;    // Warning: deleting incomplete type X
}
```

- An empty `return` statement in a function that is not declared `void`. For example, Listing 25.7 results in a warning message.

Listing 25.7 A non-void function with an empty return statement

```
int MyInit(void)
{
  int err = GetMyResources();
  if (err != -1)
  {
    err = GetMoreResources();
  }
  return; /* WARNING: empty return statement */
}
```

Listing 25.8 shows how to prevent this warning message.

Listing 25.8 A non-void function with a proper return statement

```
int MyInit(void)
{
  int err = GetMyResources();
  if (err != -1)
  {
    err = GetMoreResources();
  }
  return err; /* OK */
}
```

This pragma corresponds to the **Extended Error Checking** setting in the CodeWarrior IDE’s **C/C++ Warnings** settings panel. By default, this setting is `off`.

inline_bottom_up

Controls the bottom-up function inlining method.

Syntax

```
#pragma inline_bottom_up on | off | reset
```

Remarks

Bottom-up function inlining tries to expand up to eight levels of inline leaf functions. The maximum size of an expanded inline function and the caller of an inline function can be controlled by the pragmas shown in Listing 25.9 and Listing 25.10.

Listing 25.9 Maximum Complexity of an Inlined Function

```
// Maximum complexity of an inlined function
#pragma inline_max_size( max )          // default max == 256
```

Listing 25.10 Maximum Complexity of a Function that Calls Inlined Functions

```
// Maximum complexity of a function that calls inlined functions
#pragma inline_max_total_size( max )    // default max == 10000
```

where *max* loosely corresponds to the number of instructions in a function.

If you enable this pragma, the compiler calculates inline depth from the last function in the call chain up to the first function that starts the call chain. The number of functions the compiler inlines from the bottom depends on the values of `inline_depth`, `inline_max_size`, and `inline_max_total_size`. This method generates faster and smaller source code for some (but not all) programs with many nested inline function calls.

If you disable this pragma, top-down inlining is selected, and the `inline_depth` setting determines the limits for top-down inlining. The `inline_max_size` and `inline_max_total_size` pragmas do not affect the compiler in top-down mode.

This pragma corresponds to the **Bottom-up** setting of the **Inline Depth** menu in the CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is disabled.

inline_bottom_up_once

Performs a single bottom-up function inlining operation.

Syntax

```
#pragma inline_bottom_up_once on | off | reset
```

Remarks

By default, this pragma is `off`.

inline_depth

Controls how many passes are used to expand inline function calls.

Syntax

```
#pragma inline_depth(n)
#pragma inline_depth(smart)
```

Parameters

`n`

Sets the number of passes used to expand inline function calls. The number *n* is an integer from `0` to `1024` or the `smart` specifier. It also represents the distance allowed in the call chain from the last function up. For example, if `d` is the total depth of a call chain, then functions below a depth of `d-n` are inlined if they do not exceed the following size settings:

```
#pragma inline_max_size(n);
#pragma inline_max_total_size(n);
```

The first pragma sets the maximum function size to be considered for inlining; the second sets the maximum size to which a function is allowed to grow after the functions it calls are inlined. Here, *n* is the number of statements, operands, and operators in the function, which turns out to be roughly twice the number of instructions generated by the function. However, this number can vary from function to function. For the `inline_max_size` pragma, the default value of *n* is 256; for the `inline_max_total_size` pragma, the default value of *n* is 10000.

`smart`

The `smart` specifier is the default mode, with four passes where the passes 2-4 are limited to small inline functions. All inlineable functions are expanded if `inline_depth` is set to 1-1024.

Remarks

The pragmas `dont_inline` and `always_inline` override this pragma. This pragma corresponds to the **Inline Depth** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is disabled.

inline_max_auto_size

Determines the maximum complexity for an auto-inlined function.

Syntax

```
#pragma inline_max_auto_size ( complex )
```

Parameters

`complex`

The `complex` value is an approximation of the number of statements in a function, the current default value is 15. Selecting a higher value will inline more functions, but can lead to excessive code bloat.

Remarks

This pragma does not correspond to any panel setting.

inline_max_size

Sets the maximum number of statements, operands, and operators used to consider the function for inlining.

Syntax

```
#pragma inline_max_size ( size )
```

Parameters

`size`

The maximum number of statements, operands, and operators in the function to consider it for inlining, up to a maximum of 256.

Remarks

This pragma does not correspond to any panel setting.

inline_max_total_size

Sets the maximum total size a function can grow to when the function it calls is inlined.

Syntax

```
#pragma inline_max_total_size ( max_size )
```

Parameters

`max_size`

The maximum number of statements, operands, and operators the inlined function calls that are also inlined, up to a maximum of 7000.

Remarks

This pragma does not correspond to any panel setting.

internal

Controls the internalization of data or functions.

Syntax

```
#pragma internal on | off | reset
#pragma internal list name1 [, name2 ]*
```

Remarks

When using the `#pragma internal on` format, all data and functions are automatically internalized.

Use the `#pragma internal list` format to tag specific data or functions for internalization. It applies to all names if it is used on an overloaded function. You cannot use this pragma for C++ member functions or static class members.

Listing 25.11 shows an example:

Listing 25.11 Example of an Internalized List

```
extern int f(), g;
#pragma internal list f,g
```

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

new_mangler

Controls the inclusion or exclusion of a template instance's function return type to the mangled name of the instance.

Syntax

```
#pragma new_mangler on | off | reset
```

Remarks

The C++ standard requires that the function return type of a template instance to be included in the mangled name, which can cause incompatibilities. Enabling this pragma within a prefix file resolves those incompatibilities.

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

no_conststringconv

Disables the deprecated implicit const string literal conversion (ISO/IEC 14882-1998 C++, §4.2).

Syntax

```
#pragma no_conststringconv on | off | reset
```

Remarks

When enabled, the compiler generates an error message when it encounters an implicit const string conversion.

Listing 25.12 Example of const string conversion

```
#pragma no_conststringconv on

char *cp = "Hello World"; /* Generates an error message. */
```

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

no_static_dtors

Controls the generation of static destructors in C++.

Syntax

`#pragma no_static_dtors on | off | reset`

Remarks

If you enable this pragma, the compiler does not generate destructor calls for static data objects. Use this pragma to generate smaller object code for C++ programs that never exit (and consequently never need to call destructors for static objects).

This pragma does not correspond to any panel setting. By default, this setting is disabled.

nosyminline

Controls whether debug information is gathered for inline/template functions.

Syntax

`#pragma nosyminline on | off | reset`

Remarks

When on, debug information is not gathered for inline/template functions.

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

old_pods

Permits non-standard handling of classes, structs, and unions containing pointer-to-pointer members

Syntax

```
#pragma old_pods on | off | reset
```

Remarks

According to the ISO/IEC 14882:2003 C++ Standard, classes/structs/unions that contain ponter-to-pointer members are now considered to be plain old data (POD) types.

This pragma can be used to get the old behavior.

old_vtable

This pragma is no longer available.

opt_classresults

Controls the omission of the copy constructor call for class return types if all return statements in a function return the same local class object.

Syntax

```
#pragma opt_classresults on | off | reset
```

Remarks

Listing 25.13 shows an example.

Listing 25.13 Example #pragma opt_classresults

```
#pragma opt_classresults on
```

```
struct X {
  X();
  X(const X&);
  // ...
};

X f() {
  X x; // Object x will be constructed in function result buffer.
  // ...
  return x; // Copy constructor is not called.
}
```

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

parse_func_templ

Controls whether or not to use the new parser supported by the CodeWarrior 2.5 C++ compiler.

Syntax

```
#pragma parse_func_templ on | off | reset
```

Remarks

If you enable this pragma, your C++ source code is compiled using the newest version of the parser, which is stricter than earlier versions.

This option actually corresponds to the **ISO C++ Template Parser** option (together with pragmas parse_func_templ and warn_no_typename). By default, this pragma is disabled.

parse_mfunc_templ

Controls whether or not to use the new parser supported by the CodeWarrior 2.5 C++ compiler for member function bodies.

Syntax

```
#pragma parse_mfunc_templ on | off | reset
```

Remarks

If you enable this pragma, member function bodies within your C++ source code is compiled using the newest version of the parser, which is stricter than earlier versions.

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

RTTI

Controls the availability of runtime type information.

Syntax

```
#pragma RTTI on | off | reset
```

Remarks

If you enable this pragma, you can use runtime type information (or RTTI) features such as `dynamic_cast` and `typeid`. The other RTTI expressions are available even if you disable the **Enable RTTI** setting. Note that `*type_info::before(const type_info&)` is not implemented.

This pragma corresponds to the **Enable RTTI** setting in the CodeWarrior IDE’s **C/C++ Language** settings panel.

suppress_init_code

Controls the suppression of static initialization object code.

Syntax

```
#pragma suppress_init_code on | off | reset
```

Remarks

If you enable this pragma, the compiler does not generate any code for static data initialization such as C++ constructors.

WARNING! Using this pragma because it can produce erratic or unpredictable behavior in your program.

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

template_depth

Controls how many nested or recursive class templates you can instantiate.

```
#pragma template_depth(n)
```

Remarks

This pragma lets you increase the number of nested or recursive class template instantiations allowed. By default, *n* equals 64; it can be set from 1 to 30000. You should always use the default value unless you receive the error message

```
template too complex or recursive
```

This pragma does not correspond to any panel setting.

thread_safe_init

Controls the addition of extra code in the binary to ensure that multiple threads cannot enter a static local initialization at the same time.

Syntax

```
#pragma thread_safe_init on | off | reset
```

Remarks

A C++ program that uses multiple threads and static local initializations introduces the possiblity of contention over which thread initializes static local variable first. When the pragma is `on`, the compiler inserts calls to mutex functions around each static local initialization to avoid this problem. The C++ runtime library provides these mutex functions.

Listing 25.14 Static local initialization example

```
int func(void) {
  // There may be synchronization problems if this function is
  // called by mutliple threads.
  static int countdown = 20;
  return countdown--;
}
```

NOTE This pragma requires runtime library functions which may not be implemented on all platforms, due to the possible need for operating system support.

Listing 25.15 shows another example.

Listing 25.15 Example thread_safe_init

```
#pragma thread_safe_init on

void thread_heavy_func()
{
  // Multiple threads can now safely call this function:
  // the static local variable will be constructed only once.
  static std::string localstring = thread_unsafe_func();
}
```

NOTE When an exception is thrown from a static local initializer, the initializer is retried by the next client that enters the scope of the local.

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

warn_hidevirtual

Controls the recognition of a non-virtual member function that hides a virtual function in a superclass.

Syntax

```
#pragma warn_hidevirtual on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message if you declare a non-virtual member function that hides a virtual function in a superclass. One function hides another if it has the same name but a different argument type. Listing 25.16 shows an example.

Listing 25.16 Hidden Virtual Functions

```
class A {
  public:
    virtual void f(int);
    virtual void g(int);
};

class B: public A {
  public:
    void f(char);         // WARNING: Hides A::f(int)
    virtual void g(int); // OK: Overrides A::g(int)
};
```

The ISO/IEC 14882-1998 C++ Standard does not require this pragma.

NOTE A warning message normally indicates that the pragma name is not recognized, but an error indicates either a syntax problem or that the pragma is not valid in the given context.

This pragma corresponds to the **Hidden Virtual Functions** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel.

warn_no_explicit_virtual

Controls the issuing of warning messages if an overriding function is not declared with a virtual keyword.

Syntax

```
#pragma warn_no_explicit_virtual on | off | reset
```

Remarks

Listing 25.17 shows an example.

Listing 25.17 Example of warn_no_explicit_virtual pragma

```
#pragma warn_no_explicit_virtual on

struct A {
  virtual void f();
};

struct B {
  void f();
  // WARNING: override B::f() is declared without virtual keyword
}
```

TIP This warning message is not required by the ISO/IEC 14882-1998 C++ standard, but can help you track down unwanted overrides.

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

warn_no_typename

Controls the issuing of warning messages for missing `typenames`.

Syntax

```
#pragma warn_no_typename on | off | reset
```

Remarks

The compiler issues a warning message if a `typenames` required by the C++ standard is missing but can still be determined by the compiler based on the context of the surrounding C++ syntax.

This pragma does not correspond to any panel setting. This pragma is enabled by the ISO/IEC 14882-1998 C++ template parser.

warn_notinlined

Controls the issuing of warning messages for functions the compiler cannot inline.

Syntax

```
#pragma warn_notinlined on | off | reset
```

Remarks

The compiler issues a warning message for non-inlined inline (i.e., on those indicated by the `inline` keyword or in line in a class declaration) function calls.

This pragma corresponds to the **Non-Inlined Functions** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is disabled.

warn_structclass

Controls the issuing of warning messages for the inconsistent use of the `class` and `struct` keywords.

Syntax

```
#pragma warn_structclass on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message if you use the `class` and `struct` keywords in the definition and declaration of the same identifier.

Listing 25.18 Inconsistent use of `class` and `struct`

```
class X;
struct X { int a; }; // WARNING
```

Use this warning when using static or dynamic libraries to link with object code produced by another C++ compiler that distinguishes between class and structure variables in its name “mangling.”

This pragma corresponds to the **Inconsistent ‘class’ / ‘struct’ Usage** setting in the CodeWarrior IDE’s **C/C++ Warnings** settings panel. By default, this pragma is disabled.

wchar_type

Controls the availability of the wchar_t data type in C++ source code.

Syntax

```
#pragma wchar_type on | off | reset
```

Remarks

If you enable this pragma, `wchar_t` is treated as a built-in type. Otherwise, the compiler does not recognize this type.

This pragma corresponds to the **Enable wchar_t Support** setting in the CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is enabled.

26

Pragmas for Language Translation

asmpoundcomment

Controls whether the “#” symbol is treated as a comment character in inline assembly.

Syntax

```
#pragma asmpoundcomment on | off | reset
```

Remarks

Some targets may have additional comment characters, and may treat these characters as comments even when

```
#pragma asmpoundcomment off
```

is used.

Using this pragma may interfere with the function-level inline assembly language.

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

asmsemicolcomment

Controls whether the “`;`” symbol is treated as a comment character in inline assembly.

Syntax

```
#pragma asmsemicolcomment on | off | reset
```

Remarks

Some targets may have additional comment characters, and may treat these characters as comments even when

```
#pragma asmsemicolcomment off
```

is used.

Using this pragma may interfere with the assembly language of a specific target.

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

const_strings

Controls the `const`-ness of character string literals.

Syntax

```
#pragma const_strings [ on | off | reset ]
```

Remarks

If you enable this pragma, the type of string literals is an array `const char[`*n*`]`, or `const wchar_t[`*n*`]` for wide strings, where *n* is the length of the string literal plus 1 for a terminating `NUL` character. Otherwise, the type `char[`*n*`]` or `wchar_t[`*n*`]` is used.

This pragma does not correspond to any setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is `on` when compiling C++ source code and `off` when compiling C source code.

dollar_identifiers

Controls use of dollar signs ($) in identifiers.

Syntax

```
#pragma dollar_identifiers on | off | reset
```

Remarks

If you enable this pragma, the compiler accepts dollar signs (`$`) in identifiers. Otherwise, the compiler issues an error if it encounters anything but underscores, alphabetic, numeric character, and universal characters (\uxxxx, \Uxxxxxxxx) in an identifier.

This pragma does not correspond to any panel setting. By default, this pragma is off.

gcc_extensions

Controls the acceptance of GNU C language extensions.

Syntax

```
#pragma gcc_extensions on | off | reset
```

Remarks

If you enable this pragma, the compiler accepts GNU C extensions in C source code. This includes the following non-ANSI C extensions:

- Initialization of automatic struct or array variables with non-const values.
- Illegal pointer conversions
- sizeof(void) == 1
- sizeof(function-type) == 1
- Limited support for GCC statements and declarations within expressions.
- Macro redefinitions without a previous #undef.
- The GCC keyword typeof
- Function pointer arithmetic supported
- void* arithmetic supported
- Void expressions in return statements of void
- __builtin_constant_p (*expr*) supported
- Forward declarations of arrays of incomplete type
- Forward declarations of empty static arrays
- Pre-C99 designated initializer syntax (deprecated)
- shortened conditional expression (*c* ?: *y*)
- long __builtin_expect (long exp, long c) now accepted

This pragma corresponds to the **Enable GCC Extensions** setting in the CodeWarrior IDE’s **C/C++ Language** settings panel. By default, this pragma is disabled.

mark

Adds an item to the **Function** pop-up menu in the IDE editor.

Syntax

`#pragma mark` *itemName*

Remarks

This pragma adds *itemName* to the source file's **Function** pop-up menu. If you open the file in the CodeWarrior Editor and select the item from the **Function** pop-up menu, the editor brings you to the pragma. Note that if the pragma is inside a function definition, the item does not appear in the **Function** pop-up menu.

If *itemName* begins with "`--`", a menu separator appears in the IDE's **Function** pop-up menu:

```
#pragma mark --
```

This pragma does not correspond to any panel setting.

mpwc_newline

Controls the use of newline character convention.

Syntax

```
#pragma mpwc_newline on | off | reset
```

Remarks

If you enable this pragma, the compiler translates `'\n'` as a Carriage Return (0x0D) and `'\r'` as a Line Feed (0x0A). Otherwise, the compiler uses the ISO standard conventions for these characters.

If you enable this pragma, use ISO standard libraries that were compiled when this pragma was enabled.

If you enable this pragma and use the standard ISO standard libraries, your program will not read and write `'\n'` and `'\r'` properly. For example, printing `'\n'` brings your program's output to the beginning of the current line instead of inserting a newline.

This pragma does not correspond to any IDE panel setting. By default, this pragma is disabled.

mpwc_relax

Controls the compatibility of the `char*` and `unsigned char*` types.

Syntax

```
#pragma mpwc_relax on | off | reset
```

Remarks

If you enable this pragma, the compiler treats `char*` and `unsigned char*` as the same type. Use this setting to compile source code written before the ISO C standards. Old source code frequently uses these types interchangeably.

This setting has no effect on C++ source code.

NOTE Turning this option on may prevent the compiler from detecting some programming errors. We recommend not turning on this option.

Listing 26.1 shows how to use this pragma to relax function pointer checking.

Listing 26.1 Relaxing function pointer checking

```
#pragma mpwc_relax on
extern void f(char *);

/* Normally an error, but allowed. */
extern void(*fp1)(void *) = &f;

/* Normally an error, but allowed. */
extern void(*fp2)(unsigned char *) = &f;
```

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

multibyteaware

Controls how the **Source encoding** option in the IDE is treated

Syntax

```
#pragma multibyteaware on | off | reset
```

Remarks

This pragma is deprecated. See `#pragma text_encoding` for more details.

This pragma does not correspond to any panel setting, but the replacement option **Source encoding** appears in the CodeWarrior IDE's **C/C++ Preprocessor** settings panel. By default, this pragma is `off`.

multibyteaware_preserve_literals

Controls the treatment of multibyte character sequences in narrow character string literals.

Syntax

```
#pragma multibyteaware_preserve_literals on | off | reset
```

Remarks

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

text_encoding

Identifies the character encoding of source files.

Syntax

```
#pragma text_encoding ( "name" | unknown | reset [, global] )
```

Parameters

`name`

The IANA or MIME encoding name or an OS-specific string that identifies the text encoding. The compiler recognizes these names and maps them to its internal decoders:

```
system US-ASCII ASCII ANSI_X3.4-1968
ANSI_X3.4-1968 ANSI_X3.4 UTF-8 UTF8 ISO-2022-JP
CSISO2022JP ISO2022JP CSSHIFTJIS SHIFT-JIS
SHIFT_JIS SJIS EUC-JP EUCJP UCS-2 UCS-2BE
UCS-2LE UCS2 UCS2BE UCS2LE UTF-16 UTF-16BE
UTF-16LE UTF16 UTF16BE UTF16LE UCS-4 UCS-4BE
```

UCS-4LE UCS4 UCS4BE UCS4LE 10646-1:1993

ISO-10646-1 ISO-10646 unicode

global

Tells the compiler that the current and all subsequent files use the same text encoding. By default, text encoding is effective only to the end of the file.

Remarks

By default, `#pragma text_encoding` is only effective through the end of file. To affect the default text encoding assumed for the current and all subsequent files, supply the "global" modifier.

This pragma corresponds to the **Source Encoding** option in the CodeWarrior IDE's **C/C++ Preprocessor** settings panel. By default, this setting is `ASCII`.

trigraphs

Controls the use trigraph sequences specified in the ISO standards.

Syntax

```
#pragma trigraphs on | off | reset
```

Remarks

If you are writing code that must strictly adhere to the ANSI standard, enable this pragma.

Table 26.1 Trigraph table

Trigraph	Character
??=	#
??/	\
??'	^
??(	[
??)	]
??!	|
??<	{

Table 26.1 Trigraph table

Trigraph	Character
??>	}
??-	~

NOTE Use of this pragma may cause a portability problem for some targets.

Be careful when initializing strings or multi-character constants that contain question marks.

Listing 26.2 Example of Pragma trigraphs

```
char c = '????'; /* ERROR: Trigraph sequence expands to '??^ */
char d = '\?\?\?\?'; /* OK */
```

This pragma corresponds to the **Expand Trigraphs** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is disabled.

unsigned_char

Controls whether or not declarations of type `char` are treated as `unsigned char`.

Syntax

`#pragma unsigned_char on | off | reset`

Remarks

If you enable this pragma, the compiler treats a `char` declaration as if it were an `unsigned char` declaration.

NOTE If you enable this pragma, your code might not be compatible with libraries that were compiled when the pragma was disabled. In particular, your code might not work with the ISO standard libraries included with CodeWarrior.

This pragma corresponds to the **Use unsigned chars** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this setting is disabled.

27

Pragmas for Diagnostic Messages

extended_errorcheck

Controls the issuing of warning messages for possible unintended logical errors.

Syntax

```
#pragma extended_errorcheck on | off | reset
```

Remarks

If you enable this pragma, the compiler generates a warning message (not an error) if it encounters some common programming errors:

- An integer or floating-point value assigned to an `enum` type. Listing 27.1 shows an example.

Listing 27.1 Assigning to an Enumerated Type

```
enum Day { Sunday, Monday, Tuesday, Wednesday,
           Thursday, Friday, Saturday } d;

d = 5; /* WARNING */
d = Monday; /* OK */
d = (Day)3; /* OK */
```

- An empty `return` statement in a function that is not declared `void`. For example, Listing 27.2 results in a warning message.

Listing 27.2 A non-void function with an empty return statement

```
int MyInit(void)
{
  int err = GetMyResources();
  if (err != -1)
  {
    err = GetMoreResources();
  }
  return; /* WARNING: empty return statement */
}
```

Listing 27.3 shows how to prevent this warning message.

Listing 27.3 A non-void function with a proper return statement

```
int MyInit(void)
{
  int err = GetMyResources();
  if (err != -1)
  {
    err = GetMoreResources();
  }
  return err; /* OK */
}
```

This pragma corresponds to the **Extended Error Checking** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this setting is `off`.

maxerrorcount

Limits the number of error messages emitted while compiling a single file.

Syntax

`#pragma maxerrorcount( `*`num`*` | off )`

Parameters

`num`

Specifies the maximum number of error messages issued per source file.

`off`

Does not limit the number of error messages issued per source file.

Remarks

The total number of error messages emitted may include one final message:

`Too many errors emitted`

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

message

Tells the compiler to issue a text message to the user.

Syntax

```
#pragma message( msg )
```

Parameter

`msg`

Actual message to issue. Does not have to be a string literal.

Remarks

In the CodeWarrior IDE, the message appears in the **Errors & Warnings** window. On the command line, the message is sent to the standard error stream.

This pragma does not correspond to any panel setting.

showmessagenumber

Controls the appearance of warning or error numbers in displayed messages.

Syntax

```
#pragma showmessagenumber on | off | reset
```

Remarks

When enabled, this pragma causes messages to appear with their numbers visible. You can then use the `warning` pragma with a warning number to suppress the appearance of specific warning messages.

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

show_error_filestack

Controls the appearance of the current `#include` file stack within error messages occurring inside deeply-included files.

Syntax

```
#pragma show_error_filestack on | off | reset
```

Remarks

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

suppress_warnings

Controls the issuing of warning messages.

Syntax

```
#pragma suppress_warnings on | off | reset
```

Remarks

If you enable this pragma, the compiler does not generate warning messages, including those that are enabled.

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

sym

Controls the generation of debugger symbol information for subsequent functions.

Syntax

```
#pragma sym on | off | reset
```

Remarks

The compiler pays attention to this pragma only if you enable the debug marker for a file in the IDE project window. If you disable this pragma, the compiler does not put debugging information into the source file debugger symbol file (SYM or DWARF) for the functions that follow.

The compiler always generates a debugger symbol file for a source file that has a debug diamond next to it in the IDE project window. This pragma changes only which functions have information in that symbol file.

This pragma does not correspond to any panel setting. By default, this pragma is enabled.

unused

Controls the suppression of warning messages for variables and parameters that are not referenced in a function.

Syntax

`#pragma unused ( `*`var_name`*` [, `*`var_name`*` ]... )`

`var_name`

The name of a variable.

Remarks

This pragma suppresses the compile time warning messages for the unused variables and parameters specified in its argument list. You can use this pragma only within a function body. The listed variables must be within the scope of the function.

In C++, you cannot use this pragma with functions defined within a class definition or with template functions.

Listing 27.4 Example of Pragma unused() in C

```
#pragma warn_unusedvar on
#pragma warn_unusedarg on

static void ff(int a)
{
  int b;
#pragma unused(a,b)
/* Compiler does not warn that a and b are unused. */

}
```

Listing 27.5 Example of Pragma unused() in C++

```
#pragma warn_unusedvar on
#pragma warn_unusedarg on

static void ff(int /* No warning */)
{
  int b;
#pragma unused(b)
/* Compiler does not warn that b is unused. */

}
```

This pragma does not correspond to any CodeWarrior IDE panel setting.

warning

Controls which warning numbers are displayed during compiling.

Syntax

```
#pragma warning on | off | reset (num [, ...])
```

This alternate syntax is allowed but ignored (message numbers do not match):

```
#pragma warning(warning_type : warning_num_list [,
    warning_type: warning_num_list, ...])
```

Parameters

num

The number of the warning message to show or suppress.

warning_type

Specifies one of the following settings:

- default
- disable
- enable

warning_num_list

The *warning_num_list* is a list of warning numbers separated by spaces.

Remarks

Use the pragma showmessagenumber to display warning messages with their warning numbers.

The CodeWarrior compiler allows, but ignores, the alternative syntax for compatibility with Microsoft® compilers.

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

warning_errors

Controls whether or not warnings are treated as errors.

Syntax

```
#pragma warning_errors on | off | reset
```

Remarks

If you enable this pragma, the compiler treats all warning messages as though they were errors and does not translate your file until you resolve them.

This pragma corresponds to the **Treat All Warnings as Errors** setting in the CodeWarrior IDE's **C/C++ Warnings** panel.

warn_any_ptr_int_conv

Controls if the compiler generates a warning message when an integral type is explicitly converted to a pointer type or vice versa.

Syntax

```
#pragma warn_any_ptr_int_conv on | off | reset
```

Remarks

This pragma is useful to identify potential 64-bit pointer portability issues. An example is shown in.

Listing 27.6 Example of warn_any_ptr_int_conv

```
#pragma warn_ptr_int_conv on
```

```
short i, *ip

void func() {
   i = (short)ip;
   /* WARNING: short type is not large enough to hold pointer. */
}

#pragma warn_any_ptr_int_conv on

void bar() {
   i  = (int)ip; /* WARNING: pointer to integral conversion. */
   ip = (short *)i; /* WARNING: integral to pointer conversion. */
}
```

Remarks

This pragma corresponds to the **Pointer/Integral Conversions** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is `off`.

warn_emptydecl

Controls the recognition of declarations without variables.

Syntax

```
#pragma warn_emptydecl on | off | reset
```

Remarks

If you enable this pragma, the compiler displays a warning message when it encounters a declaration with no variables.

Listing 27.7 Examples of empty declarations in C and C++

```
#pragma warn_emptydecl on
int ; /* WARNING: empty variable declaration. */
int i; /* OK */

long j;; /* WARNING */
long j; /* OK */
```

Listing 27.8 Example of empty declaration in C++

```
#pragma warn_emptydecl on
extern "C" {
}; /* WARNING */
```

This pragma corresponds to the **Empty Declarations** setting in the CodeWarrior IDE's **C/C++ Warnings** panel. By default, this pragma is disabled.

warn_extracomma

Controls the recognition of superfluous commas in enumerations.

Syntax

```
#pragma warn_extracomma on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message when it encounters a trailing comma in enumerations. For example, Listing 27.9 is acceptable source code but generates a warning message when you enable this setting.

Listing 27.9 Warning about extra commas

```
#pragma warn_extracomma on
enum { mouse, cat, dog, };
/* WARNING: compiler expects an identifier after final comma. */
```

The compiler ignores terminating commas in enumerations when compiling source code that conforms to the ISO/IEC 9899-1999 ("C99") standard.

This pragma corresponds to the **Extra Commas** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is disabled.

warn_filenamecaps

Controls the recognition of conflicts involving case-sensitive filenames within user includes.

Syntax

```
#pragma warn_filenamecaps on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message when an `#include` directive capitalizes a filename within a user include differently from the way the filename appears on a disk. It also detects use of “8.3” DOS filenames in Windows when a long filename is available. Use this pragma to avoid porting problems to operating systems with case-sensitive file names.

By default, this pragma only checks the spelling of user includes such as the following:

```
#include "file"
```

For more information on checking system includes, see `warn_filenamecaps_system`.

This pragma corresponds to the **Include File Capitalization** setting in the CodeWarrior IDE’s **C/C++ Warnings** settings panel. By default, this pragma is `off`.

warn_filenamecaps_system

Controls the recognition of conflicts involving case-sensitive filenames within system includes.

Syntax

```
#pragma warn_filenamecaps_system on | off | reset
```

Remarks

If you enable this pragma along with `warn_filenamecaps`, the compiler issues a warning message when an `#include` directive capitalizes a filename within a system include differently from the way the filename appears on a disk. It also detects use of “8.3” DOS filenames in Windows when a long filename is available. This pragma helps avoid porting problems to operating systems with case-sensitive file names.

To check the spelling of system includes such as the following:

```
#include <file>
```

Use this pragma along with the warn_filenamecaps pragma.

This pragma corresponds to the **Check System Includes** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is off.

NOTE Some SDKs (Software Developer Kits) use "colorful" capitalization, so this pragma may issue a lot of unwanted messages.

warn_hiddenlocals

Controls the recognition of a local variable that hides another local variable.

Syntax

```
#pragma warn_hiddenlocals on | off | reset
```

Remarks

When on, the compiler issues a warning message when it encounters a local variable that hides another local variable. An example appears in Listing 27.10.

Listing 27.10 Example of hidden local variables warning

```
#pragma warn_hiddenlocals on

void func(int a)
{
    {
        int a; /* WARNING: this 'a' obscures argument 'a'.
    }
}
```

This pragma does not correspond to any CodeWarrior IDE panel setting. By default, this setting is off.

warn_illpragma

Controls the recognition of illegal pragma directives.

Syntax

```
#pragma warn_illpragma on | off | reset
```

Remarks

If you enable this pragma, the compiler displays a warning message when it encounters a pragma it does not recognize.

This pragma corresponds to the **Illegal Pragmas** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this setting is `off`.

warn_illtokenpasting

Controls whether or not to issue a warning message for improper preprocessor token pasting.

Syntax

```
#pragma warn_illtokenpasting on | off | reset
```

Remarks

An example of this is shown below:

```
#define PTR(x)  x##* / PTR(y)
```

Token pasting is used to create a single token. In this example, `y` and `x` cannot be combined. Often the warning message indicates the macros uses "`##`" unnecessarily.

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

warn_illunionmembers

Controls whether or not to issue a warning message when illegal union members are made, such as unions with reference or non-trivial class members.

Syntax

```
#pragma warn_illunionmembers on | off | reset
```

Remarks

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

warn_impl_f2i_conv

Controls the issuing of warning messages for implicit `float`-to-`int` conversions.

Syntax

```
#pragma warn_impl_f2i_conv on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message for implicitly converting floating-point values to integral values. Listing 27.11 provides an example.

Listing 27.11 Example of Implicit `float`-to-`int` Conversion

```
#pragma warn_impl_f2i_conv on

float f;
signed int si;

int main()
{
    f  = si; /* WARNING */

#pragma warn_impl_f2i_conv off
    si = f; /* OK */
}
```

This pragma corresponds to the **Float to Integer** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is `on`.

warn_impl_i2f_conv

Controls the issuing of warning messages for implicit `int`-to-`float` conversions.

Syntax

```
#pragma warn_impl_i2f_conv on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message for implicitly converting integral values to floating-point values. Listing 27.12 shows an example.

Listing 27.12 Example of implicit `int`-to-`float` conversion

```
#pragma warn_impl_i2f_conv on

float f;
signed int si;

int main()
{
    si = f; /* WARNING */

#pragma warn_impl_i2f_conv off
    f  = si; /* OK */

}
```

This pragma corresponds to the **Integer to Float** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is `off`.

warn_impl_s2u_conv

Controls the issuing of warning messages for implicit conversions between the `signed int` and `unsigned int` data types.

Syntax

`#pragma warn_impl_s2u_conv on | off | reset`

Remarks

If you enable this pragma, the compiler issues a warning message for implicitly converting either from `signed int` to `unsigned int` or vice versa. Listing 27.13 provides an example.

Listing 27.13 Example of implicit conversions between `signed int` and `unsigned int`

```
#pragma warn_impl_s2u_conv on

signed int si;
```

```
unsigned int ui;

int main()
{
    ui = si; /* WARNING */
    si = ui; /* WARNING */

#pragma warn_impl_s2u_conv off
    ui = si; /* OK */
    si = ui; /* OK */
}
```

This pragma corresponds to the **Signed / Unsigned** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is enabled.

warn_implicitconv

Controls the issuing of warning messages for all implicit arithmetic conversions.

Syntax

```
#pragma warn_implicitconv on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message for all implicit arithmetic conversions when the destination type might not represent the source value. Listing 27.14 provides an example.

Listing 27.14 Example of Implicit Conversion

```
#pragma warn_implicitconv on

float f;
signed int si;
unsigned int ui;

int main()
{
    f  = si; /* WARNING */
    si = f; /* WARNING */
    ui = si; /* WARNING */
    si = ui; /* WARNING */
}
```

NOTE This option “opens the gate” for the checking of implicit conversions. The sub-pragmas `warn_impl_f2i_conv`, `warn_impl_i2f_conv`, and `warn_impl_s2u_conv` control the classes of conversions checked.

This pragma corresponds to the **Implicit Arithmetic Conversions** setting in the CodeWarrior IDE’s **C/C++ Warnings** settings panel. By default, this pragma is `off`.

warn_largeargs

Controls the issuing of warning messages for passing non-”int” numeric values to unprototyped functions.

Syntax

```
#pragma warn_largeargs on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message if you attempt to pass a non-integer numeric value, such as a `float` or `long long`, to an unprototyped function when the `require_prototypes` pragma is disabled.

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

warn_missingreturn

Issues a warning message when a function that returns a value is missing a `return` statement.

Syntax

```
#pragma warn_missingreturn on | off | reset
```

Remarks

An example is shown in Listing 27.15.

Listing 27.15 Example of warn_missingreturn pragma

```
#pragma warn_missingreturn on
```

```
int func()
{
  /* WARNING: no return statement. */
}
```

This pragma corresponds to the **Missing 'return' Statements** option in the CodeWarrior IDE's **C/C++ Warnings** settings panel.

warn_no_side_effect

Controls the issuing of warning messages for redundant statements.

Syntax

`#pragma warn_no_side_effect on | off | reset`

Remarks

If you enable this pragma, the compiler issues a warning message when it encounters a statement that produces no side effect. To suppress this warning message, cast the statement with `(void)`. Listing 27.16 provides an example.

Listing 27.16 Example of Pragma warn_no_side_effect

```
#pragma warn_no_side_effect on
void func(int a,int b)
{
   a+b; /* WARNING: expression has no side effect */
   (void)(a+b); /* OK: void cast suppresses warning. */
}
```

This pragma corresponds to the **Expression Has No Side Effect** panel setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is `off`.

warn_padding

Controls the issuing of warning messages for data structure padding.

Syntax

`#pragma warn_padding on | off | reset`

Remarks

If you enable this pragma, the compiler warns about any bytes that were implicitly added after an ANSI C `struct` member to improve memory alignment. Refer to the appropriate *Targeting* manual for more information on how the compiler pads data structures for a particular processor or operating system.

This pragma corresponds to the **Pad Bytes Added** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this setting is `off`.

warn_pch_portability

Controls whether or not to issue a warning message when `#pragma once on` is used in a precompiled header.

Syntax

```
#pragma warn_pch_portability on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message when you use `#pragma once on` in a precompiled header. This helps you avoid situations in which transferring a precompiled header from machine to machine causes the precompiled header to produce different results. For more information, see pragma `once`.

This pragma does not correspond to any panel setting. By default, this setting is `off`.

warn_possunwant

Controls the recognition of possible unintentional logical errors.

Syntax

```
#pragma warn_possunwant on | off | reset
```

Remarks

If you enable this pragma, the compiler checks for common, unintended logical errors:

- An assignment in either a logical expression or the conditional portion of an `if`, `while`, or `for` expression. This warning message is useful if you use = when you mean to use ==. Listing 27.17 shows an example.

Listing 27.17 Confusing = and == in Comparisons

```
if (a=b) f(); /* WARNING: a=b is an assignment. */

if ((a=b)!=0) f(); /* OK: (a=b)!=0 is a comparison. */

if (a==b) f(); /* OK: (a==b) is a comparison. */
```

- An equal comparison in a statement that contains a single expression. This check is useful if you use == when you meant to use =. Listing 27.18 shows an example.

Listing 27.18 Confusing = and == Operators in Assignments

```
a == 0;         // WARNING: This is a comparison.
a = 0;          // OK: This is an assignment, no warning
```

- A semicolon (`;`) directly after a `while`, `if`, or `for` statement.

  For example, Listing 27.19 generates a warning message.

Listing 27.19 Empty statement

```
i = sockcount();
while (--i);  /* WARNING: empty loop. */
    matchsock(i);
```

If you intended to create an infinite loop, put white space or a comment between the `while` statement and the semicolon. The statements in Listing 27.20 suppress the above error or warning messages.

Listing 27.20 Intentional empty statements

```
while (i++) ; /* OK: White space separation. */
while (i++) /* OK: Comment separation */ ;
```

This pragma corresponds to the **Possible Errors** setting in the CodeWarrior IDE’s **C/C++ Warnings** settings panel. By default, this pragma is `off`.

warn_ptr_int_conv

Controls the recognition the conversion of pointer values to incorrectly-sized integral values.

Syntax

```
#pragma warn_ptr_int_conv on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message if an expression attempts to convert a pointer value to an integral type that is not large enough to hold the pointer value.

Listing 27.21 Example for #pragma warn_ptr_int_conv

```
#pragma warn_ptr_int_conv on

char *my_ptr;
char too_small = (char)my_ptr;  /* WARNING: char is too small. */
```

See also “warn_any_ptr_int_conv” on page 289.

This pragma corresponds to the **Pointer / Integral Conversions** setting in the CodeWarrior IDE’s **C/C++ Warnings** settings panel. By default, this pragma is off.

warn_resultnotused

Controls the issuing of warning messages when function results are ignored.

Syntax

```
#pragma warn_resultnotused on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message when it encounters a statement that calls a function without using its result. To prevent this, cast the statement with `(void)`. Listing 27.22 provides an example.

Listing 27.22 Example of Function Calls with Unused Results

```
#pragma warn_resultnotused on

extern int bar();
void func()
{
   bar(); /* WARNING: result of function call is not used. */
   void(bar()); /* OK: void cast suppresses warning. */
}
```

This pragma does not correspond to any panel setting. By default, this pragma is off.

warn_undefmacro

Controls the detection of undefined macros in `#if` and `#elif` directives.

Syntax

```
#pragma warn_undefmacro on | off | reset
```

Remarks

Listing 27.23 provides an example.

Listing 27.23 Example of Undefined Macro

```
#if BADMACRO == 4 /* WARNING: undefined macro. */
```

Use this pragma to detect the use of undefined macros (especially expressions) where the default value 0 is used. To suppress this warning message, check if defined first.

NOTE A warning message is only issued when a macro is evaluated. A short-circuited "`&&`" or "`||`" test or unevaluated "`? :`" will not produce a warning message.

This pragma corresponds to the **Undefined Macro in #if** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is `off`.

warn_uninitializedvar

Controls the compiler to perform some dataflow analysis and emits warning messages whenever local variables are initialized before being used.

Syntax

```
#pragma warn_uninitializedvar on | off | reset
```

Remarks

This pragma has no corresponding setting in the CodeWarrior IDE. By default, this pragma is `on`.

warn_unusedarg

Controls the recognition of unreferenced arguments.

Syntax

```
#pragma warn_unusedarg on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message when it encounters an argument you declare but do not use.

This check helps you find arguments that you either misspelled or did not use in your program. Listing 27.24 shows an example.

Listing 27.24 Warning about unused function arguments

```
void func(int temp, int error);
{
  error = do_something(); /* WARNING: temp is unused. */
}
```

To prevent this warning, you can declare an argument in a few ways:

- Use the pragma `unused`, as in Listing 27.25.

Listing 27.25 Using pragma unused() to prevent unused argument messages

```
void func(int temp, int error)
{
  #pragma unused (temp)
  /* Compiler does not warn that temp is not used. */

  error=do_something();
}
```

- Do not give the unused argument a name. Listing 27.26 shows an example.

  The compiler allows this feature in C++ source code. To allow this feature in C source code, disable ANSI strict checking.

Listing 27.26 Unused, Unnamed Arguments

```
void func(int /* temp */, int error)
{
  /* Compiler does not warn that "temp" is not used. */

  error=do_something();
}
```

This pragma corresponds to the **Unused Arguments** setting in the **C/C++ Warnings Panel**. By default, this pragma is `off`.

warn_unusedvar

Controls the recognition of unreferenced variables.

Syntax

```
#pragma warn_unusedvar on | off | reset
```

Remarks

If you enable this pragma, the compiler issues a warning message when it encounters a variable you declare but do not use.

This check helps you find variables that you either misspelled or did not use in your program. Listing 27.27 shows an example.

Listing 27.27 Unused Local Variables Example

```
int error;
void func(void)
{
  int temp, errer; /* NOTE: errer is misspelled. */
  error = do_something(); /* WARNING: temp and errer are unused. */
}
```

If you want to use this warning but need to declare a variable that you do not use, include the pragma `unused`, as in Listing 27.28.

Listing 27.28 Suppressing Unused Variable Warnings

```
void func(void)
{
  int i, temp, error;

  #pragma unused (i, temp) /* Do not warn that i and temp */
  error = do_something();     /* are not used */
}
```

This pragma corresponds to the **Unused Variables** setting in the CodeWarrior IDE's **C/C++ Warnings** settings panel. By default, this pragma is off.

28

Pragmas for Preprocessing and Precompilation

check_header_flags

Controls whether or not to ensure that a precompiled header's data matches a project's target settings.

Syntax

```
#pragma check_header_flags on | off | reset
```

Remarks

This pragma affects precompiled headers only.

If you enable this pragma, the compiler verifies that the precompiled header's preferences for `double` size, `int` size, and floating point math correspond to the build target's settings. If they do not match, the compiler generates an error message.

If your precompiled header file depends on these settings, enable this pragma. Otherwise, disable it.

This pragma does not correspond to any CodeWarrior IDE panel setting. By default, this pragma is `off`.

faster_pch_gen

Controls the performance of precompiled header generation.

Syntax

```
#pragma faster_pch_gen on | off | reset
```

Remarks

If you enable this pragma, generating a precompiled header can be much faster, depending on the header structure. However, the precompiled file can also be slightly larger.

This pragma does not correspond to any panel setting. By default, this setting is `off`.

flat_include

Controls whether or not to ignore relative path names in `#include` directives.

Syntax

```
#pragma flat_include on | off | reset
```

Remarks

For example, when `on`, the compiler converts this directive

```
#include <sys/stat.h>
```

to

```
#include <stat.h>
```

Use this pragma when porting source code from a different operating system, or when a CodeWarrior IDE project's access paths cannot reach a given file.

By default, this pragma is `off`.

fullpath_file

Controls if `__FILE__` macro expands to a full path or the base file name.

Syntax

```
#pragma fullpath_file on | off | reset
```

Remarks

When this pragma `on`, the `__FILE__` macro returns a full path to the file being compiled, otherwise it returns the base file name.

fullpath_prepdump

Shows the full path of included files in preprocessor output.

Syntax

```
#pragma fullpath_prepdump on | off | reset
```

Remarks

If you enable this pragma, the compiler shows the full paths of files specified by the `#include` directive as comments in the preprocessor output. Otherwise, only the file name portion of the path appears.

This pragma corresponds to the **Show full paths** option in the CodeWarrior IDE’s **C/C++ Preprocessor** settings panel. By default, this pragma is `off`.

keepcomments

Controls whether comments are emitted in the preprocessor output.

Syntax

```
#pragma keepcomments on | off | reset
```

Remarks

This pragma corresponds to the **Keep comments** option in the CodeWarrior IDE’s **C/C++ Preprocessor** settings panel. By default, this pragma is `off`.

line_prepdump

Shows `#line` directives in preprocessor output.

Syntax

```
#pragma line_prepdump on | off | reset
```

Remarks

If you enable this pragma, `#line` directives appear in preprocessing output. The compiler also adjusts line spacing by inserting empty lines.

Use this pragma with the command-line compiler's `-E` option to make sure that `#line` directives are inserted in the preprocessor output.

This pragma corresponds to the **Use #line** option in the CodeWarrior IDE's **C/C++ Preprocessor** settings panel. By default, this pragma is `off`.

macro_prepdump

Controls whether the compiler emits `#define` and `#undef` directives in preprocessing output.

Syntax

```
#pragma macro_prepdump on | off | reset
```

Remarks

Use this pragma to help unravel confusing problems like macros that are aliasing identifiers or where headers are redefining macros unexpectedly.

msg_show_lineref

Controls diagnostic output involving `#line` directives to show line numbers specified by the `#line` directives in error and warning messages.

Syntax

```
#pragma msg_show_lineref on | off | reset
```

Remarks

This pragma does not correspond to any CodeWarrior IDE panel setting. By default, this pragma is `on`.

msg_show_realref

Controls diagnostic output involving `#line` directives to show actual line numbers in error and warning messages.

Syntax

```
#pragma msg_show_realref on | off | reset
```

Remarks

This pragma does not correspond to any CodeWarrior IDE panel setting. By default, this pragma is `on`.

notonce

Controls whether or not the compiler lets included files be repeatedly included, even with `#pragma once on`.

Syntax

```
#pragma notonce
```

Remarks

If you enable this pragma, files can be repeatedly `#included`, even if you have enabled `#pragma once on`. For more information, see “once” on page 311.

This pragma does not correspond to any CodeWarrior IDE panel setting.

old_pragma_once

This pragma is no longer available.

once

Controls whether or not a header file can be included more than once in the same compilation unit.

Syntax

```
#pragma once [ on ]
```

Remarks

Use this pragma to ensure that the compiler includes header files only once in a source file. This pragma is especially useful in precompiled header files.

There are two versions of this pragma:

```
#pragma once
```

and

`#pragma once on`

Use `#pragma once` in a header file to ensure that the header file is included only once in a source file. Use `#pragma once on` in a header file or source file to insure that *any* file is included only once in a source file.

Beware that when using `#pragma once on`, precompiled headers transferred from one host machine to another might not give the same results during compilation. This inconsistency is because the compiler stores the full paths of included files to distinguish between two distinct files that have identical file names but different paths. Use the `warn_pch_portability` pragma to issue a warning message when you use `#pragma once on` in a precompiled header.

Also, if you enable the `old_pragma_once on` pragma, the `once` pragma completely ignores path names.

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

pop, push

Saves and restores pragma settings.

Syntax

`#pragma push`

`#pragma pop`

Remarks

The pragma `push` saves all the current pragma settings. The pragma `pop` restores all the pragma settings that resulted from the last `push` pragma. For example, see Listing 28.1.

Listing 28.1 push and pop example

```
#pragma ANSI_strict on
#pragma push /* Saves all compiler settings. */
#pragma ANSI_strict off
#pragma pop /* Restores ANSI_strict to on. */
```

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

TIP Pragmas directives that accept `on | off | reset` already form a stack of previous option values. It is not necessary to use `#pragma pop` or `#pragma push` with such pragmas.

pragma_prepdump

Controls whether pragma directives in the source text appear in the preprocessing output.

Syntax

```
#pragma pragma_prepdump on | off | reset
```

Remarks

This pragma corresponds to the **Emit #pragmas** option in the CodeWarrior IDE's **C/C++ Preprocessor** settings panel. By default, this pragma is `off`.

TIP When submitting bug reports with a preprocessor dump, be sure this option is enabled.

precompile_target

Specifies the file name for a precompiled header file.

Syntax

```
#pragma precompile_target filename
```

Parameters

`filename`

A simple file name or an absolute path name. If *filename* is a simple file name, the compiler saves the file in the same folder as the source file. If *filename* is a path name, the compiler saves the file in the specified folder.

Remarks

If you do not specify the file name, the compiler gives the precompiled header file the same name as its source file.

Listing 28.2 shows sample source code from a precompiled header source file. By using the predefined symbols __cplusplus and the pragma precompile_target, the compiler can use the same source code to create different precompiled header files for C and C++.

Listing 28.2 Using #pragma precompile_target

```
#ifdef __cplusplus
  #pragma precompile_target "MyCPPHeaders"
#else
  #pragma precompile_target "MyCHeaders"
#endif
```

This pragma does not correspond to any panel setting.

simple_prepdump

Controls the suppression of comments in preprocessing output.

Syntax

```
#pragma simple_prepdump on | off | reset
```

Remarks

By default, the compiler adds comments about the current include file being in preprocessing output. Enabling this pragma disables these comments.

This pragma corresponds to the **Emit file changes** option in the CodeWarrior IDE’s **C/C++ Preprocessor** settings panel. By default, this pragma is off.

space_prepdump

Controls whether or not the compiler removes or preserves whitespace in the preprocessor’s output.

Syntax

```
#pragma space_prepdump on | off | reset
```

Remarks

This pragma is useful for keeping the starting column aligned with the original source code, though the compiler attempts to preserve space within the line. This pragma does not apply to expanded macros.

This pragma corresponds to the **Keep whitespace** option in the CodeWarrior IDE's **C/C++ Preprocessor** settings panel. By default, this pragma is `off`.

srcrelincludes

Controls the lookup of `#include` files.

Syntax

```
#pragma srcrelincludes on | off | reset
```

Remarks

When `on`, the compiler looks for `#include` files relative to the previously included file (not just the source file). When `off`, the compiler uses the CodeWarrior IDE's access paths or the access paths specified with the `-ir` option.

Use this pragma when multiple files use the same file name and are intended to be included by another header file in that directory. This is a common practice in UNIX programming.

This pragma corresponds to the **Source-relative includes** option in the **Access Paths** panel. By default, this pragma is `off`.

syspath_once

Controls how included files are treated when `#pragma once` is enabled.

Syntax

```
#pragma syspath_once on | off | reset
```

Remarks

When this pragma and pragma `once` are set to `on`, the compiler distinguishes between identically-named header files referred to in

`#include <`*`file-name`*`>`

and

`#include "`*`file-name`*`".`

When this pragma is `off` and pragma once is `on`, the compiler will ignore a file that uses a

`#include <file-name>`

directive if it has previously encountered another directive of the form

`#include "file-name"`

for an identically-named header file.

shows an example.

This pragma does not correspond to any panel setting. By default, this setting is `on`.

Listing 28.3 Pragma syspath_once example

```
#pragma syspath_once off
#pragma once on /* Include all subsequent files only once. */
#include "sock.h"
#include <sock.h> /* Skipped because syspath_once is off. */
```

29

Pragmas for Library and Linking

always_import

Controls whether or not #include directives are treated as #pragma import directives.

Syntax

```
#pragma always_import on | off | reset
```

Remarks

If you enable this pragma, the compiler treats all #include statements as #pragma import statements.

This pragma does not correspond to any CodeWarrior IDE panel setting. By default, this pragma is off.

export

Controls the exporting of data and functions to be accessible from outside a program or library.

Syntax

```
#pragma export on | off | reset
#pragma export list name1 [, name2, ...]
```

name1, name2

Names of functions or global variables to export.

Remarks

When using the `#pragma export on` format, all functions in the source file being compiled will be accessible from outside the program or library that the compiler and linker are building.

Use the `#pragma export list` format to specify global variables and functions for exporting. In C++, this form of the pragma applies to all variants of an overloaded function. You cannot use this pragma for C++ member functions or static class members. Listing 29.1 shows an example:

Listing 29.1 Example of an Exported List

```
extern int f(),g;
#pragma export list f,g
```

force_active

Controls how "dead" functions and global variables are linked.

Syntax

`#pragma force_active on | off | reset`

Remarks

If you enable this pragma, the linker leaves functions and global in the finished application, even if the functions are never called in the program.

This pragma does not correspond to any CodeWarrior IDE panel setting. By default, this pragma is `off`.

import

Controls the importing of global data or functions.

Syntax

`#pragma import on | off | reset`

`#pragma import list` *`name1`* `[,` *`name2`*`, ...]`

`name1, name2`

Names of functions or global variables to import.

Remarks

When using the #pragma import on format, all functions are automatically imported.

Use the #pragma import list format to specify data or functions for importing. In C++, this form of the pragma applies to all variants of an overloaded function. You cannot use this pragma for C++ member functions or static class members.

Listing 29.2 shows an example:

Listing 29.2 Example of an Imported List

```
extern int f(),g;
#pragma import list f,g
```

This pragma does not correspond to any CodeWarrior IDE panel setting. By default, this pragma is off.

lib_export

Controls the exporting of data or functions.

Syntax

#pragma lib_export on | off | reset

#pragma lib_export list *name1* [, *name2*]*

Remarks

When using the #pragma lib_export on format, the linker marks all data and functions that are within the pragma's scope for export.

Use the #pragma lib_export list format to tag specific data or functions for exporting. In C++, this form of the pragma applies to all variants of an overloaded function. You cannot use this pragma for C++ member functions or static class members.

Listing 29.3 shows an example:

Listing 29.3 Example of a lib_export List

```
extern int f(),g;
#pragma lib_export list f,g
```

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

30

Pragmas for Code Generation

dont_reuse_strings

Controls whether or not to store identical character string literals separately in object code.

Syntax

```
#pragma dont_reuse_strings on | off | reset
```

Remarks

Normally, C and C++ programs should not modify character string literals. Enable this pragma if your source code follows the unconventional practice of modifying them.

If you enable this pragma, the compiler separately stores identical occurrences of character string literals in a source file.

If this pragma is disabled, the compiler stores a single instance of identical string literals in a source file. The compiler reduces the size of the object code it generates for a file if the source file has identical string literals.

The compiler always stores a separate instance of a string literal that is used to initialize a character array. Listing 30.1 shows an example.

Although the source code contains 3 identical string literals, `"cat"`, the compiler will generate 2 instances of the string in object code. The compiler will initialize `str1` and `str2` to point to the first instance of the string and will initialize `str3` to contain the second instance of the string.

Using `str2` to modify the string it points to also modifies the string that `str1` points to. The array `str3` may be safely used to modify the string it points to without inadvertently changing any other strings.

This pragma corresponds to the **Reuse Strings** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is `off`.

Listing 30.1 Reusing string literals

```
#pragma dont_reuse_strings off
void strchange(void)
{
  const char* str1 = "cat";
  char* str2 = "cat";
  char str3[] = “cat”;

  *str2 = 'h'; /* str1 and str2 point to "hat"! */
  str3[0] = 'b';
  /* OK: str3 contains "bat", *str1 and *str2 unchanged.
}
```

enumsalwaysint

Specifies the size of enumerated types.

Syntax

```
#pragma enumsalwaysint on | off | reset
```

Remarks

If you enable this pragma, the C/C++ compiler makes an enumerated type the same size as an `int`. If an enumerated constant is larger than `int`, the compiler generates an error message. Otherwise, the compiler makes an enumerated type the size of any integral type. It chooses the integral type with the size that most closely matches the size of the largest enumerated constant. The type could be as small as a `char` or as large as a `long long`.

Listing 30.2 shows an example.

Listing 30.2 Example of Enumerations the Same as Size as int

```
enum SmallNumber { One = 1, Two = 2 };
  /* If you enable enumsalwaysint, this type is
     the same size as an int. Otherwise, this type is
     the same size as a char. */

enum BigNumber
  { ThreeThousandMillion = 3000000000 };
  /* If you enable enumsalwaysint, the compiler might
```

```
    generate an error message. Otherwise, this type is
    the same size as a long long. */
```

This pragma corresponds to the **Enums Always Int** setting in the CodeWarrior IDE's **C/C++ Language** settings panel. By default, this pragma is `off`.

errno_name

Tells the optimizer how to find the `errno` identifier.

Syntax

```
#pragma errno_name id | ...
```

Remarks

When this pragma is used, the optimizer can use the identifier `errno` (either a macro or a function call) to optimize standard C library functions better. If not used, the optimizer makes worst-case assumptions about the effects of calls to the standard C library.

NOTE The MSL C library already includes a use of this pragma, so you would only need to use it for third-party C libraries.

If `errno` resolves to a variable name, specify it like this:

```
#pragma errno_name _Errno
```

If `errno` is a function call accessing ordinarily inaccessible global variables, use this form:

```
#pragma errno_name ...
```

Otherwise, do not use this pragma to prevent incorrect optimizations.

This pragma does not correspond to any panel setting. By default, this pragma is unspecified (worst case assumption).

explicit_zero_data

Controls the placement of zero-initialized data.

Syntax

```
#pragma explicit_zero_data on | off | reset
```

Remarks

Places zero-initialized data into the initialized data section instead of the BSS section when `on`.

By default, this pragma is `off`.

float_constants

Controls how floating pointing constants are treated.

Syntax

```
#pragma float_constants on | off | reset
```

Remarks

If you enable this pragma, the compiler assumes that all unqualified floating point constant values are of type `float`, not `double`. This pragma is useful when porting source code for programs optimized for the "`float`" rather than the "`double`" type.

When you enable this pragma, you can still explicitly declare a constant value as double by appending a "D" suffix.

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

instmgr_file

Controls where the instance manager database is written, to the target data directory or to a separate file.

Syntax

```
#pragma instmgr_file "name"
```

Remarks

When the **Use Instance Manager** option is on, the IDE writes the instance manager database to the project's data directory. If the `#pragma instmgr_file` is used, the database is written to a separate file.

Also, a separate instance file is always written when the command-line tools are used.

NOTE Should you need to report a bug, you can use this option to create a separate instance manager database, which can then be sent to technical support with your bug report.

longlong

Controls the availability of the `long long` type.

Syntax

```
#pragma longlong on | off | reset
```

Remarks

When this pragma is enabled and the compiler is translating C89 source code (ISO/IEC 9899-1990 standard), the compiler recognizes a data type named `long long`. The `long long` type holds twice as many bits as the `long` data type.

This pragma does not correspond to any CodeWarrior IDE panel setting.

By default, this pragma is `on` for processors that support this type. It is `off` when generating code for processors that do not support, or cannot turn on, the `long long` type.

longlong_enums

Controls whether or not enumerated types may have the size of the `long long` type.

Syntax

```
#pragma longlong_enums on | off | reset
```

Remarks

This pragma lets you use enumerators that are large enough to be `long long` integers. It is ignored if you enable the `enumsalwaysint` pragma (described in “enumsalwaysint” on page 322).

This pragma does not correspond to any panel setting. By default, this setting is enabled.

min_enum_size

Specifies the size, in bytes, of enumeration types.

Syntax

```
#pragma min_enum_size 1 | 2 | 4
```

Remarks

Turning on the `enumsalwaysint` pragma overrides this pragma. The default is 1.

options

Specifies how to align structure and class data.

Syntax

`#pragma options align=` *`alignment`*

Parameter

`alignment`

Specifies the boundary on which structure and class data is aligned in memory. Values for *alignment* range from 1 to 16, or use one of the following preset values:

Table 30.1 Structs and Classes Alignment

If *alignment* is …	The compiler …
`mac68k`	Aligns every field on a 2-byte boundaries, unless a field is only 1 byte long. This is the standard alignment for 68K Mac OS.
`mac68k4byte`	Aligns every field on 4-byte boundaries.

Table 30.1 Structs and Classes Alignment

If *alignment* is …	The compiler …
`power`	Aligns every field on its natural boundary. This is the standard alignment for PowerPC Mac OS. For example, it aligns a character on a 1-byte boundary and a 16-bit integer on a 2-byte boundary. The compiler applies this alignment recursively to structured data and arrays containing structured data. So, for example, it aligns an array of structured types containing an 4-byte floating point member on an 4-byte boundary.
`native`	Aligns every field using the standard alignment. It is equivalent to using `mac68k` for 68K Mac OS and `power` for PowerPC Mac OS.
`packed`	Aligns every field on a 1-byte boundary. It is not available in any panel. This alignment causes your code to crash or run slowly on many platforms. ***Use it with caution.***
`reset`	Resets to the value in the previous `#pragma options align` statement.

NOTE There is a space between `options` and `align`.

pool_strings

Controls how string literals are stored.

Syntax

```
#pragma pool_strings on | off | reset
```

Remarks

If you enable this pragma, the compiler collects all string constants into a single data object so your program needs one data section for all of them. If you disable this pragma, the compiler creates a unique data object for each string constant. While this decreases the number of data sections in your program, on some processors it also makes your program bigger because it uses a less efficient method to store the address of the string.

This pragma is especially useful if your program is large and has many string constants or uses the CodeWarrior Profiler.

NOTE If you enable this pragma, the compiler ignores the setting of the `pcrelstrings` pragma.

This pragma corresponds to the **Pool Strings** setting in the CodeWarrior IDE's **C/C++ Language** settings panel.

readonly_strings

Controls whether string objects are placed in a read-write or a read-only data section.

Syntax

```
#pragma readonly_strings on | off | reset
```

Remarks

If you enable this pragma, C strings used in your source code (for example, "hello") are output to the read-only data section instead of the global data section. In effect, these strings act like `const char *`, even though their type is really `char *`.

This pragma does not correspond to any IDE panel setting.

reverse_bitfields

Controls whether or not the compiler reverses the bitfield allocation.

Syntax

```
#pragma reverse_bitfields on | off | reset
```

Remarks

This pragma reverses the bitfield allocation, so that bitfields are arranged from the opposite side of the storage unit from that ordinarily used on the target. The compiler still orders the bits within a single bitfield such that the lowest-valued bit is in the right-most position.

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

store_object_files

Controls the storage location of object data, either in the target data directory or as a separate file.

Syntax

```
#pragma store_object_files on | off | reset
```

Remarks

By default, the IDE writes object data to the project's target data directory. When this pragma is on, the object data is written to a separate object file.

NOTE For some targets, the object file emitted may not be recognized as actual object data.

This pragma does not correspond to any panel setting. By default, this pragma is `off`.

31

Pragmas for Optimization

global_optimizer

Controls whether the Global Optimizer is invoked by the compiler.

Syntax

```
#pragma global_optimizer on | off | reset
```

Remarks

In most compilers, this #pragma determines whether the Global Optimizer is invoked (configured by options in the panel of the same name). If disabled, only simple optimizations and back-end optimizations are performed.

NOTE This is not the same as `#pragma optimization_level`. The Global Optimizer is invoked even at `optimization_level 0` if `#pragma global_optimizer` is enabled.

This pragma corresponds to the settings in the **Global Optimizations** panel. By default, this setting is `on`.

ipa

Specifies how to apply interprocedural analysis optimizations.

Syntax

```
#pragma ipa program | file | on | function | off
```

Remarks

See "Interprocedural Analysis" on page 167.

Place this pragma at the beginning of a source file, before any functions or data have been defined. There are three levels of interprocedural analysis:

- program-level: the compiler translates all source files in a program then optimizes object code for the entire program
- file-level: the compiler translates each file and applies this optimization to the file
- function-level: the compiler does not apply interprocedural optimization

The options `file` and `on` are equivalent. The options `function` and `off` are equivalent.

opt_common_subs

Controls the use of common subexpression optimization.

Syntax

```
#pragma opt_common_subs on | off | reset
```

Remarks

If you enable this pragma, the compiler replaces similar redundant expressions with a single expression. For example, if two statements in a function both use the expression

```
a * b * c + 10
```

the compiler generates object code that computes the expression only once and applies the resulting value to both statements.

The compiler applies this optimization to its own internal representation of the object code it produces.

This pragma does not correspond to any panel setting. By default, this settings is related to the global_optimizer pragma.

opt_dead_assignments

Controls the use of dead store optimization.

Syntax

```
#pragma opt_dead_assignments on | off | reset
```

Remarks

If you enable this pragma, the compiler removes assignments to unused variables before reassigning them.

This pragma does not correspond to any panel setting. By default, this settings is related to the "global_optimizer" on page 331 level.

opt_dead_code

Controls the use of dead code optimization.

Syntax

```
#pragma opt_dead_code on | off | reset
```

Remarks

If you enable this pragma, the compiler removes a statement that other statements never execute or call.

This pragma does not correspond to any panel setting. By default, this settings is related to the "global_optimizer" on page 331 level.

opt_lifetimes

Controls the use of lifetime analysis optimization.

Syntax

```
#pragma opt_lifetimes on | off | reset
```

Remarks

If you enable this pragma, the compiler uses the same processor register for different variables that exist in the same routine but not in the same statement.

This pragma does not correspond to any panel setting. By default, this settings is related to the "global_optimizer" on page 331 level.

opt_loop_invariants

Controls the use of loop invariant optimization.

Syntax

```
#pragma opt_loop_invariants on | off | reset
```

Remarks

If you enable this pragma, the compiler moves all computations that do not change inside a loop outside the loop, which then runs faster.

This pragma does not correspond to any panel setting.

opt_propagation

Controls the use of copy and constant propagation optimization.

Syntax

```
#pragma opt_propagation on | off | reset
```

Remarks

If you enable this pragma, the compiler replaces multiple occurrences of one variable with a single occurrence.

This pragma does not correspond to any panel setting. By default, this settings is related to the "global_optimizer" on page 331 level.

opt_strength_reduction

Controls the use of strength reduction optimization.

Syntax

```
#pragma opt_strength_reduction on | off | reset
```

Remarks

If you enable this pragma, the compiler replaces array element arithmetic instructions with pointer arithmetic instructions to make loops faster.

This pragma does not correspond to any panel setting. By default, this settings is related to the "global_optimizer" on page 331 level.

opt_strength_reduction_strict

Uses a safer variation of strength reduction optimization.

Syntax

```
#pragma opt_strength_reduction_strict on | off | reset
```

Remarks

Like the `opt_strength_reduction` pragma, this setting replaces multiplication instructions that are inside loops with addition instructions to speed up the loops. However, unlike the regular strength reduction optimization, this variation ensures that the optimization is only applied when the array element arithmetic is not of an unsigned type that is smaller than a pointer type.

This pragma does not correspond to any panel setting. The default varies according to the compiler.

opt_unroll_loops

Controls the use of loop unrolling optimization.

Syntax

```
#pragma opt_unroll_loops on | off | reset
```

Remarks

If you enable this pragma, the compiler places multiple copies of a loop's statements inside a loop to improve its speed.

This pragma does not correspond to any panel setting. By default, this settings is related to the "global_optimizer" on page 331 level.

opt_vectorize_loops

Controls the use of loop vectorizing optimization.

Syntax

```
#pragma opt_vectorize_loops on | off | reset
```

Remarks

If you enable this pragma, the compiler improves loop performance.

NOTE Do not confuse loop vectorizing with the vector instructions available in some processors. Loop vectorizing is the rearrangement of instructions in loops to improve performance. This optimization does not optimize a processor's vector data types.

By default, this pragma is `off`.

optimization_level

Controls global optimization.

Syntax

```
#pragma optimization_level 0 | 1 | 2 | 3 | 4
```

Remarks

This pragma specifies the degree of optimization that the global optimizer performs.

To select optimizations, use the pragma `optimization_level` with an argument from `0` to `4`. The higher the argument, the more optimizations performed by the global optimizer.

For more information on the optimization the compiler performs for each optimization level, refer to the *Targeting* manual for your target platform.

These pragmas correspond to the settings in the **Global Optimizations** panel. By default, this pragma is disabled.

optimize_for_size

Controls optimization to reduce the size of object code.

```
#pragma optimize_for_size on | off | reset
```

Remarks

This setting lets you choose what the compiler does when it must decide between creating small code or fast code. If you enable this pragma, the compiler creates smaller object code at the expense of speed. It also ignores the `inline` directive and generates function calls to call any function declared `inline`. If you disable this pragma, the compiler creates faster object code at the expense of size.

The pragma corresponds to the **Optimize for Size** setting on the **Global Optimizations** panel.

optimizewithasm

Controls optimization of assembly language.

Syntax

```
#pragma optimizewithasm on | off | reset
```

Remarks

If you enable this pragma, the compiler also optimizes assembly language statements in C/C++ source code.

This pragma does not correspond to any panel setting. By default, this pragma is disabled.

strictheaderchecking

Controls how strict the compiler checks headers for standard C library functions.

Syntax

```
#pragma strictheaderchecking on | off | reset
```

Remarks

The 3.2 version compiler recognizes standard C library functions. If the correct prototype is used, and, in C++, if the function appears in the “`std`” or root namespace, the compiler recognizes the function, and is able to optimize calls to it based on its documented effects.

When this #pragma is `on` (default), in addition to having the correct prototype, the declaration must also appear in the proper standard header file (and not in a user header or source file).

This pragma does not correspond to any panel setting. By default, this pragma is `on`.

32

Pragmas for ColdFire

This chapter is a a placeholder for a chapter containing target-specific material.

ColdFire Diagnostic Pragmas

SDS_debug_support

Tries to make the DWARF output file compatible with the Software Development System (SDS) debugger. The default value is `OFF`.

```
#pragma SDS_debug_support [ on | off | reset ]
```

ColdFire Library and Linking Pragmas

define_section

Specifies a predefined section or defines a new section for compiled object code.

```
#pragma define_section sname ".istr" [.ustr] [addrmode]
      [accmode]
```

Parameters

`sname`

Identifier for source references to this user-defined section.

`istr`

Section-name string for *initialized* data assigned to this section. Double quotes must surround this parameter value, which must begin with a period. (Also applies to *uninitialized* data if there is no `ustr` value.)

`ustr`

Optional: ELF section name for uninitialized data assigned to this section. Must begin with a period. Default value is the `istr` value.

`addrmode`

Optional: any of these address-mode values:

- `standard` — 32-bit absolute address (default)
- `near_absolute` — 16-bit absolute address
- `far_absolute` — 32-bit absolute address
- `near_code` — 16-bit offset from the PC address
- `far_code` — 32-bit offset from the PC address
- `near_data` — 16-bit offset from the A5 register address
- `far_data` — 32-bit offset from the A5 register address

`accmode`

Optional: any of these letter combinations:

- `R` — readable
- `RW` — readable and writable
- `RX` — readable and executable
- `RWX` — readable, writable, and executable (default)

(No other letter orders are valid: WR, XR, or XRW would be an error.)

Remarks

The compiler predefines the common ColdFire sections that Table 32.1 lists.

Table 32.1 ColdFire Predefined Sections

Applicability	Definition Pragmas
Absolute Addressing Mode	`#pragma define_section text ".text" far_absolute RX`
	`#pragma define_section data ".data" ".bss" far_absolute RW`
	`#pragma define_section sdata ".sdata" ".sbss" near_data RW`
	`#pragma define_section const ".rodata" far_absolute R`
C++, Regardless of Addressing Mode	`#pragma define_section exception ".exception" far_absolute R`
	`#pragma define_section exceptlist ".exceptlist" far_absolute R`

Table 32.1 ColdFire Predefined Sections (*continued*)

PID Addressing Mode	`#pragma define_section text ".text" far_absolute RX`
	`#pragma define_section data ".data" ".bss" far_data RW`
	`#pragma define_section sdata ".sdata" ".sbss" near_data RW`
	`#pragma define_section const ".rodata" far_absolute R`
PIC Addressing Mode	`#pragma define_section text ".text" far_code RX`
	`#pragma define_section data ".data" ".bss" far_absolute RW`
	`#pragma define_section sdata ".sdata" ".sbss" near_data RW`
	`#pragma define_section const ".rodata" far_code R`

Another use for `#pragma define_section` is redefining the attributes of predefined sections:

- To force 16-bit absolute addressing for all data, use

```
#pragma define_section data ".data" near_absolute
```

- To force 32-bit TP-relative addressing for exception tables, use:

```
#pragma define_section exceptlist ".exceptlist" far_code
#pragma define_section exception ".exception" far_code
```

You should put any such attribute-redefinition pragmas a prefix file or other header that all your program's source files will include.

NOTE The ELF linker's **Section Mappings** settings panel must map any user-defined compiler section to an appropriate segment.

ColdFire Code Generation Pragmas

codeColdFire

Controls organization and generation of ColdFire object code.

```
#pragma codeColdFire processor
```

Parameter

`processor`

Any of these specifier values: `MCF521x`, `MCF5206e`, `MCF5249`, `MCF5272`, `MCF5282`, `MCF5307`, `MCF5407`, `MCF547x`, `MCF548x` — or `reset`, which specifies the default processor.

const_multiply

Enables support for constant multiplies, using shifts and add/subtracts.

```
#pragma const_multiply [ on | off | reset ]
```

Remarks

The default value is `on`.

emac

Enables EMAC assembly instructions in inline assembly.

```
#pragma emac [ on | off | reset ]
```

Remarks

Enables inline-assembly instructions `mac`, `msac`, `macl`, `msacl`, `move`, and `movclr` for the ColdFire EMAC unit.

The default value is `OFF`.

explicit_zero_data

Specifies storage area for zero-initialized data.

```
#pragma explicit_zero_data [ on | off | reset ]
```

Remarks

The default value `OFF` specifies storage in the `.sbss` or `.bss` section. The value `ON` specifies storage in the `.data` section. The value `reset` specifies storage in the most-recent previously specified section.

Example

```
#pragma explicit_zero_data on
int in_data_section = 0;

#pragma explicit_zero_data off
int in_bss_section = 0;
```

inline_intrinsics

Controls support for inline intrinsic optimizations `strcopy` and `strlen`.

```
#pragma inline_intrinsics [ on | off | reset ]
```

Remarks

In the `strcopy` optimization, the system copies the string via a set of move-immediate commands to the source address. The system applies this optimization if the source is a string constant of fewer than 64 characters, and optimizing is set for speed.

In the `strlen` optimization, a move immediate of the length of the string to the result replaces the function call. The system applies this optimization if the source is a string constant.

The default value is `ON`.

interrupt

Controls compilation for interrupt-routine object code.

```
#pragma interrupt [ on | off | reset ]
```

Remarks

For the value `ON`, the compiler generates special prologues and epilogues for the functions this pragma encapsulates The compiler saves or restores all modified registers (both nonvolatile and scratch). Functions return via `RTE` instead of `RTS`.

You also can also use `__declspec(interrupt)` to mark functions as interrupt routines, for example:

```
__declspec(interrupt) void alpha()
{
//enter code here
}
```

readonly_strings

Enables the compiler to place strings in the `.rodata` section.

```
#pragma readonly_strings [ on | off | reset ]
```

Remarks

The default value is `ON`.

For the `OFF` value, the compiler puts strings in initialized data sections `.data` or `.sdata`, according to the string size.

section

Activates or deactivates a user-defined or predefined section.

`#pragma section` *`sname`* `begin | end`

Parameters

`sname`

Identifier for a user-defined or predefined section.

`begin`

Activates the specified section from this point in program execution.

`end`

Deactivates the specified section from this point in program execution; the section returns to its default state.

Remarks

Each call to this pragma must include a begin parameter or an end parameter, but not both.

You may use this pragma with `#pragma push` and `#pragma pop` to ease complex or frequent changes to section settings.

NOTE A simpler alternative to `#pragma section` is the `__declspec()` declaration specifier.

ColdFire Optimization Pragmas

opt_unroll_count

Limits the number of times a loop can be unrolled; fine-tunes the loop-unrolling optimization.

```
#pragma opt_unroll_count [ 0..127 | reset ]
```

Remarks

The default value is 8.

opt_unroll_instr_count

Limits the number of pseudo-instructions; fine-tunes the loop-unrolling optimization.

```
#pragma opt_unroll_instr_count [ 0..127 | reset ]
```

Remarks

There is not always a one-to-one mapping between pseudo-instructions and actual ColdFire instructions.

The default value is 100.

profile

Organizes object code for the profiler library and enables simple profiling.

```
#pragma profile [on| off| reset]
```

Remarks

Corresponds to the **Generate code for profiling** checkbox of the **ColdFire Processor** settings panel.

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