

Sourcery G++ Lite

MIPS GNU/Linux

Sourcery G++ Lite 4.3-51

Getting Started



Sourcery G++ Lite: MIPS GNU/Linux: Sourcery G++ Lite 4.3-51: Getting Started

CodeSourcery, Inc.

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Abstract

This guide explains how to install and build applications with Sourcery G++ Lite, CodeSourcery's customized, validated, and supported version of the GNU Toolchain. Sourcery G++ Lite includes everything you need for application development, including C and C++ compilers, assemblers, linkers, and libraries.

When you have finished reading this guide, you will know how to use Sourcery G++ from the command line.

Preface

This preface introduces *Getting Started With Sourcery G++ Lite*. It explains the structure of this guide and lists other sources of information that relate to Sourcery G++ Lite.

1. Intended Audience

This guide is written for people who will install and/or use Sourcery G++ Lite. This guide provides a step-by-step guide to installing Sourcery G++ Lite and to building simple applications. Parts of this document assume that you have some familiarity with using the command-line interface.

2. Organization

This document is organized into the following chapters and appendices:

Chapter 1, <i>Sourcery G++ Lite Licenses</i>	This chapter provides information about the software licenses that apply to Sourcery G++ Lite. Read this chapter to understand your legal rights and obligations as a user of Sourcery G++ Lite.
Chapter 2, <i>Sourcery G++ Subscriptions</i>	This chapter provides information about Sourcery G++ subscriptions. CodeSourcery customers with Sourcery G++ subscriptions receive comprehensive support for Sourcery G++. Read this chapter to find out how to obtain and use a Sourcery G++ subscription.
Chapter 3, <i>Sourcery G++ Lite for MIPS GNU/Linux</i>	This chapter provides information about this release of Sourcery G++ Lite including any special installation instructions, recent improvements, or other similar information. You should read this chapter before building applications with Sourcery G++ Lite.
Chapter 4, <i>Installation and Configuration</i>	This chapter describes how to download, install and configure Sourcery G++ Lite. This section describes the available installation options and explains how to set up your environment so that you can build applications.
Chapter 5, <i>Using Sourcery G++ from the Command Line</i>	This chapter explains how to build applications with Sourcery G++ Lite using the command line. In the process of reading this chapter, you will build a simple application that you can use as a model for your own programs.
Chapter 6, <i>Next Steps with Sourcery G++</i>	This chapter describes where you can find additional documentation and information about using Sourcery G++ Lite and its components.

3. Typographical Conventions

The following typographical conventions are used in this guide:

<code>> command arg ...</code>	A command, typed by the user, and its output. The “>” character is the command prompt.
command	The name of a program, when used in a sentence, rather than in literal input or output.
<code>literal</code>	Text provided to or received from a computer program.

placeholder

Text that should be replaced with an appropriate value when typing a command.

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At the end of a line in command or program examples, indicates that a long line of literal input or output continues onto the next line in the document.

Chapter 1

Sourcery G++ Lite Licenses

Sourcery G++ Lite contains software provided under a variety of licenses. Some components are “free” or “open source” software, while other components are proprietary. This chapter explains what licenses apply to your use of Sourcery G++ Lite. You should read this chapter to understand your legal rights and obligations as a user of Sourcery G++ Lite.

1.1. Licenses for Sourcery G++ Lite Components

The table below lists the major components of Sourcery G++ Lite for MIPS GNU/Linux and the license terms which apply to each of these components.

Some free or open-source components provide documentation or other files under terms different from those shown below. For definitive information about the license that applies to each component, consult the source package corresponding to this release of Sourcery G++ Lite. Sourcery G++ Lite may contain free or open-source components not included in the list below; for a definitive list, consult the source package corresponding to this release of Sourcery G++ Lite.

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GNU Binary Utilities	GNU General Public License 3.0 ¹
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GNU Debugger	GNU General Public License 3.0 ³
uClibc C Library	GNU Lesser General Public License 2.1 ⁴
GNU C Library	GNU Lesser General Public License 2.1 ⁵
Linux Kernel	GNU General Public License 2.0 ⁶
GNU Make	GNU General Public License 2.0 ⁷
GNU Core Utilities	GNU General Public License 2.0 ⁸

The CodeSourcery License is available in Section 1.2, “Sourcery G++™ Software License Agreement”.

Important

Although some of the licenses that apply to Sourcery G++ Lite are “free software” or “open source software” licenses, none of these licenses impose any obligation on you to reveal the source code of applications you build with Sourcery G++ Lite. You can develop proprietary applications and libraries with Sourcery G++ Lite.

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² <http://www.gnu.org/licenses/gpl.html>

³ <http://www.gnu.org/licenses/gpl.html>

⁴ <http://www.gnu.org/licenses/old-licenses/lgpl-2.1.html>

⁵ <http://www.gnu.org/licenses/old-licenses/lgpl-2.1.html>

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Chapter 2

Sourcery G++ Subscriptions

CodeSourcery provides support contracts for Sourcery G++. This chapter describes these contracts and explains how CodeSourcery customers can access their support accounts.

2.1. About Sourcery G++ Subscriptions

CodeSourcery offers Sourcery G++ subscriptions. Professional Edition subscriptions provide unlimited support, with no per-incident fees. CodeSourcery's support covers questions about installing and using Sourcery G++, the C and C++ programming languages, and all other topics relating to Sourcery G++. CodeSourcery provides updated versions of Sourcery G++ to resolve critical problems. Personal Edition subscriptions do not include support, but do include free upgrades as long as the subscription remains active.

CodeSourcery's support is provided by the same engineers who build Sourcery G++. A Sourcery G++ subscription is like having a team of compiler engineers and programming language experts available as consultants!

Subscription editions of Sourcery G++ also include many additional features not included in the free Lite editions:

- **Sourcery G++ IDE.** The Sourcery G++ IDE, based on Eclipse, provides a fully visual environment for developing applications, including an automated project builder, syntax-highlighting editor, and a graphical debugging interface. The debugger provides features especially useful to embedded systems programmers, including the ability to step through code at both the source and assembly level, view registers, and examine stack traces. CodeSourcery's enhancements to Eclipse include improved support for hardware debugging via JTAG or ICE units and complete integration with the rest of Sourcery G++.
- **Debug Sprites.** Sourcery G++ Debug Sprites provide hardware debugging support using JTAG and ICE devices. On some systems, Sourcery G++ Sprites can automatically program flash memory and display control registers. And the board initialization performed by each Sprite can be customized with simple XML-based configuration files to insert delays and write to particular memory addresses. Debug Sprites included in Lite editions of Sourcery G++ include only a subset of the functionality of the Sprites in the subscription editions.
- **QEMU Instruction Set Simulator.** The QEMU instruction set simulator can be used to run — and debug — programs even without target hardware. Most bare-metal configurations of Sourcery G++ include QEMU and linker scripts targeting the simulator. Configurations of Sourcery G++ for GNU/Linux targets include a user-space QEMU emulator that runs on Linux hosts.
- **Sysroot Utilities.** Subscription editions of Sourcery G++ include a set of sysroot utilities for GNU/Linux targets. These utilities simplify use of the Sourcery G++ dynamic linker and shared libraries on the target and also support remote debugging with **gdbserver**.
- **CS3.** CS3 provides a uniform, cross-platform approach to board initialization and interrupt handling on ARM EABI, ColdFire ELF, fido ELF, and Stellaris EABI platforms.
- **GNU/Linux Prelinker.** For select GNU/Linux target systems, Sourcery G++ includes the GNU/Linux prelinker. The prelinker is a postprocessor for GNU/Linux applications which can dramatically reduce application launch time. CodeSourcery has modified the prelinker to operate on non-GNU/Linux host systems, including Microsoft Windows.
- **Library Reduction Utility.** Sourcery G++ also includes a Library Reduction Utility for GNU/Linux targets. This utility allows the GNU C Library to be relinked to include only those functions used by a given collection of binaries.

- **Additional Libraries.** For some platforms, additional run-time libraries optimized for particular CPUs are available. Pre-built binary versions of the libraries with debug information are also available to subscribers.

If you would like more information about Sourcery G++ subscriptions, including a price quote or information about evaluating Sourcery G++, please send email to <sales@codesourcery.com>.

2.2. Accessing your Sourcery G++ Subscription Account

If you have a Sourcery G++ subscription, you may access your account by visiting the Sourcery G++ Portal¹. If you have a support account, but are unable to log in, send email to <support@codesourcery.com>.

¹ <https://support.codesourcery.com/GNUToolchain/>

Chapter 3

Sourcery G++ Lite for MIPS

GNU/Linux

This chapter contains information about using Sourcery G++ Lite on your target system. This chapter also contains information about changes in this release of Sourcery G++ Lite. You should read this chapter to learn how to best use Sourcery G++ Lite on your target system.

3.1. Library Configurations

Sourcery G++ includes copies of run-time libraries that have been built with optimizations for different target architecture variants or other sets of build options. Each such set of libraries is referred to as a *multilib*. When you build a target application, Sourcery G++ automatically selects the multilib matching the build options you have selected.

Each multilib corresponds to a *sysroot* directory that contains the files that should be installed on the target system. The *sysroot* contains the dynamic linker used to run your applications on the target as well as the libraries. Refer to Section 3.2.3, “Using Sourcery G++ Lite on GNU/Linux Targets” for instructions on how to install and use these support files on your target GNU/Linux system. You can find the *sysroot* directories provided with Sourcery G++ in the `mips-linux-gnu/libc` directory of your installation. In the tables below, the dynamic linker pathname is given relative to the corresponding *sysroot*.

Note that a given multilib may be compatible with additional processors and configurations beyond those explicitly named here.

The following library configurations are available in Sourcery G++ Lite for MIPS GNU/Linux.

MIPS32 revision 2 - Big-Endian, O32	
Command-line option(s):	default
Sysroot subdirectory:	./
Dynamic linker:	lib/ld.so.1

MIPS32 revision 2 - Little-Endian, O32	
Command-line option(s):	-EL
Sysroot subdirectory:	el/
Dynamic linker:	lib/ld.so.1

MIPS32 revision 2 - Big-Endian, Soft-Float, O32	
Command-line option(s):	-msoft-float
Sysroot subdirectory:	soft-float/
Dynamic linker:	lib/ld.so.1

MIPS32 revision 2 - Little-Endian, Soft-Float, O32	
Command-line option(s):	-EL -msoft-float
Sysroot subdirectory:	soft-float/el/
Dynamic linker:	lib/ld.so.1

MIPS32 revision 2 - uClibc, Big-Endian, O32	
Command-line option(s):	-muclibc
Sysroot subdirectory:	uclibc/
Dynamic linker:	lib/ld-uClibc.so.0

MIPS32 revision 2 - uClibc, Little-Endian, O32	
Command-line option(s):	<code>-muclibc -EL</code>
Sysroot subdirectory:	<code>uclibc/el/</code>
Dynamic linker:	<code>lib/ld-uClibc.so.0</code>

MIPS32 revision 2 - uClibc, Big-Endian, Soft-Float, O32	
Command-line option(s):	<code>-muclibc -msoft-float</code>
Sysroot subdirectory:	<code>uclibc/soft-float/</code>
Dynamic linker:	<code>lib/ld-uClibc.so.0</code>

MIPS32 revision 2 - uClibc, Little-Endian, Soft-Float, O32	
Command-line option(s):	<code>-muclibc -EL -msoft-float</code>
Sysroot subdirectory:	<code>uclibc/soft-float/el/</code>
Dynamic linker:	<code>lib/ld-uClibc.so.0</code>

3.2. Using Sourcery G++ Lite for MIPS GNU/Linux

3.2.1. Target Architectures

By default, Sourcery G++ Lite for MIPS GNU/Linux generates code for MIPS32r2 processors. If you wish to generate code for another MIPS processor, you must use an appropriate `-march` option when you build your application. Refer to the GCC manual for additional information about supported targets.

3.2.2. Target Kernel Requirements

The GNU C library supplied with this version of Sourcery G++ Lite requires that Linux kernel version 2.6.12 or later be installed on the target in order to run applications.

3.2.3. Using Sourcery G++ Lite on GNU/Linux Targets

In order to run and debug programs produced by Sourcery G++ on a GNU/Linux target, you must install runtime support files on the target. You may also need to set appropriate build options so that your executables can find the correct dynamic linker and libraries at runtime.

The runtime support files, referred to as the *sysroot*, are found in the `mips-linux-gnu/libc` directory of your Sourcery G++ Lite installation. The *sysroot* consists of the contents of the `etc`, `lib`, `sbin`, and `usr` directories. There may be other directories in `mips-linux-gnu/libc` that contain additional *sysroots* customized for particular combinations of command-line compiler flags, or *multilibs*. Refer to Section 3.1, “Library Configurations” for a list of the included *multilibs* in this version of Sourcery G++ Lite.

Note for Windows Host Users

The *sysroots* provided in Windows host packages for Sourcery G++ are not directly usable on the Linux target because of differences between the Windows and Linux file systems. Some files that are hard links, or copies, in the *sysroot* as installed on the Windows file system should be symbolic links on the Linux target. Additionally, some files in the *sysroot*

which should be marked executable on the Linux target are not marked executable on Windows. If you intend to use the sysroot provided with Sourcery G++ on a Windows host system as the basis for your Linux target filesystem, you must correct these issues after copying the sysroot to the target. If you are a Professional Edition customer and need assistance with these modifications, please contact CodeSourcery's support team.

There are three choices for installing the sysroot on the target:

- You can install the files in the filesystem root, replacing the system-provided files. All applications automatically use the Sourcery G++ libraries. This method is primarily useful when you are building a GNU/Linux system from scratch. Otherwise, overwriting your existing C library may break other applications on your system, or cause it to fail to boot.
- You can install the sysroot in an alternate location and build your application with the `-rpath` and `--dynamic-linker` linker options to specify the sysroot location.
- You can install the sysroot in an alternate location and explicitly invoke your application through the dynamic linker to specify the sysroot location. If you are just getting started with Sourcery G++ Lite, this may be the easiest way to get your application running, but this method does not support use of the debugger. In addition, this method only works with programs linked with the GNU C Library (glibc), not uClibc.

Setting the environment variable `LD_LIBRARY_PATH` on the target is not sufficient, since executables produced by Sourcery G++ depend on the Sourcery G++ dynamic linker included in the sysroot as well as the Sourcery G++ runtime libraries.

3.2.3.1. Installing the Sysroot

If you are modifying an existing system, rather than creating a new system from scratch, you should place the sysroot files in a new directory, rather than in the root directory of your target system.

If you choose to overwrite your existing C library, you may not be able to boot your system. You should back up your existing system before overwriting the C library and ensure that you can restore the backup even with your system offline.

When running Sourcery G++ on a GNU/Linux host, you have the alternative of installing the sysroot on the target at the same pathname where it is installed on the host system. One way to accomplish this is to NFS-mount the installation directory on both machines in the same location, rather than to copy files.

In many cases, you do not need to copy all of the files in the sysroot. For example, the `usr/include` subdirectory contains files that are only needed if you will actually be running the compiler on your target system. You do not need these files for non-native compilers. You also do not need any `.o` or `.a` files; these are used by the compiler when linking programs, but are not needed to run programs. You should definitely copy all `.so` files and the executable files in `usr/bin` and `sbin`.

You need to install the sysroot(s) corresponding to the compiler options you are using for your applications. The tables in Section 3.1, “Library Configurations” tell you which sysroot directories correspond to which compiler options. If you are unsure what sysroot is being referenced when you build your program, you can identify the sysroot by adding `-v` to your compiler command-line options, and looking at the `--sysroot=` pathname in the compiler output.

3.2.3.2. Using Linker Options to Specify the Sysroot Location

If you have installed the sysroot on the target in a location other than the file system root, you can use the `-rpath` and `--dynamic-linker` linker options to specify the sysroot location.

If you are using Sourcery G++ from the command line, follow these steps:

1. First find the correct sysroot directory, dynamic linker, and library subdirectory for your selected multilib. Refer to Section 3.1, “Library Configurations”. In the following steps, *sysroot* is the absolute path to the sysroot directory on the target corresponding to your selected multilib. For the default multilib, the dynamic linker path relative to the sysroot is `lib/ld.so.1`, and the library subdirectory is `lib`. This is used in the example below.

2. When invoking **mips-linux-gnu-gcc** to link your executable, include the command-line options:

```
-Wl,-rpath=sysroot/lib:sysroot/usr/lib \  
-Wl,--dynamic-linker=sysroot/lib/ld.so.1
```

where *sysroot* is the absolute path to the sysroot directory on the target corresponding to your selected multilib.

3. Copy the executable to the target and execute it normally.

Note that if you specify an incorrect path for `--dynamic-linker`, the common failure mode seen when running your application on the target is similar to

```
> ./hello  
./hello: No such file or directory
```

or

```
> ./hello  
./hello: bad ELF interpreter: No such file or directory
```

This can be quite confusing since it appears from the error message as if it is the `./hello` executable that is missing rather than the dynamic linker it references.

3.2.3.3. Specifying the Sysroot Location at Runtime

You can invoke the Sourcery G++ dynamic linker on the target to run your application without having to compile it with specific linker options. Note that this method of specifying the sysroot is specific to the GNU C Library (glibc) and does not work if you have linked your application with uClibc instead.

To do this, follow these steps:

1. Build your application on the host, without any additional linker options, and copy the executable to your target system.
2. Find the correct sysroot directory, dynamic linker, and library subdirectory for your selected multilib. Refer to Section 3.1, “Library Configurations”. In the following steps, *sysroot* is the absolute path to the sysroot directory on the target corresponding to your selected multilib. For the default multilib, the dynamic linker is `lib/ld.so.1`, and the library subdirectory is `lib`. This is used in the example below.
3. On the target system, invoke the dynamic linker with your executable as:

```
> sysroot/lib/ld.so.1 \  
--library-path sysroot/lib:sysroot/usr/lib \  
/path/to/your-executable
```

where *sysroot* is the absolute path to the sysroot directory on the target corresponding to your selected multilib.

Invoking the linker in this manner requires that you provide either an absolute pathname to your executable, or a relative pathname prefixed with `./`. Specifying only the name of a file in the current directory does not work.

3.2.4. Using GDB Server for Debugging

The GDB server utility provided with Sourcery G++ Lite can be used to debug a GNU/Linux application. While Sourcery G++ runs on your host system, **gdbserver** and the target application run on your target system. Even though Sourcery G++ and your application run on different systems, the debugging experience when using **gdbserver** is very similar to debugging a native application.

3.2.4.1. Running GDB Server

The GDB server executables are included in the sysroot in ABI-specific subdirectories of *sysroot/usr*. Use the executable from the sysroot and library subdirectory that match your program. See Section 3.1, “Library Configurations” for details.

You must copy the sysroot to your target system as described in Section 3.2.3.1, “Installing the Sysroot”. You must also copy the executable you want to debug to your target system.

If you have installed the sysroot in the root directory of the filesystem on the target, you can invoke **gdbserver** as:

```
> gdbserver :10000 program arg1 arg2 ...
```

where *program* is the path to the program you want to debug and *arg1 arg2 ...* are the arguments you want to pass to it. The `:10000` argument indicates that **gdbserver** should listen for connections from GDB on port 10000. You can use a different port, if you prefer.

If you have installed the sysroot in an alternate directory, invoking **gdbserver** becomes more complicated. You must build your application using the link-time options to specify the location of the sysroot, as described in Section 3.2.3.2, “Using Linker Options to Specify the Sysroot Location”. You must also invoke **gdbserver** itself using the dynamic linker provided in the Sourcery G++ sysroot, as described in Section 3.2.3.3, “Specifying the Sysroot Location at Runtime”. In other words, the command to invoke **gdbserver** in this case would be similar to:

```
> sysroot/lib/ld.so.1 \  
  --library-path sysroot/lib:sysroot/usr/lib \  
  sysroot/usr/lib/bin/gdbserver :10000 program arg1 arg2 ...
```

3.2.4.2. Connecting to GDB Server from the Debugger

You can connect to GDB server by using the following command from within GDB:

```
(gdb) target remote target:10000
```

where *target* is the host name or IP address of your target system.

When your program exits, **gdbserver** exits too. If you want to debug the program again, you must restart **gdbserver** on the target. Then, in GDB, reissue the `target` command shown above.

3.2.4.3. Setting the Sysroot in the Debugger

In order to debug shared libraries, GDB needs to map the pathnames of shared libraries on the target to the pathnames of equivalent files on the host system. Debugging of multi-threaded applications also depends on correctly locating copies of the libraries provided in the sysroot on the host system.

In some situations, the target pathnames are valid on the host system. Otherwise, you must tell GDB how to map target pathnames onto the equivalent host pathnames.

In the general case, there are two GDB commands required to set up the mapping:

```
(gdb) set sysroot-on-target target-pathname
(gdb) set sysroot host-pathname
```

This causes GDB to replace all instances of the *target-pathname* prefix in shared library pathnames reported by the target with *host-pathname* to get the location of the equivalent library on the host.

If you have installed the sysroot in the root filesystem on the target, you can omit the **set sysroot-on-target** command, and use only **set sysroot** to specify the location on the host system.

Refer to Section 3.2.3.1, “Installing the Sysroot” for more information about installing the sysroot on the target. Note that if you have installed a stripped copy of the provided libraries on the target, you should give GDB the location of an unstripped copy on the host.

3.3. Sourcery G++ Lite Release Notes

This section documents Sourcery G++ Lite changes for each released revision.

3.3.1. Changes in Sourcery G++ Lite 4.3-51

Setting breakpoints on Windows. A bug in GDB on Microsoft Windows hosts has been fixed. The bug caused setting breakpoints on a source line by using the file's full path to fail with No source file named *filename*.

Printing casted values in GDB. A GDB bug that caused incorrect output for expressions containing casts, such as in the `print *(Type *)ptr` command, has been fixed.

Bug fix for objcopy/strip. An objcopy bug that corrupted COMDAT groups when creating new binaries has been fixed. This bug also affected **strip -g**.

Bug fix for assembly listing. A bug that caused the assembler to produce corrupted listings (via the `-a` option) on Windows hosts has been fixed.

GDB update. The included version of GDB has been updated to 6.8.50.20080821. This update adds numerous bug fixes and new features, including support for decimal floating point, the new **find** command to search memory, the new `/m` (mixed source and assembly) option to the **disassemble** command, and the new **macro define** command to define C preprocessor macros interactively.

PIE linking fix. A bug in the GCC `-fpie` and `-fPIE` options has been fixed. The bug caused linker errors referring to `R_MIPS_HI16`.

Binutils support for DWARF Version 3. The **addr2line** command now supports binaries containing DWARF 3 debugging information. The **ld** command can display error messages with source locations for input files containing DWARF 3 debugging information.

GDB display of source. A bug has been fixed that prevented GDB from locating debug information in some cases. The debugger failed to display source code for or step into the affected functions.

Connecting to the target using a pipe. A bug in GDB's `target remote | program` command has been fixed. When launching the specified `program` failed, the bug caused GDB to crash, hang, or give a message `Error: No Error`.

Remote debugging improvements. The `gdbserver` utility now supports a more efficient communications protocol that can reduce latency during remote debugging. The protocol optimizations are enabled automatically when `gdbserver` operates over a TCP connection. Refer to the GDB manual for more information.

PIE support in uClibc. PIE (Position Independent Executable) support is now enabled in the included uClibc.

RPC support in uClibc. RPC (Remote Procedure Call) support is now enabled in the included uClibc. This feature is required to build BusyBox with NFS support.

Errors after loading the debugged program. An intermittent GDB bug has been fixed. The bug could cause a GDB internal error after the `load` command.

Bug fix for objdump on Windows. An `objdump` bug that caused the `-S` option not to work on Windows in some cases has been fixed.

Persistent remote server connections. A GDB bug has been fixed that caused the `target extended-remote` command to fail to tell the remote server to make the connection persistent across program invocations.

3.3.2. Changes in Sourcery G++ Lite 4.3-7

FPU defaults. The `-ffast-math` option now causes subnormal numbers to be immediately flushed to zero. It also sets the rounding mode to round-to-nearest.

DSP support. The compiler now automatically enables support for the DSP ASE when the `-march` option is used to specify a core in the 24KE, 34K, or 74K families. It is no longer necessary to provide the `-mdsp` option explicitly.

GCC version 4.3.2. Sourcery G++ Lite for MIPS GNU/Linux is now based on GCC version 4.3.2. For more information about changes from GCC version 4.2 that was included in previous releases, see <http://gcc.gnu.org/gcc-4.3/changes.html>.

3.3.3. Changes in Sourcery G++ Lite 4.2-177

Linker bug affecting Library Reduction Utility. A linker bug has been fixed that caused the `mips-linux-gnu-mklibs` Library Reduction Utility to produce invalid output when relinking `libc.so`. The bug could also affect linking of other shared libraries containing weak undefined symbols with non-default visibility.

Linker bug fix for `--gc-sections`. A linker bug that caused certain linker-generated sections to be incorrectly omitted from the executable when the `--gc-sections` option is used has been fixed.

Architecture level inference fix. The `-march=4kp` and `-march=4ksc` options now imply `-mips32` and the `-march=4ksd` option implies `-mips32r2`. The erroneous option `-march=4kf` has been removed.

Flags fix. The `-mips3d` and `-mpaired-single` options can now be used with `-mips32r2` as well as `-mips64`.

Output files removed on error. When GCC encounters an error, it now consistently removes any incomplete output files that it may have created.

-mwarn-framesize=size option. GCC has a new command-line option, `-mwarn-framesize=size`, which causes warnings if any function's stack frame exceeds the given `size`. This option is useful when generating code for environments with limited or absent stack, e.g., BIOS.

"Can't find matching LO16" linker error fixed. An assembler bug that caused errors when linking files containing mixed MIPS16 and non-MIPS16 code has been fixed.

Misaligned accesses to packed structures fix. A bug that caused GCC to generate misaligned accesses to packed structures has been fixed.

3.3.4. Changes in Sourcery G++ Lite 4.2-155

jalx instruction. The assembler no longer reports an error if the `jalx` instruction is used outside of MIPS16 mode.

3.3.5. Changes in Sourcery G++ Lite 4.2-129

Bug fix in fesetround. A bug in `fesetround` has been fixed. Earlier versions of `fesetround` incorrectly cleared the upper half of the FCSR (floating-point control and status register).

MIPS local GOT space. A linker bug that caused the error "not enough GOT space for local GOT entries" has been fixed.

Change to default target architecture. The compiler now generates code for MIPS32r2 processors by default, rather than the original MIPS32 ISA. This is an incompatible change from previous releases of Sourcery G++ Lite. To build applications for MIPS32 processors, add an explicit `-march=mips32` option to your compile and link commands. Refer to the GCC manual for additional information about supported targets and `-march` options.

3.3.6. Changes in Sourcery G++ Lite 4.2-116

GDB and Ctrl-C on Windows . GDB no longer crashes when you press **Ctrl-C** twice during remote debugging to give up waiting for the target.

MDI support in GDB. GDB now supports MDI, the MIPS Debug Interface protocol.

GCC update. The GCC package has been updated to version 4.2.3. This version includes numerous bug fixes since GCC 4.2.

GDB support for user-defined prefixed commands. The GDB **define** and **document** commands, which allow you to add new commands to the GDB command-line interface, now support creating commands within an existing prefix such as **target**. Hooks for prefixed commands are also supported. Refer to the Debugger manual for more information.

UNC pathname bug fix. A bug has been fixed that caused linker errors on Windows hosts when running a Sourcery G++ toolchain installed in a UNC path (`\\host\directory`).

GDB info registers crash fix. Executing **info registers** after executing **flushregs** no longer crashes GDB.

GDB search path bug fix. A bug in GDB has been fixed that formerly resulted in an internal error when setting `solib-search-path` or `solib-absolute-prefix` after establishing a connection to a remote target.

Binutils update. The binutils package has been updated to version 2.18.50.20080215 from the FSF trunk. This update includes numerous bug fixes.

Race fixes in setuid. Several bugs in multi-threaded `setuid` have been fixed. The bugs led to threads with incorrect privileges and hangs at thread exit. The `setgid`, `seteuid`, `setegid`, `setreuid`, `setregid`, `setresuid`, and `setresgid` functions were also affected.

3.3.7. Changes in Sourcery G++ Lite 4.2-87

Improved argument-passing code. The compiler can now generate more efficient code for certain functions whose arguments must be sign-extended to conform with language or ABI conventions. The required conversion was formerly being performed both in the called function and at all call sites; now the redundant conversion has been eliminated for functions that can only be called within the compilation unit where they are defined.

Multi-process mode for gdbserver. The `gdbserver` utility has a new command-line option, `--multi`, that allows you to use it to debug multiple program instances. Refer to the Debugger manual for more information.

Raza XLR processor support. Sourcery G++ now supports the Raza XLR processor. To generate code for this processor, use the option `-march=xlr`.

MIPS16 debugging information. GCC now produces more accurate line number information for the debugger when `-mips16` is specified.

GCC stack size limit increased. On Windows hosts, the maximum stack size for the GCC executable has been increased. This means that more complex programs can be compiled.

Invalid object file after strip. A bug in the assembler has been fixed that formerly caused `.set symbol expression` constructs to emit `symbol` in the wrong section. This in turn caused inconsistent behavior after stripping the symbol table.

Code generation improvements. The compiler's code size and instruction selection heuristics have been further tuned to produce better code for MIPS processors.

New Oction instructions. The assembler now supports the Cavium Oction instructions `saa` and `saad`.

-mcode-readable option. GCC has a new command-line option, `-mcode-readable`, that can be used to control placement of constant data in executable code sections. This option is useful when generating MIPS16 code for processors that restrict instruction access to executable sections, such as 4KSc and 4KSd processors when the code TLBs have the Read Inhibit bit set, or processors that have a dual instruction/data SRAM interface. Consult the GCC documentation for more information about this option.

GDB update. The included version of GDB has been updated to 6.7.20080107. This update includes numerous bug fixes.

gdbserver support for execution wrappers. **gdbserver** has a new command-line option, `--wrapper`, which specifies a wrapper for any programs run by **gdbserver**. The specified wrapper can prepare the system and environment for the new program.

3.3.8. Changes in Sourcery G++ Lite 4.2-85

Initial release. This is the initial release for MIPS GNU/Linux.

Chapter 4

Installation and Configuration

This chapter explains how to install Sourcery G++ Lite. You will learn how to:

1. Verify that you can install Sourcery G++ Lite on your system.
2. Download the appropriate Sourcery G++ Lite installer.
3. Install Sourcery G++ Lite.
4. Configure your environment so that you can use Sourcery G++ Lite.

4.1. Terminology

Throughout this document, the term *host system* refers to the system on which you run Sourcery G++ while the term *target system* refers to the system on which the code produced by Sourcery G++ runs. The target system for this version of Sourcery G++ is `mips-linux-gnu`.

If you are developing a workstation or server application to run on the same system that you are using to run Sourcery G++, then the host and target systems are the same. On the other hand, if you are developing an application for an embedded system, then the host and target systems are probably different.

4.2. System Requirements

4.2.1. Host Operating System Requirements

This version of Sourcery G++ supports the following host operating systems and architectures:

- Microsoft Windows NT 4, Windows 2000, Windows XP, and Windows Vista systems using IA32, AMD64, and EM64T processors.
- GNU/Linux systems using IA32, AMD64, or EM64T processors, including Debian 3.0 (and later), Red Hat Enterprise Linux 3 (and later), and SuSE Enterprise Linux 8 (and later).

Sourcery G++ is built as a 32-bit application. Therefore, even when running on a 64-bit host system, Sourcery G++ requires 32-bit host libraries. If these libraries are not already installed on your system, you must install them before installing and using Sourcery G++ Lite. Consult your operating system documentation for more information about obtaining these libraries.

4.2.2. Host Hardware Requirements

In order to install and use Sourcery G++ Lite, you must have at least 128MB of available memory.

The amount of disk space required for a complete Sourcery G++ Lite installation directory depends on the host operating system and the number of target libraries included. Typically, you should plan on at least 400MB. In addition, the graphical installer requires a similar amount of temporary space during the installation process.

4.2.3. Target System Requirements

See Chapter 3, *Sourcery G++ Lite for MIPS GNU/Linux* for requirements that apply to the target system.

4.3. Downloading an Installer

If you have received Sourcery G++ Lite on a CD, or other physical media, then you do not need to download an installer. You may skip ahead to Section 4.4, “Installing Sourcery G++ Lite”.

If you have a Sourcery G++ subscription (or evaluation), then you can log into the Sourcery G++ Portal¹ to download your Sourcery G++ toolchain(s). CodeSourcery also makes some toolchains available to the general public from the Sourcery G++ web site². These publicly available toolchains do not include all the functionality of CodeSourcery's product releases.

¹ <https://support.codesourcery.com/GNUToolchain/>

² http://www.codesourcery.com/gnu_toolchains/

Once you have navigated to the appropriate web site, download the installer that corresponds to your host operating system. For Microsoft Windows systems, the Sourcery G++ installer is provided as an executable, with the `.exe` extension. For GNU/Linux systems Sourcery G++ Lite is provided as an executable installer package with the `.bin` extension, or as a compressed archive `.tar.bz2`.

On Microsoft Windows systems, save the installer to the desktop. On GNU/Linux systems, save the download package in your home directory.

4.4. Installing Sourcery G++ Lite

The method used to install Sourcery G++ Lite depends on your host system.

4.4.1. Installing Sourcery G++ Lite on Microsoft Windows

If you have received Sourcery G++ Lite on CD, insert the CD in your computer. On most computers, the installer then starts automatically. If your computer has been configured not to automatically run CDs, open *My Computer*, and double click on the CD. If you downloaded Sourcery G++ Lite, double-click on the installer.

After the installer starts, follow the on-screen dialogs to install Sourcery G++ Lite.

If you prefer, you can run the installer in console mode rather than using the graphical interface. To do this, invoke the installer with the `-i console` command-line option. For example:

```
> /path/to/package.exe -i console
```

4.4.2. Using the Sourcery G++ Lite Installer on GNU/Linux Hosts

Start the graphical installer by invoking the executable shell script:

```
> /bin/sh ./path/to/package.bin
```

After the installer starts, follow the on-screen dialogs to install Sourcery G++ Lite.

If you prefer, or if your host system does not run the X Window System, you can run the installer in console mode rather than using the graphical interface. To do this, invoke the installer with the `-i console` command-line option. For example:

```
> /bin/sh ./path/to/package.bin -i console
```

4.4.3. Installing Sourcery G++ Lite on Solaris or GNU/Linux Hosts from a Compressed Archive

You do not need to be a system administrator to install Sourcery G++ Lite on a GNU/Linux or Solaris system. You may install Sourcery G++ Lite using any user account and in any directory to which you have write access. This guide assumes that you have decided to install Sourcery G++ Lite in the `$HOME/CodeSourcery` subdirectory of your home directory and that the filename of the package you have downloaded is `/path/to/package.tar.bz2`. After installation the toolchain will be in `$HOME/CodeSourcery/sourceryg++-4.3`.

First, uncompress the package file:

```
> bunzip2 /path/to/package.tar.bz2
```

Next, create the directory in which you wish to install the package:

```
> mkdir -p $HOME/CodeSourcery
```

Change to the installation directory:

```
> cd $HOME/CodeSourcery
```

Unpack the package:

```
> tar xf /path/to/package.tar
```

4.5. Installing Sourcery G++ Lite Updates

If you have already installed an earlier version of Sourcery G++ Lite for MIPS GNU/Linux on your system, it is not necessary to uninstall it before using the installer to unpack a new version in the same location. The installer detects that it is performing an update in that case.

If you are installing an update from a compressed archive, it is recommended that you remove any previous installation in the same location, or install in a different directory.

Note that the names of the Sourcery G++ commands for the MIPS GNU/Linux target all begin with **mips-linux-gnu**. This means that you can install Sourcery G++ for multiple target systems in the same directory without conflicts.

4.6. Uninstalling Sourcery G++ Lite

The method used to uninstall Sourcery G++ Lite depends on your host system. If you have modified any files in the installation it is recommended that you back up these changes. The uninstall procedure may remove the files you have altered.

4.6.1. Uninstalling Sourcery G++ Lite on Microsoft Windows

Select **Start**, then **Control Panel**. Select **Add or Remove Programs**. Scroll down and click on **Sourcery G++ for MIPS GNU/Linux**. Select **Change/Remove** and follow the on-screen dialogs to uninstall Sourcery G++ Lite.

You can run the uninstaller in console mode, rather than using the graphical interface, by invoking the **Uninstall** executable found in your Sourcery G++ Lite installation directory with the `-i console` command-line option.

To uninstall third-party drivers bundled with Sourcery G++ Lite, first disconnect the associated hardware device. Then use **Add or Remove Programs** to remove the drivers separately. Depending on the device, you may need to reboot your computer to complete the driver uninstall.

4.6.2. Uninstalling Sourcery G++ Lite on Microsoft Windows Vista

Select **Start**, then **Settings** and finally **Control Panel**. Select the **Uninstall a program** task. Scroll down and double click on **Sourcery G++ for MIPS GNU/Linux**. Follow the on-screen dialogs to uninstall Sourcery G++ Lite.

You can run the uninstaller in console mode, rather than using the graphical interface, by invoking the **Uninstall** executable found in your Sourcery G++ Lite installation directory with the `-i console` command-line option.

To uninstall third-party drivers bundled with Sourcery G++ Lite, first disconnect the associated hardware device. Then use `Uninstall a program` to remove the drivers separately. Depending on the device, you may need to reboot your computer to complete the driver uninstall.

4.6.3. Using the Sourcery G++ Lite Uninstaller on GNU/Linux

If you installed Sourcery G++ Lite on GNU/Linux using the installer script, then you must use the corresponding uninstaller to remove Sourcery G++ Lite. The `mips-linux-gnu` directory located in the `install` directory will be removed entirely by the uninstaller. Please back up any changes you have made to this directory, such as modified linker scripts.

Start the graphical uninstaller by invoking the executable `Uninstall` shell script located in your installation directory. After the uninstaller starts, follow the on-screen dialogs to uninstall Sourcery G++ Lite.

You can run the uninstaller in console mode, rather than using the graphical interface, by invoking the `Uninstall` script with the `-i console` command-line option.

4.6.4. Uninstalling Sourcery G++ Lite on GNU/Linux or Solaris

If you installed Sourcery G++ Lite from a `.tar.bz2` file, you can uninstall it by manually deleting the installation directory created in the install procedure.

4.7. Setting up the Environment

As with the installation process itself, the steps required to set up your environment depend on your host operating system.

4.7.1. Setting up the Environment on Microsoft Windows

On a non-Vista Microsoft Windows system, the installer automatically adds Sourcery G++ to your `PATH`. You can test that your `PATH` is set up correctly by using the following command:

```
> mips-linux-gnu-g++ -v
```

and verifying that the last line of the output contains: `Sourcery G++ Lite 4.3-51`.

On a Microsoft Windows Vista system, the installer does not automatically add Sourcery G++ to your `PATH`. To set up your `PATH` on Microsoft Windows Vista, use the following command in a `cmd.exe` shell:

```
> setx PATH "%PATH%;C:\Program Files\Sourcery G++\bin"
```

where `C:\Program Files\Sourcery G++` should be changed to the path of your Sourcery G++ Lite installation. You can verify that the command worked by starting a second `cmd.exe` shell and running:

```
> mips-linux-gnu-g++ -v
```

Verify that the last line of the output contains: `Sourcery G++ Lite 4.3-51`.

4.7.1.1. Working with Cygwin

Sourcery G++ Lite does not require Cygwin or any other UNIX emulation environment. You can use Sourcery G++ directly from the Windows command shell. You can also use Sourcery G++ from within the Cygwin environment, if you prefer.

The Cygwin emulation environment translates Windows path names into UNIX path names. For example, the Cygwin path `/home/user/hello.c` corresponds to the Windows path `c:\cygwin\home\user\hello.c`. Because Sourcery G++ is not a Cygwin application, it does not, by default, recognize Cygwin paths.

If you are using Sourcery G++ from Cygwin, you should set the `CYGPATH` environment variable. If this environment variable is set, Sourcery G++ Lite automatically translates Cygwin path names into Windows path names. To set this environment variable, type the following command in a Cygwin shell:

```
> export CYGPATH=cygpath
```

To resolve Cygwin path names, Sourcery G++ relies on the `cygpath` utility provided with Cygwin. You must provide Sourcery G++ with the full path to `cygpath` if `cygpath` is not in your `PATH`. For example:

```
> export CYGPATH=c:/cygwin/bin/cygpath
```

directs Sourcery G++ Lite to use `c:/cygwin/bin/cygpath` as the path conversion utility. The value of `CYGPATH` must be an ordinary Windows path, not a Cygwin path.

4.7.2. Setting up the Environment on GNU/Linux or Solaris

If you installed Sourcery G++ Lite using the `.bin` graphical installer then you may skip this step. The graphical installer does this setup for you.

Before using Sourcery G++ Lite you should add it to your `PATH`. The command you must use varies with the particular command shell that you are using. If you are using the C Shell (`csh` or `tcsh`), use the command:

```
> setenv PATH $HOME/CodeSourcery/sourceryg++-4.3/bin:$PATH
```

If you are using Bourne Shell (`sh`), the Korn Shell (`ksh`), or another shell, use:

```
> PATH=$HOME/CodeSourcery/sourceryg++-4.3/bin:$PATH
> export PATH
```

If you are not sure which shell you are using, try both commands. In both cases, if you have installed Sourcery G++ Lite in an alternate location, you must replace the directory above with `bin` subdirectory of the directory in which you installed Sourcery G++ Lite.

You may also wish to set the `MANPATH` environment variable so that you can access the Sourcery G++ manual pages, which provide additional information about using Sourcery G++. To set the `MANPATH` environment variable, follow the same steps shown above, replacing `PATH` with `MANPATH`, and `bin` with `share/doc/sourceryg++-mips-linux-gnu/man`.

You can test that your `PATH` is set up correctly by using the following command:

```
> mips-linux-gnu-g++
```

and verifying that you receive the message:

```
mips-linux-gnu-g++: no input files
```

Chapter 5

Using Sourcery G++ from the Command Line

This chapter demonstrates the use of Sourcery G++ Lite from the command line. This chapter assumes you have installed Sourcery G++ Lite as described in Chapter 4, *Installation and Configuration*.

5.1. Building an Application

This chapter explains how to build an application with Sourcery G++ Lite using the command line. As elsewhere in this manual, this section assumes that your target system is mips-linux-gnu, as indicated by the **mips-linux-gnu** command prefix.

Using an editor (such as **notepad** on Microsoft Windows or **vi** on UNIX-like systems), create a file named `hello.c` containing the following simple program:

```
#include <stdio.h>

int
main (void)
{
    printf("Hello World!\n");
    return 0;
}
```

Compile and link this program using the command:

```
> mips-linux-gnu-gcc -o hello hello.c
```

There should be no output from the compiler. (If you are building a C++ application, instead of a C application, replace **mips-linux-gnu-gcc** with **mips-linux-gnu-g++**.)

5.2. Running Applications on the Target System

You may need to install the Sourcery G++ runtime libraries and dynamic linker on the target system before you can run your application. Refer to Chapter 3, *Sourcery G++ Lite for MIPS GNU/Linux* for specific instructions.

To run your program on a GNU/Linux target system, use the command:

```
> ./hello
```

You should see:

```
Hello world!
```

5.3. Running Applications from GDB

You can run GDB, the GNU Debugger, on your host system to debug programs running remotely on a target board or system.

While this section explains the alternatives for using GDB to run and debug application programs, explaining the use of the GDB command-line interface is beyond the scope of this document. Please refer to the GDB manual for further instructions.

5.3.1. Connecting to an External GDB Server

Sourcery G++ Lite includes a program called **gdbserver** that can be used to debug a program running on a remote MIPS GNU/Linux target. Follow the instructions in Chapter 3, *Sourcery G++ Lite for MIPS GNU/Linux* to install and run **gdbserver** on your target system.

From within GDB, you can connect to a running **gdbserver** or other debugging stub that uses the GDB remote protocol using:

```
(gdb) target remote host:port
```

where *host* is the host name or IP address of the machine the stub is running on, and *port* is the port number it is listening on for TCP connections.

Chapter 6

Next Steps with Sourcery G++

This chapter describes where you can find additional documentation and information about using Sourcery G++ Lite and its components.

6.1. Sourcery G++ Knowledge Base

The Sourcery G++ Knowledge Base is available to registered users at the Sourcery G++ Portal¹. Here you can find solutions to common problems including installing Sourcery G++, making it work with specific targets, and interoperability with third-party libraries. There are also additional example programs and tips for making the most effective use of the toolchain and for solving problems commonly encountered during debugging. The Knowledge Base is updated frequently with additional entries based on inquiries and feedback from customers.

For more information on CodeSourcery support, see Chapter 2, *Sourcery G++ Subscriptions*.

6.2. Manuals for GNU Toolchain Components

Sourcery G++ Lite includes the full user manuals for each of the GNU toolchain components, such as the compiler, linker, assembler, and debugger. Most of the manuals include tutorial material for new users as well as serving as a complete reference for command-line options, supported extensions, and the like.

When you install Sourcery G++ Lite, links to both the PDF and HTML versions of the manuals are created in the shortcuts folder you select. If you elected not to create shortcuts when installing Sourcery G++ Lite, the documentation can be found in the `share/doc/sourceryg++-mips-linux-gnu/` subdirectory of your installation directory.

In addition to the detailed reference manuals, Sourcery G++ Lite includes a Unix-style manual page for each toolchain component. You can view these by invoking the **man** command with the pathname of the file you want to view. For example, you can first go to the directory containing the man pages:

```
> cd $INSTALL/share/doc/sourceryg++-mips-linux-gnu/man/man1
```

Then you can invoke **man** as:

```
> man ./mips-linux-gnu-gcc.1
```

Alternatively, if you use **man** regularly, you'll probably find it more convenient to add the directory containing the Sourcery G++ man pages to your `MANPATH` environment variable. This should go in your `.profile` or equivalent shell startup file; see Section 4.7, "Setting up the Environment" for instructions. Then you can invoke **man** with just the command name rather than a pathname.

Finally, note that every command-line utility program included with Sourcery G++ Lite can be invoked with a `--help` option. This prints a brief description of the arguments and options to the program and exits without doing further processing.

¹ <https://support.codesourcery.com/GNUToolchain/>