Sourcery CodeBench Lite

MIPS GNU/Linux

Sourcery CodeBench Lite 2014.11-22

Getting Started

Sourcery CodeBench Lite: MIPS GNU/Linux: Sourcery CodeBench Lite 2014.11-22: Getting Started

Mentor Graphics, Inc.

Abstract

This guide explains how to install and build applications with Sourcery CodeBench Lite, Code-Sourcery's customized and validated version of the GNU Toolchain. Sourcery CodeBench 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 CodeBench from the command line.

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Preface

This preface introduces the Sourcery CodeBench Lite Getting Started guide. It explains the structure of this guide and describes the documentation conventions used.

1. Intended Audience

This guide is written for people who will install and/or use Sourcery CodeBench Lite. This guide provides a step-by-step guide to installing Sourcery CodeBench 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, "Quick Start"
This chapter includes a brief checklist to follow when installing and using Sourcery CodeBench Lite for the first time. You may use this chapter as an abbreviated guide to the rest of this manual.

Chapter 2, "Installation and Configuration"
This chapter describes how to download, install and configure Sourcery CodeBench Lite. This section describes the available installation options and explains how to set up your environment so that you can build applications.

Chapter 3, "Sourcery CodeBench Lite for MIPS GNU/Linux"
This chapter contains information about using Sourcery CodeBench Lite that is specific to MIPS GNU/Linux targets. You should read this chapter to learn how to best use Sourcery CodeBench Lite on your target system.

Chapter 4, "Using Sourcery CodeBench from the Command Line"
This chapter explains how to build applications with Sourcery CodeBench 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 5, "Sourcery CodeBench Debug Sprite"
This chapter describes the use of the Sourcery CodeBench Debug Sprite for remote debugging. The Sprite is provided for debugging of the Linux kernel on the target board. This chapter includes information about the debugging devices and boards supported by the Sprite for MIPS GNU/Linux.

Chapter 6, "Next Steps with Sourcery CodeBench"
This chapter describes where you can find additional documentation and information about using Sourcery CodeBench Lite and its components. It also provides information about Sourcery CodeBench subscriptions. CodeSourcery customers with Sourcery CodeBench subscriptions receive comprehensive support for Sourcery CodeBench.

Appendix A, "Sourcery CodeBench Lite Release Notes"
This appendix contains information about changes in this release of Sourcery CodeBench Lite for MIPS GNU/Linux. You should read through these notes to learn about new features and bug fixes.

Appendix B, "Sourcery CodeBench Lite Licenses"
This appendix provides information about the software licenses that apply to Sourcery CodeBench Lite. Read this appendix to understand your legal rights and obligations as a user of Sourcery CodeBench Lite.

3. Typographical Conventions

The following typographical conventions are used in this guide:

`> command arg ...`	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.
`literal`	Text provided to or received from a computer program.
placeholder	Text that should be replaced with an appropriate value when typing a command.
`\`	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
Quick Start

This chapter includes a brief checklist to follow when installing and using Sourcery CodeBench Lite for the first time. You may use this chapter as an abbreviated guide to the rest of this manual.

Sourcery CodeBench Lite for MIPS GNU/Linux is intended for developers working on embedded GNU/Linux applications. It may also be used for Linux kernel development and debugging, or to build a GNU/Linux distribution.

Follow the steps given in this chapter to install Sourcery CodeBench Lite and build and run your first application program. The checklist given here is not a tutorial and does not include detailed instructions for each step; however, it will help guide you to find the instructions and reference information you need to accomplish each step. Note that this checklist is also oriented towards application debugging rather than kernel debugging.

You can find additional details about the components, libraries, and other features included in this version of Sourcery CodeBench Lite in Chapter 3, "Sourcery CodeBench Lite for MIPS GNU/Linux".

1.1. Installation and Set-Up

Install Sourcery CodeBench Lite on your host computer. You may download an installer package from the Sourcery CodeBench web site[1], or you may have received an installer on CD. The installer is an executable program that pops up a window on your computer and leads you through a series of dialogs to configure your installation. When the installation is complete, it offers to launch the Getting Started guide. For more information about installing Sourcery CodeBench Lite, including host system requirements and tips to set up your environment after installation, refer to Chapter 2, "Installation and Configuration".

1.2. Configuring Sourcery CodeBench Lite for the Target System

Identify your target libraries. Sourcery CodeBench Lite supports libraries optimized for different targets. Libraries are selected automatically by the linker, depending on the processor and other options you have specified. Refer to Section 3.2, "Library Configurations" for details.

Install runtime libraries on your target machine. In order to run programs built with the Sourcery CodeBench runtime libraries on target hardware, you must install these libraries, the Sourcery CodeBench dynamic linker, and other runtime support files -- collectively referred to as the *sysroot* -- on your GNU/Linux target system. Typically, this involves either using third-party tools to build a complete root filesystem including the Sourcery CodeBench sysroot, or using special commands when linking or running your program so it can find the sysroot installed in another location on the target. Refer to Section 3.5, "Using Sourcery CodeBench Lite on GNU/Linux Targets" for full discussion of these options. You can skip this step if you plan to run your program with the QEMU user-space emulator on a Linux host.

1.3. Building Your Program

Build your program with Sourcery CodeBench command-line tools. Create a simple test program, and follow the directions in Chapter 4, "Using Sourcery CodeBench from the Command Line" to compile and link it using Sourcery CodeBench Lite.

1.4. Running and Debugging Your Program

The steps to run or debug your program depend on your target system and how it is configured. Choose the appropriate method for your target.

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[1] http://go.mentor.com/codebench/

Debug your program in the QEMU user-space emulator. If you have installed Sourcery CodeBench on a GNU/Linux host, you can use the QEMU user-space emulator to debug your program. This is an easy way to try out Sourcery CodeBench Lite without target hardware. Refer to Section 4.3, "Running Applications with QEMU" for instructions on using QEMU.

Run your program on the MIPS GNU/Linux target. To run a program using the included Sourcery CodeBench libraries, you must install the sysroot on the target, as previously discussed. Copy the executable for your program to the target system. The method you use for launching your program depends on how you have installed the libraries and built your program. In some cases, you may need to invoke the Sourcery CodeBench dynamic linker explicitly. Refer to Section 3.5, "Using Sourcery CodeBench Lite on GNU/Linux Targets" for details.

Debug your program on the target using GDB server. You can use GDB server on a remote target to debug your program. When debugging a program that uses the included Sourcery CodeBench libraries, you must use the gdbserver executable included in the sysroot, and similar issues with respect to the dynamic linker as discussed previously apply. See Section 3.6, "Using GDB Server for Debugging" for detailed instructions. Once you have started GDB server on the target, you can connect to it from the debugger on your host system. Refer to Section 4.4, "Running Applications from GDB" for instructions on remote debugging from command-line GDB.

Chapter 2
Installation and Configuration

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

1. Verify that you can install Sourcery CodeBench Lite on your system.

2. Download the appropriate Sourcery CodeBench Lite installer.

3. Configure your environment so that you can use Sourcery CodeBench Lite.

4. Install Sourcery CodeBench Lite.

2.1. Terminology

Throughout this document, the term *host system* refers to the system on which you run Sourcery CodeBench while the term *target system* refers to the system on which the code produced by Sourcery CodeBench runs. The target system for this version of Sourcery CodeBench 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 CodeBench, 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.

2.2. System Requirements

2.2.1. Host Operating System Requirements

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

- Microsoft Windows Vista, Windows 7 and Windows 8 systems using IA32, AMD64, and Intel 64 processors.

- GNU/Linux systems using IA32, AMD64, or Intel 64 processors, including Debian 5 (and later), Red Hat Enterprise Linux 5 (and later), SuSE Enterprise Linux 10 (and later), and Ubuntu 8.04 (and later).

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

2.2.2. Host Hardware Requirements

The amount of disk space required for a complete Sourcery CodeBench Lite installation directory depends on the host operating system and the number of target libraries included. When you start the graphical installer, it checks whether there is sufficient disk space before beginning to install. Note that the graphical installer also requires additional temporary disk space during the installation process. On Microsoft Windows hosts, the installer uses the location specified by the `TEMP` environment variable for these temporary files. If there is not enough free space on that volume, the installer prompts for an alternate location. On Linux hosts, the installer puts temporary files in the directory specified by the `TMP` environment variable, or `/tmp` if that is not set.

2.2.3. Target System Requirements

See Chapter 3, "Sourcery CodeBench Lite for MIPS GNU/Linux" for requirements that apply to the target system.

2.3. Registering with the Sourcery CodeBench Portal

If you do not already have a Sourcery CodeBench Portal account, you must register for one now. You must have an active Sourcery CodeBench Lite subscription to download an installer. Evaluation subscriptions are available at no charge and also give you access to support from CodeSourcery.

If you purchased Sourcery CodeBench Lite directly from Mentor Graphics, you already have an account, and you may skip ahead to the next section. However, if you received Sourcery CodeBench Lite with a hardware development kit or from a distributor, you probably do not have an account.

To register for an account, visit the Sourcery CodeBench Portal[1]. Click on the link to register for an evaluation subscription. Follow the instructions on the web site to create your account. Then, once your account is active, click the button to request an evaluation subscription.

You should request an evaluation version of Sourcery CodeBench that matches the version you received with your development kit. Select the host system where you will install Sourcery CodeBench, and MIPS GNU/Linux as the target system where you will run applications. Then click the `Request Evaluation` button.

If there are newer versions of Sourcery CodeBench Lite than the one provided with your development kit, they will be visible through the Sourcery CodeBench Portal once your evaluation subscription is active. CodeSourcery recommends that you first work with the version of Sourcery CodeBench that came with your development kit, since CodeSourcery and the manufacturer have tested that particular combination of hardware and software. However, you may also wish to experiment with newer versions.

2.4. Downloading an Installer

If you have received Sourcery CodeBench Lite on a CD, or other physical media, then you do not need to download an installer. You may skip ahead to Section 2.5, "Installing Sourcery CodeBench Lite".

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 CodeBench installer is provided as a compressed archive with the `.zip` extension. For GNU/Linux systems Sourcery CodeBench Lite is provided as an executable installer package with the `.bin` extension.

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

2.5. Installing Sourcery CodeBench Lite

The method used to install Sourcery CodeBench Lite depends on your host system and the kind of installation package you have downloaded.

2.5.1. Using the Sourcery CodeBench Lite Installer on Microsoft Windows

If you have received Sourcery CodeBench Lite on CD, insert the CD in your computer. and double click on the CD. If you downloaded Sourcery CodeBench Lite, double-click on the installer. Extract the `.zip`. Browse to the folder where you extracted the installer and run the installer executable.

If you have an existing installation, select whether you want to install to a different location or upgrade the existing one.

After the installer starts, follow the on-screen dialogs to install Sourcery CodeBench Lite. The installer is intended to be self-explanatory and on most pages the defaults are appropriate.

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[1] https://sourcery.mentor.com/GNUToolchain/
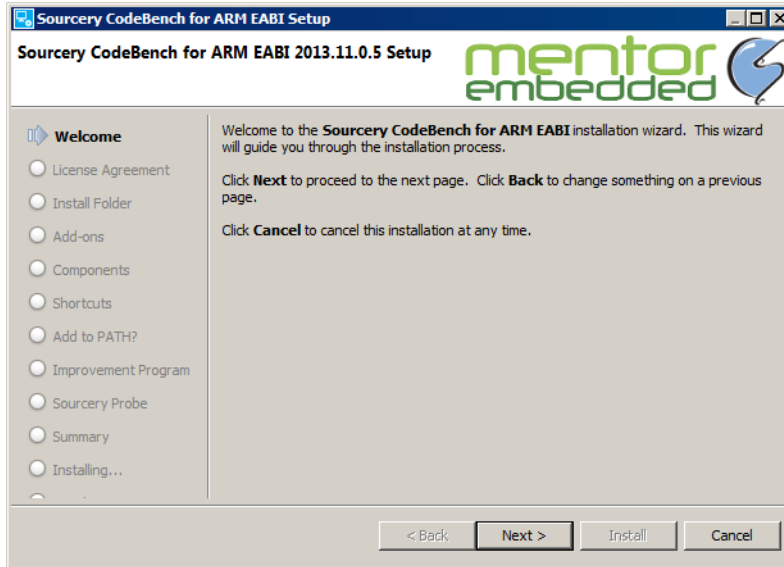
Running the Installer. The graphical installer guides you through the steps to install Sourcery CodeBench Lite.

You may want to change the install directory pathname and customize the shortcut installation.
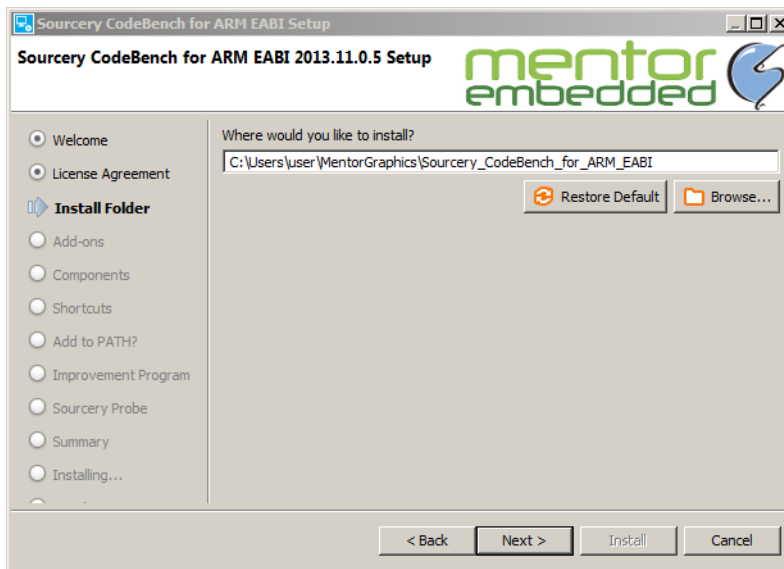

Choose Install Folder. Select the pathname to your install directory.

If you want to install add-ons, enter your Sourcery CodeBench Portal login information.
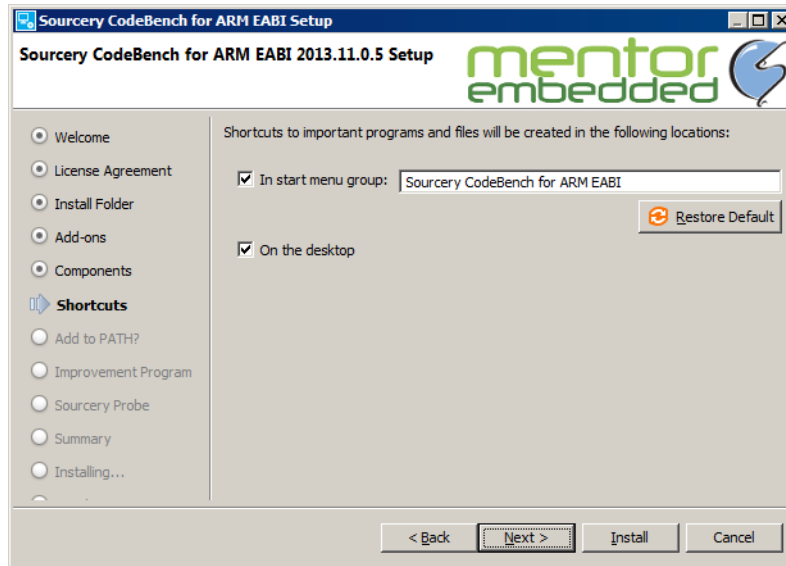
Choose Shortcut Folder.   You can customize where the installer creates shortcuts for quick access to Sourcery CodeBench Lite.

When the installer has finished, it asks if you want to launch a viewer for the Getting Started guide, or visit Mentor Embedded.
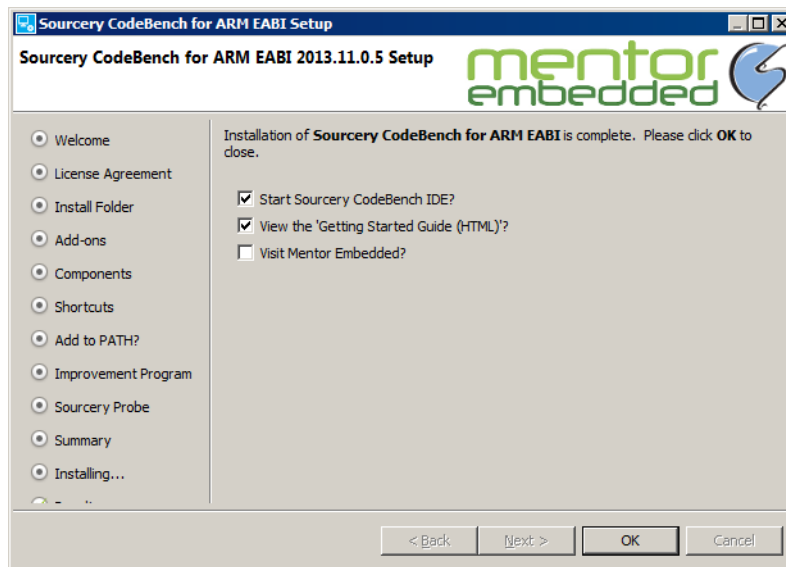
Install Complete.   You should see a screen similar to this after a successful install.

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 `-console` command-line option. For example:

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

2.5.2. Using the Sourcery CodeBench Lite Installer on GNU/Linux Hosts

Start the graphical installer by invoking the executable shell script:

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

The installer gets extracted into the default temporary directory. If you want to specify the directory for installer extraction, change the `P2_INSTALLER_TEMP_PATH` variable.

After the installer starts, follow the on-screen dialogs to install Sourcery CodeBench Lite. For additional details on running the installer, see the discussion and screen shots in the Microsoft Windows section above.

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 `-console` command-line option. For example:

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

2.5.3. Installing Sourcery CodeBench Lite from a Compressed Archive

You do not need to be a system administrator to install Sourcery CodeBench Lite from a compressed archive. You may install Sourcery CodeBench 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 CodeBench Lite in the `$HOME/CodeBench` subdirectory of your home directory and that the filename of the package you have downloaded is `/path/to/package.tar.bz2`. After installation the toolchain will be in `$HOME/CodeBench/sourceryg++-2014.11`.

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/CodeBench
```

Change to the installation directory:

```
> cd $HOME/CodeBench
```

Unpack the package:

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

2.6. Installing Sourcery CodeBench Lite Updates

If you have already installed a Sourcery CodeBench Lite for MIPS GNU/Linux version 2013.11 or later, 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.

You must uninstall any Sourcery CodeBench Lite versions prior to 2013.11 before unpacking a new version in the same location.

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 CodeBench commands for the MIPS GNU/Linux target all begin with `mips-linux-gnu`. This means that you can install Sourcery CodeBench for multiple target systems in the same directory without conflicts.

2.7. Setting up the Environment

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

2.7.1. Setting up the Environment on Microsoft Windows Hosts

2.7.1.1. Setting the `PATH`

The graphical installer for Sourcery CodeBench Lite does this setup for you, however it may not take effect until you next log in.

In order to use the Sourcery CodeBench tools from the command line, you should add them to your `PATH`. In the instructions that follow, replace *installdir* with the full pathname of your Sourcery CodeBench Lite installation directory, including the drive letter.

To set the `PATH` on a Microsoft Windows Vista system, use the following command in a `cmd.exe` shell:

```
> setx PATH "%PATH%;installdir\bin"
```

To set the `PATH` on a system running Microsoft Windows 7, from the desktop bring up the `Start` menu and right click on `Computer`. Select `Properties` and click on `Advanced system settings`. Go to the `Advanced` tab, then click on the `Environment Variables` button. Select the `PATH` variable and click `Edit`. Add the string `;installdir\bin` to the end, and click `OK`.

To set the `PATH` on a system running Microsoft Windows 8, navigate to the `Charms` menu. Click on `Search` then type `Control Panel`. Select `System` and click on `Advanced system settings`. Go to the `Advanced` tab, then click on the `Environment Variables` button. Select the `PATH` variable and click `Edit`. Add the string `;installdir\bin` to the end, and click `OK`.

You can verify that your `PATH` is set up correctly by starting a new `cmd.exe` shell and running:

```
> mips-linux-gnu-gcc -v
```

Verify that the last line of the output contains: `Sourcery CodeBench Lite 2014.11-22`.

2.7.1.2. Working with Cygwin

Sourcery CodeBench Lite does not require Cygwin or any other UNIX emulation environment. You can use Sourcery CodeBench directly from the Windows command shell. You can also use Sourcery CodeBench 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 CodeBench is not a Cygwin application, it does not, by default, recognize Cygwin paths.

If you are using Sourcery CodeBench from Cygwin, you should set the CYGPATH environment variable. If this environment variable is set, Sourcery CodeBench 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 CodeBench relies on the cygpath utility provided with Cygwin. You must provide Sourcery CodeBench with the full path to cygpath if cygpath is not in your PATH. For example:

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

directs Sourcery CodeBench 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.

2.7.2. Setting up the Environment on GNU/Linux Hosts

The graphical installer for Sourcery CodeBench Lite does this setup for you, however it may not take effect until you next log in.

Before using Sourcery CodeBench 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 installdir/bin:$PATH
```

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

```
> PATH=installdir/bin:$PATH
> export PATH
```

If you are not sure which shell you are using, try both commands. In both cases, replace installdir with the full pathname of your Sourcery CodeBench Lite installation directory.

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

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

```
> mips-linux-gnu-gcc -v
```

Verify that the last line of the output contains: Sourcery CodeBench Lite 2014.11-22.

2.8. Uninstalling Sourcery CodeBench Lite

The method used to uninstall Sourcery CodeBench Lite depends on the method you originally used to install it. 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. In particular, the mips-linux-gnu directory located in the install directory will be removed entirely by the uninstaller.

2.8.1. Using the Sourcery CodeBench Lite Uninstaller on Microsoft Windows

You should use the provided uninstaller to remove a Sourcery CodeBench Lite installation originally created by the graphical installer. Start the graphical uninstaller by invoking the Uninstall executable located in your installation directory, or use the uninstall shortcut created during installation. After the uninstaller starts, follow the on-screen dialogs to uninstall Sourcery CodeBench Lite.

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

To uninstall third-party drivers bundled with Sourcery CodeBench Lite, first disconnect the associated hardware device. Then use `Uninstall a program` (Vista and newer) or `Add or Remove Programs` (older versions of Windows) to remove the drivers separately. Depending on the device, you may need to reboot your computer to complete the driver uninstall.

2.8.2. Using the Sourcery CodeBench Lite Uninstaller on GNU/Linux

You should use the provided uninstaller to remove a Sourcery CodeBench Lite installation originally created by the executable installer script. 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 CodeBench Lite.

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

2.8.3. Uninstalling a Compressed Archive Installation

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

Chapter 3
Sourcery CodeBench Lite for MIPS GNU/Linux

This chapter contains information about features of Sourcery CodeBench Lite that are specific to MIPS GNU/Linux targets. You should read this chapter to learn how to best use Sourcery CodeBench Lite on your target system.

3.1. Included Components and Features

This section briefly lists the important components and features included in Sourcery CodeBench Lite for MIPS GNU/Linux, and tells you where you may find further information about these features.

Component	Version	Notes
GNU programming tools		
GNU Compiler Collection	4.9.1	Separate manual included.
GNU Binary Utilities	2.24.51.20140217	Includes assembler, linker, and other utilities. Separate manuals included.
Debugging support and simulators		
GNU Debugger	7.7.50-cvs	Separate manual included.
Sourcery CodeBench Debug Sprite	2014.11-22	Provided for kernel debugging only. See Chapter 5, "Sourcery CodeBench Debug Sprite".
GDB Server	N/A	Included with GDB. See Section 3.6, "Using GDB Server for Debugging".
QEMU Emulator	1.5.50	User-space emulation is supported on Linux hosts only. See Section 4.3, "Running Applications with QEMU".
Target libraries		
GNU C Library	2.20	Separate manual included.
uClibc C Library	0.9.30	
Linux Kernel Headers	3.16.2	
OpenMP	N/A	
Other utilities		
GNU Make	N/A	Build support on Windows hosts.
GNU Core Utilities	N/A	Build support on Windows hosts.
GNU/Linux Prelinker	N/A	See Section 4.5, "Using the Prelinker".

3.2. Library Configurations

Sourcery CodeBench Lite for MIPS GNU/Linux includes the following library configuration.

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

MIPS64 revision 2 - Big-Endian, N64	
Command-line option(s):	`-mabi=64`
Sysroot subdirectory:	`./`
Library subdirectories:	`lib64/` and `usr/lib64/`
Dynamic linker:	`lib64/ld.so.1`

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

MIPS64 revision 2 - Little-Endian, N64	
Command-line option(s):	`-EL -mabi=64`
Sysroot subdirectory:	`el/`
Library subdirectories:	`lib64/` and `usr/lib64/`
Dynamic linker:	`lib64/ld.so.1`

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

MIPS64 revision 2 - Big-Endian, Soft-Float, N64	
Command-line option(s):	`-msoft-float -mabi=64`
Sysroot subdirectory:	`soft-float/`
Library subdirectories:	`lib64/` and `usr/lib64/`
Dynamic linker:	`lib64/ld.so.1`

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

MIPS64 revision 2 - Little-Endian, Soft-Float, N64	
Command-line option(s):	`-EL -msoft-float -mabi=64`
Sysroot subdirectory:	`soft-float/el/`
Library subdirectories:	`lib64/` and `usr/lib64/`
Dynamic linker:	`lib64/ld.so.1`

MIPS32 revision 2 - Big-Endian, 2008 NaN, O32

Command-line option(s):	`-mnan=2008`
Sysroot subdirectory:	`nan2008/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld-linux-mipsn8.so.1`

MIPS32 revision 2 - Little-Endian, 2008 NaN, O32

Command-line option(s):	`-EL -mnan=2008`
Sysroot subdirectory:	`nan2008/el/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld-linux-mipsn8.so.1`

MIPS32 revision 2 - Little-Endian, Soft-Float, O32, microMIPS

Command-line option(s):	`-mmicromips -EL -msoft-float`
Sysroot subdirectory:	`micromips/soft-float/el/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld.so.1`

MIPS32 revision 2 - Big-Endian, O32, MIPS16

Command-line option(s):	`-mips16`
Sysroot subdirectory:	`mips16/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld.so.1`

MIPS32 revision 2 - Little-Endian, O32, MIPS16

Command-line option(s):	`-mips16 -EL`
Sysroot subdirectory:	`mips16/el/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld.so.1`

MIPS32 revision 2 - Big-Endian, Soft-Float, O32, MIPS16

Command-line option(s):	`-mips16 -msoft-float`
Sysroot subdirectory:	`mips16/soft-float/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld.so.1`

MIPS32 revision 2 - Little-Endian, Soft-Float, O32, MIPS16

Command-line option(s):	`-mips16 -EL -msoft-float`
Sysroot subdirectory:	`mips16/soft-float/el/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld.so.1`

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

MIPS32 revision 2 - uClibc, Little-Endian, O32	
Command-line option(s):	`-muclibc -EL`
Sysroot subdirectory:	`uclibc/el/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld-uClibc.so.0`

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

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

MIPS32 revision 2 - uClibc, Big-Endian, 2008 NaN, O32	
Command-line option(s):	`-muclibc -mnan=2008`
Sysroot subdirectory:	`uclibc/nan2008/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld-uClibc-mipsn8.so.0`

MIPS32 revision 2 - uClibc, Little-Endian, 2008 NaN, O32	
Command-line option(s):	`-muclibc -EL -mnan=2008`
Sysroot subdirectory:	`uclibc/nan2008/el/`
Library subdirectories:	`lib/` and `usr/lib/`
Dynamic linker:	`lib/ld-uClibc-mipsn8.so.0`

Sourcery CodeBench 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 link a target application, Sourcery CodeBench selects the multilib matching the build options you have selected.

Each multilib corresponds to a *sysroot* directory which 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 3.5, "Using Sourcery CodeBench 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 CodeBench 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.

3.3. Target Architectures

By default, Sourcery CodeBench 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.

3.4. Target Kernel Requirements

The GNU C library supplied with this version of Sourcery CodeBench Lite requires that Linux kernel version 2.6.32 or later be installed on the target in order to run applications.

To support hardware watchpoints with `gdbserver`, Linux 2.6.28 or later is required.

3.5. Using Sourcery CodeBench Lite on GNU/Linux Targets

In order to run and debug programs produced by Sourcery CodeBench on your GNU/Linux target system, 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 CodeBench 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 3.2, "Library Configurations" for a list of the included multilibs in this version of Sourcery CodeBench Lite, and the corresponding sysroot directory pathnames.

Note for Windows Host Users

The sysroots provided in Windows host packages for Sourcery CodeBench are not directly usable on the GNU/Linux target because of differences between the Windows and GNU/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 GNU/Linux target. Additionally, some files in the sysroot that should be marked executable on the GNU/Linux target are not marked executable on Windows. If you intend to use the sysroot provided with Sourcery CodeBench on a Windows host system as the basis for your GNU/Linux target filesystem, you must correct these issues after copying the sysroot to the target.

You have these choices for installing the sysroot on the target:

• You can install the files in the filesystem root on the target (that is, installing the files directly in `/etc/`, `/lib/`, and so on). All applications on the target then automatically use the Sourcery CodeBench libraries. This method is primarily useful when you are building a GNU/Linux root filesystem from scratch. If your target board already has a GNU/Linux filesystem installed, over-

writing the existing C library files is not recommended, as this 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 CodeBench 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 CodeBench depend on the Sourcery CodeBench dynamic linker included in the sysroot as well as the Sourcery CodeBench runtime libraries.

3.5.1. 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.

The next step is to identify the correct sysroot subdirectory in the Sourcery CodeBench Lite install directory on your host system. The sysroot you copy to the target must be the one that corresponds to the linker options you are using to build your applications. The tables in Section 3.2, "Library Configurations" tell you which sysroot subdirectories correspond to which sets of command-line options. From the command line, you can identify the appropriate sysroot for your program by invoking the compiler with `-print-sysroot` added to your other build options. This causes GCC to print the host sysroot pathname and exit.

The mechanism you use for copying the sysroot to your target board depends on its hardware and software configuration. You may be able to use FTP or SSH with a server already running on your target. If your target board does not have networking configured, you may be able to copy files using an SD card or USB memory stick, or via a file transfer utility over a serial line. The instructions that come with your board may include specific suggestions.

When running Sourcery CodeBench on a GNU/Linux host, as an alternative to copying files to the target system, you may be able to NFS-mount the Sourcery CodeBench Lite installation directory from your host system on the target system. It is especially convenient for debugging if you can make the sysroot pathname on the target system be identical to that on the GNU/Linux host system; refer to Section 3.6.3, "Setting the Sysroot in the Debugger" for further discussion of this issue.

Otherwise, you must copy files from the appropriate sysroot subdirectory in the `mips-linux-gnu/libc` directory of your Sourcery CodeBench Lite install to the target system. 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`.

3.5.2. 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.

Follow these steps:

1. First find the correct sysroot, dynamic linker, and library subdirectory for your selected multilib. Refer to Section 3.2, "Library Configurations". In the following steps, *sysroot* is the absolute path to the directory on the target where you have installed the sysroot corresponding to your selected multilib. *libsubdir* specifies the library subdirectories relative to the sysroot. *ldso* is the filename of the dynamic linker inside the respective *libsubdir*.

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

   ```
   -Wl,-rpath=sysroot/libsubdir:sysroot/usr/libsubdir \
   -Wl,--dynamic-linker=sysroot/libsubdir/ldso
   ```

   For the default multilib, this becomes:

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

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

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

or

```
> ./factorial
./factorial: 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 `./factorial` executable that is missing rather than the dynamic linker it references.

3.5.3. Specifying the Sysroot Location at Runtime

You can invoke the Sourcery CodeBench 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. First find the correct sysroot, dynamic linker, and library subdirectory for your selected multilib. Refer to Section 3.2, "Library Configurations". In the following steps, *sysroot* is the absolute path to the directory on the target where you have installed the sysroot corresponding to your se-

lected multilib. `libsubdir` specifies the library subdirectories relative to the sysroot. `ldso` is the filename of the dynamic linker inside the respective `libsubdir`.

3. On the target system, invoke the dynamic linker with your executable as:

```
> sysroot/libsubdir/ldso \
  --library-path sysroot/libsubdir:sysroot/usr/libsubdir \
  /path/to/your-executable
```

For the default multilib, this becomes:

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

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.

3.6. Using GDB Server for Debugging

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

3.6.1. 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 3.2, "Library Configurations" for details.

You must copy the sysroot to your target system as described in Section 3.5.1, "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 3.5.2, "Using Linker Options to Specify the Sysroot Location". You must also invoke `gdbserver` itself using the dynamic linker provided in the Sourcery CodeBench sysroot, as described in Section 3.5.3, "Specifying the Sysroot Location at Runtime". In other words, the command to invoke `gdbserver` in this case would be similar to:

```
> sysroot/libsubdir/ldso \
  --library-path sysroot/libsubdir:sysroot/usr/libsubdir \
```

```
  sysroot/usr/libsubdir/bin/gdbserver :10000 \
  program arg1 arg2 ...
```

For the default multilib, this becomes:

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

3.6.2. 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.

3.6.3. 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. In particular, this is the case if you are running GDB on a Linux host and using QEMU user-space emulation on that same host as your target. 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 path-names 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 3.5.1, "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.

3.7. GENIVI 3.0 Compliance

GENIVI is a non-profit industry alliance of automotive OEMs working on adoption of an In-Vehicle Infotainment (IVI) open-source development platform. Mentor Graphics is a member of the alliance.

A change made to the Mentor Embedded Linux kernel to support the GENIVI 3.0 specification required that same support be added to the GNU C Library included in Sourcery CodeBench.

The new `AF_BUS` socket address family, used in kernel inter-process communication, is included in GLIBC for Sourcery CodeBench Lite..

This change has not been incorporated in the upstream Linux kernel sources nor into upstream GLIBC. Therefore, this release of Sourcery CodeBench may not be compatible with future versions of the Linux kernel.

For more information about GENIVI, see the alliance website[1].

3.8. Using OpenMP

Sourcery CodeBench Lite for MIPS GNU/Linux includes the GNU OpenMP library (libgomp). This is an API that supports multi-platform shared-memory parallel programming.

To compile programs that use OpenMP features, use the `-fopenmp` command-line option. For more information about OpenMP, see `http://www.openmp.org/`.

---

[1] http://www.genivi.org

Chapter 4
Using Sourcery CodeBench from the Command Line

This chapter demonstrates the use of Sourcery CodeBench Lite from the command line.

4.1. Building an Application

This chapter explains how to build an application with Sourcery CodeBench 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 `main.c` containing the following simple factorial program:

```
#include <stdio.h>

int factorial(int n) {
  if (n == 0)
    return 1;
  return n * factorial (n - 1);
}

int main () {
  int i;
  int n;
  for (i = 0; i < 10; ++i) {
    n = factorial (i);
    printf ("factorial(%d) = %d\n", i, n);
  }
  return 0;
}
```

Compile and link this program using the command:

```
> mips-linux-gnu-gcc -o factorial main.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++`.)

4.2. Running Applications on the Target System

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

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

```
> factorial
```

You should see:

```
factorial(0) = 1
factorial(1) = 1
factorial(2) = 2
factorial(3) = 6
factorial(4) = 24
factorial(5) = 120
factorial(6) = 720
factorial(7) = 5040
```

```
factorial(8) = 40320
factorial(9) = 362880
```

4.3. Running Applications with QEMU

On Linux hosts, Sourcery CodeBench Lite includes the QEMU user-space emulator. This is a program which runs on your host computer and allows you to run and debug MIPS GNU/Linux applications without target hardware. Because QEMU's user-space emulation works by translating Linux system calls made by the target program into corresponding calls on the host Linux system, you cannot run this emulator on a Windows host.

To use QEMU, you first need to find the sysroot directory in your Sourcery CodeBench Lite install-ation that matches your compilation options, as described in Section 3.5, "Using Sourcery CodeBench Lite on GNU/Linux Targets". For example, the sysroot for the default multilib is in the `mips-linux-gnu/libc` subdirectory of your install directory.

Applications run with the QEMU emulator share the environment and file system of the host computer, so you do not need to copy the sysroot. However, you must tell QEMU where to find the sysroot on the host. You can do this by providing appropriate linker options when building your application, as described in Section 3.5.2, "Using Linker Options to Specify the Sysroot Location". Alternatively, you can invoke the dynamic linker directly to run your program, as described in Section 3.5.3, "Specifying the Sysroot Location at Runtime".

If you use linker options to set the sysroot pathname, you can invoke QEMU as:

```
> mips-linux-gnu-qemu program arguments...
```

where `program` is the executable to run, and `arguments` are any command-line arguments to your program.

If you want to invoke the dynamic linker directly instead, use a command similar to:

```
> mips-linux-gnu-qemu sysroot/lib/ld.so.1 \
  --library-path sysroot/lib:sysroot/usr/lib \
  program arguments...
```

Refer to Section 3.5.3, "Specifying the Sysroot Location at Runtime" for additional details on running the dynamic linker.

You can specify emulation of a specific CPU by providing the `--cpu` option to QEMU. The default is `24Kf`. Additional supported CPU emulations include `4Kc`, `4Km`, `4KEcR1`, `4KEmR1`, `4KEc`, `4KEm`, `24Kc`, `34Kf`, `M14K`, and `M14Kc`.

By default, QEMU reports the minimum Linux kernel version required by the GNU C library included with this release of Sourcery CodeBench to applications via the `uname` system call. You can specify some other kernel version using the `-r` command-line option. QEMU's emulation is generally inde-pendent of the kernel version on the host Linux system.

QEMU includes a built-in GDB server which you can use to debug your program with GDB. Start QEMU with the `-g port` command-line option. You can generally choose any port number that is not already in use on your host system. Then, follow the instructions in Section 4.4.2, "Connecting to an External GDB Server" to connect from GDB.

The version of QEMU included with Sourcery CodeBench Lite for MIPS GNU/Linux is configured to run in user-space emulation mode only, and other QEMU features not documented here are not

supported in Sourcery CodeBench Lite. For additional information about QEMU, visit the QEMU web site[1].

4.4. 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.

When starting GDB, give it the pathname to the program you want to debug as a command-line argument. For example, if you have built the factorial program as described in Section 4.1, "Building an Application", enter:

```
> mips-linux-gnu-gdb factorial
```

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.

4.4.1. Connecting to the Sourcery CodeBench Debug Sprite

The Sourcery CodeBench Debug Sprite is a program that runs on the host system to support hardware debugging devices. You can use the Debug Sprite to run and debug programs on a target board without an operating system, or to debug an operating system kernel. See Chapter 5, "Sourcery CodeBench Debug Sprite" for detailed information about the supported devices.

You can start the Sprite directly from within GDB:

```
(gdb) target remote | mips-linux-gnu-sprite device-url board-file
```

Refer to Section 5.2, "Invoking Sourcery CodeBench Debug Sprite" for a full description of the Sprite arguments.

4.4.2. Connecting to an External GDB Server

Sourcery CodeBench 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 CodeBench 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.

You can also use this method to connect to a QEMU user-space emulator that you have started with the `-g port` option. In the usual case where QEMU is running on the same host as the debugger, you can omit the *host* part of the GDB command and simply use:

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

For more information about starting QEMU, see Section 4.3, "Running Applications with QEMU".

---

[1] http://fabrice.bellard.free.fr/qemu

4.5. Using the Prelinker

You can make programs that use ELF shared libraries start up faster by processing the binaries with the prelinker. This utility is called the *prelinker* because it preprocesses the application binaries and shared libraries before dynamic linking. On the other hand, prelinking is performed *after* the normal linking step (`mips-linux-gnu-ld` invocation) that builds the executables and shared libraries.

Prelinking operates by performing some of the functions of the dynamic linker in advance. Specifically, it pre-assigns ELF shared libraries to virtual address slots that are the same in all prelinked applications, and writes the modified relocation information back to the ELF files for the affected libraries and applications. At program startup time, the dynamic linker checks whether the precomputed shared library relocations are still valid; if they are, several initialization steps can be skipped, resulting in an improved startup time. If not (for example, if a shared library has been modified since the program was prelinked), it falls back on the normal dynamic linking process. Prelinking is reversible and can be re-run to perform incremental updates when applications or the libraries they depend on change.

Prelinking only works on shared libraries that are explicitly linked with application programs. If your application uses `dlopen` to load shared libraries, that operation is not affected by the prelinker. This is because the prelinker cannot predict in advance which libraries are to be loaded with `dlopen`, or in what order.

For best results, the prelinker should be run on an entire set of executables and their dependent libraries at once, rather than on application executables individually. For example, the native prelinker shipped with many Linux systems is intended to operate on all of the standard system utilities and libraries. The version of the prelinker included in Sourcery CodeBench Lite additionally supports prelinking of a cross-built root file system. Invoke `mips-linux-gnu-prelink` with the `--root=`*pathname* command-line option to specify the path to the root of the target file system. All other pathnames referenced by the prelinker, including those of any executables specified on the command line, are relative to this root.

4.5.1. Configuration File

The first step in running the prelinker is to create a configuration file. This is canonically called `/etc/prelink.conf` in the target file system. Even if you plan to only prelink selected application binaries, you should create a configuration file listing the directories to search for the shared libraries referenced by the applications. The prelinker does not prelink against libraries that are neither findable from the configuration file, nor explicitly listed on the command line.

The contents of the configuration file are a list of directories on the target file system to recursively scan, and patterns matching names of files to be skipped. Specifically, it can contain lines of the following forms:

- Comment lines starting with `#`.

- Directory names to be recursively searched. Optionally, directory names can be prefixed with options `-l` (do not search across file systems) or `-h` (follow symbolic links).

- Blacklist patterns prefixed with the `-b` option, which specify directories and files to be skipped during the recursive search. The operand can be either a directory name, the name of an individual file, or a glob pattern to be matched against filenames in each directory.

For example, here is a simple configuration file.

```
# Search in these directories.
-l /lib
-l /usr/lib
# Ignore files matching these patterns.
-b /lib/firmware
-b *.h
-b *.xml
-b *.xslt
```

4.5.2. Invoking the Prelinker

The prelinker has two primary modes of operation:

1. Prelink only certain executables against a set of libraries.

   ```
   > mips-linux-gnu-prelink --root=pathname executable1 ...
   ```

   In this case, the executables to be prelinked are specified on the command line. The configuration file is used only to search for the shared libraries that are used by the given programs. If you wish, you can also specify additional library pathnames on the command line.

2. Prelink all the libraries and executables in a given set of directories.

   ```
   > mips-linux-gnu-prelink -a --root=pathname
   ```

   If the -a option is specified, then the directories listed in the configuration file are searched for executables to be prelinked, as well as for the libraries they reference. While this usage also permits additional executables and libraries to be specified on the command line, the recommended practice is to list all files of interest in the configuration file instead.

Refer to the man page for the prelinker for documentation for other command-line options.

Chapter 5
Sourcery CodeBench Debug Sprite

This chapter describes the use of the Sourcery CodeBench Debug Sprite for remote debugging. The Sprite is provided for debugging of the Linux kernel on the target board. This chapter includes information about the debugging devices and boards supported by the Sprite for MIPS GNU/Linux.

Sourcery CodeBench Lite contains the Sourcery CodeBench Debug Sprite for MIPS GNU/Linux. This Sprite is provided to allow debugging of programs running on a bare board. You can use the Sprite to debug a program when there is no operating system on the board, or for debugging the operating system itself. If the board is running an operating system, and you wish to debug a program running on that OS, you should use the facilities provided by the OS itself (for instance, using gdbserver).

The Sprite acts as an interface between GDB and external debug devices and libraries. Refer to Section 5.2, "Invoking Sourcery CodeBench Debug Sprite" for information about the specific devices supported by this version of Sourcery CodeBench Lite.

> **Note for Linux users**
>
> The Debug Sprite provided with Sourcery CodeBench Lite allows remote debugging of the Linux kernel running on the target. For remote debugging of application programs, you should use gdbserver instead. See Chapter 3, "Sourcery CodeBench Lite for MIPS GNU/Linux" for details about how to install and run gdbserver on the target.

> **Important**
>
> The Sourcery CodeBench Debug Sprite is not part of the GNU Debugger and is not free or open-source software. You may use the Sourcery CodeBench Debug Sprite only with the GNU Debugger. You may not distribute the Sourcery CodeBench Debug Sprite to any third party.

5.1. Probing for Debug Devices

Before running the Sourcery CodeBench Debug Sprite for the first time, or when attaching new debug devices to your host system, it is helpful to verify that the Sourcery CodeBench Debug Sprite recognizes your debug hardware. From the command line, invoke the Sprite with the -i option:

```
> mips-linux-gnu-sprite -i
```

This prints out a list of supported device types. For devices that can be autodetected, it additionally probes for and prints out a list of attached devices. For instance:

```
Sourcery CodeBench Debug Sprite for MIPS (Sourcery CodeBench Lite \
2014.11-22)
mdi: [lib=<file>&cfg=<file>&rst=<n>] MDI device
  mdi:///23/1 - 24KE     (Instruction)/24KE LE
  mdi:///23/2 - 24KE     (Instruction)/24KE BE
  mdi:///24/1 - 24KE     (Cycle)/24KE LE
  mdi:///24/2 - 24KE     (Cycle)/24KE BE
  mdi:///$Target/$Device - Generic MDI target/device
```

This shows that MDI (Microprocessor Debug Interface) devices are supported. Four MIPSsim devices have been autodetected. Note that additional configuration steps for the MDI library are required to allow the Sprite to autodetect devices; see Section 5.4, "MDI Devices".

5.2. Invoking Sourcery CodeBench Debug Sprite

The Debug Sprite is invoked as follows:

```
> mips-linux-gnu-sprite [options] device-url board-file
```

The `device-url` specifies the debug device to use to communicate with the board. It follows the standard format:

```
scheme:scheme-specific-part[?device-options]
```

Most device URL schemes also follow the regular format:

```
scheme:[//hostname:[port]]/path[?device-options]
```

The meanings of `hostname`, `port`, `path` and `device-options` parts depend on the `scheme` and are described below. The following schemes are supported in Sourcery CodeBench Lite for MIPS GNU/Linux:

mdi   Use a Microprocessor Debug Interface (MDI) debugging device. Refer to Section 5.4, "MDI Devices".

The optional `?device-options` portion is allowed in all schemes. These allow additional device-specific options of the form `name=value`. Multiple options are concatenated using `&`.

The `board-file` specifies an XML file that describes how to initialize the target board, as well as other properties of the board used by the debugger. If `board-file` refers to a file (via a relative or absolute pathname), it is read. Otherwise, `board-file` can be a board name, and the toolchain's board directory is searched for a matching file. See Section 5.6, "Supported Board Files" for the list of supported boards, or invoke the Sprite with the `-b` option to list the available board files. You can also write a custom board file; see Section 5.7, "Board File Syntax" for more information about the file format.

Both the `device-url` and `board-file` command-line arguments are required to correctly connect the Sprite to a target board.

5.3. Sourcery CodeBench Debug Sprite Options

The following command-line options are supported by the Sourcery CodeBench Debug Sprite:

-a   Attach to a process already running on the target. Without this option, the default behavior is to reset the target on the initial connection, in preparation for loading a new program from the debugger.

-b   Print a list of `board-file` files in the board config directory.

-h   Print a list of options and their meanings. A list of `device-url` syntaxes is also shown.

-i   Print a list of the accessible devices. If a `device-url` is also specified, only devices for that device type are scanned. Each supported device type is listed along with the options that can be appended to the `device-url`. For each discovered device, the `device-url` is printed along with a description of that device.

-l *[host]:port*   Specify the host address and port number to listen for a GDB connection. If this option is not given, the Debug Sprite communicates with GDB using stdin and stdout. If you start the Sprite from within GDB using the `target remote | mips-linux-gnu-sprite ...` command, you do not need this option.

`-m`	Listen for multiple sequential connections. Normally the Debug Sprite terminates after the first connection from GDB terminates. This option instead makes it listen for a subsequent connection. To terminate the Sprite, open a connection and send the string `END\n`.
`-q`	Do not print any messages.
`-v`	Print additional messages.

If any of `-b`, `-i` or `-h` are given, the Debug Sprite terminates after providing the information rather than waiting for a debugger connection.

5.4. MDI Devices

The Sourcery CodeBench Debug Sprite for MIPS supports MDI (Microprocessor Debug Interface) devices. Each MDI device is identified by a target number and device number; these form the `path` part of the device URL, and the `hostname` and `port` must be empty or omitted. Thus, the `device-url` has the form:

```
mdi:///targetnum/devicenum[?device-options]
```

You can also use the environment variables GDBMDITARGET and GDBMDIDEVICE to provide defaults for the `targetnum` and `devicenum`.

The following `device-options` are permitted:

`lib=filename`	This option specifies the MDI library to load. It is equivalent to setting the GDBMDILIB environment variable.
`cfg=filename`	Some MDI target libraries, such as MIPSsim, require a configuration file. (This is distinct from the Sprite's own `board-file`.) You can use this option to specify the file. It is equivalent to setting the GDBMIPSSIMCONFIG environment variable.
`rst=seconds`	This option can be used to specify a delay after the target is reset by the Sprite. If the value of `seconds` is greater than zero, then execution is resumed for the specified number of seconds; this can be used to allow power-on firmware to initialize the memory controller and peripherals. Then the target is halted again and queried for configuration.
	If the value of `seconds` is `-1`, then the target is queried immediately without reset. This is the same effect as passing the `-a` command-line option to the Sprite, which allows the Sprite to attach to a running program.
	This option is equivalent to setting the GDBMDICONNRST environment variable. If neither the option nor the environment variable are provided, the default is to reset the target and query it immediately unless the `-a` option is specified.
`group=/targetn/devicen`	This option may be specified multiple times and is cumulative. Each of the specified devices is opened and queried and they are all treated as threads of execution, subject to being enabled or active; if a device is disabled or has no active thread contexts

associated with it, it is not visible to GDB but is still under control of the Sprite in case its state changes. This option cannot be used in combination with the `team=` option.

`team=/targetn/devicen`   This option may be specified multiple times and is cumulative. The specified devices are not opened, but are associated with the base device by means of the MDI team mechanism for the purpose of synchronization. The specified devices may still be opened and controlled by another debugger (such as another instance of the Debug Sprite) independently. This option cannot be used in combination with the `group=` option.

Before you can connect to a target using the MDI API, you must tell the Debug Sprite which shared library or DLL to load for your simulator or device. On Linux hosts you should add the directory containing the shared library files to your `LD_LIBRARY_PATH` environment variable. On Windows hosts, add the directory containing the DLLs to your `PATH` environment variable. Then, either set the environment variable `GDBMDILIB` to the base name of the MDI library before starting the Debug Sprite, or use the `lib=` device option to specify the library to load.

Similarly, the `-i` command-line option can only probe for devices if you have set the `PATH` or `LD_LIBRARY_PATH` environment variable appropriately, and specify an MDI library using either the `GDBMDILIB` environment variable or the `lib=` device option. Otherwise, it reports only the generic `device-url` syntax.

For example, to use an FS2 probe on a Windows host to debug a MIPS Malta board, first add the directory containing the MDI DLLs to your `PATH`. Then you can invoke the Sprite from GDB using a command line similar to:

```
(gdb) target remote | mips-linux-gnu-sprite \
'mdi:///2/2?lib=jnetfs2mdilib.dll&rst=7' malta
```

The quotes are required to prevent special characters in the `device-url` from being interpreted by the shell.

In the above command, the `rst=7` option provides for a sufficient delay for the board's reset code to execute on connection. Since this takes several seconds, GDB may time out waiting for the Sprite to respond. You can prevent this by issuing this command before you connect to the Sprite:

```
(gdb) set remotetimeout 10
```

To use the Sprite with MIPSsim, a configuration file is required. The configuration files provided with the MIPSsim distribution are intended for use with standalone execution from the command line, rather than running the program from the debugger. So, make a copy and comment out the `APP_FILE` setting. It is also recommended that you comment out `TRACE_FILE` as well, since the trace files can be very large.

To connect to MIPSsim using the Sprite on a Linux host, first set your `LD_LIBRARY_PATH` and `GDBMDILIB` as described above. You can run the Sprite from the shell to probe for devices to verify that your setup is correct:

```
> mips-linux-gnu-sprite -i
```

Then, from GDB, use a command similar to:

```
(gdb) target remote | mips-linux-gnu-sprite \
'mdi:///23/2?cfg=24KE.cfg&rst=-1' mipssim
```

Fill in your target and device numbers as reported by the probe output, and the full pathname to your configuration file. The `rst=-1` option is required, as MIPSsim does not support reset.

This section describes only the basic MDI usage; refer to the documentation for your MDI simulator or debug device for details specific to that target. Note, in particular, that some MDI targets may require you to set up a license in addition to the steps given here.

5.5. Debugging a Remote Board

You can run the Sourcery CodeBench Debug Sprite on a different machine from the one on which GDB is running. For example, if your board is connected to a machine in your lab, you can run the debugger on your laptop and connect to the remote board. The Sourcery CodeBench Debug Sprite must run on the machine that is connected to the target board. You must have Sourcery CodeBench installed on both machines.

To use this mode, you must start the Sprite with the `-l` option and specify the port on which you want it to listen. For example:

```
> mips-linux-gnu-sprite -l :10000 device-url board-file
```

starts the Sprite listening on port 10000.

When running GDB from the command line, use the following command to connect GDB to the remote Sprite:

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

where *host* is the name of the remote machine. After this, debugging is just as if you are debugging a target board connected to your host machine.

For more detailed instructions on using the Sourcery CodeBench Debug Sprite in this way, please refer to the Sourcery CodeBench Knowledge Base[1].

5.6. Supported Board Files

The Sourcery CodeBench Debug Sprite for MIPS GNU/Linux includes support for the following target boards. Specify the appropriate *board-file* as an argument when invoking the Sprite from the command line.

Board	Config
MIPS Malta	`malta`
MIPS Malta 64-bit	`malta64`
MIPS SEAD-3 LX110	`sead3-lx110`
MIPS SEAD-3 LX50	`sead3-lx50`
MIPS Simulator	`mipssim`

---

[1] https://sourcery.mentor.com/GNUToolchain/kbentry132

5.7. Board File Syntax

The *board-file* can be a user-written XML file to describe a non-standard board. The Sourcery CodeBench Debug Sprite searches for board files in the `mips-linux-gnu/lib/boards` directory in the installation. Refer to the files in that directory for examples.

The file's DTD is:

```
<!-- Board description files

     Copyright (c) 2007-2012 Mentor Graphics Corporation.

     THIS FILE CONTAINS PROPRIETARY, CONFIDENTIAL, AND TRADE
     SECRET INFORMATION OF MENTOR GRAPHICS AND/OR ITS LICENSORS.

     You may not use or distribute this file without the express
     written permission of Mentor Graphics or its authorized
     distributor.  This file is licensed only for use with
     Sourcery CodeBench.  No other use is permitted.
     -->

<!ELEMENT board
 (category?, properties?, feature?, initialize?, memory-map?, \
debuggerDefaults?)>

<!-- Board category to group boards list into the tree -->
<!ELEMENT category (#PCDATA)>

<!ELEMENT properties
 (description?, property*)>

<!ELEMENT initialize
 (write-register | write-memory | delay
   | wait-until-memory-equal | wait-until-memory-not-equal)* >
<!ELEMENT write-register EMPTY>
<!ATTLIST write-register
         address CDATA   #REQUIRED
                         value   CDATA   #REQUIRED
                         bits    CDATA   #IMPLIED>
<!ELEMENT write-memory EMPTY>
<!ATTLIST write-memory
         address CDATA   #REQUIRED
                         value   CDATA   #REQUIRED
                         bits    CDATA   #IMPLIED>
<!ELEMENT delay EMPTY>
<!ATTLIST delay
         time CDATA    #REQUIRED>
<!ELEMENT wait-until-memory-equal EMPTY>
<!ATTLIST wait-until-memory-equal
         address CDATA   #REQUIRED
                         value   CDATA   #REQUIRED
                         timeout CDATA   #IMPLIED
                         bits    CDATA   #IMPLIED>
```

```
<!ELEMENT wait-until-memory-not-equal EMPTY>
<!ATTLIST wait-until-memory-not-equal
         address CDATA   #REQUIRED
                        value   CDATA   #REQUIRED
                        timeout CDATA   #IMPLIED
                        bits    CDATA   #IMPLIED>


<!ELEMENT memory-map (memory-device)*>
<!ELEMENT memory-device (property*, description?, sectors*)>
<!ATTLIST memory-device
                        address CDATA   #REQUIRED
         size    CDATA   #REQUIRED
         type    CDATA   #REQUIRED
                        device  CDATA   #IMPLIED>


<!ELEMENT description (#PCDATA)>
<!ELEMENT property (#PCDATA)>
<!ATTLIST property name CDATA #REQUIRED>
<!ELEMENT sectors EMPTY>
<!ATTLIST sectors
 size CDATA #REQUIRED
 count CDATA #REQUIRED>

<!-- Definition of default option values for each debug interface -->
<!ELEMENT debuggerDefaults (debugInterface*)>
<!ELEMENT debugInterface (option*)>
<!ATTLIST debugInterface
 name CDATA #REQUIRED
>
<!ELEMENT option EMPTY>
<!ATTLIST option
 name CDATA #REQUIRED
 defaultValue CDATA #REQUIRED
>


<!ENTITY % gdbtarget SYSTEM "gdb-target.dtd">
%gdbtarget;
```

All values can be provided in decimal, hex (with a `0x` prefix) or octal (with a `0` prefix). Addresses and memory sizes can use a `K`, `KB`, `M`, `MB`, `G` or `GB` suffix to denote a unit of memory. Times must use a `ms` or `us` suffix.

The following elements are available:

`<board>`   This top-level element encapsulates the entire description of the board. It can contain `<category>`, `<properties>`, `<feature>`, `<initialize>` and `<memory-map>` elements.

`<category>`   The `<category>` element specifies a '.' separated categorization of this board (e.g., Vendor.Family) to allow grouping similar boards in a tree structure.

`<properties>` The `<properties>` element specifies specific properties of the target system. This element can occur at most once. It can contain a `<description>` element.

`<initialize>` The `<initialize>` element defines an initialization sequence for the board, which the Sprite performs before downloading a program. It can contain `<write-register>`, `<write-memory>` and `<delay>` elements.

`<feature>` This element is used to inform GDB about additional registers and peripherals available on the board. It is passed directly to GDB; see the GDB manual for further details.

`<memory-map>` This element describes the memory map of the target board. It is used by GDB to determine where software breakpoints may be used and when flash programming sequences must be used. This element can occur at most once. It can contain `<memory-device>` elements.

`<memory-device>` This element specifies a region of memory. It has four attributes: `address`, `size`, `type` and `device`. The `address` and `size` attributes specify the location of the memory device. The `type` attribute specifies that device as `ram`, `rom` or `flash`. The `device` attribute is required for `flash` regions; it specifies the flash device type. The `<memory-device>` element can contain a `<description>` element.

`<write-register>` This element writes a value to a control register. It has three attributes: `address`, `value` and `bits`. The `bits` attribute, specifying the bit width of the write operation, is optional; it defaults to 32.

`<write-memory>` This element writes a value to a memory location. It has three attributes: `address`, `value` and `bits`. The `bits` attribute is optional and defaults to 32. Bit widths of 8, 16 and 32 bits are supported. The address written to must be naturally aligned for the size of the write being done.

`<delay>` This element introduces a delay. It has one attribute, `time`, which specifies the number of milliseconds, or microseconds to delay by.

`<description>` This element encapsulates a human-readable description of its enclosing element.

`<property>` The `<property>` element allows additional name/value pairs to be specified. The property name is specified in a `name` attribute. The property value is the body of the `<property>` element.

`<debuggerDefaults>` The `<debuggerDefaults>` element defines the default option values for each debug interface.

Chapter 6
Next Steps with Sourcery CodeBench

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

6.1. Sourcery CodeBench Support

If you have a Sourcery CodeBench subscription, you may manage your account by visiting the Sourcery CodeBench Portal[1]. The Portal gives you access to technical support, the latest software updates, and the Sourcery CodeBench Knowledge Base.

If you have a support account, but are unable to log in to the Portal, send email to `<sourcery_support@mentor.com>` for assistance.

6.2. Sourcery CodeBench Knowledge Base

The Sourcery CodeBench Knowledge Base is available to registered users at the Sourcery CodeBench Portal[2]. Here you can find solutions to common problems including installing Sourcery CodeBench, 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.

6.3. Manuals for GNU Toolchain Components

Sourcery CodeBench 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 CodeBench 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 CodeBench Lite, the documentation can be found in the `share/doc/mips-mips-linux-gnu/` subdirectory of your installation directory.

In addition to the detailed reference manuals, Sourcery CodeBench 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/mips-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 CodeBench man pages to your `MANPATH` environment variable. This should go in your `.profile` or equivalent shell startup file; see Section 2.7, "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 CodeBench 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.

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[1] https://sourcery.mentor.com/GNUToolchain/
[2] https://sourcery.mentor.com/GNUToolchain/

Appendix A
Sourcery CodeBench Lite Release Notes

This appendix contains information about changes in this release of Sourcery CodeBench Lite for MIPS GNU/Linux. You should read through these notes to learn about new features and bug fixes.

A.1. Changes in Sourcery CodeBench Lite for MIPS GNU/Linux

This section documents Sourcery CodeBench Lite changes for each released revision.

A.1.1. Changes in Sourcery CodeBench Lite 2014.11-22

Bug fix for incorrect code.   A bug that caused incorrect code to be generated when compiling with the `-pg` and `-fuse-caller-save` options has been fixed.

MIPS new processor support.   GCC now supports the MIPS32R3, MIPS32R5, MIPS64R3, and MIPS64R5 processors. You can use the command line options `-march=mips32r3`, `-march=mips32r5`, `-march=mips64r3`, and `-march=mips64r5` to enable code generation for these targets.

MIPS XPA support.   GAS now supports the MIPS eXtended Physical Address (XPA) ASE. You can specify the `-mxpa` option to GCC and GAS to indicate that XPA instructions are being used.

Optimized `strcmp`.   `strcmp` has now been optimized for speed.

A.1.2. Changes in Sourcery CodeBench Lite 2014.11-9

Long path support on Windows hosts.   Sourcery CodeBench Lite on Microsoft Windows hosts now supports source and object files with paths longer than 259 characters. (These were already supported on GNU/Linux hosts.)

Internal compiler error fix.   GCC now issues a diagnostic instead of crashing with an internal compiler error on code using `register` and `asm` to assign variables to registers that are reserved for special purposes (such as the program counter) or are otherwise unsuitable for the type of the variable.

Internal compiler error fix.   A bug in GCC has been fixed that sometimes caused internal compiler errors in `var-tracking.c` when compiling with optimization and debug information enabled.

GCC version 4.9.1.   Sourcery CodeBench Lite for MIPS GNU/Linux is now based on GCC version 4.9.1. For more information about changes from GCC version 4.8 that was included in previous releases, see `http://gcc.gnu.org/gcc-4.9/changes.html`.

Fix for debug information bug.   A bug has been fixed that caused errors in the GNU binary utilities, such as running out of memory during linking or displaying incorrect section sizes in objdump. The bug was triggered by objects containing uncompressed debug information for symbols whose names start with `ZLIB`.

GNU C Library version 2.20.   Sourcery CodeBench Lite for MIPS GNU/Linux now includes the GNU C Library version 2.20, replacing the previous EGLIBC version 2.18. For more information about changes, see `http://www.gnu.org/software/libc/`.

Linux kernel headers update.   Linux kernel header files have been updated to version 3.16.2.

Linux kernel headers update.   Linux kernel header files have been updated to version 3.15.

Complex variables manipulation fix.   A bug has been fixed that caused GDB to corrupt complex variables living in registers whenever their values were modified.

GDB `set mips compression` command bug fix. A bug in the GDB `set mips compression` command has been fixed that caused it to have no effect.

A.1.3. Changes in Sourcery CodeBench Lite 2014.05-27

Signaling NaN conversion bug. A bug that caused incorrect conversion of a signaling NaN between double and float types has been fixed.

Assembler symbol difference fix. A bug has been fixed that sometimes caused the assembler to miscalculate the difference between two symbols.

Fix for linker relocation overflow errors. A bug has been fixed that caused `relocation truncated to fit` errors when linking PIC objects that were compiled with the `-mxgot` option and have many symbols.

GDB memory manipulation fix. A bug has been fixed that caused GDB to read incorrect contents from breakpoint addresses, leading to unpredictable behavior and erroneous backtraces.

Line single-stepping GDB bug fix. A bug in GDB sometimes prevented line single-stepping within MIPS16 or microMIPS code from stopping at the intended place. Execution continued until the current function completed or a breakpoint was hit. The bug affected debugging with MDI devices and has been fixed now.

A.1.4. Changes in Sourcery CodeBench Lite 2014.05-4

Instrumentation bug fix. A bug that caused GCC to instrument functions tagged with `__attribute__((no_instrument_function))` when compiling with `-fprofile-arcs` has been fixed.

Fix for microMIPS illegal instruction errors. A bug that caused GCC to emit invalid microMIPS store instructions has been fixed.

GCC option `-mvirt`. GCC now passes the `-mvirt` command-line option to GAS.

GCC version 4.8.3 prerelease. Sourcery CodeBench Lite for MIPS GNU/Linux is now based on a GCC 4.8.3 prerelease snapshot from Mar 20th, 2014, SVN revision 208690. This version includes numerous other bug fixes. For more information about changes from GCC version 4.8.1 that was included in previous releases, see `http://gcc.gnu.org/gcc-4.8/changes.html`.

Optimized software floating-point routines. The software floating-point emulation routines used by GCC when linking with `-msoft-float` have been updated. The new routines provide significant speed increases.

microMIPS jump instructions. A bug that caused GCC to fail to generate the `jrc` and `jals` instructions in microMIPS mode has been fixed.

`-Weffc++` and `-Wnon-virtual-dtor` interaction. The two C++ warning options `-Weffc++` and `-Wnon-virtual-dtor` have been updated to interoperate correctly and warn about the lack of virtual destructors only in polymorphic classes.

Binutils update. The binutils package has been updated to version 2.24.51.20140217 from the FSF trunk, git revision 024a23103f04282872d4352302b1bfe04391a7a4. This update includes numerous bug fixes.

sys/ptrace.h bug fix. A bug that caused GCC to issue errors of the form `error: redefinition of 'struct ptrace_peeksiginfo_args'` when including `sys/ptrace.h` has been fixed.

Math library performance improvements. Several of the math library functions have now been optimized for speed.

Linux kernel headers update. Linux kernel header files have been updated to version 3.13.

Fix for GDB crashes. GDB has been made more robust to handle executables with incorrect DWARF-2 `.debug_line` information. Previously, GDB crashed on programs that referenced missing include directory information.

GDB update. The version of GDB has been updated to 7.7.50-cvs, git revision 024a23103f04282872d4352302b1bfe04391a7a4. This update adds numerous bug fixes and features. Refer to `http://www.gnu.org/software/gdb/news` for more information.

Installer help. The installer now displays help on Microsoft Windows hosts when invoked from the command line with the `--help` option. Formerly, this command-line option only worked on GNU/Linux hosts.

Installer temp path. The installer now allows you to change the directory where it is extracted using the `P2_INSTALLER_TEMP_PATH` environment variable. See Section 2.5, "Installing Sourcery CodeBench Lite".

Installer error dialog. On Microsoft Windows hosts the installer now displays an error dialog during a GUI installation if a fatal error occurs.

Installer logging improved. The installer now logs information related to the progress of the installation and also errors when it fails to start.

Installer 32-bit library detection. The installer checks for required 32-bit compatibility libraries on supported 64-bit GNU/Linux hosts.

Microsoft Windows XP host no longer supported. The minimum required Microsoft Windows OS needed to run Sourcery CodeBench Lite is now Windows Vista.

Installer disk space calculation. The installer for GNU/Linux hosts now correctly calculates the temporary disk space required.

A.1.5. Changes in Sourcery CodeBench Lite 2013.11-36

MIPS16 debug information bug fix. A bug in GCC has been fixed that caused incorrect debug information to be produced for mixed MIPS16 and standard MIPS code. The bug caused single-stepping problems and incorrect function call backtraces reported while debugging such code with GDB.

Internal compiler error fix. A bug that sometimes caused an internal compiler error when compiling with the `-mabi=64` option and optimizations enabled has been fixed.

microMIPS delay slots. A GCC bug that caused delay slots to remain unfilled when compiling with `-mmicromips` has been fixed.

MIPS code generation fix. A bug in GCC has been fixed that caused register corruption with the `-fuse-caller-save` option for MIPS O32 ABI targets.

Better code for short operations.   GCC no longer generates unnecessary type conversions for conditional moves on short data types. This fixes a regression from GCC 4.7.

GCC `nor` instruction tuning.   GCC has been improved to make better use of `nor` instructions in generated code.

Assembler internal error.   A bug that caused the assembler to crash with an internal error on `dmtur` instructions has been fixed.

New assembler option: `-mfix-rm7000`.   The assembler now accepts the `-mfix-rm7000` command-line option. This option causes the assembler to work around hardware errata in the `dmult` and `dmultu` instructions on RM7000 cores. In addition, GCC now accepts this command-line option and passes it through to the assembler.

Invalid assembler errors.   A bug that caused the assembler to incorrectly reject `msglds` instructions and crash with an internal error on `msgsnds` instructions has been fixed.

New installer.   The installer has changed. Please refer to Section 2.5, "Installing Sourcery CodeBench Lite" for more details. Previous versions of Sourcery CodeBench Lite cannot be updated. You must uninstall the previous version or choose a different directory during installation.

A.1.6. Changes in Sourcery CodeBench Lite 2013.11-3

Changes to included libraries.   Some library variants built with `-mmicromips` and `-mnan=2008` have been removed from Sourcery CodeBench Lite for MIPS GNU/Linux. Please refer to Section 3.2, "Library Configurations" for a list of the currently-supported multilibs.

GCC `-fremove-local-statics` option.   GCC no longer supports the `-fremove-local-statics` command-line option. The optimizations formerly controlled by this option are now carried out automatically by other optimization passes.

GCC version 4.8.1.   Sourcery CodeBench Lite for MIPS GNU/Linux is now based on GCC version 4.8.1. For more information about changes from GCC version 4.7 that was included in previous releases, see `http://gcc.gnu.org/gcc-4.8/changes.html`.

IEEE 754-2008 feature support updates.   GCC and GAS now support new options to control IEEE 754-2008 features, as follows: `-mabs=2008` replaces `-mabs2008`, `-mabs=legacy` replaces `-mno-abs2008`, `-mnan=2008` replaces `-mnan2008`, and `-mnan=legacy` replaces `-mno-nan2008`. The old options remain supported but are now deprecated and may be removed in the future. For further information about the new options please refer to the compiler and assembler manuals.

Linker plugins bug fix.   A bug that caused errors similar to `libgcc_s.so.1: could not read symbols: Nonrepresentable section on output` when linking with linker plugins active (for example, when Link Time Optimization is enabled) has been fixed.

Binutils update.   The binutils package has been updated to version 2.23.52.20130912 from the FSF trunk. This update includes numerous bug fixes.

EGLIBC version 2.18.   Sourcery CodeBench Lite for MIPS GNU/Linux now includes EGLIBC version 2.18 library which is based on GNU C Library version 2.18. For more information about changes, see `http://www.eglibc.org/news#eglibc_2_18`.

Optimized `memset`.   `memset` has now been optimized for speed.

Math library performance improvements.   Several of the math library functions have now been optimized for speed.

Linux kernel headers update.   Linux kernel header files have been updated to version 3.11.

GDB update.   The version of GDB has been updated to 7.6.50.20130726-cvs. This update adds numerous bug fixes and features. Refer to `http://www.gnu.org/software/gdb/news` for more information.

Improved GDB diagnostic.   GDB now issues an error message when an invalid option is passed to the `add-symbol-file` command.

New GDB command.   GDB now supports the `remove-symbol-file` command.

QEMU version 1.5.50.   Sourcery CodeBench Lite for MIPS GNU/Linux is now based on QEMU version 1.5.50.

QEMU trap handling bug fix for microMIPS.   A bug that caused QEMU to abort when executing a trap for integer division by zero or arithmetic overflow has been fixed for programs using the microMIPS instruction set.

QEMU signal handling bug fix.   A bug that caused QEMU to crash when jumping to or returning from a user-installed signal handler in a program using MIPS16 or microMIPS instructions has been fixed.

A.1.7. Changes in Older Releases

For information about changes in older releases of Sourcery CodeBench Lite for MIPS GNU/Linux, please refer to the Getting Started guide packaged with those releases.

Appendix B
Sourcery CodeBench Lite Licenses

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

The Mentor Graphics License is available in Section B.1, "Sourcery CodeBench Lite License Agreement".

B.1. Sourcery CodeBench Lite License Agreement

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1. **Definitions.**

    1.1. "Customer's Product" means Customer's end-user product identified by a unique SKU (including any Related SKUs) in an applicable Addenda that is developed, manufactured, branded and shipped solely by Customer or an authorized manufacturer or subcontractor on behalf of Customer to end-users or consumers;

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1.3. "Development Location" means the location where Products may be used as authorized in the applicable Addenda;

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1.5. "Embedded Software" means Software that is embeddable;

1.6. "End-User" means Customer's customer;

1.7. "Executable Code" means a compiled program translated into a machine-readable format that can be loaded into memory and run by a certain processor;

1.8. "Hardware" means a physically tangible electro-mechanical system or sub-system and associated documentation;

1.9. "Linkable Object Code" or "Object Code" means linkable code resulting from the translation, processing, or compiling of Source Code by a computer into machine-readable format;

1.10. "Mentor Embedded Linux" or "MEL" means Mentor Graphics' tools, source code, and recipes for building Linux systems;

1.11. "Open Source Software" or "OSS" means software subject to an open source license which requires as a condition for redistribution of such software, including modifications thereto, that the: (i) redistribution be in source code form or be made available in source code form; (ii) redistributed software be licensed to allow the making of derivative works; or (iii) redistribution be at no charge;

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1.13. "Products" means Software, Term-Licensed Products and/or Hardware;

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1.16. "Related SKU" means two or more Customer Products identified by logically-related SKUs, where there is no difference or change in the electrical hardware or software content between such Customer Products;

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1.18. "Source Code" means software in a form in which the program logic is readily understandable by a human being;

1.19. "Sourcery CodeBench Software" means Mentor Graphics' Development Tool for C/C++ embedded application development;

1.20. "Sourcery VSIPL++" is Software providing C++ classes and functions for writing embedded signal processing applications designed to run on one or more processors;

1.21. "Stock Keeping Unit" or "SKU" is a unique number or code used to identify each distinct product, item or service available for purchase;

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2.2. Amounts invoiced will be paid, in the currency specified on the applicable invoice, within 30 days from the date of such invoice. All invoices will be sent electronically to Customer on the date stated on the invoice unless otherwise specified in an Addendum. Any past due invoices will be subject to the imposition of interest charges in the amount of one and one-half percent per month or the applicable legal rate currently in effect, whichever is lower. Prices do not include freight, insurance, customs duties, taxes or other similar charges, which Mentor Graphics will state separately in the applicable invoice(s). Unless timely provided with a valid certificate of exemption or other evidence that items are not taxable, Mentor Graphics will invoice Customer for all applicable taxes including, but not limited to, VAT, GST, sales tax, consumption tax and service tax. Customer will make all payments free and clear of, and without reduction for, any withholding or other taxes; any such taxes imposed on payments by Customer hereunder will be Customer's sole responsibility. If Customer appoints a third party to place purchase orders and/or make payments on Customer's behalf, Customer shall be liable for payment under Orders placed by such third party in the event of default.

2.3. All Products are delivered FCA factory (Incoterms 2010), freight prepaid and invoiced to Customer, except Software delivered electronically, which shall be deemed delivered when made available to Customer for download. Mentor Graphics' delivery of Software by electronic means is subject to Customer's provision of both a primary and an alternate e-mail address.

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11.4. THIS SECTION 11 IS SUBJECT TO SECTION 9 ABOVE AND STATES: (A) THE ENTIRE LIABILITY OF MENTOR GRAPHICS AND ITS LICENSORS AND (B) CUSTOMER'S SOLE AND EXCLUSIVE REMEDY, WITH RESPECT TO ANY ALLEGED PATENT OR COPYRIGHT INFRINGEMENT OR TRADE SECRET MISAPPROPRIATION BY ANY PRODUCT PROVIDED UNDER THIS AGREEMENT.

12. **Termination and Effect of Termination.** If a Software license was provided for limited term use, such license will automatically terminate at the end of the authorized Term.

    12.1. **Termination for Breach.** This Agreement shall remain in effect until terminated in accordance with its terms. Mentor Graphics may terminate this Agreement and/or any licenses granted under this Agreement, and Customer will immediately discontinue use and distribution of Products, if Customer (a) commits any material breach of any provision of this Agreement and fails to cure such breach upon 30-days prior written notice; or (b) becomes insolvent, files a bankruptcy petition, institutes proceedings for liquidation or winding up or enters into an agreement to assign its assets for the benefit of creditors. Termination of this Agreement or any license granted hereunder will not affect Customer's obligation to pay for Products shipped or licenses granted prior to the termination, which amounts shall be payable immediately upon the date of termination. For the avoidance of doubt, nothing in this Section 12 shall be construed to prevent Mentor Graphics from seeking immediate injunctive relief in the event of any threatened or actual breach of Customer's obligations hereunder.

    12.2. **Effect of Termination.** Upon termination of this Agreement, the rights and obligations of the parties shall cease except as expressly set forth in this Agreement. Upon termination or expiration of the Term, Customer will discontinue use and/or distribution of Products, and shall return Hardware and either return to Mentor Graphics or destroy Software in Customer's possession, including all copies and documentation, and certify in writing to Mentor Graphics within ten business days of the termination date that Customer no longer possesses any of the affected Products or copies of Software in any form, except to the extent an Open Source Software license conflicts with this Section 12.2 and permits Customer's continued use of any Open Source Software portion or component of a Product. Upon termination for Customer's breach, an End-User may continue its use and/or distribution of Customer's Product so long as: (a) the End-User was licensed according to the terms of this Agreement, if applicable to such End-User, and (b) such End-User is not in breach of its agreement, if applicable, nor a party to Customer's breach.

13. **Export.** The Products provided hereunder are subject to regulation by local laws and United States government agencies, which prohibit export or diversion of certain products, information about the products, and direct or indirect products thereof, to certain countries and certain persons. Customer agrees that it will not export Products in any manner without first obtaining all necessary approval from appropriate local and United States government agencies. Customer acknowledges that the regulation of product export is in continuous modification by local governments and/or the United States Congress and administrative agencies. Customer agrees to complete all documents and to meet all requirements arising out of such modifications.

14. **U.S. Government License Rights.** Software was developed entirely at private expense. All Software is commercial computer software within the meaning of the applicable acquisition regulations. Accordingly, pursuant to US FAR 48 CFR 12.212 and DFAR 48 CFR 227.7202, use, duplication and disclosure of the Software by or for the U.S. Government or a U.S. Government subcontractor is subject solely to the terms and conditions set forth in this Agreement, except for provisions which are contrary to applicable mandatory federal laws.

15. **Third Party Beneficiary.** For any Products licensed under this Agreement and provided by Customer to End-Users, Mentor Graphics or the applicable licensor is a third party beneficiary of the agreement between Customer and End-User. Mentor Graphics Corporation, Mentor Graphics (Ireland) Limited, and other licensors may be third party beneficiaries of this Agreement with the right to enforce the obligations set forth herein.

16. **Review of License Usage.** Customer will monitor the access to and use of Software. With prior written notice, during Customer's normal business hours, and no more frequently than

once per calendar year, Mentor Graphics may engage an internationally recognized accounting firm to review Customer's software monitoring system, records, accounts and sublicensing documents deemed relevant by the internationally recognized accounting firm to confirm Customer's compliance with the terms of this Agreement or U.S. or other local export laws. Such review may include FlexNet (or successor product) report log files that Customer shall capture and provide at Mentor Graphics' request. Customer shall make records available in electronic format and shall fully cooperate with data gathering to support the license review. Mentor Graphics shall bear the expense of any such review unless a material non-compliance is revealed. Mentor Graphics shall treat as confidential information all Customer information gained as a result of any request or review and shall only use or disclose such information as required by law or to enforce its rights under this Agreement. Such license review shall be at Mentor Graphics' expense unless it reveals a material underpayment of fees of five percent or more, in which case Customer shall reimburse Mentor Graphics for the costs of such license review. Customer shall promptly pay any such fees. If the license review reveals that Customer has made an overpayment, Mentor Graphics has the option to either provide the Customer with a refund or credit the amount overpaid to Customer's next payment. The provisions of this Section 16 shall survive the termination of this Agreement.

17. **Controlling Law, Jurisdiction and Dispute Resolution.** This Agreement shall be governed by and construed under the laws of the State of California, USA, excluding choice of law rules. All disputes arising out of or in relation to this Agreement shall be submitted to the exclusive jurisdiction of the state and federal courts of California, USA. Nothing in this section shall restrict Mentor Graphics' right to bring an action (including for example a motion for injunctive relief) against Customer or its Subsidiary in the jurisdiction where Customer's or its Subsidiary's place of business is located. The United Nations Convention on Contracts for the International Sale of Goods does not apply to this Agreement.

18. **Severability.** If any provision of this Agreement is held by a court of competent jurisdiction to be void, invalid, unenforceable or illegal, such provision shall be severed from this Agreement and the remaining provisions will remain in full force and effect.

19. **Miscellaneous.** This Agreement contains the parties' entire understanding relating to its subject matter and supersedes all prior or contemporaneous agreements, including but not limited to any purchase order terms and conditions. This Agreement may only be modified in writing, signed by an authorized representative of each party. Waiver of terms or excuse of breach must be in writing and shall not constitute subsequent consent, waiver or excuse.

Rev. 120305, Part No. 252061

B.2. Licenses for Sourcery CodeBench Lite Components

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

B.2.1. Mentor Graphics Proprietary Components

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B.2.2. 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 CodeBench Lite. Sourcery CodeBench 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 CodeBench Lite.

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GNU Debugger	GNU General Public License 3.0 http://www.gnu.org/licenses/gpl.html
Sourcery CodeBench Debug Sprite	Mentor Graphics License
QEMU Emulator	GNU General Public License 2.0 http://www.gnu.org/licenses/old-licenses/gpl-2.0.html
GNU C Library	GNU Lesser General Public License 2.1 http://www.gnu.org/licenses/old-licenses/lgpl-2.1.html
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Linux Kernel Headers	GNU General Public License 2.0 http://www.gnu.org/licenses/old-licenses/gpl-2.0.html
GNU Make	GNU General Public License 2.0 http://www.gnu.org/licenses/old-licenses/gpl-2.0.html
GNU Core Utilities	GNU General Public License 2.0 http://www.gnu.org/licenses/old-licenses/gpl-2.0.html
GNU/Linux Prelinker	GNU General Public License 2.0 http://www.gnu.org/licenses/old-licenses/gpl-2.0.html

Important

Although some of the licenses that apply to Sourcery CodeBench 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 CodeBench Lite. You can develop proprietary applications and libraries with Sourcery CodeBench Lite.

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B.2.3. Third-Party Information

B.2.3.1. Opal Components

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B.2.3.4. Strategies for Implementing POSIX Condition Variables

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```