

# **Sourcery CodeBench Lite**

**MIPS ELF**

**Sourcery CodeBench Lite 2012.03-64**

**Getting Started**



---

# **Sourcery CodeBench Lite: MIPS ELF: Sourcery CodeBench Lite 2012.03-64: Getting Started**

CodeSourcery, Inc.

Copyright © 2005, 2006, 2007, 2008, 2009, 2010, 2011 CodeSourcery, Inc.

All rights reserved.

## **Abstract**

This guide explains how to install and build applications with Sourcery CodeBench Lite, CodeSourcery'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.

---

---

# Table of Contents

Preface .....	v
1. Intended Audience .....	vi
2. Organization .....	vi
3. Typographical Conventions .....	vii
1. Quick Start .....	1
1.1. Installation and Set-Up .....	2
1.2. Configuring Sourcery CodeBench Lite for the Target System .....	2
1.3. Building Your Program .....	2
1.4. Running and Debugging Your Program .....	2
2. Installation and Configuration .....	4
2.1. Terminology .....	5
2.2. System Requirements .....	5
2.3. Downloading an Installer .....	6
2.4. Installing Sourcery CodeBench Lite .....	6
2.5. Installing Sourcery CodeBench Lite Updates .....	9
2.6. Setting up the Environment .....	9
2.7. Uninstalling Sourcery CodeBench Lite .....	11
3. Sourcery CodeBench Lite for MIPS ELF .....	13
3.1. Included Components and Features .....	14
3.2. Library Configurations .....	14
3.3. CS3 Support .....	16
3.4. Using Sourcery CodeBench with MIPS Boards .....	16
3.5. Using Sourcery CodeBench with YAMON .....	17
3.6. Profiling Support .....	17
3.7. Using Flash Memory .....	17
4. Using Sourcery CodeBench from the Command Line .....	19
4.1. Building an Application .....	20
4.2. Running Applications on the Target System .....	20
4.3. Running Applications in the Simulator .....	20
4.4. Running Applications from GDB .....	21
5. CS3™: The CodeSourcery Common Startup Code Sequence .....	23
5.1. Linker Scripts .....	24
5.2. Program Startup and Termination .....	26
5.3. Memory Layout .....	29
5.4. Interrupt Vectors and Handlers .....	31
5.5. Supported Boards for MIPS ELF .....	31
6. Sourcery CodeBench Debug Sprite .....	34
6.1. Probing for Debug Devices .....	35
6.2. Debug Sprite Example .....	35
6.3. Invoking Sourcery CodeBench Debug Sprite .....	36
6.4. Sourcery CodeBench Debug Sprite Options .....	37
6.5. MDI Devices .....	37
6.6. Debugging a Remote Board .....	39
6.7. Supported Board Files .....	40
6.8. Board File Syntax .....	40
7. Next Steps with Sourcery CodeBench .....	44
7.1. Sourcery CodeBench Knowledge Base .....	45
7.2. Example Programs .....	45
7.3. Manuals for GNU Toolchain Components .....	45
A. Sourcery CodeBench Lite Release Notes .....	47
A.1. Changes in Sourcery CodeBench Lite for MIPS ELF .....	48

B. Sourcery CodeBench Lite Licenses .....	55
B.1. Licenses for Sourcery CodeBench Lite Components .....	56
B.2. Sourcery CodeBench Software License Agreement .....	57
B.3. Attribution .....	60

---

# 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 ELF”	This chapter contains information about using Sourcery CodeBench Lite that is specific to MIPS ELF 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, “CS3™: The CodeSourcery Common Startup Code Sequence”	CS3 is CodeSourcery's low-level board support library. This chapter documents the boards supported by Sourcery CodeBench Lite and the compiler and linker options you need to use with them. It also explains how you can use and modify CS3-provided definitions for memory maps, system startup code and interrupt vectors in your own code.
Chapter 6, “Sourcery CodeBench Debug Sprite”	This chapter describes the use of the Sourcery CodeBench Debug Sprite for remote debugging. The Sprite allows you to debug programs running on a bare board without an operating system. This chapter includes information about the debugging devices and boards supported by the Sprite for MIPS ELF.
Chapter 7, “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 ELF. 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:

<code>&gt; command arg ...</code>	A command, typed by the user, and its output. The “>” character is the command prompt.
<code>command</code>	The name of a program, when used in a sentence, rather than in literal input or output.
<code>literal</code>	Text provided to or received from a computer program.
<code>placeholder</code>	Text that should be replaced with an appropriate value when typing a command.
<code>\</code>	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 ELF is intended for developers working on embedded applications or firmware for boards without an operating system, or that run an RTOS or boot loader. This Sourcery CodeBench configuration is not intended for Linux or uClinux kernel or application development.

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.

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 ELF”.

## 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<sup>1</sup>, 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”.

**Install drivers for your debug device.** If you plan to use the Sourcery CodeBench Debug Sprite, you may need to install drivers, libraries, or other software on your host system. Refer to Chapter 6, “Sourcery CodeBench Debug Sprite” for a list of supported devices and information about installing drivers and other device set-up. Sourcery CodeBench Lite also supports third-party debug devices that communicate via the GDB remote serial protocol. If you plan to use one of these devices, follow the manufacturer's directions to connect the device and install any required drivers or software.

## 1.2. Configuring Sourcery CodeBench Lite for the Target System

**Identify your target board.** On bare-metal targets, you must explicitly specify a linker script for your target board on your link command line. Supported boards are listed in Chapter 5, “CS3™: The CodeSourcery Common Startup Code Sequence”. You can also choose a simulator as your target board.

## 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. On bare-metal targets, you must specify a linker script using the `-T` option on your link command line. Supported boards and linker scripts are listed in Chapter 5, “CS3™: The CodeSourcery Common Startup Code Sequence”.

## 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.

---

<sup>1</sup> <http://go.mentor.com/codebench/>

**Run or debug your program in the simulator.** Sourcery CodeBench Lite includes an instruction-set simulator, which provides an easy way to run or debug your program without requiring target hardware. The simulator can be run directly from the command line (see Section 4.3, “Running Applications in the Simulator”) or via the debugger (see Section 4.4, “Running Applications from GDB”).

**Debug your program on the target using the Debug Sprite.** You can use the Sourcery CodeBench Debug Sprite to load and execute your program on the target from the debugger. Refer to Section 4.4, “Running Applications from GDB” for instructions on using the Sprite from the GDB command line. Detailed reference material for the Sourcery CodeBench Debug Sprite, including information about supported debug devices, can be found in Chapter 6, “Sourcery CodeBench Debug Sprite”.

**Run your program on the target using YAMON.** You can run programs built with Sourcery CodeBench Lite on MIPS ELF targets via the YAMON boot monitor. For instructions, refer to Section 3.5, “Using Sourcery CodeBench with YAMON”. Note that you must select a YAMON linker script profile when building your program.

**Debug your program on the target using a third-party debug device.** Sourcery CodeBench supports debugging programs on the remote target using third-party debug devices that can communicate via the GDB remote serial protocol. For command-line GDB instructions, see Section 4.4, “Running Applications from 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. Install Sourcery CodeBench Lite.
4. Configure your environment so that you can use 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-sde-elf`.

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 XP (SP1), Windows Vista, and Windows 7 systems using IA32, AMD64, and Intel 64 processors.
- GNU/Linux systems using IA32, AMD64, or Intel 64 processors, including Debian 3.1 (and later), Red Hat Enterprise Linux 3 (and later), SuSE Enterprise Linux 8 (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.

#### **Installing on Ubuntu and Debian GNU/Linux Hosts**

The Sourcery CodeBench graphical installer is incompatible with the `dash` shell, which is the default `/bin/sh` for recent releases of the Ubuntu and Debian GNU/Linux distributions. To install Sourcery CodeBench Lite on these systems, you must make `/bin/sh` a symbolic link to one of the supported shells: `bash`, `csh`, `tcsh`, `zsh`, or `ksh`.

For example, on Ubuntu systems, the recommended way to do this is:

```
> sudo dpkg-reconfigure -pnow dash
Install as /bin/sh? No
```

This is a limitation of the installer and uninstaller only, not of the installed Sourcery CodeBench Lite toolchain.

### 2.2.2. Host Hardware Requirements

In order to install and use Sourcery CodeBench Lite, you must have at least 512MB of available memory.

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 disk specified by the `TEMP` environ-

ment 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 `IATEMPDIR` environment variable, or `/tmp` if that is not set.

### 2.2.3. Target System Requirements

See Chapter 3, “Sourcery CodeBench Lite for MIPS ELF” for requirements that apply to the target system.

## 2.3. 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 2.4, “Installing Sourcery CodeBench Lite”.

You can download Sourcery CodeBench Lite from the Sourcery CodeBench web site<sup>1</sup>. This free version of Sourcery CodeBench, which is made available to the general public, does not include all the functionality of CodeSourcery's product releases. If you prefer, you may instead purchase or register for an evaluation of CodeSourcery's product toolchains at the Sourcery CodeBench Portal<sup>2</sup>.

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 an executable with the `.exe` extension. For GNU/Linux systems Sourcery CodeBench Lite is provided as an executable installer package with the `.bin` extension. You may also install from a compressed archive with the `.tar.bz2` extension.

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

## 2.4. 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.

### 2.4.1. Using the Sourcery CodeBench Lite Installer on Microsoft Windows

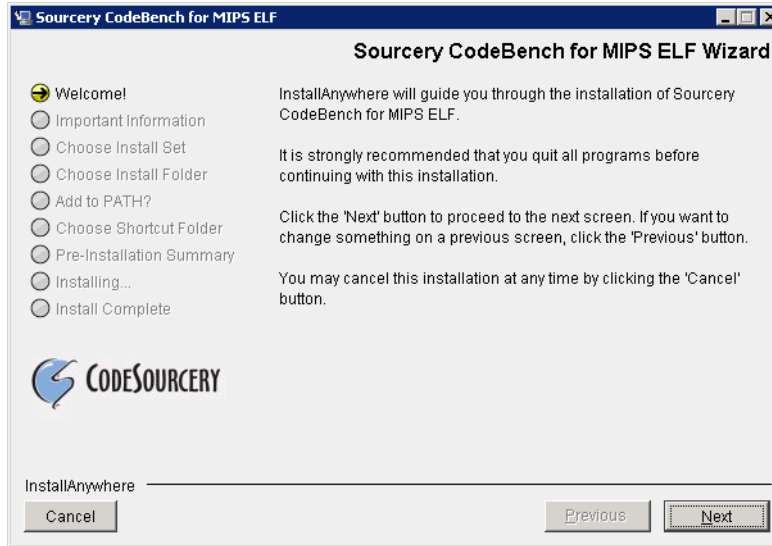
If you have received Sourcery CodeBench Lite on CD, insert the CD in your computer. On most computers, the installer then starts automatically. If your computer has been configured not to automatically run CDs, open `My Computer`, and double click on the CD. If you downloaded Sourcery CodeBench Lite,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

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.

---

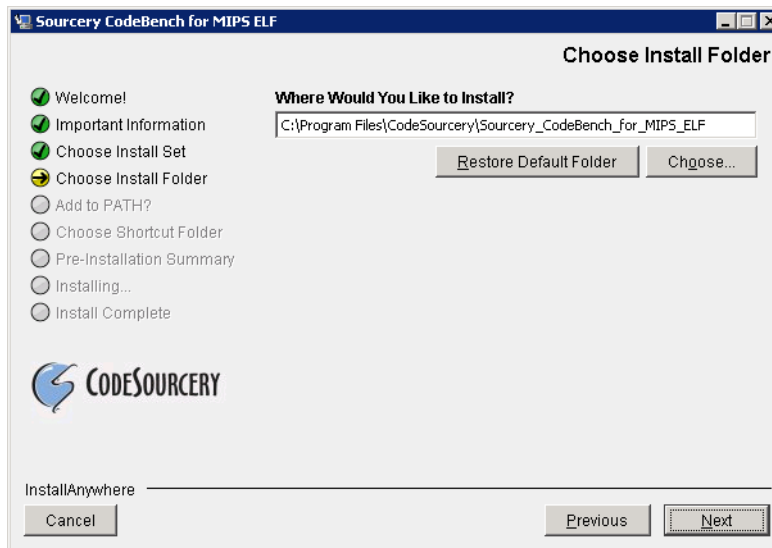
<sup>1</sup> <http://go.mentor.com/codebench/>

<sup>2</sup> <https://sourcery.mentor.com/GNUToolchain/>

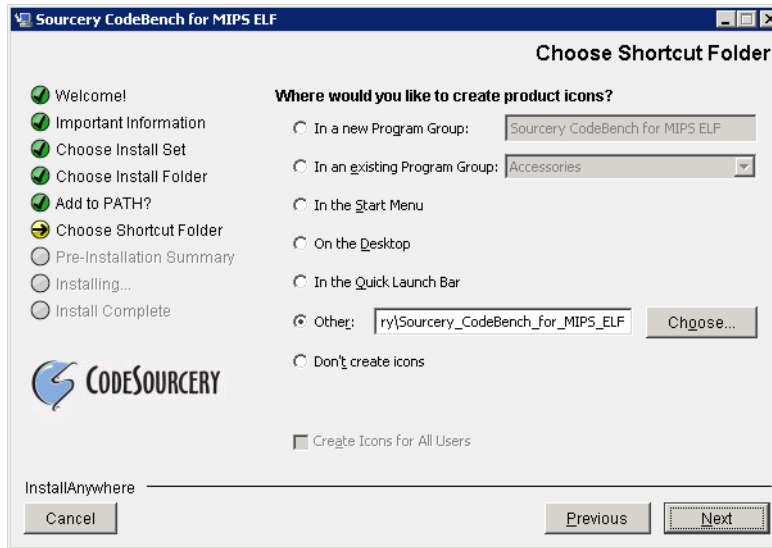


**Running the Installer.** The graphical installer guides you through the steps to install Sourcery CodeBench Lite.

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

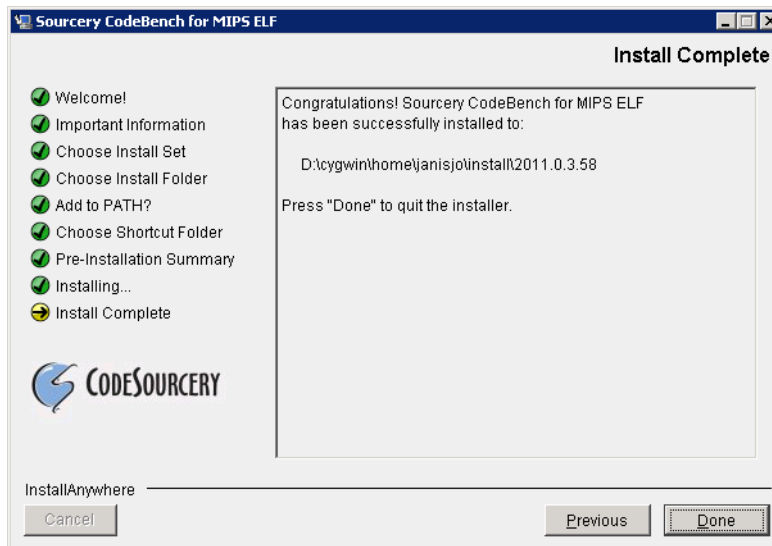


**Choose Install Folder.** Select the pathname to your install directory.



**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. Finally, the installer displays a summary screen to confirm a successful install before it exits.



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

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

## 2.4.2. 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
```

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

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

### 2.4.3. 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 `$HOME/CodeSourcery` subdirectory of your home directory and that the filename of the package you have downloaded is `/path/to/package.tar.bz2`. After installation the toolchain will be in `$HOME/CodeSourcery/sourceryg++-2012.03`.

First, uncompress the package file:

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

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

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

Change to the installation directory:

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

Unpack the package:

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

## 2.5. Installing Sourcery CodeBench Lite Updates

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

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

Note that the names of the Sourcery CodeBench commands for the MIPS ELF target all begin with `mips-sde-elf`. This means that you can install Sourcery CodeBench for multiple target systems in the same directory without conflicts.

## 2.6. Setting up the Environment

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



## 2.6.1. Setting up the Environment on Microsoft Windows Hosts

### 2.6.1.1. Setting the PATH

If you installed Sourcery CodeBench Lite using the graphical installer then you may skip this step. The installer does this setup for you.

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 older versions of Microsoft Windows, from the desktop bring up the Start menu and right click on My Computer. Select Properties, go to the Advanced tab, then click on the Environment Variables button. Select the PATH variable and click the 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-sde-elf-g++ -v
```

Verify that the last line of the output contains: Sourcery CodeBench Lite 2012.03-64.

### 2.6.1.2. 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.

## 2.6.2. Setting up the Environment on GNU/Linux Hosts

If you installed Sourcery CodeBench Lite using the graphical installer then you may skip this step. The installer does this setup for you.

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/sourceryg++-mips-sde-elf/man`.

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

```
> mips-sde-elf-g++ -v
```

Verify that the last line of the output contains: `Sourcery CodeBench Lite 2012.03-64`.

## 2.7. 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-sde-elf` directory located in the install directory will be removed entirely by the uninstaller.

### 2.7.1. 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 `-i 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.

### **2.7.2. 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 `-i console` command-line option.

### **2.7.3. 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 ELF**

This chapter contains information about features of Sourcery CodeBench Lite that are specific to MIPS ELF 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 ELF, and tells you where you may find further information about these features.

Component	Version	Notes
<b>GNU programming tools</b>		
GNU Compiler Collection	4.6.3	Separate manual included.
GNU Binary Utilities	2.21.53	Includes assembler, linker, and other utilities. Separate manuals included.
<b>Debugging support and simulators</b>		
GNU Debugger	7.2.50	Separate manual included.
Sourcery CodeBench Debug Sprite for MIPS	2012.03-64	See Chapter 6, “Sourcery CodeBench Debug Sprite”.
GDB Simulator	N/A	See Section 4.3, “Running Applications in the Simulator”.
<b>Target libraries</b>		
CodeSourcery Common Startup Code Sequence	2012.03-64	See Chapter 5, “CS3™: The CodeSourcery Common Startup Code Sequence”.
Newlib C Library	1.18.0	Separate manuals included.
<b>Other utilities</b>		
GNU Make	N/A	Build support on Windows hosts.
GNU Core Utilities	N/A	Build support on Windows hosts.

## 3.2. Library Configurations

Sourcery CodeBench Lite for MIPS ELF includes the following library configuration.

<b>MIPS32 revision 2 - Big-Endian, O32</b>	
Command-line option(s):	default
Library subdirectory:	./

<b>MIPS32 revision 2 - Little-Endian, O32</b>	
Command-line option(s):	-EL
Library subdirectory:	el/

<b>MIPS32 revision 2 - Big-Endian, O32, mips16</b>	
Command-line option(s):	-mips16
Library subdirectory:	mips16/

<b>MIPS32 revision 2 - Soft-Float, O32</b>	
Command-line option(s):	-msoft-float
Library subdirectory:	sof/

<b>MIPS32 revision 2 - Big-Endian, O32, mips16, Soft-Float</b>	
Command-line option(s):	-mips16 -msoft-float
Library subdirectory:	mips16/sof/

<b>MIPS32 revision 2 - Little-Endian, O32, mips16</b>	
Command-line option(s):	-EL -mips16
Library subdirectory:	el/mips16/

<b>MIPS32 revision 2 - Little-Endian, O32, Soft-Float</b>	
Command-line option(s):	-EL -msoft-float
Library subdirectory:	el/sof/

<b>MIPS32 revision 2 - Little-Endian, O32, mips16, Soft-Float</b>	
Command-line option(s):	-EL -mips16 -msoft-float
Library subdirectory:	el/mips16/sof/

<b>MIPS32 revision 2 - Big-Endian, O32, micromips</b>	
Command-line option(s):	-mmicromips
Library subdirectory:	micromips/

<b>MIPS32 revision 2 - Big-Endian, O32, micromips, Soft-Float</b>	
Command-line option(s):	-mmicromips -msoft-float
Library subdirectory:	micromips/sof/

<b>MIPS32 revision 2 - Little-Endian, O32, micromips</b>	
Command-line option(s):	-EL -mmicromips
Library subdirectory:	el/micromips/

<b>MIPS32 revision 2 - Little-Endian, O32, micromips, Soft-Float</b>	
Command-line option(s):	-EL -mmicromips -msoft-float
Library subdirectory:	el/micromips/sof/

<b>MIPS64 revision 2 - Big Endian, N64</b>	
Command-line option(s):	-mabi=64
Library subdirectory:	64/

<b>MIPS64 revision 2 - Big Endian, N64, Soft-Float</b>	
Command-line option(s):	-msoft-float -mabi=64
Library subdirectory:	sof/64/

<b>MIPS64 revision 2 - Little Endian, N64</b>	
Command-line option(s):	-EL -mabi=64
Library subdirectory:	el/64/

<b>MIPS64 revision 2 - Little Endian, N64, Soft-Float</b>	
Command-line option(s):	<code>-EL -msoft-float -mabi=64</code>
Library subdirectory:	<code>el/sof/64/</code>

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.

Sourcery CodeBench Lite's library support includes linker scripts that pull in appropriate CS3 startup code, as well as the libraries themselves. You can find these linker scripts in multilib-specific subdirectories of the `mips-sde-elf/lib` directory of your Sourcery CodeBench install.

### 3.3. CS3 Support

Sourcery CodeBench Lite includes CS3 linker scripts and initialization code to support three different classes of target configurations:

- Simulator targets, such as MIPSsim, running under control of the debugger.
- Malta or SEAD-3 hardware targets running in a bare-metal configuration under control of the debugger.
- Malta or SEAD-3 hardware targets running under control of the YAMON boot monitor.

You must use the appropriate linker script to match your target, since the memory layouts and startup code sequences are different in each case. Refer to Chapter 5, “CS3™: The CodeSourcery Common Startup Code Sequence” for details on the supported boards for this version of Sourcery CodeBench Lite.

For simulator and bare-metal targets, CS3 provides semihosted I/O via the debugger console on the host. For instructions on loading and running code on the target from command-line GDB, see Section 4.4, “Running Applications from GDB”.

### 3.4. Using Sourcery CodeBench with MIPS Boards

The provided CS3 linker scripts for MIPS Malta and SEAD-3 boards (both bare-metal and YAMON profiles) assume a minimum amount of RAM is available on the target. Refer to the following table for the specific requirements. If your target board has less memory, you must adjust the memory layout used by the linker by specifying a custom linker script.

<b>Board</b>	<b>Memory Requirement</b>
Malta	128MB
SEAD-3 LX50	4MB
SEAD-3 LX110	128MB

Find the linker script for your selected profile, such as `mips-sde-elf/lib/malta-ram-hosted.ld`, in your Sourcery CodeBench Lite installation and copy it to your project working directory. In your local copy, find the `MEMORY` directive and edit the `LENGTH` expression

to match the amount of memory available on your board. Then, use the full absolute pathname of your modified linker script with the `-T` command-line option when linking your program.

## 3.5. Using Sourcery CodeBench with YAMON

For YAMON targets, CS3 provides basic I/O services via the YAMON console. This section briefly covers how to load and run programs using YAMON.

To prepare an application to run from YAMON, you must first convert the executable file to SREC format. You can do this from the command line on your host system using the `objcopy` utility provided with Sourcery CodeBench Lite.

```
> mips-sde-elf-objcopy -O srec prog prog.srec
```

Next, use YAMON to load the SREC image file into RAM. For example, to load via TFTP, use a command similar to:

```
YAMON> load tftp://host/path/prog.srec
```

Then, start the program from the YAMON prompt:

```
YAMON> go .
```

For more detailed information about YAMON usage and features, refer to the *YAMON User's Manual*.

### Warning

Using YAMON with 64-bit multilibs is not fully supported and may have issues. YAMON is usually built using the O32 ABI, which is not forward-compatible with the N64 ABI used in 64-bit multilibs.

## 3.6. Profiling Support

Sourcery CodeBench Lite includes CS3 support for code profiling on MIPS ELF targets using `gprof`. To enable profiling, compile your program with the `-pg` option. You must also build your program with a hosted linker script.

You can run a program built with profiling from the debugger the same as you would any other hosted application. While your program is running, profiling data is saved in buffers in the heap memory area on the target. This may affect the amount of memory available to your application, and it is also possible that the profiler itself may run out of memory. Profiling data is written to a file on the host (`gmon.out`) only when your application exits. Since many embedded applications are structured to run indefinitely rather than exit, you may need to add an explicit `exit` call in order to collect profiling data.

For instructions on using the `mips-sde-elf-gprof` utility to process the collected `gmon.out` data, refer to the GNU Profiler (`gprof`) manual included with Sourcery CodeBench Lite.

## 3.7. Using Flash Memory

Sourcery CodeBench Lite supports development and debugging of applications loaded into flash memory on MIPS ELF targets. There are three steps involved:



1. You must use an appropriate linker script that identifies the ROM memory region on your target board, and locates the program text within that region. Refer to Chapter 5, “CS3™: The CodeSourcery Common Startup Code Sequence” for information about the boards supported by Sourcery CodeBench.
2. Next, load your program into the flash memory on your target board. You must use third-party tools to program the flash memory.
3. Finally, when debugging a program in flash memory, GDB must be told about the ROM region so that it knows where it must use hardware breakpoints to control program execution. If you are using the Sourcery CodeBench Debug Sprite to debug your program, the Sprite does this automatically, using the memory map provided in the board configuration file. Otherwise, you must provide this information explicitly.

When using GDB from the command line, you can mark the flash memory as read-only by using the command:

```
(gdb) mem start end ro
```

where *start* and *end* define the address range of the read-only memory region.

In addition to GDB's automatic use of hardware breakpoints in the ROM region, you can also set hardware breakpoints explicitly from the debugger. However, on many targets the number of available hardware breakpoints is very small. Furthermore, GDB also uses hardware breakpoints internally to implement commands such as `step`, `next`, and `finish`. Thus the number of breakpoints you can explicitly set in ROM may be fewer than the number of hardware breakpoints supported by the target system.

---

# **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-sde-elf`, as indicated by the `mips-sde-elf` 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-sde-elf-gcc -o factorial main.c -T script
```

Sourcery CodeBench requires that you specify a linker script with the `-T` option to build applications for bare-board targets. Linker errors like `undefined reference to `read'` are a symptom of failing to use an appropriate linker script. Default linker scripts are provided in `mips-sde-elf/lib`. Refer to Chapter 5, “CS3™: The CodeSourcery Common Startup Code Sequence” for information about the boards and linker scripts supported by Sourcery CodeBench Lite. You must also add the processor options for your board, as documented in that chapter, to your compile and link command lines.

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

## 4.2. Running Applications on the Target System

Consult your target board documentation for instructions on loading programs onto the target, and running them. Alternatively, you can use the Sourcery CodeBench Debug Sprite from within GDB to download and run programs on the target via a supported hardware debugging device.

## 4.3. Running Applications in the Simulator

Sourcery CodeBench Lite includes a simulator that you can use on the host system to run programs compiled for the target system. Since you do not need target hardware, this is the easiest way to try out Sourcery CodeBench.

To use the simulator run:

```
> mips-sde-elf-run factorial
```

You should see the expected output:

```
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
```

You can also use the simulator to execute target programs when debugging with GDB. See Section 4.4, “Running Applications from GDB” for more information.

The simulator supports the MIPS32r2 instruction set, including the MIPS16e, MIPS DSP and DSP Revision 2, SmartMIPS, and MIPS-3D ASEs. It can also emulate earlier variants of the MIPS architecture.

## 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. You can also run and debug programs using the GDB simulator.

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-sde-elf-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 GDB Simulator

GDB includes a simulator that allows you to debug MIPS ELF applications without target hardware. To start and connect to the simulator from within GDB, use this command:

```
(gdb) target sim
```

### 4.4.2. 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 6, “Sourcery CodeBench Debug Sprite” for detailed information about the supported devices.

You can start the Sprite directly from within GDB:

```
(gdb) target remote | mips-sde-elf-sprite arguments
```

Refer to Section 6.3, “Invoking Sourcery CodeBench Debug Sprite” for a full description of the Sprite arguments.

#### 4.4.3. Connecting to an External GDB Server

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.

#### 4.4.4. Loading and Running Applications

Connecting to a bare-metal target or simulator from GDB does not cause your program to be loaded into target memory. You must do this explicitly from GDB after you connect:

```
(gdb) load
```

Alternatively, you can use third-party tools to load your application into flash memory before starting GDB.

To begin execution of your application, you should generally use the `continue` command:

```
(gdb) continue
```

However, you should use `run` instead of `continue` to start your program if you used `target sim` to connect:

```
(gdb) run
```

---

# Chapter 5

## CS3™: The CodeSourcery Common Startup Code Sequence

CS3 is CodeSourcery's low-level board support library. This chapter documents the boards supported by Sourcery CodeBench Lite and the compiler and linker options you need to use with them. It also explains how you can use and modify CS3-provided definitions for memory maps, system startup code and interrupt vectors in your own code.

Many developers turn to the GNU toolchain for its cross-platform consistency: having a single system support so many different processors and boards helps to limit risk and keep learning curves gentle. Historically, however, the GNU toolchain has lacked a consistent set of conventions for processor- and board-level initialization, language run-time setup, and interrupt and trap handler definition.

The CodeSourcery Common Startup Code Sequence (CS3) addresses this problem. For each supported system, CS3 provides a set of linker scripts describing the system's memory map, and a board support library providing generic reset, startup, and interrupt handlers. These scripts and libraries all follow a standard set of conventions across a range of processors and boards.

In addition to providing linker support, CS3's functionality is fully integrated with the Sourcery CodeBench Debug Sprite. For each supported board, CS3 provides the board file containing the memory map and initialization sequence required for debugging applications on the board via the Sprite, as documented in Section 6.7, "Supported Board Files".

This chapter is organized in two parts. The first part explains CS3 concepts:

- Section 5.1, "Linker Scripts" provides basic information you need to know in order to select an appropriate CS3-provided linker script for your MIPS ELF board.
- CS3's program startup and termination model is discussed in Section 5.2, "Program Startup and Termination".
- Section 5.3, "Memory Layout" discusses the mapping from program sections to memory regions. It also explains how you can refer to memory regions using CS3-provided symbolic names from C, assembly language, or the linker script, and customize placement of code or data in your program.

The second part provides details about the CS3 implementation for MIPS ELF:

- Section 5.5, "Supported Boards for MIPS ELF" lists the boards supported by CS3 for MIPS ELF, and the available linker scripts for them.

## 5.1. Linker Scripts

When you build programs for MIPS ELF targets, you must use a linker script. The linker script serves several purposes:

- It determines the memory addresses for placement of code and data sections.
- It defines symbolic names for memory regions present on the board, which you can use programmatically within your code.
- It provides appropriate program startup and termination code, and causes the linker to pull in any low-level board support libraries that are required to run code on the target.
- It optionally provides a *hosting* library for basic I/O functionality.
- It provides a default interrupt vector appropriate for the target processor.

When invoking the Sourcery CodeBench linker from the command line, you must explicitly supply a linker script using the `-T` option; otherwise a link error results.

CS3 may provide multiple linker scripts for different configurations using the same board. For example, on some boards CS3 may support running the program from either RAM or ROM (flash). Some CS3 link configurations are also designed to co-exist with, or be run from, a boot monitor on

the target board. Simulator targets typically require different startup code configurations than hardware targets. In CS3 terminology, each of these different configurations is referred to as a *profile*.

The remainder of this section discusses profile and hosting selection considerations in more detail. You can find the full list of supported boards and linker scripts included in this release of Sourcery CodeBench Lite in Section 5.5, “Supported Boards for MIPS ELF”.

### 5.1.1. Program and Data Placement

Many boards have both RAM and ROM (flash) memory devices. CS3 provides distinct linker scripts to place the application either entirely in RAM, or to place code and read-only data in ROM.

Some boards have very small amounts of RAM memory. If you use large library functions (such as `printf` and `malloc`), you may overflow the available memory. You may need to use the ROM-based profile for such programs, so that the program itself is stored in ROM. You may be able to reduce the total amount of memory used by your program by replacing portions of the Sourcery CodeBench runtime library and/or startup code.

### 5.1.2. Hosting and Semihosting

CS3 is designed to support boards without an operating system. To allow functions like `open` and `write` to work without operating system support, a *semihosting* feature is supported, in conjunction with the debugger.

With semihosting enabled, these system calls are translated into equivalent function calls on your host system. You can only use these function calls while connected to the debugger; if you try to use them when disconnected from the debugger, you will get a hardware exception.

Semihosting requires support from the remote GDB debugging stub or agent, as well as the debugger itself. The Sourcery CodeBench Debug Sprite implements semihosting for all supported devices. Semihosting is also supported by the GDB Simulator included with Sourcery CodeBench Lite. However, semihosting may not be supported by debugging stubs provided by third parties. If you are using a debug device that communicates with GDB using the GDB remote protocol, check the documentation for your device to see whether semihosting is supported.

A good use of semihosting is to display debugging messages. For example, this program prints a message on the debugger console on the host:

```
#include <unistd.h>

int main () {
    write (STDERR_FILENO, "Hello, world!\n", 14);
    return 0;
}
```

The hosted CS3 linker scripts provide the semihosting support, and as such programs linked with them may only be run with the debugger. For production code, or programs where memory usage is tightly constrained, use the unhosted CS3 linker scripts instead. These scripts provide stub versions of the system calls, which return an appropriate error value in `errno`. If such a stub system call is required in the executable, the linker also produces a warning. Such a warning may indicate that you have left debugging code active, or that your program contains unused code.

As an alternative to semihosting via the debugger, some targets supported by CS3 can run a boot monitor that provides console I/O services and other basic system calls. CS3 can also provide hosting



via these facilities; where a boot monitor is supported, this is noted in the board tables below. Unlike semihosting, hosting via the boot monitor can be used when running programs outside of the debugger.

### 5.1.3. Specifying a Linker Script

When using Sourcery CodeBench from the command line or from a `Makefile`, you must add `-T script` to your linking command, where `script` is the appropriate linker script. For example, to target MIPS Malta boards, you could link with `-T malta-ram-hosted.ld`.

## 5.2. Program Startup and Termination

This section documents CS3's model for target initialization prior to invoking the `main` function of your program, and aspects of program termination that are left unspecified in the C and C++ standards. It explains how you can customize or override the default behavior for your application.

CS3 divides the startup sequence into three phases:

- The *hard reset phase* (`__cs3_reset`) includes actions such as initializing the memory controller and setting up the memory map.
- The *assembly initialization phase* (`__cs3_start_asm`) prepares the stack to run C code, and jumps to the C initialization function.
- The *C initialization phase* (`__cs3_start_c`) is responsible for initializing the data areas, running constructors for statically-allocated objects, and calling `main`.

The hard reset and assembly initialization phases are necessarily written in assembly language; at reset, there may not yet be stack to hold compiler temporaries, or perhaps even any RAM accessible to hold the stack. These phases do the minimum necessary to prepare the environment for running simple C code. Then, the code for the final phase may be written in C; CS3 leaves as much as possible to be done at this point.

The CodeSourcery board support library provides default code for all three phases. The hard reset phase is implemented by board- and profile-specific code. The assembly initialization phase is implemented by profile-specific code. The C initialization phase is implemented by generic code.

### 5.2.1. The Hard Reset Phase

This phase, which begins at `__cs3_reset`, is responsible for initializing board-specific registers, such as memory base registers and DRAM controllers, or scanning memory to check the available size. It is written in assembler and ends with a jump to `__cs3_start_asm`, which is where the assembly initialization phase begins.

The hard reset code is in a section named `.cs3.reset`. CS3 linker scripts define `__cs3_reset` as an alias for a board- and profile-specific entry point. You may override the CS3-provided reset code by defining your own `__cs3_reset` entry point in the `.cs3.reset` section.

Program execution always begins at `__cs3_reset`, whether the program is started from the reset vector, the debugger, or a boot monitor. However, the `__cs3_reset` code linked into the application is typically non-empty only for ROM-based profiles. For example, in a RAM-based profile, resetting the memory controllers would overwrite the code being executed.

When using the Sourcery CodeBench Debug Sprite, the Sprite is responsible for carrying out the hard reset actions before the program is loaded onto the target. This is performed prior to execution of both RAM- and ROM-profile applications from the debugger. Thus, when debugging a ROM-

profile application, hard reset is actually performed twice — once by the Sprite, and once by the application itself.

## 5.2.2. The Assembly Initialization Phase

This phase is responsible for initializing the stack pointer and creating an initial stack frame. The symbol `__cs3_start_asm` marks the entry point of the assembly initialization code. The assembly initialization phase ends with a call or jump to `__cs3_start_c`.

The assembly initialization phase is profile-specific. For example, while bare-board applications typically must initialize the stack themselves, CS3 also supports boot-monitor profiles where the stack is initialized by the boot monitor before it launches the application. Likewise, some simulators automatically initialize the stack pointer and initial stack frame on startup, while others require a supervisory operation on startup to determine the amount of available memory. Each of these scenarios requires different assembly initialization behavior.

Note that on bare-board targets setting the stack pointer explicitly in the assembly initialization phase is required even if the processor itself initializes the stack pointer automatically on reset. This is to support running programs from the debugger as well as from processor reset.

For backwards compatibility with previous versions of CS3, on RAM and ROM profiles the symbol `__cs3_start_asm` is actually an alias for a symbol named `_start`. However, referencing or defining `_start` directly is now deprecated.

The value of the symbol `__cs3_stack` provides the initial value of the stack pointer for profiles that must set it explicitly. The CodeSourcery linker scripts provide a default value for this symbol, which you may override by defining `__cs3_stack` yourself. See Section 5.3.3, “Heap and Stack Placement” for an example of a custom stack.

The initial stack frame is created for the use of ordinary C and C++ calling conventions. The stack should be initialized so that backtraces stop cleanly at this point; this might entail zeroing a dynamic link pointer, or providing hand-written DWARF call frame information.

The last action of the assembly initialization phase is to call the C function `__cs3_start_c`. This function never returns, and `__cs3_start_asm` need not be prepared to handle a return from it.

As with the hard reset code, the CodeSourcery board support library provides reasonable default assembly initialization code. However, you may provide your own code by providing a definition for `__cs3_start_asm`, either in an object file or a library.

## 5.2.3. The C Initialization Phase

Finally, C code can be executed. The C startup function is declared as follows:

```
void __cs3_start_c (void) __attribute__((noreturn));
```

This function performs the following steps:

- Initialize all `.data`-like sections by copying their contents. For example, ROM-profile linker scripts use this mechanism to initialize writable data in RAM from the read-only data program image.
- Clear all `.bss`-like sections.
- Run constructors for statically-allocated objects, recorded using whatever conventions are usual for C++ on the target architecture.

CS3 reserves priorities from 0 to 100 for use by initialization code. You can handle tasks like enabling interrupts, initializing coprocessors, pointing control registers at interrupt vectors, and so on by defining constructors with appropriate priorities.

- Call `main` as appropriate.
- Call `exit`, if it is available.

As with the hard reset and assembly initialization code, the CodeSourcery board support library provides a reasonable definition for the `__cs3_start_c` function. You may override this by providing a definition for `__cs3_start_c`, either in an object file or in a library.

#### 5.2.4. Arguments to `main`

The CodeSourcery-provided definition of `__cs3_start_c` can pass command-line arguments to `main` using the normal C `argc` and `argv` mechanism if the board support package provides corresponding definitions for `__cs3_argc` and `__cs3_argv`. For example:

```
int __cs3_argc;  
char **__cs3_argv;
```

These variables should be initialized using a constructor function, which is run by `__cs3_start_c` after it initializes the data segment. Use the `constructor` attribute on the function definition:

```
__attribute__((constructor))  
static void __cs3_init_args (void) {  
    __cs3_argc = ...;  
    __cs3_argv = ...;  
}
```

The constructor function may have an arbitrary name; `__cs3_init_args` is used only for illustrative purposes here.

If definitions of `__cs3_argc` and `__cs3_argv` are not provided, then the default `__cs3_start_c` function invokes `main` with zero as the `argc` argument and a null pointer as `argv`.

#### 5.2.5. Program Termination

A program running on an embedded system is usually designed never to exit — it runs until the system is powered down. The C and C++ standards leave it unspecified as to whether `exit` is called at program termination. If the program never exits, then there is no reason to include `exit`, facilities to run functions registered with `atexit`, or global destructors. This code would never be run and would therefore just waste space in the application.

The CS3 startup code, by itself, does not cause `exit` to be present in the application. It dynamically checks whether `exit` is present, and only calls it if it is. If you require `exit` to be present, either refer to it within your application, or add `-Wl, -u, exit` to the linking command line.

Similarly, code to register global destructors is only invoked when `atexit` is already in the executable; CS3, by itself, does not cause `atexit` to be present. If you require `atexit`, either refer to it within your application, or add `-Wl, -u, atexit` to the linking command line.

## 5.3. Memory Layout

Boards supported by CS3 can have multiple banks or regions of memory with different characteristics. This section describes how program sections are mapped onto memory regions, and how you can use these CS3 features to customize placement of your program's code or data in memory. CS3 also provides a uniform set of symbolic names for each region, allowing you to programmatically refer to each region's address range from C or assembly language as well as from the linker script.

### 5.3.1. Memory Regions and Program Sections

The regions that are available on a particular board are listed in the table for that board in Section 5.5, “Supported Boards for MIPS ELF”, below. There are two kinds of regions: those documented as “Memory regions”, which are general-purpose memory banks that can be used for program or data storage; and those documented as “Other regions”, which typically correspond to memory-mapped control registers or other special-purpose storage.

CS3 supports boards that include both `ram` and `rom` memory regions. The `ram` region holds the `.data` and `.bss` sections, and the `.text` section in RAM profiles. In ROM profiles, the `rom` region holds the `.text` section and initialization values for the writable data sections.

In addition, all regions documented as “Memory regions” correspond to similarly-named program sections. For example, the linker script assigns the `.ram` section to the `ram` region.

More generally, for a memory region named `R`, CS3 linker scripts define a section named `.R`, which may contain initialized data or code. There is also a section named `.bss.R` for zero-initialized data (BSS), which is placed after the initialized data section for this region.

You can explicitly locate data or code in a section corresponding to a particular memory region using section attributes in your source C or C++ code. Section attributes are especially useful on code compiled for boards that include special memory banks, such as a fast on-chip cache memory, in addition to the default `ram` and/or `rom` regions. CS3's start-up code arranges for additional data-like sections to be initialized in the same way as the default `.data` section.

As an example to illustrate the attribute syntax, you can put a variable `v` in the `.ram` section using:

```
int v __attribute__((section (".ram")));
```

To declare a function `f` in this section, use:

```
int f (void) __attribute__((section (".ram"))) {...}
```

For more information about attribute syntax, see the GCC manual.

In addition to the `.R` and `.bss.R` sections, CS3 places a `.cs3.region-head.R` section at the beginning of each region `R`. Explicitly placing data in `.cs3.region-head.R` sections is discouraged, because CS3 itself may want to place items (like interrupt vector tables) at these locations. If there is a conflict, CS3 raises an error at link time.

Regions documented as “Other regions” in the tables in Section 5.5, “Supported Boards for MIPS ELF” do not have corresponding program sections. Typically, these regions contain memory-mapped control and I/O registers and cannot be used for general data or program storage. If your program needs to manipulate data in these regions, you can use the CS3 memory map access interface declared in `cs3.h`, as described in Section 5.3.2, “Programmatic Access to the CS3 Memory Map”.

Memory maps for boards supported by Sourcery CodeBench Lite for MIPS ELF are documented in the linker scripts in the `mips-sde-elf/lib/` subdirectory of your Sourcery CodeBench installation directory.

### 5.3.2. Programmatic Access to the CS3 Memory Map

CS3 makes C declarations describing the memory regions on the target board available to your program via the header file `cs3.h`, which you can find in the `mips-sde-elf/include` directory within your install.

For each region named *R*, `cs3.h` declares a byte array variable `__cs3_region_start_R` at the region's start address, and a `size_t` variable `__cs3_region_size_R` to represent the total size of the region. These symbols are defined by the linker script and so may also be referenced from assembly language. Note that all regions are aligned on eight-byte boundaries and sizes are also multiples of eight bytes.

For memory regions that can correspond to program sections (as described in Section 5.3.1, “Memory Regions and Program Sections”), there are additional symbols `__cs3_region_init_R` and `__cs3_region_init_size_R` that describe constant data used to initialize the region. During the C initialization phase (Section 5.2, “Program Startup and Termination”), this data is copied into the lower part of the memory region. The symbol `__cs3_region_zero_size_R` represents the size of the zero-initialized `.bss.R` section following the initialized data. Any of these identifiers may actually be defined as a preprocessor macro that expands to an expression of the appropriate type and value.

To perform the memory region initializations during startup, CS3 internally uses the array variable `__cs3_regions`, which contains descriptors for all of the writable (RAM) memory regions. These descriptors are also exposed in `cs3.h`; refer to the header file for details.

### 5.3.3. Heap and Stack Placement

CS3 linker scripts provide default placement of the heap and stack in the RAM region. However, you can override the defaults by providing your own definitions of the associated CS3 variables. For example, you may put the heap and/or stack in some other memory region.

Heap placement is controlled by defining the symbol `__cs3_heap_start` at the beginning of the heap, and either the symbol `__cs3_heap_end` or the pointer variable `__cs3_heap_limit` to mark the end of the heap. For example, this fragment of C code places the heap in a region named `extsram`:

```
#define HEAPSIZE ... /* However big you want to make it. */
unsigned char __cs3_heap_start[HEAPSIZE]
    __attribute__((section(".bss.extsram"), aligned(8)));
unsigned char *__cs3_heap_limit = __cs3_heap_start + HEAPSIZE;
```

The default initial stack pointer for bare-metal profiles is given by the symbol `__cs3_stack`, and the stack grows downward from this address. Stack initialization is discussed in more detail in Section 5.2.2, “The Assembly Initialization Phase”.

You can find C declarations for the CS3 heap and stack symbols in the header file `cs3.h`.

The `cs3.h` header file also defines a macro for creating a custom stack. The custom stack is created as a block of RAM in the zero-initialized data section (BSS). The specified size must be a compile-time constant. To account for alignment, the final size of the stack may be a few bytes less than the

requested size. The symbol `__cs3_stack` is initialized to point to the last extent of the stack block, and is 16-byte aligned. For example, the following fragment of C code creates a stack of 8192 bytes:

```
#include <cs3.h>

CS3_STACK(2 * 4096);
```

As indicated in Section 5.2.2, “The Assembly Initialization Phase”, there are cases where a boot monitor or simulator overrides a custom stack.

## 5.4. Interrupt Vectors and Handlers

CS3 provides standard handlers for interrupts, exceptions and traps, but also allows you to define your own handlers as needed. In this section, we use the term *interrupt* as a generic term for this entire class of events.

Different processors handle interrupts in various ways, but there are two general approaches:

- Some processors fetch an address from an array indexed by the interrupt number, and jump to that address. We call these *address vector* processors.
- Others multiply the interrupt number by some constant factor, add a base address, and jump directly to that address. Here, the interrupt vector consists of blocks of code, so we call these *code vector* processors.
- Still other processors use a more complicated descriptor mechanism for the interrupt table.

MIPS processors use the code vector model. The remainder of this section assumes that you have some understanding of the specific requirements for your target; refer to the architecture manuals if necessary.

### 5.4.1. MIPS ELF Interrupt Vector Implementation

On MIPS ELF targets, CS3 provides interrupt and exception handling support using the MIPS SDE library interface, which is integrated with the exception support provided by the YAMON boot monitor. The interfaces are modelled on the POSIX signal handling mechanism and are declared in the C header file `mips/xcpt.h`.

### 5.4.2. Writing Interrupt Handlers

Interrupt handlers typically require special call/return and register usage conventions that are target-specific and beyond the scope of this document. In many cases, normal C functions cannot be used as interrupt handlers.

As an alternative to writing interrupt handlers in assembly language, on MIPS targets they may be written in C using the `interrupt` attribute. This tells the compiler to generate appropriate function entry and exit sequences for an interrupt handler. There are additional MIPS-specific attributes you can specify to modify the behavior of the interrupt handler. Refer to the GCC manual for more details about attribute syntax and usage.

## 5.5. Supported Boards for MIPS ELF

CS3 provides support for the following boards on MIPS ELF targets.

<b>MIPS Malta</b>		
Processor name:	unspecified	
Processor options:	none	
Memory regions:	ram	
Linker scripts:	RAM Hosted	malta-ram-hosted.ld
	RAM Unhosted	malta-ram.ld
	YAMON	malta-yamon.ld

<b>MIPS Malta 64-bit</b>		
Processor name:	unspecified	
Processor options:	none	
Memory regions:	ram	
Linker scripts:	RAM Hosted	malta64-ram-hosted.ld
	RAM Unhosted	malta64-ram.ld
	YAMON	malta64-yamon.ld

<b>MIPS SEAD-3 LX110</b>		
Processor name:	unspecified	
Processor options:	none	
Memory regions:	ram	
Linker scripts:	RAM Hosted	sead3-lx110-ram-hosted.ld
	RAM Unhosted	sead3-lx110-ram.ld
	YAMON	sead3-lx110-yamon.ld

<b>MIPS SEAD-3 LX50</b>		
Processor name:	unspecified	
Processor options:	none	
Memory regions:	ram, isram (64K Instruction SRAM), dsram (64K Data SRAM)	
Linker scripts:	RAM Hosted	sead3-lx50-ram-hosted.ld
	RAM Unhosted	sead3-lx50-ram.ld
	Dual SRAM Hosted	sead3-lx50-dual-sram-hosted.ld
	Dual SRAM Unhosted	sead3-lx50-dual-sram.ld
	YAMON	sead3-lx50-yamon.ld
	YAMON Dual SRAM	sead3-lx50-yamon-dual-sram.ld

<b>MIPSim</b>		
Processor name:	unspecified	
Processor options:	none	
Memory regions:	ram	
Linker scripts:	Simulator Hosted	mipssim-hosted.ld
	Simulator Unhosted	mipssim.ld



---

# Chapter 6

## Sourcery CodeBench Debug Sprite

This chapter describes the use of the Sourcery CodeBench Debug Sprite for remote debugging. The Sprite allows you to debug programs running on a bare board without an operating system. This chapter includes information about the debugging devices and boards supported by the Sprite for MIPS ELF.

Sourcery CodeBench Lite contains the Sourcery CodeBench Debug Sprite for MIPS ELF. 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 6.3, “Invoking Sourcery CodeBench Debug Sprite” for information about the specific devices supported by this version of Sourcery CodeBench Lite.

### 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.

## 6.1. 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-sde-elf-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 \
2012.03-64)
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 6.5, “MDI Devices”.

## 6.2. Debug Sprite Example

Start by compiling and linking a simple test program for your target board, following the instructions in Chapter 4, “Using Sourcery CodeBench from the Command Line”. Use the `-g` option to tell the compiler to generate debugging information.

For example, to build the `factorial` program to run on MIPSsim, use:

```
> mips-sde-elf-gcc -g -Tmipsim-hosted.ld main.c -o factorial
```

Next start the debugger on your host system:

```
> mips-sde-elf-gdb factorial
```

To connect GDB to the MDI target, use a command similar to:

```
(gdb) target remote | mips-sde-elf-sprite mdi:///23/2 mipssim
```

Refer to Section 6.5, “MDI Devices” for additional set-up required to use the Sprite with MDI devices.

The Sprite prints some status messages as it connects to your debug device and target board. If the connection is successful, you should see output similar to:

```
mips-sde-elf-sprite:Target reset
0x00008936 in ?? ()
(gdb)
```

Next, use GDB to load your program onto the target board.

```
(gdb) load
```

At this point you can use GDB to control the execution of your program as required. For example:

```
(gdb) break main
(gdb) continue
```

## 6.3. Invoking Sourcery CodeBench Debug Sprite

The Debug Sprite is invoked as follows:

```
> mips-sde-elf-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 ELF:

**mdi** Use a Microprocessor Debug Interface (MDI) debugging device. Refer to Section 6.5, “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 6.7, “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 6.8, “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.

## 6.4. Sourcery CodeBench Debug Sprite Options

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

- 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-sde-elf-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.

## 6.5. 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-sde-elf-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-sde-elf-sprite -i
```

Then, from GDB, use a command similar to:

```
(gdb) target remote | mips-sde-elf-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.

## 6.6. 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-sde-elf-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<sup>1</sup>.

## 6.7. Supported Board Files

The Sourcery CodeBench Debug Sprite for MIPS ELF 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
MIPSSim	mipssim

## 6.8. 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-sde-elf/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
```

<sup>1</sup> <https://sourcery.mentor.com/GNUToolchain/kbentry132>

```

| 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:

<code>&lt;board&gt;</code>	This top-level element encapsulates the entire description of the board. It can contain <code>&lt;category&gt;</code> , <code>&lt;properties&gt;</code> , <code>&lt;feature&gt;</code> , <code>&lt;initialize&gt;</code> and <code>&lt;memory-map&gt;</code> elements.
<code>&lt;category&gt;</code>	The <code>&lt;category&gt;</code> element specifies a '.' separated categorization of this board (e.g., Vendor.Family) to allow grouping similar boards in a tree structure.
<code>&lt;properties&gt;</code>	The <code>&lt;properties&gt;</code> element specifies specific properties of the target system. This element can occur at most once. It can contain a <code>&lt;description&gt;</code> element.
<code>&lt;initialize&gt;</code>	The <code>&lt;initialize&gt;</code> element defines an initialization sequence for the board, which the Sprite performs before downloading a program. It can contain <code>&lt;write-register&gt;</code> , <code>&lt;write-memory&gt;</code> and <code>&lt;delay&gt;</code> elements.
<code>&lt;feature&gt;</code>	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.
<code>&lt;memory-map&gt;</code>	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 <code>&lt;memory-device&gt;</code> elements.
<code>&lt;memory-device&gt;</code>	This element specifies a region of memory. It has four attributes: <code>address</code> , <code>size</code> , <code>type</code> and <code>device</code> . The <code>address</code> and <code>size</code> attributes specify the location of the memory device. The <code>type</code> attribute specifies that device as <code>ram</code> , <code>rom</code> or <code>flash</code> . The <code>device</code> attribute is required for <code>flash</code> regions; it specifies the flash device type. The <code>&lt;memory-device&gt;</code> element can contain a <code>&lt;description&gt;</code> element.
<code>&lt;write-register&gt;</code>	This element writes a value to a control register. It has three attributes: <code>address</code> , <code>value</code> and <code>bits</code> . The <code>bits</code> attribute, specifying the bit width of the write operation, is optional; it defaults to 32.
<code>&lt;write-memory&gt;</code>	This element writes a value to a memory location. It has three attributes: <code>address</code> , <code>value</code> and <code>bits</code> . The <code>bits</code> 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.
<code>&lt;delay&gt;</code>	This element introduces a delay. It has one attribute, <code>time</code> , 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.

---

# **Chapter 7**

## **Next Steps with Sourcery CodeBench**

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

## 7.1. Sourcery CodeBench Knowledge Base

The Sourcery CodeBench Knowledge Base is available to registered users at the Sourcery CodeBench Portal<sup>1</sup>. 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.

## 7.2. Example Programs

Sourcery CodeBench Lite includes some bundled example programs. You can find the source code for these examples in the `share/sourceryg++-mips-sde-elf-examples` directory of your Sourcery CodeBench installation.

### 7.2.1. Other Examples

The subdirectories contain a number of small, target-independent test programs. You may find these programs useful as self-contained test cases when experimenting with configuring the correct compiler and debugger settings for your target, or when learning how to use the debugger or other features of the Sourcery CodeBench toolchain.

## 7.3. 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/sourceryg++-mips-sde-elf/` 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/sourceryg++-mips-sde-elf/man/man1
```

Then you can invoke `man` as:

```
> man ./mips-sde-elf-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 2.6, “Setting up the Environment” for instructions. Then you can invoke `man` with just the command name rather than a pathname.

---

<sup>1</sup> <https://sourcery.mentor.com/GNUToolchain/>

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.

---

# **Appendix A**

## **Sourcery CodeBench Lite Release Notes**

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

## A.1. Changes in Sourcery CodeBench Lite for MIPS ELF

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

### A.1.1. Changes in Sourcery CodeBench Lite 2012.03-64

**\_\_attribute\_\_((nomips16)) code generation bug fix.** A bug in GCC that caused incorrect code to be generated for functions with the `__attribute__((nomips16))` attribute while compiling with `-mips16` has been fixed.

**C++ bug fix.** A bug that caused unpredictable program behavior in C++ programs has been fixed.

**Invalid microMIPS relocation fixed.** A bug in branch code generation for microMIPS, reported by the linker as `relocation truncated to fit: R_MICROMIPS_PC16_S1`, has been fixed.

**Improved size optimization for microMIPS.** The compiler now aligns microMIPS functions more efficiently when the `-Os` option is used.

**Compiler crash fixed.** A GCC bug that occasionally caused an internal compiler error during register allocation has been fixed.

**Register allocation bug fix.** A bug in the register allocator that caused incorrect code generation has been fixed.

**Linker `--gc-sections` bug fix.** A linker bug that incorrectly caused undefined references to be diagnosed when the `--gc-sections` option is used has been fixed.

**EVA support.** GAS now supports MIPS EVA instructions. You can specify the `-meva` option to GCC and GAS to indicate that EVA instructions are being used.

### A.1.2. Changes in Sourcery CodeBench Lite 2012.03-41

**Nondeterministic code generation bug fix.** A GCC bug has been fixed that caused nondeterministic code generation for some input files when optimizing.

**GCC version 4.6.** Sourcery CodeBench Lite for MIPS ELF is now based on GCC version 4.6. For more information about changes from GCC version 4.5 that was included in previous releases, see <http://gcc.gnu.org/gcc-4.6/changes.html>.

**Fix for internal compiler error.** A GCC bug has been fixed that caused an internal compiler error when using pointer casts in C++ `constexpr` initialization expressions.

**Compact C++ exception handling tables.** GCC now defaults to emitting a compact encoding of C++ exception handling tables, rather than using a DWARF-based scheme. For more information, refer to the documentation of the `-mcompact-eh` and `-mno-compact-eh` options in the GCC manual.

**Fix for bit-field optimization bug.** A compiler bug that caused incorrect code to be generated for programs using bit-fields has been fixed.

**Incorrect accesses to volatile memory.** The compiler no longer generates SWP, LWP, SWM or LWM instructions to access objects declared with the `volatile` type qualifier, as these instructions can cause multiple memory accesses of unspecified ordering.

**GCC version 4.6.3.** Sourcery CodeBench Lite for MIPS ELF is now based on GCC version 4.6.3. For more information about issues that have been fixed since version 4.6.1, see <http://gcc.gnu.org/gcc-4.6/changes.html>.

**GCC stack usage improvement.** GCC now generates better code for stack allocation in some cases when compiling with `-fno-strict-aliasing`.

**Linker `--gc-sections` option bug fix.** A bug has been fixed that caused the linker to incorrectly remove the `.debug_types` section when using the `--gc-sections` option.

**Installer failure during upgrade.** Some recent releases were affected by an installer bug on Windows hosts that caused installing a newer version of Sourcery CodeBench Lite into the same directory to fail with the error `Sourcery CodeBench Lite for MIPS ELF upgrade failed`. This bug has now been fixed, but the affected releases cannot be upgraded. As a workaround, uninstall the older release before installing the new version.

**C++ debugging bug fix.** A GDB bug has been fixed that caused GDB to fail to find enum constants in base classes when debugging C++ code.

**Fix for crash in GDB.** A memory corruption bug in GDB has been fixed that under very rare circumstances made it crash or exhibit other unpredictable behavior. On GNU/Linux hosts, this bug caused crashes with an error message similar to: 

```
*** glibc detected ***
mips-sde-elf-gdb: free(): invalid next size (normal): 0x09466198
*** followed by a backtrace.
```

**Fix debugger remote target interruption.** A bug in GDB's handling of requests to interrupt execution on a remote target has been fixed that caused it to stop the target but not emit a stopped MI record.

**GDB internal error fix.** A bug has been fixed that caused GDB to produce messages of the form: 

```
warning: (Internal error: pc 0x1000a0 in read in psyntab, but not
in syntab.)
```

 when taking the addresses of symbols from objects added with the `add-symbol-file` command.

### A.1.3. Changes in Sourcery CodeBench Lite 2011.09-86

**64-bit multilibs.** Sourcery CodeBench Lite now includes libraries and linker scripts to build applications for MIPS64R2 N64 ABI. Use the `-mabi=64` option to compile using 64-bit multilibs, and linker scripts for the Malta board with a 64-bit processor (e.g., `malta64-ram-hosted.ld` to link executables. Multilibs for the N64 ABI are available for all combinations of big/little endianness and hardware/software floating point. Refer to Section 3.2, "Library Configurations" for more information about the 64-bit multilibs.

**GCC crash bug fix.** A GCC bug has been fixed that caused an internal compiler error when a MIPS16 function was inlined into a MIPS32 function.

**GCC optimization bug fix.** A bug in the GCC optimizer has been fixed that caused incorrect code to be generated for some cases of multiplication by a constant when compiling with `-O2` or `-O3`.



**GCC wrong code fix.** An optimizer bug has been fixed that caused GCC to generate code with incorrect scheduling of memory reference instructions.

**Fix for assembler internal error.** A bug has been fixed that caused the assembler to abort with an assertion failure in `emit_inc_line_addr`.

#### A.1.4. Changes in Sourcery CodeBench Lite 2011.09-76

**Changes to included libraries.** Library variants built with `-mfp64`, `-mno-float`, and `-mcode-readable=no` have been removed from Sourcery CodeBench Lite for MIPS ELF. Please refer to Section 3.2, “Library Configurations” for a list of the currently-supported multilibs.

**Fix for compiler hang.** A bug that caused GCC to become stuck in an infinite loop in the optimizer has been fixed.

**Optimization bug fix.** A compiler bug has been fixed that affected some programs using type-aliased assignments to pointer variables. The bug caused incorrect code to be generated when compiled with `-O2` or `-O3`.

**Binutils version 2.21.** Sourcery CodeBench Lite for MIPS ELF is now based on binutils version 2.21.

**Assembler crash.** The assembler now warns when there is line information for the `*ABS*` section, rather than crash. This can occur when the `.offset` directive is used incorrectly.

**Fix for crash in GDB `maint print arch`.** A bug in the GDB command `maint print arch` that sometimes caused GDB to crash has been fixed.

**Remote command bug fix.** A bug in the Sourcery CodeBench Debug Sprite has been fixed that caused GDB's `monitor` remote commands to fail without performing the intended action on some versions of Windows.

**Debug Sprite option defaults.** The Sourcery CodeBench Debug Sprite now uses default option values specified in board configuration files. Options included in the device URL override the default values.

**Changes to host operating system requirements.** The minimum required Microsoft Windows OS needed to run Sourcery CodeBench Lite is now Windows XP (SP1).

#### A.1.5. Changes in Sourcery CodeBench Lite 2011.03-106

**Wrong-code bug fix.** A compiler bug that caused incorrect code to be generated for some branches with `-mbranch-likely` optimization enabled has been fixed.

**Map file name demangling bug fix.** GCC now properly passes the `--demangle` and `--no-demangle` options to the linker to control map file output. The default behavior on all hosts is now to demangle C++ names.

**MIPS16 branch bug fix.** A compiler bug that caused incorrect code to be generated for MIPS16 branches with offsets greater than 65534 or less than -65536 has been fixed.

**Smaller exception handling tables.** The compiler now marks exception handling information for template functions so that the linker can remove duplicates. This also affects non-inlined inline functions.

**Binutils support for 32-bit microMIPS instructions.** The assembler and linker now support generation of 32-bit instructions only when making microMIPS code. For more information, refer to the documentation of the `-mins32` assembler option and the `--insn32` linker option.

**GDB interrupt handling bug fix.** A bug in GDB has been fixed that caused it to sometimes fail to interrupt lengthy single-step operations (as by a **Ctrl+C** when using GDB from the command line).

**Fix GDB crash during connection to debug agent.** A bug has been fixed that caused GDB to crash while connecting to any debug agent through standard IO where the debug agent had detected an early error and terminated the communication.

**Debug Sprite register reporting bug fix.** In recent releases, the Sourcery CodeBench Debug Sprite reported an incorrect set of registers to GDB in some circumstances. This bug has been fixed.

**Improved download speed on Windows hosts.** The Sourcery CodeBench Debug Sprite now downloads binaries to the target faster when using Windows hosts.

### A.1.6. Changes in Sourcery CodeBench Lite 2011.03-92

**MIPS16 switch statement compilation fix.** A bug has been fixed that caused very large `switch` statements to be compiled incorrectly for MIPS16.

**Support for MIPS M14Ke and M14Kec processors.** Sourcery CodeBench Lite now supports the MIPS M14Ke and M14Kec processors. To compile for these targets, use the `-march=m14ke` `-mmicromips` or `-march=m14kec` `-mmicromips` command-line options.

**MIPS16 static data bug fix.** A compiler bug has been fixed that caused static data to be accessed incorrectly from position-independent MIPS16 code in rare cases.

### A.1.7. Changes in Sourcery CodeBench Lite 2011.03-76

**New Sourcery CodeBench Lite branding.** Sourcery G++ has been renamed to Sourcery CodeBench. This change affects the names of the default installation directory and installer-created shortcuts, but no internal pathnames or tool names within the installation directory have been changed.

**Improved function call profiling.** The compiler now supports the `-finstrument-function-calls` option. Please see the GCC documentation for more details.

**microMIPS linker code size optimization bug fix.** A bug has been fixed that sometimes caused the linker to generate incorrect code when the `--relax` option is used to enable certain code size optimizations that make use of the `ADDIUPC` instruction.

**Improved GDB diagnostics.** A bug has been fixed in GDB that caused cryptic `assertion fail` messages whenever a file in the unsupported SGI IRIX variation of the ELF binary format was selected. GDB now issues explanatory warning messages instead.

**Improved disassembler performance in the debugger.** GDB's disassembler has been improved to use more efficient memory access on remote targets.

### A.1.8. Changes in Sourcery G++ Lite 2011.03-52

**Interprocedural stack optimization.** The compiler has a new experimental optimization that generates code that claims less stack space. To switch this optimization on, use `-mframe-header-opt`.

**MIPS32r2 floating-point multiply-accumulate restrictions lifted.** Following clarifications to the MIPS architecture specification, GCC has been updated to allow floating-point multiply-accumulate instructions on MIPS32r2 processors in all configurations.

**Interprocedural register optimization.** The compiler has a new experimental optimization that generates better code for functions that only call functions in the same object. To switch this optimization on, use `-fuse-caller-save`.

**Incorrect C++ warning fixed.** A bug in GCC has been fixed that caused spurious warnings about lambda expressions in C++ code that does not use them.

**C++ constructor bug fix.** A compiler bug has been fixed that caused incorrect code for C++ constructors for some class hierarchies that use virtual inheritance and include empty classes. At runtime, the incorrect constructors resulted in memory corruption or other errors.

**Improved DSP code.** The compiler now makes better use of DSP accumulator registers when compiling with `-mdsp` or `-mdspr2`.

**microMIPS branches.** A compiler bug that caused sub-optimal branch instructions to be generated in microMIPS mode has been fixed.

**Addr2line bug fix.** A bug has been fixed that caused Addr2line to print `?:?:0` for any address instead of file and line number.

**24K Errata.** The `-mfix-24k` assembler option has been extended to work around Errata E48: Lost Data on Stores During Refill. In addition, GCC now accepts this command-line option and passes it through to the assembler.

**CS3 linker script changes.** CS3 linker scripts for RAM profiles have been changed to reserve only 4K at the start of memory for interrupt vectors, rather than 1M to also preserve memory used by YAMON. This change affects RAM-profile linker scripts for all supported boards, including Malta and SEAD-3 boards. YAMON-profile linker scripts for these boards are unchanged.

### A.1.9. Changes in Sourcery G++ Lite 2011.03-12

**Compiler optimization improvements.** The compiler has been enhanced with a number of optimization improvements, including:

- Smaller and faster code for compound conditionals.
- Improved filling of branch delay slots.
- Removal of superfluous sign and zero extensions.

**GCC version 4.5.2.** Sourcery G++ Lite for MIPS ELF is now based on GCC version 4.5.2.

**New `-fstrict-volatile-bitfields` option.** The compiler has a new option, `-fstrict-volatile-bitfields`, which forces access to a volatile structure member using the width that conforms to its type. Refer to the GCC manual for details.

**GCC code generation bug for casts to volatile types.** A compiler bug has been fixed that sometimes caused incorrect code for references to pointers to types with `volatile` casts.

**Improvements to synchronization primitives.** GCC's `__sync` built-in functions have been improved to make better use of MIPS atomic instructions.

**Incorrect optimization fix.** An optimizer bug that in rare cases caused incorrect code to be generated for complex AND and OR expressions containing redundant subexpressions has been fixed.

**GCC microMIPS code size improvement.** GCC has been improved to generate smaller code around function calls.

**GCC bug where accesses to volatile structure fields are optimized away.** A bug has been fixed where accesses to volatile fields of a structure were sometimes incorrectly optimized away if the structure instance was defined as non-volatile.

**Linker debug information fix.** A bug in linker processing of debug information has been fixed. The bug sometimes prevented the Sourcery G++ debugger from displaying source code if the executable was linked with the `--gc-sections` option.

**microMIPS linker code size optimization bug fix.** A bug has been fixed that sometimes caused the linker to generate incorrect code when the `--relax` option is used to enable certain code size optimizations.

**microMIPS DSP ASE.** The assembler now supports microMIPS encodings for the DSP ASE instructions.

**MCU ASE instructions assembler bug fixes.** Bugs have been fixed that caused the assembler to sometimes generate incorrect code for the MCU ASE ACLR, ASET and IRET instructions.

**COP2 instruction bug fix.** A bug in handling of the COP2 instruction's argument has been fixed in the assembler and disassembler.

**GDB microMIPS disassembler bug fix.** A bug in GDB has been fixed that caused some microMIPS instructions to disassemble incorrectly.

**Debugger warnings quieted.** GDB no longer prints `RMT ERROR` diagnostics on connection to the Sourcery G++ Debug Sprite. In spite of the alarming appearance of the messages, they were not actually indicative of a serious problem.

## A.1.10. Changes in Sourcery G++ Lite 2010.09-28

**Changes to Sourcery G++ version numbering.** Sourcery G++ product and Lite toolchains now uniformly use a version numbering scheme of the form 2012.03-64. The major and minor parts of the version number, in this case 2012.03, identify the release branch, while the final component is a build number within the branch. There are also new preprocessor macros defined by the compiler for the version number components so that you may conditionalize code for Sourcery G++ or particular Sourcery G++ versions. Details are available in the [Sourcery G++ Knowledge Base](#)<sup>1</sup>.

**Alignment attributes.** A bug has been fixed that caused the compiler to ignore alignment attributes of C++ static member variables where the attribute was present on the definition, but not the declaration.

**Compiler optimization improvements.** The compiler has been enhanced with a number of optimization improvements, including:

- More efficient assignment for structures containing bitfields.
- Better code for initializing C++ arrays with explicit element initializers.

---

<sup>1</sup> <https://support.codesourcery.com/GNUToolchain/kbentry1>

- Improved logic for eliminating/combining redundant comparisons in code with nested conditionals.
- Better selection of loop variables, resulting in fewer temporaries and more efficient register usage.
- Better code when constant addresses are used as arguments to inline assembly statements.
- Better code for copying small constant strings.

**GCC version 4.5.1.** Sourcery G++ Lite for MIPS ELF is now based on GCC version 4.5.1. For more information about changes from GCC version 4.4 that was included in previous releases, see <http://gcc.gnu.org/gcc-4.5/changes.html>.

**Archiver bug fix.** A bug has been fixed in the `ar` utility, which sometimes caused it to produce unrecognizable 64-bit files. The bug also caused similar problems in the `strip` and `objcopy` utilities when processing 64-bit archives.

**Fix for incorrect MIPS16 and microMIPS relocations.** An assembler bug has been fixed that caused incorrect relocation information to be produced for MIPS16 and microMIPS code, diagnosed by a `Can't find matching LO16 reloc` linker warning.

**Additional validation in the assembler.** The assembler now diagnoses an error, instead of producing an invalid object file, when directives such as `.hidden` are missing operands.

**Binutils update.** The binutils package has been updated to version 2.20.51.20100809 from the FSF trunk. This update includes numerous bug fixes.

**Additional alignment in CS3-defined linker scripts.** Sourcery G++ now ensures 8-byte alignment at additional points in CS3-defined linker scripts. Previously, placing a symbol in certain sections broke the initialization of the `.data` and/or `.bss` sections.

**Newlib update.** The Newlib package has been updated to version 1.18.0, with additions from the community CVS trunk as of 2010-08-12. This update provides additional wide-character functions, along with other bug fixes and enhancements.

**GDB update.** The included version of GDB has been updated to 7.2.50.20100908. This update adds numerous bug fixes and new features, including improved C++ language support, a new command to save breakpoints to a file, a new convenience variable `$_thread` that holds the number of the current thread, among many other improvements.

**GDB crash fix.** A bug has been fixed that caused GDB to crash on launch if the environment variable `CYGPATH` is set to a program that does not exist or cannot be executed.

**Debug Sprite abnormal termination bug fix.** The Sourcery G++ Debug Sprite no longer terminates abnormally if GDB is killed while the target is waiting for semihosted I/O to complete. The bug was only triggered when running GDB on a Windows host.

### A.1.11. Changes in Older Releases

For information about changes in older releases of Sourcery G++ Lite for MIPS ELF, 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.

## B.1. Licenses for Sourcery CodeBench Lite Components

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

Some free or open-source components provide documentation or other files under terms different from those shown below. For definitive information about the license that applies to each component, consult the source package corresponding to this release of Sourcery 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.

Component	License
GNU Compiler Collection	GNU General Public License 3.0 <a href="http://www.gnu.org/licenses/gpl.html">http://www.gnu.org/licenses/gpl.html</a>
GNU Binary Utilities	GNU General Public License 3.0 <a href="http://www.gnu.org/licenses/gpl.html">http://www.gnu.org/licenses/gpl.html</a>
GNU Debugger	GNU General Public License 3.0 <a href="http://www.gnu.org/licenses/gpl.html">http://www.gnu.org/licenses/gpl.html</a>
Sourcery CodeBench Debug Sprite for MIPS	CodeSourcery License
CodeSourcery Common Startup Code Sequence	CodeSourcery License
Newlib C Library	BSD License. For the text of the license and a complete list of copyright holders, see Section B.3.2, “Newlib”.
GNU Make	GNU General Public License 2.0 <a href="http://www.gnu.org/licenses/old-licenses/gpl-2.0.html">http://www.gnu.org/licenses/old-licenses/gpl-2.0.html</a>
GNU Core Utilities	GNU General Public License 2.0 <a href="http://www.gnu.org/licenses/old-licenses/gpl-2.0.html">http://www.gnu.org/licenses/old-licenses/gpl-2.0.html</a>

The CodeSourcery License is available in Section B.2, “Sourcery CodeBench Software License Agreement”.

### 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.

Sourcery CodeBench Lite may include some third party example programs and libraries in the `share/sourceryg++-mips-sde-elf-examples` subdirectory. These examples are not covered by the Sourcery CodeBench Software License Agreement. To the extent permitted by law, these examples are provided by CodeSourcery as is with no warranty of any kind, including implied warranties of merchantability or fitness for a particular purpose. Your use of each example is governed by the license notice (if any) it contains.

## B.2. Sourcery CodeBench™ Software License Agreement

1. **Parties.** The parties to this Agreement are you, the licensee (“You” or “Licensee”) and Mentor Graphics. If You are not acting on behalf of Yourself as an individual, then “You” means Your company or organization.
2. **The Software.** The Software licensed under this Agreement consists of computer programs and documentation referred to as Sourcery CodeBench™ Lite Edition (the “Software”).
3. **Definitions.**
  - 3.1. **Mentor Graphics Proprietary Components.** The components of the Software that are owned and/or licensed by Mentor Graphics and are not subject to a “free software” or “open source” license, such as the GNU Public License. The Mentor Graphics Proprietary Components of the Software include, without limitation, the Sourcery CodeBench Installer, any Sourcery CodeBench Eclipse plug-ins, the CodeSourcery C Library (CSLIBC), and any Sourcery CodeBench Debug Sprite. For a complete list, refer to the *Getting Started Guide* included with the distribution.
  - 3.2. **Open Source Software Components.** The components of the Software that are subject to a “free software” or “open source” license, such as the GNU Public License.
  - 3.3. **Proprietary Rights.** All rights in and to copyrights, rights to register copyrights, trade secrets, inventions, patents, patent rights, trademarks, trademark rights, confidential and proprietary information protected under contract or otherwise under law, and other similar rights or interests in intellectual or industrial property.
  - 3.4. **Redistributable Components.** The Mentor Graphics Proprietary Components that are intended to be incorporated or linked into Licensee object code developed with the Software. The Redistributable Components of the Software include, without limitation, CSLIBC and the CodeSourcery Common Startup Code Sequence (CS3). For a complete list, refer to the *Getting Started Guide* included with the distribution.
4. **License Grant to Proprietary Components of the Software.** You are granted a non-exclusive, royalty-free license (a) to install and use the Mentor Graphics Proprietary Components of the Software, (b) to transmit the Mentor Graphics Proprietary Components over an internal computer network, (c) to copy the Mentor Graphics Proprietary Components for Your internal use only, and (d) to distribute the Redistributable Component(s) in binary form only and only as part of Licensee object code developed with the Software that provides substantially different functionality than the Redistributable Component(s).
5. **Restrictions.** You may not: (i) copy or permit others to use the Mentor Graphics Proprietary Components of the Software, except as expressly provided above; (ii) distribute the Mentor Graphics Proprietary Components of the Software to any third party, except as expressly provided above; or (iii) reverse engineer, decompile, or disassemble the Mentor Graphics Proprietary Components of the Software, except to the extent this restriction is expressly prohibited by applicable law.
6. **“Free Software” or “Open Source” License to Certain Components of the Software.** This Agreement does not limit Your rights under, or grant You rights that supersede, the license terms of any Open Source Software Component delivered to You by Mentor Graphics. Sourcery CodeBench includes components provided under various different licenses. The *Getting Started Guide* provides an overview of which license applies to different components, and, for compon-



ents subject to the Eclipse Public License, contains information on how to obtain the source code. Definitive licensing information for each “free software” or “open source” component is available in the relevant source file.

7. **Mentor Graphics Trademarks.** Notwithstanding any provision in a “free software” or “open source” license agreement applicable to a component of the Software that permits You to distribute such component to a third party in source or binary form, You may not use any Mentor Graphics trademark, whether registered or unregistered, including without limitation, CodeSourcery™, Sourcery CodeBench™, the CodeSourcery crystal ball logo, or the Sourcery CodeBench splash screen, or any confusingly similar mark, in connection with such distribution, and You may not recompile the Open Source Software Components with the `--with-pkgversion` or `--with-bugurl` configuration options that embed Mentor Graphics trademarks in the resulting binary.
8. **Term and Termination.** This Agreement shall remain in effect unless terminated pursuant to this provision. Mentor Graphics may terminate this Agreement upon seven (7) days written notice of a material breach of this Agreement if such breach is not cured; provided that the unauthorized use, copying, or distribution of the Mentor Graphics Proprietary Components of the Software will be deemed a material breach that cannot be cured.
9. **Transfers.** You may not transfer any rights under this Agreement without the prior written consent of Mentor Graphics, which consent shall not be unreasonably withheld. A condition to any transfer or assignment shall be that the recipient agrees to the terms of this Agreement. Any attempted transfer or assignment in violation of this provision shall be null and void.
10. **Ownership.** Mentor Graphics owns and/or has licensed the Mentor Graphics Proprietary Components of the Software and all intellectual property rights embodied therein, including copyrights and valuable trade secrets embodied in its design and coding methodology. The Mentor Graphics Proprietary Components of the Software are protected by United States copyright laws and international treaty provisions. Mentor Graphics also owns all rights, title and interest in and with respect to its trade names, domain names, trade dress, logos, trademarks, service marks, and other similar rights or interests in intellectual property. This Agreement provides You only a limited use license, and no ownership of any intellectual property.
11. **Warranty Disclaimer; Limitation of Liability.** MENTOR GRAPHICS AND ITS LICENSORS PROVIDE THE SOFTWARE “AS-IS” AND PROVIDED WITH ALL FAULTS. MENTOR GRAPHICS DOES NOT MAKE ANY WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. MENTOR GRAPHICS SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF TITLE, NON-INFRINGEMENT, MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, SYSTEM INTEGRATION, AND DATA ACCURACY. THERE IS NO WARRANTY OR GUARANTEE THAT THE OPERATION OF THE SOFTWARE WILL BE UNINTERRUPTED, ERROR-FREE, OR VIRUS-FREE, OR THAT THE SOFTWARE WILL MEET ANY PARTICULAR CRITERIA OF PERFORMANCE, QUALITY, ACCURACY, PURPOSE, OR NEED. YOU ASSUME THE ENTIRE RISK OF SELECTION, INSTALLATION, AND USE OF THE SOFTWARE. THIS DISCLAIMER OF WARRANTY CONSTITUTES AN ESSENTIAL PART OF THIS AGREEMENT. NO USE OF THE SOFTWARE IS AUTHORIZED HEREUNDER EXCEPT UNDER THIS DISCLAIMER.
12. **Local Law.** If implied warranties may not be disclaimed under applicable law, then ANY IMPLIED WARRANTIES ARE LIMITED IN DURATION TO THE PERIOD REQUIRED BY APPLICABLE LAW.
13. **Limitation of Liability.** INDEPENDENT OF THE FORGOING PROVISIONS, IN NO EVENT AND UNDER NO LEGAL THEORY, INCLUDING WITHOUT LIMITATION, TORT, CONTRACT, OR STRICT PRODUCTS LIABILITY, SHALL MENTOR GRAPHICS

BE LIABLE TO YOU OR ANY OTHER PERSON FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY KIND, INCLUDING WITHOUT LIMITATION, DAMAGES FOR LOSS OF GOODWILL, WORK STOPPAGE, COMPUTER MALFUNCTION, OR ANY OTHER KIND OF COMMERCIAL DAMAGE, EVEN IF MENTOR GRAPHICS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THIS LIMITATION SHALL NOT APPLY TO LIABILITY FOR DEATH OR PERSONAL INJURY TO THE EXTENT PROHIBITED BY APPLICABLE LAW. IN NO EVENT SHALL MENTOR GRAPHICS' LIABILITY FOR ACTUAL DAMAGES FOR ANY CAUSE WHATSOEVER, AND REGARDLESS OF THE FORM OF ACTION, EXCEED THE AMOUNT PAID BY YOU IN FEES UNDER THIS AGREEMENT DURING THE PREVIOUS ONE YEAR PERIOD.

14. **Export Controls.** You agree to comply with all export laws and restrictions and regulations of the United States or foreign agencies or authorities, and not to export or re-export the Software or any direct product thereof in violation of any such restrictions, laws or regulations, or without all necessary approvals. As applicable, each party shall obtain and bear all expenses relating to any necessary licenses and/or exemptions with respect to its own export of the Software from the U.S. Neither the Software nor the underlying information or technology may be electronically transmitted or otherwise exported or re-exported (i) into Cuba, Iran, Iraq, Libya, North Korea, Sudan, Syria or any other country subject to U.S. trade sanctions covering the Software, to individuals or entities controlled by such countries, or to nationals or residents of such countries other than nationals who are lawfully admitted permanent residents of countries not subject to such sanctions; or (ii) to anyone on the U.S. Treasury Department's list of Specially Designated Nationals and Blocked Persons or the U.S. Commerce Department's Table of Denial Orders. By downloading or using the Software, Licensee agrees to the foregoing and represents and warrants that it complies with these conditions.
15. **U.S. Government End-Users.** The Software is a "commercial item," as that term is defined in 48 C.F.R. 2.101 (Oct. 1995), consisting of "commercial computer software" and "commercial computer software documentation," as such terms are used in 48 C.F.R. 12.212 (Sept. 1995). Consistent with 48 C.F.R. 12.212 and 48 C.F.R. 227.7202-1 through 227.7202-4 (June 1995), all U.S. Government End Users acquire the Software with only those rights set forth herein.
16. **Licensee Outside The U.S.** If You are located outside the U.S., then the following provisions shall apply: (i) Les parties aux presentes confirment leur volonte que cette convention de meme que tous les documents y compris tout avis qui siy rattache, soient rediges en langue anglaise (translation: "The parties confirm that this Agreement and all related documentation is and will be in the English language."); and (ii) You are responsible for complying with any local laws in your jurisdiction which might impact your right to import, export or use the Software, and You represent that You have complied with any regulations or registration procedures required by applicable law to make this license enforceable.
17. **Severability.** If any provision of this Agreement is declared invalid or unenforceable, such provision shall be deemed modified to the extent necessary and possible to render it valid and enforceable. In any event, the unenforceability or invalidity of any provision shall not affect any other provision of this Agreement, and this Agreement shall continue in full force and effect, and be construed and enforced, as if such provision had not been included, or had been modified as above provided, as the case may be.
18. **Arbitration.** Except for actions to protect intellectual property rights and to enforce an arbitrator's decision hereunder, all disputes, controversies, or claims arising out of or relating to this Agreement or a breach thereof shall be submitted to and finally resolved by arbitration under the rules of the American Arbitration Association ("AAA") then in effect. There shall be one arbitrator, and such arbitrator shall be chosen by mutual agreement of the parties in accordance

with AAA rules. The arbitration shall take place in Granite Bay, California, and may be conducted by telephone or online. The arbitrator shall apply the laws of the State of California, USA to all issues in dispute. The controversy or claim shall be arbitrated on an individual basis, and shall not be consolidated in any arbitration with any claim or controversy of any other party. The findings of the arbitrator shall be final and binding on the parties, and may be entered in any court of competent jurisdiction for enforcement. Enforcements of any award or judgment shall be governed by the United Nations Convention on the Recognition and Enforcement of Foreign Arbitral Awards. Should either party file an action contrary to this provision, the other party may recover attorney's fees and costs up to \$1000.00.

19. **Jurisdiction And Venue.** The courts of Placer County in the State of California, USA and the nearest U.S. District Court shall be the exclusive jurisdiction and venue for all legal proceedings that are not arbitrated under this Agreement.
20. **Independent Contractors.** The relationship of the parties is that of independent contractor, and nothing herein shall be construed to create a partnership, joint venture, franchise, employment, or agency relationship between the parties. Licensee shall have no authority to enter into agreements of any kind on behalf of Mentor Graphics and shall not have the power or authority to bind or obligate Mentor Graphics in any manner to any third party.
21. **Force Majeure.** Neither Mentor Graphics nor Licensee shall be liable for damages for any delay or failure of delivery arising out of causes beyond their reasonable control and without their fault or negligence, including, but not limited to, Acts of God, acts of civil or military authority, fires, riots, wars, embargoes, or communications failure.
22. **Miscellaneous.** This Agreement constitutes the entire understanding of the parties with respect to the subject matter of this Agreement and merges all prior communications, representations, and agreements. This Agreement may be modified only by a written agreement signed by the parties. If any provision of this Agreement is held to be unenforceable for any reason, such provision shall be reformed only to the extent necessary to make it enforceable. This Agreement shall be construed under the laws of the State of California, USA, excluding rules regarding conflicts of law. The application of the United Nations Convention of Contracts for the International Sale of Goods is expressly excluded. This license is written in English, and English is its controlling language.

## B.3. Attribution

This version of Sourcery CodeBench Lite may include code based on work under the following copyright and permission notices:

### B.3.1. Android Open Source Project

```
/*
 * Copyright (C) 2008 The Android Open Source Project
 * All rights reserved.
 *
 * Redistribution and use in source and binary forms, with or without
 * modification, are permitted provided that the following conditions
 * are met:
 * * Redistributions of source code must retain the above copyright
 *   notice, this list of conditions and the following disclaimer.
 * * Redistributions in binary form must reproduce the above copyright
 *   notice, this list of conditions and the following disclaimer in
 *   the documentation and/or other materials provided with the
 *   distribution.
 *
 * THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS
 * "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT
```

```
* LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS
* FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE
* COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT,
* INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING,
* BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS
* OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED
* AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY,
* OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT
* OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF
* SUCH DAMAGE.
*/
```

### B.3.2. Newlib

The newlib subdirectory is a collection of software from several sources.

Each file may have its own copyright/license that is embedded in the source file. Unless otherwise noted in the body of the source file(s), the following copyright notices will apply to the contents of the newlib subdirectory:

(1) Red Hat Incorporated

Copyright (c) 1994-2007 Red Hat, Inc. All rights reserved.

This copyrighted material is made available to anyone wishing to use, modify, copy, or redistribute it subject to the terms and conditions of the BSD License. This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY expressed or implied, including the implied warranties of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. A copy of this license is available at <http://www.opensource.org/licenses>. Any Red Hat trademarks that are incorporated in the source code or documentation are not subject to the BSD License and may only be used or replicated with the express permission of Red Hat, Inc.

(2) University of California, Berkeley

Copyright (c) 1981-2000 The Regents of the University of California. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- \* Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- \* Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- \* Neither the name of the University nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(3) David M. Gay (AT&T 1991, Lucent 1998)

The author of this software is David M. Gay.

Copyright (c) 1991 by AT&T.

Permission to use, copy, modify, and distribute this software for any purpose without fee is hereby granted, provided that this entire notice

## Sourcery CodeBench Lite Licenses

---

is included in all copies of any software which is or includes a copy or modification of this software and in all copies of the supporting documentation for such software.

THIS SOFTWARE IS BEING PROVIDED "AS IS", WITHOUT ANY EXPRESS OR IMPLIED WARRANTY. IN PARTICULAR, NEITHER THE AUTHOR NOR AT&T MAKES ANY REPRESENTATION OR WARRANTY OF ANY KIND CONCERNING THE MERCHANTABILITY OF THIS SOFTWARE OR ITS FITNESS FOR ANY PARTICULAR PURPOSE.

-----  
The author of this software is David M. Gay.

Copyright (C) 1998-2001 by Lucent Technologies  
All Rights Reserved

Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that the copyright notice and this permission notice and warranty disclaimer appear in supporting documentation, and that the name of Lucent or any of its entities not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

LUCENT DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS. IN NO EVENT SHALL LUCENT OR ANY OF ITS ENTITIES BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

(4) Advanced Micro Devices

Copyright 1989, 1990 Advanced Micro Devices, Inc.

This software is the property of Advanced Micro Devices, Inc (AMD) which specifically grants the user the right to modify, use and distribute this software provided this notice is not removed or altered. All other rights are reserved by AMD.

AMD MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARD TO THIS SOFTWARE. IN NO EVENT SHALL AMD BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH OR ARISING FROM THE FURNISHING, PERFORMANCE, OR USE OF THIS SOFTWARE.

So that all may benefit from your experience, please report any problems or suggestions about this software to the 29K Technical Support Center at 800-29-29-AMD (800-292-9263) in the USA, or 0800-89-1131 in the UK, or 0031-11-1129 in Japan, toll free. The direct dial number is 512-462-4118.

Advanced Micro Devices, Inc.  
29K Support Products  
Mail Stop 573  
5900 E. Ben White Blvd.  
Austin, TX 78741  
800-292-9263

(5) C.W. Sandmann

Copyright (C) 1993 C.W. Sandmann

This file may be freely distributed as long as the author's name remains.

(6) Eric Backus

(C) Copyright 1992 Eric Backus

---

## Sourcery CodeBench Lite Licenses

---

This software may be used freely so long as this copyright notice is left intact. There is no warrantee on this software.

(7) Sun Microsystems

Copyright (C) 1993 by Sun Microsystems, Inc. All rights reserved.

Developed at SunPro, a Sun Microsystems, Inc. business.  
Permission to use, copy, modify, and distribute this software is freely granted, provided that this notice is preserved.

(8) Hewlett Packard

(c) Copyright 1986 HEWLETT-PACKARD COMPANY

To anyone who acknowledges that this file is provided "AS IS" without any express or implied warranty:

permission to use, copy, modify, and distribute this file for any purpose is hereby granted without fee, provided that the above copyright notice and this notice appears in all copies, and that the name of Hewlett-Packard Company not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. Hewlett-Packard Company makes no representations about the suitability of this software for any purpose.

(9) Hans-Peter Nilsson

Copyright (C) 2001 Hans-Peter Nilsson

Permission to use, copy, modify, and distribute this software is freely granted, provided that the above copyright notice, this notice and the following disclaimer are preserved with no changes.

THIS SOFTWARE IS PROVIDED ``AS IS'' AND WITHOUT ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

(10) Stephane Carrez (m68hc11-elf/m68hc12-elf targets only)

Copyright (C) 1999, 2000, 2001, 2002 Stephane Carrez (stcarrez@nerim.fr)

The authors hereby grant permission to use, copy, modify, distribute, and license this software and its documentation for any purpose, provided that existing copyright notices are retained in all copies and that this notice is included verbatim in any distributions. No written agreement, license, or royalty fee is required for any of the authorized uses. Modifications to this software may be copyrighted by their authors and need not follow the licensing terms described here, provided that the new terms are clearly indicated on the first page of each file where they apply.

(11) Christopher G. Demetriou

Copyright (c) 2001 Christopher G. Demetriou  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. The name of the author may not be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED.

IN NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(12) SuperH, Inc.

Copyright 2002 SuperH, Inc. All rights reserved

This software is the property of SuperH, Inc (SuperH) which specifically grants the user the right to modify, use and distribute this software provided this notice is not removed or altered. All other rights are reserved by SuperH.

SUPERH MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARD TO THIS SOFTWARE. IN NO EVENT SHALL SUPERH BE LIABLE FOR INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH OR ARISING FROM THE FURNISHING, PERFORMANCE, OR USE OF THIS SOFTWARE.

So that all may benefit from your experience, please report any problems or suggestions about this software to the SuperH Support Center via e-mail at [softwaresupport@superh.com](mailto:softwaresupport@superh.com) .

SuperH, Inc.  
405 River Oaks Parkway  
San Jose  
CA 95134  
USA

(13) Royal Institute of Technology

Copyright (c) 1999 Kungliga Tekniska Högskolan  
(Royal Institute of Technology, Stockholm, Sweden).  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of KTH nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY KTH AND ITS CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL KTH OR ITS CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(14) Alexey Zelkin

Copyright (c) 2000, 2001 Alexey Zelkin <[phantom@FreeBSD.org](mailto:phantom@FreeBSD.org)>  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions

are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(15) Andrey A. Chernov

Copyright (C) 1997 by Andrey A. Chernov, Moscow, Russia.  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(16) FreeBSD

Copyright (c) 1997-2002 FreeBSD Project.  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(17) S. L. Moshier



Author: S. L. Moshier.

Copyright (c) 1984,2000 S.L. Moshier

Permission to use, copy, modify, and distribute this software for any purpose without fee is hereby granted, provided that this entire notice is included in all copies of any software which is or includes a copy or modification of this software and in all copies of the supporting documentation for such software.

THIS SOFTWARE IS BEING PROVIDED "AS IS", WITHOUT ANY EXPRESS OR IMPLIED WARRANTY. IN PARTICULAR, THE AUTHOR MAKES NO REPRESENTATION OR WARRANTY OF ANY KIND CONCERNING THE MERCHANTABILITY OF THIS SOFTWARE OR ITS FITNESS FOR ANY PARTICULAR PURPOSE.

(18) Citrus Project

Copyright (c)1999 Citrus Project,  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(19) Todd C. Miller

Copyright (c) 1998 Todd C. Miller <Todd.Miller@courtesan.com>  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. The name of the author may not be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(20) DJ Delorie (i386)

Copyright (C) 1991 DJ Delorie  
All rights reserved.

Redistribution and use in source and binary forms is permitted provided that the above copyright notice and following paragraph are duplicated in all such forms.

This file is distributed WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

(21) Free Software Foundation LGPL License (\*-linux\* targets only)

Copyright (C) 1990-1999, 2000, 2001 Free Software Foundation, Inc.  
This file is part of the GNU C Library.  
Contributed by Mark Kettenis <kettenis@phys.uva.nl>, 1997.

The GNU C Library is free software; you can redistribute it and/or modify it under the terms of the GNU Lesser General Public License as published by the Free Software Foundation; either version 2.1 of the License, or (at your option) any later version.

The GNU C Library is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU Lesser General Public License for more details.

You should have received a copy of the GNU Lesser General Public License along with the GNU C Library; if not, write to the Free Software Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA.

(22) Xavier Leroy LGPL License (i[3456]86-\*-linux\* targets only)

Copyright (C) 1996 Xavier Leroy (Xavier.Leroy@inria.fr)

This program is free software; you can redistribute it and/or modify it under the terms of the GNU Library General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.

This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU Library General Public License for more details.

(23) Intel (i960)

Copyright (c) 1993 Intel Corporation

Intel hereby grants you permission to copy, modify, and distribute this software and its documentation. Intel grants this permission provided that the above copyright notice appears in all copies and that both the copyright notice and this permission notice appear in supporting documentation. In addition, Intel grants this permission provided that you prominently mark as "not part of the original" any modifications made to this software or documentation, and that the name of Intel Corporation not be used in advertising or publicity pertaining to distribution of the software or the documentation without specific, written prior permission.

Intel Corporation provides this AS IS, WITHOUT ANY WARRANTY, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Intel makes no guarantee or representations regarding the use of, or the results of the use of, the software and documentation in terms of correctness, accuracy, reliability, currentness, or otherwise; and you rely on the software, documentation and results solely at your own risk.

IN NO EVENT SHALL INTEL BE LIABLE FOR ANY LOSS OF USE, LOSS OF BUSINESS, LOSS OF PROFITS, INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES OF ANY KIND. IN NO EVENT SHALL INTEL'S TOTAL LIABILITY EXCEED THE SUM PAID TO INTEL FOR THE PRODUCT LICENSED HEREUNDER.

(24) Hewlett-Packard (hppa targets only)

(c) Copyright 1986 HEWLETT-PACKARD COMPANY

To anyone who acknowledges that this file is provided "AS IS" without any express or implied warranty:

permission to use, copy, modify, and distribute this file for any purpose is hereby granted without fee, provided that the above copyright notice and this notice appears in all copies, and that the name of Hewlett-Packard Company not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. Hewlett-Packard Company makes no representations about the suitability of this software for any purpose.

(25) Henry Spencer (only \*-linux targets)

Copyright 1992, 1993, 1994 Henry Spencer. All rights reserved. This software is not subject to any license of the American Telephone and Telegraph Company or of the Regents of the University of California.

Permission is granted to anyone to use this software for any purpose on any computer system, and to alter it and redistribute it, subject to the following restrictions:

1. The author is not responsible for the consequences of use of this software, no matter how awful, even if they arise from flaws in it.
2. The origin of this software must not be misrepresented, either by explicit claim or by omission. Since few users ever read sources, credits must appear in the documentation.
3. Altered versions must be plainly marked as such, and must not be misrepresented as being the original software. Since few users ever read sources, credits must appear in the documentation.
4. This notice may not be removed or altered.

(26) Mike Barcroft

Copyright (c) 2001 Mike Barcroft <mike@FreeBSD.org>  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(27) Konstantin Chuguev (--enable-newlib-iconv)

Copyright (c) 1999, 2000  
Konstantin Chuguev. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright

- notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

iconv (Charset Conversion Library) v2.0

(28) Artem Bityuckiy (--enable-newlib-iconv)

Copyright (c) 2003, Artem B. Bityuckiy, SoftMine Corporation.  
Rights transferred to Franklin Electronic Publishers.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(29) IBM, Sony, Toshiba (only spu-\* targets)

(C) Copyright 2001,2006,  
International Business Machines Corporation,  
Sony Computer Entertainment, Incorporated,  
Toshiba Corporation,

All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- \* Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- \* Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- \* Neither the names of the copyright holders nor the names of their contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF

SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(30) - Alex Tatmanjants (targets using libc/posix)

Copyright (c) 1995 Alex Tatmanjants <alex@elvisti.kiev.ua>  
at Electronni Visti IA, Kiev, Ukraine.  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(31) - M. Warner Losh (targets using libc/posix)

Copyright (c) 1998, M. Warner Losh <imp@freebsd.org>  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(32) - Andrey A. Chernov (targets using libc/posix)

Copyright (C) 1996 by Andrey A. Chernov, Moscow, Russia.  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(33) - Daniel Eischen (targets using libc/posix)

Copyright (c) 2001 Daniel Eischen <deischen@FreeBSD.org>.  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(34) - Jon Beniston (only lm32-\* targets)

Contributed by Jon Beniston <jon@beniston.com>

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(35) - ARM Ltd (arm and thumb variant targets only)

Copyright (c) 2009 ARM Ltd  
All rights reserved.

Redistribution and use in source and binary forms, with or without

modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. The name of the company may not be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY ARM LTD ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL ARM LTD BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(36) - CodeSourcery, Inc.

Copyright (c) 2009 CodeSourcery, Inc.  
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- \* Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- \* Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- \* Neither the name of CodeSourcery nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY CODESOURCERY, INC. ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL CODESOURCERY BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

(37) MIPS Technologies, Inc

```
/*
 * Copyright (c) 2009 MIPS Technologies, Inc.
 *
 * All rights reserved.
 *
 * Redistribution and use in source and binary forms, with or without
 * modification, are permitted provided that the following conditions
 * are met:
 *
 * * Redistributions of source code must retain the above copyright
 * * notice, this list of conditions and the following disclaimer.
 * * Redistributions in binary form must reproduce the above
 * * copyright
 * * notice, this list of conditions and the following disclaimer
 * * in the documentation and/or other materials provided with
 * * the distribution.
 * * Neither the name of MIPS Technologies Inc. nor the names of its
 * * contributors may be used to endorse or promote products derived
 * * from this software without specific prior written permission.
 *
 * THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS
```

## Sourcery CodeBench Lite Licenses

---

\* "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT  
\* LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR  
\* A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT  
\* OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,  
\* SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT  
\* LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE,  
\* DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY  
\* THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT  
\* (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE  
\* OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.  
\*/