Sourcery CodeBench Lite

ARM SymbianOS

Sourcery CodeBench Lite 2012.03-42

Getting Started

Sourcery CodeBench Lite: ARM SymbianOS: Sourcery CodeBench Lite 2012.03-42: Getting Started

CodeSourcery, Inc.

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.

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Preface

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

1. Intended Audience

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

2. Organization

This document is organized into the following chapters and appendices:

Chapter 1, "Quick Start"	This chapter includes a brief checklist to follow when installing and using Sourcery CodeBench Lite for the first time. You may use this chapter as an abbreviated guide to the rest of this manual.
Chapter 2, "Installation and Configuration"	This chapter describes how to download, install and configure Sourcery CodeBench Lite. This section describes the available installation options and explains how to set up your environment so that you can build applications.
Chapter 3, "Sourcery CodeBench Lite for ARM SymbianOS"	This chapter contains information about using Sourcery CodeBench Lite that is specific to ARM SymbianOS 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, "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 ARM SymbianOS. You should read through these notes to learn about new features and bug fixes.
Appendix B, "Sourcery CodeBench Lite Licenses"	This appendix provides information about the software licenses that apply to Sourcery CodeBench Lite. Read this appendix to understand your legal rights and obligations as a user of Sourcery CodeBench Lite.

3. Typographical Conventions

The following typographical conventions are used in this guide:

`> command arg ...`	A command, typed by the user, and its output. The “>” character is the command prompt.
`command`	The name of a program, when used in a sentence, rather than in literal input or output.
`literal`	Text provided to or received from a computer program.
`placeholder`	Text that should be replaced with an appropriate value when typing a command.
`\`	At the end of a line in command or program examples, indicates that a long line of literal input or output continues onto the next line in the document.

Chapter 1
Quick Start

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

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 ARM SymbianOS”.

1.1. Installation and Set-Up

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

1.2. Building Your Program

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

1.3. 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.

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

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 `arm-none-symbianelf`.

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 -plow 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 specified by the `TEMP` environment variable for these temporary files. If there is not enough free space on that volume, the installer prompts for an alternate location. On Linux hosts, the installer puts temporary files in the directory specified by the `IATEMPDIR` environment variable, or `/tmp` if that is not set.

2.2.3. Target System Requirements

See Chapter 3, "Sourcery CodeBench Lite for ARM SymbianOS" 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[1]. 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[2].

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

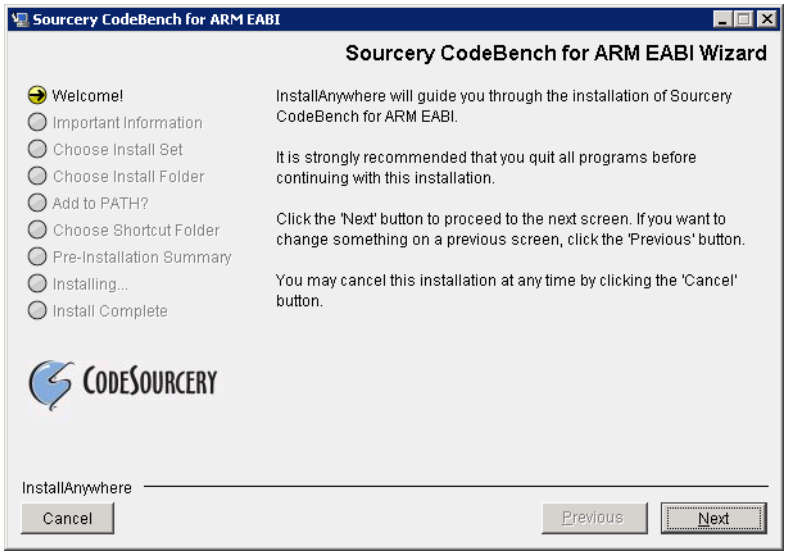
The method used to install Sourcery CodeBench Lite depends on your host system and the kind of installation package you have downloaded.

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.

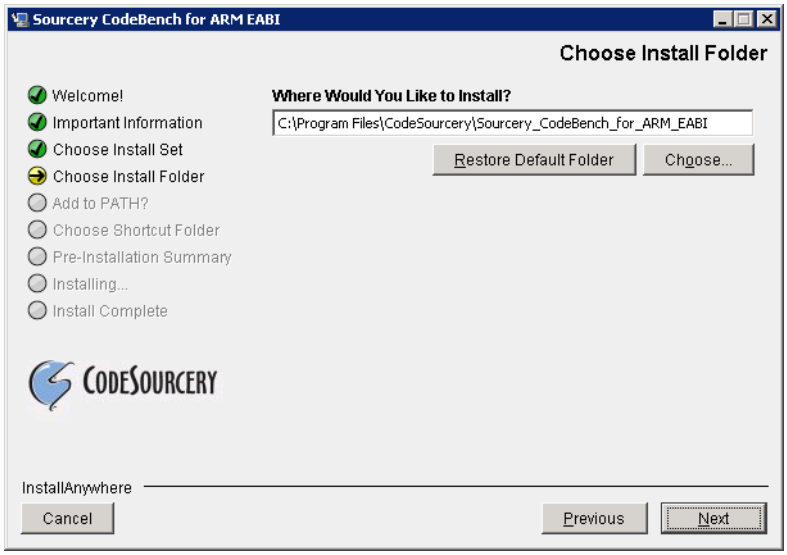
After the installer starts, follow the on-screen dialogs to install Sourcery CodeBench Lite. The installer is intended to be self-explanatory and on most pages the defaults are appropriate.

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

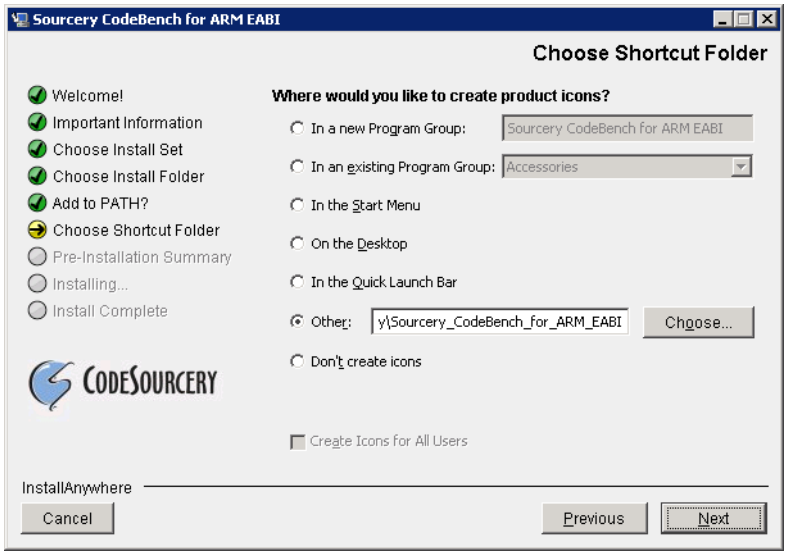


Running the Installer. The graphical installer guides you through the steps to install Sourcery CodeBench Lite.

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

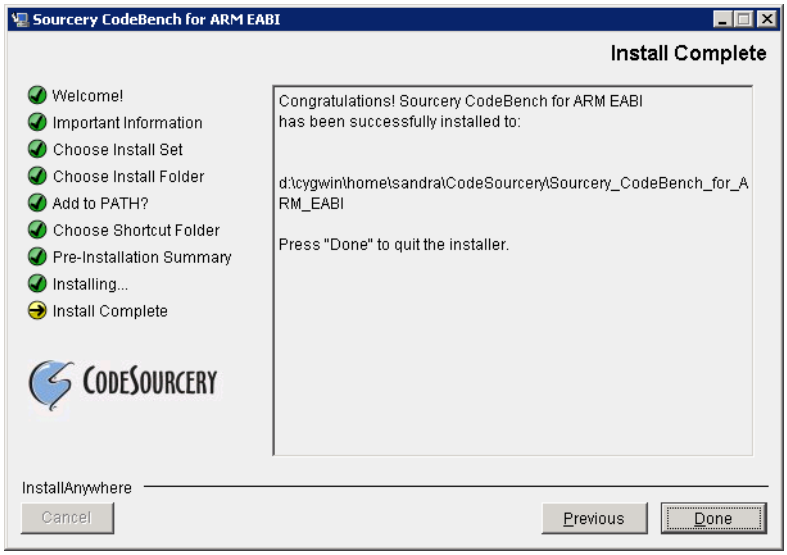


Choose Install Folder. Select the pathname to your install directory.



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 ARM SymbianOS 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 ARM SymbianOS target all begin with `arm-none-symbianelf`. 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:

```
> arm-none-symbianelf-g++ -v
```

Verify that the last line of the output contains: Sourcery CodeBench Lite 2012.03-42.

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++-arm-none-symbianelf/man`.

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

```
> arm-none-symbianelf-g++ -v
```

Verify that the last line of the output contains: `Sourcery CodeBench Lite 2012.03-42`.

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 `arm-none-symbianelf` 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 ARM SymbianOS

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

Component	Version	Notes
GNU programming tools		
GNU Compiler Collection	4.6.3	Separate manual included.
GNU Binary Utilities	2.21.53	Includes assembler, linker, and other utilities. Separate manuals included.
Debugging support and simulators		
Target libraries		
Other utilities		
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 ARM SymbianOS includes the following library configuration.

ARMv5 - Little-Endian, Soft-Float	
Command-line option(s):	default

ARMv5 - Little-Endian, VFP	
Command-line option(s):	`-mfloat-abi=softfp`

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.

3.3. Building SymbianOS Programs

Building programs for SymbianOS requires you install additional software and follow the SymbianOS build procedure.

You must install the Symbian SDK[1]. For Linux hosts, you must install the SDK on a Windows machine and then make the file system visible on your Linux host. Alternatively, for Linux hosts, the GnuPoc[2] project provides patches. Set the environment variable `EPOCROOT` to the directory containing the `epoc32` directory of your Symbian SDK installation, and also ensure your `PATH` variable includes the `$EPOCROOT/epoc32/tools` directory. The following commands also make use of `epoclib` and `epocarch` variables for convenience. For instance, if you have installed the SDK at `/opt/symbian-sdk`, enter the following commands:

```
> export EPOCROOT=/opt/symbian-sdk/s60
> PATH=$EPOCROOT/epoc32/tools:$PATH
```

[1] http://www.developer.nokia.com/Community/Wiki/How_do_I_start_programming_for_Symbian_OS%3F
[2] http://gnupoc.sourceforge.net/

```
> epocinc=$EPOCROOT/epoc32/include
> epocarch=$EPOCROOT/epoc32/release/armv5
```

SymbianOS programs do not start at `main`, but at `E32Main`. Using an editor (such as `notepad` on Microsoft Windows or `vi` on UNIX-like systems), create a file named `main.cc` containing the following console program:

```
#include <e32base.h>
#include <e32cons.h>

_LIT (KTxtEPOC32EX, "EXAMPLES");
_LIT (KTxtExampleCode, "Symbian OS Example Code");
_LIT (KTxtOK, "ok [press any key]");

LOCAL_D CConsoleBase* console;

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


LOCAL_C void callExampleL () {
  console = Console::NewL
    (KTxtExampleCode,
     TSize (KConsFullScreen, KConsFullScreen));
  CleanupStack::PushL (console);

  _LIT (KHelloWorldText, "Hello world!\n");
  console->Printf (KHelloWorldText);
  for (int i = 0; i < 10; ++i) {
    int n = factorial (i);
    _LIT (KFactorialText, "factorial(%d) = %d\n");
    console->Printf (KFactorialText, i, n);
  }

  console->Printf (KTxtOK);
  console->Getch ();
  CleanupStack::PopAndDestroy ();
}

GLDEF_C TInt E32Main () {
  __UHEAP_MARK;
  CTrapCleanup *cleanup = CTrapCleanup::New ();
  TRAPD (error, callExampleL ());
  __ASSERT_ALWAYS (!error, User::Panic (KTxtEPOC32EX, error));
  delete cleanup;
  __UHEAP_MARKEND;
  return 0;
}
```

To compile a program in `main.c` use the following command:

```
> arm-none-symbianelf-g++ -march=armv5t -mthumb -mapcs -nostdinc \
  -D__MARM__ -D__MARM_ARMV5__ -D__MARM_THUMB__ \
  -D__MARM_INTERWORK__ -D__EABI__ -D__EXE__ \
  -D_DEBUG -D_UNICODE -D__SUPPORT_CPP_EXCEPTIONS__ \
  -D__GCCE__ -D__SYMBIAN32__ -D__EPOC32__ \
  -D__S60_50__ -D__S60_3X__ -D__SERIES60_3X__ \
  -D__PRODUCT_INCLUDE__=\"$epocinc/variant/symbian_os.hrh\" \
  -include $epocinc/gcce/gcce.h \
  -I $epocinc/libc -I $epocinc -I $epocinc/variant \
  -c -g -o main.o main.cc
```

You may see some warnings. These are from Symbian SDK header files, not Sourcery CodeBench files.

You can link your application with:

```
> arm-none-symbianelf-g++ -march=armv5t -mthumb -mapcs -nostdlib \
  -Wl,--target1-abs -Wl,--no-undefined \
  -Wl,-Ttext,0x8000 -Wl,-Tdata,0x400000 \
  -Wl,--default-symver -Wl,-soname,"factorial{000a0000}.exe" \
  -Wl,--entry,_E32Startup -Wl,-u,_E32Startup \
  $epocarch/udeb/eexe.lib \
  -shared -g -o factorial.sym main.o \
  -Wl,"-(" -Wl,$epocarch/udeb/usrt2_2.lib \
  -Wl,$epocarch/udeb/ecrt0.lib -Wl,"-)" \
  -Wl,$epocarch/lib/estlib.dso \
  -Wl,$epocarch/lib/euser.dso \
  -Wl,$epocarch/lib/dfpaeabi.dso \
  -Wl,$epocarch/lib/dfprvct2_2.dso \
  -Wl,$epocarch/lib/drtaeabi.dso \
  -Wl,$epocarch/lib/scppnwdl.dso \
  -Wl,$epocarch/lib/drtrvct2_2.dso \
  -lsupc++ -lgcc -lgcc_eh
```

This produces a `factorial.sym` file that can be used by `arm-none-symbianelf-gdb`.

To run the program on SymbianOS, you must convert this file to EPOC32 format using the `elf2e32` command. The `elf2e32` command is part of the Symbian SDK and not part of Sourcery CodeBench. If you are using a Linux host, and did not install GnuPoc, you must install Wine[3] and invoke `elf2e32` as:

```
> wine $EPOCROOT/epoc32/tools/elf2e32.exe other options
```

The following command creates `factorial.exe`:

```
> elf2e32 --sid=0x00000000 --version=10.0 --uid1=0x1000007a \
  --uid2=0xe8000075 --uid3=0x00000000 --vid=0x70000001 \
  --capability=none --fpu=softvfp --targettype=EXE \
  --output="factorial.exe" --elfinput="factorial.sym" \
  --linkas="factorial{000a0000}.exe" \
  --libpath="$epocarch/lib"
```

[3] http://www.winehq.org/

3.4. SymbianOS Runtime Libraries

Sourcery CodeBench Lite does not include C or C++ runtime libraries for SymbianOS. These are provided separately by Symbian.

3.5. NEON SIMD Code

Sourcery CodeBench includes support for automatic generation of NEON SIMD vector code. Autovectorization is a compiler optimization in which loops involving normal integer or floating-point code are transformed to use NEON SIMD instructions to process several data elements at once.

To enable generation of NEON vector code, use the command-line options `-ftree-vectorize -mfpu=neon -mfloat-abi=softfp`. The `-mfpu=neon` option also enables generation of VFPv3 scalar floating-point code.

Sourcery CodeBench also includes support for manual generation of NEON SIMD code using C intrinsic functions. These intrinsics, the same as those supported by the ARM RealView® compiler, are defined in the `arm_neon.h` header and are documented in the 'ARM NEON Intrinsics' section of the GCC manual. The command-line options `-mfpu=neon -mfloat-abi=softfp` must be specified to use these intrinsics; `-ftree-vectorize` is not required.

3.6. Fixed-Point Arithmetic

Sourcery CodeBench for ARM SymbianOS includes experimental support for fixed-point arithmetic using a set of new data types, as described in the draft ISO/IEC technical report TR 18037. This support is provided for all ARM targets, and uses specialized instructions where available, e.g. saturating add and subtract operations on ARMv6T2 and above. Library functions are used for operations which are not natively supported on the target architecture.

This feature is a GNU extension, so is only available when the selected language standard includes GNU extensions (e.g. `-std=gnu90`, which is the default). Furthermore, only C is supported, not C++.

TR 18037 leaves up to the implementation the sizes of various quantities within the new data types it defines. For Sourcery CodeBench for ARM SymbianOS, these are, briefly:

- `short _Fract`: One sign bit, 7 fractional bits
- `_Fract`: One sign bit, 15 fractional bits
- `long _Fract`: One sign bit, 31 fractional bits
- `unsigned short _Fract`: 8 fractional bits
- `unsigned _Fract`: 16 fractional bits
- `unsigned long _Fract`: 32 fractional bits
- `short _Accum`: One sign bit, 7 fractional bits, 8 integral bits
- `_Accum`: One sign bit, 15 fractional bits, 16 integral bits
- `long _Accum`: One sign bit, 31 fractional bits, 32 integral bits

- `unsigned short _Accum`: 8 fractional bits, 8 integral bits
- `unsigned _Accum`: 16 fractional bits, 16 integral bits
- `unsigned long _Accum`: 32 fractional bits, 32 integral bits

These values (and various other useful constants) are also defined in the header file `stdfix.h` for use in your programs. Note that there is currently no support for the new standard-library functions described in TR 18037, nor for the pragmas controlling precision of operations.

Fixed-point extensions are not currently supported by GDB, nor are they compliant with the ARM EABI (which does not specify anything about fixed-point types at present). Code using fixed-point types cannot be expected to interact properly (across ABI boundaries) with code generated by other compilers for the ARM architecture.

3.7. Half-Precision Floating Point

Sourcery CodeBench for ARM SymbianOS includes support for half-precision (16-bit) floating point, including the new `__fp16` data type in C and C++, support for generating conversion instructions when compiling for processors that support them, and library functions for use in other cases.

To use half-precision floating point, you must explicitly enable it via the `-mfp16-format` command-line option to the compiler. For more information about `__fp16` representations and usage from C and C++, refer to the GCC manual.

3.8. ABI Compatibility

The Application Binary Interface (ABI) for the ARM Architecture is a collection of standards, published by ARM Ltd. and other organizations. The ABI makes it possible to combine tools from different vendors, including Sourcery CodeBench and ARM RealView®.

Sourcery CodeBench implements the ABI as described in these documents, which are available from the ARM Information Center[4]:

- BSABI - ARM IHI 0036B (28 October 2009)
- BPABI - ARM IHI 0037B (28 October 2009)
- EHABI - ARM IHI 0038A (28 October 2009)
- CLIBABI - ARM IHI 0039B (4 November 2009)
- AADWARF - ARM IHI 0040A (28 October 2009)
- CPPABI - ARM IHI 0041C (5 October 2009)
- AAPCS - ARM IHI 0042D (16 October 2009)
- RTABI - ARM IHI 0043C (19 October 2009)
- AAELF - ARM IHI 0044D (28 October 2009)
- ABI Addenda - ARM IHI 0045C (4 November 2009)

[4] http://infocenter.arm.com

Sourcery CodeBench currently produces DWARF version 2, rather than DWARF version 3 as specified in AADWARF.

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 arm-none-symbianelf, as indicated by the `arm-none-symbianelf` command prefix.

Building programs for SymbianOS requires unique command-line arguments and build steps to integrate with the Symbian SDK; refer to Chapter 3, “Sourcery CodeBench Lite for ARM SymbianOS” for details.

4.2. Running Applications on the Target System

Consult your target board documentation for instructions on loading programs onto the target, and running them.

Chapter 5
Next Steps with Sourcery CodeBench

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

5.1. Sourcery CodeBench Knowledge Base

The Sourcery CodeBench Knowledge Base is available to registered users at the Sourcery CodeBench Portal[1]. 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.

5.2. Example Programs

Sourcery CodeBench Lite includes some bundled example programs. You can find the source code for these examples in the `share/sourceryg++-arm-none-symbianelf-examples` directory of your Sourcery CodeBench installation.

5.2.1. 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.

5.3. 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++-arm-none-symbianelf/` 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++-arm-none-symbianelf/man/man1
```

Then you can invoke `man` as:

```
> man ./arm-none-symbianelf-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.

[1] 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 ARM SymbianOS. You should read through these notes to learn about new features and bug fixes.

A.1. Changes in Sourcery CodeBench Lite for ARM SymbianOS

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

A.1.1. Changes in Sourcery CodeBench Lite 2012.03-42

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

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 ARM SymbianOS 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.

A.1.2. Changes in Sourcery CodeBench Lite 2012.03-24

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.

Fix for internal compiler error. A bug that caused GCC to report an internal compiler error in `push_minipool_fix` has been fixed.

Internal compiler error with NEON intrinsics. A compiler bug has been fixed that caused internal compiler errors when using certain NEON intrinsics.

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

Internal compiler error. A GCC bug has been fixed that caused an internal compiler error when sign extending the result of an array subscript expression with an index greater than 255.

GCC version 4.6. Sourcery CodeBench Lite for ARM SymbianOS 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++0x `constexpr` initialization expressions.

ARM VFP9-S errata workaround. A compiler workaround for ARM Errata Notice GENC-010704 (760019: Canceled FDIV or FSQRT can be executed twice) has been implemented.

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

Additional library required on link command line. Due to internal changes in GCC's support library configuration, you must now include `-lgcc_eh` on the link command line for SymbianOS applications to avoid undefined symbol errors for exception handling support functions.

GCC version 4.6.3. Sourcery CodeBench Lite for ARM SymbianOS 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`.

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.

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

ARM miscompilation fix. A bug has been fixed that caused miscompilation of some expressions involving the minimum or maximum idiom, such as `(a > 0) ? a : 0`.

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.

Binutils version 2.21. Sourcery CodeBench Lite for ARM SymbianOS 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.

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

A.1.3. Changes in Sourcery G++ Lite 2011.03-45

Variable Length Array (VLA) alignment bug. A compiler bug that resulted in incorrectly aligned variable length arrays (VLA) in leaf functions has been fixed.

Cortex-R5 support. Sourcery G++ now includes support for ARM Cortex-R5 processors. To compile for these processors, use `-mcpu=cortex-r5`.

Inline assembly and volatile fields. A bug has been fixed that caused the compiler to incorrectly reject inline `asm` statements referring to volatile class/struct fields with errors such as `error: output number 1 not directly addressable`.

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.

Fixed-point arithmetic support. Experimental compiler support has been added for fixed-point arithmetic on ARM, as described in the draft ISO/IEC technical report TR 18037. Specialized instructions defined in recent architecture versions for performing saturating arithmetic, etc. are used when available, but are not a prerequisite for using the new language features. See Section 3.6, “Fixed-Point Arithmetic” for further details.

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.

Thumb debug information fix. A compiler bug that resulted in incorrect debug information for Thumb code has been fixed. The incorrect information prevented single stepping through some code.

Internal compiler error with pointer casting. A compiler bug has been fixed that caused internal compiler errors when accessing double-word memory locations with casted pointers under ARM mode.

Unaligned access support. The compiler now generates more efficient code for accessing packed data structures and for copying small blocks of unaligned data when targeting architectures that

permit unaligned word/halfword accesses. This feature can be controlled by the `-munaligned-access` and `-mno-unaligned-access` options, and is enabled by default for ARMv6 processors and above, except for ARMv6-M.

Internal compiler error under Thumb mode. A compiler bug has been fixed that caused internal compiler errors when generating Thumb code.

A.1.4. Changes in Sourcery G++ Lite 2011.03-8

Incorrect code for built-in comparison functions. A bug has been fixed that sometimes caused GCC's built-in comparison functions, such as `__builtin_isgreaterequal`, to incorrectly raise exceptions when invoked on unordered floating-point arguments.

GCC fixes for `-fstrict-volatile-bitfields`. GCC now honors `-fstrict-volatile-bitfields` when a bitfield is not declared volatile initially, but an object including bit fields is cast to volatile. Also, a bug was fixed that caused incorrect code to be generated for some stores to volatile bit fields when `-fstrict-volatile-bitfields` is enabled.

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

- Smaller and faster code for compound conditionals.
- Removal of superfluous sign and zero extensions.
- Improved code for multiply-and-accumulate operations on ARM.

Internal compiler error with NEON intrinsics. A compiler bug has been fixed that caused internal compiler errors when using certain NEON intrinsics.

GCC version 4.5.2. Sourcery G++ Lite for ARM SymbianOS is now based on GCC version 4.5.2.

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.

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 fixes for NEON in big-endian mode. Several compiler bugs have been fixed that could lead to incorrect code when using NEON in big-endian mode. The problems only manifested when using the auto-vectorizer (enabled by default at the `-O3` optimization level) with the `-mvectorize-with-neon-quad` option.

C++ exception handling. A defect in the implementation of the EH-ABI specification has been fixed. The defect affected the catching of pointer types in code generated by the ARM RealView® compiler but using the Sourcery G++ runtime libraries. The fix also retains backward compatibility with existing GCC-compiled code.

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.

Internal compiler error fixes. Two bugs have been fixed that caused compiler crashes in rare cases. The first bug involved code with multiple comparison operations, and the second one involved `char` to `int` conversion.

Thumb-2 assembler validation fix. The assembler now correctly rejects Thumb-2 `ADD`, `ADDS`, `SUB`, and `SUBS` instructions that have an invalid shift operand. Previously, invalid shift values were accepted and generated unpredictable instructions.

Objdump fix for multiple input files. The Objdump utility did not produce correct disassembly when processing multiple input files. This has been fixed.

A.1.5. Changes in Sourcery G++ Lite 2010.09-54

GCC fix for duplicated symbols. A GCC optimizer bug that caused multiple definitions of local symbols has been fixed. Code affected by the bug was rejected by the assembler.

NEON code generation fix. A GCC bug has been fixed that resulted in an assembler error `VFP/Neon double precision register expected`.

Static data size improvement at `-Os`. When optimizing for size, the compiler no longer implicitly adds padding bytes to align static and local arrays on word boundaries. This fixes static data size regressions introduced since GCC 4.4. The additional alignment is still used when optimizing for speed.

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. This option is enabled by default to conform to the ARM EABI. Refer to the GCC manual for details.

Internal compiler error fixes. A bug has been fixed that caused the compiler to crash on code containing a `typedef` alias for `__builtin_va_list` with option `-femit-struct-debug-baseonly`. A second bug has been fixed that caused a crash when compiling code using C99 variable-length arrays. Additionally, a compiler crash on code using 64-bit integer multiplications with NEON vectorization enabled has also been fixed.

NEON narrowing-move instructions. The compiler now supports narrowing-move instructions when auto-vectorizing for NEON. Loops accessing arrays of `char` or `short` values are now more likely to be vectorized.

Improved support for atomic memory builtins. The compiler support for built-in atomic memory access operations on ARMv7 targets has been improved. These builtins are documented in the GCC manual.

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.

Absolute branch bug fixes. A bug that caused the assembler to crash on a branch to an absolute address has been fixed. Linker handling of the resulting relocations has also been improved. Previously this caused an invalid switch to ARM mode on ARMv7-M devices.

`VMOV` instruction bug fix. A bug that caused the assembler to incorrectly reject certain valid immediate operands for the `VMOV` instruction has been fixed.

A.1.6. Changes in Sourcery G++ Lite 2010.09-20

Changes to Sourcery G++ version numbering. Sourcery G++ product and Lite toolchains now uniformly use a version numbering scheme of the form 2012.03-42. 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[1].

GCC fix for reference to undefined label. A bug in the optimizer that caused GCC to emit references to undefined labels has been fixed.

Precision improvement with vectorization enabled. The GCC auto-vectorizer no longer uses NEON floating-point instructions unless the `-funsafe-math-optimizations` option (implied by `-ffast-math`) is specified. This is because NEON hardware does not fully support the IEEE 754 standard for floating-point arithmetic. In particular, very small quantities may be flushed to zero.

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.

`naked` attribute semantics. The `naked` function attribute now also implies the `noinline` and `noclone` attributes. This fixes bugs resulting from invalid optimizations of functions with this attribute.

Stack corruption bug fix. A bug in GCC has been fixed that caused stack corruption in functions with the `interrupt` attribute.

GCC bug fix for push multiple instruction generation. A bug has been fixed that caused GCC to generate incorrect push multiple instructions, causing an assembler warning `register range not in ascending order`.

Thumb-2 internal compiler error fix. A bug has been fixed that caused the compiler to crash when compiling Thumb-2 code using 64-bit integer arithmetic.

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.
- 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.
- More optimization of references to globals in position-independent code.
- Various Thumb code generation improvements.
- Better code when constant addresses are used as arguments to inline assembly statements.
- Better code for copying small constant strings.
- Improved tuning for Cortex-M4 processors.
- Cortex-A9 specific tuning for VFP and NEON instructions.
- Use of more NEON features.

[1] https://support.codesourcery.com/GNUToolchain/kbentry1

Preprocessor symbols for floating-point calling convention. Built-in preprocessor symbols `__ARM_PCS` and `__ARM_PCS_VFP` are now defined to indicate the current floating-point calling convention.

GCC version 4.5.1. Sourcery G++ Lite for ARM SymbianOS 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`.

New `-Wdouble-promotion` warning option. The compiler has a new option, `-Wdouble-promotion`, which enables warnings about implicit promotions of `float` values to `double`. This option is useful when compiling code for processors (such as ARM Cortex-M4) that have hardware support for single-precision floating-point arithmetic only, where unintentional use of double precision results in dramatically slower code.

C++ runtime symbol visibility. A bug has been fixed that caused some symbols in the C++ runtime library (`libsupc++.a`) to have incorrect visibility attributes.

Linker bug fix. A bug that caused the linker error `relocation truncated to fit: R_ARM_THM_JUMP24` when linking some Thumb-2 applications has been fixed.

Assembler PC-relative store fix. A bug that caused the assembler to reject some valid PC-relative store instructions has been fixed. It now issues a warning instead for architectures where these instructions are deprecated.

ARMv7-A linker bug fix. A bug in the linker support for `--fix-cortex-a8`, which is enabled by default when linking ARMv7-A objects, has been fixed. Programs affected by the bug sometimes crashed with segmentation fault or illegal instruction errors.

Smaller C++ programs with `-g`. An assembler bug has been fixed that caused unnecessary references to exception-handling routines from C++ programs when debug information is enabled. For programs that do not otherwise use exceptions, this change results in smaller code size.

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.

Assembler PC-relative load fix. An assembler bug that caused the assembler to reject some references to global symbols has been fixed. This bug affected Thumb instructions of the form `ldr r0, symbol`.

Strip bug fix. A bug in the `strip` and `objcopy` utilities, which resulted in stripped object files that the linker could not recognize, has been fixed.

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

A.1.7. Changes in Older Releases

For information about changes in older releases of Sourcery G++ Lite for ARM SymbianOS, 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.

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

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Sourcery CodeBench Lite may include some third party example programs and libraries in the `share/sourceryg++-arm-none-symbianelf-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.

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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.

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