

GNU Automake

For version 1.16.3, 19 November 2020

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This manual is for GNU Automake (version 1.16.3, 19 November 2020), a program that creates GNU standards-compliant Makefiles from template files.

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Table of Contents

1	Introduction	1
2	An Introduction to the Autotools	1
2.1	Introducing the GNU Build System	1
2.2	Use Cases for the GNU Build System	2
2.2.1	Basic Installation	2
2.2.2	Standard <code>Makefile</code> Targets	4
2.2.3	Standard Directory Variables	4
2.2.4	Standard Configuration Variables	5
2.2.5	Overriding Default Configuration Setting with <code>config.site</code>	6
2.2.6	Parallel Build Trees (a.k.a. <code>VPATH</code> Builds)	6
2.2.7	Two-Part Installation	8
2.2.8	Cross-Compilation	9
2.2.9	Renaming Programs at Install Time	10
2.2.10	Building Binary Packages Using <code>DESTDIR</code>	10
2.2.11	Preparing Distributions	11
2.2.12	Automatic Dependency Tracking	11
2.2.13	Nested Packages	12
2.3	How Autotools Help	13
2.4	A Small Hello World	13
2.4.1	Creating <code>amhello-1.0.tar.gz</code>	13
2.4.2	<code>amhello</code> 's <code>configure.ac</code> Setup Explained	16
2.4.3	<code>amhello</code> 's <code>Makefile.am</code> Setup Explained	17
3	General ideas	18
3.1	General Operation	18
3.2	Strictness	19
3.3	The Uniform Naming Scheme	21
3.4	Staying below the command line length limit	22
3.5	How derived variables are named	23
3.6	Variables reserved for the user	23
3.7	Programs automake might require	24
4	Some example packages	25
4.1	A simple example, start to finish	25
4.2	Building <code>true</code> and <code>false</code>	26
5	Creating a <code>Makefile.in</code>	27

6	Scanning <code>configure.ac</code>, using <code>aclocal</code>	30
6.1	Configuration requirements	30
6.2	Other things Automake recognizes	32
6.3	Auto-generating <code>aclocal.m4</code>	36
6.3.1	<code>aclocal</code> Options	36
6.3.2	Macro Search Path	38
6.3.3	Writing your own <code>aclocal</code> macros	40
6.3.4	Handling Local Macros	41
6.3.5	Serial Numbers	42
6.3.6	The Future of <code>aclocal</code>	44
6.4	Autoconf macros supplied with Automake	45
6.4.1	Public Macros	45
6.4.2	Obsolete Macros	47
6.4.3	Private Macros	47
7	Directories	48
7.1	Recurring subdirectories	48
7.2	Conditional Subdirectories	49
7.2.1	<code>SUBDIRS</code> vs. <code>DIST_SUBDIRS</code>	50
7.2.2	Subdirectories with <code>AM_CONDITIONAL</code>	50
7.2.3	Subdirectories with <code>AC_SUBST</code>	51
7.2.4	Unconfigured Subdirectories	51
7.3	An Alternative Approach to Subdirectories	52
7.4	Nesting Packages	53
8	Building Programs and Libraries	54
8.1	Building a program	54
8.1.1	Defining program sources	55
8.1.2	Linking the program	55
8.1.3	Conditional compilation of sources	56
8.1.4	Conditional compilation of programs	58
8.2	Building a library	58
8.3	Building a Shared Library	59
8.3.1	The Libtool Concept	59
8.3.2	Building Libtool Libraries	60
8.3.3	Building Libtool Libraries Conditionally	60
8.3.4	Libtool Libraries with Conditional Sources	61
8.3.5	Libtool Convenience Libraries	62
8.3.6	Libtool Modules	63
8.3.7	<code>_LIBADD</code> , <code>_LDFLAGS</code> , and <code>_LIBTOOLFLAGS</code>	64
8.3.8	<code>LTLIBOBJ</code> s and <code>LTALLOCA</code>	64
8.3.9	Common Issues Related to Libtool's Use	64
8.3.9.1	Error: 'required file './ltmain.sh' not found'	64
8.3.9.2	Objects 'created with both libtool and without'	65
8.4	Program and Library Variables	65
8.5	Default <code>_SOURCES</code>	69
8.6	Special handling for <code>LIBOBJ</code> s and <code>ALLOCA</code>	70

8.7	Variables used when building a program	72
8.8	Yacc and Lex support	73
8.9	C++ Support	75
8.10	Objective C Support	76
8.11	Objective C++ Support	76
8.12	Unified Parallel C Support	76
8.13	Assembly Support	77
8.14	Fortran 77 Support	77
8.14.1	Preprocessing Fortran 77	78
8.14.2	Compiling Fortran 77 Files	78
8.14.3	Mixing Fortran 77 With C and C++	78
8.14.3.1	How the Linker is Chosen	79
8.15	Fortran 9x Support	80
8.15.1	Compiling Fortran 9x Files	80
8.16	Compiling Java sources using gcj	80
8.17	Vala Support	81
8.18	Support for Other Languages	81
8.19	Automatic dependency tracking	82
8.20	Support for executable extensions	82
9	Other Derived Objects	83
9.1	Executable Scripts	83
9.2	Header files	84
9.3	Architecture-independent data files	85
9.4	Built Sources	85
9.4.1	Built Sources Example	86
10	Other GNU Tools	89
10.1	Emacs Lisp	89
10.2	Gettext	89
10.3	Libtool	90
10.4	Java bytecode compilation (deprecated)	90
10.5	Python	91
11	Building documentation	92
11.1	Texinfo	92
11.2	Man Pages	95
12	What Gets Installed	96
12.1	Basics of Installation	96
12.2	The Two Parts of Install	96
12.3	Extending Installation	97
12.4	Staged Installs	97
12.5	Install Rules for the User	97
13	What Gets Cleaned	98

14	What Goes in a Distribution	98
14.1	Basics of Distribution	98
14.2	Fine-grained Distribution Control	99
14.3	The dist Hook	100
14.4	Checking the Distribution	100
14.5	The Types of Distributions	103
15	Support for test suites	104
15.1	Generalities about Testing	104
15.2	Simple Tests	105
15.2.1	Scripts-based Testsuites	105
15.2.2	Older (and discouraged) serial test harness	107
15.2.3	Parallel Test Harness	108
15.3	Custom Test Drivers	110
15.3.1	Overview of Custom Test Drivers Support	110
15.3.2	Declaring Custom Test Drivers	111
15.3.3	API for Custom Test Drivers	112
15.3.3.1	Command-line arguments for test drivers	112
15.3.3.2	Log files generation and test results recording	113
15.3.3.3	Testsuite progress output	114
15.4	Using the TAP test protocol	114
15.4.1	Introduction to TAP	114
15.4.2	Use TAP with the Automake test harness	115
15.4.3	Incompatibilities with other TAP parsers and drivers	117
15.4.4	Links and external resources on TAP	118
15.5	DejaGnu Tests	118
15.6	Install Tests	119
16	Rebuilding Makefiles	119
17	Changing Automake's Behavior	120
17.1	Options generalities	120
17.2	List of Automake options	120
18	Miscellaneous Rules	124
18.1	Interfacing to <code>etags</code>	124
18.2	Handling new file extensions	125
19	Include	126
20	Conditionals	126
20.1	Usage of Conditionals	127
20.2	Limits of Conditionals	128

21	Silencing make	129
21.1	Make is verbose by default	129
21.2	Standard and generic ways to silence make	129
21.3	How Automake can help in silencing make	130
22	When Automake Isn't Enough	132
22.1	Extending Automake Rules	133
22.2	Third-Party Makefiles	134
23	Distributing Makefile.ins	137
24	Automake API Versioning	137
25	Upgrading a Package to a Newer Automake Version	138
26	Frequently Asked Questions about Automake	139
26.1	CVS and generated files	139
26.2	missing and AM_MAINTAINER_MODE	141
26.3	Why doesn't Automake support wildcards?	143
26.4	Limitations on File Names	144
26.5	Errors with distclean	144
26.6	Flag Variables Ordering	146
26.7	Why are object files sometimes renamed?	149
26.8	Per-Object Flags Emulation	149
26.9	Handling Tools that Produce Many Outputs	150
26.10	Installing to Hard-Coded Locations	155
26.11	Debugging Make Rules	157
26.12	Reporting Bugs	158
Appendix A	Copying This Manual	159
A.1	GNU Free Documentation License	159
Appendix B	Indices	167
B.1	Macro Index	167
B.2	Variable Index	167
B.3	General Index	171

1 Introduction

Automake is a tool for automatically generating `Makefile.ins` from files called `Makefile.am`. Each `Makefile.am` is basically a series of `make` variable definitions¹, with rules being thrown in occasionally. The generated `Makefile.ins` are compliant with the GNU Makefile standards.

The GNU Makefile Standards Document (see Section “Makefile Conventions” in *The GNU Coding Standards*) is long, complicated, and subject to change. The goal of Automake is to remove the burden of Makefile maintenance from the back of the individual GNU maintainer (and put it on the back of the Automake maintainers).

The typical Automake input file is simply a series of variable definitions. Each such file is processed to create a `Makefile.in`.

Automake does constrain a project in certain ways; for instance, it assumes that the project uses Autoconf (see Section “Introduction” in *The Autoconf Manual*), and enforces certain restrictions on the `configure.ac` contents.

Automake requires `perl` in order to generate the `Makefile.ins`. However, the distributions created by Automake are fully GNU standards-compliant, and do not require `perl` in order to be built.

For more information on bug reports, See Section 26.12 [Reporting Bugs], page 158.

2 An Introduction to the Autotools

If you are new to Automake, maybe you know that it is part of a set of tools called *The Autotools*. Maybe you’ve already delved into a package full of files named `configure`, `configure.ac`, `Makefile.in`, `Makefile.am`, `aclocal.m4`, . . . , some of them claiming to be *generated by* Autoconf or Automake. But the exact purpose of these files and their relations is probably fuzzy. The goal of this chapter is to introduce you to this machinery, to show you how it works and how powerful it is. If you’ve never installed or seen such a package, do not worry: this chapter will walk you through it.

If you need some teaching material, more illustrations, or a less `automake`-centered continuation, some slides for this introduction are available in Alexandre Duret-Lutz’s Autotools Tutorial (<https://www.lrde.epita.fr/~adl/autotools.html>). This chapter is the written version of the first part of his tutorial.

2.1 Introducing the GNU Build System

It is a truth universally acknowledged, that as a developer in possession of a new package, you must be in want of a build system.

In the Unix world, such a build system is traditionally achieved using the command `make` (see Section “Overview” in *The GNU Make Manual*). You express the recipe to build your package in a `Makefile`. This file is a set of rules to build the files in the package. For instance the program `prog` may be built by running the linker on the files `main.o`,

¹ These variables are also called *make macros* in Make terminology, however in this manual we reserve the term *macro* for Autoconf’s macros.

`foo.o`, and `bar.o`; the file `main.o` may be built by running the compiler on `main.c`; etc. Each time `make` is run, it reads `Makefile`, checks the existence and modification time of the files mentioned, decides what files need to be built (or rebuilt), and runs the associated commands.

When a package needs to be built on a different platform than the one it was developed on, its `Makefile` usually needs to be adjusted. For instance the compiler may have another name or require more options. In 1991, David J. MacKenzie got tired of customizing `Makefile` for the 20 platforms he had to deal with. Instead, he handcrafted a little shell script called `configure` to automatically adjust the `Makefile` (see Section “Genesis” in *The Autoconf Manual*). Compiling his package was now as simple as running `./configure && make`.

Today this process has been standardized in the GNU project. The GNU Coding Standards (see Section “Managing Releases” in *The GNU Coding Standards*) explains how each package of the GNU project should have a `configure` script, and the minimal interface it should have. The `Makefile` too should follow some established conventions. The result? A unified build system that makes all packages almost indistinguishable by the installer. In its simplest scenario, all the installer has to do is to unpack the package, run `./configure && make && make install`, and repeat with the next package to install.

We call this build system the *GNU Build System*, since it was grown out of the GNU project. However it is used by a vast number of other packages: following any existing convention has its advantages.

The Autotools are tools that will create a GNU Build System for your package. Autoconf mostly focuses on `configure` and Automake on `Makefiles`. It is entirely possible to create a GNU Build System without the help of these tools. However it is rather burdensome and error-prone. We will discuss this again after some illustration of the GNU Build System in action.

2.2 Use Cases for the GNU Build System

In this section we explore several use cases for the GNU Build System. You can replay all of these examples on the `amhello-1.0.tar.gz` package distributed with Automake. If Automake is installed on your system, you should find a copy of this file in `prefix/share/doc/automake/amhello-1.0.tar.gz`, where *prefix* is the installation prefix specified during configuration (*prefix* defaults to `/usr/local`, however if Automake was installed by some GNU/Linux distribution it most likely has been set to `/usr`). If you do not have a copy of Automake installed, you can find a copy of this file inside the `doc/` directory of the Automake package.

Some of the following use cases present features that are in fact extensions to the GNU Build System. Read: they are not specified by the GNU Coding Standards, but they are nonetheless part of the build system created by the Autotools. To keep things simple, we do not point out the difference. Our objective is to show you many of the features that the build system created by the Autotools will offer to you.

2.2.1 Basic Installation

The most common installation procedure looks as follows.

```
~ % tar xzf amhello-1.0.tar.gz
```

```
~ % cd amhello-1.0
~/amhello-1.0 % ./configure
...
config.status: creating Makefile
config.status: creating src/Makefile
...
~/amhello-1.0 % make
...
~/amhello-1.0 % make check
...
~/amhello-1.0 % su
Password:
/home/adl/amhello-1.0 # make install
...
/home/adl/amhello-1.0 # exit
~/amhello-1.0 % make installcheck
...
```

The user first unpacks the package. Here, and in the following examples, we will use the non-portable `tar xzf` command for simplicity. On a system without GNU `tar` installed, this command should read `gunzip -c amhello-1.0.tar.gz | tar xf -`.

The user then enters the newly created directory to run the `configure` script. This script probes the system for various features, and finally creates the `Makefiles`. In this toy example there are only two `Makefiles`, but in real-world projects, there may be many more, usually one `Makefile` per directory.

It is now possible to run `make`. This will construct all the programs, libraries, and scripts that need to be constructed for the package. In our example, this compiles the `hello` program. All files are constructed in place, in the source tree; we will see later how this can be changed.

`make check` causes the package's tests to be run. This step is not mandatory, but it is often good to make sure the programs that have been built behave as they should, before you decide to install them. Our example does not contain any tests, so running `make check` is a no-op.

After everything has been built, and maybe tested, it is time to install it on the system. That means copying the programs, libraries, header files, scripts, and other data files from the source directory to their final destination on the system. The command `make install` will do that. However, by default everything will be installed in subdirectories of `/usr/local`: binaries will go into `/usr/local/bin`, libraries will end up in `/usr/local/lib`, etc. This destination is usually not writable by any user, so we assume that we have to become root before we can run `make install`. In our example, running `make install` will copy the program `hello` into `/usr/local/bin` and `README` into `/usr/local/share/doc/amhello`.

A last and optional step is to run `make installcheck`. This command may run tests on the installed files. `make check` tests the files in the source tree, while `make installcheck` tests their installed copies. The tests run by the latter can be different from those run by the former. For instance, there are tests that cannot be run in the source tree. Conversely, some

packages are set up so that `make installcheck` will run the very same tests as `make check`, only on different files (non-installed vs. installed). It can make a difference, for instance when the source tree's layout is different from that of the installation. Furthermore it may help to diagnose an incomplete installation.

Presently most packages do not have any `installcheck` tests because the existence of `installcheck` is little known, and its usefulness is neglected. Our little toy package is no better: `make installcheck` does nothing.

2.2.2 Standard Makefile Targets

So far we have come across four ways to run `make` in the GNU Build System: `make`, `make check`, `make install`, and `make installcheck`. The words `check`, `install`, and `installcheck`, passed as arguments to `make`, are called *targets*. `make` is a shorthand for `make all`, `all` being the default target in the GNU Build System.

Here is a list of the most useful targets that the GNU Coding Standards specify.

`make all` Build programs, libraries, documentation, etc. (same as `make`).

`make install`

Install what needs to be installed, copying the files from the package's tree to system-wide directories.

`make install-strip`

Same as `make install`, then strip debugging symbols. Some users like to trade space for useful bug reports. . .

`make uninstall`

The opposite of `make install`: erase the installed files. (This needs to be run from the same build tree that was installed.)

`make clean`

Erase from the build tree the files built by `make all`.

`make distclean`

Additionally erase anything `./configure` created.

`make check`

Run the test suite, if any.

`make installcheck`

Check the installed programs or libraries, if supported.

`make dist` Recreate `package-version.tar.gz` from all the source files.

2.2.3 Standard Directory Variables

The GNU Coding Standards also specify a hierarchy of variables to denote installation directories. Some of these are:

Directory variable	Default value
<code>prefix</code>	<code>/usr/local</code>
<code>exec_prefix</code>	<code>\${prefix}</code>
<code>bindir</code>	<code>\${exec_prefix}/bin</code>

```

libdir      ${exec_prefix}/lib
...
includedir  ${prefix}/include
datarootdir ${prefix}/share
datadir     ${datarootdir}
mandir      ${datarootdir}/man
infodir     ${datarootdir}/info
docdir      ${datarootdir}/doc/${PACKAGE}
...

```

Each of these directories has a role which is often obvious from its name. In a package, any installable file will be installed in one of these directories. For instance in `amhello-1.0`, the program `hello` is to be installed in `bindir`, the directory for binaries. The default value for this directory is `/usr/local/bin`, but the user can supply a different value when calling `configure`. Also the file `README` will be installed into `docdir`, which defaults to `/usr/local/share/doc/amhello`.

As a user, if you wish to install a package on your own account, you could proceed as follows:

```

~/amhello-1.0 % ./configure --prefix ~/usr
...
~/amhello-1.0 % make
...
~/amhello-1.0 % make install
...

```

This would install `~/usr/bin/hello` and `~/usr/share/doc/amhello/README`.

The list of all such directory options is shown by `./configure --help`.

2.2.4 Standard Configuration Variables

The GNU Coding Standards also define a set of standard configuration variables used during the build. Here are some:

```

CC          C compiler command
CFLAGS      C compiler flags
CXX         C++ compiler command
CXXFLAGS    C++ compiler flags
LDFLAGS     linker flags
CPPFLAGS    C/C++ preprocessor flags
...

```

`configure` usually does a good job at setting appropriate values for these variables, but there are cases where you may want to override them. For instance you may have several versions of a compiler installed and would like to use another one, you may have header files installed outside the default search path of the compiler, or even libraries out of the way of the linker.

Here is how one would call `configure` to force it to use `gcc-3` as C compiler, use header files from `~/usr/include` when compiling, and libraries from `~/usr/lib` when linking.

```
~/amhello-1.0 % ./configure --prefix ~/usr CC=gcc-3 \  
CPPFLAGS=-I$HOME/usr/include LDFLAGS=-L$HOME/usr/lib
```

Again, a full list of these variables appears in the output of `./configure --help`.

2.2.5 Overriding Default Configuration Setting with `config.site`

When installing several packages using the same setup, it can be convenient to create a file to capture common settings. If a file named `prefix/share/config.site` exists, `configure` will source it at the beginning of its execution.

Recall the command from the previous section:

```
~/amhello-1.0 % ./configure --prefix ~/usr CC=gcc-3 \  
CPPFLAGS=-I$HOME/usr/include LDFLAGS=-L$HOME/usr/lib
```

Assuming we are installing many package in `~/usr`, and will always want to use these definitions of `CC`, `CPPFLAGS`, and `LDFLAGS`, we can automate this by creating the following `~/usr/share/config.site` file:

```
test -z "$CC" && CC=gcc-3  
test -z "$CPPFLAGS" && CPPFLAGS=-I$HOME/usr/include  
test -z "$LDFLAGS" && LDFLAGS=-L$HOME/usr/lib
```

Now, any time a `configure` script is using the `~/usr` prefix, it will execute the above `config.site` and define these three variables.

```
~/amhello-1.0 % ./configure --prefix ~/usr  
configure: loading site script /home/adl/usr/share/config.site  
...
```

See Section “Setting Site Defaults” in *The Autoconf Manual*, for more information about this feature.

2.2.6 Parallel Build Trees (a.k.a. VPATH Builds)

The GNU Build System distinguishes two trees: the source tree, and the build tree. These are two directories that may be the same, or different.

The source tree is rooted in the directory containing the `configure` script. It contains all the source files (those that are distributed), and may be arranged using several subdirectories.

The build tree is rooted in the current directory at the time `configure` was run, and is populated with all object files, programs, libraries, and other derived files built from the sources (and hence not distributed). The build tree usually has the same subdirectory layout as the source tree; its subdirectories are created automatically by the build system.

If `configure` is executed in its own directory, the source and build trees are combined: derived files are constructed in the same directories as their sources. This was the case in our first installation example (see Section 2.2.1 [Basic Installation], page 2).

A common request from users is that they want to confine all derived files to a single directory, to keep their source directories uncluttered. Here is how we could run `configure` to create everything in a build tree (that is, subdirectory) called `build/`.

```
~ % tar xzf ~/amhello-1.0.tar.gz
```

```

~ % cd amhello-1.0
~/amhello-1.0 % mkdir build && cd build
~/amhello-1.0/build % ../configure
...
~/amhello-1.0/build % make
...

```

These setups, where source and build trees are different, are often called *parallel builds* or *VPATH builds*. The expression *parallel build* is misleading: the word *parallel* is a reference to the way the build tree shadows the source tree, it is not about some concurrency in the way build commands are run. For this reason we refer to such setups using the name *VPATH builds* in the following. *VPATH* is the name of the `make` feature used by the `Makefiles` to allow these builds (see Section “VPATH Search Path for All Prerequisites” in *The GNU Make Manual*).

VPATH builds have other interesting uses. One is to build the same sources with multiple configurations. For instance:

```

~ % tar xzf ~/amhello-1.0.tar.gz
~ % cd amhello-1.0
~/amhello-1.0 % mkdir debug optim && cd debug
~/amhello-1.0/debug % ../configure CFLAGS='-g -O0'
...
~/amhello-1.0/debug % make
...
~/amhello-1.0/debug % cd ../optim
~/amhello-1.0/optim % ../configure CFLAGS='-O3 -fomit-frame-pointer'
...
~/amhello-1.0/optim % make
...

```

With network file systems, a similar approach can be used to build the same sources on different machines. For instance, suppose that the sources are installed on a directory shared by two hosts: `HOST1` and `HOST2`, which may be different platforms.

```

~ % cd /nfs/src
/nfs/src % tar xzf ~/amhello-1.0.tar.gz

```

On the first host, you could create a local build directory:

```

[HOST1] ~ % mkdir /tmp/amh && cd /tmp/amh
[HOST1] /tmp/amh % /nfs/src/amhello-1.0/configure
...
[HOST1] /tmp/amh % make && sudo make install
...

```

(Here we assume that the installer has configured `sudo` so it can execute `make install` with root privileges; it is more convenient than using `su` like in Section 2.2.1 [Basic Installation], page 2).

On the second host, you would do exactly the same, possibly at the same time:

```

[HOST2] ~ % mkdir /tmp/amh && cd /tmp/amh
[HOST2] /tmp/amh % /nfs/src/amhello-1.0/configure
...

```

```
[HOST2] /tmp/amh % make && sudo make install
...
```

In this scenario, nothing forbids the `/nfs/src/amhello-1.0` directory from being read-only. In fact VPATH builds are also a means of building packages from a read-only medium such as a CD-ROM. (The FSF used to sell CD-ROMs with unpacked source code, before the GNU project grew so big.)

2.2.7 Two-Part Installation

In our last example (see Section 2.2.6 [VPATH Builds], page 6), a source tree was shared by two hosts, but compilation and installation were done separately on each host.

The GNU Build System also supports networked setups where part of the installed files should be shared amongst multiple hosts. It does so by distinguishing architecture-dependent files from architecture-independent files, and providing two `Makefile` targets to install each of these classes of files.

These targets are `install-exec` for architecture-dependent files and `install-data` for architecture-independent files. The command we used up to now, `make install`, can be thought of as a shorthand for `make install-exec install-data`.

From the GNU Build System point of view, the distinction between architecture-dependent files and architecture-independent files is based exclusively on the directory variable used to specify their installation destination. In the list of directory variables we provided earlier (see Section 2.2.3 [Standard Directory Variables], page 4), all the variables based on `exec-prefix` designate architecture-dependent directories whose files will be installed by `make install-exec`. The others designate architecture-independent directories and will serve files installed by `make install-data`. See Section 12.2 [The Two Parts of Install], page 96, for more details.

Here is how we could revisit our two-host installation example, assuming that (1) we want to install the package directly in `/usr`, and (2) the directory `/usr/share` is shared by the two hosts.

On the first host we would run

```
[HOST1] ~ % mkdir /tmp/amh && cd /tmp/amh
[HOST1] /tmp/amh % /nfs/src/amhello-1.0/configure --prefix /usr
...
[HOST1] /tmp/amh % make && sudo make install
...
```

On the second host, however, we need only install the architecture-specific files.

```
[HOST2] ~ % mkdir /tmp/amh && cd /tmp/amh
[HOST2] /tmp/amh % /nfs/src/amhello-1.0/configure --prefix /usr
...
[HOST2] /tmp/amh % make && sudo make install-exec
...
```

In packages that have installation checks, it would make sense to run `make installcheck` (see Section 2.2.1 [Basic Installation], page 2) to verify that the package works correctly despite the apparent partial installation.

2.2.8 Cross-Compilation

To *cross-compile* is to build on one platform a binary that will run on another platform. When speaking of cross-compilation, it is important to distinguish between the *build platform* on which the compilation is performed, and the *host platform* on which the resulting executable is expected to run. The following `configure` options are used to specify each of them:

`--build=build`

The system on which the package is built.

`--host=host`

The system where built programs and libraries will run.

When the `--host` is used, `configure` will search for the cross-compiling suite for this platform. Cross-compilation tools commonly have their target architecture as prefix of their name. For instance my cross-compiler for MinGW32 has its binaries called `i586-mingw32msvc-gcc`, `i586-mingw32msvc-ld`, `i586-mingw32msvc-as`, etc.

Here is how we could build `amhello-1.0` for `i586-mingw32msvc` on a GNU/Linux PC.

```
~/amhello-1.0 % ./configure --build i686-pc-linux-gnu --host i586-mingw32msvc
checking for a BSD-compatible install... /usr/bin/install -c
checking whether build environment is sane... yes
checking for gawk... gawk
checking whether make sets $(MAKE)... yes
checking for i586-mingw32msvc-strip... i586-mingw32msvc-strip
checking for i586-mingw32msvc-gcc... i586-mingw32msvc-gcc
checking for C compiler default output file name... a.exe
checking whether the C compiler works... yes
checking whether we are cross compiling... yes
checking for suffix of executables... .exe
checking for suffix of object files... o
checking whether we are using the GNU C compiler... yes
checking whether i586-mingw32msvc-gcc accepts -g... yes
checking for i586-mingw32msvc-gcc option to accept ANSI C...
...
~/amhello-1.0 % make
...
~/amhello-1.0 % cd src; file hello.exe
hello.exe: MS Windows PE 32-bit Intel 80386 console executable not relocatable
```

The `--host` and `--build` options are usually all we need for cross-compiling. The only exception is if the package being built is itself a cross-compiler: we need a third option to specify its target architecture.

`--target=target`

When building compiler tools: the system for which the tools will create output.

For instance when installing GCC, the GNU Compiler Collection, we can use `--target=target` to specify that we want to build GCC as a cross-compiler for *target*. Mixing `--build` and `--target`, we can actually cross-compile a cross-compiler; such a three-way cross-compilation is known as a *Canadian cross*.

See Section “Specifying the System Type” in *The Autoconf Manual*, for more information about these `configure` options.

2.2.9 Renaming Programs at Install Time

The GNU Build System provides means to automatically rename executables and manpages before they are installed (see Section 11.2 [Man Pages], page 95). This is especially convenient when installing a GNU package on a system that already has a proprietary implementation you do not want to overwrite. For instance, you may want to install GNU `tar` as `gtar` so you can distinguish it from your vendor's `tar`.

This can be done using one of these three `configure` options.

```
--program-prefix=prefix
    Prepend prefix to installed program names.

--program-suffix=suffix
    Append suffix to installed program names.

--program-transform-name=program
    Run sed program on installed program names.
```

The following commands would install `hello` as `/usr/local/bin/test-hello`, for instance.

```
~/amhello-1.0 % ./configure --program-prefix test-
...
~/amhello-1.0 % make
...
~/amhello-1.0 % sudo make install
...
```

2.2.10 Building Binary Packages Using DESTDIR

The GNU Build System's `make install` and `make uninstall` interface does not exactly fit the needs of a system administrator who has to deploy and upgrade packages on lots of hosts. In other words, the GNU Build System does not replace a package manager.

Such package managers usually need to know which files have been installed by a package, so a mere `make install` is inappropriate.

The `DESTDIR` variable can be used to perform a staged installation. The package should be configured as if it was going to be installed in its final location (e.g., `--prefix /usr`), but when running `make install`, the `DESTDIR` should be set to the absolute name of a directory into which the installation will be diverted. From this directory it is easy to review which files are being installed where, and finally copy them to their final location by some means.

For instance here is how we could create a binary package containing a snapshot of all the files to be installed.

```
~/amhello-1.0 % ./configure --prefix /usr
...
~/amhello-1.0 % make
...
~/amhello-1.0 % make DESTDIR=$HOME/inst install
...
~/amhello-1.0 % cd ~/inst
~/inst % find . -type f -print > ../files.lst
```

```
~/inst % tar zcvf ~/amhello-1.0-i686.tar.gz 'cat ../files.lst'
./usr/bin/hello
./usr/share/doc/amhello/README
```

After this example, `amhello-1.0-i686.tar.gz` is ready to be uncompressed in `/` on many hosts. (Using `'cat ../files.lst'` instead of `'.'` as argument for `tar` avoids entries for each subdirectory in the archive: we would not like `tar` to restore the modification time of `/`, `/usr/`, etc.)

Note that when building packages for several architectures, it might be convenient to use `make install-data` and `make install-exec` (see Section 2.2.7 [Two-Part Install], page 8) to gather architecture-independent files in a single package.

See Chapter 12 [Install], page 96, for more information.

2.2.11 Preparing Distributions

We have already mentioned `make dist`. This target collects all your source files and the necessary parts of the build system to create a tarball named `package-version.tar.gz`.

Another, more useful command is `make distcheck`. The `distcheck` target constructs `package-version.tar.gz` just as well as `dist`, but it additionally ensures most of the use cases presented so far work:

- It attempts a full compilation of the package (see Section 2.2.1 [Basic Installation], page 2): unpacking the newly constructed tarball, running `make`, `make dvi`, `make check`, `make install`, as well as `make installcheck`, and even `make dist`,
- it tests VPATH builds with read-only source tree (see Section 2.2.6 [VPATH Builds], page 6),
- it makes sure `make clean`, `make distclean`, and `make uninstall` do not omit any file (see Section 2.2.2 [Standard Targets], page 4),
- and it checks that `DESTDIR` installations work (see Section 2.2.10 [DESTDIR], page 10).

All of these actions are performed in a temporary directory, so that no root privileges are required. The exact location and the exact structure of such a subdirectory (where the extracted sources are placed, how the temporary build and install directories are named and how deeply they are nested, etc.) is to be considered an implementation detail, which can change at any time; so do not rely on it.

Releasing a package that fails `make distcheck` means that one of the scenarios we presented will not work and some users will be disappointed. Therefore it is a good practice to release a package only after a successful `make distcheck`. This of course does not imply that the package will be flawless, but at least it will prevent some of the embarrassing errors you may find in packages released by people who have never heard about `distcheck` (like `DESTDIR` not working because of a typo, or a distributed file being erased by `make clean`, or even VPATH builds not working).

See Section 2.4.1 [Creating amhello], page 13, to recreate `amhello-1.0.tar.gz` using `make distcheck`. See Section 14.4 [Checking the Distribution], page 100, for more information about `distcheck`.

2.2.12 Automatic Dependency Tracking

Dependency tracking is performed as a side-effect of compilation. Each time the build system compiles a source file, it computes its list of dependencies (in C these are the header

files included by the source being compiled). Later, any time `make` is run and a dependency appears to have changed, the dependent files will be rebuilt.

Automake generates code for automatic dependency tracking by default, unless the developer chooses to override it; for more information, see Section 8.19 [Dependencies], page 82.

When `configure` is executed, you can see it probing each compiler for the dependency mechanism it supports (several mechanisms can be used):

```
~/amhello-1.0 % ./configure --prefix /usr
...
checking dependency style of gcc... gcc3
...
```

Because dependencies are only computed as a side-effect of the compilation, no dependency information exists the first time a package is built. This is OK because all the files need to be built anyway: `make` does not have to decide which files need to be rebuilt. In fact, dependency tracking is completely useless for one-time builds and there is a `configure` option to disable this:

```
--disable-dependency-tracking
    Speed up one-time builds.
```

Some compilers do not offer any practical way to derive the list of dependencies as a side-effect of the compilation, requiring a separate run (maybe of another tool) to compute these dependencies. The performance penalty implied by these methods is important enough to disable them by default. The option `--enable-dependency-tracking` must be passed to `configure` to activate them.

```
--enable-dependency-tracking
    Do not reject slow dependency extractors.
```

See Section “Dependency Tracking Evolution” in *Brief History of Automake*, for some discussion about the different dependency tracking schemes used by Automake over the years.

2.2.13 Nested Packages

Although nesting packages isn’t something we would recommend to someone who is discovering the Autotools, it is a nice feature worthy of mention in this small advertising tour.

Autoconfiscated packages (that means packages whose build system have been created by Autoconf and friends) can be nested to arbitrary depth.

A typical setup is that package A will distribute one of the libraries it needs in a sub-directory. This library B is a complete package with its own GNU Build System. The `configure` script of A will run the `configure` script of B as part of its execution; building and installing A will also build and install B. Generating a distribution for A will also include B.

It is possible to gather several packages like this. GCC is a heavy user of this feature. This gives installers a single package to configure, build and install, while it allows developers to work on subpackages independently.

When configuring nested packages, the `configure` options given to the top-level `configure` are passed recursively to nested `configure`s. A package that does not understand an option will ignore it, assuming it is meaningful to some other package.

The command `configure --help=recursive` can be used to display the options supported by all the included packages.

See Section 7.4 [Subpackages], page 53, for an example setup.

2.3 How Autotools Help

There are several reasons why you may not want to implement the GNU Build System yourself (read: write a `configure` script and `Makefiles` yourself).

- As we have seen, the GNU Build System has a lot of features (see Section 2.2 [Use Cases], page 2). Some users may expect features you have not implemented because you did not need them.
- Implementing these features portably is difficult and exhausting. Think of writing portable shell scripts, and portable `Makefiles`, for systems you may not have handy. See Section “Portable Shell Programming” in *The Autoconf Manual*, to convince yourself.
- You will have to upgrade your setup to follow changes to the GNU Coding Standards.

The GNU Autotools take all this burden off your back and provide:

- Tools to create a portable, complete, and self-contained GNU Build System, from simple instructions. *Self-contained* meaning the resulting build system does not require the GNU Autotools.
- A central place where fixes and improvements are made: a bug-fix for a portability issue will benefit every package.

Yet there also exist reasons why you may want NOT to use the Autotools. . . For instance you may be already using (or used to) another incompatible build system. Autotools will only be useful if you do accept the concepts of the GNU Build System. People who have their own idea of how a build system should work will feel frustrated by the Autotools.

2.4 A Small Hello World

In this section we recreate the `amhello-1.0` package from scratch. The first subsection shows how to call the Autotools to instantiate the GNU Build System, while the second explains the meaning of the `configure.ac` and `Makefile.am` files read by the Autotools.

2.4.1 Creating `amhello-1.0.tar.gz`

Here is how we can recreate `amhello-1.0.tar.gz` from scratch. The package is simple enough so that we will only need to write 5 files. (You may copy them from the final `amhello-1.0.tar.gz` that is distributed with Automake if you do not want to write them.)

Create the following files in an empty directory.

- `src/main.c` is the source file for the `hello` program. We store it in the `src/` subdirectory, because later, when the package evolves, it will ease the addition of a `man/` directory for man pages, a `data/` directory for data files, etc.

```
~/amhello % cat src/main.c
```

```

#include <config.h>
#include <stdio.h>

int
main (void)
{
    puts ("Hello World!");
    puts ("This is " PACKAGE_STRING ".");
    return 0;
}

```

- README contains some very limited documentation for our little package.

```
~/amhello % cat README
This is a demonstration package for GNU Automake.
Type 'info Automake' to read the Automake manual.
```

- Makefile.am and src/Makefile.am contain Automake instructions for these two directories.

```
~/amhello % cat src/Makefile.am
bin_PROGRAMS = hello
hello_SOURCES = main.c
~/amhello % cat Makefile.am
SUBDIRS = src
dist_doc_DATA = README
```

- Finally, configure.ac contains Autoconf instructions to create the configure script.

```
~/amhello % cat configure.ac
AC_INIT([amhello], [1.0], [bug-automake@gnu.org])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([
    Makefile
    src/Makefile
])
AC_OUTPUT
```

Once you have these five files, it is time to run the Autotools to instantiate the build system. Do this using the `autoreconf` command as follows:

```
~/amhello % autoreconf --install
configure.ac: installing './install-sh'
configure.ac: installing './missing'
configure.ac: installing './compile'
src/Makefile.am: installing './depcomp'
```

At this point the build system is complete.

In addition to the three scripts mentioned in its output, you can see that `autoreconf` created four other files: `configure`, `config.h.in`, `Makefile.in`, and `src/Makefile.in`. The latter three files are templates that will be adapted to the system by `configure` under the names `config.h`, `Makefile`, and `src/Makefile`. Let's do this:

```
~/amhello % ./configure
checking for a BSD-compatible install... /usr/bin/install -c
checking whether build environment is sane... yes
checking for gawk... no
checking for mawk... mawk
checking whether make sets $(MAKE)... yes
checking for gcc... gcc
checking for C compiler default output file name... a.out
checking whether the C compiler works... yes
checking whether we are cross compiling... no
checking for suffix of executables...
checking for suffix of object files... o
checking whether we are using the GNU C compiler... yes
checking whether gcc accepts -g... yes
checking for gcc option to accept ISO C89... none needed
checking for style of include used by make... GNU
checking dependency style of gcc... gcc3
configure: creating ./config.status
config.status: creating Makefile
config.status: creating src/Makefile
config.status: creating config.h
config.status: executing depfiles commands
```

You can see `Makefile`, `src/Makefile`, and `config.h` being created at the end after `configure` has probed the system. It is now possible to run all the targets we wish (see Section 2.2.2 [Standard Targets], page 4). For instance:

```
~/amhello % make
...
~/amhello % src/hello
Hello World!
This is amhello 1.0.
~/amhello % make distcheck
...
=====
amhello-1.0 archives ready for distribution:
amhello-1.0.tar.gz
=====
```

Note that running `autoreconf` is only needed initially when the GNU Build System does not exist. When you later change some instructions in a `Makefile.am` or `configure.ac`, the relevant part of the build system will be regenerated automatically when you execute `make`.

`autoreconf` is a script that calls `autoconf`, `automake`, and a bunch of other commands in the right order. If you are beginning with these tools, it is not important to figure out in which order all of these tools should be invoked and why. However, because `Autoconf` and `Automake` have separate manuals, the important point to understand is that `autoconf` is in charge of creating `configure` from `configure.ac`, while `automake` is in charge of creating

`Makefile.ins` from `Makefile.ams` and `configure.ac`. This should at least direct you to the right manual when seeking answers.

2.4.2 `amhello`'s `configure.ac` Setup Explained

Let us begin with the contents of `configure.ac`.

```
AC_INIT([amhello], [1.0], [bug-automake@gnu.org])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([
  Makefile
  src/Makefile
])
AC_OUTPUT
```

This file is read by both `autoconf` (to create `configure`) and `automake` (to create the various `Makefile.ins`). It contains a series of M4 macros that will be expanded as shell code to finally form the `configure` script. We will not elaborate on the syntax of this file, because the Autoconf manual has a whole section about it (see Section “Writing `configure.ac`” in *The Autoconf Manual*).

The macros prefixed with `AC_` are Autoconf macros, documented in the Autoconf manual (see Section “Autoconf Macro Index” in *The Autoconf Manual*). The macros that start with `AM_` are Automake macros, documented later in this manual (see Section B.1 [Macro Index], page 167).

The first two lines of `configure.ac` initialize Autoconf and Automake. `AC_INIT` takes in as parameters the name of the package, its version number, and a contact address for bug-reports about the package (this address is output at the end of `./configure --help`, for instance). When adapting this setup to your own package, by all means please do not blindly copy Automake’s address: use the mailing list of your package, or your own mail address.

The argument to `AM_INIT_AUTOMAKE` is a list of options for `automake` (see Chapter 17 [Options], page 120). `-Wall` and `-Werror` ask `automake` to turn on all warnings and report them as errors. We are speaking of **Automake** warnings here, such as dubious instructions in `Makefile.am`. This has absolutely nothing to do with how the compiler will be called, even though it may support options with similar names. Using `-Wall -Werror` is a safe setting when starting to work on a package: you do not want to miss any issues. Later you may decide to relax things a bit. The `foreign` option tells Automake that this package will not follow the GNU Standards. GNU packages should always distribute additional files such as `ChangeLog`, `AUTHORS`, etc. We do not want `automake` to complain about these missing files in our small example.

The `AC_PROG_CC` line causes the `configure` script to search for a C compiler and define the variable `CC` with its name. The `src/Makefile.in` file generated by Automake uses the variable `CC` to build `hello`, so when `configure` creates `src/Makefile` from `src/Makefile.in`, it will define `CC` with the value it has found. If Automake is asked to create a `Makefile.in` that uses `CC` but `configure.ac` does not define it, it will suggest you add a call to `AC_PROG_CC`.

The `AC_CONFIG_HEADERS([config.h])` invocation causes the `configure` script to create a `config.h` file gathering ‘`#define`’s defined by other macros in `configure.ac`. In our case, the `AC_INIT` macro already defined a few of them. Here is an excerpt of `config.h` after `configure` has run:

```
...
/* Define to the address where bug reports for this package should be sent. */
#define PACKAGE_BUGREPORT "bug-automake@gnu.org"

/* Define to the full name and version of this package. */
#define PACKAGE_STRING "amhello 1.0"
...
```

As you probably noticed, `src/main.c` includes `config.h` so it can use `PACKAGE_STRING`. In a real-world project, `config.h` can grow really big, with one ‘`#define`’ per feature probed on the system.

The `AC_CONFIG_FILES` macro declares the list of files that `configure` should create from their `*.in` templates. Automake also scans this list to find the `Makefile.am` files it must process. (This is important to remember: when adding a new directory to your project, you should add its `Makefile` to this list, otherwise Automake will never process the new `Makefile.am` you wrote in that directory.)

Finally, the `AC_OUTPUT` line is a closing command that actually produces the part of the script in charge of creating the files registered with `AC_CONFIG_HEADERS` and `AC_CONFIG_FILES`.

When starting a new project, we suggest you start with such a simple `configure.ac`, and gradually add the other tests it requires. The command `autoscan` can also suggest a few of the tests your package may need (see Section “Using `autoscan` to Create `configure.ac`” in *The Autoconf Manual*).

2.4.3 amhello’s Makefile.am Setup Explained

We now turn to `src/Makefile.am`. This file contains Automake instructions to build and install `hello`.

```
bin_PROGRAMS = hello
hello_SOURCES = main.c
```

A `Makefile.am` has the same syntax as an ordinary `Makefile`. When `automake` processes a `Makefile.am` it copies the entire file into the output `Makefile.in` (that will be later turned into `Makefile` by `configure`) but will react to certain variable definitions by generating some build rules and other variables. Often `Makefile.am`s contain only a list of variable definitions as above, but they can also contain other variable and rule definitions that `automake` will pass along without interpretation.

Variables that end with `_PROGRAMS` are special variables that list programs that the resulting `Makefile` should build. In Automake speak, this `_PROGRAMS` suffix is called a *primary*; Automake recognizes other primaries such as `_SCRIPTS`, `_DATA`, `_LIBRARIES`, etc. corresponding to different types of files.

The ‘`bin`’ part of the `bin_PROGRAMS` tells `automake` that the resulting programs should be installed in `bindir`. Recall that the GNU Build System uses a set of variables to denote destination directories and allow users to customize these locations (see Section 2.2.3 [Standard Directory Variables], page 4). Any such directory variable can be put in front of a primary (omitting the `dir` suffix) to tell `automake` where to install the listed files.

Programs need to be built from source files, so for each program *prog* listed in a `_PROGRAMS` variable, `automake` will look for another variable named `prog_SOURCES` listing its source files. There may be more than one source file: they will all be compiled and linked together.

Automake also knows that source files need to be distributed when creating a tarball (unlike built programs). So a side-effect of this `hello_SOURCES` declaration is that `main.c` will be part of the tarball created by `make dist`.

Finally here are some explanations regarding the top-level `Makefile.am`.

```
SUBDIRS = src
dist_doc_DATA = README
```

`SUBDIRS` is a special variable listing all directories that `make` should recurse into before processing the current directory. So this line is responsible for `make` building `src/hello` even though we run it from the top-level. This line also causes `make install` to install `src/hello` before installing `README` (not that this order matters).

The line `dist_doc_DATA = README` causes `README` to be distributed and installed in `docdir`. Files listed with the `_DATA` primary are not automatically part of the tarball built with `make dist`, so we add the `dist_` prefix so they get distributed. However, for `README` it would not have been necessary: `automake` automatically distributes any `README` file it encounters (the list of other files automatically distributed is presented by `automake --help`). The only important effect of this second line is therefore to install `README` during `make install`.

One thing not covered in this example is accessing the installation directory values (see Section 2.2.3 [Standard Directory Variables], page 4) from your program code, that is, converting them into defined macros. For this, see Section “Defining Directories” in *The Autoconf Manual*.

3 General ideas

The following sections cover a few basic ideas that will help you understand how Automake works.

3.1 General Operation

Automake works by reading a `Makefile.am` and generating a `Makefile.in`. Certain variables and rules defined in the `Makefile.am` instruct Automake to generate more specialized code; for instance, a `bin_PROGRAMS` variable definition will cause rules for compiling and linking programs to be generated.

The variable definitions and rules in the `Makefile.am` are copied mostly verbatim into the generated file, with all variable definitions preceding all rules. This allows you to add almost arbitrary code into the generated `Makefile.in`. For instance, the Automake distribution includes a non-standard rule for the `git-dist` target, which the Automake maintainer uses to make distributions from the source control system.

Note that most GNU make extensions are not recognized by Automake. Using such extensions in a `Makefile.am` will lead to errors or confusing behavior.

A special exception is that the GNU make append operator, ‘+=’, is supported. This operator appends its right hand argument to the variable specified on the left. Automake will translate the operator into an ordinary ‘=’ operator; ‘+=’ will thus work with any make program.

Automake tries to keep comments grouped with any adjoining rules or variable definitions.

Generally, Automake is not particularly smart in the parsing of unusual Makefile constructs, so you’re advised to avoid fancy constructs or “creative” use of whitespace. For example, TAB characters cannot be used between a target name and the following “:” character, and variable assignments shouldn’t be indented with TAB characters. Also, using more complex macros in target names can cause trouble:

```
% cat Makefile.am
$(FOO:=x): bar
% automake
Makefile.am:1: bad characters in variable name '$(FOO'
Makefile.am:1: ':='-style assignments are not portable
```

A rule defined in `Makefile.am` generally overrides any such rule of a similar name that would be automatically generated by `automake`. Although this is a supported feature, it is generally best to avoid making use of it, as sometimes the generated rules are very particular.

Similarly, a variable defined in `Makefile.am` or `AC_SUBSTed` from `configure.ac` will override any definition of the variable that `automake` would ordinarily create. This feature is often more useful than the ability to override a rule. Be warned that many of the variables generated by `automake` are considered to be for internal use only, and their names might change in future releases.

When examining a variable definition, Automake will recursively examine variables referenced in the definition. For example, if Automake is looking at the content of `foo_SOURCES` in this snippet

```
xs = a.c b.c
foo_SOURCES = c.c $(xs)
```

it would use the files `a.c`, `b.c`, and `c.c` as the contents of `foo_SOURCES`.

Automake also allows a form of comment that is *not* copied into the output; all lines beginning with ‘##’ (leading spaces allowed) are completely ignored by Automake.

It is customary to make the first line of `Makefile.am` read:

```
## Process this file with automake to produce Makefile.in
```

3.2 Strictness

While Automake is intended to be used by maintainers of GNU packages, it does make some effort to accommodate those who wish to use it, but do not want to use all the GNU conventions.

To this end, Automake supports three levels of *strictness*—how stringently Automake should enforce conformance with GNU conventions. Each strictness level can be selected using an option of the same name; see Chapter 17 [Options], page 120.

The strictness levels are:

gnu This is the default level of strictness. Automake will check for basic compliance with the GNU standards for software packaging. See *The GNU Coding Standards* for full details of these standards. Currently the following checks are made:

- The files `INSTALL`, `NEWS`, `README`, `AUTHORS`, and `ChangeLog`, plus one of `COPYING.LIB`, `COPYING.LESSER` or `COPYING`, are required at the topmost directory of the package.

If the `--add-missing` option is given, automake will add a generic version of the `INSTALL` file as well as the `COPYING` file containing the text of the current version of the GNU General Public License existing at the time of this Automake release (version 3 as this is written, <https://www.gnu.org/copyleft/gpl.html>). However, an existing `COPYING` file will never be overwritten by automake.

- The options `no-installman` and `no-installinfo` are prohibited.

Future versions of Automake will add more checks at this level of strictness; it is advisable to be familiar with the precise requirements of the GNU standards. Future versions of Automake may, at this level of strictness, require certain non-standard GNU tools to be available to maintainer-only Makefile rules. For instance, in the future `pathchk` (see Section “`pathchk` invocation” in *GNU Coreutils*) may be required to run ‘`make dist`’.

foreign Automake will check for only those things that are absolutely required for proper operation. For instance, whereas GNU standards dictate the existence of a `NEWS` file, it will not be required in this mode. This strictness will also turn off some warnings by default (among them, portability warnings).

gnits Automake will check for compliance to the as-yet-unwritten *Gnits standards*. These are based on the GNU standards, but are even more detailed. Unless you are a Gnits standards contributor, it is recommended that you avoid this option until such time as the Gnits standard is actually published (which may never happen).

Currently, `--gnits` does all the checks that `--gnu` does, and checks the following as well:

- ‘`make installcheck`’ will check to make sure that the `--help` and `--version` really print a usage message and a version string, respectively. This is the `std-options` option (see Chapter 17 [Options], page 120).
- ‘`make dist`’ will check to make sure the `NEWS` file has been updated to the current version.
- `VERSION` is checked to make sure its format complies with Gnits standards.
- If `VERSION` indicates that this is an alpha release, and the file `README-alpha` appears in the topmost directory of a package, then it is included in the distribution. This is done in `--gnits` mode, and no other, because this mode is the only one where version number formats are constrained, and hence the only mode where Automake can automatically determine whether `README-alpha` should be included.

- The file `THANKS` is required.

3.3 The Uniform Naming Scheme

Automake variables generally follow a *uniform naming scheme* that makes it easy to decide how programs (and other derived objects) are built, and how they are installed. This scheme also supports `configure` time determination of what should be built.

At `make` time, certain variables are used to determine which objects are to be built. The variable names are made of several pieces that are concatenated together.

The piece that tells `automake` what is being built is commonly called the *primary*. For instance, the primary `PROGRAMS` holds a list of programs that are to be compiled and linked.

A different set of names is used to decide where the built objects should be installed. These names are prefixes to the primary, and they indicate which standard directory should be used as the installation directory. The standard directory names are given in the GNU standards (see Section “Directory Variables” in *The GNU Coding Standards*). Automake extends this list with `pkgdatadir`, `pkgincludedir`, `pkglibdir`, and `pkglibexecdir`; these are the same as the non-‘`pkg`’ versions, but with ‘`$(PACKAGE)`’ appended. For instance, `pkglibdir` is defined as ‘`$(libdir)/$(PACKAGE)`’.

For each primary, there is one additional variable named by prepending ‘`EXTRA_`’ to the primary name. This variable is used to list objects that may or may not be built, depending on what `configure` decides. This variable is required because Automake must statically know the entire list of objects that may be built in order to generate a `Makefile.in` that will work in all cases.

For instance, `cpio` decides at `configure` time which programs should be built. Some of the programs are installed in `bindir`, and some are installed in `sbindir`:

```
EXTRA_PROGRAMS = mt rmt
bin_PROGRAMS = cpio pax
sbin_PROGRAMS = $(MORE_PROGRAMS)
```

Defining a primary without a prefix as a variable, e.g., ‘`PROGRAMS`’, is an error.

Note that the common ‘`dir`’ suffix is left off when constructing the variable names; thus one writes ‘`bin_PROGRAMS`’ and not ‘`bindir_PROGRAMS`’.

Not every sort of object can be installed in every directory. Automake will flag those attempts it finds in error (but see below how to override the check if you really need to). Automake will also diagnose obvious misspellings in directory names.

Sometimes the standard directories—even as augmented by Automake—are not enough. In particular it is sometimes useful, for clarity, to install objects in a subdirectory of some predefined directory. To this end, Automake allows you to extend the list of possible installation directories. A given prefix (e.g., ‘`zar`’) is valid if a variable of the same name with ‘`dir`’ appended is defined (e.g., ‘`zardir`’).

For instance, the following snippet will install `file.xml` into ‘`$(datadir)/xml`’.

```
xml_dir = $(datadir)/xml
xml_DATA = file.xml
```

This feature can also be used to override the sanity checks Automake performs to diagnose suspicious directory/primary couples (in the unlikely case these checks are undesirable,

and you really know what you're doing). For example, Automake would error out on this input:

```
# Forbidden directory combinations, automake will error out on this.
pkglib_PROGRAMS = foo
doc_LIBRARIES = libquux.a
```

but it will succeed with this:

```
# Work around forbidden directory combinations. Do not use this
# without a very good reason!
my_execbindir = $(pkglibdir)
my_doclibdir = $(docdir)
my_execbin_PROGRAMS = foo
my_doclib_LIBRARIES = libquux.a
```

The ‘exec’ substring of the ‘my_execbindir’ variable lets the files be installed at the right time (see Section 12.2 [The Two Parts of Install], page 96).

The special prefix ‘noinst_’ indicates that the objects in question should be built but not installed at all. This is usually used for objects required to build the rest of your package, for instance static libraries (see Section 8.2 [A Library], page 58), or helper scripts.

The special prefix ‘check_’ indicates that the objects in question should not be built until the ‘make check’ command is run. Those objects are not installed either.

The current primary names are ‘PROGRAMS’, ‘LIBRARIES’, ‘LTLIBRARIES’, ‘LISP’, ‘PYTHON’, ‘JAVA’, ‘SCRIPTS’, ‘DATA’, ‘HEADERS’, ‘MANS’, and ‘TEXINFOS’.

Some primaries also allow additional prefixes that control other aspects of automake’s behavior. The currently defined prefixes are ‘dist_’, ‘nodist_’, ‘nobase_’, and ‘notrans_’. These prefixes are explained later (see Section 8.4 [Program and Library Variables], page 65) (see Section 11.2 [Man Pages], page 95).

3.4 Staying below the command line length limit

Traditionally, most unix-like systems have a length limitation for the command line arguments and environment contents when creating new processes (see for example <https://www.in-ulm.de/~mascheck/various/argmax/> for an overview on this issue), which of course also applies to commands spawned by make. POSIX requires this limit to be at least 4096 bytes, and most modern systems have quite high limits (or are unlimited).

In order to create portable Makefiles that do not trip over these limits, it is necessary to keep the length of file lists bounded. Unfortunately, it is not possible to do so fully transparently within Automake, so your help may be needed. Typically, you can split long file lists manually and use different installation directory names for each list. For example,

```
data_DATA = file1 ... fileN fileN+1 ... file2N
```

may also be written as

```
data_DATA = file1 ... fileN
data2dir = $(datadir)
data2_DATA = fileN+1 ... file2N
```

and will cause Automake to treat the two lists separately during `make install`. See Section 12.2 [The Two Parts of Install], page 96, for choosing directory names that will

keep the ordering of the two parts of installation Note that `make dist` may still only work on a host with a higher length limit in this example.

Automake itself employs a couple of strategies to avoid long command lines. For example, when `'${srcdir}/'` is prepended to file names, as can happen with above `$(data_DATA)` lists, it limits the amount of arguments passed to external commands.

Unfortunately, some systems' `make` commands may prepend `VPATH` prefixes like `'${srcdir}/'` to file names from the source tree automatically (see Section “Automatic Rule Rewriting” in *The Autoconf Manual*). In this case, the user may have to switch to use GNU Make, or refrain from using `VPATH` builds, in order to stay below the length limit.

For libraries and programs built from many sources, convenience archives may be used as intermediates in order to limit the object list length (see Section 8.3.5 [Libtool Convenience Libraries], page 62).

3.5 How derived variables are named

Sometimes a Makefile variable name is derived from some text the maintainer supplies. For instance, a program name listed in `'_PROGRAMS'` is rewritten into the name of a `'_SOURCES'` variable. In cases like this, Automake canonicalizes the text, so that program names and the like do not have to follow Makefile variable naming rules. All characters in the name except for letters, numbers, the strudel (`@`), and the underscore are turned into underscores when making variable references.

For example, if your program is named `sniff-glue`, the derived variable name would be `'sniff_glue_SOURCES'`, not `'sniff-glue_SOURCES'`. Similarly the sources for a library named `libmumble++.a` should be listed in the `'libmumble___a_SOURCES'` variable.

The strudel is an addition, to make the use of Autoconf substitutions in variable names less obfuscating.

3.6 Variables reserved for the user

Some Makefile variables are reserved by the GNU Coding Standards for the use of the “user”—the person building the package. For instance, `CFLAGS` is one such variable.

Sometimes package developers are tempted to set user variables such as `CFLAGS` because it appears to make their job easier. However, the package itself should never set a user variable, particularly not to include switches that are required for proper compilation of the package. Since these variables are documented as being for the package builder, that person rightfully expects to be able to override any of these variables at build time.

To get around this problem, Automake introduces an automake-specific shadow variable for each user flag variable. (Shadow variables are not introduced for variables like `CC`, where they would make no sense.) The shadow variable is named by prepending `'AM_'` to the user variable's name. For instance, the shadow variable for `YFLAGS` is `AM_YFLAGS`. The package maintainer—that is, the author(s) of the `Makefile.am` and `configure.ac` files—may adjust these shadow variables however necessary.

See Section 26.6 [Flag Variables Ordering], page 146, for more discussion about these variables and how they interact with per-target variables.

3.7 Programs automake might require

Automake sometimes requires helper programs so that the generated `Makefile` can do its work properly. There are a fairly large number of them, and we list them here.

Although all of these files are distributed and installed with Automake, a couple of them are maintained separately. The Automake copies are updated before each release, but we mention the original source in case you need more recent versions.

`ar-lib` This is a wrapper primarily for the Microsoft lib archiver, to make it more POSIX-like.

`compile` This is a wrapper for compilers that do not accept options `-c` and `-o` at the same time. It is only used when absolutely required. Such compilers are rare, with the Microsoft C/C++ Compiler as the most notable exception. This wrapper also makes the following common options available for that compiler, while performing file name translation where needed: `-I`, `-L`, `-l`, `-Wl`, and `-Xlinker`.

`config.guess`

`config.sub`

These two programs compute the canonical triplets for the given build, host, or target architecture. These programs are updated regularly to support new architectures and fix probes broken by changes in new kernel versions. Each new release of Automake comes with up-to-date copies of these programs. If your copy of Automake is getting old, you are encouraged to fetch the latest versions of these files from <https://savannah.gnu.org/git/?group=config> before making a release.

`depcomp` This program understands how to run a compiler so that it will generate not only the desired output but also dependency information that is then used by the automatic dependency tracking feature (see Section 8.19 [Dependencies], page 82).

`install-sh`

This is a replacement for the `install` program that works on platforms where `install` is unavailable or unusable.

`mdate-sh` This script is used to generate a `version.texi` file. It examines a file and prints some date information about it.

`missing` This wraps a number of programs that are typically only required by maintainers. If the program in question doesn't exist, or seems too old, `missing` will print an informative warning before failing out, to provide the user with more context and information.

`mkinstalldirs`

This script used to be a wrapper around `'mkdir -p'`, which is not portable. Now we prefer to use `'install-sh -d'` when `configure` finds that `'mkdir -p'` does not work, this makes one less script to distribute.

For backward compatibility `mkinstalldirs` is still used and distributed when `automake` finds it in a package. But it is no longer installed automatically, and it should be safe to remove it.

py-compile

This is used to byte-compile Python scripts.

test-driver

This implements the default test driver offered by the parallel testsuite harness.

texinfo.tex

When Texinfo sources are in the package, this file is required for ‘make dvi’, ‘make ps’ and ‘make pdf’. The latest version can be downloaded from <https://www.gnu.org/software/texinfo/>. A working T_EX distribution, or at least a `tex` program, is also required. Furthermore, ‘make dist’ invokes ‘make dvi’, so these become requirements for making a distribution with Texinfo sources.

ylwrap

This program wraps `lex` and `yacc` to rename their output files. It also ensures that, for instance, multiple `yacc` instances can be invoked in a single directory in parallel.

4 Some example packages

This section contains two small examples.

The first example (see Section 4.1 [Complete], page 25) assumes you have an existing project already using Autoconf, with handcrafted `Makefiles`, and that you want to convert it to using Automake. If you are discovering both tools, it is probably better that you look at the Hello World example presented earlier (see Section 2.4 [Hello World], page 13).

The second example (see Section 4.2 [true], page 26) shows how two programs can be built from the same file, using different compilation parameters. It contains some technical digressions that are probably best skipped on first read.

4.1 A simple example, start to finish

Let’s suppose you just finished writing `zardoz`, a program to make your head float from vortex to vortex. You’ve been using Autoconf to provide a portability framework, but your `Makefile.ins` have been ad-hoc. You want to make them bulletproof, so you turn to Automake.

The first step is to update your `configure.ac` to include the commands that `automake` needs. The way to do this is to add an `AM_INIT_AUTOMAKE` call just after `AC_INIT`:

```
AC_INIT([zardoz], [1.0])
AM_INIT_AUTOMAKE
...
```

Since your program doesn’t have any complicating factors (e.g., it doesn’t use `gettext`, it doesn’t want to build a shared library), you’re done with this part. That was easy!

Now you must regenerate `configure`. But to do that, you’ll need to tell `autoconf` how to find the new macro you’ve used. The easiest way to do this is to use the `aclocal` program to generate your `aclocal.m4` for you. But wait... maybe you already have an `aclocal.m4`, because you had to write some hairy macros for your program. The `aclocal` program lets you put your own macros into `acinclude.m4`, so simply rename and then run:

```
mv aclocal.m4 acinclude.m4
```



```
aclocal
autoconf
```

Now it is time to write your `Makefile.am` for `zardoz`. Since `zardoz` is a user program, you want to install it where the rest of the user programs go: `bindir`. Additionally, `zardoz` has some Texinfo documentation. Your `configure.ac` script uses `AC_REPLACE_FUNCS`, so you need to link against `$(LIBOBJJS)`. So here's what you'd write:

```
bin_PROGRAMS = zardoz
zardoz_SOURCES = main.c head.c float.c vortex9.c gun.c
zardoz_LDADD = $(LIBOBJJS)
```

```
info_TEXINFOS = zardoz.texi
```

Now you can run `'automake --add-missing'` to generate your `Makefile.in` and grab any auxiliary files you might need, and you're done!

4.2 Building `true` and `false`

Here is another, trickier example. It shows how to generate two programs (`true` and `false`) from the same source file (`true.c`). The difficult part is that each compilation of `true.c` requires different `cpp` flags.

```
bin_PROGRAMS = true false
false_SOURCES =
false_LDADD = false.o

true.o: true.c
    $(COMPILE) -DEXIT_CODE=0 -c true.c

false.o: true.c
    $(COMPILE) -DEXIT_CODE=1 -o false.o -c true.c
```

Note that there is no `true_SOURCES` definition. Automake will implicitly assume that there is a source file named `true.c` (see Section 8.5 [Default `_SOURCES`], page 69), and define rules to compile `true.o` and link `true`. The `'true.o: true.c'` rule supplied by the above `Makefile.am`, will override the Automake generated rule to build `true.o`.

`false_SOURCES` is defined to be empty—that way no implicit value is substituted. Because we have not listed the source of `false`, we have to tell Automake how to link the program. This is the purpose of the `false_LDADD` line. A `false_DEPENDENCIES` variable, holding the dependencies of the `false` target will be automatically generated by Automake from the content of `false_LDADD`.

The above rules won't work if your compiler doesn't accept both `-c` and `-o`. The simplest fix for this is to introduce a bogus dependency (to avoid problems with a parallel `make`):

```
true.o: true.c false.o
    $(COMPILE) -DEXIT_CODE=0 -c true.c

false.o: true.c
    $(COMPILE) -DEXIT_CODE=1 -c true.c && mv true.o false.o
```

As it turns out, there is also a much easier way to do this same task. Some of the above technique is useful enough that we've kept the example in the manual. However if you were

to build `true` and `false` in real life, you would probably use per-program compilation flags, like so:

```
bin_PROGRAMS = false true

false_SOURCES = true.c
false_CPPFLAGS = -DEXIT_CODE=1

true_SOURCES = true.c
true_CPPFLAGS = -DEXIT_CODE=0
```

In this case Automake will cause `true.c` to be compiled twice, with different flags. In this instance, the names of the object files would be chosen by automake; they would be `false-true.o` and `true-true.o`. (The name of the object files rarely matters.)

5 Creating a Makefile.in

To create all the `Makefile.ins` for a package, run the `automake` program in the top level directory, with no arguments. `automake` will automatically find each appropriate `Makefile.am` (by scanning `configure.ac`; see Chapter 6 [configure], page 30) and generate the corresponding `Makefile.in`. Note that `automake` has a rather simplistic view of what constitutes a package; it assumes that a package has only one `configure.ac`, at the top. If your package has multiple `configure.acs`, then you must run `automake` in each directory holding a `configure.ac`. (Alternatively, you may rely on Autoconf's `autoreconf`, which is able to recurse your package tree and run `automake` where appropriate.)

You can optionally give `automake` an argument; `.am` is appended to the argument and the result is used as the name of the input file. This feature is generally only used to automatically rebuild an out-of-date `Makefile.in`. Note that `automake` must always be run from the topmost directory of a project, even if being used to regenerate the `Makefile.in` in some subdirectory. This is necessary because `automake` must scan `configure.ac`, and because `automake` uses the knowledge that a `Makefile.in` is in a subdirectory to change its behavior in some cases.

Automake will run `autoconf` to scan `configure.ac` and its dependencies (i.e., `aclocal.m4` and any included file), therefore `autoconf` must be in your `PATH`. If there is an `AUTOCONF` variable in your environment it will be used instead of `autoconf`; this allows you to select a particular version of Autoconf. By the way, don't misunderstand this paragraph: `automake` runs `autoconf` to **scan** your `configure.ac`; this won't build `configure` and you still have to run `autoconf` yourself for this purpose.

`automake` accepts the following options:

`-a`

`--add-missing`

Automake requires certain common files to exist in certain situations; for instance, `config.guess` is required if `configure.ac` invokes `AC_CANONICAL_HOST`. Automake is distributed with several of these files (see Section 3.7 [Auxiliary Programs], page 24); this option will cause the missing ones to be automatically added to the package, whenever possible. In general if Automake tells you a file is missing, try using this option. By default Automake tries to

make a symbolic link pointing to its own copy of the missing file; this can be changed with `--copy`.

Many of the potentially-missing files are common scripts whose location may be specified via the `AC_CONFIG_AUX_DIR` macro. Therefore, `AC_CONFIG_AUX_DIR`'s setting affects whether a file is considered missing, and where the missing file is added (see Section 6.2 [Optional], page 32).

In some strictness modes, additional files are installed, see [Gnits], page 19, for more information.

`--libdir=dir`

Look for Automake data files in directory `dir` instead of in the installation directory. This is typically used for debugging.

The environment variable `AUTOMAKE_LIBDIR` provides another way to set the directory containing Automake data files. However `--libdir` takes precedence over it.

`--print-libdir`

Print the path of the installation directory containing Automake-provided scripts and data files (e.g., `texinfo.texi` and `install-sh`).

`-c`

`--copy` When used with `--add-missing`, causes installed files to be copied. The default is to make a symbolic link.

`-f`

`--force-missing`

When used with `--add-missing`, causes standard files to be reinstalled even if they already exist in the source tree. This involves removing the file from the source tree before creating the new symlink (or, with `--copy`, copying the new file).

`--foreign`

Set the global strictness to `foreign`. For more information, see Section 3.2 [Strictness], page 19.

`--gnits` Set the global strictness to `gnits`. For more information, see Section 3.2 [Strictness], page 19.

`--gnu` Set the global strictness to `gnu`. For more information, see Section 3.2 [Strictness], page 19. This is the default strictness.

`--help` Print a summary of the command line options and exit.

`-i`

`--ignore-deps`

This disables the dependency tracking feature in generated `Makefiles`; see Section 8.19 [Dependencies], page 82.

`--include-deps`

This enables the dependency tracking feature. This feature is enabled by default. This option is provided for historical reasons only and probably should not be used.

`--no-force`
Ordinarily `automake` creates all `Makefile.ins` mentioned in `configure.ac`. This option causes it to only update those `Makefile.ins` that are out of date with respect to one of their dependents.

`-o dir`
`--output-dir=dir`
Put the generated `Makefile.in` in the directory `dir`. Ordinarily each `Makefile.in` is created in the directory of the corresponding `Makefile.am`. This option is deprecated and will be removed in a future release.

`-v`
`--verbose`
Cause Automake to print information about which files are being read or created.

`--version`
Print the version number of Automake and exit.

`-W category[,category...]`
`--warnings=category[,category...]`
Output warnings about a *category* of potential problems with the package. *category* can be any of:

- `cross` Constructs compromising the ability to cross-compile the package.
- `gnu` Minor deviations from the GNU Coding Standards (see *The GNU Coding Standards*).
- `obsolete` Obsolete features or constructions.
- `override` Redefinitions of Automake rules or variables.
- `portability`
Portability issues (e.g., use of `make` features that are known to be not portable).
- `portability-recursive`
Recursive, or nested, Make variable expansions (`$(foo$(x))`). These are not universally supported, but are more portable than the other non-portable constructs diagnosed by `-Wportability`. These warnings are turned on by `-Wportability` but can then be turned off specifically by `-Wno-portability-recursive`.
- `extra-portability`
Extra portability issues, related to rarely-used tools such as the Microsoft `lib` archiver.
- `syntax` Questionable syntax, unused variables, typos, etc.
- `unsupported`
Unsupported or incomplete features.
- `all` Turn on all the above categories of warnings.

none Turn off all the above categories of warnings.
error Treat warnings as errors.

A category can be turned off by prefixing its name with ‘no-’. For instance, `-Wno-syntax` will hide the warnings about unused variables.

Warnings in the ‘gnu’, ‘obsolete’, ‘portability’, ‘syntax’, and ‘unsupported’ categories are turned on by default. The ‘gnu’ and ‘portability’ categories are turned off in `--foreign` strictness.

Turning off ‘portability’ will also turn off ‘extra-portability’, and similarly turning on ‘extra-portability’ will also turn on ‘portability’. However, turning on ‘portability’ or turning off ‘extra-portability’ will not affect the other category.

Unknown warning categories supplied as an argument to `-W` will themselves produce a warning, in the ‘unsupported’ category. This warning is never treated as an error.

The environment variable `WARNINGS` can contain a comma separated list of categories to enable. `-W` settings on the command line take precedence; for instance, `-Wnone` also turns off any warning categories enabled by `WARNINGS`.

Unknown warning categories named in `WARNINGS` are silently ignored.

If the environment variable `AUTOMAKE_JOBS` contains a positive number, it is taken as the maximum number of Perl threads to use in `automake` for generating multiple `Makefile.in` files concurrently. This is an experimental feature.

6 Scanning `configure.ac`, using `aclocal`

Automake scans the package’s `configure.ac` to determine certain information about the package. Some `autoconf` macros are required and some variables must be defined in `configure.ac`. Automake will also use information from `configure.ac` to further tailor its output.

Automake also supplies some Autoconf macros to make the maintenance easier. These macros can automatically be put into your `aclocal.m4` using the `aclocal` program.

6.1 Configuration requirements

The one real requirement of Automake is that your `configure.ac` call `AM_INIT_AUTOMAKE`. This macro does several things that are required for proper Automake operation (see Section 6.4 [Macros], page 45).

Here are the other macros that Automake requires but which are not run by `AM_INIT_AUTOMAKE`:

`AC_CONFIG_FILES`
`AC_OUTPUT`

These two macros are usually invoked as follows near the end of `configure.ac`.

```
...
AC_CONFIG_FILES([
```

```

    Makefile
    doc/Makefile
    src/Makefile
    src/lib/Makefile
    ...
  ])
  AC_OUTPUT

```

Automake uses these to determine which files to create (see Section “Creating Output Files” in *The Autoconf Manual*). A listed file is considered to be an Automake generated `Makefile` if there exists a file with the same name and the `.am` extension appended. Typically, `AC_CONFIG_FILES([foo/Makefile])` will cause Automake to generate `foo/Makefile.in` if `foo/Makefile.am` exists.

When using `AC_CONFIG_FILES` with multiple input files, as in

```
AC_CONFIG_FILES([Makefile:top.in:Makefile.in:bot.in])
```

`automake` will generate the first `.in` input file for which a `.am` file exists. If no such file exists the output file is not considered to be generated by Automake.

Files created by `AC_CONFIG_FILES`, be they Automake `Makefiles` or not, are all removed by `make distclean`. Their inputs are automatically distributed, unless they are the output of prior `AC_CONFIG_FILES` commands. Finally, rebuild rules are generated in the Automake `Makefile` existing in the subdirectory of the output file, if there is one, or in the top-level `Makefile` otherwise.

The above machinery (cleaning, distributing, and rebuilding) works fine if the `AC_CONFIG_FILES` specifications contain only literals. If part of the specification uses shell variables, `automake` will not be able to fulfill this setup, and you will have to complete the missing bits by hand. For instance, on

```

file=input
...
AC_CONFIG_FILES([output:$file],, [file=$file])

```

`automake` will output rules to clean `output`, and rebuild it. However the rebuild rule will not depend on `input`, and this file will not be distributed either. (You must add `EXTRA_DIST = input` to your `Makefile.am` if `input` is a source file.)

Similarly

```

file=output
file2=out:in
...
AC_CONFIG_FILES([$file:input],, [file=$file])
AC_CONFIG_FILES([$file2],, [file2=$file2])

```

will only cause `input` to be distributed. No file will be cleaned automatically (add `DISTCLEANFILES = output out` yourself), and no rebuild rule will be output.

Obviously `automake` cannot guess what value `$file` is going to hold later when `configure` is run, and it cannot use the shell variable `$file` in a `Makefile`. However, if you make reference to `$file` as ``${file}`’ (i.e., in a way that is compatible with `make`’s syntax) and furthermore use `AC_SUBST` to ensure

that ‘`{file}`’ is meaningful in a Makefile, then `automake` will be able to use ‘`{file}`’ to generate all of these rules. For instance, here is how the Automake package itself generates versioned scripts for its test suite:

```
AC_SUBST([APIVERSION], ...)
...
AC_CONFIG_FILES(
  [tests/aclocal- $\{APIVERSION\}$ :tests/aclocal.in],
  [chmod +x tests/aclocal- $\{APIVERSION\}$ ],
  [APIVERSION= $\{APIVERSION\}$ ])
AC_CONFIG_FILES(
  [tests/automake- $\{APIVERSION\}$ :tests/automake.in],
  [chmod +x tests/automake- $\{APIVERSION\}$ ])
```

Here cleaning, distributing, and rebuilding are done automatically, because ‘`{APIVERSION}`’ is known at make-time.

Note that you should not use shell variables to declare Makefile files for which `automake` must create `Makefile.in`. Even `AC_SUBST` does not help here, because `automake` needs to know the file name when it runs in order to check whether `Makefile.am` exists. (In the very hairy case that your setup requires such use of variables, you will have to tell Automake which `Makefile.ins` to generate on the command-line.)

It is possible to let `automake` emit conditional rules for `AC_CONFIG_FILES` with the help of `AM_COND_IF` (see Section 6.2 [Optional], page 32).

To summarize:

- Use literals for Makefiles, and for other files whenever possible.
- Use ‘`file`’ (or ‘`{file}`’ without ‘`AC_SUBST([file])`’) for files that `automake` should ignore.
- Use ‘`{file}`’ and ‘`AC_SUBST([file])`’ for files that `automake` should not ignore.

6.2 Other things Automake recognizes

Every time Automake is run it calls Autoconf to trace `configure.ac`. This way it can recognize the use of certain macros and tailor the generated `Makefile.in` appropriately. Currently recognized macros and their effects are:

`AC_CANONICAL_BUILD`
`AC_CANONICAL_HOST`
`AC_CANONICAL_TARGET`

Automake will ensure that `config.guess` and `config.sub` exist. Also, the Makefile variables `build_triplet`, `host_triplet` and `target_triplet` are introduced. See Section “Getting the Canonical System Type” in *The Autoconf Manual*.

`AC_CONFIG_AUX_DIR`

Automake will look for various helper scripts, such as `install-sh`, in the directory named in this macro invocation. (The full list of scripts is: `ar-lib`, `config.guess`, `config.sub`, `depcomp`, `compile`, `install-sh`,

`ltmain.sh`, `mdate-sh`, `missing`, `mkinstalldirs`, `py-compile`, `test-driver`, `texinfo.tex`, `ylwrap`.) Not all scripts are always searched for; some scripts will only be sought if the generated `Makefile.in` requires them.

If `AC_CONFIG_AUX_DIR` is not given, the scripts are looked for in their standard locations. For `mdate-sh`, `texinfo.tex`, and `ylwrap`, the standard location is the source directory corresponding to the current `Makefile.am`. For the rest, the standard location is the first one of `.`, `..`, or `../..` (relative to the top source directory) that provides any one of the helper scripts. See Section “Finding ‘configure’ Input” in *The Autoconf Manual*.

Required files from `AC_CONFIG_AUX_DIR` are automatically distributed, even if there is no `Makefile.am` in this directory.

`AC_CONFIG_LIBOBJ_DIR`

Automake will require the sources file declared with `AC_LIBSOURCE` (see below) in the directory specified by this macro.

`AC_CONFIG_HEADERS`

Automake will generate rules to rebuild these headers from the corresponding templates (usually, the template for a `foo.h` header being `foo.h.in`). Older versions of Automake required the use of `AM_CONFIG_HEADER`; this is no longer the case, and that macro has indeed been removed.

As with `AC_CONFIG_FILES` (see Section 6.1 [Requirements], page 30), parts of the specification using shell variables will be ignored as far as cleaning, distributing, and rebuilding is concerned.

`AC_CONFIG_LINKS`

Automake will generate rules to remove `configure` generated links on ‘`make distclean`’ and to distribute named source files as part of ‘`make dist`’.

As for `AC_CONFIG_FILES` (see Section 6.1 [Requirements], page 30), parts of the specification using shell variables will be ignored as far as cleaning and distributing is concerned. (There are no rebuild rules for links.)

`AC_LIBOBJ`

`AC_LIBSOURCE`

`AC_LIBSOURCES`

Automake will automatically distribute any file listed in `AC_LIBSOURCE` or `AC_LIBSOURCES`.

Note that the `AC_LIBOBJ` macro calls `AC_LIBSOURCE`. So if an Autoconf macro is documented to call ‘`AC_LIBOBJ([file])`’, then `file.c` will be distributed automatically by Automake. This encompasses many macros like `AC_FUNC_ALLOCA`, `AC_FUNC_MEMCMP`, `AC_REPLACE_FUNCS`, and others.

By the way, direct assignments to `LIBOBJ`s are no longer supported. You should always use `AC_LIBOBJ` for this purpose. See Section “`AC_LIBOBJ` vs. `LIBOBJ`” in *The Autoconf Manual*.

`AC_PROG_RANLIB`

This is required if any libraries are built in the package. See Section “Particular Program Checks” in *The Autoconf Manual*.

AC_PROG_CXX

This is required if any C++ source is included. See Section “Particular Program Checks” in *The Autoconf Manual*.

AC_PROG_OBJC

This is required if any Objective C source is included. See Section “Particular Program Checks” in *The Autoconf Manual*.

AC_PROG_OBJCXX

This is required if any Objective C++ source is included. See Section “Particular Program Checks” in *The Autoconf Manual*.

AC_PROG_F77

This is required if any Fortran 77 source is included. See Section “Particular Program Checks” in *The Autoconf Manual*.

AC_F77_LIBRARY_LDFLAGS

This is required for programs and shared libraries that are a mixture of languages that include Fortran 77 (see Section 8.14.3 [Mixing Fortran 77 With C and C++], page 78). See Section 6.4 [Autoconf macros supplied with Automake], page 45.

AC_FC_SRCEXT

Automake will add the flags computed by `AC_FC_SRCEXT` to compilation of files with the respective source extension (see Section “Fortran Compiler Characteristics” in *The Autoconf Manual*).

AC_PROG_FC

This is required if any Fortran 90/95 source is included. This macro is distributed with Autoconf version 2.58 and later. See Section “Particular Program Checks” in *The Autoconf Manual*.

AC_PROG_LIBTOOL

Automake will turn on processing for `libtool` (see Section “Introduction” in *The Libtool Manual*).

AC_PROG_YACC

If a Yacc source file is seen, then you must either use this macro or define the variable `YACC` in `configure.ac`. The former is preferred (see Section “Particular Program Checks” in *The Autoconf Manual*).

AC_PROG_LEX

If a Lex source file is seen, then this macro must be used. See Section “Particular Program Checks” in *The Autoconf Manual*.

AC_REQUIRE_AUX_FILE

For each `AC_REQUIRE_AUX_FILE([file])`, `automake` will ensure that `file` exists in the `aux` directory, and will complain otherwise. It will also automatically distribute the file. This macro should be used by third-party Autoconf macros that require some supporting files in the `aux` directory specified with `AC_CONFIG_AUX_DIR` above. See Section “Finding `configure` Input” in *The Autoconf Manual*.

AC_SUBST The first argument is automatically defined as a variable in each generated `Makefile.in`, unless `AM_SUBST_NOTMAKE` is also used for this variable. See Section “Setting Output Variables” in *The Autoconf Manual*.

For every substituted variable `var`, `automake` will add a line `var = value` to each `Makefile.in` file. Many Autoconf macros invoke `AC_SUBST` to set output variables this way, e.g., `AC_PATH_XTRA` defines `X_CFLAGS` and `X_LIBS`. Thus, you can access these variables as `$(X_CFLAGS)` and `$(X_LIBS)` in any `Makefile.am` if `AC_PATH_XTRA` is called.

AM_CONDITIONAL

This introduces an Automake conditional (see Chapter 20 [Conditionals], page 126).

AM_COND_IF

This macro allows `automake` to detect subsequent access within `configure.ac` to a conditional previously introduced with `AM_CONDITIONAL`, thus enabling conditional `AC_CONFIG_FILES` (see Section 20.1 [Usage of Conditionals], page 127).

AM_GNU_GETTEXT

This macro is required for packages that use GNU `gettext` (see Section 10.2 [gettext], page 89). It is distributed with `gettext`. If Automake sees this macro it ensures that the package meets some of `gettext`’s requirements.

AM_GNU_GETTEXT_INTL_SUBDIR

This macro specifies that the `intl/` subdirectory is to be built, even if the `AM_GNU_GETTEXT` macro was invoked with a first argument of ‘`external`’.

AM_MAINTAINER_MODE([*default-mode*])

This macro adds an `--enable-maintainer-mode` option to `configure`. If this is used, `automake` will cause “maintainer-only” rules to be turned off by default in the generated `Makefile.ins`, unless *default-mode* is ‘`enable`’. This macro defines the `MAINTAINER_MODE` conditional, which you can use in your own `Makefile.am`. See Section 26.2 [maintainer-mode], page 141.

AM_SUBST_NOTMAKE(*var*)

Prevent Automake from defining a variable `var`, even if it is substituted by `config.status`. Normally, Automake defines a `make` variable for each `configure` substitution, i.e., for each `AC_SUBST([var])`. This macro prevents that definition from Automake. If `AC_SUBST` has not been called for this variable, then `AM_SUBST_NOTMAKE` has no effects. Preventing variable definitions may be useful for substitution of multi-line values, where `var = @value@` might yield unintended results.

m4_include

Files included by `configure.ac` using this macro will be detected by Automake and automatically distributed. They will also appear as dependencies in `Makefile` rules.

`m4_include` is seldom used by `configure.ac` authors, but can appear in `aclocal.m4` when `aclocal` detects that some required macros come from files local to your package (as opposed to macros installed in a system-wide directory; see Section 6.3 [aclocal Invocation], page 36).

6.3 Auto-generating `aclocal.m4`

Automake includes a number of Autoconf macros that can be used in your package (see Section 6.4 [Macros], page 45); some of them are actually required by Automake in certain situations. These macros must be defined in your `aclocal.m4`; otherwise they will not be seen by `autoconf`.

The `aclocal` program will automatically generate `aclocal.m4` files based on the contents of `configure.ac`. This provides a convenient way to get Automake-provided macros, without having to search around. The `aclocal` mechanism allows other packages to supply their own macros (see Section 6.3.3 [Extending `aclocal`], page 40). You can also use it to maintain your own set of custom macros (see Section 6.3.4 [Local Macros], page 41).

At startup, `aclocal` scans all the `.m4` files it can find, looking for macro definitions (see Section 6.3.2 [Macro Search Path], page 38). Then it scans `configure.ac`. Any mention of one of the macros found in the first step causes that macro, and any macros it in turn requires, to be put into `aclocal.m4`.

Putting the file that contains the macro definition into `aclocal.m4` is usually done by copying the entire text of this file, including unused macro definitions as well as both `#` and `\n` comments. If you want to make a comment that will be completely ignored by `aclocal`, use `##` as the comment leader.

When a file selected by `aclocal` is located in a subdirectory specified as a relative search path with `aclocal`'s `-I` argument, `aclocal` assumes the file belongs to the package and uses `m4_include` instead of copying it into `aclocal.m4`. This makes the package smaller, eases dependency tracking, and cause the file to be distributed automatically. (See Section 6.3.4 [Local Macros], page 41, for an example.) Any macro that is found in a system-wide directory or via an absolute search path will be copied. So use `-I 'pwd'/reldir` instead of `-I reldir` whenever some relative directory should be considered outside the package.

The contents of `acinclude.m4`, if this file exists, are also automatically included in `aclocal.m4`. We recommend against using `acinclude.m4` in new packages (see Section 6.3.4 [Local Macros], page 41).

While computing `aclocal.m4`, `aclocal` runs `autom4te` (see Section “Using `Autom4te`” in *The Autoconf Manual*) in order to trace the macros that are really used, and omit from `aclocal.m4` all macros that are mentioned but otherwise unexpanded (this can happen when a macro is called conditionally). `autom4te` is expected to be in the `PATH`, just as `autoconf`. Its location can be overridden using the `AUTOM4TE` environment variable.

6.3.1 `aclocal` Options

`aclocal` accepts the following options:

`--automake-acdir=dir`

Look for the automake-provided macro files in `dir` instead of in the installation directory. This is typically used for debugging.

The environment variable `ACLOCAL_AUTOMAKE_DIR` provides another way to set the directory containing automake-provided macro files. However `--automake-acdir` takes precedence over it.

- `--system-acdir=dir`
Look for the system-wide third-party macro files (and the special `dirlist` file) in `dir` instead of in the installation directory. This is typically used for debugging.
- `--diff[=command]`
Run `command` on the M4 file that would be installed or overwritten by `--install`. The default `command` is `'diff -u'`. This option implies `--install` and `--dry-run`.
- `--dry-run`
Do not actually overwrite (or create) `aclocal.m4` and M4 files installed by `--install`.
- `--help`
Print a summary of the command line options and exit.
- `-I dir`
Add the directory `dir` to the list of directories searched for `.m4` files.
- `--install`
Install system-wide third-party macros into the first directory specified with `'-I dir'` instead of copying them in the output file. Note that this will happen also if `dir` is an absolute path.

When this option is used, and only when this option is used, `aclocal` will also honor `'#serial number'` lines that appear in macros: an M4 file is ignored if there exists another M4 file with the same basename and a greater serial number in the search path (see Section 6.3.5 [Serials], page 42).
- `--force`
Always overwrite the output file. The default is to overwrite the output file only when really needed, i.e., when its contents change or if one of its dependencies is younger.

This option forces the update of `aclocal.m4` (or the file specified with `--output` below) and only this file, it has absolutely no influence on files that may need to be installed by `--install`.
- `--output=file`
Cause the output to be put into `file` instead of `aclocal.m4`.
- `--print-ac-dir`
Prints the name of the directory that `aclocal` will search to find third-party `.m4` files. When this option is given, normal processing is suppressed. This option was used *in the past* by third-party packages to determine where to install `.m4` macro files, but *this usage is today discouraged*, since it causes `'$(prefix)'` not to be thoroughly honored (which violates the GNU Coding Standards), and similar semantics can be better obtained with the `ACLOCAL_PATH` environment variable; see Section 6.3.3 [Extending `aclocal`], page 40.
- `--verbose`
Print the names of the files it examines.
- `--version`
Print the version number of Automake and exit.

-W CATEGORY

--warnings=category

Output warnings falling in *category*. *category* can be one of:

syntax dubious syntactic constructs, underquoted macros, unused macros, etc.

unsupported
 unknown macros

all all the warnings, this is the default

none turn off all the warnings

error treat warnings as errors

All warnings are output by default.

The environment variable `WARNINGS` is honored in the same way as it is for `automake` (see Chapter 5 [automake Invocation], page 27).

6.3.2 Macro Search Path

By default, `aclocal` searches for `.m4` files in the following directories, in this order:

acdir-APIVERSION

This is where the `.m4` macros distributed with Automake itself are stored. *APIVERSION* depends on the Automake release used; for example, for Automake 1.11.x, *APIVERSION* = 1.11.

acdir This directory is intended for third party `.m4` files, and is configured when `automake` itself is built. This is `@datadir@/aclocal/`, which typically expands to `/${prefix}/share/aclocal/`. To find the compiled-in value of *acdir*, use the `--print-ac-dir` option (see Section 6.3.1 [aclocal Options], page 36).

As an example, suppose that `automake-1.11.2` was configured with `--prefix=/usr/local`. Then, the search path would be:

1. `/usr/local/share/aclocal-1.11.2/`
2. `/usr/local/share/aclocal/`

The paths for the *acdir* and *acdir-APIVERSION* directories can be changed respectively through `aclocal` options `--system-acdir` and `--automake-acdir` (see Section 6.3.1 [aclocal Options], page 36). Note however that these options are only intended for use by the internal Automake test suite, or for debugging under highly unusual situations; they are not ordinarily needed by end-users.

As explained in (see Section 6.3.1 [aclocal Options], page 36), there are several options that can be used to change or extend this search path.

Modifying the Macro Search Path: ‘`-I dir`’

Any extra directories specified using `-I` options (see Section 6.3.1 [aclocal Options], page 36) are *prepended* to this search list. Thus, ‘`aclocal -I /foo -I /bar`’ results in the following search path:

1. `/foo`

2. `/bar`
3. `acdir-APIVERSION`
4. `acdir`

Modifying the Macro Search Path: `dirlist`

There is a third mechanism for customizing the search path. If a `dirlist` file exists in `acdir`, then that file is assumed to contain a list of directory patterns, one per line. `aclocal` expands these patterns to directory names, and adds them to the search list *after* all other directories. `dirlist` entries may use shell wildcards such as `*`, `?`, or `[...]`.

For example, suppose `acdir/dirlist` contains the following:

```
/test1
/test2
/test3*
```

and that `aclocal` was called with the `-I /foo -I /bar` options. Then, the search path would be

1. `/foo`
2. `/bar`
3. `acdir-APIVERSION`
4. `acdir`
5. `/test1`
6. `/test2`

and all directories with path names starting with `/test3`.

If the `--system-acdir=dir` option is used, then `aclocal` will search for the `dirlist` file in `dir`; but remember the warnings above against the use of `--system-acdir`.

`dirlist` is useful in the following situation: suppose that `automake` version 1.11.2 is installed with `--prefix=/usr` by the system vendor. Thus, the default search directories are

1. `/usr/share/aclocal-1.11/`
2. `/usr/share/aclocal/`

However, suppose further that many packages have been manually installed on the system, with `$prefix=/usr/local`, as is typical. In that case, many of these “extra” `.m4` files are in `/usr/local/share/aclocal`. The only way to force `/usr/bin/aclocal` to find these “extra” `.m4` files is to always call `aclocal -I /usr/local/share/aclocal`. This is inconvenient. With `dirlist`, one may create a file `/usr/share/aclocal/dirlist` containing only the single line

```
/usr/local/share/aclocal
```

Now, the “default” search path on the affected system is

1. `/usr/share/aclocal-1.11/`
2. `/usr/share/aclocal/`
3. `/usr/local/share/aclocal/`

without the need for `-I` options; `-I` options can be reserved for project-specific needs (`my-source-dir/m4/`), rather than using them to work around local system-dependent tool installation directories.

Similarly, `dirlist` can be handy if you have installed a local copy of Automake in your account and want `aclocal` to look for macros installed at other places on the system.

Modifying the Macro Search Path: `ACLOCAL_PATH`

The fourth and last mechanism to customize the macro search path is also the simplest. Any directory included in the colon-separated environment variable `ACLOCAL_PATH` is added to the search path and takes precedence over system directories (including those found via `dirlist`), with the exception of the versioned directory `acdir-APIVERSION` (see Section 6.3.2 [Macro Search Path], page 38). However, directories passed via `-I` will take precedence over directories in `ACLOCAL_PATH`.

Also note that, if the `--install` option is used, any `.m4` file containing a required macro that is found in a directory listed in `ACLOCAL_PATH` will be installed locally. In this case, serial numbers in `.m4` are honored too, see Section 6.3.5 [Serials], page 42.

Conversely to `dirlist`, `ACLOCAL_PATH` is useful if you are using a global copy of Automake and want `aclocal` to look for macros somewhere under your home directory.

Planned future incompatibilities

The order in which the directories in the macro search path are currently looked up is confusing and/or suboptimal in various aspects, and is probably going to be changed in the future Automake release. In particular, directories in `ACLOCAL_PATH` and `acdir` might end up taking precedence over `acdir-APIVERSION`, and directories in `acdir/dirlist` might end up taking precedence over `acdir`. *This is a possible future incompatibility!*

6.3.3 Writing your own `aclocal` macros

The `aclocal` program doesn't have any built-in knowledge of any macros, so it is easy to extend it with your own macros.

This can be used by libraries that want to supply their own Autoconf macros for use by other programs. For instance, the `gettext` library supplies a macro `AM_GNU_GETTEXT` that should be used by any package using `gettext`. When the library is installed, it installs this macro so that `aclocal` will find it.

A macro file's name should end in `.m4`. Such files should be installed in `$(datadir)/aclocal`. This is as simple as writing:

```
aclocaldir = $(datadir)/aclocal
aclocal_DATA = mymacro.m4 myothermacro.m4
```

Please do use `$(datadir)/aclocal`, and not something based on the result of `'aclocal --print-ac-dir'` (see Section 26.10 [Hard-Coded Install Paths], page 155, for arguments). It might also be helpful to suggest to the user to add the `$(datadir)/aclocal` directory to his `ACLOCAL_PATH` variable (see [ACLOCAL_PATH], page 40) so that `aclocal` will find the `.m4` files installed by your package automatically.

A file of macros should be a series of properly quoted `AC_DEFUN`'s (see Section "Macro Definitions" in *The Autoconf Manual*). The `aclocal` programs also understands `AC_REQUIRE` (see Section "Prerequisite Macros" in *The Autoconf Manual*), so it is safe to put each macro

in a separate file. Each file should have no side effects but macro definitions. Especially, any call to `AC_PREREQ` should be done inside the defined macro, not at the beginning of the file.

Starting with Automake 1.8, `aclocal` will warn about all underquoted calls to `AC_DEFUN`. We realize this will annoy a lot of people, because `aclocal` was not so strict in the past and many third party macros are underquoted; and we have to apologize for this temporary inconvenience. The reason we have to be stricter is that a future implementation of `aclocal` (see Section 6.3.6 [Future of `aclocal`], page 44) will have to temporarily include all of these third party `.m4` files, maybe several times, including even files that are not actually needed. Doing so should alleviate many problems of the current implementation; however it requires a stricter style from the macro authors. Hopefully it is easy to revise the existing macros. For instance,

```
# bad style
AC_PREREQ(2.68)
AC_DEFUN(AX_FOOBAR,
[AC_REQUIRE([AX_SOMETHING])dn1
AX_FOO
AX_BAR
])
```

should be rewritten as

```
AC_DEFUN([AX_FOOBAR],
[AC_PREREQ([2.68])dn1
AC_REQUIRE([AX_SOMETHING])dn1
AX_FOO
AX_BAR
])
```

Wrapping the `AC_PREREQ` call inside the macro ensures that Autoconf 2.68 will not be required if `AX_FOOBAR` is not actually used. Most importantly, quoting the first argument of `AC_DEFUN` allows the macro to be redefined or included twice (otherwise this first argument would be expanded during the second definition). For consistency we like to quote even arguments such as `2.68` that do not require it.

If you have been directed here by the `aclocal` diagnostic but are not the maintainer of the implicated macro, you will want to contact the maintainer of that macro. Please make sure you have the latest version of the macro and that the problem hasn't already been reported before doing so: people tend to work faster when they aren't flooded by mails.

Another situation where `aclocal` is commonly used is to manage macros that are used locally by the package; Section 6.3.4 [Local Macros], page 41.

6.3.4 Handling Local Macros

Feature tests offered by Autoconf do not cover all needs. People often have to supplement existing tests with their own macros, or with third-party macros.

There are two ways to organize custom macros in a package.

The first possibility (the historical practice) is to list all your macros in `acinclude.m4`. This file will be included in `aclocal.m4` when you run `aclocal`, and its macro(s) will henceforth be visible to `autoconf`. However if it contains numerous macros, it will rapidly

become difficult to maintain, and it will be almost impossible to share macros between packages.

The second possibility, which we do recommend, is to write each macro in its own file and gather all these files in a directory. This directory is usually called `m4/`. Then it's enough to update `configure.ac` by adding a proper call to `AC_CONFIG_MACRO_DIRS`:

```
AC_CONFIG_MACRO_DIRS([m4])
```

`aclocal` will then take care of automatically adding `m4/` to its search path for `m4` files.

When '`aclocal`' is run, it will build an `aclocal.m4` that `m4_includes` any file from `m4/` that defines a required macro. Macros not found locally will still be searched in system-wide directories, as explained in Section 6.3.2 [Macro Search Path], page 38.

Custom macros should be distributed for the same reason that `configure.ac` is: so that other people have all the sources of your package if they want to work on it. Actually, this distribution happens automatically because all `m4_included` files are distributed.

However there is no consensus on the distribution of third-party macros that your package may use. Many libraries install their own macro in the system-wide `aclocal` directory (see Section 6.3.3 [Extending `aclocal`], page 40). For instance, Guile ships with a file called `guile.m4` that contains the macro `GUILE_FLAGS` that can be used to define setup compiler and linker flags appropriate for using Guile. Using `GUILE_FLAGS` in `configure.ac` will cause `aclocal` to copy `guile.m4` into `aclocal.m4`, but as `guile.m4` is not part of the project, it will not be distributed. Technically, that means a user who needs to rebuild `aclocal.m4` will have to install Guile first. This is probably OK, if Guile already is a requirement to build the package. However, if Guile is only an optional feature, or if your package might run on architectures where Guile cannot be installed, this requirement will hinder development. An easy solution is to copy such third-party macros in your local `m4/` directory so they get distributed.

Since Automake 1.10, `aclocal` offers the option `--install` to copy these system-wide third-party macros in your local macro directory, helping to solve the above problem.

With this setup, system-wide macros will be copied to `m4/` the first time you run `aclocal`. Then the locally installed macros will have precedence over the system-wide installed macros each time `aclocal` is run again.

One reason why you should keep `--install` in the flags even after the first run is that when you later edit `configure.ac` and depend on a new macro, this macro will be installed in your `m4/` automatically. Another one is that serial numbers (see Section 6.3.5 [Serials], page 42) can be used to update the macros in your source tree automatically when new system-wide versions are installed. A serial number should be a single line of the form

```
#serial nnn
```

where *nnn* contains only digits and dots. It should appear in the M4 file before any macro definition. It is a good practice to maintain a serial number for each macro you distribute, even if you do not use the `--install` option of `aclocal`: this allows other people to use it.

6.3.5 Serial Numbers

Because third-party macros defined in `*.m4` files are naturally shared between multiple projects, some people like to version them. This makes it easier to tell which of two M4 files is newer. Since at least 1996, the tradition is to use a '`#serial`' line for this.

A serial number should be a single line of the form

```
# serial version
```

where *version* is a version number containing only digits and dots. Usually people use a single integer, and they increment it each time they change the macro (hence the name of “serial”). Such a line should appear in the M4 file before any macro definition.

The ‘#’ must be the first character on the line, and it is OK to have extra words after the version, as in

```
#serial version garbage
```

Normally these serial numbers are completely ignored by `aclocal` and `autoconf`, like any genuine comment. However when using `aclocal`’s `--install` feature, these serial numbers will modify the way `aclocal` selects the macros to install in the package: if two files with the same basename exist in your search path, and if at least one of them uses a ‘#serial’ line, `aclocal` will ignore the file that has the older ‘#serial’ line (or the file that has none).

Note that a serial number applies to a whole M4 file, not to any macro it contains. A file can contain multiple macros, but only one serial.

Here is a use case that illustrates the use of `--install` and its interaction with serial numbers. Let’s assume we maintain a package called `MyPackage`, the `configure.ac` of which requires a third-party macro `AX_THIRD_PARTY` defined in `/usr/share/aclocal/thirdparty.m4` as follows:

```
# serial 1
AC_DEFUN([AX_THIRD_PARTY], [...])
```

`MyPackage` uses an `m4/` directory to store local macros as explained in Section 6.3.4 [Local Macros], page 41, and has

```
AC_CONFIG_MACRO_DIRS([m4])
```

in its `configure.ac`.

Initially the `m4/` directory is empty. The first time we run `aclocal --install`, it will notice that

- `configure.ac` uses `AX_THIRD_PARTY`
- No local macros define `AX_THIRD_PARTY`
- `/usr/share/aclocal/thirdparty.m4` defines `AX_THIRD_PARTY` with serial number 1.

Because `/usr/share/aclocal/thirdparty.m4` is a system-wide macro and `aclocal` was given the `--install` option, it will copy this file in `m4/thirdparty.m4`, and output an `aclocal.m4` that contains ‘`m4_include([m4/thirdparty.m4])`’.

The next time ‘`aclocal --install`’ is run, something different happens. `aclocal` notices that

- `configure.ac` uses `AX_THIRD_PARTY`
- `m4/thirdparty.m4` defines `AX_THIRD_PARTY` with serial number 1.
- `/usr/share/aclocal/thirdparty.m4` defines `AX_THIRD_PARTY` with serial number 1.

Because both files have the same serial number, `aclocal` uses the first it found in its search path order (see Section 6.3.2 [Macro Search Path], page 38). `aclocal` therefore ignores `/usr/share/aclocal/thirdparty.m4` and outputs an `aclocal.m4` that contains ‘`m4_include([m4/thirdparty.m4])`’.

Local directories specified with `-I` are always searched before system-wide directories, so a local file will always be preferred to the system-wide file in case of equal serial numbers.

Now suppose the system-wide third-party macro is changed. This can happen if the package installing this macro is updated. Let's suppose the new macro has serial number 2. The next time `'aclocal --install'` is run the situation is the following:

- `configure.ac` uses `AX_THIRD_PARTY`
- `m4/thirdparty.m4` defines `AX_THIRD_PARTY` with serial number 1.
- `/usr/share/aclocal/thirdparty.m4` defines `AX_THIRD_PARTY` with serial 2.

When `aclocal` sees a greater serial number, it immediately forgets anything it knows from files that have the same basename and a smaller serial number. So after it has found `/usr/share/aclocal/thirdparty.m4` with serial 2, `aclocal` will proceed as if it had never seen `m4/thirdparty.m4`. This brings us back to a situation similar to that at the beginning of our example, where no local file defined the macro. `aclocal` will install the new version of the macro in `m4/thirdparty.m4`, in this case overriding the old version. `MyPackage` just had its macro updated as a side effect of running `aclocal`.

If you are leery of letting `aclocal` update your local macro, you can run `'aclocal --diff'` to review the changes `'aclocal --install'` would perform on these macros.

Finally, note that the `--force` option of `aclocal` has absolutely no effect on the files installed by `--install`. For instance, if you have modified your local macros, do not expect `--install --force` to replace the local macros by their system-wide versions. If you want to do so, simply erase the local macros you want to revert, and run `'aclocal --install'`.

6.3.6 The Future of `aclocal`

`aclocal` is expected to disappear. This feature really should not be offered by Automake. Automake should focus on generating `Makefiles`; dealing with M4 macros really is `Autoconf`'s job. The fact that some people install Automake just to use `aclocal`, but do not use `automake` otherwise is an indication of how that feature is misplaced.

The new implementation will probably be done slightly differently. For instance, it could enforce the `m4/-`-style layout discussed in Section 6.3.4 [Local Macros], page 41.

We have no idea when and how this will happen. This has been discussed several times in the past, but someone still has to commit to that non-trivial task.

From the user point of view, `aclocal`'s removal might turn out to be painful. There is a simple precaution that you may take to make that switch more seamless: never call `aclocal` yourself. Keep this guy under the exclusive control of `autoreconf` and Automake's rebuild rules. Hopefully you won't need to worry about things breaking; when `aclocal` disappears, because everything will have been taken care of. If otherwise you used to call `aclocal` directly yourself or from some script, you will quickly notice the change.

Many packages come with a script called `bootstrap` or `autogen.sh`, that will just call `aclocal`, `libtoolize`, `gettextize` or `autopoint`, `autoconf`, `autoheader`, and `automake` in the right order. Actually this is precisely what `autoreconf` can do for you. If your package has such a `bootstrap` or `autogen.sh` script, consider using `autoreconf`. That should simplify its logic a lot (less things to maintain, yum!), it's even likely you will not need the script anymore, and more to the point you will not call `aclocal` directly anymore.

For the time being, third-party packages should continue to install public macros into `/usr/share/aclocal/`. If `aclocal` is replaced by another tool it might make sense to rename the directory, but supporting `/usr/share/aclocal/` for backward compatibility should be really easy provided all macros are properly written (see Section 6.3.3 [Extending `aclocal`], page 40).

6.4 Autoconf macros supplied with Automake

Automake ships with several Autoconf macros that you can use from your `configure.ac`. When you use one of them it will be included by `aclocal` in `aclocal.m4`.

6.4.1 Public Macros

`AM_INIT_AUTOMAKE([OPTIONS])`

Runs many macros required for proper operation of the generated Makefiles.

Today, `AM_INIT_AUTOMAKE` is called with a single argument: a space-separated list of Automake options that should be applied to every `Makefile.am` in the tree. The effect is as if each option were listed in `AUTOMAKE_OPTIONS` (see Chapter 17 [Options], page 120).

This macro can also be called in another, *deprecated* form: `AM_INIT_AUTOMAKE(PACKAGE, VERSION, [NO-DEFINE])`. In this form, there are two required arguments: the package and the version number. This usage is mostly obsolete because the *package* and *version* can be obtained from Autoconf's `AC_INIT` macro. However, differently from what happens for `AC_INIT` invocations, this `AM_INIT_AUTOMAKE` invocation supports shell variables' expansions in the `PACKAGE` and `VERSION` arguments (which otherwise defaults, respectively, to the `PACKAGE_TARNAME` and `PACKAGE_VERSION` defined via the `AC_INIT` invocation; see Section “The `AC_INIT` macro” in *The Autoconf Manual*); and this can still be useful in some selected situations. Our hope is that future Autoconf versions will improve their support for package versions defined dynamically at configure runtime; when (and if) this happens, support for the two-args `AM_INIT_AUTOMAKE` invocation will likely be removed from Automake.

If your `configure.ac` has:

```
AC_INIT([src/foo.c])
AM_INIT_AUTOMAKE([mumble], [1.5])
```

you should modernize it as follows:

```
AC_INIT([mumble], [1.5])
AC_CONFIG_SRCDIR([src/foo.c])
AM_INIT_AUTOMAKE
```

Note that if you're upgrading your `configure.ac` from an earlier version of Automake, it is not always correct to simply move the package and version arguments from `AM_INIT_AUTOMAKE` directly to `AC_INIT`, as in the example above. The first argument to `AC_INIT` should be the name of your package (e.g., ‘GNU Automake’), not the tarball name (e.g., ‘`automake`’) that you used to pass to `AM_INIT_AUTOMAKE`. Autoconf tries to derive a tarball name from

the package name, which should work for most but not all package names. (If it doesn't work for yours, you can use the four-argument form of `AC_INIT` to provide the tarball name explicitly).

By default this macro `AC_DEFINE`'s `PACKAGE` and `VERSION`. This can be avoided by passing the `no-define` option (see Section 17.2 [List of Automake options], page 120):

```
AM_INIT_AUTOMAKE([no-define ...])
```

`AM_PATH_LISPDIR`

Searches for the program `emacs`, and, if found, sets the output variable `lispdir` to the full path to Emacs' site-lisp directory.

Note that this test assumes the `emacs` found to be a version that supports Emacs Lisp (such as GNU Emacs or XEmacs). Other emacsen can cause this test to hang (some, like old versions of MicroEmacs, start up in interactive mode, requiring `C-x C-c` to exit, which is hardly obvious for a non-emacs user). In most cases, however, you should be able to use `C-c` to kill the test. In order to avoid problems, you can set `EMACS` to "no" in the environment, or use the `--with-lispdir` option to `configure` to explicitly set the correct path (if you're sure you have an `emacs` that supports Emacs Lisp).

`AM_PROG_AR([act-if-fail])`

You must use this macro when you use the archiver in your project, if you want support for unusual archivers such as Microsoft `lib`. The content of the optional argument is executed if the archiver interface is not recognized; the default action is to abort `configure` with an error message.

`AM_PROG_AS`

Use this macro when you have assembly code in your project. This will choose the assembler for you (by default the C compiler) and set `CCAS`, and will also set `CCASFLAGS` if required.

`AM_PROG_CC_C_0`

This is an obsolescent macro that checks that the C compiler supports the `-c` and `-o` options together. Note that, since Automake 1.14, the `AC_PROG_CC` is rewritten to implement such checks itself, and thus the explicit use of `AM_PROG_CC_C_0` should no longer be required.

`AM_PROG_LEX`

Like `AC_PROG_LEX` (see Section "Particular Program Checks" in *The Autoconf Manual*), but uses the `missing` script on systems that do not have `lex`. HP-UX 10 is one such system.

`AM_PROG_GCJ`

This macro finds the `gcj` program or causes an error. It sets `GCJ` and `GCJFLAGS`. `gcj` is the Java front-end to the GNU Compiler Collection.

`AM_PROG_UPC([compiler-search-list])`

Find a compiler for Unified Parallel C and define the `UPC` variable. The default `compiler-search-list` is `'upcc upc'`. This macro will abort `configure` if no Unified Parallel C compiler is found.

AM_MISSING_PROG(*name*, *program*)

Find a maintainer tool *program* and define the *name* environment variable with its location. If *program* is not detected, then *name* will instead invoke the `missing` script, in order to give useful advice to the user about the missing maintainer tool. See Section 26.2 [maintainer-mode], page 141, for more information on when the `missing` script is appropriate.

AM_SILENT_RULES

Control the machinery for less verbose build output (see Section 21.3 [Automake Silent Rules], page 130).

AM_WITH_DMALLOC

Add support for the Dmalloc package (<https://dmalloc.com/>). If the user runs `configure` with `--with-dmalloc`, then define `WITH_DMALLOC` and add `-ldmalloc` to `LIBS`.

6.4.2 Obsolete Macros

Although using some of the following macros was required in past releases, you should not use any of them in new code. *All these macros will be removed in the next major Automake version*; if you are still using them, running `autoupdate` should adjust your `configure.ac` automatically (see Section “Using `autoupdate` to Modernize `configure.ac`” in *The Autoconf Manual*). *Do it NOW!*

AM_PROG_MKDIR_P

From Automake 1.8 to 1.9.6 this macro used to define the output variable `mkdir_p` to one of `mkdir -p`, `install-sh -d`, or `mkinstalldirs`.

Nowadays Autoconf provides a similar functionality with `AC_PROG_MKDIR_P` (see Section “Particular Program Checks” in *The Autoconf Manual*), however this defines the output variable `MKDIR_P` instead. In case you are still using the `AM_PROG_MKDIR_P` macro in your `configure.ac`, or its provided variable `$(mkdir_p)` in your `Makefile.am`, you are advised to switch ASAP to the more modern Autoconf-provided interface instead; both the macro and the variable might be removed in a future major Automake release.

6.4.3 Private Macros

The following macros are private macros you should not call directly. They are called by the other public macros when appropriate. Do not rely on them, as they might be changed in a future version. Consider them as implementation details; or better, do not consider them at all: skip this section!

_AM_DEPENDENCIES**AM_SET_DEPDIR****AM_DEP_TRACK****AM_OUTPUT_DEPENDENCY_COMMANDS**

These macros are used to implement Automake’s automatic dependency tracking scheme. They are called automatically by Automake when required, and there should be no need to invoke them manually.

AM_MAKE_INCLUDE

This macro is used to discover how the user's `make` handles `include` statements. This macro is automatically invoked when needed; there should be no need to invoke it manually.

AM_PROG_INSTALL_STRIP

This is used to find a version of `install` that can be used to strip a program at installation time. This macro is automatically included when required.

AM_SANITY_CHECK

This checks to make sure that a file created in the build directory is newer than a file in the source directory. This can fail on systems where the clock is set incorrectly. This macro is automatically run from `AM_INIT_AUTOMAKE`.

7 Directories

For simple projects that distribute all files in the same directory it is enough to have a single `Makefile.am` that builds everything in place.

In larger projects, it is common to organize files in different directories, in a tree. For example, there could be a directory for the program's source, one for the testsuite, and one for the documentation; or, for very large projects, there could be one directory per program, per library or per module.

The traditional approach is to build these subdirectories recursively, employing *make recursion*: each directory contains its own `Makefile`, and when `make` is run from the top-level directory, it enters each subdirectory in turn, and invokes there a new `make` instance to build the directory's contents.

Because this approach is very widespread, Automake offers built-in support for it. However, it is worth noting that the use of `make recursion` has its own serious issues and drawbacks, and that it's well possible to have packages with a multi directory layout that make little or no use of such recursion (examples of such packages are GNU Bison and GNU Automake itself); see also the Section 7.3 [Alternative], page 52, section below.

7.1 Recursing subdirectories

In packages using `make recursion`, the top level `Makefile.am` must tell Automake which subdirectories are to be built. This is done via the `SUBDIRS` variable.

The `SUBDIRS` variable holds a list of subdirectories in which building of various sorts can occur. The rules for many targets (e.g., `all`) in the generated `Makefile` will run commands both locally and in all specified subdirectories. Note that the directories listed in `SUBDIRS` are not required to contain `Makefile.am`s; only `Makefiles` (after configuration). This allows inclusion of libraries from packages that do not use Automake (such as `gettext`; see also Section 22.2 [Third-Party Makefiles], page 134).

In packages that use subdirectories, the top-level `Makefile.am` is often very short. For instance, here is the `Makefile.am` from the GNU Hello distribution:

```
EXTRA_DIST = BUGS ChangeLog.0 README-alpha
SUBDIRS = doc intl po src tests
```

When Automake invokes `make` in a subdirectory, it uses the value of the `MAKE` variable. It passes the value of the variable `AM_MAKEFLAGS` to the `make` invocation; this can be set in `Makefile.am` if there are flags you must always pass to `make`.

The directories mentioned in `SUBDIRS` are usually direct children of the current directory, each subdirectory containing its own `Makefile.am` with a `SUBDIRS` pointing to deeper subdirectories. Automake can be used to construct packages of arbitrary depth this way.

By default, Automake generates `Makefiles` that work depth-first in postfix order: the subdirectories are built before the current directory. However, it is possible to change this ordering. You can do this by putting `'.'` into `SUBDIRS`. For instance, putting `'.'` first will cause a prefix ordering of directories.

Using

```
SUBDIRS = lib src . test
```

will cause `lib/` to be built before `src/`, then the current directory will be built, finally the `test/` directory will be built. It is customary to arrange test directories to be built after everything else since they are meant to test what has been constructed.

In addition to the built-in recursive targets defined by Automake (`all`, `check`, etc.), the developer can also define his own recursive targets. That is done by passing the names of such targets as arguments to the m4 macro `AM_EXTRA_RECURSIVE_TARGETS` in `configure.ac`. Automake generates rules to handle the recursion for such targets; and the developer can define real actions for them by defining corresponding `-local` targets.

```
% cat configure.ac
AC_INIT([pkg-name], [1.0])
AM_INIT_AUTOMAKE
AM_EXTRA_RECURSIVE_TARGETS([foo])
AC_CONFIG_FILES([Makefile sub/Makefile sub/src/Makefile])
AC_OUTPUT
% cat Makefile.am
SUBDIRS = sub
foo-local:
    @echo This will be run by "make foo".
% cat sub/Makefile.am
SUBDIRS = src
% cat sub/src/Makefile.am
foo-local:
    @echo This too will be run by a "make foo" issued either in
    @echo the 'sub/src/' directory, the 'sub/' directory, or the
    @echo top-level directory.
```

7.2 Conditional Subdirectories

It is possible to define the `SUBDIRS` variable conditionally if, like in the case of GNU Inetutils, you want to only build a subset of the entire package.

To illustrate how this works, let's assume we have two directories, `src/` and `opt/`. `src/` should always be built, but we want to decide in `configure` whether `opt/` will be built or not. (For this example we will assume that `opt/` should be built when the variable `'$want_opt'` was set to `'yes'`.)

Running `make` should thus recurse into `src/` always, and then maybe in `opt/`.

However `'make dist'` should always recurse into both `src/` and `opt/`, because `opt/` should be distributed even if it is not needed in the current configuration. This means `opt/Makefile` should be created *unconditionally*.

There are two ways to set up a project like this. You can use Automake conditionals (see Chapter 20 [Conditionals], page 126) or use Autoconf `AC_SUBST` variables (see Section “Setting Output Variables” in *The Autoconf Manual*). Using Automake conditionals is the preferred solution. Before we illustrate these two possibilities, let’s introduce `DIST_SUBDIRS`.

7.2.1 SUBDIRS vs. DIST_SUBDIRS

Automake considers two sets of directories, defined by the variables `SUBDIRS` and `DIST_SUBDIRS`.

`SUBDIRS` contains the subdirectories of the current directory that must be built (see Section 7.1 [Subdirectories], page 48). It must be defined manually; Automake will never guess a directory is to be built. As we will see in the next two sections, it is possible to define it conditionally so that some directory will be omitted from the build.

`DIST_SUBDIRS` is used in rules that need to recurse in all directories, even those that have been conditionally left out of the build. Recall our example where we may not want to build subdirectory `opt/`, but yet we want to distribute it? This is where `DIST_SUBDIRS` comes into play: `'opt'` may not appear in `SUBDIRS`, but it must appear in `DIST_SUBDIRS`.

Precisely, `DIST_SUBDIRS` is used by `'make maintainer-clean'`, `'make distclean'` and `'make dist'`. All other recursive rules use `SUBDIRS`.

If `SUBDIRS` is defined conditionally using Automake conditionals, Automake will define `DIST_SUBDIRS` automatically from the possible values of `SUBDIRS` in all conditions.

If `SUBDIRS` contains `AC_SUBST` variables, `DIST_SUBDIRS` will not be defined correctly because Automake does not know the possible values of these variables. In this case `DIST_SUBDIRS` needs to be defined manually.

7.2.2 Subdirectories with AM_CONDITIONAL

`configure` should output the `Makefile` for each directory and define a condition into which `opt/` should be built.

```
...
AM_CONDITIONAL([COND_OPT], [test "$want_opt" = yes])
AC_CONFIG_FILES([Makefile src/Makefile opt/Makefile])
...
```

Then `SUBDIRS` can be defined in the top-level `Makefile.am` as follows.

```
if COND_OPT
  MAYBE_OPT = opt
endif
SUBDIRS = src $(MAYBE_OPT)
```

As you can see, running `make` will rightly recurse into `src/` and maybe `opt/`.

As you can’t see, running `'make dist'` will recurse into both `src/` and `opt/` directories because `'make dist'`, unlike `'make all'`, doesn’t use the `SUBDIRS` variable. It uses the `DIST_SUBDIRS` variable.

In this case Automake will define ‘`DIST_SUBDIRS = src opt`’ automatically because it knows that `MAYBE_OPT` can contain ‘`opt`’ in some condition.

7.2.3 Subdirectories with `AC_SUBST`

Another possibility is to define `MAYBE_OPT` from `./configure` using `AC_SUBST`:

```
...
if test "$want_opt" = yes; then
  MAYBE_OPT=opt
else
  MAYBE_OPT=
fi
AC_SUBST([MAYBE_OPT])
AC_CONFIG_FILES([Makefile src/Makefile opt/Makefile])
...
```

In this case the top-level `Makefile.am` should look as follows.

```
SUBDIRS = src $(MAYBE_OPT)
DIST_SUBDIRS = src opt
```

The drawback is that since Automake cannot guess what the possible values of `MAYBE_OPT` are, it is necessary to define `DIST_SUBDIRS`.

7.2.4 Unconfigured Subdirectories

The semantics of `DIST_SUBDIRS` are often misunderstood by some users that try to *configure and build* subdirectories conditionally. Here by configuring we mean creating the `Makefile` (it might also involve running a nested `configure` script: this is a costly operation that explains why people want to do it conditionally, but only the `Makefile` is relevant to the discussion).

The above examples all assume that every `Makefile` is created, even in directories that are not going to be built. The simple reason is that we want ‘`make dist`’ to distribute even the directories that are not being built (e.g., platform-dependent code), hence `make dist` must recurse into the subdirectory, hence this directory must be configured and appear in `DIST_SUBDIRS`.

Building packages that do not configure every subdirectory is a tricky business, and we do not recommend it to the novice as it is easy to produce an incomplete tarball by mistake. We will not discuss this topic in depth here, yet for the adventurous here are a few rules to remember.

- `SUBDIRS` should always be a subset of `DIST_SUBDIRS`.
It makes little sense to have a directory in `SUBDIRS` that is not in `DIST_SUBDIRS`. Think of the former as a way to tell which directories listed in the latter should be built.
- Any directory listed in `DIST_SUBDIRS` and `SUBDIRS` must be configured.
I.e., the `Makefile` must exist or the recursive `make` rules will not be able to process the directory.
- Any configured directory must be listed in `DIST_SUBDIRS`.
This is so the cleaning rules remove the generated `Makefiles`. It would be correct to see `DIST_SUBDIRS` as a variable that lists all the directories that have been configured.

In order to prevent recursion in some unconfigured directory you must therefore ensure that this directory does not appear in `DIST_SUBDIRS` (and `SUBDIRS`). For instance, if you define `SUBDIRS` conditionally using `AC_SUBST` and do not define `DIST_SUBDIRS` explicitly, it will be default to `$(SUBDIRS)`; another possibility is to force `DIST_SUBDIRS = $(SUBDIRS)`.

Of course, directories that are omitted from `DIST_SUBDIRS` will not be distributed unless you make other arrangements for this to happen (for instance, always running `make dist` in a configuration where all directories are known to appear in `DIST_SUBDIRS`; or writing a `dist-hook` target to distribute these directories).

In a few packages, unconfigured directories are not even expected to be distributed. Although these packages do not require the aforementioned extra arrangements, there is another pitfall. If the name of a directory appears in `SUBDIRS` or `DIST_SUBDIRS`, `automake` will make sure the directory exists. Consequently `automake` cannot be run on such a distribution when one directory has been omitted. One way to avoid this check is to use the `AC_SUBST` method to declare conditional directories; since `automake` does not know the values of `AC_SUBST` variables it cannot ensure the corresponding directory exists.

7.3 An Alternative Approach to Subdirectories

If you've ever read Peter Miller's excellent paper, *Recursive Make Considered Harmful*, the preceding sections on the use of `make` recursion will probably come as unwelcome advice. For those who haven't read the paper, Miller's main thesis is that recursive `make` invocations are both slow and error-prone.

`Automake` provides sufficient cross-directory support² to enable you to write a single `Makefile.am` for a complex multi-directory package.

By default an installable file specified in a subdirectory will have its directory name stripped before installation. For instance, in this example, the header file will be installed as `$(includedir)/stdio.h`:

```
include_HEADERS = inc/stdio.h
```

However, the `'nobase_'` prefix can be used to circumvent this path stripping. In this example, the header file will be installed as `$(includedir)/sys/types.h`:

```
nobase_include_HEADERS = sys/types.h
```

² We believe. This work is new and there are probably warts. See Chapter 1 [Introduction], page 1, for information on reporting bugs.

‘nobase_’ should be specified first when used in conjunction with either ‘dist_’ or ‘nodist_’ (see Section 14.2 [Fine-grained Distribution Control], page 99). For instance:

```
nobase_dist_pkgdata_DATA = images/vortex.pgm sounds/whirl.ogg
```

Finally, note that a variable using the ‘nobase_’ prefix can often be replaced by several variables, one for each destination directory (see Section 3.3 [Uniform], page 21). For instance, the last example could be rewritten as follows:

```
imagesdir = $(pkgdatadir)/images
soundsdir = $(pkgdatadir)/sounds
dist_images_DATA = images/vortex.pgm
dist_sounds_DATA = sounds/whirl.ogg
```

This latter syntax makes it possible to change one destination directory without changing the layout of the source tree.

Currently, ‘nobase_*_LTLIBRARIES’ are the only exception to this rule, in that there is no particular installation order guarantee for an otherwise equivalent set of variables without ‘nobase_’ prefix.

7.4 Nesting Packages

In the GNU Build System, packages can be nested to arbitrary depth. This means that a package can embed other packages with their own `configure`, `Makefiles`, etc.

These other packages should just appear as subdirectories of their parent package. They must be listed in `SUBDIRS` like other ordinary directories. However the subpackage’s `Makefiles` should be output by its own `configure` script, not by the parent’s `configure`. This is achieved using the `AC_CONFIG_SUBDIRS` Autoconf macro (see Section “Configuring Other Packages in Subdirectories” in *The Autoconf Manual*).

Here is an example package for an `arm` program that links with a `hand` library that is a nested package in subdirectory `hand/`.

arm’s `configure.ac`:

```
AC_INIT([arm], [1.0])
AC_CONFIG_AUX_DIR([.])
AM_INIT_AUTOMAKE
AC_PROG_CC
AC_CONFIG_FILES([Makefile])
# Call hand’s ./configure script recursively.
AC_CONFIG_SUBDIRS([hand])
AC_OUTPUT
```

arm’s `Makefile.am`:

```
# Build the library in the hand subdirectory first.
SUBDIRS = hand

# Include hand’s header when compiling this directory.
AM_CPPFLAGS = -I$(srcdir)/hand

bin_PROGRAMS = arm
arm_SOURCES = arm.c
```

```
# link with the hand library.
arm_LDADD = hand/libhand.a
```

Now here is `hand`'s `hand/configure.ac`:

```
AC_INIT([hand], [1.2])
AC_CONFIG_AUX_DIR([.])
AM_INIT_AUTOMAKE
AC_PROG_CC
AM_PROG_AR
AC_PROG_RANLIB
AC_CONFIG_FILES([Makefile])
AC_OUTPUT
```

and its `hand/Makefile.am`:

```
lib_LIBRARIES = libhand.a
libhand_a_SOURCES = hand.c
```

When `'make dist'` is run from the top-level directory it will create an archive `arm-1.0.tar.gz` that contains the `arm` code as well as the `hand` subdirectory. This package can be built and installed like any ordinary package, with the usual `'./configure && make && make install'` sequence (the `hand` subpackage will be built and installed by the process).

When `'make dist'` is run from the `hand` directory, it will create a self-contained `hand-1.2.tar.gz` archive. So although it appears to be embedded in another package, it can still be used separately.

The purpose of the `'AC_CONFIG_AUX_DIR([.])'` instruction is to force Automake and Autoconf to search for auxiliary scripts in the current directory. For instance, this means that there will be two copies of `install-sh`: one in the top-level of the `arm` package, and another one in the `hand/` subdirectory for the `hand` package.

The historical default is to search for these auxiliary scripts in the parent directory and the grandparent directory. So if the `'AC_CONFIG_AUX_DIR([.])'` line was removed from `hand/configure.ac`, that subpackage would share the auxiliary script of the `arm` package. This may look like a gain in size (a few kilobytes), but it is actually a loss of modularity as the `hand` subpackage is no longer self-contained (`'make dist'` in the subdirectory will not work anymore).

Packages that do not use Automake need more work to be integrated this way. See Section 22.2 [Third-Party Makefiles], page 134.

8 Building Programs and Libraries

A large part of Automake's functionality is dedicated to making it easy to build programs and libraries.

8.1 Building a program

In order to build a program, you need to tell Automake which sources are part of it, and which libraries it should be linked with.

This section also covers conditional compilation of sources or programs. Most of the comments about these also apply to libraries (see Section 8.2 [A Library], page 58) and libtool libraries (see Section 8.3 [A Shared Library], page 59).

8.1.1 Defining program sources

In a directory containing source that gets built into a program (as opposed to a library or a script), the `PROGRAMS` primary is used. Programs can be installed in `bindir`, `sbindir`, `libexecdir`, `pkglibexecdir`, or not at all (`noinst_`). They can also be built only for ‘make check’, in which case the prefix is ‘`check_`’.

For instance:

```
bin_PROGRAMS = hello
```

In this simple case, the resulting `Makefile.in` will contain code to generate a program named `hello`.

Associated with each program are several assisting variables that are named after the program. These variables are all optional, and have reasonable defaults. Each variable, its use, and default is spelled out below; we use the “hello” example throughout.

The variable `hello_SOURCES` is used to specify which source files get built into an executable:

```
hello_SOURCES = hello.c version.c getopt.c getopt1.c getopt.h system.h
```

This causes each mentioned `.c` file to be compiled into the corresponding `.o`. Then all are linked to produce `hello`.

If `hello_SOURCES` is not specified, then it defaults to the single file `hello.c` (see Section 8.5 [Default `_SOURCES`], page 69).

Multiple programs can be built in a single directory. Multiple programs can share a single source file, which must be listed in each `_SOURCES` definition.

Header files listed in a `_SOURCES` definition will be included in the distribution but otherwise ignored. In case it isn’t obvious, you should not include the header file generated by `configure` in a `_SOURCES` variable; this file should not be distributed. Lex (`.l`) and Yacc (`.y`) files can also be listed; see Section 8.8 [Yacc and Lex], page 73.

8.1.2 Linking the program

If you need to link against libraries that are not found by `configure`, you can use `LDADD` to do so. This variable is used to specify additional objects or libraries to link with; it is inappropriate for specifying specific linker flags; you should use `AM_LDFLAGS` for this purpose.

Sometimes, multiple programs are built in one directory but do not share the same link-time requirements. In this case, you can use the `prog_LDADD` variable (where `prog` is the name of the program as it appears in some `_PROGRAMS` variable, and usually written in lowercase) to override `LDADD`. If this variable exists for a given program, then that program is not linked using `LDADD`.

For instance, in GNU `cpio`, `pax`, `cpio` and `mt` are linked against the library `libcpio.a`. However, `rmt` is built in the same directory, and has no such link requirement. Also, `mt` and

`rmt` are only built on certain architectures. Here is what `cpio`'s `src/Makefile.am` looks like (abridged):

```
bin_PROGRAMS = cpio pax $(MT)
libexec_PROGRAMS = $(RMT)
EXTRA_PROGRAMS = mt rmt

LDADD = ../lib/libcpio.a $(INTLLIBS)
rmt_LDADD =

cpio_SOURCES = ...
pax_SOURCES = ...
mt_SOURCES = ...
rmt_SOURCES = ...
```

`prog_LDADD` is inappropriate for passing program-specific linker flags (except for `-l`, `-L`, `-dlopen` and `-dlpreopen`). So, use the `prog_LDFLAGS` variable for this purpose.

It is also occasionally useful to have a program depend on some other target that is not actually part of that program. This can be done using either the `prog_DEPENDENCIES` or the `EXTRA_prog_DEPENDENCIES` variable. Each program depends on the contents both variables, but no further interpretation is done.

Since these dependencies are associated to the link rule used to create the programs they should normally list files used by the link command. That is `*.$(OBJEXT)`, `*.a`, or `*.la` files. In rare cases you may need to add other kinds of files such as linker scripts, but *listing a source file in `_DEPENDENCIES` is wrong*. If some source file needs to be built before all the components of a program are built, consider using the `BUILT_SOURCES` variable instead (see Section 9.4 [Sources], page 85).

If `prog_DEPENDENCIES` is not supplied, it is computed by Automake. The automatically-assigned value is the contents of `prog_LDADD`, with most configure substitutions, `-l`, `-L`, `-dlopen` and `-dlpreopen` options removed. The configure substitutions that are left in are only `'$(LIBOBJ)'` and `'$(ALLOCA)'`; these are left because it is known that they will not cause an invalid value for `prog_DEPENDENCIES` to be generated.

Section 8.1.3 [Conditional Sources], page 56, shows a situation where `_DEPENDENCIES` may be used.

The `EXTRA_prog_DEPENDENCIES` may be useful for cases where you merely want to augment the automake-generated `prog_DEPENDENCIES` rather than replacing it.

We recommend that you avoid using `-l` options in `LDADD` or `prog_LDADD` when referring to libraries built by your package. Instead, write the file name of the library explicitly as in the above `cpio` example. Use `-l` only to list third-party libraries. If you follow this rule, the default value of `prog_DEPENDENCIES` will list all your local libraries and omit the other ones.

8.1.3 Conditional compilation of sources

You can't put a configure substitution (e.g., `'@FOO@'` or `'$(FOO)'` where `FOO` is defined via `AC_SUBST`) into a `_SOURCES` variable. The reason for this is a bit hard to explain, but suffice to say that it simply won't work. Automake will give an error if you try to do this.

Fortunately there are two other ways to achieve the same result. One is to use configure substitutions in `_LDADD` variables, the other is to use an Automake conditional.

Conditional Compilation using `_LDADD` Substitutions

Automake must know all the source files that could possibly go into a program, even if not all the files are built in every circumstance. Any files that are only conditionally built should be listed in the appropriate `EXTRA_` variable. For instance, if `hello-linux.c` or `hello-generic.c` were conditionally included in `hello`, the `Makefile.am` would contain:

```
bin_PROGRAMS = hello
hello_SOURCES = hello-common.c
EXTRA_hello_SOURCES = hello-linux.c hello-generic.c
hello_LDADD = $(HELLO_SYSTEM)
hello_DEPENDENCIES = $(HELLO_SYSTEM)
```

You can then set up the `$(HELLO_SYSTEM)` substitution from `configure.ac`:

```
...
case $host in
  *linux*) HELLO_SYSTEM='hello-linux.${OBJEXT}' ;;
  *)      HELLO_SYSTEM='hello-generic.${OBJEXT}' ;;
esac
AC_SUBST([HELLO_SYSTEM])
...
```

In this case, the variable `HELLO_SYSTEM` should be replaced by either `hello-linux.o` or `hello-generic.o`, and added to both `hello_DEPENDENCIES` and `hello_LDADD` in order to be built and linked in.

Conditional Compilation using Automake Conditionals

An often simpler way to compile source files conditionally is to use Automake conditionals. For instance, you could use this `Makefile.am` construct to build the same `hello` example:

```
bin_PROGRAMS = hello
if LINUX
hello_SOURCES = hello-linux.c hello-common.c
else
hello_SOURCES = hello-generic.c hello-common.c
endif
```

In this case, `configure.ac` should set up the `LINUX` conditional using `AM_CONDITIONAL` (see Chapter 20 [Conditionals], page 126).

When using conditionals like this you don't need to use the `EXTRA_` variable, because Automake will examine the contents of each variable to construct the complete list of source files.

If your program uses a lot of files, you will probably prefer a conditional `+=`.

```
bin_PROGRAMS = hello
hello_SOURCES = hello-common.c
if LINUX
hello_SOURCES += hello-linux.c
else
```



```
hello_SOURCES += hello-generic.c
endif
```

8.1.4 Conditional compilation of programs

Sometimes it is useful to determine the programs that are to be built at configure time. For instance, GNU `cpio` only builds `mt` and `rmt` under special circumstances. The means to achieve conditional compilation of programs are the same you can use to compile source files conditionally: substitutions or conditionals.

Conditional Programs using configure Substitutions

In this case, you must notify Automake of all the programs that can possibly be built, but at the same time cause the generated `Makefile.in` to use the programs specified by `configure`. This is done by having `configure` substitute values into each `_PROGRAMS` definition, while listing all optionally built programs in `EXTRA_PROGRAMS`.

```
bin_PROGRAMS = cpio pax $(MT)
libexec_PROGRAMS = $(RMT)
EXTRA_PROGRAMS = mt rmt
```

As explained in Section 8.20 [EXEEXT], page 82, Automake will rewrite `bin_PROGRAMS`, `libexec_PROGRAMS`, and `EXTRA_PROGRAMS`, appending `$(EXEEXT)` to each binary. Obviously it cannot rewrite values obtained at run-time through `configure` substitutions, therefore you should take care of appending `$(EXEEXT)` yourself, as in `'AC_SUBST([MT], ['mt${EXEEXT}'])'`.

Conditional Programs using Automake Conditionals

You can also use Automake conditionals (see Chapter 20 [Conditionals], page 126) to select programs to be built. In this case you don't have to worry about `$(EXEEXT)` or `EXTRA_PROGRAMS`.

```
bin_PROGRAMS = cpio pax
if WANT_MT
  bin_PROGRAMS += mt
endif
if WANT_RMT
  libexec_PROGRAMS = rmt
endif
```

8.2 Building a library

Building a library is much like building a program. In this case, the name of the primary is `LIBRARIES`. Libraries can be installed in `libdir` or `pkglibdir`.

See Section 8.3 [A Shared Library], page 59, for information on how to build shared libraries using `libtool` and the `LTLIBRARIES` primary.

Each `_LIBRARIES` variable is a list of the libraries to be built. For instance, to create a library named `libcpio.a`, but not install it, you would write:

```
noinst_LIBRARIES = libcpio.a
libcpio_a_SOURCES = ...
```

The sources that go into a library are determined exactly as they are for programs, via the `_SOURCES` variables. Note that the library name is canonicalized (see Section 3.5 [Canonicalization], page 23), so the `_SOURCES` variable corresponding to `libcpio.a` is `'libcpio_a_SOURCES'`, not `'libcpio.a_SOURCES'`.

Extra objects can be added to a library using the `library_LIBADD` variable. This should be used for objects determined by `configure`. Again from `cpio`:

```
libcpio_a_LIBADD = $(LIBOBJS) $(ALLOCA)
```

In addition, sources for extra objects that will not exist until configure-time must be added to the `BUILT_SOURCES` variable (see Section 9.4 [Sources], page 85).

Building a static library is done by compiling all object files, then by invoking `'$(AR) $(ARFLAGS)'` followed by the name of the library and the list of objects, and finally by calling `'$(RANLIB)'` on that library. You should call `AC_PROG_RANLIB` from your `configure.ac` to define `RANLIB` (Automake will complain otherwise). You should also call `AM_PROG_AR` to define `AR`, in order to support unusual archivers such as Microsoft lib. `ARFLAGS` will default to `cru`; you can override this variable by setting it in your `Makefile.am` or by `AC_SUBST`ing it from your `configure.ac`. You can override the `AR` variable by defining a per-library `maude_AR` variable (see Section 8.4 [Program and Library Variables], page 65).

Be careful when selecting library components conditionally. Because building an empty library is not portable, you should ensure that any library always contains at least one object.

To use a static library when building a program, add it to `LDADD` for this program. In the following example, the program `cpio` is statically linked with the library `libcpio.a`.

```
noinst_LIBRARIES = libcpio.a
libcpio_a_SOURCES = ...

bin_PROGRAMS = cpio
cpio_SOURCES = cpio.c ...
cpio_LDADD = libcpio.a
```

8.3 Building a Shared Library

Building shared libraries portably is a relatively complex matter. For this reason, GNU Libtool (see Section “Introduction” in *The Libtool Manual*) was created to help build shared libraries in a platform-independent way.

8.3.1 The Libtool Concept

Libtool abstracts shared and static libraries into a unified concept henceforth called *libtool libraries*. Libtool libraries are files using the `.la` suffix, and can designate a static library, a shared library, or maybe both. Their exact nature cannot be determined until `./configure` is run: not all platforms support all kinds of libraries, and users can explicitly select which libraries should be built. (However the package’s maintainers can tune the default; see Section “The `LT_INIT` macro” in *The Libtool Manual*.)

Because object files for shared and static libraries must be compiled differently, libtool is also used during compilation. Object files built by libtool are called *libtool objects*: these are files using the `.lo` suffix. Libtool libraries are built from these libtool objects.

You should not assume anything about the structure of `.la` or `.lo` files and how `libtool` constructs them: this is `libtool`'s concern, and the last thing one wants is to learn about `libtool`'s guts. However the existence of these files matters, because they are used as targets and dependencies in `Makefiles`' rules when building `libtool` libraries. There are situations where you may have to refer to these, for instance when expressing dependencies for building source files conditionally (see Section 8.3.4 [Conditional Libtool Sources], page 61).

People considering writing a plug-in system, with dynamically loaded modules, should look into `libltdl`: `libtool`'s dlopening library (see Section "Using `libltdl`" in *The Libtool Manual*). This offers a portable dlopening facility to load `libtool` libraries dynamically, and can also achieve static linking where unavoidable.

Before we discuss how to use `libtool` with Automake in detail, it should be noted that the `libtool` manual also has a section about how to use Automake with `libtool` (see Section "Using Automake with Libtool" in *The Libtool Manual*).

8.3.2 Building Libtool Libraries

Automake uses `libtool` to build libraries declared with the `LTLIBRARIES` primary. Each `_LTLIBRARIES` variable is a list of `libtool` libraries to build. For instance, to create a `libtool` library named `libgettext.la`, and install it in `libdir`, write:

```
lib_LTLIBRARIES = libgettext.la
libgettext_la_SOURCES = gettext.c gettext.h ...
```

Automake predefines the variable `pkglibdir`, so you can use `pkglib_LTLIBRARIES` to install libraries in `'$(libdir)/@PACKAGE@/'`.

If `gettext.h` is a public header file that needs to be installed in order for people to use the library, it should be declared using a `_HEADERS` variable, not in `libgettext_la_SOURCES`. Headers listed in the latter should be internal headers that are not part of the public interface.

```
lib_LTLIBRARIES = libgettext.la
libgettext_la_SOURCES = gettext.c ...
include_HEADERS = gettext.h ...
```

A package can build and install such a library along with other programs that use it. This dependency should be specified using `LDADD`. The following example builds a program named `hello` that is linked with `libgettext.la`.

```
lib_LTLIBRARIES = libgettext.la
libgettext_la_SOURCES = gettext.c ...
```

```
bin_PROGRAMS = hello
hello_SOURCES = hello.c ...
hello_LDADD = libgettext.la
```

Whether `hello` is statically or dynamically linked with `libgettext.la` is not yet known: this will depend on the configuration of `libtool` and the capabilities of the host.

8.3.3 Building Libtool Libraries Conditionally

Like conditional programs (see Section 8.1.4 [Conditional Programs], page 58), there are two main ways to build conditional libraries: using Automake conditionals or using Autoconf `AC_SUBSTITutions`.

The important implementation detail you have to be aware of is that the place where a library will be installed matters to libtool: it needs to be indicated *at link-time* using the `-rpath` option.

For libraries whose destination directory is known when Automake runs, Automake will automatically supply the appropriate `-rpath` option to libtool. This is the case for libraries listed explicitly in some installable `_LTLIBRARIES` variables such as `lib_LTLIBRARIES`.

However, for libraries determined at configure time (and thus mentioned in `EXTRA_LTLIBRARIES`), Automake does not know the final installation directory. For such libraries you must add the `-rpath` option to the appropriate `_LDFLAGS` variable by hand.

The examples below illustrate the differences between these two methods.

Here is an example where `WANTEDLIBS` is an `AC_SUBST`ed variable set at `./configure-time` to either `libfoo.la`, `libbar.la`, both, or none. Although `'$(WANTEDLIBS)'` appears in the `lib_LTLIBRARIES`, Automake cannot guess it relates to `libfoo.la` or `libbar.la` at the time it creates the link rule for these two libraries. Therefore the `-rpath` argument must be explicitly supplied.

```
EXTRA_LTLIBRARIES = libfoo.la libbar.la
lib_LTLIBRARIES = $(WANTEDLIBS)
libfoo_la_SOURCES = foo.c ...
libfoo_la_LDFLAGS = -rpath '$(libdir)'
libbar_la_SOURCES = bar.c ...
libbar_la_LDFLAGS = -rpath '$(libdir)'
```

Here is how the same `Makefile.am` would look using Automake conditionals named `WANT_LIBFOO` and `WANT_LIBBAR`. Now Automake is able to compute the `-rpath` setting itself, because it's clear that both libraries will end up in `'$(libdir)'` if they are installed.

```
lib_LTLIBRARIES =
if WANT_LIBFOO
lib_LTLIBRARIES += libfoo.la
endif
if WANT_LIBBAR
lib_LTLIBRARIES += libbar.la
endif
libfoo_la_SOURCES = foo.c ...
libbar_la_SOURCES = bar.c ...
```

8.3.4 Libtool Libraries with Conditional Sources

Conditional compilation of sources in a library can be achieved in the same way as conditional compilation of sources in a program (see Section 8.1.3 [Conditional Sources], page 56). The only difference is that `_LIBADD` should be used instead of `_LDADD` and that it should mention libtool objects (`.lo` files).

So, to mimic the `hello` example from Section 8.1.3 [Conditional Sources], page 56, we could build a `libhello.la` library using either `hello-linux.c` or `hello-generic.c` with the following `Makefile.am`.

```
lib_LTLIBRARIES = libhello.la
libhello_la_SOURCES = hello-common.c
EXTRA_libhello_la_SOURCES = hello-linux.c hello-generic.c
```

```
libhello_la_LIBADD = $(HELLO_SYSTEM)
libhello_la_DEPENDENCIES = $(HELLO_SYSTEM)
```

And make sure `configure` defines `HELLO_SYSTEM` as either `hello-linux.lo` or `hello-generic.lo`.

Or we could simply use an Automake conditional as follows.

```
lib_LTLIBRARIES = libhello_la
libhello_la_SOURCES = hello-common.c
if LINUX
libhello_la_SOURCES += hello-linux.c
else
libhello_la_SOURCES += hello-generic.c
endif
```

8.3.5 Libtool Convenience Libraries

Sometimes you want to build libtool libraries that should not be installed. These are called *libtool convenience libraries* and are typically used to encapsulate many sublibraries, later gathered into one big installed library.

Libtool convenience libraries are declared by directory-less variables such as `noinst_LTLIBRARIES`, `check_LTLIBRARIES`, or even `EXTRA_LTLIBRARIES`. Unlike installed libtool libraries they do not need an `-rpath` flag at link time (actually this is the only difference).

Convenience libraries listed in `noinst_LTLIBRARIES` are always built. Those listed in `check_LTLIBRARIES` are built only upon ‘make check’. Finally, libraries listed in `EXTRA_LTLIBRARIES` are never built explicitly: Automake outputs rules to build them, but if the library does not appear as a Makefile dependency anywhere it won’t be built (this is why `EXTRA_LTLIBRARIES` is used for conditional compilation).

Here is a sample setup merging libtool convenience libraries from subdirectories into one main `libtop_la` library.

```
# -- Top-level Makefile.am --
SUBDIRS = sub1 sub2 ...
lib_LTLIBRARIES = libtop_la
libtop_la_SOURCES =
libtop_la_LIBADD = \
    sub1/libsub1_la \
    sub2/libsub2_la \
    ...

# -- sub1/Makefile.am --
noinst_LTLIBRARIES = libsub1_la
libsub1_la_SOURCES = ...

# -- sub2/Makefile.am --
# showing nested convenience libraries
SUBDIRS = sub2.1 sub2.2 ...
noinst_LTLIBRARIES = libsub2_la
libsub2_la_SOURCES =
```

```

libsub2_la_LIBADD = \
    sub21/libsub21.la \
    sub22/libsub22.la \
    ...

```

When using such a setup, beware that `automake` will assume `libtop.la` is to be linked with the C linker. This is because `libtop_la_SOURCES` is empty, so `automake` picks C as default language. If `libtop_la_SOURCES` was not empty, `automake` would select the linker as explained in Section 8.14.3.1 [How the Linker is Chosen], page 79.

If one of the sublibraries contains non-C source, it is important that the appropriate linker be chosen. One way to achieve this is to pretend that there is such a non-C file among the sources of the library, thus forcing `automake` to select the appropriate linker. Here is the top-level Makefile of our example updated to force C++ linking.

```

SUBDIRS = sub1 sub2 ...
lib_LTLIBRARIES = libtop.la
libtop_la_SOURCES =
# Dummy C++ source to cause C++ linking.
nodist_EXTRA_libtop_la_SOURCES = dummy.cxx
libtop_la_LIBADD = \
    sub1/libsub1.la \
    sub2/libsub2.la \
    ...

```

'`EXTRA_*_SOURCES`' variables are used to keep track of source files that might be compiled (this is mostly useful when doing conditional compilation using `AC_SUBST`; see Section 8.3.4 [Conditional Libtool Sources], page 61), and the `nodist_` prefix means the listed sources are not to be distributed (see Section 8.4 [Program and Library Variables], page 65). In effect the file `dummy.cxx` does not need to exist in the source tree. Of course if you have some real source file to list in `libtop_la_SOURCES` there is no point in cheating with `nodist_EXTRA_libtop_la_SOURCES`.

8.3.6 Libtool Modules

These are libtool libraries meant to be dlopened. They are indicated to libtool by passing `-module` at link-time.

```

pkglib_LTLIBRARIES = mymodule.la
mymodule_la_SOURCES = doit.c
mymodule_la_LDFLAGS = -module

```

Ordinarily, Automake requires that a library's name start with `lib`. However, when building a dynamically loadable module you might wish to use a "nonstandard" name. Automake will not complain about such nonstandard names if it knows the library being built is a libtool module, i.e., if `-module` explicitly appears in the library's `_LDFLAGS` variable (or in the common `AM_LDFLAGS` variable when no per-library `_LDFLAGS` variable is defined).

As always, `AC_SUBST` variables are black boxes to Automake since their values are not yet known when `automake` is run. Therefore if `-module` is set via such a variable, Automake cannot notice it and will proceed as if the library was an ordinary libtool library, with strict naming.

If `mymodule_la_SOURCES` is not specified, then it defaults to the single file `mymodule.c` (see Section 8.5 [Default `_SOURCES`], page 69).

8.3.7 `_LIBADD`, `_LDFLAGS`, and `_LIBTOOLFLAGS`

As shown in previous sections, the `'library_LIBADD'` variable should be used to list extra libtool objects (`.lo` files) or libtool libraries (`.la`) to add to *library*.

The `'library_LDFLAGS'` variable is the place to list additional libtool linking flags, such as `-version-info`, `-static`, and a lot more. See Section “Link mode” in *The Libtool Manual*.

The `libtool` command has two kinds of options: mode-specific options and generic options. Mode-specific options such as the aforementioned linking flags should be lumped with the other flags passed to the tool invoked by `libtool` (hence the use of `'library_LDFLAGS'` for libtool linking flags). Generic options include `--tag=tag` and `--silent` (see Section “Invoking `libtool`” in *The Libtool Manual* for more options). They should appear before the mode selection on the command line; in `Makefile.am` they should be listed in the `'library_LIBTOOLFLAGS'` variable.

If `'library_LIBTOOLFLAGS'` is not defined, then the variable `AM_LIBTOOLFLAGS` is used instead.

These flags are passed to `libtool` after the `--tag=tag` option computed by Automake (if any), so `'library_LIBTOOLFLAGS'` (or `AM_LIBTOOLFLAGS`) is a good place to override or supplement the `--tag=tag` setting.

The `libtool` rules also use a `LIBTOOLFLAGS` variable that should not be set in `Makefile.am`: this is a user variable (see Section 26.6 [Flag Variables Ordering], page 146). It allows users to run `'make LIBTOOLFLAGS=--silent'`, for instance. Note that the verbosity of `libtool` can also be influenced by the Automake support for silent rules (see Section 21.3 [Automake Silent Rules], page 130).

8.3.8 `LTLIBOBJS` and `LTALLOCA`

Where an ordinary library might include `'$(LIBOBJS)'` or `'$(ALLOCA)'` (see Section 8.6 [LIBOBJS], page 70), a libtool library must use `'$(LTLIBOBJS)'` or `'$(LTALLOCA)'`. This is required because the object files that libtool operates on do not necessarily end in `.o`.

Nowadays, the computation of `LTLIBOBJS` from `LIBOBJS` is performed automatically by Autoconf (see Section “`AC_LIBOBJ` vs. `LIBOBJS`” in *The Autoconf Manual*).

8.3.9 Common Issues Related to Libtool’s Use

8.3.9.1 Error: ‘required file `./ltmain.sh` not found’

Libtool comes with a tool called `libtoolize` that will install libtool’s supporting files into a package. Running this command will install `ltmain.sh`. You should execute it before `aclocal` and `automake`.

People upgrading old packages to newer autotools are likely to face this issue because older Automake versions used to call `libtoolize`. Therefore old build scripts do not call `libtoolize`.

Since Automake 1.6, it has been decided that running `libtoolize` was none of Automake’s business. Instead, that functionality has been moved into the `autoreconf` com-

mand (see Section “Using autoreconf” in *The Autoconf Manual*). If you do not want to remember what to run and when, just learn the `autoreconf` command. Hopefully, replacing existing `bootstrap` or `autogen.sh` scripts by a call to `autoreconf` should also free you from any similar incompatible change in the future.

8.3.9.2 Objects ‘created with both libtool and without’

Sometimes, the same source file is used both to build a libtool library and to build another non-libtool target (be it a program or another library).

Let’s consider the following `Makefile.am`.

```
bin_PROGRAMS = prog
prog_SOURCES = prog.c foo.c ...

lib_LTLIBRARIES = libfoo.la
libfoo_la_SOURCES = foo.c ...
```

(In this trivial case the issue could be avoided by linking `libfoo.la` with `prog` instead of listing `foo.c` in `prog_SOURCES`. But let’s assume we really want to keep `prog` and `libfoo.la` separate.)

Technically, it means that we should build `foo.$(OBJEXT)` for `prog`, and `foo.lo` for `libfoo.la`. The problem is that in the course of creating `foo.lo`, libtool may erase (or replace) `foo.$(OBJEXT)`, and this cannot be avoided.

Therefore, when Automake detects this situation it will complain with a message such as

```
object 'foo.$(OBJEXT)' created both with libtool and without
```

A workaround for this issue is to ensure that these two objects get different basenames. As explained in Section 26.7 [Renamed Objects], page 149, this happens automatically when per-target flags are used.

```
bin_PROGRAMS = prog
prog_SOURCES = prog.c foo.c ...
prog_CFLAGS = $(AM_CFLAGS)

lib_LTLIBRARIES = libfoo.la
libfoo_la_SOURCES = foo.c ...
```

Adding ‘`prog_CFLAGS = $(AM_CFLAGS)`’ is almost a no-op, because when the `prog_CFLAGS` is defined, it is used instead of `AM_CFLAGS`. However as a side effect it will cause `prog.c` and `foo.c` to be compiled as `prog-prog.$(OBJEXT)` and `prog-foo.$(OBJEXT)`, which solves the issue.

8.4 Program and Library Variables

Associated with each program is a collection of variables that can be used to modify how that program is built. There is a similar list of such variables for each library. The canonical name of the program (or library) is used as a base for naming these variables.

In the list below, we use the name “maude” to refer to the program or library. In your `Makefile.am` you would replace this with the canonical name of your program. This list also refers to “maude” as a program, but in general the same rules apply for both static and

dynamic libraries; the documentation below notes situations where programs and libraries differ.

`maude_SOURCES`

This variable, if it exists, lists all the source files that are compiled to build the program. These files are added to the distribution by default. When building the program, Automake will cause each source file to be compiled to a single `.o` file (or `.lo` when using `libtool`). Normally these object files are named after the source file, but other factors can change this. If a file in the `_SOURCES` variable has an unrecognized extension, Automake will do one of two things with it. If a suffix rule exists for turning files with the unrecognized extension into `.o` files, then `automake` will treat this file as it will any other source file (see Section 8.18 [Support for Other Languages], page 81). Otherwise, the file will be ignored as though it were a header file.

The prefixes `dist_` and `nodist_` can be used to control whether files listed in a `_SOURCES` variable are distributed. `dist_` is redundant, as sources are distributed by default, but it can be specified for clarity if desired.

It is possible to have both `dist_` and `nodist_` variants of a given `_SOURCES` variable at once; this lets you easily distribute some files and not others, for instance:

```
nodist_maude_SOURCES = nodist.c
dist_maude_SOURCES = dist-me.c
```

By default the output file (on Unix systems, the `.o` file) will be put into the current build directory. However, if the option `subdir-objects` is in effect in the current directory then the `.o` file will be put into the subdirectory named after the source file. For instance, with `subdir-objects` enabled, `sub/dir/file.c` will be compiled to `sub/dir/file.o`. Some people prefer this mode of operation. You can specify `subdir-objects` in `AUTOMAKE_OPTIONS` (see Chapter 17 [Options], page 120).

`EXTRA_maude_SOURCES`

Automake needs to know the list of files you intend to compile *statically*. For one thing, this is the only way Automake has of knowing what sort of language support a given `Makefile.in` requires.³ This means that, for example, you can't put a configure substitution like `@my_sources@` into a `_SOURCES` variable. If you intend to conditionally compile source files and use `configure` to substitute the appropriate object names into, e.g., `_LDADD` (see below), then you should list the corresponding source files in the `EXTRA_` variable.

This variable also supports `dist_` and `nodist_` prefixes. For instance, `nodist_EXTRA_maude_SOURCES` would list extra sources that may need to be built, but should not be distributed.

`maude_AR` A static library is created by default by invoking `'$(AR) $(ARFLAGS)'` followed by the name of the library and then the objects being put into the library. You can override this by setting the `_AR` variable. This is usually used with C++; some C++ compilers require a special invocation in order to instantiate all the

³ There are other, more obscure reasons for this limitation as well.

templates that should go into a library. For instance, the SGI C++ compiler likes this variable set like so:

```
libmaude_a_AR = $(CXX) -ar -o
```

maude_LIBADD

Extra objects can be added to a *library* using the `_LIBADD` variable. For instance, this should be used for objects determined by `configure` (see Section 8.2 [A Library], page 58).

In the case of libtool libraries, `maude_LIBADD` can also refer to other libtool libraries.

maude_LDADD

Extra objects (`*.$(OBJEXT)`) and libraries (`*.a`, `*.la`) can be added to a *program* by listing them in the `_LDADD` variable. For instance, this should be used for objects determined by `configure` (see Section 8.1.2 [Linking], page 55).

`_LDADD` and `_LIBADD` are inappropriate for passing program-specific linker flags (except for `-l`, `-L`, `-dlopen` and `-dlpreopen`). Use the `_LDFLAGS` variable for this purpose.

For instance, if your `configure.ac` uses `AC_PATH_XTRA`, you could link your program against the X libraries like so:

```
maude_LDADD = $(X_PRE_LIBS) $(X_LIBS) $(X_EXTRA_LIBS)
```

We recommend that you use `-l` and `-L` only when referring to third-party libraries, and give the explicit file names of any library built by your package. Doing so will ensure that `maude_DEPENDENCIES` (see below) is correctly defined by default.

maude_LDFLAGS

This variable is used to pass extra flags to the link step of a program or a shared library. It overrides the `AM_LDFLAGS` variable.

maude_LIBTOOLFLAGS

This variable is used to pass extra options to `libtool`. It overrides the `AM_LIBTOOLFLAGS` variable. These options are output before `libtool`'s `--mode=mode` option, so they should not be mode-specific options (those belong to the compiler or linker flags). See Section 8.3.7 [Libtool Flags], page 64.

maude_DEPENDENCIES

EXTRA_maude_DEPENDENCIES

It is also occasionally useful to have a target (program or library) depend on some other file that is not actually part of that target. This can be done using the `_DEPENDENCIES` variable. Each target depends on the contents of such a variable, but no further interpretation is done.

Since these dependencies are associated with the link rule used to create the programs they should normally list files used by the link command. That is `*.$(OBJEXT)`, `*.a`, or `*.la` files for programs; `*.lo` and `*.la` files for Libtool libraries; and `*.$(OBJEXT)` files for static libraries. In rare cases you may need to add other kinds of files such as linker scripts, but *listing a source file in `_DEPENDENCIES` is wrong*. If some source file needs to be built before all the

components of a program are built, consider using the `BUILT_SOURCES` variable (see Section 9.4 [Sources], page 85).

If `_DEPENDENCIES` is not supplied, it is computed by Automake. The automatically-assigned value is the contents of `_LDADD` or `_LIBADD`, with most configure substitutions, `-l`, `-L`, `-dlopen` and `-dlpreopen` options removed. The configure substitutions that are left in are only `$(LIBOBJJS)` and `$(ALLOCA)`; these are left because it is known that they will not cause an invalid value for `_DEPENDENCIES` to be generated.

`_DEPENDENCIES` is more likely used to perform conditional compilation using an `AC_SUBST` variable that contains a list of objects. See Section 8.1.3 [Conditional Sources], page 56, and Section 8.3.4 [Conditional Libtool Sources], page 61.

The `EXTRA*_DEPENDENCIES` variable may be useful for cases where you merely want to augment the automake-generated `_DEPENDENCIES` variable rather than replacing it.

`maude_LINK`

You can override the linker on a per-program basis. By default the linker is chosen according to the languages used by the program. For instance, a program that includes C++ source code would use the C++ compiler to link. The `_LINK` variable must hold the name of a command that can be passed all the `.o` file names and libraries to link against as arguments. Note that the name of the underlying program is *not* passed to `_LINK`; typically one uses ``${@}`:

```
maude_LINK = $(CCLD) -magic -o `${@}
```

If a `_LINK` variable is not supplied, it may still be generated and used by Automake due to the use of per-target link flags such as `_CFLAGS`, `_LDFLAGS` or `_LIBTOOLFLAGS`, in cases where they apply.

```
maude_CCASFLAGS
maude_CFLAGS
maude_CPPFLAGS
maude_CXXFLAGS
maude_FFLAGS
maude_GCJFLAGS
maude_LFLAGS
maude_OBJCFLAGS
maude_OBJCXXFLAGS
maude_RFLAGS
maude_UPCFLAGS
maude_YFLAGS
```

Automake allows you to set compilation flags on a per-program (or per-library) basis. A single source file can be included in several programs, and it will potentially be compiled with different flags for each program. This works for any language directly supported by Automake. These *per-target compilation flags* are `'_CCASFLAGS'`, `'_CFLAGS'`, `'_CPPFLAGS'`, `'_CXXFLAGS'`, `'_FFLAGS'`, `'_GCJFLAGS'`, `'_LFLAGS'`, `'_OBJCFLAGS'`, `'_OBJCXXFLAGS'`, `'_RFLAGS'`, `'_UPCFLAGS'`, and `'_YFLAGS'`.

When using a per-target compilation flag, Automake will choose a different name for the intermediate object files. Ordinarily a file like `sample.c` will be compiled to produce `sample.o`. However, if the program's `_CFLAGS` variable is set, then the object file will be named, for instance, `maude-sample.o`. (See also Section 26.7 [Renamed Objects], page 149.)

In compilations with per-target flags, the ordinary ‘AM_’ form of the flags variable is *not* automatically included in the compilation (however, the user form of the variable *is* included). So for instance, if you want the hypothetical `maude` compilations to also use the value of `AM_CFLAGS`, you would need to write:

```
maude_CFLAGS = ... your flags ... $(AM_CFLAGS)
```

See Section 26.6 [Flag Variables Ordering], page 146, for more discussion about the interaction between user variables, ‘AM_’ shadow variables, and per-target variables.

`maude_SHORTNAME`

On some platforms the allowable file names are very short. In order to support these systems and per-target compilation flags at the same time, Automake allows you to set a “short name” that will influence how intermediate object files are named. For instance, in the following example,

```
bin_PROGRAMS = maude
maude_CPPFLAGS = -DSOMEFLAG
maude_SHORTNAME = m
maude_SOURCES = sample.c ...
```

the object file would be named `m-sample.o` rather than `maude-sample.o`.

This facility is rarely needed in practice, and we recommend avoiding it until you find it is required.

8.5 Default `_SOURCES`

`_SOURCES` variables are used to specify source files of programs (see Section 8.1 [A Program], page 54), libraries (see Section 8.2 [A Library], page 58), and Libtool libraries (see Section 8.3 [A Shared Library], page 59).

When no such variable is specified for a target, Automake will define one itself. The default is to compile a single C file whose base name is the name of the target itself, with any extension replaced by `AM_DEFAULT_SOURCE_EXT`, which defaults to `.c`.

For example if you have the following somewhere in your `Makefile.am` with no corresponding `libfoo_a_SOURCES`:

```
lib_LIBRARIES = libfoo.a sub/libc++.a
```

`libfoo.a` will be built using a default source file named `libfoo.c`, and `sub/libc++.a` will be built from `sub/libc++.c`. (In older versions `sub/libc++.a` would be built from `sub_libc__a.c`, i.e., the default source was the canonicalized name of the target, with `.c` appended. We believe the new behavior is more sensible, but for backward compatibility `automake` will use the old name if a file or a rule with that name exists and `AM_DEFAULT_SOURCE_EXT` is not used.)

Default sources are mainly useful in test suites, when building many test programs each from a single source. For instance, in

```
check_PROGRAMS = test1 test2 test3
AM_DEFAULT_SOURCE_EXT = .cpp
```

`test1`, `test2`, and `test3` will be built from `test1.cpp`, `test2.cpp`, and `test3.cpp`. Without the last line, they will be built from `test1.c`, `test2.c`, and `test3.c`.

Another case where this is convenient is building many Libtool modules (`modulen.la`), each defined in its own file (`modulen.c`).

```
AM_LDFLAGS = -module
lib_LTLIBRARIES = module1.la module2.la module3.la
```

Finally, there is one situation where this default source computation needs to be avoided: when a target should not be built from sources. We already saw such an example in Section 4.2 [true], page 26; this happens when all the constituents of a target have already been compiled and just need to be combined using a `_LDADD` variable. Then it is necessary to define an empty `_SOURCES` variable, so that `automake` does not compute a default.

```
bin_PROGRAMS = target
target_SOURCES =
target_LDADD = libmain.a libmisc.a
```

8.6 Special handling for LIBOBJS and ALLOCA

The `$(LIBOBJS)` and `$(ALLOCA)` variables list object files that should be compiled into the project to provide an implementation for functions that are missing or broken on the host system. They are substituted by `configure`.

These variables are defined by Autoconf macros such as `AC_LIBOBJ`, `AC_REPLACE_FUNCS` (see Section “Generic Function Checks” in *The Autoconf Manual*), or `AC_FUNC_ALLOCA` (see Section “Particular Function Checks” in *The Autoconf Manual*). Many other Autoconf macros call `AC_LIBOBJ` or `AC_REPLACE_FUNCS` to populate `$(LIBOBJS)`.

Using these variables is very similar to doing conditional compilation using `AC_SUBST` variables, as described in Section 8.1.3 [Conditional Sources], page 56. That is, when building a program, `$(LIBOBJS)` and `$(ALLOCA)` should be added to the associated `*_LDADD` variable, or to the `*_LIBADD` variable when building a library. However there is no need to list the corresponding sources in `'EXTRA*_SOURCES'` nor to define `*_DEPENDENCIES`. Automake automatically adds `$(LIBOBJS)` and `$(ALLOCA)` to the dependencies, and it will discover the list of corresponding source files automatically (by tracing the invocations of the `AC_LIBSOURCE` Autoconf macros). If you have already defined `*_DEPENDENCIES` explicitly for an unrelated reason, then you either need to add these variables manually, or use `'EXTRA*_DEPENDENCIES'` instead of `*_DEPENDENCIES`.

These variables are usually used to build a portability library that is linked with all the programs of the project. We now review a sample setup. First, `configure.ac` contains some checks that affect either `LIBOBJS` or `ALLOCA`.

```
# configure.ac
...
AC_CONFIG_LIBOBJ_DIR([lib])
...
AC_FUNC_MALLOC          dn1 May add malloc.$(OBJEXT) to LIBOBJS
AC_FUNC_MEMCMP          dn1 May add memcmp.$(OBJEXT) to LIBOBJS
```

```

AC_REPLACE_FUNCS([strdup]) dn1 May add strdup.$(OBJEXT) to LIBOBJS
AC_FUNC_ALLOCA             dn1 May add alloca.$(OBJEXT) to ALLOCA
...
AC_CONFIG_FILES([
  lib/Makefile
  src/Makefile
])
AC_OUTPUT

```

The `AC_CONFIG_LIBOBJ_DIR` tells Autoconf that the source files of these object files are to be found in the `lib/` directory. Automake can also use this information, otherwise it expects the source files are to be in the directory where the `'$(LIBOBJS)'` and `'$(ALLOCA)'` variables are used.

The `lib/` directory should therefore contain `malloc.c`, `memcmp.c`, `strdup.c`, `alloca.c`. Here is its `Makefile.am`:

```

# lib/Makefile.am

noinst_LIBRARIES = libcompat.a
libcompat_a_SOURCES =
libcompat_a_LIBADD = $(LIBOBJS) $(ALLOCA)

```

The library can have any name, of course, and anyway it is not going to be installed: it just holds the replacement versions of the missing or broken functions so we can later link them in. Many projects also include extra functions, specific to the project, in that library: they are simply added on the `_SOURCES` line.

There is a small trap here, though: `'$(LIBOBJS)'` and `'$(ALLOCA)'` might be empty, and building an empty library is not portable. You should ensure that there is always something to put in `libcompat.a`. Most projects will also add some utility functions in that directory, and list them in `libcompat_a_SOURCES`, so in practice `libcompat.a` cannot be empty.

Finally here is how this library could be used from the `src/` directory.

```

# src/Makefile.am

# Link all programs in this directory with libcompat.a
LDADD = ../lib/libcompat.a

bin_PROGRAMS = tool1 tool2 ...
tool1_SOURCES = ...
tool2_SOURCES = ...

```

When option `subdir-objects` is not used, as in the above example, the variables `'$(LIBOBJS)'` or `'$(ALLOCA)'` can only be used in the directory where their sources lie. E.g., here it would be wrong to use `'$(LIBOBJS)'` or `'$(ALLOCA)'` in `src/Makefile.am`. However if both `subdir-objects` and `AC_CONFIG_LIBOBJ_DIR` are used, it is OK to use these variables in other directories. For instance `src/Makefile.am` could be changed as follows.

```

# src/Makefile.am

AUTOMAKE_OPTIONS = subdir-objects

```

```
LDADD = $(LIBOBJS) $(ALLOCA)

bin_PROGRAMS = tool1 tool2 ...
tool1_SOURCES = ...
tool2_SOURCES = ...
```

Because ‘\$(LIBOBJS)’ and ‘\$(ALLOCA)’ contain object file names that end with ‘.\$(OBJEXT)’, they are not suitable for Libtool libraries (where the expected object extension is `.lo`): `LTLIBOBJS` and `LTALLOCA` should be used instead.

`LTLIBOBJS` is defined automatically by Autoconf and should not be defined by hand (as in the past), however at the time of writing `LTALLOCA` still needs to be defined from `ALLOCA` manually. See Section “AC_LIBOBJ vs. LIBOBJS” in *The Autoconf Manual*.

8.7 Variables used when building a program

Occasionally it is useful to know which `Makefile` variables Automake uses for compilations, and in which order (see Section 26.6 [Flag Variables Ordering], page 146); for instance, you might need to do your own compilation in some special cases.

Some variables are inherited from Autoconf; these are `CC`, `CFLAGS`, `CPPFLAGS`, `DEFS`, `LDFLAGS`, and `LIBS`.

There are some additional variables that Automake defines on its own:

AM_CPPFLAGS

The contents of this variable are passed to every compilation that invokes the C preprocessor; it is a list of arguments to the preprocessor. For instance, `-I` and `-D` options should be listed here.

Automake already provides some `-I` options automatically, in a separate variable that is also passed to every compilation that invokes the C preprocessor. In particular it generates `-I.`, `-I$(srcdir)`, and a `-I` pointing to the directory holding `config.h` (if you’ve used `AC_CONFIG_HEADERS`). You can disable the default `-I` options using the `nostdinc` option.

When a file to be included is generated during the build and not part of a distribution tarball, its location is under `$(builddir)`, not under `$(srcdir)`. This matters especially for packages that use header files placed in sub-directories and want to allow builds outside the source tree (see Section 2.2.6 [VPATH Builds], page 6). In that case we recommend using a pair of `-I` options, such as, e.g., `-Isome/subdir -I$(srcdir)/some/subdir` or `-I$(top_builddir)/some/subdir -I$(top_srcdir)/some/subdir`. Note that the reference to the build tree should come before the reference to the source tree, so that accidentally leftover generated files in the source directory are ignored.

`AM_CPPFLAGS` is ignored in preference to a per-executable (or per-library) `_CPPFLAGS` variable if it is defined.

INCLUDES This does the same job as `AM_CPPFLAGS` (or any per-target `_CPPFLAGS` variable if it is used). It is an older name for the same functionality. This variable is deprecated; we suggest using `AM_CPPFLAGS` and per-target `_CPPFLAGS` instead.

AM_CFLAGS

This is the variable the `Makefile.am` author can use to pass in additional C compiler flags. In some situations, this is not used, in preference to the per-executable (or per-library) `_CFLAGS`.

COMPILE

This is the command used to actually compile a C source file. The file name is appended to form the complete command line.

AM_LDFLAGS

This is the variable the `Makefile.am` author can use to pass in additional linker flags. In some situations, this is not used, in preference to the per-executable (or per-library) `_LDFLAGS`.

LINK

This is the command used to actually link a C program. It already includes `'-o $@'` and the usual variable references (for instance, `CFLAGS`); it takes as “arguments” the names of the object files and libraries to link in. This variable is not used when the linker is overridden with a per-target `_LINK` variable or per-target flags cause Automake to define such a `_LINK` variable.

8.8 Yacc and Lex support

Automake has somewhat idiosyncratic support for Yacc and Lex.

Automake assumes that the `.c` file generated by `yacc` (or `lex`) should be named using the basename of the input file. That is, for a yacc source file `foo.y`, Automake will cause the intermediate file to be named `foo.c` (as opposed to `y.tab.c`, which is more traditional).

The extension of a yacc source file is used to determine the extension of the resulting C or C++ source and header files. Note that header files are generated only when the `-d` Yacc option is used; see below for more information about this flag, and how to specify it. Files with the extension `.y` will thus be turned into `.c` sources and `.h` headers; likewise, `.yy` will become `.cc` and `.hh`, `.y++` will become `c++` and `h++`, `.yxx` will become `.cxx` and `.hxx`, and `.ypp` will become `.cpp` and `.hpp`.

Similarly, lex source files can be used to generate C or C++; the extensions `.l`, `.ll`, `.l++`, `.lxx`, and `.lpp` are recognized.

You should never explicitly mention the intermediate (C or C++) file in any `SOURCES` variable; only list the source file.

The intermediate files generated by `yacc` (or `lex`) will be included in any distribution that is made. That way the user doesn't need to have `yacc` or `lex`.

If a yacc source file is seen, then your `configure.ac` must define the variable `YACC`. This is most easily done by invoking the macro `AC_PROG_YACC` (see Section “Particular Program Checks” in *The Autoconf Manual*).

When `yacc` is invoked, it is passed `AM_YFLAGS` and `YFLAGS`. The latter is a user variable and the former is intended for the `Makefile.am` author.

`AM_YFLAGS` is usually used to pass the `-d` option to `yacc`. Automake knows what this means and will automatically adjust its rules to update and distribute the header file built by `'yacc -d'`⁴. What Automake cannot guess, though, is where this header will be used: it

⁴ Please note that `automake` recognizes `-d` in `AM_YFLAGS` only if it is not clustered with other options; for example, it won't be recognized if `AM_YFLAGS` is `-dt`, but it will be if `AM_YFLAGS` is `-d -t` or `-t -d`.

is up to you to ensure the header gets built before it is first used. Typically this is necessary in order for dependency tracking to work when the header is included by another file. The common solution is listing the header file in `BUILT_SOURCES` (see Section 9.4 [Sources], page 85) as follows.

```
BUILT_SOURCES = parser.h
AM_YFLAGS = -d
bin_PROGRAMS = foo
foo_SOURCES = ... parser.y ...
```

If a `lex` source file is seen, then your `configure.ac` must define the variable `LEX`. You can use `AC_PROG_LEX` to do this (see Section “Particular Program Checks” in *The Autoconf Manual*), but using the `AM_PROG_LEX` macro (see Section 6.4 [Macros], page 45) is recommended.

When `lex` is invoked, it is passed `AM_LFLAGS` and `LFLAGS`. The latter is a user variable and the former is intended for the `Makefile.am` author.

When `AM_MAINTAINER_MODE` (see Section 26.2 [maintainer-mode], page 141) is used, the rebuild rule for distributed Yacc and Lex sources are only used when `maintainer-mode` is enabled, or when the files have been erased.

When `lex` or `yacc` sources are used, `automake -a` automatically installs an auxiliary program called `ylwrap` in your package (see Section 3.7 [Auxiliary Programs], page 24). This program is used by the build rules to rename the output of these tools, and makes it possible to include multiple `yacc` (or `lex`) source files in a single directory. (This is necessary because `yacc`’s output file name is fixed, and a parallel make could conceivably invoke more than one instance of `yacc` simultaneously.)

For `yacc`, simply managing locking is insufficient. The output of `yacc` always uses the same symbol names internally, so it isn’t possible to link two `yacc` parsers into the same executable.

We recommend using the following renaming hack used in `gdb`:

```
#define yymaxdepth c_maxdepth
#define yyparse c_parse
#define yylex c_lex
#define yyerror c_error
#define yylval c_lval
#define yychar c_char
#define yydebug c_debug
#define yypact c_pact
#define yyr1 c_r1
#define yyr2 c_r2
#define yydef c_def
#define yychk c_chk
#define yypgo c_pgo
#define yyact c_act
#define yyexca c_exca
#define yyerrflag c_errflag
#define yynerrs c_nerrs
#define yyps c_ps
```

```

#define yypv      c_pv
#define yys       c_s
#define yy_yps    c_yps
#define yyystate  c_state
#define yytmp     c_tmp
#define yyv       c_v
#define yy_yyv    c_yyv
#define yyval     c_val
#define yyllloc   c_llloc
#define yyreds    c_reds
#define yytoks    c_toks
#define yylhs     c_yylhs
#define yylen     c_yylen
#define yydefred  c_yydefred
#define yydgoto   c_yydgoto
#define yysindex  c_yysindex
#define yyrindex  c_yyrindex
#define yygindex  c_yygindex
#define yytable   c_yytable
#define yycheck   c_yycheck
#define yynname   c_yynname
#define yyrule    c_yyrule

```

For each define, replace the ‘c_’ prefix with whatever you like. These defines work for `bison`, `byacc`, and traditional `yaccs`. If you find a parser generator that uses a symbol not covered here, please report the new name so it can be added to the list.

8.9 C++ Support

Automake includes full support for C++.

Any package including C++ code must define the output variable `CXX` in `configure.ac`; the simplest way to do this is to use the `AC_PROG_CXX` macro (see Section “Particular Program Checks” in *The Autoconf Manual*).

A few additional variables are defined when a C++ source file is seen:

- `CXX` The name of the C++ compiler.
- `CXXFLAGS` Any flags to pass to the C++ compiler.
- `AM_CXXFLAGS` The maintainer’s variant of `CXXFLAGS`.
- `CXXCOMPILE` The command used to actually compile a C++ source file. The file name is appended to form the complete command line.
- `CXXLINK` The command used to actually link a C++ program.

8.10 Objective C Support

Automake includes some support for Objective C.

Any package including Objective C code must define the output variable `OBJC` in `configure.ac`; the simplest way to do this is to use the `AC_PROG_OBJC` macro (see Section “Particular Program Checks” in *The Autoconf Manual*).

A few additional variables are defined when an Objective C source file is seen:

`OBJC` The name of the Objective C compiler.

`OBJCFLAGS`

Any flags to pass to the Objective C compiler.

`AM_OBJCFLAGS`

The maintainer’s variant of `OBJCFLAGS`.

`OBJCCOMPILE`

The command used to actually compile an Objective C source file. The file name is appended to form the complete command line.

`OBJCLINK` The command used to actually link an Objective C program.

8.11 Objective C++ Support

Automake includes some support for Objective C++.

Any package including Objective C++ code must define the output variable `OBJCXX` in `configure.ac`; the simplest way to do this is to use the `AC_PROG_OBJCXX` macro (see Section “Particular Program Checks” in *The Autoconf Manual*).

A few additional variables are defined when an Objective C++ source file is seen:

`OBJCXX` The name of the Objective C++ compiler.

`OBJCXXFLAGS`

Any flags to pass to the Objective C++ compiler.

`AM_OBJCXXFLAGS`

The maintainer’s variant of `OBJCXXFLAGS`.

`OBJCXXCOMPILE`

The command used to actually compile an Objective C++ source file. The file name is appended to form the complete command line.

`OBJCXXLINK`

The command used to actually link an Objective C++ program.

8.12 Unified Parallel C Support

Automake includes some support for Unified Parallel C.

Any package including Unified Parallel C code must define the output variable `UPC` in `configure.ac`; the simplest way to do this is to use the `AM_PROG_UPC` macro (see Section 6.4.1 [Public Macros], page 45).

A few additional variables are defined when a Unified Parallel C source file is seen:

`UPC` The name of the Unified Parallel C compiler.

UPCFLAGS Any flags to pass to the Unified Parallel C compiler.

AM_UPCFLAGS

The maintainer's variant of **UPCFLAGS**.

UPCCOMPILE

The command used to actually compile a Unified Parallel C source file. The file name is appended to form the complete command line.

UPCLINK The command used to actually link a Unified Parallel C program.

8.13 Assembly Support

Automake includes some support for assembly code. There are two forms of assembler files: normal (**.s**) and preprocessed by **CPP** (**.S** or **.sx**).

The variable **CCAS** holds the name of the compiler used to build assembly code. This compiler must work a bit like a C compiler; in particular it must accept **-c** and **-o**. The values of **CCASFLAGS** and **AM_CCASFLAGS** (or its per-target definition) is passed to the compilation. For preprocessed files, **DEFS**, **DEFAULT_INCLUDES**, **INCLUDES**, **CPPFLAGS** and **AM_CPPFLAGS** are also used.

The autoconf macro **AM_PROG_AS** will define **CCAS** and **CCASFLAGS** for you (unless they are already set, it simply sets **CCAS** to the C compiler and **CCASFLAGS** to the C compiler flags), but you are free to define these variables by other means.

Only the suffixes **.s**, **.S**, and **.sx** are recognized by **automake** as being files containing assembly code.

8.14 Fortran 77 Support

Automake includes full support for Fortran 77.

Any package including Fortran 77 code must define the output variable **F77** in **configure.ac**; the simplest way to do this is to use the **AC_PROG_F77** macro (see Section "Particular Program Checks" in *The Autoconf Manual*).

A few additional variables are defined when a Fortran 77 source file is seen:

F77 The name of the Fortran 77 compiler.

FFLAGS Any flags to pass to the Fortran 77 compiler.

AM_FFLAGS

The maintainer's variant of **FFLAGS**.

RFLAGS Any flags to pass to the Ratfor compiler.

AM_RFLAGS

The maintainer's variant of **RFLAGS**.

F77COMPILE

The command used to actually compile a Fortran 77 source file. The file name is appended to form the complete command line.

FLINK The command used to actually link a pure Fortran 77 program or shared library.

Automake can handle preprocessing Fortran 77 and Ratfor source files in addition to compiling them⁵. Automake also contains some support for creating programs and shared libraries that are a mixture of Fortran 77 and other languages (see Section 8.14.3 [Mixing Fortran 77 With C and C++], page 78).

These issues are covered in the following sections.

8.14.1 Preprocessing Fortran 77

`N.f` is made automatically from `N.F` or `N.r`. This rule runs just the preprocessor to convert a preprocessable Fortran 77 or Ratfor source file into a strict Fortran 77 source file. The precise command used is as follows:

```
.F      $(F77) -F $(DEFS) $(INCLUDES) $(AM_CPPFLAGS) $(CPPFLAGS)
        $(AM_FFLAGS) $(FFLAGS)

.r      $(F77) -F $(AM_FFLAGS) $(FFLAGS) $(AM_RFLAGS) $(RFLAGS)
```

8.14.2 Compiling Fortran 77 Files

`N.o` is made automatically from `N.f`, `N.F` or `N.r` by running the Fortran 77 compiler. The precise command used is as follows:

```
.f      $(F77) -c $(AM_FFLAGS) $(FFLAGS)

.F      $(F77) -c $(DEFS) $(INCLUDES) $(AM_CPPFLAGS) $(CPPFLAGS)
        $(AM_FFLAGS) $(FFLAGS)

.r      $(F77) -c $(AM_FFLAGS) $(FFLAGS) $(AM_RFLAGS) $(RFLAGS)
```

8.14.3 Mixing Fortran 77 With C and C++

Automake currently provides *limited* support for creating programs and shared libraries that are a mixture of Fortran 77 and C and/or C++. However, there are many other issues related to mixing Fortran 77 with other languages that are *not* (currently) handled by Automake, but that are handled by other packages⁶.

Automake can help in two ways:

1. Automatic selection of the linker depending on which combinations of source code.
2. Automatic selection of the appropriate linker flags (e.g., `-L` and `-l`) to pass to the automatically selected linker in order to link in the appropriate Fortran 77 intrinsic and run-time libraries.

These extra Fortran 77 linker flags are supplied in the output variable `FLIBS` by the `AC_F77_LIBRARY_LDFLAGS` Autoconf macro. See Section “Fortran Compiler Characteristics” in *The Autoconf Manual*.

If Automake detects that a program or shared library (as mentioned in some `_PROGRAMS` or `_LTLIBRARIES` primary) contains source code that is a mixture of Fortran 77 and C and/or

⁵ Much, if not most, of the information in the following sections pertaining to preprocessing Fortran 77 programs was taken almost verbatim from Section “Catalogue of Rules” in *The GNU Make Manual*.

⁶ For example, the `cfortran` package (<https://www-zeus.desy.de/~burow/cfortran/>) addresses all of these inter-language issues, and runs under nearly all Fortran 77, C and C++ compilers on nearly all platforms. However, `cfortran` is not yet Free Software, but it will be in the next major release.

C++, then it requires that the macro `AC_F77_LIBRARY_LDFLAGS` be called in `configure.ac`, and that either `$(FLIBS)` appear in the appropriate `_LDADD` (for programs) or `_LIBADD` (for shared libraries) variables. It is the responsibility of the person writing the `Makefile.am` to make sure that `$(FLIBS)` appears in the appropriate `_LDADD` or `_LIBADD` variable.

For example, consider the following `Makefile.am`:

```
bin_PROGRAMS = foo
foo_SOURCES  = main.cc foo.f
foo_LDADD    = libfoo.la $(FLIBS)

pkglib_LTLIBRARIES = libfoo.la
libfoo_la_SOURCES  = bar.f baz.c zardoz.cc
libfoo_la_LIBADD   = $(FLIBS)
```

In this case, Automake will insist that `AC_F77_LIBRARY_LDFLAGS` is mentioned in `configure.ac`. Also, if `$(FLIBS)` hadn't been mentioned in `foo_LDADD` and `libfoo_la_LIBADD`, then Automake would have issued a warning.

8.14.3.1 How the Linker is Chosen

When a program or library mixes several languages, Automake chooses the linker according to the following priorities. (The names in parentheses are the variables containing the link command.)

1. Native Java (`GCJLINK`)
2. Objective C++ (`OBJCXXLINK`)
3. C++ (`CXXLINK`)
4. Fortran 77 (`F77LINK`)
5. Fortran (`FCLINK`)
6. Objective C (`OBJCLINK`)
7. Unified Parallel C (`UPCLINK`)
8. C (`LINK`)

For example, if Fortran 77, C and C++ source code is compiled into a program, then the C++ linker will be used. In this case, if the C or Fortran 77 linkers required any special libraries that weren't included by the C++ linker, then they must be manually added to an `_LDADD` or `_LIBADD` variable by the user writing the `Makefile.am`.

Automake only looks at the file names listed in `_SOURCES` variables to choose the linker, and defaults to the C linker. Sometimes this is inconvenient because you are linking against a library written in another language and would like to set the linker more appropriately. See Section 8.3.5 [Libtool Convenience Libraries], page 62, for a trick with `nodist_EXTRA_..._SOURCES`.

A per-target `_LINK` variable will override the above selection. Per-target link flags will cause Automake to write a per-target `_LINK` variable according to the language chosen as above.

8.15 Fortran 9x Support

Automake includes support for Fortran 9x.

Any package including Fortran 9x code must define the output variable `FC` in `configure.ac`; the simplest way to do this is to use the `AC_PROG_FC` macro (see Section “Particular Program Checks” in *The Autoconf Manual*).

A few additional variables are defined when a Fortran 9x source file is seen:

<code>FC</code>	The name of the Fortran 9x compiler.
<code>FCFLAGS</code>	Any flags to pass to the Fortran 9x compiler.
<code>AM_FCFLAGS</code>	The maintainer’s variant of <code>FCFLAGS</code> .
<code>FCCOMPILE</code>	The command used to actually compile a Fortran 9x source file. The file name is appended to form the complete command line.
<code>FCLINK</code>	The command used to actually link a pure Fortran 9x program or shared library.

8.15.1 Compiling Fortran 9x Files

`file.o` is made automatically from `file.f90`, `file.f95`, `file.f03`, or `file.f08` by running the Fortran 9x compiler. The precise command used is as follows:

```
.f90      $(FC) $(AM_FCFLAGS) $(FCFLAGS) -c $(FCFLAGS_f90) $<
.f95      $(FC) $(AM_FCFLAGS) $(FCFLAGS) -c $(FCFLAGS_f95) $<
.f03      $(FC) $(AM_FCFLAGS) $(FCFLAGS) -c $(FCFLAGS_f03) $<
.f08      $(FC) $(AM_FCFLAGS) $(FCFLAGS) -c $(FCFLAGS_f08) $<
```

8.16 Compiling Java sources using gcj

Automake includes support for natively compiled Java, using `gcj`, the Java front end to the GNU Compiler Collection (rudimentary support for compiling Java to bytecode using the `javac` compiler is also present, *albeit deprecated*; see Section 10.4 [Java], page 90).

Any package including Java code to be compiled must define the output variable `GCJ` in `configure.ac`; the variable `GCJFLAGS` must also be defined somehow (either in `configure.ac` or `Makefile.am`). The simplest way to do this is to use the `AM_PROG_GCJ` macro.

By default, programs including Java source files are linked with `gcj`.

As always, the contents of `AM_GCJFLAGS` are passed to every compilation invoking `gcj` (in its role as an ahead-of-time compiler, when invoking it to create `.class` files, `AM_JAVACFLAGS` is used instead). If it is necessary to pass options to `gcj` from `Makefile.am`, this variable, and not the user variable `GCJFLAGS`, should be used.

`gcj` can be used to compile `.java`, `.class`, `.zip`, or `.jar` files.

When linking, `gcj` requires that the main class be specified using the `--main=` option. The easiest way to do this is to use the `_LDFLAGS` variable for the program.

8.17 Vala Support

Automake provides initial support for Vala (<https://www.vala-project.org/>). This requires `valac` version 0.7.0 or later, and currently requires the user to use GNU `make`.

```
foo_SOURCES = foo.vala bar.vala zardoc.c
```

Any `.vala` file listed in a `_SOURCES` variable will be compiled into C code by the Vala compiler. The generated `.c` files are distributed. The end user does not need to have a Vala compiler installed.

Automake ships with an Autoconf macro called `AM_PROG_VALAC` that will locate the Vala compiler and optionally check its version number.

`AM_PROG_VALAC` (*[minimum-version]*, *[action-if-found]*, [Macro]
[action-if-not-found]) Search for a Vala compiler in `PATH`. If it is found, the variable `VALAC` is set to point to it (see below for more details). This macro takes three optional arguments. The first argument, if present, is the minimum version of the Vala API required to compile this package. For Vala releases, this is the same as the major and minor release number; e.g., when `valac --version` reports `0.48.7`, `valac --api-version` reports `0.48`. If a compiler is found and satisfies *minimum-version*, then *action-if-found* is run (this defaults to do nothing). Otherwise, *action-if-not-found* is run. If *action-if-not-found* is not specified, the default value is to print a warning in case no compiler is found, or if a too-old version of the compiler is found.

There are a few variables that are used when compiling Vala sources:

VALAC Absolute path to the Vala compiler, or simply `'valac'` if no suitable Vala compiler could be found at configure runtime.

VALAFLAGS Additional arguments for the Vala compiler.

AM_VALAFLAGS The maintainer's variant of `VALAFLAGS`.

```
lib_LTLIBRARIES = libfoo.la
libfoo_la_SOURCES = foo.vala
```

Note that currently, you cannot use per-target `*_VALAFLAGS` (see Section 26.7 [Renamed Objects], page 149) to produce different C files from one Vala source file.

8.18 Support for Other Languages

Automake currently only includes full support for C, C++ (see Section 8.9 [C++ Support], page 75), Objective C (see Section 8.10 [Objective C Support], page 76), Objective C++ (see Section 8.11 [Objective C++ Support], page 76), Fortran 77 (see Section 8.14 [Fortran 77 Support], page 77), Fortran 9x (see Section 8.15 [Fortran 9x Support], page 80), and Java (see Section 8.16 [Java Support with gcj], page 80). There is only rudimentary support for other languages, support for which will be improved based on user demand.

Some limited support for adding your own languages is available via the suffix rule handling (see Section 18.2 [Suffixes], page 125).

8.19 Automatic dependency tracking

As a developer it is often painful to continually update the `Makefile.am` whenever the include-file dependencies change in a project. Automake supplies a way to automatically track dependency changes (see Section 2.2.12 [Dependency Tracking], page 11).

Automake always uses complete dependencies for a compilation, including system headers. Automake’s model is that dependency computation should be a side effect of the build. To this end, dependencies are computed by running all compilations through a special wrapper program called `depcomp`. `depcomp` understands how to coax many different C and C++ compilers into generating dependency information in the format it requires. ‘`automake -a`’ will install `depcomp` into your source tree for you. If `depcomp` can’t figure out how to properly invoke your compiler, dependency tracking will simply be disabled for your build.

Experience with earlier versions of Automake (see Section “Dependency Tracking Evolution” in *Brief History of Automake*) taught us that it is not reliable to generate dependencies only on the maintainer’s system, as configurations vary too much. So instead Automake implements dependency tracking at build time.

Automatic dependency tracking can be suppressed by putting `no-dependencies` in the variable `AUTOMAKE_OPTIONS`, or passing `no-dependencies` as an argument to `AM_INIT_AUTOMAKE` (this should be the preferred way). Or, you can invoke `automake` with the `-i` option. Dependency tracking is enabled by default.

The person building your package also can choose to disable dependency tracking by configuring with `--disable-dependency-tracking`.

8.20 Support for executable extensions

On some platforms, such as Windows, executables are expected to have an extension such as `.exe`. On these platforms, some compilers (GCC among them) will automatically generate `foo.exe` when asked to generate `foo`.

Automake provides mostly-transparent support for this. Unfortunately *mostly* doesn’t yet mean *fully*. Until the English dictionary is revised, you will have to assist Automake if your package must support those platforms.

One thing you must be aware of is that, internally, Automake rewrites something like this:

```
bin_PROGRAMS = liver
```

to this:

```
bin_PROGRAMS = liver$(EXEEXT)
```

The targets Automake generates are likewise given the ‘`$(EXEEXT)`’ extension.

The variables `TESTS` and `XFAIL_TESTS` (see Section 15.2 [Simple Tests], page 105) are also rewritten if they contain filenames that have been declared as programs in the same `Makefile`. (This is mostly useful when some programs from `check_PROGRAMS` are listed in `TESTS`.)

However, Automake cannot apply this rewriting to `configure` substitutions. This means that if you are conditionally building a program using such a substitution, then your `configure.ac` must take care to add ‘`$(EXEEXT)`’ when constructing the output variable.

Sometimes maintainers like to write an explicit link rule for their program. Without executable extension support, this is easy—you simply write a rule whose target is the name of the program. However, when executable extension support is enabled, you must instead add the ‘\$(EXEEXT)’ suffix.

This might be a nuisance for maintainers who know their package will never run on a platform that has executable extensions. For those maintainers, the `no-exeext` option (see Chapter 17 [Options], page 120) will disable this feature. This works in a fairly ugly way; if `no-exeext` is seen, then the presence of a rule for a target named `foo` in `Makefile.am` will override an automake-generated rule for ‘`foo$(EXEEXT)`’. Without the `no-exeext` option, this use will give a diagnostic.

9 Other Derived Objects

Automake can handle derived objects that are not C programs. Sometimes the support for actually building such objects must be explicitly supplied, but Automake will still automatically handle installation and distribution.

9.1 Executable Scripts

It is possible to define and install programs that are scripts. Such programs are listed using the `SCRIPTS` primary name. When the script is distributed in its final, installable form, the `Makefile` usually looks as follows:

```
# Install my_script in $(bindir) and distribute it.
dist_bin_SCRIPTS = my_script
```

Scripts are not distributed by default; as we have just seen, those that should be distributed can be specified using a `dist_` prefix as with other primaries.

Scripts can be installed in `bindir`, `sbindir`, `libexecdir`, `pkglibexecdir`, or `pkgdatadir`.

Scripts that need not be installed can be listed in `noinst_SCRIPTS`, and among them, those which are needed only by ‘`make check`’ should go in `check_SCRIPTS`.

When a script needs to be built, the `Makefile.am` should include the appropriate rules. For instance the `automake` program itself is a Perl script that is generated from `automake.in`. Here is how this is handled:

```
bin_SCRIPTS = automake
CLEANFILES = $(bin_SCRIPTS)
EXTRA_DIST = automake.in

do_subst = sed -e 's,[@]datadir[@],$(datadir),g' \
             -e 's,[@]PERL[@],$(PERL),g' \
             -e 's,[@]PACKAGE[@],$(PACKAGE),g' \
             -e 's,[@]VERSION[@],$(VERSION),g' \
             ...

automake: automake.in Makefile
        $(do_subst) < $(srcdir)/automake.in > automake
```

```
chmod +x automake
```

Such scripts for which a build rule has been supplied need to be deleted explicitly using `CLEANFILES` (see Chapter 13 [Clean], page 98), and their sources have to be distributed, usually with `EXTRA_DIST` (see Section 14.1 [Basics of Distribution], page 98).

Another common way to build scripts is to process them from `configure` with `AC_CONFIG_FILES`. In this situation Automake knows which files should be cleaned and distributed, and what the rebuild rules should look like.

For instance if `configure.ac` contains

```
AC_CONFIG_FILES([src/my_script], [chmod +x src/my_script])
```

to build `src/my_script` from `src/my_script.in`, then a `src/Makefile.am` to install this script in `$(bindir)` can be as simple as

```
bin_SCRIPTS = my_script
CLEANFILES = $(bin_SCRIPTS)
```

There is no need for `EXTRA_DIST` or any build rule: Automake infers them from `AC_CONFIG_FILES` (see Section 6.1 [Requirements], page 30). `CLEANFILES` is still useful, because by default Automake will clean targets of `AC_CONFIG_FILES` in `distclean`, not `clean`.

Although this looks simpler, building scripts this way has one drawback: directory variables such as `$(datadir)` are not fully expanded and may refer to other directory variables.

9.2 Header files

Header files that must be installed are specified by the `HEADERS` family of variables. Headers can be installed in `includedir`, `oldincludedir`, `pkgincludedir` or any other directory you may have defined (see Section 3.3 [Uniform], page 21). For instance,

```
include_HEADERS = foo.h bar/bar.h
```

will install the two files as `$(includedir)/foo.h` and `$(includedir)/bar.h`.

The `nobase_` prefix is also supported:

```
nobase_include_HEADERS = foo.h bar/bar.h
```

will install the two files as `$(includedir)/foo.h` and `$(includedir)/bar/bar.h` (see Section 7.3 [Alternative], page 52).

Usually, only header files that accompany installed libraries need to be installed. Headers used by programs or convenience libraries are not installed. The `noinst_HEADERS` variable can be used for such headers. However when the header actually belongs to a single convenience library or program, we recommend listing it in the program's or library's `_SOURCES` variable (see Section 8.1.1 [Program Sources], page 55) instead of in `noinst_HEADERS`. This is clearer for the `Makefile.am` reader. `noinst_HEADERS` would be the right variable to use in a directory containing only headers and no associated library or program.

All header files must be listed somewhere; in a `_SOURCES` variable or in a `_HEADERS` variable. Missing ones will not appear in the distribution.

For header files that are built and must not be distributed, use the `nodist_` prefix as in `nodist_include_HEADERS` or `nodist_prog_SOURCES`. If these generated headers are needed during the build, you must also ensure they exist before they are used (see Section 9.4 [Sources], page 85).

9.3 Architecture-independent data files

Automake supports the installation of miscellaneous data files using the `DATA` family of variables.

Such data can be installed in the directories `datadir`, `sysconfdir`, `sharedstatedir`, `localstatedir`, or `pkgdatadir`.

By default, data files are *not* included in a distribution. Of course, you can use the `dist_` prefix to change this on a per-variable basis.

Here is how Automake declares its auxiliary data files:

```
dist_pkgdata_DATA = clean-kr.am clean.am ...
```

9.4 Built Sources

Because Automake's automatic dependency tracking works as a side-effect of compilation (see Section 8.19 [Dependencies], page 82) there is a bootstrap issue: a target should not be compiled before its dependencies are made, but these dependencies are unknown until the target is first compiled.

Ordinarily this is not a problem, because dependencies are distributed sources: they preexist and do not need to be built. Suppose that `foo.c` includes `foo.h`. When it first compiles `foo.o`, `make` only knows that `foo.o` depends on `foo.c`. As a side-effect of this compilation `depcomp` records the `foo.h` dependency so that following invocations of `make` will honor it. In these conditions, it's clear there is no problem: either `foo.o` doesn't exist and has to be built (regardless of the dependencies), or accurate dependencies exist and they can be used to decide whether `foo.o` should be rebuilt.

It's a different story if `foo.h` doesn't exist by the first `make` run. For instance, there might be a rule to build `foo.h`. This time `file.o`'s build will fail because the compiler can't find `foo.h`. `make` failed to trigger the rule to build `foo.h` first by lack of dependency information.

The `BUILT_SOURCES` variable is a workaround for this problem. A source file listed in `BUILT_SOURCES` is made when `'make all'`, `'make check'`, `'make install'`, `'make install-exec'` (or `make dist`) is run, before other targets are processed. However, such a source file is not *compiled* unless explicitly requested by mentioning it in some other `_SOURCES` variable.

So, to conclude our introductory example, we could use `'BUILT_SOURCES = foo.h'` to ensure `foo.h` gets built before any other target (including `foo.o`) during `'make all'` or `'make check'`.

`BUILT_SOURCES` is actually a bit of a misnomer, as any file which must be created early in the build process can be listed in this variable. Moreover, all built sources do not necessarily have to be listed in `BUILT_SOURCES`. For instance, a generated `.c` file doesn't need to appear in `BUILT_SOURCES` (unless it is included by another source), because it's a known dependency of the associated object.

To emphasize, `BUILT_SOURCES` is honored only by `'make all'`, `'make check'`, `'make install'`, and `make install-exec` (and `'make dist'`). This means you cannot build an arbitrary target (e.g., `'make foo'`) in a clean tree if it depends on a built source. However it will succeed if you have run `'make all'` earlier, because accurate dependencies are already available.

The next section illustrates and discusses the handling of built sources on a toy example.

9.4.1 Built Sources Example

Suppose that `foo.c` includes `bindir.h`, which is installation-dependent and not distributed: it needs to be built. Here `bindir.h` defines the preprocessor macro `bindir` to the value of the `make` variable `bindir` (inherited from `configure`).

We suggest several implementations below. It's not meant to be an exhaustive listing of all ways to handle built sources, but it will give you a few ideas if you encounter this issue.

First Try

This first implementation will illustrate the bootstrap issue mentioned in the previous section (see Section 9.4 [Sources], page 85).

Here is a tentative `Makefile.am`.

```
# This won't work.
bin_PROGRAMS = foo
foo_SOURCES = foo.c
nodist_foo_SOURCES = bindir.h
CLEANFILES = bindir.h
bindir.h: Makefile
    echo '#define bindir "$(bindir)"' >${@}
```

This setup doesn't work, because Automake doesn't know that `foo.c` includes `bindir.h`. Remember, automatic dependency tracking works as a side-effect of compilation, so the dependencies of `foo.o` will be known only after `foo.o` has been compiled (see Section 8.19 [Dependencies], page 82). The symptom is as follows.

```
% make
source='foo.c' object='foo.o' libtool=no \
depfile='.deps/foo.Po' tmpdepfile='.deps/foo.TPo' \
depmode=gcc /bin/sh ./depcomp \
gcc -I. -I. -g -O2 -c 'test -f 'foo.c' || echo './'foo.c
foo.c:2: bindir.h: No such file or directory
make: *** [foo.o] Error 1
```

In this example `bindir.h` is not distributed nor installed, and it is not even being built on-time. One may wonder if the `'nodist_foo_SOURCES = bindir.h'` line has any use at all. This line simply states that `bindir.h` is a source of `foo`, so for instance, it should be inspected while generating tags (see Section 18.1 [Tags], page 124). In other words, it does not help our present problem, and the build would fail identically without it.

Using BUILT_SOURCES

A solution is to require `bindir.h` to be built before anything else. This is what `BUILT_SOURCES` is meant for (see Section 9.4 [Sources], page 85).

```
bin_PROGRAMS = foo
foo_SOURCES = foo.c
nodist_foo_SOURCES = bindir.h
BUILT_SOURCES = bindir.h
CLEANFILES = bindir.h
```

```
bindir.h: Makefile
        echo '#define bindir "$(bindir)">' >$@
```

See how `bindir.h` gets built first:

```
% make
echo '#define bindir "/usr/local/bin"' >bindir.h
make all-am
make[1]: Entering directory '/home/adl/tmp'
source='foo.c' object='foo.o' libtool=no \
depfile='.deps/foo.Po' tmpdepfile='.deps/foo.TPo' \
depmode=gcc /bin/sh ./depcomp \
gcc -I. -I. -g -O2 -c 'test -f 'foo.c' || echo './'foo.c
gcc -g -O2 -o foo foo.o
make[1]: Leaving directory '/home/adl/tmp'
```

However, as said earlier, `BUILT_SOURCES` applies only to the `all`, `check`, and `install` targets. It still fails if you try to run `'make foo'` explicitly:

```
% make clean
test -z "bindir.h" || rm -f bindir.h
test -z "foo" || rm -f foo
rm -f *.o
% : > .deps/foo.Po # Suppress previously recorded dependencies
% make foo
source='foo.c' object='foo.o' libtool=no \
depfile='.deps/foo.Po' tmpdepfile='.deps/foo.TPo' \
depmode=gcc /bin/sh ./depcomp \
gcc -I. -I. -g -O2 -c 'test -f 'foo.c' || echo './'foo.c
foo.c:2: bindir.h: No such file or directory
make: *** [foo.o] Error 1
```

Recording Dependencies manually

Usually people are happy enough with `BUILT_SOURCES` because they never build targets such as `'make foo'` before `'make all'`, as in the previous example. However if this matters to you, you can avoid `BUILT_SOURCES` and record such dependencies explicitly in the `Makefile.am`.

```
bin_PROGRAMS = foo
foo_SOURCES = foo.c
nodist_foo_SOURCES = bindir.h
foo.$(OBJEXT): bindir.h
CLEANFILES = bindir.h
bindir.h: Makefile
        echo '#define bindir "$(bindir)">' >$@
```

You don't have to list *all* the dependencies of `foo.o` explicitly, only those that might need to be built. If a dependency already exists, it will not hinder the first compilation and will be recorded by the normal dependency tracking code. (Note that after this first compilation the dependency tracking code will also have recorded the dependency between `foo.o` and `bindir.h`, so our explicit dependency is really useful to the first build only.)

Adding explicit dependencies like this can be a bit dangerous if you are not careful enough. This is due to the way Automake tries not to overwrite your rules (it assumes you know better than it). `foo.$(OBJEXT): bindir.h` supersedes any rule Automake may want to output to build `foo.$(OBJEXT)`. It happens to work in this case because Automake doesn't have to output any `foo.$(OBJEXT):` target: it relies on a suffix rule instead (i.e., `.c.$(OBJEXT):`). Always check the generated `Makefile.in` if you do this.

Build `bindir.h` from `configure`

It's possible to define this preprocessor macro from `configure`, either in `config.h` (see Section "Defining Directories" in *The Autoconf Manual*), or by processing a `bindir.h.in` file using `AC_CONFIG_FILES` (see Section "Configuration Actions" in *The Autoconf Manual*).

At this point it should be clear that building `bindir.h` from `configure` works well for this example. `bindir.h` will exist before you build any target, hence will not cause any dependency issue.

The Makefile can be shrunk as follows. We do not even have to mention `bindir.h`.

```
bin_PROGRAMS = foo
foo_SOURCES = foo.c
```

However, it's not always possible to build sources from `configure`, especially when these sources are generated by a tool that needs to be built first.

Build `bindir.c`, not `bindir.h`.

Another attractive idea is to define `bindir` as a variable or function exported from `bindir.o`, and build `bindir.c` instead of `bindir.h`.

```
noinst_PROGRAMS = foo
foo_SOURCES = foo.c bindir.h
nodist_foo_SOURCES = bindir.c
CLEANFILES = bindir.c
bindir.c: Makefile
    echo 'const char bindir[] = "$(bindir)";' > $@
```

`bindir.h` contains just the variable's declaration and doesn't need to be built, so it won't cause any trouble. `bindir.o` is always dependent on `bindir.c`, so `bindir.c` will get built first.

Which is best?

There is no panacea, of course. Each solution has its merits and drawbacks.

You cannot use `BUILT_SOURCES` if the ability to run `'make foo'` on a clean tree is important to you.

You won't add explicit dependencies if you are leery of overriding an Automake rule by mistake.

Building files from `./configure` is not always possible, neither is converting `.h` files into `.c` files.

10 Other GNU Tools

Since Automake is primarily intended to generate `Makefile.ins` for use in GNU programs, it tries hard to interoperate with other GNU tools.

10.1 Emacs Lisp

Automake provides some support for Emacs Lisp. The `LISP` primary is used to hold a list of `.el` files. Possible prefixes for this primary are `lisp_` and `noinst_`. Note that if `lisp_LISP` is defined, then `configure.ac` must run `AM_PATH_LISPDIR` (see Section 6.4 [Macros], page 45).

Lisp sources are not distributed by default. You can prefix the `LISP` primary with `dist_`, as in `dist_lisp_LISP` or `dist_noinst_LISP`, to indicate that these files should be distributed.

Automake will byte-compile all Emacs Lisp source files using the Emacs found by `AM_PATH_LISPDIR`, if any was found. When performing such byte-compilation, the flags specified in the (developer-reserved) `AM_ELCFLAGS` and (user-reserved) `ELCFLAGS` make variables will be passed to the Emacs invocation.

Byte-compiled Emacs Lisp files are not portable among all versions of Emacs, so it makes sense to turn this off if you expect sites to have more than one version of Emacs installed. Furthermore, many packages don't actually benefit from byte-compilation. Still, we recommend that you byte-compile your Emacs Lisp sources. It is probably better for sites with strange setups to cope for themselves than to make the installation less nice for everybody else.

There are two ways to avoid byte-compiling. Historically, we have recommended the following construct.

```
lisp_LISP = file1.el file2.el
ELCFILES =
```

`ELCFILES` is an internal Automake variable that normally lists all `.elc` files that must be byte-compiled. Automake defines `ELCFILES` automatically from `lisp_LISP`. Emptying this variable explicitly prevents byte-compilation.

Since Automake 1.8, we now recommend using `lisp_DATA` instead:

```
lisp_DATA = file1.el file2.el
```

Note that these two constructs are not equivalent. `_LISP` will not install a file if Emacs is not installed, while `_DATA` will always install its files.

10.2 Gettext

If `AM_GNU_GETTEXT` is seen in `configure.ac`, then Automake turns on support for GNU gettext, a message catalog system for internationalization (see Section “Introduction” in *GNU gettext utilities*).

The `gettext` support in Automake requires the addition of one or two subdirectories to the package: `po` and possibly also `intl`. The latter is needed if `AM_GNU_GETTEXT` is not invoked with the ‘external’ argument, or if `AM_GNU_GETTEXT_INTL_SUBDIR` is used. Automake ensures that these directories exist and are mentioned in `SUBDIRS`.

10.3 Libtool

Automake provides support for GNU Libtool (see Section “Introduction” in *The Libtool Manual*) with the `LT_LIBRARIES` primary. See Section 8.3 [A Shared Library], page 59.

10.4 Java bytecode compilation (deprecated)

Automake provides some minimal support for Java bytecode compilation with the `JAVA` primary (in addition to the support for compiling Java to native machine code; see Section 8.16 [Java Support with `gcj`], page 80). Note however that *the interface and most features described here are deprecated*. Future Automake releases will strive to provide a better and cleaner interface, which however *won't be backward-compatible*; the present interface will probably be removed altogether some time after the introduction of the new interface (if that ever materializes). In any case, the current `JAVA` primary features are frozen and will no longer be developed, not even to take bug fixes.

Any `.java` files listed in a `_JAVA` variable will be compiled with `JAVAC` at build time. By default, `.java` files are not included in the distribution; you should use the `dist_` prefix to distribute them.

Here is a typical setup for distributing `.java` files and installing the `.class` files resulting from their compilation.

```
javadir = $(datadir)/java
dist_java_JAVA = a.java b.java ...
```

Currently Automake enforces the restriction that only one `_JAVA` primary can be used in a given `Makefile.am`. The reason for this restriction is that, in general, it isn't possible to know which `.class` files were generated from which `.java` files, so it would be impossible to know which files to install where. For instance, a `.java` file can define multiple classes; the resulting `.class` file names cannot be predicted without parsing the `.java` file.

There are a few variables that are used when compiling Java sources:

JAVAC The name of the Java compiler. This defaults to `'javac'`.

JAVACFLAGS

The flags to pass to the compiler. This is considered to be a user variable (see Section 3.6 [User Variables], page 23).

AM_JAVACFLAGS

More flags to pass to the Java compiler. This, and not `JAVACFLAGS`, should be used when it is necessary to put Java compiler flags into `Makefile.am`.

JAVAROOT The value of this variable is passed to the `-d` option to `javac`. It defaults to `'$(top_builddir)'`.

CLASSPATH_ENV

This variable is a shell expression that is used to set the `CLASSPATH` environment variable on the `javac` command line. (In the future we will probably handle class path setting differently.)

10.5 Python

Automake provides support for Python compilation with the `PYTHON` primary. A typical setup is to call `AM_PATH_PYTHON` in `configure.ac` and use a line like the following in `Makefile.am`:

```
python_PYTHON = tree.py leave.py
```

Any files listed in a `_PYTHON` variable will be byte-compiled with `py-compile` at install time. `py-compile` actually creates both standard (`.pyc`) and optimized (`.pyo`) byte-compiled versions of the source files. Note that because byte-compilation occurs at install time, any files listed in `noinst_PYTHON` will not be compiled. Python source files are included in the distribution by default; prepend `nodist_` (as in `nodist_python_PYTHON`) to omit them.

Automake ships with an Autoconf macro called `AM_PATH_PYTHON` that will determine some Python-related directory variables (see below). If you have called `AM_PATH_PYTHON` from `configure.ac`, then you may use the variables `python_PYTHON` or `pkgpython_PYTHON` to list Python source files in your `Makefile.am`, depending on where you want your files installed (see the definitions of `pythondir` and `pkgpythondir` below).

`AM_PATH_PYTHON` (*[version]*, *[action-if-found]*, [Macro]
[action-if-not-found])

Search for a Python interpreter on the system. This macro takes three optional arguments. The first argument, if present, is the minimum version of Python required for this package: `AM_PATH_PYTHON` will skip any Python interpreter that is older than *version*. If an interpreter is found and satisfies *version*, then *action-if-found* is run. Otherwise, *action-if-not-found* is run.

If *action-if-not-found* is not specified, as in the following example, the default is to abort `configure`.

```
AM_PATH_PYTHON([2.2])
```

This is fine when Python is an absolute requirement for the package. If Python ≥ 2.5 was only *optional* to the package, `AM_PATH_PYTHON` could be called as follows.

```
AM_PATH_PYTHON([2.5],,[:])
```

If the `PYTHON` variable is set when `AM_PATH_PYTHON` is called, then that will be the only Python interpreter that is tried.

`AM_PATH_PYTHON` creates the following output variables based on the Python installation found during configuration.

PYTHON The name of the Python executable, or `‘.’` if no suitable interpreter could be found.

Assuming *action-if-not-found* is used (otherwise `./configure` will abort if Python is absent), the value of `PYTHON` can be used to set up a conditional in order to disable the relevant part of a build as follows.

```
AM_PATH_PYTHON(,[:])
AM_CONDITIONAL([HAVE_PYTHON], [test "$PYTHON" != :])
```

PYTHON_VERSION

The Python version number, in the form *major.minor* (e.g., `‘2.5’`). This is currently the value of `‘%u.%u’ % sys.version_info[:2]`.

PYTHON_PREFIX

The string ‘`{prefix}`’. This term may be used in future work that needs the contents of Python’s ‘`sys.prefix`’, but general consensus is to always use the value from `configure`.

PYTHON_EXEC_PREFIX

The string ‘`{exec_prefix}`’. This term may be used in future work that needs the contents of Python’s ‘`sys.exec_prefix`’, but general consensus is to always use the value from `configure`.

PYTHON_PLATFORM

The canonical name used by Python to describe the operating system, as given by ‘`sys.platform`’. This value is sometimes needed when building Python extensions.

pythondir

The directory name for the `site-packages` subdirectory of the standard Python install tree.

pkgpythondir

This is the directory under `pythondir` that is named after the package. That is, it is ‘`{pythondir}/{PACKAGE}`’. It is provided as a convenience.

pyexecdir

This is the directory where Python extension modules (shared libraries) should be installed. An extension module written in C could be declared as follows to Automake:

```
pyexec_LTLIBRARIES = quaternion.la
quaternion_la_SOURCES = quaternion.c support.c support.h
quaternion_la_LDFLAGS = -avoid-version -module
```

pkgpyexecdir

This is a convenience variable that is defined as ‘`{pyexecdir}/{PACKAGE}`’.

All of these directory variables have values that start with either ‘`{prefix}`’ or ‘`{exec_prefix}`’ unexpanded. This works fine in `Makefiles`, but it makes these variables hard to use in `configure`. This is mandated by the GNU coding standards, so that the user can run ‘`make prefix=/foo install`’. The Autoconf manual has a section with more details on this topic (see Section “Installation Directory Variables” in *The Autoconf Manual*). See also Section 26.10 [Hard-Coded Install Paths], page 155.

11 Building documentation

Currently Automake provides support for Texinfo and man pages.

11.1 Texinfo

If the current directory contains Texinfo source, you must declare it with the `TEXINFOS` primary. Generally Texinfo files are converted into info, and thus the `info_TEXINFOS` variable is most commonly used here. Any Texinfo source file should have the `.texi` extension.

Automake also accepts `.txi` or `.texinfo` extensions, but their use is discouraged now, and will elicit runtime warnings.

Automake generates rules to build `.info`, `.dvi`, `.ps`, `.pdf` and `.html` files from your Texinfo sources. Following the GNU Coding Standards, only the `.info` files are built by `'make all'` and installed by `'make install'` (unless you use `no-installinfo`, see below). Furthermore, `.info` files are automatically distributed so that Texinfo is not a prerequisite for installing your package.

It is worth noting that, contrary to what happens with the other formats, the generated `.info` files are by default placed in `srcdir` rather than in the `builddir`. This can be changed with the `info-in-builddir` option.

Other documentation formats can be built on request by `'make dvi'`, `'make ps'`, `'make pdf'` and `'make html'`, and they can be installed with `'make install-dvi'`, `'make install-ps'`, `'make install-pdf'` and `'make install-html'` explicitly. `'make uninstall'` will remove everything: the Texinfo documentation installed by default as well as all the above optional formats.

All of these targets can be extended using `'-local'` rules (see Section 22.1 [Extending], page 133).

If the `.texi` file `@includes version.texi`, then that file will be automatically generated. The file `version.texi` defines four Texinfo flags you can reference using `@value{EDITION}`, `@value{VERSION}`, `@value{UPDATED}`, and `@value{UPDATED-MONTH}`.

EDITION

VERSION Both of these flags hold the version number of your program. They are kept separate for clarity.

UPDATED This holds the date the primary `.texi` file was last modified.

UPDATED-MONTH

This holds the name of the month in which the primary `.texi` file was last modified.

The `version.texi` support requires the `mdate-sh` script; this script is supplied with Automake and automatically included when `automake` is invoked with the `--add-missing` option.

If you have multiple Texinfo files, and you want to use the `version.texi` feature, then you have to have a separate version file for each Texinfo file. Automake will treat any include in a Texinfo file that matches `vers*.texi` just as an automatically generated version file.

Sometimes an info file actually depends on more than one `.texi` file. For instance, in GNU Hello, `hello.texi` includes the file `fdl.texi`. You can tell Automake about these dependencies using the `texi_TEXINFOS` variable. Here is how GNU Hello does it:

```
info_TEXINFOS = hello.texi
hello_TEXINFOS = fdl.texi
```

By default, Automake requires the file `texinfo.tex` to appear in the same directory as the `Makefile.am` file that lists the `.texi` files. If you used `AC_CONFIG_AUX_DIR` in `configure.ac` (see Section “Finding ‘configure’ Input” in *The Autoconf Manual*), then `texinfo.tex` is looked for there. In both cases, `automake` then supplies `texinfo.tex` if

`--add-missing` is given, and takes care of its distribution. However, if you set the `TEXINFO_TEX` variable (see below), it overrides the location of the file and turns off its installation into the source as well as its distribution.

The option `no-texinfo.tex` can be used to eliminate the requirement for the file `texinfo.tex`. Use of the variable `TEXINFO_TEX` is preferable, however, because that allows the `dvi`, `ps`, and `pdf` targets to still work.

Automake generates an `install-info` rule; some people apparently use this. By default, info pages are installed by `make install`, so running `make install-info` is pointless. This can be prevented via the `no-installinfo` option. In this case, `.info` files are not installed by default, and user must request this explicitly using `make install-info`.

By default, `make install-info` and `make uninstall-info` will try to run the `install-info` program (if available) to update (or create/remove) the `$(infodir)/dir` index. If this is undesired, it can be prevented by exporting the `AM_UPDATE_INFO_DIR` variable to `"no"`.

The following variables are used by the Texinfo build rules.

MAKEINFO The name of the program invoked to build `.info` files. This variable is defined by Automake. If the `makeinfo` program is found on the system then it will be used by default; otherwise `missing` will be used instead.

MAKEINFOHTML

The command invoked to build `.html` files. Automake defines this to `$(MAKEINFO) --html`.

MAKEINFOFLAGS

User flags passed to each invocation of `$(MAKEINFO)` and `$(MAKEINFOHTML)`. This user variable (see Section 3.6 [User Variables], page 23) is not expected to be defined in any `Makefile`; it can be used by users to pass extra flags to suit their needs.

AM_MAKEINFOFLAGS

AM_MAKEINFOHTMLFLAGS

Maintainer flags passed to each `makeinfo` invocation. Unlike `MAKEINFOFLAGS`, these variables are meant to be defined by maintainers in `Makefile.am`. `$(AM_MAKEINFOFLAGS)` is passed to `makeinfo` when building `.info` files; and `$(AM_MAKEINFOHTMLFLAGS)` is used when building `.html` files.

For instance, the following setting can be used to obtain one single `.html` file per manual, without node separators.

```
AM_MAKEINFOHTMLFLAGS = --no-headers --no-split
```

`AM_MAKEINFOHTMLFLAGS` defaults to `$(AM_MAKEINFOFLAGS)`. This means that defining `AM_MAKEINFOFLAGS` without defining `AM_MAKEINFOHTMLFLAGS` will impact builds of both `.info` and `.html` files.

TEXI2DVI The name of the command that converts a `.texi` file into a `.dvi` file. This defaults to `texi2dvi`, a script that ships with the Texinfo package.

TEXI2PDF The name of the command that translates a `.texi` file into a `.pdf` file. This defaults to `$(TEXI2DVI) --pdf --batch`.

DVIPS The name of the command that builds a `.ps` file out of a `.dvi` file. This defaults to `'dvips'`.

TEXINFO_TEX

If your package has Texinfo files in many directories, you can use the variable `TEXINFO_TEX` to tell Automake where to find the canonical `texinfo.tex` for your package. The value of this variable should be the relative path from the current `Makefile.am` to `texinfo.tex`:

```
TEXINFO_TEX = ../doc/texinfo.tex
```

11.2 Man Pages

A package can also include man pages (but see the GNU standards on this matter, Section “Man Pages” in *The GNU Coding Standards*.) Man pages are declared using the `MANS` primary. Generally the `man_MANS` variable is used. Man pages are automatically installed in the correct subdirectory of `mandir`, based on the file extension.

File extensions such as `.1c` are handled by looking for the valid part of the extension and using that to determine the correct subdirectory of `mandir`. Valid section names are the digits ‘0’ through ‘9’, and the letters ‘l’ and ‘n’.

Sometimes developers prefer to name a man page something like `foo.man` in the source, and then rename it to have the correct suffix, for example `foo.1`, when installing the file. Automake also supports this mode. For a valid section named *section*, there is a corresponding directory named `'mansectiondir'`, and a corresponding `_MANS` variable. Files listed in such a variable are installed in the indicated section. If the file already has a valid suffix, then it is installed as-is; otherwise the file suffix is changed to match the section.

For instance, consider this example:

```
man1_MANS = rename.man thesame.1 alsothesame.1c
```

In this case, `rename.man` will be renamed to `rename.1` when installed, but the other files will keep their names.

By default, man pages are installed by `'make install'`. However, since the GNU project does not require man pages, many maintainers do not expend effort to keep the man pages up to date. In these cases, the `no-installman` option will prevent the man pages from being installed by default. The user can still explicitly install them via `'make install-man'`.

For fast installation, with many files it is preferable to use `'mansection_MANS'` over `'man_MANS'` as well as files that do not need to be renamed.

Man pages are not currently considered to be source, because it is not uncommon for man pages to be automatically generated. Therefore they are not automatically included in the distribution. However, this can be changed by use of the `dist_` prefix. For instance here is how to distribute and install the two man pages of GNU `cpio` (which includes both Texinfo documentation and man pages):

```
dist_man_MANS = cpio.1 mt.1
```

The `nobase_` prefix is meaningless for man pages and is disallowed.

Executables and manpages may be renamed upon installation (see Section 2.2.9 [Renaming], page 10). For manpages this can be avoided by use of the `notrans_` prefix. For

instance, suppose an executable ‘foo’ allowing to access a library function ‘foo’ from the command line. The way to avoid renaming of the `foo.3` manpage is:

```
man_MANS = foo.1
notrans_man_MANS = foo.3
```

‘notrans_’ must be specified first when used in conjunction with either ‘dist_’ or ‘nodist_’ (see Section 14.2 [Fine-grained Distribution Control], page 99). For instance:

```
notrans_dist_man3_MANS = bar.3
```

12 What Gets Installed

Naturally, Automake handles the details of actually installing your program once it has been built. All files named by the various primaries are automatically installed in the appropriate places when the user runs ‘make install’.

12.1 Basics of Installation

A file named in a primary is installed by copying the built file into the appropriate directory. The base name of the file is used when installing.

```
bin_PROGRAMS = hello subdir/goodbye
```

In this example, both ‘hello’ and ‘goodbye’ will be installed in ‘\$(bindir)’.

Sometimes it is useful to avoid the basename step at install time. For instance, you might have a number of header files in subdirectories of the source tree that are laid out precisely how you want to install them. In this situation you can use the `nobase_` prefix to suppress the base name step. For example:

```
nobase_include_HEADERS = stdio.h sys/types.h
```

will install `stdio.h` in ‘\$(includedir)’ and `types.h` in ‘\$(includedir)/sys’.

For most file types, Automake will install multiple files at once, while avoiding command line length issues (see Section 3.4 [Length Limitations], page 22). Since some `install` programs will not install the same file twice in one invocation, you may need to ensure that file lists are unique within one variable such as ‘`nobase_include_HEADERS`’ above.

You should not rely on the order in which files listed in one variable are installed. Likewise, to cater for parallel make, you should not rely on any particular file installation order even among different file types (library dependencies are an exception here).

12.2 The Two Parts of Install

Automake generates separate `install-data` and `install-exec` rules, in case the installer is installing on multiple machines that share directory structure—these targets allow the machine-independent parts to be installed only once. `install-exec` installs platform-dependent files, and `install-data` installs platform-independent files. The `install` target depends on both of these targets. While Automake tries to automatically segregate objects into the correct category, the `Makefile.am` author is, in the end, responsible for making sure this is done correctly.

Variables using the standard directory prefixes ‘data’, ‘info’, ‘man’, ‘include’, ‘oldinclude’, ‘pkgdata’, or ‘pkginclude’ are installed by `install-data`.

Variables using the standard directory prefixes ‘bin’, ‘sbin’, ‘libexec’, ‘sysconf’, ‘localstate’, ‘lib’, or ‘pkglib’ are installed by `install-exec`.

For instance, `data_DATA` files are installed by `install-data`, while `bin_PROGRAMS` files are installed by `install-exec`.

Any variable using a user-defined directory prefix with ‘exec’ in the name (e.g., `myexecbin_PROGRAMS`) is installed by `install-exec`. All other user-defined prefixes are installed by `install-data`.

12.3 Extending Installation

It is possible to extend this mechanism by defining an `install-exec-local` or `install-data-local` rule. If these rules exist, they will be run at ‘make install’ time. These rules can do almost anything; care is required.

Automake also supports two install hooks, `install-exec-hook` and `install-data-hook`. These hooks are run after all other install rules of the appropriate type, `exec` or `data`, have completed. So, for instance, it is possible to perform post-installation modifications using an install hook. See Section 22.1 [Extending], page 133, for some examples.

12.4 Staged Installs

Automake generates support for the `DESTDIR` variable in all install rules. `DESTDIR` is used during the ‘make install’ step to relocate install objects into a staging area. Each object and path is prefixed with the value of `DESTDIR` before being copied into the install area. Here is an example of typical `DESTDIR` usage:

```
mkdir /tmp/staging &&
make DESTDIR=/tmp/staging install
```

The `mkdir` command avoids a security problem if the attacker creates a symbolic link from `/tmp/staging` to a victim area; then `make` places install objects in a directory tree built under `/tmp/staging`. If `/gnu/bin/foo` and `/gnu/share/aclocal/foo.m4` are to be installed, the above command would install `/tmp/staging/gnu/bin/foo` and `/tmp/staging/gnu/share/aclocal/foo.m4`.

This feature is commonly used to build install images and packages (see Section 2.2.10 [DESTDIR], page 10).

Support for `DESTDIR` is implemented by coding it directly into the install rules. If your `Makefile.am` uses a local install rule (e.g., `install-exec-local`) or an install hook, then you must write that code to respect `DESTDIR`.

See Section “Makefile Conventions” in *The GNU Coding Standards*, for another usage example.

12.5 Install Rules for the User

Automake also generates rules for targets `uninstall`, `installdirs`, and `install-strip`.

Automake supports `uninstall-local` and `uninstall-hook`. There is no notion of separate uninstalls for “exec” and “data”, as these features would not provide additional functionality.

Note that `uninstall` is not meant as a replacement for a real packaging tool.

13 What Gets Cleaned

The GNU Makefile Standards specify a number of different clean rules. See Section “Standard Targets for Users” in *The GNU Coding Standards*.

Generally the files that can be cleaned are determined automatically by Automake. Of course, Automake also recognizes some variables that can be defined to specify additional files to clean. These variables are `MOSTLYCLEANFILES`, `CLEANFILES`, `DISTCLEANFILES`, and `MAINTAINERCLEANFILES`.

When cleaning involves more than deleting some hard-coded list of files, it is also possible to supplement the cleaning rules with your own commands. Simply define a rule for any of the `mostlyclean-local`, `clean-local`, `distclean-local`, or `maintainer-clean-local` targets (see Section 22.1 [Extending], page 133). A common case is deleting a directory, for instance, a directory created by the test suite:

```
clean-local:
    -rm -rf testSubDir
```

Since `make` allows only one set of rules for a given target, a more extensible way of writing this is to use a separate target listed as a dependency:

```
clean-local: clean-local-check
.PHONY: clean-local-check
clean-local-check:
    -rm -rf testSubDir
```

As the GNU Standards aren’t always explicit as to which files should be removed by which rule, we’ve adopted a heuristic that we believe was first formulated by François Pinard:

- If `make` built it, and it is commonly something that one would want to rebuild (for instance, a `.o` file), then `mostlyclean` should delete it.
- Otherwise, if `make` built it, then `clean` should delete it.
- If `configure` built it, then `distclean` should delete it.
- If the maintainer built it (for instance, a `.info` file), then `maintainer-clean` should delete it. However `maintainer-clean` should not delete anything that needs to exist in order to run ‘`./configure && make`’.

We recommend that you follow this same set of heuristics in your `Makefile.am`.

14 What Goes in a Distribution

14.1 Basics of Distribution

The `dist` rule in the generated `Makefile.in` can be used to generate a gzipped `tar` file and other flavors of archive for distribution. The file is named based on the `PACKAGE` and `VERSION` variables automatically defined by either the `AC_INIT` invocation or by a *deprecated* two-arguments invocation of the `AM_INIT_AUTOMAKE` macro (see Section 6.4.1 [Public Macros], page 45, for how these variables get their values, from either defaults or explicit values—it’s slightly trickier than one would expect). More precisely the gzipped `tar` file is named ‘`${PACKAGE}-${VERSION}.tar.gz`’.

You can use the `make` variable `GZIP_ENV` to control how `gzip` is run. The default setting is `--best`.

You can set the environment variable `TAR` to override the tar program used; it defaults to `tar`.

For the most part, the files to distribute are automatically found by Automake: all source files are automatically included in a distribution, as are all `Makefile.am` and `Makefile.in` files. Automake also has a built-in list of commonly used files that are automatically included if they are found in the current directory (either physically, or as the target of a `Makefile.am` rule); this list is printed by `'automake --help'`. Note that some files in this list are actually distributed only if other certain conditions hold (for example, the `config.h.top` and `config.h.bot` files are automatically distributed only if, e.g., `'AC_CONFIG_HEADERS([config.h])'` is used in `configure.ac`). Also, files that are read by `configure` (i.e. the source files corresponding to the files specified in various Autoconf macros such as `AC_CONFIG_FILES` and siblings) are automatically distributed. Files included in a `Makefile.am` (using `include`) or in `configure.ac` (using `m4_include`), and helper scripts installed with `'automake --add-missing'` are also distributed.

Still, sometimes there are files that must be distributed, but which are not covered in the automatic rules. These files should be listed in the `EXTRA_DIST` variable. You can mention files from subdirectories in `EXTRA_DIST`.

You can also mention a directory in `EXTRA_DIST`; in this case the entire directory will be recursively copied into the distribution. Please note that this will also copy *everything* in the directory, including, e.g., Subversion's `.svn` private directories or CVS/RCS version control files; thus we recommend against using this feature as-is. However, you can use the `dist-hook` feature to ameliorate the problem; see Section 14.3 [The dist Hook], page 100.

If you define `SUBDIRS`, Automake will recursively include the subdirectories in the distribution. If `SUBDIRS` is defined conditionally (see Chapter 20 [Conditionals], page 126), Automake will normally include all directories that could possibly appear in `SUBDIRS` in the distribution. If you need to specify the set of directories conditionally, you can set the variable `DIST_SUBDIRS` to the exact list of subdirectories to include in the distribution (see Section 7.2 [Conditional Subdirectories], page 49).

14.2 Fine-grained Distribution Control

Sometimes you need tighter control over what does *not* go into the distribution; for instance, you might have source files that are generated and that you do not want to distribute. In this case Automake gives fine-grained control using the `dist` and `nodist` prefixes. Any primary or `_SOURCES` variable can be prefixed with `dist_` to add the listed files to the distribution. Similarly, `nodist_` can be used to omit the files from the distribution.

As an example, here is how you would cause some data to be distributed while leaving some source code out of the distribution:

```
dist_data_DATA = distribute-this
bin_PROGRAMS = foo
nodist_foo_SOURCES = do-not-distribute.c
```

14.3 The dist Hook

Occasionally it is useful to be able to change the distribution before it is packaged up. If the `dist-hook` rule exists, it is run after the distribution directory is filled, but before the actual distribution archives are created. One way to use this is for removing unnecessary files that get recursively included by specifying a directory in `EXTRA_DIST`:

```
EXTRA_DIST = doc
dist-hook:
    chmod -R u+w $(distdir)/doc
    rm -rf `find $(distdir)/doc -type d -name .svn`
```

Note that the `dist-hook` recipe shouldn't assume that the regular files in the distribution directory are writable; this might not be the case if one is packaging from a read-only source tree, or when a `make distcheck` is being done. For similar reasons, the recipe shouldn't assume that the subdirectories put into the distribution directory as an effect of having them listed in `EXTRA_DIST` are writable. So, if the `dist-hook` recipe wants to modify the content of an existing file (or `EXTRA_DIST` subdirectory) in the distribution directory, it should explicitly to make it writable first:

```
EXTRA_DIST = README doc
dist-hook:
    chmod u+w $(distdir)/README $(distdir)/doc
    echo "Distribution date: `date`" >> $(distdir)/README
    rm -f $(distdir)/doc/HACKING
```

Two variables that come handy when writing `dist-hook` rules are `$(distdir)` and `$(top_distdir)`.

`$(distdir)` points to the directory where the `dist` rule will copy files from the current directory before creating the tarball. If you are at the top-level directory, then `distdir = $(PACKAGE)-$(VERSION)`. When used from subdirectory named `foo/`, then `distdir = ../$(PACKAGE)-$(VERSION)/foo`. `$(distdir)` can be a relative or absolute path, do not assume any form.

`$(top_distdir)` always points to the root directory of the distributed tree. At the top-level it's equal to `$(distdir)`. In the `foo/` subdirectory `top_distdir = ../$(PACKAGE)-$(VERSION)`. `$(top_distdir)` too can be a relative or absolute path.

Note that when packages are nested using `AC_CONFIG_SUBDIRS` (see Section 7.4 [Sub-packages], page 53), then `$(distdir)` and `$(top_distdir)` are relative to the package where `make dist` was run, not to any sub-packages involved.

14.4 Checking the Distribution

Automake also generates a `distcheck` rule that can be of help to ensure that a given distribution will actually work. Simplifying a bit, we can say this rule first makes a distribution, and then, *operating from it*, takes the following steps (in this order):

- tries to do a `VPATH` build (see Section 2.2.6 [VPATH Builds], page 6), with the `srcdir` and all its content made *read-only*;
- tries to make the printable documentation, if any (with `make dvi`),
- runs the test suite (with `make check`) on this fresh build;

- installs the package in a temporary directory (with `make install`), and runs the test suite on the resulting installation (with `make installcheck`);
- checks that the package can be correctly uninstalled (by `make uninstall`) and cleaned (by `make distclean`);
- finally, makes another tarball to ensure the distribution is self-contained.

All of these actions are performed in a temporary directory. The exact location and the exact structure of such a directory (where the read-only sources are placed, how the temporary build and install directories are named and how deeply they are nested, etc.) is to be considered an implementation detail, which can change at any time; so do not rely on it.

DISTCHECK_CONFIGURE_FLAGS

Building the package involves running `./configure`. If you need to supply additional flags to `configure`, define them in the `AM_DISTCHECK_CONFIGURE_FLAGS` variable in your top-level `Makefile.am`. The user can still extend or override the flags provided there by defining the `DISTCHECK_CONFIGURE_FLAGS` variable, on the command line when invoking `make`. It's worth noting that `make distcheck` needs complete control over the `configure` options `--srcdir` and `--prefix`, so those options cannot be overridden by `AM_DISTCHECK_CONFIGURE_FLAGS` nor by `DISTCHECK_CONFIGURE_FLAGS`.

Also note that developers are encouraged to strive to make their code buildable without requiring any special configure option; thus, in general, you shouldn't define `AM_DISTCHECK_CONFIGURE_FLAGS`. However, there might be few scenarios in which the use of this variable is justified. GNU `m4` offers an example. GNU `m4` configures by default with its experimental and seldom used "changeword" feature disabled; so in this case it is useful to have `make distcheck` run `configure` with the `--with-changeword` option, to ensure that the code for changeword support still compiles correctly. GNU `m4` also employs the `AM_DISTCHECK_CONFIGURE_FLAGS` variable to stress-test the use of `--program-prefix=g`, since at one point the `m4` build system had a bug where `make installcheck` was wrongly assuming it could blindly test "m4", rather than the just-installed "gm4".

dvi and distcheck

Ordinarily, `make distcheck` runs `make dvi`. It does nothing if the distribution contains no Texinfo sources. If the distribution does contain a Texinfo manual, by default the `dvi` target will run `TEX` to make sure it can be successfully processed (see Section 11.1 [Texinfo], page 92).

However, you may wish to test the manual by producing `pdf` (e.g., if your manual uses images in formats other than `eps`), `html` (if you don't have `TEX` at all), some other format, or just skip the test entirely (not recommended). You can change the target that is run by setting the variable `AM_DISTCHECK_DVI_TARGET` in your `Makefile.am`; for example,

```
AM_DISTCHECK_DVI_TARGET = pdf
```

To make `dvi` into a do-nothing target, see the example for `EMPTY_AUTOMAKE_TARGETS` in Section 22.2 [Third-Party Makefiles], page 134.

distcheck-hook

If the `distcheck-hook` rule is defined in your top-level `Makefile.am`, then it will be invoked by `distcheck` after the new distribution has been unpacked, but before the unpacked copy is configured and built. Your `distcheck-hook` can do almost anything, though as always caution is advised. Generally this hook is used to check for potential distribution errors not caught by the standard mechanism. Note that `distcheck-hook` as well as `AM_DISTCHECK_CONFIGURE_FLAGS` and `DISTCHECK_CONFIGURE_FLAGS` are not honored in a subpackage `Makefile.am`, but the flags from `AM_DISTCHECK_CONFIGURE_FLAGS` and `DISTCHECK_CONFIGURE_FLAGS` are passed down to the `configure` script of the subpackage.

distcleancheck

Speaking of potential distribution errors, `distcheck` also ensures that the `distclean` rule actually removes all built files. This is done by running `make distcleancheck` at the end of the `VPATH` build. By default, `distcleancheck` will run `distclean` and then make sure the build tree has been emptied by running `$(distcleancheck_listfiles)`. Usually this check will find generated files that you forgot to add to the `DISTCLEANFILES` variable (see Chapter 13 [Clean], page 98).

The `distcleancheck` behavior should be OK for most packages, otherwise you have the possibility to override the definition of either the `distcleancheck` rule, or the `$(distcleancheck_listfiles)` variable. For instance, to disable `distcleancheck` completely, add the following rule to your top-level `Makefile.am`:

```
distcleancheck:
    @:
```

If you want `distcleancheck` to ignore built files that have not been cleaned because they are also part of the distribution, add the following definition instead:

```
distcleancheck_listfiles = \
    find . -type f -exec sh -c 'test -f $(srcdir)/$$1 || echo $$1' \
    sh '{} ' ;'
```

The above definition is not the default because it's usually an error if your `Makefiles` cause some distributed files to be rebuilt when the user builds the package. (Think about the user missing the tool required to build the file; or if the required tool is built by your package, consider the cross-compilation case where it can't be run.) There is an entry in the FAQ about this (see Section 26.5 [Errors with `distclean`], page 144); make sure you read it before playing with `distcleancheck_listfiles`.

distuninstallcheck

`distcheck` also checks that the `uninstall` rule works properly, both for ordinary and `DESTDIR` builds. It does this by invoking `make uninstall`, and then it checks the install tree to see if any files are left over. This check will make sure that you correctly coded your `uninstall`-related rules.

By default, the checking is done by the `distuninstallcheck` rule, and the list of files in the install tree is generated by `$(distuninstallcheck_listfiles)` (this is a variable whose value is a shell command to run that prints the list of files to `stdout`).

Either of these can be overridden to modify the behavior of `distcheck`. For instance, to disable this check completely, you would write:

```
distuninstallcheck:
    @:
```

14.5 The Types of Distributions

Automake generates rules to provide archives of the project for distributions in various formats. Their targets are:

`dist-gzip`

Generate a ‘`gzip`’ tar archive of the distribution. This is the only format enabled by default.

`dist-bzip2`

Generate a ‘`bzip2`’ tar archive of the distribution. `bzip2` archives are frequently smaller than gzipped archives. By default, this rule makes ‘`bzip2`’ use a compression option of `-9`. To make it use a different one, set the `BZIP2` environment variable. For example, ‘`make dist-bzip2 BZIP2=-7`’.

`dist-lzip`

Generate an ‘`lzip`’ tar archive of the distribution. `lzip` archives are frequently smaller than `bzip2`-compressed archives.

`dist-xz`

Generate an ‘`xz`’ tar archive of the distribution. `xz` archives are frequently smaller than `bzip2`-compressed archives. By default, this rule makes ‘`xz`’ use a compression option of `-e`. To make it use a different one, set the `XZ_OPT` environment variable. For example, run this command to use the default compression ratio, but with a progress indicator: ‘`make dist-xz XZ_OPT=-ve`’.

`dist-zip`

Generate a ‘`zip`’ archive of the distribution.

`dist-tarZ`

Generate a tar archive of the distribution, compressed with the historical (and obsolescent) program `compress`. This option is deprecated, and it and the corresponding functionality will be removed altogether in Automake 2.0.

`dist-shar`

Generate a ‘`shar`’ archive of the distribution. This format archive is obsolescent, and use of this option is deprecated. It and the corresponding functionality will be removed altogether in Automake 2.0.

`dist-zstd`

Generate a ‘`zstd`’ tar archive of the distribution. By default, this rule makes ‘`zstd`’ use a compression option of `-19`. To make it use a different one, set the `ZSTD_OPT` environment variable. For example, run this command to use the default compression ratio, but with a progress indicator: ‘`make dist-zstd ZSTD_OPT=-19v`’. However, note that for compatibility with `zstd` itself, you may instead set the `ZSTD_CLEVEL` environment variable, in which case, any `ZSTD_OPT` setting is ignored.

The rule `dist` (and its historical synonym `dist-all`) will create archives in all the enabled formats (see Section 17.2 [List of Automake options], page 120, for how to change this list). By default, only the `dist-gzip` target is hooked to `dist`.

15 Support for test suites

Automake can generate code to handle two kinds of test suites. One is based on integration with the `dejagnu` framework. The other (and most used) form is based on the use of generic test scripts, and its activation is triggered by the definition of the special `TESTS` variable. This second form allows for various degrees of sophistication and customization; in particular, it allows for concurrent execution of test scripts, use of established test protocols such as TAP, and definition of custom test drivers and test runners.

In either case, the testsuite is invoked via `‘make check’`.

15.1 Generalities about Testing

The purpose of testing is to determine whether a program or system behaves as expected (e.g., known inputs produce the expected outputs, error conditions are correctly handled or reported, and older bugs do not resurface).

The minimal unit of testing is usually called *test case*, or simply *test*. How a test case is defined or delimited, and even what exactly *constitutes* a test case, depends heavily on the testing paradigm and/or framework in use, so we won't attempt any more precise definition. The set of the test cases for a given program or system constitutes its *testsuite*.

A *test harness* (also *testsuite harness*) is a program or software component that executes all (or part of) the defined test cases, analyzes their outcomes, and reports or registers these outcomes appropriately. Again, the details of how this is accomplished (and how the developer and user can influence it or interface with it) varies wildly, and we'll attempt no precise definition.

A test is said to *pass* when it can determine that the condition or behaviour it means to verify holds, and is said to *fail* when it can determine that such condition of behaviour does *not* hold.

Sometimes, tests can rely on non-portable tools or prerequisites, or simply make no sense on a given system (for example, a test checking a Windows-specific feature makes no sense on a GNU/Linux system). In this case, accordingly to the definition above, the tests can neither be considered passed nor failed; instead, they are *skipped*—i.e., they are not run, or their result is anyway ignored for what concerns the count of failures and successes. Skips are usually explicitly reported though, so that the user will be aware that not all of the testsuite has really run.

It's not uncommon, especially during early development stages, that some tests fail for known reasons, and that the developer doesn't want to tackle these failures immediately (this is especially true when the failing tests deal with corner cases). In this situation, the better policy is to declare that each of those failures is an *expected failure* (or *xfail*). In case a test that is expected to fail ends up passing instead, many testing environments will flag the result as a special kind of failure called *unexpected pass* (or *xpass*).

Many testing environments and frameworks distinguish between test failures and hard errors. As we've seen, a test failure happens when some invariant or expected behaviour of the software under test is not met. A *hard error* happens when e.g., the set-up of a test case scenario fails, or when some other unexpected or highly undesirable condition is encountered (for example, the program under test experiences a segmentation fault).

15.2 Simple Tests

15.2.1 Scripts-based Testsuites

If the special variable `TESTS` is defined, its value is taken to be a list of programs or scripts to run in order to do the testing. Under the appropriate circumstances, it's possible for `TESTS` to list also data files to be passed to one or more test scripts defined by different means (the so-called “log compilers”, see Section 15.2.3 [Parallel Test Harness], page 108).

Test scripts can be executed serially or concurrently. Automake supports both these kinds of test execution, with the parallel test harness being the default. The concurrent test harness relies on the concurrence capabilities (if any) offered by the underlying `make` implementation, and can thus only be as good as those are.

By default, only the exit statuses of the test scripts are considered when determining the testsuite outcome. But Automake allows also the use of more complex test protocols, either standard (see Section 15.4 [Using the TAP test protocol], page 114) or custom (see Section 15.3 [Custom Test Drivers], page 110). You can't enable such protocols when the serial harness is used, though. In the rest of this section we are going to concentrate mostly on protocol-less tests, since we cover test protocols in a later section (again, see Section 15.3 [Custom Test Drivers], page 110).

When no test protocol is in use, an exit status of 0 from a test script will denote a success, an exit status of 77 a skipped test, an exit status of 99 a hard error, and any other exit status will denote a failure.

You may define the variable `XFAIL_TESTS` to a list of tests (usually a subset of `TESTS`) that are expected to fail; this will effectively reverse the result of those tests (with the provision that skips and hard errors remain untouched). You may also instruct the testsuite harness to treat hard errors like simple failures, by defining the `DISABLE_HARD_ERRORS` make variable to a nonempty value.

Note however that, for tests based on more complex test protocols, the exact effects of `XFAIL_TESTS` and `DISABLE_HARD_ERRORS` might change, or they might even have no effect at all (for example, in tests using TAP, there is no way to disable hard errors, and the `DISABLE_HARD_ERRORS` variable has no effect on them).

The result of each test case run by the scripts in `TESTS` will be printed on standard output, along with the test name. For test protocols that allow more test cases per test script (such as TAP), a number, identifier and/or brief description specific for the single test case is expected to be printed in addition to the name of the test script. The possible results (whose meanings should be clear from the previous Section 15.1 [Generalities about Testing], page 104) are `PASS`, `FAIL`, `SKIP`, `XFAIL`, `XPASS` and `ERROR`. Here is an example of output from a hypothetical testsuite that uses both plain and TAP tests:

```
PASS: foo.sh
PASS: zardoz.tap 1 - Daemon started
PASS: zardoz.tap 2 - Daemon responding
SKIP: zardoz.tap 3 - Daemon uses /proc # SKIP /proc is not mounted
PASS: zardoz.tap 4 - Daemon stopped
SKIP: bar.sh
PASS: mu.tap 1
XFAIL: mu.tap 2 # TODO frobnication not yet implemented
```


A testsuite summary (expected to report at least the number of run, skipped and failed tests) will be printed at the end of the testsuite run. By default, the first line of the summary has the form:

```
Testsuite summary for package-string
```

where *package-string* is the name and version of the package. If you have several independent test suites for different parts of the package, though, it can be misleading for each suite to imply it is for the whole package. Or, in complex projects, you may wish to add the current directory or other information to the testsuite header line. So you can override the ‘for *package-string*’ suffix on that line by setting the `AM_TESTSUITE_SUMMARY_HEADER` variable. The value of this variable is used unquoted in a shell echo command, so you must include any necessary quotes. For example, the default value is

```
AM_TESTSUITE_SUMMARY_HEADER = ' for $(PACKAGE_STRING)'
```

including the double quotes (interpreted by the shell) and the leading space (since the value is output directly after the ‘Testsuite summary’). The `$(PACKAGE_STRING)` is substituted by `make`.

If the standard output is connected to a capable terminal, then the test results and the summary are colored appropriately. The developer and the user can disable colored output by setting the `make` variable ‘`AM_COLOR_TESTS=no`’; the user can in addition force colored output even without a connecting terminal with ‘`AM_COLOR_TESTS=always`’. It’s also worth noting that some `make` implementations, when used in parallel mode, have slightly different semantics (see Section “Parallel make” in *The Autoconf Manual*), which can break the automatic detection of a connection to a capable terminal. If this is the case, the user will have to resort to the use of ‘`AM_COLOR_TESTS=always`’ in order to have the testsuite output colorized.

Test programs that need data files should look for them in `srcdir` (which is both a `make` variable and an environment variable made available to the tests), so that they work when building in a separate directory (see Section “Build Directories” in *The Autoconf Manual*), and in particular for the `distcheck` rule (see Section 14.4 [Checking the Distribution], page 100).

The `AM_TESTS_ENVIRONMENT` and `TESTS_ENVIRONMENT` variables can be used to run initialization code and set environment variables for the test scripts. The former variable is developer-reserved, and can be defined in the `Makefile.am`, while the latter is reserved for the user, which can employ it to extend or override the settings in the former; for this to work portably, however, the contents of a non-empty `AM_TESTS_ENVIRONMENT` *must* be terminated by a semicolon.

The `AM_TESTS_FD_REDIRECT` variable can be used to define file descriptor redirections for the test scripts. One might think that `AM_TESTS_ENVIRONMENT` could be used for this purpose, but experience has shown that doing so portably is practically impossible. The main hurdle is constituted by Korn shells, which usually set the close-on-exec flag on file descriptors opened with the `exec` builtin, thus rendering an idiom like `AM_TESTS_ENVIRONMENT = exec 9>&2`; ineffectual. This issue also affects some Bourne shells, such as the HP-UX’s `/bin/sh`,

```
AM_TESTS_ENVIRONMENT = \  
## Some environment initializations are kept in a separate shell  
## file 'tests-env.sh', which can make it easier to also run tests
```

```

## from the command line.
. $(srcdir)/tests-env.sh; \
## On Solaris, prefer more POSIX-compliant versions of the standard
## tools by default.
if test -d /usr/xpg4/bin; then \
    PATH=/usr/xpg4/bin:$$PATH; export PATH; \
fi;
## With this, the test scripts will be able to print diagnostic
## messages to the original standard error stream, even if the test
## driver redirects the stderr of the test scripts to a log file
## before executing them.
AM_TESTS_FD_REDIRECT = 9>&2

```

Note however that `AM_TESTS_ENVIRONMENT` is, for historical and implementation reasons, *not* supported by the serial harness (see Section 15.2.2 [Serial Test Harness], page 107).

Automake ensures that each file listed in `TESTS` is built before it is run; you can list both source and derived programs (or scripts) in `TESTS`; the generated rule will look both in `srcdir` and `'.'`. For instance, you might want to run a C program as a test. To do this you would list its name in `TESTS` and also in `check_PROGRAMS`, and then specify it as you would any other program.

Programs listed in `check_PROGRAMS` (and `check_LIBRARIES`, `check_LTLIBRARIES`...) are only built during `make check`, not during `make all`. You should list there any program needed by your tests that does not need to be built by `make all`. Note that `check_PROGRAMS` are *not* automatically added to `TESTS` because `check_PROGRAMS` usually lists programs used by the tests, not the tests themselves. Of course you can set `TESTS = $(check_PROGRAMS)` if all your programs are test cases.

15.2.2 Older (and discouraged) serial test harness

First, note that today the use of this harness is strongly discouraged in favour of the parallel test harness (see Section 15.2.3 [Parallel Test Harness], page 108). Still, there are *few* situations when the advantages offered by the parallel harness are irrelevant, and when test concurrency can even cause tricky problems. In those cases, it might make sense to still use the serial harness, for simplicity and reliability (we still suggest trying to give the parallel harness a shot though).

The serial test harness is enabled by the Automake option `serial-tests`. It operates by simply running the tests serially, one at the time, without any I/O redirection. It's up to the user to implement logging of tests' output, if that's required or desired.

For historical and implementation reasons, the `AM_TESTS_ENVIRONMENT` variable is *not* supported by this harness (it will be silently ignored if defined); only `TESTS_ENVIRONMENT` is, and it is to be considered a developer-reserved variable. This is done so that, when using the serial harness, `TESTS_ENVIRONMENT` can be defined to an invocation of an interpreter through which the tests are to be run. For instance, the following setup may be used to run tests with Perl:

```

TESTS_ENVIRONMENT = $(PERL) -Mstrict -w
TESTS = foo.pl bar.pl baz.pl

```

It's important to note that the use of `TESTS_ENVIRONMENT` endorsed here would be *invalid* with the parallel harness. That harness provides a more elegant way to achieve the same effect, with the further benefit of freeing the `TESTS_ENVIRONMENT` variable for the user (see Section 15.2.3 [Parallel Test Harness], page 108).

Another, less serious limitation of the serial harness is that it doesn't really distinguish between simple failures and hard errors; this is due to historical reasons only, and might be fixed in future Automake versions.

15.2.3 Parallel Test Harness

By default, Automake generated a parallel (concurrent) test harness. It features automatic collection of the test scripts output in `.log` files, concurrent execution of tests with `make -j`, specification of inter-test dependencies, lazy reruns of tests that have not completed in a prior run, and hard errors for exceptional failures.

The parallel test harness operates by defining a set of `make` rules that run the test scripts listed in `TESTS`, and, for each such script, save its output in a corresponding `.log` file and its results (and other “metadata”, see Section 15.3.3 [API for Custom Test Drivers], page 112) in a corresponding `.trs` (as in **T**est **R**esults) file. The `.log` file will contain all the output emitted by the test on its standard output and its standard error. The `.trs` file will contain, among the other things, the results of the test cases run by the script.

The parallel test harness will also create a summary log file, `TEST_SUITE_LOG`, which defaults to `test-suite.log` and requires a `.log` suffix. This file depends upon all the `.log` and `.trs` files created for the test scripts listed in `TESTS`.

As with the serial harness above, by default one status line is printed per completed test, and a short summary after the suite has completed. However, standard output and standard error of the test are redirected to a per-test log file, so that parallel execution does not produce intermingled output. The output from failed tests is collected in the `test-suite.log` file. If the variable ‘`VERBOSE`’ is set, this file is output after the summary.

Each couple of `.log` and `.trs` files is created when the corresponding test has completed. The set of log files is listed in the read-only variable `TEST_LOGS`, and defaults to `TESTS`, with the executable extension if any (see Section 8.20 [EXEEXT], page 82), as well as any suffix listed in `TEST_EXTENSIONS` removed, and `.log` appended. Results are undefined if a test file name ends in several concatenated suffixes. `TEST_EXTENSIONS` defaults to `.test`; it can be overridden by the user, in which case any extension listed in it must be constituted by a dot, followed by a non-digit alphabetic character, followed by any number of alphabetic characters. For example, ‘`.sh`’, ‘`.T`’ and ‘`.t1`’ are valid extensions, while ‘`.x-y`’, ‘`.6c`’ and ‘`.t.1`’ are not.

It is important to note that, due to current limitations (unlikely to be lifted), configure substitutions in the definition of `TESTS` can only work if they will expand to a list of tests that have a suffix listed in `TEST_EXTENSIONS`.

For tests that match an extension `.ext` listed in `TEST_EXTENSIONS`, you can provide a custom “test runner” using the variable `ext_LOG_COMPILER` (note the upper-case extension) and pass options in `AM_ext_LOG_FLAGS` and allow the user to pass options in `ext_LOG_FLAGS`. It will cause all tests with this extension to be called with this runner. For all tests without a registered extension, the variables `LOG_COMPILER`, `AM_LOG_FLAGS`, and `LOG_FLAGS` may be used. For example,

```

TESTS = foo.pl bar.py baz
TEST_EXTENSIONS = .pl .py
PL_LOG_COMPILER = $(PERL)
AM_PL_LOG_FLAGS = -w
PY_LOG_COMPILER = $(PYTHON)
AM_PY_LOG_FLAGS = -v
LOG_COMPILER = ./wrapper-script
AM_LOG_FLAGS = -d

```

will invoke ‘\$(PERL) -w foo.pl’, ‘\$(PYTHON) -v bar.py’, and ‘./wrapper-script -d baz’ to produce `foo.log`, `bar.log`, and `baz.log`, respectively. The `foo.trs`, `bar.trs` and `baz.trs` files will be automatically produced as a side-effect.

It’s important to note that, differently from what we’ve seen for the serial test harness (see Section 15.2.2 [Serial Test Harness], page 107), the `AM_TESTS_ENVIRONMENT` and `TESTS_ENVIRONMENT` variables *cannot* be used to define a custom test runner; the `LOG_COMPILER` and `LOG_FLAGS` (or their extension-specific counterparts) should be used instead:

```

## This is WRONG!
AM_TESTS_ENVIRONMENT = PERL5LIB=$(srcdir)/lib $(PERL) -Mstrict -w

## Do this instead.
AM_TESTS_ENVIRONMENT = PERL5LIB=$(srcdir)/lib; export PERL5LIB;
LOG_COMPILER = $(PERL)
AM_LOG_FLAGS = -Mstrict -w

```

By default, the test suite harness will run all tests, but there are several ways to limit the set of tests that are run:

- You can set the `TESTS` variable. For example, you can use a command like this to run only a subset of the tests:

```
env TESTS="foo.test bar.test" make -e check
```

Note however that the command above will unconditionally overwrite the `test-suite.log` file, thus clobbering the recorded results of any previous testsuite run. This might be undesirable for packages whose testsuite takes a long time to execute. Luckily, this problem can easily be avoided by also overriding `TEST_SUITE_LOG` at runtime; for example,

```
env TEST_SUITE_LOG=partial.log TESTS="..." make -e check
```

will write the result of the partial testsuite runs to the `partial.log`, without touching `test-suite.log`.

- You can set the `TEST_LOGS` variable. By default, this variable is computed at `make` run time from the value of `TESTS` as described above. For example, you can use the following:

```
set x subset*.log; shift
env TEST_LOGS="foo.log $*" make -e check
```

The comments made above about `TEST_SUITE_LOG` overriding applies here too.

- By default, the test harness removes all old per-test `.log` and `.trs` files before it starts running tests to regenerate them. The variable `RECHECK_LOGS` contains the set of `.log` (and, by implication, `.trs`) files which are removed. `RECHECK_LOGS` defaults to `TEST_LOGS`, which means all tests need to be rechecked. By overriding this variable, you can

choose which tests need to be reconsidered. For example, you can lazily rerun only those tests which are outdated, i.e., older than their prerequisite test files, by setting this variable to the empty value:

```
env RECHECK_LOGS= make -e check
```

- You can ensure that all tests are rerun which have failed or passed unexpectedly, by running `make recheck` in the test directory. This convenience target will set `RECHECK_LOGS` appropriately before invoking the main test harness.

In order to guarantee an ordering between tests even with `make -jN`, dependencies between the corresponding `.log` files may be specified through usual `make` dependencies. For example, the following snippet lets the test named `foo-execute.test` depend upon completion of the test `foo-compile.test`:

```
TESTS = foo-compile.test foo-execute.test
foo-execute.log: foo-compile.log
```

Please note that this ordering ignores the *results* of required tests, thus the test `foo-execute.test` is run even if the test `foo-compile.test` failed or was skipped beforehand. Further, please note that specifying such dependencies currently works only for tests that end in one of the suffixes listed in `TEST_EXTENSIONS`.

Tests without such specified dependencies may be run concurrently with parallel `make -jN`, so be sure they are prepared for concurrent execution.

The combination of lazy test execution and correct dependencies between tests and their sources may be exploited for efficient unit testing during development. To further speed up the edit-compile-test cycle, it may even be useful to specify compiled programs in `EXTRA_PROGRAMS` instead of with `check_PROGRAMS`, as the former allows intertwined compilation and test execution (but note that `EXTRA_PROGRAMS` are not cleaned automatically; see Section 3.3 [Uniform], page 21).

The variables `TESTS` and `XFAIL_TESTS` may contain conditional parts as well as configure substitutions. In the latter case, however, certain restrictions apply: substituted test names must end with a nonempty test suffix like `.test`, so that one of the inference rules generated by `automake` can apply. For literal test names, `automake` can generate per-target rules to avoid this limitation.

Please note that it is currently not possible to use `$(srcdir)/` or `$(top_srcdir)/` in the `TESTS` variable. This technical limitation is necessary to avoid generating test logs in the source tree and has the unfortunate consequence that it is not possible to specify distributed tests that are themselves generated by means of explicit rules, in a way that is portable to all `make` implementations (see Section “Make Target Lookup” in *The Autoconf Manual*, the semantics of FreeBSD and OpenBSD `make` conflict with this). In case of doubt you may want to require to use GNU `make`, or work around the issue with inference rules to generate the tests.

15.3 Custom Test Drivers

15.3.1 Overview of Custom Test Drivers Support

Starting from Automake version 1.12, the parallel test harness allows the package authors to use third-party custom test drivers, in case the default ones are inadequate for their purposes, or do not support their testing protocol of choice.

A custom test driver is expected to properly run the test programs passed to it (including the command-line arguments passed to those programs, if any), to analyze their execution and outcome, to create the `.log` and `.trs` files associated to these test runs, and to display the test results on the console. It is responsibility of the author of the test driver to ensure that it implements all the above steps meaningfully and correctly; Automake isn't and can't be of any help here. On the other hand, the Automake-provided code for testsuite summary generation offers support for test drivers allowing several test results per test script, if they take care to register such results properly (see Section 15.3.3.2 [Log files generation and test results recording], page 113).

The exact details of how test scripts' results are to be determined and analyzed is left to the individual drivers. Some drivers might only consider the test script exit status (this is done for example by the default test driver used by the parallel test harness, described in the previous section). Other drivers might implement more complex and advanced test protocols, which might require them to parse and interpret the output emitted by the test script they're running (examples of such protocols are TAP and SubUnit).

It's very important to note that, even when using custom test drivers, most of the infrastructure described in the previous section about the parallel harness remains in place; this includes:

- list of test scripts defined in `TESTS`, and overridable at runtime through the redefinition of `TESTS` or `TEST_LOGS`;
- concurrency through the use of `make`'s option `-j`;
- per-test `.log` and `.trs` files, and generation of a summary `.log` file from them;
- `recheck` target, `RECHECK_LOGS` variable, and lazy reruns of tests;
- inter-test dependencies;
- support for `check_*` variables (`check_PROGRAMS`, `check_LIBRARIES`, ...);
- use of `VERBOSE` environment variable to get verbose output on testsuite failures;
- definition and honoring of `TESTS_ENVIRONMENT`, `AM_TESTS_ENVIRONMENT` and `AM_TESTS_FD_REDIRECT` variables;
- definition of generic and extension-specific `LOG_COMPILER` and `LOG_FLAGS` variables.

On the other hand, the exact semantics of how (and if) testsuite output colorization, `XFAIL_TESTS`, and hard errors are supported and handled is left to the individual test drivers.

15.3.2 Declaring Custom Test Drivers

Custom testsuite drivers are declared by defining the make variables `LOG_DRIVER` or `ext_LOG_DRIVER` (where `ext` must be declared in `TEST_EXTENSIONS`). They must be defined to programs or scripts that will be used to drive the execution, logging, and outcome report of the tests with corresponding extensions (or of those with no registered extension in the case of `LOG_DRIVER`). Clearly, multiple distinct test drivers can be declared in the same `Makefile.am`. Note moreover that the `LOG_DRIVER` variables are *not* a substitute for the `LOG_COMPILER` variables: the two sets of variables can, and often do, usefully and legitimately coexist.

The developer-reserved variable `AM_LOG_DRIVER_FLAGS` and the user-reserved variable `LOG_DRIVER_FLAGS` can be used to define flags that will be passed to each invocation of

LOG_DRIVER, with the user-defined flags obviously taking precedence over the developer-reserved ones. Similarly, for each extension *ext* declared in TEST_EXTENSIONS, flags listed in AM_ext_LOG_DRIVER_FLAGS and ext_LOG_DRIVER_FLAGS will be passed to invocations of ext_LOG_DRIVER.

15.3.3 API for Custom Test Drivers

Note that *the APIs described here are still highly experimental*, and will very likely undergo tightenings and likely also extensive changes in the future, to accommodate for new features or to satisfy additional portability requirements.

The main characteristic of these APIs is that they are designed to share as much infrastructure, semantics, and implementation detail as possible with the parallel test harness and its default driver.

15.3.3.1 Command-line arguments for test drivers

A custom driver can rely on various command-line options and arguments being passed to it automatically by the Automake-generated test harness. It is *mandatory* that it understands all of them (even if the exact interpretation of the associated semantics can legitimately change between a test driver and another, and even be a no-op in some drivers).

Here is the list of options:

`--test-name=NAME`

The name of the test, with VPATH prefix (if any) removed. This can have a suffix and a directory component (as in e.g., `sub/foo.test`), and is mostly meant to be used in console reports about testsuite advancements and results (see Section 15.3.3.3 [Testsuite progress output], page 114).

`--log-file=PATH.log`

The `.log` file the test driver must create (see [Basics of test metadata], page 108). If it has a directory component (as in e.g., `sub/foo.log`), the test harness will ensure that such directory exists *before* the test driver is called.

`--trs-file=PATH.trs`

The `.trs` file the test driver must create (see [Basics of test metadata], page 108). If it has a directory component (as in e.g., `sub/foo.trs`), the test harness will ensure that such directory exists *before* the test driver is called.

`--color-tests={yes|no}`

Whether the console output should be colorized or not (see [Simple tests and color-tests], page 106, to learn when this option gets activated and when it doesn't).

`--expect-failure={yes|no}`

Whether the tested program is expected to fail.

`--enable-hard-errors={yes|no}`

Whether “hard errors” in the tested program should be treated differently from normal failures or not (the default should be `yes`). The exact meaning of “hard error” is highly dependent from the test protocols or conventions in use.

`--` Explicitly terminate the list of options.

The first non-option argument passed to the test driver is the program to be run, and all the following ones are command-line options and arguments for this program.

Note that the exact semantics attached to the `--color-tests`, `--expect-failure` and `--enable-hard-errors` options are left up to the individual test drivers. Still, having a behaviour compatible or at least similar to that provided by the default driver is advised, as that would offer a better consistency and a more pleasant user experience.

15.3.3.2 Log files generation and test results recording

The test driver must correctly generate the files specified by the `--log-file` and `--trs-file` option (even when the tested program fails or crashes).

The `.log` file should ideally contain all the output produced by the tested program, plus optionally other information that might facilitate debugging or analysis of bug reports. Apart from that, its format is basically free.

The `.trs` file is used to register some metadata through the use of custom reStructured-Text fields. This metadata is expected to be employed in various ways by the parallel test harness; for example, to count the test results when printing the testsuite summary, or to decide which tests to re-run upon `make recheck`. Unrecognized metadata in a `.trs` file is currently ignored by the harness, but this might change in the future. The list of currently recognized metadata follows.

`:test-result:`

The test driver must use this field to register the results of *each* test case run by a test script file. Several `:test-result:` fields can be present in the same `.trs` file; this is done in order to support test protocols that allow a single test script to run more test cases.

The only recognized test results are currently `PASS`, `XFAIL`, `SKIP`, `FAIL`, `XPASS` and `ERROR`. These results, when declared with `:test-result:`, can be optionally followed by text holding the name and/or a brief description of the corresponding test; the harness will ignore such extra text when generating `test-suite.log` and preparing the testsuite summary.

`:recheck:`

If this field is present and defined to `no`, then the corresponding test script will *not* be run upon a `make recheck`. What happens when two or more `:recheck:` fields are present in the same `.trs` file is undefined behaviour.

`:copy-in-global-log:`

If this field is present and defined to `no`, then the content of the `.log` file will *not* be copied into the global `test-suite.log`. We allow to forsake such copying because, while it can be useful in debugging and analysis of bug report, it can also be just a waste of space in normal situations, e.g., when a test script is successful. What happens when two or more `:copy-in-global-log:` fields are present in the same `.trs` file is undefined behaviour.

`:test-global-result:`

This is used to declare the "global result" of the script. Currently, the value of this field is needed only to be reported (more or less verbatim) in the generated global log file `$(TEST_SUITE_LOG)`, so it's quite free-form. For example, a

test script which runs 10 test cases, 6 of which pass and 4 of which are skipped, could reasonably have a `PASS/SKIP` value for this field, while a test script which runs 19 successful tests and one failed test could have an `ALMOST PASSED` value. What happens when two or more `:test-global-result:` fields are present in the same `.trs` file is undefined behaviour.

Let's see a small example. Assume a `.trs` file contains the following lines:

```
:test-result: PASS server starts
:global-log-copy: no
:test-result: PASS HTTP/1.1 request
:test-result: FAIL HTTP/1.0 request
:recheck: yes
:test-result: SKIP HTTPS request (TLS library wasn't available)
:test-result: PASS server stops
```

Then the corresponding test script will be re-run by `make check`, will contribute with *five* test results to the testsuite summary (three of these tests being successful, one failed, and one skipped), and the content of the corresponding `.log` file will *not* be copied into the global log file `test-suite.log`.

15.3.3.3 Testsuite progress output

A custom test driver also has the task of displaying, on the standard output, the test results as soon as they become available. Depending on the protocol in use, it can also display the reasons for failures and skips, and, more generally, any useful diagnostic output (but remember that each line on the screen is precious, so that cluttering the screen with overly verbose information is bad idea). The exact format of this progress output is left up to the test driver; in fact, a custom test driver might *theoretically* even decide not to do any such report, leaving it all to the testsuite summary (that would be a very lousy idea, of course, and serves only to illustrate the flexibility that is granted here).

Remember that consistency is good; so, if possible, try to be consistent with the output of the built-in Automake test drivers, providing a similar “look & feel”. In particular, the testsuite progress output should be colorized when the `--color-tests` is passed to the driver. On the other end, if you are using a known and widespread test protocol with well-established implementations, being consistent with those implementations' output might be a good idea too.

15.4 Using the TAP test protocol

15.4.1 Introduction to TAP

TAP, the Test Anything Protocol, is a simple text-based interface between testing modules or programs and a test harness. The tests (also called “TAP producers” in this context) write test results in a simple format on standard output; a test harness (also called “TAP consumer”) will parse and interpret these results, and properly present them to the user, and/or register them for later analysis. The exact details of how this is accomplished can vary among different test harnesses. The Automake harness will present the results on the console in the usual fashion (see [Testsuite progress on console], page 105), and will use the `.trs` files (see [Basics of test metadata], page 108) to store the test results and

related metadata. Apart from that, it will try to remain as compatible as possible with pre-existing and widespread utilities, such as the `prove` utility (<https://metacpan.org/pod/distribution/Test-Harness/bin/prove>), at least for the simpler usages.

TAP started its life as part of the test harness for Perl, but today it has been (mostly) standardized, and has various independent implementations in different languages; among them, C, C++, Perl, Python, PHP, and Java. For a semi-official specification of the TAP protocol, please refer to the documentation of ‘`Test::Harness`’ (<https://metacpan.org/pod/Test::Harness>).

The most relevant real-world usages of TAP are obviously in the testsuites of `perl` and of many Perl modules. Still, other important third-party packages, such as `git` (<https://git-scm.com/>), also use TAP in their testsuite.

15.4.2 Use TAP with the Automake test harness

Currently, the TAP driver that comes with Automake requires some by-hand steps on the developer’s part (this situation should hopefully be improved in future Automake versions). You’ll have to grab the `tap-driver.sh` script from the Automake distribution by hand, copy it in your source tree, and use the Automake support for third-party test drivers to instruct the harness to use the `tap-driver.sh` script and the `awk` program found by `AM_INIT_AUTOMAKE` to run your TAP-producing tests. See the example below for clarification.

Apart from the options common to all the Automake test drivers (see Section 15.3.3.1 [Command-line arguments for test drivers], page 112), `tap-driver.sh` supports the following options, whose names are chosen for enhanced compatibility with the `prove` utility.

`--ignore-exit`

Causes the test driver to ignore the exit status of the test scripts; by default, the driver will report an error if the script exits with a non-zero status. This option has effect also on non-zero exit statuses due to termination by a signal.

`--comments`

Instruct the test driver to display TAP diagnostics (i.e., lines beginning with the ‘`#`’ character) in the testsuite progress output too; by default, TAP diagnostics are only copied to the `.log` file.

`--no-comments`

Revert the effects of `--comments`.

`--merge`

Instruct the test driver to merge the test scripts’ standard error into their standard output. This is necessary if you want to ensure that diagnostics from the test scripts are displayed in the correct order relative to test results; this can be of great help in debugging (especially if your test scripts are shell scripts run with shell tracing active). As a downside, this option might cause the test harness to get confused if anything that appears on standard error looks like a test result.

`--no-merge`

Revert the effects of `--merge`.

`--diagnostic-string=STRING`

Change the string that introduces TAP diagnostics from the default value of ‘`#`’ to `STRING`. This can be useful if your TAP-based test scripts produce verbose

output on which they have limited control (because, say, the output comes from other tools invoked in the scripts), and it might contain text that gets spuriously interpreted as TAP diagnostics: such an issue can be solved by redefining the string that activates TAP diagnostics to a value you know won't appear by chance in the tests' output. Note however that this feature is non-standard, as the "official" TAP protocol does not allow for such a customization; so don't use it if you can avoid it.

Here is an example of how the TAP driver can be set up and used.

```
% cat configure.ac
AC_INIT([GNU Try Tap], [1.0], [bug-automake@gnu.org])
AC_CONFIG_AUX_DIR([build-aux])
AM_INIT_AUTOMAKE([foreign -Wall -Werror])
AC_CONFIG_FILES([Makefile])
AC_REQUIRE_AUX_FILE([tap-driver.sh])
AC_OUTPUT

% cat Makefile.am
TEST_LOG_DRIVER = env AM_TAP_AWK='$(AWK)' $(SHELL) \
    $(top_srcdir)/build-aux/tap-driver.sh
TESTS = foo.test bar.test baz.test
EXTRA_DIST = $(TESTS)

% cat foo.test
#!/bin/sh
echo 1..4 # Number of tests to be executed.
echo 'ok 1 - Swallows fly'
echo 'not ok 2 - Caterpillars fly # TODO metamorphosis in progress'
echo 'ok 3 - Pigs fly # SKIP not enough acid'
echo '# I just love word plays ...'
echo 'ok 4 - Flies fly too :-)'

% cat bar.test
#!/bin/sh
echo 1..3
echo 'not ok 1 - Bummer, this test has failed.'
echo 'ok 2 - This passed though.'
echo 'Bail out! Ennui kicking in, sorry...'
echo 'ok 3 - This will not be seen.'

% cat baz.test
#!/bin/sh
echo 1..1
echo ok 1
# Exit with error, even if all the tests have been successful.
exit 7
```

```

% cp PREFIX/share/automake-APIVERSSION/tap-driver.sh .
% autoreconf -vi && ./configure && make check
...
PASS: foo.test 1 - Swallows fly
XFAIL: foo.test 2 - Caterpillars fly # TODO metamorphosis in progress
SKIP: foo.test 3 - Pigs fly # SKIP not enough acid
PASS: foo.test 4 - Flies fly too :-)
FAIL: bar.test 1 - Bummer, this test has failed.
PASS: bar.test 2 - This passed though.
ERROR: bar.test - Bail out! Ennui kicking in, sorry...
PASS: baz.test 1
ERROR: baz.test - exited with status 7
...
Please report to bug-automake@gnu.org
...
% echo exit status: $?
exit status: 1

% env TEST_LOG_DRIVER_FLAGS='--comments --ignore-exit' \
    TESTS='foo.test baz.test' make -e check
...
PASS: foo.test 1 - Swallows fly
XFAIL: foo.test 2 - Caterpillars fly # TODO metamorphosis in progress
SKIP: foo.test 3 - Pigs fly # SKIP not enough acid
# foo.test: I just love word plays...
PASS: foo.test 4 - Flies fly too :-)
PASS: baz.test 1
...
% echo exit status: $?
exit status: 0

```

15.4.3 Incompatibilities with other TAP parsers and drivers

For implementation or historical reasons, the TAP driver and harness as implemented by Automake have some minor incompatibilities with the mainstream versions, which you should be aware of.

- A `Bail out!` directive doesn't stop the whole testsuite, but only the test script it occurs in. This doesn't follow TAP specifications, but on the other hand it maximizes compatibility (and code sharing) with the "hard error" concept of the default testsuite driver.
- The `version` and `pragma` directives are not supported.
- The `--diagnostic-string` option of our driver allows modification of the string that introduces TAP diagnostics from the default value of `"#"`. The standard TAP protocol currently has no way to allow this, so if you use it your diagnostic will be lost to more compliant tools like `prove` and `Test::Harness`.
- And there are probably some other small and yet undiscovered incompatibilities, especially in corner cases or with rare usages.

15.4.4 Links and external resources on TAP

Here are some links to more extensive official or third-party documentation and resources about the TAP protocol and related tools and libraries.

- ‘Test::Harness’ (<https://metacpan.org/pod/Test::Harness>), the (mostly) official documentation about the TAP format and protocol.
- `prove` (<https://metacpan.org/pod/distribution/Test-Harness/bin/prove>), the most famous command-line TAP test driver, included in the distribution of `perl` and ‘Test::Harness’ (<https://metacpan.org/pod/distribution/Test-Harness/lib/Test/Harness.pm>).
- The TAP wiki (<https://testanything.org/>).
- A “gentle introduction” to testing for Perl coders: ‘Test::Tutorial’ (<https://metacpan.org/pod/distribution/Test-Simple/lib/Test/Tutorial.pod>).
- ‘Test::Simple’ (<https://metacpan.org/pod/distribution/Test-Simple/lib/Test/Simple.pm>) and ‘Test::More’ (<https://metacpan.org/pod/distribution/Test-Simple/lib/Test/More.pm>), the standard Perl testing libraries, which are based on TAP.
- C TAP Harness (<https://www.eyrie.org/~eagle/software/c-tap-harness/>), a C-based project implementing both a TAP producer and a TAP consumer.
- `tap4j` (<https://tap4j.org/>), a Java-based project implementing both a TAP producer and a TAP consumer.

15.5 DejaGnu Tests

If `dejagnu` (see Section “Introduction” in *DejaGnu*) appears in `AUTOMAKE_OPTIONS`, then a `dejagnu`-based test suite is assumed. The variable `DEJATOOL` is a list of names that are passed, one at a time, as the `--tool` argument to `runtest` invocations; it defaults to the name of the package.

The variable `RUNTESTDEFAULTFLAGS` holds the `--tool` and `--srcdir` flags that are passed to `dejagnu` by default; this can be overridden if necessary.

The variables `EXPECT` and `RUNTEST` can also be overridden to provide project-specific values. For instance, you will need to do this if you are testing a compiler toolchain, because the default values do not take into account host and target names.

The contents of the variable `RUNTESTFLAGS` are passed to the `runtest` invocation. This is considered a “user variable” (see Section 3.6 [User Variables], page 23). If you need to set `runtest` flags in `Makefile.am`, you can use `AM_RUNTESTFLAGS` instead.

Automake will generate rules to create a local `site.exp` file, defining various variables detected by `configure`. This file is automatically read by `DejaGnu`. It is OK for the user of a package to edit this file in order to tune the test suite. However this is not the place where the test suite author should define new variables: this should be done elsewhere in the real test suite code. Especially, `site.exp` should not be distributed.

Still, if the package author has legitimate reasons to extend `site.exp` at `make` time, he can do so by defining the variable `EXTRA_DEJAGNU_SITE_CONFIG`; the files listed there will be considered `site.exp` prerequisites, and their content will be appended to it (in the same order in which they appear in `EXTRA_DEJAGNU_SITE_CONFIG`). Note that files are *not* distributed by default.

For more information regarding DejaGnu test suites, see *The DejaGnu Manual*.

15.6 Install Tests

The `installcheck` target is available to the user as a way to run any tests after the package has been installed. You can add tests to this by writing an `installcheck-local` rule.

16 Rebuilding Makefiles

Automake generates rules to automatically rebuild Makefiles, `configure`, and other derived files like `Makefile.in`.

If you are using `AM_MAINTAINER_MODE` in `configure.ac`, then these automatic rebuilding rules are only enabled in maintainer mode.

Sometimes it is convenient to supplement the rebuild rules for `configure` or `config.status` with additional dependencies. The variables `CONFIGURE_DEPENDENCIES` and `CONFIG_STATUS_DEPENDENCIES` can be used to list these extra dependencies. These variables should be defined in all Makefiles of the tree (because these two rebuild rules are output in all of them), so it is safer and easier to `AC_SUBST` them from `configure.ac`. For instance, the following statement will cause `configure` to be rerun each time `version.sh` is changed.

```
AC_SUBST([CONFIG_STATUS_DEPENDENCIES], ['$(top_srcdir)/version.sh'])
```

Note the `$(top_srcdir)/` in the file name. Since this variable is to be used in all Makefiles, its value must be sensible at any level in the build hierarchy.

Beware not to mistake `CONFIGURE_DEPENDENCIES` for `CONFIG_STATUS_DEPENDENCIES`.

`CONFIGURE_DEPENDENCIES` adds dependencies to the `configure` rule, whose effect is to run `autoconf`. This variable should be seldom used, because `automake` already tracks `m4_included` files. However it can be useful when playing tricky games with `m4_esyscmd` or similar non-recommendable macros with side effects. Be also aware that interactions of this variable with the Section “`autom4te cache`” in *The Autoconf Manual* are quite problematic and can cause subtle breakage, so you might want to disable the cache if you want to use `CONFIGURE_DEPENDENCIES`.

`CONFIG_STATUS_DEPENDENCIES` adds dependencies to the `config.status` rule, whose effect is to run `configure`. This variable should therefore carry any non-standard source that may be read as a side effect of running `configure`, like `version.sh` in the example above.

Speaking of `version.sh` scripts, we recommend against them today. They are mainly used when the version of a package is updated automatically by a script (e.g., in daily builds). Here is what some old-style `configure.acs` may look like:

```
AC_INIT
. $srcdir/version.sh
AM_INIT_AUTOMAKE([name], $VERSION_NUMBER)
...
```

Here, `version.sh` is a shell fragment that sets `VERSION_NUMBER`. The problem with this example is that `automake` cannot track dependencies (listing `version.sh` in `CONFIG_STATUS_DEPENDENCIES`, and distributing this file is up to the user), and that it uses the obsolete

form of `AC_INIT` and `AM_INIT_AUTOMAKE`. Upgrading to the new syntax is not straightforward, because shell variables are not allowed in `AC_INIT`'s arguments. We recommend that `version.sh` be replaced by an M4 file that is included by `configure.ac`:

```
m4_include([version.m4])
AC_INIT([name], VERSION_NUMBER)
AM_INIT_AUTOMAKE
...
```

Here `version.m4` could contain something like `'m4_define([VERSION_NUMBER], [1.2])'`. The advantage of this second form is that `automake` will take care of the dependencies when defining the rebuild rule, and will also distribute the file automatically. An inconvenience is that `autoconf` will now be rerun each time the version number is bumped, when only `configure` had to be rerun in the previous setup.

17 Changing Automake's Behavior

17.1 Options generalities

Various features of Automake can be controlled by options. Except where noted otherwise, options can be specified in one of several ways. Most options can be applied on a per-`Makefile` basis when listed in a special `Makefile` variable named `AUTOMAKE_OPTIONS`. Some of these options only make sense when specified in the toplevel `Makefile.am` file. Options are applied globally to all processed `Makefile` files when listed in the first argument of `AM_INIT_AUTOMAKE` in `configure.ac`, and some options which require changes to the `configure` script can only be specified there. These are annotated below.

As a general rule, options specified in `AUTOMAKE_OPTIONS` take precedence over those specified in `AM_INIT_AUTOMAKE`, which in turn take precedence over those specified on the command line.

Also, some care must be taken about the interactions among strictness level and warning categories. As a general rule, strictness-implied warnings are overridden by those specified by explicit options. For example, even if `'portability'` warnings are disabled by default in `foreign` strictness, a usage like this will end up enabling them:

```
AUTOMAKE_OPTIONS = -Wportability foreign
```

However, a strictness level specified in a higher-priority context will override all the explicit warnings specified in a lower-priority context. For example, if `configure.ac` contains:

```
AM_INIT_AUTOMAKE([-Wportability])
```

and `Makefile.am` contains:

```
AUTOMAKE_OPTIONS = foreign
```

then `'portability'` warnings will be *disabled* in `Makefile.am`.

17.2 List of Automake options

```
gnits
gnu
foreign
```

Set the strictness as appropriate. See Section 3.2 [Strictness], page 19. The `gnits` option also implies options `readme-alpha` and `check-news`.

check-news

Cause `'make dist'` to fail unless the current version number appears in the first few lines of the `NEWS` file.

dejagnu Cause `dejagnu`-specific rules to be generated. See Section 15.5 [DejaGnu Tests], page 118.

dist-bzip2

Hook `dist-bzip2` to `dist`.

dist-lzip

Hook `dist-lzip` to `dist`.

dist-xz Hook `dist-xz` to `dist`.

dist-zip Hook `dist-zip` to `dist`.

dist-zstd

Hook `dist-zstd` to `dist`.

dist-shar

Hook `dist-shar` to `dist`. Use of this option is deprecated, as the `'shar'` format is obsolescent and problematic. Support for it will be removed altogether in Automake 2.0.

dist-tarZ

Hook `dist-tarZ` to `dist`. Use of this option is deprecated, as the `'compress'` program is obsolete. Support for it will be removed altogether in Automake 2.0.

filename-length-max=99

Abort if file names longer than 99 characters are found during `'make dist'`. Such long file names are generally considered not to be portable in tarballs. See the `tar-v7` and `tar-ustar` options below. This option should be used in the top-level `Makefile.am` or as an argument of `AM_INIT_AUTOMAKE` in `configure.ac`; it will be ignored otherwise. It will also be ignored in sub-packages of nested packages (see Section 7.4 [Subpackages], page 53).

info-in-builddir

Instruct Automake to place the generated `.info` files in the `builddir` rather than in the `srcdir`. Note that this might make `VPATH` builds with some non-GNU make implementations more brittle.

no-define

This option is meaningful only when passed as an argument to `AM_INIT_AUTOMAKE`. It will prevent the `PACKAGE` and `VERSION` variables from being `AC_DEFINED`. But notice that they will remain defined as shell variables in the generated `configure`, and as make variables in the generated `Makefile`; this is deliberate, and required for backward compatibility.

no-dependencies

This is similar to using `--ignore-deps` on the command line, but is useful for those situations where you don't have the necessary bits to make automatic dependency tracking work (see Section 8.19 [Dependencies], page 82). In this case the effect is to effectively disable automatic dependency tracking.

no-dist Don't emit any code related to `dist` target. This is useful when a package has its own method for making distributions.

no-dist-gzip

Do not hook `dist-gzip` to `dist`.

no-exeext

If your `Makefile.am` defines a rule for target `foo`, it will override a rule for a target named `foo$(EXEEXT)`. This is necessary when `EXEEXT` is found to be empty. However, by default `automake` will generate an error for this use. The `no-exeext` option will disable this error. This is intended for use only where it is known in advance that the package will not be ported to Windows, or any other operating system using extensions on executables.

no-installinfo

The generated `Makefile.in` will not cause info pages to be built or installed by default. However, `info` and `install-info` targets will still be available. This option is disallowed at `gnu` strictness and above.

no-installman

The generated `Makefile.in` will not cause man pages to be installed by default. However, an `install-man` target will still be available for optional installation. This option is disallowed at `gnu` strictness and above.

nostdinc This option can be used to disable the standard `-I` options that are ordinarily automatically provided by Automake.

no-texinfo.tex

Don't require `texinfo.tex`, even if there are texinfo files in this directory.

serial-tests

Enable the older serial test suite harness for `TESTS` (see Section 15.2.2 [Serial Test Harness], page 107, for more information).

parallel-tests

Enable test suite harness for `TESTS` that can run tests in parallel (see Section 15.2.3 [Parallel Test Harness], page 108, for more information). This option is only kept for backward-compatibility, since the parallel test harness is the default now.

readme-alpha

If this release is an alpha release, and the file `README-alpha` exists, then it will be added to the distribution. If this option is given, version numbers are expected to follow one of two forms. The first form is `'major.minor.alpha'`, where each element is a number; the final period and number should be left off for non-alpha releases. The second form is `'major.minoralpha'`, where `alpha` is a letter; it should be omitted for non-alpha releases.

std-options

Make the `installcheck` rule check that installed scripts and programs support the `--help` and `--version` options. This also provides a basic check that the program's run-time dependencies are satisfied after installation.

In a few situations, programs (or scripts) have to be exempted from this test. For instance, `false` (from GNU `coreutils`) is never successful, even for `--help` or `--version`. You can list such programs in the variable `AM_INSTALLCHECK_STD_OPTIONS_EXEMPT`. Programs (not scripts) listed in this variable should be suffixed by `'$(EXEEXT)'` for the sake of Windows or OS/2. For instance, suppose we build `false` as a program but `true.sh` as a script, and that neither of them support `--help` or `--version`:

```
AUTOMAKE_OPTIONS = std-options
bin_PROGRAMS = false ...
bin_SCRIPTS = true.sh ...
AM_INSTALLCHECK_STD_OPTIONS_EXEMPT = false$(EXEEXT) true.sh
```

subdir-objects

If this option is specified, then objects are placed into the subdirectory of the build directory corresponding to the subdirectory of the source file. For instance, if the source file is `subdir/file.cxx`, then the output file would be `subdir/file.o`.

tar-v7**tar-ustar****tar-pax**

These three mutually exclusive options select the tar format to use when generating tarballs with `'make dist'`. (The tar file created is then compressed according to the set of `no-dist-gzip`, `dist-bzip2`, `dist-lzip`, `dist-xz`, `dist-zstd` and `dist-tarZ` options in use.)

These options must be passed as arguments to `AM_INIT_AUTOMAKE` (see Section 6.4 [Macros], page 45) because they can require additional configure checks. Automake will complain if it sees such options in an `AUTOMAKE_OPTIONS` variable.

`tar-v7` selects the old V7 tar format. This is the historical default. This antiquated format is understood by all tar implementations and supports file names with up to 99 characters. When given longer file names some tar implementations will diagnose the problem while others will generate broken tarballs or use non-portable extensions. Furthermore, the V7 format cannot store empty directories. When using this format, consider using the `filename-length-max=99` option to catch file names too long.

`tar-ustar` selects the ustar format defined by POSIX 1003.1-1988. This format is old enough to be portable: As of 2018, it is supported by the native `tar` command on GNU, FreeBSD, NetBSD, OpenBSD, AIX, HP-UX, and Solaris, at least. It fully supports empty directories. It can store file names with up to 256 characters, provided that the file name can be split at directory separator in two parts, first of them being at most 155 bytes long. So, in most cases the maximum file name length will be shorter than 256 characters.

`tar-pax` selects the new pax interchange format defined by POSIX 1003.1-2001. It does not limit the length of file names. However, this format is very young and should probably be restricted to packages that target only very modern platforms. As of 2018, this format is supported by the native `tar` command only on GNU, FreeBSD, and OpenBSD systems; it is not supported by the native `tar` command on NetBSD, AIX, HP-UX, or Solaris. There are moves to change the pax format in an upward-compatible way, so this option may refer to a more recent version in the future.

See Section “Controlling the Archive Format” in *GNU Tar*, for further discussion about tar formats.

`configure` knows several ways to construct these formats. It will not abort if it cannot find a tool up to the task (so that the package can still be built), but ‘`make dist`’ will fail.

version A version number (e.g., ‘0.30’) can be specified. If Automake is not the same version or newer than the version specified, creation of the `Makefile.in` will be suppressed.

`-Wcategory` or `--warnings=category`

These options behave exactly like their command-line counterpart (see Chapter 5 [automake Invocation], page 27). This allows you to enable or disable some warning categories on a per-file basis. You can also setup some warnings for your entire project; for instance, try ‘`AM_INIT_AUTOMAKE([-Wall])`’ in your `configure.ac`.

Unrecognized options are diagnosed by `automake`.

If you want an option to apply to all the files in the tree, you can use the `AM_INIT_AUTOMAKE` macro in `configure.ac`. See Section 6.4 [Macros], page 45.

18 Miscellaneous Rules

There are a few rules and variables that didn’t fit anywhere else.

18.1 Interfacing to etags

Automake will generate rules to generate `TAGS` files for use with GNU Emacs under some circumstances.

If any C, C++ or Fortran 77 source code or headers are present, then `tags` and `TAGS` rules will be generated for the directory. All files listed using the `_SOURCES`, `_HEADERS`, and `_LISP` primaries will be used to generate tags. Note that generated source files that are not distributed must be declared in variables like `nodist_noinst_HEADERS` or `nodist_prog_SOURCES` or they will be ignored.

A `tags` rule will be output at the topmost directory of a multi-directory package. When run from this topmost directory, ‘`make tags`’ will generate a `TAGS` file that includes by reference all `TAGS` files from subdirectories.

The `tags` rule will also be generated if the variable `ETAGS_ARGS` is defined. This variable is intended for use in directories that contain taggable source that `etags` does not under-

stand. The user can use the `ETAGSFLAGS` to pass additional flags to `etags`; `AM_ETAGSFLAGS` is also available for use in `Makefile.am`.

Here is how Automake generates tags for its source, and for nodes in its Texinfo file:

```
ETAGS_ARGS = automake.in --lang=none \
  --regex='/^@node[ \t]+\([\^,]+\)/\1/' automake.texi
```

If you add file names to `ETAGS_ARGS`, you will probably also want to define `TAGS_DEPENDENCIES`. The contents of this variable are added directly to the dependencies for the `tags` rule.

Automake also generates a `ctags` rule that can be used to build vi-style tags files. The variable `CTAGS` is the name of the program to invoke (by default `ctags`); `CTAGSFLAGS` can be used by the user to pass additional flags, and `AM_CTAGSFLAGS` can be used by the `Makefile.am`.

Automake will also generate an `ID` rule that will run `mkid` on the source. This is only supported on a directory-by-directory basis.

Similarly, the `cscope` rule will create a list of all the source files in the tree and run `cscope` to build an inverted index database. The variable `CSCOPE` is the name of the program to invoke (by default `cscope`); `CSCOPEFLAGS` and `CSCOPE_ARGS` can be used by the user to pass additional flags and file names respectively, while `AM_CSCOPEFLAGS` can be used by the `Makefile.am`. Note that, currently, the Automake-provided `cscope` support, when used in a `VPATH` build, might not work well with non-GNU make implementations (especially with make implementations performing Section “VPATH rewrites” in *The Autoconf Manual*).

Finally, Automake also emits rules to support the GNU Global Tags program (<https://www.gnu.org/software/global/>). The `GTags` rule runs Global Tags and puts the result in the top build directory. The variable `GTags_ARGS` holds arguments that are passed to `gtags`.

18.2 Handling new file extensions

It is sometimes useful to introduce a new implicit rule to handle a file type that Automake does not know about.

For instance, suppose you had a compiler that could compile `.foo` files to `.o` files. You would simply define a suffix rule for your language:

```
.foo.o:
    foocc -c -o $@ $<
```

Then you could directly use a `.foo` file in a `_SOURCES` variable and expect the correct results:

```
bin_PROGRAMS = doit
doit_SOURCES = doit.foo
```

This was the simpler and more common case. In other cases, you will have to help Automake to figure out which extensions you are defining your suffix rule for. This usually happens when your extension does not start with a dot. Then, all you have to do is to put a list of new suffixes in the `SUFFIXES` variable **before** you define your implicit rule.

For instance, the following definition prevents Automake from misinterpreting the `‘.idlC.cpp:’` rule as an attempt to transform `.idlC` files into `.cpp` files.

```
SUFFIXES = .idl C.cpp
```

```
.idlC.cpp:
    # whatever
```

As you may have noted, the `SUFFIXES` variable behaves like the `.SUFFIXES` special target of `make`. You should not touch `.SUFFIXES` yourself, but use `SUFFIXES` instead and let Automake generate the suffix list for `.SUFFIXES`. Any given `SUFFIXES` go at the start of the generated suffixes list, followed by Automake generated suffixes not already in the list.

19 Include

Automake supports an `include` directive that can be used to include other Makefile fragments when `automake` is run. Note that these fragments are read and interpreted by `automake`, not by `make`. As with conditionals, `make` has no idea that `include` is in use.

There are two forms of `include`:

```
include $(srcdir)/file
```

Include a fragment that is found relative to the current source directory.

```
include $(top_srcdir)/file
```

Include a fragment that is found relative to the top source directory.

Note that if a fragment is included inside a conditional, then the condition applies to the entire contents of that fragment.

Makefile fragments included this way are always distributed because they are needed to rebuild `Makefile.in`.

Inside a fragment, the construct `%reldir%` is replaced with the directory of the fragment relative to the base `Makefile.am`. Similarly, `%canon_reldir%` is replaced with the canonicalized (see Section 3.5 [Canonicalization], page 23) form of `%reldir%`. As a convenience, `%D%` is a synonym for `%reldir%`, and `%C%` is a synonym for `%canon_reldir%`.

A special feature is that if the fragment is in the same directory as the base `Makefile.am` (i.e., `%reldir%` is `.`), then `%reldir%` and `%canon_reldir%` will expand to the empty string as well as eat, if present, a following slash or underscore respectively.

Thus, a makefile fragment might look like this:

```
bin_PROGRAMS += %reldir%/mumble
%canon_reldir%_mumble_SOURCES = %reldir%/one.c
```

20 Conditionals

Automake supports a simple type of conditional.

These conditionals are not the same as conditionals in GNU Make. Automake conditionals are checked at configure time by the `configure` script, and affect the translation from `Makefile.in` to `Makefile`. They are based on options passed to `configure` and on results that `configure` has discovered about the host system. GNU Make conditionals are checked at `make` time, and are based on variables passed to the `make` program or defined in the `Makefile`.

Automake conditionals will work with any `make` program.

20.1 Usage of Conditionals

Before using a conditional, you must define it by using `AM_CONDITIONAL` in the `configure.ac` file (see Section 6.4 [Macros], page 45).

`AM_CONDITIONAL` (*conditional*, *condition*) [Macro]

The conditional name, *conditional*, should be a simple string starting with a letter and containing only letters, digits, and underscores. It must be different from ‘TRUE’ and ‘FALSE’, which are reserved by Automake.

The shell *condition* (suitable for use in a shell `if` statement) is evaluated when `configure` is run. Note that you must arrange for *every* `AM_CONDITIONAL` to be invoked every time `configure` is run. If `AM_CONDITIONAL` is run conditionally (e.g., in a shell `if` statement), then the result will confuse `automake`.

Conditionals typically depend upon options that the user provides to the `configure` script. Here is an example of how to write a conditional that is true if the user uses the `--enable-debug` option.

```
AC_ARG_ENABLE([debug],
[ --enable-debug    Turn on debugging],
[case "${enableval}" in
  yes) debug=true ;;
  no)  debug=false ;;
  *) AC_MSG_ERROR([bad value ${enableval} for --enable-debug]) ;;
esac], [debug=false])
AM_CONDITIONAL([DEBUG], [test x$debug = xtrue])
```

Here is an example of how to use that conditional in `Makefile.am`:

```
if DEBUG
DBG = debug
else
DBG =
endif
noinst_PROGRAMS = $(DBG)
```

This trivial example could also be handled using `EXTRA_PROGRAMS` (see Section 8.1.4 [Conditional Programs], page 58).

You may only test a single variable in an `if` statement, possibly negated using ‘!’. The `else` statement may be omitted. Conditionals may be nested to any depth. You may specify an argument to `else` in which case it must be the negation of the condition used for the current `if`. Similarly you may specify the condition that is closed on the `endif` line:

```
if DEBUG
DBG = debug
else !DEBUG
DBG =
endif !DEBUG
```

Unbalanced conditions are errors. The `if`, `else`, and `endif` statements should not be indented, i.e., start on column one.

The `else` branch of the above two examples could be omitted, since assigning the empty string to an otherwise undefined variable makes no difference.

In order to allow access to the condition registered by `AM_CONDITIONAL` inside `configure.ac`, and to allow conditional `AC_CONFIG_FILES`, `AM_COND_IF` may be used:

```
AM_COND_IF (conditional, [if-true], [if-false]) [Macro]
  If conditional is fulfilled, execute if-true, otherwise execute if-false. If either branch contains AC_CONFIG_FILES, it will cause automake to output the rules for the respective files only for the given condition.
```

`AM_COND_IF` macros may be nested when `m4` quotation is used properly (see Section “M4 Quotation” in *The Autoconf Manual*).

Here is an example of how to define a conditional config file:

```
AM_CONDITIONAL([SHELL_WRAPPER], [test "x$with_wrapper" = xtrue])
AM_COND_IF([SHELL_WRAPPER],
           [AC_CONFIG_FILES([wrapper:wrapper.in])])
```

20.2 Limits of Conditionals

Conditionals should enclose complete statements like variables or rules definitions. `Automake` cannot deal with conditionals used inside a variable definition, for instance, and is not even able to diagnose this situation. The following example would not work:

```
# This syntax is not understood by Automake
AM_CPPFLAGS = \
  -DFEATURE_A \
if WANT_DEBUG
  -DDEBUG \
endif
  -DFEATURE_B
```

However the intended definition of `AM_CPPFLAGS` can be achieved with

```
if WANT_DEBUG
  DEBUGFLAGS = -DDEBUG
endif
AM_CPPFLAGS = -DFEATURE_A $(DEBUGFLAGS) -DFEATURE_B
```

or

```
AM_CPPFLAGS = -DFEATURE_A
if WANT_DEBUG
AM_CPPFLAGS += -DDEBUG
endif
AM_CPPFLAGS += -DFEATURE_B
```

More details and examples of conditionals are described alongside various `Automake` features in this manual (see Section 7.2 [Conditional Subdirectories], page 49, see Section 8.1.3 [Conditional Sources], page 56, see Section 8.1.4 [Conditional Programs], page 58, see Section 8.3.3 [Conditional Libtool Libraries], page 60, see Section 8.3.4 [Conditional Libtool Sources], page 61).

21 Silencing make

21.1 Make is verbose by default

Normally, when executing the set of rules associated with a target, **make** prints each rule before it is executed. This behaviour, while having been in place for a long time, and being even mandated by the POSIX standard, starkly violates the “silence is golden” UNIX principle⁷:

When a program has nothing interesting or surprising to say, it should say nothing. Well-behaved Unix programs do their jobs unobtrusively, with a minimum of fuss and bother. Silence is golden.

In fact, while such verbosity of **make** can theoretically be useful to track bugs and understand reasons of failures right away, it can also hide warning and error messages from **make**-invoked tools, drowning them in a flood of uninteresting and seldom useful messages, and thus allowing them to go easily undetected.

This problem can be very annoying, especially for developers, who usually know quite well what’s going on behind the scenes, and for whom the verbose output from **make** ends up being mostly noise that hampers the easy detection of potentially important warning messages.

21.2 Standard and generic ways to silence make

Here we describe some common idioms/tricks to obtain a quieter make output, with their relative advantages and drawbacks. In the next section (Section 21.3 [Automake Silent Rules], page 130) we’ll see how Automake can help in this respect, providing more elaborate and flexible idioms.

- **make -s**

This simply causes **make** not to print *any* rule before executing it.

The **-s** flag is mandated by POSIX, universally supported, and its purpose and function are easy to understand.

But it also has its serious limitations too. First of all, it embodies an “all or nothing” strategy, i.e., either everything is silenced, or nothing is; this lack of granularity can sometimes be a fatal flaw. Moreover, when the **-s** flag is used, the **make** output might turn out to be too terse; in case of errors, the user won’t be able to easily see what rule or command have caused them, or even, in case of tools with poor error reporting, what the errors were!

- **make >/dev/null || make**

Apparently, this perfectly obeys the “silence is golden” rule: warnings from `stderr` are passed through, output reporting is done only in case of error, and in that case it should provide a verbose-enough report to allow an easy determination of the error location and causes.

However, calling **make** two times in a row might hide errors (especially intermittent ones), or subtly change the expected semantics of the **make** calls — these things can clearly make debugging and error assessment very difficult.

⁷ See also <http://catb.org/~esr/writings/taoup/html/ch11s09.html>.

- `make --no-print-directory`

This is GNU make specific. When called with the `--no-print-directory` option, GNU make will disable printing of the working directory by invoked sub-makes (the well-known “*Entering/Leaving directory ...*” messages). This helps to decrease the verbosity of the output, but experience has shown that it can also often render debugging considerably harder in projects using deeply-nested `make` recursion.

As an aside, notice that the `--no-print-directory` option is automatically activated if the `-s` flag is used.

21.3 How Automake can help in silencing make

The tricks and idioms for silencing `make` described in the previous section can be useful from time to time, but we’ve seen that they all have their serious drawbacks and limitations. That’s why automake provides support for a more advanced and flexible way of obtaining quieter output from `make` (for most rules at least).

To give the gist of what Automake can do in this respect, here is a simple comparison between a typical `make` output (where silent rules are disabled) and one with silent rules enabled:

```
% cat Makefile.am
bin_PROGRAMS = foo
foo_SOURCES = main.c func.c
% cat main.c
int main (void) { return func (); } /* func used undeclared */
% cat func.c
int func (void) { int i; return i; } /* i used uninitialized */
```

The make output is by default very verbose. This causes warnings from the compiler to be somewhat hidden, and not immediate to spot.

```
% make CFLAGS=-Wall
gcc -DPACKAGE_NAME=\"foo\" -DPACKAGE_TARNAME=\"foo\" ...
-DPACKAGE_STRING=\"foo 1.0\" -DPACKAGE_BUGREPORT=\"\" ...
-DPACKAGE=\"foo\" -DVERSION=\"1.0\" -I. -Wall -MT main.o
-MD -MP -MF .deps/main.Tpo -c -o main.o main.c
main.c: In function ‘main’:
main.c:3:3: warning: implicit declaration of function ‘func’
mv -f .deps/main.Tpo .deps/main.Po
gcc -DPACKAGE_NAME=\"foo\" -DPACKAGE_TARNAME=\"foo\" ...
-DPACKAGE_STRING=\"foo 1.0\" -DPACKAGE_BUGREPORT=\"\" ...
-DPACKAGE=\"foo\" -DVERSION=\"1.0\" -I. -Wall -MT func.o
-MD -MP -MF .deps/func.Tpo -c -o func.o func.c
func.c: In function ‘func’:
func.c:4:3: warning: ‘i’ used uninitialized in this function
mv -f .deps/func.Tpo .deps/func.Po
gcc -Wall -o foo main.o func.o
```

Clean up, so that we we can rebuild everything from scratch.

```
% make clean
test -z "foo" || rm -f foo
rm -f *.o
```

Silent rules enabled: the output is minimal but informative. In particular, the warnings from the compiler stick out very clearly.

```
% make V=0 CFLAGS=-Wall
CC      main.o
main.c: In function 'main':
main.c:3:3: warning: implicit declaration of function 'func'
CC      func.o
func.c: In function 'func':
func.c:4:3: warning: 'i' used uninitialized in this function
CCLD   foo
```

Also, in projects using libtool, the use of silent rules can automatically enable the libtool's `--silent` option:

```
% cat Makefile.am
lib_LTLIBRARIES = libx.la

% make # Both make and libtool are verbose by default.
...
libtool: compile: gcc -DPACKAGE_NAME=\"foo\" ... -DLT_OBJDIR=\".libs/\"
-I. -g -O2 -MT libx.lo -MD -MP -MF .deps/libx.Tpo -c libx.c -fPIC
-DPIC -o .libs/libx.o
mv -f .deps/libx.Tpo .deps/libx.Plo
/bin/sh ./libtool --tag=CC --mode=link gcc -g -O2 -o libx.la -rpath
/usr/local/lib libx.lo
libtool: link: gcc -shared .libs/libx.o -Wl,-soname -Wl,libx.so.0
-o .libs/libx.so.0.0.0
libtool: link: cd .libs && rm -f libx.so && ln -s libx.so.0.0.0 libx.so
...

% make V=0
CC      libx.lo
CCLD   libx.la
```

For Automake-generated Makefiles, the user may influence the verbosity at `configure` run time as well as at `make` run time:

- Passing `--enable-silent-rules` to `configure` will cause build rules to be less verbose; the option `--disable-silent-rules` will cause normal verbose output.
- At `make` run time, the default chosen at `configure` time may be overridden: `make V=1` will produce verbose output, `make V=0` less verbose output.

Note that silent rules are *disabled* by default; the user must enable them explicitly at either `configure` run time or at `make` run time. We think that this is a good policy, since it provides the casual user with enough information to prepare a good bug report in case anything breaks.

Still, notwithstanding the rationales above, a developer who really wants to make silent rules enabled by default in his own package can do so by calling `AM_SILENT_RULES([yes])` in `configure.ac`.

Users who prefer to have silent rules enabled by default can edit their `config.site` file to make the variable `enable_silent_rules` default to ‘yes’. This should still allow disabling silent rules at `configure` time and at `make` time.

For portability to different `make` implementations, package authors are advised to not set the variable `V` inside the `Makefile.am` file, to allow the user to override the value for subdirectories as well.

To work at its best, the current implementation of this feature normally uses nested variable expansion ‘`$(var1$(V))`’, a `Makefile` feature that is not required by POSIX 2008 but is widely supported in practice. On the rare `make` implementations that do not support nested variable expansion, whether rules are silent is always determined at `configure` time, and cannot be overridden at `make` time. Future versions of POSIX are likely to require nested variable expansion, so this minor limitation should go away with time.

To extend the silent mode to your own rules, you have a few choices:

- You can use the predefined variable `AM_V_GEN` as a prefix to commands that should output a status line in silent mode, and `AM_V_at` as a prefix to commands that should not output anything in silent mode. When output is to be verbose, both of these variables will expand to the empty string.
- You can silence a recipe unconditionally with `@`, and then use the predefined variable `AM_V_P` to know whether `make` is being run in silent or verbose mode; adjust the verbose information your recipe displays accordingly:

```
generate-headers:
    ... [commands defining a shell variable '$headers'] ...; \
    if $(AM_V_P); then set -x; else echo " GEN [headers]"; fi; \
    rm -f $$headers && generate-header --flags $$headers
```

- You can add your own variables, so strings of your own choice are shown. The following snippet shows how you would define your own equivalent of `AM_V_GEN`:

```
pkg_verbose = $(pkg_verbose_@AM_V@)
pkg_verbose_ = $(pkg_verbose_@AM_DEFAULT_V@)
pkg_verbose_0 = @echo PKG-GEN $@;

foo: foo.in
    $(pkg_verbose)cp $(srcdir)/foo.in $@
```

As a final note, observe that, even when silent rules are enabled, the `--no-print-directory` option is still required with GNU `make` if the “*Entering/Leaving directory ...*” messages are to be disabled.

22 When Automake Isn’t Enough

In some situations, where Automake is not up to one task, one has to resort to handwritten rules or even handwritten `Makefiles`.

22.1 Extending Automake Rules

With some minor exceptions (for example `_PROGRAMS` variables, `TESTS`, or `XFAIL_TESTS`) being rewritten to append `$(EXEEXT)`, the contents of a `Makefile.am` is copied to `Makefile.in` verbatim.

These copying semantics mean that many problems can be worked around by simply adding some `make` variables and rules to `Makefile.am`. Automake will ignore these additions.

Since a `Makefile.in` is built from data gathered from three different places (`Makefile.am`, `configure.ac`, and `automake` itself), it is possible to have conflicting definitions of rules or variables. When building `Makefile.in` the following priorities are respected by `automake` to ensure the user always has the last word:

- User defined variables in `Makefile.am` have priority over variables `AC_SUBST`ed from `configure.ac`, and `AC_SUBST`ed variables have priority over `automake`-defined variables.
- As far as rules are concerned, a user-defined rule overrides any `automake`-defined rule for the same target.

These overriding semantics make it possible to fine tune some default settings of Automake, or replace some of its rules. Overriding Automake rules is often inadvisable, particularly in the topmost directory of a package with subdirectories. The `-Woverride` option (see Chapter 5 [automake Invocation], page 27) comes in handy to catch overridden definitions.

Note that Automake does not make any distinction between rules with commands and rules that only specify dependencies. So it is not possible to append new dependencies to an `automake`-defined target without redefining the entire rule.

However, various useful targets have a `-local` version you can specify in your `Makefile.am`. Automake will supplement the standard target with these user-supplied targets.

The targets that support a local version are `all`, `info`, `dvi`, `ps`, `pdf`, `html`, `check`, `install-data`, `install-dvi`, `install-exec`, `install-html`, `install-info`, `install-pdf`, `install-ps`, `uninstall`, `installdirs`, `installcheck` and the various `clean` targets (mostly `mostlyclean`, `clean`, `distclean`, and `maintainer-clean`).

Note that there are no `uninstall-exec-local` or `uninstall-data-local` targets; just use `uninstall-local`. It doesn't make sense to `uninstall` just data or just executables.

For instance, here is one way to erase a subdirectory during `'make clean'` (see Chapter 13 [Clean], page 98).

```
clean-local:
    -rm -rf testSubDir
```

You may be tempted to use `install-data-local` to install a file to some hard-coded location, but you should avoid this (see Section 26.10 [Hard-Coded Install Paths], page 155).

With the `-local` targets, there is no particular guarantee of execution order; typically, they are run early, but with parallel `make`, there is no way to be sure of that.

In contrast, some rules also have a way to run another rule, called a *hook*; hooks are always executed after the main rule's work is done. The hook is named after the principal tar-

get, with ‘-hook’ appended. The targets allowing hooks are `install-data`, `install-exec`, `uninstall`, `dist`, and `distcheck`.

For instance, here is how to create a hard link to an installed program:

```
install-exec-hook:
    ln $(DESTDIR)$(bindir)/program$(EXEEXT) \
        $(DESTDIR)$(bindir)/proglink$(EXEEXT)
```

Although cheaper and more portable than symbolic links, hard links will not work everywhere (for instance, OS/2 does not have `ln`). Ideally you should fall back to ‘`cp -p`’ when `ln` does not work. An easy way, if symbolic links are acceptable to you, is to add `AC_PROG_LN_S` to `configure.ac` (see Section “Particular Program Checks” in *The Autoconf Manual*) and use ‘`$(LN_S)`’ in `Makefile.am`.

For instance, here is how you could install a versioned copy of a program using ‘`$(LN_S)`’:

```
install-exec-hook:
    cd $(DESTDIR)$(bindir) && \
        mv -f prog$(EXEEXT) prog-$(VERSION)$(EXEEXT) && \
        $(LN_S) prog-$(VERSION)$(EXEEXT) prog$(EXEEXT)
```

Note that we rename the program so that a new version will erase the symbolic link, not the real binary. Also we `cd` into the destination directory in order to create relative links.

When writing `install-exec-hook` or `install-data-hook`, please bear in mind that the `exec/data` distinction is based on the installation directory, not on the primary used (see Section 12.2 [The Two Parts of Install], page 96). So a `foo_SCRIPTS` will be installed by `install-data`, and a `barexec_SCRIPTS` will be installed by `install-exec`. You should define your hooks accordingly.

22.2 Third-Party Makefiles

In most projects all `Makefiles` are generated by Automake. In some cases, however, projects need to embed subdirectories with handwritten `Makefiles`. For instance, one subdirectory could be a third-party project with its own build system, not using Automake.

It is possible to list arbitrary directories in `SUBDIRS` or `DIST_SUBDIRS` provided each of these directories has a `Makefile` that recognizes all the following recursive targets.

When a user runs one of these targets, that target is run recursively in all subdirectories. This is why it is important that even third-party `Makefiles` support them.

all Compile the entire package. This is the default target in Automake-generated `Makefiles`, but it does not need to be the default in third-party `Makefiles`.

distdir Copy files to distribute into ‘`$(distdir)`’, before a tarball is constructed. Of course this target is not required if the `no-dist` option (see Chapter 17 [Options], page 120) is used.

The variables ‘`$(top_distdir)`’ and ‘`$(distdir)`’ (see Section 14.3 [The dist Hook], page 100) will be passed from the outer package to the subpackage when the `distdir` target is invoked. These two variables have been adjusted for the directory that is being recursed into, so they are ready to use.

```

install
install-data
install-exec
uninstall
    Install or uninstall files (see Chapter 12 [Install], page 96).

install-dvi
install-html
install-info
install-ps
install-pdf
    Install only some specific documentation format (see Section 11.1 [Texinfo],
    page 92).

installdirs
    Create install directories, but do not install any files.

check
installcheck
    Check the package (see Chapter 15 [Tests], page 104).

mostlyclean
clean
distclean
maintainer-clean
    Cleaning rules (see Chapter 13 [Clean], page 98).

dvi
pdf
ps
info
html
    Build the documentation in various formats (see Section 11.1 [Texinfo],
    page 92).

tags
ctags
    Build TAGS and CTAGS (see Section 18.1 [Tags], page 124).

```

If you have ever used Gettext in a project, this is a good example of how third-party Makefiles can be used with Automake. The Makefiles that `gettextize` puts in the `po/` and `intl/` directories are handwritten Makefiles that implement all of these targets. That way they can be added to `SUBDIRS` in Automake packages.

Directories that are only listed in `DIST_SUBDIRS` but not in `SUBDIRS` need only the `distclean`, `maintainer-clean`, and `distdir` rules (see Section 7.2 [Conditional Subdirectories], page 49).

Usually, many of these rules are irrelevant to the third-party subproject, but they are required for the whole package to work. It's OK to have a rule that does nothing, so if you are integrating a third-party project with no documentation or tag support, you could simply augment its Makefile as follows:

```

EMPTY_AUTOMAKE_TARGETS = dvi pdf ps info html tags ctags
.PHONY: $(EMPTY_AUTOMAKE_TARGETS)

```

```
$(EMPTY_AUTOMAKE_TARGETS):
```

To be clear, there is nothing special about the variable name `EMPTY_AUTOMAKE_TARGETS`; the name could be anything.

Another aspect of integrating third-party build systems is whether they support `VPATH` builds (see Section 2.2.6 [VPATH Builds], page 6). Obviously if the subpackage does not support `VPATH` builds the whole package will not support `VPATH` builds. This in turns means that `make distcheck` will not work, because it relies on `VPATH` builds. Some people can live without this (actually, many Automake users have never heard of `make distcheck`). Other people may prefer to revamp the existing `Makefiles` to support `VPATH`. Doing so does not necessarily require Automake; only Autoconf is needed (see Section “Build Directories” in *The Autoconf Manual*). The necessary substitutions: `@srcdir@`, `@top_srcdir@`, and `@top_builddir@` are defined by `configure` when it processes a `Makefile` (see Section “Preset Output Variables” in *The Autoconf Manual*); they are not computed by the `Makefile` like the aforementioned `$(distdir)` and `$(top_distdir)` variables.

It is sometimes inconvenient to modify a third-party `Makefile` to introduce the above required targets. For instance, one may want to keep the third-party sources untouched to ease upgrades to new versions.

Here are two other ideas. If GNU `make` is assumed, one possibility is to add to that subdirectory a `GNUmakefile` that defines the required targets and includes the third-party `Makefile`. For this to work in `VPATH` builds, `GNUmakefile` must lie in the build directory; the easiest way to do this is to write a `GNUmakefile.in` instead, and have it processed with `AC_CONFIG_FILES` from the outer package. For example if we assume `Makefile` defines all targets except the documentation targets, and that the `check` target is actually called `test`, we could write `GNUmakefile` (or `GNUmakefile.in`) like this:

```
# First, include the real Makefile
include Makefile
# Then, define the other targets needed by Automake Makefiles.
.PHONY: dvi pdf ps info html check
dvi pdf ps info html:
check: test
```

A similar idea that does not use `include` is to write a proxy `Makefile` that dispatches rules to the real `Makefile`, either with `$(MAKE) -f Makefile.real $(AM_MAKEFLAGS) target` (if it's OK to rename the original `Makefile`) or with `cd subdir && $(MAKE) $(AM_MAKEFLAGS) target` (if it's OK to store the subdirectory project one directory deeper). The good news is that this proxy `Makefile` can be generated with Automake. All we need are `-local` targets (see Section 22.1 [Extending], page 133) that perform the dispatch. Of course the other Automake features are available, so you could decide to let Automake perform distribution or installation. Here is a possible `Makefile.am`:

```
all-local:
    cd subdir && $(MAKE) $(AM_MAKEFLAGS) all
check-local:
    cd subdir && $(MAKE) $(AM_MAKEFLAGS) test
clean-local:
    cd subdir && $(MAKE) $(AM_MAKEFLAGS) clean
```

```

# Assuming the package knows how to install itself
install-data-local:
    cd subdir && $(MAKE) $(AM_MAKEFLAGS) install-data
install-exec-local:
    cd subdir && $(MAKE) $(AM_MAKEFLAGS) install-exec
uninstall-local:
    cd subdir && $(MAKE) $(AM_MAKEFLAGS) uninstall

# Distribute files from here.
EXTRA_DIST = subdir/Makefile subdir/program.c ...

```

Pushing this idea to the extreme, it is also possible to ignore the subproject build system and build everything from this proxy `Makefile.am`. This might sound very sensible if you need `VPATH` builds but the subproject does not support them.

23 Distributing `Makefile.ins`

Automake places no restrictions on the distribution of the resulting `Makefile.ins`. We still encourage software authors to distribute their work under terms like those of the GPL, but doing so is not required to use Automake.

Some of the files that can be automatically installed via the `--add-missing` switch do fall under the GPL. However, these also have a special exception allowing you to distribute them with your package, regardless of the licensing you choose.

24 Automake API Versioning

New Automake releases usually include bug fixes and new features. Unfortunately they may also introduce new bugs and incompatibilities. This makes four reasons why a package may require a particular Automake version.

Things get worse when maintaining a large tree of packages, each one requiring a different version of Automake. In the past, this meant that any developer (and sometimes users) had to install several versions of Automake in different places, and switch `'$PATH'` appropriately for each package.

Starting with version 1.6, Automake installs versioned binaries. This means you can install several versions of Automake in the same `'$prefix'`, and can select an arbitrary Automake version by running `automake-1.6` or `automake-1.7` without juggling with `'$PATH'`. Furthermore, `Makefiles` generated by Automake 1.6 will use `automake-1.6` explicitly in their rebuild rules.

The number `'1.6'` in `automake-1.6` is Automake's API version, not Automake's version. If a bug fix release is made, for instance Automake 1.6.1, the API version will remain 1.6. This means that a package that works with Automake 1.6 should also work with 1.6.1; after all, this is what people expect from bug fix releases.

If your package relies on a feature or a bug fix introduced in a release, you can pass this version as an option to Automake to ensure older releases will not be used. For instance, use this in your `configure.ac`:

```
AM_INIT_AUTOMAKE([1.6.1])    dnl Require Automake 1.6.1 or better.
```


or, in a particular `Makefile.am`:

```
AUTOMAKE_OPTIONS = 1.6.1 # Require Automake 1.6.1 or better.
```

Automake will print an error message if its version is older than the requested version.

What is in the API

Automake's programming interface is not easy to define. Basically it should include at least all **documented** variables and targets that a `Makefile.am` author can use, any behavior associated with them (e.g., the places where '-hook's are run), the command line interface of `automake` and `aclocal`, ...

What is not in the API

Every undocumented variable, target, or command line option is not part of the API. You should avoid using them, as they could change from one version to the other (even in bug fix releases, if this helps to fix a bug).

If it turns out you need to use such an undocumented feature, contact `automake@gnu.org` and try to get it documented and exercised by the test-suite.

25 Upgrading a Package to a Newer Automake Version

Automake maintains three kinds of files in a package.

- `aclocal.m4`
- `Makefile.ins`
- auxiliary tools like `install-sh` or `py-compile`

`aclocal.m4` is generated by `aclocal` and contains some Automake-supplied M4 macros. Auxiliary tools are installed by '`automake --add-missing`' when needed. `Makefile.ins` are built from `Makefile.am` by `automake`, and rely on the definitions of the M4 macros put in `aclocal.m4` as well as the behavior of the auxiliary tools installed.

Because all of these files are closely related, it is important to regenerate all of them when upgrading to a newer Automake release. The usual way to do that is

```
aclocal # with any option needed (such as -I m4)
autoconf
automake --add-missing --force-missing
```

or more conveniently:

```
autoreconf -vfi
```

The use of `--force-missing` ensures that auxiliary tools will be overridden by new versions (see Chapter 5 [automake Invocation], page 27).

It is important to regenerate all of these files each time Automake is upgraded, even between bug fix releases. For instance, it is not unusual for a bug fix to involve changes to both the rules generated in `Makefile.in` and the supporting M4 macros copied to `aclocal.m4`.

Presently `automake` is able to diagnose situations where `aclocal.m4` has been generated with another version of `aclocal`. However it never checks whether auxiliary scripts are

up-to-date. In other words, `automake` will tell you when `aclocal` needs to be rerun, but it will never diagnose a missing `--force-missing`.

Before upgrading to a new major release, it is a good idea to read the file `NEWS`. This file lists all changes between releases: new features, obsolete constructs, known incompatibilities, and workarounds.

26 Frequently Asked Questions about Automake

This chapter covers some questions that often come up on the mailing lists.

26.1 CVS and generated files

Background: distributed generated Files

Packages made with `Autoconf` and `Automake` ship with some generated files like `configure` or `Makefile.in`. These files were generated on the developer's machine and are distributed so that end-users do not have to install the maintainer tools required to rebuild them. Other generated files like Lex scanners, Yacc parsers, or Info documentation are usually distributed on similar grounds.

`Automake` output generates rules in `Makefiles` to rebuild these files. For instance, `make` will run `autoconf` to rebuild `configure` whenever `configure.ac` is changed. This makes development safer by ensuring a `configure` is never out-of-date with respect to `configure.ac`.

As generated files shipped in packages are up-to-date, and because `tar` preserves timestamps, these rebuild rules are not triggered when a user unpacks and builds a package.

Background: CVS and Timestamps

Unless you use CVS keywords (in which case files must be updated at commit time), CVS preserves timestamp during `'cvs commit'` and `'cvs import -d'` operations.

When you check out a file using `'cvs checkout'` its timestamp is set to that of the revision that is being checked out.

However, during `cvs update`, files will have the date of the update, not the original timestamp of this revision. This is meant to make sure that `make` notices that sources files have been updated.

This timestamp shift is troublesome when both sources and generated files are kept under CVS. Because CVS processes files in lexical order, `configure.ac` will appear newer than `configure` after a `cvs update` that updates both files, even if `configure` was newer than `configure.ac` when it was checked in. Calling `make` will then trigger a spurious rebuild of `configure`.

Living with CVS in Autoconfiscated Projects

There are basically two clans amongst maintainers: those who keep all distributed files under CVS, including generated files, and those who keep generated files *out* of CVS.

All Files in CVS

- The CVS repository contains all distributed files so you know exactly what is distributed, and you can check out any prior version entirely.
- Maintainers can see how generated files evolve (for instance, you can see what happens to your `Makefile.ins` when you upgrade Automake and make sure they look OK).
- Users do not need Autotools to build a check-out of the project; it works just like a released tarball.
- If users use `cvs update` to update their copy, instead of `cvs checkout` to fetch a fresh one, timestamps will be inaccurate. Some rebuild rules will be triggered and attempt to run developer tools such as `autoconf` or `automake`.

Calls to such tools are all wrapped into a call to the `missing` script discussed later (see Section 26.2 [maintainer-mode], page 141), so that the user will see more descriptive warnings about missing or out-of-date tools, and possible suggestions about how to obtain them, rather than just some “command not found” error, or (worse) some obscure message from some older version of the required tool they happen to have installed.

Maintainers interested in keeping their package buildable from a CVS checkout even for those users that lack maintainer-specific tools might want to provide a helper script (or to enhance their existing bootstrap script) to fix the timestamps after a `cvs update` or a `git checkout`, to prevent spurious rebuilds. In case of a project committing the Autotools-generated files, as well as the generated `.info` files, such a script might look something like this:

```
#!/bin/sh
# fix-timestamp.sh: prevents useless rebuilds after "cvs update"
sleep 1
# aclocal-generated aclocal.m4 depends on locally-installed
# '.m4' macro files, as well as on 'configure.ac'
touch aclocal.m4
sleep 1
# autoconf-generated configure depends on aclocal.m4 and on
# configure.ac
touch configure
# so does autoheader-generated config.h.in
touch config.h.in
# and all the automake-generated Makefile.in files
touch `find . -name Makefile.in -print`
# finally, the makeinfo-generated '.info' files depend on the
# corresponding '.texi' files
touch doc/*.info
```

- In distributed development, developers are likely to have different versions of the maintainer tools installed. In this case rebuilds triggered by timestamp lossage will lead to spurious changes to generated files. There are several solutions to this:
 - All developers should use the same versions, so that the rebuilt files are identical to files in CVS. (This starts to be difficult when each project you work on uses different versions.)
 - Or people use a script to fix the timestamp after a checkout (the GCC folks have such a script).

- Or `configure.ac` uses `AM_MAINTAINER_MODE`, which will disable all of these rebuild rules by default. This is further discussed in Section 26.2 [maintainer-mode], page 141.
- Although we focused on spurious rebuilds, the converse can also happen. CVS's timestamp handling can also let you think an out-of-date file is up-to-date. For instance, suppose a developer has modified `Makefile.am` and has rebuilt `Makefile.in`, and then decides to do a last-minute change to `Makefile.am` right before checking in both files (without rebuilding `Makefile.in` to account for the change).

This last change to `Makefile.am` makes the copy of `Makefile.in` out-of-date. Since CVS processes files alphabetically, when another developer 'cvs update's his or her tree, `Makefile.in` will happen to be newer than `Makefile.am`. This other developer will not see that `Makefile.in` is out-of-date.

Generated Files out of CVS

One way to get CVS and `make` working peacefully is to never store generated files in CVS, i.e., do not CVS-control files that are `Makefile` targets (also called *derived* files).

This way developers are not annoyed by changes to generated files. It does not matter if they all have different versions (assuming they are compatible, of course). And finally, timestamps are not lost; changes to sources files can't be missed as in the `Makefile.am/Makefile.in` example discussed earlier.

The drawback is that the CVS repository is not an exact copy of what is distributed and that users now need to install various development tools (maybe even specific versions) before they can build a checkout. But, after all, CVS's job is versioning, not distribution.

Allowing developers to use different versions of their tools can also hide bugs during distributed development. Indeed, developers will be using (hence testing) their own generated files, instead of the generated files that will be actually released. The developer who prepares the tarball might be using a version of the tool that produces bogus output (for instance a non-portable C file), something other developers could have noticed if they weren't using their own versions of this tool.

Third-party Files

Another class of files not discussed here (because they do not cause timestamp issues) are files that are shipped with a package, but maintained elsewhere. For instance, tools like `gettextize` and `autopoint` (from Gettext) or `libtoolize` (from Libtool), will install or update files in your package.

These files, whether they are kept under CVS or not, raise similar concerns about version mismatch between developers' tools. The Gettext manual has a section about this; see Section "Integrating with Version Control Systems" in *GNU gettext tools*.

26.2 missing and AM_MAINTAINER_MODE

missing

The `missing` script is a wrapper around several maintainer tools, designed to warn users if a maintainer tool is required but missing. Typical maintainer tools are `autoconf`, `automake`,

`bison`, etc. Because files generated by these tools are shipped with the other sources of a package, these tools shouldn't be required during a user build and they are not checked for in `configure`.

However, if for some reason a rebuild rule is triggered and involves a missing tool, `missing` will notice it and warn the user, even suggesting how to obtain such a tool (at least in case it is a well-known one, like `makeinfo` or `bison`). This is more helpful and user-friendly than just having the rebuild rules spewing out a terse error message like `'sh: tool: command not found'`. Similarly, `missing` will warn the user if it detects that a maintainer tool it attempted to use seems too old (be warned that diagnosing this correctly is typically more difficult than detecting missing tools, and requires cooperation from the tool itself, so it won't always work).

If the required tool is installed, `missing` will run it and won't attempt to continue after failures. This is correct behavior during development: developers love fixing failures. However, users with missing or too old maintainer tools may get an error when the rebuild rule is spuriously triggered, halting the build. This failure to let the build continue is one of the arguments of the `AM_MAINTAINER_MODE` advocates.

AM_MAINTAINER_MODE

`AM_MAINTAINER_MODE` allows you to choose whether the so called "rebuild rules" should be enabled or disabled. With `AM_MAINTAINER_MODE([enable])`, they are enabled by default; otherwise they are disabled by default. In the latter case, if you have `AM_MAINTAINER_MODE` in `configure.ac`, and run `./configure && make`, then `make` will *never* attempt to rebuild `configure`, `Makefile.ins`, `Lex` or `Yacc` outputs, etc. I.e., this disables build rules for files that are usually distributed and that users should normally not have to update.

The user can override the default setting by passing either `'--enable-maintainer-mode'` or `'--disable-maintainer-mode'` to `configure`.

People use `AM_MAINTAINER_MODE` either because they do not want their users (or themselves) annoyed by timestamp lossage (see Section 26.1 [CVS], page 139), or because they simply can't stand the rebuild rules and prefer running maintainer tools explicitly.

`AM_MAINTAINER_MODE` also allows you to disable some custom build rules conditionally. Some developers use this feature to disable rules that need exotic tools that users may not have available.

Several years ago François Pinard pointed out several arguments against this `AM_MAINTAINER_MODE` macro. Most of them relate to insecurity. By removing dependencies you get non-dependable builds: changes to source files can have no effect on generated files and this can be very confusing when unnoticed. He adds that security shouldn't be reserved to maintainers (what `--enable-maintainer-mode` suggests), on the contrary. If one user has to modify a `Makefile.am`, then either `Makefile.in` should be updated or a warning should be output (this is what Automake uses `missing` for) but the last thing you want is that nothing happens and the user doesn't notice it (this is what happens when rebuild rules are disabled by `AM_MAINTAINER_MODE`).

Jim Meyering, the inventor of the `AM_MAINTAINER_MODE` macro, was swayed by François' arguments, and got rid of `AM_MAINTAINER_MODE` in all of his packages.

Still many people continue to use `AM_MAINTAINER_MODE`, because it helps them working on projects where all files are kept under version control, and because `missing` isn't enough if you have the wrong version of the tools.

26.3 Why doesn't Automake support wildcards?

Developers are lazy. They would often like to use wildcards in `Makefile.am`, so that they would not need to remember to update `Makefile.am` every time they add, delete, or rename a file.

There are several objections to this:

- When using CVS (or similar) developers need to remember they have to run `'cvs add'` or `'cvs rm'` anyway. Updating `Makefile.am` accordingly quickly becomes a reflex. Conversely, if your application doesn't compile because you forgot to add a file in `Makefile.am`, it will help you remember to `'cvs add'` it.
- Using wildcards makes it easy to distribute files by mistake. For instance, some code a developer is experimenting with (a test case, say) that should not be part of the distribution.
- Using wildcards it's easy to omit some files by mistake. For instance, one developer creates a new file, uses it in many places, but forgets to commit it. Another developer then checks out the incomplete project and is able to run `'make dist'` successfully, even though a file is missing. By listing files, `'make dist'` *will* complain.
- Wildcards are not portable to some non-GNU `make` implementations, e.g., NetBSD `make` will not expand globs such as `'*'` in prerequisites of a target.
- Finally, it's really hard to *forget* to add a file to `Makefile.am`: files that are not listed in `Makefile.am` are not compiled or installed, so you can't even test them.

Still, these are philosophical objections, and as such you may disagree, or find enough value in wildcards to dismiss all of them. Before you start writing a patch against Automake to teach it about wildcards, let's see the main technical issue: portability.

Although `'$(wildcard ...)'` works with GNU `make`, it is not portable to other `make` implementations.

The only way Automake could support `'$(wildcard ...)'` is by expanding `'$(wildcard ...)'` when `automake` is run. The resulting `Makefile.ins` would be portable since they would list all files and not use `'$(wildcard ...)'`. However that means developers would need to remember to run `automake` each time they add, delete, or rename files.

Compared to editing `Makefile.am`, this is a very small gain. Sure, it's easier and faster to type `'automake; make'` than to type `'emacs Makefile.am; make'`. But nobody bothered enough to write a patch to add support for this syntax. Some people use scripts to generate file lists in `Makefile.am` or in separate `Makefile` fragments.

Even if you don't care about portability, and are tempted to use `'$(wildcard ...)'` anyway because you target only GNU Make, you should know there are many places where Automake needs to know exactly which files should be processed. As Automake doesn't know how to expand `'$(wildcard ...)'`, you cannot use it in these places. `'$(wildcard ...)'` is a black box comparable to `AC_SUBST`d variables as far Automake is concerned.

You can get warnings about `'$(wildcard ...)'` constructs using the `-Wportability` flag.

26.4 Limitations on File Names

Automake attempts to support all kinds of file names, even those that contain unusual characters or are unusually long. However, some limitations are imposed by the underlying operating system and tools.

Most operating systems prohibit the use of the null byte in file names, and reserve `/` as a directory separator. Also, they require that file names are properly encoded for the user's locale. Automake is subject to these limits.

Portable packages should limit themselves to POSIX file names. These can contain ASCII letters and digits, `_`, `.`, and `-`. File names consist of components separated by `/`. File name components cannot begin with `-`.

Portable POSIX file names cannot contain components that exceed a 14-byte limit, but nowadays it's normally safe to assume the more-generous XOPEN limit of 255 bytes. POSIX limits file names to 255 bytes (XOPEN allows 1023 bytes), but you may want to limit a source tarball to file names of 99 bytes to avoid interoperability problems with old versions of `tar`.

If you depart from these rules (e.g., by using non-ASCII characters in file names, or by using lengthy file names), your installers may have problems for reasons unrelated to Automake. However, if this does not concern you, you should know about the limitations imposed by Automake itself. These limitations are undesirable, but some of them seem to be inherent to underlying tools like Autoconf, Make, M4, and the shell. They fall into three categories: install directories, build directories, and file names.

The following characters:

```
newline " # $ ' `
```

should not appear in the names of install directories. For example, the operand of `configure's --prefix` option should not contain these characters.

Build directories suffer the same limitations as install directories, and in addition should not contain the following characters:

```
& @ \
```

For example, the full name of the directory containing the source files should not contain these characters.

Source and installation file names like `main.c` are limited even further: they should conform to the POSIX/XOPEN rules described above. In addition, if you plan to port to non-POSIX environments, you should avoid file names that differ only in case (e.g., `makefile` and `Makefile`). Nowadays it is no longer worth worrying about the 8.3 limits of DOS file systems.

26.5 Errors with `distclean`

This is a diagnostic you might encounter while running `'make distcheck'`.

As explained in Section 14.4 [Checking the Distribution], page 100, `'make distcheck'` attempts to build and check your package for errors like this one.

`'make distcheck'` will perform a `VPATH` build of your package (see Section 2.2.6 [VPATH Builds], page 6), and then call `'make distclean'`. Files left in the build directory after `'make distclean'` has run are listed after this error.

This diagnostic really covers two kinds of errors:

- files that are forgotten by `distclean`;
- distributed files that are erroneously rebuilt.

The former left-over files are not distributed, so the fix is to mark them for cleaning (see Chapter 13 [Clean], page 98); this is obvious and doesn't deserve more explanation.

The latter bug is not always easy to understand and fix, so let's proceed with an example. Suppose our package contains a program for which we want to build a man page using `help2man`. GNU `help2man` produces simple manual pages from the `--help` and `--version` output of other commands (see Section "Overview" in *The Help2man Manual*). Because we don't want to force our users to install `help2man`, we decide to distribute the generated man page using the following setup.

```
# This Makefile.am is bogus.
bin_PROGRAMS = foo
foo_SOURCES = foo.c
dist_man_MANS = foo.1

foo.1: foo$(EXEEXT)
    help2man --output=foo.1 ./foo$(EXEEXT)
```

This will effectively distribute the man page. However, `'make distcheck'` will fail with:

```
ERROR: files left in build directory after distclean:
./foo.1
```

Why was `foo.1` rebuilt? Because although distributed, `foo.1` depends on a non-distributed built file: `foo$(EXEEXT)`. `foo$(EXEEXT)` is built by the user, so it will always appear to be newer than the distributed `foo.1`.

`'make distcheck'` caught an inconsistency in our package. Our intent was to distribute `foo.1` so users do not need to install `help2man`, however since this rule causes this file to be always rebuilt, users *do* need `help2man`. Either we should ensure that `foo.1` is not rebuilt by users, or there is no point in distributing `foo.1`.

More generally, the rule is that distributed files should never depend on non-distributed built files. If you distribute something generated, distribute its sources.

One way to fix the above example, while still distributing `foo.1`, is to not depend on `foo$(EXEEXT)`. For instance, assuming `foo --version` and `foo --help` do not change unless `foo.c` or `configure.ac` change, we could write the following `Makefile.am`:

```
bin_PROGRAMS = foo
foo_SOURCES = foo.c
dist_man_MANS = foo.1

foo.1: foo.c $(top_srcdir)/configure.ac
    $(MAKE) $(AM_MAKEFLAGS) foo$(EXEEXT)
    help2man --output=foo.1 ./foo$(EXEEXT)
```

This way, `foo.1` will not get rebuilt every time `foo$(EXEEXT)` changes. The `make` call makes sure `foo$(EXEEXT)` is up-to-date before `help2man`. Another way to ensure this would be to use separate directories for binaries and man pages, and set `SUBDIRS` so that binaries are built before man pages.

We could also decide not to distribute `foo.1`. In this case it's fine to have `foo.1` dependent upon `foo$(EXEEXT)`, since both will have to be rebuilt. However, it would be impossible to build the package in a cross-compilation, because building `foo.1` involves an *execution* of `foo$(EXEEXT)`.

Another context where such errors are common is when distributed files are built by tools that are built by the package. The pattern is similar:

```
distributed-file: built-tools distributed-sources
                build-command
```

should be changed to

```
distributed-file: distributed-sources
                $(MAKE) $(AM_MAKEFLAGS) built-tools
                build-command
```

or you could choose not to distribute `distributed-file`, if cross-compilation does not matter.

The points made through these examples are worth a summary:

- Distributed files should never depend upon non-distributed built files.
- Distributed files should be distributed with all their dependencies.
- If a file is *intended* to be rebuilt by users, then there is no point in distributing it.

For desperate cases, it's always possible to disable this check by setting `distcleancheck_listfiles` as documented in Section 14.4 [Checking the Distribution], page 100. Make sure you do understand the reason why 'make distcheck' complains before you do this. `distcleancheck_listfiles` is a way to *hide* errors, not to fix them. You can always do better.

26.6 Flag Variables Ordering

What is the difference between `AM_CFLAGS`, `CFLAGS`, and `mumble_CFLAGS`?

Why does `automake` output `CPPFLAGS` after `AM_CPPFLAGS` on compile lines? Shouldn't it be the converse?

My `configure` adds some warning flags into `CXXFLAGS`. In one `Makefile.am` I would like to append a new flag, however if I put the flag into `AM_CXXFLAGS` it is prepended to the other flags, not appended.

Compile Flag Variables

This section attempts to answer all the above questions. We will mostly discuss `CPPFLAGS` in our examples, but actually the answer holds for all the compile flags used in Automake: `CCASFLAGS`, `CFLAGS`, `CPPFLAGS`, `CXXFLAGS`, `FCFLAGS`, `FFLAGS`, `GCJFLAGS`, `LDFLAGS`, `LFLAGS`, `LIBTOOLFLAGS`, `OBJCFLAGS`, `OBJCXXFLAGS`, `RFLAGS`, `UPCFLAGS`, and `YFLAGS`.

`CPPFLAGS`, `AM_CPPFLAGS`, and `mumble_CPPFLAGS` are three variables that can be used to pass flags to the C preprocessor (actually these variables are also used for other languages

like C++ or preprocessed Fortran). `CPPFLAGS` is the user variable (see Section 3.6 [User Variables], page 23), `AM_CPPFLAGS` is the Automake variable, and `mumble_CPPFLAGS` is the variable specific to the `mumble` target (we call this a per-target variable, see Section 8.4 [Program and Library Variables], page 65).

Automake always uses two of these variables when compiling C sources files. When compiling an object file for the `mumble` target, the first variable will be `mumble_CPPFLAGS` if it is defined, or `AM_CPPFLAGS` otherwise. The second variable is always `CPPFLAGS`.

In the following example,

```
bin_PROGRAMS = foo bar
foo_SOURCES = xyz.c
bar_SOURCES = main.c
foo_CPPFLAGS = -DFOO
AM_CPPFLAGS = -DBAZ
```

`xyz.o` will be compiled with `'$(foo_CPPFLAGS) $(CPPFLAGS)'`, (because `xyz.o` is part of the `foo` target), while `main.o` will be compiled with `'$(AM_CPPFLAGS) $(CPPFLAGS)'` (because there is no per-target variable for target `bar`).

The difference between `mumble_CPPFLAGS` and `AM_CPPFLAGS` being clear enough, let's focus on `CPPFLAGS`. `CPPFLAGS` is a user variable, i.e., a variable that users are entitled to modify in order to compile the package. This variable, like many others, is documented at the end of the output of `'configure --help'`.

For instance, someone who needs to add `/home/my/usr/include` to the C compiler's search path would configure a package with

```
./configure CPPFLAGS='-I /home/my/usr/include'
```

and this flag would be propagated to the compile rules of all Makefiles.

It is also not uncommon to override a user variable at `make`-time. Many installers do this with `prefix`, but this can be useful with compiler flags too. For instance, if, while debugging a C++ project, you need to disable optimization in one specific object file, you can run something like

```
rm file.o
make CXXFLAGS=-O0 file.o
make
```

The reason `'$(CPPFLAGS)'` appears after `'$(AM_CPPFLAGS)'` or `'$(mumble_CPPFLAGS)'` in the compile command is that users should always have the last say. It probably makes more sense if you think about it while looking at the `'CXXFLAGS=-O0'` above, which should supersede any other switch from `AM_CXXFLAGS` or `mumble_CXXFLAGS` (and this of course replaces the previous value of `CXXFLAGS`).

You should never redefine a user variable such as `CPPFLAGS` in `Makefile.am`. Use `'automake -Woverride'` to diagnose such mistakes. Even something like

```
CPPFLAGS = -DDATADIR="\$(datadir)\ " @CPPFLAGS@
```

is erroneous. Although this preserves `configure`'s value of `CPPFLAGS`, the definition of `DATADIR` will disappear if a user attempts to override `CPPFLAGS` from the `make` command line.

```
AM_CPPFLAGS = -DDATADIR="\$(datadir)\ "
```

is all that is needed here if no per-target flags are used.

You should not add options to these user variables within `configure` either, for the same reason. Occasionally you need to modify these variables to perform a test, but you should reset their values afterwards. In contrast, it is OK to modify the ‘AM_’ variables within `configure` if you `AC_SUBST` them, but it is rather rare that you need to do this, unless you really want to change the default definitions of the ‘AM_’ variables in all `Makefiles`.

What we recommend is that you define extra flags in separate variables. For instance, you may write an Autoconf macro that computes a set of warning options for the C compiler, and `AC_SUBST` them in `WARNINGCFLAGS`; you may also have an Autoconf macro that determines which compiler and which linker flags should be used to link with library `libfoo`, and `AC_SUBST` these in `LIBFOOCFLAGS` and `LIBFOOLDFLAGS`. Then, a `Makefile.am` could use these variables as follows:

```
AM_CFLAGS = $(WARNINGCFLAGS)
bin_PROGRAMS = prog1 prog2
prog1_SOURCES = ...
prog2_SOURCES = ...
prog2_CFLAGS = $(LIBFOOCFLAGS) $(AM_CFLAGS)
prog2_LDFLAGS = $(LIBFOOLDFLAGS)
```

In this example both programs will be compiled with the flags substituted into ‘`$(WARNINGCFLAGS)`’, and `prog2` will additionally be compiled with the flags required to link with `libfoo`.

Note that listing `AM_CFLAGS` in a per-target `CFLAGS` variable is a common idiom to ensure that `AM_CFLAGS` applies to every target in a `Makefile.in`.

Using variables like this gives you full control over the ordering of the flags. For instance, if there is a flag in `$(WARNINGCFLAGS)` that you want to negate for a particular target, you can use something like ‘`prog1_CFLAGS = $(AM_CFLAGS) -no-flag`’. If all of these flags had been forcefully appended to `CFLAGS`, there would be no way to disable one flag. Yet another reason to leave user variables to users.

Finally, we have avoided naming the variable of the example `LIBFOO_LDFLAGS` (with an underscore) because that would cause Automake to think that this is actually a per-target variable (like `mumble_LDFLAGS`) for some non-declared `LIBFOO` target.

Other Variables

There are other variables in Automake that follow similar principles to allow user options. For instance, Texinfo rules (see Section 11.1 [Texinfo], page 92) use `MAKEINFOFLAGS` and `AM_MAKEINFOFLAGS`. Similarly, DejaGnu tests (see Section 15.5 [DejaGnu Tests], page 118) use `RUNTESTDEFAULTFLAGS` and `AM_RUNTESTDEFAULTFLAGS`. The tags and `ctags` rules (see Section 18.1 [Tags], page 124) use `ETAGSFLAGS`, `AM_ETAGSFLAGS`, `CTAGSFLAGS`, and `AM_CTAGSFLAGS`. Java rules (see Section 10.4 [Java], page 90) use `JAVACFLAGS` and `AM_JAVACFLAGS`. None of these rules support per-target flags (yet).

To some extent, even `AM_MAKEFLAGS` (see Section 7.1 [Subdirectories], page 48) obeys this naming scheme. The slight difference is that `MAKEFLAGS` is passed to sub-makes implicitly by `make` itself.

`ARFLAGS` (see Section 8.2 [A Library], page 58) is usually defined by Automake and has neither an `AM_` nor a per-target cousin.

Finally you should not think that the existence of a per-target variable implies the existence of an `AM_` variable or of a user variable. For instance, the `mumble_LDADD` per-target variable overrides the makefile-wide `LDADD` variable (which is not a user variable), and `mumble_LIBADD` exists only as a per-target variable. See Section 8.4 [Program and Library Variables], page 65.

26.7 Why are object files sometimes renamed?

This happens when per-target compilation flags are used. Object files need to be renamed just in case they would clash with object files compiled from the same sources, but with different flags. Consider the following example.

```
bin_PROGRAMS = true false
true_SOURCES = generic.c
true_CPPFLAGS = -DEXIT_CODE=0
false_SOURCES = generic.c
false_CPPFLAGS = -DEXIT_CODE=1
```

Obviously the two programs are built from the same source, but it would be bad if they shared the same object, because `generic.o` cannot be built with both `'-DEXIT_CODE=0'` and `'-DEXIT_CODE=1'`. Therefore automake outputs rules to build two different objects: `true-generic.o` and `false-generic.o`.

automake doesn't actually look whether source files are shared to decide if it must rename objects. It will just rename all objects of a target as soon as it sees per-target compilation flags used.

It's OK to share object files when per-target compilation flags are not used. For instance, `true` and `false` will both use `version.o` in the following example.

```
AM_CPPFLAGS = -DVERSION=1.0
bin_PROGRAMS = true false
true_SOURCES = true.c version.c
false_SOURCES = false.c version.c
```

Note that the renaming of objects is also affected by the `_SHORTNAME` variable (see Section 8.4 [Program and Library Variables], page 65).

26.8 Per-Object Flags Emulation

One of my source files needs to be compiled with different flags. How do I do that?

Automake supports per-program and per-library compilation flags (see Section 8.4 [Program and Library Variables], page 65, and Section 26.6 [Flag Variables Ordering], page 146). With this you can define compilation flags that apply to all files compiled for a target. For instance, in

```
bin_PROGRAMS = foo
foo_SOURCES = foo.c foo.h bar.c bar.h main.c
foo_CFLAGS = -some -flags
```

`foo-foo.o`, `foo-bar.o`, and `foo-main.o` will all be compiled with `'-some -flags'`. (If you wonder about the names of these object files, see Section 26.7 [Renamed Objects], page 149.)

Note that `foo_CFLAGS` gives the flags to use when compiling all the C sources of the *program* `foo`; it has nothing to do with `foo.c` or `foo-foo.o` specifically.

What if `foo.c` needs to be compiled into `foo.o` using some specific flags, that none of the other files requires? Obviously per-program flags are not directly applicable here. Something like per-object flags are expected, i.e., flags that would be used only when creating `foo-foo.o`. Automake does not support that; however this is easy to simulate using a library that contains only that object, and compiling this library with per-library flags.

```
bin_PROGRAMS = foo
foo_SOURCES = bar.c bar.h main.c
foo_CFLAGS = -some -flags
foo_LDADD = libfoo.a
noinst_LIBRARIES = libfoo.a
libfoo_a_SOURCES = foo.c foo.h
libfoo_a_CFLAGS = -some -other -flags
```

Here `foo-bar.o` and `foo-main.o` will all be compiled with ‘`-some -flags`’, while `libfoo_a-foo.o` will be compiled using ‘`-some -other -flags`’. Eventually, all three objects will be linked to form `foo`.

This trick can also be achieved using Libtool convenience libraries, for instance ‘`noinst_LTLIBRARIES = libfoo.la`’ (see Section 8.3.5 [Libtool Convenience Libraries], page 62).

Another tempting idea to implement per-object flags is to override the compile rules `automake` would output for these files. Automake will not define a rule for a target you have defined, so you could think about defining the ‘`foo-foo.o: foo.c`’ rule yourself. We recommend against this, because this is error prone. For instance, if you add such a rule to the first example, it will break the day you decide to remove `foo_CFLAGS` (because `foo.c` will then be compiled as `foo.o` instead of `foo-foo.o`, see Section 26.7 [Renamed Objects], page 149). Also in order to support dependency tracking, the two `.o/.obj` extensions, and all the other flags variables involved in a compilation, you will end up modifying a copy of the rule previously output by `automake` for this file. If a new release of Automake generates a different rule, your copy will need to be updated by hand.

26.9 Handling Tools that Produce Many Outputs

This section describes a `make` idiom that can be used when a tool produces multiple output files. It is not specific to Automake and can be used in ordinary `Makefiles`.

Suppose we have a program called `foo` that will read one file called `data.foo` and produce two files named `data.c` and `data.h`. We want to write a `Makefile` rule that captures this one-to-two dependency.

The naive rule is incorrect:

```
# This is incorrect.
data.c data.h: data.foo
    foo data.foo
```

What the above rule really says is that `data.c` and `data.h` each depend on `data.foo`, and can each be built by running ‘`foo data.foo`’. In other words it is equivalent to:

```
# We do not want this.
```

```

data.c: data.foo
        foo data.foo
data.h: data.foo
        foo data.foo

```

which means that `foo` can be run twice. Usually it will not be run twice, because `make` implementations are smart enough to check for the existence of the second file after the first one has been built; they will therefore detect that it already exists. However there are a few situations where it can run twice anyway:

- The most worrying case is when running a parallel `make`. If `data.c` and `data.h` are built in parallel, two `'foo data.foo'` commands will run concurrently. This is harmful.
- Another case is when the dependency (here `data.foo`) is (or depends upon) a phony target.

A solution that works with parallel `make` but not with phony dependencies is the following:

```

data.c data.h: data.foo
        foo data.foo
data.h: data.c

```

The above rules are equivalent to

```

data.c: data.foo
        foo data.foo
data.h: data.foo data.c
        foo data.foo

```

therefore a parallel `make` will have to serialize the builds of `data.c` and `data.h`, and will detect that the second is no longer needed once the first is over.

Using this pattern is probably enough for most cases. However it does not scale easily to more output files (in this scheme all output files must be totally ordered by the dependency relation), so we will explore a more complicated solution.

Another idea is to write the following:

```

# There is still a problem with this one.
data.c: data.foo
        foo data.foo
data.h: data.c

```

The idea is that `'foo data.foo'` is run only when `data.c` needs to be updated, but we further state that `data.h` depends upon `data.c`. That way, if `data.h` is required and `data.foo` is out of date, the dependency on `data.c` will trigger the build.

This is almost perfect, but suppose we have built `data.h` and `data.c`, and then we erase `data.h`. Then, running `'make data.h'` will not rebuild `data.h`. The above rules just state that `data.c` must be up-to-date with respect to `data.foo`, and this is already the case.

What we need is a rule that forces a rebuild when `data.h` is missing. Here it is:

```

data.c: data.foo
        foo data.foo
data.h: data.c
## Recover from the removal of $@

```

```

@test -f $@ || rm -f data.c
@test -f $@ || $(MAKE) $(AM_MAKEFLAGS) data.c

```

It is tempting to use a single test as follows:

```

data.h: data.c
## Recover from the removal of $@
@if test -f $@; then ;; else \
  rm -f data.c; \
  $(MAKE) $(AM_MAKEFLAGS) data.c; \
fi

```

but that would break ‘make -n’: at least GNU `make` and Solaris `make` execute recipes containing the ‘\$(MAKE)’ string even when they are running in dry mode. So if we didn’t break the recipe above in two invocations, the file `data.c` would be removed even upon ‘make -n’. Not nice.

The above scheme can be extended to handle more outputs and more inputs. One of the outputs is selected to serve as a witness to the successful completion of the command, it depends upon all inputs, and all other outputs depend upon it. For instance, if `foo` should additionally read `data.bar` and also produce `data.w` and `data.x`, we would write:

```

data.c: data.foo data.bar
  foo data.foo data.bar
data.h data.w data.x: data.c
## Recover from the removal of $@
@test -f $@ || rm -f data.c
@test -f $@ || $(MAKE) $(AM_MAKEFLAGS) data.c

```

However there are now three minor problems in this setup. One is related to the timestamp ordering of `data.h`, `data.w`, `data.x`, and `data.c`. Another one is a race condition if a parallel `make` attempts to run multiple instances of the recover block at once. Finally, the recursive rule breaks ‘make -n’ when run with GNU `make` (as well as some other `make` implementations), as it may remove `data.h` even when it should not (see Section “How the MAKE Variable Works” in *The GNU Make Manual*).

Let us deal with the first problem. `foo` outputs four files, but we do not know in which order these files are created. Suppose that `data.h` is created before `data.c`. Then we have a weird situation. The next time `make` is run, `data.h` will appear older than `data.c`, the second rule will be triggered, a shell will be started to execute the ‘if...fi’ command, but actually it will just execute the `then` branch, that is: nothing. In other words, because the witness we selected is not the first file created by `foo`, `make` will start a shell to do nothing each time it is run.

A simple riposte is to fix the timestamps when this happens.

```

data.c: data.foo data.bar
  foo data.foo data.bar
data.h data.w data.x: data.c
  @test ! -f $@ || touch $@
## Recover from the removal of $@
@test -f $@ || rm -f data.c
@test -f $@ || $(MAKE) $(AM_MAKEFLAGS) data.c

```

Another solution is to use a different and dedicated file as witness, rather than using any of `foo`'s outputs.

```
data.stamp: data.foo data.bar
    @rm -f data.tmp
    @touch data.tmp
    foo data.foo data.bar
    @mv -f data.tmp $@

data.c data.h data.w data.x: data.stamp
## Recover from the removal of $@
    @test -f $@ || rm -f data.stamp
    @test -f $@ || $(MAKE) $(AM_MAKEFLAGS) data.stamp
```

`data.tmp` is created before `foo` is run, so it has a timestamp older than output files output by `foo`. It is then renamed to `data.stamp` after `foo` has run, because we do not want to update `data.stamp` if `foo` fails.

This solution still suffers from the second problem: the race condition in the recover rule. If, after a successful build, a user erases `data.c` and `data.h`, and runs `'make -j'`, then `make` may start both recover rules in parallel. If the two instances of the rule execute `'$(MAKE) $(AM_MAKEFLAGS) data.stamp'` concurrently the build is likely to fail (for instance, the two rules will create `data.tmp`, but only one can rename it).

Admittedly, such a weird situation does not arise during ordinary builds. It occurs only when the build tree is mutilated. Here `data.c` and `data.h` have been explicitly removed without also removing `data.stamp` and the other output files. `make clean`; `make` will always recover from these situations even with parallel makes, so you may decide that the recover rule is solely to help non-parallel make users and leave things as-is. Fixing this requires some locking mechanism to ensure only one instance of the recover rule rebuilds `data.stamp`. One could imagine something along the following lines.

```
data.c data.h data.w data.x: data.stamp
## Recover from the removal of $@
    @if test -f $@; then ;; else \
        trap 'rm -rf data.lock data.stamp' 1 2 13 15; \
    ## mkdir is a portable test-and-set
        if mkdir data.lock 2>/dev/null; then \
    ## This code is being executed by the first process.
        rm -f data.stamp; \
        $(MAKE) $(AM_MAKEFLAGS) data.stamp; \
        result=$$?; rm -rf data.lock; exit $$result; \
    else \
    ## This code is being executed by the follower processes.
    ## Wait until the first process is done.
        while test -d data.lock; do sleep 1; done; \
    ## Succeed if and only if the first process succeeded.
        test -f data.stamp; \
    fi; \
    fi
```

Using a dedicated witness, like `data.stamp`, is very handy when the list of output files is not known beforehand. As an illustration, consider the following rules to compile many

*.el files into *.elc files in a single command. It does not matter how `ELFILES` is defined (as long as it is not empty: empty targets are not accepted by POSIX).

```
ELFILES = one.el two.el three.el ...
ELCFILES = $(ELFILES:=c)

elc-stamp: $(ELFILES)
    @rm -f elc-temp
    @touch elc-temp
    $(elisp_comp) $(ELFILES)
    @mv -f elc-temp $@

$(ELCFILES): elc-stamp
    @if test -f $@; then ;; else \
## Recover from the removal of $@
    trap 'rm -rf elc-lock elc-stamp' 1 2 13 15; \
    if mkdir elc-lock 2>/dev/null; then \
## This code is being executed by the first process.
    rm -f elc-stamp; \
    $(MAKE) $(AM_MAKEFLAGS) elc-stamp; \
    rmdir elc-lock; \
    else \
## This code is being executed by the follower processes.
## Wait until the first process is done.
    while test -d elc-lock; do sleep 1; done; \
## Succeed if and only if the first process succeeded.
    test -f elc-stamp; exit $$?; \
    fi; \
fi
```

These solutions all still suffer from the third problem, namely that they break the promise that ‘`make -n`’ should not cause any actual changes to the tree. For those solutions that do not create lock files, it is possible to split the recover rules into two separate recipe commands, one of which does all work but the recursion, and the other invokes the recursive ‘`$(MAKE)`’. The solutions involving locking could act upon the contents of the ‘`MAKEFLAGS`’ variable, but parsing that portably is not easy (see Section “The Make Macro `MAKEFLAGS`” in *The Autoconf Manual*). Here is an example:

```
ELFILES = one.el two.el three.el ...
ELCFILES = $(ELFILES:=c)

elc-stamp: $(ELFILES)
    @rm -f elc-temp
    @touch elc-temp
    $(elisp_comp) $(ELFILES)
    @mv -f elc-temp $@

$(ELCFILES): elc-stamp
## Recover from the removal of $@
```

```

@dry=; for f in x $$MAKEFLAGS; do \
  case $$f in \
    **|--*);; \
    *) dry=:;; \
  esac; \
done; \
if test -f $@; then ;; else \
  $$dry trap 'rm -rf elc-lock elc-stamp' 1 2 13 15; \
  if $$dry mkdir elc-lock 2>/dev/null; then \
## This code is being executed by the first process.
  $$dry rm -f elc-stamp; \
  $(MAKE) $(AM_MAKEFLAGS) elc-stamp; \
  $$dry rmdir elc-lock; \
  else \
## This code is being executed by the follower processes.
## Wait until the first process is done.
  while test -d elc-lock && test -z "$$dry"; do \
    sleep 1; \
  done; \
## Succeed if and only if the first process succeeded.
  $$dry test -f elc-stamp; exit $$?; \
fi; \
fi

```

For completeness it should be noted that GNU `make` is able to express rules with multiple output files using pattern rules (see Section “Pattern Rule Examples” in *The GNU Make Manual*). We do not discuss pattern rules here because they are not portable, but they can be convenient in packages that assume GNU `make`.

26.10 Installing to Hard-Coded Locations

My package needs to install some configuration file. I tried to use the following rule, but ‘`make distcheck`’ fails. Why?

```

# Do not do this.
install-data-local:
  $(INSTALL_DATA) $(srcdir)/afile $(DESTDIR)/etc/afile

```

My package needs to populate the installation directory of another package at install-time. I can easily compute that installation directory in `configure`, but if I install files therein, ‘`make distcheck`’ fails. How else should I do it?

These two setups share their symptoms: ‘`make distcheck`’ fails because they are installing files to hard-coded paths. In the latter case the path is not really hard-coded in the package, but we can consider it to be hard-coded in the system (or in whichever tool that supplies the path). As long as the path does not use any of the standard directory variables (‘`$(prefix)`’, ‘`$(bindir)`’, ‘`$(datadir)`’, etc.), the effect will be the same: user-installations are impossible.


```
(setq load-path (cdr load-path)))' >confstest.out
lispdir='sed -n
-e 's,/$,,'
-e '/.*\lib\/*emacs\site-lisp$/{
  s,.*\lib/\(x*emacs/site-lisp\)$,${libdir}/\1,;p;q;
}'
-e '/.*\share\/*emacs\site-lisp$/{
  s,.*\share/\(x*emacs/site-lisp\)$,${datarootdir}/\1,;p;q;
}'
confstest.out'
```

I.e., it just picks the first directory that looks like `*/lib/*emacs/site-lisp` or `*/share/*emacs/site-lisp` in the search path of emacs, and then substitutes `'${libdir}'` or `'${datadir}'` appropriately.

The emacs case looks complicated because it processes a list and expects two possible layouts; otherwise it's easy, and the benefits for non-root users are really worth the extra `sed` invocation.

26.11 Debugging Make Rules

The rules and dependency trees generated by `automake` can get rather complex, and leave the developer head-scratching when things don't work as expected. Besides the debug options provided by the `make` command (see Section "Options Summary" in *The GNU Make Manual*), here's a couple of further hints for debugging makefiles generated by `automake` effectively:

- If less verbose output has been enabled in the package with the use of silent rules (see Section 21.3 [Automake Silent Rules], page 130), you can use `make V=1` to see the commands being executed.
- `make -n` can help show what would be done without actually doing it. Note however, that this will *still execute* commands prefixed with '+', and, when using GNU `make`, commands that contain the strings `'$(MAKE)'` or `'${MAKE}'` (see Section "Instead of Execution" in *The GNU Make Manual*). Typically, this is helpful to show what recursive rules would do, but it means that, in your own rules, you should not mix such recursion with actions that change any files.⁸ Furthermore, note that GNU `make` will update prerequisites for the Makefile file itself even with `-n` (see Section "Remaking Makefiles" in *The GNU Make Manual*).
- `make SHELL="/bin/bash -vx"` can help debug complex rules. See Section "The Make Macro SHELL" in *The Autoconf Manual*, for some portability quirks associated with this construct.
- `echo 'print: ; @echo "$(VAR)'" | make -f Makefile -f - print` can be handy to examine the expanded value of variables. You may need to use a target other than 'print' if that is already used or a file with that name exists.
- <http://bashdb.sourceforge.net/remake/> provides a modified GNU `make` command called `remake` that copes with complex GNU `make`-specific Makefiles and allows tracing execution, examining variables, and calling rules interactively, much like a debugger.

⁸ Automake's 'dist' and 'distcheck' rules had a bug in this regard in that they created directories even with `-n`, but this has been fixed in Automake 1.11.

26.12 Reporting Bugs

Most nontrivial software has bugs. Automake is no exception. Although we cannot promise we can or will fix a bug, and we might not even agree that it is a bug, we want to hear about problems you encounter. Often we agree they are bugs and want to fix them.

To make it possible for us to fix a bug, please report it. In order to do so effectively, it helps to know when and how to do it.

Before reporting a bug, it is a good idea to see if it is already known. You can look at the GNU Bug Tracker (<https://debbugs.gnu.org/>) and the bug-automake mailing list archives (<https://lists.gnu.org/archive/html/bug-automake/>) for previous bug reports. We previously used a Gnats database for bug tracking, but it is no longer online.

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Appendix B Indices

B.1 Macro Index

-		AC_SUBST	35
_AM_DEPENDENCIES	47	AM_COND_IF	35, 128
A		AM_CONDITIONAL	35, 127
AC_CANONICAL_BUILD	32	AM_DEP_TRACK	47
AC_CANONICAL_HOST	32	AM_GNU_GETTEXT	35
AC_CANONICAL_TARGET	32	AM_GNU_GETTEXT_INTL_SUBDIR	35
AC_CONFIG_AUX_DIR	32, 53	AM_INIT_AUTOMAKE	30, 45
AC_CONFIG_FILES	30	AM_MAINTAINER_MODE	119, 142
AC_CONFIG_HEADERS	33	AM_MAINTAINER_	
AC_CONFIG_LIBOBJ_DIR	33, 71	MODE(@r[@vardefault-mode@r]@comment) ...	35
AC_CONFIG_LINKS	33	AM_MAKE_INCLUDE	48
AC_CONFIG_SUBDIRS	53	AM_MISSING_PROG	47
AC_DEFUN	41	AM_OUTPUT_DEPENDENCY_COMMANDS	47
AC_F77_LIBRARY_LDFLAGS	34	AM_PATH_LISPDIR	46
AC_FC_SRCEXT	34	AM_PATH_PYTHON	91
AC_INIT	45	AM_PROG_AR	46
AC_LIBOBJ	33, 64, 70	AM_PROG_AS	46
AC_LIBSOURCE	33, 70	AM_PROG_CC_C_O	46
AC_LIBSOURCES	33	AM_PROG_GCJ	46
AC_OUTPUT	30	AM_PROG_INSTALL_STRIP	48
AC_PREREQ	41	AM_PROG_LEX	46
AC_PROG_CXX	34	AM_PROG_MKDIR_P	47
AC_PROG_F77	34	AM_PROG_UPC	46
AC_PROG_FC	34	AM_PROG_VALAC	81
AC_PROG_LEX	34, 46	AM_SANITY_CHECK	48
AC_PROG_LIBTOOL	34	AM_SET_DEPDIR	47
AC_PROG_OBJC	34	AM_SILENT_RULES	47
AC_PROG_OBJCXX	34	AM_SUBST_NOTMAKE(<i>var</i>)	35
AC_PROG_RANLIB	33	AM_WITH_DMALLOC	47
AC_PROG_YACC	34		
AC_REQUIRE_AUX_FILE	34	M	
		m4_include	35, 99

B.2 Variable Index

-		_PYTHON	91
_DATA	85	_SCRIPTS	83
_HEADERS	84	_SOURCES	55, 69
_LIBRARIES	58	_TEXINFOS	92, 93
_LISP	89	A	
_LOG_COMPILE	108	ACLOCAL_AUTOMAKE_DIR	36
_LOG_COMPILER	108	ALLOCA	64, 70
_LOG_DRIVER	111	AM_CCASFLAGS	77
_LOG_DRIVER_FLAGS	111	AM_CFLAGS	73
_LOG_FLAGS	108	AM_COLOR_TESTS	106
_LTLIBRARIES	60	AM_CPPFLAGS	72, 77
_MANS	95	AM_CXXFLAGS	75
_PROGRAMS	21, 55		

AM_DEFAULT_SOURCE_EXT	69
AM_DEFAULT_V	132
AM_DEFAULT_VERBOSITY	132
AM_DISTCHECK_CONFIGURE_FLAGS	101
AM_ETAGSFLAGS	125
AM_ext_LOG_DRIVER_FLAGS	111
AM_ext_LOG_FLAGS	108
AM_FCFLAGS	80
AM_FFLAGS	77
AM_GCJFLAGS	80
AM_INSTALLCHECK_STD_OPTIONS_EXEMPT	123
AM_JAVACFLAGS	90
AM_LDFLAGS	55, 73
AM_LFLAGS	74
AM_LIBTOOLFLAGS	64
AM_LOG_DRIVER_FLAGS	111
AM_LOG_FLAGS	108
AM_MAKEFLAGS	49
AM_MAKEINFOFLAGS	94
AM_MAKEINFOHTMLFLAGS	94
AM_OBJCFLAGS	76
AM_OBJCXXFLAGS	76
AM_RFLAGS	77
AM_RUNTESTFLAGS	118
AM_TESTS_ENVIRONMENT	106
AM_TESTS_FD_REDIRECT	106
AM_TESTSUITE_SUMMARY_HEADER	106
AM_UPCFLAGS	77
AM_UPDATE_INFO_DIR	94
AM_V	132
AM_V_at	132
AM_V_GEN	132
AM_VALAFLAGS	81
AM_YFLAGS	73
AR	46
AUTOCONF	27
AUTOM4TE	36
AUTOMAKE_JOBS	30
AUTOMAKE_LIBDIR	28
AUTOMAKE_OPTIONS	45, 82, 120

B

bin_PROGRAMS	55
bin_SCRIPTS	83
build_triplet	32
BUILT_SOURCES	85
BZIP2	103

C

CC	72
CCAS	46, 77
CCASFLAGS	46, 77
CFLAGS	72
check	22
check_LTLIBRARIES	62
check_PROGRAMS	55, 69
check_SCRIPTS	83
CLASSPATH_ENV	90
CLEANFILES	98
COMPILE	73
CONFIG_STATUS_DEPENDENCIES	119
CONFIGURE_DEPENDENCIES	119
CPPFLAGS	72, 77
CXX	75
CXXCOMPILE	75
CXXFLAGS	75
CXXLINK	75, 79

D

data_DATA	85
DATA	22, 85
DEFS	72
DEJATOOL	118
DESTDIR	10, 97
DISABLE_HARD_ERRORS	105
dist	52, 99
dist_lisp_LISP	89
dist_noinst_LISP	89
DIST_SUBDIRS	50, 99
DISTCHECK_CONFIGURE_FLAGS	101
distcleancheck_listfiles	102, 146
DISTCLEANFILES	98, 102
distdir	100, 134
distuninstallcheck_listfiles	102
DVIPS	95

E

EMACS	46
EMPTY_AUTOMAKE_TARGETS	135
ETAGS_ARGS	125
ETAGSFLAGS	125
EXPECT	118
ext_LOG_COMPILE	108
ext_LOG_COMPILER	108
ext_LOG_DRIVER	111
ext_LOG_DRIVER_FLAGS	111
ext_LOG_FLAGS	108
EXTRA_DIST	99
EXTRA_maude_DEPENDENCIES	56, 67
EXTRA_maude_SOURCES	66
EXTRA_PROGRAMS	58

F

F77	77
F77COMPILE	77
F77LINK	79
FC	80
FCCOMPILE	80
FCFLAGS	80
FCLINK	79, 80
FFLAGS	77
FLIBS	78
FLINK	77

G

GCJ	46
GCJFLAGS	46, 80
GCJLINK	79
GTAGS_ARGS	125
GZIP_ENV	98

H

HEADERS	22
host_triplet	32

I

include_HEADERS	84
INCLUDES	72
info_TEXINFOS	92

J

JAVA	22
JAVAC	90
JAVACFLAGS	90
JAVAROOT	90

L

LDADD	55
LDFLAGS	72
LFLAGS	74
lib_LIBRARIES	58
lib_LTLIBRARIES	60
libexec_PROGRAMS	55
libexec_SCRIPTS	83
LIBOBS	33, 64, 70
LIBRARIES	22
LIBS	72
LIBTOOLFLAGS	64
LINK	73, 79
lisp_LISP	89
lispdir	46
LISP	22
localstate_DATA	85
LOG_COMPILE	108
LOG_COMPILER	108

LOG_DRIVER	111
LOG_DRIVER_FLAGS	111
LOG_FLAGS	108
LTALLOCA	64, 70
LTLIBOBS	64, 70
LTLIBRARIES	22

M

MAINTAINERCLEANFILES	98
MAKE	49
MAKEINFO	94
MAKEINFOFLAGS	94
MAKEINFOHTML	94
man_MANS	95
MANS	22
maude_AR	66
maude_CCASFLAGS	68
maude_CFLAGS	68
maude_CPPFLAGS	68
maude_CXXFLAGS	68
maude_DEPENDENCIES	56, 67
maude_FFLAGS	68
maude_GCJFLAGS	68
maude_LDADD	55, 67
maude_LDFLAGS	56, 67
maude_LFLAGS	68
maude_LIBADD	59, 67
maude_LIBTOOLFLAGS	64, 67
maude_LINK	68
maude_OBJCFLAGS	68
maude_OBJCXXFLAGS	68
maude_RFLAGS	68
maude_SHORTNAME	69
maude_SOURCES	66
maude_UPCFLAGS	68
maude_YFLAGS	68
MISSING	47
mkdir_p	47
MKDIR_P	47
MOSTLYCLEANFILES	98

N

nobase	52
nodist	52, 99
noinst	22
noinst_HEADERS	84
noinst_LIBRARIES	58
noinst_LISP	89
noinst_LTLIBRARIES	62
noinst_PROGRAMS	55
noinst_SCRIPTS	83
notrans	95

O

OBJC	76
OBJCCOMPILE	76
OBJCFLAGS	76
OBJCLINK	76, 79
OBJCXX	76
OBJCXXCOMPILE	76
OBJCXXFLAGS	76
OBJCXXLINK	76, 79
oldinclude_HEADERS	84

P

PACKAGE	98
pkgdata_DATA	85
pkgdata_SCRIPTS	83
pkgdatadir	21
pkginclude_HEADERS	84
pkgincludedir	21
pkglib_LIBRARIES	58
pkglib_LTLIBRARIES	60
pkglibdir	21
pkglibexec_PROGRAMS	55
pkglibexec_SCRIPTS	83
pkglibexecdir	21
pkgpyexecdir	92
pkgpythondir	92
PROGRAMS	21, 22
pyexecdir	92
PYTHON_EXEC_PREFIX	92
PYTHON_PLATFORM	92
PYTHON_PREFIX	92
PYTHON_VERSION	91
pythondir	92
PYTHON	22, 91

R

RECHECK_LOGS	109
RFLAGS	77
RUNTEST	118
RUNTESTDEFAULTFLAGS	118
RUNTESTFLAGS	118

S

sbin_PROGRAMS	55
sbin_SCRIPTS	83
SCRIPTS	22, 83
sharedstate_DATA	85
SOURCES	55, 69
SUBDIRS	48, 99
SUFFIXES	125
sysconf_DATA	85

T

TAGS_DEPENDENCIES	125
target_triplet	32
TAR	99
TEST_EXTENSIONS	108
TEST_LOGS	108
TEST_SUITE_LOG	108
TESTS	106, 108
TESTS_ENVIRONMENT	106
TEXI2DVI	94
TEXI2PDF	94
TEXINFO_TEX	95
TEXINFOS	22, 93
top_distdir	100, 134

U

UPC	46, 76
UPCCOMPILE	77
UPCFLAGS	77
UPCLINK	77, 79

V

V	131
VALAC	81
VALAFLAGS	81
VERBOSE	108
VERSION	98

W

WARNINGS	30, 38
WITH_DMALLOC	47

X

XFAIL_TESTS	105
XZ_OPT	103

Y

YACC	34
YFLAGS	73

Z

ZSTD_CLEVEL	103
ZSTD_OPT	103

B.3 General Index

#	
## (special Automake comment)	19
#serial syntax	42
\$	
\$(LIBOBJS) and empty libraries	71
+	
+=	18
—	
--add-missing	27
--automake-acdir	36
--build=build	9
--copy	28
--diff	37
--disable-dependency-tracking	12
--disable-maintainer-mode	35
--disable-silent-rules	131
--dry-run	37
--enable-debug, example	127
--enable-dependency-tracking	12
--enable-maintainer-mode	35
--enable-silent-rules	131
--force	37
--force-missing	28
--foreign	20, 28
--gnits	20, 28
--gnu	20, 28
--help	28, 37
--help check	123
--help=recursive	13
--host=host	9
--include-deps	28
--install	37
--libdir	28
--no-force	29
--output	37
--output-dir	29
--prefix	5
--print-ac-dir	37
--print-libdir	28
--program-prefix=prefix	10
--program-suffix=suffix	10
--program-transform-name=program	10
--system-acdir	37
--target=target	9
--verbose	29, 37
--version	29, 37
--version check	123
--warnings	29, 38
--with-dmalloc	47
-a	27
-c	28
-f	28
-hook targets	133
-i	28
-I	37
-l and LDADD	56
-local targets	133
-module, libtool	63
-o	29
-v	29
-W	29, 38
-Wall	16
-Werror	16
.	
.la suffix, defined	59
.log files	108
.trs files	108
:	
:copy-in-global-log:	113
:recheck:	113
:test-global-result:	113
:test-result:	113
—	
_DATA primary, defined	85
_DEPENDENCIES, defined	56
_HEADERS primary, defined	84
_JAVA primary, defined	90
_LDFLAGS, defined	56
_LDFLAGS, libtool	64
_LIBADD, libtool	64
_LIBRARIES primary, defined	58
_LIBTOOLFLAGS, libtool	64
_LISP primary, defined	89
_LTLIBRARIES primary, defined	60
_MANS primary, defined	95
_PROGRAMS primary variable	21
_PYTHON primary, defined	91
_SCRIPTS primary, defined	83
_SOURCES and header files	55
_SOURCES primary, defined	55
_SOURCES, default	69
_SOURCES, empty	70
_TEXINFOS primary, defined	92

A

AC_CONFIG_FILES, conditional 128
AC_SUBST and SUBDIRS 51
acinclude.m4, defined 25
aclocal and serial numbers 42
aclocal program, introduction 25
aclocal search path 38
aclocal's scheduled death 44
aclocal, extending 40
aclocal, invocation 36
aclocal, invoking 36
aclocal, Options 36
aclocal, using 30
aclocal.m4, preexisting 25
ACLOCAL_PATH 40
Adding new SUFFIXES 125
all 4, 133
all-local 133
ALLOCA, and Libtool 64
ALLOCA, example 70
ALLOCA, special handling 70
AM_CCASFLAGS and CCASFLAGS 146
AM_CFLAGS and CFLAGS 146
AM_CONDITIONAL and SUBDIRS 50
AM_CPPFLAGS and CPPFLAGS 146
AM_CXXFLAGS and CXXFLAGS 146
AM_FCFLAGS and FCFLAGS 146
AM_FFLAGS and FFLAGS 146
AM_GCJFLAGS and GCJFLAGS 146
AM_INIT_AUTOMAKE, example use 25
AM_LDFLAGS and LDFLAGS 146
AM_LFLAGS and LFLAGS 146
AM_LIBTOOLFLAGS and LIBTOOLFLAGS 146
AM_MAINTAINER_MODE, purpose 142
AM_OBJCFLAGS and OBJCFLAGS 146
AM_OBJCXXFLAGS and OBJXXCFLAGS 146
AM_RFLAGS and RFLAGS 146
AM_UPCFLAGS and UPCFLAGS 146
AM_YFLAGS and YFLAGS 146
amhello-1.0.tar.gz, creation 13
amhello-1.0.tar.gz, location 2
amhello-1.0.tar.gz, use cases 2
Append operator 18
ar-lib 24
ARG_MAX 22
autogen.sh and autoreconf 64
autom4te 36
Automake constraints 1
automake options 27
Automake parser, limitations of 19
Automake requirements 1, 30
Automake targets, no-op 135
automake, invocation 27
automake, invoking 27
Automake, recursive operation 19
Automatic dependency tracking 82
Automatic linker selection 79
autoreconf and libtoolize 64

autoreconf, example 14
autoscan 17
Autotools, introduction 2
Autotools, purpose 13
autoupdate 47
Auxiliary programs 24
Avoiding man page renaming 95
Avoiding path stripping 52

B

Binary package 10
bootstrap and autoreconf 64
Bugs, reporting 1
build tree and source tree 6
BUILT_SOURCES, defined 85

C

C++ support 75
canonicalizing Automake variables 23
CCASFLAGS and AM_CCASFLAGS 146
CFLAGS and AM_CFLAGS 146
cfortran 78
check 4, 104, 133
check-local 133
check-news 121
'check_' primary prefix, definition 22
check_PROGRAMS example 69
clean 4, 133
clean-local 98, 133
Colorized testsuite output 106
command line length limit 22
Comment, special to Automake 19
Compilation of Java to bytecode 90
Compilation of Java to native code 80
compile 24
Compile Flag Variables 146
Complete example 25
Conditional example, --enable-debug 127
conditional libtool libraries 60
Conditional programs 58
Conditional subdirectories 49
Conditional SUBDIRS 49
Conditionals 126
config.guess 24, 27
config.site example 6
config.sub 24
configuration variables, overriding 5
Configuration, basics 2
Configure substitutions in TESTS 108
configure.ac, Hello World 16
configure.ac, scanning 30
conflicting definitions 133
Constraints of Automake 1
convenience libraries, libtool 62
copying semantics 133
cpio example 21

CPPFLAGS and AM_CPPFLAGS 146
 cross-compilation 9
 cross-compilation example 9
 CVS and generated files 139
 CVS and third-party files 141
 CVS and timestamps 139
 CXXFLAGS and AM_CXXFLAGS 146

D

DATA primary, defined 85
 debug build, example 7
 debugging rules 157
 default _SOURCES 69
 default source, Libtool modules example 70
 default verbosity for silent rules 131
 definitions, conflicts 133
 dejagnu 118, 121
 depcomp 24, 82
 dependencies and distributed files 144
 Dependency tracking 11, 82
 Dependency tracking, disabling 82
 directory variables 4
 dirlist 39
 Disabling dependency tracking 82
 Disabling hard errors 105
 dist 4, 98
 dist-bzip2 103, 121
 dist-gzip 103
 dist-hook 100, 133
 dist-lzip 103, 121
 dist-shar 103, 121
 dist-tarZ 103, 121
 dist-xz 103, 121
 dist-zip 103, 121
 dist-zstd 103, 121
 dist_ and nobase_ 52
 dist_ and notrans_ 96
 DIST_SUBDIRS, explained 50
 distcheck 15, 100
 distcheck better than dist 11
 distcheck example 15
 distcheck-hook 101
 distclean 4, 133, 144
 distclean, diagnostic 144
 distclean-local 98, 133
 distcleancheck 102
 distdir 134
 Distinction between errors and
 failures in testsuites 104
 Distributions, preparation 11
 distuninstallcheck 102
 dmalloc, support for 47
 do-nothing Automake targets 135
 dvi 93, 101, 133
 dvi-local 133
 DVI output using Texinfo 92

E

E-mail, bug reports 1
 EDITION Texinfo flag 93
 else 127
 empty _SOURCES 70
 empty Automake targets 135
 Empty libraries 59
 Empty libraries and '\$(LIBOBJ)' 71
 endif 127
 eps images 101
 Example conditional --enable-debug 127
 Example conditional AC_CONFIG_FILES 128
 Example Hello World 13
 Example of recursive operation 19
 Example of shared libraries 60
 Example, EXTRA_PROGRAMS 21
 Example, false and true 26
 Example, mixed language 79
 Executable extension 82
 Exit status 77, special interpretation 105
 Exit status 99, special interpretation 105
 expected failure 104
 Expected test failure 105
 expected test failure 104
 Extending aclocal 40
 Extending list of installation directories 21
 Extension, executable 82
 Extra files distributed with Automake 27
 EXTRA_, prepending 21
 EXTRA_prog_SOURCES, defined 57
 EXTRA_PROGRAMS, defined 21, 58

F

false Example 26
 FCFLAGS and AM_FCFLAGS 146
 Features of the GNU Build System 2
 FFLAGS and AM_FFLAGS 146
 file names, limitations on 144
 filename-length-max=99 121
 Files distributed with Automake 27
 First line of Makefile.am 19
 Flag variables, ordering 146
 Flag Variables, Ordering 146
 FLIBS, defined 78
 foreign 16, 120
 foreign strictness 20
 Fortran 77 support 77
 Fortran 77, mixing with C and C++ 78
 Fortran 77, Preprocessing 78
 Fortran 9x support 80

G

GCJFLAGS and AM_GCJFLAGS 146
 generated files and CVS 139
 generated files, distributed 139
 Gettext support 89
 git-dist 18
 git-dist, non-standard example 18
 gnits 120
 gnits strictness 20
 gnu 120
 gnu strictness 20
 GNU Build System, basics 2
 GNU Build System, features 2
 GNU Build System, introduction 1
 GNU Build System, use cases 2
 GNU Coding Standards 2
 GNU Gettext support 89
 GNU make extensions 18
 GNU Makefile standards 1
 GNUmakefile including Makefile 136

H

hard error 104
 Header files in `_SOURCES` 55
 HEADERS primary, defined 84
 HEADERS, installation directories 84
 Hello World example 13
 hook targets 133
 HP-UX 10, `lex` problems 46
 html 93, 133
 html-local 133
 HTML output using `Texinfo` 92

I

id 125
 if 127
 include 99, 126
 include, distribution 99
 Including Makefile fragment 126
 indentation in `Makefile.am` 19
 info 122, 133
 info-in-builddir 121
 info-local 133
 install 4, 96, 133
 Install hook 97
 Install, two parts of 96
 install-data 8, 96, 133
 install-data-hook 133
 install-data-local 97, 133
 install-dvi 93, 133
 install-dvi-local 133
 install-exec 8, 96, 133
 install-exec-hook 133
 install-exec-local 97, 133
 install-html 93, 133
 install-html-local 133

install-info 94, 122, 133
 install-info target 94
 install-info-local 133
 install-man 95, 122
 install-man target 95
 install-pdf 93, 133
 install-pdf-local 133
 install-ps 93, 133
 install-ps-local 133
 install-sh 24
 install-strip 4, 97
 Installation directories, extending list 21
 Installation support 96
 Installation, basics 2
 installcheck 4, 133
 installcheck-local 133
 installdirs 97, 133
 installdirs-local 133
 Installing headers 84
 Installing scripts 83
 installing versioned binaries 134
 Interfacing with third-party packages 134
 Invocation of `aclocal` 36
 Invocation of `automake` 27
 Invoking `aclocal` 36
 Invoking `automake` 27

J

Java support with `gcj` 80
 Java to bytecode, compilation 90
 Java to native code, compilation 80
 JAVA primary, defined 90
 JAVA restrictions 90

L

lazy test execution 109
 LDADD and `-l` 56
 LDFLAGS and AM_LDFLAGS 146
`lex` problems with HP-UX 10 46
`lex`, multiple lexers 74
 LFLAGS and AM_LFLAGS 146
`libltdl`, introduction 60
 LIBOBJS, and `Libtool` 64
 LIBOBJS, example 70
 LIBOBJS, special handling 70
 LIBRARIES primary, defined 58
`libtool` convenience libraries 62
`libtool` libraries, conditional 60
`libtool` library, definition 59
`libtool` modules 63
`Libtool` modules, default source example 70
`libtool`, introduction 59
 LIBTOOLFLAGS and AM_LIBTOOLFLAGS 146
`libtoolize` and `autoreconf` 64
`libtoolize`, no longer run by `automake` 64
 Limitations of `automake` parser 19

Linking Fortran 77 with C and C++ 78
 LISP primary, defined 89
 LN_S example 134
 local targets 133
 LTALLOCA, special handling 64
 LTLIBOBS, special handling 64
 LTLIBRARIES primary, defined 60
 ltmain.sh not found 64

M

m4_include, distribution 99
 Macro search path 38
 macro serial numbers 42
 Macros Automake recognizes 32
 maintainer-clean-local 98
 make check 104
 ‘make clean’ support 98
 ‘make dist’ 98
 ‘make distcheck’ 100
 ‘make distclean’, diagnostic 144
 ‘make distcleancheck’ 102
 ‘make distuninstallcheck’ 102
 ‘make install’ support 96
 ‘make installcheck’, testing --help
 and --version 123
 Make rules, overriding 19
 Make targets, overriding 19
 Makefile fragment, including 126
 Makefile.am, first line 19
 Makefile.am, Hello World 17
 Man page renaming, avoiding 95
 MANS primary, defined 95
 many outputs, rules with 150
 mdate-sh 24, 93
 MinGW cross-compilation example 9
 missing program 24
 missing, purpose 141
 Mixed language example 79
 Mixing Fortran 77 with C and C++ 78
 Mixing Fortran 77 with C and/or C++ 78
 mkdir -p, macro check 47
 mkinstalldirs 24
 modules, libtool 63
 mostlyclean 133
 mostlyclean-local 98, 133
 multiple configurations, example 7
 Multiple configure.ac files 27
 Multiple lex lexers 74
 multiple outputs, rules with 150
 Multiple yacc parsers 74

N

Nested packages 12
 Nesting packages 53
 no-define 46, 121
 no-dependencies 82, 122
 no-dist 122
 no-dist-gzip 122
 no-exeext 122
 no-installinfo 94, 122
 no-installinfo option 94
 no-installman 95, 122
 no-installman option 95
 no-op Automake targets 135
 no-texinfo.tex 122
 nobase_ and dist_ or nodist_ 52
 nobase_ prefix 52
 nodist_ and nobase_ 52
 nodist_ and notrans_ 96
 ‘noinst_’ primary prefix, definition 22
 Non-GNU packages 19
 Non-standard targets 18
 nostdinc 122
 notrans_ and dist_ or nodist_ 96
 notrans_ prefix 95

O

OBJCFLAGS and AM_OBJCFLAGS 146
 OBJCXXFLAGS and AM_OBJCXXFLAGS 146
 Objective C support 76
 Objective C++ support 76
 Objects in subdirectory 66
 obsolete macros 47
 optimized build, example 7
 Option, --warnings=category 124
 Option, -Wcategory 124
 Option, check-news 121
 Option, dejagnu 121
 Option, dist-bzip2 121
 Option, dist-lzip 121
 Option, dist-shar 121
 Option, dist-tarZ 121
 Option, dist-xz 121
 Option, dist-zip 121
 Option, dist-zstd 121
 Option, filename-length-max=99 121
 Option, foreign 120
 Option, gnits 120
 Option, gnu 120
 Option, info-in-builddir 121
 Option, no-define 121
 Option, no-dependencies 122
 Option, no-dist 122
 Option, no-dist-gzip 122
 Option, no-exeext 122
 Option, no-installinfo 94, 122
 Option, no-installman 95, 122
 Option, no-texinfo.tex 122

Option, `nostdinc` 122
 Option, `parallel-tests` 122
 Option, `readme-alpha` 122
 Option, `serial-tests` 122
 Option, `tar-pax` 123
 Option, `tar-ustar` 123
 Option, `tar-v7` 123
 Option, `version` 124
 Option, `warnings` 124
 Options, `aclocal` 36
 Options, `automake` 27
 Options, `std-options` 123
 Options, `subdir-objects` 123
 Ordering flag variables 146
 Overriding make rules 19
 Overriding make targets 19
 Overriding make variables 19
 overriding rules 133
 overriding semantics 133

P

`PACKAGE`, directory 21
`PACKAGE`, prevent definition 46
 Packages, nested 12
 Packages, preparation 11
 Parallel build trees 6
`parallel-tests` 122
 Path stripping, avoiding 52
 pax format 123
 pdf 93, 133
`pdf-local` 133
 PDF output using Texinfo 92
 Per-object flags, emulated 149
 per-target compilation flags, defined 68
`pkgdatadir`, defined 21
`pkgincludedir`, defined 21
`pkglibdir`, defined 21
`pkglibexecdir`, defined 21
 Preparing distributions 11
 Preprocessing Fortran 77 78
 Primary variable, `DATA` 85
 Primary variable, defined 21
 Primary variable, `HEADERS` 84
 Primary variable, `JAVA` 90
 Primary variable, `LIBRARIES` 58
 Primary variable, `LISP` 89
 Primary variable, `LTLIBRARIES` 60
 Primary variable, `MANS` 95
 Primary variable, `PROGRAMS` 21
 Primary variable, `PYTHON` 91
 Primary variable, `SCRIPTS` 83
 Primary variable, `SOURCES` 55
 Primary variable, `TEXINFOS` 92
`prog_LDADD`, defined 55
 Programs, auxiliary 24
 Programs, conditional 58
 Programs, renaming during installation 10

`PROGRAMS` primary variable 21
`PROGRAMS`, `bindir` 55
 Proxy Makefile for third-party packages 136
 ps 93, 133
`ps-local` 133
 PS output using Texinfo 92
`py-compile` 25
`PYTHON` primary, defined 91

R

Ratfor programs 78
 read-only source tree 8
`readme-alpha` 122
`README-alpha` 20
 rebuild rules 119, 139
`recheck` 110
 Recognized macros by Automake 32
 Recursive operation of Automake 19
 recursive targets and third-party Makefiles ... 134
 Register test case result 113
 Register test result 113
 Renaming programs 10
 Reporting bugs 1
 Requirements of Automake 30
 Requirements, Automake 1
 Restrictions for `JAVA` 90
 reStructuredText field,
 `:copy-in-global-log:` 113
 reStructuredText field, `:recheck:` 113
 reStructuredText field,
 `:test-global-result:` 113
 reStructuredText field, `:test-result:` 113
`RFLAGS` and `AM_RFLAGS` 146
 rules with multiple outputs 150
 rules, conflicting 133
 rules, debugging 157
 rules, overriding 133

S

Scanning `configure.ac` 30
`SCRIPTS` primary, defined 83
`SCRIPTS`, installation directories 83
 Selecting the linker automatically 79
 serial number and `--install` 37
 serial numbers in macros 42
`serial-tests` 122
`serial-tests`, Using 107
 Shared libraries, support for 59
 Silencing `make` 129
 Silent `make` 129
 Silent `make` rules 129
 Silent rules 129
 silent rules and `libtool` 131
`site.exp` 118
 source tree and build tree 6
 source tree, read-only 8

SOURCES primary, defined 55
 Special Automake comment 19
 Staged installation 10
std-options 123
 Strictness, command line 27
 Strictness, defined 19
 Strictness, **foreign** 20
 Strictness, **gnits** 20
 Strictness, **gnu** 20
 su, before **make install** 3
subdir-objects 123
 Subdirectories, building conditionally 49
 Subdirectories, configured conditionally 51
 Subdirectories, not distributed 52
 Subdirectory, objects in 66
 SUBDIRS and AC_SUBST 51
 SUBDIRS and AM_CONDITIONAL 50
 SUBDIRS, conditional 49
 SUBDIRS, explained 48
 Subpackages 12, 53
 suffix **.la**, defined 59
 suffix **.lo**, defined 59
 SUFFIXES, adding 125
 Support for C++ 75
 Support for Fortran 77 77
 Support for Fortran 9x 80
 Support for GNU Gettext 89
 Support for Java with gcj 80
 Support for Objective C 76
 Support for Objective C++ 76
 Support for Unified Parallel C 76
 Support for Vala 81

T

tags 124
 TAGS support 124
 tar formats 123
 tar-pax 123
 tar-ustar 123
 tar-v7 123
 Target, **install-info** 94
 Target, **install-man** 95
 targets, making into no-op 135
 test case 104
 Test case result, registering 113
 test failure 104
 test harness 104
 test metadata 108
 test pass 104
 Test result, registering 113
 test skip 104
 Test suites 104
test-driver 25
 Tests, expected failure 105
 testsuite harness 104
 Testsuite progress on console 105
 Texinfo flag, **EDITION** 93

Texinfo flag, **UPDATED** 93
 Texinfo flag, **UPDATED-MONTH** 93
 Texinfo flag, **VERSION** 93
texinfo.tex 25, 93
 TEXINFOS primary, defined 92
 third-party files and CVS 141
 Third-party packages, interfacing with 134
 timestamps and CVS 139
 Transforming program names 10
 trees, source vs. build 6
 true Example 26

U

underquoted **AC_DEFUN** 41
 unexpected pass 104
 unexpected test pass 104
 Unified Parallel C support 76
 Uniform naming scheme 21
uninstall 4, 97, 133
uninstall-hook 133
uninstall-local 133
 Unit tests 110
 Unpacking 3
 UPCFLAGS and AM_UPCFLAGS 146
 UPDATED Texinfo flag 93
 UPDATED-MONTH Texinfo flag 93
 Use Cases for the GNU Build System 2
 user variables 23
 Using **aclocal** 30
 ustar format 123

V

v7 tar format 123
 Vala Support 81
 variables, conflicting 133
 Variables, overriding 19
 variables, reserved for the user 23
version.m4, example 119
version.sh, example 119
 VERSION Texinfo flag 93
 VERSION, prevent definition 46
 versioned binaries, installing 134
 VPATH builds 6

W

wildcards 143
 Windows 82

X

xfail 104
 xpass 104

Y

yacc, multiple parsers 74
YFLAGS and AM_YFLAGS 146
ylwrap 25, 74

Z

zardoz example 26