

# Foreword (1/2)

This presentation targets developers familiar with Unix development tools (shell, make, compiler) that want to learn Autotools.

The latest version of this document can be retrieved from  
<http://www.lrde.epita.fr/~adl/autotools.html>

Please mail me corrections and suggestions **about this document** at [adl@gnu.org](mailto:adl@gnu.org).

Do not send me any general question about the Autotools. Use the appropriate mailing list instead ([autoconf@gnu.org](mailto:autoconf@gnu.org), or [automake@gnu.org](mailto:automake@gnu.org)).

## Foreword (2/2)

This document was updated for the following releases of the Autotools:

GNU Autoconf	2.61	(November 2006)
GNU Automake	1.10.1	(January 2008)
GNU Libtool	1.5.26	(February 2008)
GNU Gettext	0.17	(November 2007)

These were the last releases at the time of writing.

- The usage of these tools has improved a lot over the last years.
- Some syntaxes used here will not work with older tools.
- This a deliberate choice:
  - New users should learn today's recommended usages.
  - Make sure you have up-to-date tools and do not bother with old releases.

# Using GNU Autotools

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Trivial source code examples displayed in this tutorial (such as the C files, [Makefile.am](#)s, and [configure.ac](#)s of all the ‘amhello’ projects) can be reused as if they were in the public domain.

# Part I

## The GNU Build System

# Portable Packages

# Sources of Non-Portability in C

Consider C functions...

- that do not exist everywhere (e.g., `strtod()`)
- that have different names (e.g., `strchr()` vs. `index()`)
- that have varying prototypes  
(e.g., `int setpgrp(void);` vs. `int setpgrp(int, int);`)
- that can behave differently (e.g., `malloc(0);`)
- that might require other libraries  
(is `pow()` in *libm.so* or in *libc.so*?)
- that can be defined in different headers  
(*string.h* vs. *strings.h* vs. *memory.h*)

How should a package deal with those?

# Possible Solutions

- Slice the code with lots of `#if/#else`
- Create substitution macros
- Create substitution functions

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The latter two are to be preferred.



# Code Cluttered with #if/#else

## Excerpt of ffcall-1.10's alloc\_trampoline()

```
#if !defined(CODE_EXECUTABLE)
    static long pagesize = 0;
#endif
#if defined(EXECUTABLE_VIA_MMAP_DEVZERO)
    static int zero_fd;
#endif
    if (!pagesize) {
#if defined(HAVE_MACH_VM)
        pagesize = vm_page_size;
#else
        pagesize = getpagesize();
#endif
    }
#if defined(EXECUTABLE_VIA_MMAP_DEVZERO)
    zero_fd = open("/dev/zero", O_RDONLY, 0644);
    if (zero_fd < 0) {
        fprintf(stderr, "trampoline: _Cannot_open_/dev/zero!\n");
        abort();
    }
#endif
    }
```

# Substitution macros

Excerpt of coreutils-5.2.1's *system.h*

```
#if ! HAVE_FSEEKO && ! defined fseeko
# define fseeko(s, o, w) ((o) == (long) (o) \
                        ? fseek (s, o, w) \
                        : (errno = EOVERFLOW, -1))
#endif
```

Then use `fseeko()` whether it exists or not.

# Substitution functions

If `strdup()` does not exist, link your program with a replacement definition such as

*strdup.c* (from the GNU C library)

```
char *
strdup (const char *s)
{
    size_t len = strlen (s) + 1;
    void *new = malloc (len);
    if (new == NULL)
        return NULL;
    return (char *) memcpy (new, s, len);
}
```

# Uniform Builds

# Need for Automatic Configuration

- Maintaining a collection of `#define` for each system by hand is cumbersome.
- Requiring users to add the necessary `-D`, `-I`, and `-l` compilation options to *Makefile* is burdensome.
- Complicated builds hinder the acceptance of free software.

# Need for Automatic Configuration

- Maintaining a collection of `#define` for each system by hand is cumbersome.
- Requiring users to add the necessary `-D`, `-I`, and `-l` compilation options to *Makefile* is burdensome.
- Complicated builds hinder the acceptance of free software.
- In 1991 people started to write shell scripts to **guess** these settings for some GNU packages.
- Since then the *configure* script is mandatory in any package of the GNU project.

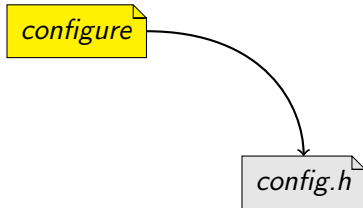
# *configure*'s Purpose



*configure*

- *configure* probes the systems for required functions, libraries, and tools

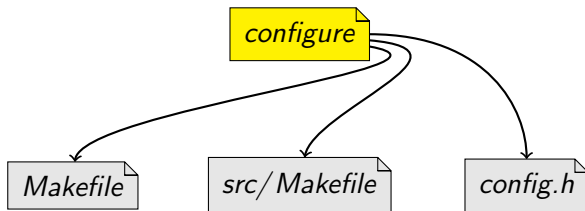
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- then it generates a *config.h* file with all `#defines`



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- *configure* probes the systems for required functions, libraries, and tools
- then it generates a *config.h* file with all `#defines`
- as well as *Makefiles* to build the package

# GNU Coding Standards

<http://www.gnu.org/prep/standards/>

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- program behavior
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  - standard command line options,
  - etc.

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- **configuration**

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Practices that packages of the GNU project should follow:

- program behavior
  - how to report errors,
  - standard command line options,
  - etc.
- coding style
- configuration
- *Makefile* conventions
- etc.

# The User Point of View

# Standard Installation Procedure

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

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~/amhello-1.0 % ./configure
...
~/amhello-1.0 % make
...
~/amhello-1.0 % make check
...
~/amhello-1.0 % su
Password:
/home/adl/amhello-1.0 # make install
...
```

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...
~/amhello-1.0 % make
...
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...
~/amhello-1.0 % su
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/home/adl/amhello-1.0 # make install
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/home/adl/amhello-1.0 # exit
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Password:
/home/adl/amhello-1.0 # make install
...
/home/adl/amhello-1.0 # exit
~/amhello-1.0 % make installcheck
...
```



# Standard Makefile Targets

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

`'make install'` Install what needs to be installed.

`'make install-strip'` Same as `'make install'`, then strip debugging symbols.

`'make uninstall'` The opposite of `'make install'`.

`'make clean'` Erase what has been built (the opposite of `'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'` Create *PACKAGE-VERSION.tar.gz*.

# Standard File System Hierarchy

Directory variable	Default value
prefix	<i>/usr/local</i>
exec-prefix	prefix
bindir	exec-prefix/ <i>bin</i>
libdir	exec-prefix/ <i>lib</i>
...	
includedir	prefix/ <i>include</i>
datarootdir	prefix/ <i>share</i>
datadir	datarootdir
mandir	datarootdir/ <i>man</i>
infodir	datarootdir/ <i>info</i>
...	

```
~/amhello-1.0 %
```

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...	

```
~/amhello-1.0 % ./configure --prefix ~/usr
```

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datadir	datarootdir
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~/amhello-1.0 % ./configure --prefix ~/usr
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datadir	datarootdir
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...	

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

# Standard Configuration Variables

'./configure' automatically detects many settings.  
You can force some of them using configuration variables.

**CC** C compiler command

**CFLAGS** C compiler flags

**CXX** C++ compiler command

**CXXFLAGS** C++ compiler flags

**LDFlags** linker flags

**CPPFLAGS** C/C++ preprocessor flags

... See './configure --help' for a full list.

```
~/amhello-1.0 %
```

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**LDFlags** linker flags

**CPPFLAGS** C/C++ preprocessor flags

... See './configure --help' for a full list.

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

# The Power User Point of View



# Overriding Default Configuration Settings with *config.site*

Recall that old command

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

# Overriding Default Configuration Settings with *config.site*

Recall that old command

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

Common configuration settings can be put in *prefix/share/config.site*

```
~/amhello-1.0 % cat ~/usr/share/config.site  
test -z "$CC" && CC=gcc-3  
test -z "$CPPFLAGS" && CPPFLAGS=-I$HOME/usr/include  
test -z "$LDFLAGS" && LDFLAGS=-L$HOME/usr/lib
```

# Overriding Default Configuration Settings with *config.site*

Recall that old command

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

Common configuration settings can be put in *prefix/share/config.site*

```
~/amhello-1.0 % cat ~/usr/share/config.site  
test -z "$CC" && CC=gcc-3  
test -z "$CPPFLAGS" && CPPFLAGS=-I$HOME/usr/include  
test -z "$LDFLAGS" && LDFLAGS=-L$HOME/usr/lib
```

Reducing the command to...

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

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

Objects files, programs, and libraries are built where *configure* was run.

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

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Objects files, programs, and libraries are built where *configure* was run.

```
~ % tar xzf ~/amhello-1.0.tar.gz  
~ % cd amhello-1.0  
~/amhello-1.0 % mkdir build && cd build
```

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Objects files, programs, and libraries are built where *configure* was run.

```
~ % tar xzf ~/amhello-1.0.tar.gz
~ % cd amhello-1.0
~/amhello-1.0 % mkdir build && cd build
~/amhello-1.0/build % ../configure
```

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Objects files, programs, and libraries are built where *configure* was run.

```
~ % tar xzf ~/amhello-1.0.tar.gz
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~/amhello-1.0 % mkdir build && cd build
~/amhello-1.0/build % ../configure
~/amhello-1.0/build % make
...
```



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Objects files, programs, and libraries are built where *configure* was run.

```
~ % 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
...
```

Sources files are in *~/amhello-1.0/*,  
built files are all in *~/amhello-1.0/build/*.

# Parallel Build Trees for Multiple Architectures

Builds for multiple architectures can share the same source tree.

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Have the source on a (possibly read-only) shared directory

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

# Parallel Build Trees for Multiple Architectures

Builds for multiple architectures can share the same source tree.

Have the source on a (possibly read-only) shared directory

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

Compilation on first host

```
~ % mkdir /tmp/amh && cd /tmp/amh  
/tmp/amh % /nfs/src/amhello-1.0/configure  
/tmp/amh % make && sudo make install
```

# Parallel Build Trees for Multiple Architectures

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Have the source on a (possibly read-only) shared directory

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

Compilation on first host

```
~ % mkdir /tmp/amh && cd /tmp/amh  
/tmp/amh % /nfs/src/amhello-1.0/configure  
/tmp/amh % make && sudo make install
```

Compilation on second host

```
~ % mkdir /tmp/amh && cd /tmp/amh  
/tmp/amh % /nfs/src/amhello-1.0/configure  
/tmp/amh % make && sudo make install
```

# Parallel Build Trees for Multiple Architectures

Builds for multiple architectures can share the same source tree.

Have the source on a (possibly read-only) shared directory

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

Compilation on first host

```
~ % mkdir /tmp/amh && cd /tmp/amh  
/tmp/amh % /nfs/src/amhello-1.0/configure  
/tmp/amh % make && sudo make install
```

Compilation on second host, **assuming shared data**

```
~ % mkdir /tmp/amh && cd /tmp/amh  
/tmp/amh % /nfs/src/amhello-1.0/configure  
/tmp/amh % make && sudo make install-exec
```

# Two Part Installation

```
'make install'  
=  
'make install-exec'  
+  
'make install-data'
```

# Two Part Installation

```
'make install'
=
'make install-exec'  install platform-dependent files
+
'make install-data'
```



# Two Part Installation

`'make install'`  
=  
`'make install-exec'`    install platform-dependent files  
+  
`'make install-data'`    install platform-independent files  
                          (can be shared among multiple machines)

# Cross-Compilation

```
~/amhello-1.0 % ./configure
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 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 ANSI C...
...
```

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checking whether we are using the GNU C compiler... yes
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...
```

# Cross-Compilation

```
~/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...  
...
```

# Cross-Compilation

```
~/amhello-1.0 % ./configure --build i686-pc-linux-gnu \  
                  --host i586-mingw32msvc  
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...
```

# Cross-Compilation

```
~/amhello-1.0 % ./configure --build i686-pc-linux-gnu \  
                --host i586-mingw32msvc  
...  
~/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
```

Of course you need a cross-compiler installed first.

# Cross-Compilation

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~/amhello-1.0 % ./configure --build i686-pc-linux-gnu \  
                  --host i586-mingw32msvc  
...  
~/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
```

Of course you need a cross-compiler installed first.

Cross-compilation *configure* options:

'--build=**BUILD**' The system on which the package is built.

'--host=**HOST**' The system where built programs & libraries will run.

'--target=**TARGET**' Only when building compiler tools: the system for which the tools will create output.

For simple cross-compilation, only '--host=**HOST**' is needed.

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Maybe *hello* is already a command on this host?



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`--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.

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append **SUFFIX** to installed program names,

`--program-transform-name=PROGRAM`

run `'sed PROGRAM'` on installed program names.

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

Will install *hello* as `/usr/local/bin/test-hello`.

# The Packager Point of View

# Building Binary Packages Using DESTDIR

**DESTDIR** is used to relocate a package at install time.

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~/amhello-1.0 % ./configure --prefix /usr  
...
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~/amhello-1.0 % ./configure --prefix /usr  
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...
```

# Building Binary Packages Using DESTDIR

**DESTDIR** is used to relocate a package at install time.

```
~/amhello-1.0 % ./configure --prefix /usr
...
~/amhello-1.0 % make
...
~/amhello-1.0 % make DESTDIR=$HOME/inst install
...
```

# Building Binary Packages Using DESTDIR

**DESTDIR** is used to relocate a package at install time.

```
~/amhello-1.0 % ./configure --prefix /usr
...
~/amhello-1.0 % make
...
~/amhello-1.0 % make DESTDIR=$HOME/inst install
...
~/amhello-1.0 % cd ~/inst
~/inst % tar zcvf ~/amhello-1.0-i686.tar.gz .
./
./usr/
./usr/bin/
./usr/bin/hello
```

... and `~/amhello-1.0-i686.tar.gz` is ready to be uncompressed in / on many hosts.

# The Maintainer Point of View



# Preparing Distributions

`'make dist'` Create *PACKAGE-VERSION.tar.gz*

`'make distcheck'` Likewise, with many sanity checks. Prefer this one!

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`'make dist'` Create *PACKAGE-VERSION.tar.gz*

`'make distcheck'` Likewise, with many sanity checks. **Prefer this one!**

`'make distcheck'` ensures most of the use cases presented so far work.

- It tests VPATH builds (with read-only source tree)
- It ensures `'make clean'`, `'make distclean'`, and `'make uninstall'` do not omit files,
- It checks that **DESTDIR** installations work,
- It runs the test suite (both `'make check'` and `'make installcheck'`).

Releasing a package that fails `'make distcheck'` means releasing a package that will disappoint many users.

# Automatic Dependency Tracking

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

Dependency tracking is performed as a side-effect of compilation.  
Several methods are supported, and checked for by *configure*.  
(The gcc3 method above is the fastest.)

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Several methods are supported, and checked for by *configure*.  
(The gcc3 method above is the fastest.)

Dependency tracking is only needed when the source files change;  
it can be safely disabled for throw-away installation builds.  
Slow methods must be enabled explicitly.

'*--disable-dependency-tracking*' speed up one-time builds

'*--enable-dependency-tracking*' do not reject slow dependency  
extractors

# Nested Packages

- *Autoconfiscated* packages can be nested to arbitrary depth.
  - A package can distribute a third-party library it uses in a subdirectory.
  - It's possible to gather many packages this way to distribute a set of tools.

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  - A single package to configure, build, and install.
  - 'configure' options are passed recursively to sub-packages.
  - 'configure --help=recursive' shows the help of all sub-packages.
- For maintainers:
  - Easier integration.
  - The sub-package is autonomous.

# The configure Process



# The (simplified) *configure* process



*Makefile.in*

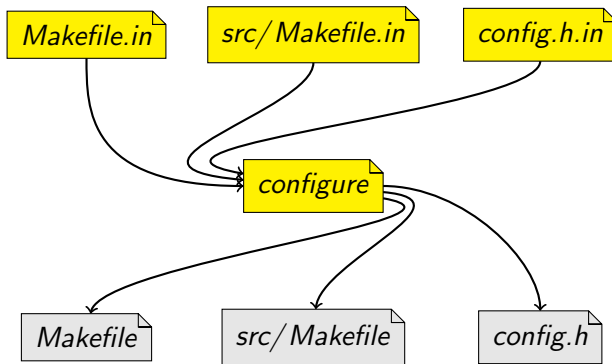
*src/Makefile.in*

*config.h.in*

*configure*

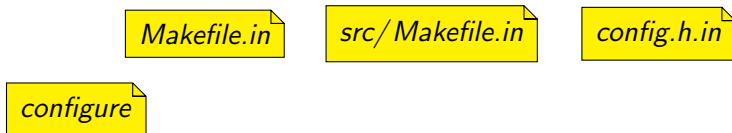
*\*.in* files are configuration templates

# The (simplified) *configure* process

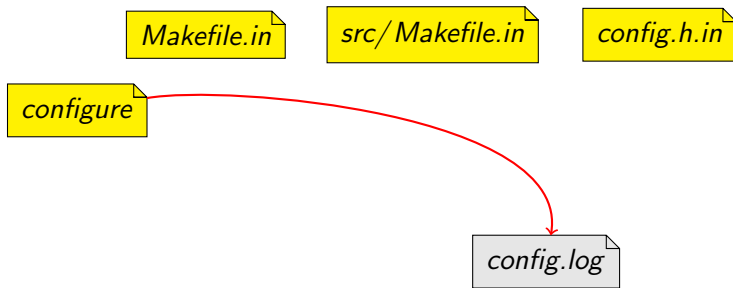


*\*.in* files are configuration templates  
from which *configure* generates the configuration files to use for building

# The (real) *configure* process

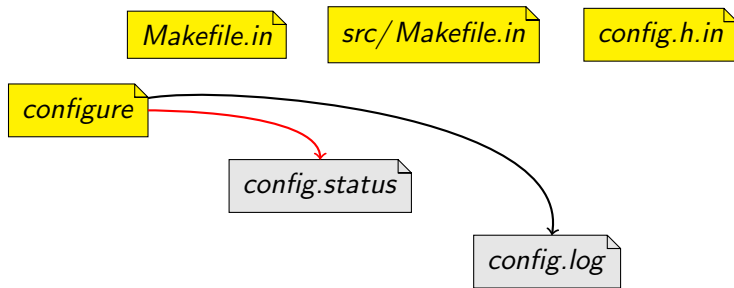


# The (real) *configure* process



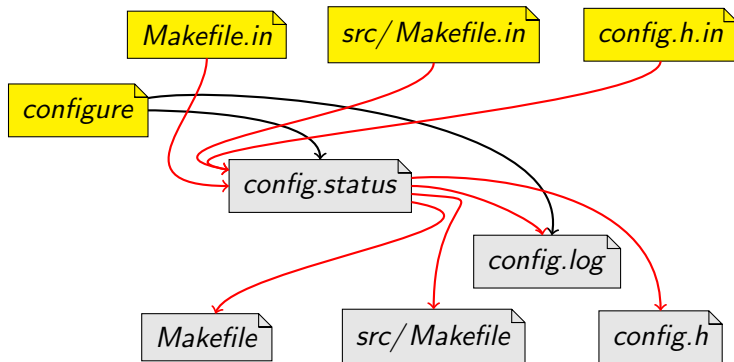
*config.log* contains a trace of the configuration

# The (real) *configure* process



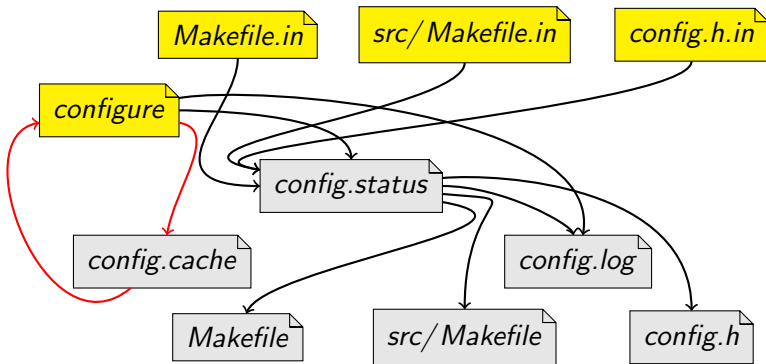
*config.status* will actually process the templates

# The (real) *configure* process



*config.status* will actually process the templates

# The (real) *configure* process



'`configure -C`' caches results in `config.cache` to speed up reconfigurations

# Why We Need Tools



# Why We Need Tools

If you try to mimic this build system by hand, you'll discover that

- The GNU Build System has a lot of features.  
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- You will have to upgrade your setup to follow changes of the GNU Coding Standards.

GNU Autotools provide:

- Tools to create the GNU Build System from simple instructions.
- A central place where fixes and improvements are made.  
(A bug-fix for a portability issue benefits every package.)

## Part II

# GNU Autotools

# Hello World



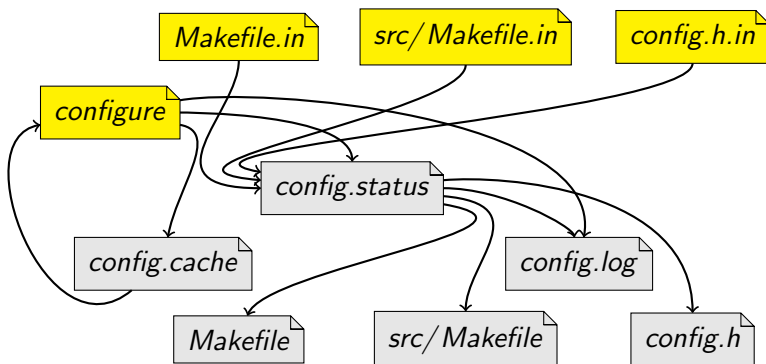
# *src/main.c* for Hello World

*src/main.c*

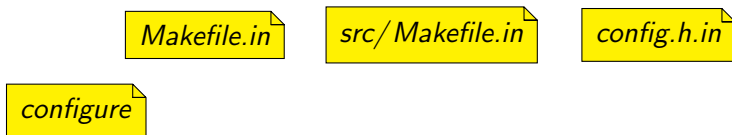
```
#include <config.h>
#include <stdio.h>

int
main (void)
{
    puts ("Hello _World!");
    puts ("This _is _" PACKAGE_STRING " .");
    return 0;
}
```

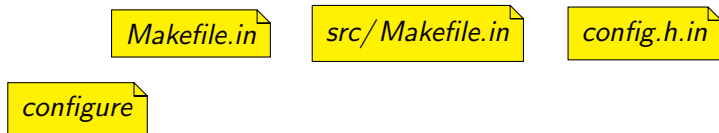
# Generating All Template Files



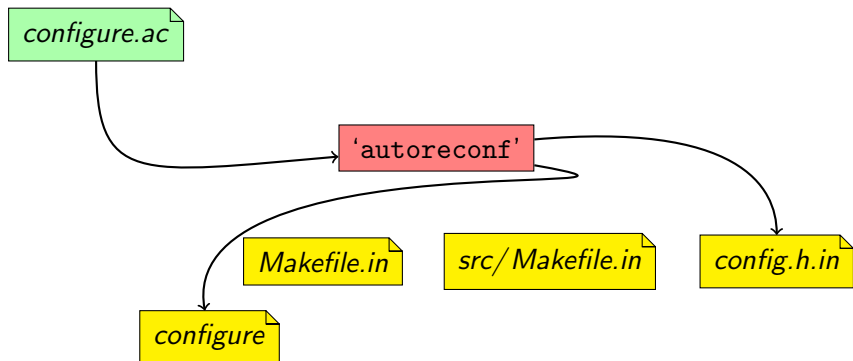
# Generating All Template Files



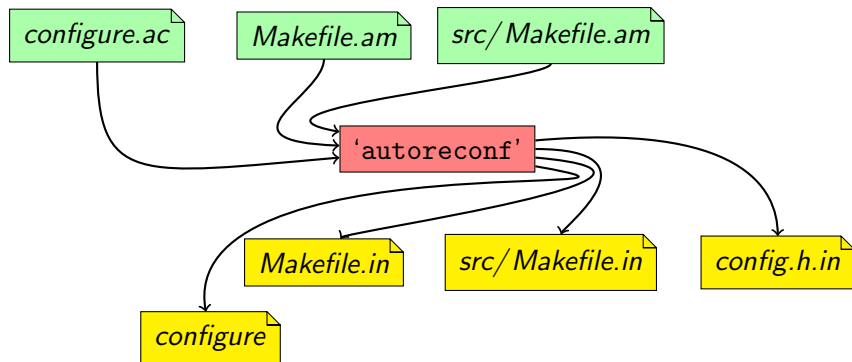
# Generating All Template Files



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# Autotools Inputs

## *configure.ac*

```
AC_INIT([amhello], [1.0],  
        [bug-report@address])  
AM_INIT_AUTOMAKE([  
    -Wall -Werror foreign])  
AC_PROG_CC  
AC_CONFIG_HEADERS([config.h])  
AC_CONFIG_FILES([  
    Makefile  
    src/Makefile  
])  
AC_OUTPUT
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## *Makefile.am*

```
SUBDIRS = src
```



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    Makefile  
    src/Makefile  
])  
AC_OUTPUT
```

## *Makefile.am*

```
SUBDIRS = src
```

## *src/Makefile.am*

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

# Preparing the Package

```
~/amhello % ls -R
.:
Makefile.am  configure.ac  src/

./src:
Makefile.am  main.c
~/amhello %
```

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Makefile.am  main.c
~/amhello % autoreconf --install
configure.ac:4: installing './install-sh'
configure.ac:4: installing './missing'
src/Makefile.am: installing './depcomp'
~/amhello %
```

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.:
Makefile.am      configure.ac
Makefile.in      depcomp*
aclocal.m4       install-sh*
autom4te.cache/  missing*
```

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.:
Makefile.am      configure.ac
Makefile.in      depcomp*
aclocal.m4       install-sh*
autom4te.cache/  missing*
config.h.in      src/
configure*

./autom4te.cache:
output.0  requests  traces.1
output.1  traces.0

./src:
Makefile.am  Makefile.in  main.c
```

# Preparing the Package

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~/amhello % ls -R
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Makefile.am      configure.ac
Makefile.in      depcomp*
aclocal.m4       install-sh*
autom4te.cache/  missing*
config.h.in      src/           expected configuration templates
configure*

./autom4te.cache:
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./src:
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definitions for third-party macros  
used in *configure.ac*

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Makefile.in      depcomp*
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autom4te.cache/  missing*
config.h.in      src/          auxiliary tools
configure*       used during the build

./autom4te.cache:
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output.1  traces.0

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Makefile.am      configure.ac
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autom4te.cache/  missing*
config.h.in      src/           Autotools cache files
configure*

./autom4te.cache:
output.0  requests  traces.1
output.1  traces.0

./src:
Makefile.am  Makefile.in  main.c
```

# Preparing the Package

```
~/amhello % ./configure
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 gcc... gcc
...
checking dependency style of gcc... gcc3
configure: creating ./config.status
config.status: creating Makefile
config.status: creating src/Makefile
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config.status: executing depfiles commands
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~/amhello % make
...
```

# Preparing the Package

```
~/amhello % src/hello  
Hello World!  
This is amhello 1.0.  
~/amhello %
```

# Preparing the Package

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

# Preparing the Package

```
~/amhello % tar ztf amhello-1.0.tar.gz
amhello-1.0/
amhello-1.0/Makefile.am
amhello-1.0/Makefile.in
amhello-1.0/aclocal.m4
amhello-1.0/config.h.in
amhello-1.0/configure
amhello-1.0/configure.ac
amhello-1.0/depcomp
amhello-1.0/install-sh
amhello-1.0/missing
amhello-1.0/src/
amhello-1.0/src/Makefile.am
amhello-1.0/src/Makefile.in
amhello-1.0/src/main.c
~/amhello %
```

# Introducing Core Autotools



# Two Core Packages

GNU Autoconf

GNU Automake

# Two Core Packages

## GNU Autoconf

'autoconf' Create *configure* from *configure.ac*.

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- 'autoconf' Create *configure* from *configure.ac*.
- 'autoheader' Create *config.h.in* from *configure.ac*.
- 'autoreconf' Run all tools in the right order.

## GNU Automake

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## GNU Automake

- 'automake' Create *Makefile.ins* from *Makefile.ams* and *configure.ac*.
- 'aclocal' Scan *configure.ac* for uses of third-party macros, and gather definitions in *aclocal.m4*.

# Two Core Packages

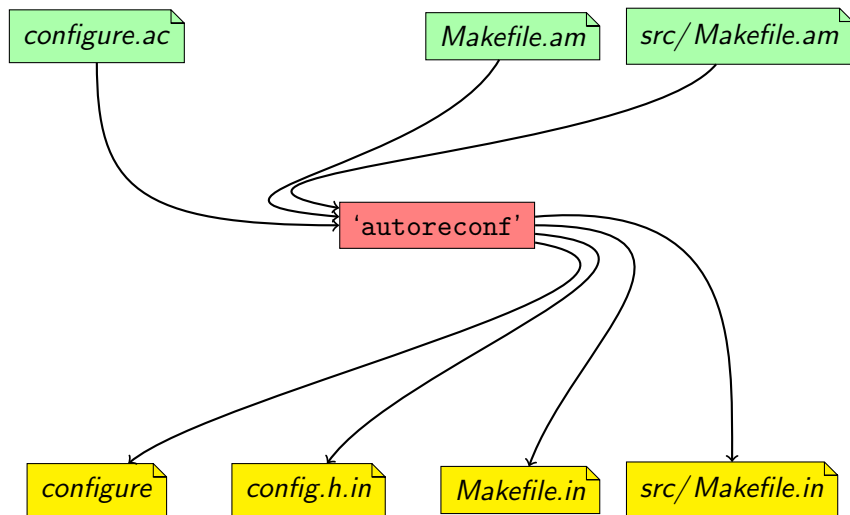
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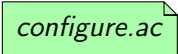
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## Behind 'autoreconf'



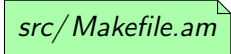
# Behind 'autoreconf'



*configure.ac*



*Makefile.am*



*src/Makefile.am*



*configure*



*config.h.in*

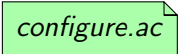


*Makefile.in*



*src/Makefile.in*

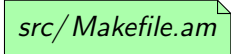
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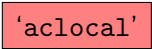
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*Makefile.am*



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'aclocal'



*configure*



*config.h.in*

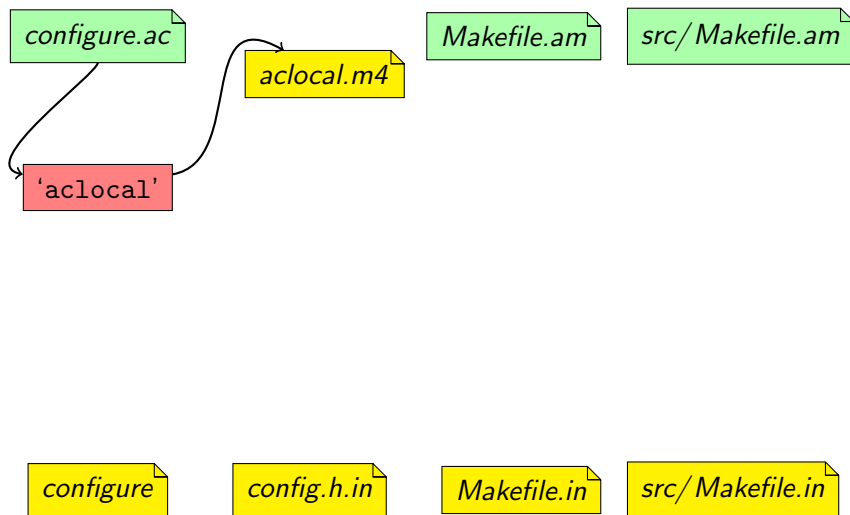


*Makefile.in*

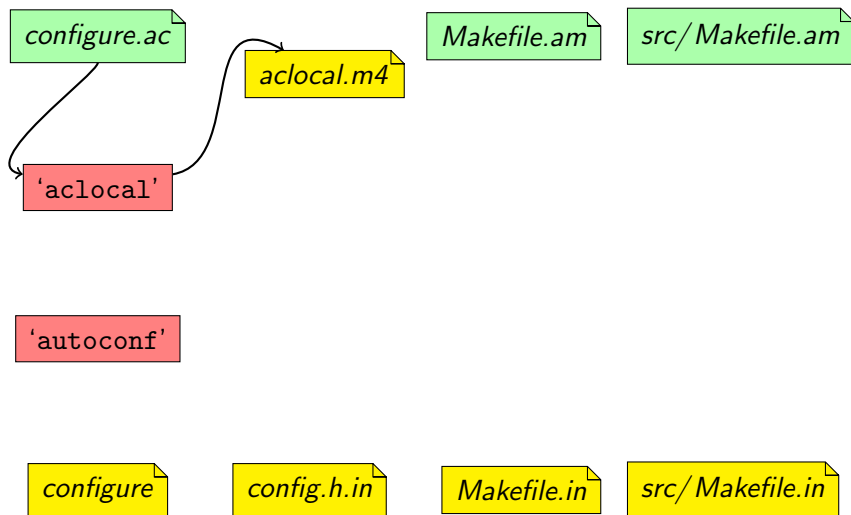


*src/Makefile.in*

## Behind 'autoreconf'

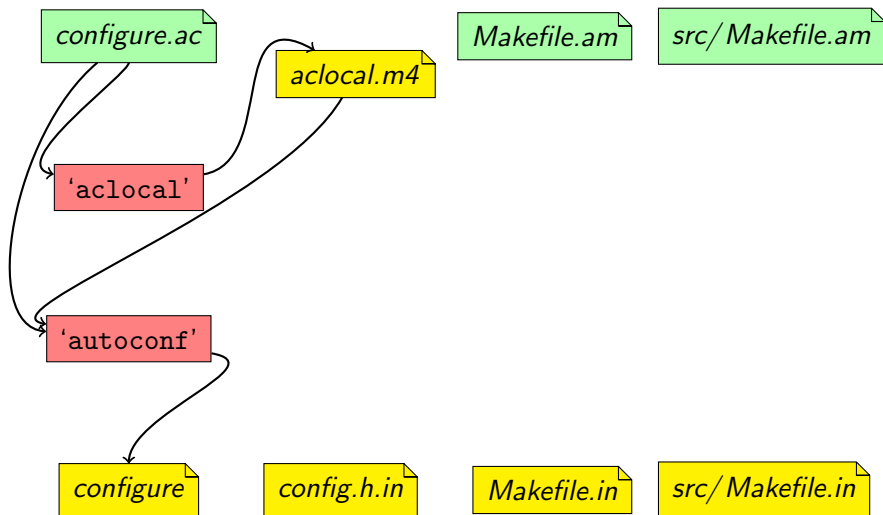


## Behind 'autoreconf'

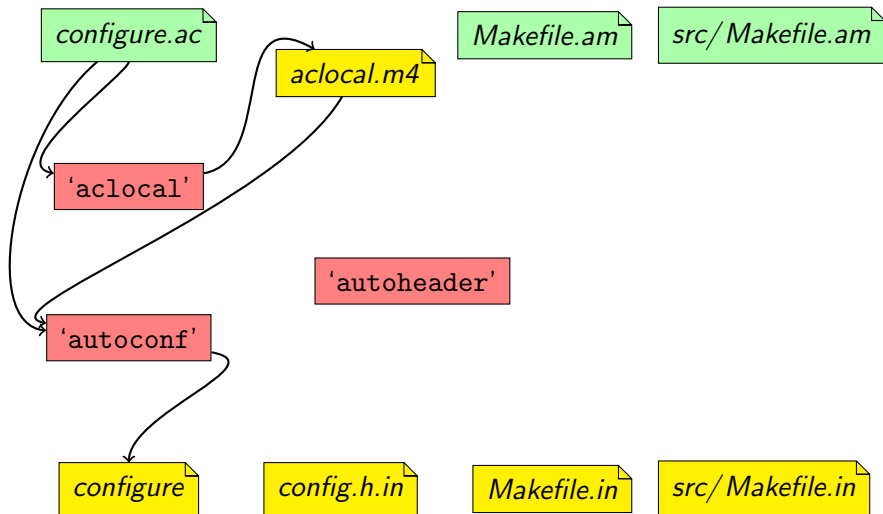




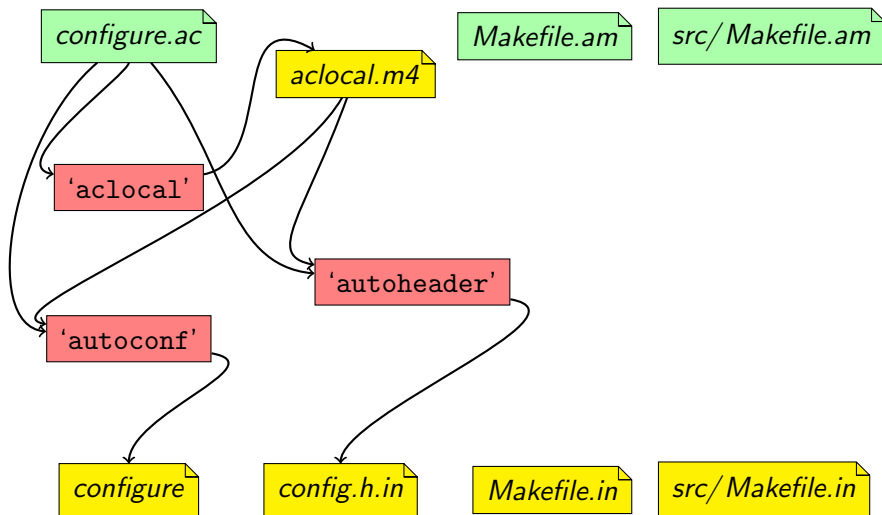
## Behind 'autoreconf'



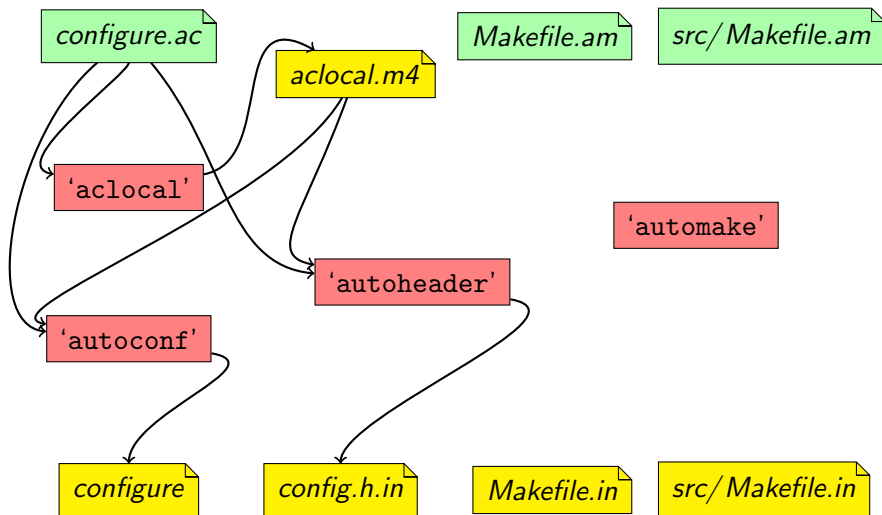
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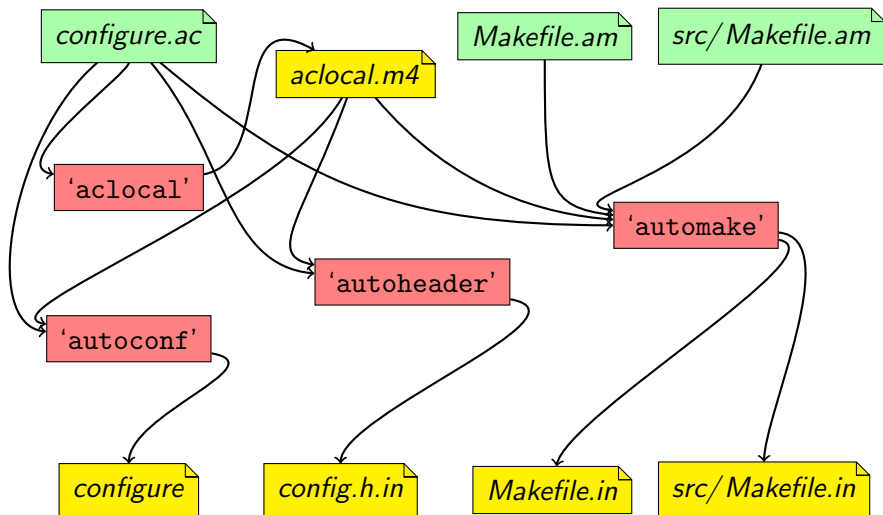
## Behind 'autoreconf'



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## Behind 'autoreconf'



# 'autoreconf' is Your Friend

In practice,

- You do not have to remember the interaction of all tools.
- Use 'autoreconf --install' to setup the package initially.
- Rely on the rebuild rules (output in *Makefiles*) to rerun the right autotool when you change some input file.
- You only need a rough idea of the purpose of each tool to understand errors. (What tool complains and about what?)

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'autoheader' Creates *config.h.in* from *configure.ac*.

'automake' Creates *Makefile.in*s from *Makefile.am*s and *configure.ac*.

'aclocal' Scans *configure.ac* for uses of third-party macros, and gather definitions in *aclocal.m4*.

'autom4te' Autoconf driver for M4. All tools that process *configure.ac* do so through 'autom4te'.

# Hello World Explained



# amhello's *configure.ac* explained

## *configure.ac*

```
AC_INIT([amhello], [1.0], [bug-report@address])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
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AC_OUTPUT
```

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AC_OUTPUT
```

- Initialize Autoconf. Specify package's name, version number, and bug-report address.

# amhello's *configure.ac* explained

## *configure.ac*

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

- Initialize Autoconf. Specify package's name, version number, and bug-report address.
- Initialize Automake. Turn on all Automake warnings and report them as errors. This is a **foreign** package.

# foreign Ignores some GNU Coding Standards

```
configure.ac
```

```
...
```

```
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
```

```
...
```

```
~/amhello % autoreconf --install
```

```
configure.ac:2: installing './install-sh'
```

```
configure.ac:2: installing './missing'
```

```
src/Makefile.am: installing './depcomp'
```

# foreign Ignores some GNU Coding Standards

*configure.ac* without the foreign option

```
...  
AM_INIT_AUTOMAKE([-Wall -Werror])  
...
```

```
~/amhello % autoreconf --install  
configure.ac:2: installing './install-sh'  
configure.ac:2: installing './missing'  
src/Makefile.am: installing './depcomp'  
Makefile.am: installing './INSTALL'  
Makefile.am: required file './NEWS' not found  
Makefile.am: required file './README' not found  
Makefile.am: required file './AUTHORS' not found  
Makefile.am: required file './ChangeLog' not found  
Makefile.am: installing './COPYING'  
autoreconf: automake failed with exit status: 1
```

# amhello's *configure.ac* explained

## *configure.ac*

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

- Initialize Autoconf. Specify package's name, version number, and bug-report address.
- Initialize Automake. Turn on all Automake warnings and report them as errors. This is a **foreign** package.

# amhello's *configure.ac* explained

## *configure.ac*

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- Initialize Autoconf. Specify package's name, version number, and bug-report address.
- Initialize Automake. Turn on all Automake warnings and report them as errors. This is a foreign package.
- Check for a C compiler.
- Declare *config.h* as output header.



# amhello's *configure.ac* explained

## *configure.ac*

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AC_INIT([amhello], [1.0], [bug-report@address])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
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AC_OUTPUT
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- Declare *config.h* as output header.
- Declare *Makefile* and *src/Makefile* as output files.

# amhello's *configure.ac* explained

## *configure.ac*

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- Initialize Autoconf. Specify package's name, version number, and bug-report address.
- Initialize Automake. Turn on all Automake warnings and report them as errors. This is a foreign package.
- Check for a C compiler.
- Declare *config.h* as output header.
- Declare *Makefile* and *src/Makefile* as output files.
- Actually output all declared files.

# amhello's *Makefile.am* explained

## *Makefile.am*

```
SUBDIRS = src
```

- Build recursively in *src/*.

# amhello's *Makefile.am* explained

## *Makefile.am*

```
SUBDIRS = src
```

- Build recursively in *src/*.
- Nothing else is declared for the current directory.  
(The top-level *Makefile.am* is usually short.)

# amhello's *src/Makefile.am* explained

## *src/Makefile.am*

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

- We are building some programs.

# amhello's *src/Makefile.am* explained

## *src/Makefile.am*

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

- We are building some programs.
- These programs will be installed in *bindir*.

# Standard File System Hierarchy

Directory variable	Default value
prefix	<i>/usr/local</i>
exec-prefix	prefix
bindir	exec-prefix/ <i>bin</i>
libdir	exec-prefix/ <i>lib</i>
...	
includedir	prefix/ <i>include</i>
datarootdir	prefix/ <i>share</i>
datadir	datarootdir
mandir	datarootdir/ <i>man</i>
infodir	datarootdir/ <i>info</i>
...	

# amhello's *src/Makefile.am* explained

## *src/Makefile.am*

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

- We are building some programs.
- These programs will be installed in **bindir**.



# amhello's *src/Makefile.am* explained

## *src/Makefile.am*

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

- We are building some programs.
- These programs will be installed in *bindir*.
- There is only one program to build: *hello*.

# amhello's *src/Makefile.am* explained

## *src/Makefile.am*

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

- We are building some programs.
- These programs will be installed in *bindir*.
- There is only one program to build: *hello*.
- To create *hello*, just compile *main.c*.

# Using Autoconf

## From *configure.ac* to *configure* and *config.h.in*

- 'autoconf' is a macro processor.
- It converts *configure.ac*, which is a shell script using macro instructions, into *configure*, a full-fledged shell script.

# From *configure.ac* to *configure* and *config.h.in*

- 'autoconf' is a macro processor.
- It converts *configure.ac*, which is a shell script using macro instructions, into *configure*, a full-fledged shell script.
- Autoconf offers many macros to perform common configuration checks.
- It is not uncommon to have a *configure.ac* without shell constructs, using only macros.

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- While processing *configure.ac* it is also possible to trace the occurrences of macros. This is how ‘autoheader’ creates *config.h.in*. It just looks for the macros that `#define` symbols.

# From *configure.ac* to *configure* and *config.h.in*

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- Autoconf offers many macros to perform common configuration checks.
- It is not uncommon to have a *configure.ac* without shell constructs, using only macros.
- While processing *configure.ac* it is also possible to trace the occurrences of macros. This is how ‘autoheader’ creates *config.h.in*. It just looks for the macros that `#define` symbols.
- The real macro processor actually is GNU M4. Autoconf offers some infrastructure on top of that, plus the pool of macros.

# Discovering M4

## *example.m4*

```
m4_define(NAME1, Harry)↵  
m4_define(NAME2, Sally)↵  
m4_define(MET, $1 met $2)↵  
MET(NAME1, NAME2)↵
```

~ %



# Discovering M4

## *example.m4*

```
m4_define(NAME1, Harry)↵  
m4_define(NAME2, Sally)↵  
m4_define(MET, $1 met $2)↵  
MET(NAME1, NAME2)↵
```

```
~ % m4 -P example.m4
```

```
↵  
↵  
↵
```

```
Harry met Sally↵
```

# Discovering M4

## *example.m4*

```
m4_define(NAME1, Harry)↵  
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~ % m4 -P example.m4  
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↵  
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↵  
↵  
Harry met Sally↵
```

# Discovering M4

*example.m4*

```
↵  
m4_define(NAME2, Sally)↵  
m4_define(MET, $1 met $2)↵  
MET(NAME1, NAME2)↵
```

```
~ % m4 -P example.m4  
↵  
↵  
↵  
Harry met Sally↵
```

# Discovering M4

*example.m4*

```
↵  
m4_define(NAME2, Sally)↵  
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```

```
~ % m4 -P example.m4
```

```
↵  
↵  
↵  
Harry met Sally↵
```

# Discovering M4

*example.m4*

```
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m4_define(NAME2, Sally)↵  
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# Discovering M4

*example.m4*

```
↵  
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m4_define(MET, $1 met $2)↵  
MET(NAME1, NAME2)↵
```

```
~ % m4 -P example.m4
```

```
↵  
↵  
↵  
Harry met Sally↵
```



# Discovering M4

*example.m4*

```
↵  
↵  
m4_define(MET, $1 met $2)↵  
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```
~ % m4 -P example.m4
```

```
↵  
↵  
↵  
Harry met Sally↵
```

# Discovering M4

*example.m4*

```
↵  
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m4_define(MET, $1 met $2)↵  
MET(NAME1, NAME2)↵
```

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~ % m4 -P example.m4  
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↵  
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# Discovering M4

*example.m4*

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*example.m4*

```
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MET(NAME1, NAME2)↵
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~ % m4 -P example.m4
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```
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↵  
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```

# Discovering M4

*example.m4*

↵  
↵  
↵

MET(NAME1, NAME2)↵

~ % m4 -P example.m4

↵  
↵  
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# Discovering M4

*example.m4*

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↵  
↵

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# Discovering M4

*example.m4*

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# Discovering M4

*example.m4*

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*example.m4*

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- The macro's arguments are processed
- Then the macro is expanded
- Finally the output of the macro is processed too

# M4 Quoting

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- A string can be protected from processing using **quotes**.

## *example.m4*

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m4_define(NAME1, 'Harry, Jr.')
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```
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```
m4_define(MET, $1 met $2)
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MET(NAME1, NAME2)
```

# M4 Quoting

- The macro's arguments are processed
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This is a source of many mistakes for the unwary.

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Can you guess the output of the above?

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*example.m4*

↵

↵

m4\_define(MET, \$1 met \$2)↵

MET(NAME1, NAME2)↵

Can you guess the output of the above?



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↵  
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Can you guess the output of the above?

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↵  
↵  
↵  
↵

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*example.m4*

↵  
↵  
↵

MET(Harry, Jr., NAME2)↵

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↵  
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*example.m4*

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↵  
↵

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Can you guess the output of the above?

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*example.m4*

↵  
↵  
↵

MET(Harry, Jr., NAME2)↵

Can you guess the output of the above?

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*example.m4*

↵  
↵  
↵

MET(Harry, Jr., Sally)↵

Can you guess the output of the above?

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This is a source of many mistakes for the unwary.

*example.m4*

↵  
↵  
↵

MET(Harry, Jr., Sally)↵

Can you guess the output of the above?



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- The macro's arguments are processed
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*example.m4*

↵  
↵  
↵

**MET**(Harry, Jr., Sally)↵

Can you guess the output of the above?

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- The macro's arguments are processed
- Then the macro is expanded
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- A string can be protected from processing using quotes.

This is a source of many mistakes for the unwary.

*example.m4*

```
␣  
␣  
␣  
␣
```

```
Harry met Jr.␣
```

Can you guess the output of the above?

# M4 Quoting

- The macro's arguments are processed
- Then the macro is expanded
- Finally the output of the macro is processed too
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*example.m4*

```
↵  
↵  
↵  
↵
```

```
Harry met Jr.↵
```

Can you guess the output of the above?

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- Then the macro is expanded
- Finally the output of the macro is processed too
- A string can be protected from processing using quotes.

This is a source of many mistakes for the unwary.

*example.m4*

↵  
↵  
↵

Harry met Jr.↵

Can you guess the output of the above?

# M4 Quoting

- The macro's arguments are processed
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*example.m4*

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↵  
↵  
↵  
↵
```

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Harry met Jr.↵
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### *example.m4*

```
m4_define('NAME1', 'Harry, Jr.')
```

```
m4_define('NAME2', 'Sally')
```

```
m4_define('MET', '$1 met $2')
```

```
MET('NAME1', 'NAME2')
```

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# M4 Quoting Rule of the Thumb

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## *example.m4*

```
m4_define(NAME1, 'Harry, Jr.')
```

```
m4_define('NAME2', 'Sally')
```

```
m4_define('MET', '$1 met $2')
```

```
MET('NAME1', 'NAME2')
```

# M4 Quoting Rule of the Thumb

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## *example.m4*

```
m4_define(NAME1, Harry, Jr.)↵  
m4_define('NAME2', 'Sally')↵  
m4_define('MET', '$1 met $2')↵  
MET('NAME1', 'NAME2')↵
```

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
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## *example.m4*

```
↵  
m4_define('NAME2', 'Sally')↵  
m4_define('MET', '$1 met $2')↵  
MET('NAME1', 'NAME2')↵
```

# M4 Quoting Rule of the Thumb

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*example.m4*

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↵  
m4_define(NAME2, 'Sally')↵  
m4_define('MET', '$1 met $2')↵  
MET('NAME1', 'NAME2')↵
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*example.m4*

```
↵  
m4_define(NAME2, Sally)↵  
m4_define('MET', '$1 met $2')↵  
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*example.m4*

```
↵  
↵  
m4_define('MET', '$1 met $2')↵  
MET('NAME1', 'NAME2')↵
```



# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
- So it is processed only after it has been output.

*example.m4*

```
↵  
↵  
m4_define(MET, '$1 met $2')↵  
MET('NAME1', 'NAME2')↵
```

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
- So it is processed only after it has been output.

*example.m4*

```
↵  
↵  
m4_define(MET, $1 met $2)↵  
MET('NAME1', 'NAME2')↵
```

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
- So it is processed only after it has been output.

*example.m4*

↵  
↵  
↵

MET('NAME1', 'NAME2')↵

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
- So it is processed only after it has been output.

*example.m4*

↵  
↵  
↵

MET(NAME1, 'NAME2')↵

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
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*example.m4*

↵  
↵  
↵

**MET**(NAME1, NAME2)↵

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
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*example.m4*

↵  
↵  
↵

NAME1 met NAME2↵

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*example.m4*

↵  
↵  
↵

NAME1 met NAME2↵

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
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*example.m4*

↵  
↵  
↵

Harry, Jr. met NAME2↵



# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
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*example.m4*

↵  
↵  
↵

Harry, Jr. met NAME2↵

# M4 Quoting Rule of the Thumb

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*example.m4*

↵  
↵  
↵

Harry, Jr. met NAME2↵

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- Quote each macro argument once.
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*example.m4*

↵  
↵  
↵

Harry, Jr. **met** NAME2↵

# M4 Quoting Rule of the Thumb

- Quote each macro argument once.
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*example.m4*

↵  
↵  
↵

Harry, Jr. met NAME2↵

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↵  
↵

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*example.m4*

↵  
↵  
↵

Harry, Jr. met Sally↵

# Spacing Matters

## *example.m4*

```
m4_define('NAME1', 'Harry, Jr.')
```

```
m4_define('NAME2', 'Sally')
```

```
m4_define('MET', '$1 met $2')
```

```
MET('NAME1', 'NAME2')
```

```
~ % m4 -P example.m4
```

```
↵
```

```
↵
```

```
↵
```

```
Harry, Jr. met Sally
```




# Spacing Matters


- The parenthesis must stick to the macro name.

## *example.m4*


```
m4_define('NAME1', 'Harry, Jr.')
```


```
m4_define('NAME2', 'Sally')
```

```
m4_define('MET', '$1 met $2')
```


```
MET_( 'NAME1', 'NAME2')
```



```
~ % m4 -P example.m4
```



```
met_(NAME1, NAME2)
```



# Spacing Matters

- The parenthesis must stick to the macro name.
- Spaces after or inside quotes are part of the arguments.

## *example.m4*

```
m4_define('NAME1', 'Harry, Jr.')
```

```
m4_define('NAME2', 'Sally')
```

```
m4_define('MET', '$1 met $2')
```

```
MET('NAME1', 'NAME2')
```

```
~ % m4 -P example.m4
```

```
↵
```

```
↵
```

```
↵
```

```
Harry, Jr. met Sally
```

# Spacing Matters

- The parenthesis must stick to the macro name.
- Spaces after or inside quotes are part of the arguments.
- Spaces before quotes are ignored.

## *example.m4*

```
m4_define('NAME1', 'Harry, Jr.')
```

```
m4_define('NAME2', 'Sally')
```

```
m4_define('MET', '$1 met $2')
```

```
MET('NAME1', 'NAME2')
```

```
~ % m4 -P example.m4
```

```
↵
```

```
↵
```

```
↵
```

```
Harry, Jr. met Sally
```

# Autoconf on Top of M4

- Autoconf = M4 with more machinery, and many predefined macros.

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```
if [ "$x" = "$y" ]; then ...
```

# Autoconf on Top of M4

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# Autoconf on Top of M4

- Autoconf = M4 with more machinery, and many predefined macros.
- The quotes are [ and ] (instead of ' and ').
- For this reason we use the test command instead of [ in shell fragments:

```
if test "$x" = "$y"; then ...
```

- Macros are defined with AC\_DEFUN.

```
AC_DEFUN([NAME1], [Harry, Jr.])  
AC_DEFUN([NAME2], [Sally])  
AC_DEFUN([MET], [$1 met $2])  
MET([NAME1], [NAME2])
```



# The Structure of a *configure.ac*

## *configure.ac*

# Prelude.

AC\_INIT([**PACKAGE**], [**VERSION**], [**BUG-REPORT-ADDRESS**])

# Checks for programs.

# Checks for libraries.

# Checks for header files.

# Checks for typedefs, structures, and compiler characteristics.

# Checks for library functions.

# Output files.

AC\_CONFIG\_FILES([**FILES**])

AC\_OUTPUT

# The Structure of a *configure.ac*

## *configure.ac*

# Prelude.

AC\_INIT([amhello], [1.0], [bug-report@address])

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# Checks for library functions.

# Output files.

AC\_CONFIG\_FILES([FILES])

AC\_OUTPUT

# The Structure of a *configure.ac*

## *configure.ac*

```
# Prelude.  
AC_INIT([amhello], [1.0], [bug-report@address])  
AM_INIT_AUTOMAKE([-Wall -Werror foreign])  
  
# Checks for programs.  
  
# Checks for libraries.  
# Checks for header files.  
# Checks for typedefs, structures, and compiler characteristics.  
# Checks for library functions.  
# Output files.  
  
AC_CONFIG_FILES([FILES])  
AC_OUTPUT
```

# The Structure of a *configure.ac*

## *configure.ac*

```
# Prelude.  
AC_INIT([amhello], [1.0], [bug-report@address])  
AM_INIT_AUTOMAKE([-Wall -Werror foreign])  
# Checks for programs.  
AC_PROG_CC  
# Checks for libraries.  
# Checks for header files.  
# Checks for typedefs, structures, and compiler characteristics.  
# Checks for library functions.  
# Output files.  
  
AC_CONFIG_FILES([FILES])  
AC_OUTPUT
```

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# Checks for libraries.  
  
# Checks for header files.  
  
# Checks for typedefs, structures, and compiler characteristics.  
  
# Checks for library functions.  
  
# Output files.  
  
  
AC_CONFIG_FILES([Makefile src/Makefile])  
AC_OUTPUT
```

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# Checks for libraries.  
# Checks for header files.  
# Checks for typedefs, structures, and compiler characteristics.  
# Checks for library functions.  
# Output files.  
AC_CONFIG_HEADERS([config.h])  
AC_CONFIG_FILES([Makefile src/Makefile])  
AC_OUTPUT
```

# Useful Autoconf Macros for Prelude

`AC_INIT(PACKAGE, VERSION, BUG-REPORT-ADDRESS)`

Mandatory Autoconf initialization.

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Require a minimum Autoconf version. E.g. `AC_PREREQ([2.61])`



# Useful Autoconf Macros for Prelude

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Mandatory Autoconf initialization.

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**AC\_CONFIG\_SRCDIR(FILE)**

A safety check. **FILE** should be a distributed source file, and this makes sure that 'configure' is not run from outer space. E.g. `AC_CONFIG_SRCDIR([src/main.c])`.

# Useful Autoconf Macros for Prelude

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Mandatory Autoconf initialization.

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**AC\_CONFIG\_SRCDIR(FILE)**

A safety check. **FILE** should be a distributed source file, and this makes sure that 'configure' is not run from outer space. E.g. `AC_CONFIG_SRCDIR([src/main.c])`.

**AC\_CONFIG\_AUX\_DIR(DIRECTORY)**

Auxiliary scripts such as *install-sh* and *depcomp* should be in **DIRECTORY**. E.g. `AC_CONFIG_AUX_DIR([build-aux])`.

# Preparing the Package

```
~/amhello % ls -R
.:
Makefile.am      configure.ac
Makefile.in      depcomp*
aclocal.m4       install-sh*
autom4te.cache/  missing*
config.h.in      src/
configure*       auxiliary tools
                  used during the build

./autom4te.cache:
output.0  requests  traces.1
output.1  traces.0
```

## AC\_CONFIG\_AUX\_DIR Example

### *configure.ac*

```
AC_INIT([amhello], [1.1], [bug-report@address])
```

```
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
```

```
AC_PROG_CC
```

```
AC_CONFIG_HEADERS([config.h])
```

```
AC_CONFIG_FILES([Makefile src/Makefile])
```

```
AC_OUTPUT
```

```
% autoreconf --install
```

```
configure.ac:3: installing 'missing'
```

```
configure.ac:3: installing 'install-sh'
```

```
src/Makefile.am: installing 'depcomp'
```

# AC\_CONFIG\_AUX\_DIR Example

## *configure.ac*

```
AC_INIT([amhello], [1.1], [bug-report@address])
AC_CONFIG_AUX_DIR([build-aux])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([Makefile src/Makefile])
AC_OUTPUT
```

```
% autoreconf --install
configure.ac:3: installing 'build-aux/missing'
configure.ac:3: installing 'build-aux/install-sh'
src/Makefile.am: installing 'build-aux/depcomp'
```

# Useful Program Checks

`AC_PROG_CC`, `AC_PROG_CXX`, `AC_PROG_F77`, ...

Compiler checks. (Handle search cross-compilers if needed.)

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Find good implementations and set `$SED`, `$YACC`, `$LEX`, etc.

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`AC_PROG_SED`, `AC_PROG_YACC`, `AC_PROG_LEX`, ...

Find good implementations and set `$SED`, `$YACC`, `$LEX`, etc.

`AC_CHECK_PROGS(VAR, PROGS, [VAL-IF-NOT-FOUND])`

Define `VAR` to the first `PROGS` found, or to `VAL-IF-NOT-FOUND` otherwise.

```
AC_CHECK_PROGS([TAR], [tar gtar], [:])
if test "$TAR" = :; then
  AC_MSG_ERROR([This package needs tar.])
fi
```

... and many more



# Useful Program Checks

`AC_PROG_CC`, `AC_PROG_CXX`, `AC_PROG_F77`, ...

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Find good implementations and set `$SED`, `$YACC`, `$LEX`, etc.

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Define `VAR` to the first `PROGS` found, or to `VAL-IF-NOT-FOUND` otherwise.

```
AC_CHECK_PROGS([TAR], [tar gtar], [:])
if test "$TAR" = :; then
    AC_MSG_ERROR([This package needs tar.])
fi
```

... and many more

# Useful Autoconf Action Macros

`AC_MSG_ERROR(ERROR-DESCRIPTION, [EXIT-STATUS])`

Print `ERROR-DESCRIPTION` (also to *config.log*) and abort  
'configure'.

`AC_MSG_WARN(ERROR-DESCRIPTION)`

Likewise, but don't abort.

# Useful Autoconf Action Macros

`AC_MSG_ERROR(ERROR-DESCRIPTION, [EXIT-STATUS])`

Print `ERROR-DESCRIPTION` (also to *config.log*) and abort 'configure'.

`AC_MSG_WARN(ERROR-DESCRIPTION)`

Likewise, but don't abort.

`AC_DEFINE(VARIABLE, VALUE, DESCRIPTION)`

Output the following to *config.h*.

```
/* DESCRIPTION */  
#define VARIABLE VALUE
```

# Useful Autoconf Action Macros

`AC_MSG_ERROR(ERROR-DESCRIPTION, [EXIT-STATUS])`

Print `ERROR-DESCRIPTION` (also to *config.log*) and abort 'configure'.

`AC_MSG_WARN(ERROR-DESCRIPTION)`

Likewise, but don't abort.

`AC_DEFINE(VARIABLE, VALUE, DESCRIPTION)`

Output the following to *config.h*.

```
/* DESCRIPTION */
#define VARIABLE VALUE
```

`AC_SUBST(VARIABLE, [VALUE])`

Define \$(`VARIABLE`) as `VALUE` in *Makefile*.

```
AC_SUBST([FOO], [foo])
```

```
FOO=foo
```

```
AC_SUBST([FOO])
```

```
AC_SUBST([FOO])
```

```
FOO=foo
```

All equivalent.

# Checking for Libraries

```
AC_CHECK_LIB(LIBRARY, FUNCT, [ACT-IF-FOUND], [ACT-IF-NOT])
```

Check whether `LIBRARY` exists and contains `FUNCT`.  
Execute `ACT-IF-FOUND` if it does, `ACT-IF-NOT` otherwise.

# Checking for Libraries

```
AC_CHECK_LIB(LIBRARY, FUNCT, [ACT-IF-FOUND], [ACT-IF-NOT])
```

Check whether **LIBRARY** exists and contains **FUNCT**.

Execute **ACT-IF-FOUND** if it does, **ACT-IF-NOT** otherwise.

```
AC_CHECK_LIB([efence], [malloc], [EFENCELIB=-leference])  
AC_SUBST([EFENCELIB])
```

... we would later use `$(EFENCELIB)` in the link rule.

# Checking for Libraries

```
AC_CHECK_LIB(LIBRARY, FUNCT, [ACT-IF-FOUND], [ACT-IF-NOT])
```

Check whether **LIBRARY** exists and contains **FUNCT**.  
Execute **ACT-IF-FOUND** if it does, **ACT-IF-NOT** otherwise.

```
AC_CHECK_LIB([efence], [malloc], [EFENCELIB=-leference])  
AC_SUBST([EFENCELIB])
```

... we would later use `$(EFENCELIB)` in the link rule.

If **ACT-IF-FOUND** is not set and the library is found, `AC_CHECK_LIB` will do `LIBS="-lLIBRARY $LIBS"` and `#define HAVE_LIBLIBRARY`.  
(Automake uses `$LIBS` for linking everything.)

# Checking for Headers

`AC_CHECK_HEADERS(HEADERS...)`

Check for `HEADERS` and `#define HAVE_HEADER_H` for each header found.



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```
AC_CHECK_HEADERS([sys/param.h unistd.h])  
AC_CHECK_HEADERS([wchar.h])
```

Might `#define HAVE_SYS_PARAM_H`, `HAVE_UNISTD_H`, and `HAVE_WCHAR_H`.

# Checking for Headers

`AC_CHECK_HEADERS(HEADERS...)`

Check for `HEADERS` and `#define HAVE_HEADER_H` for each header found.

```
AC_CHECK_HEADERS([sys/param.h unistd.h])  
AC_CHECK_HEADERS([wchar.h])
```

Might `#define HAVE_SYS_PARAM_H, HAVE_UNISTD_H, and HAVE_WCHAR_H.`

```
#if HAVE_UNISTD_H  
# include <unistd.h>  
#endif
```

# Checking for Headers

`AC_CHECK_HEADERS(HEADERS...)`

Check for `HEADERS` and `#define HAVE_HEADER_H` for each header found.

```
AC_CHECK_HEADERS([sys/param.h unistd.h])
AC_CHECK_HEADERS([wchar.h])
```

Might `#define HAVE_SYS_PARAM_H, HAVE_UNISTD_H, and HAVE_WCHAR_H.`

```
#if HAVE_UNISTD_H
# include <unistd.h>
#endif
```

`AC_CHECK_HEADER(HEADER, [ACT-IF-FOUND], [ACT-IF-NOT])`

Check only one header.

# Output Commands

## `AC_CONFIG_HEADERS(HEADERS...)`

Create `HEADER` for all `HEADER.in`. Use only one such header unless you know what you are doing ('autoheader' creates `HEADER.in` only for the first `HEADER`).

`HEADERS` contain definitions made with `AC_DEFINE`.

# Output Commands

## AC\_CONFIG\_HEADERS(HEADERS...)

Create **HEADER** for all **HEADER.in**. Use only one such header unless you know what you are doing ('autoheader' creates **HEADER.in** only for the first **HEADER**).

**HEADERS** contain definitions made with **AC\_DEFINE**.

```
AC_CONFIG_HEADERS([config.h])
```

Will create *config.h* from *config.h.in*

# Output Commands

## `AC_CONFIG_HEADERS(HEADERS...)`

Create **HEADER** for all **HEADER.in**. Use only one such header unless you know what you are doing ('autoheader' creates **HEADER.in** only for the first **HEADER**).

**HEADERS** contain definitions made with `AC_DEFINE`.

```
AC_CONFIG_HEADERS([config.h:config.hin])
```

Will create *config.h* from *config.hin* (DJGPP supports only 1 dot).

# Output Commands

## AC\_CONFIG\_HEADERS(HEADERS...)

Create **HEADER** for all **HEADER.in**. Use only one such header unless you know what you are doing ('autoheader' creates **HEADER.in** only for the first **HEADER**).

**HEADERS** contain definitions made with AC\_DEFINE.

## AC\_CONFIG\_HEADERS([config.h:config.hin])

Will create *config.h* from *config.hin* (DJGPP supports only 1 dot).

## AC\_CONFIG\_FILES(FILES...)

Create **FILE** for all **FILE.in**.

**FILES** contain definitions made with AC\_SUBST.

# Output Commands

## `AC_CONFIG_HEADERS(HEADERS...)`

Create **HEADER** for all **HEADER.in**. Use only one such header unless you know what you are doing ('autoheader' creates **HEADER.in** only for the first **HEADER**).

**HEADERS** contain definitions made with `AC_DEFINE`.

```
AC_CONFIG_HEADERS([config.h:config.hin])
```

Will create *config.h* from *config.hin* (DJGPP supports only 1 dot).

## `AC_CONFIG_FILES(FILES...)`

Create **FILE** for all **FILE.in**.

**FILES** contain definitions made with `AC_SUBST`.

```
AC_CONFIG_FILES([Makefile sub/Makefile script.sh:script.in])
```



# Output Commands

## AC\_CONFIG\_HEADERS(HEADERS...)

Create **HEADER** for all **HEADER.in**. Use only one such header unless you know what you are doing ('autoheader' creates **HEADER.in** only for the first **HEADER**).

**HEADERS** contain definitions made with AC\_DEFINE.

```
AC_CONFIG_HEADERS([config.h:config.hin])
```

Will create *config.h* from *config.hin* (DJGPP supports only 1 dot).

## AC\_CONFIG\_FILES(FILES...)

Create **FILE** for all **FILE.in**.

**FILES** contain definitions made with AC\_SUBST.

```
AC_CONFIG_FILES([Makefile sub/Makefile script.sh:script.in])
```

Automake creates **FILE.in** for each **FILE** that has a **FILE.am**.

# Output Commands

## AC\_CONFIG\_HEADERS(HEADERS...)

Create **HEADER** for all **HEADER.in**. Use only one such header unless you know what you are doing ('autoheader' creates **HEADER.in** only for the first **HEADER**).

**HEADERS** contain definitions made with AC\_DEFINE.

```
AC_CONFIG_HEADERS([config.h:config.hin])
```

Will create *config.h* from *config.hin* (DJGPP supports only 1 dot).

## AC\_CONFIG\_FILES(FILES...)

Create **FILE** for all **FILE.in**.

**FILES** contain definitions made with AC\_SUBST.

```
AC_CONFIG_FILES([Makefile sub/Makefile script.sh:script.in])
```

Automake creates **FILE.in** for each **FILE** that has a **FILE.am**.

It's legitimate to process non-*Makefile* too.

## AC\_CONFIG\_FILES([script.sh:script.in]) Example

*script.in*

```
#!/bin/sh
SED='@SED@'
TAR='@TAR@'
d=$1; shift; mkdir "$d"
for f; do
    "$SED" 's/#.*//' "$f" \
    >"$d/$f"
done
"$TAR" cf "$d.tar" "$d"
```

*.in* files are templates

# AC\_CONFIG\_FILES([script.sh:script.in]) Example

*script.in*

```
#!/bin/sh
SED='@SED@'
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for f; do
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    >"$d/$f"
done
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```

*.in* files are templates where @XYZ@ are placeholders for AC\_SUBST([XYZ]) definitions.

## AC\_CONFIG\_FILES([script.sh:script.in]) Example

*script.in*

```
#!/bin/sh
SED='@SED@'
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d=$1; shift; mkdir "$d"
for f; do
    "$SED" 's/#.*//' "$f" \
        >"$d/$f"
done
"$TAR" cf "$d.tar" "$d"
```

*script.sh*

```
#!/bin/sh
SED='/usr/xpg4/bin/sed'
TAR='/usr/bin/tar'
d=$1; shift; mkdir "$d"
for f; do
    "$SED" 's/#.*//' "$f" \
        >"$d/$f"
done
"$TAR" cf "$d.tar" "$d"
```

*.in* files are templates where @XYZ@ are placeholders for AC\_SUBST([XYZ]) definitions. 'config.status' substitutes them.

## AC\_CONFIG\_FILES([script.sh:script.in]) Example

*script.in*

```
#!/bin/sh
SED='@SED@'
TAR='@TAR@'
d=$1; shift; mkdir "$d"
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*script.sh*

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done
"$TAR" cf "$d.tar" "$d"
```

*.in* files are templates where **@XYZ@** are placeholders for `AC_SUBST([XYZ])` definitions. 'config.status' substitutes them.

*Makefile.in*s also use **@XYZ@** as placeholders but Automake makes all `XYZ=@XYZ@` definitions and you may simply use `$(XYZ)` as needed.

# Using Automake

# Automake Principles

- Automake helps creating portable and GNU-standard compliant *Makefiles*.



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Automake will get in your way if you don't fit the mold.
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  - Consider *Makefile.ins* as internal details.
- *Makefile.ams* follow roughly the same syntax as *Makefiles* however they usually contains only variable definitions.
  - 'automake' creates build rules from these definitions.
  - It's OK to add extra *Makefile* rules in *Makefile.am*:  
'automake' will preserve them in the output.

# Declaring Automake in *configure.ac*

```
AM_INIT_AUTOMAKE([OPTIONS...])
```

Check for tools needed by 'automake'-generated *Makefiles*.



# The Structure of a *configure.ac*

## *configure.ac*

```
# Prelude.  
AC_INIT([amhello], [1.0], [bug-report@address])  
AM_INIT_AUTOMAKE([-Wall -Werror foreign])  
  
# Checks for programs.  
  
# Checks for libraries.  
# Checks for header files.  
# Checks for typedefs, structures, and compiler characteristics.  
# Checks for library functions.  
# Output files.  
  
AC_CONFIG_FILES([FILES])  
AC_OUTPUT
```

# Declaring Automake in *configure.ac*

`AM_INIT_AUTOMAKE([OPTIONS...])`

Check for tools needed by 'automake'-generated *Makefiles*.

Useful options:

`-Wall` Turn all warnings on.

`-Werror` Report warnings as errors.

`foreign` Relax some GNU standard requirements.

`1.10.1` Require a minimum version of 'automake'.

`dist-bzip2` Also create tar.bz2 archives during 'make dist' and 'make distcheck'.

`tar-ustar` Create tar archives using the ustar format.

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`AC_CONFIG_FILES(FILES...)`

Automake creates *FILE.in* for each *FILE* that has a *FILE.am*.

`AC_CONFIG_FILES([Makefile sub/Makefile])`

... and write *Makefile.am* and *sub/Makefile.am*

# where\_PRIMARY Convention for Declaring Targets

*Makefile.am*

```
where_PRIMARY = targets ...
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targets should be built as...

\_PROGRAMS

\_LIBRARIES

\_LTLIBRARIES (Libtool libraries)

\_HEADERS

\_SCRIPTS

\_DATA

# where\_PRIMARY Convention for Declaring Targets

*Makefile.am*

```
where_PRIMARY = targets ...
```

targets should be installed in...

```
bin_ $(bindir)
```

```
lib_ $(libdir)
```

```
...
```

targets should be built as...

```
_PROGRAMS
```

```
_LIBRARIES
```

```
_LTLIBRARIES (Libtool libraries)
```

```
_HEADERS
```

```
_SCRIPTS
```

```
_DATA
```

# Standard File System Hierarchy

Directory variable	Default value
prefix	<i>/usr/local</i>
exec-prefix	prefix
bindir	exec-prefix/ <i>bin</i>
libdir	exec-prefix/ <i>lib</i>
...	
includedir	prefix/ <i>include</i>
datarootdir	prefix/ <i>share</i>
datadir	datarootdir
mandir	datarootdir/ <i>man</i>
infodir	datarootdir/ <i>info</i>
...	

# where\_PRIMARY Convention for Declaring Targets

*Makefile.am*

**where**\_PRIMARY = targets ...

targets should be installed in...

bin\_ \$(bindir)

lib\_ \$(libdir)

...

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\_PROGRAMS

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# where\_PRIMARY Convention for Declaring Targets

*Makefile.am*

**where**\_PRIMARY = **targets** ...

**targets** should be installed in...

**bin\_** \$(bindir)

**lib\_** \$(libdir)

...

**custom\_** \$(customdir)

You define customdir.

**targets** should be built as...

**\_PROGRAMS**

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**targets** should be installed in...

**bin\_** \$(bindir)

**lib\_** \$(libdir)

...

**custom\_** \$(customdir)

You define customdir.

**noinst\_** Not installed.

**targets** should be built as...

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**\_LTLIBRARIES** (Libtool libraries)

**\_HEADERS**

**\_SCRIPTS**

**\_DATA**

# where\_PRIMARY Convention for Declaring Targets

## *Makefile.am*

```
where_PRIMARY = targets ...
```

**targets** should be installed in...

`bin_ $(bindir)`

`lib_ $(libdir)`

...

`custom_ $(customdir)`

You define customdir.

`noinst_` Not installed.

`check_` Built by 'make check'.

**targets** should be built as...

`_PROGRAMS`

`_LIBRARIES`

`_LTLIBRARIES` (Libtool libraries)

`_HEADERS`

`_SCRIPTS`

`_DATA`

# where\_PRIMARY Convention for Declaring Targets

## Makefile.am

```
option_where_PRIMARY = targets ...
```

targets should be installed in...

bin\_ \$(bindir)

lib\_ \$(libdir)

...

custom\_ \$(customdir)

You define customdir.

noinst\_ Not installed.

check\_ Built by 'make check'.

targets should be built as...

\_PROGRAMS

\_LIBRARIES

\_LTLIBRARIES (Libtool libraries)

\_HEADERS

\_SCRIPTS

\_DATA

Optionally: dist\_ Distribute targets (if not the default)

nodist\_ Don't.

# Declaring Sources

## *Makefile.am*

```
bin_PROGRAMS = foo run-me  
foo_SOURCES = foo.c foo.h print.c print.h  
run_me_SOURCES = run.c run.h print.c
```

- These programs will be installed in  $\$(bindir)$ .

# Declaring Sources

## *Makefile.am*

```
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foo_SOURCES = foo.c foo.h print.c print.h  
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```

- These programs will be installed in `$(bindir)`.
- The sources of each `program` go into `programs_SOURCES`.

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- Non-alphanumeric characters are mapped to `'_'`.

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- Automake automatically computes the list of objects to build and link from these files.



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- Header files are not compiled. We list them only so they get distributed (Automake does not distribute files it does not know about).

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- Header files are not compiled. We list them only so they get distributed (Automake does not distribute files it does not know about).
- It's OK to use the same source for two programs.
- Compiler and linker are inferred from the extensions.

# (Static) Libraries

- Add `AC_PROG_RANLIB` to *configure.ac*.

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## *Makefile.am*

```
lib_LIBRARIES = libfoo.a libbar.a
libfoo_a_SOURCES = foo.c privfoo.h
libbar_a_SOURCES = bar.c privbar.h
include_HEADERS = foo.h bar.h
```

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- Public headers will be installed in `$(includedir)`.



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include_HEADERS = foo.h bar.h
```

- These libraries will be installed in  $\$(libdir)$ .
- Library names must match  $\text{lib}^*.a$ .
- Public headers will be installed in  $\$(includedir)$ .
- Private headers are not installed, like ordinary sources files.

# Directory Layout

- You may have one *Makefile* (hence one *Makefile.am*) per directory.

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- You may have one *Makefile* (hence one *Makefile.am*) per directory.
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*configure.ac*

```
AC_CONFIG_FILES([Makefile lib/Makefile src/Makefile  
                 src/dira/Makefile src/dirb/Makefile])
```

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## *configure.ac*

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- 'make' is run at the top-level.
- *Makefile.am* should fix the order in which to recurse directories using the **SUBDIRS** variable.

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## *Makefile.am*

```
SUBDIRS = lib src
```

## *src/Makefile.am*

```
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- The current directory is implicitly built after subdirectories.

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- You can put '.' where you want to override this.

## *src/Makefile.am*

```
SUBDIRS = dira dirb .
```

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```

## `$(srcdir)` and VPATH Builds

- Remember VPATH builds: a source file is not necessary in the current directory.

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

Objects files, programs, and libraries are built where *configure* was run.

```
~ % 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
...
```

Sources files are in *~/amhello-1.0/*,  
built files are all in *~/amhello-1.0/build/*.

## `$(srcdir)` and VPATH Builds

- Remember VPATH builds: a source file is not necessary in the current directory.
- There are two twin trees: the **build tree**, and the **source tree**.
  - *Makefile* and objects files are in the build tree.
  - *Makefile.in*, *Makefile.am*, and source files are in the source tree.
  - If './configure' is run in the current directory, the two trees are one.

## `$(srcdir)` and `VPATH` Builds

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  - If `./configure` is run in the current directory, the two trees are one.
- In each *Makefile*, `'config.status'` will define `$(srcdir)`: the path to the matching source directory.

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- In each *Makefile*, `'config.status'` will define `$(srcdir)`: the path to the matching source directory.
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  - *Makefile* and objects files are in the build tree.
  - *Makefile.in*, *Makefile.am*, and source files are in the source tree.
  - If './configure' is run in the current directory, the two trees are one.
- In each *Makefile*, 'config.status' will define  $\$(srcdir)$ : the path to the matching source directory.
- When referring to sources files or targets in Automake variables, you do not have to worry about *source* vs. *build*, because 'make' will check both directories.
- You may need  $\$(srcdir)$  when specifying flags for tools, or writing custom commands. E.g., to tell the compiler to include headers from *dir/*, you should write `-I$(srcdir)/dir`, not `-Idir`. (`-Idir` would fetch headers from the build tree.)

# Convenience Libraries

*lib/Makefile.am*

```
noinst_LIBRARIES = libcompat.a  
libcompat_a_SOURCES = xalloc.c xalloc.h
```



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```
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```

- This is a convenience library, used only when building the package.

## *src/Makefile.am*

```
LDADD = ../lib/libcompat.a  
AM_CPPFLAGS = -I$(srcdir)/../lib  
bin_PROGRAMS = foo run-me  
foo_SOURCES = foo.c foo.h print.c print.h  
run_me_SOURCES = run.c run.h print.c
```

# Convenience Libraries

## *lib/Makefile.am*

```
noinst_LIBRARIES = libcompat.a  
libcompat_a_SOURCES = xalloc.c xalloc.h
```

- This is a convenience library, used only when building the package.

## *src/Makefile.am*

```
LDADD = ../lib/libcompat.a  
AM_CPPFLAGS = -I$(srcdir)/../lib  
bin_PROGRAMS = foo run-me  
foo_SOURCES = foo.c foo.h print.c print.h  
run_me_SOURCES = run.c run.h print.c
```

- **LDADD** is added when linking all programs.

# Convenience Libraries

## *lib/Makefile.am*

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noinst_LIBRARIES = libcompat.a  
libcompat_a_SOURCES = xalloc.c xalloc.h
```

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## *src/Makefile.am*

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LDADD = ../lib/libcompat.a  
AM_CPPFLAGS = -I$(srcdir)/../lib  
bin_PROGRAMS = foo run-me  
foo_SOURCES = foo.c foo.h print.c print.h  
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## *src/Makefile.am*

```
bin_PROGRAMS = foo run-me  
foo_SOURCES = foo.c foo.h print.c print.h  
run_me_SOURCES = run.c run.h print.c  
run_me_LDADD = ../lib/libcompat.a  
run_me_CPPFLAGS = -I$(srcdir)/../lib
```

- **LDADD** is added when linking all programs.
- **AM\_CPPFLAGS** contains additional preprocessor flags.
- You can use per-target variables: they apply to a single program.

# Per-Target Flags

Assuming `foo` is a program or library:

`foo_CFLAGS` Additional C compiler flags

`foo_CPPFLAGS` Additional preprocessor flags (`-Is` and `-Ds`)

The default value for `foo_XXXFLAGS` is `$(AM_XXXFLAGS)`.

# Per-Target Flags

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`foo_LDADD` Additional link objects, `-ls` and `-Ls` (if `foo` is a program)

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Use plain file names to refer to libraries inside your package (keep `-ls` and `-Ls` for external libraries only).

## *src/Makefile.am*

```
bin_PROGRAMS = foo run-me
foo_SOURCES = foo.c foo.h print.c print.h
run_me_SOURCES = run.c run.h print.c
run_me_CPPFLAGS = -I$(srcdir)/../lib
run_me_LDADD = ../lib/libcompat.a
```



# Checking for Libraries

```
AC_CHECK_LIB(LIBRARY, FUNCT, [ACT-IF-FOUND], [ACT-IF-NOT])
```

Check whether `LIBRARY` exists and contains `FUNCT`.

Execute `ACT-IF-FOUND` if it does, `ACT-IF-NOT` otherwise.

```
AC_CHECK_LIB([efence], [malloc], [EFENCELIB=-leference])  
AC_SUBST([EFENCELIB])
```

... we would later use `$(EFENCELIB)` in the link rule.

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run_me_LDADD = ../lib/libcompat.a $(EFENCELIB)
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'make dist' and 'make distcheck' create a tarball containing:

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- Common files such as *ChangeLog*, *NEWS*, etc.  
See 'automake --help' for a list of those files.

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See 'automake --help' for a list of those files.
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## *Makefile.am*

```
SUBDIRS = lib src  
EXTRA_DIST = HACKING
```

... will additionally distribute *HACKING*.

# Conditionals: Usage

- *Conditionals* allow for conditional builds and unconditional distribution.



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bin_PROGRAMS = foo
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endif
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- In all cases *foo.c* and *bar.c* are distributed regardless of *WANT\_BAR*.
- This is portable. 'config.status' will comment rules of *Makefile.in* that must be disabled.
- *WANT\_BAR* must be declared and valued in *configure.ac*.

# Conditionals: Declaration

`AM_CONDITIONAL(NAME, CONDITION)`

Declare conditional `NAME`. `CONDITION` should be a shell instruction that succeeds iff `NAME` should be enabled.



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*configure.ac*

```
AC_CHECK_HEADER([bar.h], [use_bar=yes])  
AM_CONDITIONAL([WANT_BAR], [test "$use_bar" = yes])
```

Will enable `WANT_BAR` only if `bar.h` is present on the system.

# Extending Automake Rules

- The contents of *Makefile.am* is copied almost verbatim to *Makefile.in*.
- ‘automake’ adds new rules and variables in *Makefile.in*, to achieve the semantics of the special variables you have defined.
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  - Build idiosyncratic files (generate a *FAQ* from some random source)
  - ...
- It’s OK to define variables that are meaningless to Automake.
  - For use in custom rules.
- **Beware of conflicts:** your definitions (of variables or rules) will override those of Automake.
  - -Wall will diagnose these.

# Recommendations

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- Use `-Wall -Werror`.
- Keep Your Setup Simple (KYSS!).
  - You will spend a large part of time debugging your cunning tricks if you try to automatize too much.
- Do not lie to Automake.
  - Automake can be annoying, but when you lie it gets worse!

# Lost? 'autoreconf' is Still Your Friend

If 'make' fails to rebuild configuration files, run 'autoreconf' manually.

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~/amhello % autoreconf --install
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~/amhello % autoreconf --install
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If this does not help, try harder.

```
~/amhello % autoreconf --install --force
```

If this still does not help, try even harder.

```
~/amhello % make -k maintainer-clean  
~/amhello % autoreconf --install --force
```

Do this only when necessary. Each of these commands will cause your package to take longer to reconfigure and recompile.

## Part III

### More Autotools

# Writing Autoconf Macros

# Writing an Autoconf Macro? Why? How?

Two fundamentally different types of new macros:

- Macros that factor related tests in a single reusable entity.
- Macros that implements new tests.

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Two fundamentally different types of new macros:

- Macros that factor related tests in a single reusable entity.
  - High-level.
  - Combination of existing lower-level macros.
  - May not use shell code at all.
- Macros that implements new tests.
  - Low-level.
  - Actually code the check.
  - Need to bother with caching values.

# Defining Macros

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AC_DEFUN(MACRO-NAME, MACRO-BODY)
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Define MACRO-NAME as MACRO-BODY.

Avoid names that may conflict.

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`m4_` Original M4 macros, plus M4sugar macros.

`AS_` M4sh macros (macroized shell constructs)

`AH_` Autoheader macros

`AC_` Autoconf macros (written on top of the above layers)

`AM_` Automake macros

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**AS\_** M4sh macros (macroized shell constructs)

**AH\_** **Auto**header macros

**AC\_** **Auto**conf macros (written on top of the above layers)

**AC\_CHECK\_** Generic checks.

**AC\_FUNC\_** Specific function checks.

**AC\_HEADER\_** Specific header checks.

**AC\_PROG\_** Specific program checks.

    ...

**AM\_** **Auto**make macros

**AT\_** **Auto**test macros

## `mkdir()` Example

- POSIX systems define `mkdir()` with two arguments.
- On Mingw32 (at least), `mkdir()` takes only one argument.
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```
#if HAVE_MKDIR
# if MKDIR_ONE_ARG
#   define mkdir(a,b) mkdir(a)
# endif
#else
# if HAVE__MKDIR
#   define mkdir(a,b) _mkdir(a)
# else
#   error "Don't know how to create a directory."
# endif
#endif
```

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# if HAVE__MKDIR
#  define mkdir(a,b) _mkdir(a)
# else
#  error "Don't know how to create a directory."
# endif
#endif
```

Let's write an Autoconf macro to define **these C macros**

# Writing a High-Level Macro: AX\_FUNC\_MKDIR

```
AC_DEFUN([AX_FUNC_MKDIR],  
[AC_CHECK_FUNCS([mkdir _mkdir])  
AC_CHECK_HEADERS([io.h])  
AX_FUNC_MKDIR_ONE_ARG  
)
```



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- Suggested name space for extension macros.

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- Suggested name space for extension macros.
- Use same convention as Autoconf for categorizing macros.
- Defines HAVE\_MKDIR and HAVE\_\_MKDIR.

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)
```

- Suggested name space for extension macros.
- Use same convention as Autoconf for categorizing macros.
- Defines `HAVE_MKDIR` and `HAVE__MKDIR`.
- Defines `HAVE_IO_H` if *`io.h`* exists.  
(`mkdir()` may also be defined there, and *`sys/stat.h`* and *`unistd.h`* are always tested by `AC_PROG_CC`)

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```

- Suggested name space for extension macros.
- Use same convention as Autoconf for categorizing macros.
- Defines `HAVE_MKDIR` and `HAVE__MKDIR`.
- Defines `HAVE_IO_H` if *io.h* exists.  
(`mkdir()` may also be defined there, and *sys/stat.h* and *unistd.h* are always tested by `AC_PROG_CC`)
- Will define `MKDIR_ONE_ARG...` once written.

# Checking mkdir()'s number of arguments

```
# _AX_FUNC_MKDIR_ONE_ARG(IF-ONE-ARG, IF-TWO-ARGS)
# -----
# Execute IF-TWO-ARGS if mkdir() accepts two
# arguments; execute IF-ONE-ARG otherwise.
AC_DEFUN([_AX_FUNC_MKDIR_ONE_ARG],
[AC_TRY_COMPILE([
#include <sys/stat.h>
#if HAVE_UNISTD_H
# include <unistd.h>
#endif
#if HAVE_IO_H
# include <io.h>
#endif
], [mkdir (".", 0700);], [$2], [$1]))]
```

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```

## Comments

Showcase of the traditional style used to document autoconf macros.

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], [mkdir (".", 0700);], [$2], [$1]))
```

## AC\_TRY\_COMPILE

Creates a small program and attempt to compile it. In our case it will execute one of the `_AX_FUNC_MKDIR_ONE_ARG` arguments depending on whether the program compiled or not.



# Checking `mkdir()`'s number of arguments

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- Wait! That's not enough for an Autoconf check: we should also add some *checking whether...* message on top of this.

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```

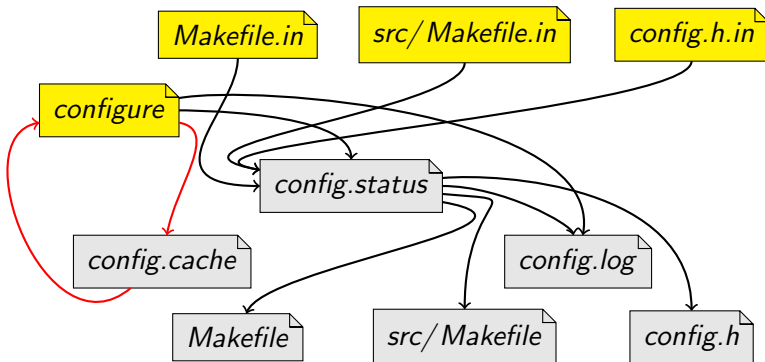
- Wait! That's not enough for an Autoconf check: we should also add some *checking whether...* message on top of this.
- We use the `_AX` prefix for helper macros not meant to be used directly.

# Writing a Low-Level Macro

Low-level macros need to

- print a *checking whether...* message
- do the actual check
- cache the result of the check

# The (real) *configure* process



'`configure -C`' caches results in `config.cache` to speed up reconfigurations

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Most of this is achieved via the `AC_CACHE_CHECK` macro.

```
AC_DEFUN(MACRO-NAME,  
[AC_CACHE_CHECK(WHETHER-MESSAGE,  
                CACHE-VARIABLE,  
                CODE-TO-SET-CACHE-VARIABLE)  
CODE-USING-CACHE-VARIABLE])
```

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```

- The `CACHE-VARIABLE` should match `*_cv_*`.

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[AC_CACHE_CHECK(WHETHER-MESSAGE,  
                CACHE-VARIABLE,  
                CODE-TO-SET-CACHE-VARIABLE)  
CODE-USING-CACHE-VARIABLE])
```

- The `CACHE-VARIABLE` should match `*_cv_*`.
- `CODE-TO-SET-CACHE-VARIABLE` should contain the check. It will be skipped when the cache is used.

# Writing a Low-Level Macro

Low-level macros need to

- print a *checking whether...* message
- do the actual check
- cache the result of the check

Most of this is achieved via the `AC_CACHE_CHECK` macro.

```
AC_DEFUN(MACRO-NAME,  
[AC_CACHE_CHECK(WHETHER-MESSAGE,  
                CACHE-VARIABLE,  
                CODE-TO-SET-CACHE-VARIABLE)  
CODE-USING-CACHE-VARIABLE])
```

- The `CACHE-VARIABLE` should match `*_cv_*`.
- `CODE-TO-SET-CACHE-VARIABLE` should contain the check. It will be skipped when the cache is used.
- `CODE-USING-CACHE-VARIABLE` is always executed, use `AC_SUBST` and `AC_DEFINE` here.



## A Low-Level Macro: AX\_FUNC\_MKDIR\_ONE\_ARG

```
AC_DEFUN([AX_FUNC_MKDIR_ONE_ARG],  
[AC_CACHE_CHECK([whether mkdir takes one argument],  
                [ax_cv_mkdir_one_arg],  
                [_AX_FUNC_MKDIR_ONE_ARG([ax_cv_mkdir_one_arg=yes],  
                                         [ax_cv_mkdir_one_arg=no])])]  
if test x"$ax_cv_mkdir_one_arg" = xyes; then  
    AC_DEFINE([MKDIR_ONE_ARG], 1,  
              [Define if mkdir takes only one argument.])  
fi) # AX_FUNC_MKDIR_ONE_ARG
```

# A Low-Level Macro: AX\_FUNC\_MKDIR\_ONE\_ARG

```
AC_DEFUN([AX_FUNC_MKDIR_ONE_ARG],  
[AC_CACHE_CHECK([whether mkdir takes one argument],  
                [ax_cv_mkdir_one_arg],  
                [_AX_FUNC_MKDIR_ONE_ARG([ax_cv_mkdir_one_arg=yes],  
                                         [ax_cv_mkdir_one_arg=no]))]  
if test x"$ax_cv_mkdir_one_arg" = xyes; then  
    AC_DEFINE([MKDIR_ONE_ARG], 1,  
              [Define if mkdir takes only one argument.])  
fi]) # AX_FUNC_MKDIR_ONE_ARG
```

- AC\_CACHE\_CHECK
  - prints *checking whether mkdir...*
  - does the check (unless already done)
  - cache the result in `ax_cv_mkdir_one_arg`

# A Low-Level Macro: AX\_FUNC\_MKDIR\_ONE\_ARG

```
AC_DEFUN([AX_FUNC_MKDIR_ONE_ARG],  
[AC_CACHE_CHECK([whether mkdir takes one argument],  
    [ax_cv_mkdir_one_arg],  
    [_AX_FUNC_MKDIR_ONE_ARG([ax_cv_mkdir_one_arg=yes],  
        [ax_cv_mkdir_one_arg=no])])]  
if test x"$ax_cv_mkdir_one_arg" = xyes; then  
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```

- AC\_CACHE\_CHECK
  - prints *checking whether mkdir...*
  - does the check (unless already done)
  - cache the result in `ax_cv_mkdir_one_arg`
- Keep configuration actions outside AC\_CACHE\_CHECK: they have to be executed whether the check is run or cached.

# Recommendations for Writing Autoconf Macros

- Test for features, not for systems.
  - E.g., check whether `mkdir()` takes one argument, not whether you are compiling for Win32.
  - Your package will be more likely to adapt to untested systems.

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  - E.g., check for `_mkdir()` even if `mkdir()` exists.

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- Remember to `[quote]`.
- Read the *Portable Shell* section of the Autoconf manual, before writing shell code.

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- Do not reinvent the wheel.
  - Autoconf comes with a lot of well-tested macros. Use them.
- Remember to [quote].
- Read the *Portable Shell* section of the Autoconf manual, before writing shell code.
- Test your macros on different systems.
  - Check test results in [config.log](http://www.testdrive.hp.com/).
  - Get accounts on foreign systems:  
<http://www.testdrive.hp.com/>  
<http://sourceforge.net/docs/E02/>



# Managing Custom Macros with 'aclocal'

## *aclocal.m4* and Third-Party Macros

- 'autoconf' knows only the macros it provides.  
(`m4_*`, `AS_*`, `AH_*`, `AC_*`, `AT_*`).
- 'autoconf' knows nothing about macro supplied by third-party tools  
(e.g., Automake's `AM_*` macros).

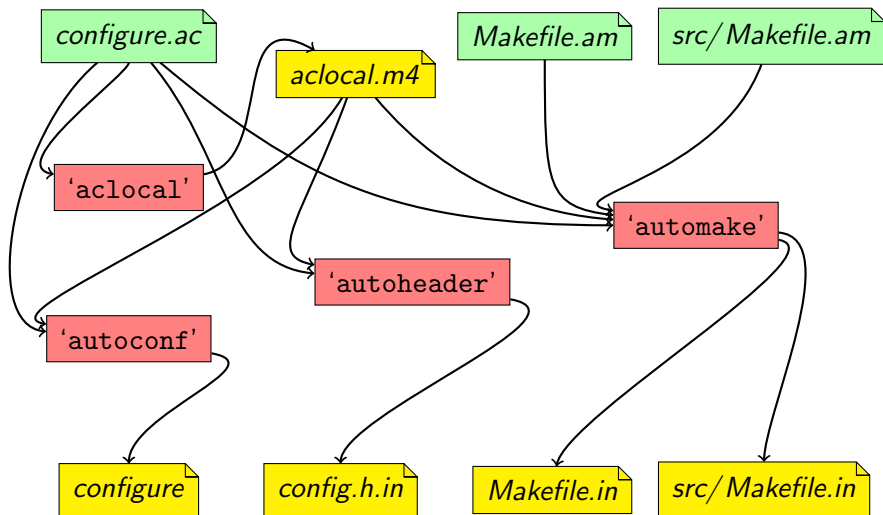
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- 'aclocal' automates the construction of *aclocal.m4* from various sources.

# Behind 'autoreconf'



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- 'aclocal' automates the construction of *aclocal.m4* from various sources.

'aclocal' searches macros in

- directories specified with `-I` options
- a system-wide directory (usually `/usr/share/aclocal/`) where third-party packages may install their macros
- Automake's own private macro directory

# Managing Custom Macros in Your Package

- Create a *m4/* subdirectory.

- Put your macros there.

E.g., define `AX_FUNC_MKDIR` and `AX_FUNC_MKDIR_ONE_ARG` in *m4/mkdir.m4*.

(The extension *must* be *\*.m4*)

# Managing Custom Macros in Your Package

- Create a `m4/` subdirectory.
- Put your macros there.  
E.g., define `AX_FUNC_MKDIR` and `AX_FUNC_MKDIR_ONE_ARG` in `m4/mkdir.m4`.  
(The extension *must* be `*.m4`)
- Add `ACLOCAL_AMFLAGS = -I m4` to the top-level `Makefile.am`.
- Add `AC_CONFIG_MACRO_DIR([m4])` to `configure.ac`. (This is not strictly needed yet, but let's be future-proof.)

The `ACLOCAL_AMFLAGS` are used by 'autoreconf' and by the `Makefile` rebuild rule when they need to run 'aclocal'.



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Local macros that are used are automatically distributed. (Those that are not used are simply ignored.)

You need such a setup to use Gettext, and the upcoming Libtool 2.0.

# Libtool

# Shared Libraries: A Portability Hell

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  - *libhello.so*
  - *libhello.dll*
  - *libhello.sl*
  - *libhello.dylib*
  - ...

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  - ...
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- There is no way for a developer to keep track of all these details.
  - Quiz: match each of the above example with its OS.
- Not all systems support shared libraries.



# Shared Libraries: Libtool's Solution

- A new library format that abstracts all the others
  - [libhello.la](http://libhello.la) (libtool archive)

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- A wrapper script for the compiler and linker
  - translates operations involving *libhello.la* into the correct operation for the current system using the real library

# Shared Libraries: Libtool's Solution

- A new library format that abstracts all the others
  - *libhello.la* (libtool archive)
- A wrapper script for the compiler and linker
  - translates operations involving *libhello.la* into the correct operation for the current system using the real library
- In a *Makefile.am*, you simply create and link against *\*.la* files.
- These operations are translated appropriately.

# Setting Up Libtool: Roadmap

- Call `AC_PROG_LIBTOOL` in *configure.ac*.

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- Use `_LTLIBRARIES` to declare libtool archives in *Makefile.am*

## *Makefile.am*

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

# Setting Up Libtool: Roadmap

- Call `AC_PROG_LIBTOOL` in *configure.ac*.
- Use `_LTLIBRARIES` to declare libtool archives in *Makefile.am*
- Use `_LDADD` to link against local libtool archives.

## *Makefile.am*

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

bin_PROGRAMS = runme
runme_SOURCES = main.c
runme_LDADD = libfoo.la
```

# Hello World Using Libtool: C Files

## *lib/say.c*

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

void say_hello (void)
{
    puts ("Hello World!");
    puts ("This is " PACKAGE_STRING ".");
}
```

## *lib/say.h*

```
void say_hello (void);
```

## *src/main.c*

```
#include "say.h"

int main (void)
{
    say_hello ();
    return 0;
}
```

# Hello World Using Libtool: *Makefile.ams*

## *lib/Makefile.am*

```
lib_LTLIBRARIES = libhello.la  
libhello_la_SOURCES = say.c say.h
```

## *src/Makefile.am*

```
AM_CPPFLAGS = -I$(srcdir)/../lib  
bin_PROGRAMS = hello  
hello_SOURCES = main.c  
hello_LDADD = ../lib/libhello.la
```

## *Makefile.am*

```
SUBDIRS = lib src
```



# Hello World Using Libtool: *configure.ac*

## *configure.ac*

```
AC_INIT([amhello], [2.0], [bug-report@address])
AC_CONFIG_AUX_DIR([build-aux])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_LIBTOOL
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([Makefile lib/Makefile src/Makefile])
AC_OUTPUT
```

# Hello World Using Libtool: 'autoreconf'

```
~/amhello % ls -R
```

# Hello World Using Libtool: 'autoreconf'

```
~/amhello % ls -R
.:
Makefile.am  configure.ac  lib/  src/

./lib:
Makefile.am  say.c  say.h

./src:
Makefile.am  main.c
```

# Hello World Using Libtool: 'autoreconf'

```
~/amhello % autoreconf --install
```

# Hello World Using Libtool: 'autoreconf'

```
~/amhello % autoreconf --install
```

```
Putting files in AC_CONFIG_AUX_DIR, 'build-aux'.
```

```
configure.ac: installing 'build-aux/install-sh'
```

```
configure.ac: installing 'build-aux/missing'
```

```
lib/Makefile.am: installing 'build-aux/depcomp'
```

```
~/amhello %
```

# Hello World Using Libtool: 'autoreconf'

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~/amhello % autoreconf --install  
Putting files in AC_CONFIG_AUX_DIR, 'build-aux'.  
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configure.ac: installing 'build-aux/missing'  
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~/amhello % ./configure --prefix ~/test  
...  
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```

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...
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...
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```

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configure.ac: installing 'build-aux/install-sh'
configure.ac: installing 'build-aux/missing'
lib/Makefile.am: installing 'build-aux/depcomp'
~/amhello % ./configure --prefix ~/test
...
~/amhello % make && make install
...
~/amhello % ~/test/bin/hello
Hello World!
This is amhello 2.0.
~/amhello %
```



# What Was Built and Installed

```
~/amhello % ls -R ~/test
/home/adl/test:
bin/  lib/
/home/adl/test/bin:
hello*
/home/adl/test/lib:
libhello.a      libhello.so@    libhello.so.0.0.0*
libhello.la*    libhello.so.0@
~/amhello %
```

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libhello.la*    libhello.so.0@
~/amhello % ldd ~/test/bin/hello
libhello.so.0 => /home/adl/test/lib/libhello.so.0 (0xb7fe7000)
libc.so.6 => /lib/tls/libc.so.6 (0xb7e9c000)
lib/ld-linux.so.2 => /lib/ld-linux.so.2 (0xb7fea000)
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~/amhello % ldd src/hello
not a dynamic executable
~/amhello % file src/hello
src/hello: Bourne shell script text executable
```

# Building Shared or Static Libraries

- By default, both static and shared libraries are built.
- This default can be changed in a package using two macros:  
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  - `--enable-shared` build shared libraries
  - `--disable-shared` don't
  - `--enable-static` build static libraries
  - `--disable-static` don't
- At least one flavor is built, always.
- Some systems don't leave any choice.

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Do not debug the shell script!

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"src/hello": not in executable format: File format not recognized  
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## Do not debug the shell script!

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~/amhello % gdb -q src/hello  
"src/hello": not in executable format: File format not recognized  
(gdb)
```

## Prefix such commands with `libtool --mode=execute`

```
~/amhello % libtool --mode=execute gdb -q src/hello
```

# Versioning Libtool Libraries: Interfaces

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- A library can implement several interfaces.
  - E.g., adding new functions changes the interface, but does not break old interfaces.
- Hence libtool's versioning format encodes a range of supported interfaces.

Interface numbers are not release numbers.



# Versioning Libtool Libraries: Version Triplets

**CURRENT** The latest interface implemented.

**REVISION** The implementation number of **CURRENT**  
(read: number of bugs fixed...)

**AGE** The number of interfaces implemented, minus one.  
The library supports all interfaces between **CURRENT** – **AGE**  
and **CURRENT**.

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and **CURRENT**.

These numbers should be specified using `-version-info`.

## lib/Makefile.am

```
lib_LTLIBRARIES = libhello.la
libhello_la_SOURCES = say.c say.h
libhello_la_LDFLAGS = -version-info CURRENT:REVISION:AGE
```

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and **CURRENT**.

These numbers should be specified using `-version-info`.

## lib/Makefile.am

```
lib_LTLIBRARIES = libhello.la
libhello_la_SOURCES = say.c say.h
libhello_la_LDFLAGS = -version-info 0:0:0
```

The default version is 0:0:0. It's also a good initial version.

# Versioning Libtool Libraries: Bumping Versions

Remember to bump library versions before a release.

Suppose the old version was **CURRENT** **REVISION** **AGE**.

If you have	bump the version to
not changed the interface (bug fixes)	<b>CURRENT</b> : <b>REVISION</b> + 1 : <b>AGE</b>
augmented the interface (new functions)	<b>CURRENT</b> + 1 : 0 : <b>AGE</b> + 1
broken old interface (e.g. removed functions)	<b>CURRENT</b> + 1 : 0 : 0

# Introducing Gettext

# Introducing Gettext

- Internationalization

- Localization

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Changing a program to support for multiple languages and cultural habits.

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# Introducing Gettext

- Internationalization

Changing a program to support for multiple languages and cultural habits.

- Localization

Providing an internationalized package the necessary bits to support one's native language and cultural habits.



# Introducing Gettext

- **Internationalization** = I18n

Changing a program to support for multiple languages and cultural habits.

- **Localization** = L10n

Providing an internationalized package the necessary bits to support one's native language and cultural habits.

# Introducing Gettext

- Internationalization = I18n

Changing a program to support for multiple languages and cultural habits.

- Character handling (unicode...)
- Locale awareness (date formats, currencies, numbers, time zones, etc.)
- Localizability
  - Isolate localizable items (messages, pictures, etc.)
  - Implement infrastructure necessary for localizing above items.

- Localization = L10n

Providing an internationalized package the necessary bits to support one's native language and cultural habits.

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- Translate localizable items (messages, pictures, etc.) for one language.

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## The programmer's work.

- Localization = L10n

Providing an internationalized package the necessary bits to support one's native language and cultural habits.

- Translate localizable items (messages, pictures, etc.) for one language.

## The translator's work.

# Introducing Gettext

- Internationalization = I18n

Changing a program to support for multiple languages and cultural habits.

- Character handling (unicode...)
- Locale awareness (date formats, currencies, numbers, time zones, etc.)
- **Localizability**
  - **Isolate localizable items** (messages, pictures, etc.)
  - **Implement infrastructure necessary for localizing above items.**

The programmer's work.

- Localization = L10n

Providing an internationalized package the necessary bits to support one's native language and cultural habits.

- Translate localizable items (messages, pictures, etc.) for one language.

The translator's work.

**Gettext = complete toolset for translating messages output by programs.**

# Translating Messages Made Easy

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

void say_hello (void)
{
    puts ("Hello World!");
    puts ("This is " PACKAGE_STRING ".");
}
```

- The program is written in English.

# Translating Messages Made Easy

```
#include <config.h>
#include <stdio.h>
#include "gettext.h"
#define _(string) gettext (string)
void say_hello (void)
{
    puts (_("Hello World!"));
    printf (_("This is %s.\n"), PACKAGE_STRING);
}
```

- The program is written in English.
- Messages that must be translated are marked with `_(...)`.
  - 'xgettext' builds catalogs of translatable messages from such strings.
  - Translators will provide translated catalogs for their locale.

# Translating Messages Made Easy

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#include <config.h>
#include <stdio.h>
#include "gettext.h"
#define _(string) gettext (string)
void say_hello (void)
{
    puts (_("Hello World!"));
    printf (_("This is %s.\n"), PACKAGE_STRING);
}
```

- The program is written in English.
- Messages that must be translated are marked with `_(...)`.
  - 'xgettext' builds catalogs of translatable messages from such strings.
  - Translators will provide translated catalogs for their locale.
- **gettext** looks up the translation of the English message in the current locale's catalog.



# Internationalizing a Package, Start to Finish

# Internationalizing a Package, Start to Finish

## Roadmap:

- 1 Start with a non-internationalized Hello World.
- 2 Invoke `AM_GNU_GETTEXT` from *configure.ac*
- 3 Run 'gettextize' to provide the basic infrastructure.
- 4 Fill in the configuration files left by 'gettextize'.
- 5 Update *src/Makefile.am* to link *hello* with the necessary library.
- 6 Update the code:
  - Initialize Gettext in `main()`
  - Mark translatable strings.
- 7 Generate messages catalogs automatically.

We'll talk about localization once this is done.

# Non Internationalized Hello World (1/2)

## *src/main.c*

```
#include "say.h"

int
main (void)
{
    say_hello ();
    return 0;
}
```

## *src/say.h*

```
#ifndef AMHELLO_SAY_H
# define AMHELLO_SAY_H
void say_hello (void);
#endif
```

## *src/say.c*

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

void say_hello (void)
{
    puts ("Hello World!");
    puts ("This is " PACKAGE_STRING ".");
}
```

## Non Internationalized Hello World (2/2)

### *configure.ac*

```
AC_INIT([amhello], [3.0], [bug-report@address])
AC_CONFIG_AUX_DIR([build-aux])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([Makefile src/Makefile])
AC_OUTPUT
```

### *Makefile.am*

```
SUBDIRS = src
```

### *src/Makefile.am*

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

# Update *configure.ac* for Gettext

## *configure.ac*

```
AC_INIT([amhello], [3.0], [bug-report@address])
AC_CONFIG_AUX_DIR([build-aux])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AM_GNU_GETTEXT_VERSION([0.17])
AM_GNU_GETTEXT([external])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([Makefile src/Makefile])
AC_OUTPUT
```

# Update *configure.ac* for Gettext

## *configure.ac*

```
AC_INIT([amhello], [3.0], [bug-report@address])
AC_CONFIG_AUX_DIR([build-aux])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AM_GNU_GETTEXT_VERSION([0.17])
AM_GNU_GETTEXT([external])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([Makefile src/Makefile])
AC_OUTPUT
```

- `AM_GNU_GETTEXT_VERSION` = *exactly* which Gettext version to use.

# Update *configure.ac* for Gettext

## *configure.ac*

```
AC_INIT([amhello], [3.0], [bug-report@address])
AC_CONFIG_AUX_DIR([build-aux])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AM_GNU_GETTEXT_VERSION([0.17])
AM_GNU_GETTEXT([external])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([Makefile src/Makefile])
AC_OUTPUT
```

- `AM_GNU_GETTEXT_VERSION` = *exactly* which Gettext version to use.
- `AM_GNU_GETTEXT([external])`
  - the GNU libc or an external (= not distributed) Gettext library will be used if found
  - NLS (Native Language System) will be disabled otherwise

# Running 'gettextize'

You should run 'gettextize':

- A first time, to install the Gettext infrastructure in your package.
- Each time you upgrade Gettext to a new version.

```
~/amhello %
```



# Running 'gettextize'

You should run 'gettextize':

- A first time, to install the Gettext infrastructure in your package.
- Each time you upgrade Gettext to a new version.

```
~/amhello % gettextize --copy --no-changelog  
[...]  
~/amhello %
```

- Install most of the Gettext infrastructure.

# Running 'gettextize'

You should run 'gettextize':

- A first time, to install the Gettext infrastructure in your package.
- Each time you upgrade Gettext to a new version.

```
~/amhello % gettextize --copy --no-changelog  
[...]  
~/amhello % cp /usr/share/gettext/gettext.h src
```

- Install most of the Gettext infrastructure.
- Copy *gettext.h* in the source tree, it will be distributed.

# Gettextize Updated Some Files

## *configure.ac*

```
AC_INIT([amhello], [3.0], [bug-report@address])
AC_CONFIG_AUX_DIR([build-aux])
AM_GNU_GETTEXT_VERSION([0.17])
AM_GNU_GETTEXT([external])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
AC_CONFIG_HEADERS([config.h])
AC_CONFIG_FILES([Makefile src/Makefile po/Makefile.in])
AC_OUTPUT
```

## *Makefile.am*

```
SUBDIRS = po src
ACLOCAL_AMFLAGS = -I m4
EXTRA_DIST = ...
```

## *src/Makefile.am*

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

## *po/Makevars* and *po/POTFILES.in*

Fill *po/Makevars.template* and rename it as *po/Makevars*:

### *po/Makevars*

```
DOMAIN = $(PACKAGE)
subdir = po
top_builddir = ..
XGETTEXT_OPTIONS = --keyword=_ --keyword=N_
COPYRIGHT HOLDER = Your Name or Your Employer
MSGID_BUGS_ADDRESS = $(PACKAGE_BUGREPORT)
EXTRA_LOCALE_CATEGORIES =
```

# *po/Makevars* and *po/POTFILES.in*

Fill *po/Makevars.template* and rename it as *po/Makevars*:

## *po/Makevars*

```
DOMAIN = $(PACKAGE)
subdir = po
top_builddir = ..
XGETTEXT_OPTIONS = --keyword=_ --keyword=N_
COPYRIGHT HOLDER = Your Name or Your Employer
MSGID_BUGS_ADDRESS = $(PACKAGE_BUGREPORT)
EXTRA_LOCALE_CATEGORIES =
```

**\$(PACKAGE\_BUGREPORT)** is the third argument of AC\_INIT. Some packages use a mailing list dedicated to translation issues instead.

## *po/Makevars* and *po/POTFILES.in*

Fill *po/Makevars.template* and rename it as *po/Makevars*:

### *po/Makevars*

```
DOMAIN = $(PACKAGE)
subdir = po
top_builddir = ..
XGETTEXT_OPTIONS = --keyword=_ --keyword=N_
COPYRIGHT HOLDER = Your Name or Your Employer
MSGID_BUGS_ADDRESS = $(PACKAGE_BUGREPORT)
EXTRA_LOCALE_CATEGORIES =
```

List sources files that (may) contain translatable strings in *POTFILES.in*.

### *po/POTFILES.in*

```
src/main.c
src/say.c
```

# What's Next?

## Done:

- ① Start with a non-internationalized Hello World.
- ② Invoke `AM_GNU_GETTEXT` from *configure.ac*
- ③ Run 'gettextize' to provide the basic infrastructure.
- ④ Fill in the configuration files left by 'gettextize'.

Now, 'autoreconf --install; ./configure; make' should work.

# What's Next?

Done:

- 1 Start with a non-internationalized Hello World.
- 2 Invoke `AM_GNU_GETTEXT` from *configure.ac*
- 3 Run 'gettextize' to provide the basic infrastructure.
- 4 Fill in the configuration files left by 'gettextize'.

Now, 'autoreconf --install; ./configure; make' should work.

To do:

- 5 Update *src/Makefile.am* to link *hello* with the necessary library.
- 6 Update the code:
  - Initialize Gettext in `main()`
  - Mark translatable strings.
- 7 Generate messages catalogs automatically.



# Updating *src/Makefile.am*

## src/Makefile.am

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

# Updating *src/Makefile.am*

## src/Makefile.am

```
bin_PROGRAMS = hello
hello_SOURCES = main.c say.c say.h
hello_LDADD = $(LIBINTL)
```

- `$(LIBINTL)` lists the libraries any internationalized program should be linked against.

# Updating *src/Makefile.am*

## src/Makefile.am

```
bin_PROGRAMS = hello
hello_SOURCES = main.c say.c say.h
LDADD = $(LIBINTL)
```

- `$(LIBINTL)` lists the libraries any internationalized program should be linked against.
- We can strip the leading `hello_` and use the global `LDADD` instead.

# Updating *src/Makefile.am*

## src/Makefile.am

```
bin_PROGRAMS = hello
hello_SOURCES = main.c say.c say.h gettext.h
LDADD = $(LIBINTL)
```

- `$(LIBINTL)` lists the libraries any internationalized program should be linked against.
- We can strip the leading `hello_` and use the global `LDADD` instead.
- Mention *gettext.h* (we will use it shortly) so it is distributed.

# Updating *src/Makefile.am*

## src/Makefile.am

```
AM_CPPFLAGS = -DLOCALEDIR=\"$(localedir)\"  
bin_PROGRAMS = hello  
hello_SOURCES = main.c say.c say.h gettext.h  
LDADD = $(LIBINTL)
```

- `$(LIBINTL)` lists the libraries any internationalized program should be linked against.
- We can strip the leading `hello_` and use the global `LDADD` instead.
- Mention [\*gettext.h\*](#) (we will use it shortly) so it is distributed.
- `$(LOCALEDIR)` is the place where message catalogs are installed. This is needed during initialization.

# Initializing Gettext

*src/main.c*

```
#include "say.h"
int
main (void)
{

    say_hello();
    return 0;
}
```

# Initializing Gettext

*src/main.c*

```
#include <locale.h>

#include "say.h"
int
main (void)
{
    setlocale (LC_ALL, "");

    say_hello();
    return 0;
}
```

- Initialize the locale as specified in the environment.  
(E.g., the user sets LANG=fr\_FR in the environment to get French messages.)

# Initializing Gettext

*src/main.c*

```
#include <config.h>
#include <locale.h>
#include "gettext.h"
#include "say.h"
int
main (void)
{
    setlocale (LC_ALL, "");
    bindtextdomain (PACKAGE,
                   LOCALEDIR);
    textdomain (PACKAGE);
    say_hello();
    return 0;
}
```

- Initialize the locale as specified in the environment.  
(E.g., the user sets LANG=fr\_FR in the environment to get French messages.)
- Tell Gettext where to find message catalogs for this program.  
(All programs in the same package usually share the same message catalog.)



# Marking Strings for Translation

*src/say.c*

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

void say_hello (void)
{
    puts ("Hello World!");
    puts ("This is " PACKAGE_STRING ".");
}
```

# Marking Strings for Translation

*src/say.c*

```
#include <config.h>
#include <stdio.h>
#include "gettext.h"
#define _(string) gettext (string)
void say_hello (void)
{
    puts (_("Hello World!"));
    printf (_("This is %s.\n"), PACKAGE_STRING);
}
```

- Messages that must be translated are marked with `_(...)`.

# Marking Strings for Translation

*src/say.c*

```
#include <config.h>
#include <stdio.h>
#include "gettext.h"
#define _(string) gettext (string)
void say_hello (void)
{
    puts (_("Hello World!"));
    printf (_("This is %s.\n"), PACKAGE_STRING);
}
```

- Messages that must be translated are marked with `_(...)`.
- NLS (Native Language System) can be disabled.
  - Explicitly with `./configure --disable-nls`
  - Implicitly if no gettext implementation is installed.

Then [gettext.h](#) defines `gettext()`, `textdomain()`, ..., as no-ops.

# Building the Whole Shebang

Our Hello World is now internationalized.

```
~/amhello % autoreconf --install  
...  
~/amhello % ./configure  
...  
~/amhello % make  
...
```

# Building the Whole Shebang

Our Hello World is now internationalized.

```
~/amhello % autoreconf --install
...
~/amhello % ./configure
...
~/amhello % make
...
Making all in po
make amhello.pot-update
...
```

The *po/* directory contains messages catalogs.

*po/amhello.pot* is the template message catalog.

Updating *po/amhello.pot* is costly and occurs only before releases (e.g., during 'make distcheck') or if the file did not exist (our case above).

It can be updated explicitly with 'cd po; make update-po'.

# Localizing a Package

# *po/amhello.pot*: The PO Template File

```
# ... COMMENTS ...
#, fuzzy
msgid ""
msgstr ""
"Project-Id-Version: PACKAGE VERSION\n"
"Report-Msgid-Bugs-To: bug-report@address\n"
"POT-Creation-Date: 2005-03-05 00:27+0100\n"
"PO-Revision-Date: YEAR-MO-DA HO:MI+ZONE\n"
"Last-Translator: FULL NAME <EMAIL@ADDRESS>\n"
"Language-Team: LANGUAGE <LL@li.org>\n"
"MIME-Version: 1.0\n"
"Content-Type: text/plain; charset=CHARSET\n"
"Content-Transfer-Encoding: 8bit\n"

#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

# *po/amhello.pot*: The PO Template File

```
# ... COMMENTS ...
#, fuzzy
msgid ""
msgstr ""
"Project-Id-Version: PACKAGE VERSION\n"
"Report-Msgid-Bugs-To: bug-report@address\n"
"POT-Creation-Date: 2005-03-05 00:27+0100\n"
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"Language-Team: LANGUAGE <LL@li.org>\n"
"MIME-Version: 1.0\n"
"Content-Type: text/plain; charset=CHARSET\n"
"Content-Transfer-Encoding: 8bit\n"
```

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""
```

```
#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```



## *po/amhello.pot*: List of Messages

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

## *po/amhello.pot*: List of Messages

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

- msgids identify all strings in the package

## *po/amhello.pot*: List of Messages

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

- msgids identify all strings in the package
- empty msgstrs are placeholders for translations

## *po/amhello.pot*: List of Messages

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

- `msgid`s identify all strings in the package
- empty `msgstr`s are placeholders for translations
- the location of each string is shown, so the translator can check the context if needed

## *po/amhello.pot*: List of Messages

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

- `msgid`s identify all strings in the package
- empty `msgstr`s are placeholders for translations
- the location of each string is shown, so the translator can check the context if needed
- additional flags can be used

# *po/amhello.pot*: The PO Template File

```
# ... COMMENTS ...
#, fuzzy
msgid ""
msgstr ""
"Project-Id-Version: PACKAGE VERSION\n"
"Report-Msgid-Bugs-To: bug-report@address\n"
"POT-Creation-Date: 2005-03-05 00:27+0100\n"
"PO-Revision-Date: YEAR-MO-DA HO:MI+ZONE\n"
"Last-Translator: FULL NAME <EMAIL@ADDRESS>\n"
"Language-Team: LANGUAGE <LL@li.org>\n"
"MIME-Version: 1.0\n"
"Content-Type: text/plain; charset=CHARSET\n"
"Content-Transfer-Encoding: 8bit\n"
```

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""
```

```
#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

# *po/amhello.pot*: The PO Template File

```
# ... COMMENTS ...
#, fuzzy
msgid ""
msgstr ""
"Project-Id-Version: PACKAGE VERSION\n"
"Report-Msgid-Bugs-To: bug-report@address\n"
"POT-Creation-Date: 2005-03-05 00:27+0100\n"
"PO-Revision-Date: YEAR-MO-DA HO:MI+ZONE\n"
"Last-Translator: FULL NAME <EMAIL@ADDRESS>\n"
"Language-Team: LANGUAGE <LL@li.org>\n"
"MIME-Version: 1.0\n"
"Content-Type: text/plain; charset=CHARSET\n"
"Content-Transfer-Encoding: 8bit\n"

#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

## *po/amhello.pot*: The Header Entry

```
msgid ""  
msgstr ""  
"Project-Id-Version: PACKAGE VERSION\n"  
"Report-Msgid-Bugs-To: bug-report@address\n"  
"POT-Creation-Date: 2005-03-05 00:27+0100\n"  
"PO-Revision-Date: YEAR-MO-DA HO:MI+ZONE\n"  
"Last-Translator: FULL NAME <EMAIL@ADDRESS>\n"  
"Language-Team: LANGUAGE <LL@li.org>\n"  
"MIME-Version: 1.0\n"  
"Content-Type: text/plain; charset=CHARSET\n"  
"Content-Transfer-Encoding: 8bit\n"
```

The translation of the empty string is a special entry that will be filled with administrative information.



# How to Add a New Language?

- 1 Initialize *po/LL.po* or *po/LL\_CC.po* from *po/amhello.pot*, using 'msginit'.

*LL* is your language code, and *CC* is your country code

*pt* is Portuguese

*pt\_BR* is Brazilian Portuguese

(The annexes of the Gettext manual show lists of *LLs* and *CCs*.)

- 2 Fill in *po/LL.po* (or *po/LL\_CC.po*)
- 3 List the new translation in *po/LINGUAS*

# How to Add a New Language?

- 1 Initialize *po/LL.po* or *po/LL\_CC.po* from *po/amhello.pot*, using 'msginit'.  
LL is your language code, and CC is your country code  
pt is Portuguese  
pt\_BR is Brazilian Portuguese  
(The annexes of the Gettext manual show lists of LLs and CCs.)
- 2 Fill in *po/LL.po* (or *po/LL\_CC.po*)
- 3 List the new translation in *po/LINGUAS*

Let's add a French translation for *amhello*.






# Preparing *po/fr.po*

```
~/amhello % cd po  
~/amhello/po % msginit -l fr  
...  
~/amhello/po % emacs fr.po &
```

# Preparing *po/fr.po*

```
~/amhello % cd po
~/amhello/po % msginit -l fr
...
~/amhello/po % emacs fr.po &
```

The PO mode of 'emacs' ( po-mode):

- The buffer is modified only indirectly.
-  on a message will open a buffer to edit the translation.
- Use   after you have completed the translation, to get back to the updated *amhello.pot* buffer.
- Once all strings are translated, use  to save and check the file.
- Use  to remove fuzzy attributes.

# *po/fr.po*: Message Translations

```
#: src/say.c:9
msgid "Hello World!"
msgstr ""

#: src/say.c:10
#, c-format
msgid "This is %s.\n"
msgstr ""
```

# *po/fr.po*: Message Translations

```
#: src/say.c:9  
msgid "Hello World!"  
msgstr "Bonjour Monde !"
```

```
#: src/say.c:10  
#, c-format  
msgid "This is %s.\n"  
msgstr "Ceci est %s.\n"
```

## *po/fr.po*: Header

```
msgid ""
msgstr ""
"Project-Id-Version: amhello 3.0\n"
"Report-Msgid-Bugs-To: bug-report@address\n"
"POT-Creation-Date: 2005-03-05 00:27+0100\n"
"PO-Revision-Date: 2005-03-15 20:54+0100\n"
"Last-Translator: Alexandre Duret-Lutz <adl@gnu.org>\n"
"Language-Team: French\n"
"MIME-Version: 1.0\n"
"Content-Type: text/plain; charset=ASCII\n"
"Content-Transfer-Encoding: 8bit\n"
"Plural-Forms: nplurals=2; plural=(n > 1);\n"
```

- ‘msginit’ filled these fields.

## *po/fr.po*: Header

```
msgid ""
msgstr ""
"Project-Id-Version: amhello 3.0\n"
"Report-Msgid-Bugs-To: bug-report@address\n"
"POT-Creation-Date: 2005-03-05 00:27+0100\n"
"PO-Revision-Date: 2005-03-15 20:54+0100\n"
"Last-Translator: Alexandre Duret-Lutz <adl@gnu.org>\n"
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msgstr ""  
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"POT-Creation-Date: 2005-03-05 00:27+0100\n"  
"PO-Revision-Date: 2005-03-15 20:54+0100\n"  
"Last-Translator: Alexandre Duret-Lutz <adl@gnu.org>\n"  
"Language-Team: French\n"  
"MIME-Version: 1.0\n"  
"Content-Type: text/plain; charset=iso-8859-1\n"  
"Content-Transfer-Encoding: 8bit\n"  
"Plural-Forms: nplurals=2; plural=(n > 1);\n"
```

- 'msginit' filled these fields.
- You may have to customize it a bit.

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msgstr ""
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"Plural-Forms: nplurals=2; plural=(n > 1);\n"
```

- 'msginit' filled these fields.
- You may have to customize it a bit.
- The revision date will also be updated on save.

## *po/fr.po*: Validation and Addition

Once *po/fr.po* is completed, hit . This will:

- 1 Update the revision date
- 2 Save the file
- 3 Run `'msgfmt --statistics --check'` on *po/fr.po*, to validate it.

## *po/fr.po*: Validation and Addition

Once *po/fr.po* is completed, hit . This will:

- 1 Update the revision date
- 2 Save the file
- 3 Run `'msgfmt --statistics --check'` on *po/fr.po*, to validate it.

We can now register the language.

```
~/amhello/po % echo fr >> LINGUAS
```

# hello now Speaks French!

```
~/amhello % ./configure --prefix ~/test  
~/amhello %
```

# hello now Speaks French!

```
~/amhello % ./configure --prefix ~/test  
~/amhello % make  
~/amhello %
```

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```
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~/amhello % make  
~/amhello % cd po  
~/amhello/po %
```

# hello now Speaks French!

```
~/amhello % ./configure --prefix ~/test  
~/amhello % make  
~/amhello % cd po  
~/amhello/po % make update-po  
~/amhello/po %
```

## update-po

This step is needed because we just created *fr.po*, and it has to be compiled. This happens automatically during 'make dist'.



# hello now Speaks French!

```
~/amhello % ./configure --prefix ~/test  
~/amhello % make  
~/amhello % cd po  
~/amhello/po % make update-po  
~/amhello/po % cd ..  
~/amhello %
```

# hello now Speaks French!

```
~/amhello % ./configure --prefix ~/test  
~/amhello % make  
~/amhello % cd po  
~/amhello/po % make update-po  
~/amhello/po % cd ..  
~/amhello % make install  
~/amhello %
```

# hello now Speaks French!

```
~/amhello % ./configure --prefix ~/test
~/amhello % make
~/amhello % cd po
~/amhello/po % make update-po
~/amhello/po % cd ..
~/amhello % make install
~/amhello % ~/test/bin/hello
Hello World!
This is amhello 3.0.
~/amhello %
```

# hello now Speaks French!

```
~/amhello % ./configure --prefix ~/test
~/amhello % make
~/amhello % cd po
~/amhello/po % make update-po
~/amhello/po % cd ..
~/amhello % make install
~/amhello % ~/test/bin/hello
Hello World!
This is amhello 3.0.
~/amhello % LANG=fr_FR ~/test/bin/hello
Bonjour Monde !
Ceci est amhello 3.0.
```

# Updating Message Catalogs

Because maintainers can change the strings marked for translation, the messages catalogs are varying, and are not always up-to-date.

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Varying messages. `update-po` modify `*.po` file:

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- Obsolete translations, not used anymore, are commented.
- Messages with tiny changes keep their translation, but are marked fuzzy.

Translators remove fuzzy attributes (`(\Tab)`) after verification.

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Not up-to-date. `gettext` copes with incomplete translations as follows.

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**Not up-to-date.** `gettext` copes with incomplete translations as follows.

- Untranslated messages are output untranslated.
- Fuzzy messages are also output untranslated. (Better output the original sentence, rather than an inappropriate translation.)

**Good practice: the string freeze.** Two weeks before a release, run ‘`make update-po`’ and send the *\*.pot* file to translators. Don’t change or add strings from this point on. Let translators send you updated *\*.po* files.



# Language Teams & The Translation Project

`http://www.iro.umontreal.ca/translation/`

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- Translators gather in *Language Teams* (consider joining the team of your own language) to discuss issues.
- Maintainer submit *\*.pot* files and are notified when *\*.po* files are updated.
- Pages in The Translation Project will show where work is needed (consider adopting an orphan *\*.po* file.)

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This is only one way of getting a project translated. A lot of packages have dedicated translators and deal with them directly.

# Nested Packages

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- *Autoconfiscated* packages can be nested to arbitrary depth.
  - A package can distribute a third-party library it uses in a subdirectory.
  - It's possible to gather many packages this way to distribute a set of tools.
- For installers:
  - A single package to configure, build, and install.
  - 'configure' options are passed recursively to sub-packages.
  - 'configure --help=recursive' shows the help of all sub-packages.
- For maintainers:
  - Easier integration.
  - The sub-package is autonomous.

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- In *Makefile.am*, this directory must appear in **SUBDIRS** so 'make' recurses into it.
- *configure.ac* should also declare this directory

```
AC_CONFIG_SUBDIRS([subdir])
```

so 'configure' calls *subdir/configure* recursively.



# Nested Packages Example

The *arm* program links with an *hand* library, a nested package in *hand/*.

## *arm's configure.ac*

```
AC_INIT([arm], [1.0])
AM_INIT_AUTOMAKE([-Wall -Werror foreign])
AC_PROG_CC
AC_CONFIG_FILES([Makefile src/Makefile])
AC_CONFIG_SUBDIRS([hand])
AC_OUTPUT
```

## *arm's Makefile.am*

```
SUBDIRS = hand src
```

## *arm's src/Makefile.am*

```
AM_CPPFLAGS = -I$(top_srcdir)/hand
bin_PROGRAMS = arm
arm_SOURCES = arm.c
arm_LDADD = ../hand/libhand.a
```

# The End

# Where to go Now?

- Locate the reference manuals in your preferred format.
  - Autoconf, Automake, Libtool, and Gettext all install reference manuals in the Info format. (Try 'info Autoconf', 'info Automake', etc.)
  - The web pages of these tools also have [.html](#) or [.pdf](#) versions.
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- Subscribe to these tools' mailing lists, to see other people's uses of the tools.
- Pick a package that uses these tools and dissect its setup.
  - Try picking something written by somebody who isn't just another neophyte!
  - I recommend looking at *GNU Coreutils*.