

# C project development and management on Linux

A general introduction and project template

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# Example C project

We are starting with an example C project with **multiple subdirectories** symbolizing a complex project structure. Each directory is responsible for a single binary. All besides the core functions should reside in the `lib` directory.

```
dachu@LAPTOP-RMAEL4E0:~/auto_proj_1$ tree -R
.
├── alice
│   └── alice.c
├── bob
│   └── bob.c
├── lib
│   ├── lib.c
│   └── lib.h
└── readme.md

3 directories, 5 files
```

Tree structure of the example project.

# lib/lib.c & lib/lib.h

```
1  #include <stdio.h>
2  #include <stdlib.h>
3
4  void print_hello (int actor) {
5      if (actor == 1) printf("Hello from Alice!\n");
6      else if (actor == 2) printf("Hello from Bob!\n");
7      else printf("Error input actor!\n");
8  }
```

Code of lib/lib.c.

```
1  #ifndef LIB_H
2  #define LIB_H
3
4  /* @param actor [int], specifying actor
5   */
6  void print_hello (int actor);
7
8  #endif
```

Code of lib/lib.h.

# alice/alice.c & bob/bob.c

Both entry points `alice/alice.c` and `bob/bob.c` are dependent on the function `print_hello`.

```
1  #include <stdio.h>
2  #include <stdlib.h>
3
4  #include "../lib/lib.h"
5
6  int main (void) {
7      print_hello(1);
8      return 0;
9  }
```

Code of `alice/alice.c`.

```
1  #include <stdio.h>
2  #include <stdlib.h>
3
4  #include "../lib/lib.h"
5
6  int main (void) {
7      print_hello(2);
8      return 0;
9  }
```

Code of `bob/bob.c`.

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# Development process

- ❶ Select building target.
  - Binary
  - Library: static (\*.o) and shared (\*.so)
  - Archive of library (\*.a)
  - Libtool library (\*.la)
- ❷ Project positioning.
  - Multi-platform support (like CPU architectures, available resources)
  - Embedded platform
  - Library dependency and availability
  - Distribution method (like APT, SourceForge, GitHub, binary, source code)
- ❸ Code in C.
- ❹ Build with compiler. (compile, link, ...)
  - Language standards (like C99)
  - Flags (like -Wall)
  - Dependent library headers
  - Dependent library pre-compiled binary
  - Code optimization (like -O2 -O3)
  - Debugging information
  - Debug and profiling (like Valgrind, sanitizers, FlameGraph)
    - Memory (heap) error (memory leak)
    - Thread error (racing)
    - Cache
    - Branch-prediction
- ❺ Install, uninstall, system integration.



# Deployment checks

How can we ensure that once the project is built, it can be executed correctly, consistently, and without problems?

- Pre-Build check list

- Compiler: gcc, g++, clang, llvm, ...
- Required software, library, function
- Version (like  $> 1.0.0$ )
- Command execution location in project

- Post-Build

- Can be executed or linked both locally and at the installing location
- Execution result is correct and consistent

The thing is, coding C is just a fraction of creating binaries and libraries.

# Manual compile

If the project is not complicated, manually compiling everything or using a Bash script is acceptable. However, installing, uninstalling, and cleaning are not implemented.

```
2 gcc -c lib/lib.c -std=c99 -Wall -o lib/lib.o
3 gcc alice/alice.c lib/lib.o -std=c99 -Wall -o alice/alice.bin
4 gcc bob/bob.c lib/lib.o -std=c99 -Wall -o bob/bob.bin
```

Commands for manual gcc compilation.

```
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_1$ tree -R
.
├── alice
│   ├── alice.bin
│   └── alice.c
├── bob
│   ├── bob.bin
│   └── bob.c
├── lib
│   ├── lib.c
│   ├── lib.h
│   └── lib.o
└── readme.md

3 directories, 8 files
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_1$ ./alice/alice.bin
Hello from Alice!
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_1$ ./bob/bob.bin
Hello from Bob!
```

Tree structure and execution results after compilation.

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# Makefile

```
1 CC=gcc
2 FLAG=-Wall
3 STD=-std=c99
4
5 DIR_A=alice
6 DIR_B=bob
7 DIR_LIB=lib
8
9 # Compile / Build
10 all: alice.bin bob.bin
11
12 $(DIR_A).bin: $(DIR_LIB).o $(DIR_A)/$(DIR_A).c
13     $(CC) $(DIR_A)/$(DIR_A).c $(DIR_LIB)/$(DIR_LIB).o $(STD) $(FLAG) -I../$(DIR_LIB) -o $(DIR_A)/$@
14
15 $(DIR_B).bin: $(DIR_LIB).o $(DIR_B)/$(DIR_B).c
16     $(CC) $(DIR_B)/$(DIR_B).c $(DIR_LIB)/$(DIR_LIB).o $(STD) $(FLAG) -I../$(DIR_LIB) -o $(DIR_B)/$@
17
18 $(DIR_LIB).o: $(DIR_LIB)/$(DIR_LIB).c
19     $(CC) -c $~ $(STD) $(FLAG) -o $(DIR_LIB)/$@
20
21 # Install (not implemented)
22
23 # Clear build / aux files
24 clean:
25     rm */*.bin \
26         */*.o
27
28 # Uninstall (not implemented)
```

Example of a Makefile with build and clean targets.

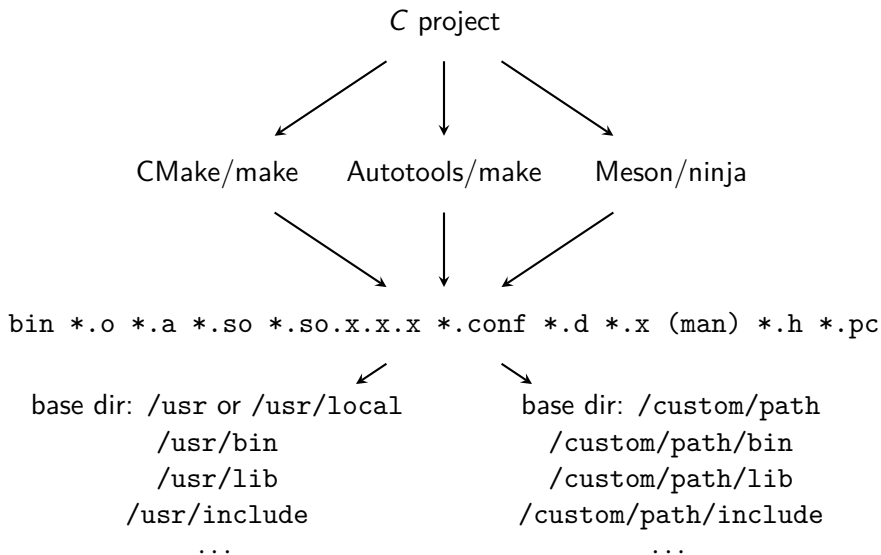
# Makefile compile

```
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ make
gcc -c lib/lib.c -std=c99 -Wall -o lib/lib.o
gcc alice/alice.c lib/lib.o -std=c99 -Wall -I../lib -o alice/alice.bin
gcc bob/bob.c lib/lib.o -std=c99 -Wall -I../lib -o bob/bob.bin
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ tree -R
.
├── alice.bin
├── alice.c
├── bob.bin
├── bob.c
├── lib.c
├── lib.h
├── lib.o
├── Makefile
└── readme.md
3 directories, 9 files
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ alice/alice.bin
Hello from Alice!
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ bob/bob.bin
Hello from Bob!
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ make clean
rm *.bin \
    */*.o
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ tree -R
.
├── alice.c
├── bob.c
├── lib.c
├── lib.h
├── Makefile
└── readme.md
3 directories, 6 files
```

Tree structure and execution results after compilation.

- Work similar to *Bash*
- Can specify a single target with all of its dependency compiled
- Takes a lot of time to configure if there are too many files
- All actions include **building**, **installing**, **uninstalling**, and **clearing** require knowledge of conversion and manual configuration

# Development pipeline with build systems



# Why build systems

- Dependency checks on existence and version (`pkg-config`)
- Multi-platform portability (`config.h` and `./configure`)
- Standardized build process
- Standardized conventions (like `./configure --prefix=/path --exec-path=/path`)
- Incremental build, which only build changed files
- Library management (`libtool`)
- Run tests after compilation if existed



# Common build systems

Build system	Autotools/make	CMake/make	Meson/ninja
Common usecase	GNU libraries	C++ projects	GNOME
Common files to identify	configure.ac Makefile.am	CMakeLists.txt	meson.build meson.options
Build command	cd \$project_dir ./configure make make install	cd \$project_dir mkdir build cd build cmake .. make make install	cd \$project_dir meson setup _build meson compile -C _build meson install -C _build

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# Steps for creating a C project managed by Autotools

## Phase I: Initial setup

- 1 Create and configure main `Makefile.am`.
- 2 Create and configure `Makefile.am` in every subdirectories.
- 3 Use `autoscan` to generate the starting point of `configure.scan`.
- 4 Modify `configure.scan` with project settings into `configure.ac`.
- 5 Use `autoreconf` to generate `./configure`.

# Steps for creating a C project managed by Autotools

## Phase II: Build

- 1 Execute `./configure` to generate Makefiles.
- 2 Execute `make` in the root directory of the project to build. (include testing)
- 3 Execute `make install` in the root directory of the project to install.

## Phase III: Prepare for distribution

- 1 Execute `make clean` to remove build results in project.
- 2 Execute `make distclean` to remove everything generated with `./configure`.
- 3 Compress the directory (`*.tar.gz`) for release.

# I: ./Makefile.am

```
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R .
.
├── alice.c
├── Makefile.am
├── bob.c
├── Makefile.am
├── lib.c
├── lib.h
├── Makefile.am
├── Makefile.am
└── README
3 directories, 9 files
```

Tree structure after creating Makefile.am.

```
1  DIR_A=alice
2  DIR_B=bob
3  DIR_LIB=lib
4
5  SUBDIRS = $(DIR_LIB) $(DIR_A) $(DIR_B)
6
7  EXTRA_DIST = m4/.keepdir
8  ACLOCAL_AMFLAGS = -I m4 --install
9
10 dist_doc_DATA = README
```

Code for ./Makefile.am.

# I: Makefile.am for directory alice to build a binary

```
1 project = auto_proj_3
2 common_cflag = -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef \
3               -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 \
4               -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum \
5               -Wconversion -Wunreachable-code -Wformat=2
6
7 bindir = $(exec_prefix)/bin/$(project)
8
9 bin_PROGRAMS = alice
10
11 alice_SOURCES = alice.c
12 alice_CFLAGS = $(common_cflag)
13 alice_LDADD = -L/usr/local/lib -lm ../lib/lib.la
14 alice_LDFLAGS = -I/usr/local/include -I../lib
```

Code for ./alice/Makefile.am.

# I: Makefile.am for directories bob to build a binary

```
1 project = auto_proj_3
2 common_cflag = -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef \
3               -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 \
4               -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum \
5               -Wconversion -Wunreachable-code -Wformat=2
6
7 bindir = $(exec_prefix)/bin/$(project)
8
9 bin_PROGRAMS = bob
10
11 bob_SOURCES = bob.c
12 bob_CFLAGS = $(common_cflag)
13 bob_LDADD = -L/usr/local/lib -lm ../lib/lib.la
14 bob_LDFLAGS = -I/usr/local/include -I../lib
```

Code for ./bob/Makefile.am.

# I: Makefile.am for directory lib to build a LibTool library

```
1  project = auto_proj_3
2  common_cflag = -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef \
3                -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 \
4                -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum \
5                -Wconversion -Wunreachable-code -Wformat=2
6
7  libdir = $(exec_prefix)/lib/$(project)
8  lib_ladir = $(exec_prefix)/include/$(project)
9
10 lib_LTLIBRARIES = lib.la
11
12 lib_la_SOURCES = lib.c
13 lib_la_HEADERS = lib.h
14 lib_la_CFLAGS = $(common_cflag)
```

Code for ./lib/Makefile.am.



# l: autoscan for configure template configure.scan

```
1      #                                -- Autoconf --
2      # Process this file with autoconf to produce a configure script.
3
4      AC_PREREQ([2.71])
5      AC_INIT([FULL-PACKAGE-NAME], [VERSION], [BUG-REPORT-ADDRESS])
6      AC_CONFIG_SRCDIR([alice/alice.c])
7      AC_CONFIG_HEADERS([config.h])
8
9      # Checks for programs.
10     AC_PROG_CC
11
12     # Checks for libraries.
13     # FIXME: Replace 'main' with a function in '-lm':
14     AC_CHECK_LIB([m], [main])
15
16     # Checks for header files.
17
18     # Checks for typedefs, structures, and compiler characteristics.
19
20     # Checks for library functions.
21
22     AC_CONFIG_FILES([Makefile
23                     alice/Makefile
24                     bob/Makefile
25                     lib/Makefile])
26     AC_OUTPUT
```

Scan result of the project structure in configure.scan.

# l: autoscan for configure template configure.ac

```
1  #                                      -*- Autoconf -*-
2   # Process this file with autoconf to produce a configure script.
3
4  AC_PREREQ([2.71])
5  AC_INIT([auto_proj_3], [1.0.0], [dachuan516@gmail.com])
6  AC_CONFIG_SRCDIR([alice/alice.c])
7  AC_CONFIG_HEADERS([config.h])
8  AC_CONFIG_AUX_DIR([build-aux])
9  AC_CONFIG_MACRO_DIR([m4])
10 AM_INIT_AUTOMAKE([-Wall -Werror foreign subdir-objects])
11 AM_PROG_AR
12
13  # Checks for programs.
14 AC_PROG_CC
15 AM_MISSING_PROG(awk_path, awk)
16 LT_INIT([disable-static])  # or AC_DISABLE_SHARED
17
18  # Checks for libraries.
19  # FIXME: Replace 'main' with a function in '-lm':
20  #AC_CHECK_LIB([trace], [trace_create_packet], [],
21  #           [echo -e "\nfunction trace_create_packet from libtrace not found\n"; exit 1])
22  #PKG_PROG_PKG_CONFIG
23  #PKG_CHECK_MODULES([MARIADB], [mariadb >= 3.1.22])
```

Modified configure.ac. (part 1)

# l: autoscan for configure template configure.ac

```
25  # Checks for header files.
26  AC_CHECK_HEADER([stdio.h],
27                  [AC_DEFINE([HAVE_STDIO_H], [1])],
28                  [AC_MSG_ERROR([missing standard library])])
29
30  # Checks for typedefs, structures, and compiler characteristics.
31  AC_TYPE_SIZE_T
32  AC_TYPE_INT8_T
33  AC_TYPE_INT16_T
34  AC_TYPE_INT32_T
35  AC_TYPE_INT64_T
36  AC_TYPE_UINT8_T
37  AC_TYPE_UINT16_T
38  AC_TYPE_UINT32_T
39  AC_TYPE_UINT64_T
40
41  # Checks for library functions.
42  #AC_CHECK_FUNC
43
44  AC_CONFIG_FILES([Makefile
45                  alice/Makefile
46                  bob/Makefile
47                  lib/Makefile])
48  AC_SUBST([ADD_LIBS])
49  AC_SUBST([EXTRA_LIBS])
50  AC_SUBST([ADD_LDFLAGS])
51  AC_SUBST([ADD_INCLS])
52  AC_SUBST([LTLIBOBJS])
53  AC_OUTPUT
```

Modified configure.ac. (part 2)

# l: autoreconf -iv

```
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
├── alice.c
├── Makefile.am
├── autoscan.log
├── bob.c
├── Makefile.am
├── configure.ac
├── configure.scan
├── lib.c
├── lib.h
├── Makefile.am
├── Makefile.am
└── README

3 directories, 12 files
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ autoreconf -iv
autoreconf: export WARNINGS=
autoreconf: Entering directory '.'
autoreconf: configure.ac: not using Gettext
autoreconf: running: aclocal -I m4 --install
aclocal: installing 'm4/libtool.m4' from '/usr/share/aclocal/libtool.m4'
aclocal: installing 'm4/ltoptions.m4' from '/usr/share/aclocal/ltoptions.m4'
aclocal: installing 'm4/ltsugar.m4' from '/usr/share/aclocal/ltsugar.m4'
aclocal: installing 'm4/ltversion.m4' from '/usr/share/aclocal/ltversion.m4'
aclocal: installing 'm4/lt-obsolete.m4' from '/usr/share/aclocal/lt-obsolete.m4'
autoreconf: configure.ac: tracing
autoreconf: configure.ac: creating directory build-aux
autoreconf: running: libtoolize --copy
libtoolize: putting auxiliary files in AC_CONFIG_AUX_DIR, 'build-aux'.
libtoolize: copying file 'build-aux/ltmain.sh'
autoreconf: configure.ac: not using Initool
autoreconf: configure.ac: not using Gtkdoc
autoreconf: running: aclocal -I m4 --install
autoreconf: running: /usr/bin/autoconf
autoreconf: running: /usr/bin/autoheader
autoreconf: running: automake --add-missing --copy --no-force
configure.ac:11: installing 'build-aux/ar-lib'
configure.ac:11: installing 'build-aux/compile'
configure.ac:16: installing 'build-aux/config.guess'
configure.ac:16: installing 'build-aux/config.sub'
configure.ac:10: installing 'build-aux/install-sh'
configure.ac:10: installing 'build-aux/missing'
alice/Makefile.am: installing 'build-aux/depcomp'
autoreconf: Leaving directory '.'
```

Generate auxiliary files.

# l: autoreconf -iv

```
jachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
├── aclocal.m4
├── [redacted]
│   ├── alice.c
│   ├── Makefile.am
│   └── Makefile.in
├── [redacted]
│   ├── output.0
│   ├── output.1
│   ├── output.2
│   ├── output.3
│   ├── requests
│   ├── traces.0
│   ├── traces.1
│   ├── traces.2
│   └── traces.3
├── autoscan.log
├── [redacted]
│   ├── bob.c
│   ├── Makefile.am
│   └── Makefile.in
├── [redacted]
│   ├── ar-lib
│   ├── compile
│   ├── config.guess
│   ├── config.sub
│   ├── depcomp
│   ├── install-sh
│   ├── ltmain.sh
│   ├── missing
│   ├── config.h.in
│   ├── configure
│   ├── configure.ac
│   └── configure.scan
├── [redacted]
│   ├── lib.c
│   ├── lib.h
│   ├── Makefile.am
│   └── Makefile.in
├── [redacted]
│   ├── libtool.m4
│   ├── lt-obsolete.m4
│   ├── ltoptions.m4
│   ├── ltsugar.m4
│   └── ltversion.m4
├── Makefile.am
├── Makefile.in
└── README

5 directories, 41 files
```

Tree structure of generate auxiliary files.

# ll: ./configure

```
jack@LAPTOP-RNAEL4E0:/mnt/d/Note Database/Subject/ACN Advanced Computer Networking/autotools_intro/proj/auto_proj_39: ./configure
checking for a BSD-compatible install... /usr/bin/install -c
checking whether build environment is sane... yes
checking for a race-free mkdir -p... /usr/bin/mkdir -p
checking for gawk... gawk
checking whether make sets $(MAKE)... yes
checking whether make supports nested variables... yes
checking whether make supports the include directive... yes (GNU style)
checking for gcc... gcc
checking whether the C compiler works... yes
checking for C compiler default output file name... a.out
checking for suffix of executables...
checking whether we are cross compiling... no
checking for suffix of object files... o
checking whether the compiler supports GNU C... yes
checking whether gcc accepts -g... yes
checking for gcc option to enable C11 features... none needed
checking whether gcc understands -c and -o together... yes
checking dependency style of gcc... gcc3
checking for ar... ar
checking the archiver (ar) interface... ar
checking for gcc... (cached) gcc
checking whether the compiler supports GNU C... (cached) yes
checking whether gcc accepts -g... (cached) yes
checking for gcc option to enable C11 features... (cached) none needed
checking whether gcc understands -c and -o together... (cached) yes
checking dependency style of gcc... (cached) gcc3
checking build system type... x86_64-pc-linux-gnu
checking host system type... x86_64-pc-linux-gnu
checking how to print strings... printf
checking for a sed that does not truncate output... /usr/bin/sed
checking for grep that handles long lines and -e... /usr/bin/grep
checking for egrep... /usr/bin/grep -E
checking for fgrep... /usr/bin/grep -F
checking for ld used by gcc... /usr/bin/ld
checking if the linker (/usr/bin/ld) is GNU ld... yes
checking for BSD- or MS-compatible name lister (nm)... /usr/bin/nm -B
checking the name lister (/usr/bin/nm -B) interface... BSD nm
checking whether ln -s works... yes
checking the maximum length of command line arguments... 1572864
checking how to convert x86_64-pc-linux-gnu file names to x86_64-pc-linux-gnu format... func_convert_file_noop
checking how to convert x86_64-pc-linux-gnu file names to toolchain format... func_convert_file_noop
checking for /usr/bin/option to reload object files... -r
checking for objdump... objdump
checking how to recognize dependent libraries... pass_all
checking for dltool... no
checking how to associate runtime and link libraries... printf %s\n
checking for archiver @FILE support... @
checking for strip... strip
checking for ranlib... ranlib
checking command to parse /usr/bin/nm -B output from gcc object... ok
checking for sysroot... no
checking for a working dd... /usr/bin/dd
checking how to truncate binary pipes... /usr/bin/dd bs=4096 count=1
checking for mt... mt
checking if mt is a manifest tool... no
checking for stdio.h... yes
checking for stdlib.h... yes
checking for string.h... yes
checking for inttypes.h... yes
checking for stdint.h... yes
checking for strings.h... yes
checking for sys/stat.h... yes
checking for sys/types.h... yes
checking forunistd.h... yes
```

## Generate Makefile for installing platform. (part 1)

## ll: ./configure

```
checking for unistd.h... yes
checking for dlfcn.h... yes
checking for objdir... libs
checking if gcc supports -fno-rtti -fno-exceptions... no
checking for gcc option to produce PIC... -fPIC -DPIC
checking if gcc PIC flag -fPIC -DPIC works... yes
checking if gcc static flag -static works... yes
checking if gcc supports -c -o file.o... yes
checking if gcc supports -c -o file.o... (cached) yes
checking whether the gcc linker (/usr/bin/ld -m elf_x86_64) supports shared libraries... yes
checking whether -lc should be explicitly linked in... no
checking dynamic linker characteristics... GNU/Linux ld.so
checking how to hardcode library paths into programs... immediate
checking whether stripping libraries is possible... yes
checking if libtool supports shared libraries... yes
checking whether to build shared libraries... yes
checking whether to build static libraries... no
checking for stdio.h... (cached) yes
checking for size_t... yes
checking for int8_t... yes
checking for int16_t... yes
checking for int32_t... yes
checking for int64_t... yes
checking for uint8_t... yes
checking for uint16_t... yes
checking for uint32_t... yes
checking for uint64_t... yes
checking that generated files are newer than configure... done
configure: creating ./config.status
config.status: creating Makefile
config.status: creating alice/Makefile
config.status: creating bob/Makefile
config.status: creating lib/Makefile
config.status: creating config.h
config.status: executing depfiles commands
config.status: executing libtool commands
```

Generate Makefile for installing platform. (part 2)

# ll: ./configure

```
sachu@LAPTOP-RMALL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
├── alocal.m4
├── alice.c
├── Makefile
├── Makefile.am
├── Makefile.in
├── output.0
├── output.1
├── output.2
├── output.3
├── requests
├── traces.0
├── traces.1
├── traces.2
├── traces.3
├── autotools.log
├── bob.c
├── Makefile
├── Makefile.am
├── Makefile.in
├── ar-lib
├── compile
├── config.guess
├── config.sub
├── depcomp
├── install-sh
├── ltmain.sh
├── missing
├── config.h
├── config.h.in
├── config.log
├── config.status
├── configure
├── configure.ac
├── configure.scan
├── lib.c
├── lib.h
├── Makefile
├── Makefile.am
├── Makefile.in
├── libtool
├── libtool.m4
├── lt-obsolete.m4
├── ltoptions.m4
├── ltugrad.m4
├── ltversion.m4
├── Makefile
├── Makefile.am
├── Makefile.in
├── README
├── stamp-h1
└── 8 directories, 50 files
```

Tree structure of generated files including Makefile.



```
ll: make
```

[illegible]

## Project building.

# ll: make

```
hachu@LAPTOP-RMAEL4ED:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
├── aclocal.m4
├── alice
├── alice-alice.o
├── alice.c
├── Makefile
├── Makefile.am
├── Makefile.in
├── output.0
├── output.1
├── output.2
├── output.3
├── requests
├── traces.0
├── traces.1
├── traces.2
├── traces.3
├── autoscan.log
├── bob
├── bob-bob.o
├── bob.c
├── Makefile
├── Makefile.am
├── Makefile.in
├── ar-lib
├── compile
├── config.guess
├── config.sub
├── depcomp
├── install-sh
├── ltmain.sh
├── mtssing
├── config.h
├── config.h.in
├── config.log
├── config.status
├── configure
├── configure.ac
├── configure.scan
├── lib.c
├── lib.h
├── lib.la
├── lib.lo
├── Makefile
├── Makefile.am
├── Makefile.in
├── libtool
├── libtool.m4
├── lt-obsolete.m4
├── ltoptions.m4
├── ltsugar.m4
├── ltversion.m4
├── Makefile
├── Makefile.am
├── Makefile.in
├── README
├── stamp-h1
```

Tree structure of built project.

# ll: make install

```
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ sudo make install
[sudo] password for dachu:
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
make[2]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
/usr/bin/mkdir -p /usr/local/lib/auto_proj_3
/bin/bash ./libtool --mode=install /usr/bin/install -c lib.la /usr/local/lib/auto_proj_3
libtool: install: /usr/bin/install -c .libs/lib.so.0.0.0 /usr/local/lib/auto_proj_3/lib.so.0.0.0
libtool: install: /usr/local/lib/auto_proj_3.66 ln -s -f lib.so.0.0.0 lib.so.0 || { rm -f lib.so.0.66 ln -s lib.so.0.0.0 lib.so.0; }; }
libtool: install: /usr/local/lib/auto_proj_3.66 ln -s -f lib.so.0.0.0 lib.so.0 || { rm -f lib.so.66 ln -s lib.so.0.0.0 lib.so.0; }; }
libtool: install: /usr/bin/install -c .libs/lib.la /usr/local/lib/auto_proj_3/lib.la
libtool: finish: PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/snap/bin:/sbin ldconfig -n /usr/local/lib/auto_proj_3
Libraries have been installed in:
  /usr/local/lib/auto_proj_3
If you ever happen to want to link against installed libraries
in a given directory, LIBDIR, you must either use libtool, and
specify the full pathnames of the library, or use the '-L' linker
flag during linking and do at least one of the following:
  - add LIBDIR to the 'LD_LIBRARY_PATH' environment variable
    during execution
  - add LIBDIR to the 'LD_RUN_PATH' environment variable
    during linking
  - use the '-Wl,-rpath -Wl,LIBDIR' linker flag
  - have your system administrator add LIBDIR to '/etc/ld.so.conf'
See any operating system documentation about shared libraries for
more information, such as the ld(1) and ld.so(8) manual pages.
-----
/usr/bin/mkdir -p /usr/local/include/auto_proj_3
/usr/bin/install -c -m 644 lib.h /usr/local/include/auto_proj_3
make[2]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
make[2]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
/usr/bin/mkdir -p /usr/local/bin/auto_proj_3
/bin/bash ./libtool --mode=install /usr/bin/install -c alice /usr/local/bin/auto_proj_3
libtool: install: /usr/bin/install -c .libs/alice /usr/local/bin/auto_proj_3/alice
make[2]: Nothing to be done for 'install-data-am'.
make[2]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
make[2]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
/usr/bin/mkdir -p /usr/local/bin/auto_proj_3
/bin/bash ./libtool --mode=install /usr/bin/install -c bob /usr/local/bin/auto_proj_3
libtool: install: /usr/bin/install -c .libs/bob /usr/local/bin/auto_proj_3/bob
make[2]: Nothing to be done for 'install-data-am'.
make[2]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
make[2]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
make[2]: Nothing to be done for 'install-exec-am'.
/usr/bin/mkdir -p /usr/local/share/doc/auto_proj_3
/usr/bin/install -c -m 644 README /usr/local/share/doc/auto_proj_3
make[2]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls /usr/local/lib/auto_proj_3/
lib.la lib.so lib.so.0 lib.so.0.0
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls /usr/local/include/auto_proj_3/
lib.h
```

Execution result and installed files.

# ll: make uninstall

```
dachugLAPTOP-RMAE14E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ sudo make uninstall
Making uninstall in lib
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
/bin/bash ../libtool --mode=uninstall rm -f '/usr/local/lib/auto_proj_3/lib.la'
libtool: uninstall: rm -f '/usr/local/lib/auto_proj_3/lib.la' /usr/local/lib/auto_proj_3/lib.so.0 /usr/local/lib/auto_proj_3/lib.so /usr/local/lib/auto_proj_3/lib.so
( cd '/usr/local/include/auto_proj_3' && rm -f lib.h )
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
Making uninstall in alice
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
( cd '/usr/local/bin/auto_proj_3' && rm -f alice )
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
Making uninstall in bob
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
( cd '/usr/local/bin/auto_proj_3' && rm -f bob )
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
( cd '/usr/local/share/doc/auto_proj_3' && rm -f README )
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
dachugLAPTOP-RMAE14E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls /usr/local/bin/auto_proj_3/
dachugLAPTOP-RMAE14E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls /usr/local/lib/auto_proj_3/
dachugLAPTOP-RMAE14E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls /usr/local/include/auto_proj_3/
dachugLAPTOP-RMAE14E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ make clean
```

Removing all installed files.

# III: make clean

```
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ make clean
Making clean in lib
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
test -z "lib.la" || rm -f lib.la
rm -f ./so_locations
rm -rf .libs _libs
rm -f *.o
rm -f *.lo
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
Making clean in alice
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
rm -rf .libs _libs
rm -f *.o
rm -f *.lo
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
Making clean in bob
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
rm -rf .libs _libs
rm -f *.o
rm -f *.lo
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
rm -rf .libs _libs
rm -f *.o
rm -f *.lo
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
```

Remove all compiled files.

# III: make clean

```
sachu@LAPTOP-RMAEL4E0:/mnt/d/note_Database/Subject/ACH_Advanced_Computer_Networking/autotools_Intro/proj/auto_proj_3$ tree -R
.
├── alocal.m4
├── alice.c
├── Makefile
├── Makefile.am
├── Makefile.in
├── output.0
├── output.1
├── output.2
├── output.3
├── requests
├── traces.0
├── traces.1
├── traces.2
├── traces.3
├── autotools.log
├── bob.c
├── Makefile
├── Makefile.am
├── Makefile.in
├── ar-lib
├── compile
├── config.guess
├── config.sub
├── depcomp
├── install-sh
├── ltmain.sh
├── missing
├── config.h
├── config.h.in
├── config.log
├── config.status
├── configure
├── configure.ac
├── configure.scan
├── lib.c
├── lib.h
├── Makefile
├── Makefile.am
├── Makefile.in
├── libtool
├── libtool.m4
├── lt-obsolete.m4
├── ltoptions.m4
├── ltsugar.m4
├── ltversion.m4
├── Makefile
├── Makefile.am
├── Makefile.in
├── README
├── stamp-h1
└── 6 directories, 50 files
```

Tree structure after execution.

# III: make distclean

```
jachug@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ make distclean
Making distclean in lib
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
test -z "lib_la" || rm -f lib_la
rm -f *.so locations
rm -rf .libs _libs
rm -f *.o
rm -f *.lo
rm -f *.tab.c
test -z "" || rm -f
test . = "." || test -z "" || rm -f
rm -f TAGS ID GTAGS GRTAGS GSYMS GPATH tags
rm -f ./deps/lib.Plo
rm -f Makefile
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
Making distclean in alice
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
rm -rf .libs _libs
rm -f *.o
rm -f *.lo
rm -f *.tab.c
test -z "" || rm -f
test . = "." || test -z "" || rm -f
rm -f TAGS ID GTAGS GRTAGS GSYMS GPATH tags
rm -f ./deps/alice-alice.Po
rm -f Makefile
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
Making distclean in bob
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
rm -rf .libs _libs
rm -f *.o
rm -f *.lo
rm -f *.tab.c
test -z "" || rm -f
test . = "." || test -z "" || rm -f
rm -f TAGS ID GTAGS GRTAGS GSYMS GPATH tags
rm -f ./deps/bob-bob.Po
rm -f Makefile
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
rm -rf .libs _libs
rm -f *.lo
test -z "" || rm -f
test . = "." || test -z "" || rm -f
rm -f config.h stamp-h1
rm -f libtool config.lt
rm -f TAGS ID GTAGS GRTAGS GSYMS GPATH tags
rm -f cscope.out cscope.in.out cscope.po.out cscope.files
make[1]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
rm -f config.status config.cache config.log configure.lineno config.status.lineno
rm -f Makefile
```

Remove almost all files generated from ./configure.

# III: make distclean

```
dachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
├── aclocal.m4
├── alice.c
├── Makefile.am
├── Makefile.in
├── output.0
├── output.1
├── output.2
├── output.3
├── requests
├── traces.0
├── traces.1
├── traces.2
├── traces.3
├── autoscan.log
├── bob.c
├── Makefile.am
├── Makefile.in
├── ar-lib
├── compile
├── config.guess
├── config.sub
├── depcomp
├── install-sh
├── ltmain.sh
├── missing
├── config.h.in
├── configure
├── configure.ac
├── configure.scan
├── lib.c
├── lib.h
├── Makefile.am
├── Makefile.in
├── libtool.m4
├── lt-obsolete.m4
├── ltoptions.m4
├── ltsugar.m4
├── ltversion.m4
├── Makefile.am
├── Makefile.in
├── README
6 directories, 41 files
```

Tree structure after execution.



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