

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

① Select building target.

- Binary
- Library: static (*.o) and shared (*.so)
- Archive of library (*.a)
- Libtool library (*.la)

② 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)

③ Code in C.

④ 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

⑤ 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.

```
cachu@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

5 directories, 8 files
cachu@LAPTOP-RMAEL4E0:/mnt/d>Note_Database\Subject\ACN_Advanced_Computer_Networking\autotools_intro\proj\auto_proj_1$ ./alice/alice.bin
Hello from Alice!
cachu@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-RMAEL4EO:~/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-RMAEL4EO:~/mnt/d>Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ tree -R
.
├── Alice
│   ├── alice.bin
│   └── alice.c
├── Bob
│   ├── bob.bin
│   └── bob.c
└── lib
    ├── lib.c
    ├── lib.h
    └── lib.o
├── Makefile
└── readme.md

3 directories, 9 files
dachu@LAPTOP-RMAEL4EO:~/mnt/d>Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ ./alice/alice.bin
Hello from Alice!
dachu@LAPTOP-RMAEL4EO:~/mnt/d>Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ ./bob/bob.bin
Hello from Bob!
dachu@LAPTOP-RMAEL4EO:~/mnt/d>Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ make clean
rm */*.bin \
    */*.o
dachu@LAPTOP-RMAEL4EO:~/mnt/d>Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_2$ tree -R
.
├── Alice
│   └── alice.c
├── Bob
│   └── bob.c
└── lib
    ├── lib.c
    └── lib.h
├── Makefile
└── readme.md

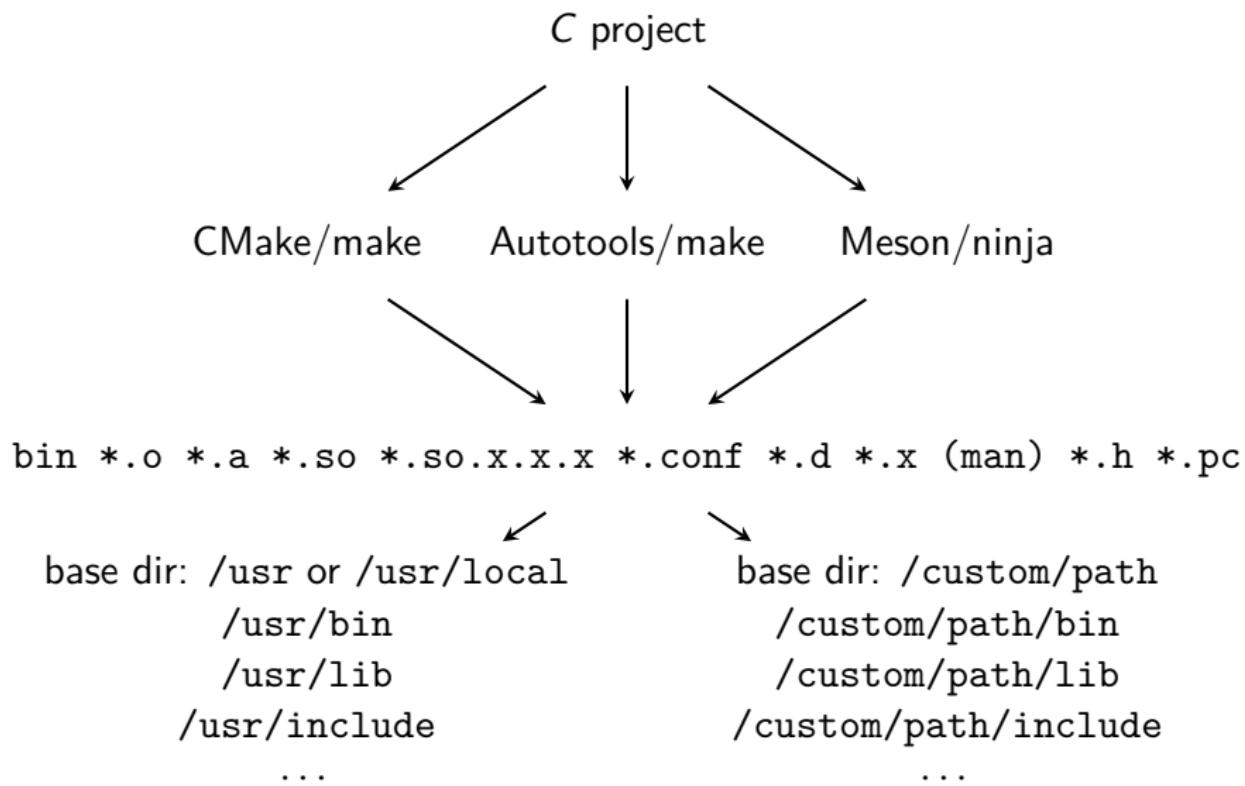
3 directories, 6 files
```

Tree structure and execution results after compilation.

Makefile

- 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 convention 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 `autoscans` 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

```
[root@Laptop-RMAEL4EO:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3]# tree -R .
.
├── alice
│   ├── alice.c
│   └── Makefile.am
├── bob
│   ├── bob.c
│   └── Makefile.am
└── lib
    ├── lib.c
    ├── lib.h
    ├── 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.

I: 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.

I: 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)

I: 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

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

3 directories, 12 files
dachug@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/lversion.m4' from `/usr/share/aclocal/lversion.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 Inttool
autoreconf: configure.ac: not using Gkdoc
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.

|: autoreconf -iv

```
jachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
├── aclocal.m4
│   ├── alices.c
│   ├── Makefile.am
│   └── Makefile.in
├── autom4te.cache
│   ├── output.0
│   ├── output.1
│   ├── output.2
│   ├── output.3
│   ├── requests
│   ├── traces.0
│   ├── traces.1
│   ├── traces.2
│   └── traces.3
├── autoscan.log
└── libtool
    ├── ar-lbb
    ├── compile
    ├── config.guess
    ├── config.sub
    ├── depcomp
    ├── install-sh
    ├── ltmain.sh
    ├── missing
    ├── config.h.in
    ├── configure
    ├── configure.ac
    └── configure.scan
    └── lib
        ├── lib.c
        ├── lib.h
        ├── Makefile.am
        └── Makefile.in
    └── 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.

II: ./configure

```
machu@LAPTOP-RMAEL4EO:~/mnt/d/Note_Database/Subject/ACM_Advanced_Computer_Networking'autotools_intro/proj/auto_proj_3$ ./configure
checking for a BSD-compatible install... /usr/bin/install -c
checking whether the installed environment is sane... yes
checking for a race-free mkdir -p... /usr/bin/mkdir -p
checking for gawk...
checking whether make sets $MAKE... yes
checking whether make supports nested variables... yes
checking whether make handles supports the include directive... yes (GNU style)
checking for gcc...
checking for C compiler works... yes
checking for C compiler default output file name... a.out
checking for suffix or executables... .
checking for suffix or object files... o
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 set that does not truncate output... /usr/bin/sed
checking for a sed that truncates long lines and -e... /usr/bin/sed
checking for egrep... /usr/bin/grep -E
checking for grep... /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 nm... /usr/bin/nm -B
checking if nm is of MS-DOS type... no
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/ld option to reload object files... -r
Checking for objdump... objdump
Checking how to recognize dependent libraries... pass_all
Checking for ranlib... no
Checking how to associate runtime and link libraries... printf %s\n
Checking for archiver @FILE support... @
Checking for strip... strip
Checking for ranlib...
Checking command to parse /usr/bin/nm -B output from gcc object... ok
Checking for mt... no
Checking for ar... 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 for 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 stdbool.h... yes
Checking for sys/types.h... yes
Checking for sys/stat.h... yes
Checking for sys/types.h... yes
Checking for unistd.h... yes
```

Generate Makefile for installing platform. (part 1)

II: ./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 -fPIC -DPIC works... yes
Checking if gcc supports -fPIC -DPIC... 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 can build 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 lib/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

```
dachu@LAPTOP-RMAEL4E0:/mnt/d>Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
└── aclocal.m4
    ├── alices.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.c
        ├── Makefile
        ├── Makefile.am
        └── Makefile.in
    └── config
        ├── ac
        ├── ar-lib
        ├── compile
        ├── config.guess
        ├── config.sub
        ├── depcomp
        ├── install-sh
        ├── missing
        ├── config.h
        ├── config.h.in
        ├── config.log
        ├── config.status
        ├── configure
        ├── configure.ac
        └── configure.scan
            ├── lib
            │   ├── lib.c
            │   ├── lib.h
            │   ├── Makefile
            │   └── Makefile.am
            └── libtool
                ├── libtool.m4
                ├── lt-obsolete.m4
                ├── ltoptions.m4
                ├── lt sugar.m4
                └── ltversion.m4
            ├── Makefile
            ├── Makefile.am
            └── Makefile.in
        └── README
    └── stamp-hi
6 directories, 50 files
```

Tree structure of generated files including Makefile.

||: make

```
dash@dashLaptop-BMEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ make
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
Making all in lib
make[2]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
depbase= ./libtool --tag=CC --mode=compile gcc -DHAVE_CONFIG_H -I . -I .. -g -O2 -MT lib.so -MD -MP -MF $depbase.Tpo -c -o lib.lo lib.c &&
/bin/bash ./libtool --tag=CC --mode=compile gcc -DHAVE_CONFIG_H -I . -I .. -g -O2 -MT lib.lo -MD -MP -MF $depbase.Tpo -c -o lib.lo lib.c &&
mv -f $depbase.Tpo $depbase.Plo
/bin/bash ./libtool --tag=CC --mode=link gcc -g -O2 -MT lib.so -MD -MP -MF $depbase.Tlo -Llib -rpath /usr/local/lib/auto_proj_3/lib/lib
/bin/bash ./libtool --tag=CC --mode=link gcc -g -O2 -Wl,-soname -Wl,lib.so.0 -o lib.so.0.0.0
libtool: link: gcc -shared -FPIE -DPIC -Llib -o lib.so.0.0.0 -g -O2 -Wl,-soname -Wl,lib.so.0 -o lib.so.0.0.0
libtool: link: (cd "lib"; rm -f lib.so.0.0.0; ln -s lib.so.0.0.0 lib.so.0)
libtool: link: (cd "lib"; rm -f lib.so.0.0.0; ln -s lib.so.0.0.0 lib.so)
libtool: link: (cd "lib"; rm -f lib.so; ln -s lib.so.0 lib.so)
make[2]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
Making all in alice
make[2]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/alice'
gcc -DHAVE_CONFIG_H -I . -I .. -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -MT alice-alice.o -MD -MP -MF .deps/alice-alice.Tpo -c -o alice-alice.o
test -f 'alice.c' || echo "/bin/bash ./libtool --tag=CC --mode=link gcc -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -I/usr/local/include -I../lib -o alice alice-alice.o"
mv -f .deps/alice-alice.Tpo .deps/alice-alice.Po
/bin/bash ./libtool --tag=CC --mode=link gcc -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -I/usr/local/include -I../lib -o alice alice-alice.o
libtool: link: gcc -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -I/usr/local/include -I../lib -o alice alice-alice.o -L/usr/local/lib -lalice
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'
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/bob'
gcc -DHAVE_CONFIG_H -I . -I .. -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -MT bob-bob.o -MD -MP -MF .deps/bob-bob.Tpo -c -o bob-bob.o test -f 'bob.c'
test -f 'bob.c' || echo "/bin/bash ./libtool --tag=CC --mode=link gcc -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -I/usr/local/include -I../lib -o bob bob-bob.o -L/usr/local/lib -lbob
mv -f .deps/bob-bob.Tpo .deps/bob-bob.Po
/bin/bash ./libtool --tag=CC --mode=link gcc -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -I/usr/local/include -I../lib -o lib/bob bob-bob.o -L/usr/local/lib -lalice
libtool: link: gcc -Wno-implicit-function-declaration -Wextra -Wall -Wfloat-equal -Wundef -Wshadow -Wpointer-arith -Wcast-align -Wstrict-prototypes -Wstrict-overflow=5 -Wwrite-strings -Waggregate-return -Wcast-qual -Wswitch-default -Wswitch-enum -Wconversion -Wunreachable-code -Wformat=2 -g -O2 -I/usr/local/include -I../lib -o lib/bob bob-bob.o -L/usr/local/lib -lalice
libtool: link: (cd "lib"; rm -f lib.so.0.0.0; ln -s lib.so.0.0.0 lib.so)
libtool: link: (cd "lib"; rm -f lib.so; ln -s lib.so.0 lib.so)
make[2]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/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'
```

Project building.

||: make

```
jachu@LAPTOP-RMAEL4E0:/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ tree -R
.
+-- aclocal.m4
+-- alice
|   +-- alice
|   |   +-- alice-glice.o
|   |   +-- alice.h
|   |   +-- Makefile
|   |   +-- Makefile.am
|   |   +-- Makefile.in
+-- output
|   +-- output_0
|   +-- output_1
|   +-- output_2
|   +-- output_3
+-- requests
+-- traces
|   +-- traces_0
|   +-- traces_1
|   +-- traces_2
|   +-- traces_3
+-- autoscan.log
+-- bob
|   +-- bob
|   +-- bob-bob.o
|   +-- bob.c
|   +-- Makefile
|   +-- Makefile.am
|   +-- Makefile.in
+-- ar-lib
|   +-- ar-lib
|   +-- compile
|   +-- config.guess
|   +-- config.sub
|   +-- depcomp
|   +-- install-sh
|   +-- ltmain.sh
|   +-- missing
|   +-- config.h
|   +-- config.h.in
|   +-- config.status
|   +-- configure
|   +-- configure.ac
|   +-- configure.scan
+-- lib
|   +-- lib.c
|   +-- lib.h
|   +-- lib.la
|   +-- lib.lo
|   +-- Makefile
|   +-- Makefile.am
|   +-- Makefile.in
+-- libtool
+-- libtool.m4
+-- lt-obsolete.m4
+-- lt-obsolete.h4
+-- lt-sugar.m4
+-- ltversion.m4
+-- Makefile
+-- Makefile.am
+-- Makefile.in
+-- README
+-- stamp-h1
```

Tree structure of built project.

II: make install

```
dachug@LAPTOP-RMAEL4EO:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ sudo make install
[sudo] password for dachug:
Making install in lib
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'
make[2]: Leaving directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3/lib'
/bin/bash ./libtool --mode=install /usr/bin/install -c lib.so.1 '/usr/local/lib/auto_proj_3'
libtool: install: /usr/bin/install -c lib.so.0.0.0 '/usr/local/lib/auto_proj_3/lib.so.0.0.0'
libtool: install: (cd /usr/local/lib/auto_proj_3 && { ln -s f lib.so.0.0 lib.so.0 || { rm -f lib.so.0 && ln -s lib.so.0.0 lib.so; } })
libtool: install: (cd /usr/local/lib/auto_proj_3 && { rm -f lib.so.0.0.0 lib.so.0.0 || { rm -f lib.so && ln -s lib.so.0.0 lib.so; } })
libtool: install: PATH=/usr/local/sbin:/usr/local/bin:/bin:/sbin:/usr/bin:/snap/bin:sbin" ldconfig -n /usr/local/lib/auto_proj_3
libtool: finish: PATH=/usr/local/sbin:/usr/local/bin:/bin:/sbin:/usr/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 --rpath option on every call to libtool or set the LIBDIR
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'
Making install in alice
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'
libtool: install: /usr/bin/install -c alice '/usr/local/bin/auto_proj_3'
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'
Making install in bob
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'
/lib/bin/.../libtool --mode=install /usr/bin/install -c bob '/usr/local/bin/auto_proj_3'
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 -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'
dachug@LAPTOP-RMAEL4EO:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls -l /usr/local/bin/auto_proj_3/
alice bob
dachug@LAPTOP-RMAEL4EO:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls -l /usr/local/lib/auto_proj_3/
lib.so.0 lib.so.0.0.0 lib.so.0.0.0
dachug@LAPTOP-RMAEL4EO:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls -l /usr/local/include/auto_proj_3/
lib.h
```

Execution result and installed files.

II: make uninstall

```
lachulu@LAPTOP-RMAE14E0:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ sudo make uninstall
make[1]: Entering directory '/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3'
rm -f /usr/local/lib/auto_proj_3/lib.so
libtool: uninstall: rm -f /usr/local/lib/auto_proj_3/lib.so.0.0.0 /usr/local/lib/auto_proj_3/lib.so.0 /usr/local/lib/auto_proj_3/lib.so
(cd '/usr/local/include/auto_proj_3' && rm -f 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'
(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'
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'
make[1]: 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'
lachulu@LAPTOP-RMAE14E0:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls -l /usr/local/bin/auto_proj_3/
lachulu@LAPTOP-RMAE14E0:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls /usr/local/lib/auto_proj_3/
lachulu@LAPTOP-RMAE14E0:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ ls /usr/local/include/auto_proj_3/
lachulu@LAPTOP-RMAE14E0:~/mnt/d/Note_Database/Subject/ACN_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3$ rm -rf ./lib ./include ./bin
```

Removing all installed files.

III: make clean

```
dachu@LAPTOP-RMAEL4EO:/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 -f 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 -f 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

```
[root@LAPTOP-RMAEL4E0:/mnt/d>Note_Database/Subject/ACH_Advanced_Computer_Networking/autotools_intro/proj/auto_proj_3]$ tree -R
.
└── aclocal.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
    └── autoscan.log
        ├── bob.c
        ├── Makefile
        ├── Makefile.am
        └── Makefile.in
    └── libltdl
        ├── ar-ltdl
        ├── config
        ├── config.guess
        ├── config.sub
        ├── depcomp
        ├── install-sh
        └── ltmain.sh
            ├── missing
            ├── config.h
            ├── config.h.in
            ├── config.log
            ├── config.status
            ├── configure
            ├── configure.ac
            └── configure.scan
                ├── ltlib.c
                ├── ltlib.h
                ├── Makefile
                ├── Makefile.am
                └── Makefile.in
    └── libtool
        ├── libtool.l.m4
        ├── lt-obsolete.m4
        ├── ltoptions.m4
        ├── ltSugar.m4
        └── ltversion.m4
        ├── Makefile
        ├── Makefile.am
        └── Makefile.in
    └── README
    └── stamp-h1
5 directories, 58 files
```

Tree structure after execution.

III: make distclean

```
dachu@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 -rf _src_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 -f 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 -f 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
    ├── elice.c
    └── Makefile.am
        └── Makefile.in
.
└── output
    ├── 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
.
└── lib
    ├── ar-lib
    ├── compile
    ├── config.guess
    ├── config.sub
    ├── depcomp
    ├── install-sh
    ├── ltmain.sh
    ├── missing
    ├── config.h.in
    ├── configure
    ├── configure.ac
    └── configure.scan
.
└── lib
    ├── ltb.c
    ├── ltb.h
    ├── Makefile.am
    └── Makefile.in
.
└── liblbt
    ├── liblbttool.m4
    ├── lt-obsolete.m4
    ├── ltoptions.m4
    ├── ltSugar.m4
    └── ltVersion.m4
.
└── Makefile.am
    └── Makefile.in
.
└── README
6 directories, 41 files
```

Tree structure after execution.

Table of Contents

- 1 Example C project
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- 4 Autotools demo
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 - Phase III: Prepare for distribution
- 5 Issues when compiling from sources
 - Distinguish build systems
 - Resolve dependency issue

Compile from source process

After the distribution source is found, follows the following steps to compile.

- ① Find installing steps in `readme.md`, `README`, or `INSTALL`.
- ② If not, find `configure` to execute.
- ③ If not, find custom installing scripts like `bootstrap`, `autogen` often in *Bash* or *Shell* syntax.
- ④ If not, find corresponding configuration files of each build systems. If identified, use the convention compiling commands.
- ⑤ In the build process, the build system might inform about missing dependency. Find the distribution source and repeat the process.

Example: pcre2

The screenshot shows the GitHub repository page for pcre2. The repository has 1,622 commits, 31 watching, and 185 forks. The most recent commit, "Implement PCRE2_UNREACHABLE assertion for MS Visual C_...", was made 17 hours ago. The repository has 883 stars and is public. It includes sections for About, Releases (with PCRE2-10.44), Packages, Contributors (47), and Deployments (481). The commit list is shown below:

File	Description	Time Ago
CMakelists.txt	Implement PCRE2_UNREACHABLE assertion for MS Visual C_...	17 hours ago
COPYING	Fix erroneous COPYING file.	9 years ago
BUILD.bazel	Remove pcre2_upctables.c from explicit building by Bazel an...	last year
AUTHORS	File fixes for 10.43	7 months ago
132html	Add a TH (title) macro to pcre2demo3 (#292)	last year
.gitmodules	Use sijt as a submodule (#443)	3 weeks ago
.gitignore	update build.zig to support zig 0.13.0 (#416)	3 months ago
.bazelrc	bazel support (#136)	2 years ago
testdata	Guard against out-of-bounds memory access when parsing --...	5 days ago
vms	Add assertion macros. use new PCRE2_UNREACHABLE assertio...	2 weeks ago
src	Silence one warning in pcre2test code (when compiled with ..	17 hours ago
maint	Make maint/RunPerlTest public	3 weeks ago
doc	Update documentation for acan substring patterns - now su...	last week
ms4	build: improve portability of assertions (#452)	4 days ago
deps	Use sijt as a submodule (#443)	3 weeks ago
github/workflows	ci: make clang dev job failures fatal (#461)	last week
alexneward	Silence one warning in pcre2test code (when compiled with ..	17 hours ago

Example: pcre2

https://github.com/pcre2Project/pcre2

File	Description	Last Commit
132html	Add a TH (title) macro to pcre2demo3 (#292)	last year
AUTHORS	File tidy for 10.43	7 months ago
BUILD.bazel	Remove pcre2_uictables.c from explicit building by Bazel an...	last year
CMakeLists.txt	Implement PCRE2_UNREACHABLE assertion for MS Visual C...	17 hours ago
COPYING	Fix erroneous COPYING file.	9 years ago
ChangeLog	Fix non-recognition of some octal escapes in substitute repl...	last week
CheckMan	Fix documentation typos and upgrade documentation check...	4 years ago
CleanTxt	Documentation scripts	10 years ago
Detrail	Documentation scripts	10 years ago
HACKING	Update documentation for scan_substring; also some code t...	2 weeks ago
LICENCE	File tidy for 10.43	7 months ago
MODULE.bazel	bazel support (#136)	2 years ago
Makefile.am	build: improve portability of assertions (#452)	4 days ago
NEWS	Final file tidy for 10.44	3 months ago
NON-AUTOTOOLS-BUILD	autotools fix --enable-jit+auto (#454)	last week
PrepareRelease	build: improve portability of assertions (#452)	4 days ago
README	build: improve portability of assertions (#452)	4 days ago
README.md	More GitHub URL updates	2 years ago
RunGrepTest	Fix oversight in RunGrepTest in 10.45/2 fix broken in "make ...	2 weeks ago
RunGrepTest.bat	Add --disable-pcre2grep-callout-fork configuration setting.	6 years ago
RunTest	Code for variable-length lookbehinds	last year
RunTest.bat	windows update CI to make test errors visible (#419)	3 months ago
WORKSPACE.bazel	bazel support (#136)	2 years ago
autogen.sh	Add basic configuration files.	11 years ago
build.vsix	candidate build.vsix for download (#170) (PR #170)	3 months ago

Contributors: 33 contributors

Deployments: 481

github-pages: 16 hours ago

480 deployments

Languages:

- C 67.0%
- Shell 3.4%
- Python 1.9%
- M4 1.2%
- CMake 1.7%
- Batchfile 1.5%
- Other 2.7%

Example: pcre2

REALME.md	More GitHub URL updates	2 years ago
RunGrepTest	Fix oversight in RunGrepTest in 1045/2 fix broken in "make ..	2 weeks ago
RunGrepTest.bat	Add --disable-pcre2grep-callout-fork configuration setting.	6 years ago
RunTest	Code for variable-length lookbehinds	last year
RunTest.bat	windows update CI to make test errors visible (#419)	3 months ago
WORKSPACE.bazel	bazel support (#136)	2 years ago
autogen.sh	Add basic configuration files.	11 years ago
build.zig	update build.zig to support zig 0.13.0 (#416)	3 months ago
config-cmake.h.in	Implement PCRE2_UNREACHABLE assertion for MS Visual C...	17 hours ago
configure.ac	Implement PCRE2_UNREACHABLE assertion for MS Visual C...	17 hours ago
index.md	More GitHub URL updates	2 years ago
libpcre2-16.pc.in	Fix Windows debug builds (Bugzilla #2600) using CMake.	4 years ago
libpcre2-32.pc.in	Fix Windows debug builds (Bugzilla #2600) using CMake.	4 years ago
libpcre2-8.pc.in	Fix Windows debug builds (Bugzilla #2600) using CMake.	4 years ago
libpcre2-posix.pc.in	windows: integrate visibility attributes without conflicts (#249)	last year
pcre2-config.in	Prefer PCRE2POSIX_SHARED to PCRE2_STATIC for pcre2posix.	last year
pore2_fuzzer.dict	Commit an experimental fuzzer dictionary.	7 years ago
pore2_fuzzer_options	Set max length for fuzzer input in an attempt to get rid of ls...	4 months ago
pore2_fuzzer_16.dict	Fuzzer: fix JIT fuzzing (#322)	7 months ago
pore2_fuzzer_16.options	Set max length for fuzzer input in an attempt to get rid of ls...	4 months ago
pore2_fuzzer_32.dict	Fuzzer: fix JIT fuzzing (#322)	7 months ago
pore2_fuzzer_32.options	Set max length for fuzzer input in an attempt to get rid of ls...	4 months ago
perftest.sh	Code for variable-length lookbehinds	last year
README	License	License

Example: pcre2

The above project structure is an example of source code distribution for development. Boxed files might not exist in the release version, and some new files might appear. Therefore, the same analysis on how to build the project should be done in the same way but after uncompressed the distributed software.

The pcre2 example should actually be compiled with the following commands:

```
1 #!/bin/bash
2
3 ./configure --prefix=/opt --exec-prefix=/opt
4 make -j4
5 make -j4 install
```

Code to compile lib pcre2 with custom flags.

Exercise: Build pcre2

Step 1: Find the distribution.

The screenshot shows a web browser window on an Ubuntu 64-bit 23.04 desktop. The URL is https://github.com/PCRE2Project/pcre2/releases. The page displays the 'PCRE2-10.44' release, which was published on Jun 7 by Philip Hazel. The release notes state: "This is mostly a bug-fix and tidy-up release. An explicit limit can now be set on the size of a compiled pattern." Below the notes, there is a table of assets:

Asset	Size	Published
pcre2-10.44.tar.bz2	1.84 MB	Jun 7
pcre2-10.44.tar.bz2.sig	310 Bytes	Jun 7
pcre2-10.44.targz	2.49 MB	Jun 7
pcre2-10.44.tar.gz.sig	310 Bytes	Jun 7
pcre2-10.44.zip	2.7 MB	Jun 7
pcre2-10.44.zip.sig	310 Bytes	Jun 7
Source code (zip)	310 Bytes	Jun 7
Source code (tar.gz)	310 Bytes	Jun 7

Below the table, it says "9 people reacted". The browser interface includes a search bar, a notifications icon, and a sign-in link.

Exercise: Build pcre2

Step 2: Copy the download link. (for downloading)

The screenshot shows a web browser window displaying the GitHub release page for the pcre2 project. The URL in the address bar is <https://github.com/PCRE2Project/pcre2/releases>. The main content area shows the 'PCRE2-10.44' release, which is described as a bug-fix and tidy-up release. Below this, there is a table of assets:

Asset	Size	Last Modified
pcre2-10.44.tar.bz2	1.84 MB	Jun 7
pcre2-10.44.tar.bz2.sig	310 Bytes	Jun 7
pcre2-10.44.tar.gz	2.43 MB	Jun 7
pcre2-10.44.tar.gz	310 Bytes	Jun 7
pcre2-10.44.zip	2.7 MB	Jun 7
pcre2-10.44.zip.sig	310 Bytes	Jun 7
Source code (ZIP)	Bookmark Link...	
Source code (TAR.GZ)	Save Link As...	
Source code (TAR)	Save Link to Pocket	
Copy Link	Copy Link	
Search Google for "pcre2-10.44.tar..."	Inspect (Q)	

A context menu is open over the first row of the table, specifically over the link for 'pcre2-10.44.tar.bz2'. The 'Copy Link' option is highlighted in the menu.

Exercise: Build pcre2

Step 3: Download the compressed source code.

```
Ubuntu 64-bit 23.04 (Desktop) 61 - VMware Workstation 17 Player (Non-commercial use only)
Player 11:17:11 ④
user@test:~/Downloads$ wget https://github.com/PCREProject/pcre2/releases/download/pcre2-18.44/pcre2-18.44.tar.gz
--2024-09-11 17:18:49.. https://github.com/PCREProject/pcre2/releases/download/pcre2-18.44/pcre2-18.44.tar.gz
Resolving github.com (github.com)... 28.27.177.113
Connecting to github.com (github.com)[28.27.177.113]:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://objects.githubusercontent.com/github-production-release-asset-2e65be/398251321/6477f166-a346-426b-b835-9add986e527c?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=releaseassetproduction%2F20240911%2Fus-east-1%2F53%2Faws4_request&X-Amz-Date=20240911T091034Z&X-Amz-Expires=3008X-Amz-Signature=fffafaf8941c370361b6a0e75cf4019ca1d920a8bc2e5d0de93df428X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=398251321&response-content-disposition=attachment&XBN20filename=30pcre2-18.44.tar.gz&response-content-type=application/x-facet-stream [following]
--2024-09-11 17:18:49.. https://objects.githubusercontent.com/github-production-release-asset-2e65be/398251321/6477f166-a346-426b-b835-9add986e527c?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=releaseassetproduction%2F20240911%2Fus-east-1%2F53%2Faws4_request&X-Amz-Date=20240911T091034Z&X-Amz-Expires=3008X-Amz-Signature=fffafaf8941c370361b6a0e75cf4019ca1d920a8bc2e5d0de93df428X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=398251321&response-content-disposition=attachment&XBN20filename=30pcre2-18.44.tar.gz&response-content-type=application/x-facet-stream
Resolving objects.githubusercontent.com (objects.githubusercontent.com)... 185.199.110.133, 185.199.109.133, 185.199.108.133, ...
Connecting to objects.githubusercontent.com (objects.githubusercontent.com)|185.199.110.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 2552792 (2.4M) [application/octet-stream]
Saving to: 'pcre2-18.44.tar.gz'

pcre2-18.44.tar.gz          100%[=====]  2.43M  6.38MB/s   in 0.4s

2024-09-11 17:18:50 (6.38 MB/s) - 'pcre2-18.44.tar.gz' saved [2552792/2552792]
user@test:~/Downloads$
```

Exercise: Build pcre2

Step 4: Create a directory with custom naming and uncompress the source code into it. Notice that there are binary **./configure** existed, and can be used for building.

```
user@test:~/Downloads$ wget https://github.com/PCRE2Project/pcre2/releases/download/pcre2-10.44/pcre2-10.44.tar.gz
--2024-09-11 17:15:22.  https://github.com/PCRE2Project/pcre2/releases/download/pcre2-10.44/pcre2-10.44.tar.gz
Resolving github.com (github.com)... 20.27.177.113
Connecting to github.com (github.com)|20.27.177.113|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://objects.githubusercontent.com/github-production/release-asset/2e65be3/398251321/6477f166-a346-426b-bd35-9add986e527c?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=releaseasset@production%2F20240911%2Fus-east-1%2F3%2Faws4_request&X-Amz-Date=20240911T091523Z&X-Amz-Expires=3088X-Amz-Signature=3627df11c2366341cd46695e458c9dcbe100c3148f8dbbd65e64da29c482091b8X-Amz-SignedHeaders=host&actor_id=398251321&response-content-disposition=attachment%3B%20filename%3Dpcre2-10.44.tar.gz&response-content-type=application/x-tar&response-content-encoding=deflate
[following]
? [? ] 2024-09-11 17:15:22.000000000 http://objects.githubusercontent.com (objects.githubusercontent.com) | 185.199.100.133, 185.199.111.133, 185.199.110.133 ...
HTTP request sent, awaiting response... 200 OK
Length: 2552792 (2.4M) [application/octet-stream]
Saving to: 'pcre2-10.44.tar.gz'

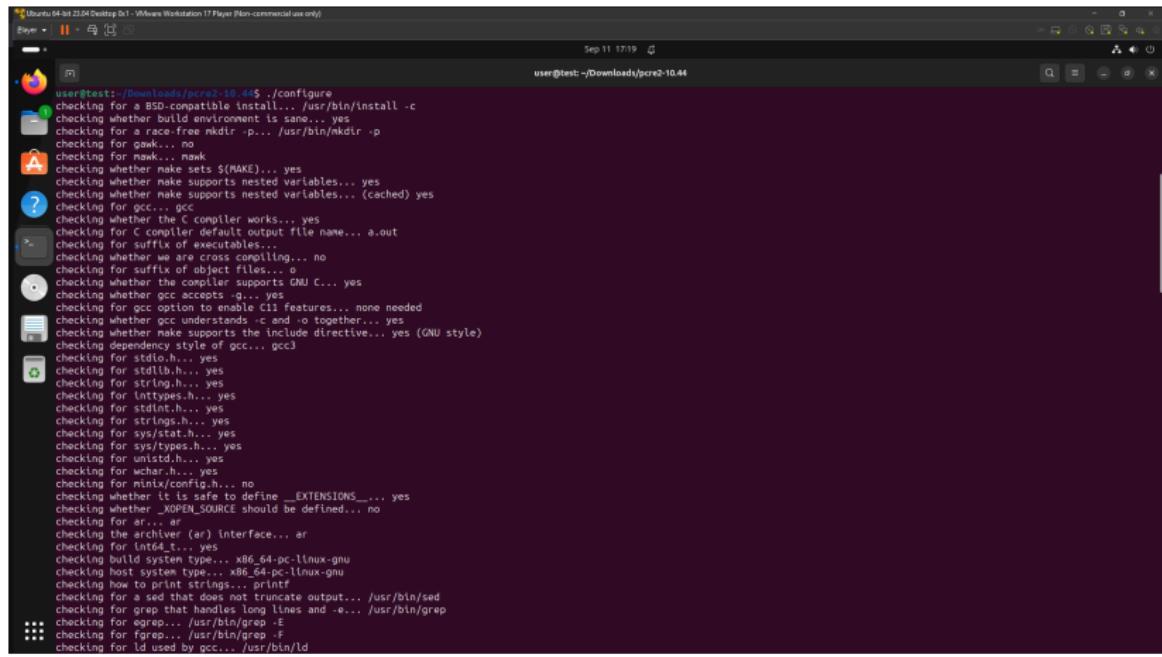
pcre2-10.44.tar.gz 100%[=====] 2.43M 5.68MB/s in 0.4s

2024-09-11 17:15:24 (5.68 MB/s) . 'pcre2-10.44.tar.gz' saved [2552792/2552792]

user@test:~/Downloads$ mkdir pcre2-10.44
user@test:~/Downloads$ tar xf pcre2-10.44.tar.gz -C pcre2-10.44 --strip-components=1
1333 files, 0 Changelog, 0 Checklists.txt, config.sub, depcomp, INSTALL, libpcre2-8.pc.in, md, NEWS, PrepareRelease, RunTest, test-driver
eLocal.m4, CheckManifest, config, configure, Detrell, install-sh, libpcre2-2-posix.pc.in, Makefile.am, NON-AUTOTOOLS-BUILD, README, RunTest.bat
ar.lib, CleanTxt, config-cmake.h, in configure.ac, doc, libpcre2-16.pc.in, LICENSE, Makefile.in, pcre2-config.ln, RunGrepTest, src, vms
AUTHORS, create, config.guess, COPYING, HACKING, libpcre2-32.pc.in, ltmain.sh, missing, perltest.sh, RunGrepTest.bat, testdata
user@test:~/Downloads$
```

Exercise: Build pcre2

Step 5: Execute ./configure to configure files for building.

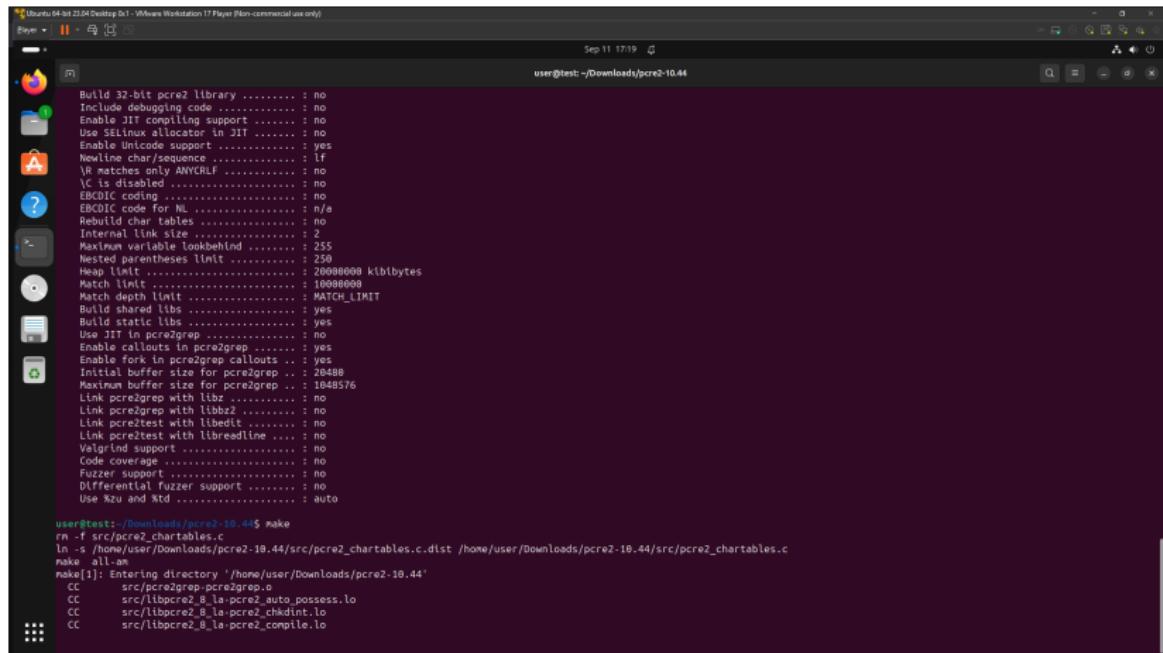


The screenshot shows a terminal window on a Linux desktop environment. The title bar indicates it's a 64-bit desktop session in VMware Workstation 17 Player. The command entered is `./configure`. The terminal output shows the configuration process for pcre2 version 10.44, displaying numerous checks for various system headers and tools like gawk, make, gcc, and grep, all of which pass with a 'yes' response.

```
user@test:~/Downloads/pcre2-10.44$ ./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... no
checking for mawk... mawk
checking whether make sets $(MAKE)... yes
checking whether make supports nested variables... yes
checking whether make supports nested variables... (cached) yes
checking for gcc... gcc
checking whether the compiler works... yes
checking for the 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 whether make supports the include directive... yes (GNU style)
checking dependency style of gcc... gcc3
checking for stat.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 for sys/unistd.h... yes
checking for wchar.h... yes
checking for minix/config.h... no
checking whether it is safe to define __EXTENSIONS__... yes
checking whether __XOPEN_SOURCE should be defined... no
checking for rcs_id
checking the archiver (ar) interface... ar
checking for Int64.t... yes
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 set 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
```

Exercise: Build pcre2

Step 6: Make sure no error is shown in the output and execute make to build

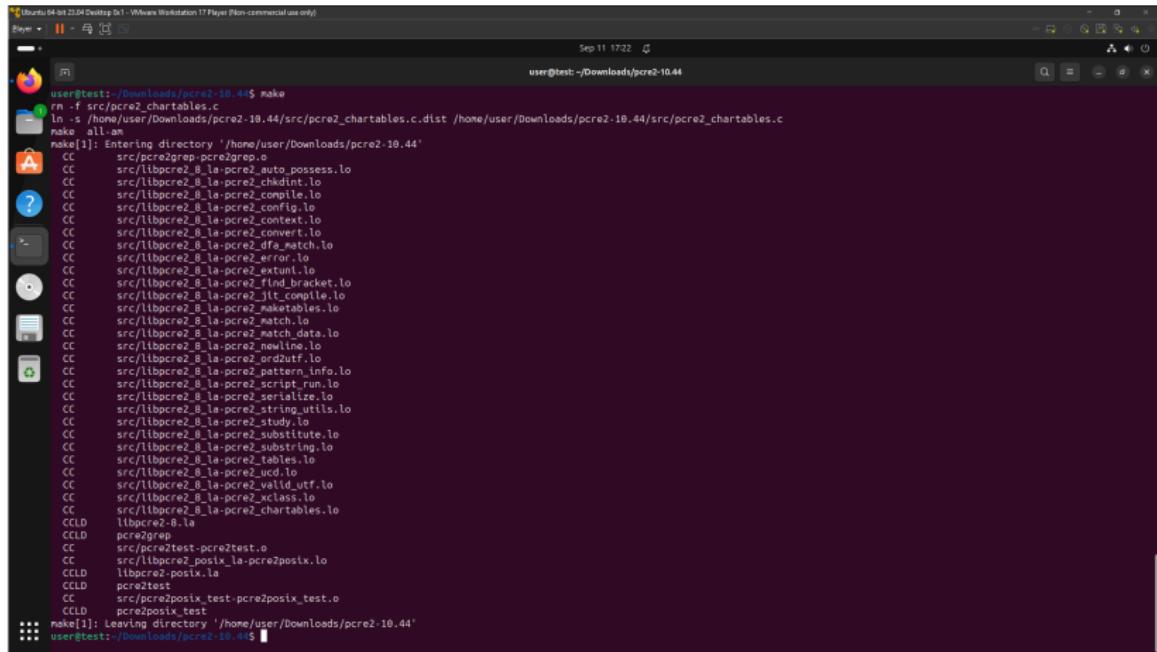


The screenshot shows a terminal window on an Ubuntu 64-bit desktop environment. The title bar indicates it is running in VMware Workstation 17 Player. The terminal displays the configuration and build process for the pcre2 library version 10.44.

```
Build 32-bit pcre2 library ..... : no
Include debugging code ..... : no
Enable JIT compiling support ..... : no
Use SELinux allocator in JIT ..... : no
Enable Unicode support ..... : yes
Newline char/sequence ..... : lf
\R matches only ANYCRLF ..... : no
\C is disabled ..... : no
EBCDIC coding ..... : no
ED0102 encoding for NL ..... : n/a
Rebuild char tables ..... : no
Internal link size ..... : 2
Maximum variable lookbehind ..... : 255
Nested parentheses limit ..... : 250
Heap limit ..... : 20000000 kbytes
Match limit ..... : 10000000
Match depth limit ..... : MATCH_LIMIT
Build shared libs ..... : yes
Build static libs ..... : yes
Use C++ in pcre2grep ..... : no
Enable exec() in pcre2grep ..... : yes
Enable fork() in pcre2grep callouts ..... : yes
Initial buffer size for pcre2grep ..... : 2048B
Maximum buffer size for pcre2grep ..... : 1048576
Link pcre2grep with libbz ..... : no
Link pcre2grep with libbz2 ..... : no
Link pcre2test with libedit ..... : no
Link pcre2test with libreadline ..... : no
Valgrind support ..... : no
Code coverage ..... : no
Fuzzer support ..... : no
Differential fuzzer support ..... : no
Use RZU and std ..... : auto

user@test:~/Downloads/pcre2-10.44$ make
rn -f src/pcre2_chartables.c
ln -s /home/user/Downloads/pcre2-10.44/src/pcre2_chartables.c.dist /home/user/Downloads/pcre2-10.44/src/pcre2_chartables.c
make all-am
make[1]: Entering directory '/home/user/Downloads/pcre2-10.44'
CC    src/pcre2grep-pcre2grep.o
CC    src/libpcre2_8_la-pcre2_auto_posess.lo
CC    src/libpcre2_8_la-pcre2_chkdint.lo
CC    src/libpcre2_8_la-pcre2_compile.lo
```

Exercise: Build pcre2



The screenshot shows a terminal window on an Ubuntu 64-bit 23.04 desktop. The title bar reads "Ubuntu 64-bit 23.04 Desktop - VMware Workstation 17 Player [Non-commercial use only]". The terminal window has a dark background and displays the following command-line session:

```
user@test:/Downloads/pcre2-10.44$ make
rn -f src/pcre2_chartables.c
ln -s /home/user/Downloads/pcre2-10.44/src/pcre2_chartables.c.dist /home/user/Downloads/pcre2-10.44/src/pcre2_chartables.c
make all-am
make[1]: Entering directory '/home/user/Downloads/pcre2-10.44'
  CC  src/pcre2grep-pcre2grep.o
  CC  src/libpcre2_8_la-pcre2_posix.lo
  CC  src/libpcre2_8_la-pcre2_chdrnt.lo
  CC  src/libpcre2_8_la-pcre2_compile.lo
  CC  src/libpcre2_8_la-pcre2_config.lo
  CC  src/libpcre2_8_la-pcre2_context.lo
  CC  src/libpcre2_8_la-pcre2_convert.lo
  CC  src/libpcre2_8_la-pcre2_dfa_match.lo
  CC  src/libpcre2_8_la-pcre2_error.lo
  CC  src/libpcre2_8_la-pcre2_extuni.lo
  CC  src/libpcre2_8_la-pcre2_find_bracket.lo
  CC  src/libpcre2_8_la-pcre2_jit_compile.lo
  CC  src/libpcre2_8_la-pcre2_jit_exec.lo
  CC  src/libpcre2_8_la-pcre2_match.lo
  CC  src/libpcre2_8_la-pcre2_match_data.lo
  CC  src/libpcre2_8_la-pcre2_newline.lo
  CC  src/libpcre2_8_la-pcre2_ord2utf.lo
  CC  src/libpcre2_8_la-pcre2_pattern_info.lo
  CC  src/libpcre2_8_la-pcre2_script_run.lo
  CC  src/libpcre2_8_la-pcre2_serialize.lo
  CC  src/libpcre2_8_la-pcre2_string_utils.lo
  CC  src/libpcre2_8_la-pcre2_study.lo
  CC  src/libpcre2_8_la-pcre2_substitute.lo
  CC  src/libpcre2_8_la-pcre2_substring.lo
  CC  src/libpcre2_8_la-pcre2_table.lo
  CC  src/libpcre2_8_la-pcre2_ucd.lo
  CC  src/libpcre2_8_la-pcre2_valid_utf.lo
  CC  src/libpcre2_8_la-pcre2_xclass.lo
  CC  src/libpcre2_8_la-pcre2_chartables.lo
  CC LD libpcre2_8_la
  CC LD pcre2grep
  CC  src/pcre2test-pcre2test.o
  CC  src/libpcre2_posix_la-pcre2posix.lo
  CC LD libpcre2_posix_la
  CC LD pcre2test
  CC  src/pcre2posix_test-pcre2posix_test.o
  CC LD pcre2posix_test
make[1]: Leaving directory '/home/user/Downloads/pcre2-10.44'
```

Result of building pcre2.

Exercise: Build json-c

Step 1: Download, uncompress, and examine the content of the project.

The screenshot shows a terminal window with two tabs. The left tab shows the command to download the project from GitHub:

```
user@test:~/Downloads$ wget https://github.com/json-c/json-c/archive/refs/tags/json-c-0.17-20230812.tar.gz
```

The right tab shows the extracted directory structure:

```
user@test:~/Downloads/jsonc-0.17
```

```
user@test:~/Downloads/jsonc-0.17$ ls
```

File/Folder	Description
abi-check.sh	Script for ABI compatibility checks
Android.configure.mk	Makefile configuration for Android
MakeLists.txt	Top-level CMakeLists.txt file
appveyor.yml	YAML configuration for AppVeyor CI
COPYING	License file (MIT License)
arraylist.c	Implementation of an array list
debug.c	Implementation of a debug logger
arraylist.h	Header for the array list
debug.h	Header for the debug logger
json-config.h.in	Template header for JSON configuration
AUTHORS	Contributor list
doc	Documentation directory
bench	Benchmarking script
fuzz	Fuzz testing script
INSTALL	Installation instructions
ChangeLog	Change log file
json-c.sym	Symfony configuration file
json_c_version.c	Implementation of the JSON C version
json_c_version.h	Header for the JSON C version
issues_closed_for_0.13.nd	Issue tracking report for 0.13
issues_closed_for_0.14.nd	Issue tracking report for 0.14
issues_closed_for_0.15.nd	Issue tracking report for 0.15
issues_closed_for_0.16.nd	Issue tracking report for 0.16
issues_closed_for_0.17.nd	Issue tracking report for 0.17
json_object.c	Implementation of the JSON object
json_object.h	Header for the JSON object
json_object_private.h	Private header for the JSON object
json_patch.c	Implementation of the JSON patch
json_patch.h	Header for the JSON patch
json_vlist.c	Implementation of the JSON vlist
json_vlist.h	Header for the JSON vlist
json_pointer.c	Implementation of the JSON pointer
json_pointer.h	Header for the JSON pointer
ltbjson.c	Implementation of the JSON pointer
ltbjson.h	Header for the JSON pointer
linkhash.c	Implementation of the linkhash
linkhash.h	Header for the linkhash
json_object_private.h	Private header for the JSON object
json_objecter.c	Implementation of the JSON objecter
json_tokerer.h	Header for the JSON objecter
math_compat.h	Math compatibility header
RELEASE_CHECKLIST.txt	Release checklist
NENS	National Engineering News Service
sprintf_compat.h	Sprintf compatibility header
strdup_compat.h	Strdup compatibility header
printbuf.h	Printbuf header
random_seed.c	Random seed generation
random_seed.h	Random seed header
README	Project README
README.html	HTML version of the README
tests	Test suite directory
vasprintf_compat.h	Vasprintf compatibility header
README.md	Markdown version of the README

Exercise: Build json-c

Step 2: Check INSTALL and README.md for installation steps.

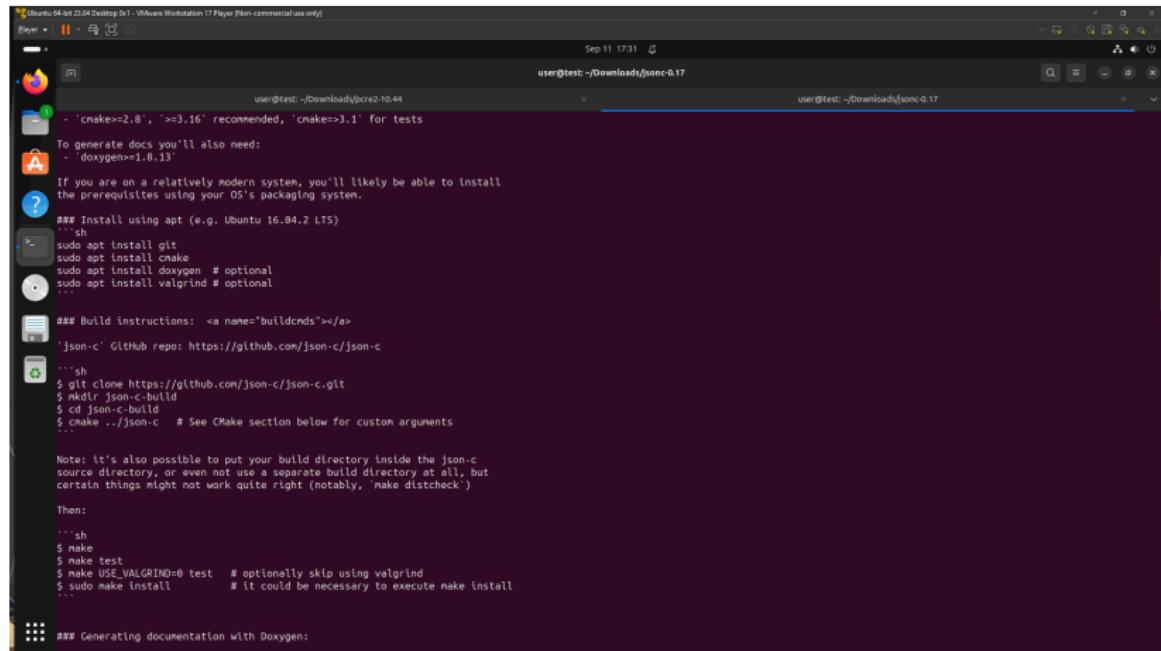
The screenshot shows a terminal window on an Ubuntu 64-bit 23.04 desktop. The user is navigating through the json-c source code directory and running build commands. The terminal output includes:

```
user@test:~/Downloads/jsonc-0.17$ cd jsonc-0.17 && ls
abl-check.sh    json_c_version.c      json_patch.c      json_util.h      printbuf.h      strerror_override.c
Android.configure.json  json_c_version.h  json_patch.h     json_visit.c   random_seed.c  strerror_override.h
apk              json_inttypes.h      json_pointer.c  json_visit.h   random_seed.h  STYLE.txt
appveyor.yml    json_inttypes.h      json_pointer.h  json_tokener.c libjson.c      tests
COPYING         json_object.c       json_pointer_private.h linkhash.c  README.html  vasprintf_compat.h
arraylist.c     json_object.c       json_object_iterator.c json_tokener.c linkhash.h  README.nd
arraylist.h     json_object.h      json_object_iterator.h json_types.h  NEWS          sprintf_compat.h
AUTHORS        json_object.h      json_object_private.h json_util.c   printbuf.c   strdup_compat.h
docs           json_config.h      json_object_private.h
bench           json_config.h      json_object_private.h
fuzz            json_c_ocin.h     json_object_private.h
ChangeLog      INSTALL          json_c_sym.h      json_util.c
user@test:~/Downloads/jsonc-0.17$ cat INSTALL
See README.md for installation instructions.
user@test:~/Downloads/jsonc-0.17$ cat README.md
\mainpage
[json-c]
-----
1. [Overview and Build Status](#overview)
2. [Getting Help](#gettinghelp)
3. [Building on Unix](#buildunix)
  * [Prerequisites](#installprereq)
  * [Build Commands](#buildcmds)
4. [CMake Options](#cmake)
5. [Testing](#testing)
6. [Building with vcpkg](#buildvcpkg)
  * [Android](#android)
7. [Linking to libjson-c](#linking)
8. [Using json-c](#using)

JSON-C - A JSON implementation in C <a name="overview"></a>
-----
JSON-C implements a reference counting object model that allows you to easily construct JSON objects in C, output them as JSON formatted strings and parse JSON formatted strings back into the C representation of JSON objects. It aims to conform to [RFC 8259](https://www.rfc-editor.org/rfc/rfc8259).
```

Exercise: Build json-c

Step 3: Locate official installation steps.



The screenshot shows a terminal window with two tabs. The left tab displays build instructions for json-c, and the right tab shows the command to clone the repository. The terminal is running on an Ubuntu 64-bit desktop environment.

```
user@test:~/Downloads/jsonc-0.17$ git clone https://github.com/json-c/json-c
Cloning into 'json-c'...
remote: Counting objects: 100, done.
remote: Total 100 (delta 0), reused 0 (delta 0), pack-reused 100
Unpacking objects: 100% (100/100), done.
user@test:~/Downloads/jsonc-0.17$ cd json-c
user@test:~/Downloads/jsonc-0.17$ ./configure
user@test:~/Downloads/jsonc-0.17$ make
user@test:~/Downloads/jsonc-0.17$ sudo make install
user@test:~/Downloads/jsonc-0.17$ cd ..
user@test:~/Downloads$ ls
json-c  json-c-0.17  json-c-0.17.tar.gz
```

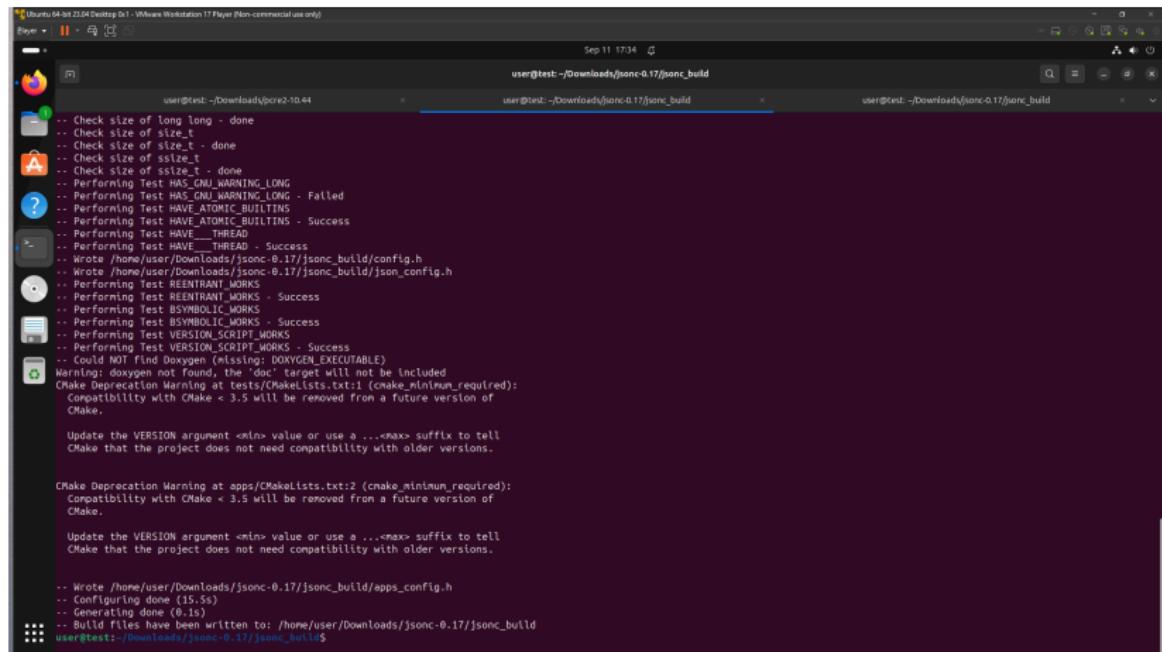
Terminal content (Left Tab):

```
user@test: ~/Downloads/jsonc-0.17$ cmake >=2.8', '>=3.16' recommended, 'cmake>=3.1' for tests
To generate docs you'll also need:
- 'doxygen>=1.0.13'
If you are on a relatively modern system, you'll likely be able to install the prerequisites using your OS's packaging system.
## Install using apt (e.g. Ubuntu 16.04.2 LTS)
...sh
sudo apt install git
sudo apt install cmake
sudo apt install doxygen # optional
sudo apt install valgrind # optional
...
## Build instructions: <a name="builddnld"></a>
'json-c' GitHub repo: https://github.com/json-c/json-c
...sh
$ git clone https://github.com/json-c/json-c.git
$ mkdir json-c-build
$ cd json-c-build
$ cmake .. /json-c # See CMake section below for custom arguments
...
Note: it's also possible to put your build directory inside the json-c source directory, or even not use a separate build directory at all, but certain things might not work quite right (notably, 'make distcheck')

Then:
...sh
$ make
$ make test
$ make USE_VALGRIND=0 test # optionally skip using valgrind
$ sudo make install # it could be necessary to execute make install
...
### Generating documentation with Doxygen:
```

Exercise: Build json-c

Step 4: Follows the installation steps.



The screenshot shows a terminal window with three tabs open, all running under the user 'test' on an Ubuntu 64-bit 22.04 desktop. The tabs are:

- user@test: ~/Downloads/brc2-10.44
- user@test: ~/Downloads/jsonc-0.17/jsonc_build
- user@test: ~/Downloads/jsonc-0.17/jsonc_build

The terminal output for the second tab (the main build directory) shows the following build process:

```
-- Check size of long long - done
-- Check size of size_t
-- Check size of size_t - done
-- Check size of ssize_t
-- Check size of ssize_t - done
-- Performing Test HAS_GNU_WARNING_LONG
-- Performing Test HAS_GNU_WARNING_LONG - Failed
-- Performing Test HAVE_ATOMIC_BUILTLINS
-- Performing Test HAVE_ATOMIC_BUILTLINS - Success
-- Performing Test HAVE_THREADS
-- Performing Test HAVE_THREADS - Success
-- Wrote '/home/user/Downloads/jsonc-0.17/jsonc_build/config.h'
-- Wrote '/home/user/Downloads/jsonc-0.17/jsonc_build/jsonc_config.h'
-- Performing Test REENTRANT_WORKS
-- Performing Test REENTRANT_WORKS - Success
-- Performing Test BSYMBOLIC_WORKS
-- Performing Test BSYMBOLIC_WORKS - Success
-- Performing Test VERSION_SCRIPT_WORKS
-- Performing Test VERSION_SCRIPT_WORKS - Success
-- Could NOT find Doxygen (Missing: DOXYGEN_EXECUTABLE)
Warning: doxygen not found, the doc target will not be included
CMake Deprecation Warning at tests/CMakeLists.txt:1 (cmake_minimum_required):
  Compatibility with CMake < 3.5 will be removed from a future version of
  CMake.

Update the VERSION argument <min> value or use a ...<max> suffix to tell
CMake that the project does not need compatibility with older versions.

CMake Deprecation Warning at apps/CMakeLists.txt:2 (cmake_minimum_required):
  Compatibility with CMake < 3.5 will be removed from a future version of
  CMake.

Update the VERSION argument <min> value or use a ...<max> suffix to tell
CMake that the project does not need compatibility with older versions.

-- Wrote '/home/user/Downloads/jsonc-0.17/jsonc_build/apps_config.h'
-- Configuring done (15.5s)
-- Generating done (0.1s)
-- Build files have been written to: /home/user/Downloads/jsonc-0.17/jsonc_build
```

The third tab shows the command being run: `user@test:~/Downloads/jsonc-0.17/jsonc_build$`

Executed `mkdir jsonc_build && cd json_cbuild && cmake ..`

Exercise: Build json-c

Notice there are two warnings indicating dependency issues.

- **doxygen not found**: Find the distribution of doxygen and install it.
- **CMake deprecation**: Update CMake version or compile CMake from source for the latest version.

These kinds of problems can appear frequently. But make sure to check whether the corresponding *.pc files of dependency exists in default location. Sometimes the build system will not install the *.pc files (especially Meson), making other build systems cannot find the required dependency with **pkg-config**.

Exercise: Build json-c

Step 5: Build the project. (The warnings are skipped)

The screenshot shows a terminal window with three tabs. The active tab is titled "user@test: ~/Downloads/jsonc-0.17/jsonc_build". The terminal output shows the build process for the json-c project:

```
user@test:~/Downloads/jsonc-0.17/jsonc_build
user@test:~/Downloads/jsonc-0.17/jsonc_build
user@test:~/Downloads/jsonc-0.17/jsonc_build

CMake Make that the project does not need compatibility with older versions.

A ... Wrote /home/user/Downloads/jsonc-0.17/jsonc_build/apps_config.h
... Configuring done (15.5s)
... Generating done (0.1s)
... Build files have been written to: /home/user/Downloads/jsonc-0.17/jsonc_build
user@test:~/Downloads/jsonc-0.17/jsonc_build
[ 1%] Building C object CMakeFiles/json-c.dir/arravlist.c.o
[ 2%] Building C object CMakeFiles/json-c.dir/debug.c.o
[ 3%] Building C object CMakeFiles/json-c.dir/json_version.c.o
[ 4%] Building C object CMakeFiles/json-c.dir/json_object.c.o
[ 5%] Building C object CMakeFiles/json-c.dir/json_object_iterator.c.o
[ 6%] Building C object CMakeFiles/json-c.dir/json_tokener.c.o
[ 7%] Building C object CMakeFiles/json-c.dir/json_util.c.o
[ 8%] Building C object CMakeFiles/json-c.dir/json_visit.c.o
[ 10%] Building C object CMakeFiles/json-c.dir/linkhash.c.o
[ 11%] Building C object CMakeFiles/json-c.dir/prntbufc.c.o
[ 12%] Building C object CMakeFiles/json-c.dir/random_seed.c.o
[ 13%] Building C object CMakeFiles/json-c.dir/strror_override.c.o
[ 14%] Building C object CMakeFiles/json-c.dir/json_pointer.c.o
[ 15%] Building C object CMakeFiles/json-c.dir/json_patch.c.o
[ 17%] Linking C shared library libjson-c.so
[ 17%] Built target json-c
[ 18%] Building C object CMakeFiles/json-c-static.dir/arravlist.c.o
[ 19%] Building C object CMakeFiles/json-c-static.dir/debug.c.o
[ 20%] Building C object CMakeFiles/json-c-static.dir/json_c_version.c.o
[ 21%] Building C object CMakeFiles/json-c-static.dir/json_object.c.o
[ 22%] Building C object CMakeFiles/json-c-static.dir/json_object_iterator.c.o
[ 23%] Building C object CMakeFiles/json-c-static.dir/json_tokener.c.o
[ 25%] Building C object CMakeFiles/json-c-static.dir/json_util.c.o
[ 26%] Building C object CMakeFiles/json-c-static.dir/json_visit.c.o
[ 27%] Building C object CMakeFiles/json-c-static.dir/linkhash.c.o
[ 28%] Building C object CMakeFiles/json-c-static.dir/random_seed.c.o
[ 29%] Building C object CMakeFiles/json-c-static.dir/strror_override.c.o
[ 31%] Building C object CMakeFiles/json-c-static.dir/json_pointer.c.o
[ 32%] Building C object CMakeFiles/json-c-static.dir/json_patch.c.o
[ 34%] Linking C static library libjson-c.a
[ 34%] Built target json-c-static
[ 35%] Building C object tests/CMakeFiles/testIFormatted.dir/testI.c.o
[ 36%] Building C object tests/CMakeFiles/testIFormatted.dir/parse_flags.c.o
[ 37%] Linking C executable testIFormatted
```

Exercise: Build json-c

Finally, the build process is finished.

The screenshot shows a terminal window with three tabs, each displaying the build log for the json-c project. The logs show the compilation of various C source files into object and executable files across different subdirectories of the source code. The build process is completed successfully.

```
user@test:~/Downloads/jsonc-0.17/jsonc_build
[ 70K] Linking C executable test_locale
[ 70K] Built target test_locale
[ 71K] Building C object tests/Makefiles/test_null.dir/test_null.c.o
[ 72K] Linking C executable tests/test_null
[ 72K] Built target test_null
[ 73K] Building C object tests/MakeFiles/test_parse.dir/test_parse.c.o
[ 75K] Linking C executable test_parse
[ 75K] Built target test_parse
[ 75K] Building C object tests/MakeFiles/test_parse_int64.dir/test_parse_int64.c.o
[ 77K] Linking C executable test_parse_int64
[ 77K] Built target test_parse_int64
[ 78K] Building C object tests/MakeFiles/test_printbuf.dir/test_printbuf.c.o
[ 79K] Linking C executable test_printbuf
[ 79K] Built target test_printbuf
[ 80K] Building C object tests/MakeFiles/test_set_serializer.dir/test_set_serializer.c.o
[ 81K] Linking C executable test_set_serializer
[ 81K] Built target test_set_serializer
[ 82K] Building C object tests/MakeFiles/test_set_value.dir/test_set_value.c.o
[ 84K] Linking C executable test_set_value
[ 84K] Built target test_set_value
[ 85K] Building C object tests/MakeFiles/test_strerror.dir/test_strerror.c.o
[ 86K] Linking C executable test_strerror
[ 86K] Built target test_strerror
[ 87K] Building C object tests/MakeFiles/test_util_file.dir/test_util_file.c.o
[ 88K] Linking C executable test_util_file
[ 88K] Built target test_util_file
[ 89K] Building C object tests/MakeFiles/test_visit.dir/test_visit.c.o
[ 90K] Linking C executable test_visit
[ 90K] Built target test_visit
[ 92K] Building C object tests/MakeFiles/test_object_iterator.dir/test_object_iterator.c.o
[ 93K] Linking C executable test_object_iterator
[ 93K] Built target test_object_iterator
[ 94K] Building C object tests/MakeFiles/test_json_pointer.dir/test_json_pointer.c.o
[ 95K] Linking C executable test_json_pointer
[ 95K] Built target test_json_pointer
[ 96K] Building C object tests/MakeFiles/test_json_patch.dir/test_json_patch.c.o
[ 97K] Linking C executable test_json_patch
[ 97K] Built target test_json_patch
[ 98K] Building C object apps/MakeFiles/json_parse.dir/json_parse.c.o
[100K] Linking C executable json_parse
[100K] Built target json_parse
user@test:~/Downloads/jsonc-0.17/jsonc_build$
```

Reference

- [Day 16] - Static and Dynamic Libraries (ar, objdump, ld, ldd) - Crash Course in C Programming by Mike Shah
- Write Better Code! | How to Create Shared Libraries in C/C++
- Red Hat Documentation 3.2.3. Autotools Documentation