

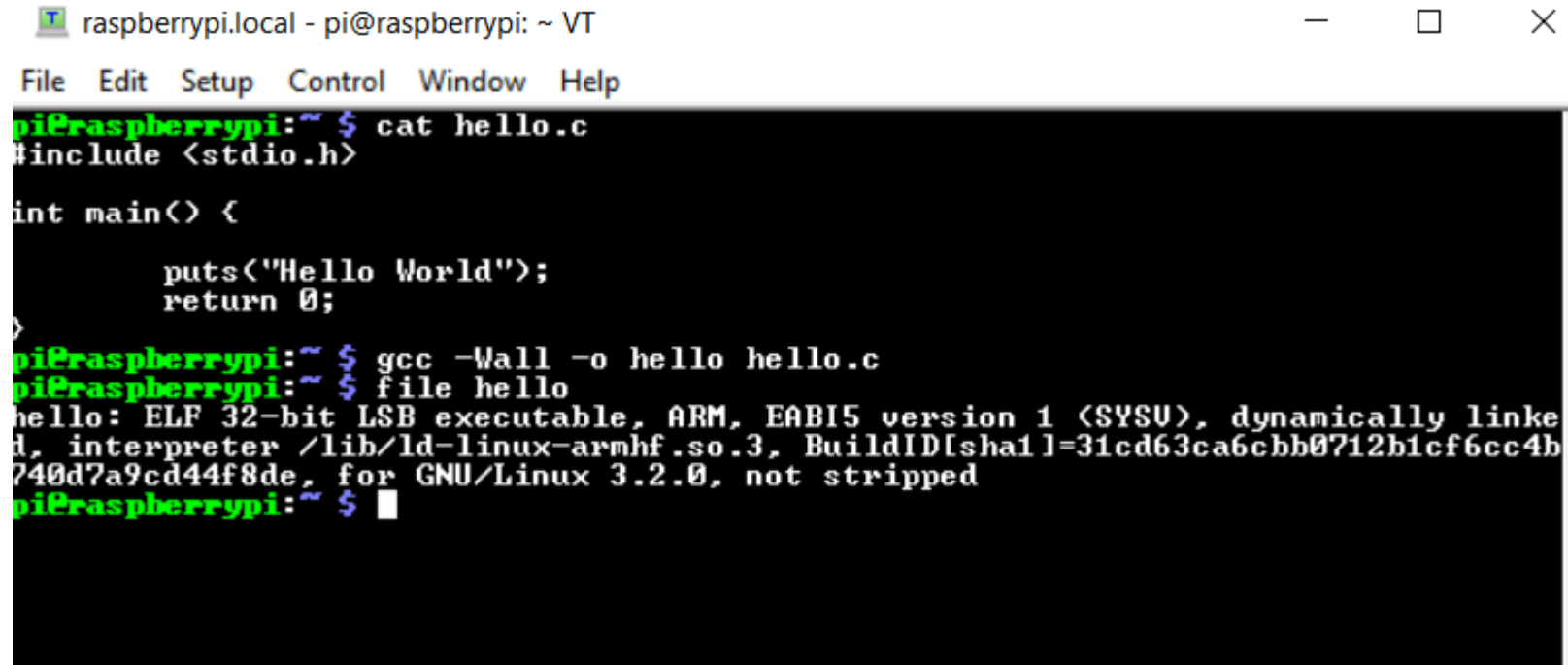
UCSD Embedded Linux Assignment 6

By

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Step 1. Compiling hello.c, host and target



```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~$ cat hello.c
#include <stdio.h>

int main() {
    puts("Hello World");
    return 0;
}
pi@raspberrypi:~$ gcc -Wall -o hello hello.c
pi@raspberrypi:~$ file hello
hello: ELF 32-bit LSB executable, ARM, EABI5 version 1 (SYSV), dynamically linked, interpreter /lib/ld-linux-armhf.so.3, BuildID[sha1]=31cd63ca6cbb0712b1cf6cc4b740d7a9cd44f8de, for GNU/Linux 3.2.0, not stripped
pi@raspberrypi:~$
```

Step 2. Lists symbols from object file – raspberrypi

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~$ nm hello
U abort@GLIBC_2.4
00010494 r all_implied_fbits
00010530 r all_implied_fbits
0002102c B __bss_end__
0002102c B __bss_end__
00021028 B __bss_start__
00021028 B __bss_start__
00010350 t call_weak_fn
00021028 b completed.0
00021020 D __data_start
00021020 W data_start
00010374 t deregister_tm_clones
000103d8 t __do_global_dtors_aux
00020f14 d __do_global_dtors_aux_fini_array_entry
00021024 D __dso_handle
00020f18 d _DYNAMIC
00021028 D _edata
0002102c B __end__
0002102c B __end__
00010488 T _fini
00010400 t frame_dummy
00020f10 d __frame_dummy_init_array_entry
000105c8 r __FRAME_END__
00021000 d __GLOBAL_OFFSET_TABLE__
w __gmon_start__
000102c4 T _init
00020f14 d __init_array_end
00020f10 d __init_array_start
00010490 R _IO_stdin_used
00010484 T __libc_csu_fini
00010424 T __libc_csu_init
U __libc_start_main@GLIBC_2.4
00010404 T main
U puts@GLIBC_2.4
000103a0 t register_tm_clones
00010314 T _start
00021028 D __TMC_END__
pi@raspberrypi:~$
```

Step 3. Build for RPi/armv7l, move to embedded system and try running. (For the below demo, since I do not have another target running using uclibc, I will just paste the instructor's file to show I have followed through it.)

```
$ cat hello.c
#include <stdio.h>
int main() {
    printf("Hello World\n");
    return 0;
}
$ gcc -Wall -o hello hello.c

$ file hello
hello: ELF 32-bit LSB executable, ARM, EABI5 version 1 (SYSV), dynamically linked,
interpreter /lib/ld-linux-armhf.so.3, BuildID[sha1]=31cd63ca6cbb0712b1cf6cc4b740d7a9cd44f8de,
for GNU/Linux 3.2.0, not stripped

$ ./hello
Hello World

$ cp hello hello-rpi

$ scp hello-rpi root@10.176.100.92:..

$ ssh root@10.176.100.92

# uname -a
Linux custom-soc 4.4.106-ts-armv7l #1 PREEMPT Sun Jan 1 00:00:00 EST 2017 armv7l GNU/Linux
#
# ./hello-rpi
-sh: ./hello-rpi: not found

# ls -l hello-rpi
-rwxr-xr-x  1 root  root           8072 Aug 29 17:34 hello-rpi
```

Step 4. readelf (-a for all info)

```
Version symbols section '.gnu.version' contains 5 entries:
Addr: 0x0000000000010272 Offset: 0x000272 Link: 5 (.dynsym)
000: 0 (*local*) 0 (*local*) 2 (GLIBC_2.4) 2 (GLIBC_2.4)
004: 2 (GLIBC_2.4)

Version needs section '.gnu.version_r' contains 1 entry:
Addr: 0x000000000001027c Offset: 0x00027c Link: 6 (.dynstr)
000000: Version: 1 File: libc.so.6 Cnt: 1
0x0010: Name: GLIBC_2.4 Flags: none Version: 2

Displaying notes found in: .note.gnu.build-id
Owner Data size Description
GNU 0x00000014NT_GNU_BUILD_ID (unique build ID bitstring)
Build ID: 31cd63ca6cbb0712b1cf6cc4b740d7a9cd44f8de

Displaying notes found in: .note.ABI-tag
Owner Data size Description
GNU 0x00000010NT_GNU_ABI_TAG (ABI version tag)
OS: Linux, ABI: 3.2.0
Attribute Section: aeabi
File Attributes
Tag_CPU_name: "6"
Tag_CPU_arch: v6
Tag_ARM_ISA_use: Yes
Tag_THUMB_ISA_use: Thumb-1
Tag_FP_arch: VFPv2
Tag_ABI_PCS_wchar_t: 4
Tag_ABI_FP_rounding: Needed
Tag_ABI_FP_denormal: Needed
Tag_ABI_FP_exceptions: Needed
Tag_ABI_FP_number_model: IEEE 754
Tag_ABI_align_needed: 8-byte
Tag_ABI_align_preserved: 8-byte, except leaf SP
Tag_ABI_enum_size: int
Tag_ABI_VFP_args: VFP registers
Tag_CPU_unaligned_access: v6
```

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```
No version information found in this file.
Attribute Section: aeabi
File Attributes
Tag_CPU_name: "7-A"
Tag_CPU_arch: v7
Tag_CPU_arch_profile: Application
Tag_ARM_ISA_use: Yes
Tag_THUMB_ISA_use: Thumb-2
Tag_FP_arch: VFPv3-D16
Tag_ABI_PCS_wchar_t: 4
Tag_ABI_FP_denormal: Needed
Tag_ABI_FP_exceptions: Needed
Tag_ABI_FP_number_model: IEEE 754
Tag_ABI_align_needed: 8-byte
Tag_ABI_enum_size: int
Tag_ABI_VFP_args: VFP registers
Tag_CPU_unaligned_access: v6
```

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Step 5. Adding RPi files to custom embedded system

```
# mkdir /lib/arm-linux-gnueabihf
# cp /media/mmcblk0p1/ld-2.31.so /lib/arm-linux-gnueabihf/.
# ln -s /lib/arm-linux-gnueabihf/ld-2.31.so /lib/ld-linux-armhf.so.3
# ./hello-rpi
./hello-rpi: error while loading shared libraries: libc.so.6: cannot open shared object file: No such file or directory
#
```

```
# cp /media/mmcblk0p1/libc-2.31.so /lib/arm-linux-gnueabihf/.
# ln -s /lib/arm-linux-gnueabihf/libc-2.31.so /lib/arm-linux-gnueabihf/libc.so.6

# ./hello-rpi
Hello World
```

← It works!

Step 6. Results of Downloading buildroot

```
kevin890200@ubuntu: ~/Desktop
kevin890200@ubuntu:~$ ls
BBB_Workspace  Documents  Music      Public  Templates
Desktop        Downloads  Pictures   snap    Videos
kevin890200@ubuntu:~$ cd Desktop/
kevin890200@ubuntu:~/Desktop$ ls
buildroot-2023.02.6.tar.gz
kevin890200@ubuntu:~/Desktop$ tar tf buildroot-2023.02.6.tar.gz | head
buildroot-2023.02.6/
buildroot-2023.02.6/.checkpackageignore
buildroot-2023.02.6/.clang-format
buildroot-2023.02.6/.defconfig
buildroot-2023.02.6/.flake8
buildroot-2023.02.6/.gitignore
buildroot-2023.02.6/.gitlab-ci.yml
buildroot-2023.02.6/.shellcheckrc
buildroot-2023.02.6/CHANGES
buildroot-2023.02.6/COPYING
kevin890200@ubuntu:~/Desktop$
```

Step 7. Extract tarball

```
kevin890200@ubuntu: ~/Desktop
kevin890200@ubuntu:~$ ls
BBB_Workspace  Documents  Music     Public  Templates
Desktop        Downloads  Pictures  snap    Videos
kevin890200@ubuntu:~$ cd Desktop/
kevin890200@ubuntu:~/Desktop$ ls
buildroot-2023.02.6.tar.gz
kevin890200@ubuntu:~/Desktop$ tar tf buildroot-2023.02.6.tar.gz | head
buildroot-2023.02.6/
buildroot-2023.02.6/.checkpackageignore
buildroot-2023.02.6/.clang-format
buildroot-2023.02.6/.defconfig
buildroot-2023.02.6/.flake8
buildroot-2023.02.6/.gitignore
buildroot-2023.02.6/.gitlab-ci.yml
buildroot-2023.02.6/.shellcheckrc
buildroot-2023.02.6/CHANGES
buildroot-2023.02.6/COPYING
kevin890200@ubuntu:~/Desktop$ tar xf buildroot-2023.02.6.tar.gz
kevin890200@ubuntu:~/Desktop$ ls buildroot-2023.02.6 | wc -l
20
kevin890200@ubuntu:~/Desktop$ ls buildroot-2023.02.6
arch  boot  Config.in  configs  DEVELOPERS  fs  Makefile  package  support  toolchain
board  CHANGES  Config.in.legacy  COPYING  docs  linux  Makefile.legacy  README  system  utils
kevin890200@ubuntu:~/Desktop$
```


Step 8. Explore make help

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
kevin890200@ubuntu:~/Desktop/buildroot-2023.02.6$ make help
Cleaning:
  clean          - delete all files created by build
  distclean      - delete all non-source files (including .config)

Build:
  all            - make world
  toolchain      - build toolchain
  sdk            - build relocatable SDK

Configuration:
  menuconfig     - interactive curses-based configurator
  nconfig        - interactive ncurses-based configurator
  xconfig        - interactive Qt-based configurator
  gconfig        - interactive GTK-based configurator
  oldconfig      - resolve any unresolved symbols in .config
  synconfig      - Same as oldconfig, but quietly, additionally update deps
  olddefconfig   - Same as synconfig but sets new symbols to their default value
  randconfig     - New config with random answer to all options
  defconfig      - New config with default answer to all options;
                   BR2_DEFCONFIG, if set on the command line, is used as input
  savedefconfig  - Save current config to BR2_DEFCONFIG (minimal config)
  update-defconfig - Same as savedefconfig
  allyesconfig   - New config where all options are accepted with yes
  allnoconfig    - New config where all options are answered with no
```

Step 9. make menuconfig attempt

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
kevin890200@ubuntu:~/Desktop/buildroot-2023.02.6$ make menuconfig
mkdir -p /home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/lxdialog
PKG_CONFIG_PATH="" make CC="/usr/bin/gcc" HOSTCC="/usr/bin/gcc" \
    obj=/home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config -C support/kconfig -f Makefile.br mconf
/usr/bin/gcc -DCURSES_LOC="curses.h" -DLOCALE -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-conf
ig -DCONFIG_="" -MM *.c > /home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/.depend 2>/dev/null
|| :
/usr/bin/gcc -DCURSES_LOC="curses.h" -DLOCALE -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-conf
ig -DCONFIG_="" -c conf.c -o /home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/conf.o
*** Unable to find the ncurses libraries or the
*** required header files.
*** 'make menuconfig' requires the ncurses libraries.
***
*** Install ncurses (ncurses-devel or libncurses-dev
*** depending on your distribution) and try again.
***
make[2]: *** [Makefile:253: /home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/dochecklxdialog] Err
or 1
make[1]: *** [Makefile:959: /home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/mconf] Error 2
make: *** [Makefile:82: _all] Error 2
kevin890200@ubuntu:~/Desktop/buildroot-2023.02.6$
```

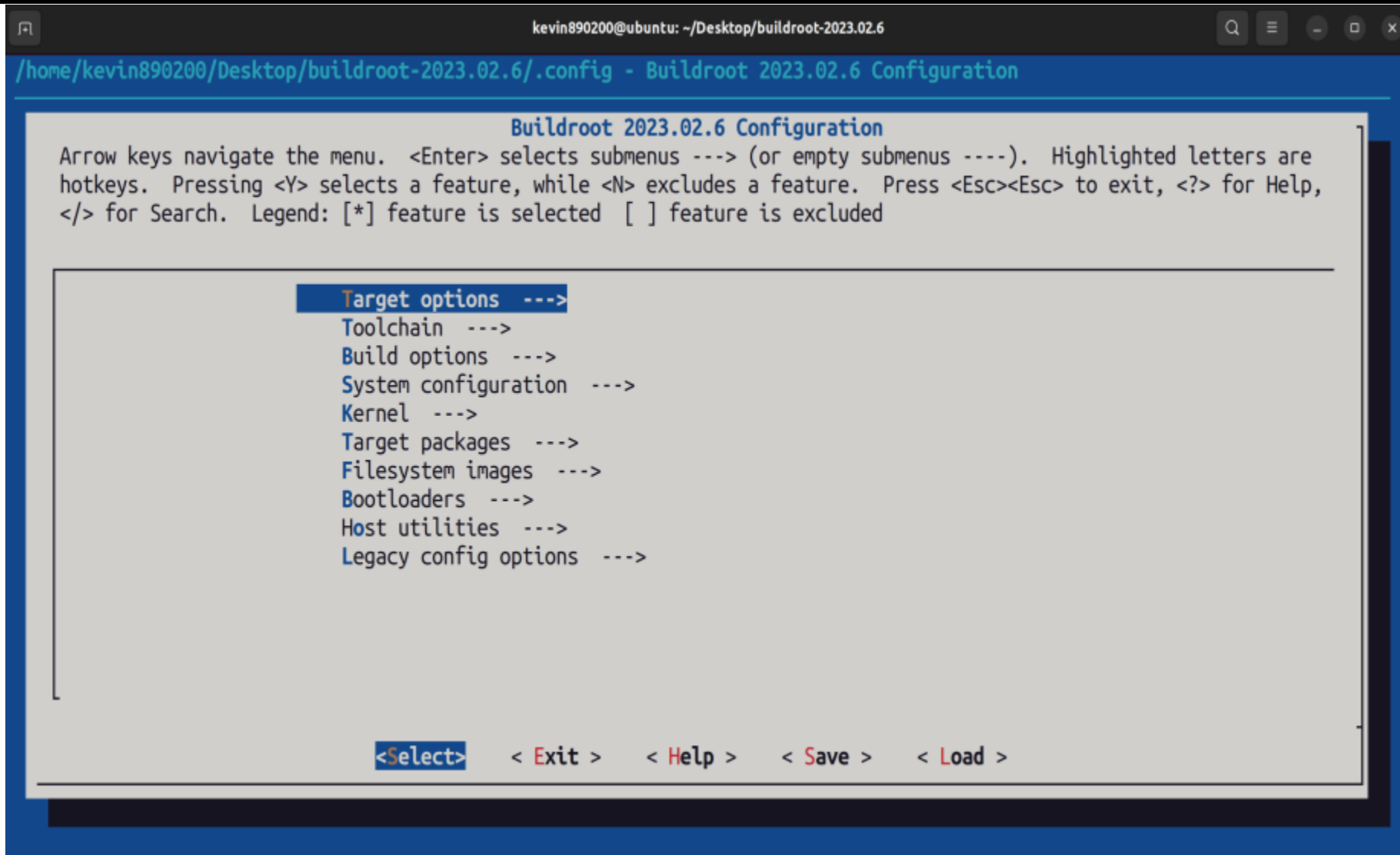
Step 10. apt-cache search libncurses

```
kevin890200@ubuntu:~/Desktop/buildroot-2023.02.6$ apt-cache search libncurses
libncurses-dev - developer's libraries for ncurses
libncurses5-dev - transitional package for libncurses-dev
libncurses6 - shared libraries for terminal handling
libncursesw5-dev - transitional package for libncurses-dev
libncursesw6 - shared libraries for terminal handling (wide character support)
libtinfo-dev - transitional package for libncurses-dev
libncurses-gst - Ncurses bindings for GNU Smalltalk
libncurses5 - shared libraries for terminal handling (legacy version)
libncursesada-doc - Ada binding to the ncurses text interface library: documentation
libncursesada6.2.3 - Ada binding to the ncurses text interface library: shared library
libncursesada9-dev - Ada binding to the ncurses text interface library: development
libncursesw5 - shared libraries for terminal handling (wide character legacy version)
```

Step 11. sudo apt-get install libncurses-dev

```
kevin890200@ubuntu:~/Desktop/buildroot-2023.02.6$ sudo apt-get install libncurses-dev
[sudo] password for kevin890200:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer required:
  apg ethtool gnome-control-center-faces gnome-online-accounts libcolord-gtk1 libfreerdp-server2-2 libgnome-bg-4-1
  libgsound0 libgssdp-1.2-0 libgupnp-1.2-1 libgupnp-av-1.0-3 libgupnp-dlna-2.0-4 libmsspack0 libntfs-3g89
  librygel-core-2.6-2 librygel-db-2.6-2 librygel-renderer-2.6-2 librygel-server-2.6-2 libvncserver1 libxmlsec1-openssl
  mobile-broadband-provider-info network-manager-gnome open-vm-tools python3-certifi python3-macaroonbakery
  python3-protobuf python3-pymacaroons python3-requests python3-rfc3339 python3-tz rygel zerofree
Use 'sudo apt autoremove' to remove them.
Suggested packages:
  ncurses-doc
The following NEW packages will be installed:
  libncurses-dev
0 upgraded, 1 newly installed, 0 to remove and 105 not upgraded.
Need to get 381 kB of archives.
After this operation, 2,407 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu jammy-updates/main amd64 libncurses-dev amd64 6.3-2ubuntu0.1 [381 kB]
Fetched 381 kB in 1s (507 kB/s)
Selecting previously unselected package libncurses-dev:amd64.
(Reading database ... 234047 files and directories currently installed.)
Preparing to unpack .../libncurses-dev_6.3-2ubuntu0.1_amd64.deb ...
Unpacking libncurses-dev:amd64 (6.3-2ubuntu0.1) ...
Setting up libncurses-dev:amd64 (6.3-2ubuntu0.1) ...
Processing triggers for man-db (2.10.2-1) ...
```


Step 12. make menuconfig works



The screenshot shows a terminal window titled "kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6". The terminal displays the "Buildroot 2023.02.6 Configuration" menu. At the top, a header bar reads "/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration". Below this, instructions explain how to navigate the menu using arrow keys, Enter, Y, N, Esc, and search. A legend indicates that features marked with an asterisk are selected. The main menu lists several options, with "Target options" currently selected and highlighted in blue. At the bottom, a navigation bar shows "< Select >" as the active option, along with "< Exit >", "< Help >", "< Save >", and "< Load >".

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration

Buildroot 2023.02.6 Configuration
Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

Target options --->
Toolchain --->
Build options --->
System configuration --->
Kernel --->
Target packages --->
Filesystem images --->
Bootloaders --->
Host utilities --->
Legacy config options --->

< Select >  < Exit >  < Help >  < Save >  < Load >
```

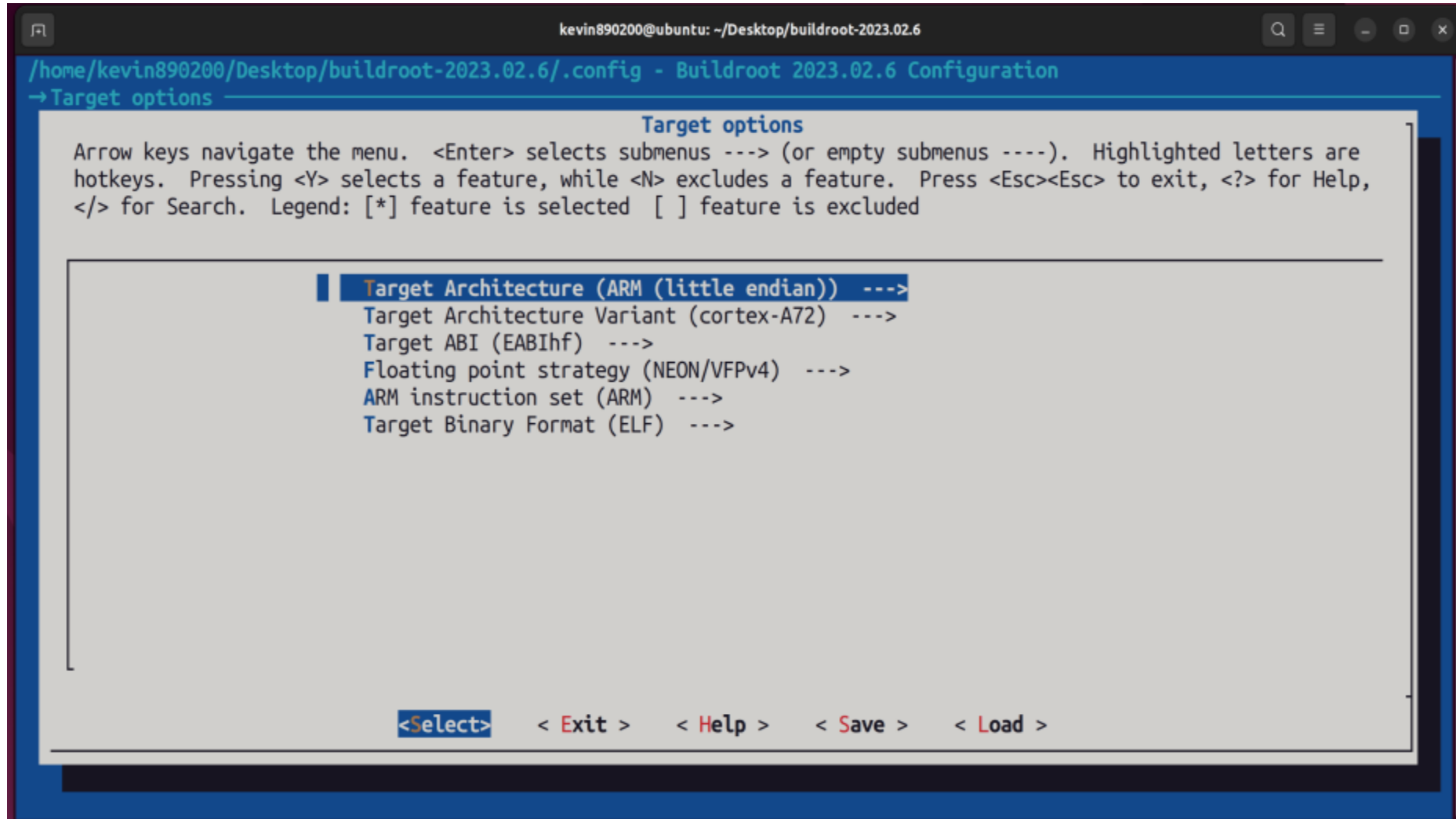
Step 13. Configs Directory

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
kevin890200@ubuntu:~/Desktop/buildroot-2023.02.6$ ls configs/
aarch64_efi_defconfig
acmesystems_acqua_a5_256mb_defconfig
acmesystems_acqua_a5_512mb_defconfig
acmesystems_aria_g25_128mb_defconfig
acmesystems_aria_g25_256mb_defconfig
acmesystems_arietta_g25_128mb_defconfig
acmesystems_arietta_g25_256mb_defconfig
amarula_vyasa_rk3288_defconfig
andes_ae350_45_defconfig
arcturus_ucls1012a_defconfig
arcturus_ucp1020_defconfig
armadeus_apf27_defconfig
armadeus_apf28_defconfig
armadeus_apf51_defconfig
arm_foundationv8_defconfig
aspeed_ast2500evb_defconfig
aspeed_ast2600evb_defconfig
asus_tinker_rk3288_defconfig
at91sam9260eknf_defconfig
at91sam9g20dfc_defconfig
at91sam9g45m10ek_defconfig
at91sam9rlek_defconfig
at91sam9x5ek_defconfig
at91sam9x5ek_dev_defconfig
at91sam9x5ek_mmc_defconfig
at91sam9x5ek_mmc_dev_defconfig
atmel_sama5d27_som1_ek_mmc_dev_defconfig
odroidxu4_defconfig
olimex_a10_olinuxino_lime_defconfig
olimex_a13_olinuxino_defconfig
olimex_a20_olinuxino_lime2_defconfig
olimex_a20_olinuxino_lime_defconfig
olimex_a20_olinuxino_micro_defconfig
olimex_a33_olinuxino_defconfig
olimex_a64_olinuxino_defconfig
olimex_imx233_olinuxino_defconfig
olimex_stmp157_olinuxino_lime_defconfig
olpc_xo175_defconfig
olpc_xo1_defconfig
openblocks_a6_defconfig
orange_pi_lite2_defconfig
orange_pi_lite_defconfig
orange_pi_one_defconfig
orange_pi_one_plus_defconfig
orange_pi_pc_defconfig
orange_pi_pc_plus_defconfig
orange_pi_r1_defconfig
orange_pi_zero_defconfig
orange_pi_zero_plus2_defconfig
orange_pi_zero_plus_defconfig
pandaboard_defconfig
pcengines_apu2_defconfig
pc_x86_64_bios_defconfig
pc_x86_64_efi_defconfig
```

Step 14. make raspberrypi4_defconfig

```
kevin890200@ubuntu:~/Desktop/buildroot-2023.02.6$ make raspberrypi4_defconfig
mkdir -p /home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/lxdialog
PKG_CONFIG_PATH="" make CC="/usr/bin/gcc" HOSTCC="/usr/bin/gcc" \
    obj=/home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config -C support/kconfig -f Makefile.br conf
/usr/bin/gcc -I/usr/include/ncursesw -DCURSES_LOC="<urses.h>" -DNCURSES_WIDECHAR=1 -DLOCALE -I/home/kevin890200/Desktop/b
uildroot-2023.02.6/output/build/buildroot-config -DCONFIG_="" /home/kevin890200/Desktop/buildroot-2023.02.6/output/build
/buildroot-config/conf.o /home/kevin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/zconf.tab.o -o /home/k
evin890200/Desktop/buildroot-2023.02.6/output/build/buildroot-config/conf
#
# configuration written to /home/kevin890200/Desktop/buildroot-2023.02.6/.config
#
```

Step 15. Target Options after the config



The screenshot shows a terminal window titled "kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6". The main title bar of the application is "/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration". The menu is currently on the "Target options" screen, which is indicated by a blue header bar with the text "→ Target options".

Below the header, the text "Target options" is centered. A paragraph of instructions follows: "Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [] feature is excluded".

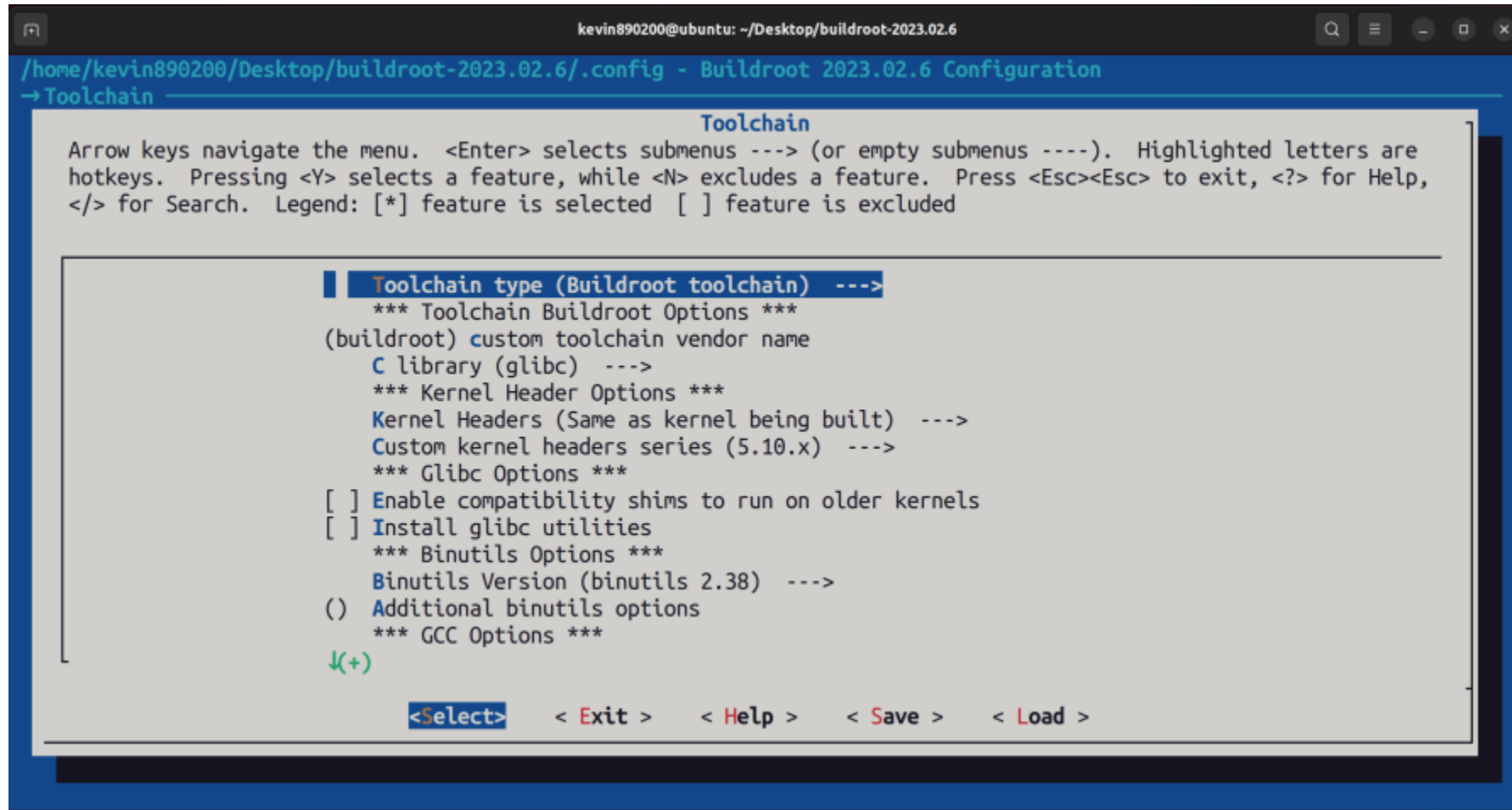
The main menu area contains a list of options, each followed by "---->". The first option, "Target Architecture (ARM (little endian))", is highlighted with a blue background. The other options are "Target Architecture Variant (cortex-A72)", "Target ABI (EABIhf)", "Floating point strategy (NEON/VFPv4)", "ARM instruction set (ARM)", and "Target Binary Format (ELF)".

At the bottom of the menu, there is a row of navigation options: "<Select>", "< Exit >", "< Help >", "< Save >", and "< Load >". The "<Select>" option is highlighted with a blue background.

Step 16. Observe default raspberrypi architecture

```
pi@raspberrypi:~$ arch
armv7l
pi@raspberrypi:~$ file /bin/bash
/bin/bash: ELF 32-bit LSB executable, ARM, EABI5 version 1 (SYSV), dynamically linked, interpreter /lib/ld-linux-armhf.so.3, BuildID[sha1]=f12e6d40fb262ad0037b6ec43162208b76d4da71, for GNU/Linux 3.2.0, stripped
pi@raspberrypi:~$
```

Step 17. Toolchain



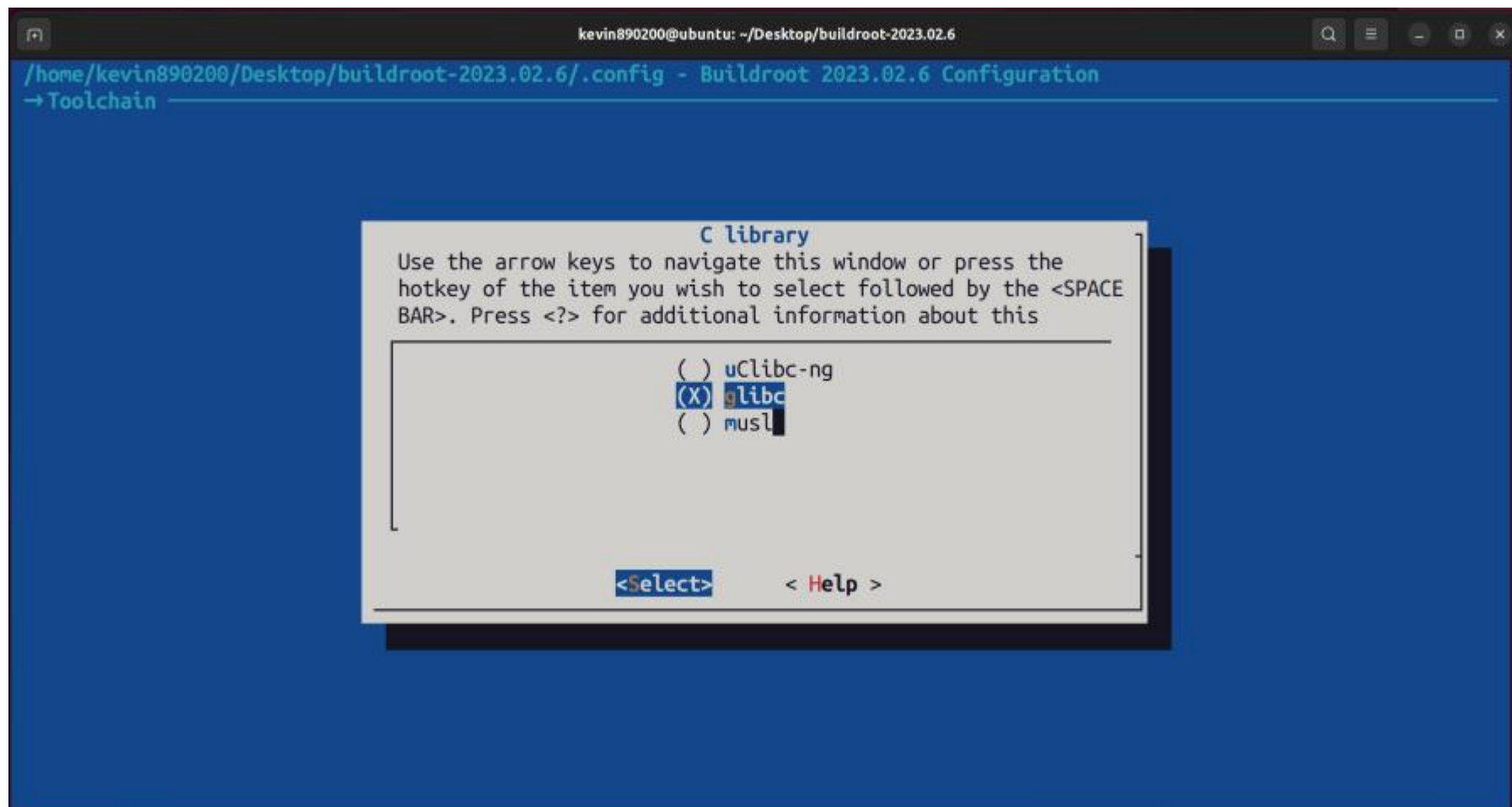
```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration
→Toolchain

Toolchain
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

Toolchain type (Buildroot toolchain) --->
*** Toolchain Buildroot Options ***
(buildroot) custom toolchain vendor name
C library (glibc) --->
*** Kernel Header Options ***
Kernel Headers (Same as kernel being built) --->
Custom kernel headers series (5.10.x) --->
*** Glibc Options ***
[ ] Enable compatibility shims to run on older kernels
[ ] Install glibc utilities
*** Binutils Options ***
Binutils Version (binutils 2.38) --->
() Additional binutils options
*** GCC Options ***
↓(+)
```

<Select> <Exit> <Help> <Save> <Load>

Step 18. C Library



Step 19. Build Options

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration
→ Build options

Build options
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

Commands --->
(/home/kevin890200/Desktop/buildroot-2023.02.6/configs/raspberrypi4_defconfig) Location to s
$(TOPDIR)/dl) Download dir
$(BASE_DIR)/host) Host dir
Mirrors and Download locations --->
(0) Number of jobs to run simultaneously (0 for auto)
[ ] Enable compiler cache
[ ] build packages with debugging symbols
[ ] build packages with runtime debugging info
[*] strip target binaries
( ) executables that should not be stripped
( ) directories that should be skipped when stripping
gcc optimization level (optimize for size) --->
[ ] build packages with link-time optimisation
↓(+)
```

<Select> <Exit> <Help> <Save> <Load>

Step 20. System Configuration

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration
→System configuration

System configuration
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

Root FS skeleton (default target skeleton) --->
(builroot) System hostname
(Welcome to Buildroot) System banner
  Passwords encoding (sha-256) --->
  Init system (BusyBox) --->
  /dev management (Dynamic using devtmpfs only) --->
(system/device_table.txt) Path to the permission tables
[ ] support extended attributes in device tables
[ ] Use symlinks to /usr for /bin, /sbin and /lib
[*] Enable root login with password
() Root password
  /bin/sh (busybox' default shell) --->
[*] Run a getty (login prompt) after boot --->
[*] remount root filesystem read-write during boot
↓(+)
```

<Select> < Exit > < Help > < Save > < Load >

Step 21. Kernel

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration
→ Kernel

Kernel

Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

[*] Linux Kernel
    Kernel version (Custom tarball) --->
    ($ (call github,raspberrypi,linux,0b54dbda3cca2beb51e236a25738784e90853b64)/linux-0b54dbda3cc
    () Custom kernel patches
    Kernel configuration (Using an in-tree defconfig file) --->
    (bcm2711) Defconfig name
    () Additional configuration fragment files
    () Custom boot logo file path
    Kernel binary format (zImage) --->
    Kernel compression format (gzip compression) --->
    [*] Build a Device Tree Blob (DTB)
    [ ] DTB is built by kernel itself
    (bcm2711-rpi-4-b) In-tree Device Tree Source file names
    () Out-of-tree Device Tree Source file paths
    ↓(+)

<Select> <Exit> <Help> <Save> <Load>
```

Step 22. Packages

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration
→Target packages

Target packages
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

-* BusyBox
(package/busybox/busybox.config) BusyBox configuration file to use?
() Additional BusyBox configuration fragment files
[ ] Show packages that are also provided by busybox
[ ] Individual binaries
[ ] Install the watchdog daemon startup script
Audio and video applications --->
Compressors and decompressors --->
Debugging, profiling and benchmark --->
Development tools --->
Filesystem and flash utilities --->
Fonts, cursors, icons, sounds and themes --->
Games --->
Graphic libraries and applications (graphic/text) --->
↓(+)

<Select> < Exit > < Help > < Save > < Load >
```

Step 23. Filesystem images

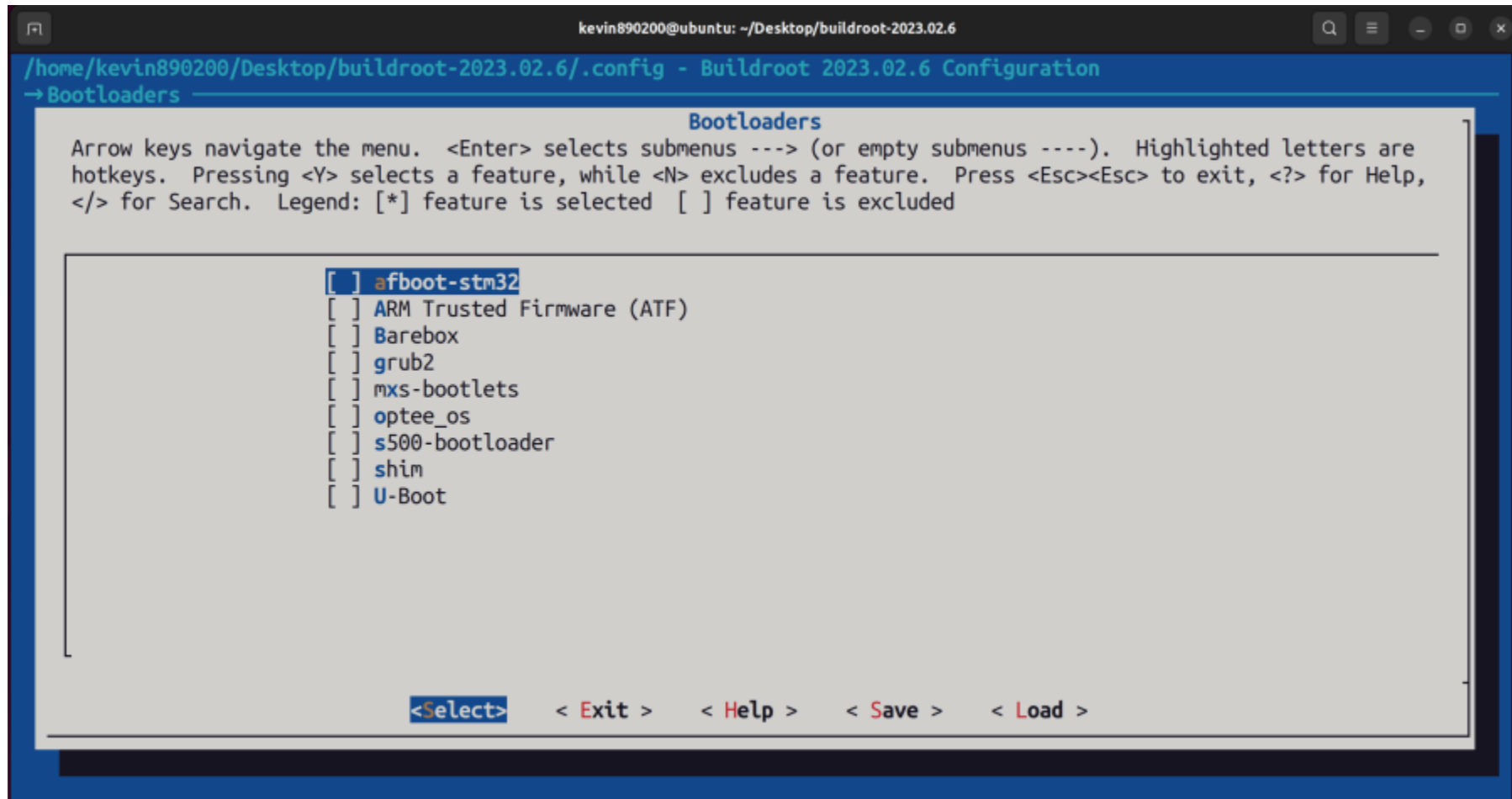
```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration
→Filesystem images

                                Filesystem images
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

[ ] axfs root filesystem
[ ] btrfs root filesystem
[ ] cloop root filesystem for the target device
[ ] cpio the root filesystem (for use as an initial RAM filesystem)
[ ] cramfs root filesystem
[ ] erofs root filesystem
[*] ext2/3/4 root filesystem
    ext2/3/4 variant (ext4) --->
(rootfs) filesystem label
(120M) exact size
(0) exact number of inodes (leave at 0 for auto calculation)
(256) inode size
(5) reserved blocks percentage
(-0 ^64bit) additional mke2fs options
↓(+)
```

<Select> <Exit> <Help> <Save> <Load>

Step 24. Bootloaders



The screenshot shows a terminal window with the title bar "kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6". The terminal content is the Buildroot configuration interface. The title bar of the configuration window is "/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration". The current menu is "Bootloaders". A help text block explains navigation: "Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [] feature is excluded". A list of bootloaders is shown, with "afboot-stm32" highlighted. At the bottom, there are navigation buttons: "<Select>", "< Exit >", "< Help >", "< Save >", and "< Load >".

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
/home/kevin890200/Desktop/buildroot-2023.02.6/.config - Buildroot 2023.02.6 Configuration
-> Bootloaders

                                Bootloaders
Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are
hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help,
</> for Search. Legend: [*] feature is selected [ ] feature is excluded

[ ] afboot-stm32
[ ] ARM Trusted Firmware (ATF)
[ ] Barebox
[ ] grub2
[ ] mxs-bootlets
[ ] optee_os
[ ] s500-bootloader
[ ] shim
[ ] U-Boot

<Select>  < Exit >  < Help >  < Save >  < Load >
```

Step 25. Type make to begin build. After some time, my build is successful and not having the errors like instructor faced, maybe because I built on ubuntu linux system, not on raspberrypi directly.

```
kevin890200@ubuntu: ~/Desktop/buildroot-2023.02.6
_INVERT_LIMB=1 -DHAVE___GMPN_RSBLSH1_N=1 -DMPFR_LONG_WITHIN_LIMB=1 -DMPFR_INTMAX_WITHIN_LIMB=1 -DHAVE_GETRUSAGE=1 -I. -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/host/include -O2 -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/host/include -c get_d64.c -fPIC -DPIC -o .libs/get_d64.o
/bin/bash ../libtool --tag=CC --mode=compile /usr/bin/gcc -DHAVE_STDIO_H=1 -DHAVE_INTTYPES_H=1 -DHAVE_STDINT_H=1 -DLT_OBJDIR=\".libs/\" -DHAVE_LITTLE_ENDIAN=1 -DHAVE_CLOCK_GETTIME=1 -DHAVE_LOCALE_H=1 -DHAVE_WCHAR_H=1 -DHAVE_STDARG=1 -DHAVE_STRUCT_LCONV_DECIMAL_POINT=1 -DHAVE_STRUCT_LCONV_THOUSANDS_SEP=1 -DHAVE_ALLOCA_H=1 -DHAVE_ALLOCA=1 -DHAVE_UINTPTR_T=1 -DHAVE_VA_COPY=1 -DHAVE_SETLOCALE=1 -DHAVE_GETTIMEOFDAY=1 -DHAVE_SIGNAL=1 -DHAVE_SIGACTION=1 -DHAVE_LONG_LONG=1 -DHAVE_INTMAX_T=1 -DMPFR_HAVE_INTMAX_MAX=1 -DMPFR_HAVE_NORETURN=1 -DMPFR_HAVE_BUILTIN_UNREACHABLE=1 -DMPFR_HAVE_CONSTRUCTOR_ATTR=1 -DMPFR_HAVE_FESTROUND=1 -DHAVE_SUBNORM_DBL=1 -DHAVE_SUBNORM_FLT=1 -DHAVE_SIGNEDZ=1 -DHAVE_ROUND=1 -DHAVE_TRUNC=1 -DHAVE_FLOOR=1 -DHAVE_CEIL=1 -DHAVE_NEARBYINT=1 -DHAVE_DOUBLE_IEEE_LITTLE_ENDIAN=1 -DHAVE_LDOUBLE_IEEE_EXT_LITTLE=1 -DMPFR_USE_THREAD_SAFE=1 -DMPFR_USE_C11_THREAD_SAFE=1 -DMPFR_WANT_DECIMAL_FLOATS=1 -DDECIMAL_BID_FORMAT=1 -DHAVE_DECIMAL128_IEEE_LITTLE_ENDIAN=1 -DMPFR_WANT_FLOAT128=1 -DMPFR_USE_STATIC_ASSERT=1 -DHAVE_ATTRIBUTE_MODE=1 -DPRINTF_L=1 -DPRINTF_T=1 -DPRINTF_GROUPFLAG=1 -DHAVE___GMPN_SBP11_DIVAPPR_Q=1 -DHAVE___GMPN_INVERT_LIMB=1 -DHAVE___GMPN_RSBLSH1_N=1 -DMPFR_LONG_WITHIN_LIMB=1 -DMPFR_INTMAX_WITHIN_LIMB=1 -DHAVE_GETRUSAGE=1 -I. -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/host/include -O2 -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/host/include -c -o jn.lo jn.c
/bin/bash ../libtool --tag=CC --mode=compile /usr/bin/gcc -DHAVE_STDIO_H=1 -DHAVE_INTTYPES_H=1 -DHAVE_STDINT_H=1 -DLT_OBJDIR=\".libs/\" -DHAVE_LITTLE_ENDIAN=1 -DHAVE_CLOCK_GETTIME=1 -DHAVE_LOCALE_H=1 -DHAVE_WCHAR_H=1 -DHAVE_STDARG=1 -DHAVE_STRUCT_LCONV_DECIMAL_POINT=1 -DHAVE_STRUCT_LCONV_THOUSANDS_SEP=1 -DHAVE_ALLOCA_H=1 -DHAVE_ALLOCA=1 -DHAVE_UINTPTR_T=1 -DHAVE_VA_COPY=1 -DHAVE_SETLOCALE=1 -DHAVE_GETTIMEOFDAY=1 -DHAVE_SIGNAL=1 -DHAVE_SIGACTION=1 -DHAVE_LONG_LONG=1 -DHAVE_INTMAX_T=1 -DMPFR_HAVE_INTMAX_MAX=1 -DMPFR_HAVE_NORETURN=1 -DMPFR_HAVE_BUILTIN_UNREACHABLE=1 -DMPFR_HAVE_CONSTRUCTOR_ATTR=1 -DMPFR_HAVE_FESTROUND=1 -DHAVE_SUBNORM_DBL=1 -DHAVE_SUBNORM_FLT=1 -DHAVE_SIGNEDZ=1 -DHAVE_ROUND=1 -DHAVE_TRUNC=1 -DHAVE_FLOOR=1 -DHAVE_CEIL=1 -DHAVE_NEARBYINT=1 -DHAVE_DOUBLE_IEEE_LITTLE_ENDIAN=1 -DHAVE_LDOUBLE_IEEE_EXT_LITTLE=1 -DMPFR_USE_THREAD_SAFE=1 -DMPFR_USE_C11_THREAD_SAFE=1 -DMPFR_WANT_DECIMAL_FLOATS=1 -DDECIMAL_BID_FORMAT=1 -DHAVE_DECIMAL128_IEEE_LITTLE_ENDIAN=1 -DMPFR_WANT_FLOAT128=1 -DMPFR_USE_STATIC_ASSERT=1 -DHAVE_ATTRIBUTE_MODE=1 -DPRINTF_L=1 -DPRINTF_T=1 -DPRINTF_GROUPFLAG=1 -DHAVE___GMPN_SBP11_DIVAPPR_Q=1 -DHAVE___GMPN_INVERT_LIMB=1 -DHAVE___GMPN_RSBLSH1_N=1 -DMPFR_LONG_WITHIN_LIMB=1 -DMPFR_INTMAX_WITHIN_LIMB=1 -DHAVE_GETRUSAGE=1 -I. -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/host/include -O2 -I/home/kevin890200/Desktop/buildroot-2023.02.6/output/host/include -c -o yn.lo yn.c
```

Step 26. After building, copy the image to sd card and boot it up. (I do not have another SD card to test, so just copy the command)

```
sudo dd if=output/images/sdcard.img of=/dev/sdX bs=4M conv=fsync status=progress
```

Important! Replace sdX with your SDCard!