# UCSD Embedded Linux Assignment 8

By

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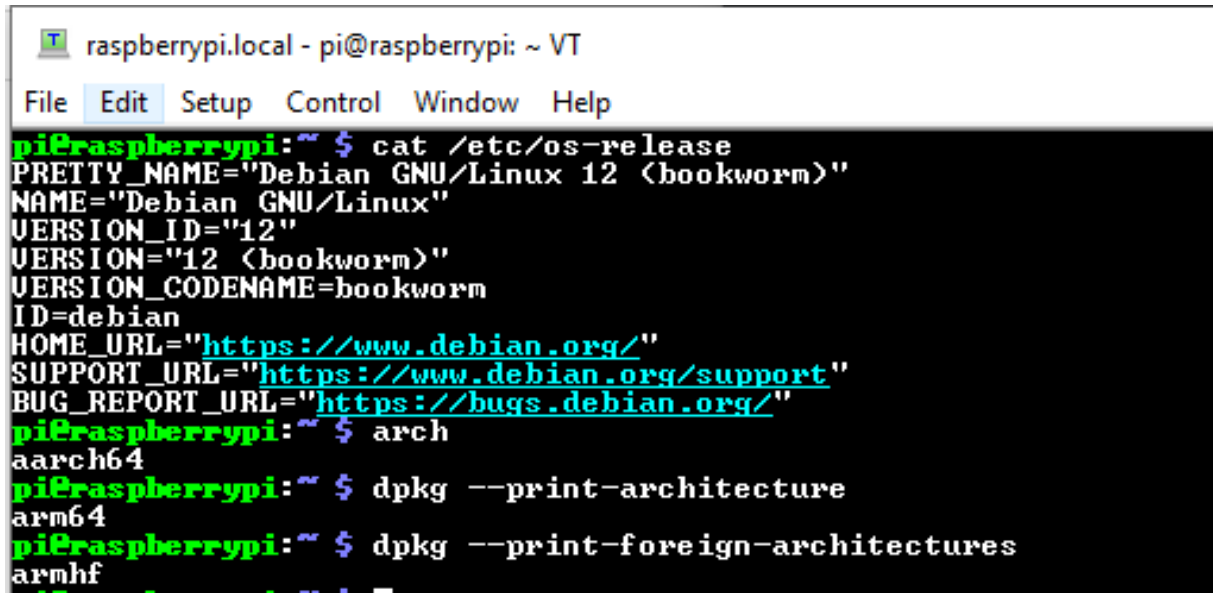
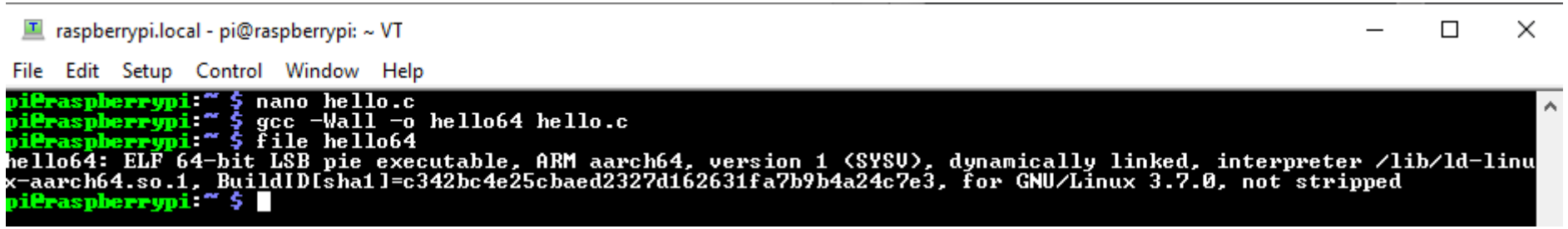
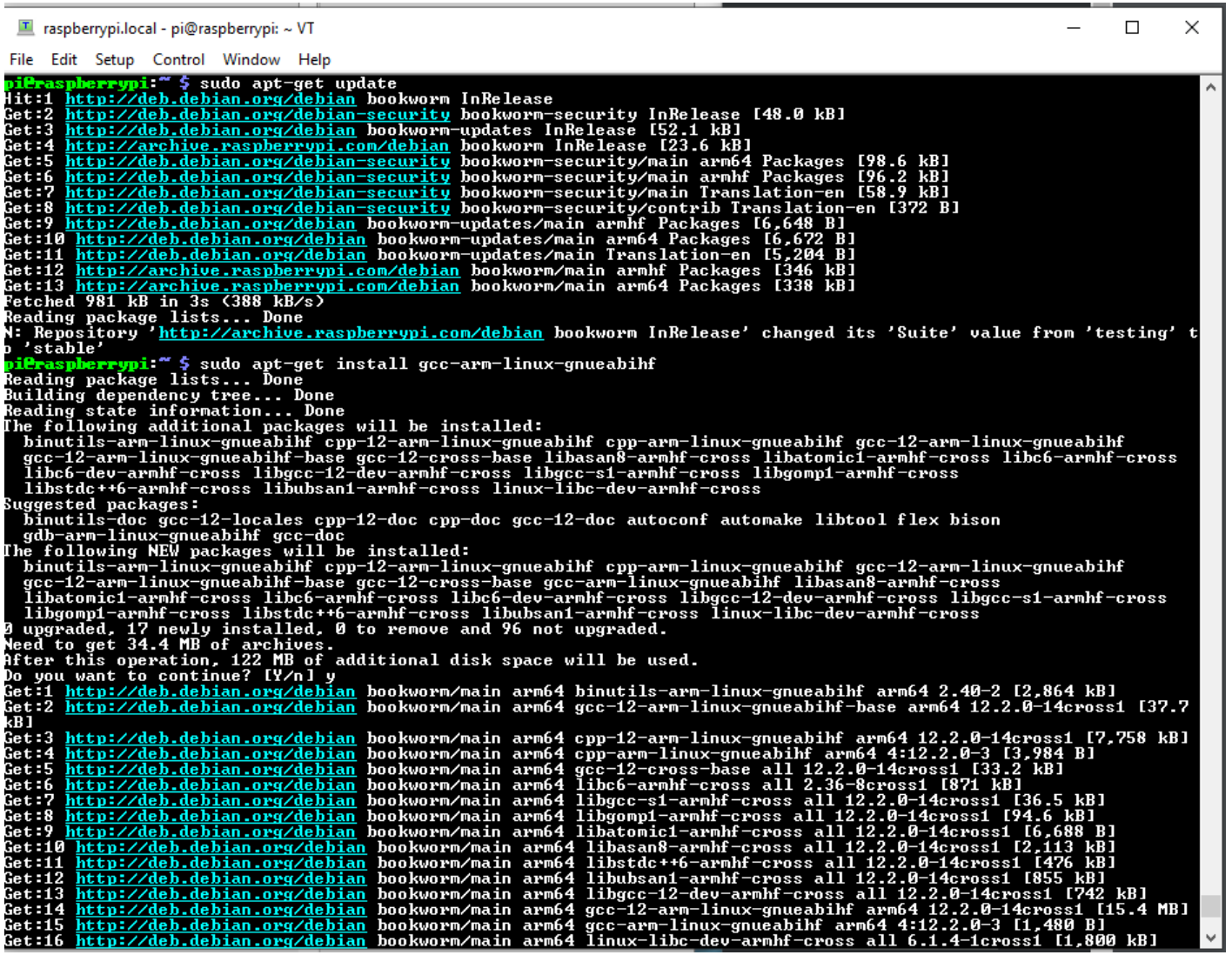
# Step 1. Point of reference, brand new install



# Step 2. hello.c – aarch64



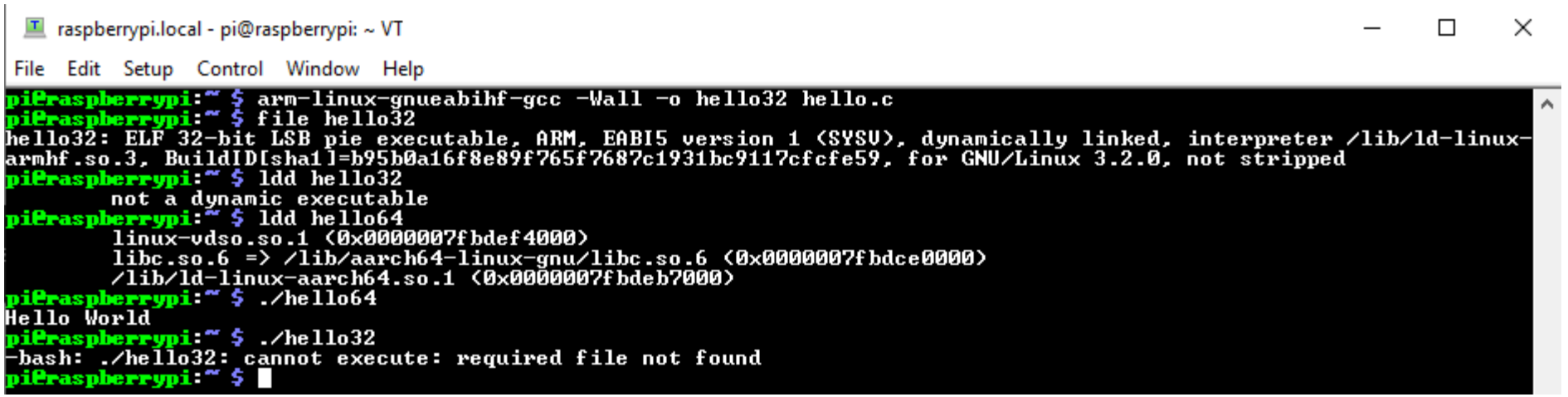
# Step 3. Install cross compiler - armhf



# Step 4. Results – cross toolchain

```
pi@raspberrypi:~ $ arm-linux-gnueabihf-
arm-linux-gnueabihf-addr2line      arm-linux-gnueabihf-gcc-nm          arm-linux-gnueabihf-ld.bfd
arm-linux-gnueabihf-ar             arm-linux-gnueabihf-gcc-nm-12       arm-linux-gnueabihf-ld.gold
arm-linux-gnueabihf-as             arm-linux-gnueabihf-gcc-ranlib      arm-linux-gnueabihf-lto-dump
arm-linux-gnueabihf-c++filt        arm-linux-gnueabihf-gcc-ranlib-12   arm-linux-gnueabihf-lto-dump-12
arm-linux-gnueabihf-cpp            arm-linux-gnueabihf-gcov            arm-linux-gnueabihf-nm
arm-linux-gnueabihf-cpp-12         arm-linux-gnueabihf-gcov-12         arm-linux-gnueabihf-objcopy
arm-linux-gnueabihf-dwp            arm-linux-gnueabihf-gcov-dump       arm-linux-gnueabihf-objdump
arm-linux-gnueabihf-elfedit        arm-linux-gnueabihf-gcov-dump-12    arm-linux-gnueabihf-ranlib
arm-linux-gnueabihf-gcc            arm-linux-gnueabihf-gcov-tool       arm-linux-gnueabihf-readelf
arm-linux-gnueabihf-gcc-12         arm-linux-gnueabihf-gcov-tool-12    arm-linux-gnueabihf-size
arm-linux-gnueabihf-gcc-ar         arm-linux-gnueabihf-gprof           arm-linux-gnueabihf-strings
arm-linux-gnueabihf-gcc-ar-12      arm-linux-gnueabihf-ld              arm-linux-gnueabihf-strip
```

# Step 5. Results



# Step 6. readelf –a hello32 vs hello64

```
pi@raspberrypi:~ $ readelf -a hello32
ELF Header:
  Magic:   7f 45 4c 46 01 01 01 00 00 00 00 00 00 00 00 00
  Class:                             ELF32
  Data:                              2's complement, little endian
  Version:                           1 (current)
  OS/ABI:                            UNIX - System V
  ABI Version:                       0
  Type:                              DYN (Position-Independent Executable file)
  Machine:                           ARM
  Version:                           0x1
  Entry point address:               0x409
  Start of program headers:          52 (bytes into file)
  Start of section headers:          6692 (bytes into file)
  Flags:                             0x5000400, Version5 EABI, hard-float ABI
  Size of this header:               52 (bytes)
  Size of program headers:           32 (bytes)
  Number of program headers:         9
  Size of section headers:           40 (bytes)
  Number of section headers:         29
  Section header string table index: 28

Section Headers:
  [Nr] Name              Type            Addr     Off    Size   ES Flg Lk Inf Al
  [ 0]                   NULL            00000000 000000 000000 00      0   0  0
  [ 1] .interp           PROGBITS        00000154 000154 000019 00   A  0   0  1
  [ 2] .note.gnu.bu[...] NOTE            00000170 000170 000024 00   A  0   0  4
  [ 3] .note.ABI-tag     NOTE            00000194 000194 000020 00   A  0   0  4
  [ 4] .gnu.hash         GNU_HASH        000001b4 0001b4 000018 04   A  5   0  4
  [ 5] .dynsym           DYNSYM          000001cc 0001cc 0000a0 10   A  6   3  4
  [ 6] .dynstr           STRTAB          0000026c 00026c 000091 00   A  0   0  1
  [ 7] .gnu.version      VERSYM          000002fe 0002fe 000014 02   A  5   0  2
  [ 8] .gnu.version_r    VERNEED         00000314 000314 000030 00   A  6   1  4
  [ 9] .rel.dyn          REL             00000344 000344 000040 08   A  5   0  4
  [10] .rel.plt          REL             00000384 000384 000028 08  AI  5  21  4
  [11] .init             PROGBITS        000003ac 0003ac 00000c 00  AX  0   0  4
  [12] .plt              PROGBITS        000003b8 0003b8 000050 04  AX  0   0  4
  [13] .text             PROGBITS        00000408 000408 000114 00  AX  0   0  4
  [14] .fini             PROGBITS        0000051c 00051c 000008 00  AX  0   0  4
  [15] .rodata           PROGBITS        00000524 000524 000130 00   A  0   0  4
  [16] .ARM.exidx        ARM_EXIDX       00000654 000654 000008 00  AL 13   0  4
  [17] .eh_frame         PROGBITS        0000065c 00065c 000004 00   A  0   0  4
  [18] .init_array       INIT_ARRAY      00001f08 000f08 000004 04  WA  0   0  4
  [19] .fini_array       FINI_ARRAY      00001f0c 000f0c 000004 04  WA  0   0  4
  [20] .dynamic          DYNAMIC         00001f10 000f10 0000f0 08  WA  6   0  4
  [21] .got              PROGBITS        00002000 001000 000034 04  WA  0   0  4
  [22] .data             PROGBITS        00002034 001034 000008 00  WA  0   0  4
  [23] .bss              NOBITS          0000203c 00103c 000004 00  WA  0   0  1
  [24] .comment          PROGBITS        00000000 00103c 00001f 01  MS  0   0  1
  [25] .ARM.attributes   ARM_ATTRIBUTES  00000000 00105b 000033 00      0   0  1
  [26] .symtab           SYMTAB          00000000 001090 000660 10     27  79  4
  [27] .strtab           STRTAB          00000000 0016f0 00022c 00      0   0  1
  [28] .shstrtab         STRTAB          00000000 00191c 000105 00      0   0  1
Key to Flags:
  W (write), A (alloc), X (execute), M (merge), S (strings), I (info),
  L (link order), O (extra OS processing required), G (group), T (TLS),
```

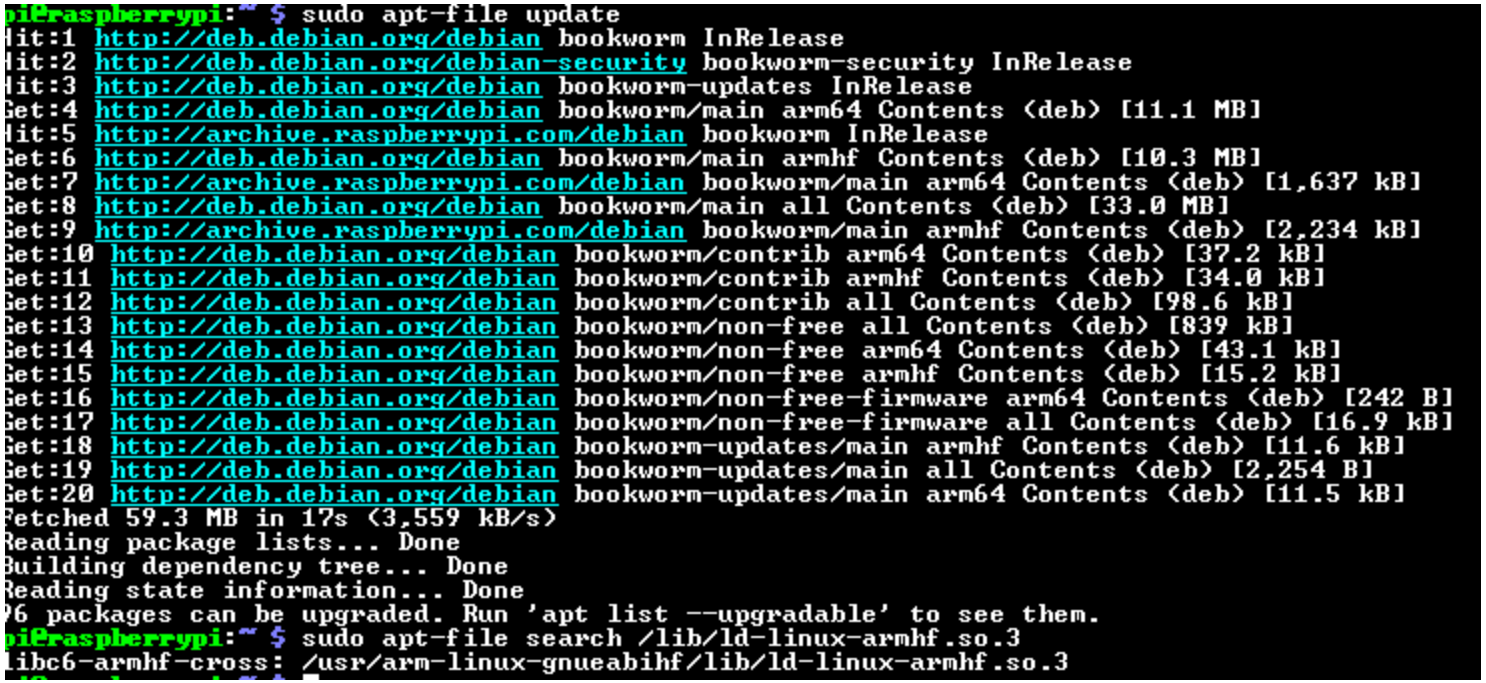
```
pi@raspberrypi:~ $ readelf -a hello64
ELF Header:
  Magic:   7f 45 4c 46 02 01 01 00 00 00 00 00 00 00 00 00
  Class:                             ELF64
  Data:                              2's complement, little endian
  Version:                           1 (current)
  OS/ABI:                            UNIX - System V
  ABI Version:                       0
  Type:                              DYN (Position-Independent Executable file)
  Machine:                           AArch64
  Version:                           0x1
  Entry point address:               0x640
  Start of program headers:          64 (bytes into file)
  Start of section headers:          68576 (bytes into file)
  Flags:                             0x0
  Size of this header:               64 (bytes)
  Size of program headers:           56 (bytes)
  Number of program headers:         9
  Size of section headers:           64 (bytes)
  Number of section headers:         29
  Section header string table index: 28

Section Headers:
  [Nr] Name              Type             Address           Offset
       Size              EntSize          Flags  Link  Info  Align
  [ 0]                   NULL             0000000000000000  00000000
       0000000000000000  0000000000000000           0     0     0
  [ 1] .interp           PROGBITS         0000000000000238  00000238
       000000000000001b  0000000000000000   A       0     0     1
  [ 2] .note.gnu.bu[...] NOTE             0000000000000254  00000254
       0000000000000024  0000000000000000   A       0     0     4
  [ 3] .note.ABI-tag     NOTE             0000000000000278  00000278
       0000000000000020  0000000000000000   A       0     0     4
  [ 4] .gnu.hash         GNU_HASH         0000000000000298  00000298
       000000000000001c  0000000000000000   A       5     0     8
  [ 5] .dynsym           DYNSYM           00000000000002b8  000002b8
       00000000000000f0  0000000000000018   A       6     3     8
  [ 6] .dynstr           STRTAB           00000000000003a8  000003a8
       0000000000000092  0000000000000000   A       0     0     1
  [ 7] .gnu.version      VERSYM           000000000000043a  0000043a
       0000000000000014  0000000000000002   A       5     0     2
  [ 8] .gnu.version_r    VERNEED          0000000000000450  00000450
       0000000000000030  0000000000000000   A       6     1     8
  [ 9] .rela.dyn         RELA             0000000000000480  00000480
       00000000000000c0  0000000000000018   A       5     0     8
  [10] .rela.plt         RELA             0000000000000540  00000540
       0000000000000078  0000000000000018  AI       5    22     8
  [11] .init             PROGBITS         00000000000005b8  000005b8
       0000000000000018  0000000000000000  AX       0     0     4
  [12] .plt              PROGBITS         00000000000005d0  000005d0
       0000000000000070  0000000000000000  AX       0     0    16
  [13] .text             PROGBITS         0000000000000640  00000640
       0000000000000134  0000000000000000  AX       0     0    64
  [14] .fini             PROGBITS         0000000000000774  00000774
       0000000000000014  0000000000000000  AX       0     0     4
  [15] .rodata           PROGBITS         0000000000000788  00000788
```

# Step 7. readelf –a hello32 and hello64 interpret

```
pi@raspberrypi:~ $ readelf -a hello32 | grep interpret
      [Requesting program interpreter: /lib/ld-linux-armhf.so.3]
pi@raspberrypi:~ $ readelf -a hello64 | grep interpret
      [Requesting program interpreter: /lib/ld-linux-aarch64.so.1]
pi@raspberrypi:~ $ ls /lib/ld-*
/lib/ld-linux-aarch64.so.1
```

# Step 8. apt-file list



# Step 9. Install libc6:armhf

```
pi@raspberrypi:~ $ sudo apt-get install libc6:armhf
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  gcc-12-base:armhf libgcc-s1:armhf libidn2-0:armhf libunistring2:armhf
Suggested packages:
  glibc-doc:armhf locales:armhf libnss-nis:armhf libnss-nisplus:armhf
The following NEW packages will be installed:
  gcc-12-base:armhf libc6:armhf libgcc-s1:armhf libidn2-0:armhf libunistring2:armhf
0 upgraded, 5 newly installed, 0 to remove and 96 not upgraded.
Need to get 2,713 kB of archives.
After this operation, 11.4 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://deb.debian.org/debian bookworm/main armhf gcc-12-base armhf 12.2.0-14 [37.5 kB]
Get:2 http://deb.debian.org/debian bookworm/main armhf libgcc-s1 armhf 12.2.0-14 [36.6 kB]
Get:3 http://deb.debian.org/debian bookworm/main armhf libunistring2 armhf 1.0-2 [409 kB]
Get:4 http://deb.debian.org/debian bookworm/main armhf libidn2-0 armhf 2.3.3-1+b1 [120 kB]
Get:5 http://archive.raspberrypi.com/debian bookworm/main armhf libc6 armhf 2.36-9+rpt2+deb12u3 [2,110 kB]
Fetched 2,713 kB in 2s (1,436 kB/s)
Preconfiguring packages ...
Selecting previously unselected package gcc-12-base:armhf.
(Reading database ... 127650 files and directories currently installed.)
Preparing to unpack .../gcc-12-base_12.2.0-14_armhf.deb ...
Unpacking gcc-12-base:armhf (12.2.0-14) ...
Selecting previously unselected package libgcc-s1:armhf.
Preparing to unpack .../libgcc-s1_12.2.0-14_armhf.deb ...
Unpacking libgcc-s1:armhf (12.2.0-14) ...
Selecting previously unselected package libc6:armhf.
Preparing to unpack .../libc6_2.36-9+rpt2+deb12u3_armhf.deb ...
Unpacking libc6:armhf (2.36-9+rpt2+deb12u3) ...
Selecting previously unselected package libunistring2:armhf.
Preparing to unpack .../libunistring2_1.0-2_armhf.deb ...
Unpacking libunistring2:armhf (1.0-2) ...
Selecting previously unselected package libidn2-0:armhf.
Preparing to unpack .../libidn2-0_2.3.3-1+b1_armhf.deb ...
Unpacking libidn2-0:armhf (2.3.3-1+b1) ...
Setting up gcc-12-base:armhf (12.2.0-14) ...
Setting up libgcc-s1:armhf (12.2.0-14) ...
Setting up libc6:armhf (2.36-9+rpt2+deb12u3) ...
Setting up libunistring2:armhf (1.0-2) ...
Setting up libidn2-0:armhf (2.3.3-1+b1) ...
Processing triggers for libc-bin (2.36-9+rpt2+deb12u3) ...
pi@raspberrypi:~ $
```

# Step 10. We can run both 64 bits and 32 bits target

```
pi@raspberrypi:~ $ nano hello.c
pi@raspberrypi:~ $ arm-linux-gnueabihf-gcc -Wall -o hello32 hello.c
pi@raspberrypi:~ $ gcc -Wall -o hello64 hello.c
pi@raspberrypi:~ $ ./hello32
Hello World
sizeof(p): 4
pi@raspberrypi:~ $ ./hello64
Hello World
sizeof(p): 8
pi@raspberrypi:~ $ cat hello.c
#include <stdio.h>
#include <inttypes.h>

int main() {
    puts("Hello World");
    char *p = "hello";
    printf("sizeof(p): %" PRIuPTR "\n", sizeof(p));
    return 0;
}
pi@raspberrypi:~ $
```

# Step 11. Clone micropython

```
pi@raspberrypi:~ $ git clone --depth=1 https://github.com/micropython/micropython
Cloning into 'micropython'...
remote: Enumerating objects: 5570, done.
remote: Counting objects: 100% (5570/5570), done.
remote: Compressing objects: 100% (4529/4529), done.
remote: Total 5570 (delta 1341), reused 3075 (delta 718), pack-reused 0
Receiving objects: 100% (5570/5570), 7.97 MiB | 8.04 MiB/s, done.
Resolving deltas: 100% (1341/1341), done.
pi@raspberrypi:~ $ cd micropython/
pi@raspberrypi:~/micropython $ ls
ACKNOWLEDGEMENTS    CODEOFCONDUCT.md  docs     examples  lib      logo       ports  pyproject.toml  shared  tools
CODECONVENTIONS.md  CONTRIBUTING.md   drivers  extmod    LICENSE  mpy-cross  py     README.md       tests
pi@raspberrypi:~/micropython $
```

# Step 12. Building micropython for linux – missing libffi

```
pi@raspberrypi:~/micropython $ cd ports
pi@raspberrypi:~/micropython/ports $ ls
bare-arm  embed  esp8266  minimal  pic16bit  qemu-arm    rp2   stm32  webassembly  zephyr
cc3200    esp32  mimxrt   nrf      powerpc   renesas-ra  samd  unix   windows
pi@raspberrypi:~/micropython/ports $ cd unix
pi@raspberrypi:~/micropython/ports/unix $ ls
alloc.c          input.c    modffi.c      modtermios.c           mpbtstackport_h4.c   mpnimbleport.c  README.md
coverage.c       input.h    modjni.c      modtime.c              mpbtstackport_usb.c  mpnimbleport.h  unix_mphal.c
coveragecpp.cpp  main.c     modmachine.c  mpbthciport.c          mpconfigport.h       mpthreadport.c  variants
fatfs_port.c     Makefile   modos.c       mpbtstackport_common.c mpconfigport.mk      mpthreadport.h
gccollect.c      mbedtls    modsocket.c   mpbtstackport.h        mphalport.h          qstrdefsport.h
pi@raspberrypi:~/micropython/ports/unix $ make submodules
Use make V=1 or set BUILD_VERBOSE in your environment to increase build verbosity.
Package libffi was not found in the pkg-config search path.
Perhaps you should add the directory containing `libffi.pc'
to the PKG_CONFIG_PATH environment variable
Package 'libffi', required by 'virtual:world', not found
Package libffi was not found in the pkg-config search path.
Perhaps you should add the directory containing `libffi.pc'
to the PKG_CONFIG_PATH environment variable
Package 'libffi', required by 'virtual:world', not found
Updating submodules: lib/mbedtls lib/berkeley-db-1.xx lib/micropython-lib
Submodule 'lib/berkeley-db-1.xx' (https://github.com/pfalcon/berkeley-db-1.xx) registered for path '../../lib/berkeley-db-1.xx'
Submodule 'lib/mbedtls' (https://github.com/ARMmbed/mbedtls.git) registered for path '../../lib/mbedtls'
Submodule 'lib/micropython-lib' (https://github.com/micropython/micropython-lib.git) registered for path '../../lib/micropython
-lib'
Cloning into '/home/pi/micropython/lib/berkeley-db-1.xx'...
Cloning into '/home/pi/micropython/lib/mbedtls'...
Cloning into '/home/pi/micropython/lib/micropython-lib'...
Submodule path '../../lib/berkeley-db-1.xx': checked out '35aaec4418ad78628a3b935885dd189d41ce779b'
Submodule path '../../lib/mbedtls': checked out '981743de6fcdbe672e482b6fd724d31d0a0d2476'
Submodule path '../../lib/micropython-lib': checked out 'e025c843b60e93689f0f991d753010bb5bd6a722'
pi@raspberrypi:~/micropython/ports/unix $ make
Use make V=1 or set BUILD_VERBOSE in your environment to increase build verbosity.
Package libffi was not found in the pkg-config search path.
Perhaps you should add the directory containing `libffi.pc'
to the PKG_CONFIG_PATH environment variable
Package 'libffi', required by 'virtual:world', not found
Package libffi was not found in the pkg-config search path.
Perhaps you should add the directory containing `libffi.pc'
to the PKG_CONFIG_PATH environment variable
Package 'libffi', required by 'virtual:world', not found
mkdir -p build-standard/genhdr
GEN build-standard/genhdr/mpversion.h
GEN build-standard/genhdr/qstr.i.last
modffi.c:40:10: fatal error: ffi.h: No such file or directory
   40 | #include <ffi.h>
      |          ^~~~~~~
compilation terminated.
Command '['gcc', '-E', '-DMICROPY_VFS_FAT=1', '-DMICROPY_VFS_LFS1=1', '-DMICROPY_VFS_LFS2=1', '-DMICROPY_PY_SSL=1', '-DMBEDTLS_
CONFIG_FILE="mbedtls/mbedtls_config.h"', '-DMICROPY_SSL_MBEDTLS=1', '-I../../lib/mbedtls/include', '-DMICROPY_PY_BTREE=1', '-DF
FCONF_H="lib/oofatfs/ffconf.h"', '-DLFS1_NO_MALLOC', '-DLFS1_NO_DEBUG', '-DLFS1_NO_WARN', '-DLFS1_NO_ERROR', '-DLFS1_NO_ASSERT'
, '-DLFS2_NO_MALLOC', '-DLFS2_NO_DEBUG', '-DLFS2_NO_WARN', '-DLFS2_NO_ERROR', '-DLFS2_NO_ASSERT', '-I../../lib/berkeley-db-1.xx
/PORT/include', '-I.', '-I../..', '-Ibuild-standard', '-I../../shared/readline', '-Wall', '-Werror', '-Wextra', '-Wno-unused-pa
rameter', '-Wpointer-arith', '-Wdouble-promotion', '-Wfloat-conversion', '-std=gnu99', '-DUNIX', '-Os', '-DNDEBUG', '-fdata-sec
tions', '-ffunction-sections', '-Ivariants/standard', '-g', '-U', '_FORTIFY_SOURCE', '-DMICROPY_USE_READLINE=1', '-DMICROPY_PY_
TERMIOS=1', '-DMICROPY_PY_SOCKET=1', '-DMICROPY_PY_THREAD=1', '-DMICROPY_PY_THREAD_GIL=0', '-DMICROPY_PY_FFI=1', '-DMPZ_DIG_SIZ
E=16', '-DMICROPY_ROM_TEXT_COMPRESSION=1', '-DNO_QSTR', '../../extmod/modselect.c', '../../extmod/modsocket.c', '../../extmod/m
odssl_axtls.c', '../../extmod/modssl_mbedtls.c', '../../extmod/modtime.c', '../../extmod/moductypes.c', '../../extmod/modwebrep
l.c', '../../extmod/modwebsocket.c', '../../extmod/network_cyw43.c', '../../extmod/network_esp_hosted.c', '../../extmod/network
_lwip.c', '../../extmod/network_ninaw10.c', '../../extmod/network_wiznet5k.c', '../../extmod/os_dupterm.c', '../../extmod/vfs.c
', '../../extmod/vfs_blockdev.c', '../../extmod/vfs_fat.c', '../../extmod/vfs_fat_diskio.c', '../../extmod/vfs_fat_file.c', '..
/../extmod/vfs_lfs.c', '../../extmod/vfs_posix.c', '../../extmod/vfs_posix_file.c', '../../extmod/vfs_reader.c', '../../extmod/
virtpin.c', '../../shared/libc/abort_.c', '../../shared/libc/printf.c', 'main.c', 'gccollect.c', 'unix_mphal.c', 'mpthreadport.
c', 'input.c', 'modmachine.c', 'alloc.c', 'fatfs_port.c', 'mpbthciport.c', 'mpbtstackport_common.c', 'mpbtstackport_h4.c', 'mpb
tstackport_usb.c', 'mpnimbleport.c', 'modtermios.c', 'modsocket.c', 'modffi.c', 'modjni.c', '../../shared/runtime/gchelper_gene
ric.c', '../../shared/timeutils/timeutils.c', '../../shared/readline/readline.c']' returned non-zero exit status 1.
make: *** [../../py/mkrules.mk:122: build-standard/genhdr/qstr.i.last] Error 1
make: *** Deleting file 'build-standard/genhdr/qstr.i.last'
pi@raspberrypi:~/micropython/ports/unix $ apt-cache search libffi
libffindex0 - library for simple index/database for huge amounts of small files
libffindex0-dev - library for simple index/database for huge amounts of small files (development)
libgirepository-1.0-1 - Library for handling GObject introspection data (runtime library)
libghc-libffi-dev - A binding to libffi
libghc-libffi-doc - A binding to libffi; documentation
libghc-libffi-prof - A binding to libffi; profiling libraries
```

# Step 13. apt show libffi-dev

```
pi@raspberrypi:~/micropython/ports/unix $ apt show libffi-dev
Package: libffi-dev
Version: 3.4.4-1
Priority: optional
Section: libdevel
Source: libffi
Maintainer: Debian GCC Maintainers <debian-gcc@lists.debian.org>
Installed-Size: 293 kB
Depends: libffi8 (= 3.4.4-1)
Conflicts: libffi4-dev
Homepage: https://sourceware.org/libffi/
Tag: devel::library, role::devel-lib
Download-Size: 56.0 kB
APT-Sources: http://deb.debian.org/debian bookworm/main arm64 Packages
Description: Foreign Function Interface library (development files)
 This package contains the headers and static library files necessary for
 building programs which use libffi.
 .
 A foreign function interface is the popular name for the interface that
 allows code written in one language to call code written in another
 language.

pi@raspberrypi:~/micropython/ports/unix $
```

# Step 14. sudo apt install libffi-dev

```
pi@raspberrypi:~/micropython/ports/unix $ sudo apt install libffi-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following NEW packages will be installed:
  libffi-dev
0 upgraded, 1 newly installed, 0 to remove and 96 not upgraded.
Need to get 56.0 kB of archives.
After this operation, 293 kB of additional disk space will be used.
Get:1 http://deb.debian.org/debian bookworm/main arm64 libffi-dev arm64 3.4.4-1 [56.0 kB]
Fetched 56.0 kB in 0s (397 kB/s)
Selecting previously unselected package libffi-dev:arm64.
(Reading database ... 127937 files and directories currently installed.)
Preparing to unpack .../libffi-dev_3.4.4-1_arm64.deb ...
Unpacking libffi-dev:arm64 (3.4.4-1) ...
Setting up libffi-dev:arm64 (3.4.4-1) ...
Processing triggers for man-db (2.11.2-2) ...
pi@raspberrypi:~/micropython/ports/unix $ dpkg -L libffi-dev
/.
/usr
/usr/include
/usr/include/aarch64-linux-gnu
/usr/include/aarch64-linux-gnu/ffi.h
/usr/include/aarch64-linux-gnu/ffitarget.h
/usr/lib
/usr/lib/aarch64-linux-gnu
/usr/lib/aarch64-linux-gnu/libffi.a
/usr/lib/aarch64-linux-gnu/libffi_pic.a
/usr/lib/aarch64-linux-gnu/pkgconfig
/usr/lib/aarch64-linux-gnu/pkgconfig/libffi.pc
/usr/share
/usr/share/doc
/usr/share/doc/libffi8
/usr/share/doc/libffi8/README.md.gz
/usr/share/doc/libffi8/html
/usr/share/doc/libffi8/html/Arrays-Unions-Enums.html
/usr/share/doc/libffi8/html/Closure-Example.html
/usr/share/doc/libffi8/html/Complex-Type-Example.html
/usr/share/doc/libffi8/html/Complex.html
/usr/share/doc/libffi8/html/Index.html
/usr/share/doc/libffi8/html/Introduction.html
/usr/share/doc/libffi8/html/Memory-Usage.html
/usr/share/doc/libffi8/html/Missing-Features.html
/usr/share/doc/libffi8/html/Multiple-ABIs.html
/usr/share/doc/libffi8/html/Primitive-Types.html
/usr/share/doc/libffi8/html/Simple-Example.html
/usr/share/doc/libffi8/html/Size-and-Alignment.html
/usr/share/doc/libffi8/html/Structures.html
/usr/share/doc/libffi8/html/The-Basics.html
/usr/share/doc/libffi8/html/The-Closure-API.html
/usr/share/doc/libffi8/html/Thread-Safety.html
/usr/share/doc/libffi8/html/Type-Example.html
/usr/share/doc/libffi8/html/Types.html
/usr/share/doc/libffi8/html/Using-libffi.html
/usr/share/doc/libffi8/html/index.html
/usr/share/doc-base
/usr/share/doc-base/libffi-dev.libffi
/usr/share/info
/usr/share/info/libffi.info.gz
/usr/share/man
/usr/share/man/man3
/usr/share/man/man3/ffi.3.gz
/usr/share/man/man3/ffi_call.3.gz
/usr/share/man/man3/ffi_prep_cif.3.gz
/usr/share/man/man3/ffi_prep_cif_var.3.gz
/usr/lib/aarch64-linux-gnu/libffi.so
/usr/share/doc/libffi-dev
pi@raspberrypi:~/micropython/ports/unix $
```

# Step 15. Also install the armhf version

```
pi@raspberrypi:~/micropython/ports/unix $ sudo apt install libffi-dev:armhf
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  libffi8:armhf
The following NEW packages will be installed:
  libffi-dev:armhf libffi8:armhf
0 upgraded, 2 newly installed, 0 to remove and 96 not upgraded.
Need to get 74.5 kB of archives.
After this operation, 353 kB of additional disk space will be used.
Do you want to continue? [Y/n]
```

# Step 16. make and try to run it

```
pi@raspberrypi:~/micropython/ports/unix $ make
Use make V=1 or set BUILD_VERBOSE in your environment to increase build verbosity.
GEN build-standard/genhdr/qstr.i.last
GEN build-standard/genhdr/qstr.split
GEN build-standard/genhdr/qstrdefs.collected.h
QSTR updated
GEN build-standard/genhdr/qstrdefs.generated.h
GEN build-standard/genhdr/moduledefs.split
GEN build-standard/genhdr/moduledefs.collected
Module registrations updated
GEN build-standard/genhdr/moduledefs.h
GEN build-standard/genhdr/root_pointers.split
GEN build-standard/genhdr/root_pointers.collected
Root pointer registrations updated
GEN build-standard/genhdr/root_pointers.h
GEN build-standard/genhdr/compressed.split
GEN build-standard/genhdr/compressed.collected
Compressed data updated
GEN build-standard/genhdr/compressed.data.h
mkdir -p build-standard/build-standard/
mkdir -p build-standard/extmod/
mkdir -p build-standard/lib/berkeley-db-1.xx/btree/
mkdir -p build-standard/lib/berkeley-db-1.xx/mpool/
mkdir -p build-standard/lib/littlefs/
mkdir -p build-standard/lib/mbedtls/library/
mkdir -p build-standard/lib/mbedtls_errors/
mkdir -p build-standard/lib/oofatfs/
mkdir -p build-standard/py/
mkdir -p build-standard/shared/libc/
mkdir -p build-standard/shared/readline/
mkdir -p build-standard/shared/runtime/
mkdir -p build-standard/shared/timeutils/
CC ../../py/mpstate.c
CC ../../py/nlr.c
CC ../../py/nlrx86.c
CC ../../py/nlrx64.c
CC ../../py/nlrthumb.c
CC ../../py/nlraarch64.c
CC ../../py/nlrmips.c
CC ../../py/nlrpowerpc.c
CC ../../py/nlrxtensa.c
CC ../../py/nlrsetjmp.c
CC ../../py/malloc.c
CC ../../py/gc.c
CC ../../py/pystack.c
CC ../../py/qstr.c
CC ../../py/vstr.c
CC ../../py/mpprint.c
CC ../../py/unicode.c
CC ../../py/mpz.c
CC ../../py/reader.c
```

```
pi@raspberrypi:~/micropython/ports/unix $ ./build-standard/micropython
MicroPython 6117aa6 on 2023-11-18; linux [GCC 12.2.0] version
Use Ctrl-D to exit, Ctrl-E for paste mode
>>> print("Hello micropython")
Hello micropython
>>>
```

# Step 17. Compile for 32 bit machine, it is successful.

```
pi@raspberrypi:~/micropython/ports/unix $ make CROSS_COMPILE=arm-linux-gnueabihf-
Use make V=1 or set BUILD_VERBOSE in your environment to increase build verbosity.
GEN build-standard/genhdr/qstr.i.last
GEN build-standard/genhdr/qstr.split
GEN build-standard/genhdr/qstrdefs.collected.h
QSTR updated
GEN build-standard/genhdr/qstrdefs.generated.h
GEN build-standard/genhdr/moduledefs.split
GEN build-standard/genhdr/moduledefs.collected
Module registrations updated
GEN build-standard/genhdr/moduledefs.h
GEN build-standard/genhdr/root_pointers.split
GEN build-standard/genhdr/root_pointers.collected
Root pointer registrations updated
GEN build-standard/genhdr/root_pointers.h
GEN build-standard/genhdr/compressed.split
GEN build-standard/genhdr/compressed.collected
Compressed data updated
GEN build-standard/genhdr/compressed.data.h
mkdir -p build-standard/build-standard/
mkdir -p build-standard/extmod/
mkdir -p build-standard/lib/berkeley-db-1.xx/btree/
mkdir -p build-standard/lib/berkeley-db-1.xx/mpool/
mkdir -p build-standard/lib/littlefs/
mkdir -p build-standard/lib/mbedtls/library/
mkdir -p build-standard/lib/mbedtls_errors/
mkdir -p build-standard/lib/oofatfs/
mkdir -p build-standard/py/
mkdir -p build-standard/shared/libc/
mkdir -p build-standard/shared/readline/
mkdir -p build-standard/shared/runtime/
mkdir -p build-standard/shared/timeutils/
CC ../../py/mpstate.c
CC ../../py/nlr.c
CC ../../py/nlrx86.c
CC ../../py/nlrx64.c
CC ../../py/nlrthumb.c
CC ../../py/nlraarch64.c
CC ../../py/nlrmips.c
CC ../../py/nlrpowerpc.c
CC ../../py/nlrxtensa.c
CC ../../py/nlrsetjmp.c
CC ../../py/malloc.c
CC ../../py/gc.c
CC ../../py/pystack.c
CC ../../py/qstr.c
CC ../../py/vstr.c
CC ../../py/mpprint.c
CC ../../py/unicode.c
CC ../../py/mpz.c
CC ../../py/reader.c
CC ../../py/lexer.c
CC ../../py/parse.c
CC ../../py/scope.c
CC ../../py/compile.c
CC ../../py/emitcommon.c
CC ../../py/emitbc.c
CC ../../py/asmbase.c
CC ../../py/asmx64.c
CC ../../py/emitnx64.c
CC ../../py/asmx86.c
CC ../../py/emitnx86.c
CC ../../py/asmthumb.c
CC ../../py/emitnthumb.c
CC ../../py/emitinlinethumb.c
CC ../../py/asmarm.c
CC ../../py/emitnarm.c
CC ../../py/asmxtensa.c
CC ../../py/emitnxtensa.c
CC ../../py/emitinlinextensa.c
CC ../../py/emitnxtensawin.c
CC ../../py/formatfloat.c
CC ../../py/parsenumbase.c
CC ../../py/parsenum.c
CC ../../py/emitglue.c
```

```
pi@raspberrypi:~/micropython/ports/unix $ file build-standard/micropython
build-standard/micropython: ELF 32-bit LSB pie executable, ARM, EABI5 version 1 (SYSV), dynamically linked, interpreter /lib/ld-linu
x-armhf.so.3, BuildID[sha1]=8a33f2468ed72b8263e7b54573daf57506171ad2, for GNU/Linux 3.2.0, stripped
pi@raspberrypi:~/micropython/ports/unix $
```

Step 18. When trying to run on 32 bit target, issues happened. Since I do not have another 32 bit target, I will just copy and paste the slides here.

```
scp ./build-standard/micropython metaembedded@192.168.4.34:./Downloads/.
metaembedded@192.168.4.34's password:
micropython
```

```
ssh metaembedded@192.168.4.34
metaembedded@192.168.4.34's password:
Linux raspberrypi 6.1.21-v7l+ #1642 SMP Mon Apr  3 17:22:30 BST 2023 armv7l

$ arch
armv7l

$ ldd Downloads/micropython
Downloads/micropython: /lib/arm-linux-gnueabihf/libc.so.6: version `GLIBC_2.33' not found (required by Downloads/micropython)
Downloads/micropython: /lib/arm-linux-gnueabihf/libc.so.6: version `GLIBC_2.34' not found (required by Downloads/micropython)
  linux-vdso.so.1 (0xbeeec000)
  /usr/lib/arm-linux-gnueabihf/libarmmem-${PLATFORM}.so => /usr/lib/arm-linux-gnueabihf/libarmmem-v7l.so (0xb6e55000)
  libm.so.6 => /lib/arm-linux-gnueabihf/libm.so.6 (0xb6dd1000)
  libffi.so.8 => not found
  libc.so.6 => /lib/arm-linux-gnueabihf/libc.so.6 (0xb6c7d000)
  /lib/ld-linux-armhf.so.3 (0xb6ed2000)
```

Issue #2

Issue #1

# Step 19. If facing libffi.so.8 missing, simply copy this file from host to target

```
$ scp dev@192.168.4.73:/usr/lib/arm-linux-gnueabihf/libffi.so.8 ~/Downloads
. . .


$ sudo mv Downloads/libffi.so.8 /usr/lib/arm-linux-gnueabihf/.

$ ldd Downloads/micropython
Downloads/micropython: /lib/arm-linux-gnueabihf/libc.so.6: version `GLIBC_2.33' not found (required by Downloac
micropython)
Downloads/micropython: /lib/arm-linux-gnueabihf/libc.so.6: version `GLIBC_2.34' not found (required by Downloac
micropython)
  linux-vdso.so.1 (0xbed92000)
  /usr/lib/arm-linux-gnueabihf/libarmmem-${PLATFORM}.so => /usr/lib/arm-linux-gnueabihf/libarmmem-v7l.so
(0xb6ea9000)
  libm.so.6 => /lib/arm-linux-gnueabihf/libm.so.6 (0xb6e25000)
  libffi.so.8 => /lib/arm-linux-gnueabihf/libffi.so.8 (0xb6e04000)
  libc.so.6 => /lib/arm-linux-gnueabihf/libc.so.6 (0xb6cb0000)
  /lib/ld-linux-armhf.so.3 (0xb6f26000)
  libgcc_s.so.1 => /lib/arm-linux-gnueabihf/libgcc_s.so.1 (0xb6c83000)
```

Issue #1 Solved!

# Step 20. glib has versioned symbols

```
pi@raspberrypi:~/micropython/ports/unix $ getconf -a | grep LIBC
GNU_LIBC_VERSION                   glibc 2.36
pi@raspberrypi:~/micropython/ports/unix $ readelf --version-info /lib/arm-linux-gnueabihf/libc.so.6 | head

Version symbols section '.gnu.version' contains 3095 entries:
 Addr: 0x000000000001990a  Offset: 0x0001990a  Link: 4 (.dynsym)
  000:   0 (*local*)       0 (*local*)       0 (*local*)       22 (GLIBC_PRIVATE)
  004:  22 (GLIBC_PRIVATE)  23 (GLIBC_2.4)    22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)
  008:  22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)
  00c:  22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)
  010:  23 (GLIBC_2.4)    22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)  22 (GLIBC_PRIVATE)
  014:  23 (GLIBC_2.4)    22 (GLIBC_PRIVATE)   2 (GLIBC_2.4)     2h(GLIBC_2.4)
  018:   2 (GLIBC_2.4)     2 (GLIBC_2.4)    1d (GLIBC_2.34)    2 (GLIBC_2.4)
pi@raspberrypi:~/micropython/ports/unix $ readelf --version-info /lib/arm-linux-gnueabihf/libc.so.6 | grep GLIBC_2.30
  15c:  19 (GLIBC_2.30)    5 (GLIBC_2.7)     2h(GLIBC_2.4)     2 (GLIBC_2.4)
  18c:   2h(GLIBC_2.4)    19 (GLIBC_2.30)    2 (GLIBC_2.4)     2 (GLIBC_2.4)
  2f4:  19h(GLIBC_2.30)    2 (GLIBC_2.4)     2 (GLIBC_2.4)     2 (GLIBC_2.4)
  704:   2 (GLIBC_2.4)     2 (GLIBC_2.4)     2 (GLIBC_2.4)    19h(GLIBC_2.30)
  850:  21 (GLIBC_PRIVATE)  19 (GLIBC_2.30)    2h(GLIBC_2.4)     2 (GLIBC_2.4)
  8ac:  19h(GLIBC_2.30)    2h(GLIBC_2.4)     2 (GLIBC_2.4)     2h(GLIBC_2.4)
  8d0:  21 (GLIBC_PRIVATE)  19h(GLIBC_2.30)    2 (GLIBC_2.4)     1d (GLIBC_2.34)
  99c:   2 (GLIBC_2.4)     2 (GLIBC_2.4)     2h(GLIBC_2.4)    19 (GLIBC_2.30)
  ac8:  17h(GLIBC_2.28)   1d (GLIBC_2.34)   19 (GLIBC_2.30)    2 (GLIBC_2.4)
  ba0:   2 (GLIBC_2.4)     2 (GLIBC_2.4)     2h(GLIBC_2.4)    19h(GLIBC_2.30)
  0x0350: Rev: 1  Flags: none  Index: 25  Cnt: 2  Name: GLIBC_2.30
  0x0390: Parent 1: GLIBC_2.30
```

# Step 21. No symbol versioning

```
pi@raspberrypi:~/micropython/ports/unix $ gcc -shared -o libmylib.so mylibv1.c
pi@raspberrypi:~/micropython/ports/unix $ readelf -a libmylib.so | grep -E 'hello' -B 3
     5: 0000000000000000     0 NOTYPE  WEAK   DEFAULT  UND __gmon_start__
     6: 0000000000000000     0 FUNC    GLOBAL DEFAULT  UND puts@GLIBC_2.17 (2)
     7: 0000000000000000     0 NOTYPE  WEAK   DEFAULT  UND _ITM_registerTMC[...]
     8: 00000000000005d4    32 FUNC    GLOBAL DEFAULT   11 hello
--
    61: 00000000000004a0     0 NOTYPE  LOCAL  DEFAULT   10 $x
    62: 0000000000000000     0 NOTYPE  WEAK   DEFAULT  UND _ITM_deregisterT[...]
    63: 0000000000000000     0 FUNC    WEAK   DEFAULT  UND __cxa_finalize@G[...]
    64: 00000000000005d4    32 FUNC    GLOBAL DEFAULT   11 hello
pi@raspberrypi:~/micropython/ports/unix $ cat mylibv1.c
#include <stdio.h>

void hello() {
    puts("Hello: v1");
}
pi@raspberrypi:~/micropython/ports/unix $
```

# Step 22. Symbol versioning

```
pi@raspberrypi:~/micropython/ports/unix $ cat mylibv1.version
MYLIB_1.0 {
    global: hello;
};
pi@raspberrypi:~/micropython/ports/unix $ gcc -shared -Wl,--version-script,mylibv1.version -o libmylib.so mylibv1.c
pi@raspberrypi:~/micropython/ports/unix $ readelf -a libmylib.so | grep -E 'hello' -B 3
     6: 0000000000000000     0 FUNC    GLOBAL DEFAULT  UND puts@GLIBC_2.17 (3)
     7: 0000000000000000     0 NOTYPE  WEAK   DEFAULT  UND _ITM_registerTMC[...]
     8: 0000000000000000     0 OBJECT  GLOBAL DEFAULT  ABS MYLIB_1.0
     9: 0000000000000644    32 FUNC    GLOBAL DEFAULT   12 hello@@MYLIB_1.0
--
```