

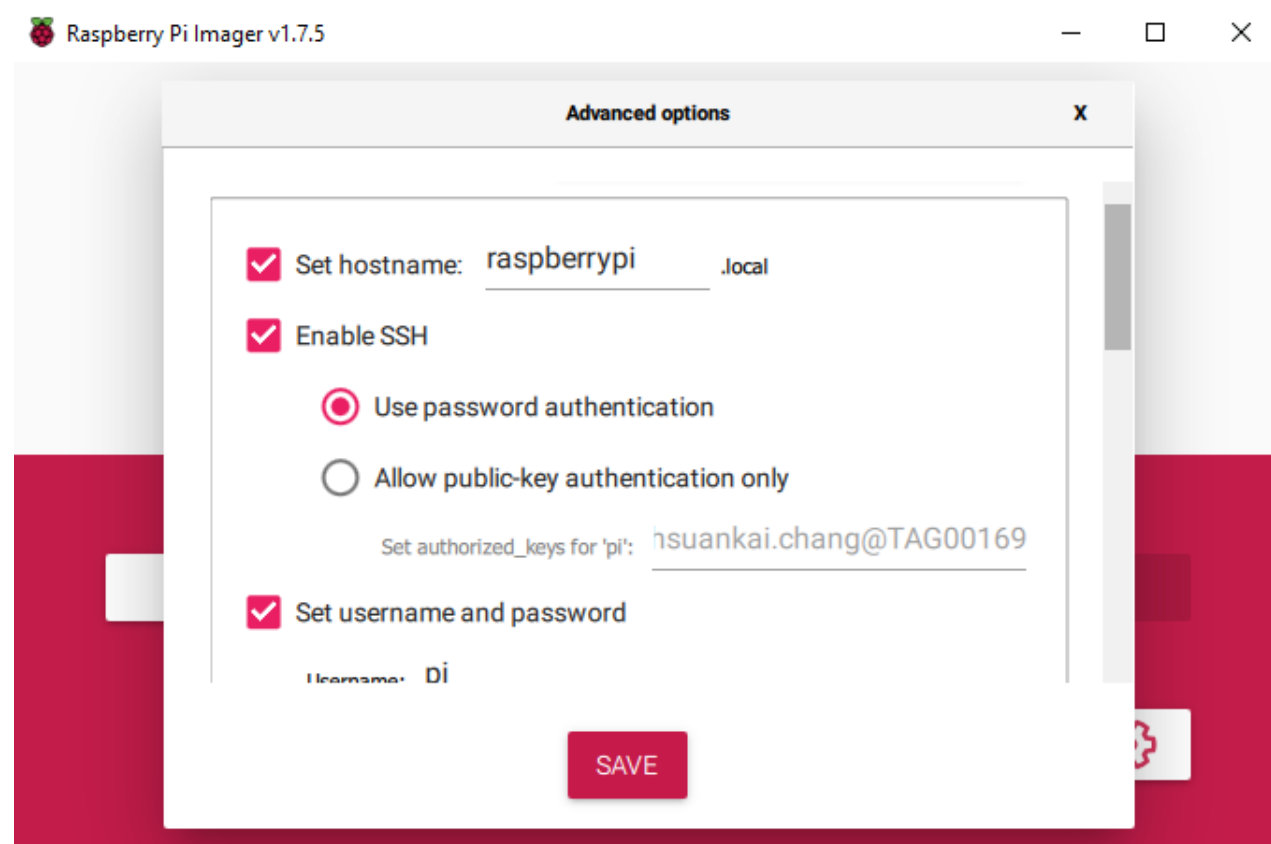
UCSD Embedded Linux Assignment 1

By

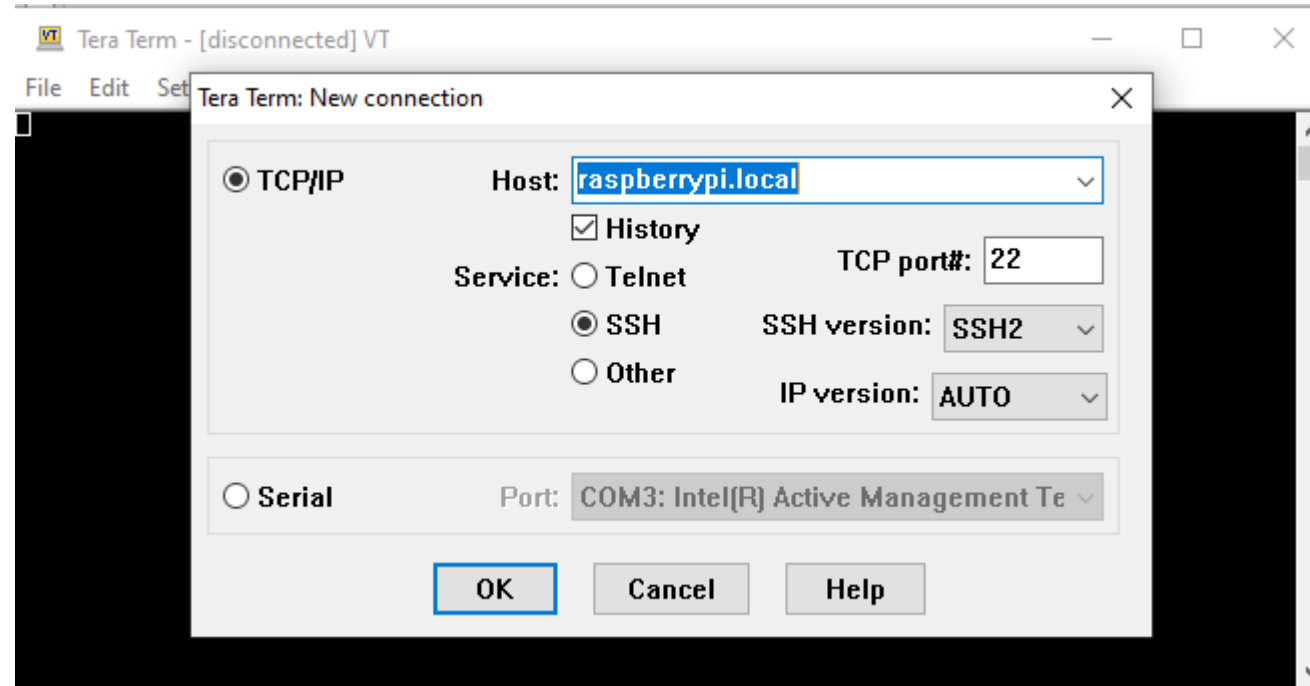
Hsuankai Chang

hsuankac@umich.edu

Step 1. Flash the image file of the raspberrypi using raspberrypi imager into the micro sd card. Since I am using the headless connection way, I will have to enable to SSH connection in the advanced settings. Noted that I still set my raspberrypi as default username: pi and password: raspberry.



Step 2. After writing the image to the SD card is complete, plug the SD card into raspberrypi, connect the power and ethernet cable. Start the power and use tera term to log into the raspberrypi.



Step 3. Type the username and password for the pi, then enable the VNC connection by typing in `sudo raspi-config`. Then go to interface options, VNC, choose yes to enable

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
Linux raspberrypi 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr  3 17:24:16 BST 2023 aarc
h64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed May  3 01:50:07 2023 from 169.254.105.192

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set
a new password.

pi@raspberrypi:~$ sudo raspi-config
pi@raspberrypi:~$
```

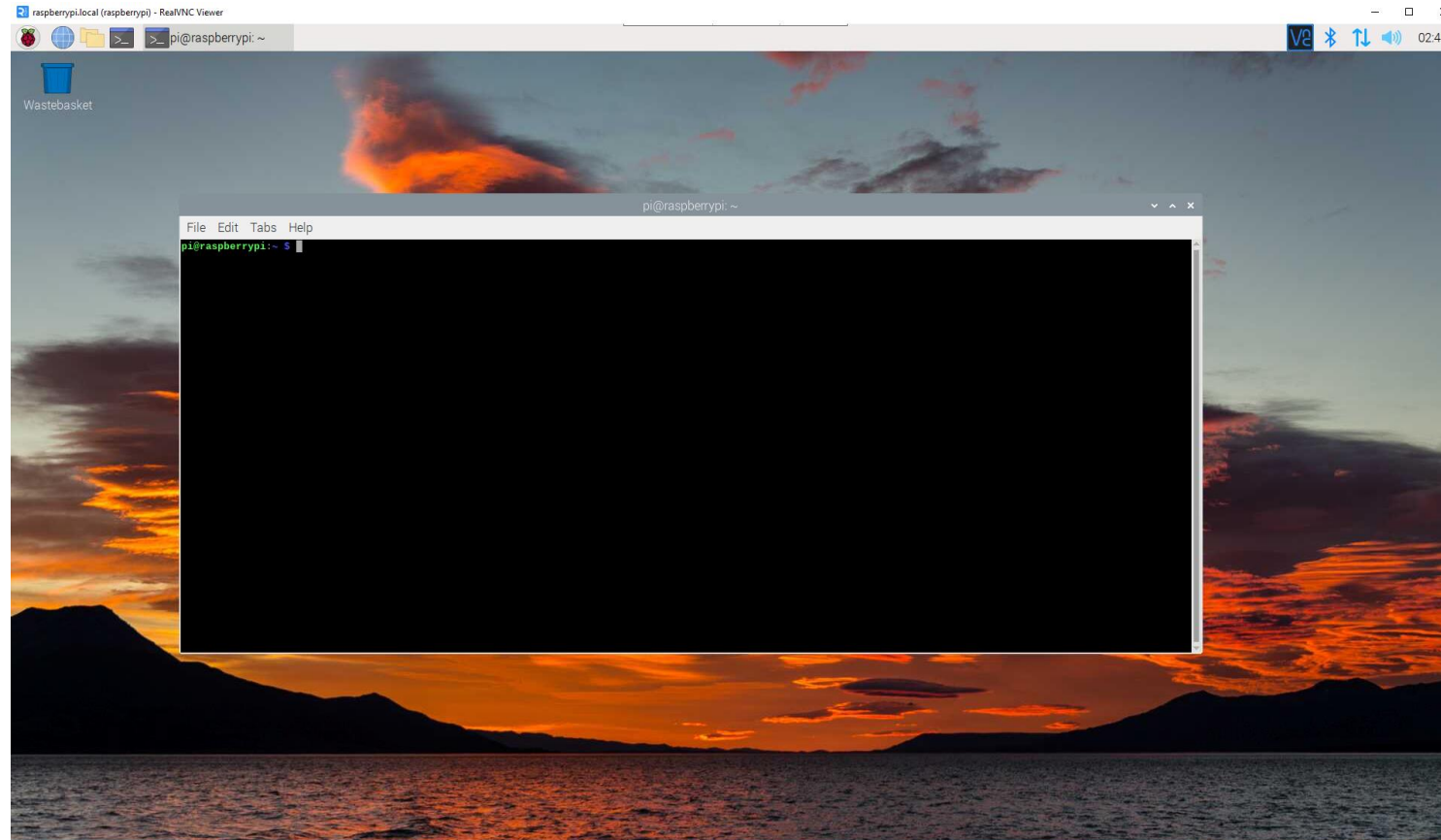
```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help

Raspberry Pi Software Configuration Tool (raspi-config)

I1 Legacy Camera Enable/disable legacy camera support
I2 SSH Enable/disable remote command line access using SSH
I3 UNC Enable/disable graphical remote access using RealVNC
I4 SPI Enable/disable automatic loading of SPI kernel module
I5 I2C Enable/disable automatic loading of I2C kernel module
I6 Serial Port Enable/disable shell messages on the serial connection
I7 1-Wire Enable/disable one-wire interface
I8 Remote GPIO Enable/disable remote access to GPIO pins

<Select> <Back>
```

Step 4. Install VNC software, then log into the PI. Username and password is the same as SSH log in



Step 5. Output for the command cat /etc/os-release

```
File Edit Tabs Help
pi@raspberrypi:~ $ ^[[200~cat /etc/os-release~
bash: $'\E[200~cat': command not found
pi@raspberrypi:~ $ cat /etc/os-release
PRETTY_NAME="Raspbian GNU/Linux 11 (bullseye)"
NAME="Raspbian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
ID=raspbian
ID_LIKE=debian
HOME_URL="http://www.raspbian.org/"
SUPPORT_URL="http://www.raspbian.org/RaspbianForums"
BUG_REPORT_URL="http://www.raspbian.org/RaspbianBugs"
pi@raspberrypi:~ $ █
```

Step 6. Output for the command `uname -a`

```
File Edit Tabs Help
pi@raspberrypi:~ $ ^[[200~cat /etc/os-release~
bash: $'\E[200~cat': command not found
pi@raspberrypi:~ $ cat /etc/os-release
PRETTY_NAME="Raspbian GNU/Linux 11 (bullseye)"
NAME="Raspbian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
ID=raspbian
ID_LIKE=debian
HOME_URL="http://www.raspbian.org/"
SUPPORT_URL="http://www.raspbian.org/RaspbianForums"
BUG_REPORT_URL="http://www.raspbian.org/RaspbianBugs"
pi@raspberrypi:~ $ uname -a
Linux raspberrypi 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr  3 17:24:16 BST 2023 aarch64 GNU/Linux
pi@raspberrypi:~ $
```

Step 7. Output for the command arch

```
File Edit Tabs Help
pi@raspberrypi:~ $ ^[[200~cat /etc/os-release~
bash: $'\E[200~cat': command not found
pi@raspberrypi:~ $ cat /etc/os-release
PRETTY_NAME="Raspbian GNU/Linux 11 (bullseye)"
NAME="Raspbian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
ID=raspbian
ID_LIKE=debian
HOME_URL="http://www.raspbian.org/"
SUPPORT_URL="http://www.raspbian.org/RaspbianForums"
BUG_REPORT_URL="http://www.raspbian.org/RaspbianBugs"
pi@raspberrypi:~ $ uname -a
Linux raspberrypi 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr  3 17:24:16 BST 2023 aarch64 GNU/Linux
pi@raspberrypi:~ $ arch
aarch64
pi@raspberrypi:~ $ █
```


Step 8. Build and run the hello.c file, test is successful

```
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:~ $ ./hello
Hello World
pi@raspberrypi:~ $
```

Step 9. Try to build the hello.o file, test is successful

```
pi@raspberrypi:~ $ gcc -Wall -c hello hello.c
gcc: warning: hello: linker input file unused because linking not done
pi@raspberrypi:~ $ ls
Bookshelf  Documents  hello      hello.o    math.c     math.o     math-test.c  math-test-dynamic.c  Pictures  Templates
Desktop    Downloads  hello.c    libmath.so math.h     math-test  math-test-dynamic  Music              Public    Videos
pi@raspberrypi:~ $
```

```
pi@raspberrypi:~ $ file hello.o
hello.o: ELF 32-bit LSB relocatable, ARM, EABI5 version 1 (SYSV), not stripped
pi@raspberrypi:~ $
```

Step 10. Show your math.h, math.c source code and also the commands/output of building and running of the code

```
pi@raspberrypi:~ $ cat math.h
#ifndef _MATH_H_
#define _MATH_H_

int sum(int a, int b);
int prod(int a, int b);

#endif

pi@raspberrypi:~ $ cat math.c
#include "math.h"

int sum(int a, int b) {
    return a + b;
}

int prod(int a, int b) {
    return a * b;
}

pi@raspberrypi:~ $ gcc -Wall -c math.c
pi@raspberrypi:~ $ file math.o
math.o: ELF 32-bit LSB relocatable, ARM, EABI5 version 1 (SYSV), not stripped
pi@raspberrypi:~ $
```

Step 11. Show your math-test.c source code and also the commands/output of building and running of the code

```
pi@raspberrypi:~ $ cat math-test.c
#include <stdio.h>
#include "math.h"

int main() {
    int value = sum(10, 20);
    printf("value: %d\n", value);

    value = prod(10, 20);
    printf("value: %d\n", value);

    return 0;
}
pi@raspberrypi:~ $ gcc -Wall -o math-test math.o math-test.c
pi@raspberrypi:~ $ ./math-test
value: 30
value: 200
pi@raspberrypi:~ $ ldd math-test
        /usr/lib/arm-linux-gnueabihf/libarmmem-${PLATFORM}.so => /usr/lib/arm-linux-gnueabihf/libarmmem-v8l.so (0xf7ed9000)
        libc.so.6 => /lib/arm-linux-gnueabihf/libc.so.6 (0xf7d72000)
        /lib/ld-linux-armhf.so.3 (0xf7eee000)
pi@raspberrypi:~ $
```

Step 12. Show your commands for creating libmath.so. Compile math-test.c and libmath.so

```
pi@raspberrypi:~ $ gcc -Wall -shared -o libmath.so math.c
pi@raspberrypi:~ $ file libmath.so
libmath.so: ELF 32-bit LSB shared object, ARM, EABI5 version 1 (SYSV), dynamically linked, BuildID[sha1]=a268dcd293b017e288884667572225f02d17c02f, not stripped
pi@raspberrypi:~ $ gcc -Wall -o math-test math-test.c -lmath -L.
pi@raspberrypi:~ $ ldd math-test
        /usr/lib/arm-linux-gnueabi/libarmmem-${PLATFORM}.so => /usr/lib/arm-linux-gnueabi/libarmmem-v8l.so (0xf7d63000)
        libmath.so => not found
        libc.so.6 => /lib/arm-linux-gnueabi/libc.so.6 (0xf7bfc000)
        /lib/ld-linux-armhf.so.3 (0xf7d78000)
pi@raspberrypi:~ $ LD_LIBRARY_PATH=. ldd math-test
        /usr/lib/arm-linux-gnueabi/libarmmem-${PLATFORM}.so => /usr/lib/arm-linux-gnueabi/libarmmem-v8l.so (0xf79c1000)
        libmath.so => ./libmath.so (0xf79af000)
        libc.so.6 => /lib/arm-linux-gnueabi/libc.so.6 (0xf7848000)
        /lib/ld-linux-armhf.so.3 (0xf79d6000)
pi@raspberrypi:~ $ ./math-test
./math-test: error while loading shared libraries: libmath.so: cannot open shared object file: No such file or directory
pi@raspberrypi:~ $ LD_LIBRARY_PATH=. ./math-test
value: 30
value: 200
pi@raspberrypi:~ $
```

Step 13. Show your math-test-dynamic.c source code and also the commands/output of building and running of the code

```
pi@raspberrypi:~ $ cat math-test-dynamic.c
#include <stdio.h>
#include <dlfcn.h>
#include "math.h"

int main() {
    void *handle = dlopen("libmath.so", RTLD_LAZY);
    if(!handle) {
        fprintf(stderr, "%s\n", dlerror());
        return 1;
    }

    int (*sum)(int a, int b);
    sum = dlsym(handle, "sum");
    if(!sum) {
        fprintf(stderr, "%s\n", dlerror());
    }
    else{
        int value = sum(10, 20);
        printf("value: %d\n", value);
    }
    dlclose(handle);
    return 0;
}

pi@raspberrypi:~ $ gcc -Wall -o math-test-dynamic math-test-dynamic.c -ldl
pi@raspberrypi:~ $ ldd math-tet-dynamic
ldd: ./math-tet-dynamic: No such file or directory
pi@raspberrypi:~ $ ldd math-test-dynamic
/usr/lib/arm-linux-gnueabi/libarmmem-${PLATFORM}.so => /usr/lib/arm-linux-gnueabi/libarmmem-v8l.so (0xf7f97000)
libdl.so.2 => /lib/arm-linux-gnueabi/libdl.so.2 (0xf7f70000)
libc.so.6 => /lib/arm-linux-gnueabi/libc.so.6 (0xf7e1c000)
/lib/ld-linux-armhf.so.3 (0xf7fac000)
pi@raspberrypi:~ $ LD_LIBRARY_PATH=. ./math-test-dynamic
value: 30
pi@raspberrypi:~ $
```