Lab 0.1 Edge Computer and Headless Environment Setup

Learning Goals

Students will be able to:

1. Model the essential steps to setup network connection to Raspberry Pi
2. Contrast the different network connection options available for Raspberry Pi
3. Perform basic setup and get access to Raspberry Pi in headless system

1.1 Introduction

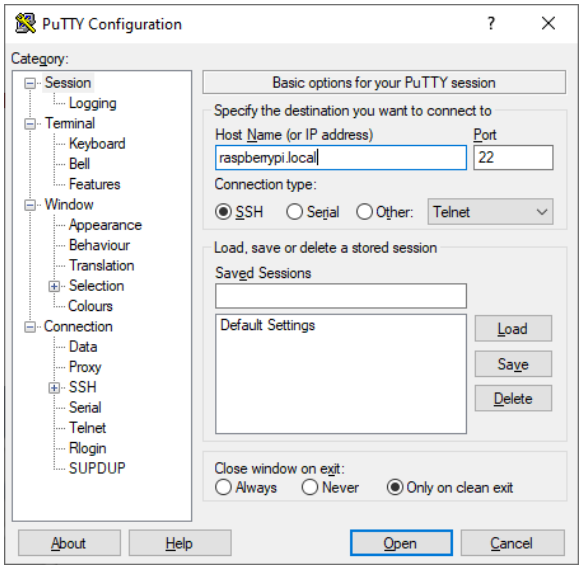
Headless and remote access allows us to control and manage the edge device without hardware interface and visiting the site. In this lab, you will do basic setup and make the wireless or wired connection of Raspberry Pi to a network and access it using SSH and VNC software.

1.2 Access to Raspberry Pi using SSH

In this section we will access Raspberry Pi using SSH via the ethernet cable. In Prelab 1, you've install PuTTY on your laptop. PuTTY will be used for SSH software for Windows. If you are using Linux, let TA know. Follow the steps below.

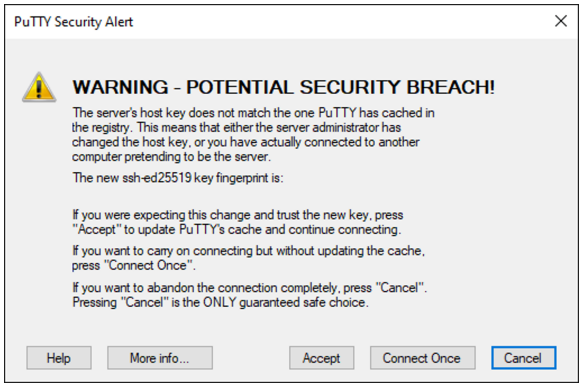
1. Run PuTTY on your laptop
2. Use *raspberrypi.local* for Host Name

    ※ Note that default port number for SSH is 22.



3. Click 'Open'
4. Click 'Accept' in PuTTY Security Alert

※ You will see Security Alert message as below. This case is okay because we we know the Raspberry Pi is connected to the laptop. But be careful when you get access to SSH machine in open network.



5. Default user credential is below.

> user: pi

> password: raspberrypi

You will see the terminal window of Raspberry pi as Figure 1. This is SSH access to headless computer. Through SSH, you can do all: setup, manage file systems, write code, install packages, and so on.

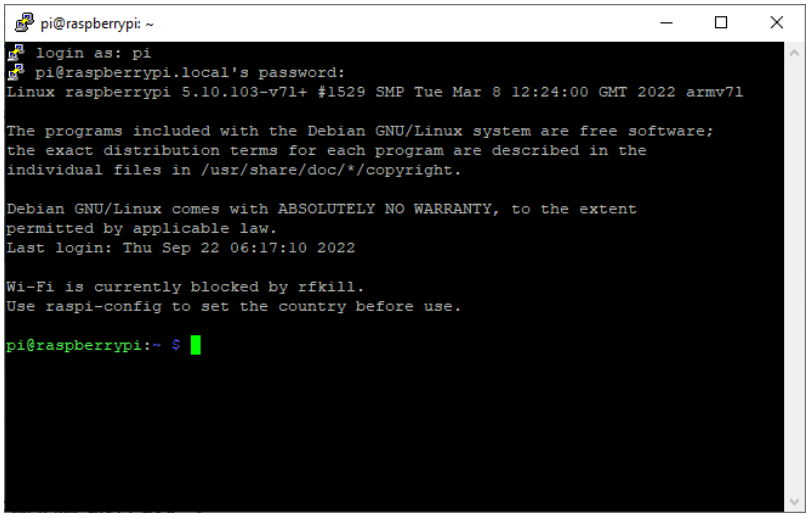
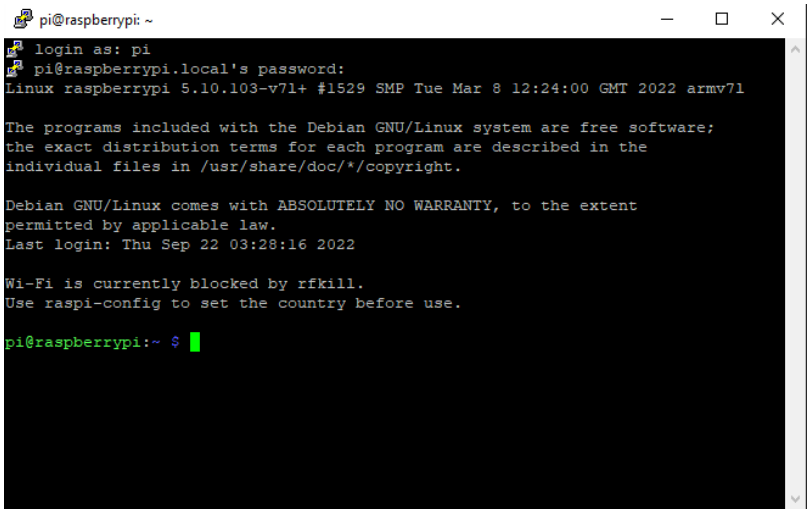


Figure 1 SSH access to Raspberry Pi

Task 1.1

Capture your PuTTY window after login to Raspberry Pi as Figure 1 and attach it to the report below:



1.3 Basic setup of Raspberry Pi

Now, you can access Raspberry Pi from your laptop using SSH via an Ethernet cable. Even if your laptop can use the Internet, Raspberry Pi is not because we haven't make the Internet connection yet. We will deal with the Internet sharing in the next section. Before that, let's do basic configurations for Raspberry Pi such as 'Country', 'Keyboard', 'Timezone', and so on.

The essential configurations can be set up using 'sudo raspi-config' command.

Raspberry Pi - Linux - Terminal

```
sudo raspi-config
```

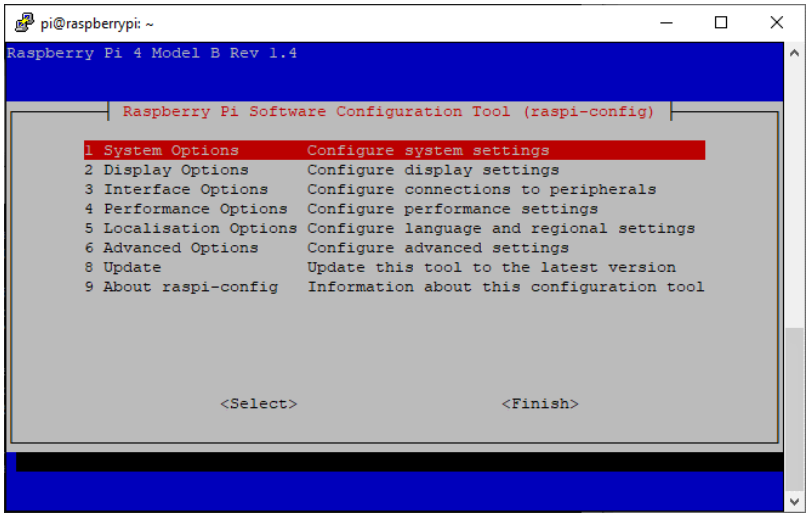


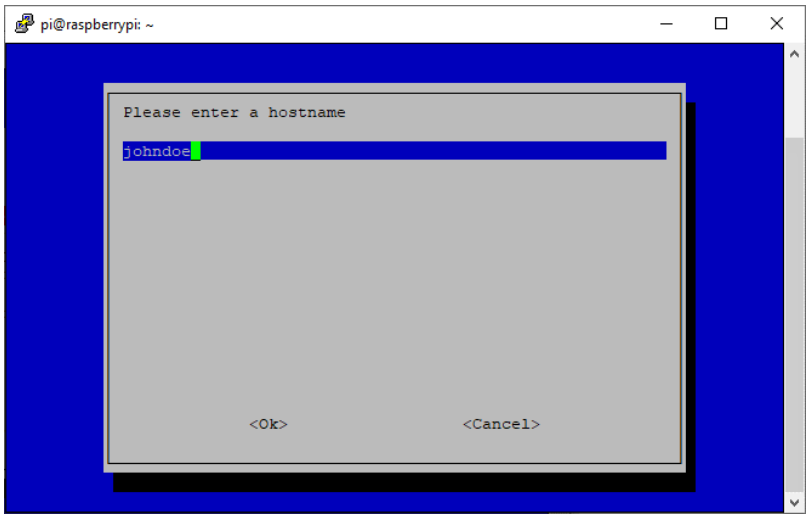
Figure 2 Raspberry Pi Configuration Tool

※ sudo is a Linux command meaning 'super user do'. This command means execute raspi-config command in super user (root/admin) privilege.

Figure 2 shows an interface windows of *'raspi-config'*. You use keyboard (number keys, arrow keys, Enter, ESC, Space, etc.) to manipulate the configuration setting. Try to move using keyboard. For the basic configurations, follow the steps below.

1. Change hostname (computer name) as your 'firstnamelastname' (ex) johndoe)

    > Location: System Options/Hostname



2. Change password

> Location: System Options/Password

※ You have to memorize your password.

3. Enable 'VNC' interface

> Location: Interface Options/VNC

4. Change timezone to 'US/Eastern'

> Location: Localisation Options/Timezone

5. Change WLAN country to 'US United States'

> Location: Localisation Options/WLAN country

6. Finish (save) raspi-config

※ Raspberry Pi may ask you 'Would you like to reboot now?' If you choose , you can skip step 7.

7. Reboot Raspberry Pi using the command below

Raspberry Pi - Linux - Terminal

```
sudo reboot
```

※ We will frequently use 'sudo reboot' after configuration changes, package installations, and so on so that the changes can be reflected properly.

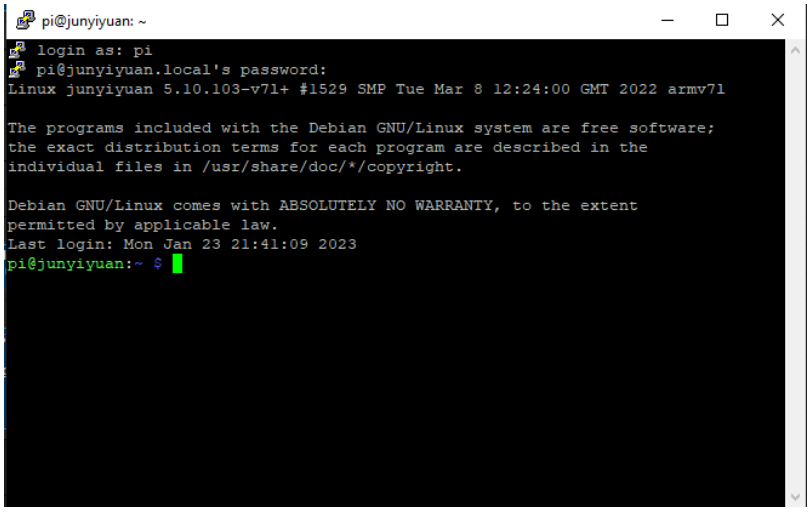
※ If you execute 'sudo reboot', the ethernet connection must be inactive because the Raspberry Pi restarts.

Now, you finished basic setup for Raspberry Pi other than the network connection.

Task 1.2

Capture your PuTTY window after rebooting as Figure 1 and attach it to the report below:

※ You have to use a new host name to access Raspberry Pi. For example, the host name in PuTTY is johndoe.local. The login account is the same (pi) but the password is changed.



1.4 Assign static IP and the Internet connection sharing

In this section, we will make the Raspberry Pi use the Internet by routing network of the laptop. We fist assign static IP addresses for both laptop and the Raspberry Pi. For the network sharing and routing, we will use the Internet sharing of your Windows machine so that the Raspberry Pi can get the Internet access through your laptop. Note that your laptop must be connected to the Internet.

The ethernet IP of your laptop will be `192.168.137.1` and the ethernet IP of Raspberry Pi will be `192.168.137.2`, as shown in Figure 3.

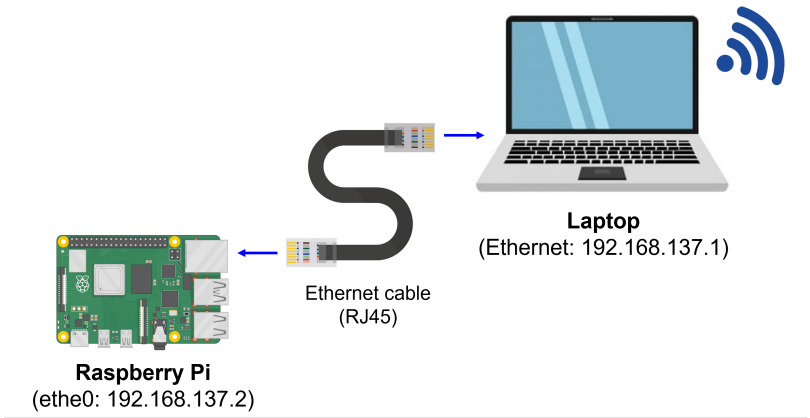


Figure 3 Wired connection configuration between Raspberry Pi and laptop

Let's set up your Raspberry Pi. Follow the steps below after get access to the Raspberry Pi using PuTTY.

1. Type `sudo nano /etc/dhcpcd.conf`

※ This command line menas edit 'dhcpcd.conf' file at '/etc' directory using 'nano' editor in the root privilege.

2. Write the following at the end of the *'dhcpcd.conf'* file.

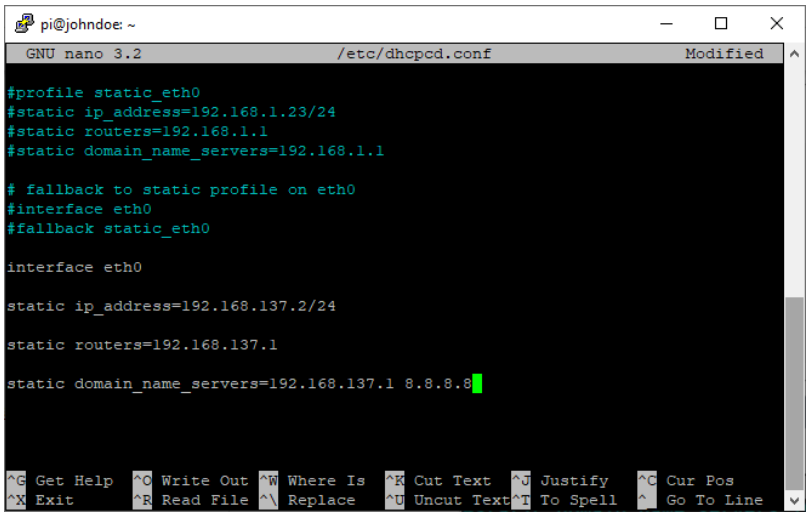
Raspberry Pi - /etc/dhcpcd.conf

```
interface eth0

static ip_address=192.168.137.2/24

static routers=192.168.137.1

static domain_name_servers=192.168.137.1 8.8.8.8
```

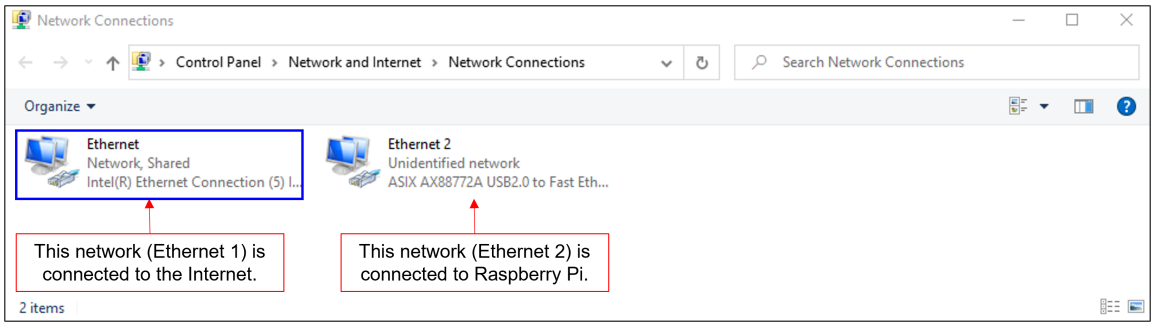


※ You can easily paste the text using right-click of your mouse on the PuTTY window after copying the text.

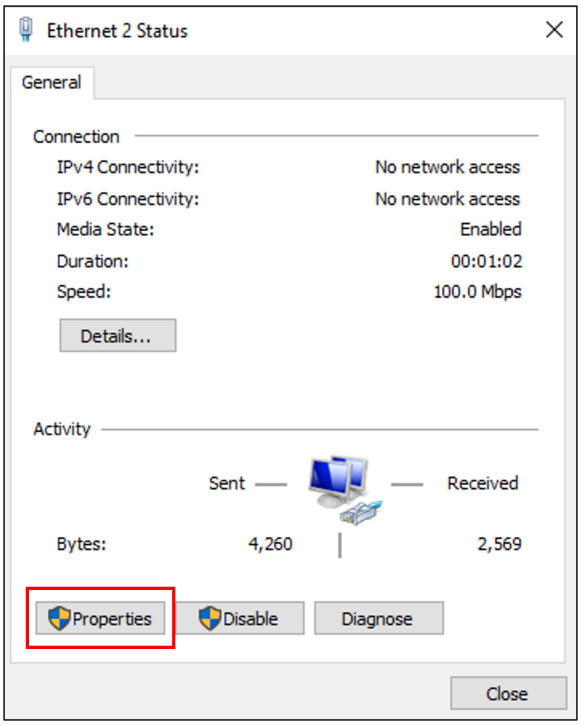
3. Save this configuration file (Shortcut: Ctrl+o)
4. Exit this configuration file (Shortcut: Ctrl+x)
5. Reboot the Raspberry Pi in the terminal using `sudo reboot` command and then unplug the ethernet cable temporarily.

Next, let's set up your laptop (Windows 10). Follow the steps below.

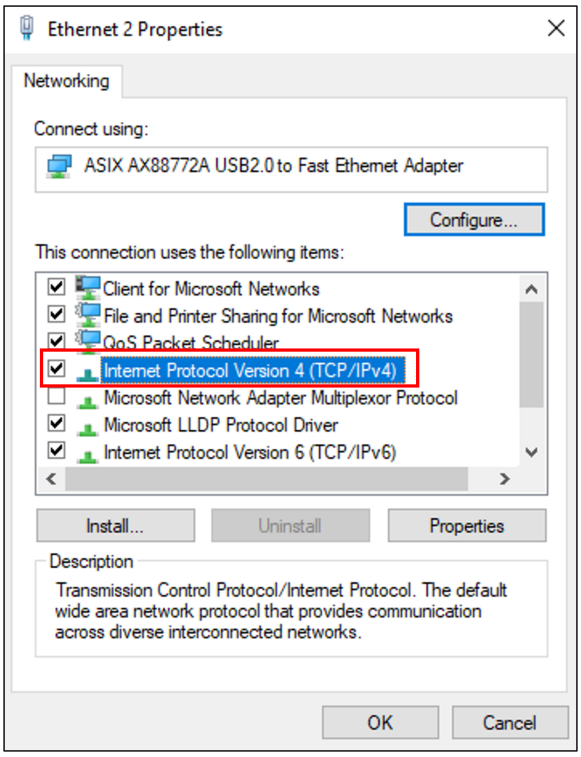
1. Open '*Network Connection*' in '*Control Panel*'



2. Double click the network connected to Raspberry Pi ('*Ethernet 2*' in this example)
3. Click '*Properties*'



4. Double click '*Internet Protocol Version 4 (TCP/IPv4)*'



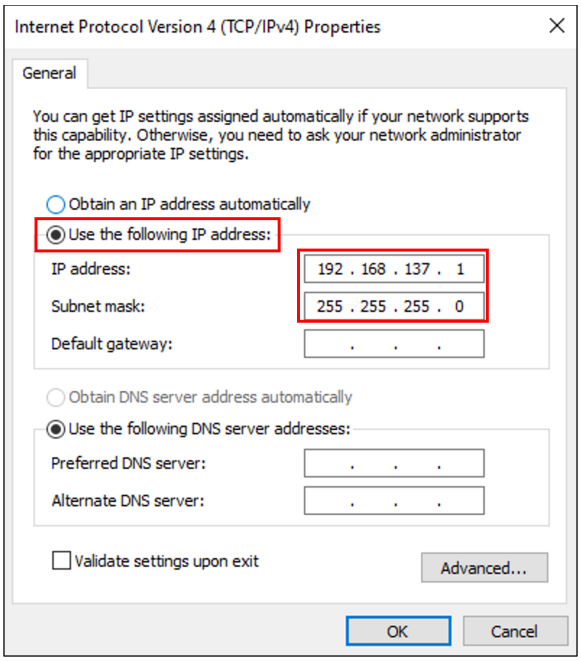
5. Click '*Use the following IP address*'

6. Set '*IP address*' and '*subnet mask*' as followed:

> IP address: 192.168.137.1

\

> Subnet mask: 255.255.255.0



7. click '*OK*'

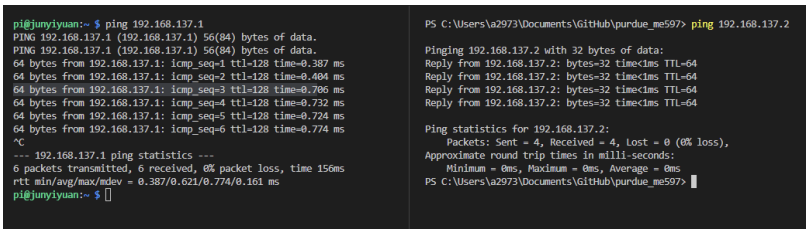
Now, static IP assignment for the wired (ethernet) connection is done. Plug the ethernet cable into Raspberry Pi again. Then, access it using PuTTY. You can use the same host name. Let's see if it works using ping test by performing Task1.3.

Do you think the static IP address of the Raspberry Pi can be used as the host name for SSH access in PuTTY? Try it!

Task 1.3

Capture your ping test results from both machines each other and attach those to the report below:

※ If you want to halt a process or execution in the terminal, the shortcut is Ctrl+c.

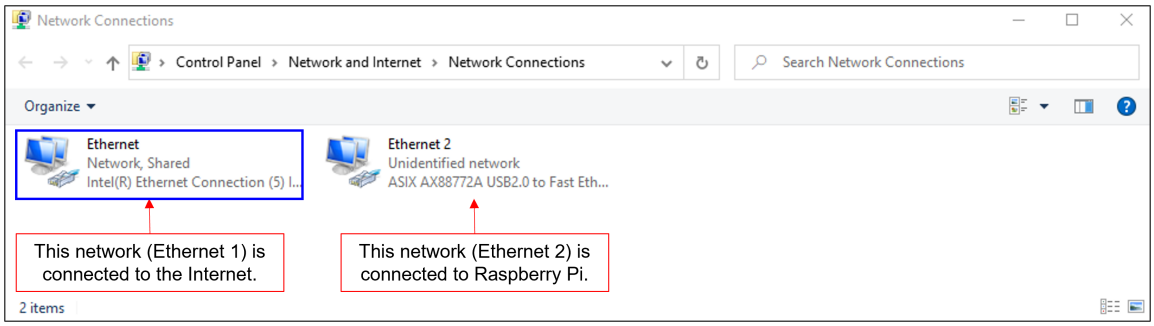


1.5 Internet connection sharing

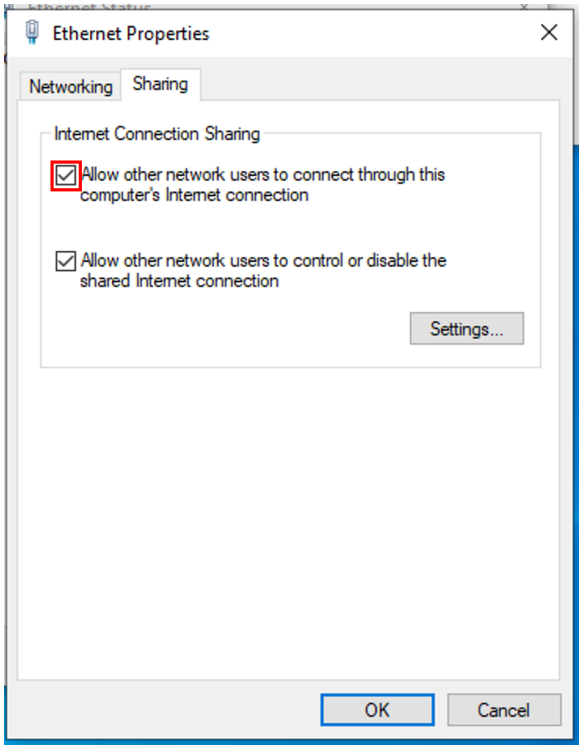
In some cases, you may experience that Raspberry Pi cannot be connected to the Wifi. For example, Purdue's open Wifi (eduroam or PAL3.0) does not allow the Internet connection from Raspberry Pi because of security reasons. However, Raspberry Pi can use the laptop's internet connection via internet connection sharing. Leave the ethernet cable connection between laptop and Raspberry Pi and follow the step below.

1. Open '*Network Connections*' of '*Control Panel*'
2. Double click your network that is connected to the Internet (not the '*Ethernet #*' connected to Raspberry

Pi; in this case, the network '*Ethernet*' is connected to the Internet. If you are using Wifi, you should choose it.)



3. Click '*Properties*'
4. Check '*Allow other network users to connect through this computer's Internet connection*' box in *'Sharing'* tab (You may need to select the network (Ethernet) connected to Raspberry Pi of 'Home networking connection' if you have more than 2 networks.)



5. Click '*OK*'

Now, you are all set for the network connection. Although Raspberry Pi does not have Wifi connection, it can access the Internet via the network connection to laptop. Try ping test by performing Task 1.4

Task 1.4

Capture your ping test results from the Raspberry Pi to Purdue webpage (purdue.edu, `ping purdue.edu`) and attach it to the report below:

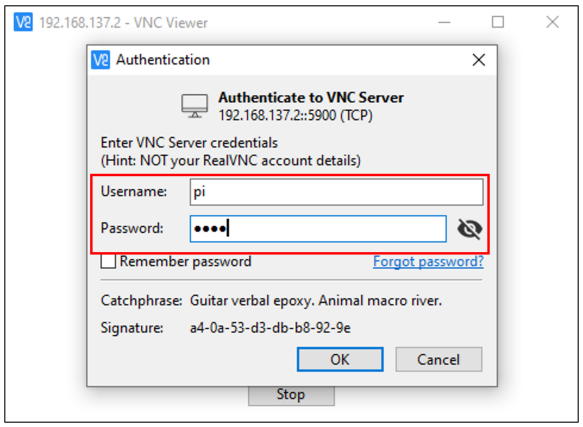
※ If want to halt a process or execution in the terminal, the shortcut is Ctrl+c.

```
pi@junyiyuan:~ $ ping purdue.edu
PING purdue.edu (128.210.7.200) 56(84) bytes of data.
64 bytes from purdue.edu (128.210.7.200): icmp_seq=1 ttl=236 time=29.9 ms
64 bytes from purdue.edu (128.210.7.200): icmp_seq=2 ttl=236 time=42.6 ms
64 bytes from purdue.edu (128.210.7.200): icmp_seq=3 ttl=236 time=31.1 ms
64 bytes from purdue.edu (128.210.7.200): icmp_seq=4 ttl=236 time=32.6 ms
^C
--- purdue.edu ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 7ms
rtt min/avg/max/mdev = 29.855/34.038/42.605/5.039 ms
pi@junyiyuan:~ $
```

1.6 VNC access using VNC Viewer

In Prelab 1, you've installed VNC Viewer on your laptop. Follow the direction below. If you are using Linux, use Remmina instead of VNC Viewer.

1. Run VNC Viewer on your laptop
2. Type your IP address (`192.168.137.2`) or the host name of the Raspberry PI (johndoe.local) and then hit '*Enter*'
3. Type your login credential (username and password) on the pop-up window



4. Click '*OK*'

If you see the error window as Figure 4, go to the next, **Troubleshooting Help**, to resolve the display issue.

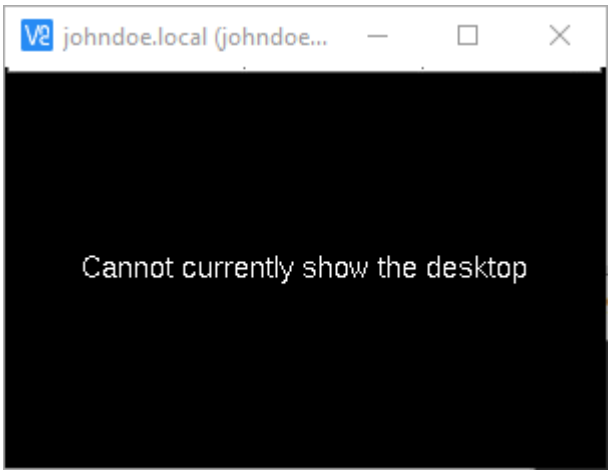


Figure 4 VNC Viewer Error

Now you you will see the familiar screen like Figure 5. Play with it! The names of the Taskbar Icons are in Figure 6. If you create an account of RealVNC (https://www.realvnc.com/en/raspberrypi/) and your Raspberry Pi is connected to the Internet, you can also access Raspberry Pi via the Internet that means your laptop and Raspberry Pi do not need to be on the same local network for VNC access. A nice instruction is in MagPi (https://magpi.raspberrypi.com/articles/vnc-raspberry-pi, available on Jan. 13, 2022). Try file transfer using VNC Viewer between Raspberry Pi and laptop as well.

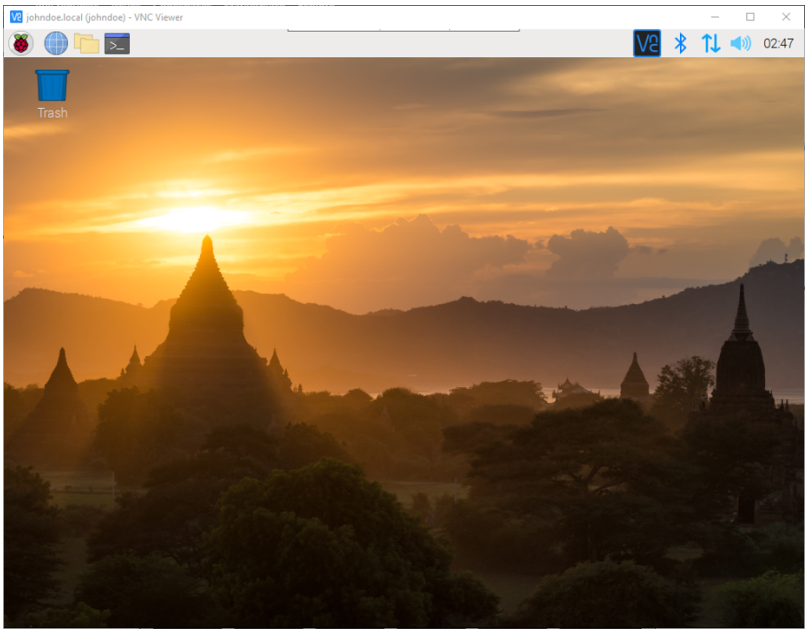


Figure 5 Raspberry Pi GUI using VNC Viewer

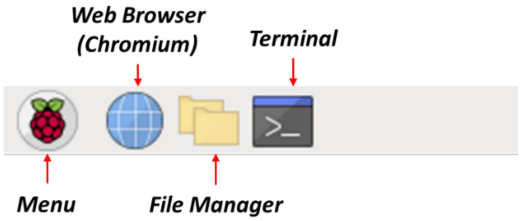


Figure 5 Taskbar Icons of Raspberry Pi GUI

Troubleshooting Help

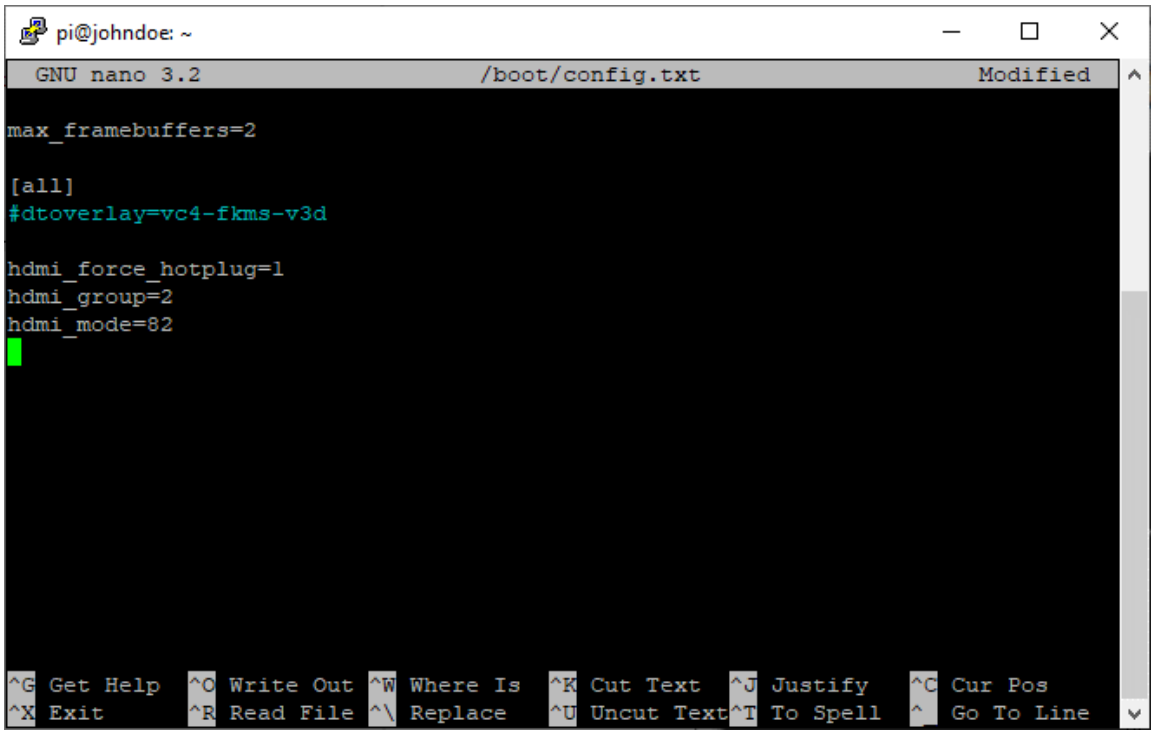
After you start Raspberry Pi without display connection to it, you may see VNC access error, “Cannot currently show the desktop” as Figure 4. This is because Raspberry Pi cannot have monitor to show output without any connected display. But SSH works. Try it using PuTTY:

To resolve this issue, you need to make Raspberry Pi have forced display input when booted. Follow the step below after access the Raspberry Pi using PuTTY.

1. Type `sudo nano /boot/config.txt`
2. Write following at the end of 'config.txt'

Raspberry Pi - /boot/config.txt

```
hdmi_force_hotplug=1
hdmi_group=2
hdmi_mode=82
```



- hdmi_force_hotplug=1 means making a forced plugin of HDMI port 1.
- hdmi_group=2 means DMT (Display Monitor Timings) group which is the same as a monitor.
- hdmi_mode=82means resolution is 1920×1080 in 60 Hz. You can change resolution you want according to your

preference or your laptop display resolution. Refer to Table and Raspberry Pi documentation (https://www.raspberrypi.com/documentation/computers/config_txt.html, available on Jan. 13, 2023)

hdmi_mode	Resolution	Aspect Ratio	Refresh Rate
5	640x480 (480p)	4:3	60 Hz
9	800x600	4:3	60 Hz
16	1024x768	4:3	60 Hz
51	1600x1200	4:3	60 Hz
82	1920x1080 (1080p)	4:3	60 Hz
85	1280x720 (720p)	4:3	60 Hz

After saving the 'config.txt' file, reboot Raspberry Pi. Try to access VNC again. Is it working?

Now, you are all set for a headless computer for remote access. In the following lab, you do not need to bring any physical interfaces, a monitor, keyboard, or mouse.

1.7 Raspberry Pi terminal and packages

The terminal is a useful application. It allows you to navigate file directories and control your Raspberry Pi using typed commands instead of clicking on menu options. It's often in many tutorials and project guides, including the ones on our website.

In addition, we can take advantage of Raspberry Pi packages. In the terminal, we can install, uninstall, and manage the packages.

Let's try to install a Linux package. Install *'tmux'* package on your Raspberry Pi using command below.

Raspberry Pi - Terminal

```
sudo apt install tmux -y
```

If you don't know or are unclear about a Linux command, google it! Or you can see a manual using command 'man packagename'such as below. Try 'man tmux'.

Raspberry Pi - Terminal

```
man apt
```

- This shows the manual document of 'apt' command.
- Tips: to change page, press PgUp or PgDn and to exit, press 'q'.

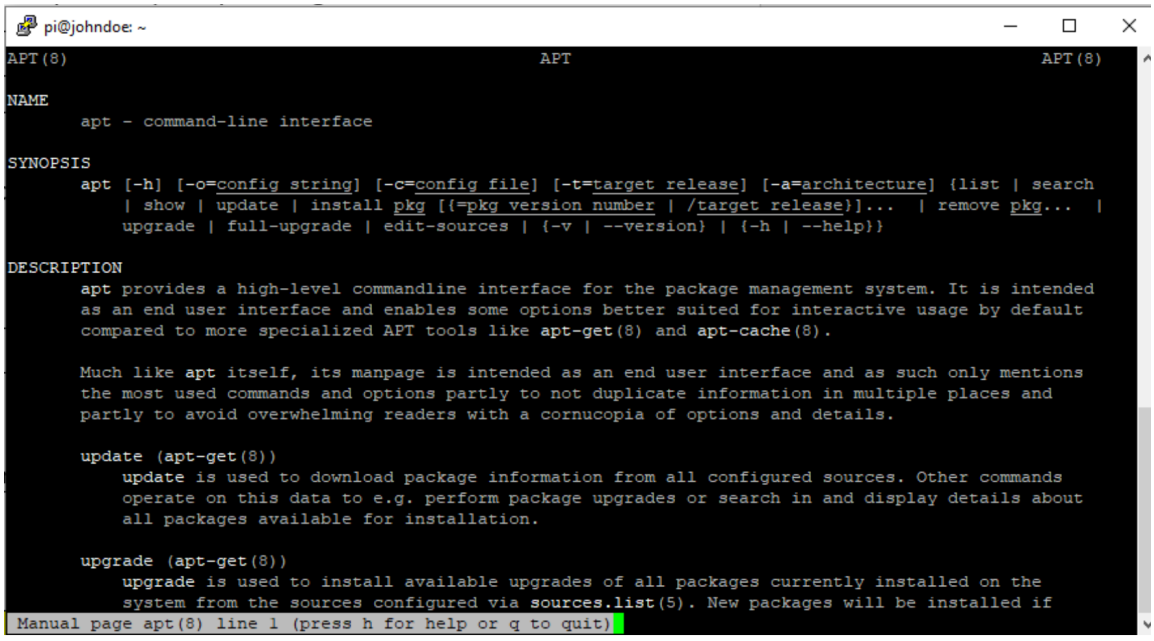


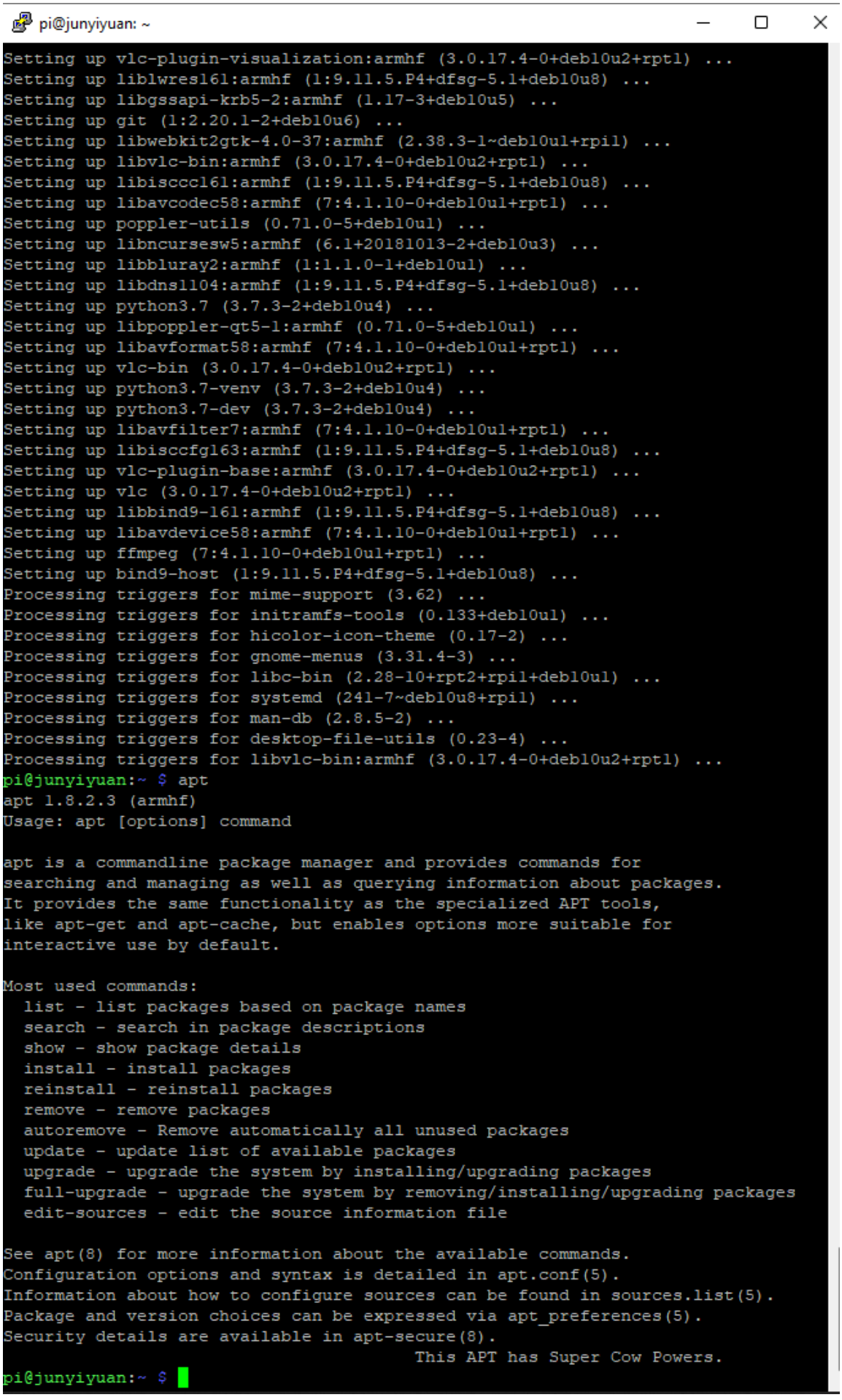
Figure 2 Manual of 'apt' command

It is recommended to go through a Raspberry Pi terminal guideline (https://raspberrypi-guide.github.io/programming/working-with-the-command-line, available on Jan. 13, 2023).

Try update and upgrade packages using `sudo apt update` and `sudo apt upgrade`.

Task 1.5

Capture your terminal after upgrading packages using `apt` command and attach it in the space below:


pi@junyiyuan: ~
Setting up vlc-plugin-visualization:armhf (3.0.17.4-0+deb10u2+rpt1) ...
Setting up liblwres161:armhf (1:9.11.5.P4+dfsg-5.1+deb10u8) ...
Setting up libgssapi-krb5-2:armhf (1.17-3+deb10u5) ...
Setting up git (1:2.20.1-2+deb10u6) ...
Setting up libwebkit2gtk-4.0-37:armhf (2.38.3-1~deb10u1+rpi1) ...
Setting up libvlc-bin:armhf (3.0.17.4-0+deb10u2+rpt1) ...
Setting up libisccc161:armhf (1:9.11.5.P4+dfsg-5.1+deb10u8) ...
Setting up libavcodec58:armhf (7:4.1.10-0+deb10u1+rpt1) ...
Setting up poppler-utils (0.71.0-5+deb10u1) ...
Setting up libncursesw5:armhf (6.1+20181013-2+deb10u3) ...
Setting up libbluray2:armhf (1:1.1.0-1+deb10u1) ...
Setting up libdns1104:armhf (1:9.11.5.P4+dfsg-5.1+deb10u8) ...
Setting up python3.7 (3.7.3-2+deb10u4) ...
Setting up libpoppler-qt5-1:armhf (0.71.0-5+deb10u1) ...
Setting up libavformat58:armhf (7:4.1.10-0+deb10u1+rpt1) ...
Setting up vlc-bin (3.0.17.4-0+deb10u2+rpt1) ...
Setting up python3.7-venv (3.7.3-2+deb10u4) ...
Setting up python3.7-dev (3.7.3-2+deb10u4) ...
Setting up libavfilter7:armhf (7:4.1.10-0+deb10u1+rpt1) ...
Setting up libisccfg163:armhf (1:9.11.5.P4+dfsg-5.1+deb10u8) ...
Setting up vlc-plugin-base:armhf (3.0.17.4-0+deb10u2+rpt1) ...
Setting up vlc (3.0.17.4-0+deb10u2+rpt1) ...
Setting up libbind9-161:armhf (1:9.11.5.P4+dfsg-5.1+deb10u8) ...
Setting up libavdevice58:armhf (7:4.1.10-0+deb10u1+rpt1) ...
Setting up ffmpeg (7:4.1.10-0+deb10u1+rpt1) ...
Setting up bind9-host (1:9.11.5.P4+dfsg-5.1+deb10u8) ...
Processing triggers for mime-support (3.62) ...
Processing triggers for initramfs-tools (0.133+deb10u1) ...
Processing triggers for hicolor-icon-theme (0.17-2) ...
Processing triggers for gnome-menus (3.31.4-3) ...
Processing triggers for libc-bin (2.28-10+rpt2+rpi1+deb10u1) ...
Processing triggers for systemd (241-7~deb10u8+rpi1) ...
Processing triggers for man-db (2.8.5-2) ...
Processing triggers for desktop-file-utils (0.23-4) ...
Processing triggers for libvlc-bin:armhf (3.0.17.4-0+deb10u2+rpt1) ...
pi@junyiyuan:~ $ apt
apt 1.8.2.3 (armhf)
Usage: apt [options] command
apt is a commandline package manager and provides commands for
searching and managing as well as querying information about packages.
It provides the same functionality as the specialized APT tools,
like apt-get and apt-cache, but enables options more suitable for
interactive use by default.
Most used commands:
list - list packages based on package names
search - search in package descriptions
show - show package details
install - install packages
reinstall - reinstall packages
remove - remove packages
autoremove - Remove automatically all unused packages
update - update list of available packages
upgrade - upgrade the system by installing/upgrading packages
full-upgrade - upgrade the system by removing/installing/upgrading packages
edit-sources - edit the source information file
See apt(8) for more information about the available commands.
Configuration options and syntax is detailed in apt.conf(5).
Information about how to configure sources can be found in sources.list(5).
Package and version choices can be expressed via apt_preferences(5).
Security details are available in apt-secure(8).
This APT has Super Cow Powers.
pi@junyiyuan:~ $

1.4 Looking Forward to Lab 2 (Router Network Connection)

At the beginning of Lab 2, you will be instructed with the SSID (Service Set Identifier) and password of the Wifi that we will continue using all following lab sessions. Access your Raspberry Pi using SSH or VNC Viewer. Connect the Wifi on Raspberry Pi. Check your IP address using 'ifconfig' command in 'Terminal'. And then, let TA know the IP address (wlan0).

In addition, in the lab, your laptop should be in the same network. Connect the Wifi on your laptop. And then check your Wifi IP address of your laptop using 'ipconfig' command in 'Command Prompt', and let TA know it.

TA will assign the static IP address of your laptop and Raspberry Pi. Note the two IP addresses.

Now, you do not need to use the ethernet cable anymore in lab. Try the section above (Remote access to Raspberry Pi) using Wifi network in the lab.

Deliverable

Response to the following prompts

In [ ]:
```
#@title 1. Summarize Lab0 (e.g., what did you learn?)

Text = 'in lab 0 I learned how to use putty and vnc to remote into the raspberry pi

print(Text)
```

```
in lab 0 I learned how to use putty and vnc to remote into the raspberry pi, and h
ow to assign static ip addresses. Also how to share internet bettwen the laptop an
d the raspberry pi. and how to use sudo apt get update upgrade
```

In [ ]:
```
#@title 2. Compare SSH and VNC. What are the pros and cons of each remote access me

Text = '''
ssh: pros: fast, light weight, easyer to use after getting used to command line int
vnc: pros: have a UI. better for people who not yet used to CLI; con: much heavier
''' #@param {type:"string"}

print(Text)
```

```
ssh: pros: fast, light weight, easyer to use after getting used to command line in
terface; con: sometime some program may draw something on the screen. the ssh will
not see it if remote through termial
vnc: pros: have a UI. better for people who not yet used to CLI; con: much heavier
than ssh, meaning not all singal board computer can run it smoothly, it also eat u
p more ethernet bandwidth.
```

Task 1.6

Model Unit 1 (prelab + lab) by creating a flow diagram that illustrates the logic, sequence, and processes of the unit.

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https://app.diagrams.net/#HGeorge0023%2Fpurdue_me597%2Fmain%2Flab%2Flab0%2Fimgs%2

- Note: the Prelab was already completed, you may use that as a starting point.

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