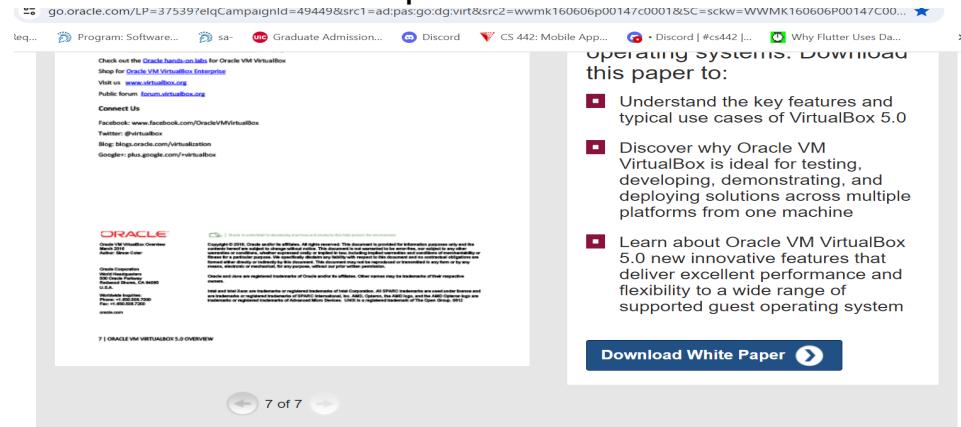


1. Setup VM, Linux, and basic testing:

a) Read Oracle VirtualBox White Paper

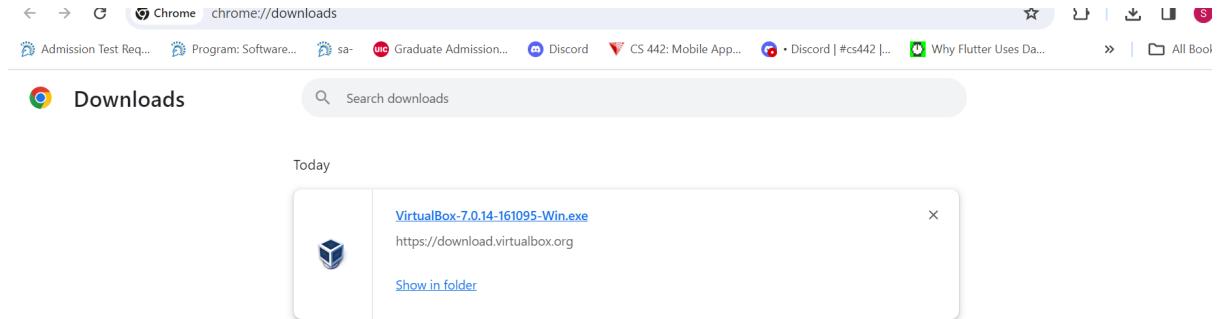


The screenshot shows a web page for the Oracle VM VirtualBox White Paper. The page has a header with navigation links like 'Program: Software...', 'sa...', 'Graduate Admission...', 'Discord', 'CS 442: Mobile App...', 'Discord | #cs442 | ...', 'Why Flutter Uses Da...', and a search bar. Below the header is a sidebar with links to 'Check out the Oracle VirtualBox White Paper', 'Shop for Oracle VM VirtualBox Enterprise', 'Visit us: www.virtualbox.org', 'Public forum: forum.virtualbox.org', 'Connect Us: Facebook: www.facebook.com/OracleVMVirtualBox, Twitter: @virtualbox, Blog: blog.oracle.com/virtualization, Google+: plus.google.com/+virtualbox'. The main content area features a large image of the white paper cover, which is titled '7 | Oracle VM VIRTUALBOX 5.0 OVERVIEW'. To the right of the image is a list of bullet points under the heading 'OPERATING SYSTEMS. DOWNLOAD THIS PAPER TO:':

- Understand the key features and typical use cases of VirtualBox 5.0
- Discover why Oracle VM VirtualBox is ideal for testing, developing, demonstrating, and deploying solutions across multiple platforms from one machine
- Learn about Oracle VM VirtualBox 5.0 new innovative features that deliver excellent performance and flexibility to a wide range of supported guest operating system

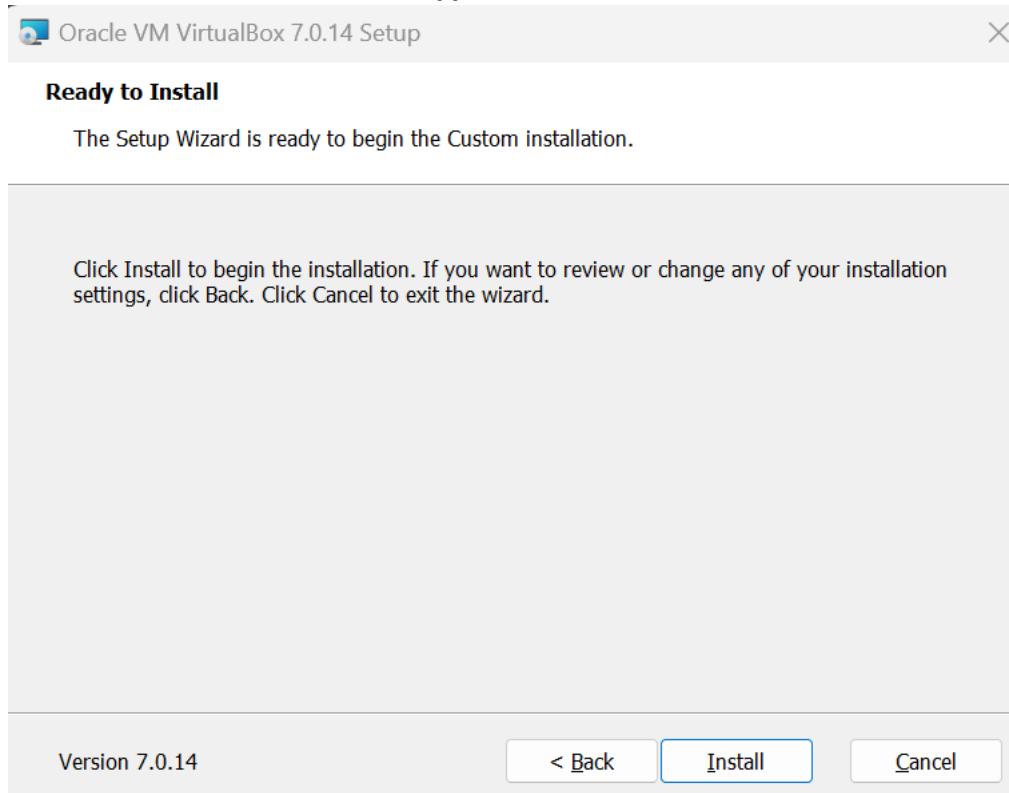
At the bottom right is a blue 'Download White Paper' button with a white arrow icon.

b) Download Oracle VirtualBox 7.0



The screenshot shows a browser window with the address bar 'chrome://downloads'. The page title is 'Downloads' and there is a search bar 'Search downloads'. Below the search bar, it says 'Today'. A download item for 'VirtualBox-7.0.14-161095-Win.exe' is listed, with the URL 'https://download.virtualbox.org' and a 'Show in folder' link. The download icon is a blue cube.

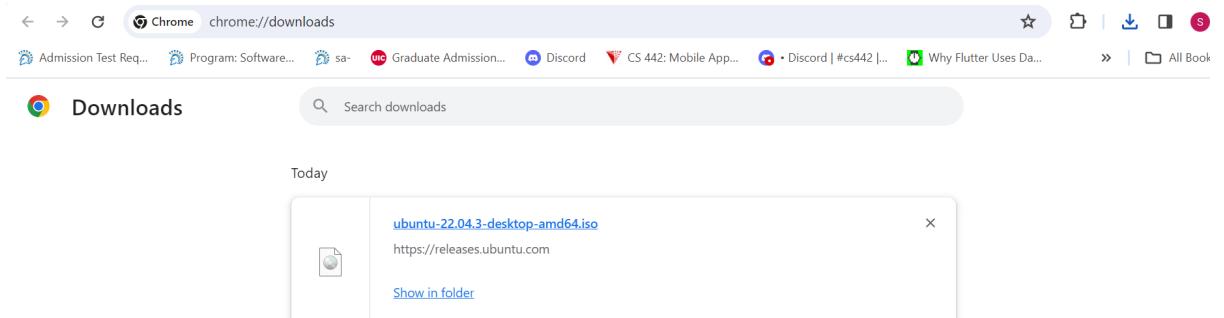
c) Install VirtualBox 7.0 (for M1/M2 Apple, use UTM)



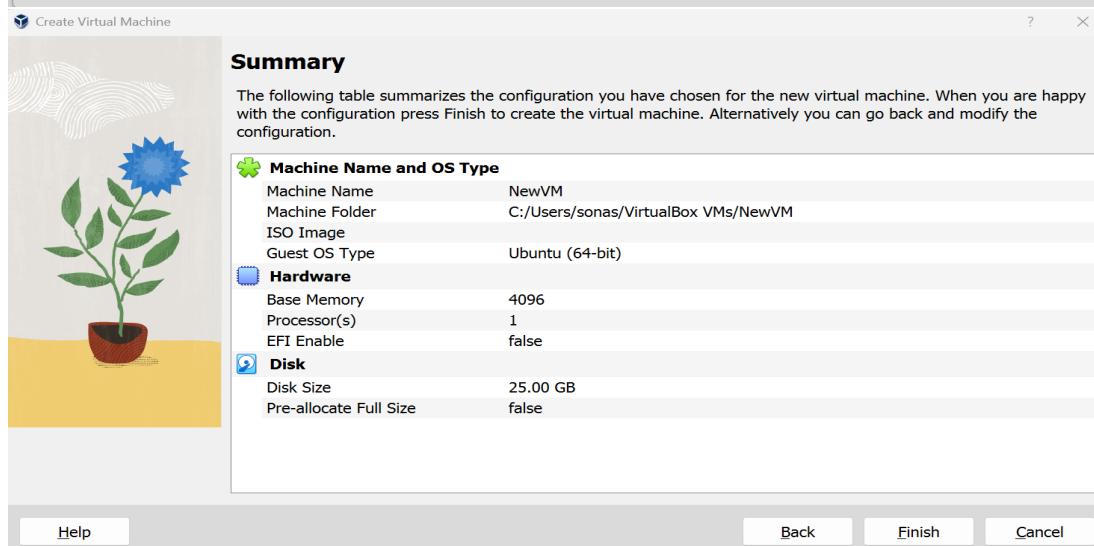
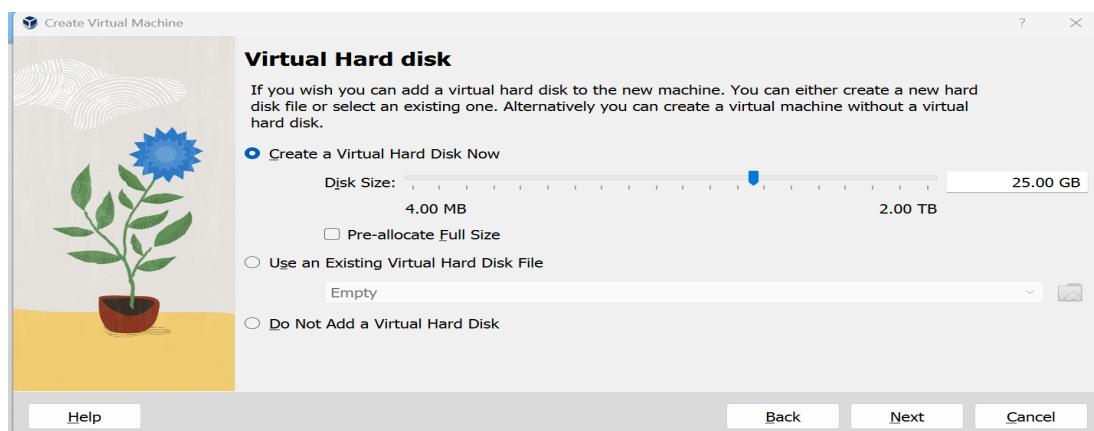
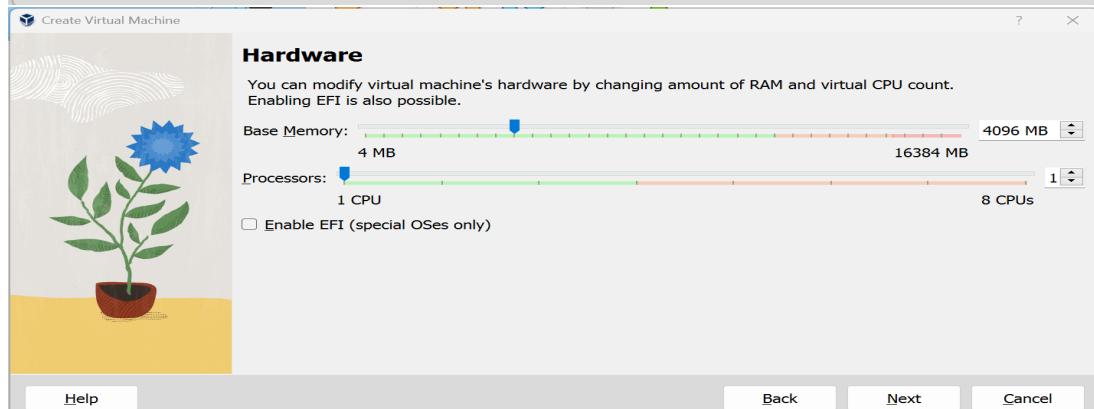
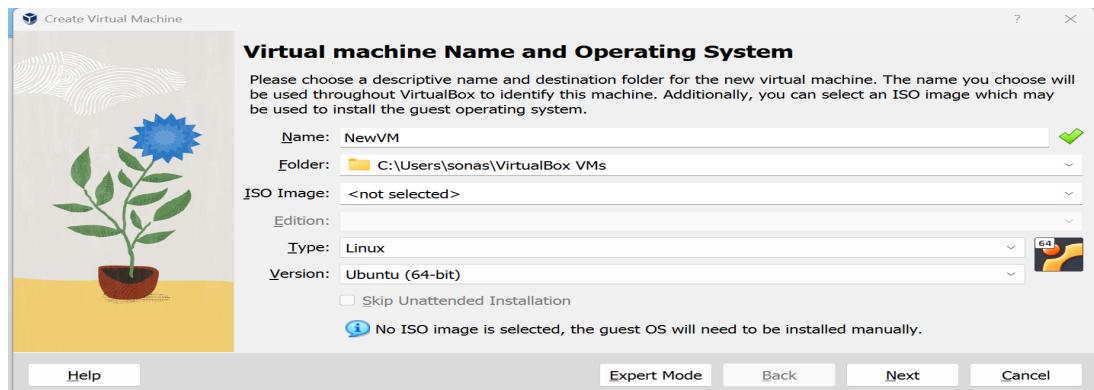
The screenshot shows the 'Ready to Install' step of the Oracle VM VirtualBox 7.0.14 Setup wizard. The title bar says 'Oracle VM VirtualBox 7.0.14 Setup'. The main content area says 'Ready to Install' and 'The Setup Wizard is ready to begin the Custom installation.' Below this is a large text box with the instruction: 'Click Install to begin the installation. If you want to review or change any of your installation settings, click Back. Click Cancel to exit the wizard.' At the bottom are three buttons: 'Version 7.0.14' (left), '< Back' (middle), 'Install' (middle), and 'Cancel' (right).

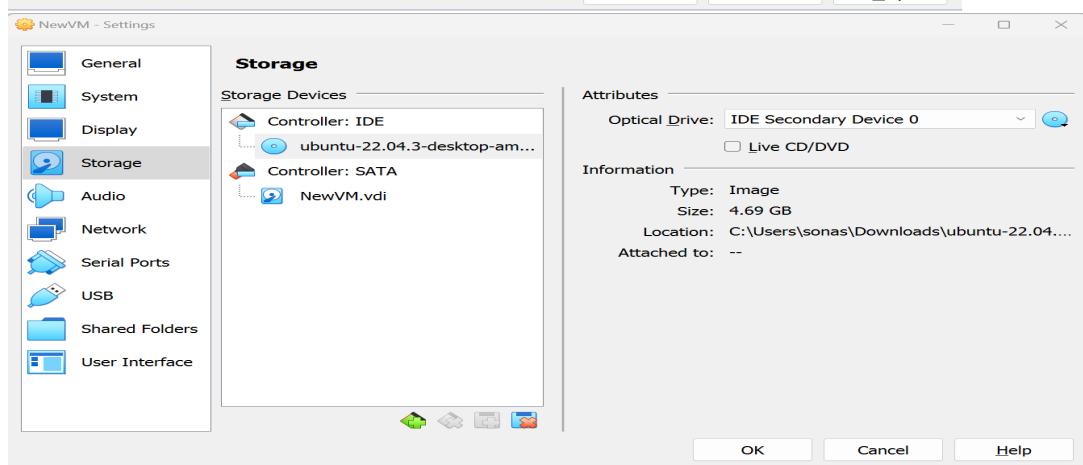
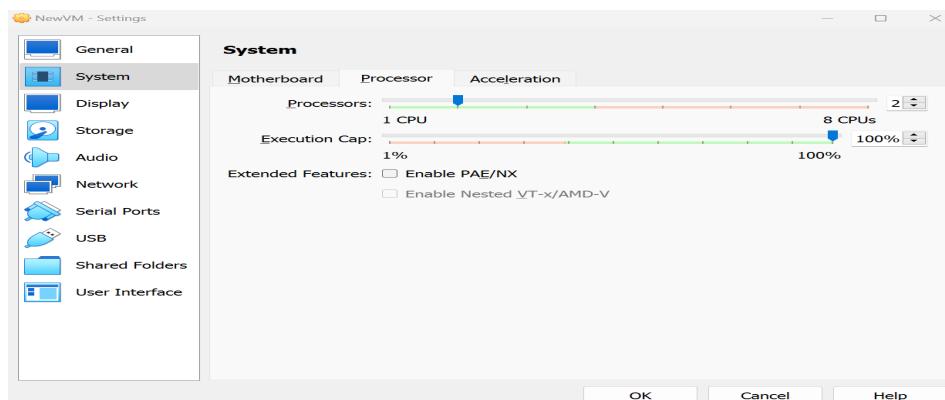
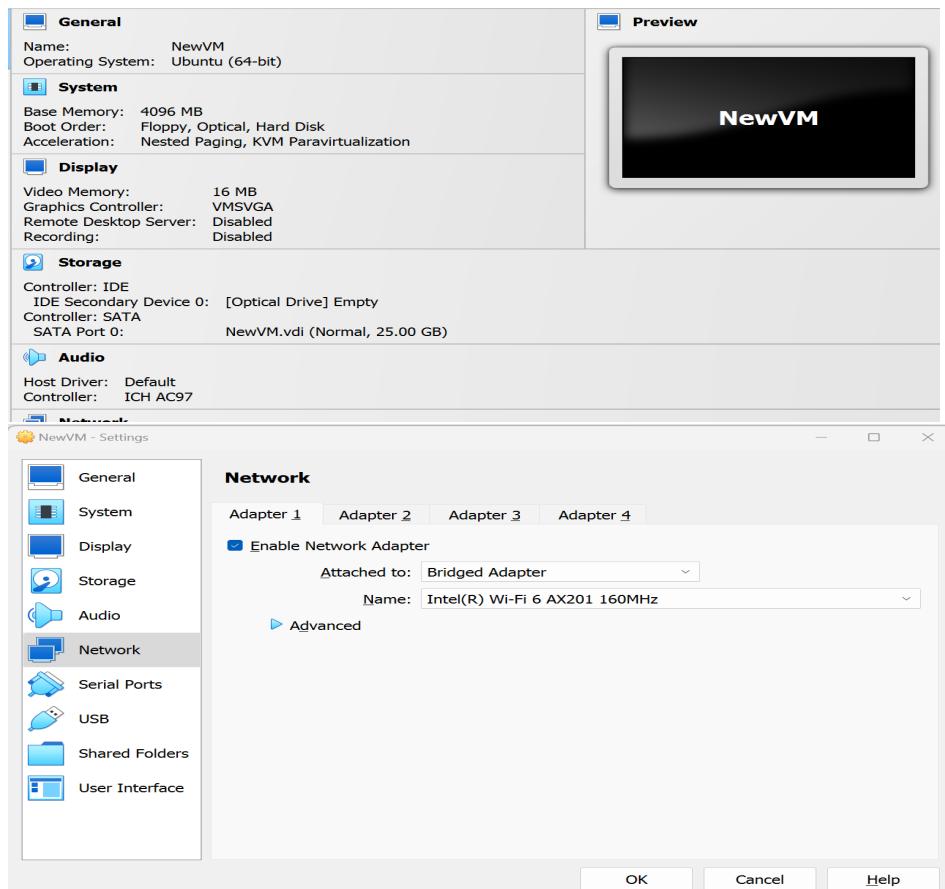


d) Download Ubuntu 22.04 Linux ISO image

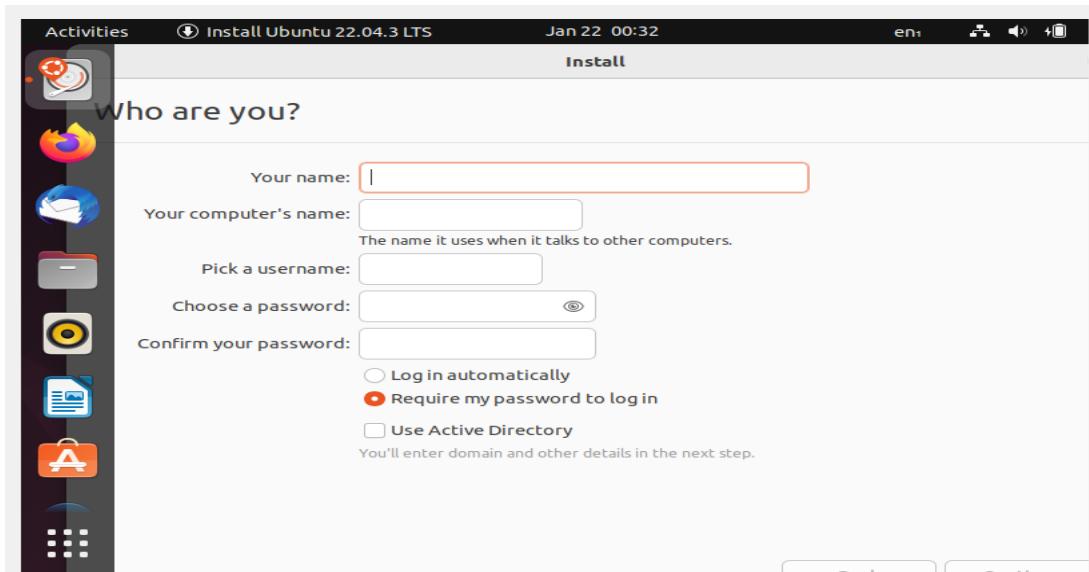


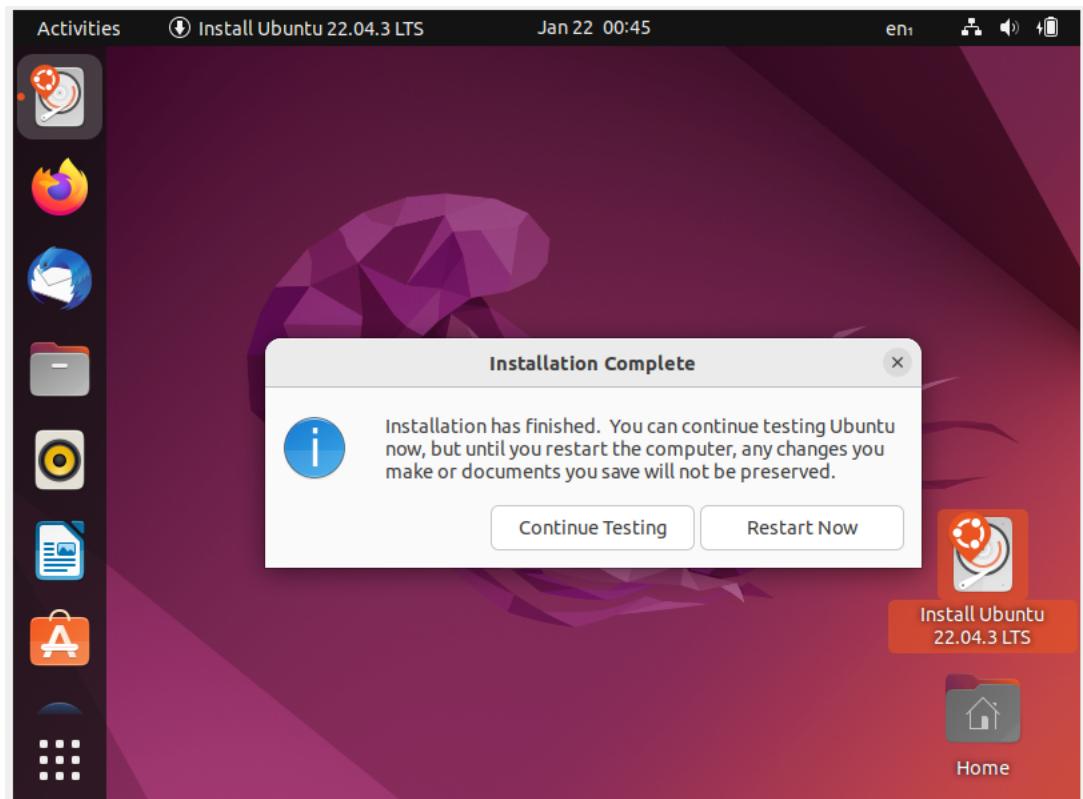
e) Create Virtual Machine (VM), to support Linux, Ubuntu, 64-bit, 4GB RAM, Virtual Disk 25GB, VDI image, dynamically allocated, 2-core, and a network interface (1GbE or WiFi) with Bridged Adapter



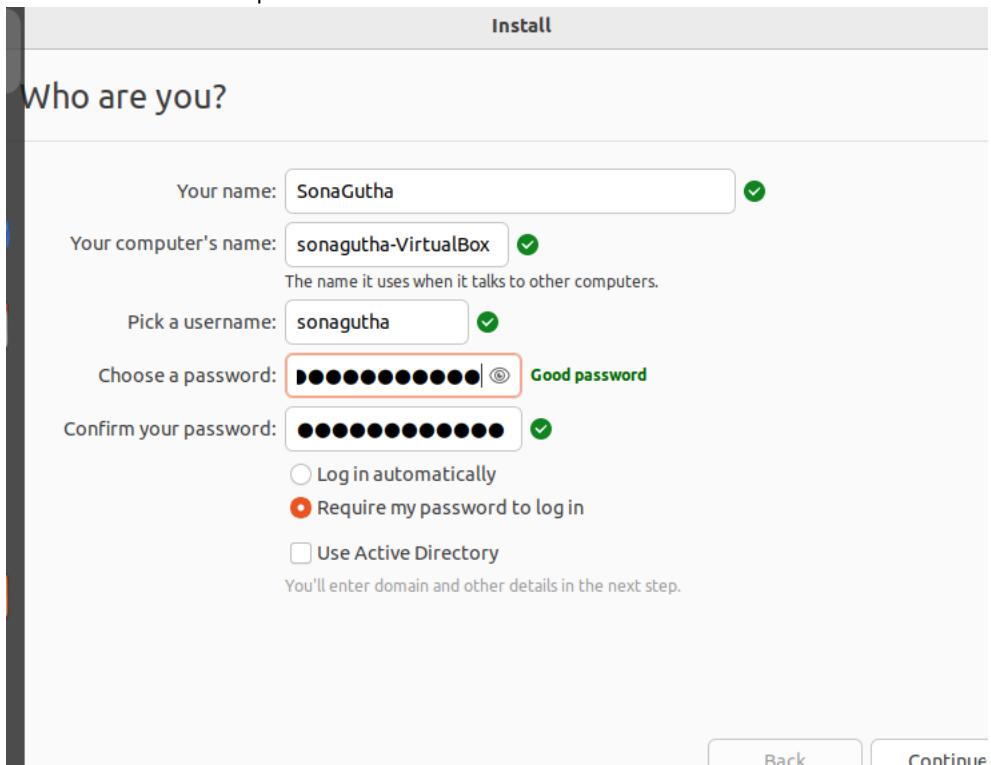


f) Install Linux from the ISO image





g) Create a user id and password



h) Turn on Firewall and block all ports

```
sonagutha@sonagutha-VirtualBox:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), deny (outgoing), disabled (routed)
New profiles: skip
```

i) Enable SSH access to your new Linux installation; open SSH port in firewall

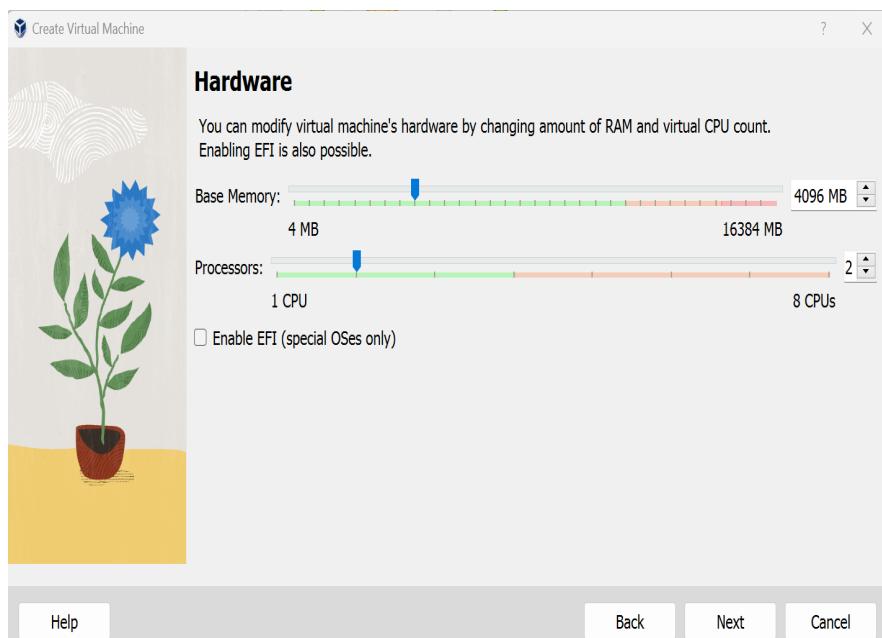
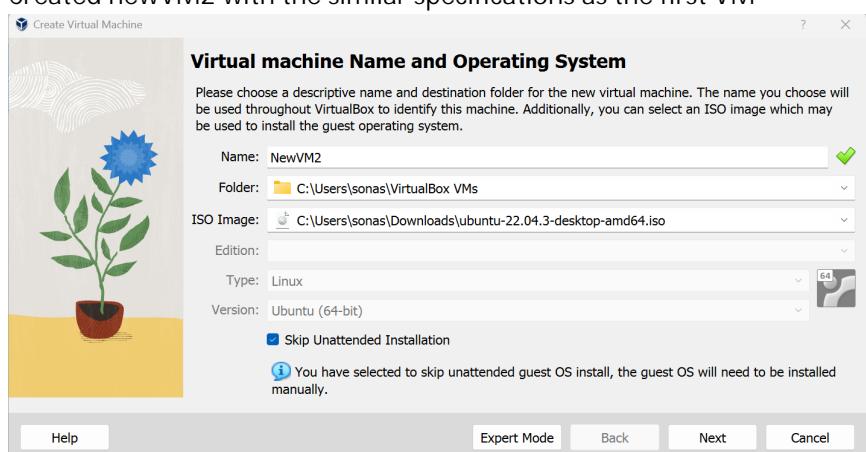
```
sonagutha@sonagutha-VirtualBox:~$ sudo ufw allow 22
Rule added
Rule added (v6)
sonagutha@sonagutha-VirtualBox:~$ sudo ufw reload
Firewall reloaded
sonagutha@sonagutha-VirtualBox:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), deny (outgoing), disabled (routed)
New profiles: skip

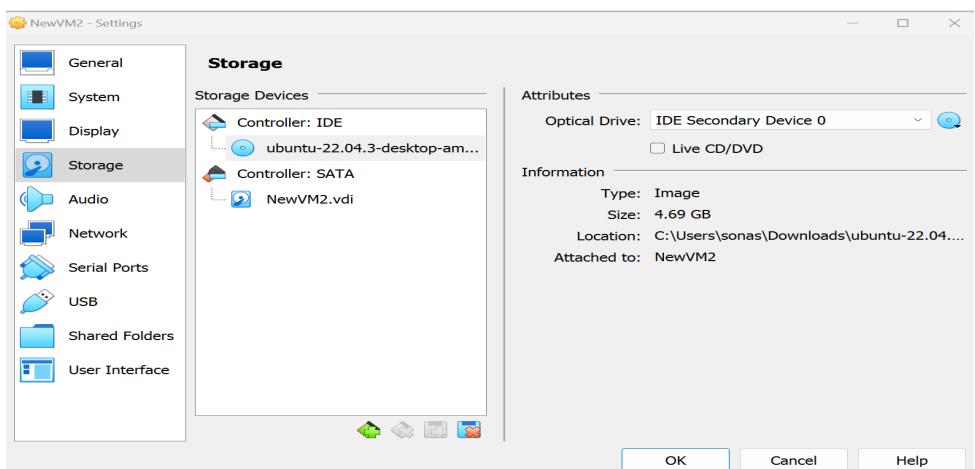
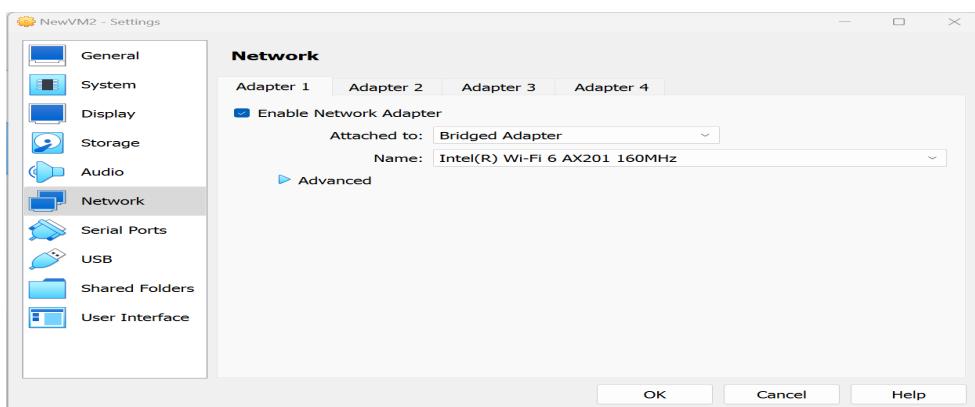
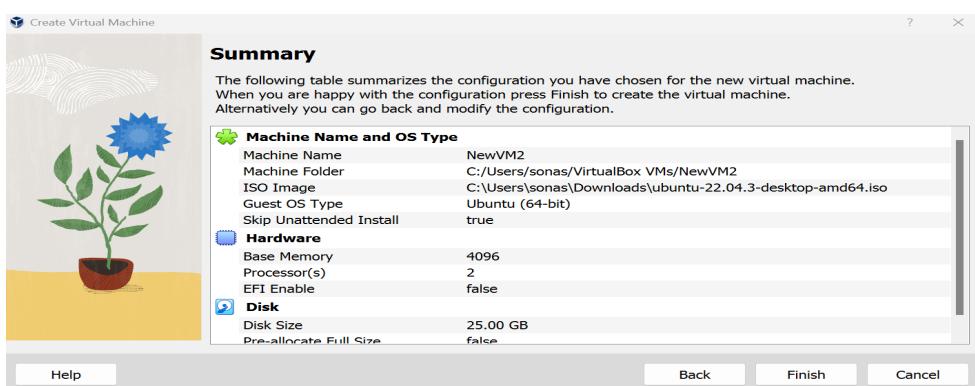
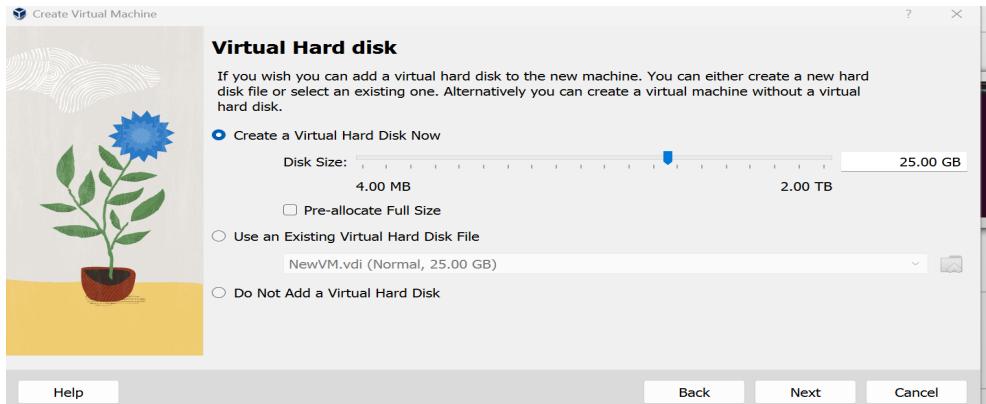
To                         Action      From
--                         --          --
22                         ALLOW IN   Anywhere
22 (v6)                     ALLOW IN   Anywhere (v6)

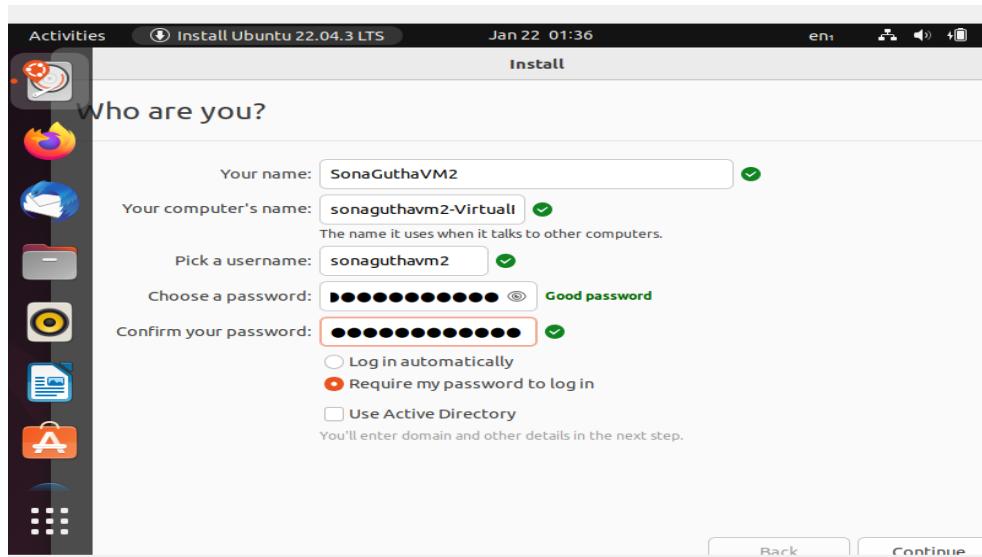
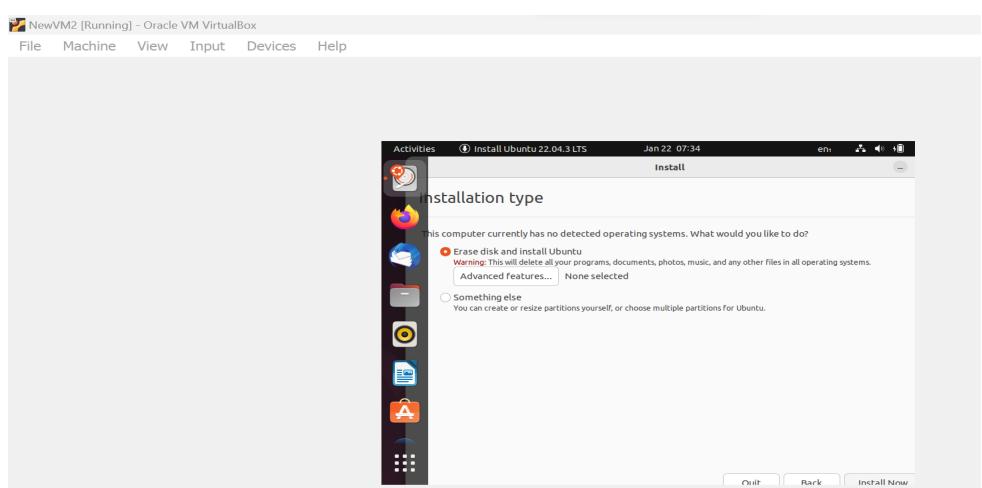
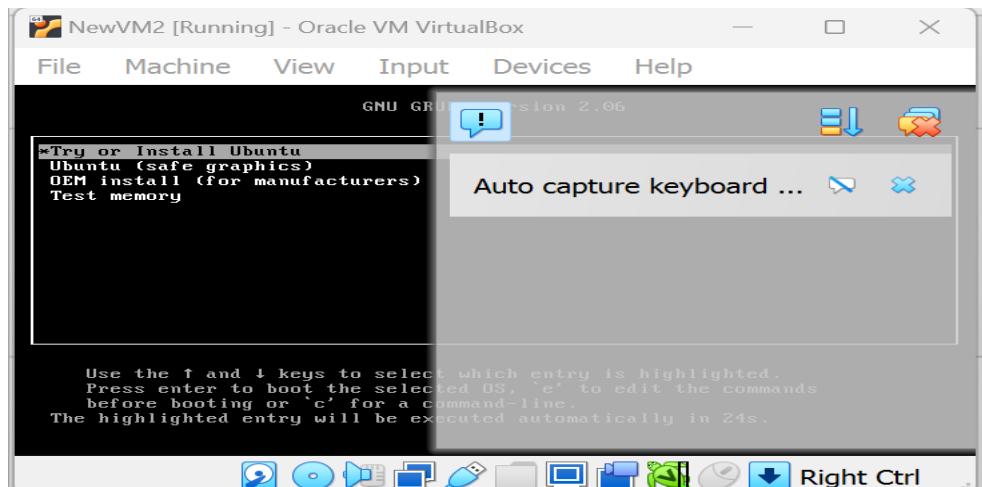
sonagutha@sonagutha-VirtualBox:~$
```

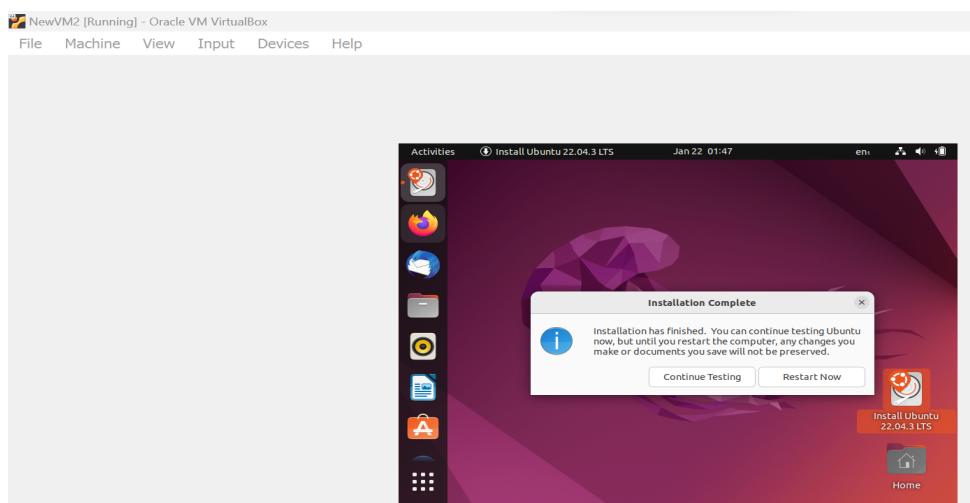
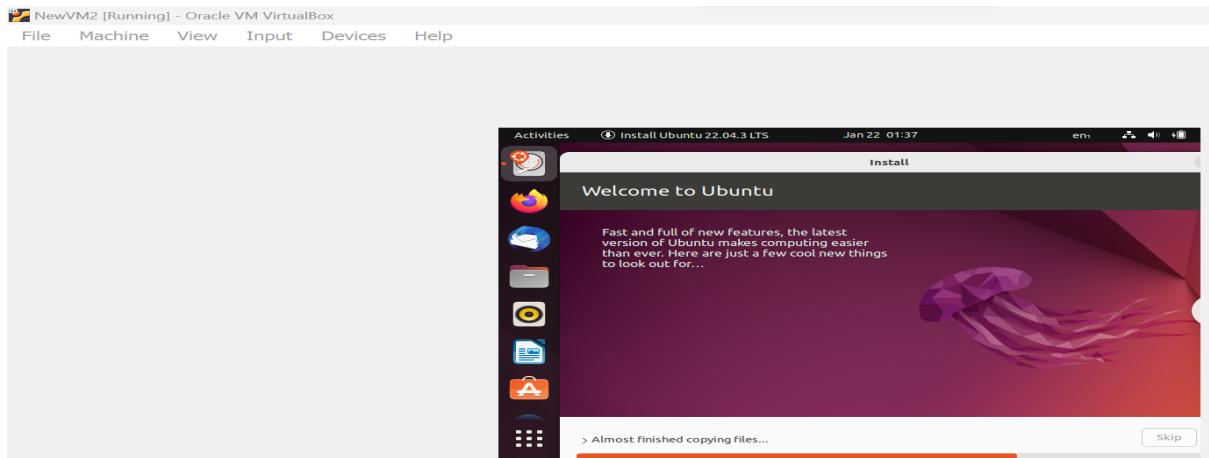
j) Repeat steps 5 through 9, and create another VM with the same specifications as the first one

Created newVM2 with the similar specifications as the first VM









```
Processing triggers for ufw (0.36.1-4ubuntu0.1) ...
sonaguthavm2@sonaguthavm2-VirtualBox:~$ sudo ufw default deny incoming
Default incoming policy changed to 'deny'
(be sure to update your rules accordingly)
sonaguthavm2@sonaguthavm2-VirtualBox:~$ sudo ufw default deny outgoing
Default outgoing policy changed to 'deny'
(be sure to update your rules accordingly)
sonaguthavm2@sonaguthavm2-VirtualBox:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), deny (outgoing), disabled (routed)
New profiles: skip
sonaguthavm2@sonaguthavm2-VirtualBox:~$
```

```
sonaguthavm2@sonaguthavm2-VirtualBox:~$ sudo ufw allow 22
Rule added
Rule added (v6)
sonaguthavm2@sonaguthavm2-VirtualBox:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), deny (outgoing), disabled (routed)
New profiles: skip

To                         Action      From
--                         --         --
22                         ALLOW IN   Anywhere
22 (v6)                     ALLOW IN   Anywhere (v6)

sonaguthavm2@sonaguthavm2-VirtualBox:~$
```

- k) Create private/public keys and install them properly in both of your new VMs

VM1

```
sonagutha@sonagutha-VirtualBox:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/sonagutha/.ssh/id_rsa):
/home/sonagutha/.ssh/id_rsa already exists.
Overwrite (y/n)? y
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/sonagutha/.ssh/id_rsa
Your public key has been saved in /home/sonagutha/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:3PGYnIk4ArCwGRI+eHdv1o6vzAt7krjnJP4Pn/6dTgY sonagutha@sonagutha-VirtualBox
The key's randomart image is:
+---[RSA 3072]---+
|*.
|=*
|=oo . . .
| ..o . + = B
| . o S E .
| . + o .
| ..+... . o
| ..o+B.o + .
| o=+X+o.+
+---[SHA256]---+
sonagutha@sonagutha-VirtualBox:~$ ssh sonagutha@10.0.2.15
sonagutha@10.0.2.15's password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 6.5.0-14-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

Expanded Security Maintenance for Applications is not enabled.

184 updates can be applied immediately.
133 of these updates are standard security updates.
To see these additional updates run: apt list --upgradable

8 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.com/esm

*** System restart required ***
Last login: Mon Jan 22 14:06:53 2024 from 10.0.2.15
```

VM2

```
sonaguthavm2@sonaguthavm2-VirtualBox:~$ ssh-keygen
Enter file in which to save the key (/home/sonaguthavm2/.ssh/id_rsa):
/home/sonaguthavm2/.ssh/id_rsa already exists.
Overwrite (y/n)? y
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/sonaguthavm2/.ssh/id_rsa
Your public key has been saved in /home/sonaguthavm2/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:J1GcxLzJmdMnD8nkuLGV0wieg4uyGI6pHJA5T8PJab4 sonaguthavm2@sonaguthavm2-V
irtualBox
The key's randomart image is:
+---[RSA 3072]---+
|       +.oB.. |
|      .*o*=*+.|
|      ... *.=.|
| = o     o . * ..|
| = 0 . . S o o |
| .* = o o o |
| . = o . |
| .... |
| ..E |
+---[SHA256]---+
sonaguthavm2@sonaguthavm2-VirtualBox:~$
```

```
sonaguthavm2@sonaguthavm2-VirtualBox:~$ ssh sonaguthavm2@10.0.2.15
sonaguthavm2@10.0.2.15's password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 6.5.0-14-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

Expanded Security Maintenance for Applications is not enabled.

185 updates can be applied immediately.
134 of these updates are standard security updates.
To see these additional updates run: apt list --upgradable

7 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.com/esm

Failed to connect to https://changelogs.ubuntu.com/meta-release-lts. Check your Internet connection or proxy settings

*** System restart required ***
Last login: Tue Jan 23 03:27:05 2024 from 10.0.2.15
```

i) Test that you can connect remotely to your VMs with your keys, from one VM to the other VM

```
sonagutha@sonagutha-VirtualBox:~/Desktop$ ssh sonaguthavm2@10.0.2.15
sonaguthavm2@10.0.2.15's password:
Permission denied, please try again.
sonaguthavm2@10.0.2.15's password:
Permission denied, please try again.
sonaguthavm2@10.0.2.15's password:
\
```

2) Show an example of using the following commands (hint: you can use man to find more information about each one); take screen shots of your commands; make sure to clear the screen between each command; explain in your own words what these commands do:

a) ssh

ssh is a protocol that creates a secure connection over network.

```
sonagutha@sonagutha-VirtualBox:~$ ssh sonagutha@10.0.2.15
The authenticity of host '10.0.2.15 (10.0.2.15)' can't be established.
ED25519 key fingerprint is SHA256:/00ZDdzxnasySVXcOHDJFYWeM6ckGeDHmGeKQEUNMjc.
This host key is known by the following other names/addresses:
  ~/.ssh/known_hosts:1: [hashed name]
Are you sure you want to continue connecting (yes/no/[fingerprint])? Yes
Warning: Permanently added '10.0.2.15' (ED25519) to the list of known hosts.
Enter passphrase for key '/home/sonagutha/.ssh/id_rsa':
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 6.5.0-14-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

Expanded Security Maintenance for Applications is not enabled.

188 updates can be applied immediately.
137 of these updates are standard security updates.
To see these additional updates run: apt list --upgradable

7 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.com/esm
```

b) ssh-keygen

This command is used to create secure key pairs(public and private) for the authentication of SSH.

```
sonagutha@sonagutha-VirtualBox:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/sonagutha/.ssh/id_rsa):
/home/sonagutha/.ssh/id_rsa already exists.
```

c)scp

This command is used to securely copy files between different hosts using SSH.

```
[-o ssh_option] [-P port] [-S program] source ... target
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop  Downloads  file2.txt  hello.txt  newfile.txt  Pictures  snap      Videos
Documents  file2      file.tar  Music      newfolder  Public    Templates
sonagutha@sonagutha-VirtualBox:~$ scp file2.txt sonaguthavm2@10.0.2.15:~/Desktop/
```

d)history

This command gives the history of commands ran in the terminal.

```
sonagutha@sonagutha-VirtualBox:~$ history
1 ssh-keygen
2 man scp
3 man history
4 history
```

e) sudo

This command allows the user to execute the commands as a superuser as per security policy. Sudo stands for “superuser do”.

The below command allows 22 port which is for ssh. The firewall is reloaded using sudo command, and again then status is checked using the sudo command.

```
sonagutha@sonagutha-VirtualBox:~$ sudo ufw allow 22
Rule added
Rule added (v6)
sonagutha@sonagutha-VirtualBox:~$ sudo ufw reload
Firewall reloaded
sonagutha@sonagutha-VirtualBox:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), deny (outgoing), disabled (routed)
New profiles: skip

To                         Action      From
--                         --          --
22                         ALLOW IN   Anywhere
22 (v6)                    ALLOW IN   Anywhere (v6)

sonagutha@sonagutha-VirtualBox:~$
```

f) ip

This command allows to view or configure network related information, routes. The below command displays the ip route for the virtual box.

```
sonagutha@sonagutha-VirtualBox:~$ ip route
default via 10.0.2.2 dev enp0s3 proto dhcp metric 20100
10.0.2.0/24 dev enp0s3 proto kernel scope link src 10.0.2.15 metric 100
169.254.0.0/16 dev enp0s3 scope link metric 1000
```

g) touch

This command is used to create a new file and also modifies the files access timestamps when the file is accessed. Here file1.txt is created using touch command and it displays the file creation timestamp. Later on, when the file1 is accessed, the last access timestamp got modified.

```
sonagutha@sonagutha-VirtualBox:~$ touch file1.txt
sonagutha@sonagutha-VirtualBox:~$ ls -l file1.txt
-rw-rw-r-- 1 sonagutha sonagutha 0 Jan 22 14:21 file1.txt
```

```
sonagutha@sonagutha-VirtualBox:~$ ls -l file1.txt
-rw-rw-r-- 1 sonagutha sonagutha 0 Jan 22 14:26 file1.txt
sonagutha@sonagutha-VirtualBox:~$
```

h) ls

This command is used to list all the files; directories present under a directory. It can also display hidden files, file details, sort the files by modified time.

```
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop Documents Downloads file1.txt Music Pictures Public snap Templates Videos
sonagutha@sonagutha-VirtualBox:~$
```

i) Mkdir

This command is used to create new directory or directories. Nested directories can also be created using this command. In the below, a directory named newfolder is created using this command.

```
sonagutha@sonagutha-VirtualBox:~$ mkdir newfolder
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop Documents Downloads file1.txt Music newfolder Pictures Public snap Templates Videos
sonagutha@sonagutha-VirtualBox:~$ cd newfolder
sonagutha@sonagutha-VirtualBox:~/newfolder$
```

j) cd

This command is used to navigate to a different directory from the current directory. It is also used to navigate to the specified directory. Here using this command, we have navigated to newfolder.

```
sonagutha@sonagutha-VirtualBox:~$ mkdir newfolder
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop Documents Downloads file1.txt Music newfolder Pictures Public snap Templates Videos
sonagutha@sonagutha-VirtualBox:~$ cd newfolder
sonagutha@sonagutha-VirtualBox:~/newfolder$
```

k) dd

This command is used to copy the contents from one file to another file. The file specified with if is the source file and the file specified with the of is the destination file. Below, the file is empty, so the 0 bytes are copied.

```
sonagutha@sonagutha-VirtualBox:~$ dd if=file1.txt of=file2.txt
0+0 records in
0+0 records out
0 bytes copied, 0.000165676 s, 0.0 kB/s
```

l) fdisk

This command is used to manipulate disk partitions or create disk partitions or delete disk partitions. Here the disk partitions list details are displayed using the below command.

```
sonagutha@sonagutha-VirtualBox:~$ sudo fdisk -x
[sudo] password for sonagutha:
Disk /dev/loop0: 4 KiB, 4096 bytes, 8 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes

Disk /dev/loop1: 63.45 MiB, 66531328 bytes, 129944 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes

Disk /dev/loop2: 349.7 MiB, 366682112 bytes, 716176 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
```

m) apt

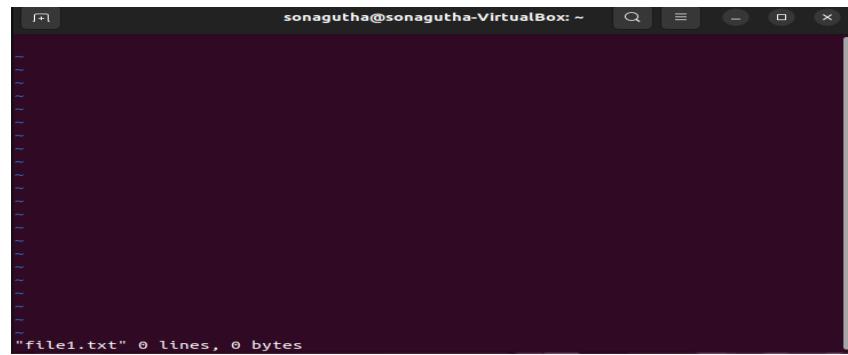
This command is used to manage software packages, to install/ upgrade/ delete the software packages. Here the below command is updating the software packages.

```
sonagutha@sonagutha-VirtualBox:~$ sudo apt-get update
Hit:1 http://us.archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://us.archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Hit:3 http://us.archive.ubuntu.com/ubuntu jammy-backports InRelease
Get:4 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:5 http://us.archive.ubuntu.com/ubuntu jammy-updates/main i386 Packages [552 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1,282 kB]
Get:7 http://us.archive.ubuntu.com/ubuntu jammy-updates/restricted i386 Packages [33.6 kB]
Get:8 http://us.archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1,282 kB]
Get:9 http://us.archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [209 kB]
Get:10 http://us.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1,032 kB]
Get:11 http://us.archive.ubuntu.com/ubuntu jammy-updates/universe i386 Packages [681 kB]
Get:12 http://us.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42 kB]
```

n) vi

This command is used to edit contents directly into the file and save the information.

```
sonagutha@sonagutha-VirtualBox:~$ vi file1.txt
```



o) time

This command is used to know the amount of time it takes to run a command in the terminal. The below command will display the amount of real time it took to execute sleep 5 command. The user and the sys is 0 as the sleep is not cpu intensive command .

```
sonagutha@sonagutha-VirtualBox:~$ time -p sleep 5
real 5.33
user 0.00
sys 0.00
```

p) tar

This command is used to create archive files, extract then or delete them. It combines/zips multiple files together and creates a .tar file. Here file1.txt and file2.txt are combined into file.tar.

```
sonagutha@sonagutha-VirtualBox:~$ tar -cf file.tar file1.txt file2.txt
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop  Downloads  file2  file.tar  newfolder  Public  Templates
Documents  file1.txt  file2.txt  Music    Pictures  snap    Videos
sonagutha@sonagutha-VirtualBox:~$
```

q) rm

This command is a remove command use to remove files, directories from the location. In the below, file1.txt is removed using rm command.

```
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop  Downloads  file2      file.tar  newfolder  Public  Templates
Documents  file1.txt  file2.txt  Music    Pictures  snap    Videos
sonagutha@sonagutha-VirtualBox:~$ rm file1.txt
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop  Downloads  file2.txt  Music    Pictures  snap    Videos
Documents  file2      file.tar  newfolder  Public  Templates
sonagutha@sonagutha-VirtualBox:~$
```

r) cat

This command is used to create files, view files, combine or concatenate files or append contents to a file and display output. Below hello.txt file is created using cat command and data is entered. Again cat command is used to view the hello.txt file contents.

```
sonagutha@sonagutha-VirtualBox:~$ cat > hello.txt
Hello
sonagutha@sonagutha-VirtualBox:~$ cat  hello.txt
Hello
sonagutha@sonagutha-VirtualBox:~$
```

s) bash

This command is used to launch Bourne again shell to run bash scripts. Here bash command opens the new bash, and then next line will run single command in shell to echo Hi .

```
sonagutha@sonagutha-VirtualBox:~$ bash
sonagutha@sonagutha-VirtualBox:~$ bash -c "echo Hi"
Hi
sonagutha@sonagutha-VirtualBox:~$
```

t) more

This command is used to view text files with one screen at a time. It makes easier to read larger files. We can navigate to different pages using space.

```
sonagutha@sonagutha-VirtualBox:~/Documents$ more Untitled\ 1.odt
PoX^e2^L'mimetypeapplication/vnd.oasis.opendocument.textPoXConfigurations2/acc
--More--(1%)
```

u) watch

This command is used to execute a command multiple times periodically and displays the output. Here, this command continuously watches the disk space used.

```
sonagutha@sonagutha-VirtualBox:~$ watch df -h
```

```
Every 2.0s: df -h          sonagutha-VirtualBox: Mon Jan 22 21:38:19 2024
Filesystem      Size  Used  Avail Use% Mounted on
tmpfs          391M  1.4M  390M  1% /run
/dev/sda3        24G   13G  9.8G  58% /
tmpfs          2.0G     0  2.0G  0% /dev/shm
tmpfs          5.0M  4.0K  5.0M  1% /run/lock
/dev/sda2        512M   6.1M  506M  2% /boot/efi
tmpfs          391M  104K  391M  1% /run/user/1000
```

v) ps

This command displays the information of the processes that are currently running on the system. Here, it displays the current processes running on the system.

```
sonagutha@sonagutha-VirtualBox:~$ ps
  PID TTY      TIME CMD
 1951 pts/0    00:00:00 bash
 3059 pts/0    00:00:00 bash
 3072 pts/0    00:00:00 bash
 3375 pts/0    00:00:00 ps
```

w) top

This command gives the interactive real time and dynamic view of the processes running on the system and the usage of the current systems resources. Below displays the statistics, resource information and so on that are currently running on the system.

```
sonagutha@sonagutha-VirtualBox:~$ top
top - 21:45:11 up  5:00,  1 user,  load average: 0.01, 0.02, 0.01
Tasks: 188 total,  1 running, 187 sleeping,  0 stopped,  0 zombie
%CPU(s): 0.0 us, 6.5 sy, 0.0 ni, 93.5 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
MiB Mem : 3907.2 total, 1758.9 free, 793.5 used, 1354.9 buff/cache
MiB Swap: 2680.0 total, 2680.0 free, 0.0 used. 2858.9 avail Mem
```

x) htop

This command is the updated or enhanced version of the regular top command which provides the user friendly interactive features to display the real time information. It provides feature for easier navigation, colour coded display as below.

```
sonagutha@sonagutha-VirtualBox:~$ htop
locales-launch: Data of en_US locale not found, generating, please wait...
[ 0.0% ] Tasks: 122, 263 thr, 70 kthr; 0 running
[ 2.1% ] Load average: 0.20 0.06 0.02
Mem[|||||] 873M/3.82G Uptime: 05:08:05
Swp[          ] 0K/2.62G
```

Main	I/O	PRI	NI	VIRT	RES	SHR	S	CPU%\\MEM%	TIME+	Command
4520	sonagutha	20	0	5984	4608	3456	R	2.0 0.1	0:00.28	/snap/htop/4
1469	sonagutha	20	0	4438M	364M	135M	S	0.7 9.3	0:52.75	/usr/bin/gno
1516	sonagutha	20	0	4438M	364M	135M	S	0.7 9.3	0:29.89	/usr/bin/gno
1517	sonagutha	20	0	4438M	364M	135M	S	0.7 9.3	0:31.21	/usr/bin/gno
1933	sonagutha	20	0	845M	60844	45496	S	0.7 1.5	0:08.68	/usr/libexec
1	root	20	0	163M	13160	8296	S	0.0 0.3	0:02.80	/sbin/init s
187	root	19	-1	48276	18048	16512	S	0.0 0.5	0:00.96	/lib/systemd
218	root	20	0	26736	6912	4736	S	0.0 0.2	0:00.22	/lib/systemd
411	systemd-oo	20	0	14824	6912	6144	S	0.0 0.2	0:12.19	/lib/systemd
414	systemd-re	20	0	25528	13664	9472	S	0.0 0.3	0:02.02	/lib/systemd
415	systemd-ti	20	0	89376	7552	6656	S	0.0 0.2	0:00.21	/lib/systemd
449	systemd-ti	20	0	89376	7552	6656	S	0.0 0.2	0:00.44	/lib/systemd
603	root	20	0	234M	7640	6872	S	0.0 0.2	0:00.09	/usr/libexec
604	root	20	0	2812	1920	1792	S	0.0 0.0	0:00.26	/usr/sbin/ac
606	avahi	20	0	7628	4096	3712	S	0.0 0.1	0:00.14	avahi-daemon

F1:Help F2:Setup F3:Search F4:Filter F5:Tree F6:Sort By F7:Nice - F8:Nice + F9:Kill F10:Quit

y) gcc

It is GNU compiler collection. This command is set of compilers of different programming languages such as C, C++. Here, this command is used to display compile the hello.c program.

```
collect2: error: ld returned 1 exit status
sonagutha@sonagutha-VirtualBox:~$ gcc hello.c -o hello
sonagutha@sonagutha-VirtualBox:~$ ./hello
Hello sonagutha@sonagutha-VirtualBox:~$
```

z) tail

This command is used to view the information present in the last few lines of a file. We specify the number of lines that can be displayed for the last.

```
sonagutha@sonagutha-VirtualBox:~$ tail -n 6 hello.c
printf("Hello");
return 0;
}
```

aa) grep

This command is used to search for a pattern in a single text file or multiple text files.

```
sonagutha@sonagutha-VirtualBox:~$ grep "<" hello.c
#include <stdio.h>
```

bb) kill

This command is used to kill the processes when the command is executed by sending signal to processes. Below the process id 5405 is terminated.

```
sonagutha@sonagutha-VirtualBox:~$ kill 5405
```

cc) killall

This command is used to kill the processes when the command is executed by sending signal to processes based on their name instead of the process id.

```
sonagutha@sonagutha-VirtualBox:~$ killall firefox
```

dd) du

This command is used to estimate the usage of space by files and directories. Below displays the desktop's diskspace usage.

```
sonagutha@sonagutha-VirtualBox:~$ du -h Desktop
4.0K    Desktop/c
8.0K    Desktop
```

ee) df

This command is used to display the disk space used by the system. Below displays the diskspace usage by all file systems.

```
sonagutha@sonagutha-VirtualBox:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
tmpfs          391M   1.5M  390M   1% /run
/dev/sda3       24G   14G  9.6G  58% /
tmpfs          2.0G     0  2.0G   0% /dev/shm
tmpfs          5.0M   4.0K  5.0M   1% /run/lock
/dev/sda2       512M   6.1M  506M   2% /boot/efi
tmpfs          391M  112K  391M   1% /run/user/1000
```

ff) screen

This command is used to create new terminals and also allows to run multiple terminals. Below displays the available screen session.

```
sonagutha@sonagutha-VirtualBox:~$ screen -ls
There is a screen on:
    6889.pts-0.sonagutha-VirtualBox (01/22/2024 10:34:33 PM)          (Attached)
1 Socket in /run/screen/S-sonagutha.
```

gg) vim

It is an improved text editor which provides efficient way to edit text. Here file1.txt is edited and saved using vim command



hh) chmod

This command provides option to change then permission of the files and directories and also provides option to create, read, write and execute file. Here the first chmod command gives read write access to the user. The second command gives the read write access to the user and group.

```
sonagutha@sonagutha-VirtualBox:~$ chmod u+rwx file1.txt
sonagutha@sonagutha-VirtualBox:~$ chmod ug+rwx file1.txt
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop  Downloads  file2  file.tar  hello.c  Music  newfolder  Public  Templates
Documents  file1.txt  file2.txt  hello  hello.txt  newfile.txt  Pictures  snap  Videos
sonagutha@sonagutha-VirtualBox:~$
```

ii) chown

This command is used to change the ownership of the user or group for the files and directories to a new user and or new group. Here the ownership of the file1.txt is changed to new owner abc.

```
sonagutha@sonagutha-VirtualBox:~$ sudo chown abc file1.txt
```

jj) useradd

This command is used to create new users. Below new user abc is created using this command.

```
sonagutha@sonagutha-VirtualBox:~$ sudo adduser abc
Adding user `abc' ...
Adding new group `abc' (1001) ...
Adding new user `abc' (1001) with group `abc' ...
Creating home directory `/home/abc' ...
Copying files from `/etc/skel' ...
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
Sorry, passwords do not match.
New password:
BAD PASSWORD: The password fails the dictionary check - it is too simplistic/systemic
Retype new password:
passwd: password updated successfully
Changing the user information for abc
Enter the new value, or press ENTER for the default
  Full Name []:
  Room Number []:
  Work Phone []:
  Home Phone []:
  Other []:
```

kk) mv

This command is used to move or rename the file and directories from once location to another. Here, this command is used to move file2.txt to desktop

```
sonagutha@sonagutha-VirtualBox:~$ ls
Desktop  Downloads  file2  file.tar  hello.c  Music  newfolder  Public  Templates
Documents  file1.txt  file2.txt  hello  hello.txt  newfile.txt  Pictures  snap  Videos
sonagutha@sonagutha-VirtualBox:~$ mv file2.txt /Desktop
mv: cannot move 'file2.txt' to '/Desktop': Permission denied
sonagutha@sonagutha-VirtualBox:~$ mv file2.txt Desktop
sonagutha@sonagutha-VirtualBox:~$ cd Desktop
sonagutha@sonagutha-VirtualBox:~/Desktop$ ls
c  file2.txt
sonagutha@sonagutha-VirtualBox:~/Desktop$
```

ll) man

This command is used to give the detailed information about different commands used in linux. Below gives the information about the apt command

```
sonagutha@sonagutha-VirtualBox:~$ man apt
```

```

APT(8)                               APT                               APT(8)

NAME
    apt - command-line interface

SYNOPSIS
    apt [-h] [-o=config_string] [-c=config_file] [-t=target_release] [-a=architecture] {list | search | show |
    update | install pkg [{=pkg_version_number} | /target_release]}... | remove pkg... | upgrade |
    full-upgrade | edit-sources | {-v | --version} | {-h | --help} }

DESCRIPTION
    apt provides a high-level commandline interface for the package management system. It is intended as an end
    user interface and enables some options better suited for interactive usage by default compared to more
    specialized APT tools like apt-get(8) and apt-cache(8).

    Much like apt itself, its manpage is intended as an end user interface and as such only mentions the most
    used commands and options partly to not duplicate information in multiple places and partly to avoid
    overwhelming readers with a cornucopia of options and details.

    update (apt-get(8))
        update is used to download package information from all configured sources. Other commands operate on
        this data to e.g. perform package upgrades or search in and display details about all packages available
        for installation.

    upgrade (apt-get(8))
        upgrade is used to install available upgrades of all packages currently installed on the system from the
        sources configured via sources.list(s). New packages will be installed if required to satisfy
        dependencies, but existing packages will never be removed. If an upgrade for a package requires the
        removal of an installed package the upgrade for this package isn't performed.

    full-upgrade (apt-get(8))
        full-upgrade performs the function of upgrade but will remove currently installed packages if this is
        needed to upgrade the system as a whole.

```

mm) locate

This command is used to locate the files/directories faster. Here , this command is used to locate file2.txt

```

sonagutha@sonagutha-VirtualBox:~$ locate file2.txt
/home/sonagutha/Desktop/file2.txt

```

nn) find

This command provides utility to search and locate files/directories. Here a starting directory is specified from where the searching starts and looks for the search information. If any directory is not specified, it starts from current directory.

```

sonagutha@sonagutha-VirtualBox:~$ ls
Desktop  Downloads  file2  hello  hello.txt  newfile.txt  Pictures  snap      Videos
Documents  file1.txt  file.tar  hello.c  Music      newfolder  Public    Templates
sonagutha@sonagutha-VirtualBox:~$ find -name file2.txt
./Desktop/file2.txt
sonagutha@sonagutha-VirtualBox:~$ 

```

oo) sed

This is a stream editor used for manipulating or transforming text. Here the occurrences of 'a' in file2 is substituted with 'b'.

```

sonagutha@sonagutha-VirtualBox:~/Desktop$ sed 's/a/b/g' file2.txt
b b b b b

```

pp) awk

This command is used for pattern scanning and text processing. This command will find the pattern and perform the action on the file specified. Here pattern 'a' is matched in file2.txt, so the print action is performed.

```

sonagutha@sonagutha-VirtualBox:~/Desktop$ awk '/a/ { print }' file2.txt
a a a a

```

qq) diff

This command is used to compare the information of two files or directories and display the differences between the files or directories. Below displays the difference between file1.txt,file2.txt

```
sonagutha@sonagutha-VirtualBox:~/Desktop$ diff file1.txt file2.txt
1,3c1
< a
< d
< c
...
> a a a a a
```

rr) sort

This command is used to sort lines of text in file alphabetically or numerically. Here the contents of the file1.txt are sorted alphabetically.

```
sonagutha@sonagutha-VirtualBox:~/Desktop$ sort file1.txt
a
c
d
```

ss) export

This command is used to set environmental variables which are key value pairs. Below a new environment variable is created with value hello.

```
sonagutha@sonagutha-VirtualBox:~$ export NEW_VAR="Hello"
sonagutha@sonagutha-VirtualBox:~$ echo $NEW_VAR
Hello
sonagutha@sonagutha-VirtualBox:~$
```

tt) pwd

This command is used to print the name of the current working directory.

```
sonagutha@sonagutha-VirtualBox:~$ pwd
/home/sonagutha
```

uu) crontab

This command is used to maintain cron job for the users. We can add, view, remove cron jobs using this command. Below command is used to edit crontab

```
sonagutha@sonagutha-VirtualBox:~$ crontab -e
no crontab for sonagutha - using an empty one

GNU nano 6.2                               /tmp/crontab.02hFpk/crontab
# Edit this file to introduce tasks to be run by cron.
#
# Each task to run has to be defined through a single line
# indicating with different fields when the task will be run
# and what command to run for the task
#
# To define the time you can provide concrete values for
# minute (m), hour (h), day of month (dom), month (mon),
# and day of week (dow) or use '*' in these fields (for 'any').
#
# Notice that tasks will be started based on the cron's system
# daemon's notion of time and timezones.
#
# Output of the crontab jobs (including errors) is sent through
# email to the user the crontab file belongs to (unless redirected).
#
# For example, you can run a backup of all your user accounts
# at 5 a.m every week with:
# 0 5 * * 1 tar -zcf /var/backups/home.tgz /home/
#
# For more information see the manual pages of crontab(5) and cron(8)
#
# m h  dom mon dow   command
```

vv) mount

This command is used to attach the file system to the directory. The below command lists the existing mounted files.

```
sonagutha@sonagutha-VirtualBox:~$ mount -l
```

```
bpf on /sys/fs/bpf type bpf (rw,nosuid,nodev,noexec,relatime,mode=700)
sysfs on /sys type sysfs (rw,relatime)
hugepages on /dev/hugepages type hugepages (rw,relatime,page_size=2M)
mqueue on /dev/queue type mqueue (rw,nosuid,nodev,noexec,relatime)
debugfs on /sys/kernel/debug type debugfs (rw,nosuid,nodev,noexec,relatime)
tracesfs on /sys/kernel/tracing type traces (rw,nosuid,nodev,noexec,relatime)
fusectl on /sys/fs/fuse/connections type fusectl (rw,nosuid,nodev,noexec,relatime)
configfs on /sys/kernel/config type configfs (rw,nosuid,nodev,noexec,relatime)
ramfs on /run/credentials/systemd-susers.service type ramfs (ro,nosuid,nodev,noexec,relatime,mode=700)
/var/lib/snapd/snaps/bare_5.snap on /snap/bare/5 type squashfs (ro,nodev,relatime,errors=continue,threads=1)
/var/lib/snapd/snaps/core20_1974.snap on /snap/core20/1974 type squashfs (ro,nodev,relatime,errors=continue)
/var/lib/snapd/snaps/firefox_2987.snap on /snap/firefox/2987 type squashfs (ro,nodev,relatime,errors=continue)
/var/lib/snapd/snaps/gnome-3-38-2004_143.snap on /snap/gnome-3-38-2004/143 type squashfs (ro,nodev,relatime,errors=continue)
/var/lib/snapd/snaps/gnome-42-2204_120.snap on /snap/gnome-42-2204/120 type squashfs (ro,nodev,relatime,errors=continue)
/var/lib/snapd/snaps/gtk-common-themes_1535.snap on /snap/gtk-common-themes/1535 type squashfs (ro,nodev,relatime,errors=continue)
/var/lib/snapd/snaps/snap-store_959.snap on /snap/snap-store/959 type squashfs (ro,nodev,relatime,errors=continue)
/var/lib/snapd/snaps/snapsd_19457.snap on /snap/snapsd/19457 type squashfs (ro,nodev,relatime,errors=continue)
/var/lib/snapd/snaps/snapsd-desktop-integration_83.snap on /snap/snapsd-desktop-integration/83 type squashfs (ro,nodev,relatime,errors=continue,threads=single,x-gdu.hide)
/var/lib/snapd/snaps/core22_858.snap on /snap/core22/858 type squashfs (ro,nodev,relatime,errors=continue)
/dev/sda3 on /var/snap/firefox/common/host-hunspell type ext4 (ro,noexec,noatime,errors=remount-ro)
/dev/sda2 on /boot/efi type vfat (rw,relatime,mask=0077,codepage=437,iocharset=iso8859-1,shortname=0)
binfmt_misc on /proc/sys/fs/binfmt_misc type binfmt_misc (rw,nosuid,nodev,noexec,relatime)
tmpfs on /run/snapd/ns type tmpfs (rw,nosuid,nodev,noexec,relatime,size=400100k,mode=755,inode64)
nsfs on /run/snapd/ns/snapd-desktop-integration.mnt type nsfs (rw)
tmpfs on /run/user/1000 type tmpfs (rw,nosuid,nodev,relatime,size=400096k,nr_inodes=100024,mode=700,uid=1000,gvfsd-fuse on /run/user/1000/gvfs type fuse.gvfsd-fuse (rw,nosuid,nodev,relatime,user_id=1000,group_id=1000)
portal on /run/user/1000/doc type fuse.portal (rw,nosuid,nodev,relatime,user_id=1000,group_id=1000)
/var/lib/snapd/snaps/htop_4079.snap on /snap/htop/4079 type squashfs (ro,nodev,relatime,errors=continue)
nsfs on /run/snapd/ns/htop.mnt type nsfs (rw)
```

ww) passwd

This command is used to change the password of the user or the other users. Here the password for the user abc is changed using this command

```
nsfs on /run/snapd/ns/firefox.mnt type nsfs (rw)
sonagutha@sonagutha-VirtualBox:~$ sudo passwd abc
[sudo] password for sonagutha:
New password:
BAD PASSWORD: The password fails the dictionary check - it is too simplistic/systematic
Retype new password:
passwd: password updated successfully
sonagutha@sonagutha-VirtualBox:~$
```

xx) uname

This command displays then system information. Here, this command is used to display basic system information and machine hardware architecture.

```
sonagutha@sonagutha-VirtualBox:~$ uname -m
x86_64
sonagutha@sonagutha-VirtualBox:~$ uname
Linux
sonagutha@sonagutha-VirtualBox:~$
```

yy) whereis

This command is used to locate binary, source and manual information for a specified command. This command is used to locate the information for ls command.

```
sonagutha@sonagutha-VirtualBox:~$ whereis ls
ls: /usr/bin/ls /usr/share/man/man1/ls.1.gz
sonagutha@sonagutha-VirtualBox:~$
```

zz) whatis

This command provides one-line short description for the specified command. Here short description for the ls command is displayed using this command.

```
sonagutha@sonagutha-VirtualBox:~$ whatis ls
ls (1)           - list directory contents
```

aaa) less

This command is opposite of more. Provides easy navigation, scrolling, searching in a file. Using this command able to scroll through hello.c file

```
sonagutha@sonagutha-VirtualBox:~$ less hello.c
#include <stdio.h>
int main(){
printf("hello");
return 0;
}
```



bbb) su

It is substitute user. It is used to switch the user. By default, it switches to root if no user is specified. Switched to abc user using this command,

```
sonagutha@sonagutha-VirtualBox:~$ su abc
Password:
abc@sonagutha-VirtualBox:/home/sonagutha$
```

ccc) ping

This command is used to check the reachability of network hosts. Here network host is pinged with 2 ping packets using this command.

```
sonagutha@sonagutha-VirtualBox:~$ ping -c 2 10.0.2.15
PING 10.0.2.15 (10.0.2.15) 56(84) bytes of data.
64 bytes from 10.0.2.15: icmp_seq=1 ttl=64 time=0.038 ms
64 bytes from 10.0.2.15: icmp_seq=2 ttl=64 time=0.059 ms

--- 10.0.2.15 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1024ms
rtt min/avg/max/mdev = 0.038/0.048/0.059/0.010 ms
```

ddd) traceroute

This command is used trace the route from source to destination. Here the maximum number of hops is set to 10 hops.

```
sonagutha@sonagutha-VirtualBox:~$ traceroute -m 10 10.0.2.15
traceroute to 10.0.2.15 (10.0.2.15), 10 hops max, 60 byte packets
 1  sonagutha-VirtualBox (10.0.2.15)  0.094 ms  0.007 ms  0.004 ms
```

eee) date

This command displays the current date and time in default format.

```
sonagutha@sonagutha-VirtualBox:~$ date
Tue Jan 23 12:32:37 AM CST 2024
```

fff) wget

This command is used to download files from the web.

```
sonagutha@sonagutha-VirtualBox:~$ wget https://blackboard.iit.edu/ultra/courses/_142972_1/cl/outline
--2024-01-23 00:37:30-- https://blackboard.iit.edu/ultra/courses/_142972_1/cl/outline
Resolving blackboard.iit.edu (blackboard.iit.edu)... 52.54.5.70, 54.158.218.55
Connecting to blackboard.iit.edu (blackboard.iit.edu)|52.54.5.70|:443... connected.
HTTP request sent, awaiting response... 302 Moved Temporarily
Location: /?new_loc=%2Fultra%2Fcourses%2F_142972_1%2Fcl%2Foutline [following]
--2024-01-23 00:37:31-- https://blackboard.iit.edu/?new_loc=%2Fultra%2Fcourses%2F_142972_1%2Fcl%2Foutline
Reusing existing connection to blackboard.iit.edu:443.
HTTP request sent, awaiting response... 302
Location: /auth-saml/saml/login?apId=_3409_1&redirectTo=https%3A%2F%2Fblackboard.iit.edu%2Fultra%2Fcourses%2F_142972_1%2Fcl%2Foutline [following]
--2024-01-23 00:37:31-- https://blackboard.iit.edu/auth-saml/saml/login?apId=_3409_1&redirectTo=https%3A%2F%2Fblackboard.iit.edu%2Fultra%2Fcourses%2F_142972_1%2Fcl%2Foutline
Reusing existing connection to blackboard.iit.edu:443.
HTTP request sent, awaiting response... 200
Length: 4376 (4.3K) [text/html]
Saving to: 'outline'

outline                                         100%[=====] 4.27K  ---KB/s   in 0s

2024-01-23 00:37:31 (1.49 GB/s) - 'outline' saved [4376/4376]
```

ggg) wc

This command is used to display the count of words, lines, characters, bytes in a file.

```
sonagutha@sonagutha-VirtualBox:~$ wc hello.txt
1 1 6 hello.txt
```

hhh) clear

This command is used to clear the terminal screen.

```
-x  do not attempt to clear the terminal's scrollback buffer using the extended "E3" capability.

HISTORY
A clear command appeared in 2.79BSD dated February 24, 1979.  Later that was provided in Unix 8th edition (1985).

AT&T adapted a different BSD program (tset) to make a new command (tput), and used this to replace the clear command with
a shell script which calls tput clear, e.g.,
/usr/bin/tput ${1:+-T$1} clear 2> /dev/null
exit

In 1989, when Keith Bostic revised the BSD tput command to make it similar to the AT&T tput, he added a shell script for
the clear command:
exec tput clear

sonagutha@sonagutha-VirtualBox:~$ clear
```

```
sonagutha@sonagutha-VirtualBox:~$
```

3) Write bash scripts to do the following

a) Write a script called “disk-benchmark-background.sh” that uses the dd command to run a benchmark against the local disk in the background, that captures all the output (both standard out and error output) to a file “disk-benchmark-background-log.txt”. Use the “time” command to show how long the benchmark took to complete. The benchmark should run for at least 10 seconds, and it should complete even if the ssh (or bash) session is terminated.

When **disk-benchmark-background.sh** is ran, the output is as below. The benchmark will run for at least 10 seconds and completes even if the session is terminated. Uploaded the script and generated log file on git.

```
sonagutha@sonagutha-VirtualBox:~/Desktop$ bash disk-benchmark-background.sh
date: extra operand '%s'
Try 'date --help' for more information.
nohup: ignoring input and appending output to 'nohup.out'
Background Benchmark is running
Benchmark ran for atleast 1706063961 seconds
```

b) Write a script called “network-test.sh” that takes input a file “network-test-machine-list.txt” with a list of DNS names (e.g. google.com, iit.edu, anl.gov), each name on a separate line, and runs the ping utility collecting 3 samples from each DNS name, and writing the RTT (round trip time) average latency into a file “network-test-latency.txt” where each line will have the DNS name and average RTT separated by a space. Make sure it works with at least 10 DNS names, but it should work for an unspecified number of DNS names.

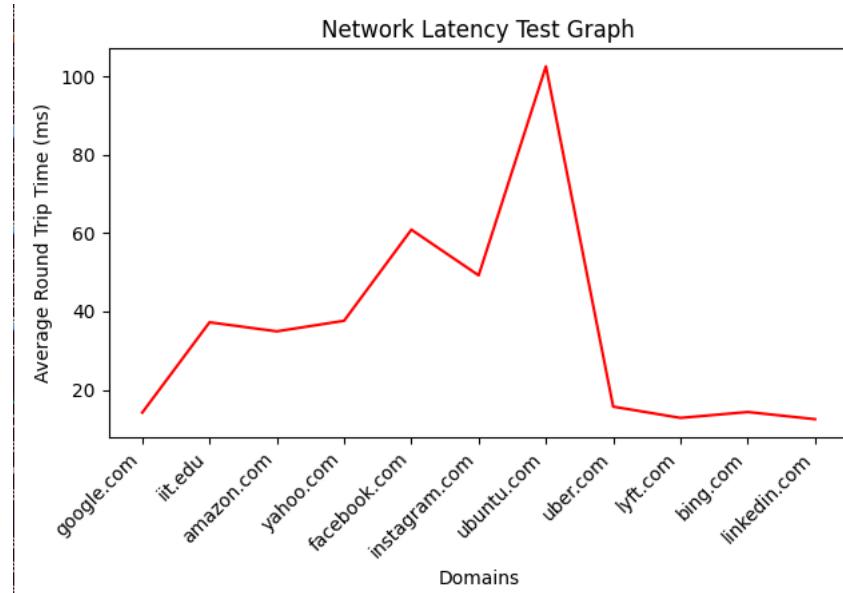
The input file consists of 11 domain names. When the network-test.sh is ran the average of 3 RTT is printed along with the domain name separated with a space in separated lines. Uploaded bash script, the input and output files to git.

```
sonagutha@sonagutha-VirtualBox:~/Desktop$ bash network-test.sh
google.com..
iit.edu..
amazon.com..
yahoo.com..
facebook.com..
instagram.com..
ubuntu.com..
uber.com..
lyft.com..
bing.com..
linkedin.com..
Completed. Please check network-test-latency.txt
```

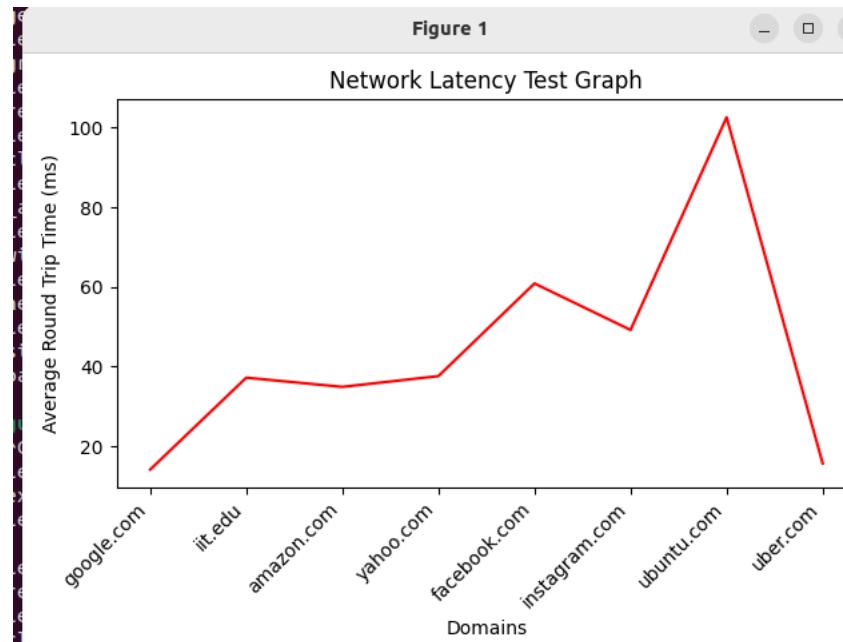
c) Write a Python matplotlib script to generate a graph of the “network-test-latency.txt” data. The graph should automatically adjust to the number of entries, and the scale of the data

Checked in networktestmatplotlibscript.py script which generated graph to git.

Below shows the graph generated based on the **network-test-latency.txt** data.



Removed 3 domain entries from the text, the graph automatically adjusted to the number of entries, and the scale of the data without any changes to the script.



4. Answer the following questions about VMs:

- a) In the system configuration of the VM, explain how changing the number of processors changes the behavior of your VM. Explain a scenario where you want to set this to the minimum, and a scenario where you want to set it to the maximum. Why is setting it to the maximum potentially a bad idea?**

The number of processors changes the virtual machine's behaviour and processing power.

The processors can be configured to minimum when the system has to perform simple tasks, optimized resource utilization and doesn't require extensive parallel processing. For instance, minimum number of processors can be configured in a scenario for development and testing processes to run applications where the workload is not heavily dependent on resources. It can also be used in a scenario to set light weigh servers which handle simple tasks, to run basic applications on web servers.

The processors can be configured to maximum when the system has to perform more tasks at a time, run resource intensive applications and to run multiple applications parallelly. It increases the performance of the virtual machine. For instance, maximum number of the processors can be configured in a scenario where system has to perform high level computations, processing large scales of data which reduces processing time and to host multiple virtual machines at a time.

However, setting the processors to the maximum is potentially a bad idea as it can impact the performance of the system negatively. It leads to resource contention if the number of physical CPU cores are not available on the host machine. It can increase the overhead which reduces the efficiency of the virtual machine. Not to mention, the higher licensing costs that occur to configure maximum processors without enhanced performance.

Setting up the number of processors should be done based on the requirements so there will not be any detrimental effect on efficiency and performance. There should not be any limitations on host machine in terms of physical CPU cores available to configure the specified number of processors.

- b) In the system configuration of the VM, under the Acceleration Tab, explain the difference between the paravirtualization options: None, Legacy, Minimal, Hyper-V, and KVM. Explain which one would be best to use with Ubuntu Linux, and why.**

Paravirtualization is a virtualization technique where the guest operating system is interacts with the hypervisor directly. In the system configuration of the VM, under the Acceleration Tab, the None, Legacy, Minimal, Hyper-V and KVM options are provided. These options optimize the communication between the guest OS and the hypervisor. The differences between each of these options are as below.

None: This option does not provide paravirtualization. The guest operating system and the hypervisor communication are not optimized and it the virtual machine runs in the emulation mode.

Legacy: This option provides traditional virtualization techniques and does not offer the modern day paravirtualization techniques for virtualization. This might not offer efficiency and same performance as the latest paravirtualization.

Minimal: As the name suggests, this option provides minimal/basic paravirtualization. It offers basic level of paravirtualization between guest operating system and hypervisor, offers improved performance and efficiency than legacy.

Hyper-V: This option provides the paravirtualization compatible to Microsoft Hyper-V hypervisor. When a VM is running on a Hyper-V host, this option can be chosen for the improved performance. It is specifically for the VMs running on the hyper v environment. This provides effective way for the guest operating system to communicate with Hyper-V hypervisor.

KVM: It is kernel- based virtual machine. This paravirtualization option takes the benefit from the virtualization support provided form the Linux kernel. The guest operating system is completely aware of the virtualization layer which provides optimized communication with the hypervisor. This provides better performance and efficient virtualization to Linux environments.

KVM (kernel- based virtual machine) is best suited paravirtualization option to use with Ubuntu Linux as the virtualization is built on the capabilities of the Linux kernel. It provides high performance, efficient use of the resources, compatibility, minimal overhead, native integration which makes KVM ideal for the Linux platforms.

c) In storage devices when configuring the VM, there are multiple types of storage controllers: explain the difference between the IDE, SATA, and NVMe controller. Give an example for each type of storage controller of a scenario where you may want to use this type of controller

The communication between the virtual machined and the storage devices id provided by the storage controllers. In storage devices when configuring a virtual machine (VM), there are multiple types of the storage controllers such as between IDE, SATA, and NVMe controllers. The differences between IDE, SATA, and NVMe controllers, along with the scenario is as below.

IDE Controller: It is Integrated Drive Electronics Controller. This controller provides the behaviour of the traditional/older IDE controllers in VM. This is used to connect hard disk drives, cd, DVD drives in physical environment and may not perform as efficient as latest controllers. It provides compatibility between legacy systems and operating system.

Ex: This controller can be used in the scenario when the running the virtual machines with older operating system which does not have any latest storage controllers, and also for lightweight servers which performs simple tasks with minimal requirement on resources.

SATA Controller: It is Serial ATA Controller. This is the modern controller that has widely replaces older IDE controller. This employee a serial interface to connect storage devices such as hardware disk drives and solid-state drives. It supports SSD unlike IDE controllers. It is much faster performance and efficient compared to IDE. It supports hot-swapping where a device can be replaced or added or removed even when the system is running.

Ex: This controller can be used in the scenarios such as general-purpose computing to perform everyday tasks such as editing and browsing. They can also be used be used for backup severs with ability to handle backup operations.

NVMe Controller: It is Non-Volatile Memory Express Controller. This is responsible for implementing NVMe protocol. This protocol operates over PCIe (Peripheral Component Interconnect Express) interface which provides low latency and high speed for the quicker data transfer between the NVMe storage devices and the CPU. This is the latest and the advanced controller from the 3 controllers

mentioned. It is specifically designed to optimize non-volatile device such as SSD and provide high speed and efficiency compared to SATA.

Ex: This controller can be used in the scenarios such as high performing computing environment with quick access to the storage, real time date processing applications such as trading. Also, can be used in database servers which will improve performance of database driven application.

d) In the network configuration of the VM, there are multiple types of network adapters: explain the difference between NAT, Bridged Adapter, Internal Network, and Host-only Network. Give an example for each type of network of a scenario where you may want to use this type of network

In the network configuration of the VM, there are multiple types of network adapters such as NAT, Bridged Adapter, Internal Network, and Host-only Network. The difference between each of these adapters and their example are as below.

NAT Adapter: NAT refers to Network Address Translation. This adapter allows the virtual machine to share the host IP address while utilizing its own internal range of IP addresses which provides the interactions between the external network and the VM.

Ex: This adapter can be used in scenario such as accessing internet without the need of using external unique IP address but only using single public IP address which is budget-friendly for businesses and also conserves public IP addresses.

Bridged Adapter: This adapter setting connects the virtual machine to a physical network directly allowing it to appear as the separate network on the device. It bridges the virtual machine to the local network. The VM interacts with other devices on the network similar to physical machine. The provide good performance in terms of network, allows efficient transfer of data.

Ex: This adapter can be used in scenario such as testing web application on a VM and its accessibility to other devices on the network. It allows VM to have its own identity which helps to interact directly with other devices on the network. It also allows VM to access shared files on the network.

Internal Network: This adapter settings allows virtual machines to communicate with each other on the same host but does not allow the virtual machines communication over external network. Similar to bridged network, the virtual machine can communicate directly with the physical network but is limited to other VMs on the same network. The higher level of isolation makes the internal network secure. It allows then resource sharing within the closed network.

Ex: This adapter can be used in scenario such as developing software in a development environment with multiple virtual machines. It allows users to interact with different modules on the internal network privately. It can be used in installing software's and other configuration in offices.

Host-only Network: This adapter settings allows the communication between the virtual machines and the host machines without exposure to the external network including the internet creating a closed network environment. It is essentially a private network VMs only communicate with each other and with the host machine. It allows resource sharing with in the closed network environment.

Ex: This adapter can be used in scenario such as developing and testing applications that requires the communication between the hosts and the virtual machines with in secure environments. This adapter is chosen when secure environment and isolation is crucial.

e) For the USB configuration of the VM, explain the difference between USB 1.1, 2.0, and 3.0 controllers.

For the USB configuration of the VM, the difference between USB 1.1, 2.0, and 3.0 controllers is as follows. These are the USB interfaces corresponding to different generations with different data transfer speeds.

USB 1.1 Controller: This is also known as full speed USB. It allows the maximum bandwidth of 12Mbps. It supports peripherals such as mouse, keyboards etc. This is ideal to connect with devices with lower bandwidths.

USB 2.0 Controller: This is also known as highspeed USB. This is an improvement over USB 1.1. It allows the maximum bandwidth of 480 Mbps. This is backward compatible with USB 1.1, due to USB 1.1 bandwidth limitation, USB 1.1 support is limited to bandwidth of 12 MBPS. It provides high data transfer rates. It is suitable for cameras, video adapters.

USB 3.0 Controller: This is also known as SuperSpeed USB. This is an improvement over USB 3.0. It allows the maximum bandwidth of 4.8 Gbps. This is backward compatible with USB 1.1 and USB 2.0. It supports full duplex communication and has increased data transfer rates compared to USB 2.0. It is suitable for high-performance peripherals such as external SSDs and high-resolution webcams.