

# CS554 - Homework #0 - FALL 21

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1

a.

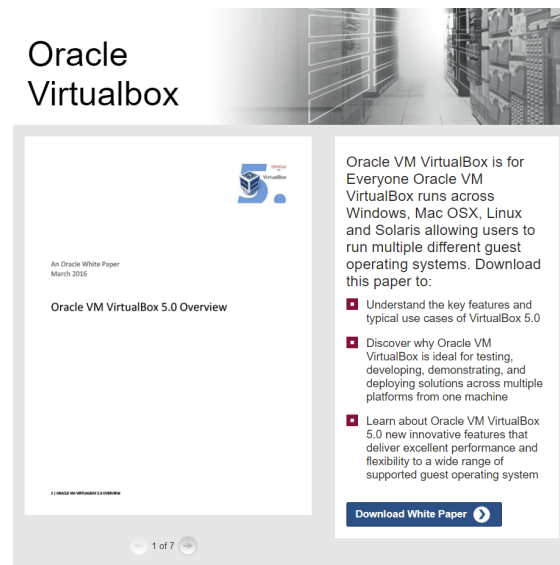


Figure 1: Oracle Virtual Box White paper

b. Downloading Oracle Virtualbox



Figure 2: Oracle Virtual Box V. 6.1.26 Download

d. Downloading Ubuntu Desktop 20.04.3 LTS Linux ISO image

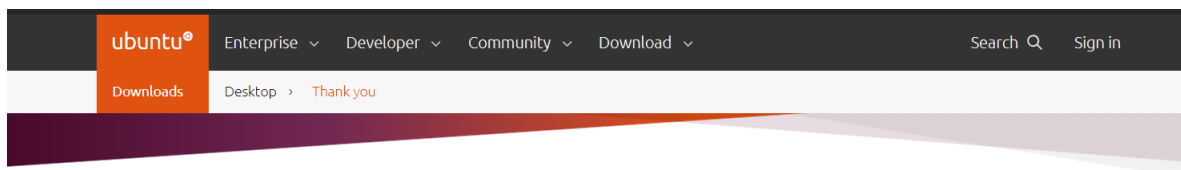


Figure 3: Ubuntu Desktop 20.04.3 LTS Linux ISO Download

c, e.

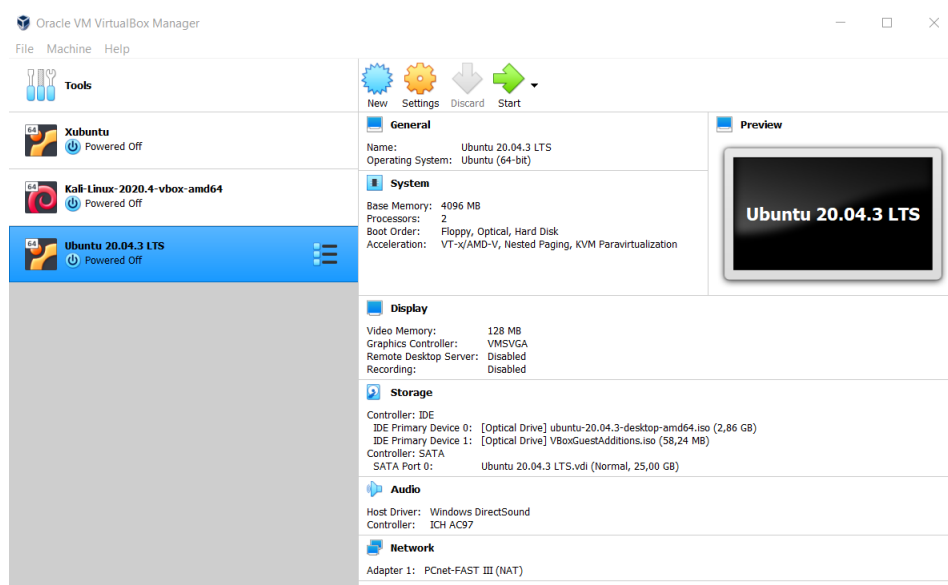


Figure 4: Ubuntu VM Created

f, g.

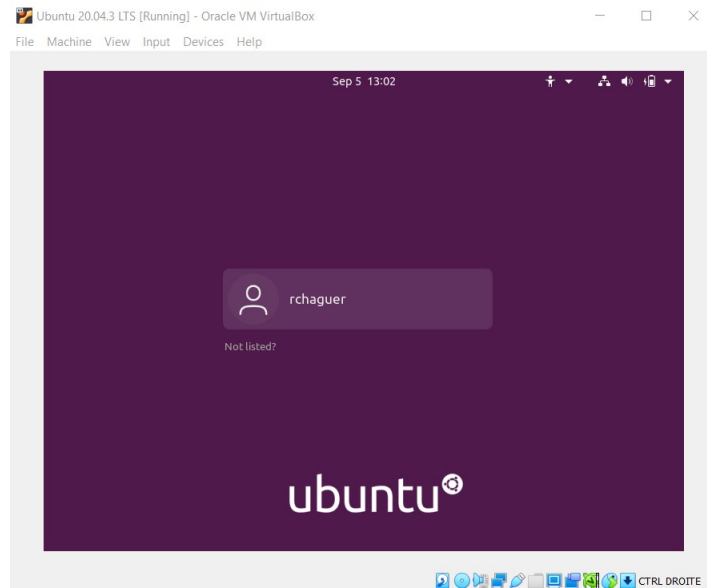


Figure 5: Linux installed from ISO image

h.

```
rchaguer@UbuntuVM: ~
rchaguer@UbuntuVM:~$ ls
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
rchaguer@UbuntuVM:~$ sudo ufw enable
[sudo] password for rchaguer:
Firewall is active and enabled on system startup
rchaguer@UbuntuVM:~$ sudo ufw status
Status: active
rchaguer@UbuntuVM:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), allow (outgoing), disabled (routed)
New profiles: skip
rchaguer@UbuntuVM:~$
```

Figure 6: Firewall enabled and All ports blocked

i.

```
rchaguer@UbuntuVM:~$ sudo systemctl enable --now ssh
Synchronizing state of ssh.service with SysV service script with /lib/systemd/s
ystemd-sysv-install.
Executing: /lib/systemd/systemd-sysv-install enable ssh
```

Figure 7: Enabling SSH access

```
rchaguer@UbuntuVM: ~  
rchaguer@UbuntuVM:~$ sudo ufw allow ssh  
Rule added  
Rule added (v6)  
rchaguer@UbuntuVM:~$ sudo ufw status verbose  
Status: active  
Logging: on (low)  
Default: deny (incoming), allow (outgoing), disabled (routed)  
New profiles: skip  
  
To Action From  
--  
22/tcp ALLOW IN Anywhere  
22/tcp (v6) ALLOW IN Anywhere (v6)  
  
rchaguer@UbuntuVM:~$  
rchaguer@UbuntuVM:~$
```

Figure 8: Opening SSH port in firewall

j.

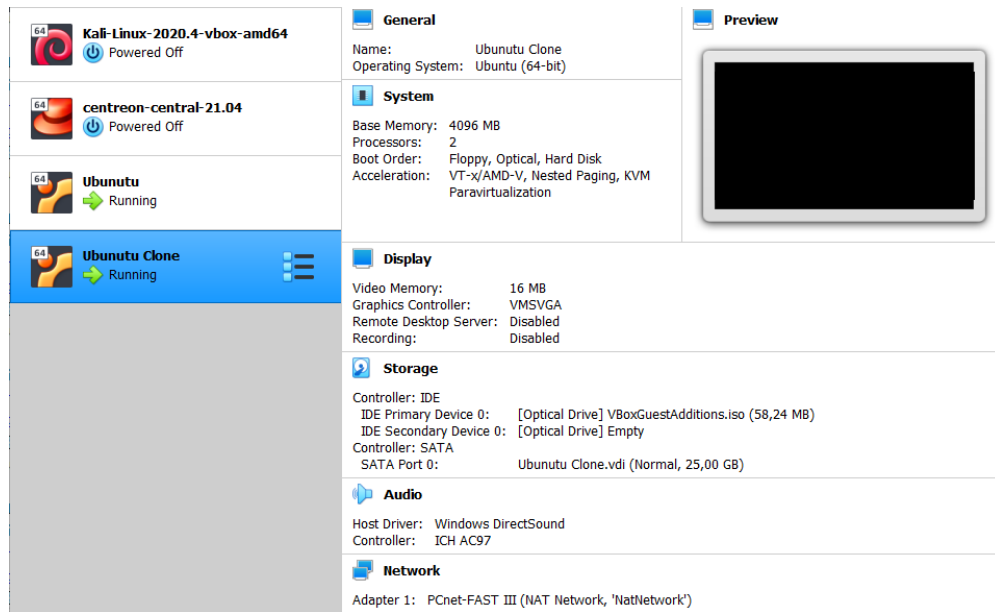


Figure 9: Creating another VM with same configuration and putting both of the VMs in the same NAT network

k.

```
ielomariaaoui@ielomariaaoui-VirtualBox: ~  
ielomariaaoui@ielomariaaoui-VirtualBox:~$ ssh-keygen  
Generating public/private rsa key pair.  
Enter file in which to save the key (/home/ielomariaaoui/.ssh/id_rsa):  
Enter passphrase (empty for no passphrase):  
Enter same passphrase again:  
Your identification has been saved in /home/ielomariaaoui/.ssh/id_rsa  
Your public key has been saved in /home/ielomariaaoui/.ssh/id_rsa.pub  
The key fingerprint is:  
SHA256:pFnwkrAaz1v/pfiW029SKTRF8feBSju5GHBWJiVGZmo ielomariaaoui@ielomariaaoui-VirtualBox  
The key's randomart image is:  
+---[RSA 3072]-----+  
| . . .B.+ .O. |  
| o += = o. |  
| . . oE+o . o .o|  
| = .*. . * + |  
| . o + S. * . . |  
| o . o + o |  
| . . .+.o |  
| o+oo . |  
| .o+. +. |  
+---[SHA256]-----+
```

Figure 10: Creating private/public keys

```
ielomariaaoui@ielomariaaoui-VirtualBox: ~  
ielomariaaoui@ielomariaaoui-VirtualBox:~$ ls ~/.ssh  
id_rsa id_rsa.pub  
ielomariaaoui@ielomariaaoui-VirtualBox:~$
```

Figure 11: Testing key generation

```
ielomariaaoui@ielomariaaoui-VirtualBox:~$ ssh-copy-id -i ~/.ssh/id_rsa.pub ielomariaaoui@10.0.2.4  
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/ielomariaaoui/.ssh/id_rsa.pub"  
The authenticity of host '10.0.2.4 (10.0.2.4)' can't be established.  
ECDSA key fingerprint is SHA256:8gwQpB32AqqwLz7TuTN0Tc9PD2L24RG3FHi7bziVC0c.  
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes  
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed  
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys  
ielomariaaoui@10.0.2.4's password:  
  
Number of key(s) added: 1  
  
Now try logging into the machine, with: "ssh 'ielomariaaoui@10.0.2.4'"  
and check to make sure that only the key(s) you wanted were added.
```

Figure 12: Copying public key from one VM to the other for both VMs

- 1.

```

telomartialaoui@telomartialaoui-VirtualBox:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UNKNOWN group default qlen 1000
    link/ether 08:00:27:9b:7d:cb brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.4/24 brd 10.0.2.255 scope global dynamic noprefixroute enp0s3
        valid_lft 506sec preferred_lft 506sec
    inet6 fe80::b92c:26c0:26f3:1c34/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
telomartialaoui@telomartialaoui-VirtualBox:~$ ssh telomartialaoui@10.0.2.15
Welcome to Ubuntu 20.04.3 LTS (GNU/Linux 5.11.0-27-generic x86_64)

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

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

Your Hardware Enablement Stack (HWE) is supported until April 2025.
Last login: Sun Sep  5 14:20:25 2021 from 10.0.2.4
telomartialaoui@telomartialaoui-VirtualBox:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UNKNOWN group default qlen 1000
    link/ether 08:00:27:76:b2:69 brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic noprefixroute enp0s3
        valid_lft 483sec preferred_lft 483sec
    inet6 fe80::7cbc:bd8c:3ce:882a/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
telomartialaoui@telomartialaoui-VirtualBox:~$ exit
logout
Connection to 10.0.2.15 closed.
telomartialaoui@telomartialaoui-VirtualBox:~$

```

Figure 13: Testing connection between VMs

## 2

- a : **ssh** : Connect two hosts through a secure encrypted connection.

```

telomartialaoui@telomartialaoui-VirtualBox:~$ ssh telomartialaoui@10.0.2.15
Welcome to Ubuntu 20.04.3 LTS (GNU/Linux 5.11.0-27-generic x86_64)

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

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

Your Hardware Enablement Stack (HWE) is supported until April 2025.
Last login: Sun Sep  5 14:21:03 2021 from 10.0.2.4
telomartialaoui@telomartialaoui-VirtualBox:~$

```

- b : **ssh-keygen** : Create a key pair for public key authentication.

```
ielomariaaoui@ielomariaaoui-VirtualBox: ~  
ielomariaaoui@ielomariaaoui-VirtualBox:~$ ssh-keygen  
Generating public/private rsa key pair.  
Enter file in which to save the key (/home/ielomariaaoui/.ssh/id_rsa):  
Enter passphrase (empty for no passphrase):  
Enter same passphrase again:  
Your identification has been saved in /home/ielomariaaoui/.ssh/id_rsa  
Your public key has been saved in /home/ielomariaaoui/.ssh/id_rsa.pub  
The key fingerprint is:  
SHA256:pFnwkrAaz1v/pfiW029SKTRF8feBSju5GHBWJiVGZmo ielomariaaoui@ielomariaaoui  
-VirtualBox  
The key's randomart image is:  
+---[RSA 3072]-----+  
| . . .B.+ .O. |  
| o += = o. |  
| . . oE+o . o .o|  
| = .*+ . * + |  
| . o + S. * . ..|  
| o . o + o |  
| . . .+.o |  
| o+oo . |  
| .o+. +. |  
+---[SHA256]-----+
```

- c : **scp** : Securely copy files and directories between two distant locations through ssh.  
A dummy file is created in "Ubuntu Clone" VM.

```
Ubuntu Clone [Running] - Oracle VM VirtualBox  
File Machine View Input Devices Help  
Activities Terminal  
ielomariaaoui@ielomariaaoui-VirtualBox:~$ cd Documents/  
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ touch dummyfile  
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ ls  
dummyfile  
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$
```

We copy this file securely with scp to "Ubuntu" VM.

```
Ubuntu [Running] - Oracle VM VirtualBox  
File Machine View Input Devices Help  
Activities Terminal Sep 5 15:10  
ielomariaaoui@ielomariaaoui-VirtualBox:~$ scp ielomariaaoui@10.0.2.4:~/Documents/dummyfile ./Downloads/  
dummyfile 100% 0 0.0KB/s 00:00  
ielomariaaoui@ielomariaaoui-VirtualBox:~$ ls Downloads/  
dummyfile  
ielomariaaoui@ielomariaaoui-VirtualBox:~$
```

- d : **history** : Show the history of the commands that executed in the shell.

```

telomariaaoui@telomariaaoui-VirtualBox:~$ history
1  ./autorun.sh
2  sudo apt install gcc perl make
3  sudo ./autorun.sh
4  restart -now
5  sudo ufw enable
6  sudo ufw status verbose
7  sudo apt update
8  sudo apt install openssh-server
9  sudo systemctl status ssh
10 sudo systemctl status ssh
11 sudo ufw allow ssh
12 ssh-keygen
13 ip config
14 ip addr
15 ipconfig
16 ifconfig
17 ip addr
18 ls
19 cat ~/.ssh/rsa_pub
20 cat ~/.ssh/id_rsa
21 ls ~/.ssh/
22 cat ~/.ssh/id_rsa.pub
23 clear
24 ls ~/.ssh
25 ip addrr
26 ip addr
27 service sshd status
28 ip addr
29 man ssh-keygen
30 ls
31 ls ~/.ssh
32 ssh-copy-id -i ~/.ssh/id_rsa.pub ielomariaaoui@10.0.2.4
33 ip addr
34 clear
35 ip addr
36 clear
37 scp ielomariaaoui@10.0.2.4:~/Documents/dummyfile ./Downloads/
38 ls Downloads/
39 history

```

- e : **sudo** : Execute a command as a Super Admin with superior privileges.

```

telomariaaoui@telomariaaoui-VirtualBox:~$ apt install hello-world
E: Could not open lock file /var/lib/dpkg/lock-frontent - open (13: Permission denied)
E: Unable to acquire the dpkg frontend lock (/var/lib/dpkg/lock-frontent), are you root?
telomariaaoui@telomariaaoui-VirtualBox:~$ sudo apt install hello-world
[sudo] password for ielomariaaoui: 

```

- f : **ip** : Manage and Configure the Network devices, interfaces and tunnels.

```

telomariaaoui@telomariaaoui-VirtualBox:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
   link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
   inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
   inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UNKNOWN group default qlen 1000
   link/ether 08:00:27:76:b2:69 brd ff:ff:ff:ff:ff:ff
   inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic noprefixroute enp0s3
       valid_lft 448sec preferred_lft 448sec
   inet6 fe80::7cbc:bd8c:3ce:882a/64 scope link noprefixroute
       valid_lft forever preferred_lft forever

```

- g : **dd** : Convert and Copy files.

In the following exmaple, 100 Mb of zeros were copied to the garbage can

```

telomariaaoui@telomariaaoui-VirtualBox:~$ dd if=/dev/zero of=/dev/null bs=100M count=1
1+0 records in
1+0 records out
104857600 bytes (105 MB, 100 MiB) copied, 0.527046 s, 199 MB/s
telomariaaoui@telomariaaoui-VirtualBox:~$ 

```

- h : **fdisk** : Manage Disks' partition tables.

Available partitions can be viewed using the command below.



```

i@lonartalaoui@lonartalaoui-VirtualBox:~$ sudo fdisk -l
[sudo] password for i@lonartalaoui:
Disk /dev/loop0: 216.96 MiB, 227471360 bytes, 444280 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: 99.35 MiB, 104169472 bytes, 203456 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: 55.45 MiB, 58130432 bytes, 113536 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/loop3: 219 MiB, 229638144 bytes, 448512 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/loop4: 65.1 MiB, 68259840 bytes, 133320 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/loop5: 50.98 MiB, 53432320 bytes, 104360 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/loop6: 32.3 MiB, 33865728 bytes, 66144 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

```

- i : **apt** : Install, Update, Remove and Manage deb packages on Ubuntu (Debian).

```

i@lonartalaoui@lonartalaoui-VirtualBox:~$ sudo apt install cmake
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  cmake-data libjsoncpp1 libhash0
Suggested packages:
  cmake-doc ninja-build
The following NEW packages will be installed:
  cmake cmake-data libjsoncpp1 libhash0
0 upgraded, 4 newly installed, 0 to remove and 21 not upgraded.
Need to get 5,470 kB of archives.
After this operation, 28.3 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu focal/main amd64 cmake-data all 3.16.3-1ubuntu1 [1,612 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libjsoncpp1 amd64 1.7.4-3.1ubuntu2 [75.6 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/main amd64 libhash0 amd64 1.3.9-1 [113 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal/main amd64 cmake amd64 3.16.3-1ubuntu1 [3,669 kB]
Fetched 5,470 kB in 3s (1,944 kB/s)
Selecting previously unselected package cmake-data.
(Reading database ... 152830 files and directories currently installed.)
Preparing to unpack .../cmake-data_3.16.3-1ubuntu1_all.deb ...
Unpacking cmake-data (3.16.3-1ubuntu1) ...
Selecting previously unselected package libjsoncpp1:amd64.
Preparing to unpack .../libjsoncpp1_1.7.4-3.1ubuntu2_amd64.deb ...
Unpacking libjsoncpp1:amd64 (1.7.4-3.1ubuntu2) ...
Selecting previously unselected package libhash0:amd64.
Preparing to unpack .../libhash0_1.3.9-1_amd64.deb ...
Unpacking libhash0:amd64 (1.3.9-1) ...
Selecting previously unselected package cmake.
Preparing to unpack .../cmake_3.16.3-1ubuntu1_amd64.deb ...
Unpacking cmake (3.16.3-1ubuntu1) ...
Setting up libhash0:amd64 (1.3.9-1) ...
Setting up cmake-data (3.16.3-1ubuntu1) ...
Setting up libjsoncpp1:amd64 (1.7.4-3.1ubuntu2) ...
Setting up cmake (3.16.3-1ubuntu1) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
i@lonartalaoui@lonartalaoui-VirtualBox:~$

```

- j : **vi** : Open VIM text editor.

```

VIM - Vi Improved

version 8.1.2269
by Bram Moolenaar et al.
Modified by team+vim@tracker.debian.org
Vim is open source and freely distributable

Help poor children in Uganda!
type :help iccf<Enter> for information

type :q<Enter> to exit
type :help<Enter> or <F1> for on-line help
type :help version8<Enter> for version info

0.0-1 All

```

- k : **time** : Determine the period of time a given command takes to run.

```
telomariaoui@telomariaoui-VirtualBox:~$ time ls
Desktop  Downloads  Music  Pictures  Public  snap  Templates  Videos

real    0m0.003s
user    0m0.003s
sys     0m0.000s
telomariaoui@telomariaoui-VirtualBox:~$
```

- l : **tar** : Compress, Decompress and Manage archives in Linux.

```
telomariaoui@telomariaoui-VirtualBox:~/Downloads$ tar -cvf dummyarchive.tar dummyfile
dummyfile
telomariaoui@telomariaoui-VirtualBox:~/Downloads$ ls
dummyarchive.tar  dummyfile
telomariaoui@telomariaoui-VirtualBox:~/Downloads$
```

- m : **cat** : Read, Concatenate and Write file contents and print on the standard output.

```
telomariaoui@telomariaoui-VirtualBox:~/Downloads$ echo "hello world" >> dummyfile
telomariaoui@telomariaoui-VirtualBox:~/Downloads$ cat dummyfile
hello world
telomariaoui@telomariaoui-VirtualBox:~/Downloads$
```

- n : **watch** : Run any command multiple times and displays the outputs and errors.

```
ielomariaoui@telomariaoui-VirtualBox: ~/Downloads
Every 2.0s: ls                               ielomariaoui-VirtualBox: Sun Sep  5 15:35:54 2021

dummyarchive.tar
dummyfile
```

- o : **ps** : Show the list of the current active processes

```
telomariaoui@telomariaoui-VirtualBox:~$ firefox &
[1] 4250
telomariaoui@telomariaoui-VirtualBox:~$ ps
  PID TTY          TIME CMD
 2198 pts/0    00:00:00 bash
 4250 pts/0    00:00:01 firefox
 4297 pts/0    00:00:00 ps
telomariaoui@telomariaoui-VirtualBox:~$
```

- p : **top** : Show in real-time the list with details of the running processes.

```
top - 15:37:45 up 1:23, 1 user, load average: 0.21, 0.11, 0.03
Tasks: 200 total, 1 running, 199 sleeping, 0 stopped, 0 zombie
%Cpu(s): 4.7 us, 10.0 sy, 0.0 ni, 84.7 id, 0.0 wa, 0.0 hi, 0.6 si, 0.0
MiB Mem : 3933.7 total, 1216.4 free, 1137.5 used, 1579.8 buff/cache
MiB Swap: 1162.4 total, 1162.4 free, 0.0 used, 2520.8 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+
1003	telomar+	20	0	883896	105896	62644	S	18.9	2.6	0:43.35
1288	telomar+	20	0	4274580	399620	134408	S	16.9	9.9	0:46.45
2187	telomar+	20	0	824108	51756	38692	S	3.0	1.3	0:11.07
1197	telomar+	20	0	163996	2824	2452	S	0.7	0.1	0:41.65
122	root	0	-20	0	0	0	I	0.3	0.0	0:01.61
1342	telomar+	20	0	162912	6592	5952	S	0.3	0.2	0:00.14
4224	root	20	0	0	0	0	I	0.3	0.0	0:00.10
1	root	20	0	102056	11400	8272	S	0.0	0.3	0:02.64
2	root	20	0	0	0	0	S	0.0	0.0	0:00.01
3	root	0	-20	0	0	0	I	0.0	0.0	0:00.00
4	root	0	-20	0	0	0	I	0.0	0.0	0:00.00
5	root	20	0	0	0	0	I	0.0	0.0	0:02.76
6	root	0	-20	0	0	0	I	0.0	0.0	0:00.00
8	root	0	-20	0	0	0	I	0.0	0.0	0:00.00

- q : **htop** : Interactive Process Viewer version of **top**. Visualize the information in colors and a more user-friendly way.

```

1  [|||] 2.7% Tasks: 120, 396 thr; 1 running
2  [|||] 3.4% Load average: 0.29 0.15 0.04
Mem[|||||||] 1.15G/3.84G Uptime: 01:24:50
Swp[|] 0K/1.14G

  PID USER      PRI  NI  VIRT   RES   SHR  S  CPU% MEM%   TIME+  Command
5126 telomaria  20   0 19348  3932  3252  R   0.7  0.1  0:00.06 htop
1   root       20   0   99M 11400  8272  S   0.0  0.3  0:02.64 /sbin/init s
232 root       19  -1 59916 29136 27548  S   0.0  0.7  0:00.85 /lib/systemd
252 root       20   0  2496   516   448  S   0.0  0.0  0:00.01 bpfilter_umh
263 root       20   0 24068  7544  4104  S   0.0  0.2  0:00.31 /lib/systemd
580 systemd-r  20   0 24032 13392  9316  S   0.0  0.3  0:00.28 /lib/systemd
589 systemd-t  20   0 90260  6208  5436  S   0.0  0.2  0:00.00 /lib/systemd
581 systemd-t  20   0 90260  6208  5436  S   0.0  0.2  0:00.11 /lib/systemd
634 root       20   0 244M  9300  8320  S   0.0  0.2  0:00.34 /usr/lib/acc
695 root       20   0 244M  9300  8320  S   0.0  0.2  0:00.00 /usr/lib/acc
620 root       20   0 244M  9300  8320  S   0.0  0.2  0:00.41 /usr/lib/acc
621 root       20   0  2548   776   712  S   0.0  0.0  0:00.33 /usr/sbin/ac
624 avahi       20   0  8532  3568  3240  S   0.0  0.1  0:00.15 avahi-daemon
F1?elp F2Setup F3Search F4Filter F5Free F6SortBy F7Vice F8Vice F9Kill F10?

```

- r : gcc : C and C++ Compiler

```

telomariaoui@telomariaoui-VirtualBox:~$ cd Documents/
telomariaoui@telomariaoui-VirtualBox:~/Documents$ ls
hello.c
telomariaoui@telomariaoui-VirtualBox:~/Documents$ gcc hello.c
telomariaoui@telomariaoui-VirtualBox:~/Documents$ ls
a.out hello.c
telomariaoui@telomariaoui-VirtualBox:~/Documents$ ./a.out
Hello, World!telomariaoui@telomariaoui-VirtualBox:~/Documents$

```

- s : tail : Display the last lines of file.

```

telomariaoui@telomariaoui-VirtualBox:~/Documents$ tail -n 3 hello.c
printf("Hello, World!");
return 0;
}telomariaoui@telomariaoui-VirtualBox:~/Documents$

```

- t : grep : Search for patterns in files.

```

telomariaoui@telomariaoui-VirtualBox:~/Documents$ cat hello.c | grep -i "
hello"
printf("Hello, World!");
telomariaoui@telomariaoui-VirtualBox:~/Documents$

```

- u : kill : Send different types of Signals to processes using PID.

```

telomariaoui@telomariaoui-VirtualBox:~/Documents$ ps
  PID TTY          TIME CMD
 2198 pts/0    00:00:00 bash
 4250 pts/0    00:00:11 firefox
 4322 pts/0    00:00:08 Web Content
 4361 pts/0    00:00:01 WebExtensions
 4416 pts/0    00:00:00 Web Content
 5211 pts/0    00:00:00 vi
 5834 pts/0    00:00:00 ps
telomariaoui@telomariaoui-VirtualBox:~/Documents$ kill -KILL 5211
telomariaoui@telomariaoui-VirtualBox:~/Documents$ ps
  PID TTY          TIME CMD
 2198 pts/0    00:00:00 bash
 4250 pts/0    00:00:11 firefox
 4322 pts/0    00:00:08 Web Content
 4361 pts/0    00:00:01 WebExtensions
 4416 pts/0    00:00:00 Web Content
 5835 pts/0    00:00:00 ps
[2]+  Killed                  vi hello.c
telomariaoui@telomariaoui-VirtualBox:~/Documents$

```

- v : killall : Same as kill, but using process names.

```

telomariaaoui@telomariaaoui-VirtualBox:~/Documents$ vi
[1]+  Stopped                  vi
telomariaaoui@telomariaaoui-VirtualBox:~/Documents$ ps
  PID TTY          TIME CMD
 2198 pts/0    00:00:00 bash
 6325 pts/0    00:00:00 vi
 6326 pts/0    00:00:00 ps
telomariaaoui@telomariaaoui-VirtualBox:~/Documents$ killall -s 9 vi
[1]+  Killed                  vi
telomariaaoui@telomariaaoui-VirtualBox:~/Documents$ ps
  PID TTY          TIME CMD
 2198 pts/0    00:00:00 bash
 6329 pts/0    00:00:00 ps
telomariaaoui@telomariaaoui-VirtualBox:~/Documents$

```

- w : **du** : Display the disk usage of a given file or directory in bytes.

```

telomariaaoui@telomariaaoui-VirtualBox:~/Documents$ ls
a.out  hello.c
telomariaaoui@telomariaaoui-VirtualBox:~/Documents$ du a.out
20     a.out
telomariaaoui@telomariaaoui-VirtualBox:~/Documents$

```

- x : **df** : Get a detailed report on the system's disk space usage.

```

telomariaaoui@telomariaaoui-VirtualBox:~/Documents$ df
Filesystem      1K-blocks    Used Available Use% Mounted on
udev            1984428      0   1984428   0% /dev
tmpfs           402812      1412    401400   1% /run
/dev/sda5       25152772  7901472  15950564  34% /
tmpfs           2014044    20392   1993652   2% /dev/shm
tmpfs           5120        4      5116     1% /run/lock
tmpfs           2014044      0   2014044   0% /sys/fs/cgroup
/dev/loop0      222208     222208    0 100% /snap/code/73
/dev/loop2      56832     56832    0 100% /snap/core18/2128
/dev/loop3      224256     224256    0 100% /snap/gnome-3-34-1804/72
/dev/loop1      101760     101760    0 100% /snap/core/11606
/dev/loop4      66688     66688    0 100% /snap/gtk-common-themes/1515
/dev/loop5      52224     52224    0 100% /snap/snap-store/547
/dev/loop6      33152     33152    0 100% /snap/snapd/12704
/dev/sda1       523248      4    523244   1% /boot/efi
tmpfs           402808      40    402768   1% /run/user/1000
/dev/sr0        59642     59642    0 100% /media/telomariaaoui/VBox_GA
s_6.1.26
telomariaaoui@telomariaaoui-VirtualBox:~/Documents$

```

- y : **screen** : Launch and Use multiple shell sessions from a single ssh session.

```

GNU Screen version 4.08.00 (GNU) 05-Feb-20

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version.

This program is distributed in the hope that it will be useful, but WITHOUT

[Press Space for next page; Return to end.]

```

- z : **vim** : Launch the VIM text editor.

[illegible]

- aa : **chmod** : Change a file or directory rights (Read, Write, Execute).

```
telomartialaoui@telomartialaoui-VirtualBox:~/Documents$ ls -al hello.c
-rw-rw-r-- 1 telomartialaoui telomartialaoui 126 Sep 5 15:42 hello.c
telomartialaoui@telomartialaoui-VirtualBox:~/Documents$ chmod +x hello.c
telomartialaoui@telomartialaoui-VirtualBox:~/Documents$ ls -al hello.c
-rwxrwxr-x 1 telomartialaoui telomartialaoui 126 Sep 5 15:42 hello.c
telomartialaoui@telomartialaoui-VirtualBox:~/Documents$
```

- **bb : chown** : Change the User or Group ownership of a given file.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ ls -al hello.c
-rwxrwxr-x 1 telomarlalaoui telomarlalaoui 126 Sep 5 15:42 hello.c
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ sudo chown root hello.c
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ ls -al hello.c
-rwxrwxr-x 1 root telomarlalaoui 126 Sep 5 15:42 hello.c
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- **cc : useradd** : Create and Configure new users.

```
ielomari@ielomari-VirtualBox:~$ sudo useradd dummyuser
ielomari@ielomari-VirtualBox:~$
```

- **dd** : **man** : Provide the reference manual for commands.

```

LS(1)                                User Commands                                LS(1)
NAME
    ls - list directory contents

SYNOPSIS
    ls [OPTION]... [FILE]...

DESCRIPTION
    List information about the FILES (the current directory by default).
    Sort entries alphabetically if none of -cftuvSUX nor --sort is
    specified.

    Mandatory arguments to long options are mandatory for short options
    too.

    -a, --all
        do not ignore entries starting with .

    -A, --almost-all
        do not ignore entries starting with .

Manual page ls(1) line 1 (press h for help or q to quit)

```

- **ee : locate** : Locate a file by the name.

```
telomaria@telomaria-VirtualBox:~$ locate hello.c
/home/telomaria/Documents/hello.c
/snap/gnome-3-34-1804/72/usr/lib/peas-demo/plugins/pythonhello/__pycache__/pythonhello.cpython-36.opt-1.pyc
/snap/gnome-3-34-1804/72/usr/lib/peas-demo/plugins/pythonhello/__pycache__/pythonhello.cpython-36.pyc
```

- **ff : find** : Search for a file recursively in a given directory.

```
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ mkdir dummydirectory
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ mv hello.c dummydirectory/
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ cd ..
ielomariaaoui@ielomariaaoui-VirtualBox:~$ find Documents/ -name hello.c
Documents/dummydirectory/hello.c
ielomariaaoui@ielomariaaoui-VirtualBox:~$
```

- **gg : sed** : (Stream Editor) Perform basic text manipulation on files.

```
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ cat dummyfile
Hello friend!
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ sed "s/Hello/Bye/" dummyfile
Bye friend!
```

- **hh : awk** : Process textual data files and text patterns.

```
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ ls -al
total 16
drwxr-xr-x  3 ielomariaaoui ielomariaaoui 4096 Sep  5 16:13 .
drwxr-xr-x 19 ielomariaaoui ielomariaaoui 4096 Sep  5 16:03 ..
drwxrwxr-x  2 ielomariaaoui ielomariaaoui 4096 Sep  5 16:11 dummydirectory
-rw-rw-r--  1 ielomariaaoui ielomariaaoui  14 Sep  5 16:14 dummyfile
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ ls -al | grep -v total
| awk '{print $3, $9}'
ielomariaaoui .
ielomariaaoui ..
ielomariaaoui dummydirectory
ielomariaaoui dummyfile
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$
```

- **ii : diff** : Compare between different files lines.

```
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ cp dummyfile ./dummyfile2
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ ls
dummydirectory dummyfile dummyfile2
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ diff dummyfile dummyfile2
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ echo "++" >> dummyfile2
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ diff dummyfile dummyfile2
e2
1a2
> ++
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$
```

- **jj : sort** : Sort the lines of files.

```
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ echo -e "b\nd\na\nc" > dummyfile
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ cat dummyfile
b
d
a
c
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ sort dummyfile
a
b
c
d
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$
```

- **kk : export** : Export environment variables to child processes.

```
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$ export -p | head -5
declare -x COLORTERM="truecolor"
declare -x DBUS_SESSION_BUS_ADDRESS="unix:path=/run/user/1000/bus"
declare -x DESKTOP_SESSION="ubuntu"
declare -x DISPLAY=":0"
declare -x GDMSESSION="ubuntu"
ielomariaaoui@ielomariaaoui-VirtualBox:~/Documents$
```

- ll : **pwd** : Print current working directory.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ pwd
/home/telomarlalaoui/Documents
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- mm : **crontab** : Display, Edit and Remove scheduled cron jobs.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ crontab -l
no crontab for telomarlalaoui
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- nn : **mount** : Mount the file system found on a device to the Linux system.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ mount -l | head -5
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
udev on /dev type devtmpfs (rw,nosuid,noexec,relatime,size=1984428k,nr_inodes=496107,mode=755,inode64)
devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)
tmpfs on /run type tmpfs (rw,nosuid,nodev,noexec,relatime,size=402812k,mode=755,inode64)
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- oo : **passwd** : Change User password.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ sudo passwd -Sa | head -5
root L 09/05/2021 0 99999 7 -1
daemon L 08/19/2021 0 99999 7 -1
bin L 08/19/2021 0 99999 7 -1
sys L 08/19/2021 0 99999 7 -1
sync L 08/19/2021 0 99999 7 -1
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- pp : **uname** : Display System Information.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ uname -a
Linux telomarlalaoui-VirtualBox 5.11.0-27-generic #29~20.04.1-Ubuntu SMP Wed Aug 11 15:58:17 UTC 2021 x86_64 x86_64 x86_64 GNU/Linux
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- qq : **whereis** : Locate execution files of a given command.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ whereis gcc
gcc: /usr/bin/gcc /usr/lib/gcc /usr/share/gcc /usr/share/man/man1/gcc.1.gz
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- rr : **whatis** : Display a one-line manual page description of a given command.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$ whatis gcc
gcc (1) - GNU project C and C++ compiler
telomarlalaoui@telomarlalaoui-VirtualBox:~/Documents$
```

- ss : **su** : Run commands with another user's privileges.

```
telomarlalaoui@telomarlalaoui-VirtualBox:~$ su -l dummyuser
Password:
su: warning: cannot change directory to /home/dummyuser: No such file or directory
$ exit
telomarlalaoui@telomarlalaoui-VirtualBox:~$ su -p dummyuser
Password:
dummyuser@telomarlalaoui-VirtualBox:~$
```

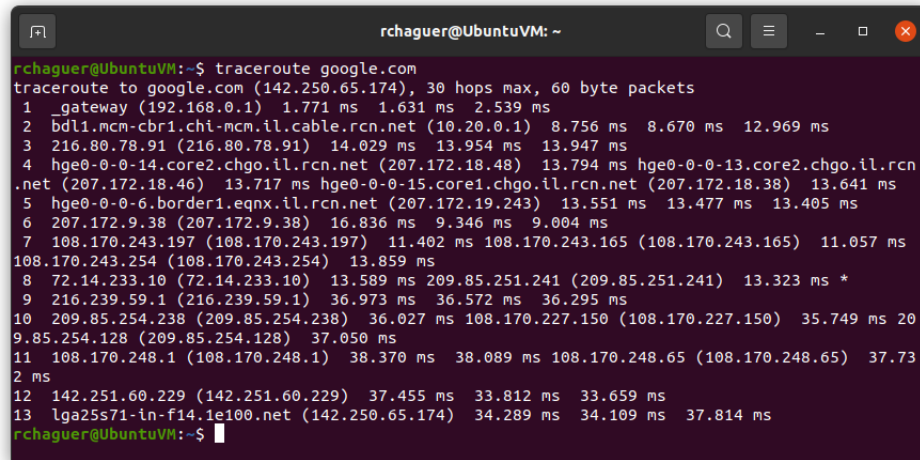
- tt : **ping** : Check whether a network is available and if a host is reachable by sending packages.

```

telomariaoui@telomariaoui-VirtualBox:~$ ping 10.0.2.4
PING 10.0.2.4 (10.0.2.4) 56(84) bytes of data:
64 bytes from 10.0.2.4: icmp_seq=1 ttl=64 time=1.12 ms
64 bytes from 10.0.2.4: icmp_seq=2 ttl=64 time=3.34 ms
64 bytes from 10.0.2.4: icmp_seq=3 ttl=64 time=4.16 ms
64 bytes from 10.0.2.4: icmp_seq=4 ttl=64 time=3.50 ms
64 bytes from 10.0.2.4: icmp_seq=5 ttl=64 time=1.07 ms
64 bytes from 10.0.2.4: icmp_seq=6 ttl=64 time=3.88 ms
64 bytes from 10.0.2.4: icmp_seq=7 ttl=64 time=0.960 ms
^C
--- 10.0.2.4 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6012ms
rtt min/avg/max/mdev = 0.960/2.573/4.159/1.345 ms
telomariaoui@telomariaoui-VirtualBox:~$

```

- uu : **traceroute** : Display the route of packets from your computer on their way to a given host.

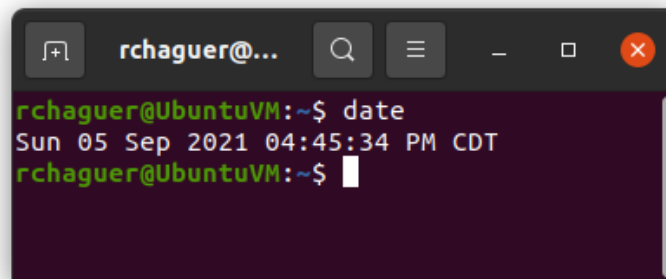


```

rchaguer@UbuntuVM: ~
rchaguer@UbuntuVM:~$ traceroute google.com
traceroute to google.com (142.250.65.174), 30 hops max, 60 byte packets
 1 _gateway (192.168.0.1)  1.771 ms  1.631 ms  2.539 ms
 2 bdl1.mcm-cbr1.chi-mcm.il.cable.rcn.net (10.20.0.1)  8.756 ms  8.670 ms  12.969 ms
 3 216.80.78.91 (216.80.78.91)  14.029 ms  13.954 ms  13.947 ms
 4 hge0-0-0-14.core2.chgo.il.rcn.net (207.172.18.48)  13.794 ms hge0-0-0-13.core2.chgo.il.rcn
.net (207.172.18.46)  13.717 ms hge0-0-0-15.core1.chgo.il.rcn.net (207.172.18.38)  13.641 ms
 5 hge0-0-0-6.border1.eqnx.il.rcn.net (207.172.19.243)  13.551 ms  13.477 ms  13.405 ms
 6 207.172.9.38 (207.172.9.38)  16.836 ms  9.346 ms  9.004 ms
 7 108.170.243.197 (108.170.243.197)  11.402 ms 108.170.243.165 (108.170.243.165)  11.057 ms
108.170.243.254 (108.170.243.254)  13.859 ms
 8 72.14.233.10 (72.14.233.10)  13.589 ms 209.85.251.241 (209.85.251.241)  13.323 ms *
 9 216.239.59.1 (216.239.59.1)  36.973 ms  36.572 ms  36.295 ms
10 209.85.254.238 (209.85.254.238)  36.027 ms 108.170.227.150 (108.170.227.150)  35.749 ms 20
9.85.254.128 (209.85.254.128)  37.050 ms
11 108.170.248.1 (108.170.248.1)  38.370 ms  38.089 ms 108.170.248.65 (108.170.248.65)  37.73
2 ms
12 142.251.60.229 (142.251.60.229)  37.455 ms  33.812 ms  33.659 ms
13 lga25s71-in-f14.1e100.net (142.250.65.174)  34.289 ms  34.109 ms  37.814 ms
rchaguer@UbuntuVM:~$

```

- vv : **date** : Display the system date and time.

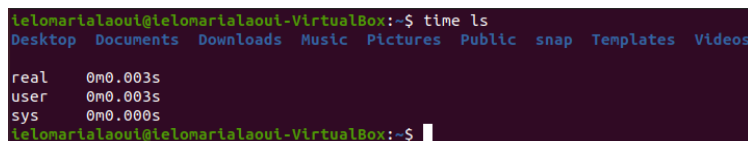


```

rchaguer@UbuntuVM:~$ date
Sun 05 Sep 2021 04:45:34 PM CDT
rchaguer@UbuntuVM:~$

```

- ww : **time** : Determine the period of time a given command takes to run.



```

telomariaoui@telomariaoui-VirtualBox:~$ time ls
Desktop  Documents  Downloads  Music  Pictures  Public  snap  Templates  Videos
real    0m0.003s
user    0m0.003s
sys     0m0.000s
telomariaoui@telomariaoui-VirtualBox:~$

```

- xx : **wget** : Download files using HTTP, HTTPS, and FTP protocols.



```
rchaguer@UbuntuVM: ~  
rchaguer@UbuntuVM:~$ wget https://s28.q4cdn.com/301451537/files/doc_downloads/test.pdf  
--2021-09-05 16:42:23-- https://s28.q4cdn.com/301451537/files/doc_downloads/test.pdf  
Resolving s28.q4cdn.com (s28.q4cdn.com)... 68.70.205.4, 68.70.205.2, 68.70.205.3, ...  
Connecting to s28.q4cdn.com (s28.q4cdn.com)[68.70.205.4]:443... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 3908 (3.8K) [application/pdf]  
Saving to: 'test.pdf'  
  
test.pdf          100%[=====] 3.82K  --.-KB/s  in 0s  
  
2021-09-05 16:42:23 (2.12 GB/s) - 'test.pdf' saved [3908/3908]  
rchaguer@UbuntuVM:~$
```

- **yy : wc** : Get the newline count, word count and byte count from a given file.

```
rchaguer@UbuntuVM: ~  
rchaguer@UbuntuVM:~$ wc /tmp/dumpfile.txt  
9 12 69 /tmp/dumpfile.txt  
rchaguer@UbuntuVM:~$
```

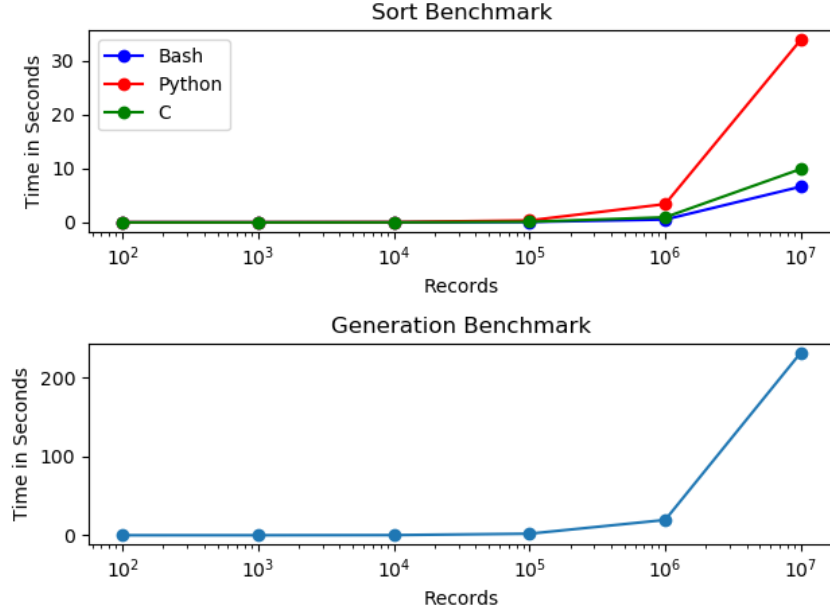
- **zz : pwgen** : Generate passwords which are easily memorized by humans.

```
rchaguer@UbuntuVM:~$ pwgen  
ixai80hv aim80obv vee4mo7M vaiP2pha eing5Amo iG3ohgh8 quex0Equ ohSei2li  
Jee4uyah aetu90Be Xah5lohm vao5EiNe fei5eiNg pool8aer soiLohf6 RotaiNg4  
Eiwaesh3 ailahRe9 vueL10oc lohr3Ice aeloh80i Naakoh4I eiV0Pu7x She9Eup3  
ooX2tee1 gaeco7Te reik6euc ohL6reeB fiemu40o veeT3iow ISohf7ci aiJee5ea  
Mee9Tooj Xu8oe6wa Suuji0bu iey0Phe5 OhNgoov7 gieNg8sh Shahbu1w vi2wai8D  
thae7ohW vai9toXe Laim9E15 oozeu3Qu johV5tee Ohzie4ie NiwiK1Ph wae80ogh  
iKi2dies ahf2eiTh beiyoo9N Tei3eish xahPh2Ie quai9ahH la5shaWa tu6Lahth  
Euiz2iek OoCh0equ aex5Laih eite9Foo Bu8aoc8t fishoo00 Eip5ohel nairu1Ah  
uongle40 aejo75up baeZiph6 Eethoo0o ohch9toM oekShieC Zie16Kou waiL8ahl  
aL5shaid Oo4iola4 eri0taev Jool9coo Koos6ixa Heix4our tah9Noos Eej6yeng  
ohy2Uuro joiTh8ba ieSh3Cha equei30h ooV4eena oYai0gie yil30oTh mu1Ca0gu  
Uf5soh9r pi20omoh OoBee9jo jaeQui0 mley6Shu am6Eiyow Lei6oosh vit0Xo3B  
Haimoh30 Kaengup6 teeyu3Ee miPhii9x ki9aeQui Eit1yuu6 hejohJ5E heis4iR  
ohb6Ree1 ohkuz80h iSohFu6a iegu9uX3 uo0Cha8h aeVaPh6i IVahv7gu at1Hi7oe  
zu5Iedec Ce2Ahzei Uvei5chu liJah9ki ozi1EZoo aeGaK9ah Wei9XieR aiTai8Ph  
Zahxie4a yei4Gejo quoh3Thi quiB2wu2 neetaeP4 aem0aeZ0 OghieY9u Woo5phah  
Wleng3oh jaaTh2gu eth5Ahp7 EYaos1un xa1Eeghu Aig0ohj2 Tukoh4ai boK4opei  
azoi0Goi aipheeY5 roh1Choo ohGh0eiz shok9aci Dee0Iegh boh4Fee4 Bahsh3Uo  
euGh2vai aiJ8elph EiHaioSh eePh8zim lahsat2U ahfiet6N AeZie1ne ohqu2oQu  
yeiPah4A eiluuc9F yeQuiEC8 eel3obat Hair9ahx iB2cieji ui6eiWee vai0oti  
rchaguer@UbuntuVM:~$
```

### 3

All the required scripts are present in the source folder of our project.

- a. *generate-dataset.sh*
- b. *sort-data.sh*
- c. *sort-data.c*
- d. *sort-data.py*
- e. *generate-graph.py*



## 4

### a. Number of Processor Configuration

The decision to increase or decrease number of processors available to a VM's use must be taken after knowing the purpose of the VM. If the user will use the guest operating system to do casual work, 1 to 2 processors are more than enough. On the contrary, if the VM will be used to do computation, gaming, simulation and complex applications, adding processors is recommended and can be even compulsory for a fully functional guest OS.

In general, using all of the processors for a VM is really a bad idea as this consumes all of the host machine's computing power and would definitely cause bad performance. But, there is some scenarios where we want to bypass the host machine completely, the following link is a youtube video where we try to operate seven VMs with 2 CPUs and 7 GPUs: <https://www.youtube.com/watch?v=LX0aCkbt41I>. The title of the video is "7 Gamers and 1 CPU" as these VMs will be used for gaming, the number of processors available for each VM's use is maximised.

### b. Paravirtualization Configuration

In Oracle's paravirtualization providers documentation, the paravirtualization options are defined as follows:

- **None:** Specifying none explicitly turns off exposing any paravirtualization interface.
- **Legacy:** The legacy option is chosen for VMs which were created with older VirtualBox versions and will pick a paravirtualization interface while starting the VM with VirtualBox 5.0 and newer.
- **Minimal:** Announces the presence of a virtualized environment. Additionally, reports the TSC and APIC frequency to the guest operating system. This provider is mandatory for running any Mac OS X guests.
- **Hyper-V:** Presents a Microsoft Hyper-V hypervisor interface which is recognized by Windows 7 and newer operating systems. Oracle VM VirtualBox's implementation currently supports paravirtualized clocks, APIC frequency reporting, guest debugging, guest crash reporting and relaxed timer checks. This provider is recommended for Windows guests.

- **KVM:** Presents a Linux KVM hypervisor interface which is recognized by Linux kernels starting with version 2.6.25. VirtualBox's implementation currently supports paravirtualized clocks and SMP spinlocks. ***This provider is recommended for Linux guests.***

#### c. Storage Control Configuration

- **IDE:** Integrated Drive Electronics is a standard way for a storage device to connect to a computer. *Example use case:* IDE has maximum compatibility but lacks transfer speed firstly and support for new technology such as native command queuing and hot-plugging hard drives.
- **SATA:** Serial Advanced Technology Attachment is the new standard for connecting and transferring data components inside of your computer. It is a bus interface that connects host bus adapters to mass storage devices. If a virtual machine has multiple hard disks or CD/DVD-ROM devices, you can add up to three additional SATA controllers to assign the devices to. When you spread the devices among several controllers, you can improve performance and avoid data traffic congestion. *Example use case:* SATA is a great technology to have in your computer when storing information that you don't need to use on a regular basis, because it works at a slower pace when it transfers data out of the storage drive.
- **NVMe:** Non-Volatile Memory express is a new storage access and transport protocol for flash and next-generation solid-state drives (SSDs) that delivers the highest throughput and fastest response times yet for all types of enterprise workloads. Using an NVMe controller in a VM significantly reduces the software overhead for processing guest OS I/O, as compared to AHCI SATA or SCSI controllers. *Example use case:* NVMe storage is already being used in business scenarios where every microsecond counts such as AI, ML, big data, e-commerce or even devops enabling you to run more iterations in less time.

#### d. Network Configuration

- **NAT:** With NAT, a virtual machine does not have its own IP address on the external network. Instead, a separate private network is set up on the host system. In the default configuration, a virtual machine gets an address on this private network from the virtual DHCP server. The virtual machine and the host system share a single network identity that is not visible on the external network.
- **Bridged Adapter:** Bridged networking connects a virtual machine to a network by using the network adapter on the host system. If the host system is on a network, bridged networking is often the easiest way to give the virtual machine access to that network.
- **Internal Network:** This can be used to create a different kind of software-based network which is visible to selected virtual machines, but not to applications running on the host or to the outside world.
- **Host-only Network:** Host-only networking creates a network that is completely contained within the host computer. Host-only networking provides a network connection between the virtual machine and the host system by using a virtual network adapter that is visible on the host operating system.

#### e. USB Configuration

- **USB 1.1** operates at a maximum transfer bandwidth of 12Mb/s. This type of USB connection is sufficient to connect devices that require little bandwidth, such as a keyboard, mouse, printer, etc.
- **USB 2.0** operates at a maximum transfer bandwidth of 480Mb/s called *high speed* and uses only 4 pins. The connector is often black in color.
- **USB 3.0** operates at a maximum transfer bandwidth of 5Gb/s called *super speed* and it uses a blue connector with more pins, to differentiate it from **USB 2.0**.