

Part 1-

- **Step a**

Oracle VirtualBox White Paper pdf was received after filling in my information. Please see a link:

[http://www.oracle.com/us/technologies/virtualization/oracle-vm-virtualbox-overview-2981353.pdf
?elq_mid=53772&sh=&cmid=WWMK160606P00147C0001](http://www.oracle.com/us/technologies/virtualization/oracle-vm-virtualbox-overview-2981353.pdf?elq_mid=53772&sh=&cmid=WWMK160606P00147C0001)

- **Steps b - f**

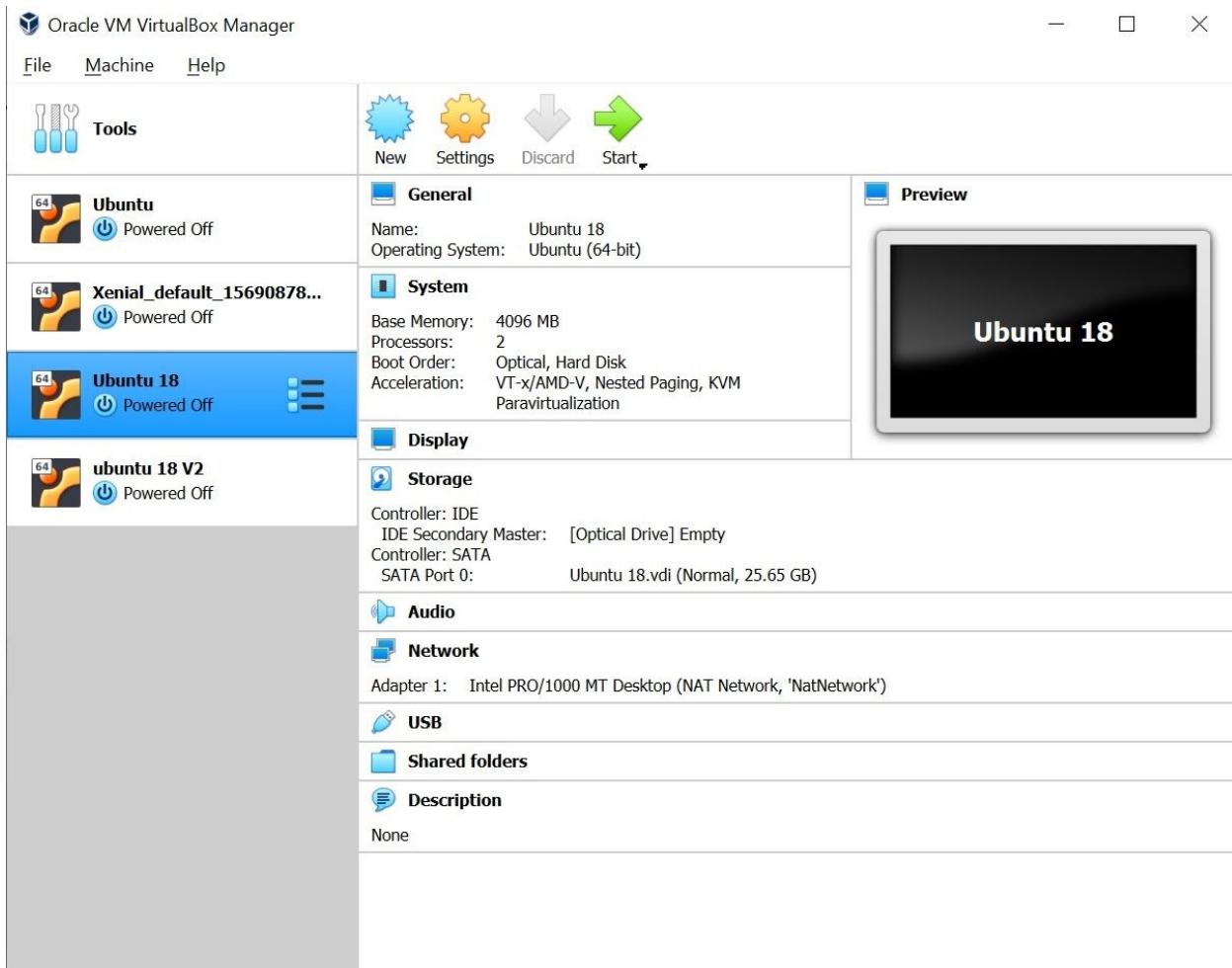
Technical spec brief summary for both VM's:

	VM 1	VM 2
VM	Virtual Box 6.1.2	Virtual Box 6.1.2
Ubuntu desktop version	18.04.3 LTS Linux	18.04.3 LTS Linux
Username	allie	allieb
RAM	4096MB	4096MB
Virtual disk	25.65GB	25.65GB
Cores	2	2
Network interface	NAT Network	NAT Network
IP number	10.0.2.15	10.0.2.4

Virtual box version, as specified in the assignment requirements:

Both VMs have identical technical configurations, as specified in step e.

Below VM1 technical spec overview:



About

- Date & Time
- Users
- Default Applications


Ubuntu 18.04.3 LTS

Device name	allie-VirtualBox
Memory	3.9 GiB
Processor	Intel® Core™ i7-8565U CPU @ 1.80GHz × 2
Graphics	llvmpipe (LLVM 8.0, 256 bits)
GNOme	3.28.2
OS type	64-bit
Virtualization	Oracle
Disk	27.0 GB

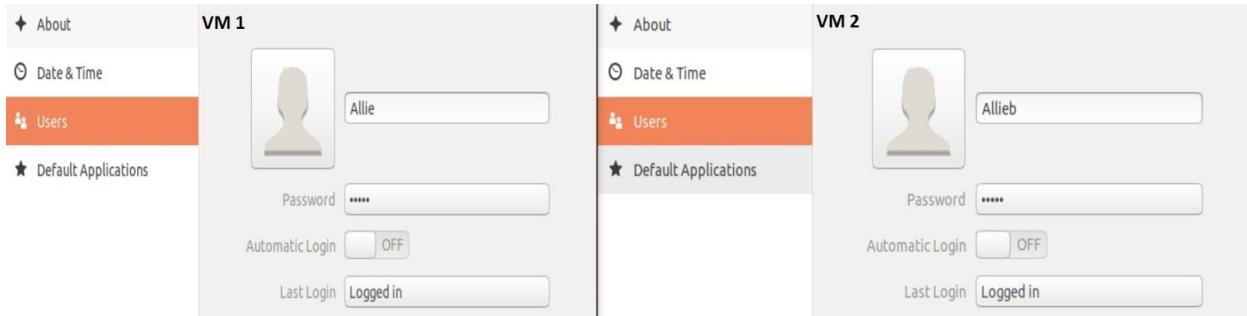
About

- Date & Time
- Users
- Default Applications


Ubuntu 18.04.3 LTS

Device name	allieb-VirtualBox
Memory	3.9 GiB
Processor	Intel® Core™ i7-8565U CPU @ 1.80GHz
Graphics	llvmpipe (LLVM 8.0, 256 bits)
GNOme	3.28.2
OS type	64-bit
Virtualization	Oracle
Disk	27.0 GB

A user and password was created in each VM:



Enabling Firewall and blocking all incoming traffic excluding port 22, which is used for ssh

<pre>allie@allie-VirtualBox:~\$ sudo ufw status verbose Status: active Logging: on (low) Default: deny (incoming), allow (outgoing), disabled (routed) New profiles: skip</pre>	<pre>allie@allieb-VirtualBox:~\$ sudo ufw status verbose Status: active Logging: on (low) Default: deny (incoming), allow (outgoing), disabled (routed) New profiles: skip</pre>																								
<table border="1"> <thead> <tr> <th>To</th> <th>Action</th> <th>From</th> </tr> </thead> <tbody> <tr> <td>..</td> <td>.....</td> <td>....</td> </tr> <tr> <td>22</td> <td>ALLOW IN</td> <td>Anywhere</td> </tr> <tr> <td>22 (v6)</td> <td>ALLOW IN</td> <td>Anywhere (v6)</td> </tr> </tbody> </table>	To	Action	From	22	ALLOW IN	Anywhere	22 (v6)	ALLOW IN	Anywhere (v6)	<table border="1"> <thead> <tr> <th>To</th> <th>Action</th> <th>From</th> </tr> </thead> <tbody> <tr> <td>..</td> <td>.....</td> <td>....</td> </tr> <tr> <td>22</td> <td>ALLOW IN</td> <td>Anywhere</td> </tr> <tr> <td>22 (v6)</td> <td>ALLOW IN</td> <td>Anywhere (v6)</td> </tr> </tbody> </table>	To	Action	From	22	ALLOW IN	Anywhere	22 (v6)	ALLOW IN	Anywhere (v6)
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To establish an ssh connection between the two VMs, I've downloaded and used a software name OpenSSH.

- **Step k**

Generating public and private key. Unless specified otherwise, both keys will be stored in `~/.ssh` folder protected by a passphrase.

```
allieb@allieb-VirtualBox:~/.ssh$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/allieb/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/allieb/.ssh/id_rsa.
Your public key has been saved in /home/allieb/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:+XZix3YQGP+8TTdomhs//CM6uTnaQ9UuBlXVUsOsO8 allieb@allieb-VirtualBox
The key's randomart image is:
+---[RSA 2048]---+
|      ... * |
|      ..+.. |
|      .* oo |
|      . +.B o |
|      S . *.o.+|
|      o +.* =.|
|      . = *E+ ..|
|      * =@.. |
|      .=*=.B. |
+---[SHA256]---+
```

The screenshot is for VM2, I've went through the same steps for VM1.

Next, I installed the public key on remote host and executing ssh command to test the connection.

Installing VM1's key on VM2

```
allie@allie-VirtualBox:~$ ssh-copy-id allieb@10.0.2.15
The authenticity of host '10.0.2.15 (10.0.2.15)' can't be established.
ECDSA key fingerprint is SHA256:M06+LTKNcAahK2nE0v1Pa8ElFtBQLv72469tGBxqzK8.
Are you sure you want to continue connecting (yes/no)? y
Please type 'yes' or 'no': 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 promp
ted now it is to install the new keys
allieb@10.0.2.15's password:
Permission denied, please try again.
allieb@10.0.2.15's password:
Permission denied, please try again.
allieb@10.0.2.15's password:

Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'allieb@10.0.2.15'"
```

Testing the connection:

```
allie@allie-VirtualBox:~$ ssh allieb@10.0.2.15
Welcome to Ubuntu 18.04.3 LTS (GNU/Linux 5.0.0-23-generic x86_64)

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

260 packages can be updated.
153 updates are security updates.

Your Hardware Enablement Stack (HWE) is supported until April 2023.
allieb@allieb-VirtualBox:~$ █
```

Repeating the same steps for installing VM2's key on VM1

```
allieb@allieb-VirtualBox:~$ ssh-copy-id allie@10.0.2.4
/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 promp
ted now it is to install the new keys
allie@10.0.2.4's password:

Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'allie@10.0.2.4'"
```

```

allieb@allieb-VirtualBox:~$ ssh allie@10.0.2.4
Welcome to Ubuntu 18.04.3 LTS (GNU/Linux 5.0.0-23-generic x86_64)

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

 * Canonical Livepatch is available for installation.
 - Reduce system reboots and improve kernel security. Activate at:
   https://ubuntu.com/livepatch

269 packages can be updated.
156 updates are security updates.

Your Hardware Enablement Stack (HWE) is supported until April 2023.
Last login: Tue Jan 28 19:18:24 2020 from 10.0.2.4
allie@allie-VirtualBox:~$ 

```

Stored keys in each VM. The screenshot was taken after sending the public key to the remove VM, which explains the additional listed keys.

File	Owner	Size	Last Modified	Permissions
authorized_keys	allie allie	406	Jan 28 16:22	-rw-----
id_rsa	allie allie	1766	Jan 27 17:18	-rw-----
id_rsa.pub	allie allie	404	Jan 27 17:18	-rw-r--r--
known_hosts	allie allie	222	Jan 28 16:11	-rw-r--r--

Part 2 -

a. ssh

The ssh command creates a secure connection between two remote hosts (server and client) over insecure network.

\$ssh <username>@<remote hostname>

```

allie@allie-VirtualBox:~$ ssh allieb@10.0.2.15
Welcome to Ubuntu 18.04.3 LTS (GNU/Linux 5.0.0-23-generic x86_64)

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

260 packages can be updated.
153 updates are security updates.

Your Hardware Enablement Stack (HWE) is supported until April 2023.
Last login: Tue Jan 28 16:12:55 2020 from 10.0.2.4
allieb@allieb-VirtualBox:~$ 

```

b. ssh-keygen

Generates a public and private authentication set of keys. By default this comment generate keys using RSA algorithm and saves it in ssh folder in home directory.

\$ssh-keygen

```
allieb@allieb-VirtualBox:~/ssh$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/allieb/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/allieb/.ssh/id_rsa.
Your public key has been saved in /home/allieb/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:+XZix3YQGP+8TTdomhs//CM6uTnaQ9UuBlXVUsOsO8 allieb@allieb-VirtualBox
The key's randomart image is:
+---[RSA 2048]---+
|       ...*|
|       ...+..|
|       .* oo |
|       . +.B o|
| S . *..o.+|
| o +.* =.|
| . = *E+ .|
| * =@.. |
| .*=.=B. |
+---[ SHA256 ]---
```

c. scp

I copied the files between two different servers (one local and one remote OR two remote) in a secure way using ssh protocol.

```
$[filename] <username>@<remotehost> : [file location at destination]
```

```
allie@allie-VirtualBox:~/Documents$ scp test.odt allieb@10.0.2.15:~/Documents/
test.odt                                         100% 8155      2.5MB/s   00:00
allie@allie-VirtualBox:~/Documents$
```

The file successfully transferred to the other VM and now appears in Document folder

```
allieb@allieb-VirtualBox:~/Documents$ ls -l
total 8
-rw-rw-r-- 1 allieb allieb 8155 Jan 28 19:46 test.odt
```

d. history

Displays last used commands sorted by chronological order, oldest to newest. Unless specified otherwise, the returned list will contain the maximum number of commands to display.

The user can use arguments such as top, less, grep to filter out results.

```
$history
```

```
allie@allie-VirtualBox:~/Documents$ history
1 exit
2 ssh allie@10.0.2.4
3 ssh allieb@10.0.2.4
4 hostname -I
5 ssh allieb@10.0.2.15
6 clear
7 ssh allieb@10.0.2.15
8 cd ~/Documents/
9 ;s
10 ls
11 scp test allieb@10.0.2.15:/home/allieb/Documents/
12 scp test allieb@10.0.2.15:~/Documents/
13 scp test.odt allieb@10.0.2.15:~/Documents/
14 clear
15 hostory
16 history
```

e. sudo

Leverage the user's current permissioning level to a superuser (root) to carry out tasks which require admin level permissioning.

*Note, although I have the highest permissioning level on my computer, for security reasons, I need to execute the command using sudo and to authenticate my user.

```
$sudo apt install vim
```

```
allie@allie-VirtualBox:~$ apt install vim
E: Could not open lock file /var/lib/dpkg/lock-frontend - open (13: Permission
denied)
E: Unable to acquire the dpkg frontend lock (/var/lib/dpkg/lock-frontend), are
you root?
allie@allie-VirtualBox:~$ sudo apt install vim
[sudo] password for allie:
Reading package lists... Done
Building dependency tree
Reading state information... Done
```

f. ip

Allows to view and perform network related tasks, such as configuration, adding and deleting.

\$ip addr - shows the comprehensive information on the network such as IP address (iv4 and iv6), MAC address, etc.

```
$ip addr
```

```
allie@allie-VirtualBox:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group defau
lt 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 UP g
roup default qlen 1000
    link/ether 08:00:27:81:6f:4f 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 478sec preferred_lft 478sec
        inet6 fe80::a4f0:7b73:9b67:bid2/64 scope link noprefixroute
            valid_lft forever preferred_lft forever
```

g. dd

Backup, copy and restore an entire hardware memory or partition.

```
$sudo dd if=/dev/sda of=~/partition.img bs=16
```

if - input file

of - output file

bs - read / write BYTES at a time

```
allie@allie-VirtualBox:~$ sudo dd if=/dev/sda of=~/partition.img bs=16
^C140791581+0 records in
140791580+0 records out
2252665280 bytes (2.3 GB, 2.1 GiB) copied, 300.773 s, 7.5 MB/s
allie@allie-VirtualBox:~$ █
```

h. fdisk

Fdisk command administrate disk partition table, allowing the user to view, create, delete, change, resize, copy and move partitions on a hard drive.

```
$sudo fdisk -l
```

l - listing all partition

```
allie@allie-VirtualBox:~$ sudo fdisk -l
Disk /dev/loop0: 4.2 MiB, 4403200 bytes, 8600 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: 160.2 MiB, 167931904 bytes, 327992 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: 14.8 MiB, 15462400 bytes, 30200 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: 149.9 MiB, 157184000 bytes, 307000 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: 54.7 MiB, 57294848 bytes, 111904 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
```

i. apt

Apt command manage and synchronize linux packages from authenticate source.

```
$sudo apt update
```

Downloads most recent software updates. It's essential to run apt update before upgrading software.

```
allie@allie-VirtualBox:~$ sudo apt update
[sudo] password for allie:
Get:1 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Hit:2 http://us.archive.ubuntu.com/ubuntu bionic InRelease
Get:3 http://us.archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]
Get:5 http://security.ubuntu.com/ubuntu bionic-security/main i386 Packages [427 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages [844 kB]
Get:7 http://security.ubuntu.com/ubuntu bionic-security/main amd64 Packages [621 kB]
Get:8 http://us.archive.ubuntu.com/ubuntu bionic-updates/main i386 Packages [638 kB]
Get:9 http://security.ubuntu.com/ubuntu bionic-security/main Translation-en [203 kB]
Get:10 http://security.ubuntu.com/ubuntu bionic-security/main amd64 DEP-11 Meta data [38.6 kB]
Get:11 http://security.ubuntu.com/ubuntu bionic-security/main DEP-11 48x48 Icons [17.6 kB]
Get:12 http://security.ubuntu.com/ubuntu bionic-security/main DEP-11 64x64 Icons [41.5 kB]
Get:13 http://security.ubuntu.com/ubuntu bionic-security/restricted amd64 Packages [20.2 kB]
Get:14 http://security.ubuntu.com/ubuntu bionic-security/restricted Translation-en [5,804 B]
Get:15 http://security.ubuntu.com/ubuntu bionic-security/universe i386 Packages
```

j. vi

Vi is a text editor that exists in most Linux distributions. The screenshot demonstrates using vi command to display the content of usa.txt file on screen.

\$vi usa.txt

```
allie@allie-VirtualBox:~$ cd ~/Documents/  
allie@allie-VirtualBox:~/Documents$ vi usa.txt  
allie@allie-VirtualBox:~/Documents$ █
```

k. time

Measures and display a summary of how long it took to for a command complete execution. The example below shows a report for ping command execution.

```
$time ping google.com
```

```
allie@allie-VirtualBox:~/Documents$ time ping google.com
PING google.com (216.58.192.142) 56(84) bytes of data.
64 bytes from ord36s01-in-f142.1e100.net (216.58.192.142): icmp_seq=1 ttl=55 time=6.75 ms
64 bytes from ord36s01-in-f142.1e100.net (216.58.192.142): icmp_seq=2 ttl=55 time=4.61 ms
64 bytes from ord36s01-in-f142.1e100.net (216.58.192.142): icmp_seq=3 ttl=55 time=6.77 ms
64 bytes from ord36s01-in-f142.1e100.net (216.58.192.142): icmp_seq=4 ttl=55 time=4.88 ms
64 bytes from ord36s01-in-f142.1e100.net (216.58.192.142): icmp_seq=5 ttl=55 time=7.11 ms
64 bytes from ord36s01-in-f142.1e100.net (216.58.192.142): icmp_seq=6 ttl=55 time=16.0 ms
64 bytes from ord36s01-in-f142.1e100.net (216.58.192.142): icmp_seq=7 ttl=55 time=6.35 ms
^C
--- google.com ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6012ms
rtt min/avg/max/mdev = 4.614/7.506/16.054/3.605 ms

real    0m6.660s
user    0m0.005s
sys     0m0.000s
```

I. tar

Extract and archive files.

```
$tar cvf usa.file *.txt
```

cvf - creates a new archive file name use.

*.txt - archive all txt files in current folder

```
allie@allie-VirtualBox:~$ cd ~/Documents/
allie@allie-VirtualBox:~/Documents$ tar cvf usa.file *.txt
chicago.txt
usa1.txt
usa.txt
allie@allie-VirtualBox:~/Documents$ ls
chicago.txt  test.odt  'Untitled 1.odt'  usa1.txt  usa.file  usa.txt
allie@allie-VirtualBox:~/Documents$
```

m. cat

Cat command reads data from a file and display its content on screen. Can be used to output multiple files

```
$cat ~/Documents/usa.txt
```

```
allie@allie-VirtualBox:~$ cat ~/Documents/usa.txt
Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Daleware
Florrida
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
```

n. watch

Once executed, watch command monitor changes over time.

In the example below, the output doesn't indicate any changes as it's supposed to, which is ok, since there hasn't been any change in the current files on the system and the memory size.

```
$watch -d free -m
d - highlight differences between updates
m - display memory in MB
```

```
Every 2.0s: free -m                               allie-VirtualBox: Wed Jan 29 15:42:49 2020
total        used         free      shared  buff/cache   available
Mem:       3942       1213       1883          45        845       2462
Swap:      1217           0       1217
```

o. ps

Print active processes. User can choose to display/filter processes by using arguments. E.g ps prints processes for current shell, ps -A prints all active processes in the system.

```
$ps / ps -A
```

```
allie@allie-VirtualBox:~/Documents$ ps -A
  PID TTY      TIME CMD
    1 ?        00:00:03 systemd
    2 ?        00:00:00 kthreadd
    3 ?        00:00:00 rcu_gp
    4 ?        00:00:00 rcu_par_gp
    6 ?        00:00:00 kworker/0:0H-kb
    7 ?        00:00:01 kworker/u4:0-ev
    8 ?        00:00:00 mm_percpu_wq
    9 ?        00:00:00 ksoftirqd/0
   10 ?       00:00:00 rcu_sched
   11 ?       00:00:00 migration/0
   12 ?       00:00:00 idle_inject/0
   13 ?       00:00:05 kworker/0:1-eve
   14 ?       00:00:00 cpuhp/0
   15 ?       00:00:00 cpuhp/1
   16 ?       00:00:00 idle_inject/1
   17 ?       00:00:00 migration/1
   18 ?       00:00:00 ksoftirqd/1
   20 ?       00:00:00 kworker/1:0H-kb
   21 ?       00:00:00 kdevtmpfs
   22 ?       00:00:00 netns
   23 ?       00:00:00 rcu_tasks_kthre
   24 ?       00:00:00 kauditd
   25 ?       00:00:00 khungtaskd
   26 ?       00:00:00 oom_reaper
   27 ?       00:00:00 writeback
   28 ?       00:00:00 kcompactd0
```

p. top

Shows a list of all running processes in the VM.

\$top -u allie

u - filter by user

```
top - 23:25:01 up 3:10, 1 user, load average: 0.07, 0.04, 0.10
Tasks: 234 total, 1 running, 195 sleeping, 0 stopped, 0 zombie
%CPU(s): 5.0 us, 0.3 sy, 0.0 ni, 94.5 id, 0.2 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 4037172 total, 1217504 free, 1464864 used, 1354804 buff/cache
KiB Swap: 1246644 total, 1246644 free, 0 used. 2275704 avail Mem

      PID USER      PR  NI    VIRT    RES    SHR S %CPU %MEM     TIME+ COMMAND
 1408 allie    20   0 3495060 368360 110976 S  8.9  9.1  2:52.21 gnome-she+
 1256 allie    20   0 577896 98616 58420 S  0.7  2.4  0:28.65 Xorg
 4581 allie    20   0 51324 3952 3304 R  0.7  0.1  0:00.24 top
 1866 allie    20   0 802140 37476 27996 S  0.3  0.9  0:08.30 gnome-terminal
 1236 allie    20   0 77028 8340 6800 S  0.0  0.2  0:00.61 systemd
 1237 allie    20   0 195916 2584 44 S  0.0  0.1  0:00.00 (sd-pam)
 1250 allie    20   0 583276 8108 6956 S  0.0  0.2  0:00.16 gnome-keyring
 1254 allie    20   0 212128 5860 5252 S  0.0  0.1  0:00.01 gdm-x-session
 1264 allie    20   0 52328 6644 3648 S  0.0  0.2  0:01.37 dbus-daemon
 1267 allie    20   0 569444 15852 13128 S  0.0  0.4  0:00.47 gnome-session
 1362 allie    20   0 11300 320 0 S  0.0  0.0  0:00.07 ssh-agent
 1365 allie    20   0 291952 7240 6240 S  0.0  0.2  0:00.15 gvfsd
 1370 allie    20   0 432020 7868 6988 S  0.0  0.2  0:00.03 gvfsd-fuse
 1381 allie    20   0 367864 8824 7940 S  0.0  0.2  0:00.01 at-spi-bus+
 1386 allie    20   0 49924 4324 3816 S  0.0  0.1  0:00.09 dbus-daemon
 1389 allie    20   0 220776 6868 6160 S  0.0  0.2  0:00.38 at-spi2-r+
 1419 allie    9  -11 1434872 15268 11660 S  0.0  0.4  0:01.67 pulseaudio
 1429 allie    20   0 377948 10468 8256 S  0.0  0.3  0:06.17 ibus-daemon+
 1433 allie    20   0 296784 8436 7704 S  0.0  0.2  0:00.01 ibus-dconf
 1435 allie    20   0 356280 22416 17656 S  0.0  0.6  0:00.20 ibus-x11
 1437 allie    20   0 294596 8268 7536 S  0.0  0.2  0:00.08 ibus-port+
```

q. htop

Htop provides an overall view of the system's resources and server processes.

\$htop -u allie

u - filter by user

```

1 [|||] 1.3%] Tasks: 137, 312 thr; 1 running
2 [|||] 2.0%] Load average: 0.01 0.05 0.01
Mem[|||||] 951M/3.85G] Uptime: 02:52:36
Swp[ 0K/1.19G]

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
2833 allie 20 0 40564 4664 3884 R 2.0 0.1 0:00.24 htop -u allie
1404 allie 20 0 3369M 252M 97M S 0.7 6.4 0:31.73 /usr/bin/gnome-s
1410 allie 20 0 3369M 252M 97M S 0.7 6.4 0:02.01 /usr/bin/gnome-s
1411 allie 20 0 3369M 252M 97M S 0.0 6.4 0:01.91 /usr/bin/gnome-s
1252 allie 20 0 474M 63148 36452 S 0.0 1.6 0:04.68 /usr/lib/xorg/Xo
1704 allie 20 0 782M 37612 28364 S 0.0 0.9 0:02.75 /usr/lib/gnome-t
1415 allie 9 -11 1400M 12492 9208 S 0.0 0.3 0:00.43 /usr/bin/pulseau
1434 allie 20 0 287M 8240 7504 S 0.0 0.2 0:00.04 /usr/lib/ibus/ib
1549 allie 20 0 1064M 24580 19196 S 0.0 0.6 0:00.23 /usr/lib/gnome-s
1232 allie 20 0 77072 8240 6664 S 0.0 0.2 0:00.22 /lib/systemd/sys
1233 allie 20 0 111M 2544 40 S 0.0 0.1 0:00.00 (sd-pam)
1247 allie 20 0 281M 7704 6756 S 0.0 0.2 0:00.00 /usr/bin/gnome-k
1248 allie 20 0 281M 7704 6756 S 0.0 0.2 0:00.02 /usr/bin/gnome-k
1401 allie 20 0 281M 7704 6756 S 0.0 0.2 0:00.00 /usr/bin/gnome-k
1246 allie 20 0 281M 7704 6756 S 0.0 0.2 0:00.07 /usr/bin/gnome-k
1251 allie 20 0 207M 5932 5304 S 0.0 0.1 0:00.00 /usr/lib/gdm3/gd
1261 allie 20 0 207M 5932 5304 S 0.0 0.1 0:00.00 /usr/lib/gdm3/gd
1250 allie 20 0 207M 5932 5304 S 0.0 0.1 0:00.03 /usr/lib/gdm3/gd
1255 allie 20 0 474M 63148 36452 S 0.0 1.6 0:00.00 /usr/lib/xorg/Xo
1256 allie 20 0 474M 63148 36452 S 0.0 1.6 0:00.00 /usr/lib/xorg/Xo

F1Help F2Setup F3Search F4Filter F5Tree F6SortByF7Nice -F8Nice +F9Kill F10Quit

```

r. gcc

Compiler for C and C++.

\$gcc -Wall evenOrodd.c -o opt

Wall - checks for errors

o - output file name

```

allie@allie-VirtualBox:~/Documents$ gcc -Wall evenOrodd.c -o opt
allie@allie-VirtualBox:~/Documents$ ls
chicago.txt  opt  'Untitled 1.odt'  usa.file
evenOrodd.c  test.odt  usa1.txt  usa.txt
allie@allie-VirtualBox:~/Documents$ 

```

s. tail

Print the last n lines of a file.

\$tail -2 ~/Document/usa.txt

2 - specify the number of lines, counting from the end of the file, to display.

```

allie@allie-VirtualBox:~$ tail -2 ~/Documents/usa.txt
Iowa
Kansas

```

t. grep

Search for a word expression in a text, filter out results that doesn't contain searched word.

\$history | grep allie

```
allie@allie-VirtualBox:~/Documents$ history | grep allie
2 ssh allie@10.0.2.4
3 ssh allieb@10.0.2.4
5 ssh allieb@10.0.2.15
7 ssh allieb@10.0.2.15
11 scp test allieb@10.0.2.15:/home/allieb/Documents/
12 scp test allieb@10.0.2.15:~/Documents/
13 scp test.odt allieb@10.0.2.15:~/Documents/
17 history | grep allie
```

u. kill

Force to stop a running process by sending a signal.

```
$kill -l
```

```
allie@allie-VirtualBox:~/Documents$ pidof firefox
7735 7691 7648 7600
allie@allie-VirtualBox:~/Documents$ kill 7735
allie@allie-VirtualBox:~/Documents$ pidof firefox
7691 7648 7600
```

v. killall

Force stop all processes by specifying process' name.

```
$kill {name}
```

```
allie@allie-VirtualBox:~/Documents$ killall firefox
allie@allie-VirtualBox:~/Documents$ pidof firefox
allie@allie-VirtualBox:~/Documents$
```

w. du

Du command estimates file space usage or file's size.

```
$du -a -h ~/Document
```

a - count size for file and directory

h - print size in human readableformat

```
allie@allie-VirtualBox:~/Documents$ du -a -h ~/Documents/
4.0K /home/allie/Documents/usa.txt
4.0K /home/allie/Documents/chicago.txt
8.0K /home/allie/Documents/test.odt
8.0K /home/allie/Documents/Untitled 1.odt
28K /home/allie/Documents/
allie@allie-VirtualBox:~/Documents$
```

x. df

Shows the amount of available space in the file system.

```
$df --total
```

Total - print grand total

h - human readable format

```

allie@allie-VirtualBox:~$ df -h --total
Filesystem      Size   Used  Avail Use% Mounted on
udev            2.0G     0    2.0G  0% /dev
tmpfs           395M  1.6M  393M  1% /run
/dev/sda1        26G   6.4G   18G  27% /
tmpfs           2.0G     0    2.0G  0% /dev/shm
tmpfs           5.0M   4.0K   5.0M  1% /run/lock
tmpfs           2.0G     0    2.0G  0% /sys/fs/cgroup
/dev/loop2        55M   55M     0 100% /snap/core18/1066
/dev/loop3        45M   45M     0 100% /snap/gtk-common-themes/1440
/dev/loop0        4.3M  4.3M     0 100% /snap/gnome-calculator/544
/dev/loop1        3.8M  3.8M     0 100% /snap/gnome-system-monitor/100
/dev/loop4        55M   55M     0 100% /snap/core18/1650
/dev/loop5        15M   15M     0 100% /snap/gnome-characters/399
/dev/loop6        3.8M  3.8M     0 100% /snap/gnome-system-monitor/127
/dev/loop7        1.0M  1.0M     0 100% /snap/gnome-logs/81
/dev/loop8        89M   89M     0 100% /snap/core/7270
/dev/loop9        150M  150M    0 100% /snap/gnome-3-28-1804/67
/dev/loop10       161M  161M    0 100% /snap/gnome-3-28-1804/116
/dev/loop12       1.0M  1.0M     0 100% /snap/gnome-logs/61
/dev/loop11       90M   90M     0 100% /snap/core/8268
/dev/loop13       15M   15M     0 100% /snap/gnome-characters/296
/dev/loop14       4.2M  4.2M     0 100% /snap/gnome-calculator/406
/dev/loop15       43M   43M     0 100% /snap/gtk-common-themes/1313
tmpfs            395M  28K   395M  1% /run/user/121
tmpfs            395M  24K   395M  1% /run/user/1000
total            33G  7.1G   25G  23% -
allie@allie-VirtualBox:~$ █

```

y. screen

This command allows to create multiple terminal sessions and to manage them, e.g run different programs on each, disattached one from another, display all in one.

```
$screen -S allie
```

```
$screen -ls
```

S - create a terminal name allie

ls - list all terminal sessions

```

allie@allie-VirtualBox:~$ screen -ls
There is a screen on:
    1879.newWindow  (01/29/2020 09:25:14 PM)          (Attached)
1 Socket in /run/screen/S-allie.
allie@allie-VirtualBox:~$ █

```

z. Vim

Text editor, an improved version of vi.

```
$vim ~/Document/usa.txt
```

aa. chmod

Change file or folder's permissions. Permissions can be granted per user, group or other.

```
$chmod g=r usa.txt
```

g - group

r - read only

```
allie@allie-VirtualBox:~/Documents$ ls -l
total 24
-rw-rw-r-- 1 allie allie 139 Jan 28 23:11 chicago.txt
-rw-rw-r-- 1 allie allie 8155 Jan 28 19:40 test.odt
-rw-rw-r-- 1 allie allie 8149 Jan 28 19:40 'Untitled 1.odt'
-rw-rw-r-- 1 allie allie 133 Jan 28 23:15 usa.txt
allie@allie-VirtualBox:~/Documents$ chmod g=r usa.txt
allie@allie-VirtualBox:~/Documents$ ls -l
total 24
-rw-rw-r-- 1 allie allie 139 Jan 28 23:11 chicago.txt
-rw-rw-r-- 1 allie allie 8155 Jan 28 19:40 test.odt
-rw-rw-r-- 1 allie allie 8149 Jan 28 19:40 'Untitled 1.odt'
-rw-r--r-- 1 allie allie 133 Jan 28 23:15 usa.txt
allie@allie-VirtualBox:~/Documents$
```

bh chown

Change file's ownership from current user to a new defined user

```
$sudo chown newuser chicago.txt
```

```
allie@allie-VirtualBox:~/Documents$ sudo chown newuser usa.txt
[sudo] password for allie:
allie@allie-VirtualBox:~/Documents$ ls -l
total 40
-rw-rw-r-- 1 newuser allie 139 Jan 28 23:11 chicago.txt
-rw-rw-r-- 1 allie allie 8155 Jan 28 19:40 test.odt
-rw-rw-r-- 1 allie allie 8149 Jan 28 19:40 'Untitled 1.odt'
-rw-r--r-- 1 allie allie 123 Jan 29 08:19 usa1.txt
-rw-rw-r-- 1 allie allie 10240 Jan 29 17:09 usa.file
-rw-r--r-- 1 newuser allie 133 Jan 28 23:15 usa.txt
allie@allie-VirtualBox:~/Documents$
```

cc. useradd

Creates a new user.

```
$sudo useradd newuser
```

```
allie@allie-VirtualBox:~/Documents$ sudo useradd newuser
[sudo] password for allie:
allie@allie-VirtualBox:~/Documents$ sudo passwd newuser
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```

dd. man

Display user man per Linux command.

```
$man ls
```

```
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 list implied . and ..

    --author
        with -l, print the author of each file

    -b, --escape
        print C-style escapes for nongraphic characters
Manual page ls(1) line 1 (press h for help or q to quit)
```

ee. locate

Finds files by their name or type and print its location.

```
$locate “*.html” -n 5
```

n - show n results

```
allie@allie-VirtualBox:~$ locate "*.html" -n 5
/usr/share/adium/message-styles/ubuntu.AdiumMessageStyle/Contents/Resources/Demo.html
/usr/share/adium/message-styles/ubuntu.AdiumMessageStyle/Contents/Resources/Header.html
/usr/share/adium/message-styles/ubuntu.AdiumMessageStyle/Contents/Resources/Staus.html
/usr/share/adium/message-styles/ubuntu.AdiumMessageStyle/Contents/Resources/Template.html
/usr/share/adium/message-styles/ubuntu.AdiumMessageStyle/Contents/Resources/Incoming/Content.html
allie@allie-VirtualBox:~$ █
```

ff. find

Find command searches a file or a directories by properties like, file name, folder, file type, creation/modification date and owner. It starts the search at a given starting point and run through the folder hierarchy searching for the file.

```
$find -name usa.txt
```

name - search by name property

```
allie@allie-VirtualBox:~/Documents$ find -name usa.txt
./usa.txt
allie@allie-VirtualBox:~/Documents$ █
```

gg. sed

Perform actions on file, such as search, find and replace, insertion and delete.

```
$sed 's/Kansas/Kentucky/p' usa.txt
```

s - replace original/new value

p - print new value twice

```
Daleware
Florrida
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
allie@allie-VirtualBox:~/Documents$ sed 's/Kansas/kentucky/p' usa.txt
Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Daleware
Florrida
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
kentucky
kentucky
allie@allie-VirtualBox:~/Documents$ █
```

hh. awk

Add formatting styling to output.

```
$awk '{print NR, $0}' usa.txt  
'{print NR, $0}' - display line numbers
```

```
allie@allie-VirtualBox:~/Documents$ awk '{print NR, $0}' usa.txt  
1 Alabama  
2 Alaska  
3 Arizona  
4 Arkansas  
5 California  
6 Colorado  
7 Connecticut  
8 Daleware  
9 Florrida  
10 Georgia  
11 Hawaii  
12 Idaho  
13 Illinois  
14 Indiana  
15 Iowa  
16 Kansas  
allie@allie-VirtualBox:~/Documents$ █
```

ii. diff

Compare the content of 2 files and output the difference.

```
$diff usa.txt usa1.txt
```

```
allie@allie-VirtualBox:~/Documents$ diff usa.txt usa1.txt  
2d1  
< Alaska  
6d4  
< Colorado  
12d9  
< Idaho  
16c13,14  
< Kansas  
--  
> Kentucky  
> Louisiana
```

jj. sort

Sort file's content, if not specified otherwise, sort by ascending alphabetical order.

```
$sort usa1.txt
```

Before:

```
allie@allie-VirtualBox:~/Documents$ cat usa1.txt  
Kentucky  
Hawaii  
Arizona  
Arkansas  
Alabama  
Connecticut  
Daleware  
Louisiana  
California  
Georgia  
Illinois  
Indiana  
Iowa  
Florrida
```

After:

```
allie@allie-VirtualBox:~/Documents$ sort usal.txt
Alabama
Arizona
Arkansas
California
Connecticut
Daleware
Florrida
Georgia
Hawaii
Illinois
Indiana
Iowa
Kentucky
Louisiana
allie@allie-VirtualBox:~/Documents$ █
```

kk. export

Print all system variables or functions that can be passed to other processes.

\$export -p

p - print all variables on current shell

```
allie@allie-VirtualBox:~/Documents$ export -p
declare -x CLUTTER_IM_MODULE="xim"
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"
declare -x GJS_DEBUG_OUTPUT="stderr"
declare -x GJS_DEBUG_TOPICS="JS ERROR;JS LOG"
declare -x GNOME_DESKTOP_SESSION_ID="this-is-deprecated"
declare -x GNOME_SHELL_SESSION_MODE="ubuntu"
declare -x GNOME_TERMINAL_SCREEN="/org/gnome/Terminal/screen/c9e95c8c_e18b_4930
_a82a_420421375986"
declare -x GNOME_TERMINAL_SERVICE=":1.58"
declare -x GPG_AGENT_INFO="/run/user/1000/gnupg/S.gpg-agent:0:1"
declare -x GTK_IM_MODULE="ibus"
declare -x GTK_MODULES="gail:atk-bridge"
declare -x HOME="/home/allie"
declare -x IM_CONFIG_PHASE="2"
declare -x LANG="en_US.UTF-8"
declare -x LESSCLOSE="/usr/bin/lesspipe %s %s"
declare -x LESSOPEN="| /usr/bin/lesspipe %s"
declare -x LOGNAME="allie"
declare -x LS_COLORS="rs=0:di=01;34:ln=01;36:mh=00:pi=40;33:so=01;35:do=01;35:b
d=40;33:01:cd=40;33:01:or=40;31:01:mi=00:su=37;41:sg=30;43:ca=30;41:tw=30;42:ow
=34;42:st=37;44:ex=01;32:*.tar=01;31:*.tgz=01;31:*.arc=01;31:*.arj=01;31:*.taz=
01;31:*.lha=01;31:*.lz4=01;31:*.lzh=01;31:*.lzma=01;31:*.tlz=01;31:*.txz=01;31:
```

ll. pwd

Print directory's path.

\$pwd

```
allie@allie-VirtualBox:~/Documents$ pwd
/home/allie/Documents
allie@allie-VirtualBox:~/Documents$ █
```

mm. crontab

Print scheduled cron jobs. In the screenshot below, the command return without results since there are no scheduled jobs.

```
$crontab -l  
l - display current cron jobs
```

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

nn. mount

Mount a filesystem and attach it to Linux filesystem or remove an existing file system.

```
$mount -l  
l - list existing files
```

```
allie@allie-VirtualBox:~$ mount -l  
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,relatime,size=1994716k,nr_inodes=498679,mode=755)  
devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)  
tmpfs on /run type tmpfs (rw,nosuid,noexec,relatime,size=403720k,mode=755)  
/dev/sda1 on / type ext4 (rw,relatime,errors=remount-ro)  
securityfs on /sys/kernel/security type securityfs (rw,nosuid,nodev,noexec,relatime)  
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)  
tmpfs on /run/lock type tmpfs (rw,nosuid,nodev,noexec,relatime,size=5120k)  
tmpfs on /sys/fs/cgroup type tmpfs (ro,nosuid,nodev,noexec,mode=755)  
cgroup on /sys/fs/cgroup/unified type cgroup2 (rw,nosuid,nodev,noexec,relatime,nsdelegate)  
cgroup on /sys/fs/cgroup/systemd type cgroup (rw,nosuid,nodev,noexec,relatime,xattr,name=systemd)  
pstore on /sys/fs/pstore type pstore (rw,nosuid,nodev,noexec,relatime)  
cgroup on /sys/fs/cgroup/blkio type cgroup (rw,nosuid,nodev,noexec,relatime,blkio)  
cgroup on /sys/fs/cgroup/perf_event type cgroup (rw,nosuid,nodev,noexec,relatime,perf_event)  
cgroup on /sys/fs/cgroup/cpu,cpuacct type cgroup (rw,nosuid,nodev,noexec,relatime,cpu,cpuacct)  
cgroup on /sys/fs/cgroup/pids type cgroup (rw,nosuid,nodev,noexec,relatime,pids)  
cgroup on /sys/fs/cgroup/freezer type cgroup (rw,nosuid,nodev,noexec,relatime,f
```

oo. passwd

Command to change a password for an existing user.

```
$sudo passwd newuser
```

```
allie@allie-VirtualBox:~/Documents$ sudo useradd newuser  
[sudo] password for allie:  
allie@allie-VirtualBox:~/Documents$ sudo passwd newuser  
Enter new UNIX password:  
Retype new UNIX password:  
passwd: password updated successfully
```

pp. uname

Print information about the system

```
$uname -a
```

a - prints the information in the following format:

Kernel name, network node hostname, kernel release date, kernel version, machine hardware name, hardware platform, operating system

```
allie@allie-VirtualBox:~/Documents$ uname -a
Linux allie-VirtualBox 5.0.0-23-generic #24~18.04.1-Ubuntu SMP Mon Jul 29 16:12
:28 UTC 2019 x86_64 x86_64 x86_64 GNU/Linux
allie@allie-VirtualBox:~/Documents$ █
```

qq. whereis

Return a directory of command's source/binary.

```
$whereis ls
```

```
$whereis top
```

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

rr. whatis

Return a single line command man, in the screenshot below, whatis return a brief description of top and cat command

```
$whatis top
```

```
$whatis cat
```

```
allie@allie-VirtualBox:~$ whatis top
top (1)          - display Linux processes
allie@allie-VirtualBox:~$ whatis cat
cat (1)          - concatenate files and print on the standard output
allie@allie-VirtualBox:~$ █
```

ss. su

Su command allow to change the current user to a superuser or another user. In the screenshot below I switched from my user to newuser and back to my own user.

```
$su -l newuser
```

```
$su -l allie
```

```
allie@allie-VirtualBox:~$ su -l newuser
Password:
No directory, logging in with HOME=/
$ su -l allie
Password:
allie@allie-VirtualBox:~$
```

tt. ping

Checks connectivity between source and destination by sending a data packet and tracking its status.

```
$ ping google.com
```

```
allie@allie-VirtualBox:~/Documents$ ping google.com
PING google.com (172.217.1.142) 56(84) bytes of data.
64 bytes from atl14s07-in-f142.1e100.net (172.217.1.142): icmp_seq=1 ttl=49 time
e=30.7 ms
64 bytes from atl14s07-in-f142.1e100.net (172.217.1.142): icmp_seq=2 ttl=49 time
e=30.9 ms
64 bytes from atl14s07-in-f142.1e100.net (172.217.1.142): icmp_seq=3 ttl=49 time
e=30.5 ms
64 bytes from atl14s07-in-f142.1e100.net (172.217.1.142): icmp_seq=4 ttl=49 time
e=52.7 ms
64 bytes from atl14s07-in-f142.1e100.net (172.217.1.142): icmp_seq=5 ttl=49 time
e=30.1 ms
^C
--- google.com ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4016ms
rtt min/avg/max/mdev = 30.125/35.033/52.784/8.880 ms
allie@allie-VirtualBox:~/Documents$
```

uu. traceroute

A tool that shows the path to send a packet from your computer to a destination, as well as the time at each hop.

**Traceroute command didn't work on my Linux environment. To demonstrate the command and its output I used my Window's machine and the equivalent command for Windows CLI.

```
$tracert
```

In the screenshot below, the packet passed 6 routers until reached its destination at 23.203.41.188.

```
ayelie@LAPTOP-M4QQBPEF MINGW64 ~
$ tracert ynet.co.il

Tracing route to ynet.co.il [23.203.41.188]
over a maximum of 30 hops:
1   1 ms    2 ms    2 ms  104.194.112.1
2   70 ms   3 ms    1 ms  216.47.159.165
3   4 ms    3 ms    4 ms  5-2-3.bear2.Cincinnati1.Level3.net [4.71.182.25]
4   *        *        * Request timed out.
5   6 ms    3 ms    2 ms  4.79.77.246
6   14 ms   14 ms   22 ms  ae3.ct1-ord4.netarch.akamai.com [23.203.151.219]
7   13 ms   11 ms    9 ms  a23-203-41-188.deploy.static.akamaitechnologies.com [23.203.41.188]

Trace complete.
```

vv. Date

Displays system's time and date.

```
$date -u  
u - shows UTC timezone time and date
```

```
allie@allie-VirtualBox:~$ date  
Wed Jan 29 13:14:40 CST 2020  
allie@allie-VirtualBox:~$ date -u  
Wed Jan 29 19:14:43 UTC 2020  
allie@allie-VirtualBox:~$ █
```

xx. wget

Download file from URL using protocols such as HTTP, HTTPS, FTP.

```
$wget -r http://iit.edu -A jpeg
```

```
allie@allie-VirtualBox:~$ wget -r http://iit.edu -A jpeg  
--2020-01-29 14:53:30-- http://iit.edu/  
Resolving iit.edu (iit.edu)... 174.143.130.167, 2001:4800:7819:104:be76:4eff:fe  
04:88c6  
Connecting to iit.edu (iit.edu)|174.143.130.167|:80... connected.  
HTTP request sent, awaiting response... 302 Found  
Location: https://iit.edu/ [following]  
--2020-01-29 14:53:30-- https://iit.edu/  
Connecting to iit.edu (iit.edu)|174.143.130.167|:443... connected.  
HTTP request sent, awaiting response... 302 Found  
Location: https://www.iit.edu/ [following]  
--2020-01-29 14:53:31-- https://www.iit.edu/  
Resolving www.iit.edu (www.iit.edu)... 50.19.226.237  
Connecting to www.iit.edu (www.iit.edu)|50.19.226.237|:443... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 73384 (72K) [text/html]  
Saving to: 'iit.edu/index.html.tmp'  
  
iit.edu/index.html. 100%[=====] 71.66K --.-KB/s in 0.03s  
2020-01-29 14:53:31 (2.02 MB/s) - 'iit.edu/index.html.tmp' saved [73384/73384]  
  
Removing iit.edu/index.html.tmp since it should be rejected.  
  
FINISHED --2020-01-29 14:53:31--  
Total wall clock time: 0.4s  
Downloaded: 1 files, 72K in 0.03s (2.02 MB/s)  
allie@allie-VirtualBox:~$ █
```

yy. wc

Print file's number of lines, word count, byte and character count.

```
$wc ~/Document/usa.txt
```

```
allie@allie-VirtualBox:~$ wc ~/Documents/usa.txt  
16 16 133 /home/allie/Documents/usa.txt  
allie@allie-VirtualBox:~$ █
```

zz. pwgen

Generates random and strong passwords.

```
$pwgen -s -1  
s - generate secure password
```

```
allie@allie-VirtualBox:~$ pwgen -s -1  
VS6BJwLk  
allie@allie-VirtualBox:~$
```

3a.

```
varungunda@VarunPC:~/Documents/VarunIllinoisTech/Spring 2020/Cloud Computing/HW1/new3$ time ./generate-dataset.sh ten_thousand 10000
real    0m28.028s
user    0m20.788s
sys     0m8.329s
```

10,000 records is give as the input and the output is the text file ten_thousand.txt. This took 28 secs.

3b & 3c

```
varungunda@VarunPC:~/Documents/VarunIllinoisTech/Spring 2020/Cloud Computing/HW1/new3$ time ./generate-dataset.sh thousand 1000
real    0m2.775s
user    0m2.049s
sys     0m0.830s
```

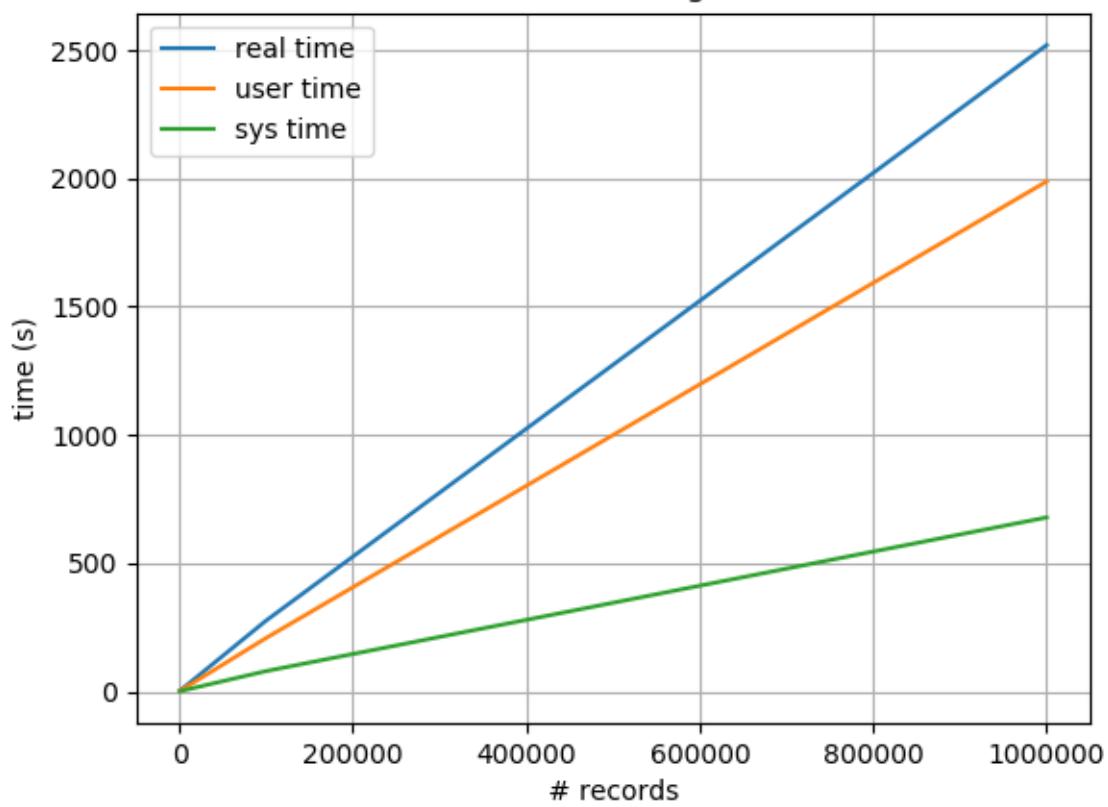
```
varungunda@VarunPC:~/Documents/VarunIllinoisTech/Spring 2020/Cloud Computing/HW1/new3$ time ./generate-dataset.sh hund_thousand 100000
real    4m35.551s
user    3m27.686s
sys     1m18.962s
```

```
varungunda@VarunPC:~/Documents/VarunIllinoisTech/Spring 2020/Cloud Computing/HW1/new3$ time ./generate-dataset.sh one_million 1000000
real    42m0.063s
user    33m8.312s
sys     11m18.246s
```

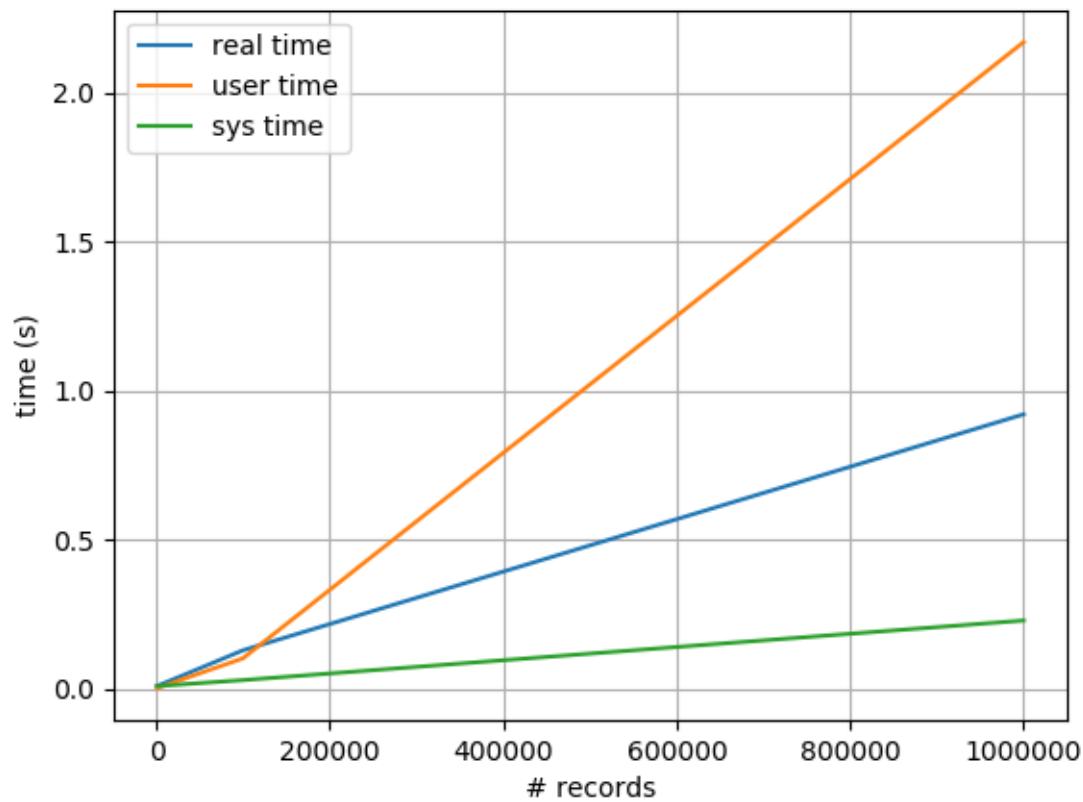
```
varungunda@VarunPC:~/Documents/VarunIllinoisTech/Spring 2020/Cloud Computing/HW1/new3$ time ./sort-data.sh thousand.txt
real    0m0.008s
user    0m0.001s
sys     0m0.008s
varungunda@VarunPC:~/Documents/VarunIllinoisTech/Spring 2020/Cloud Computing/HW1/new3$ time ./sort-data.sh hund_thousand.txt
real    0m0.128s
user    0m0.101s
sys     0m0.028s
varungunda@VarunPC:~/Documents/VarunIllinoisTech/Spring 2020/Cloud Computing/HW1/new3$ time ./sort-data.sh one_million.txt
real    0m0.920s
user    0m2.169s
sys     0m0.228s
```

Sorting for files with different number of records took the time as seen in the above figure. The following graphs show the time taken for generation as well as sorting of the records.

Time for Generating Records



Time for Sorting Records



4a.

For virtual machines that are used for simple (like office in windows vm) and internet productivity applications, having multiple virtual processors is not beneficial. Hence, a single virtual processor is ideal for desktop applications. However, adding more virtual processors may be beneficial and can increase the application performance when we have server workload and data-intensive computing applications (like video encoding, modeling and scientific applications). Also, in some cases, adding more processors to the vm can cause a decrease in overall performance of the vm and the host machine. This occurs if the OS or the application is not using the processors efficiently.

Setting the number of processors to maximum is potentially a bad idea. The host operating system may not be able to perform important background tasks since all processors are assigned to the virtual machine. However, these background tasks must be completed by the host operating system. This results in reduction of the performance.

4b.

None: This option turns off exposing paravirtualization interface.

Legacy: This option is for the VMs that were created with older versions of VirtualBox. This will pick a paravirtualization interface when starting the VM with Oracle VM VirtualBox 5.0 and newer.

Default: Selects an appropriate interface when starting the VM, depending on the guest OS type.

Minimal: This announces the presence of a virtualized environment. Also, reports the TSC and APIC frequency to the guest operating system. This provider is mandatory for running any Mac OS X 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.

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.

Hence, KVM (Kernel-based Virtual Machine) is best suitable for Ubuntu Linux since provides hypervisor interface that is recognized by linux kernels. Also, it was merged into linux kernel mainline in kernel version 2.6.20 which makes it ideal for Ubuntu Linux.

4c.

In a computing device, hard disks and CD/DVD drives are connected to a device called hard disk controller which drives hard disk operation and data transfers. Following 3 are hard disk controllers:

IDE: These controllers are an advanced extension of the disk controller in IBM PC/AT (1984). It supports hard disks, CD-ROM drives and other types of removable media.

Scenarios when the guest OS has no support for SCSI or SATA devices, the VM should always be see an IDE controller. Hence, IDE controller may be used when guest OS has no support for other controllers. If the VM type is legacy OS, the we use IDE controller.

SATA: This controller is more recent compared to a standard IDE. It supports much higher speeds and more devices per controller in comparison to the IDE. In addition, devices can be added or removed while the system is running. Since this is fast and uses less CPU resources compared to IDE controller, and can connect up to 30 virtual hard disks to one machine, VirtualBox uses SATA as the default for the newly created virtual machines. Hence, if we have a large number of virtual disks with limited performance, we would prefer to go with SATA,

NVMe: This is a standard controller for connecting a non volatile memory directly over PCI express to lift the bandwidth limitation of SATA protocol for solid state devices. The command set in this is very simple and enables to achieve the maximum throughput and is not compatible with ATA or SCSI. Not all OSes support NVMe. This option is suitable for a fast and low latency storage.

4d.

NAT: This is the default mode and is best suitable if you are only going to browse the web, download files and view email inside the guest. A virtual machine with NAT enabled acts much like a real computer that connects to the Internet through a router. The router, in this case, is the Oracle VM VirtualBox networking engine, which maps traffic from and to the virtual machine transparently.

Bridged Adapter: The VM is connected to the network using a network adapter on the host system. Oracle VM virtualbox uses a device driver on the host system that filters data from the physical network adapter, it enables Oracle VM VirtualBox to intercept data from the physical network and inject data into it, effectively creating a new network interface in software.

The host can send data to the guest through this interface and receive data from it. Anyone on the host network can access quests and VMs have the same access to the internet as the host. WE typically use this mode when we want to connect a VM to a network.

Internal Network: Just like bridged networking, here the VM can communicate directly with the outside world. But the outside world is limited to other Vms on the same host which connect to the same internal network. This is very secure since access from outside the host is not possible.

Host-only Network: This is a hybrid between the bridged and internal networking modes. The VM can talk to each other and the host as if they were connected through a physical ethernet switch. The VM can't talk to the world outside the host since they are not connected to a physical networking interface. Host-only networking is particularly useful for preconfigured virtual appliances, where multiple virtual machines are shipped together and designed to cooperate.

4e.

USB 1.1 (full-bandwidth USB) is the first release that was adopted by the industry. This specification allowed for a maximum bandwidth of 12 Mbps. It's ideal for connecting devices with low bandwidth requirements, like keyboard, mouse, printer etc.,

USB 2.0 (Hi-Speed USB) is an improvement over USB 1.1. Its bandwidth increased to 480Mbps. This controller also supported USB 1.1 devices but the bandwidth is limited to 12 Mbps. This is best suited for supporting mass storage devices, video adapter, data transfer cables etc.,

USB 3.0 (SuperSpeed) made improvements over USB 2.0. Its bandwidth increased to 4.8Gbps, supports full duplex communication and an increase of the amount of power available to connected devices. Also, USB 3.0 controllers supported backwards compatibility. This is best suited for large mass storage devices, video adapters, data transfer cables etc.,

5.

A) What is a core and hardware thread in modern processor?

Core: Cores are the workers in the cpu, it does the jobs given by the Operating System.

Thread: Threads are sequences of commands given to the cores. Threads can be called as the virtual cores or logical cores.

A core can be classified into two types: (1) a Physical and (2) a Logical core. A Physical core is the hardware lying inside a computer where as a Logical core is a thread. The total number of cores/logical cores are effectively calculated as the multiplication of the number of physical cores to the number of threads.

B)

- (a) Intel CPU(x86) - Xeon E7-8890V4 - 24 core -48 THREADS - 2.2 GHz(Base frequency) - 3.40 (Max Frequency) - 60 MB Cache - 165 W - 14 NM - 3 TB max memory - 85 GB/s - \$8,631.56
- (b) AMD CPU (x86) - EPYC 7702P - 64 core - 2 GHz - 200W - 128 threads - 200W TDP - 256 MB L3 Cache - \$ 4783.99
- (c) IBM CPU(Power9) IBM Power System E980 - 192 cores(maximum) - 64TB Memory - 512K L2 - 120 MB L3 - 128 GB L4 - 230 GB/s
- (d) ThunderX CPU (ARM) - Server H270-T70 - \$18,047.82 - 384 cores- 8TB Memory- 28 nm technology- 2.0 Ghz
- (e) NVIDIA GPU - NVIDIA TITAN V - 6 Graphics processing clusters - 80 Streaming multiprocessors - 5120 CUDA cores - 1200 MHz(Base clock) - 1455 MHz(Boost clock) - 850 MHz(Memory clock) - 1.7 Gbps(Memory Data Rate) - 4608K L2 cache - 12 nm - 250 W TDP

C) Why do we not have processors running at high speeds?

At present, the top speed hits some GHz around 10, which requires a sophisticated cooling equipment to cool down. A feasible clock speed is in the halves of 10 GHz. Many constraints come into play in deciding the attainable clock speed such as the transistor size(the smaller the transistors get, the more brittle they become and more electricity they leak making it impossible to drive them at high speed), heat that is going to be generated (the higher the clock speed of the processor, the more heat it generates, and this heat is deadly to the high-precision and high-speed silicon).

D) Describe Moore's Law. Is it going to go on forever?

Moore's law states that the number of transistors per chip doubles every year, as well as the speed of computing doubles every two years, while the cost halves. This was a prediction by

Gordon Moore in the year of 1965. As of 2018 the 14nm transistors are available, but looking into the future the moore's law would probably not be applicable since silicon transistors which are smaller than the current size become too small that the electrons experience Quantum tunneling through the transistor even when it's closed. Now that it has become difficult to roll out smaller transistors in the two year time frame, the Moore's law can be invalid in near future around 2025

6.

A) Why is threading useful on a single-core processor.

Multi-Threading can be implemented in single-core processor too. Consider an application that is GUI rich, and has to execute an excessive computation (let's say this takes 1 minute) and display the result on the GUI. If you use only a single thread, then GUI controls won't be responsive when the computation is going on. Here, if we implement the application with two threads, one for GUI rendering and one for computation, the user will be able to interact even when the computation is happening.

B) Do more threads always mean better performance?

NO, it depends.

Firstly, less number of threads does not totally utilize the cores, CPU does wait for the response of other operations, and take a long time to finish the job.

Later, more number of threads ends up in queuing which in turn costs time, also can bog down the program. A good solution is to limit the number of threads, which is called as thread optimization. With optimization, CPU and threads go hand in hand and maximum CPU time is utilized while it is on wait.

C) Is super-linear speedup possible? Explain why or why not.

Yes, super-linear speedup is possible. Consider a situation where the working set of the sequential program does not fit in the cache. Then there are an excessive number of cache misses. This results in an increase in the time since data has to be loaded from memory. However, depending on the program, when you run it in parallel(with two threads), the working set might fit in two caches and hence no cache misses may occur. Here, the serial execution time is more than 2 times the parallel execution time and here you get super linear speedup.

D) Why are locks needed in a multi-threaded program?

Race condition is a type of concurrency occurs on a parallel execution of a program by multiple threads. This occurs when multiple threads work on a single object without sync and the updation fails. For example, if thread A is trying to change a variable and is suspended for some

reason, and meanwhile if the thread B is updating the same variable results in a conflict. So, in order to avoid this, a lock on a variable for a thread completes the job without any interruption.

E)Would it make sense to limit the number of threads in a server process?

Yes, Because some amount memory will be allocated for the private stack on initiating a thread, So too many threads may utilize high memory which is not good for the server. Also, Independent threads to an operating system may not operate properly since it may result in page faults and thus I/O which leads to page thrashing and performance degradation.