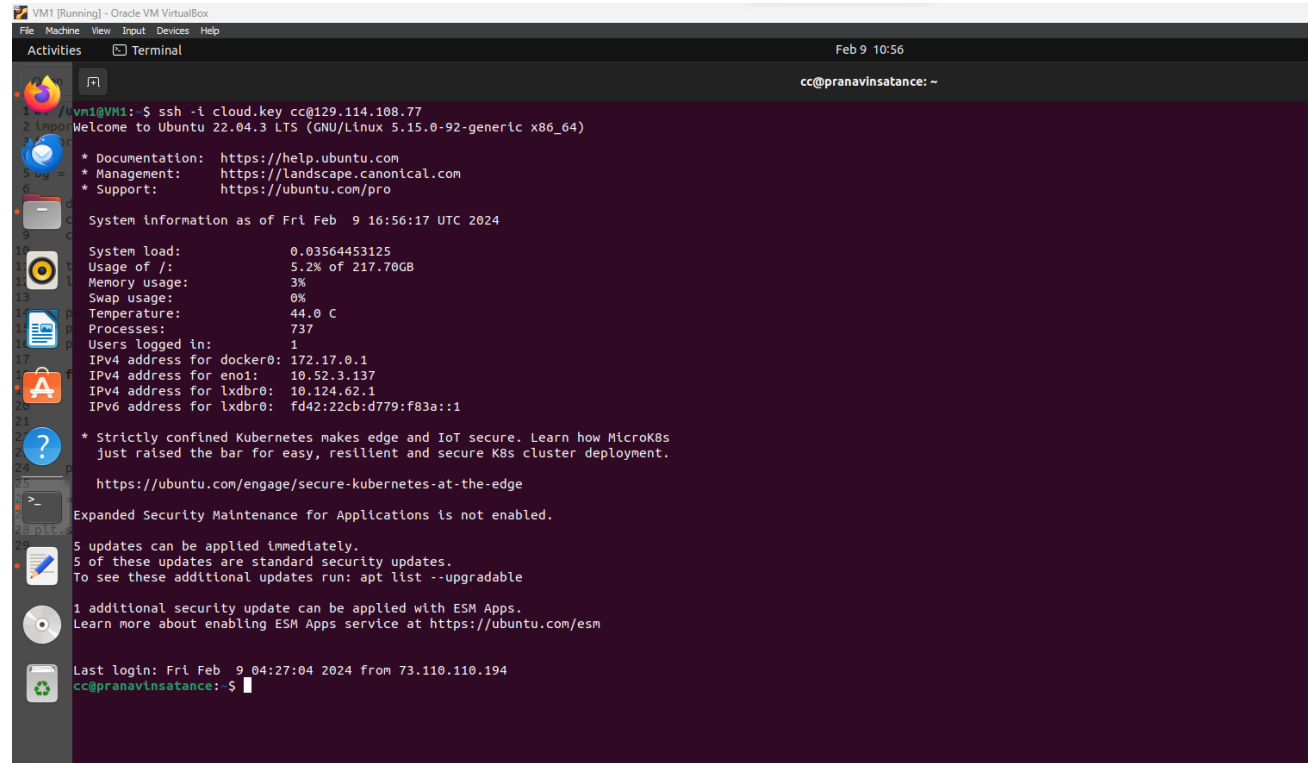


# ASSIGNMENT-2

**Pranav Murali**  
**A20555824**

## Cloud connection



```
VM1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Feb 9 10:56
cc@pranavinsatance: ~

1 /vm1@VM1: $ ssh -i cloud.key cc@129.114.108.77
2 Import Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-92-generic x86_64)

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

System information as of Fri Feb  9 16:56:17 UTC 2024

System load:          0.03564453125
Usage of /:            5.2% of 217.70GB
Memory usage:         3%
Swap usage:           0%
Temperature:          44.0 C
Processes:             737
Users logged in:       1
IPv4 address for docker0: 172.17.0.1
IPv4 address for eno1:    10.52.3.137
IPv4 address for lxdbr0:  10.124.62.1
IPv6 address for lxdbr0:  fd42:22cb:d779:f83a::1

* Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
  just raised the bar for easy, resilient and secure K8s cluster deployment.

https://ubuntu.com/engage/secure-kubernetes-at-the-edge

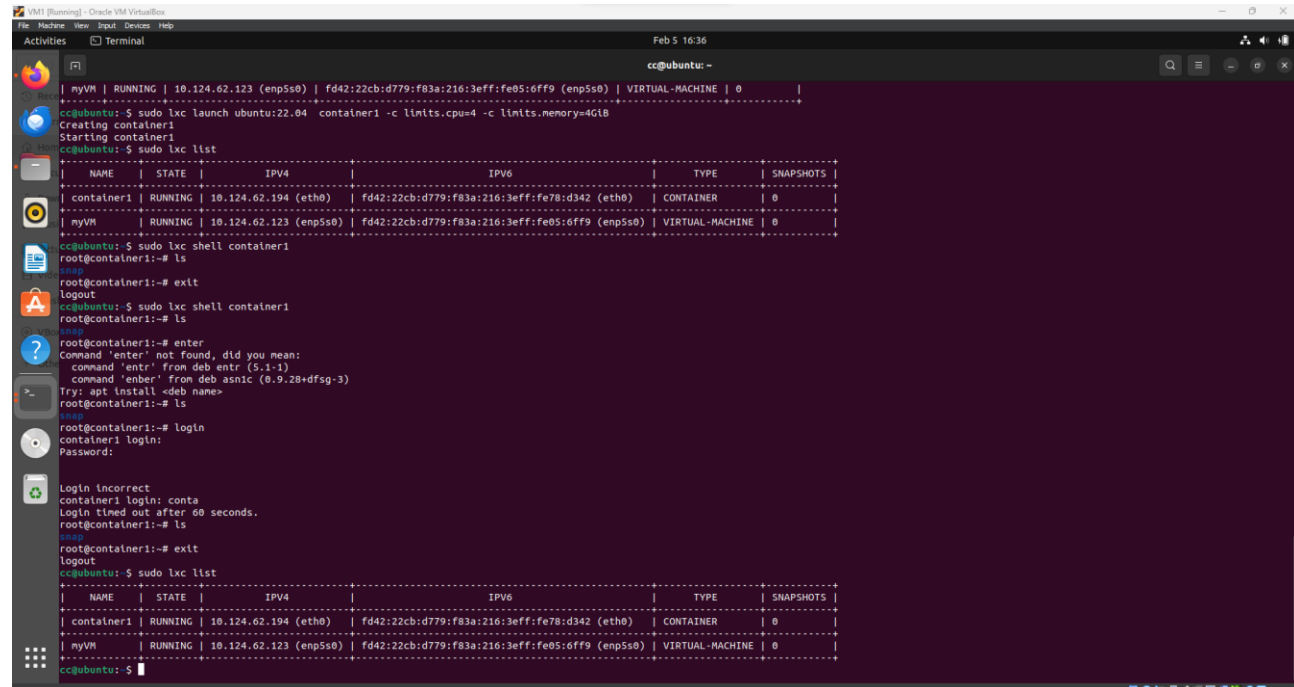
Expanded Security Maintenance for Applications is not enabled.

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

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

Last login: Fri Feb  9 04:27:04 2024 from 73.110.110.194
cc@pranavinsatance: $
```

## Container and VM created



```
VM1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities Terminal Feb 5 16:36
cc@ubuntu: ~

| myVM | RUNNING | 10.124.62.123 (enp5s0) | fd42:22cb:d779:f83a:216:3eff:fe05:6ff9 (enp5s0) | VIRTUAL-MACHINE | 0 |
+-----+-----+-----+-----+-----+-----+-----+
cc@ubuntu: $ sudo lxc launch ubuntu:22.04 container1 -c limits.cpu=4 -c limits.memory=4GiB
Creating container1
Starting container1
cc@ubuntu: $ sudo lxc list
+-----+-----+-----+-----+-----+-----+-----+
| NAME | STATE | IPV4 | IPV6 | TYPE | SNAPSHOTS |
+-----+-----+-----+-----+-----+-----+-----+
| container1 | RUNNING | 10.124.62.194 (eth0) | fd42:22cb:d779:f83a:216:3eff:fe78:d342 (eth0) | CONTAINER | 0 |
+-----+-----+-----+-----+-----+-----+-----+
| myVM | RUNNING | 10.124.62.123 (enp5s0) | fd42:22cb:d779:f83a:216:3eff:fe05:6ff9 (enp5s0) | VIRTUAL-MACHINE | 0 |
+-----+-----+-----+-----+-----+-----+-----+
cc@ubuntu: $ sudo lxc shell container1
root@container1:~# ls
snap
root@container1:~# exit
logout
cc@ubuntu: $ sudo lxc shell container1
root@container1:~# ls
snap
root@container1:~# enter
Command 'enter' not found, did you mean:
  command 'entr' from deb entr (5.1-1)
  command 'enber' from deb asnic (0.9.28+dfsg-3)
Try: apt install <deb name>
root@container1:~# ls
snap
root@container1:~# login
container1 login:
Password:
Login incorrect
container1 login: conta
Login timed out after 60 seconds.
root@container1:~# ls
snap
root@container1:~# exit
logout
cc@ubuntu: $ sudo lxc list
+-----+-----+-----+-----+-----+-----+-----+
| NAME | STATE | IPV4 | IPV6 | TYPE | SNAPSHOTS |
+-----+-----+-----+-----+-----+-----+-----+
| container1 | RUNNING | 10.124.62.194 (eth0) | fd42:22cb:d779:f83a:216:3eff:fe78:d342 (eth0) | CONTAINER | 0 |
+-----+-----+-----+-----+-----+-----+-----+
| myVM | RUNNING | 10.124.62.123 (enp5s0) | fd42:22cb:d779:f83a:216:3eff:fe05:6ff9 (enp5s0) | VIRTUAL-MACHINE | 0 |
+-----+-----+-----+-----+-----+-----+-----+
cc@ubuntu: $
```

## CPU:

- Strong scaling studies: Fixed prime numbers limit at 100,000. Then, measure the performance of each virtualization technologies when varying the number of threads.
- Sample command (you might need to use additional command line arguments):  
`$ sysbench cpu --cpu-max-prime=100000 --threads=1 run`
- Fill in the below using benchmark results of each scale regarding the processor performance:  
Note that the efficiency denotes a relative performance of a virtualization type vs. baremetal. EX:
  - Baremetal: 10 events per second
  - Container: 9 events per second
  - VM: 8 events per second

This translates to the efficiency of:

- Baremetal: 100%
- Container: 90% (Container is 10% slower than Baremetal)
- VM: 80% (VM is 20% slower than Baremetal)

Virtualization Type	Threads	Avg. Latency (ms)	Measured Throughput (Events per Second)	Efficiency
Baremetal	1	28.11	35.56	100
Container	1	28.26	35.37	99.47
Virtual Machine	1	28.37	35.23	99.07
Baremetal	2	28.12	71.06	100
Container	2	28.33	70.55	99.28
Virtual Machine	2	28.37	70.46	99.04
Baremetal	4	28.12	142.09	100
Container	4	30.38	131.19	92.33
Virtual Machine	4	28.30	141.28	99.34
Baremetal	8	28.09	284.27	100
Container	8	56.50	140.74	49.51
Virtual Machine	8	72.14	141.36	49.93
Baremetal	16	28.27	565.15	100
Container	16	112.09	141.44	25.03
Virtual Machine	16	112.29	141.84	25.13
Baremetal	32	31.92	1000.04	100
Container	32	222.57	141.43	14.14
Virtual Machine	32	223.62	141.77	14.20
Baremetal	64	48.48	1317.14	100
Container	64	439.57	141.66	10.76
Virtual Machine	64	442.07	142.09	10.70

```
cc@pranavinsatance:~$ sudo lxc shell container1
root@container1:~# nano networkcontainer.sh
root@container1:~# ./cpuctextcontainer.sh
Threads Avg. Latency (ms)      Measured Throughput (Events per Second)
1        28.26   35.37
2        28.33   70.55
4        30.38   131.19
8        56.50   140.74
16       112.09  141.44
32       222.57  141.43
64       439.57  141.66
root@container1:~#
```

```
cc@pranavinsatance: ~
cc@pranavinsatance:~$ ./cpuctestbare.sh
Threads Avg. Latency (ms)      Measured Throughput (Events per Second) Efficiency
1        28.11   35.56  100.00
2        28.12   71.06  100.00
4        28.12  142.09  100.00
8        28.09  284.27  100.00
16       28.27  565.15  100.00
32       31.92 1000.04  100.00
64       48.48 1317.14  100.00
cc@pranavinsatance:~$
```

```
root@myVM:~# nano cputestvm.sh
root@myVM:~# ./cputestvm.sh
Threads Avg. Latency (ms)      Measured Throughput (Events per Second)
1        28.37   35.23
2        28.37   70.46
4        28.30  141.28
16       112.29  141.84
32       223.62  141.77
64       442.07  142.09
root@myVM:~#
```

**Efficiency = (vm or container measured Throughput/baremetal measured Throughput)\*100**

## Memory:

- Strong scaling studies: Fixed total data size in memory at 120GB. Then, measure the performance of each virtualization technologies with the following specifications:
  - Block size: 1KB i.e.,  $2^{10}$  to  $2^{20}$  bytes
  - Operations: Read
  - Access pattern: Random
- Sample command:  
\$ sysbench memory --memory-block-size=1K --memory-total-size=120G --threads=1 run
- Fill in the below using benchmark results of each scale/type regarding the memory performance: Similar to efficiency example in CPU benchmark, the efficiency denotes a relative performance of a virtualization type vs. baremetal.

Virtualization Type	Threads	Block Size (KB)	Operation	Access Pattern	Total Operations	Throughput (MiB/sec)	Efficiency
Baremetal	1	1	Read	Random	47578731	4645.04	100
Container	1	1	Read	Random	41161665	4017.73	86.50
Virtual Machine	1	1	Read	Random	42375020	4136.19	89.05
Baremetal	2	1	Read	Random	62988787	6149.59	100
Container	2	1	Read	Random	59958945	5854.04	95.19
Virtual Machine	2	1	Read	Random	56073237	5473.29	89.00
Baremetal	4	1	Read	Random	61182239	5973.20	100
Container	4	1	Read	Random	33080994	3229.84	54.07
Virtual Machine	4	1	Read	Random	69210308	6757.30	113.13
Baremetal	8	1	Read	Random	41076365	4010.25	100
Container	8	1	Read	Random	32991963	3221.17	80.32
Virtual Machine	8	1	Read	Random	69360870	6772.17	168.87
Baremetal	16	1	Read	Random	39400751	3846.83	100
Container	16	1	Read	Random	32520912	3175.17	82.54
Virtual Machine	16	1	Read	Random	69620981	6797.54	176.70
Baremetal	32	1	Read	Random	52018301	5078.69	100
Container	32	1	Read	Random	32623170	3185.09	62.71
Virtual Machine	32	1	Read	Random	71327932	6964.11	137.12
Baremetal	64	1	Read	Random	70963582	6928.38	100
Container	64	1	Read	Random	33146373	3236.09	46.71
Virtual Machine	64	1	Read	Random	70046274	6838.87	98.71

```

cc@pranavinsatance:~$ ./networkbare.sh
Threads Total Operations      Throughput (MiB/sec)
1         47578731          4645.04
2         62988787          6149.59
4         61182239          5973.20
8         41076365          4010.25
16        39400751          3846.83
32        52018301          5078.69
64        70963582          6928.38
cc@pranavinsatance:~$ nano networkbare.sh
cc@pranavinsatance:~$ sudo lxc shell myVM
root@myVM:~# nano networkvm.sh
root@myVM:~# ./networkvm.sh
-bash: ./networkvm.sh: Permission denied
root@myVM:~# chmod u+x networkvm.sh
root@myVM:~# ./networkvm.sh
Threads Total Operations      Throughput (MiB/sec)
1         42375020          4136.19
2         56073237          5473.29
4         69210308          6757.30
8         69360870          6772.17
16        69620981          6797.54
32        71327932          6964.11
64        70046274          6838.87
root@myVM:~# exit
logout
cc@pranavinsatance:~$ sudo lxc shell container
Error: Instance not found
cc@pranavinsatance:~$ sudo lxc shell container1
root@container1:~# nano networkcontainer.sh
root@container1:~# ./networkcontainer.sh
-bash: ./networkcontainer.sh: Permission denied
root@container1:~# chmod u+x networkcontainer.sh
root@container1:~# ./networkcontainer.sh
Threads Total Operations      Throughput (MiB/sec)
1         41161665          4017.73
2         59958945          5854.04
4         33080994          3229.84
8         32991963          3221.17
16        32520912          3175.17
32        32623170          3185.09
64        33146373          3236.09
root@container1:~# exit
logout

```

## Disk:

- Strong scaling studies: Fixed total data size on disk at 120GB. Then, measure the performance of each virtualization technologies with the following specifications:
  - Number of files: 128
  - File block size: 4,096 bytes
  - Total file size: 120GB
  - Test mode: Random Read
  - IO Mode: Synchronous
  - Extra IO flag: DirectIO
- Sample commands:  

```
$ sysbench fileio --file-num=128 --file-block-size=4096 --file-total-size=120G --file-test-mode=rndrd --file-io-mode=sync --file-extra-flags=direct --threads=1 <prepare/run/cleanup>
```
- Fill in the below using benchmark results of each scale/type regarding the I/O performance:
- Similar to efficiency example in CPU benchmark, the efficiency denotes a relative performance of a virtualization type vs. baremetal.

Virtualization Type	Threads	Block Size (KB)	Operation	Access Pattern	I/O Mode	I/O Flag	Total Operations	Measured Throughput (MiB/s)	Efficiency
Baremetal	1	4	Read	Random	SYNC	DirectIO			
Container	1	4	Read	Random	SYNC	DirectIO	381570		
Virtual Machine	1	4	Read	Random	SYNC	DirectIO			
Baremetal	2	4	Read	Random	SYNC	DirectIO			
Container	2	4	Read	Random	SYNC	DirectIO	737237		
Virtual Machine	2	4	Read	Random	SYNC	DirectIO			
Baremetal	4	4	Read	Random	SYNC	DirectIO			
Container	4	4	Read	Random	SYNC	DirectIO	1315837		
Virtual Machine	4	4	Read	Random	SYNC	DirectIO			
Baremetal	8	4	Read	Random	SYNC	DirectIO			
Container	8	4	Read	Random	SYNC	DirectIO	1306997		
Virtual Machine	8	4	Read	Random	SYNC	DirectIO			
Baremetal	16	4	Read	Random	SYNC	DirectIO			
Container	16	4	Read	Random	SYNC	DirectIO	1300893		
Virtual Machine	16	4	Read	Random	SYNC	DirectIO			
Baremetal	32	4	Read	Random	SYNC	DirectIO			
Container	32	4	Read	Random	SYNC	DirectIO	1295967		
Virtual Machine	32	4	Read	Random	SYNC	DirectIO			
Baremetal	64	4	Read	Random	SYNC	DirectIO			
Container	64	4	Read	Random	SYNC	DirectIO	1304732		
Virtual Machine	64	4	Read	Random	SYNC	DirectIO			

```
cc@pranavinsatance:~$ sudo lxc shell container1
root@container1:~# nano 3.sh
root@container1:~# ./3.sh
Threads: 1 | Total Operations:  | Measured Throughput:
Threads: 1 | Total Operations: 381570 | Measured Throughput:
Threads: 2 | Total Operations: 737237 | Measured Throughput:
Threads: 4 | Total Operations: 1315837 | Measured Throughput:
Threads: 8 | Total Operations: 1306997 | Measured Throughput:
Threads: 16 | Total Operations: 1300893 | Measured Throughput:
Threads: 32 | Total Operations: 1295967 | Measured Throughput:
Threads: 64 | Total Operations: 1304732 | Measured Throughput:
Threads: 1 | Total Operations:  | Measured Throughput:
```

## Network:

- Strong scaling studies using one server vs.  $N$  number of clients. Measure the performance of each virtualization technologies with the following specifications:
  - a. Server TCP window size: 1MB
  - b. Client TCP write buffer size: 8,192KB
  - c. Client TCP window size: 2.5MB
  - d. Naggle algorithm: Off
- The configuration of client/server should communicate using TCP over local loopback.
- Sample commands:

```
$ iperf -s -w 1M
```

```
$ iperf -c 127.0.0.1 -e -i 1 --nodelay -l 8192K --trip-times --parallel 1
```
- Fill in the below using benchmark results of each scale/type regarding the I/O performance:
- Similar to efficiency example in CPU benchmark, the efficiency denotes a relative performance of a virtualization type vs. baremetal.

Virtualization Type	Server	Client Threads	Latency (ms)	Measured Throughput (Gbits/s)	Efficiency
Baremetal	1	1	1.910	46.3	
Container	1	1	2.037	42.7	
Virtual Machine	1	1	2.137	40.1	
Baremetal	1	2	2.110	41.5	
Container	1	2	2.055	41.2	
Virtual Machine	1	2	2.035	42.8	
Baremetal	1	4	2.133	40.8	
Container	1	4	3.727	23.5	
Virtual Machine	1	4	1.809	43.5	
Baremetal	1	8	2.656	32.4	
Container	1	8	4.549	14.9	
Virtual Machine	1	8	3.717	18.9	
Baremetal	1	16	3.241	26.7	
Container	1	16	10.28	6.45	
Virtual Machine	1	16	7.763	9.03	
Baremetal	1	32	5.571	15.9	
Container	1	32	17.765	4.9	
Virtual Machine	1	32	15.800	4.95	
Baremetal	1	64	7.437	13.3	
Container	1	64	22.657	3.06	
Virtual Machine	1	64	37.145	1.66	



## System used

Chameleon Instance: compute\_haswell\_ib at CHI@NACC

o CPU: 2x Intel® Xeon® E5-2670 v3 @2.30GHz

o Memory: 8x 16GB (128GB) of DDR4-2,133 ECC Registered RAM

o Disk: 1x Seagate ST9250610NS SATA 7,200 RPM HDD

o Network: Broadcom NetXtreme II BCM57800 1/10 Gigabit Ethernet

## Hardware Discovery

Check the availability calendar at each site for details on when resources are available for reservation.

CHI@TACC [↗](#)

CHI@UC [↗](#)

CHI@NU [↗](#)

CHI@NCAR [↗](#)

CHI@EVL [↗](#)

CHI@IIT [↗](#)

## Resource Browser

Applied Filters: compute\_haswell\_ib ✕ tacc ✕ x86\_64 ✕ CPUS: 2 ✕ Threads: 48 ✕ RAM: 128 GiB ✕  
otherDescription: Intel(R) Xeon(R) CPU E5-2670 v3 @ 2.30GHz ✕