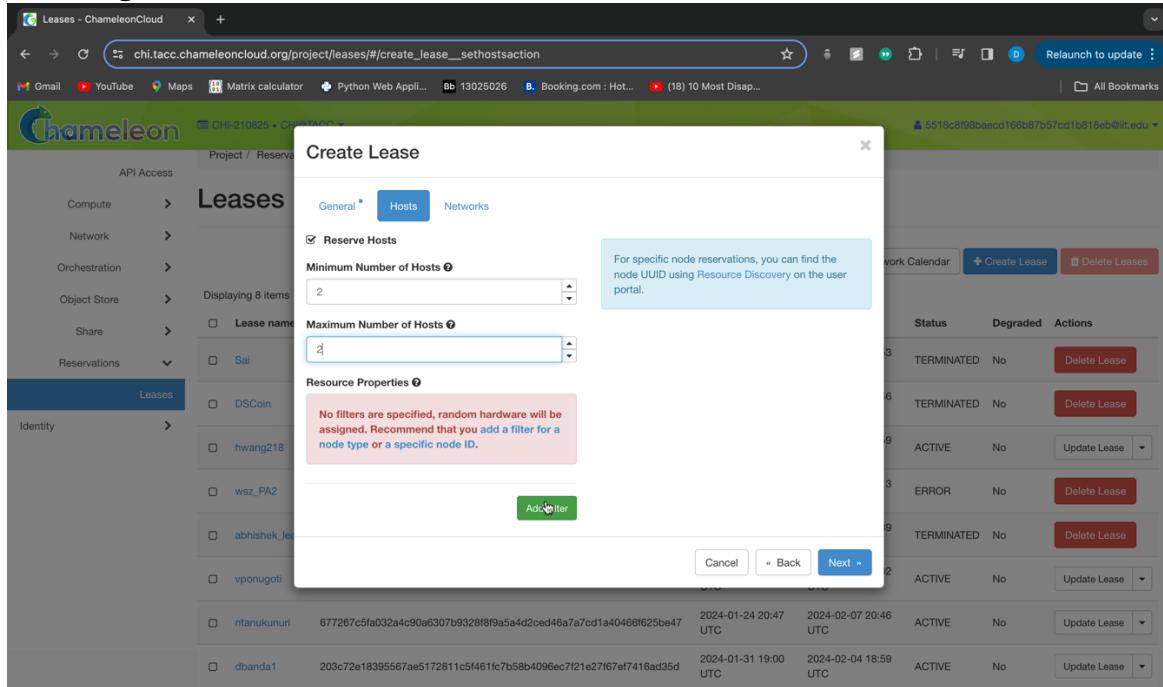


# CS 553 – Assignment 2

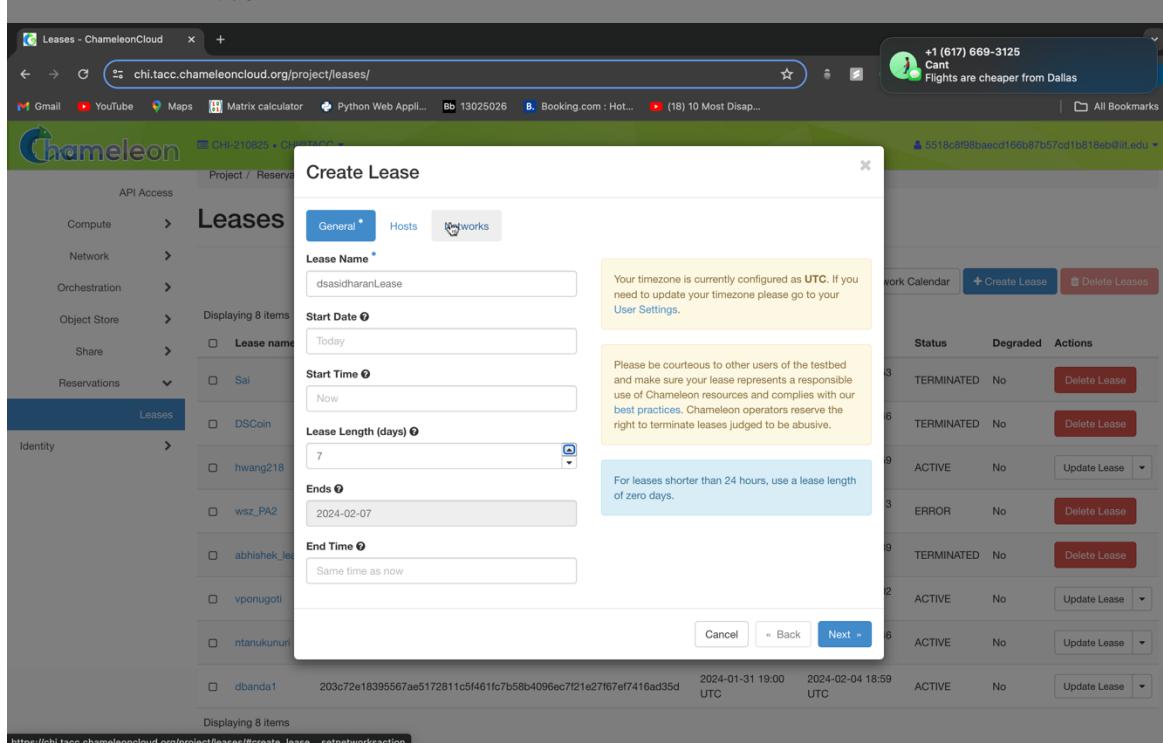
## Creating A Chameleon Virtual Instance

### Creating a Lease



The screenshot shows the 'Create Lease' dialog box in the 'Hosts' tab. The 'General' tab is selected. Under 'Hosts', the 'Reserve Hosts' checkbox is checked, and the 'Minimum Number of Hosts' is set to 2. A note says: 'For specific node reservations, you can find the node UUID using Resource Discovery on the user portal.' The 'Maximum Number of Hosts' is set to 2. A note below says: 'No filters are specified, random hardware will be assigned. Recommend that you add a filter for a node type or a specific node ID.' A green 'Add another' button is present. At the bottom are 'Cancel', 'Back', and 'Next >' buttons.

Lease Name	Start Date	End Date	Status	Actions
dsasidharanLease	2024-01-24 20:47 UTC	2024-02-07 20:46 UTC	ACTIVE	Update Lease
ntanukunuri	2024-01-31 19:00 UTC	2024-02-04 18:59 UTC	ACTIVE	Update Lease
dbanda1	2024-01-31 19:00 UTC	2024-02-04 18:59 UTC	ACTIVE	Update Lease

The screenshot shows the 'Create Lease' dialog box in the 'Networks' tab. The 'General' tab is selected. The 'Lease Name' is 'dsasidharanLease'. A note says: 'Your timezone is currently configured as UTC. If you need to update your timezone please go to your User Settings.' The 'Start Date' is 'Today', 'Start Time' is 'Now', 'Lease Length (days)' is '7', and 'Ends' is '2024-02-07'. A note says: 'Please be courteous to other users of the testbed and make sure your lease represents a responsible use of Chameleon resources and complies with our best practices. Chameleon operators reserve the right to terminate leases judged to be abusive.' The 'End Time' is 'Same time as now'. At the bottom are 'Cancel', 'Back', and 'Next >' buttons.

Lease Name	Start Date	End Date	Status	Actions
dsasidharanLease	Today	2024-02-07	ACTIVE	Update Lease
ntanukunuri	2024-01-31	2024-02-04	ACTIVE	Update Lease
dbanda1	2024-01-31	2024-02-04	ACTIVE	Update Lease

## Instance Creation

Instances - ChameleonCloud

chi.tacc.chameleoncloud.org/project/instances/

Relaunch to update

Launch Instance

Project API Access Compute Instances

Source Networks Network Ports Key Pair

Details

Source

Launch Instance Delete Instance

Allocated

Displaying 1 item

Name	Chameleon Supported	Updated	Size	Format
CC-Ubuntu22.04-20230301	Yes	11/15/23 10:21 PM	1.73 GB	QCOW2

Available (430)

Select one

Displaying 7 items

Name	Chameleon Supported	Updated	Size	Format
CC-Ubuntu22.04	No	1/29/24 8:19 PM	1.56 GB	QCOW2
CC-Ubuntu22.04-20231115	No	1/29/24 8:18 PM	1.73 GB	QCOW2
CC-Ubuntu22.04-ARM64	Yes	5/18/23 8:51 PM	1.69 GB	QCOW2
CC-Ubuntu22.04-CUDA	No	1/29/24 8:18 PM	6.20 GB	QCOW2

Task Power State Age

None Running 1 hour, 36 minutes

None Running 1 day, 22 hours

None Running 6 days, 23 hours

None Running 6 days, 23 hours

Instances - ChameleonCloud

chi.tacc.chameleoncloud.org/project/instances/

Relaunch to update

Launch Instance Delete Instance

Import Key Pair

Project API Access Compute Instances

Source Networks Network Ports Key Pair

Details

Key Pair Name \*

Key Type \*

SSH Key

Choose File No file chosen

Load Public Key from a file

Public Key \* (Modified)

Content size: 591 bytes of 16.00 KB

```
ssh-rsa
AAAAE3NzaC1yc2EAAAQABAAABgQCIIHBXFgJhbXpdoeyCSo4k[...]
```

Cancel Import Key Pair

Set admin password

Cancel Show Advanced

Launch Instance

ntanuku 22.04-202301301

ubuntu 10.52.3.15, 129.114.108.155

baremetal 677267c5fa032a4c90a6307b9328f8f9a5e4d2ced46a7a7cd1a40466f625be47

nishitha Active

None Running 6 days, 23 hours

## Floating IP Created

Instance Name	Image Name	IP Address	Flavor	Created By	Key Pair	Status	Task	Power State	Age	Actions
dsasidharan_instance_1	CC-U buntu	10.52.2.189	baremetal	07784a8718d7cbfcf745948885eb9ec85df8a9f0beead572557ebe295942d585	DToC	Build	Spawning	No State	0 minutes	<button>Edit Instance</button>
129.114.108.11	dsasidharanIP	dsasidharan_instance_1 10.52.2.189				public	Active			<button>Disassociate</button>
Instance Name	Image Name	IP Address	Flavor	Created By	Key Pair	Status	Task	Power State	Age	Actions
dsasidharan_instance_1	CC-U buntu	10.52.2.189, 129.114.108.11	baremetal	07784a8718d7cbfcf745948885eb9ec85df8a9f0beead572557ebe295942d585	DToC	Build	Spawning	No State		

Connecting to the Instance from the terminal and setting up first time steups

```
[(base) darshannair@Darshans-MacBook-Pro ~ % ssh cc@129.114.108.11
The authenticity of host '129.114.108.11 (129.114.108.11)' can't be established.
ED25519 key fingerprint is SHA256:HzRzHKgfHg+apJKgmfKgGIkDldYYe/giJp46tsEpclg.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '129.114.108.11' (ED25519) to the list of known hosts.
Welcome to Ubuntu 22.04.2 LTS (GNU/Linux 5.15.0-60-generic x86_64)

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

 System information as of Wed Jan 31 22:50:04 UTC 2024

 System load:  0.0          Temperature:          56.0  C
 Usage of /:   1.0% of 418.61GB  Processes:            1381
 Memory usage: 0%          Users logged in:      1
 Swap usage:   0%          IPv4 address for enp152s0np0: 10.52.2.189

 * Introducing Expanded Security Maintenance for Applications.
   Receive updates to over 25,000 software packages with your
   Ubuntu Pro subscription. Free for personal use.

   https://ubuntu.com/pro

 Expanded Security Maintenance for Applications is not enabled.

 0 updates can be applied immediately.

 Enable ESM Apps to receive additional future security updates.
 See https://ubuntu.com/esm or run: sudo pro status

 The list of available updates is more than a week old.
 To check for new updates run: sudo apt update

 Last login: Wed Jan 31 21:07:23 2024
 cc@ubuntu:~$ █

Last login: Wed Jan 31 21:07:23 2024
cc@ubuntu:~$ sudo apt update && sudo apt upgrade -y█
```

```
[cc@ubuntu:~$ sudo lxd init
[Would you like to use LXD clustering? (yes/no) [default=no]:
[Do you want to configure a new storage pool? (yes/no) [default=yes]:
[Name of the new storage pool [default=default]:
[Name of the storage backend to use (cephobject, dir, lvm, zfs, btrfs, ceph) [default=zfs]:
[Create a new ZFS pool? (yes/no) [default=yes]:
[Would you like to use an existing empty block device (e.g. a disk or partition)? (yes/no) [default=no]:
[Size in GiB of the new loop device (1GiB minimum) [default=30GiB]: 150GiB
[Would you like to connect to a MAAS server? (yes/no) [default=no]:
[Would you like to create a new local network bridge? (yes/no) [default=yes]:
[What should the new bridge be called? [default=lxdbr0]:
[What IPv4 address should be used? (CIDR subnet notation, "auto" or "none") [default=auto]:
[What IPv6 address should be used? (CIDR subnet notation, "auto" or "none") [default=auto]:
[Would you like the LXD server to be available over the network? (yes/no) [default=no]:
[Would you like stale cached images to be updated automatically? (yes/no) [default=yes]:
[Would you like a YAML "lxd init" preseed to be printed? (yes/no) [default=no]:
cc@ubuntu:~$ ]
```

### *Adding Network Rules*

```
[cc@ubuntu:~$ sudo ufw allow in on lxdbr0
Rule added
Rule added (v6)
[cc@ubuntu:~$ sudo ufw route allow in on lxdbr0
Rule added
Rule added (v6)
[cc@ubuntu:~$ sudo ufw route allow out on lxdbr0
Rule added
Rule added (v6)
cc@ubuntu:~$ ]
```

*I lost the above instance as I forgot to renew my lease so I followed the exact same steps as the above to create a new instance on the UC server*

### *Creating a VM within the instance (Just to show working, has been automated)*

```
[cc@ubuntu:~$ sudo lxc launch ubuntu:22.04 dsasiharanVM --vm -c limits.cpu=4 -c limits.memory=4GiB
Creating dsasiharanVM
Starting dsasiharanVM
[cc@ubuntu:~$ sudo lxc shell dsasiharanVM
Error: Instance not found
[cc@ubuntu:~$ sudo lxc shell dsasiharanVM
[root@dsasiharanVM:~# ls
snap
[root@dsasiharanVM:~# exit
logout
cc@ubuntu:~$ ]
```

### *Creating a Container within the instance (Just to show working, has been automated)*

```
[cc@ubuntu:~$ sudo lxc launch ubuntu:22.04 dsasiharanC1 -c limits.cpu=4 -c limits.memory=4GiB
Creating dsasiharanC1
Starting dsasiharanC1
[cc@ubuntu:~$ sudo lxc list
+---+ +---+ +---+ +---+ +---+ +---+ +---+
| NAME | STATE | IPV4 | | IPV6 | | TYPE | SNAPSHOTS |
+---+ +---+ +---+ +---+ +---+ +---+ +---+
| dsasiharanC1 | RUNNING | 10.158.128.23 (eth0) | fd42:7ca4:3352:e14b:216:3eff:fc12:27dc (eth0) | CONTAINER | 0 |
+---+ +---+ +---+ +---+ +---+ +---+ +---+
| dsasiharanVM | RUNNING | 10.158.128.68 (enp5s0) | fd42:7ca4:3352:e14b:216:3eff:fefb:fb1d (enp5s0) | VIRTUAL-MACHINE | 0 |
+---+ +---+ +---+ +---+ +---+ +---+ +---+
cc@ubuntu:~$ ]
```

*Downloading packages (Just to show working, has been automated)*

```
cc@dsasidharan-instance:~$ sudo apt install sysbench
cc@dsasidharan-instance:~$ sudo apt install iperf
```

*Connecting to Vm from Baremetal (Just to show working, has been automated)*

```
[cc@dsasidharan-instance:~$ ssh root@10.158.128.68
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-1049-kvm x86_64)

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

 System information as of Thu Feb  1 20:33:44 UTC 2024

 System load:          0.0
 Usage of /:           16.2% of 9.51GB
 Memory usage:         4%
 Swap usage:           0%
 Processes:            107
 Users logged in:     0
 IPv4 address for enp5s0: 10.158.128.68
 IPv6 address for enp5s0: fd42:7ca4:3352:e14b:216:3eff:febf:fb1d

 * 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.

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

 Enable ESM Apps to receive additional future security updates.
 See https://ubuntu.com/esm or run: sudo pro status

Last login: Thu Feb  1 20:31:40 2024 from 10.158.128.1
root@dsasiharanVM:~# █
```

*Connecting to Container from Baremetal (Just to show working, has been automated)*

```

connection to 10.158.128.23 closed by local host.
[cc@dsasidharan-instance:~$ sudo lxc list
+-----+-----+-----+-----+-----+-----+-----+
| NAME | STATE | IPV4 | IPV6 | TYPE | SNAPSHTS |
+-----+-----+-----+-----+-----+-----+
| dsasidharanC1 | RUNNING | 10.158.128.23 (eth0) | fd42:7ca4:3352:e14b:216:3eff:fe12:27dc (eth0) | CONTAINER | 0 |
+-----+-----+-----+-----+-----+-----+
| dsasidharanVM | RUNNING | 10.158.128.68 (enp5s0) | fd42:7ca4:3352:e14b:216:3eff:febf:fb1d (enp5s0) | VIRTUAL-MACHINE | 0 |
+-----+-----+-----+-----+-----+-----+
[cc@dsasidharan-instance:~$ ssh root@10.158.128.23
The authenticity of host '10.158.128.23 (10.158.128.23)' can't be established.
ED25519 key fingerprint is SHA256:R+f8s8246faRQ+J9U9Kbsx9pRl8VuI3j7gmDjEtJGE4.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '10.158.128.23' (ED25519) to the list of known hosts.
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 Thu Feb  1 20:34:16 UTC 2024

 System load:          0.06884765625
 Usage of /home:        unknown
 Memory usage:         3%
 Swap usage:           0%
 Temperature:          52.0  C
 Processes:             25
 Users logged in:      0
 IPv4 address for eth0: 10.158.128.23
 IPv6 address for eth0: fd42:7ca4:3352:e14b:216:3eff:fe12:27dc

 * 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.

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

 Enable ESM Apps to receive additional future security updates.
 See https://ubuntu.com/esm or run: sudo pro status

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

root@dsasidharanC1:~# 
```

## INSTANCE SPECIFICATIONS

Chameleon Instance: compute\_haswell at CHI@UC

CPU: Intel(R) Xeon(R) Gold 6240R CPU @ 2.40GHz

Memory: 12x DIMM DDR4 Synchronous Registered (Buffered) 3200 MHz (0.3 ns)

HMA82GR7CJR8N-XN 16GiB size 3200MHz (0.3ns) clock

Disk: ATA Disk SSDSC2KB480G8R DL69 447GiB Solid State Device

Network: MT27710 Family Mellanox Technologies 25Gbit/s capacity 33MHz clock Ethernet

```
ccddasidharan-Instance:~$ lscpu
Architecture:          x86_64
CPU op-mode(s):        32-bit, 64-bit
Address sizes:         46 bits physical, 48 bits virtual
Byte Order:            Little Endian
CPU(s):                96
Online CPU(s) list:   0-95
Vendor ID:             GenuineIntel
Model name:            Intel(R) Xeon(R) Gold 6240R CPU @ 2.40GHz
CPU family:            6
Model:                 85
Threads(s) per core:  2
Core(s) per socket:   24
Socket(s):             2
Stepping:              7
CPU MHz:               4800.0000
CPU min MHz:          1000.0000
BogoMIPS:              4800.00
Flags:                 fpusse dts mmx sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp lm constant_tsc art arch_perfmon pebs bts rep_good nopl xtprology nonstop_tsc cpuid saperfmpf pmiclmu1dq dts64 monitor ds_cpl vmx smx est tm2 ssse3 sdbg fma cx16 pdcm pcid dca ssse4_1 ssse4_2 x2apic popcnt tsc_descend_timer aes aes_xavf f16c rdrand lahf_lm abm 3dnowprefetch cpuid_fault epb cat_13 cdp_13 invpcid_single intel_ppin ssbd mba ibrs ibpb stibp ibrs_enhanced hadow vmmn flexpriority ept vpid ept_ad fsgsbase tsc_a_djust bmi1 avx2 smp bni2 ems invpcid cmq mpn rdt_a avx512f avx512dq rdseed adx smp cflushtop clwb intel_pt avx512cd a2b4avx512vl xsaveopt xsavexc xgetbvl xsavexc cqm_llc cqm_occup_llc cqm_mbm_total cqm_mbm_local dtherm ida arat pln pts pku ospkc avx512_vnni md_clear flush_llid arch_capabilities
Virtualization features:
Virtualization:        VT-x
Caches (sum of all):
  L1d:                 1.5 MiB (48 instances)
  L1i:                 1.5 MiB (48 instances)
  L2:                  48 MiB (48 instances)
  L3:                  71.5 MiB (2 instances)
NUMA:
  NUMA node(s):        2
  NUMA node0 CPU(s):   0,2,4,6,8,10,12,14,16,18,20,22,24,26,28,30,32,34,36,38,40,42,44,46,48,50,52,54,56,58,60,62,64,66,68,70,72,74,76,78,80,82,84,86,88,90,92,94
  NUMA node1 CPU(s):   1,3,5,7,9,11,13,15,17,19,21,23,25,27,29,31,33,35,37,39,41,43,45,47,49,51,53,55,57,59,61,63,65,67,69,71,73,75,77,79,81,83,85,87,89,91,93,95
Vulnerabilities:
  Gather data sampling: Mitigation: Microcode
  Itlb multihit:        KVM: Mitigation: Split huge pages
  L1tf:                 Not affected
  Mds:                  Not affected
  Meltdown:             Not affected
  Msr stale data:       Mitigation: Clear CPU buffers; SMT vulnerable
  Retbleed:              Mitigation: Enhanced IBRS
  Spec rstack overflow: Not affected
  Spec store bypass:    Mitigation: Speculative Store Bypass disabled via prctl and seccomp
  Spectre v1:            Mitigation: usercopy/swaps barriers and __user pointer sanitization
  Spectre v2:            Mitigation: Enhanced IBRS, IBPB conditional, RSB filling, PBRBS-EIBRS SW sequence
  Srbds:                 Not affected
  Tx sync abort:         Mitigation: TSX disabled
ccddasidharan-Instance:~$ 
```

```
*-network:0
  description: Ethernet interface
  product: MT27710 Family [ConnectX-4 Lx]
  vendor: Mellanox Technologies
  physical id: 0
  bus info: pci@0000:19:00.0
  logical name: eno1np0
  version: 00
  serial: 0b:ce:f6:43:4f:c6
  capacity: 250bit/s
  width: 64 bits
  clock: 33MHz
  capabilities: pclexpress vpd msix pm bus_master cap_list rom ethernet physical 1000bt-fd 1000bt-fd 2500bt-fd autonegotiation
  configuration: autonegotiation=on broadcast=yes driver=mlx5_core driverversion=5.15.0-94-generic duplex=full firmware=14.28.4512 (DEL2810000034) latency=0 link=yes multicast=yes
  resources: irq:37 memory:a0000000-1fffffff memory:9d800000-9d8fffff
```

```
/dev/sda:  
  
ATA device, with non-removable media  
  Model Number:        SSDSC2KB480G8R  
  Serial Number:      BTYF113100LS480BGN  
  Firmware Revision:  XCV1DL69  
  Media Serial Num:  
  Media Manufacturer:  
  Transport:          Serial, ATA8-AST, SATA 1.0a, SATA II Extensions, SATA Rev 2.5, SATA Rev 2.6, SATA Rev 3.0  
Standards:  
  Used: unknown (minor revision code 0x006d)  
  Supported: 10 9 8 7 6 5  
  Likely used: 10  
Configuration:  
  Logical      max      current  
  cylinders    16383    0  
  heads        16       0  
  sectors/track 63       0  
 --  
  LBA    user addressable sectors:  268435455  
  LBA48  user addressable sectors:  937703088  
  Logical  Sector size:            512 bytes  
  Physical Sector size:          4096 bytes  
  Logical Sector-0 offset:       0 bytes  
  device size with M = 1024*1024: 457862 MBytes  
  device size with M = 1000*1000:  480103 MBytes (480 GB)  
  cache/buffer size = unknown  
  Form Factor: 2.5 inch  
  Nominal Media Rotation Rate: Solid State Device
```

### *Benchmarks (Completely Automated)*

*Below shown graphs and tables are present in the github as well*

# CPU Benchmark

## For Bare Metal

```
echo '' >> 'cpu_eval_b_1.txt';echo 'CPU EVAL FOR THREAD COUNT 1' >> 'cpu_eval_b_1.txt';echo '' >> 'cpu_eval_b_1.txt'; sysbench cpu --cpu-max-prime=100000 --threads=1 run >> 'cpu_eval_b_1.txt'
echo '' >> 'cpu_eval_b_2.txt';echo 'CPU EVAL FOR THREAD COUNT 2' >> 'cpu_eval_b_2.txt';echo '' >> 'cpu_eval_b_2.txt'; sysbench cpu --cpu-max-prime=100000 --threads=2 run >> 'cpu_eval_b_2.txt'
echo '' >> 'cpu_eval_b_4.txt';echo 'CPU EVAL FOR THREAD COUNT 4' >> 'cpu_eval_b_4.txt';echo '' >> 'cpu_eval_b_4.txt'; sysbench cpu --cpu-max-prime=100000 --threads=4 run >> 'cpu_eval_b_4.txt'
echo '' >> 'cpu_eval_b_8.txt';echo 'CPU EVAL FOR THREAD COUNT 8' >> 'cpu_eval_b_8.txt';echo '' >> 'cpu_eval_b_8.txt'; sysbench cpu --cpu-max-prime=100000 --threads=8 run >> 'cpu_eval_b_8.txt'
echo '' >> 'cpu_eval_b_16.txt';echo 'CPU EVAL FOR THREAD COUNT 16' >> 'cpu_eval_b_16.txt';echo '' >> 'cpu_eval_b_16.txt'; sysbench cpu --cpu-max-prime=100000 --threads=16 run >> 'cpu_eval_b_16.txt'
echo '' >> 'cpu_eval_b_32.txt';echo 'CPU EVAL FOR THREAD COUNT 32' >> 'cpu_eval_b_32.txt';echo '' >> 'cpu_eval_b_32.txt'; sysbench cpu --cpu-max-prime=100000 --threads=32 run >> 'cpu_eval_b_32.txt'
echo '' >> 'cpu_eval_b_64.txt';echo 'CPU EVAL FOR THREAD COUNT 64' >> 'cpu_eval_b_64.txt';echo '' >> 'cpu_eval_b_64.txt'; sysbench cpu --cpu-max-prime=100000 --threads=64 run >> 'cpu_eval_b_64.txt'
exit
ccddasidharan-instance:~$ echo '' >> 'cpu_eval_b_1.txt';echo 'CPU EVAL FOR THREAD COUNT 1' >> 'cpu_eval_b_1.txt';echo '' >> 'cpu_eval_b_1.txt'; sysbench cpu --cpu-max-prime=100000 --threads=1 run >> 'cpu_eval_b_1.txt'
ccddasidharan-instance:~$ echo '' >> 'cpu_eval_b_2.txt';echo 'CPU EVAL FOR THREAD COUNT 2' >> 'cpu_eval_b_2.txt';echo '' >> 'cpu_eval_b_2.txt'; sysbench cpu --cpu-max-prime=100000 --threads=2 run >> 'cpu_eval_b_2.txt'
ccddasidharan-instance:~$ echo '' >> 'cpu_eval_b_4.txt';echo 'CPU EVAL FOR THREAD COUNT 4' >> 'cpu_eval_b_4.txt';echo '' >> 'cpu_eval_b_4.txt'; sysbench cpu --cpu-max-prime=100000 --threads=4 run >> 'cpu_eval_b_4.txt'
ccddasidharan-instance:~$ echo '' >> 'cpu_eval_b_8.txt';echo 'CPU EVAL FOR THREAD COUNT 8' >> 'cpu_eval_b_8.txt';echo '' >> 'cpu_eval_b_8.txt'; sysbench cpu --cpu-max-prime=100000 --threads=8 run >> 'cpu_eval_b_8.txt'
```

Similar Output for all the baremetal threads

## For VM

```
ep 15: sudo lxc exec THREADVM-2 -- bash -c 'echo "THREADVM-2 has been initialized with 2 cores" >> "VM.txt"'; sleep 2; sudo lxc exec THREADVM-2 -- bash -c 'sudo apt update; sudo apt install -y sysbench'; lxc exec THREADVM-2 -- bash -c 'sysbench cpu --cpu-max-prime=100000 --threads=2 run' >> 'cpu_eval_v_2.txt'; sudo lxc stop 'THREADVM-2' && sudo lxc delete 'THREADVM-2'; exit
ccddasidharan-instance:~$ echo '' >> 'cpu_eval_v_2.txt';echo 'CPU EVAL FOR THREAD COUNT 2' >> 'cpu_eval_v_2.txt';echo '' >> 'cpu_eval_v_2.txt'; sudo lxc launch ubuntu:22.04 'THREADVM-2' -- vm -c limits.2 -c limits.memory=4GiB; sleep 15; sudo lxc exec THREADVM-2 -- bash -c 'echo "THREADVM-2 has been initialized with 2 cores" >> "VM.txt"'; sleep 2; sudo lxc exec THREADVM-2 -- bash -c 'sudo apt update; sudo install -y sysbench'; sudo lxc exec THREADVM-2 -- bash -c 'sysbench cpu --cpu-max-prime=100000 --threads=2 run' >> 'cpu_eval_v_2.txt'; sudo lxc stop 'THREADVM-2' && sudo lxc delete 'THREADVM-2'; exit
creating THREADVM-2
starting THREADVM-2
starting THREADVM-2
```

```

Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1142 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [211 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1366 kB]
Get:9 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [224 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [839 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [160 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 c-n-f Metadata [16.8 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages [37.1 kB]
Get:15 http://security.ubuntu.com/ubuntu jammy-security/multiverse Translation-en [7476 B]
Get:16 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 c-n-f Metadata [260 B]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:18 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/multiverse Translation-en [112 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Get:21 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1366 kB]
Get:22 http://archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [272 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1412 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [233 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1044 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [235 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:31 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-backports/main Translation-en [10.5 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:34 http://archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:35 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:38 http://archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
Fetched 29.4 MB in 4s (7778 kB/s)
Reading package lists... Done
Building dependency tree... Done

```

Similar Output for all the VM thread benchmarks

*For Container*

```

;sudo lxc exec THREADC-4 -- bash -c 'echo "THREADC-4 has been initialized with 4 cores" >> "C.txt"';sleep 2;sudo lxc exec THREADC-4 -- bash -c 'sudo apt upd
THREADC-4 -- bash -c 'sysbench cpu --cpu-max-prime=100000 --threads=4 run' >> 'cpu_eval_c_4.txt';sudo lxc stop 'THREADC-4' && sudo lxc delete 'THREADC-4';ex
cc@dasasidharan-instance:~$ echo '' >> 'cpu_eval_c_4.txt';echo 'CPU EVAL FOR THREAD COUNT 4' >> 'cpu_eval_c_4.txt';echo '' >> 'cpu_eval_c_4.txt';sudo lxc lau
limits.memory=4Gib;sleep 15;sudo lxc exec THREADC-4 -- bash -c 'echo "THREADC-4 has been initialized with 4 cores" >> "C.txt"';sleep 2;sudo lxc exec THREADC
-y sysbench';sudo lxc exec THREADC-4 -- bash -c 'sysbench cpu --cpu-max-prime=100000 --threads=4 run' >> 'cpu_eval_c_4.txt';sudo lxc stop 'THREADC-4' && sud
Creating THREADC-4
Starting THREADC-4

```

```

Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1142 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [211 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1366 kB]
Get:9 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [224 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [839 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [160 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 c-n-f Metadata [16.8 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages [37.1 kB]
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Get:16 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 c-n-f Metadata [260 B]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:18 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
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Get:20 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
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Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1412 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [233 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1044 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [235 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:31 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-backports/main Translation-en [10.5 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:34 http://archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:35 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:38 http://archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
Fetched 29.4 MB in 4s (7778 kB/s)
Reading package lists... Done
Building dependency tree... Done

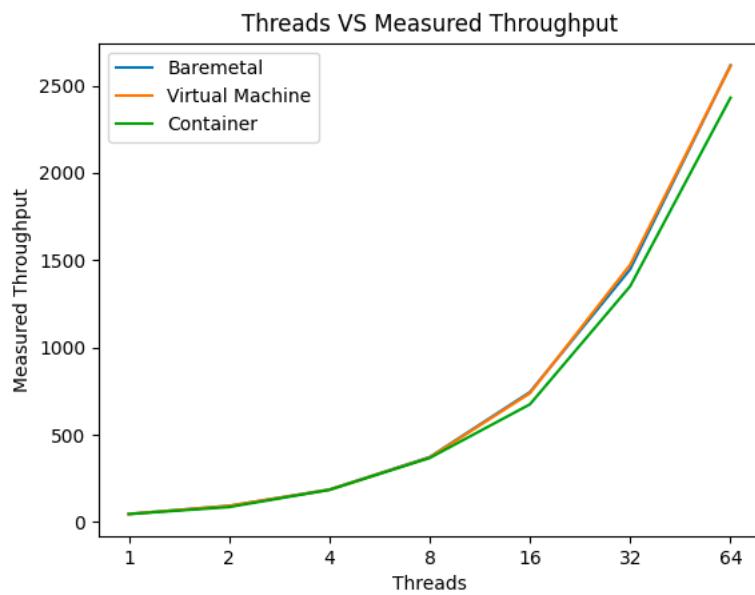
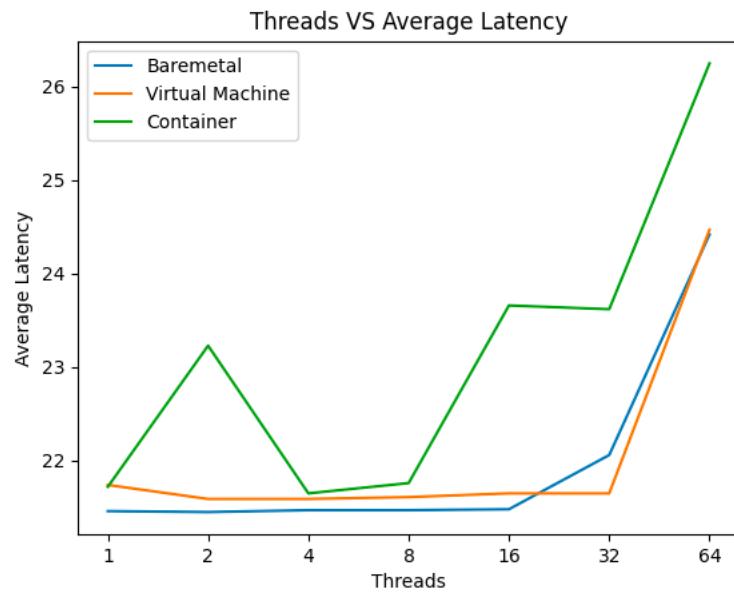
```

Similar Output for all the Container thread benchmarks

*Graphs Generated Automatically when running the benchmark*

[cpu\\_latency.png](#)

[figure\\_throughput.png](#)



*Table Generated Automatically when running the benchmark as a csv file.  
Imported here as a table*

```
[cc@dsasidharan-instance:~$ cat cpu_eval.csv
Virtualization Type,Threads,Avg. Latency(ms),Measured Throughput(Events per Second),Efficiency
BareMetal,1,21.46,46.58,100.0%
Virtual Machine,1,21.77,45.93,98.60455130957493%
Container,1,21.5,46.5,99.82825246887076%
BareMetal,2,21.48,93.06,100.0%
Virtual Machine,2,21.61,92.52,99.41972920696325%
Container,2,21.68,92.05,98.91467870191273%
BareMetal,4,21.48,186.09,100.0%
Virtual Machine,4,21.62,184.84,99.3282820140792%
Container,4,24.06,166.19,89.306249664141%
BareMetal,8,21.48,372.25,100.0%
Virtual Machine,8,21.66,369.08,99.14842175957018%
Container,8,24.97,319.49,85.82672934855609%
BareMetal,16,21.48,744.03,100.0%
Virtual Machine,16,21.66,736.81,99.02960902114162%
Container,16,23.01,693.74,93.2408639436582%
BareMetal,32,21.92,1457.44,100.0%
Virtual Machine,32,22.17,1441.48,98.90492919091008%
Container,32,25.11,1270.21,87.15350203095839%
BareMetal,64,24.42,2616.34,100.0%
Virtual Machine,64,25.5,2504.41,95.72188629918129%
Container,64,26.6,2398.95,91.69106461698402%
cc@dsasidharan-instance:~$ ]
```

Virtualization Type	Threads	Avg. Latency(ms)	Measured Throughput(Events per Second)	Efficiency
BareMetal	1	21.46	46.58	100.00%
Virtual Machine	1	21.74	46	98.75%
Container	1	21.72	46.03	98.82%
BareMetal	2	21.45	93.15	100.00%
Virtual Machine	2	21.59	92.63	99.44%
Container	2	23.23	85.95	92.27%
BareMetal	4	21.47	185.98	100.00%
Virtual Machine	4	21.59	185.08	99.52%
Container	4	21.65	184.56	99.24%
BareMetal	8	21.47	372.24	100.00%
Virtual Machine	8	21.61	369.69	99.31%
Container	8	21.76	367.08	98.61%
BareMetal	16	21.48	744.35	100.00%
Virtual Machine	16	21.65	738.01	99.15%
Container	16	23.66	674.56	90.62%
BareMetal	32	22.06	1448.51	100.00%

Virtual Machine	32	21.65	1474.6	101.80%
Container	32	23.62	1351.26	93.29%
BareMetal	64	24.42	2615.73	100.00%
Virtual Machine	64	24.47	2611.58	99.84%
Container	64	26.25	2430.44	92.92%

## Memory Benchmark

### For BareMetal

```

echo '' >> 'memory_eval_b_1.txt';echo 'MEMORY EVAL FOR THREAD COUNT 1' >> 'memory_eval_b_1.txt';echo '' >> 'memory_eval_b_1.txt'; sysbench memory --memory-block-size=1K --memory-total-size=128G --memory-o
per=read --memory-access-mode=rnd --threads=1 run >> 'memory_eval_b_1.txt'
echo '' >> 'memory_eval_b_2.txt';echo 'MEMORY EVAL FOR THREAD COUNT 2' >> 'memory_eval_b_2.txt';echo '' >> 'memory_eval_b_2.txt'; sysbench memory --memory-block-size=1K --memory-total-size=128G --memory-o
per=read --memory-access-mode=rnd --threads=2 run >> 'memory_eval_b_2.txt'
echo '' >> 'memory_eval_b_4.txt';echo 'MEMORY EVAL FOR THREAD COUNT 4' >> 'memory_eval_b_4.txt';echo '' >> 'memory_eval_b_4.txt'; sysbench memory --memory-block-size=1K --memory-total-size=128G --memory-o
per=read --memory-access-mode=rnd --threads=4 run >> 'memory_eval_b_4.txt'
echo '' >> 'memory_eval_b_8.txt';echo 'MEMORY EVAL FOR THREAD COUNT 8' >> 'memory_eval_b_8.txt';echo '' >> 'memory_eval_b_8.txt'; sysbench memory --memory-block-size=1K --memory-total-size=128G --memory-o
per=read --memory-access-mode=rnd --threads=8 run >> 'memory_eval_b_8.txt'
echo '' >> 'memory_eval_b_16.txt';echo 'MEMORY EVAL FOR THREAD COUNT 16' >> 'memory_eval_b_16.txt';echo '' >> 'memory_eval_b_16.txt'; sysbench memory --memory-block-size=1K --memory-total-size=128G --memo
ry-oper=read --memory-access-mode=rnd --threads=16 run >> 'memory_eval_b_16.txt'
echo '' >> 'memory_eval_b_32.txt';echo 'MEMORY EVAL FOR THREAD COUNT 32' >> 'memory_eval_b_32.txt';echo '' >> 'memory_eval_b_32.txt'; sysbench memory --memory-block-size=1K --memory-total-size=128G --memo
ry-oper=read --memory-access-mode=rnd --threads=32 run >> 'memory_eval_b_32.txt'
echo '' >> 'memory_eval_b_64.txt';echo 'MEMORY EVAL FOR THREAD COUNT 64' >> 'memory_eval_b_64.txt';echo '' >> 'memory_eval_b_64.txt'; sysbench memory --memory-block-size=1K --memory-total-size=128G --memo
ry-oper=read --memory-access-mode=rnd --threads=64 run >> 'memory_eval_b_64.txt'
exit
cc@dsasidharan-Instance:~$ echo '' >> 'memory_eval_b_1.txt';echo 'MEMORY EVAL FOR THREAD COUNT 1' >> 'memory_eval_b_1.txt';echo '' >> 'memory_eval_b_1.txt'; sysbench memory --memory-block-size=1K --memory
-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=1 run >> 'memory_eval_b_1.txt'
cc@dsasidharan-Instance:~$ echo '' >> 'memory_eval_b_2.txt';echo 'MEMORY EVAL FOR THREAD COUNT 2' >> 'memory_eval_b_2.txt';echo '' >> 'memory_eval_b_2.txt'; sysbench memory --memory-block-size=1K --memory
-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=2 run >> 'memory_eval_b_2.txt'
cc@dsasidharan-Instance:~$ echo '' >> 'memory_eval_b_4.txt';echo 'MEMORY EVAL FOR THREAD COUNT 4' >> 'memory_eval_b_4.txt';echo '' >> 'memory_eval_b_4.txt'; sysbench memory --memory-block-size=1K --memory
-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=4 run >> 'memory_eval_b_4.txt'
cc@dsasidharan-Instance:~$ echo '' >> 'memory_eval_b_8.txt';echo 'MEMORY EVAL FOR THREAD COUNT 8' >> 'memory_eval_b_8.txt';echo '' >> 'memory_eval_b_8.txt'; sysbench memory --memory-block-size=1K --memory
-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=8 run >> 'memory_eval_b_8.txt'
cc@dsasidharan-Instance:~$ echo '' >> 'memory_eval_b_16.txt';echo 'MEMORY EVAL FOR THREAD COUNT 16' >> 'memory_eval_b_16.txt';echo '' >> 'memory_eval_b_16.txt'; sysbench memory --memory-block-size=1K --me
mory-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=16 run >> 'memory_eval_b_16.txt'
cc@dsasidharan-Instance:~$ echo '' >> 'memory_eval_b_32.txt';echo 'MEMORY EVAL FOR THREAD COUNT 32' >> 'memory_eval_b_32.txt';echo '' >> 'memory_eval_b_32.txt'; sysbench memory --memory-block-size=1K --me
mory-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=32 run >> 'memory_eval_b_32.txt'
cc@dsasidharan-Instance:~$ echo '' >> 'memory_eval_b_64.txt';echo 'MEMORY EVAL FOR THREAD COUNT 64' >> 'memory_eval_b_64.txt';echo '' >> 'memory_eval_b_64.txt'; sysbench memory --memory-block-size=1K --me
mory-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=64 run >> 'memory_eval_b_64.txt'

```

### For VM

```

echo '' >> 'memory_eval_v_1.txt';echo 'MEMORY EVAL FOR THREAD COUNT 1' >> 'memory_eval_v_1.txt';echo '' >> 'memory_eval_v_1.txt';sudo lxc launch ubuntu:22.04 'THREADVM-1' --vm -c limits.cpu=1 -c limits.memory=4GiB;sleep 15;sudo lxc exec THREADVM-1 -- bash -c 'echo "THREADVM-1 has been initialized with 1 cores" >> "VM.txt"';sleep 2;sudo lxc exec THREADVM-1 -- bash -c 'sudo apt update;sudo apt install -y sysbench';sudo lxc exec THREADVM-1 -- bash -c 'sysbench memory --memory-block-size=1K --memory-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=1 run' >> 'memory_eval_v_1.txt';sudo lxc stop 'THREADVM-1' && sudo lxc delete 'THREADVM-1';exit
cc@ccsasidharan-Instance:$ echo '' >> 'memory_eval_v_1.txt';echo 'MEMORY EVAL FOR THREAD COUNT 1' >> 'memory_eval_v_1.txt';echo '' >> 'memory_eval_v_1.txt';sudo lxc launch ubuntu:22.04 'THREADVM-1' --vm -c limits.cpu=1 -c limits.memory=4GiB;sleep 15;sudo lxc exec THREADVM-1 -- bash -c 'echo "THREADVM-1 has been initialized with 1 cores" >> "VM.txt"';sleep 2;sudo lxc exec THREADVM-1 -- bash -c 'sudo apt update;sudo apt install -y sysbench';sudo lxc exec THREADVM-1 -- bash -c 'sysbench memory --memory-block-size=1K --memory-total-size=128G --memory-oper=read --memory-access-mode=rnd --threads=1 run' >> 'memory_eval_v_1.txt';sudo lxc stop 'THREADVM-1' && sudo lxc delete 'THREADVM-1';exit
Creating THREADVM-1
Starting THREADVM-1

Starting THREADVM-1
Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1142 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [211 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1366 kB]
Get:9 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [224 kB]
Get:11 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [839 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [160 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 c-n-f Metadata [16.8 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages [37.1 kB]
Get:15 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:16 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
Get:17 http://security.ubuntu.com/ubuntu jammy-security/multiverse Translation-en [7476 B]
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Get:22 http://archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [272 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1412 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [233 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1044 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [235 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:31 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
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Get:33 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:34 http://archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:35 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:38 http://archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
94% [9 Translation-en store 0 B]

```

*For Container*

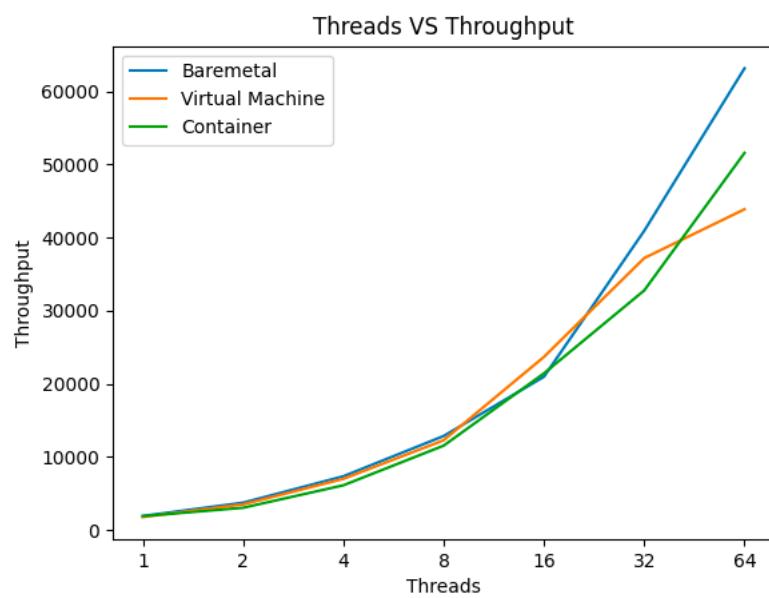
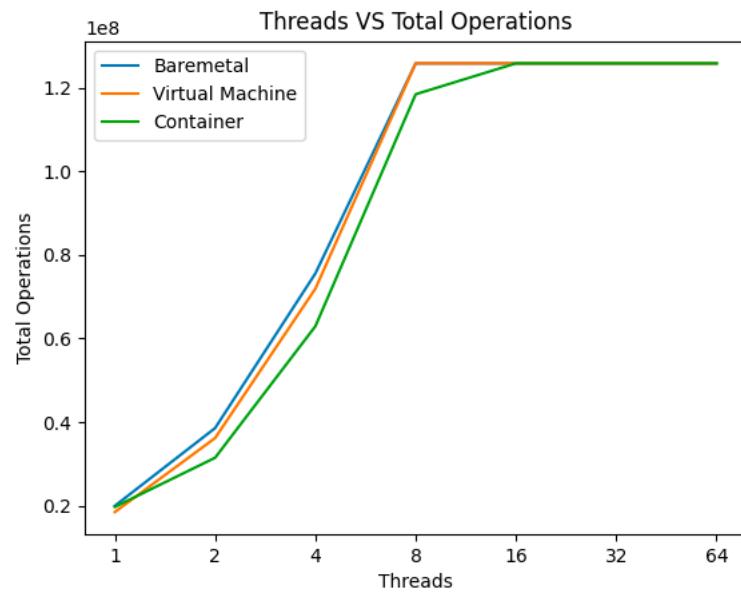
```

ts.cpu=4 -c limits.memory=4GiB;sleep 15;sudo lxc exec THREADC-4 -- bash -c 'echo "THREADC-4 has been initialized with 4 cores" >> "C.txt"
apt install -y sysbench';sudo lxc exec THREADC-4 -- bash -c 'sysbench memory --memory-block-size=1K --memory-total-size=120G --memory-op
4.txt';sudo lxc stop 'THREADC-4' && sudo lxc delete 'THREADC-4';exit
Creating THREADC-4
Starting THREADC-4
Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1142 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [221 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1366 kB]
Get:9 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [224 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [839 kB]
Get:11 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [160 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 c-n-f Metadata [16.8 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages [37.1 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/multiverse Translation-en [7476 B]
Get:15 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 c-n-f Metadata [260 B]
Get:16 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:18 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/multiverse Translation-en [112 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Get:21 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1366 kB]
Get:22 http://archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [272 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1412 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [233 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1044 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [235 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:31 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-backports/main Translation-en [10.5 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:34 http://archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:35 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:38 http://archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
95% [16 Translation-en store 0 B]■

```

*Graphs Generated Automatically when running the benchmark*

**memory\_operations.png**  
**memory\_throughput.png**



*Table Generated Automatically when running the benchmark as a csv file.  
Imported here as a table*

```
[cc@dsasidharan-instance:~$ cat memory_eval.csv
Virtualization Type,Threads,BlockSize (KB),Operation,Access Pattern,Total Operations,Throughput(MiB/sec),Efficiency
BareMetal,1,1,Read,Random,19963448.0,1949.16,100.0%
Virtual Machine,1,1,Read,Random,18485037.0,1804.89,92.59835005848673%
Container,1,1,Read,Random,19714882.0,1924.97,98.75895257444232%
BareMetal,2,1,Read,Random,38575050.0,3766.29,100.0%
Virtual Machine,2,1,Read,Random,36188043.0,3533.36,93.81539923903895%
Container,2,1,Read,Random,31482950.0,3073.99,81.61851583388426%
BareMetal,4,1,Read,Random,75568095.0,7378.23,100.0%
Virtual Machine,4,1,Read,Random,71921946.0,7022.5,95.17865395901185%
Container,4,1,Read,Random,62940391.0,6145.54,83.29287647579433%
BareMetal,8,1,Read,Random,125829120.0,12879.87,100.0%
Virtual Machine,8,1,Read,Random,125829120.0,12299.94,95.49739244262558%
Container,8,1,Read,Random,118435404.0,11564.14,89.78460186321755%
BareMetal,16,1,Read,Random,125829120.0,20979.51,100.0%
Virtual Machine,16,1,Read,Random,125829120.0,23692.62,112.93218955066158%
Container,16,1,Read,Random,125829120.0,21438.34,102.18703868679488%
BareMetal,32,1,Read,Random,125829120.0,40923.7,100.0%
Virtual Machine,32,1,Read,Random,125829120.0,37195.99,90.89107289907804%
Container,32,1,Read,Random,125829120.0,32775.44,80.08914149991327%
BareMetal,64,1,Read,Random,125829120.0,63125.55,100.0%
Virtual Machine,64,1,Read,Random,125829120.0,43870.08,69.49655092114048%
Container,64,1,Read,Random,125829120.0,51568.5,81.69196149578102%
cc@dsasidharan-instance:~$ ]
```

Virtualization Type	Threads	BlockSize (KB)	Operation	Access Pattern	Total Operations	Throughput(MiB/sec)	Efficiency
BareMetal	1	1	Read	Random	19963448	1949.16	100.0%
Virtual Machine	1	1	Read	Random	18485037	1804.89	92.60%
Container	1	1	Read	Random	19714882	1924.97	98.76%
BareMetal	2	1	Read	Random	38575050	3766.29	100.0%
Virtual Machine	2	1	Read	Random	36188043	3533.36	93.82%
Container	2	1	Read	Random	31482950	3073.99	81.62%
BareMetal	4	1	Read	Random	75568095	7378.23	100.0%
Virtual Machine	4	1	Read	Random	71921946	7022.5	95.18%
Container	4	1	Read	Random	62940391	6145.54	83.29%
BareMetal	8	1	Read	Random	125829120	12879.87	100.0%
Virtual Machine	8	1	Read	Random	125829120	12299.94	95.50%
Container	8	1	Read	Random	118435404	11564.14	89.78%
BareMetal	16	1	Read	Random	125829120	20979.51	100.0%

Virtual Machine	16	1	Read	Random	125829120	23692.62	112.9 %
Container	16	1	Read	Random	125829120	21438.34	102.1 %
BareMetal	32	1	Read	Random	125829120	40923.7	100.0 %
Virtual Machine	32	1	Read	Random	125829120	37195.99	90.89 %
Container	32	1	Read	Random	125829120	32775.44	80.09 %
BareMetal	64	1	Read	Random	125829120	63125.55	100.0 %
Virtual Machine	64	1	Read	Random	125829120	43870.08	69.50 %
Container	64	1	Read	Random	125829120	51568.5	81.69 %

## *Disk Benchmark*

*Works fine but did not get a chance to run it completely. So I have graphs upto virtual machine. No container. I have included table and graphs without container. Python code includes container analysis as well but I have commented it out.*

*For BareMetal*

```
~ -- cc@dsasidharan-instance: ~ -- ssh cc@192.5.87.150 ~ -- cc@dsasidharan-instance: ~ -- ssh cc@192.5.87.150 +  
Creating file test_file.16  
Creating file test_file.17  
Creating file test_file.18  
Creating file test_file.19  
Creating file test_file.20  
Creating file test_file.21  
Creating file test_file.22  
Creating file test_file.23  
Creating file test_file.24  
Creating file test_file.25  
Creating file test_file.26  
Creating file test_file.27  
Creating file test_file.28  
Creating file test_file.29  
Creating file test_file.30  
Creating file test_file.31  
Creating file test_file.32  
Creating file test_file.33  
Creating file test_file.34  
Creating file test_file.35  
Creating file test_file.36  
Creating file test_file.37  
Creating file test_file.38  
Creating file test_file.39  
Creating file test_file.40  
Creating file test_file.41  
Creating file test_file.42  
Creating file test_file.43  
Creating file test_file.44  
Creating file test_file.45  
Creating file test_file.46  
Creating file test_file.47  
Creating file test_file.48  
Creating file test_file.49  
Creating file test_file.50  
Creating file test_file.51  
Creating file test_file.52  
Creating file test_file.53  
Creating file test_file.54  
Creating file test_file.55  
Creating file test_file.56  
Creating file test_file.57  
Creating file test_file.58  
Creating file test_file.59  
Creating file test_file.60  
Creating file test_file.61  
Creating file test_file.62  
Creating file test_file.63  
Creating file test_file.64  
Creating file test_file.65  
Creating file test_file.66  
Creating file test_file.67  
Creating file test_file.68  
Creating file test_file.69  
Creating file test_file.70  
Creating file test_file.71  
Creating file test_file.72  
Creating file test_file.73  
Creating file test_file.74  
[disk_eval0:sysbench] "dsasidharan-instance" 03:59 10-Feb-24
```

For VM

SAME FOR ALL VMS

Creating a VM

Creating THREADVM-8  
Starting THREADVM-8  
[disk\_eval0:THREADVM-8]

Overriding the disk space for the VM

Device root overridden for THREADVM-8

Update the VM and install sysbench

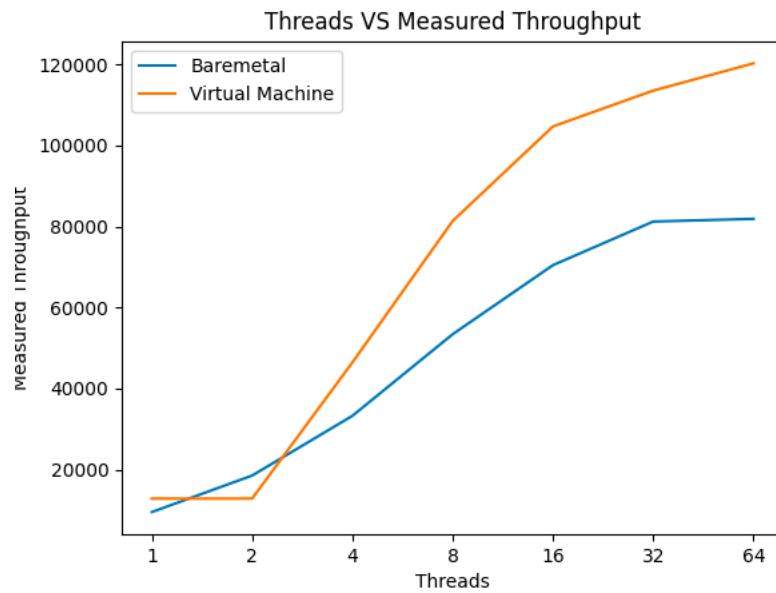
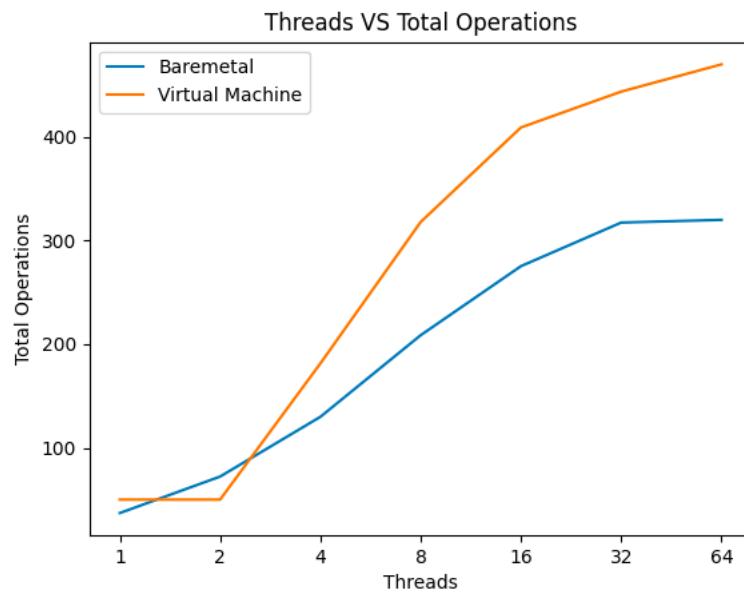
```
Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1142 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [211 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1366 kB]
Get:9 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [224 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [839 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [160 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 c-n-f Metadata [16.8 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages [37.1 kB]
Get:15 http://security.ubuntu.com/ubuntu jammy-security/multiverse Translation-en [7476 B]
Get:16 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 c-n-f Metadata [260 B]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:18 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/multiverse Translation-en [112 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Get:21 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1366 kB]
Get:22 http://archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [272 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1412 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [233 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1044 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [235 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:31 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-backports/main Translation-en [10.5 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:34 http://archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:35 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:38 http://archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
Fetched 29.4 MB in 4s (7778 kB/s)
Reading package lists... Done
Building dependency tree... Done
```

*Creating test files for benchmark*

```
extra file open flags: direction
Creating file test_file.0
Creating file test_file.1
Creating file test_file.2
Creating file test_file.3
Creating file test_file.4
Creating file test_file.5
Creating file test_file.6
Creating file test_file.7
Creating file test_file.8
Creating file test_file.9
Creating file test_file.10
Creating file test_file.11
Creating file test_file.12
Creating file test_file.13
Creating file test_file.14
Creating file test_file.15
Creating file test_file.16
Creating file test_file.17
Creating file test_file.18
Creating file test_file.19
Creating file test_file.20
Creating file test_file.21
Creating file test_file.22
Creating file test_file.23
Creating file test_file.24
Creating file test_file.25
Creating file test_file.26
Creating file test_file.27
Creating file test_file.28
Creating file test_file.29
Creating file test_file.30
Creating file test_file.31
Creating file test_file.32
Creating file test_file.33
Creating file test_file.34
Creating file test_file.35
Creating file test_file.36
Creating file test_file.37
Creating file test_file.38
Creating file test_file.39
Creating file test_file.40
Creating file test_file.41
Creating file test_file.42
Creating file test_file.43
Creating file test_file.44
Creating file test_file.45
Creating file test_file.46
Creating file test_file.47
Creating file test_file.48
Creating file test_file.49
Creating file test_file.50
```

*Graphs Generated Automatically when running the benchmark.*

**disk\_operations.png**  
**disk\_throughput.png**



*Table Generated Automatically when running the benchmark as a csv file.  
Imported here as a table.*

```
cc@dsasidharan-instance:~$ cat disk_eval.csv
Virtualization Type,Threads,BlockSize (KB),Operation,Access Pattern,I/O Mode,I/O Flag,Total Operations,Measured Throughput(MiB/sec),Efficiency
BareMetal,1,4,Read,Random,Sync,DirectIO,37.05,9484.48,100.0%
Virtual Machine,1,4,Read,Random,Sync,DirectIO,50.03,12807.32,135.0344984648605%
BareMetal,2,4,Read,Random,Sync,DirectIO,72.25,18495.52,100.0%
Virtual Machine,2,4,Read,Random,Sync,DirectIO,50.03,12807.32,69.24552540290838%
BareMetal,4,4,Read,Random,Sync,DirectIO,129.88,33248.79,100.0%
Virtual Machine,4,4,Read,Random,Sync,DirectIO,181.39,46435.09,139.65948836032828%
BareMetal,8,4,Read,Random,Sync,DirectIO,208.61,53405.03,100.0%
Virtual Machine,8,4,Read,Random,Sync,DirectIO,317.84,81368.2,152.36055480167317%
BareMetal,16,4,Read,Random,Sync,DirectIO,275.24,70462.33,100.0%
Virtual Machine,16,4,Read,Random,Sync,DirectIO,409.05,104715.66,148.61225849329708%
BareMetal,32,4,Read,Random,Sync,DirectIO,317.31,81231.97,100.0%
Virtual Machine,32,4,Read,Random,Sync,DirectIO,443.66,113578.1,139.819457782447%
BareMetal,64,4,Read,Random,Sync,DirectIO,319.91,81898.15,100.0%
Virtual Machine,64,4,Read,Random,Sync,DirectIO,469.94,120304.74,146.8955525857422%
cc@dsasidharan-instance:~$
```

Virtualization Type	Threads	Block Size (KB)	Operation	Access Pattern	I/O Mode	I/O Flag	Total Operations	Measured Throughput(MiB/sec)	Efficiency
BareMetal	1	4	Read	Random	Sync	DirectIO	37.05	9484.48	100.00%
Virtual Machine	1	4	Read	Random	Sync	DirectIO	50.03	12807.32	135.03%
BareMetal	2	4	Read	Random	Sync	DirectIO	72.25	18495.52	100.00%
Virtual Machine	2	4	Read	Random	Sync	DirectIO	50.03	12807.32	69.25%
BareMetal	4	4	Read	Random	Sync	DirectIO	129.88	33248.79	100.00%
Virtual Machine	4	4	Read	Random	Sync	DirectIO	181.39	46435.09	139.66%
BareMetal	8	4	Read	Random	Sync	DirectIO	208.61	53405.03	100.00%
Virtual Machine	8	4	Read	Random	Sync	DirectIO	317.84	81368.2	152.36%
BareMetal	16	4	Read	Random	Sync	DirectIO	275.24	70462.33	100.00%
Virtual Machine	16	4	Read	Random	Sync	DirectIO	409.05	104715.66	148.61%
BareMetal	32	4	Read	Random	Sync	DirectIO	317.31	81231.97	100.00%
Virtual Machine	32	4	Read	Random	Sync	DirectIO	443.66	113578.1	139.82%
BareMetal	64	4	Read	Random	Sync	DirectIO	319.91	81898.15	100.00%
Virtual Machine	64	4	Read	Random	Sync	DirectIO	469.94	120304.74	146.90%

## *Network Benchmark*

## *For Baremetal*

For *VM*

```

echo '' >> 'network_eval_v_1.txt';echo 'NETWORK EVAL FOR THREAD COUNT 1' >> 'network_eval_v_1.txt';echo '' >> 'network_eval_v_1.txt';sudo lxc launch ubuntu:22.04 'THREADVM-1' --vm-c limits.cpu=1 -c limit s.memory=4G16;sleep 15;sudo lxc exec THREADVM-1 -- bash -c 'echo "THREADVM-1 has been initialized with 1 cores" >> "VM.txt"';sleep 2;sudo lxc exec THREADVM-1 -- bash -c 'sudo apt update & sudo apt install -y iperf';sudo lxc exec THREADVM-1 -- bash -c 'iperf -c 127.0.0.1 -e -1 --nodelay -l 8192K -w 2500K --trip-times --parallel 1;killl iperf';sleep 2' >> 'network_eval_v_1.txt';sudo lxc stop 'THREADVM-1' && sudo lxc delete 'THREADVM-1';exit
cc0d5a5d1000-:~$ echo '' >> 'network_eval_v_1.txt';echo 'NETWORK EVAL FOR THREAD COUNT 1' >> 'network_eval_v_1.txt';echo '' >> 'network_eval_v_1.txt';sudo lxc launch ubuntu:22.04 'THREADVM-1' --vm-c limits.cpu=1 -c limit s.memory=4G16;sleep 15;sudo exec THREADVM-1 -- bash -c 'echo "THREADVM-1 has been initialized with 1 cores" >> "VM.txt"';sleep 2;sudo lxc launch THREADVM-1 -- bash -c 'sudo apt update & sudo apt install -y iperf';sudo lxc exec THREADVM-1 -- bash -c 'iperf -s -w 1M &' >> 'server_eval_v_1.txt' & sudo lxc exec THREADVM-1 -- bash -c 'iperf -c 127.0.0.1 -e -1 --nodelay -l 8192K -w 2500K --trip-times --parallel 1;killl iperf';sleep 2' >> 'network_eval_v_1.txt';sudo lxc stop 'THREADVM-1' && sudo lxc delete 'THREADVM-1';exit
Creating THREADVM-1
Starting THREADVM-1

```

```
Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1142 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [211 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1366 kB]
Get:9 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [224 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [839 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [160 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 c-n-f Metadata [16.8 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages [37.1 kB]
Get:15 http://security.ubuntu.com/ubuntu jammy-security/multiverse Translation-en [7476 B]
Get:16 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 c-n-f Metadata [260 B]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:18 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/multiverse Translation-en [112 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Get:21 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1366 kB]
Get:22 http://archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [272 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1412 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [233 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1044 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [235 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:31 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-backports/main Translation-en [10.5 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:34 http://archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:35 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:38 http://archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
Fetched 29.4 MB in 4s (7778 kB/s)
Reading package lists... Done
Building dependency tree... Done
```

*The server and client are opened two sperate windows within a tmux session and its output is recorded.  
Do not attach to the tmux session for some odd reason it cause problems. Let the program take place and just wait for it to finish.*

*Similar for all VMs*

*For Container*

```
Performing Container Network Benchmark
Creating THREADC-1
Starting THREADC-1
[REDACTED]
Deleting the VM
Creating THREADC-4
Starting THREADC-4
[REDACTED]
```

```

Hit:1 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [1142 kB]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [211 kB]
Get:8 http://security.ubuntu.com/ubuntu jammy-security/restricted amd64 Packages [1366 kB]
Get:9 http://security.ubuntu.com/ubuntu jammy-security/restricted Translation-en [224 kB]
Get:10 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [839 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:12 http://security.ubuntu.com/ubuntu jammy-security/universe Translation-en [160 kB]
Get:13 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 c-n-f Metadata [16.8 kB]
Get:14 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 Packages [37.1 kB]
Get:15 http://security.ubuntu.com/ubuntu jammy-security/multiverse Translation-en [7476 B]
Get:16 http://security.ubuntu.com/ubuntu jammy-security/multiverse amd64 c-n-f Metadata [260 B]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:18 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/multiverse Translation-en [112 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Get:21 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [1366 kB]
Get:22 http://archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [272 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [1412 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy-updates/restricted Translation-en [233 kB]
Get:25 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1044 kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en [235 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 c-n-f Metadata [22.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 Packages [42.1 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse Translation-en [10.1 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 c-n-f Metadata [472 B]
Get:31 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 Packages [41.7 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-backports/main Translation-en [10.5 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-backports/main amd64 c-n-f Metadata [388 B]
Get:34 http://archive.ubuntu.com/ubuntu jammy-backports/restricted amd64 c-n-f Metadata [116 B]
Get:35 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 Packages [24.3 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy-backports/universe Translation-en [16.5 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy-backports/universe amd64 c-n-f Metadata [644 B]
Get:38 http://archive.ubuntu.com/ubuntu jammy-backports/multiverse amd64 c-n-f Metadata [116 B]
Fetched 29.4 MB in 4s (7778 kB/s)
Reading package lists... Done
Building dependency tree... Done

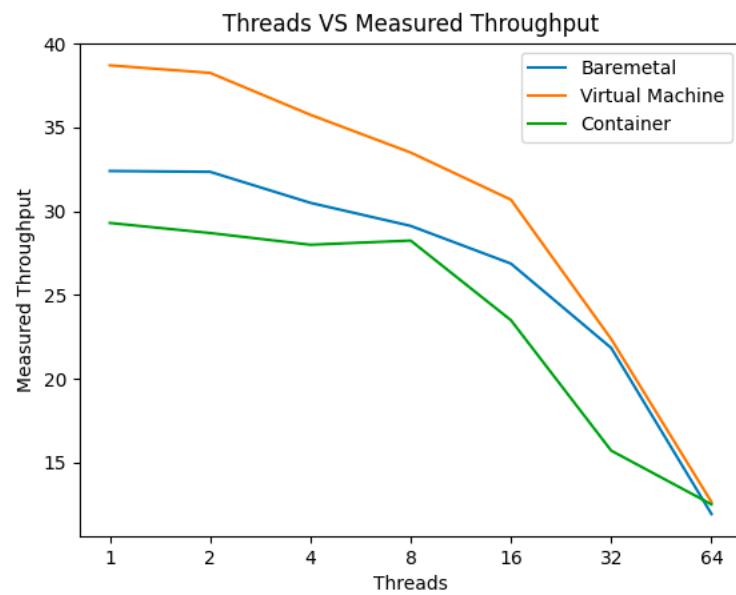
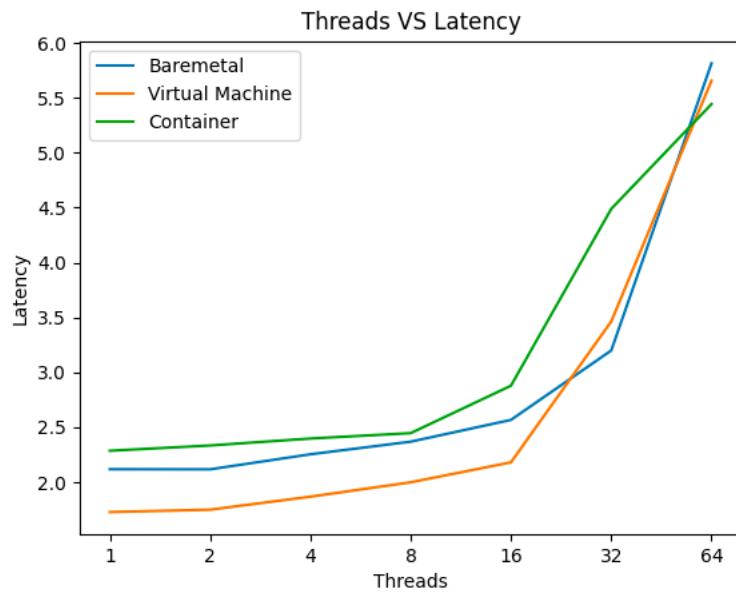
```

*Similar output for all the containers*

As figures cannot be shown within the Linux instance. I will be showing it below

*Graphs Generated Automatically when running the benchmark*

**network\_latency.png**  
**network\_throughput.png**



*Table Generated Automatically when running the benchmark as a csv file.  
Imported here as a table*

```
[cc@dsasidharan-instance:~$ cat network_eval.csv
Virtualization Type,Server,Client Threads,Latency,Measured Throughput(MiB/sec),Efficiency
BareMetal,1,1,2.119,32.4,100.0%
Virtual Machine,1,1,1.729,38.7,119.44444444444446%
Container,1,1,2.287,29.3,90.4320987654321%
BareMetal,1,2,2.118,32.35,100.0%
Virtual Machine,1,2,1.7505,38.25,118.23802163833075%
Container,1,2,2.335,28.7,88.71715610510046%
BareMetal,1,4,2.25475,30.5,100.0%
Virtual Machine,1,4,1.869,35.75,117.21311475409837%
Container,1,4,2.39825,28.0,91.80327868852459%
BareMetal,1,8,2.3695,29.125,100.0%
Virtual Machine,1,8,1.99975,33.5,115.0214592274678%
Container,1,8,2.44725,28.25,96.99570815450643%
BareMetal,1,16,2.56769,26.875,100.0%
Virtual Machine,1,16,2.18138,30.6875,114.18604651162792%
Container,1,16,2.87894,23.5,87.44186046511628%
BareMetal,1,32,3.19937,21.8438,100.0%
Virtual Machine,1,32,3.46341,22.375,102.4318113148811%
Container,1,32,4.48797,15.7188,71.96000695849622%
BareMetal,1,64,5.81298,11.9375,100.0%
Virtual Machine,1,64,5.6548,12.6562,106.02052356020944%
Container,1,64,5.44209,12.5156,104.84272251308899%
cc@dsasidharan-instance:~$
```

Virtualization Type	Server	Client Threads	Latency	Measured Throughput(MiB/sec)	Efficiency
BareMetal	1	1	2.119	32.4	100.00%
Virtual Machine	1	1	1.729	38.7	119.44%
Container	1	1	2.287	29.3	90.43%
BareMetal	1	2	2.118	32.35	100.00%
Virtual Machine	1	2	1.7505	38.25	118.24%
Container	1	2	2.335	28.7	88.72%
BareMetal	1	4	2.25475	30.5	100.00%
Virtual Machine	1	4	1.869	35.75	117.21%
Container	1	4	2.39825	28	91.80%
BareMetal	1	8	2.3695	29.125	100.00%
Virtual Machine	1	8	1.99975	33.5	115.02%
Container	1	8	2.44725	28.25	97.00%
BareMetal	1	16	2.56769	26.875	100.00%
Virtual Machine	1	16	2.18138	30.6875	114.19%
Container	1	16	2.87894	23.5	87.44%
BareMetal	1	32	3.19937	21.8438	100.00%

Virtual Machine	1	32	3.46341	22.375	102.43%
Container	1	32	4.48797	15.7188	71.96%
BareMetal	1	64	5.81298	11.9375	100.00%
Virtual Machine	1	64	5.6548	12.6562	106.02%
Container	1	64	5.44209	12.5156	104.84%