CS553 (HW - 2)

CPU :

Virtualization Type	Threads	Avg. Latency (ms)	Measured Throughput (Events per Second)	Efficiency
Baremetal	1	28.12	35.55	100%
Container	1	28.33	35.28	99.24%
Virtual Machine	1	28.36	35.23	99.09%
Baremetal	2	28.11	71.11	100%
Container	2	28.09	71.09	99.97%
Virtual Machine	2	28.41	70.30	98.86%
Baremetal	4	28.09	142.22	100%
Container	4	29.37	135.80	95.48%
Virtual Machine	4	28.26	141.43	99.44%
Baremetal	8	28.10	284.44	100%
Container	8	56.46	140.87	49.52%
Virtual Machine	8	56.19	142.22	50%
Baremetal	16	28.39	562.94	100%
Container	16	112.13	141.24	25.08%
Virtual Machine	16	112.01	142.08	25.23%
Baremetal	32	31.87	1001.75	100%
Container	32	221.55	141.75	14.15%
Virtual Machine	32	223.22	142.03	14.17%
Baremetal	64	48.51	1315.38	100%
Container	64	438.28	141.14	10.72%
Virtual Machine	64	442.98	142.13	10.80%

Example efficiency calculations:

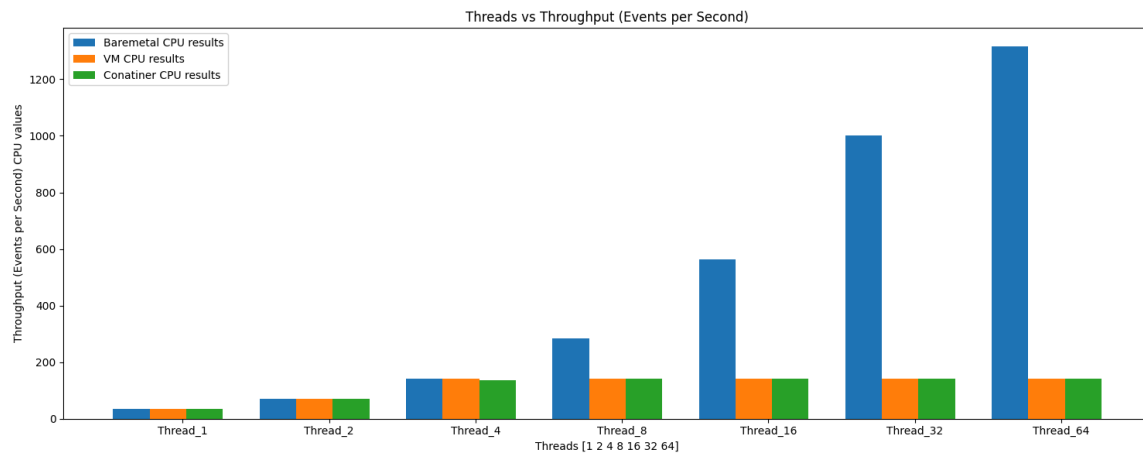Efficiency at Thread = 1 and type = container
> => 100 - ((bare-metal - container) / bare-metal) * 100
> => 100 - ((35.55 - 35.28) / 35.55) *100 => ~ 99.24%

Efficiency at Thread = 1 and type = VM
> => 100 - ((bare-metal - VM) / bare-metal) * 100
> => 100 - ((35.55 - 35.23) / 35.55) *100 => ~ 99.09%

The above bar graph shows threads vs. throughput (events per second) in bare metal, container, and virtual machines.
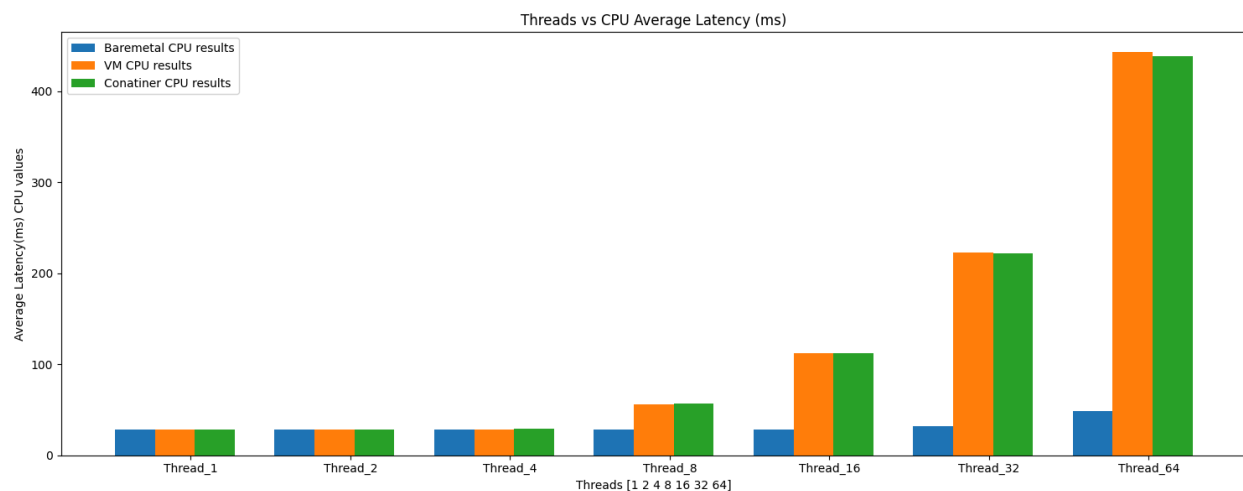
The above bar graph shows threads vs. CPU average latency (events per second) in bare metal, container, and virtual machines.

```
root@DILA-VMACHINE1:~/Assignment2# vi cpu-benchmark.sh
root@DILA-VMACHINE1:~/Assignment2# chmod +x cpu-benchmark.s
root@DILA-VMACHINE1:~/Assignment2# sh cpu-benchmark.sh
------- Started 1 ---------
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Prime numbers limit: 100000

Initializing worker threads...

Threads started!

CPU speed:
    events per second:    35.23

General statistics:
    total time:                      10.0131s
    total number of events:          353

Latency (ms):
         min:                            28.07
         avg:                            28.36
         max:                            57.49
         95th percentile:                28.16
         sum:                         10012.46

Threads fairness:
    events (avg/stddev):       353.0000/0.00
    execution time (avg/stddev):   10.0125/0.00
Events per seconds : 35.23
Latency Avg (ms): 28.36
------- Ended 1 ---------

------- Started 2 ---------
```

```
root@DILA-CONTAINER1:~/Assignment2# chmod +x cpu-benchmark.sh
root@DILA-CONTAINER1:~/Assignment2# sh cpu-benchmark.sh
------- Started 1 ---------
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Prime numbers limit: 100000

Initializing worker threads...

Threads started!

CPU speed:
    events per second:    35.28

General statistics:
    total time:                      10.0013s
    total number of events:          353

Latency (ms):
         min:                            28.02
         avg:                            28.33
         max:                            50.39
         95th percentile:                28.16
         sum:                         10000.72

Threads fairness:
    events (avg/stddev):       353.0000/0.00
    execution time (avg/stddev):   10.0007/0.00
Events per seconds : 35.28
Latency Avg (ms): 28.33
------- Ended 1 ---------
```

```
cc@dila-instance:~/Assignment2$ cat baremetal-cpu-benchmark-results.csv
Threads, AvgLatency, Events
Thread_1, 28.12, 35.55
Thread_2, 28.11, 71.11
Thread_4, 28.09, 142.22
Thread_8, 28.10, 284.44
Thread_16, 28.39, 562.94
Thread_32, 31.87, 1001.75
Thread_64, 48.51, 1315.38
cc@dila-instance:~/Assignment2$
```

Memory :

Virtualization Type	Threads	Block Size (KB)	Operation	Access Pattern	Total Operations	Throughput (MiB/sec)	Efficiency
Baremetal	1	1	Read	Random	13875798	1354.66	100%
Container	1	1	Read	Random	13299499	1298.30	95.83%
Virtual Machine	1	1	Read	Random	13273065	1295.57	95.63%

Baremetal	2	1	Read	Random	27451384	2680.04	100%
Container	2	1	Read	Random	26269132	2564.75	95.69%
Virtual Machine	2	1	Read	Random	26183155	2555.73	95.36%
Baremetal	4	1	Read	Random	54501465	5320.86	100%
Container	4	1	Read	Random	48673333	4752.17	89.31%
Virtual Machine	4	1	Read	Random	52246423	5101.01	95.86%
Baremetal	8	1	Read	Random	105457637	10295.61	100%
Container	8	1	Read	Random	50010487	4882.75	47.42%
Virtual Machine	8	1	Read	Random	52588597	5134.56	49.87%
Baremetal	16	1	Read	Random	125829120	19231.74	100%
Container	16	1	Read	Random	49909987	4872.96	25.33%
Virtual Machine	16	1	Read	Random	52549608	5130.73	26.67%
Baremetal	32	1	Read	Random	125829120	30790.06	100%
Container	32	1	Read	Random	50001489	4881.81	15.85%
Virtual Machine	32	1	Read	Random	52605650	5136.11	16.68%
Baremetal	64	1	Read	Random	125829120	39171.62	100%
Container	64	1	Read	Random	49775336	4859.61	12.40%
Virtual Machine	64	1	Read	Random	52451132	5120.96	13.07%

Example efficiency calculations:

Efficiency at Thread = 1 and type = container

=> 100 - ((bare-metal - container) / bare-metal) * 100

=> 100 - ((1354.66 - 1298.30) / 1354.66) *100 => ~ 95.83%
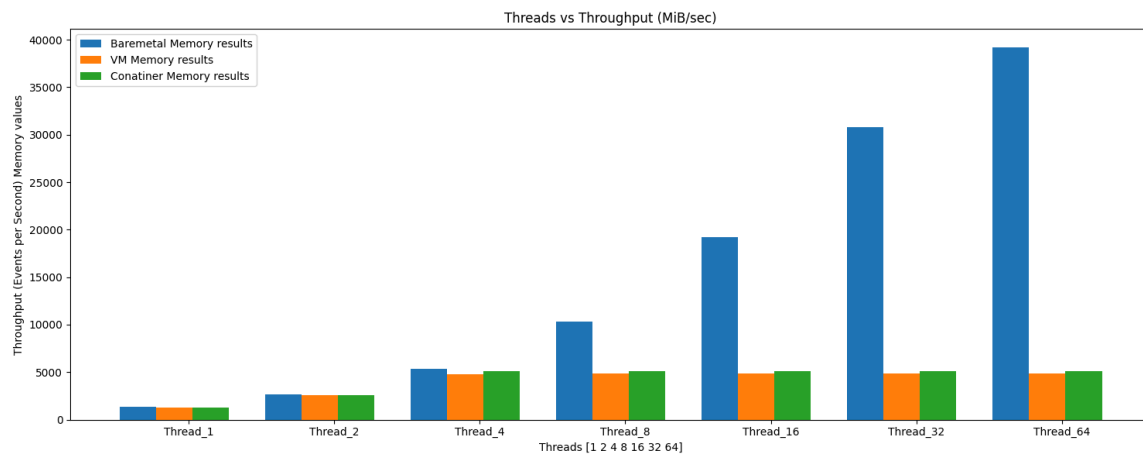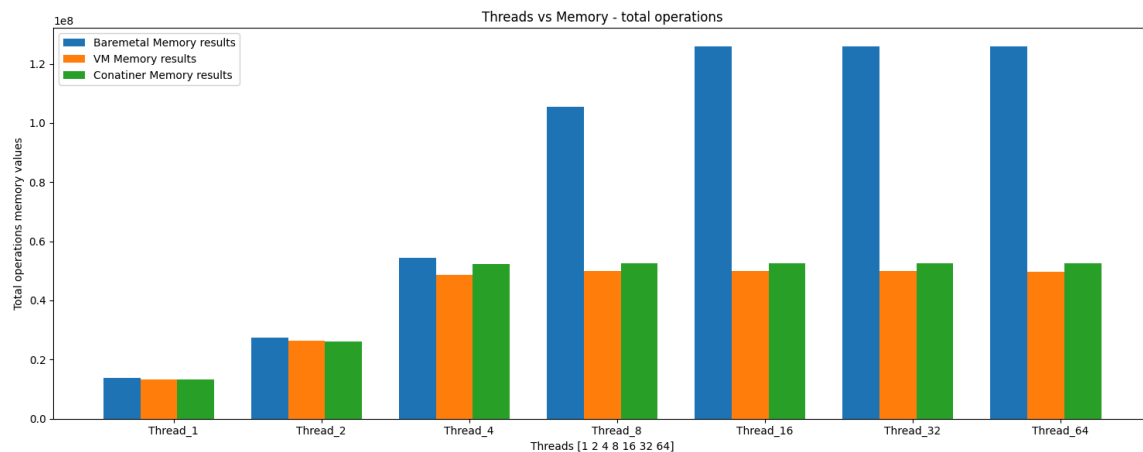
Efficiency at Thread = 1 and type = VM

$\Rightarrow 100 - ((\text{bare-metal} - \text{VM}) / \text{bare-metal}) * 100$

$\Rightarrow 100 - ((1354.66 - 1295.57) / 1354.66) * 100 \Rightarrow \sim 95.63$

The above bar graph shows threads vs. throughput (MiB/sec) in bare metal, container, and virtual machines.

The above bar graph shows threads vs. total operations in bare metal, container, and virtual machines.

```
[root@DILA-CONTAINER1:~/Assignment2# cat container-memory-benchmark-results.csv
Thread,TotalOperations,Throughput
Thread_1,13299499,1298.30
Thread_2,26269132,2564.75
Thread_4,48673333,4752.17
Thread_8,50010487,4882.75
Thread_16,49909987,4872.96
Thread_32,50001489,4881.81
Thread_64,49775336,4859.61
root@DILA-CONTAINER1:~/Assignment2#
```

```
cc@dila-instance:~/Assignment2$ cat baremetal-memory-benchmark-results.csv
Thread,TotalOperations,Throughput
Thread_1,13875798,1354.66
Thread_2,27451384,2680.04
Thread_4,54501465,5320.86
Thread_8,105457637,10295.61
Thread_16,125829120,19231.74
Thread_32,125829120,30790.06
Thread_64,125829120,39171.62
cc@dila-instance:~/Assignment2$ █
```

```
root@DILA-VMACHINE1:~/Assignment2# cat vm-memory-benchmark-results.csv
Thread,TotalOperations,Throughput
Thread_1,13273065,1295.57
Thread_2,26183155,2555.73
Thread_4,52246423,5101.01
Thread_8,52588597,5134.56
Thread_16,52549608,5130.73
Thread_32,52605650,5136.11
Thread_64,52451132,5120.96
root@DILA-VMACHINE1:~/Assignment2# █
```

```
root@DILA-VMACHINE1:~/Assignment2# chmod +x memory-benchmark.sh
root@DILA-VMACHINE1:~/Assignment2# sh memory-benchmark.sh
----------STARTED----------
sysbench memory --memory-block-size=1K --memory-total-size=120G --memory-oper=read --memory-access-m
ode=rnd --threads=1
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Running memory speed test with the following options:
  block size: 1KiB
  total size: 122880MiB
  operation: read
  scope: global

Initializing worker threads...

Threads started!

Total operations: 13273065 (1326661.14 per second)

12961.98 MiB transferred (1295.57 MiB/sec)


General statistics:
    total time:                          10.0001s
    total number of events:              13273065

Latency (ms):
         min:                                 0.00
         avg:                                 0.00
         max:                                 0.71
         95th percentile:                     0.00
         sum:                              8245.05

Threads fairness:
    events (avg/stddev):           13273065.0000/0.00
    execution time (avg/stddev):   8.2450/0.00+

Total operations: 13273065
transferred : 1295.57

operationInfo : 13273065

Thread_1 13273065 1295.57
----------ENDED----------
```

Disk:

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	7880.77	30.78	100%
Container	1	4	Read	Random	SYNC	DirectIO	37990.37	148.40	482.13%
Virtual Machine	1	4	Read	Random	SYNC	DirectIO	12978.25	50.70	164.71%
Baremetal	2	4	Read	Random	SYNC	DirectIO	15963.34	62.36	100%
Container	2	4	Read	Random	SYNC	DirectIO	70995.35	277.33	444.72%
Virtual Machine	2	4	Read	Random	SYNC	DirectIO	29521.84	115.32	184.92%
Baremetal	4	4	Read	Random	SYNC	DirectIO	29184.44	114.00	100%
Container	4	4	Read	Random	SYNC	DirectIO	128270.72	501.06	439.52%
Virtual Machine	4	4	Read	Random	SYNC	DirectIO	47767.18	186.59	163.67%
Baremetal	8	4	Read	Random	SYNC	DirectIO	47314.50	184.82	100%
Container	8	4	Read	Random	SYNC	DirectIO	129078.62	504.21	272.81%
Virtual Machine	8	4	Read	Random	SYNC	DirectIO	85067.79	332.30	179.79%
Baremetal	16	4	Read	Random	SYNC	DirectIO	65851.77	257.23	100%
Container	16	4	Read	Random	SYNC	DirectIO	129609.87	506.29	196.82%
Virtual Machine	16	4	Read	Random	SYNC	DirectIO	103157.18	402.96	156.65%
Baremetal	32	4	Read	Random	SYNC	DirectIO	78841.00	307.97	100%
Container	32	4	Read	Random	SYNC	DirectIO	128007.58	500.03	162.36%

Virtual Machine	32	4	Read	Random	SYNC	Dire ctIO	110752.90	432.63	140.47%
Baremetal	64	4	Read	Random	SYNC	Dire ctIO	78842.74	307.98	100%
Container	64	4	Read	Random	SYNC	Dire ctIO	129198.60	504.68	163.86%
Virtual Machine	64	4	Read	Random	SYNC	Dire ctIO	134507.53	525.42	170.60%

Example efficiency calculations:
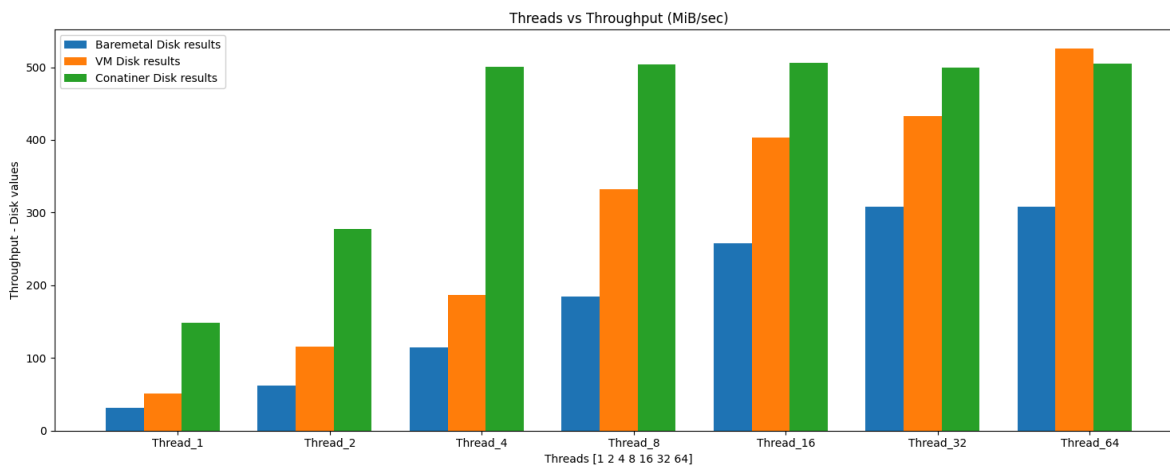
Efficiency at Thread = 1 and type = container
=> 100 - ((bare-metal - container) / bare-metal) * 100
=> 100 - ((30.78 - 148.40) / 30.78) * 100 => ~ 482.13%
Efficiency at Thread = 1 and type = VM
=> 100 - ((bare-metal - VM) / bare-metal) * 100
=> 100 - ((30.78 - 50.70) / 30.78) * 100 => ~ 164.71%

Threads vs Throughput (MiB/sec)

The above bar graph shows threads vs. throughput (MiB/sec) in bare metal, container, and virtual machines.

Threads vs Disk - total operations
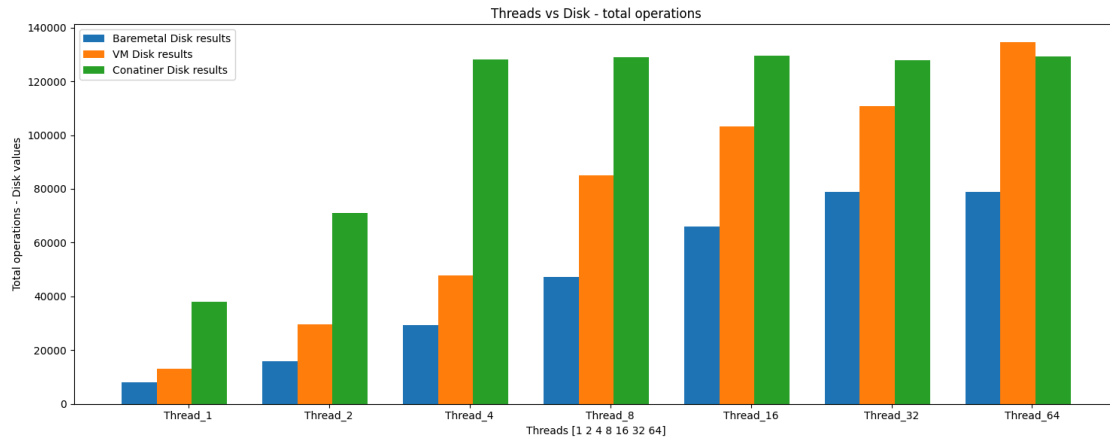
The above bar graph shows threads vs. total operations in bare metal, container, and virtual machines.

```
[root@DILA-CONTAINER1:~/Assignment2# chmod +x disk-benchmark.sh
[root@DILA-CONTAINER1:~/Assignment2# sh disk-benchmark.sh
Running sysbench with 1 threads... Fri Feb  9 09:03:07 PM UTC 2024
---------------------- STARTED ---------------------------



sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Extra file open flags: directio
128 files, 960MiB each
120GiB total file size
Block size 4KiB
Number of IO requests: 0
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Initializing worker threads...

Threads started!


File operations:
    reads/s:                    37990.37
    writes/s:                   0.00
    fsyncs/s:                   0.00

Throughput:
    read, MiB/s:                148.40
    written, MiB/s:             0.00

General statistics:
    total time:                 10.0001s
    total number of events:     380014

Latency (ms):
        min:                            0.03
        avg:                            0.03
        max:                            0.43
        95th percentile:                0.03
        sum:                         9899.28

Threads fairness:
    events (avg/stddev):        380014.0000/0.00
    execution time (avg/stddev):   9.8993/0.00+
-----------------------------------------------
File operations: reads/s: 37990.37 writes/s: 0.00 fsyncs/s: 0.00 Throughput:
Throughput: read, MiB/s: 148.40 written, MiB/s: 0.00 General statistics: total time: 10.0001s
37990.37
148.40
-----------------------------------------------
```

```
root@DILA-CONTAINER1:~/Assignment2# cat container-disk-benchmark-results.csv
Thread,TotalOperations,Throughput
Thread_1,37990.37,148.40
Thread_2,70995.35,277.33
Thread_4,128270.72,501.06
Thread_8,129078.62,504.21
Thread_16,129609.87,506.29
Thread_32,128007.58,500.03
Thread_64,129198.60,504.68
root@DILA-CONTAINER1:~/Assignment2#
```

Network:

Virtualization Type	Server	Client Threads	Latency (ms)	Measured Throughput (Gbits/s)	Efficiency
Baremetal	1	1	2.271	30.6	100%
Container	1	1	1.881	36.6	119.60%
Virtual Machine	1	1	2.256	30.8	100.65%
Baremetal	1	2	2.228	31.2	100%
Container	1	2	1.911	36.1	115.70
Virtual Machine	1	2	2.176	32.0	102.56
Baremetal	1	4	2.326	29.9	100%
Container	1	4	1.892	36.3	121.40%
Virtual Machine	1	4	2.225	31.3	104.68%
Baremetal	1	8	2.283	30.4	100%
Container	1	8	1.911	36.1	118.75%
Virtual Machine	1	8	2.194	31.7	104.27%
Baremetal	1	16	2.260	30.7	100%
Container	1	16	1.914	36.0	117.26%

Virtual Machine	1	16	2.214	31.4	**102.28%**
Baremetal	1	32	2.213	31.4	**100%**
Container	1	32	1.905	36.1	**114.96**
Virtual Machine	1	32	2.222	31.3	**99.68%**
Baremetal	1	64	2.271	30.6	**100%**
Container	1	64	1.893	36.3	**118.62%**
Virtual Machine	1	64	2.362	29.4	**96.07%**

Example efficiency calculations:

Efficiency at Thread = 1 and type = container

=> 100 - ((bare-metal - container) / bare-metal) * 100

=> 100 - ((30.6 - 36.6) / 30.6) * 100 => ~ 119.60%

Efficiency at Thread = 1 and type = VM

=> 100 - ((bare-metal - VM) / bare-metal) * 100

=> 100 - ((30.6 - 30.8) / 30.6) * 100 => ~ 100.65%
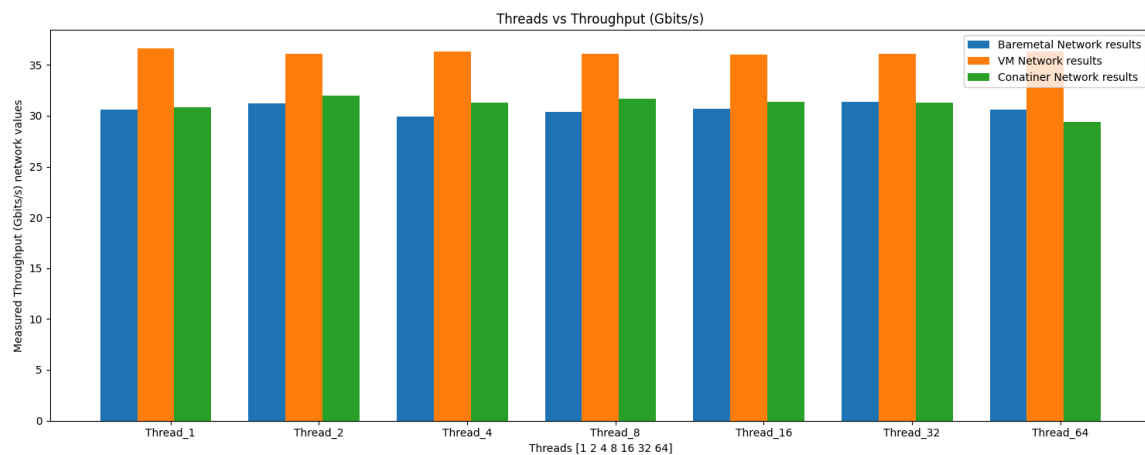
The above bar graph shows threads vs. throughput (Gbits/s) in bare metal, container, and virtual machines.

Threads vs Network - Average Latency
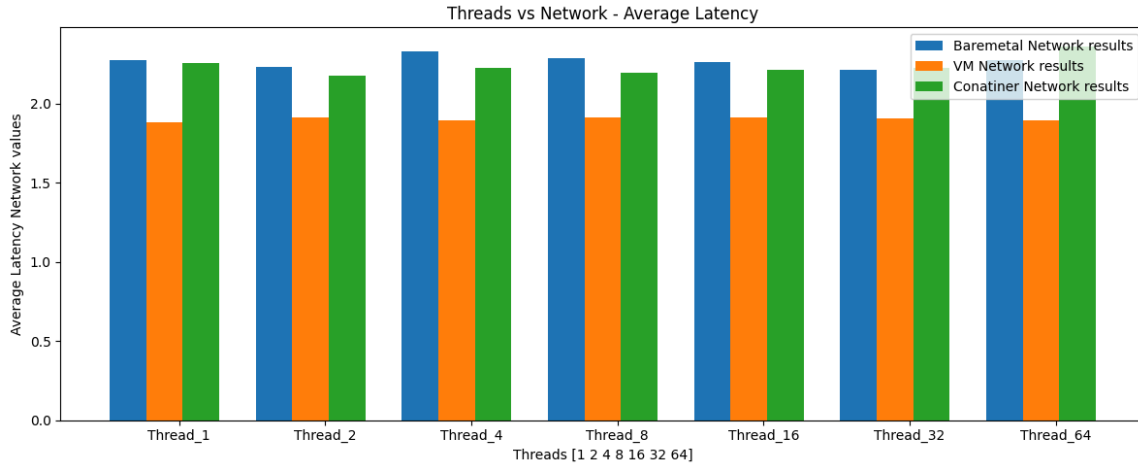
The above bar graph shows threads vs. average latency in bare metal, container, and virtual machines.

```
[cc@dila-instance:~/Assignment2$ chmod +x network-benchmark.sh        ]
[cc@dila-instance:~/Assignment2$ sh network-benchmark.sh              ]
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size:  416 KByte (WARNING: requested 1.00 MByte)
------------------------------------------------------------
[  1] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 43874 (trip-times) (sock=4) (pe
er 2.1.5) on 2024-02-10 00:38:43 (UTC)
[ ID] Interval           Transfer     Bandwidth     Burst Latency avg/min/max/stdev (cnt/size) in
P NetPwr  Reads=Dist
[  1] 0.0000-10.0024 sec  35.1 GBytes  30.2 Gbits/sec  2.302/2.189/4.105/0.080 ms (4498/8388608)
 8.28 MByte 1638399  292670=1048:966:1219:1412:1264:1224:959:284453
Average Latency: 2.302
Measured Throughput (Gbits/s) : 30.2
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size:  416 KByte (WARNING: requested 1.00 MByte)
------------------------------------------------------------
[  1] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 49102 (trip-times) (sock=4) (pe
er 2.1.5) on 2024-02-10 00:38:55 (UTC)
[ ID] Interval           Transfer     Bandwidth     Burst Latency avg/min/max/stdev (cnt/size) in
P NetPwr  Reads=Dist
[  1] 0.0000-10.0038 sec  35.1 GBytes  30.1 Gbits/sec  2.304/2.217/4.121/0.081 ms (4494/8388608)
 8.28 MByte 1635387  292457=712:702:1481:1847:1587:1481:712:283674
Average Latency: 2.304
Measured Throughput (Gbits/s) : 30.1
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size:  416 KByte (WARNING: requested 1.00 MByte)
------------------------------------------------------------
[  1] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 43868 (trip-times) (sock=4) (pe
er 2.1.5) on 2024-02-10 00:39:07 (UTC)
[ ID] Interval           Transfer     Bandwidth     Burst Latency avg/min/max/stdev (cnt/size) in
P NetPwr  Reads=Dist
[  1] 0.0000-10.0032 sec  35.1 GBytes  30.1 Gbits/sec  2.304/2.206/4.102/0.082 ms (4492/8388608)
 8.28 MByte 1634633  292303=1150:947:1160:1438:1231:1166:946:284055
Average Latency: 2.304
Measured Throughput (Gbits/s) : 30.1
------------------------------------------------------------
```

```
[root@DILA-VMACHINE1:~/Assignment2# cat vm-network-results.csv
Threads,AverageLatency,Throughput
Thread_1,2.256,30.8
Thread_2,2.176,32.0
Thread_4,2.225,31.3
Thread_8,2.194,31.7
Thread_16,2.214,31.4
Thread_32,2.222,31.3
Thread_64,2.362,29.4
root@DILA-VMACHINE1:~/Assignment2#
```

Other requirements:

Chameleon Instance: compute_skylate at CHI@TACC
Instance name: dila_Instance
CPU: Intel(R) Xeon(R) CPU E5-2670 v3 @ 2.30GHz
Memory: 8x 16GB (128GB) of DDR4-2
Disk: 1x Seagate ST9250610NS SATA 7,200 RPM HDD
Network: Broadcom NetXtreme II BCM57800 1/10 Gigabit

Screenshots

The below screenshot represents the successful login to ssh.

```
[(base) denesh@Deneshwaras-MacBook-Air ~ % chmod +x ~/.ssh
[(base) denesh@Deneshwaras-MacBook-Air ~ % cd ~/.ssh
[(base) denesh@Deneshwaras-MacBook-Air .ssh % ls
DILA_KEY.pem          known_hosts          mackeys          macsshkey          macsshkey.pub.pub
KP_JAN_31.pem         known_hosts.old      mackeys.pub      macsshkey.pub
[(base) denesh@Deneshwaras-MacBook-Air .ssh % ssh cc@129.114.109.131 -i DILA_KEY.pem
The authenticity of host '129.114.109.131 (129.114.109.131)' can't be established.
ED25519 key fingerprint is SHA256:bfsZZdQ3EpC9lZNjNxszTSB8LuSbKTB3Gb5KUYPMhx4.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '129.114.109.131' (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 Sun Feb  4 21:08:48 UTC 2024

  System load:  0.1435546875     Temperature:            51.0 C
  Usage of /:   2.0% of 217.70GB  Processes:             531
  Memory usage: 0%                Users logged in:       1
  Swap usage:   0%                IPv4 address for eno1: 10.52.3.33


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: Sun Feb  4 21:02:40 2024
```

The below screenshot is used to create a new virtual machine.

```
[cc@ubuntu:~$ sudo lxc launch images:ubuntu/22.04 DILA-VM1 --vm -c limits.cpu=4 -c limits.memory=4GiB
Creating DILA-VM1
Starting DILA-VM1
[cc@ubuntu:~$ lxc list
If this is your first time running LXD on this machine, you should also run: lxd init
To start your first container, try: lxc launch ubuntu:22.04
Or for a virtual machine: lxc launch ubuntu:22.04 --vm

Error: Get "http://unix.socket/1.0": dial unix /var/snap/lxd/common/lxd/unix.socket: connect: permission denied
[cc@ubuntu:~$ sudo lxc list
+----------+---------+----------------------+-----------------------------------------------+-----------------+-----------+
|   NAME   |  STATE  |         IPV4         |                      IPV6                     |      TYPE       | SNAPSHOTS |
+----------+---------+----------------------+-----------------------------------------------+-----------------+-----------+
| DILA-VM1 | RUNNING | 10.35.224.183 (enp5s0) | fd42:1e89:9bde:ab:216:3eff:fe34:7bcf (enp5s0) | VIRTUAL-MACHINE | 0         |
+----------+---------+----------------------+-----------------------------------------------+-----------------+-----------+
```

The below command is used to create a new container.

```
[cc@ubuntu:~$ sudo lxc launch images:ubuntu/22.04 DILA-CONTAINER1 -c limits.cpu=4 -c limits.memory=4GiB
Creating DILA-CONTAINER1
Starting DILA-CONTAINER1
[cc@ubuntu:~$ sudo lxc list
+----------------+---------+-------------------------+-----------------------------------------+-----------------+-----------+
|      NAME      |  STATE  |          IPV4           |                   IPV6                  |      TYPE       | SNAPSHOTS |
+----------------+---------+-------------------------+-----------------------------------------+-----------------+-----------+
| DILA-CONTAINER1 | RUNNING | 10.35.224.209 (eth0)    | fd42:1e89:9bde:ab:216:3eff:fed3:19c7 (eth0)   | CONTAINER       | 0         |
+----------------+---------+-------------------------+-----------------------------------------+-----------------+-----------+
| DILA-VM1       | RUNNING | 10.35.224.183 (enp5s0)  | fd42:1e89:9bde:ab:216:3eff:fe34:7bcf (enp5s0) | VIRTUAL-MACHINE | 0         |
+----------------+---------+-------------------------+-----------------------------------------+-----------------+-----------+
cc@ubuntu:~$
```

Virtual machine configurations:

```
[cc@ubuntu:~$ sudo lxc shell DILA-VM1
[root@DILA-VM1:~# uname
Linux
[root@DILA-VM1:~# 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):                  4
  On-line CPU(s) list:   0-3
Vendor ID:               GenuineIntel
  Model name:            Intel(R) Xeon(R) CPU E5-2670 v3 @ 2.30GHz
    CPU family:          6
    Model:               63
    Thread(s) per core:  1
    Core(s) per socket:  4
    Socket(s):           1
    Stepping:            2
    BogoMIPS:            4599.99
    Flags:               fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 ss ht s
                         ogy cpuid tsc_known_freq pni pclmulqdq vmx ssse3 fma cx16 pdcm pcid sse4_1 sse4_2 x2apic movbe popcnt tsc
                         lt invpcid_single pti ssbd ibrs ibpb stibp tpr_shadow vnmi ept vpid ept_ad fsgsbase tsc_adjust bmi1 avx2
Virtualization features:
  Virtualization:        VT-x
Caches (sum of all):
  L1d:                   128 KiB (4 instances)
  L1i:                   128 KiB (4 instances)
  L2:                    16 MiB (4 instances)
  L3:                    16 MiB (1 instance)
NUMA:
  NUMA node(s):          1
  NUMA node0 CPU(s):     0-3
Vulnerabilities:
  Gather data sampling:  Not affected
  Itlb multihit:         Not affected
  L1tf:                  Mitigation; PTE Inversion; VMX flush not necessary, SMT disabled
  Mds:                   Mitigation; Clear CPU buffers; SMT Host state unknown
  Meltdown:              Mitigation; PTI
  Mmio stale data:       Vulnerable: Clear CPU buffers attempted, no microcode; SMT Host state unknown
  Retbleed:              Not affected
  Spec rstack overflow:  Not affected
  Spec store bypass:     Mitigation; Speculative Store Bypass disabled via prctl and seccomp
  Spectre v1:            Mitigation; usercopy/swapgs barriers and __user pointer sanitization
  Spectre v2:            Mitigation; Retpolines, IBPB conditional, IBRS_FW, STIBP disabled, RSB filling, PBRSB-eIBRS Not affected
  Srbds:                 Not affected
  Tsx async abort:       Not affected
root@DILA-VM1:~#
```

Container Configurations:

```
[cc@ubuntu:~$ sudo lxc shell DILA-CONTAINER1
[root@DILA-CONTAINER1:~# 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):                 48
  On-line CPU(s) list:  11,12,23,26
  Off-line CPU(s) list: 0-10,13-22,24,25,27-47
Vendor ID:              GenuineIntel
  Model name:           Intel(R) Xeon(R) CPU E5-2670 v3 @ 2.30GHz
    CPU family:         6
    Model:              63
    Thread(s) per core: 2
    Core(s) per socket: 12
    Socket(s):          2
    Stepping:           2
    CPU max MHz:        3100.0000
    CPU min MHz:        1200.0000
    BogoMIPS:           4601.07
    Flags:              fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush dts acpi mmx fxsr sse sse2 ss ht
                         bts rep_good nopl xtopology nonstop_tsc cpuid aperfmperf pni pclmulqdq dtes64 monitor ds_cpl vmx smx est tm2 ss
                        cnt tsc_deadline_timer aes xsave avx f16c rdrand lahf_lm abm cpuid_fault epb invpcid_single pti ssbd ibrs ibpb s
                        st bmi1 avx2 smep bmi2 erms invpcid cqm xsaveopt cqm_llc cqm_occup_llc dtherm ida arat pln pts md_clear flush_l1
Virtualization features:
  Virtualization:       VT-x
Caches (sum of all):
  L1d:                  768 KiB (24 instances)
  L1i:                  768 KiB (24 instances)
  L2:                   6 MiB (24 instances)
  L3:                   60 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
  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
Vulnerabilities:
  Itlb multihit:        KVM: Mitigation: Split huge pages
  L1tf:                 Mitigation; PTE Inversion; VMX conditional cache flushes, SMT vulnerable
  Mds:                  Mitigation; Clear CPU buffers; SMT vulnerable
  Meltdown:             Mitigation; PTI
  Mmio stale data:      Mitigation; Clear CPU buffers; SMT vulnerable
  Retbleed:             Not affected
  Spec store bypass:    Mitigation; Speculative Store Bypass disabled via prctl and seccomp
  Spectre v1:           Mitigation; usercopy/swapgs barriers and __user pointer sanitization
  Spectre v2:           Mitigation; Retpolines, IBPB conditional, IBRS_FW, STIBP conditional, RSB filling, PBRSB-eIBRS Not affected
  Srbds:                Not affected
  Tsx async abort:      Not affected
root@DILA-CONTAINER1:~#
```