CS553 Cloud computing - Homework 2

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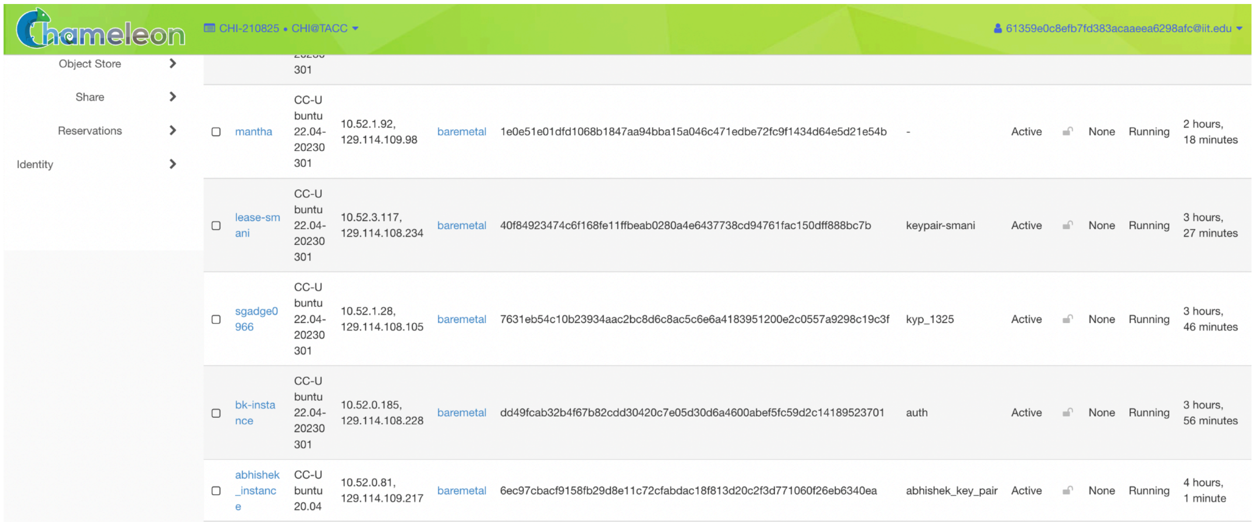
Chameleon instance setup

- Chameleon Instance: compute_cascadelake_r at CHI@TACC
- CPU: 96x Intel(R) Xeon(R) Gold 6240R CPU @ 2.40GHz
- Memory: 12x 16GB (192GB) of DIMM DDR4 Synchronous Registered (Buffered) 3200 MHz (0.3 ns)
- Disk: 1x MTFDDAK480TDS - Micron 480GB TLC SATA 6Gb/s 2.5-Inch Solid State Drive
- Network: BCM57414 NetXtreme-E 10Gb/25Gb RDMA Ethernet Controller



		301									
□	mantha	CC-Ubuntu22.04-20230301	10.52.1.92, 129.114.109.98	baremetal	1e0e51e01dfd1068b1847aa94bba15a046c471edbe72fc9f1434d64e5d21e54b	-	Active	🔓	None	Running	2 hours, 18 minutes
□	lease-smani	CC-Ubuntu22.04-20230301	10.52.3.117, 129.114.108.234	baremetal	40f84923474c6f168fe11ffbeab0280a4e6437738cd94761fac150dff888bc7b	keypair-smani	Active	🔓	None	Running	3 hours, 27 minutes
□	sgadge0966	CC-Ubuntu22.04-20230301	10.52.1.28, 129.114.108.105	baremetal	7631eb54c10b23934aac2bc8d6c8ac5c6e6a4183951200e2c0557a9298c19c3f	kyp_1325	Active	🔓	None	Running	3 hours, 46 minutes
□	bk-instance	CC-Ubuntu22.04-20230301	10.52.0.185, 129.114.108.228	baremetal	dd49fcab32b4f67b82cdd30420c7e05d30d6a4600abef5fc59d2c14189523701	auth	Active	🔓	None	Running	3 hours, 56 minutes
□	abhishek_instance	CC-Ubuntu20.04	10.52.0.81, 129.114.109.217	baremetal	6ec97cbacf9158fb29d8e11c72cfabdac18f813d20c2f3d771060f26eb6340ea	abhishek_key_pair	Active	🔓	None	Running	4 hours, 1 minute

VM and container setups

I used lxd to set up the container and the virtual machine.

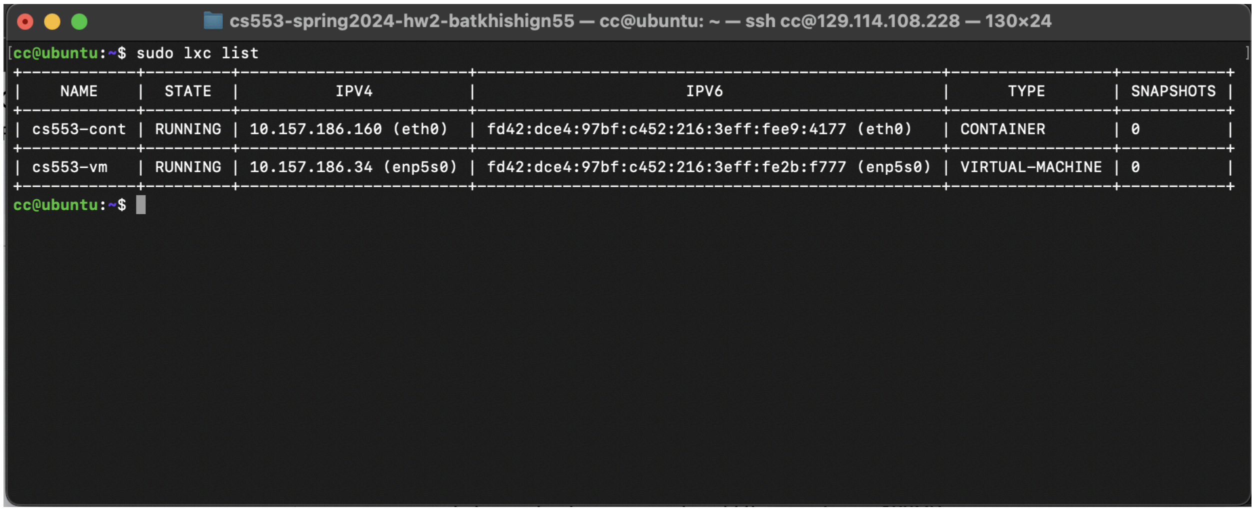
Command to start the container:

- sudo lxc launch ubuntu:22.04 cs553-cont

Command to start the virtual machine:

- sudo lxc launch ubuntu:22.04 cs553-vm --vm -c limits.cpu=64 -c limits.memory=128GiB
- sudo lxc config device override cs553-vm root size=196GB

The last command is necessary to allocate more disk space to the vm.



cs553-spring2024-hw2-batkhishign55 — cc@ubuntu: ~ — ssh cc@129.114.108.228 — 130×24

```
cc@ubuntu:~$ sudo lxc list
+------------+---------+------------------------+-------------------------------------------------+-----------------+-----------+
|    NAME    |  STATE  |          IPV4          |                      IPV6                       |      TYPE       | SNAPSHOTS |
+------------+---------+------------------------+-------------------------------------------------+-----------------+-----------+
| cs553-cont | RUNNING | 10.157.186.160 (eth0)  | fd42:dce4:97bf:c452:216:3eff:fee9:4177 (eth0)   | CONTAINER       | 0         |
+------------+---------+------------------------+-------------------------------------------------+-----------------+-----------+
| cs553-vm   | RUNNING | 10.157.186.34 (enp5s0) | fd42:dce4:97bf:c452:216:3eff:fe2b:f777 (enp5s0) | VIRTUAL-MACHINE | 0         |
+------------+---------+------------------------+-------------------------------------------------+-----------------+-----------+
cc@ubuntu:~$
```

After we set up the container and the vm, we need to be able to copy files between the host and them, for instance: benchmark script and log files. To achieve that, I created rsa key pair in the host and added it to the authorized keys files in the container and the vm. Now, we can copy files between them.

To copy the benchmark scripts from the host:

- scp bk_bench.sh root@10.18.107.204:~/

To collect the benchmarking results to the host (run the command from host):

- scp -r root@10.18.107.204:~/bench ./

Benchmark results

I have written **bk_bench.sh** script to automate the testing and saving the results to files. After running the benchmark and collecting them in the host machine, we can use **bk_plot.py** script to plot graphs for each of the benchmarks (cpu, memory, disk and network) from the raw log files. The instruction to use these scripts is in the README.md file.

CPU benchmark

The command:

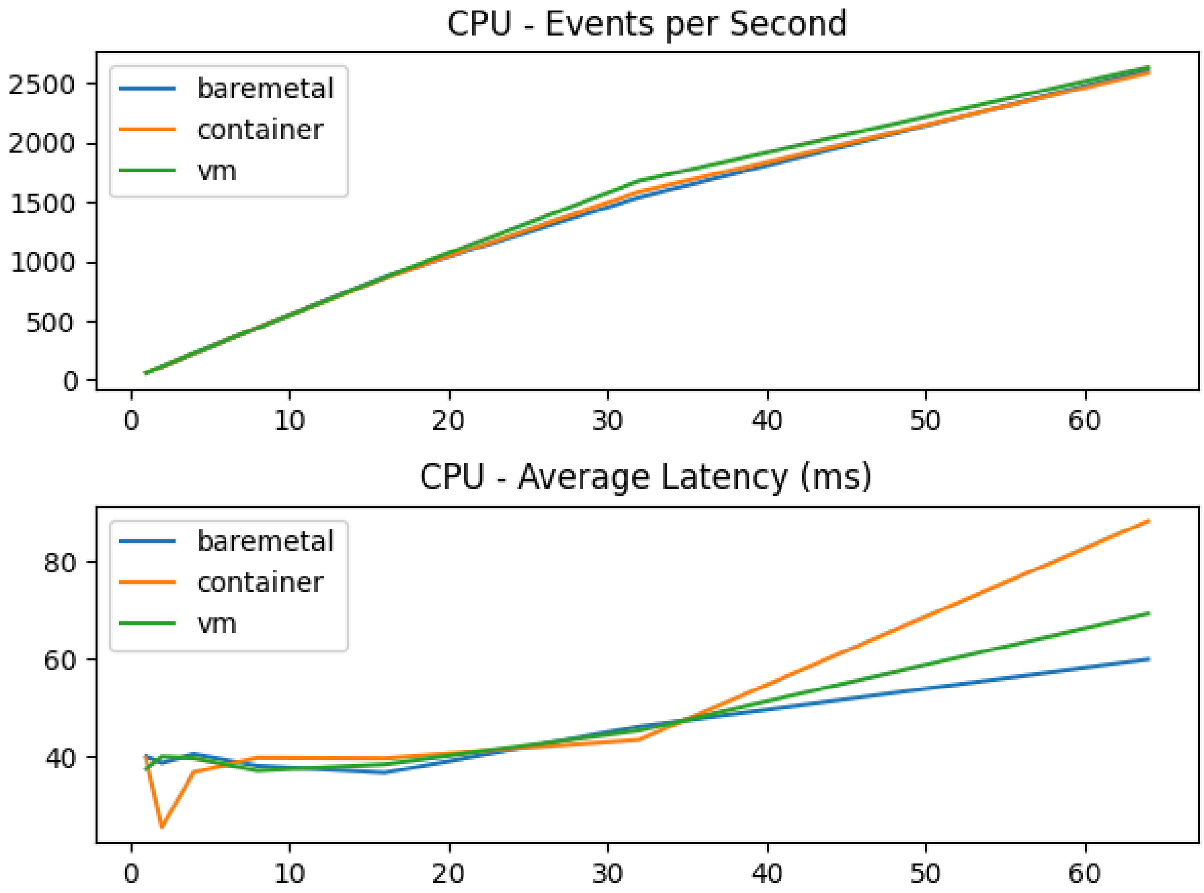
- sysbench cpu --cpu-max-prime=100000 --threads=$i run

To run the command using the script in bare metal for example:

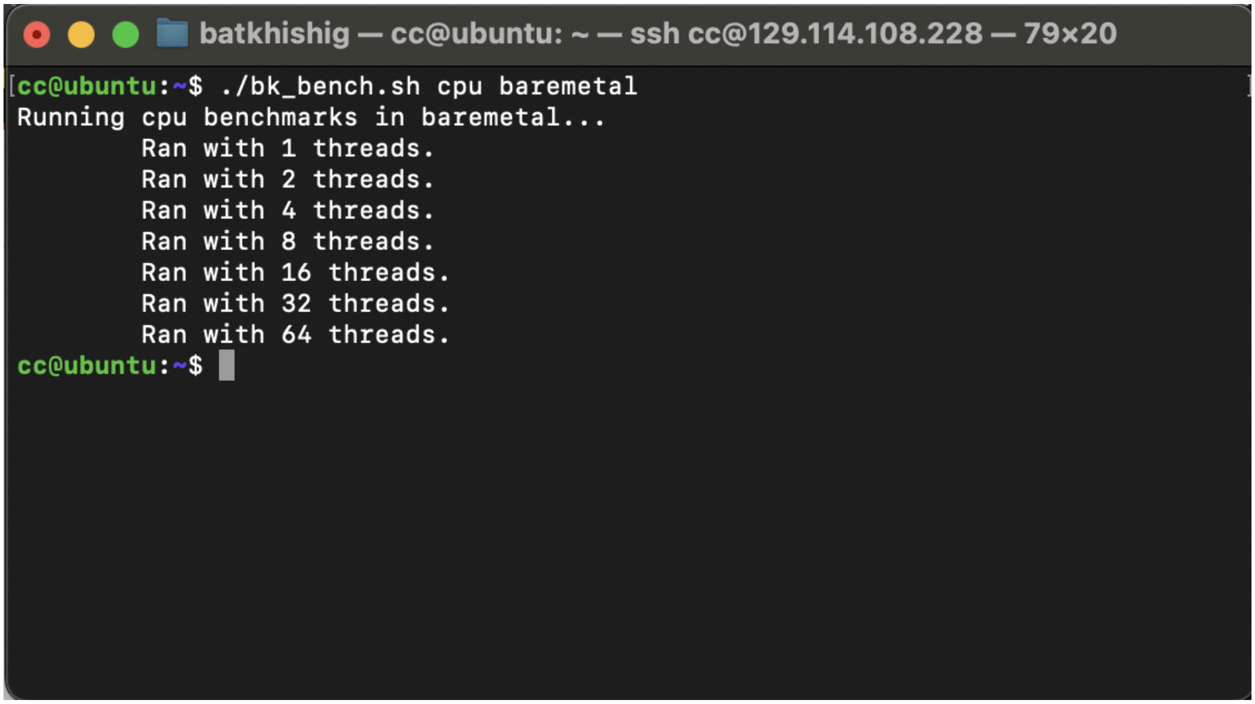
- bk_bench.sh cpu baremetal

Virtualization Type	Threads	Avg. Latency (ms)	Measured Throughput (Events per Second)	Efficiency
Baremetal	1	40.13	59.2	100%
Container	1	39.71	58.88	99.46%
Virtual Machine	1	37.6	57.49	97.11%
Baremetal	2	38.82	115.9	100%
Container	2	25.69	115.41	99.58%
Virtual Machine	2	40.08	115.16	99.36%
Baremetal	4	40.58	222.59	100%
Container	4	36.89	221.83	99.66%
Virtual Machine	4	39.76	226.83	101.9%
Baremetal	8	38.21	439.88	100%
Container	8	39.86	439.66	99.95%
Virtual Machine	8	37.2	437.38	99.43%
Baremetal	16	36.78	869.0	100%
Container	16	39.72	857.25	98.65%
Virtual Machine	16	38.52	864.11	99.44%
Baremetal	32	46.22	1537.04	100%
Container	32	43.52	1584.32	103.08%
Virtual Machine	32	45.39	1676.12	109.05%
Baremetal	64	59.9	2607.88	100%
Container	64	88.1	2584.16	99.09%
Virtual Machine	64	69.18	2632.87	100.96%

Graph:

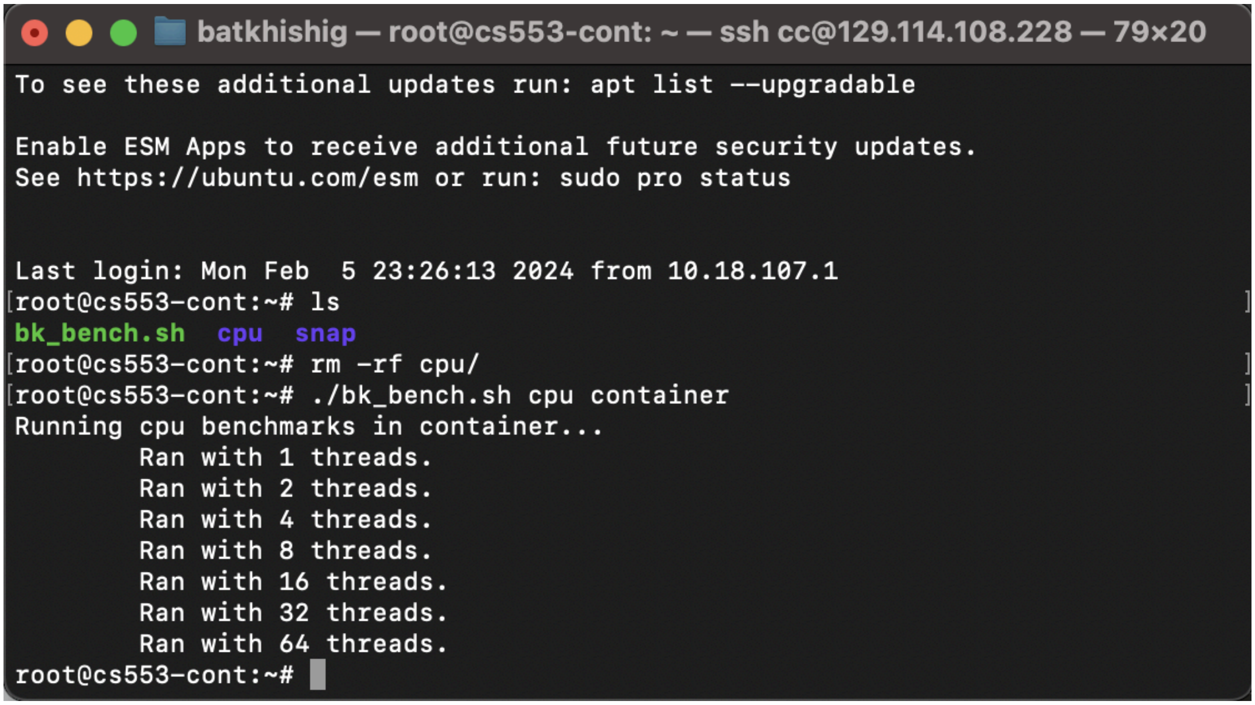


Some screenshots from running the test:



batkhishig — cc@ubuntu: ~ — ssh cc@129.114.108.228 — 79×20

```
cc@ubuntu:~$ ./bk_bench.sh cpu baremetal
Running cpu benchmarks in baremetal...
        Ran with 1 threads.
        Ran with 2 threads.
        Ran with 4 threads.
        Ran with 8 threads.
        Ran with 16 threads.
        Ran with 32 threads.
        Ran with 64 threads.
cc@ubuntu:~$ 
```



batkhishig — root@cs553-cont: ~ — ssh cc@129.114.108.228 — 79×20

```
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: Mon Feb  5 23:26:13 2024 from 10.18.107.1
root@cs553-cont:~# ls
bk_bench.sh  cpu  snap
root@cs553-cont:~# rm -rf cpu/
root@cs553-cont:~# ./bk_bench.sh cpu container
Running cpu benchmarks in container...
        Ran with 1 threads.
        Ran with 2 threads.
        Ran with 4 threads.
        Ran with 8 threads.
        Ran with 16 threads.
        Ran with 32 threads.
        Ran with 64 threads.
root@cs553-cont:~# 
```

Memory benchmark

The command:

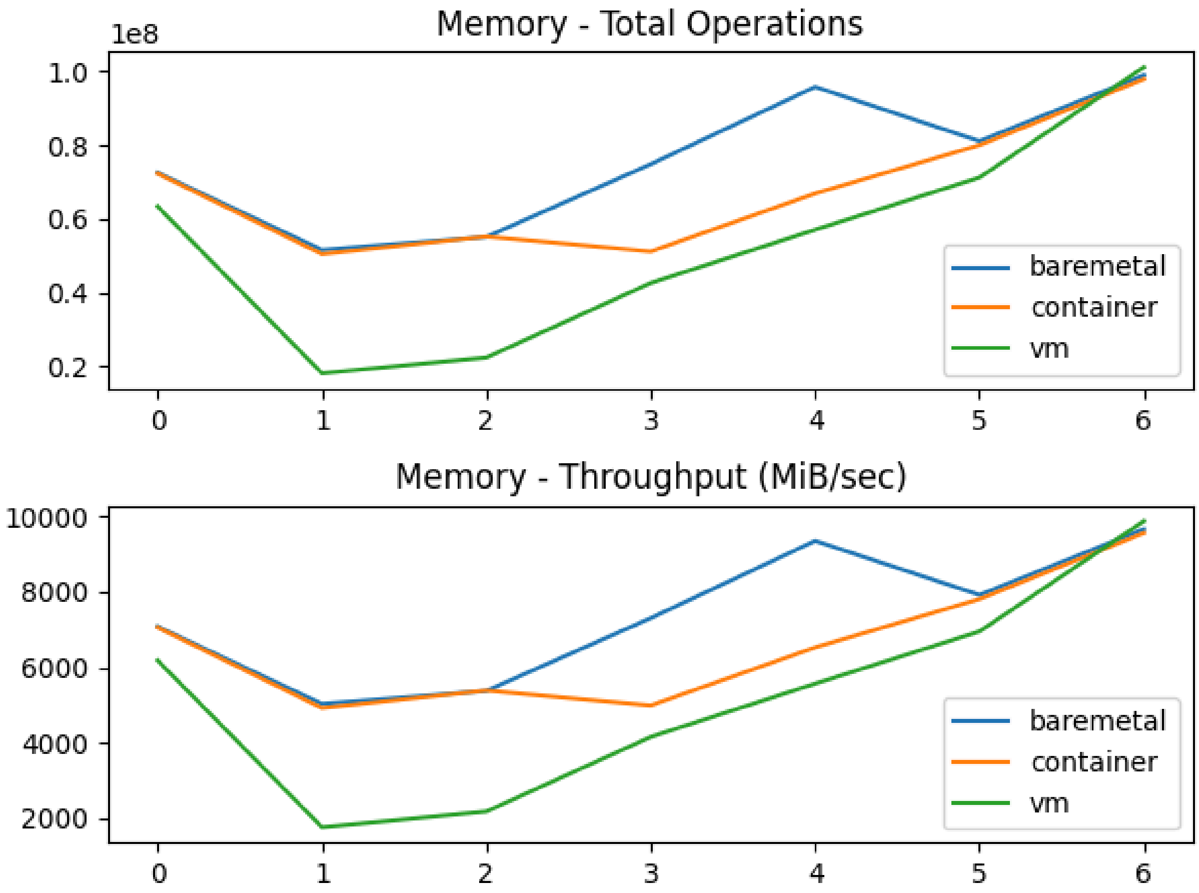
- sysbench memory --memory-block-size=1K --memory-total-size=120G --threads=$i run

To run the command using the script in bare metal for example:

- bk_bench.sh mem baremetal

Virtualization Type	Threads	Block Size (KB)	Operation	Access Pattern	Total Operations	Throughput (MiB/sec)	Efficiency
Baremetal	1	1	Read	Random	72578462.0	7084.25	100%
Container	1	1	Read	Random	72346142.0	7061.49	99.68%
VM	1	1	Read	Random	63397495.0	6188.04	87.35%
Baremetal	2	1	Read	Random	51583492.0	5034.99	100%
Container	2	1	Read	Random	50463249.0	4925.54	97.83%
VM	2	1	Read	Random	18110795.0	1767.74	35.11%
Baremetal	4	1	Read	Random	55106940.0	5378.91	100%
Container	4	1	Read	Random	55211259.0	5389.04	100.19%
VM	4	1	Read	Random	22342457.0	2180.79	40.54%
Baremetal	8	1	Read	Random	74854911.0	7306.51	100%
Container	8	1	Read	Random	51157572.0	4993.31	68.34%
VM	8	1	Read	Random	42609756.0	4158.98	56.92%
Baremetal	16	1	Read	Random	95840264.0	9354.76	100%
Container	16	1	Read	Random	66907914.0	6530.59	69.81%
VM	16	1	Read	Random	57065847.0	5570.0	59.54%
Baremetal	32	1	Read	Random	81138116.0	7922.28	100%
Container	32	1	Read	Random	80026623.0	7811.03	98.6%
VM	32	1	Read	Random	71244148.0	6953.8	87.76%
Baremetal	64	1	Read	Random	98996230.0	9665.76	100%
Container	64	1	Read	Random	97947835.0	9563.45	98.94%
VM	64	1	Read	Random	101182023.0	9878.96	102.21%

Graph:



Disk benchmark

The command:

- sysbench fileio --file-num=128 --file-block-size=4096 --file-total-size=120G --file-test-mode=rndrd --file-io-mode=sync --file-extra-flags=direct prepare
- sysbench fileio --file-num=128 --file-block-size=4096 --file-total-size=120G --file-test-mode=rndrd --file-io-mode=sync --file-extra-flags=direct --threads=$i run
- sysbench fileio --file-num=128 --file-block-size=4096 --file-total-size=120G --file-test-mode=rndrd --file-io-mode=sync --file-extra-flags=direct cleanup

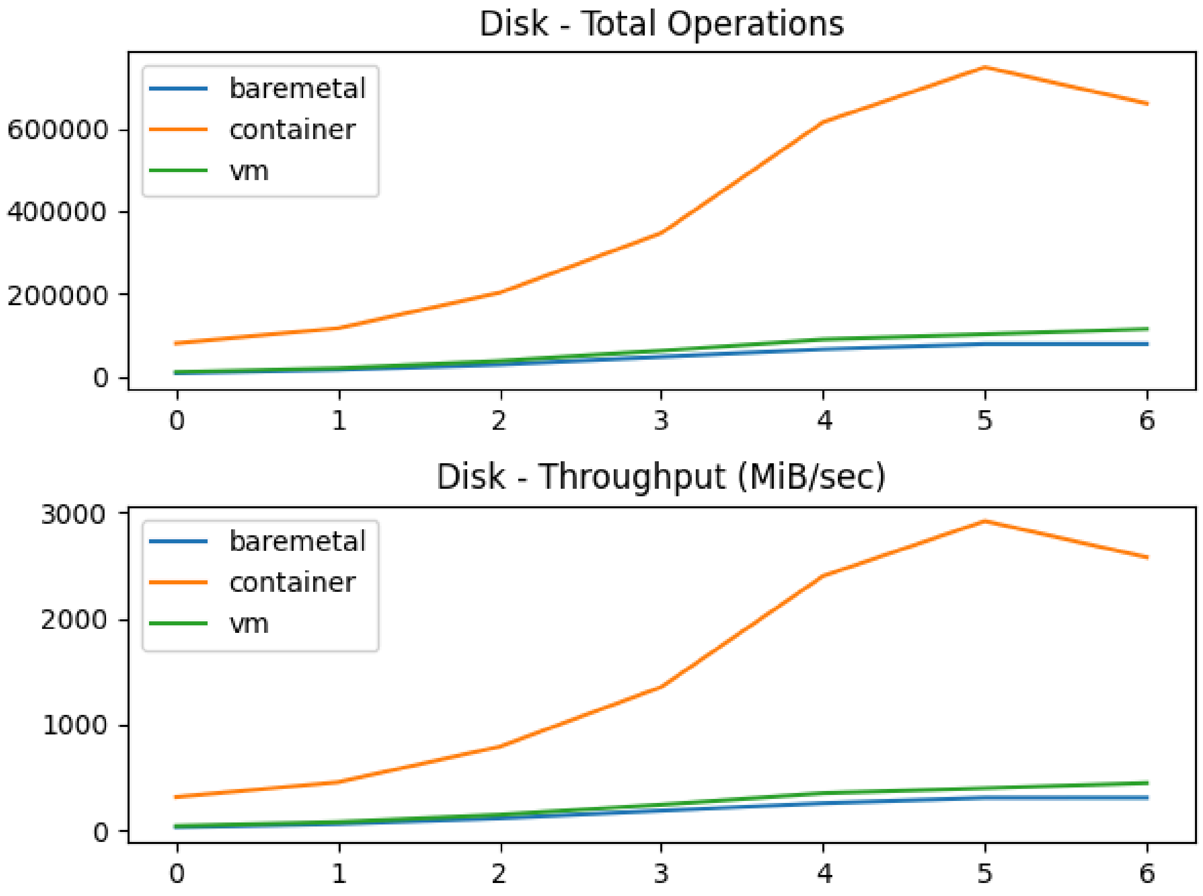
To run the command using the script in bare metal for example:

- bk_bench.sh disk baremetal

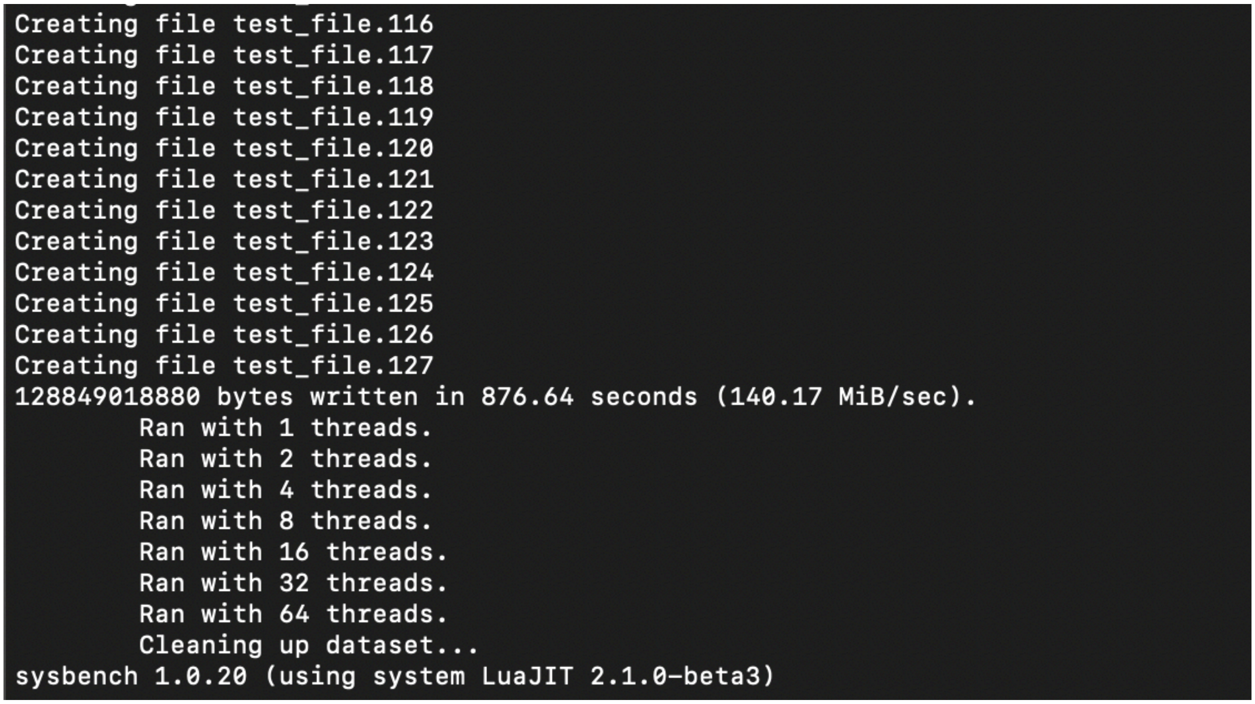
Virtualization Type	Threads	Block Size (KB)	Operation	Access Pattern	I/O Mode	I/O Flag	Total Operations	Throughput (MiB/sec)	Efficiency
Baremetal	1	4	Read	Random	SYNC	DirectIO	7984.11	31.19	100%
Container	1	4	Read	Random	SYNC	DirectIO	80598.49	314.84	1009.43%

VM	1	4	Read	Random	SYNC	DirectIO	11093.7	43.33	138.92%
Baremetal	2	4	Read	Random	SYNC	DirectIO	16085.46	62.83	100%
Container	2	4	Read	Random	SYNC	DirectIO	116727.87	455.97	725.72%
VM	2	4	Read	Random	SYNC	DirectIO	20360.64	79.53	126.58%
Baremetal	4	4	Read	Random	SYNC	DirectIO	29258.17	114.29	100%
Container	4	4	Read	Random	SYNC	DirectIO	202580.43	791.33	692.39%
VM	4	4	Read	Random	SYNC	DirectIO	37627.44	146.98	128.6%
Baremetal	8	4	Read	Random	SYNC	DirectIO	47441.72	185.32	100%
Container	8	4	Read	Random	SYNC	DirectIO	346798.81	1354.68	730.99%
VM	8	4	Read	Random	SYNC	DirectIO	62370.24	243.63	131.46%
Baremetal	16	4	Read	Random	SYNC	DirectIO	65883.68	257.36	100%
Container	16	4	Read	Random	SYNC	DirectIO	615117.82	2402.8	933.63%
VM	16	4	Read	Random	SYNC	DirectIO	89768.89	350.66	136.25%
Baremetal	32	4	Read	Random	SYNC	DirectIO	78957.74	308.43	100%
Container	32	4	Read	Random	SYNC	DirectIO	747924.38	2921.58	947.24%
VM	32	4	Read	Random	SYNC	DirectIO	102053.22	398.65	129.25%
Baremetal	64	4	Read	Random	SYNC	DirectIO	78995.89	308.58	100%
Container	64	4	Read	Random	SYNC	DirectIO	660480.98	2580.0	836.09%
VM	64	4	Read	Random	SYNC	DirectIO	114847.53	448.62	145.38%

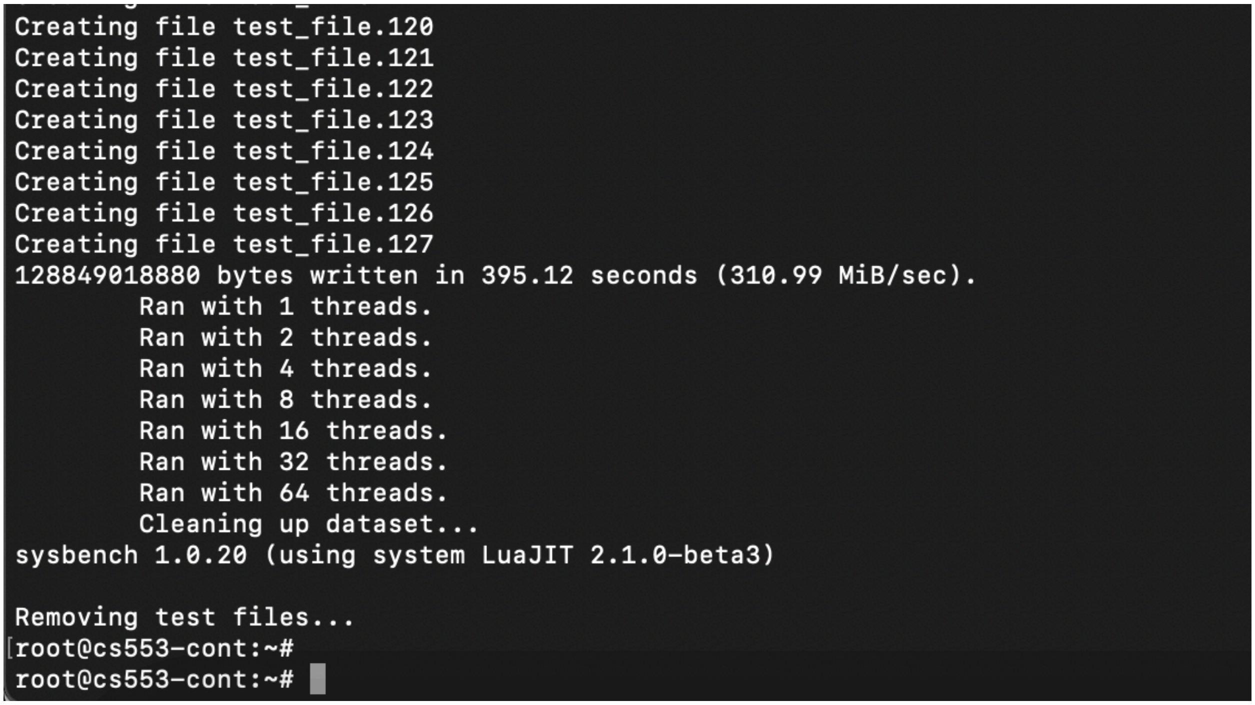
Graph:



Some screenshots from running the test:



```
Creating file test_file.116
Creating file test_file.117
Creating file test_file.118
Creating file test_file.119
Creating file test_file.120
Creating file test_file.121
Creating file test_file.122
Creating file test_file.123
Creating file test_file.124
Creating file test_file.125
Creating file test_file.126
Creating file test_file.127
128849018880 bytes written in 876.64 seconds (140.17 MiB/sec).
        Ran with 1 threads.
        Ran with 2 threads.
        Ran with 4 threads.
        Ran with 8 threads.
        Ran with 16 threads.
        Ran with 32 threads.
        Ran with 64 threads.
        Cleaning up dataset...
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)
```



```
Creating file test_file.120
Creating file test_file.121
Creating file test_file.122
Creating file test_file.123
Creating file test_file.124
Creating file test_file.125
Creating file test_file.126
Creating file test_file.127
128849018880 bytes written in 395.12 seconds (310.99 MiB/sec).
        Ran with 1 threads.
        Ran with 2 threads.
        Ran with 4 threads.
        Ran with 8 threads.
        Ran with 16 threads.
        Ran with 32 threads.
        Ran with 64 threads.
        Cleaning up dataset...
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Removing test files...
[root@cs553-cont:~#
root@cs553-cont:~#
```

Network benchmark

The terminal1:

- iperf -s -w 1M

The terminal2:

- iperf -c 127.0.0.1 -e -i 1 --nodelay -l 8192K --trip-times --parallel $i >> ./bench/$mode/$virt/${mode}_$i.log

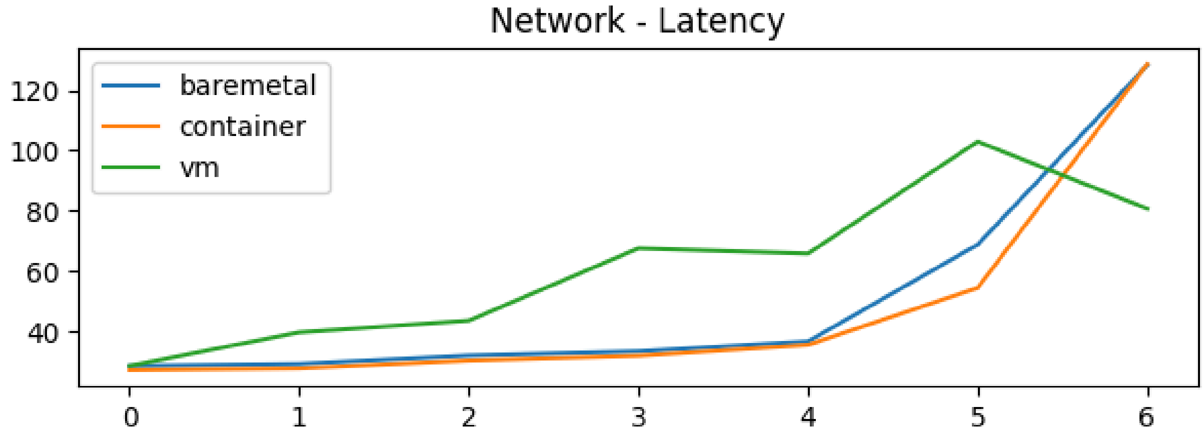
To run the command using the script in bare metal for example:

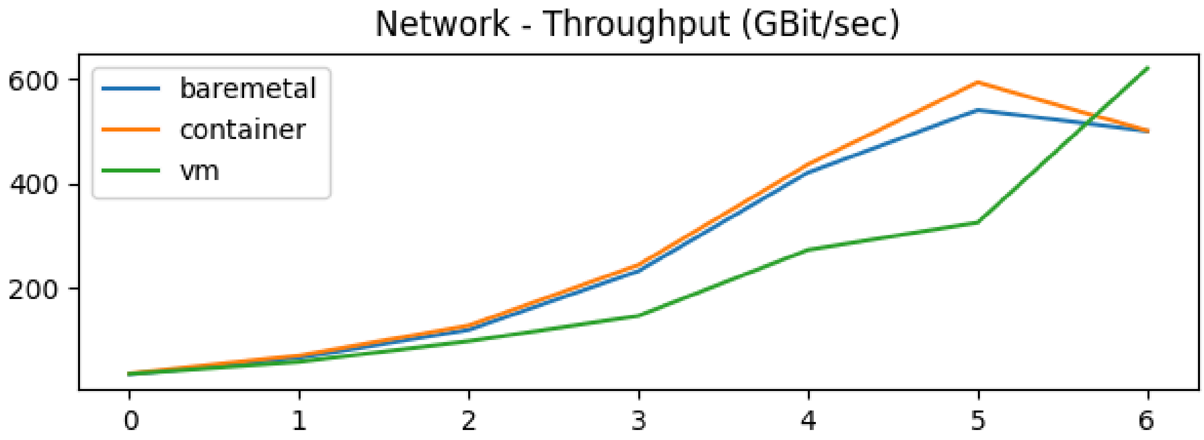
- bk_bench.sh net baremetal

You still need another terminal for iperf server.

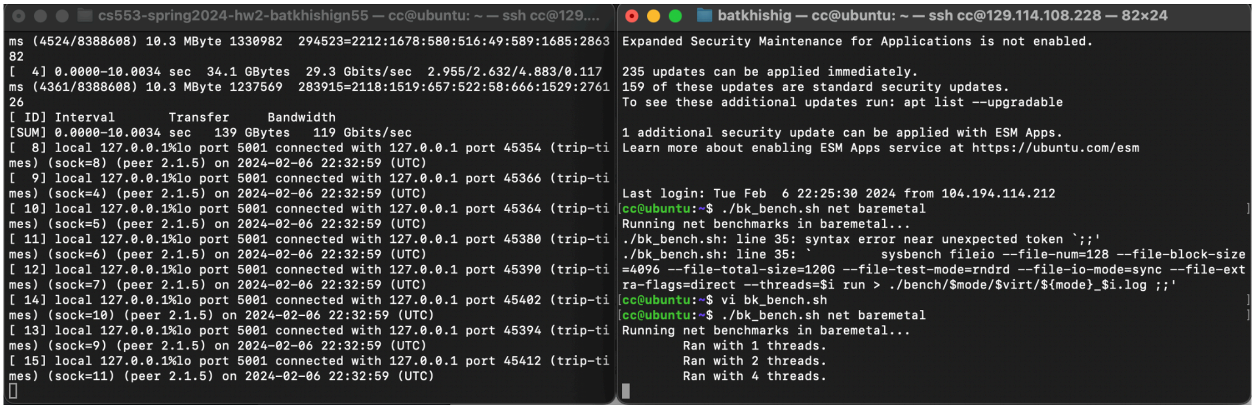
Virtualization Type	Server	Threads	Latency (ms)	Measured Throughput (Gbits/s)	Efficiency
Baremetal	1	1	28.5	34.41	100%
Container	1	1	27.1	35.83	104.13%
Virtual Machine	1	1	28.5	35.14	102.12%
Baremetal	1	2	29.15	65.65	100%
Container	1	2	27.65	70.11	106.79%
Virtual Machine	1	2	39.6	57.93	88.24%
Baremetal	1	4	31.93	119.42	100%
Container	1	4	30.27	127.68	106.92%
Virtual Machine	1	4	43.48	97.57	81.7%
Baremetal	1	8	33.34	231.9	100%
Container	1	8	31.86	243.79	105.13%
Virtual Machine	1	8	67.51	146.21	64.05%
Baremetal	1	16	36.58	420.92	100%
Container	1	16	35.44	436.56	103.72%
Virtual Machine	1	16	65.77	272.61	64.77%
Baremetal	1	32	68.74	540.87	100%
Container	1	32	54.39	593.88	109.85
Virtual Machine	1	32	102.93	325.0	60.09%
Baremetal	1	64	128.3	500.52	100%
Container	1	64	128.64	501.41	100.18%
Virtual Machine	1	64	80.66	620.81	124.03%

Graph:





Some screenshots from running the test:


cs553-spring2024-hw2-batkhishign55 — cc@ubuntu: ~ — ssh cc@129....
batkhishig — cc@ubuntu: ~ — ssh cc@129.114.108.228 — 82×24

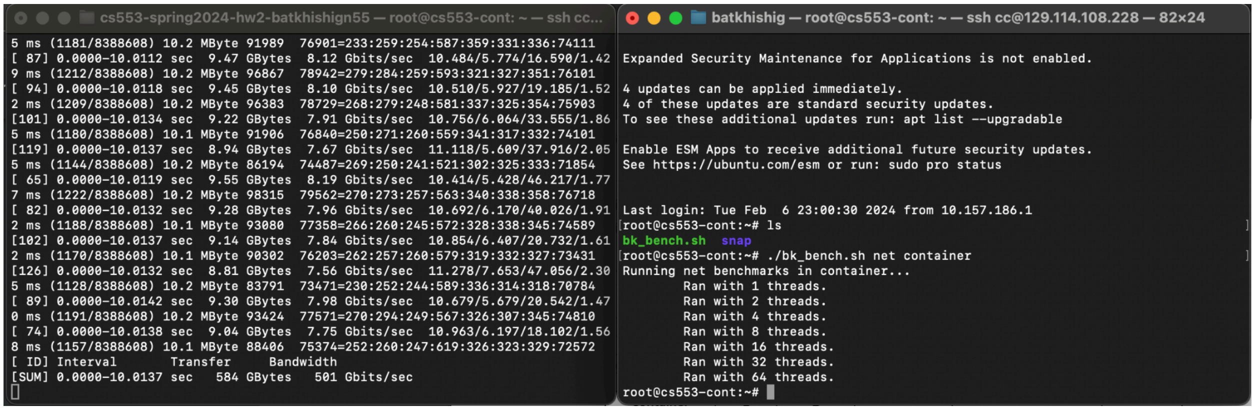
```
ms (4524/8388608) 10.3 MByte 1330982  294523=2212:1678:580:516:49:589:1685:2863
82
[  4] 0.0000-10.0034 sec  34.1 GBytes  29.3 Gbits/sec  2.955/2.632/4.883/0.117
ms (4361/8388608) 10.3 MByte 1237569  283915=2118:1519:657:522:58:666:1529:2761
26
[ ID] Interval       Transfer     Bandwidth
[SUM] 0.0000-10.0034 sec   139 GBytes   119 Gbits/sec
[  8] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45354 (trip-ti
mes) (sock=8) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
[  9] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45366 (trip-ti
mes) (sock=4) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
[ 10] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45364 (trip-ti
mes) (sock=5) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
[ 11] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45380 (trip-ti
mes) (sock=6) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
[ 12] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45390 (trip-ti
mes) (sock=7) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
[ 14] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45402 (trip-ti
mes) (sock=10) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
[ 13] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45394 (trip-ti
mes) (sock=9) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
[ 15] local 127.0.0.1%lo port 5001 connected with 127.0.0.1 port 45412 (trip-ti
mes) (sock=11) (peer 2.1.5) on 2024-02-06 22:32:59 (UTC)
```

```
Expanded Security Maintenance for Applications is not enabled.

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

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


Last login: Tue Feb  6 22:25:30 2024 from 104.194.114.212
cc@ubuntu:~$ ./bk_bench.sh net baremetal
Running net benchmarks in baremetal...
./bk_bench.sh: line 35: syntax error near unexpected token `;;'
./bk_bench.sh: line 35: `          sysbench fileio --file-num=128 --file-block-size
=4096 --file-total-size=120G --file-test-mode=rndrd --file-io-mode=sync --file-ext
ra-flags=direct --threads=$i run > ./bench/$mode/$virt/${mode}_$i.log ;;'
cc@ubuntu:~$ vi bk_bench.sh
cc@ubuntu:~$ ./bk_bench.sh net baremetal
Running net benchmarks in baremetal...
        Ran with 1 threads.
        Ran with 2 threads.
        Ran with 4 threads.
```


cs553-spring2024-hw2-batkhishign55 — root@cs553-cont: ~ — ssh cc...
batkhishig — root@cs553-cont: ~ — ssh cc@129.114.108.228 — 82×24

```
5 ms (1181/8388608) 10.2 MByte 91989  76901=233:259:254:587:359:331:336:74111
[ 87] 0.0000-10.0112 sec  9.47 GBytes  8.12 Gbits/sec  10.484/5.774/16.590/1.42
9 ms (1212/8388608) 10.2 MByte 96867  78942=279:284:259:593:321:327:351:76101
[ 94] 0.0000-10.0118 sec  9.45 GBytes  8.10 Gbits/sec  10.510/5.927/19.185/1.52
2 ms (1209/8388608) 10.2 MByte 96383  78729=268:279:248:581:337:325:354:75903
[101] 0.0000-10.0134 sec  9.22 GBytes  7.91 Gbits/sec  10.756/6.064/33.555/1.86
5 ms (1180/8388608) 10.1 MByte 91906  76840=250:271:260:559:341:317:332:74101
[119] 0.0000-10.0137 sec  8.94 GBytes  7.67 Gbits/sec  11.118/5.609/37.916/2.05
5 ms (1144/8388608) 10.2 MByte 86194  74487=269:250:241:521:302:325:333:71854
[ 65] 0.0000-10.0119 sec  9.55 GBytes  8.19 Gbits/sec  10.414/5.428/46.217/1.77
7 ms (1222/8388608) 10.2 MByte 98315  79562=270:273:257:563:340:338:358:76718
[ 82] 0.0000-10.0132 sec  9.28 GBytes  7.96 Gbits/sec  10.692/6.170/40.026/1.91
2 ms (1188/8388608) 10.1 MByte 93080  77358=266:260:245:572:328:338:345:74589
[102] 0.0000-10.0137 sec  9.14 GBytes  7.84 Gbits/sec  10.854/6.407/20.732/1.61
2 ms (1170/8388608) 10.1 MByte 90302  76203=262:257:260:579:319:332:327:73431
[126] 0.0000-10.0132 sec  8.81 GBytes  7.56 Gbits/sec  11.278/7.653/47.056/2.30
5 ms (1128/8388608) 10.2 MByte 83791  73471=230:252:244:589:336:314:318:70784
[ 89] 0.0000-10.0142 sec  9.30 GBytes  7.98 Gbits/sec  10.679/5.679/20.542/1.47
0 ms (1191/8388608) 10.2 MByte 93424  77571=270:294:249:567:326:307:345:74810
[ 74] 0.0000-10.0138 sec  9.04 GBytes  7.75 Gbits/sec  10.963/6.197/18.102/1.56
8 ms (1157/8388608) 10.1 MByte 88406  75374=252:260:247:619:326:323:329:72572
[ ID] Interval       Transfer     Bandwidth
[SUM] 0.0000-10.0137 sec   584 GBytes   501 Gbits/sec
```

```
Expanded Security Maintenance for Applications is not enabled.

4 updates can be applied immediately.
4 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: Tue Feb  6 23:00:30 2024 from 10.157.186.1
root@cs553-cont:~# ls
bk_bench.sh  snap
root@cs553-cont:~# ./bk_bench.sh net container
Running net benchmarks in container...
        Ran with 1 threads.
        Ran with 2 threads.
        Ran with 4 threads.
        Ran with 8 threads.
        Ran with 16 threads.
        Ran with 32 threads.
        Ran with 64 threads.
root@cs553-cont:~#
```