

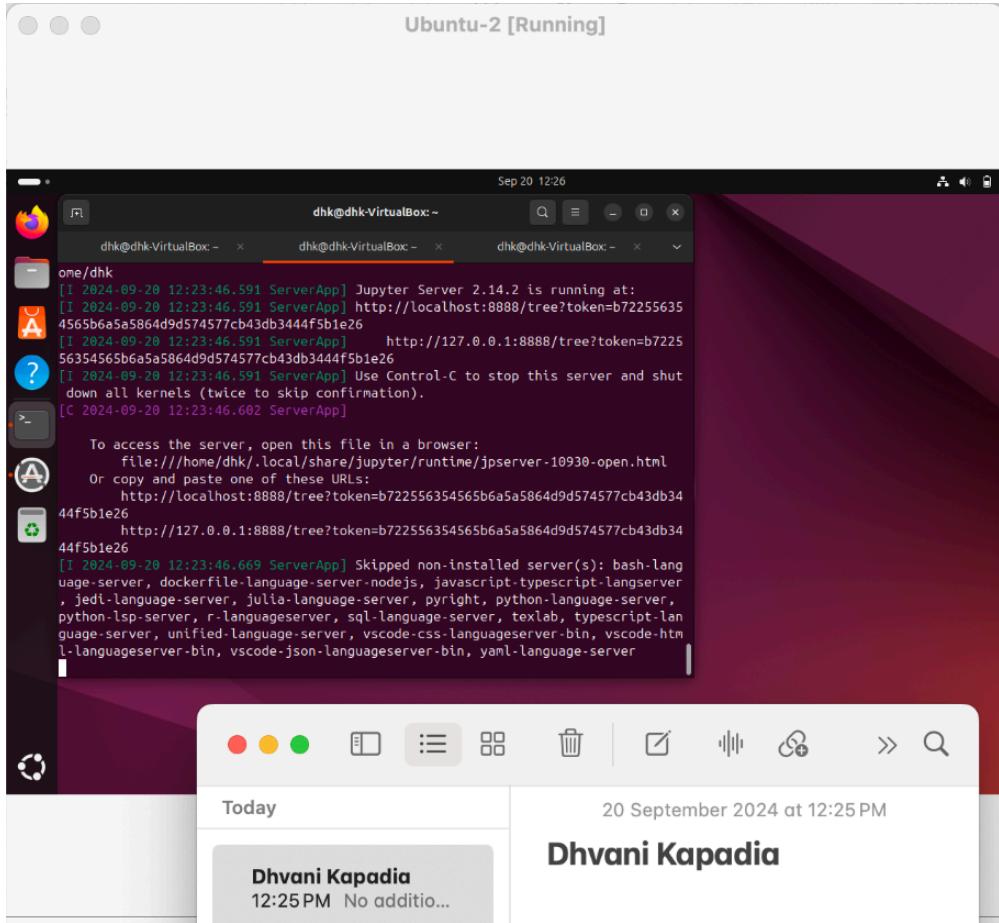
3)

For comparison I have utilized Sysbench.

3.1 CPU comparison:

- VM

Workload: Jupyter Notebook



```
Sep 20 12:27
dhk@dhk-VirtualBox:~$ sysbench cpu --cpu-max-prime=10000 run
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: 10000
Initializing worker threads...
Threads started!

CPU speed:
events per second: 524.54

General statistics:
total time: 10.0009s
total number of events: 5247

Latency (ms):
min: 1.12
avg: 1.98
max: 107.71
95th percentile: 3.19
sum: 9976.32

Threads fairness:
events (avg/stddev): 5247.0000/0.00
```

Today 20 September 2024 at 12:25 PM Dhvani Kapadia

```
Sep 20 12:27
dhk@dhk-VirtualBox:~$ sysbench cpu --cpu-max-prime=10000 run
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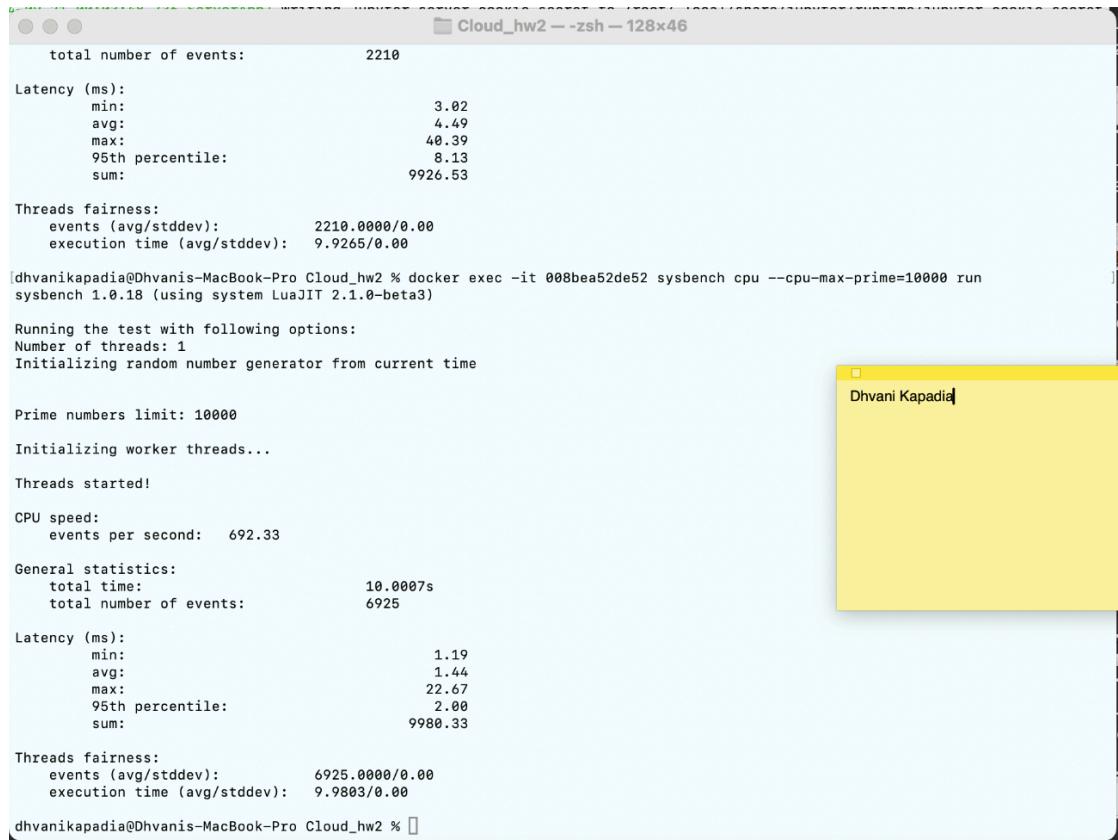
Latency (ms):
min: 1.12
avg: 1.90
max: 107.71
95th percentile: 3.19
sum: 9976.32

Threads fairness:
events (avg/stddev): 5247.0000/0.00
execution time (avg/stddev): 9.9763/0.00
```

Today 20 September 2024 at 12:25 PM Dhvani Kapadia

- Docker

Workload: Jupyter Notebook



The terminal window displays the output of a sysbench CPU test. The test parameters are set to run with 1 thread, a prime limit of 10000, and a total number of events of 2210. The test shows a CPU speed of approximately 692.33 events per second. General statistics include a total time of 10.0007 seconds and a total number of events of 6925. Latency statistics show a minimum of 1.19 ms, an average of 1.44 ms, a maximum of 22.67 ms, a 95th percentile of 2.00 ms, and a sum of 9980.33 ms. Threads fairness statistics show events (avg/stddev) of 2210.0000/0.00 and execution time (avg/stddev) of 9.9265/0.00.

```
total number of events: 2210
Latency (ms):
    min: 3.02
    avg: 4.49
    max: 40.39
    95th percentile: 8.13
    sum: 9926.53

Threads fairness:
    events (avg/stddev): 2210.0000/0.00
    execution time (avg/stddev): 9.9265/0.00

[dhvanikapadia@Dhvanis-MacBook-Pro Cloud_hw2 % docker exec -it 008bea52de52 sysbench cpu --cpu-max-prime=10000 run
sysbench 1.0.18 (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: 10000

Initializing worker threads...

Threads started!

CPU speed:
    events per second: 692.33

General statistics:
    total time: 10.0007s
    total number of events: 6925

Latency (ms):
    min: 1.19
    avg: 1.44
    max: 22.67
    95th percentile: 2.00
    sum: 9980.33

Threads fairness:
    events (avg/stddev): 6925.0000/0.00
    execution time (avg/stddev): 9.9803/0.00

dhvanikapadia@Dhvanis-MacBook-Pro Cloud_hw2 % ]
```

A yellow Jupyter Notebook interface window titled "Dhvani Kapadia" is visible in the background, indicating the workload being tested.

3.2 Memory comparison:

VM

```
dhk@dhk-VirtualBox: ~ sysbench memory --memory-block-size=1M --memory-total-size=10G run
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: 1024KiB
total size: 10240MiB
operation: write
scope: global

Initializing worker threads...
Threads started!

Total operations: 10240 ( 7563.10 per second)
10240.00 MiB transferred (7563.10 MiB/sec)

General statistics:
    total time: 1.3468s
    total number of events: 10240

Latency (ms):
    min: 0.06
    avg: 0.13
```

```
dhk@dhk-VirtualBox: ~ dhk@dhk-VirtualBox: ~ dhk@dhk-VirtualBox: ~
block size: 1024KiB
total size: 10240MiB
operation: write
scope: global

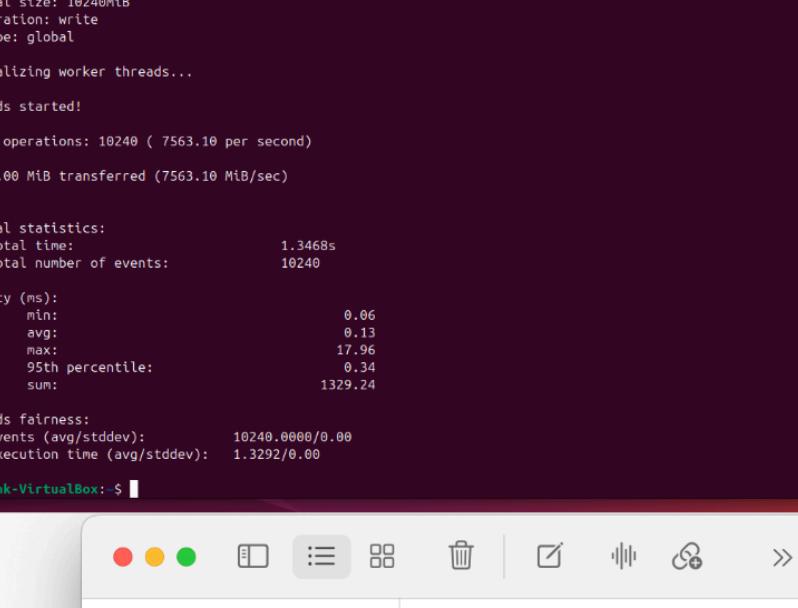
Initializing worker threads...
Threads started!
Total operations: 10240 ( 7563.10 per second)
10240.00 MiB transferred (7563.10 MiB/sec)

General statistics:
    total time: 1.3468s
    total number of events: 10240

Latency (ms):
    min: 0.06
    avg: 0.13
    max: 17.96
    95th percentile: 0.34
    sum: 1329.24

Threads fairness:
    events (avg/stddev): 10240.0000/0.00
    execution time (avg/stddev): 1.3292/0.00

dhk@dhk-VirtualBox: ~ |
```



Docker

```

Threads fairness:
events (avg/stddev):      6925.0000/0.00
execution time (avg/stddev): 9.9803/0.00

dhvanikapadia@Dhvanis-MacBook-Pro Cloud_hw2 % docker exec -it 008bea52de52 sysbench memory --memory-block-size=1M --memory-total-size=10G run

sysbench 1.0.18 (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: 1024KiB
total size: 10240MiB
operation: write
scope: global

Initializing worker threads...

Threads started!

Total operations: 10240 (11192.81 per second)
10240.00 MiB transferred (11192.81 MiB/sec)

General statistics:
total time:          0.9078s
total number of events: 10240

Latency (ms):
min:                 0.08
avg:                 0.08
max:                 1.31
95th percentile:    0.13
sum:                867.80

Threads fairness:
events (avg/stddev):      10240.0000/0.00
execution time (avg/stddev): 0.8678/0.00

dhvanikapadia@Dhvanis-MacBook-Pro Cloud_hw2 %

```

CONTAINER ID	NAME	CPU %	MEM USAGE / LIMIT	MEM %	NET I/O	BLOCK I/O	PIDS
008bea52de52	youthful_lichterman	0.00%	125.1MiB / 3.825GiB	3.19%	1.16kB / 0B	64.6MB / 16.4kB	1

2)

- As seen from the above test performed using the assistance of Sysbench Docker has outperformed Virtual Box.
- Even if the difference is small, it would be significant if more applications or more taxing workload is used.
- Both the tests, CPU as well as Memory showed that docker was slightly better in performance than Virtual Machine
- The paper mentioned that this would be the case due to the QEMU layer present in VM which makes it less efficient than Docker.

Analysis for CPU

- Even though the execution time per event is less in VM, Docker executed more events in the same time

- Additionally min latency is less of VM but as the max latency is way more compared to Docker, the average latency of docker turns out to be less

Analysis for memory:

- Here, min latency is less of VM but as the max latency is way more compared to Docker, the average latency of docker turns out to be less
- Execution time for Docker is less compared to that of VM